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RDT&E PROJECT NO. 1M643324D59204

USATECOM PROJECT NO. 7-7-0887-01

INTEGRATED ENGINEERING AND SERVICE TEST OF TANK, COLLAPSIBLE, SELF-SUPPORTING, 5,000-BARREL (TEMPERATE)

FINAL REPORT

BY

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1LT, TC

DANIEL S. GAFFORD

C. MIGUEL DUNCAN

DECEMBER 1968

U S ARMY
GENERAL EQUIPMENT TEST ACTIVITY
FORT LEE, VIRGINIA

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DEPARTMENT OF THE ARMY
HEADQUARTERS. U.S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND. MARYLAND 21005

AMSTE-GE

30 JAN 1969

SUBJECT: Final Reports of Engineering and Service Tests of Tank, Collapsible, Self-Supporting, 5000 Barrel Capacity Unit, USATECOM Project Nos. 7-7-0887-01 and 7-7-0887-04

Commanding General
U. S. Army Materiel Command
ATTN: AMCRD-JG
Washington, D. C. 20315

1. References:

a. DA approved SDR for Tank, Collapsible, Self-Supporting, 1250, 2500, and 5000 Barrels, dated 21 February 1966.

b. Final Report of Integrated Engineering and Service Test (Temperate) of Tank, Collapsible, Self-Supporting, 5000 Barrel, USATECOM Project No. 7-7-0887-01, USAGETA, December 1968.

c. Final Report of Service Test (Temperate Winter) of Tank, Collapsible, Self-Supporting, 500 Barrel Capacity, USATECOM Project No. 7-7-0887-03, USAATC, 21 April 1968, with USATECOM transmittal letter to AMC 20 June 1968.

d. Final Report of Integrated Engineering and Service Test of Tank, Collapsible, Self-Supporting, 5,000-Barrel Capacity, USATECOM Project No. 7-7-0887-04, YPG, October 1968.

e. Final Report of Integrated Engineering and Service Test (Tropic) of Tank, Collapsible, Self-Supporting, 5000 Barrel Capacity, USATECOM Project No. 7-7-0887-05, USATTC, March 1968, with USATECOM transmittal letter to AMC 2 May 1968.

SUBJECT: Final Reports of Engineering and Service Tests of Tank, Collapsible, Self-Supporting, 5000 Barrel Capacity Unit, USATECOM Project Nos. 7-7-0887-01 and 7-7-0887-04

2. Subject reports are approved and furnished for information and retention.

3. The test program of the 5000-barrel self-supporting tank, as developed by U. S. Army Mobility Equipment Research and Development Center, was conducted as follows:

a. An integrated engineering and service test was conducted by U. S. Army General Equipment Test Activity (under intermediate climatic conditions of 14°F to 98°F) from March 1967 to October 1968. All physical testing at USAGETA was terminated 25 July 1968 due to failure at Yuma Proving Ground of a similar test item.

b. An integrated engineering and service test was conducted by Yuma Proving Ground under desert climatic conditions from May 1967 thru July 1968. Actual filling of the tank was delayed until February 1968 pending resolution of safety provisions at the test site. Testing was terminated after 4-1/2 months of operation when the tank split.

c. An integrated engineering and service test was conducted by the U. S. Army Tropic Test Center under tropic climatic conditions from June 1967 thru January 1968. Testing was terminated after seven months because deterioration of tank material made it unserviceable and in danger of imminent failure. Results of this test are as contained in final report with USATECOM transmittal letter (reference 1e), which concludes that the 5000-barrel capacity tank is unsuitable for Army use because of failure of the fabric and sealants under tropic climatic conditions.

d. A service test was conducted under lower limit intermediate climatic conditions by the U. S. Army Arctic Test Center from December 1967 thru April 1968. Results of this test are as contained in final report with USATECOM transmittal letter (reference 1c), which concludes that the item, as tested, satisfactorily withstood the rigors of one winter season, operating at temperatures down to -25°F, with storage down to -66°F.

4. Results of engineering and service tests are as follows:

a. Engineering and Service Test (Temperate)

(1) The test tanks met the essential requirements of the SDR (Appendix II of reference 1a) except as follows:

(a) The five-year shelf life could not be verified because of limited test time.

(b) Mission reliability could not be determined because of an insufficient number of test items and limited test time. (Availability was 100 per cent.)

(c) The filled tank silhouette height exceeded the six-foot established requirement.

(d) Suitability for air transport could not be fully determined because a tiedown system had not been developed.

(2) One deficiency was encountered as follows: The vent pipe submerged in a pool of water because of heavy rainfall when the tank was approximately 1/4 full, and the fuel was forced through the vent pipe, causing a safety hazard (Appendix III of reference 1b).

(3) Four shortcomings were encountered (Appendix III of reference 1a) as follows:

(a) Pinhole leaks developed in the tank material early in the test.

(b) Numerous wet spots appeared on the tank at corners and seams especially during hot weather.

(c) The strength of the shipping container flooring is inadequate for handling with a forklift truck.

b. Engineering and Service Test (Desert)

(1) Under hot dry climatic conditions the tank met the essential requirements of the SDR (Appendix III of reference 1d) except as follows:

(a) The tank presents a hazard to personnel and property because of a high potential of sudden rupture.

(b) The tank did not have the minimum required life of 12 months.

(c) Because of premature tank failure, the tank did not meet the required reliability of 96 per cent for a mission duration of 12 months.

(d) The tank did not meet the high strength requirement as evidenced by the catastrophic failure after 4-1/2 months of operation.

(e) The tank was 7 feet 2 inches high when filled, and did not meet the height limitation of 6 feet.

(f) The tank did not meet the requirements of being satisfactorily employed in a hot dry climate.

(2) One deficiency was encountered during the desert test, i.e., premature tank deterioration resulted in a major rupture of the tank (Appendix III of reference 1d).

(3) One shortcoming was encountered during the desert test, i.e., the instructions in the draft technical manual for preparing the berm are inadequate (paragraphs 2.4.1 and 2.4.4 of reference 1d).

c. The tank met maintainability requirements of the SDR. Required maintenance was accomplished in an operational environment without difficulty except that an inch-pound torque wrench is required (paragraph 2.1, Appendix III of reference 1b).

5. As a result of degradation of the tank material under tropic environmental conditions, the catastrophic failure of the tank at Yuma Proving Ground, and laboratory data obtained by U. S. Army Mobility Equipment Research and Development Center subsequent to the initiation of the engineering and service test program, USAMERDC procured new tanks. These are currently under test at the U. S. Army Tropic Test Center.

6. It is concluded that:

a. The item did not meet all the essential requirements of the SDR.

b. The tank is not adequately durable and reliable under tropic and desert climatic conditions.

c. The item is adequately maintainable.

d. The seven-foot height of the test item did not create problems during emplacement, displacement, and use.

e. The tank, as tested, is unsuitable for Army use.

7. It is recommended that:

a. One modified tank crate with appropriate lifting eyes, tiedown system, and stronger flooring, and containing a salvaged 5000 BBL capacity tank be furnished to USATECOM for air transportability and handling tests.

b. New improved tanks be furnished to USATECOM for retest at YPG for determining suitability for Army use under hot dry climatic conditions.

c. Suitability for use under lower limit intermediate climate of the new improved tanks be determined by cold chamber tests of representative samples.

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SUBJECT: Final Reports of Engineering and Service Tests of Tank, Collapsible, Self-Supporting, 5000-Barrel Capacity Unit, USATECOM Project Nos. 7-7-0887-01 and 7-7-0887-04

d. The draft technical manuals be improved, as outlined in Appendix IV-D of reference 1b.

FOR THE COMMANDER:

WILLIAM H. HUBBARD
Colonel, GS
Deputy Chief of Staff

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RDT&E PROJECT NO. 1M643324D59204

USATECOM PROJECT NO. 7-7-0887-01

INTEGRATED ENGINEERING AND SERVICE TEST OF TANK, COLLAPSIBLE, SELF-SUPPORTING, 5,000-BARREL (TEMPERATE)

TEST REPORT

BY

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DECEMBER 1968

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Colonel, QMC
Commanding Officer

U. S. ARMY
GENERAL EQUIPMENT TEST ACTIVITY
FORT LEE, VIRGINIA

U. S. ARMY GENERAL EQUIPMENT TEST ACTIVITY
FORT LEE, VIRGINIA

USATECOM 7-7-0887-01

Final Report of
Integrated Engineering and Service Test of
Tank, Collapsible, Self-Supporting, 5,000-Barrel (Temperate)

Conducted at Fort Lee, Fort Story, and Camp Pickett, Virginia

December 1968

Abstract

An Integrated Engineering and Service Test of Tank, Collapsible, Self-Supporting, 5,000-Barrel (Temperate) was conducted during the period March 1967 - October 1968 to determine technical performance and safety characteristics of the tank and its associated tools and equipment as described in the SDR and the technical characteristics, and as indicated by the particular design, and to determine the suitability of the item and its maintenance package for use by the Army.

It was concluded that: the tank meets the requirements of the SDR except as indicated in paragraph 1.4a and is suitable for use by the U. S. Army under intermediate climatic conditions; technical performance characteristics are satisfactory; the mission of handling POL product was adequately demonstrated; maintenance features of the tank are compatible with TOE organizational capabilities; no contingencies arose in transporting the crated test item and accessories by railcar, appropriate standard military vehicles, or oceangoing vessels; safety aspects of the test items were confirmed; and the test item is capable of being relocated once during its service life.

It is recommended that: the Tank, Collapsible, Self-Supporting, 5,000-Barrel, be considered suitable for use by the U. S. Army in the intermediate climatic zone; the deficiency and shortcomings (App. III) be corrected; suggested revisions to the manual be incorporated as stated in Appendix IV-D; quality control of the tanks during manufacture be increased; a torque-wrench be included in the tank maintenance package; stand-off device be provided at tank inlet; suitable means of restraining the crated item for air transport be developed; and responsible agencies be requested to prepare appropriate instructions for transporting the test item in accordance with transportability findings contained in this report.

FOREWORD

The U. S. Army General Equipment Test Activity was responsible for preparing the test plan, executing the test, and preparing the test report. The authority for conducting this test was Reference 1, Appendix V. The RDT&E Project Number is 1M643324D59204.

TABLE OF CONTENTS

SECTION 1. INTRODUCTION

1.1 BACKGROUND

a. Today's highly mechanized Army requires adequate supplies of petroleum, oil, and lubricants for a variety of uses. Metal tanks for permanent storage involve great cost and complexity of instaliation. The U. S. Army Mobility Equipment Research and Development Center is developing a family of self-supporting collapsible tanks to provide temporary bulk storage of POL in theaters of operations as well as at intermediate points along trunk pipeline systems.

b. The 5,000-barrel capacity collapsible tank is a member of this family and is being developed to overcome the undesirable characteristics of metal tanks. The 5,000-barrel collapsible tanks are constructed of a single-ply fabric barrier sandwiched between polyurethane elastomer coatings. This new lightweight, high-strength fabric allows ease in handling, transportability, and installation.

c. Collapsible tanks are normally installed by Corps of Engineer troops and are operated by Quartermaster petroleum supply personnel. During their intended service life of one year, the tanks can be relocated one time. The tanks may also be used for initial storage before permanent facilities can be constructed at fixed installations, airfields, or at temporary supply points.

d. The U. S. Army General Equipment Test Activity was directed by reference 1, Appendix I, to conduct an integrated engineering and service test of two 5,000-barrel collapsible tanks. Testing was terminated by direction of USATECOM on 25 July 1968 due to test item failures at the Tropic Test Center at Coco Solo Fuel Test Facility in Panama Canal Zone.

1.2 DESCRIPTION OF MATERIEL

The test item is a 5,000-barrel capacity self-supporting collapsible tank of reinforced synthetic material. Included in the tank are one common inlet-outlet fitting assembly, a bottom drain plug and valve, and a combination overflow-vent fitting assembly. Except for dimensions, capacity, and number of inlet-outlets, the tank is identical in design to the 1250- and 2500-barrel tanks previously tested. The tank is installed by Engineer construction units on a flat rectangular ground surface having less than a 1-percent slope and surrounded by an earthen berm. The tank area when emptied is approximately 48 by 98 feet in size. When installed, the tank is operated by Quartermaster petroleum units. Uncrated, the tank weighs approximately 2,160 pounds. When filled to capacity (Fig. 1), the tank

Figure 1. 5,000-barrel capacity collapsible tank.

extends to a height of about 7 1/2 feet. The manifold assembly of the 5,000-barrel tank is similar to that of the 2500-barrel tank in that it includes ten 20-foot sections of 6-inch diameter steel tubing.

1.3 TEST OBJECTIVE

To determine the technical performance and safety characteristics of the 5,000-barrel capacity self-supporting collapsible tank and its associated tools and equipment as described in the SDR and the technical characteristics, and as indicated by the particular design, and to determine the suitability of the item and its maintenance package for use by the Army.

1.4 SUMMARY OF RESULTS

a. The test items satisfied the requirements as set forth in the Small Development Requirements, except for the following:

(1) Because of a limited amount of test time, the 5-year shelf life could not be verified.

(2) The minimum acceptable mission reliability of 96 percent could not be met due to insufficient number of test items and limited test time. Availability was 100 percent.

(3) The filled tank presented a silhouette height greater than 6 feet.

(4) Suitability for air transport could not be fully determined since no tiedown system has been developed. However, the item's size and weight presented no loading problem aboard the standard military (Army - Air Force) cargo aircraft listed in paragraph 2.7.5.3.

(5) Separate tasks were assigned to YPG and TTC for extreme environmental testing.

(6) No method was available for the tank to be made semifixed by simple means.

b. Personnel having MOS 76W (petroleum storage specialist) were capable of being oriented and trained on operation and maintenance of the item after 1 hour of training.

c. The tank is capable of being easily installed using equipment normally available in Engineer units.

d. The tank displayed a service life of more than 12 months, and it safely and efficiently received, stored, and discharged product during that time.

e. The methods which were developed for gaging the tank did not provide the accuracy required for strict fuel accountability; however, they were considered to be sufficiently accurate for approximations in field service conditions.

f. The manifold system was found to be easily installed by user personnel. Minimal personnel were required because of the use of 6-inch tubing and lightweight valves. The lightweight hoses were also easily maneuvered and installed.

g. The tank water drain-off system was effectively utilized.

h. The draft technical manual was adequate, subject to minor revisions.

i. Operator and organizational maintenance actions were performed in an operational environment without difficulty.

j. The item tended to "roll" or creep downhill due to slope of terrain.

k. A torque wrench calibrated in inch-pounds is needed to adjust and tighten bolts on the inlet-outlet closure plate.

l. The item was found to be capable of being reassembled, transported by semitrailer, and reinstalled at least once during its service life.

m. The following shortcomings and deficiency in addition to those shortcomings listed in paragraph 1.4a were observed:

(1) Leaking occurred around the locking insert bolt gasket of the closure plate.

(2) Leakage occurred on the tank fabric surface at points where poor manufacturing quality control was noted.

(3) Numerous large wet spots were detected on the tank surface, especially in corners and along seams.

(4) With the tank approximately one-quarter full and after a heavy rainfall, the vent pipe submerged in a pool of water. MOGAS escaped through the vent pipe (deficiency).

(5) The tank crates sustained some damage during movement. Boards on the crate bottom brushed upward. The crate cover was found to be extremely clumsy. No lifting eyes or bolts were present for removing the top from the crate.

(6) During emptying operations, the tank bottom was drawn into the inlet-outlet elbow by pump suction, greatly restricting the flow of product.

(7) Once emplaced, it was found to be difficult to reposition the tank within its berm due to adhesion of the pit bottom and tank fabric.

n. The crated item was safely transported by rail, and met the requirements of the International Universal Gage Diagram.

o. The crated test item and its appurtenances were safely transported without damage by an appropriate size standard military vehicle, all landing craft, the LARC XV and LARC LX amphibious lighters and oceangoing vessels.

1.5 CONCLUSIONS

a. The collapsible tank met the requirements of the SDR except as indicated in paragraph 1.4a and is suitable for use by the U. S. Army under intermediate climatic conditions.

b. The technical performance characteristics (tank fabric, Reid Vapor Pressure (RVP), accessories) are satisfactory.

c. The tank mission of handling, storing, and dispensing petroleum product was adequately demonstrated.

d. Maintenance features of the tank are compatible with TOE organizational capabilities. Minimal additional training and new skill for MOS-qualified maintenance and operator personnel are required.

e. The draft technical manual should be changed to incorporate the changes listed in Appendix IV-D.

f. Although a minimum acceptable mission reliability of 96 percent could not be demonstrated due to insufficient time and number of items, the tank performed adequately for a minimum of 12 months without failure and with an availability of 100 percent.

g. No contingencies arose in transporting the crated test item and accessories by railcar, standard military vehicles of appropriate capacity, or oceangoing vessels.

h. The best method for highway transport of the crated tanks and accessories is by stake and platform semitrailers. Suitability for air transport of the tank has not been determined.

i. The containerized tank is capable of being off-loaded from beached landing craft by a crawler crane into an M54 cargo truck for transporting across the beach.

j. The containerized test item can be skidded over the ramp of a beached landing craft and towed over the beach by bulldozer or 5-ton truck.

k. The containerized tank and its accessories will fit into the Air Force and Army standard cargo aircraft listed in paragraph 2.7.5.3. Full transportability determinations cannot be made until the appropriate agency develops an adequate tiedown method.

l. The safety aspects of the test items were confirmed. No unsafe conditions existed except as stated in paragraph 1.4m(4).

m. Human factor considerations are all satisfactory with the exception of that stated in paragraph 1.4m(7).

n. Accessory packing and the tank protective wrapping are adequate, but the packing crates need more acceptable structural design to fully protect the tank, prevent crate damage, and allow more ease of handling.

o. Ground on which tank is emplaced should have a slope no greater than 0.5 percent to prevent the tank from creeping downhill after repeated fill and decant cycles.

p. The test item is capable of being repacked with moderate difficulty, transported, reinstalled, and put back into operation without damage to the tank or any effect in operations.

1.6 RECOMMENDATIONS

It is recommended that:

a. The 5,000-barrel capacity collapsible tank be considered suitable for use by the U.S. Army in the intermediate climatic zone.

b. The deficiency and the shortcomings listed in Appendix III be corrected.

c. Suggested revisions to the manual be incorporated as stated in Appendix IV-D.

d. Quality control of the tanks during manufacture be increased.

e. Torque wrench (inch-pound) be included in tank maintenance package.

f. Stand-off device be provided at tank inlet to preclude fabric being drawn into elbow.

g. A suitable means of restraining the crated items for air transport be developed.

h. Responsible agencies be requested to prepare appropriate instructions for transporting the test item in accordance with transportability findings contained in this report.

SECTION 2. DETAILS OF TEST

2.1 INTRODUCTION

a. The engineering test was initiated by the U. S. Army General Equipment Test Activity, Fort Lee, Virginia, upon receipt of the test items and the safety statement in June 1967, in accordance with the plan of test dated December 1966. All testing was completed and terminated in October 1968.

b. Installation of the test items for integrated engineering and service testing at the USAGETA Petroleum Test Facility was accomplished by engineering and service test personnel utilizing engineer-type equipment. Data were collected to include time, man-hours, and tools and equipment required for site preparation and tank installation.

c. Engineering tests consisted of the evaluation of the technical capabilities of the two items furnished for tests when installed in an actual fuel storage and transfer system utilizing MOGAS as test fuel. Analyses were conducted on fuel samples taken from the test items during operation to determine if the fuel was altered by contact with the construction material of the test tanks. The tank construction fabric was periodically examined for evidence of visual deterioration caused by exposure to the test fuel or environmental conditions. Upon completion of all testing, fabric samples were taken from the tank and subjected to a complete materials analysis for comparison with analysis conducted on new, unused tank fabric samples.

d. Additional engineering test data and all service test data were obtained during the 1-year operational performance phase of the test. Twenty full cycles and 75 partial cycles were obtained on each tank using a combination of both engineering test and QM TOE personnel. Gaging techniques were developed by engineering personnel and evaluated by service test personnel. During this entire phase, the tanks were continuously monitored for their ability to withstand field service conditions normally encountered in a temperate climatic zone.

e. Transportability tests were conducted at Fort Lee, Camp Pickett, and Fort Story, Virginia. Rail, primary and secondary road, cross-country, marine, and air transportability characteristics were obtained through various studies and actual application where necessary or feasible.

2.2 INSPECTION (ES)

2.2.1 Objective

To determine the physical characteristics of the test item and to insure that it was complete and in satisfactory operational condition prior to initiation of tests.

2.2.2 Method

a. Each of the two test items was weighed, measured, photographed, and examined in the crated condition. Each item was then uncrated, unrolled, and examined, noting all shortages, damages, and functional deficiencies. Items after being disassembled into their major components were inspected, weighed, measured, and photographed for identification.

b. A logbook was maintained on each test item. All significant chronological events, as well as operational and maintenance events, damages, and mechanical deficiencies were recorded.

2.2.3 Results

a. Two 5,000-barrel capacity test items, serial numbers P-2677 and P-2679 (hereafter referred to as Tank No. 1 and Tank No. 2 respectively) with accessories were received for testing as shown in Figures 2, 3, 4, 5, 6, and 7.

b. Each test item was rolled on a 6-inch steel mandrel mounted in a shipping crate fabricated of 2 x 4, 4 x 4, and 5/8-inch plywood material and reinforced with steel plating and angle iron. The shipping crate dimensions are listed below. Stenciling on the shipping crate was found to be adequate and indicated where and how the crate should be lifted.

Length	-	22 feet 4 inches
Width	-	4 feet 4 inches
Height	-	4 feet 5 inches
Weight	-	4,750 pounds

c. To open the shipping crate it was necessary to lift the crate top off the framework; however, no method for attaching lifting hooks was evident. Large bolts were driven through the top corners of each crate in order to allow attachment of lifting hooks. The crate top was then removed using a 10,000-pound crane truck after the bolts had been removed

Figure 2. Test item as received in crated condition.

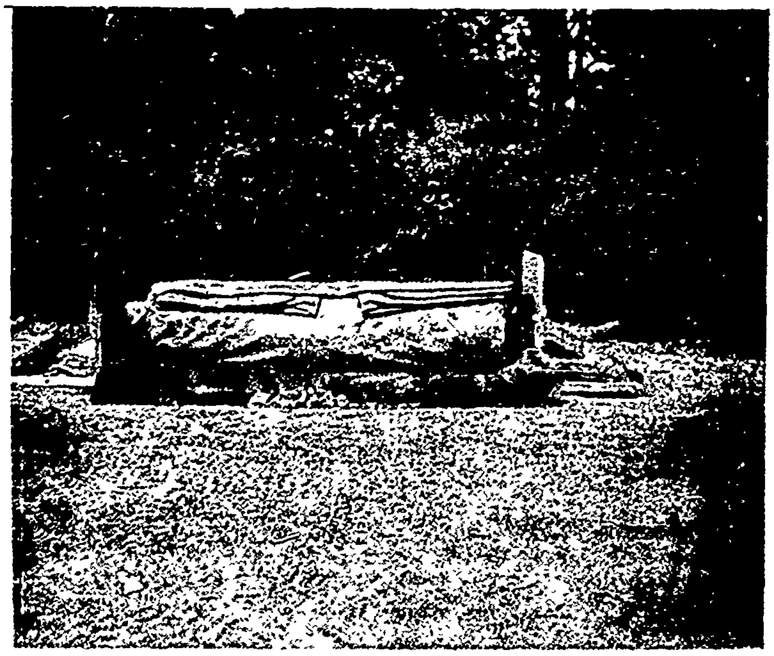

Figure 3. Test item as received with components in partially crated condition.

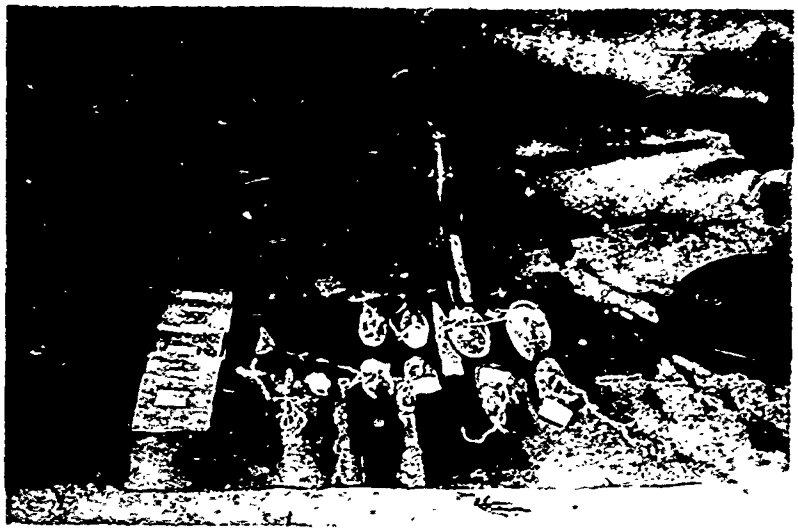

Figure 4. Components of repair kit and water drain assembly.

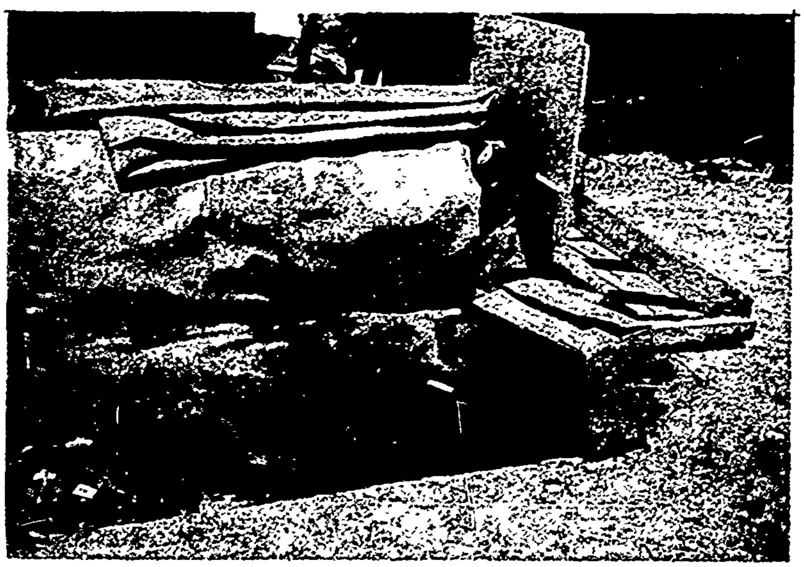

Figure 5. Water drain assembly, inlet/outlet elbow, and vent pipe.

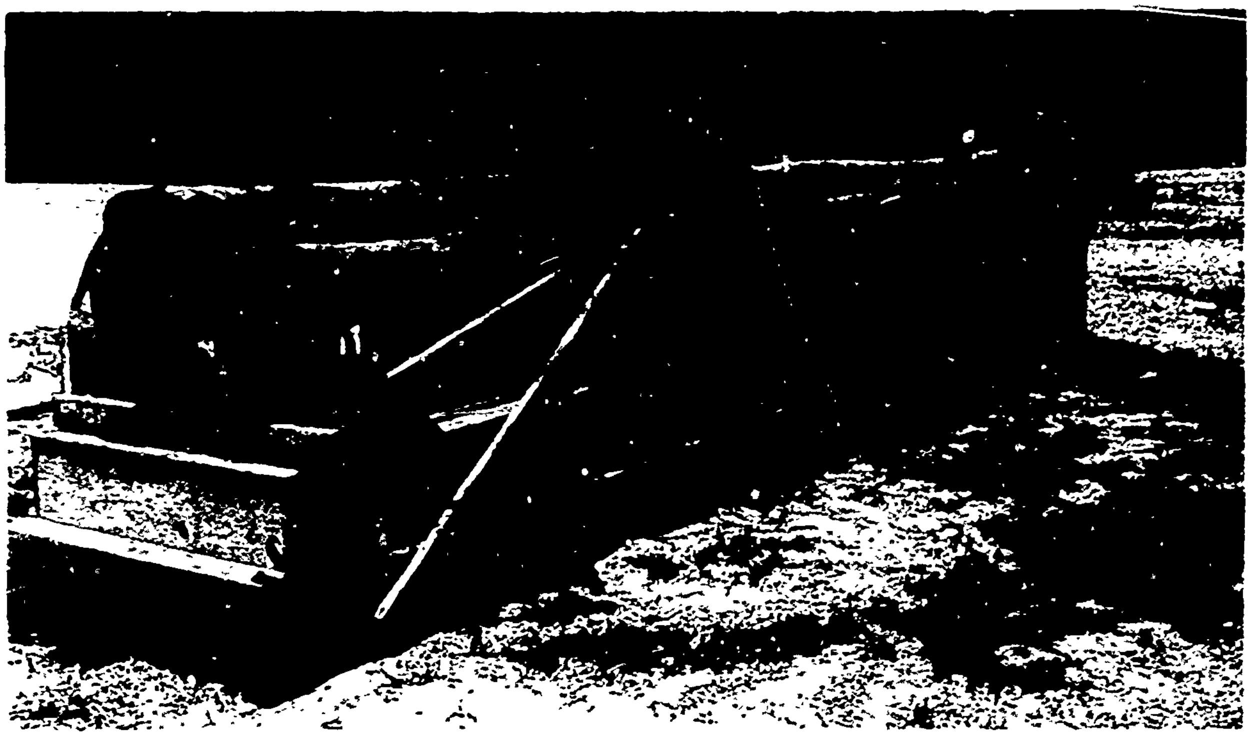

Figure 6. Manifold assembly for both test items as received for tests.

Figure 7. Top front view of manifold assembly showing couplings and accessories.

from the bottom of the crate. A protective wrapping of fabric similar to the tank construction fabric, secured with three nylon straps, was removed from the test item. Both test items were inspected in the rolled condition for evidence of damage during shipment. The complete surface of the test items was inspected in the unrolled condition during initial installation in the preliminary operations subtest.

d. The following cardboard containers were secured with nylon straps in one end of each shipping crate. Unpacked contents are shown in Figures 4 and 5.

(1) Box No. 1 - Repair Kit - 12 x 6 x 7-inches

Contents:

2 each 5-502 "O" Rings
4 each MS29503-25 "O" Rings
4 each 3-inch Sealing Clamps
4 each 5-inch Sealing Clamps
4 each 7 1/2-inch Sealing Clamps

(2) Box No. 2 - Water Drain, Vent Pipe and Inlet/Outlet Assemblies - 27 x 11 x 16-inches

Contents:

1 each Dewatering Hose - 3/4-inch x 8-feet
1 each 1/2 x 4-inch Galvanized Pipe Nipples
1 each 3/4 x 1/2-inch Galvanized Reducer
1 each 3/4-inch Gate Valves
1 each 2 x 18-inch Vent Pipe Assembly
1 each 6-inch - 90° Elbow - Inlet/Outlet Assembly

e. Manifolding for both test items was received packed in one unit constructed of 2 x 4 and 2 x 6-inch wooden material and of the following dimensions:

Length - 25 feet 6 inches
Width - 4 feet 4 inches
Height - 4 feet 5 inches

The crate possessed adequate blocking to allow handling by forklift trucks, the hoseline and pipe sections being strapped in place with 2-inch steel banding materials. Subject crate as shown in Figure 6 contained the following contents:

4 each 6-inch Butterfly Valves
44 each 6-inch Victaulic Couplings
20 each 20-foot section 6-inch Victaulic Lightweight steel tubing
6 each 25-foot section 6-inch Lightweight Hoseline

2.2.4 Analysis

a. No damages or deficiencies in the test items, accessories, or manifolds were detected during the initial inspection.

b. The shipping crates for the test items and their manifolds were found to be adequate and of very strong construction. Stenciling and handling instructions on the crates were also determined to be adequate.

2.3 INSTALLATION (ES)

2.3.1 Objective

To determine the amount and degree of site preparation required, the rapidity and ease of installation by TOE Engineer Units, and the configuration of the installed facilities.

2.3.2 Method

a. Prior to site preparation, a topographic survey was made of the test area to insure good water drainage and to select an area having good vapor drainage, avoiding depressions and low areas. A soil survey was conducted, revealing a reddish sandy clay mixture. All samples indicated the soil would support the test items.

b. Site preparation, berm construction, tank installation, and assembly of manifolds were accomplished using a motor grader, a front end loader, a bulldozer and a 10,000-pound crane. Manual work was accomplished with hand tools (rakes, picks, and shovels). Appendix I-A gives complete installation data. An opening in the berm, left during site preparation, allowed the 10,000-pound crane to enter the bermed area, and position the rolled tank with sling attached to each end of the mandrel. The test items were unrolled and unfolded using nine personnel and the 10,000-pound crane.

After installation of the vent pipe, water drain assembly, and inlet/outlet assembly, the manifolds were assembled and interconnected to facilitate pumping operations and to determine additional tubing requirements to allow the minimum required distances for tank dispersion.

c. A 4-inch diameter berm drain pipe with valve was installed through the base of the berm at the low end to facilitate and regulate drainage.

d. After complete installation, both tanks were filled to capacity to determine the maximum height of the silhouette configuration.

2.3.3 Results

a. Site preparation and berm construction were readily accomplished with equipment organic to an Engineer construction-type TOE Unit. Appendix I-A gives complete installation data.

b. Due to lack of markings on the rolled test item indicating which direction the tank was rolled on the mandrel, the item had to be partially unrolled to determine the location of the inlet/outlet (only one inlet/outlet flange and one water drain flange provided on the test item), before the tank could be positioned within the berm.

c. Nine personnel attempted to unroll the tank but experienced much difficulty due to the weight of the item. Long ropes were then attached with loops on each end of the mandrel and tension applied by use of the 10,000-pound crane. The nine men available then unrolled the item with little difficulty, as shown in Figures 8 and 9. The items were unfolded by positioning the men equally along each side. A total of 60 minutes was required to position, unroll, and unfold each test item. Some difficulty was encountered in unfolding the items since no hand holds were provided such as with the 1250- and 2500-barrel capacity tanks. It is felt that these hand holds ease positioning and unfolding; however, they are not strictly required.

d. The vent assembly, water drain assembly, and inlet/outlet assembly were installed in 30 minutes on Tank No. 1; however, additional time was required on Tank No. 2 since problems were encountered with the locking provision of the inlet/outlet elbow assembly. An examination showed that the locking pin was 1/8 inch too short and would not allow the elbow to be locked in place. The defective pin was replaced with a new pin which was machined 1/8 inch longer. Utilizing the new pin, locking of the elbow assembly was accomplished without difficulty. No problems were encountered with Tank No. 1.

e. Upon completion of installation, both test items were filled to capacity with MOGAS test fuel to determine their maximum silhouette height.

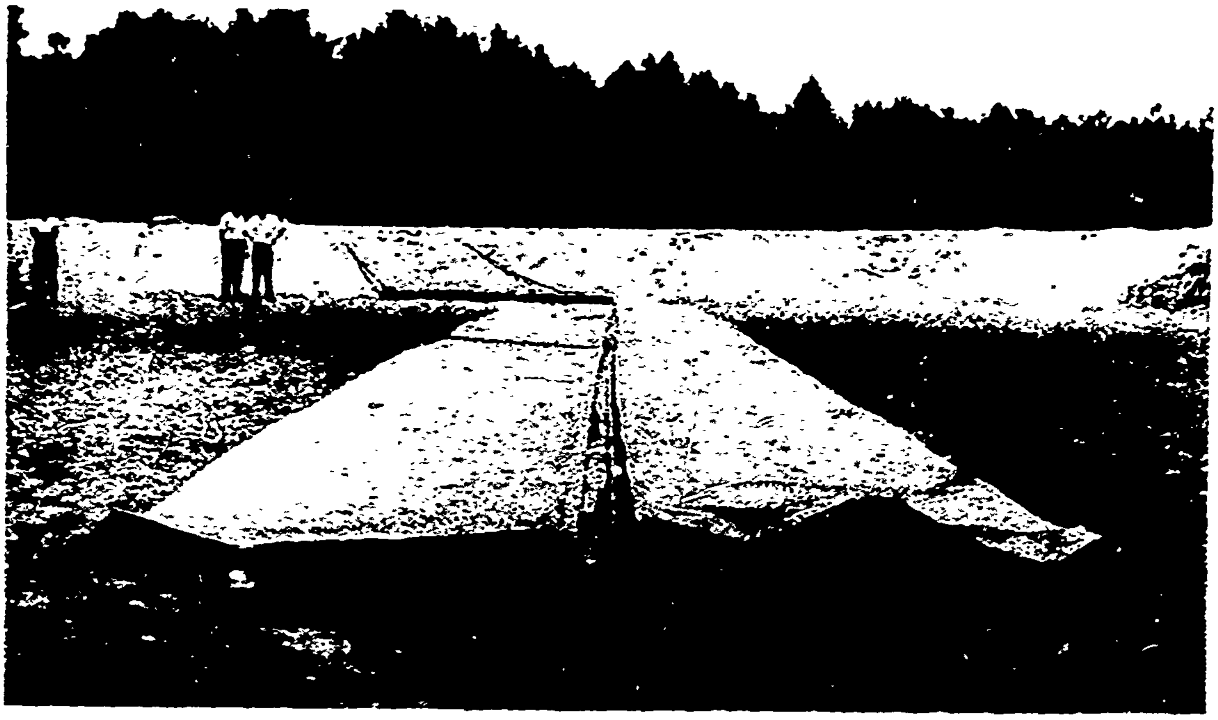

Figure 8. Unrolled tank partially unfolded.

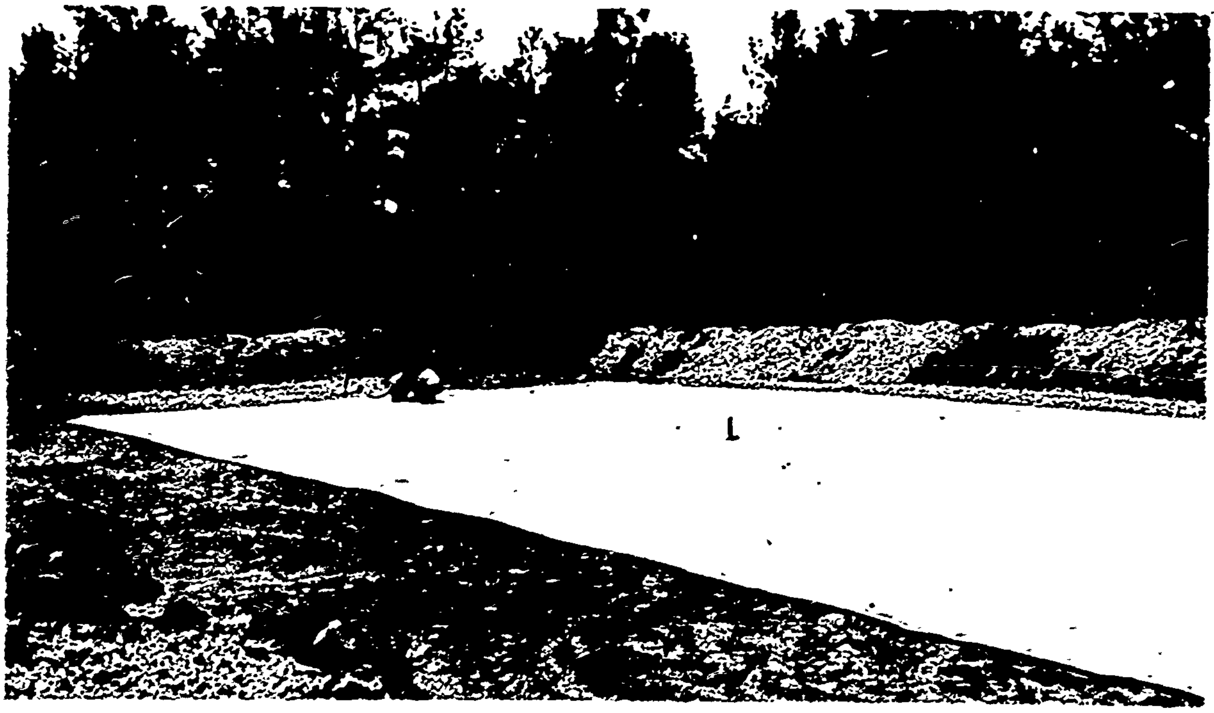

Figure 9. Completely unrolled and unfolded tank in berm.

It was necessary to empty both tanks of fuel as leaks were detected from around the locking insert bolts on the inlet/outlet flange. Efforts to tighten each nut were unsuccessful, since there was no way to hold the bolt head, allowing the bolts to slip. After the tanks were emptied, the locking inserts were removed and examined. It was found that the thread seal gaskets had been damaged, allowing fuel to leak through the bolt holes. The same problem existed with both test items. New thread seal gaskets were obtained from the developer and installed as shown in the draft technical manual. Upon refilling each tank with fuel, leakage from around the locking inserts was again detected. In order to continue with the test the inlet/outlet closure plates with locking inserts were removed from a 1250- and a 2500-barrel capacity item which had previously undergone tests. These locking inserts were secured to the closure plates with bolts which utilized dome nuts. No evidence of leakage was detected when these substitute closure plates were installed on the test items and test operations were continued.

2.3.4 Analysis

a. Due to the nonavailability of Engineer TOE personnel and equipment, Fort Lee Post Engineers prepared both test sites. Equipment used and operator skill level paralleled that of equipment and personnel organic to an Engineer construction TOE Unit.

b. Berm preparation for both test items was prepared from existing cut material with the use of a front loader. Due to the 3-percent slope of the existing terrain, a motor grader was used to partially cut and free the installation sites to overall slopes of 0.864 and 0.976 percent for tanks 1 and 2 respectively. Additional fill material needed for berm construction was obtained from the areas outside and inside the berm.

c. After submission of equipment performance reports on the leakage problem with closure plates, the developer agreed to furnish modified closure plates for tests. These modified closure plates were received 7 months after initial leakage and were used for the remaining 5 months of testing. No leakage resulted as they were identical to those plates furnished with the 1250- and 2500-barrel test items. Equipment performance reports submitted by this activity recommended that a one-piece combination closure plate and locking insert be utilized which would eliminate all chance of leakage.

d External means for making the tank semifixed were not employed. No hand holds are present on the item. Since the empty tank weight is 2,160 pounds, any movement due to external forces would be highly unlikely. With the tank in a filled or partially filled condition, the weight of fuel would prevent movement due to winds, and if the berm filled to a depth of 6 to 8 inches with water during a rainstorm, movement would not occur if the tank contained over 2 feet of product. Drainage of the berm would preclude floating of the tank when in an empty state. With the item in a dry condition, a field expedient such as laying sections of pipe or dirt on the corners or edges would provide the stability required during stormy or gusty conditions.

e. The silhouette height of the filled tank averaged approximately 8 feet. This did not detract from the usefullness or performance of the item nor did it produce any detrimental conditions. The SDR for the 1250- and 2500-barrel collapsible tanks was adopted for the 5,000-barrel tank, thereby preventing compliance with the 6-foot height requirement. To reduce the height of the filled test item to 6 feet, an increase in width and length could be affected. However, any increases in area of the tank would render the item more clumsy and harder to install. An additional 1,560 square feet of tank area would be required to maintain a maximum silhouette height of 6 feet.

2.4 PRELIMINARY OPERATIONS (ES)

2.4.1 Objective

To train engineering and service test personnel in the use and operation of the test items and to orient them in the safety hazards as pertaining to the test item and supporting equipment.

2.4.2 Method

After the test items were unpacked and inspected, all engineering and service test personnel received a 1-hour briefing on the proper installation, use, and operation of the test items, based on operating instructions provided by the developer. This briefing also included safety requirements listed in the developer's safety statement and the GETA Master Safety Program.

2.4.3 Results

None of the test personnel experienced difficulty in understanding installation, use, and operation of the test item with only one hour's instruction.

2.4.4 Analysis

Personnel can be trained to install and operate the test items with only 1-hour of instruction.

2.5 TECHNICAL PERFORMANCE (ET)

The following tests were conducted to determine the technical performance of the 5,000-barrel collapsible storage tanks.

2.5.1 Tank Fabric Study

2.5.1.1 Objectives

a. To determine if the material used in tank construction is lightweight, high strength, and resistant to water and to all standard military liquid hydrocarbon fuels.

b. To determine if the material used in tank construction is resistant to fungi, affords minimum loss of fuel by diffusion, and is affected by stored fuel.

2.5.1.2 Method

a. Since efforts to obtain samples of new unused fabric from the manufacturer were unsuccessful, the fabric analyses conducted by the developer were accepted as the initial control data for the new unused construction fabric.

b. Upon completion of all testing operations and after a total of 14 months' exposure, tank fabric samples were cut from various areas of the tank surface.

c. Upon the initiation of fuel cycling operations, fabric deformation points (6-inch lines in a vertical and horizontal orientation) were established at various locations on the surface of the test items. The change in dimensions of subject deformation points was determined when the test items were empty, filled, and after completion of all testing.

2.5.1.3 Results

a. Comparisons of values determined from materials studies on initial unexposed fabric samples (conducted by MERDC) and final exposed fabric samples (conducted by GETA) showed the following variances in analysis values due to prolonged exposure to fuel, alternate stressing during fuel cycling operations, and test site temperate environmental conditions during the test period (App. I-B).

Breaking Strength - Bottom samples showed a slight increase in strength of 9.6 and 0.8 percent in the warp and fill directions respectively while top samples showed a decrease of 4 percent in the warp direction and an increase of 6 percent in the fill direction.

Tear Strength - Bottom samples showed a decrease of 20 and 17 percent in the warp and fill direction respectively while top samples increased in strength by 19 and 52 percent in the warp and fill direction.

Puncture Resistance - Both top and bottom samples decreased in resistance to puncture by 32 and 43 percent.

Abrasion Resistance - Resistance to abrasion decreased radically by a factor of 528 percent.

Coating to Fabric Adhesion - Exterior coating to fabric adhesion decreased by an average of 67 percent and interior coating to fabric adhesion decreased by 76 percent.

Peel Strength - End seams showed a decrease of 10 percent while body seams increased in strength by 29 percent.

Shear Strength - Body seams showed a decrease in strength of 19 percent.

Water Vapor Transmission - Permeability of tank fabric to water vapor increased by 133 percent.

Fuel Vapor Transmission - Fuel vapor transmission tests were not conducted by MERDC on the new unexposed tank fabric however "end of test" results on exposed fabric samples showed comparable rates to water vapor ranging from 0.03 to 0.06 fl. oz/sq. ft, for MOGAS and CITE fuel. AVGAS showed the lowest rate of all five fuels of 0.007 fl. oz./sq. ft. while DF-1 and JP-4 showed the highest of 0.1 and 0.3 fl. oz/sq. ft. respectively.

b. Comparisons of measurements taken on fabric deformation points when filled to capacity and empty showed no perceivable stretch to occur in either the vertical or horizontal axis, however a shear-like stress in the fabric was detected as evidenced by a 10 to 20 degree variation from the vertical of the deformation point with the tank in the empty condition. No change in the horizontal axis was detected. The shear-like warp in the vertical axis of the fabric could also be detected in the overall appearance of the test item in the filled condition as reflected by a tendency to roll toward one corner.

2.5.1.4 Analysis

a. A one- and two-way analysis of variance was conducted on data derived from tests conducted in paragraph 2.5.1.3a to determine if a significant[1] difference existed between fabric samples taken from

[1] 95-percent confidence level.

various locations on the test item. Duncan's Multiple Range Test was used in the comparison of the means. Analyses conducted showed that for individual tests accomplished, significant differences existed between data resulting from samples from various locations; however, these significant differences for sampling locations were not consistent from one test to the other. It was therefore concluded that none of the individual sampling locations experienced a higher degree of overall deterioration than the others.

b. Comparisons of test results on exposed fabric samples and new unexposed fabric samples may not be totally reliable since materials analysis tests were conducted by different laboratories, different personnel, and with different test equipment, however, each test was conducted according to the same specifications.

(1) From overall Breaking Strength and Tear Strength test data observed, the top fabric appeared to have slightly increased in strength (possibly due to a curing process because of exposure to the atmosphere) while the bottom fabric showed deterioration as evidenced by a decrease in strength.

(2) Deterioration in the outer coating of the tank fabric as evidenced by a "chalking" or "softening" effect was also reflected by a radical decrease of 528 percent in resistance to abrasion, decrease of 67 percent in exterior coating to fabric adhesion, and increase of 33 percent water vapor permeability.

(3) Test data showed only a minor degradation in seam strength (peel and shear) while values actually increased for body seams.

2.5.2 Fabric and Accessory Exposure

2.5.2.1 Objective. To determine if the tanks, repair kits, manifolds, and appurtenances are designed to minimize the effects of corrosive action, deterioration, and other chemical action resulting from a mixture of water, impurities, and standard military liquid hydrocarbon fuels having an aromatic content not to exceed 40 percent.

2.5.2.2 Method

a. Daily inspections were made of both test items during test operations for evidences of fabric deterioration, wet spots, or seam slippage.

b. During test operation, mechanized repair clamps were applied to both test items and inspected periodically for evidence of corrosion or deterioration from contact with fuels or water (Fig. 10).

c. Daily inspections of all portions of the manifold and appurtenances were conducted during testing operations to determine if corrosion or deterioration was resulting from contact with fuel or water.

d. Initially and periodically during the test, laboratory analyses were conducted on the MOGAS test fuel utilized in cycling operations for API gravity, existent gum, Reid vapor pressure and bromatic content to detect changes in the fuel resulting from exposure to the tank fabric. Fuel analyses were discontinued after 7 months as it was necessary to mix the test fuel with a new batch of MOGAS in order to meet other testing commitments.

e. Monthly inspections were made of the interior of both test items by removing the closure plate and examining the inside of the tanks for evidence of deterioration from exposure to fuels, water, or contaminants.

2.5.2.3 Results

a. Within one week of initiation of fuel cycling operations hundreds of minute wet spots (1/8" to 1/4" diameter) were detected on both test items. Wet spots did not appear to be restricted to seam areas and were evident on the top and sides of both items when in the filled conditions. Inspections showed that after a 60-day period approximately 50 percent of the wet spots disappeared, the remaining 50 percent did not increase noticeably during the remainder of the test period. No evidence of seam slippage was detected during the test; however, this activity received directions to terminate testing operations during the fourteenth month of testing due to seam slippage resulting in catastrophic failure of the test items at other test locations. Inspection of the tank fabric showed deterioration of the outer tank coating to have occurred as evidenced by a softening or chalking effect of the coating especially on Tank No. 1; however, fabric analysis upon completion of testing did not show that this deterioration had reduced the test items' capabilities excessively.

b. Examinations of mechanical repair clamps applied to the test items showed that at least one clamp rusted excessively. It was apparently not fabricated of rustproof materials as were the majority of the clamps which showed no evidence of rust.

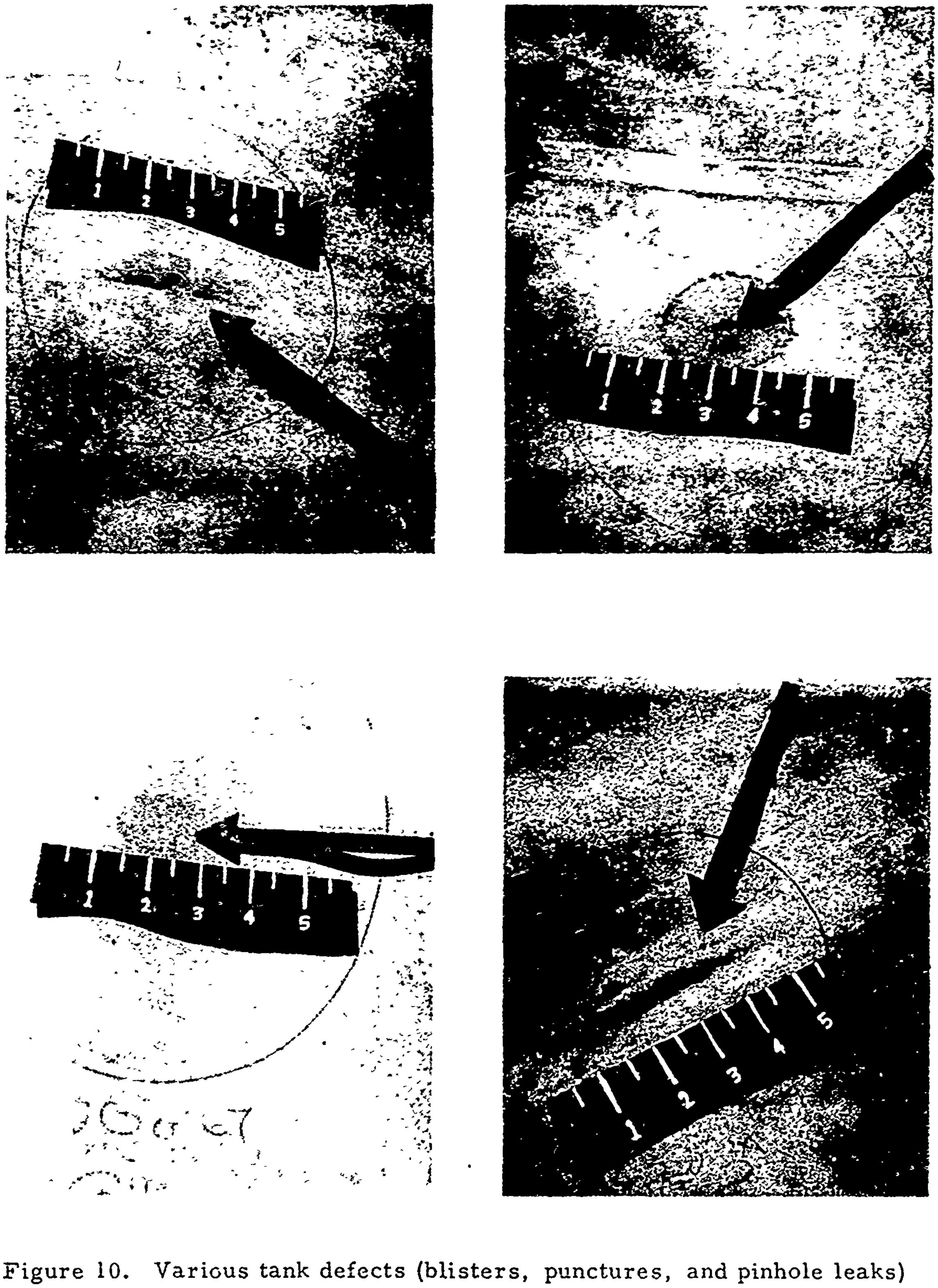

Figure 10. Various tank defects (blisters, punctures, and pinhole leaks) detected during testing operations and repaired utilizing mechanical repair clamps.

c. Daily inspections of all portions of the manifold and appurtenances showed no unusual deterioration or corrosion resulting from contact with fuel or water.

d. Results of laboratory analyses conducted on the MOGAS test fuel used in fuel cycling operations are shown in Table I.

TABLE I

TEST FUEL ANALYSES

Test Conducted	Initial	60 Days	6- Month Exposure
API Gravity	62.2 API degrees	61.2	61.2
Existent Gum	2.0 mg/100 ml	3.0	3.2 mg/100 ml
Reid Vapor Pressure	8.0 psi	7.84	7.30
Aromatic Content	20%	15	15

2.5.2.4 Analysis

a. The construction fabric of the test items successfully withstood the 12-month testing period of fuel cycling operations; however, appearance of exterior coating indicated most of the tank's use life had been expended and the safe use of the items beyond the 12-month period was questionable. Wet spots, however, were not judged to be a problem area. Approximately 50 percent of the wet spots disappeared during the first 60 days of use and the remainder did not appreciably enlarge in size during the test period. None of the wet spots were large enough to constitute an actual leak, however, they indicate basic shortcomings in tank construction techniques.

b. All portions of the manifold and appurtenances were found to be sufficiently resistant to the corrosive effects of fuel or water, except the mechanized repair clamps. Only clamps fabricated of rustproof materials should be furnished.

c. Evaluation of test fuel analyses on fuel samples taken at the initiation of testing, after 60 days and after 6 months showed that none of the major fuel properties tested had changed appreciably due to contact with the tank construction fabric and manifold, cycling between the two test items, or exposure to the environmental conditions at the test site. It was found, however, that existent gum analyses conducted during the seventh month showed a radical increase of up to 8.6 mg/100 ml, which is far in excess of the allowable limits of 4.0 mg/100 ml (Military

Specification G-3056B - MOGAS). It is therefore recommended that fuel stored in tanks of this type should be turned over completely at least once every 6 months.

2.5.3 Static Fuel Storage

2.5.3.1 Objective. To determine if the Reid Vapor Pressure was decreased by more than 2 psi after a 60-day exposure as specified in AR 705-15 when the tank is three-quarters or more full.

2.5.3.2 Method. Tank II was filled to 98-percent capacity with MOGAS test fuel conforming to MIL-G-3056B and allowed to remain in static storage for a 60-day period. Fuel samples were taken for Reid Vapor Pressure Analyses at the beginning and end of the 60-day test period.

2.5.3.3 Results. Results for Reid Vapor Pressure analyses at test initiation averaged 8.0 psi and after 60 days static storage decreased only 0.16 psi to 7.84 psi.

2.5.3.4 Analysis. Laboratory analyses showed that the Reid Vapor Pressure of the fuel stored in the tank did not drop more than 2 psi after an exposure of 60 days.

2.6 OPERATIONAL PERFORMANCE (ES)

2.6.1 Objectives

To determine the following:

a. The ability of the tanks to safely, durably, and efficiently store bulk fuel during normal operations in a temperate zone POL storage facility.

b. If the tanks have a simple water drain-off system, where settling contamination such as water and solids tend to locate within the tank, and if that location is critical.

c. If the tanks are capable of utilization with 4- and 6-inch hose line systems and with 4, 6, and 8-inch coupled or welded pipeline systems.

d. If equipment or techniques can be developed to enable the contents of the tanks to be gaged to permit effective operational control.

e. If the test items will continue to perform satisfactorily when exposed to flow fluctuations resulting from intermittent pump action or other causes.

f. The degree of interchangeability of tank component parts and assemblies.

2.6.2 Method

a. During the 12-month testing period, MOGAS test fuel conforming to MIL-G-3056B was stored statically and transferred between tanks so as to simulate the tank's usage in an actual POL storage system. The tanks were considered in continuous use throughout the test period, and mission duration was based on 24 hours a day.

b. Storage and transfer operations were conducted in various climatic conditions, in rain and snow with temperatures ranging from $+98^{o}$F. to $+14^{o}$F. Pumping operations were conducted by Quartermaster TOE personnel. The test items were subjected to a total of 20 complete cycles and 75 partial cycles of operations with the test fuel remaining stored in the items between cycles.

c. During storage and transfer operations, the items were inspected for evidence of leakage, cracks, blisters, pinholes or creasing, adequacy of venting provisions to release excess vapor, and efficiency and speed of operation of tank valves.

d. Observations were made to determine if precipitation resulted in pooling of water on the tank's surface when the item is filled to various capacities. The water drain assembly was used periodically to drain off condensed water and test item components were used with other capacity collapsible tanks to determine interchangeability. Particular attention was given to the water drain-off system during freezing temperatures to check freezing of the drain line and valve. Near the end of the test period attention was given to the collection of settling contaminants which could possibly restrict the drain-off system.

e. To test compatibility of the tanks with various hoseline systems, the existing 6-inch single stage pump was removed from the system and was replaced with a standard military 350-gpm pump and adequate 4-inch hoseline to connect both tanks. A coupled 6- to 4-inch reducer was connected to the filler elbow and adapted to the 4-inch hoseline with a 4-inch grooved-to-quick coupling. The product was then cycled between the tanks. Compatibility also was checked with 8-inch coupled lines by use of 8 to 6-inch reducers, as well as with welded lines by use of flange-to-groove and flange-to-welded end adapter.

f. Since no equipment or techniques were provided or recommended by the draft technical manual to allow the contents of the tanks to be gaged, two such methods were devised and tested during cycling operations. One method was to measure tank height at corresponding metered volumes. This height-volume relationship was established using 4-inch 600-gpm bidirectional flowmeters.

g. To determine if the test items would continue to function satisfactorily when exposed to flow fluctuations resulting from intermittent pump action or other causes, the items were subjected to pressure surges by starting and stopping the pumping unit and by rapidly opening and closing the main tank valve when operating at maximum rpm. These pressure surges, however, were restricted to under 20 psi due to limitations of the test system.

h. After 51 weeks in operation, Tank No. 2 was completely decanted, disconnected, and prepared for relocation. Decanting was accomplished using a 6-inch double stage pump up to the point where pump suction drawing the fabric into the outlet made this method unfeasible, with 2500 gallons remaining. A 350-gpm wheel-mounted pump was employed until approximately 300 to 400 gallons remained in the tank. The suction line was simply plunged into the product through the inlet-outlet flange. When the product could no longer be drawn, a 50-gpm pump was utilized to reduce the fuel remaining in the tank to approximately 75 gallons. Additional fuel was removed by disconnecting the water drain assembly and allowing drainage into drip pans. The tank was folded longitudinally (Fig. 11) and rolled on the mandrel (Fig. 12). During the rolling process, vapor was built up in the tank. A pillow effect occurred. To remove the vapor, a 2-inch incision was made in the upper surface of the tank (Figs. 13 and 14). This cut was repaired using a 3-inch mechanical clamp (Fig. 15). A 10,000-pound capacity crane was used to lift the tank and mandrel onto the bottom section of the original crate on an M172 lowbed semitrailer (Fig. 16). For additional data see App. I-E. The movement consisted of a 4-mile trip including cross-country, dirt, and hard-surfaced roads. Upon completion of the movement phase, the tank was off-loaded, reinstalled in its original berm, and recommitted to use.

2.6.3 Results

a. The test tanks were found to be capable of safely, durably, and efficiently storing bulk fuel during normal petroleum operations under temperate environmental conditions. Minor problems, however, were experienced in at least one instance with rainfall pooling around the vent pipe when the tank was filled to only a 25-percent capacity (Figs. 17 and 18).

Figure 11. Tank folded longitudinally; fuel being removed through water drain.

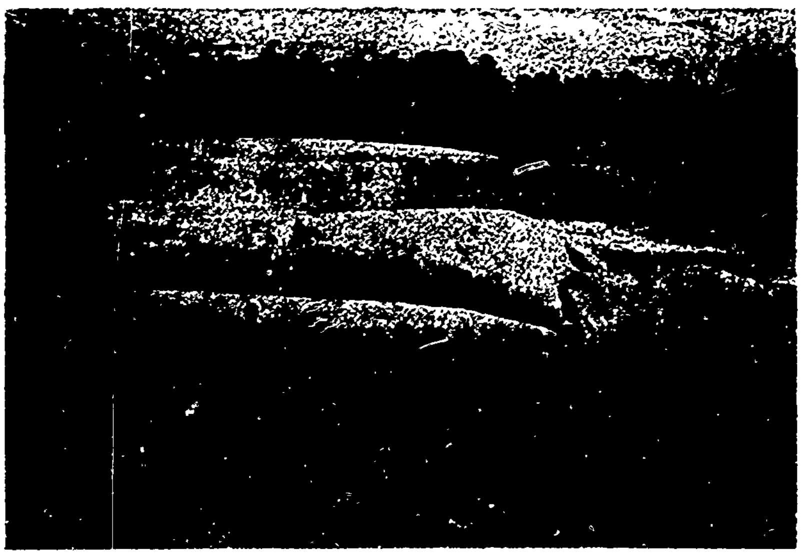

Figure 12. Tank partially rolled on mandrel.

Figure 13. Incision being made to vent entrapped air.

Figure 14. Results of incision.

Figure 15. Incision sealed with mechanical clamp.

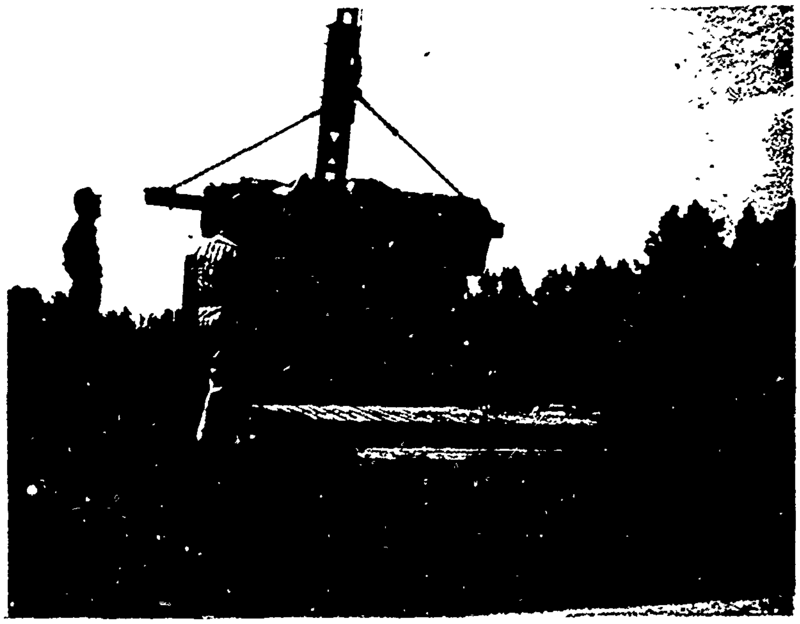

Figure 16. Lifting tank into crate aboard "low boy" semitrailer.

Figure 17. Pooling of water within berm after 1.74-inch rainfall.

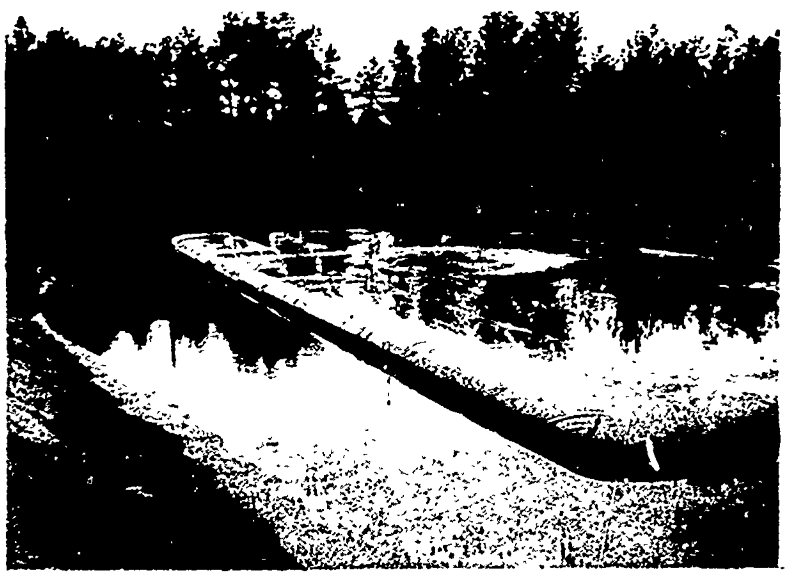

Figure 18. Pooling of water on tank surface; vent pipe submerged.

The weight of the water caused the vent pipe to submerge, which allowed fuel to flow out onto the tank surface. Approximately 5,000 gallons of fuel was lost from the test item; however, the fuel was later recovered from within the tank berm. A modification to prevent submersion of the vent pipe due to water pooling was designed but it was not tested due to termination of the test project. The modification consisted of replacing the vent pipe with a 2-inch elbow, 25 feet of 2-inch suction hose with vent pipe cap attached, and a 4 x 4 post of sufficient length to secure the hose end with vent cap well above the top surface of the tank when filled to capacity. This same modification was found very satisfactory when tested on the 10,000-barrel Hasty Storage reservoir.

b. Continuous use of the tanks throughout more than 12 months resulted in minimal operational problems (Par. 2.6.3a) during transfer of product or in storage.

c. The water drain-off system provided with the tanks was functional, adequate, and reliable for the removal of bottom water. During subfreezing weather, bottom water was drained daily to prevent the drain line and valve from freezing.

d. The tanks were compatible with 4- and 6-inch hoseline systems and with 4, 6, and 8-inch coupled or welded pipeline systems if the proper fittings (couplings, reducers, gaskets, flanges of the appropriate sizes) are available to allow connections.

e. Techniques were developed to allow the contents of the tanks to be gaged; however, both methods developed did not have a comparable accuracy to the methods used in gaging steel tanks and both required a flow meter for initial calibration.

(1) "String Method" - This method consisted of measuring the relative height of the top surface of the tank, adjacent to the vent pipe. Two 4 by 4-inch posts were set on either side of the test item and extended 10 feet above the surface of the ground. A cord was then stretched across the tank so as to be barely tangental to the tank surface at a point adjacent to the vent pipe. Each post was then calibrated by marking each inch increase in height of tank surface and recording the actual volume of fuel in the tank at that point as indicated by the flow meter. Subsequent tank capacities could then be determined without the aid of the flow meter. merely by measuring the tank height.

(2) "Fluid Column Method" - This method consisted of mounting a vertical tygon tube "stand pipe" attached to the water drain valve, to a 4 x 4 post positioned adjacent to the inlet/outlet assembly. The fluid column

gaging assembly was constructed of the following components assembled as shown in Figure 19.

(a) 12' section of 3/8" diameter clear tygon tubing

(b) 3/4" x 3" galvanized nipple - 2 each

(c) 3/4" galvanized tee - 1 each

(d) 3/4" gate valve

(e) 3/4" x 3/8" reducer - 1 each

(f) 3/8" x 3" galvanized nipple - 2 each

(g) 3/8" galvanized elbow

A flow meter was used initially for calibration in inches and gallons of the upright to which the tubing was attached. Thereafter. periodic readings from the fluid column were compared with meter readings.

f. Limitations of the test system restricted pressure surging effects to less than 20 psi. Both test items performed satisfactorily under these conditions.

g. All parts and assemblies organic to the test items were found to be interchangeable with the 1250- and 2500-barrel collapsible storage tanks.

h. No additional sections of steel tubing were required to supplement the tank manifolds for connection of both tanks utilizing minimum safety clearances as recommended in TM 5-343.

i. The movement and relocation phase was accomplished with moderate difficulty. A total of 16 hours was consumed in decanting the remaining 2500 gallons from Tank No. 2, folding the tank, rolling on the mandrel, and loading on a low bed semitrailer. Twenty men were used to fold, roll, and position the test item for movement, and a 10,000-pound capacity warehouse crane was utilized to load the tank on the semitrailer.

j. After movement, the test item was relocated in its original berm without difficulty. The tank was unloaded, repositioned. unrolled, and unfolded by approximately 35 men in 2 hours.

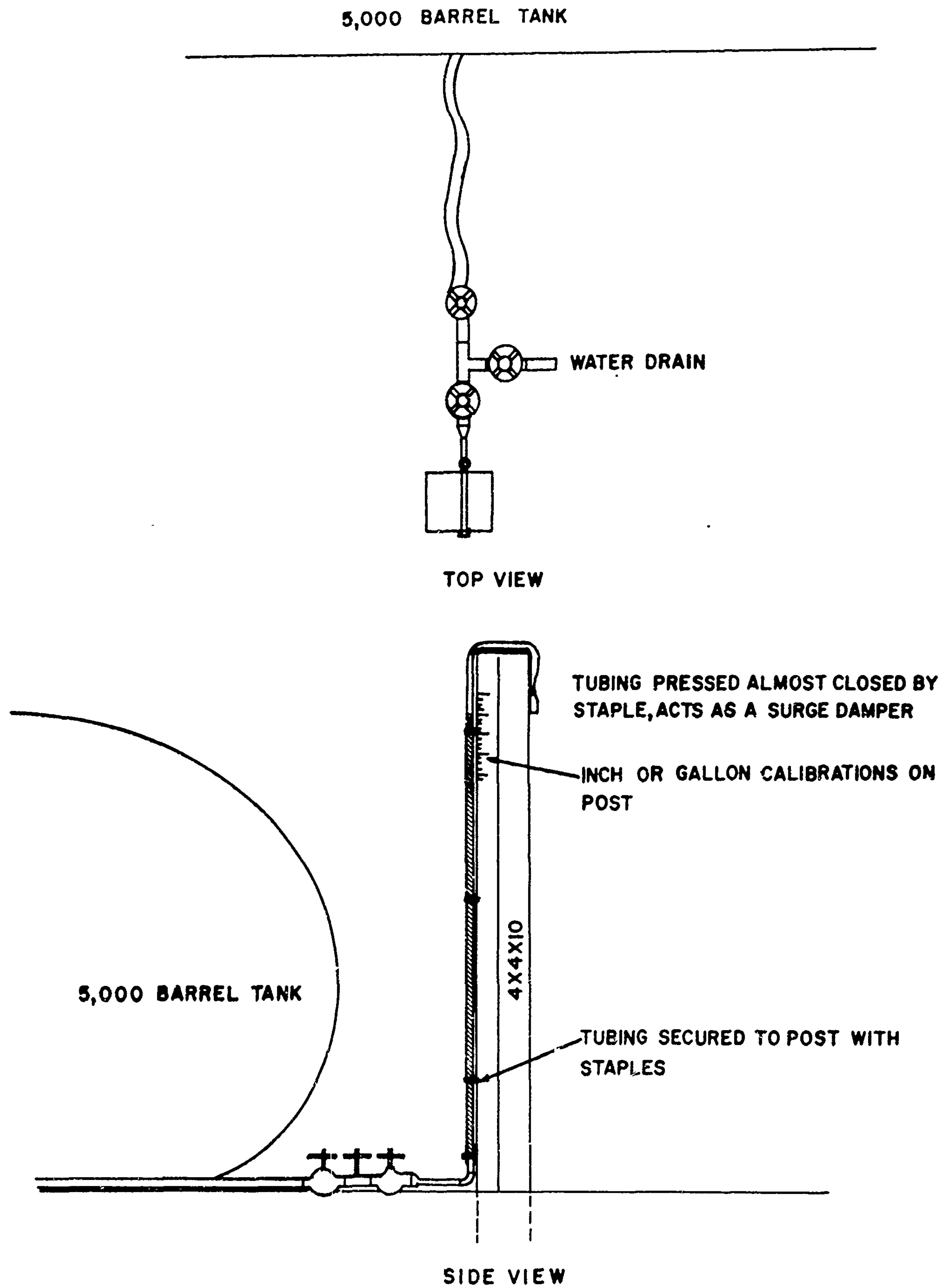

FIGURE 19. ASSEMBLED COMPONENTS OF COLUMN GAGING ASSEMBLY

2.6.4 Analysis

a. Neither gaging method was determined to be sufficiently accurate for purposes of accountability but they were adequate for field approximations. The "fluid column" method was found to be most convenient, requiring fewer personnel, and providing a higher degree of repeatability than the string method. Comparison of accuracy for the two methods showed the "fluid column" method to provide 8 percent variation from the actual observed meter reading while variations of 10 percent were noted for the string method. However, an advantage of the "fluid column" method is that it furnishes a continuous visual indication of tank ullage or innage.

b. Since operating and surge pressures of greater than 20 psi could not be obtained during the test, due to test system limitations, it is recommended that pressure reduction equipment be utilized on inlet fuel lines in all instances where inlet fuel pressures or surges exceed 20 psi.

c. Due to the design of the test items, with only one inlet/outlet assembly and opening, it is not possible to receive product into the tank and issue product simultaneously. Normal petroleum field operational requirements frequently do not allow a halt in issue operations while product is being received into the bulk fuel storage tank. An inlet/outlet opening is needed at each of the opposite ends of the tank as was furnished with the 1250- and 2500-barrel capacity items; however, only a blank closure plate for the second inlet/outlet opening was provided. A second complete inlet/outlet assembly should be furnished with each tank in addition to the blank closure plate to allow both tank openings to be used simultaneously if needed.

d. The required shelf life of 5 years for the test item could not be determined due to insufficient test time.

2.7 TRANSPORTABILITY (ST)

2.7.1 Rail Transportability

2.7.1.1 Objective. To determine adaptability of the test item for movement by railcars.

2.7.1.2 Method. The crated item was loaded by a 20-ton mobile crane onto an 80-ton capacity military standard foreign service flatcar equipped with an AAR Coupler on one end and a foreign service screw coupler and buffers on the other end (Fig. 20). Two 5/8-inch wire rope slings were used to lift the crate by passing one under each end of the container. Four antiskid plates were placed under each outside longitudinal skid prior to

Figure 20. Containerized collapsible tank (5,000 barrel) loaded on an 80-ton Foreign Service Railcar prior to rail humping tests.

lowering the container onto the railcar platform. The item was then secured as shown in Figure 21 by a three-man crew. Recording accelerometers were affixed to the topside at one end of the crate. Additional accelerometers were then mounted on the flatcar. These accelerometers measured the shock forces in the vertical, longitudinal, and transverse directions. An electric timer to determine the exact speed of the 80-ton railcar was located on the rail approximately 10 feet ahead of the point of impact. Activation is by passage of the leading railcar wheel. A fifth wheel calibrated in 1/10th-mph increments was used on the switching locomotives to determine the speed at which to release the flatcar for impact. After instrumentation of the crated test item, the flatcar, and locomotive, the flatcar containing the test item was then humped in a forward direction once at each speed of approximately 2 and 4 mph and three times at each speed of approximately 6, 8, and 10 mph and then humped in the opposite direction once at 2 and 4 mph and three times at 6, 8, and 10 mph. The testing was accomplished by impacting the flatcar carrying the test item into four empty railcars having a gross weight of 186,600 pounds and which had their brakes set. After completion of the rail humping tests, the flatcar with a car deck of 51 inches from the top of the rail was passed through the International Universal Gage, the Association of American Railroads (AAR), and the Composite (Broad Gage) Diagrams. A study of Military Standard, Railway Cars, Flat, Domestic and Foreign Service (MIL-STD-435A) was also performed to determine the capability of the item to be transported without restriction on other flatcars, foreign and domestic, having a deck height greater than 51 inches.

2.7.1.3 Results. The crated test item was secured by a 3-man crew in 50 minutes and was transported by the 80-ton military foreign service flatcar without difficulty or damage. There are no lifting or tiedown devices on the shipping containers; however, none are required for transportation. The method of tiedown shown in Figure 21 was adequate to withstand humping at speeds up to 10 mph in both directions. The maximum "G" forces on the test item which occurred during the humping test were 15 in the longitudinal direction, 5 in the transverse direction, and 13 in the vertical direction (App. I-C). The item when loaded on a military standard 80-ton foreign service flatcar, having a car deck height of 51 inches above the top of the rail, met the International Universal Gage, the AAR, and the Composite (Broad Gage) Clearance Diagrams. It was determined through study that the crated test item can be transported on all foreign service and domestic flatcars without restriction as regards routing.

2.7.1.4 Analysis

a. The method of tiedown described in Figure 21 should be adequate for all individual rail shipments of the crated 5,000-barrel capacity tanks. If multiple units are to be shipped, the use of suitable flatcars which would permit in-line stacking, and side-by-side loading methods on domestic railroads and in-line and side-by-side loading methods on International Universal Gage and Composite (Foreign Service) railcars.

b. If accessories, such as manifolds, valves, pumps and filters are to be stowed and shipped in the present empty compartments on either end of the container, then adequate packaging and securing of these components should be insured. Since no damages to the crate were incurred during the rail humping tests, the addition of the components in the void spaces would not adversly offset the crate during rail shipments.

2.7.2 <u>Highway and Cross-Country Transportability</u>

2.7.2.1 Objective. To determine the adaptability of the test item for movement by standard military vehicles within CONUS and overseas areas.

2.7.2.2 Method

a. The crated item was shipped from the manufacturer's plant located in Arizona to Fort Lee, Virginia, loaded inside a commercial semitrailer van. Upon arrival, the item was inspected for method of securing and for any evidence of damage received enroute. The crated item was then unloaded from the inclosed van by "snaking" it out of the end of the van by a 5-ton mobile crane, and then employing a second 5-ton crane to lift and hold the unsupported end of the crate while the trailer was driven out from under it. The item was then lowered to the ground.

b. The crated test item and appurtenances were loaded onto a standard military 5-ton cargo truck (M54) by a 20-ton military standard mobile crane. The end gate was placed in a horizontal position to furnish additional support under the container. Restraint of the item was accomplished by two 20-foot lengths of 3/8-inch chain, one passed over each end of the crate and then through tiedown eyes located on the vehicle frame. A third length of chain was made fast to the underside of the container frame and the vehicle pintle to prevent the load from sliding rearward (Fig. 22). The test item was then transported over highways for a distance of 100 miles, on secondary hilly roads for 35 miles, and over a 17-mile cross-country course. Attempts were also made to negotiate 60-percent forward slopes and 30-percent side slopes, the normal operational capability of standard military cargo vehicles.

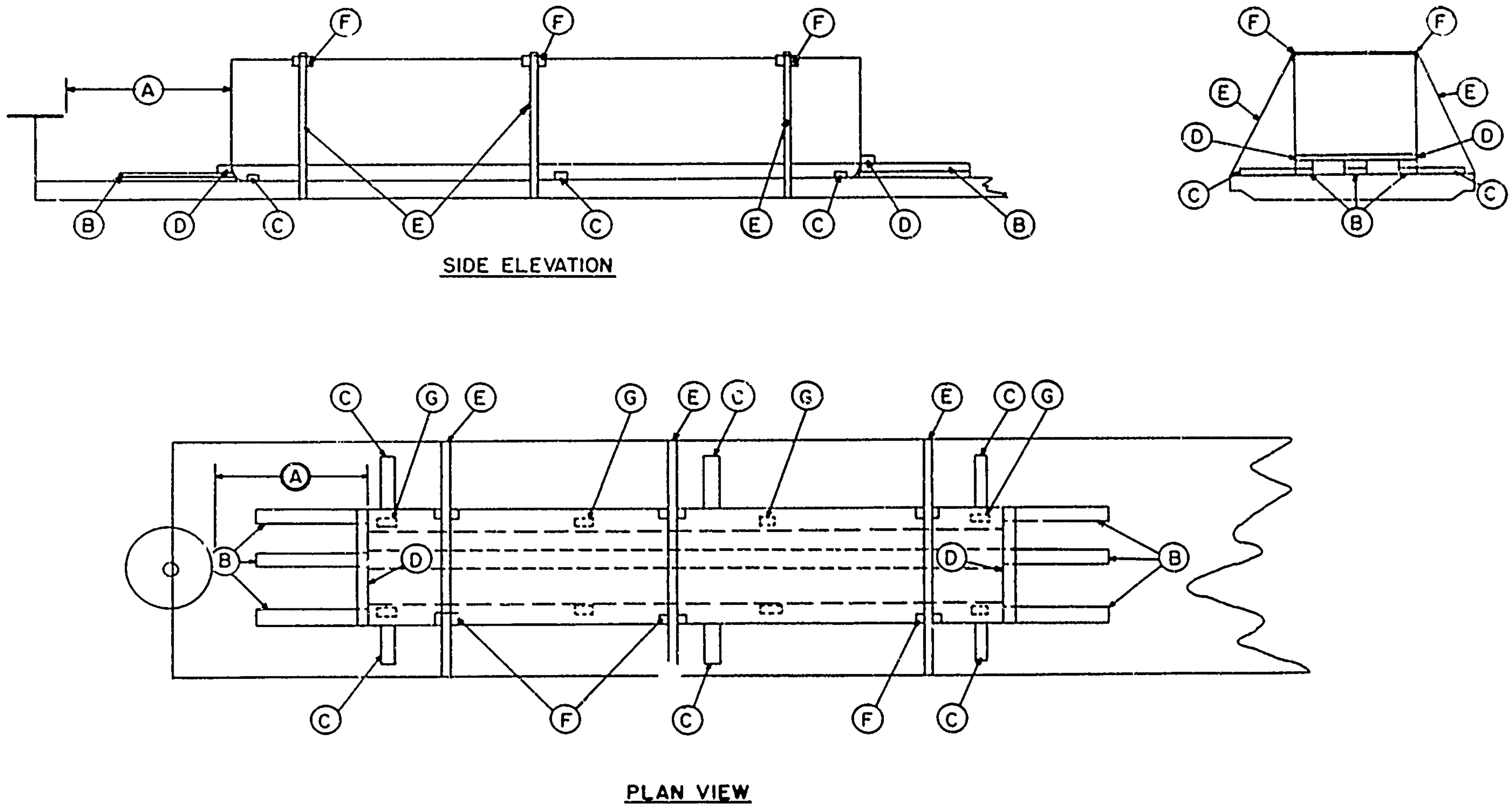

FIGURE 21. BLOCKING AND RESTRAINING ON RAILROAD FLATCARS.

BILL OF MATERIAL (Pertains to Figure 21)

Item	Amount or No.
Lumber, 2x6 in	68 Linear Feet
Nails, 30d (4 in)	108
Band, High Tension Steel, 1 1/2 inch	60 Linear Feet
Plates, Corner Protection	6
Plates, Antiskid	8

MATERIAL SPECIFICATIONS

Lumber: Douglas Fir or comparable with straight grain and free of material defects, Fed Spec MM-L-751.
Nails: Common, Cement-Coated, Fed Spec FF-N-105.

LEGEND: To Figure 21:

Item	No Req'd	Application
A	--	Brake wheel clearance. Six-inch clearance in back of, on both sides, and above brake wheel, with 4 inches required below the wheel.
B	6 each	Each to consist of two pieces of 2x6x48-inch lumber. Locate longitudinally against each of the units' skids both front and rear. Nail lower piece to the car floor with six 30d nails in a staggered pattern and the top piece to the one below with six 30d nails in an opposite staggered pattern.
C	6 each	Each to consist of one piece of 2x6x24-inch lumber. Locate transversely against the units outside skids. Nail to car floor with four 30d nails in a staggered pattern.
D	2 each	Each to consist of one piece of 2x6x48-inch lumber. Locate on top of B cleats and nail to each of the three B cleats with two 30d nails.
E	3 each	1 1/4 in x .035 high tension bands. Place over top of box approximately 2 feet from each end and one across the middle. Pass ends through stake pockets, tighten with a band tensioner and secure each band end with two clamps.
F	6 each	Corner Protectors. Place one between edge of box and high tension band.
G	8 each	Antiskid Plates. Place 4 each under each of the unit's outside skids.

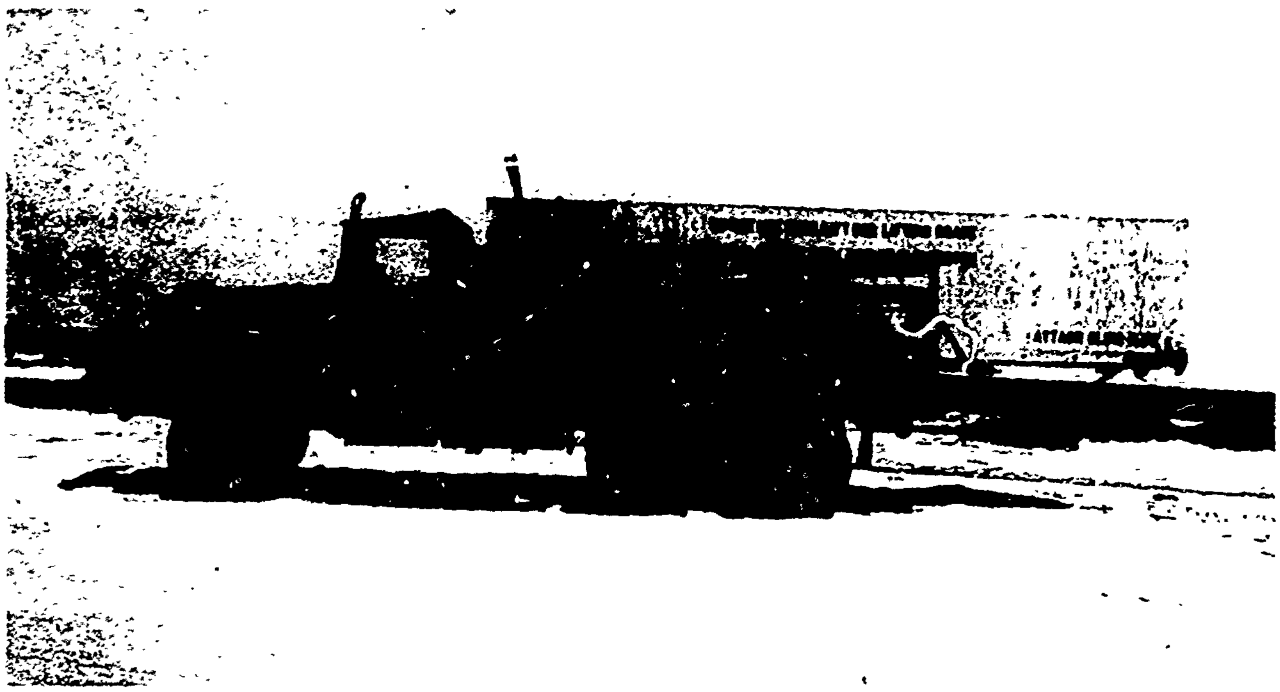

Figure 22. 5,000 barrel container loaded on an M54, 5-ton cargo vehicle. Arrow indicates relocated spare wheel and tire.

Figure 23. Damaged container as received by USAGETA.

c. The crated test item was also loaded onto an M52-M127 tractor-trailer combination by a standard military 20-ton mobile crane. The item was restrained on the flat bed by two 20-foot lengths of 3/8-inch chains passed over the load and through the trailer stake pockets. Tensioning of the chains was accomplished by chain binders. The item was transported on this vehicle over secondary roads for a distance of 10 miles, inspected for evidence of shifting or damage and then off-loaded.

2.7.2.3 Results

a. The container, housing the test item, was received in a damaged condition. The first five boards of the 3/4- by 3 1/2-inch soft wood flooring on each end of the crate had been torn loose from the main frame, the fifth one was also splintered and broken as if punctured by the tine ends of a forklift truck (Fig. 23). The crate contents, however, had not been damaged. No transportability tests were conducted using forklifts because instruction on side of the container states "do not use forklift for lifting crate" and the present configuration would not permit it.

b. The containerized test item and appurtenances can be transported without damage on an M54 cargo truck. However, a 6-foot 6-inch overhang condition exists beyond the horizontal end gate even after relocating the vehicle's spare wheel from its installed position, across the end of the cargo body, to alongside the container (Fig. 22). The crated test item can be transported along slopes of 30 percent while loaded on an M54, 5-ton cargo truck, but the vehicle is not able to climb or descend forward slopes in excess of approximately 35 percent because of the extreme overhang of the container which results in load/ground interference.

c. The crated test item and appurtenances were transportable by the M52/M127 tractor semitrailer combination over secondary roads without difficulty or damage. The method of tiedown as described in paragraph 2.7.2.2c was adequate. The load is within the maximum height limitation permitted by AR 705-8 for overseas movements (132 inches).

2.7.2.4 Analysis

a. The present configuration of the container does not allow lifting, moving, or loading by forklift trucks. Skids should be notched at the center of the container to accept the largest capacity forklift's tines when in the maximum spread position. Forklift operations will also require that the bottom of the box be reinforced in the tine area and at both ends to prevent structural and/or content damage during lifts. The ability to handle the item with forklifts will greatly enhance its movement and loading adaptability.

b. Transporting the containerized item on the M54 cargo vehicle over various types of roadways and cross-country terrain is undesirable because of the excessive load projection. Further, if it is intended, in the future, to utilize the 4- by 4-foot void presently existing on each end of the container as a stowage and shipping area for tank accessories and appurtenances, the added weight could possibly create an unstable load and/or an undesirable load condition for the vehicle. The standard M52/M127 tractor trailer combination is considered to be the more suitable vehicle for movement of the item over roadways and, within the vehicle's limited capability, over cross-country terrain.

2.7.3 Marine Transportability

2.7.3.1 Objective. To determine the adaptability of the test item for movement by marine craft (oceangoing and inland waterways).

2.7.3.2 Method. This phase of the movement adaptability tests was accomplished by comparing the physical dimensions and weight of the crated item and its appurtenances against hatch sizes, compartment sizes, and boom capacities of the Liberty, Victory, and Mariner class vessels. A study was made to determine the item's capability of being loaded aboard and transported by an LCM-6, LCM-8, LCU, LST, and amphibious vehicles. Department of the Army Field Manual FM 55-15 "Transportation Reference Data" was used for these studies.

2.7.3.3 Results

a. The 5,000-barrel collapsible tank in its container and its appurtenances can be transported by all oceangoing cargo vessels subject to the limitations shown in Appendix I-D. Loading can be accomplished with the normal lifting slings found aboard these ships or in marine terminals.

b. The study indicated that the containerized tank and its appurtenances are transportable by landing craft of the LCM-6, LCM-8, LCU, and LST class, and by the LARC XV and LARC LX. The item cannot be transported within the cargo well of the LARC V.

2.7.3.4 Analysis. While the crated item can be transported by all standard landing craft presently in the system, it cannot be loaded aboard these types of vessels by forklift trucks even if the container is redesigned to accept this method. The length of the container exceeds the width of the cargo wells and/or entry openings of the ramps. Loading or discharging must be accomplished either by a terminal or mobile crane, or by the ship's hoisting gear. In the event the material handling equipment is not available, the item can be discharged from landing craft by "snaking" it off with a tow cable attached to an appropriate size vehicle, or its winch.

2.7.4 Logistics-over-the-Shore (LOTS)

2.7.4.1 Objective. To determine the capability of the test item to be handled in a LOTS operation.

2.7.4.2 Method

a. The crated test item was transported on an M54 5-ton cargo truck, winch equipped, from Fort Lee, Virginia, to Fort Story, Virginia, a distance of 100 miles in approximately 3 hours without any difficulty.

b. The test item was to be off-loaded from a landing craft simulating a LOTS operation; however, due to the rough surf encountered, an LCM-8 was unable to beach in a dry ramp condition and was not utilized. The crated test item was loaded over the side into the cargo well of a LARC LX by a 10-ton, tracked, crawler crane, using a 1/2" chain sling (Fig. 24).

c. The LARC LX was positioned at the waters edge simulating a beached landing craft and the test item off-loaded over the ramp of the LARC LX and moved across the shoreline by the following methods:

(1) Sling lifted over the side by 10-ton crawler crane.

(2) Snaked off over the ramp by a bulldozer winch attached to a 1/2" chain bound around the front end of the crate (Fig. 25) and skid-towed across the beach approximately 200 yards inland from the shoreline.

(3) Snaked off over the ramp by winch of the M-54, 5-ton cargo truck, as outlined in (2) above.

d. On the beach, the crated test item was reloaded by the crawler crane into the M-54, 5-ton cargo truck, and transported over the beach, through loose dry sand and dunes cross-country to a simulated assembly point 2 miles inland.

2.7.4.3 Results

a. The crated test item was off-loaded, without difficulty, from a LARC LX simulating a beached landing craft under a dry ramp condition by a tracked 10-ton crawler crane equipped with a standard 5-ton sling assembly.

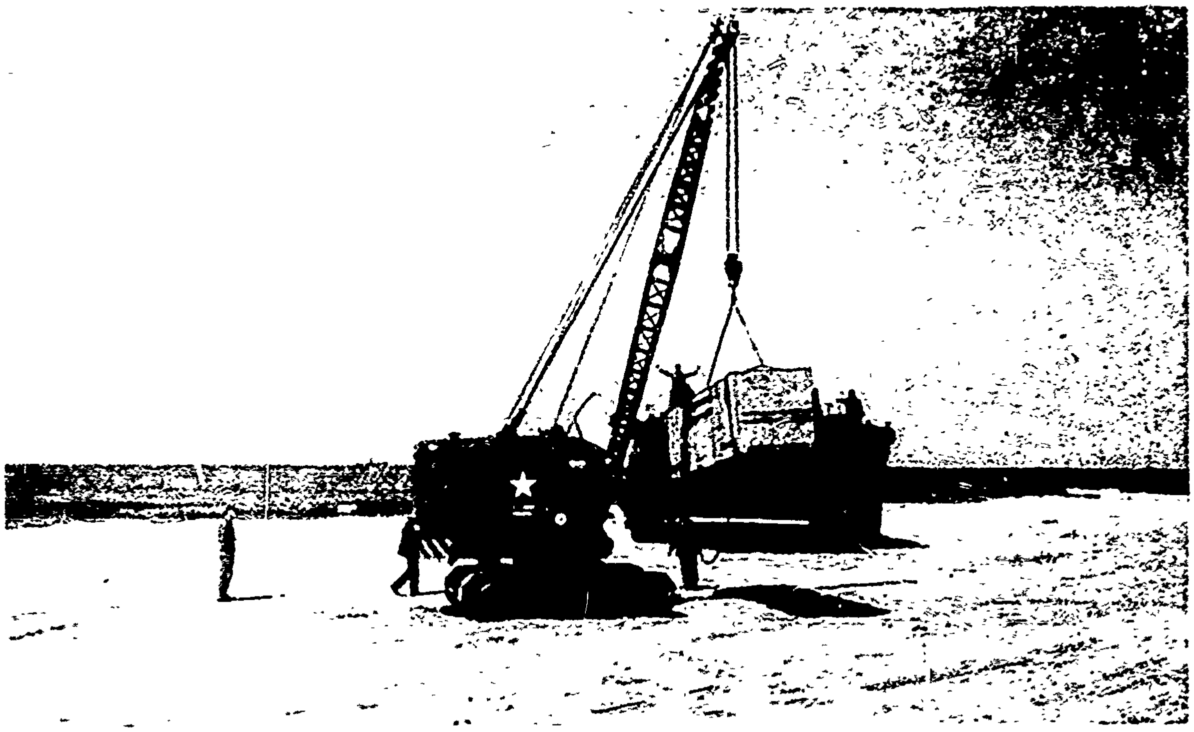

Figure 24. Crated tank being lifted aboard LARC LX.

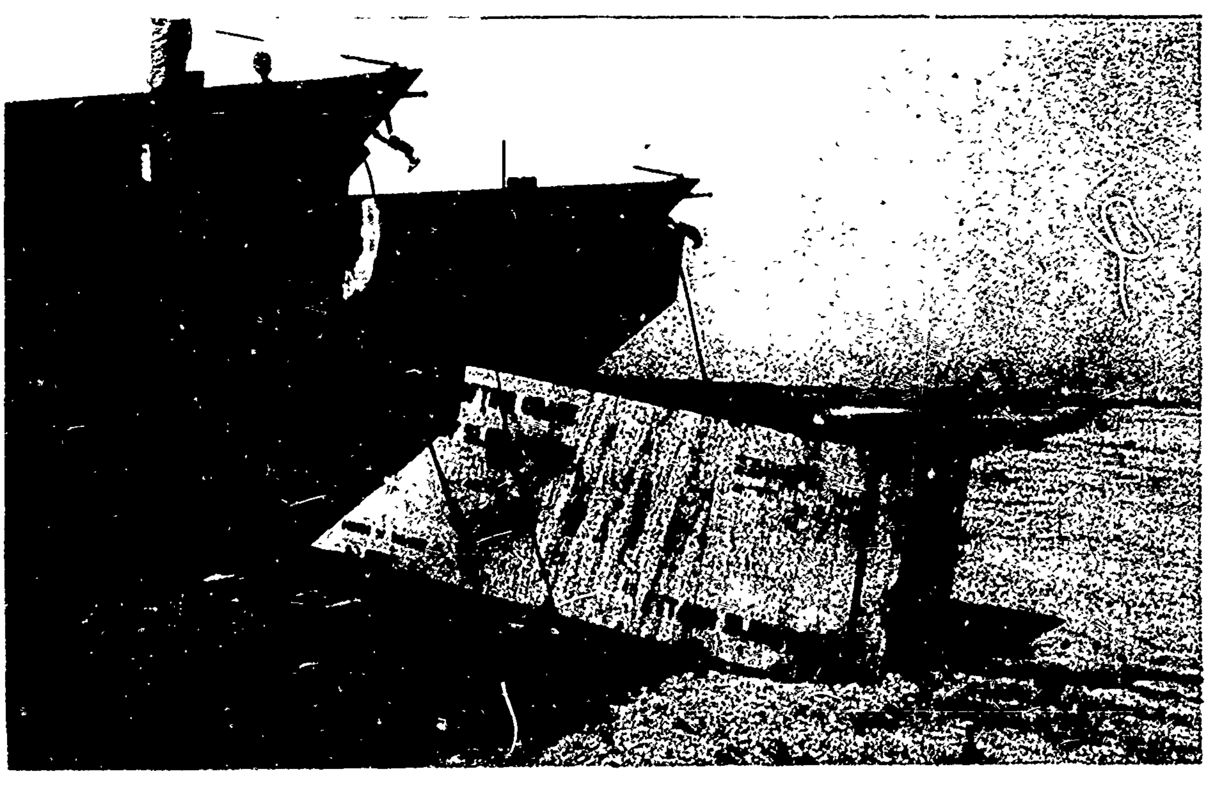

Figure 25. Crated tank being towed across ramp of LARC LX.

b. The crated test item was skidded and snaked off over dry ramp of the LARC LX by a cable from a bulldozer and M-54 truck without difficulty.

c. The crated test item was transported by the M-54 5-ton cargo truck over loose dry sand, sand slopes, and cross-country without difficulty.

2.7.4.4 Analysis. The crated test item can be brought ashore by landing craft and off-loaded by a crawler crane or skidded over a dry ramp and across the beach by a suitable vehicle. The towing vehicle should have a winch or suitable device to elevate the front end of the crate so it does not become embedded in the sand.

2.7.5 Air Transportability

2.7.5.1 Objective. To determine if the physical dimensions and weight of the crated item will permit transporting by standard cargo aircraft.

2.7.5.2 Method. A study was made comparing the physical dimensions and weight of the crated test item and its appurtenances with dimensions of the openings and cargo compartment and the load carrying capability of standard military cargo aircraft including helicopters, as an internal load. These data were compiled from Department of the Army Field Manual, FM 55-15, Transportation Reference Data.

2.7.5.3 Results. Based on a typical logistical mission of 2500 nautical miles (4,625.0 km), one way, the crated system is within the dimensional and weight limitations of the following standard Air Force fixed wing and Army helicopter cargo aircraft:

C119G	Packet	C135	Stratolifter
C123B	Provider	C141A	Starlifter
C124C	Globemaster	CH37B	Mojave
C130A-B	Hercules	CH47A	Chinook
C133A-B	Cargo Master		

2.7.5.4 Analysis. Although the study indicated that the crated test item and its appurtenances would fit inside the various aircraft listed, its ability to be air transportable is dependent upon an adequate means of securing the item.

2.8 EFFECTS OF NUCLEAR WEAPONS (ST)

2.8.1 Objective

To determine the capability of the test item to withstand the effects of nuclear weapons.

2.8.2 Method

DA Pamphlet 39-3, "The Effects of Nuclear Weapons," dated April 1962, was used as guidance in evaluating the capability of the 1250- and 2500-barrel test items to withstand the effects of nuclear weapons. It was also used as guidance in comparison against similar capabilities of conventional cylindrical steel tanks. Engineering technical test data were used to show seam strength, puncture resistance, and fabric strength. Evaluation tests were conducted to determine the fabric resistance to high temperature and ignition. Results presented with regard to the 5,000-barrel tank are essentially the same as for the 1250- and 2500-barrel tanks.

2.8.3 Results

a. The collapsible tank is susceptible to nuclear blast and thermal radiation effects.

b. Studies indicate that collapsible tanks are less susceptible to nuclear effects than upright cylindrical steel tanks.

2.8.4 Analysis

a. Blast Effects. Analytical work indicates that the chief cause of failure in a conventional tank is the lifting of the tank from its foundation and actual collapse of the tank sides. This becomes more critical with the increase of free vapor space in the tank. The test items which can be described as floating-roof, nonbreathing tanks have virtually no free gas space. This greatly offsets and reduces the effect of overburden. Reduction in the effect of overburden is also aided by low tank profile and a relatively close, substantially constructed berm having a height approximately equal to that of the tank. The berm also limits missile damage against the test item, which has a rather low puncture resistance of 254 pounds (App. I-B) on the tank top.

b. Thermal Radiation. Laboratory tests of the fabric from the 2500-barrel tank indicated signs of damage at approximately 550°F. when smoke was detected with a visible charring and melting of material. At approximately 850°F., the fabric started to glow and decompose into ash.

The apparent high susceptibility to thermal radiation damage, dependent on the energy level, makes the collapsible fabric tanks quite vulnerable to nuclear attack. By comparison, the sealing and gasket material used in the construction of steel bolted tanks is similar to the fabric material of the collapsible tanks, and energy levels sufficient to cause decomposition of the test item fabric would also cause decomposition of the bolted tank gasket material, rendering it a virtual total loss due to leakage of product.

2.9 MAINTAINABILITY and RELIABILITY EVALUATION (ST)

2.9.1 Objectives

a. To determine whether the item meets maintenance and maintainability requirements as defined by the SDR and as set forth in USATECOM Regulation 750-15, and to evaluate the associated maintenance literature with emphasis on ease of inspection and maintenance, installation in a minimum time and effort, reliability of component parts, and handling and servicing with specified tools and equipment.

b. To determine the repairability of the tank, using the tank repair kit furnished with the test item.

2.9.2 Method

a. Upon receipt of the test item, the maintenance test package was inspected to evaluate its contents for completeness.

b. Two 5,000-barrel, collapsible, self-supporting fuel storage tanks were installed by petroleum specialist MOS 76W20 and used and maintained under service type test conditions in a TOE environment at Fort Lee, Virginia. The test was conducted on a continuous basis 24 hours daily for a period of 12 months pumping MOGAS in and out of the tank until 20 full cycles and 75 partial cycles were achieved.

c. Accumulated records of scheduled, unscheduled, and simulated maintenance, repair parts usage, and service life data were summarized and evaluated. Computations were made to determine maintainability indicators (such as mean time between maintenance (MTBM), mean time between failures (MTBF), and mean downtime (MDT)) and maintenance, reliability, and other indicators as required by USATECOM Regulation 750-15.

d. Scheduled, unscheduled, and simulated maintenance actions were performed by 63K30 and 76W40 MOS personnel from USAGETA at

Fort Lee, Virginia, utilizing the basic issue items and common tools of both the general mechanics tool sets and organizational No. 2 common tool set (FSN 4910-754-0650). There are no requirements to perform maintenance above the organizational level.

e. TM 5-5430-202-12, with Supplement No. 1, dated May 1967, was used by organizational maintenance personnel for installation and performance of all maintenance actions and evaluated for completeness, accuracy, simplicity, and clarity.

2.9.3 Results

a. The initial inspection of the test items was performed according to instructions in DTM 5-5430-202-12 and Supplement No. 1. All basic issue items were received, and the maintenance package was complete (App. IV-A).

b. Daily preventive maintenance performed by the operator required approximately 0.3 hour and consisted of inspection of all fittings, valves, hoses, tubing - couplings, and tank body for leaks or punctures.

c. Corrective maintenance actions were performed during the engineer phase of the test and consisted of adjustment (torqueing) of bolts on the closure plates and vent pipe flanges to 20 to 30 inch-pounds, as specified in the technical manual and labels on the test items. An inch-pound torque wrench was not available at organizational maintenance level, but it was obtained through direct support.

d. Two unscheduled maintenance actions were required during the engineer phase of the test to control leakage and were performed by the operators using the sealing clamps (App. IV-C) provided in the repair kit. Time for repair was 0.1 hour each. Repairs were made without interruption of operation of the test items when the tanks were not completely filled.

e. The only organizational maintenance performed was a simulated relocation (moving to new location) of one test item. Twenty-one students from the Quartermaster School (Petroleum Dept) at Fort Lee, Virginia, assisted in replacing the test item. Relocation required 0.9 clock hour and 18.9 man-hours after complete draining of the test item had been accomplished. Draining the test item was the only problem encountered, and was solved by puncturing the tank in the appropriate place as it was folded and rolled to permit emission of vapors. The puncture was repaired immediately by a mechanical clamp.

f. The only other organizational maintenance task shown on the Maintenance Allocation Chart (MAC) was repair of the valve,[2] and it was not performed because it was determined to be beyond the scope of organizational maintenance. After coordination with the QM Petroleum School, it was recommended that the valves be repaired at the depot level and that only replacement be performed in the field by organizational maintenance. All other maintenance actions on the MAC were simulated (App. IV-B) by 76W20 MOS personnel under the supervision of 76W40 MOS personnel, except for two repair actions which were reviewed.

g. The maintenance and reliability data relevant to the service phase of the test are presented in Table II. Since no maintenance was required during the service test and no failures occurred, the regular maintainability indicators (mean time between failure, mean downtime, mean time to repair, mean active maintenance downtime, mean time between maintenance, and maintenance ratio) were indeterminable; and the inherent, achieved, and operational availabilities were 100 percent. The Maintenance and Reliability Analysis Chart, which lists all maintenance tasks performed (simulated), is included as Appendix IV-B.

TABLE II

SERVICE TEST MAINTENANCE AND RELIABILITY DATA

Mission Time = 12 months
Required operational life = 12 months
No. of test items = 2
Operating time for each test item = 12 months
No. of failures = none
Maintenance man-hours
(scheduled and unscheduled) = none
Maintenance clock hours
(scheduled and unscheduled) = none
Downtime = none

h. Scheduled, unscheduled, and simulated maintenance were performed without difficulty by test mechanics utilizing the basic issue items and common tools of the general mechanics tool set and organizational common tool set No. 2 (FSN 4910-754-0650). A required tool (inch-pound torque wrench) was not available at the test site and was borrowed from the Direct Support Maintenance Shop at Fort Lee. The parts analysis chart (App. IV-C) indicates the parts used during the test.

[2]Butterfly valve.

i. Draft Technical Manual 5-5430-202-12 and Supplement No. 1, dated June 1967 (App. IV-A) were used by organizational maintenance personnel for all scheduled maintenance actions. There were no unscheduled maintenance actions at organizational level during the conduct of the test. Recommended changes and additions to the manual were submitted and are included as Appendix IV-D.

2.9.4 Analysis

a. Operator was capable of adequately performing the prescribed daily maintenance.

b. Inspection for leaks may be enhanced by daily use of a vapor type tester (Explosimeter), especially along the bottom tank area.

c. Corrective maintenance action requiring inch-pound torqueing of bolts requires the use of an inch-pound torque wrench. Substitute wrenches should not be used because of the obvious hazard of breaking the bolts due to over-torqueing. Experience indicates that removal of the broken portion of the bolt from the rubberized mounting will cause additional damage to the test item.

d. The repair kit sealing clamps used on the two unscheduled maintenance actions were satisfactory, and no problems were encountered.

e. Replacing the test item was simulated using the original location, during a period when the tank was empty. Draining the item through the bottom drain, after all possible product was removed through the inlet/outlet elbow, required several hours. The 21 students used were considered a logical task force for the job. The directions for folding the tank must be followed very closely for successful replacement in the minimum (recorded) time.

f. Repairing the valves in the field is not considered feasible because of the conditions involved and the availability of replacement parts. The test NCO (MOS 76W40) reported the valves as replacement items in the field, and repair is only recommended as emergency action. Normally, repair should be a depot maintenance function.

g. Each of two tanks was tested continuously for 12 months, a period equal to both the essential operational life and the mission time of the tanks . Although no failures occurred during the 12-month test, the 96-percent reliability requirement could not be validated at any significant confidence level because of an insufficient number of test items. Since no failures occurred, there is no evidence that the tanks are incapable of meeting the reliability requirement.

h. The tanks are satisfactorily maintainable with the general mechanics tool set and tools available at the organizational level. Consideration should be made of including an inch-pound torque wrench in the maintenance package which will improve the performance of maintenance. Safety-type tools (spark proof) would decrease the inherent hazard of the general mechanics tool set.

i. Draft Technical Manual 5-5430-202-12 and Supplement No. 1, dated June 1967, are considered adequate; and the instructions, illustrations, and the MAC are satisfactory for use. Incorporation of suggested changes will improve the manual (App. IV-D).

2.10 SAFETY (ES)

2.10.1 Objectives

a. To determine and confirm the safety characteristics of the test item and procedures of operation.

b. To provide reasonable safeguards against accidents occurring in use of the equipment.

2.10.2 Method

a. During installation and the early stages of testing, observations were made to detect any condition which might present a safety hazard, to determine the cause, and to note steps taken to alleviate the hazard encountered. A safety release was issued as the result of engineering tests in accordance with USATECOM Regulation 385-6.

b. Integrated engineering and service operational performance tests adhered to safety procedures developed during initial test phases stated in the safety release and as defined in the draft technical manual.

2.10.3 Results

a. During the initial phases of the engineering portion of the test, a safety statement could not be issued due to leakage around the closure plate. This condition was subsequently corrected.

b. During the operational performance phases, both test items were found to be safe for all operations. They were found to possess no further safety hazards, providing the items are handled in accordance with instructions included in the draft technical manual and normal POL safety procedures.

c. The safety procedures and precautions presented in the developer's safety statement (Ref. 3, App. V) were found to be acceptable and should be used in all cases.

d. Grounding rods (not provided with the test items) should be imbedded to a minimum depth of 8 feet. Where rock or impregnable ground are encountered, the rods should be buried in a horizontal trench, not less than 8 feet in length and 2 feet in depth. The electrodes should be separated at least 6 feet from any other electrodes including those used for signal circuits, radio, lightning rods, or any other purpose. The 5,000-barrel collapsible tank should be grounded by attaching one electrode preferably to the inlet/outlet plate flange. Resistance of the electrode to ground circuit should not exceed 25 ohms. No. 14 cable is recommended for leads from flange to electrode.

e. During operations the pooling of rainwater on the tank with the resultant fuel flow out of the submerged vent pipe constituted a potential safety hazard. The action described in paragraph 2.6.3a corrects this potential hazard.

2.10.4 Analysis

a. The tank was isolated by insertion of a 2-foot section of 6-inch diameter glass tubing close to the tank inlet to determine if any electrostatic buildup resulted from turbulence in the tank during filling operations. Electrostatic buildup was found to be negligible; however, since the actual amount of electrical charge generated by the flow of product through a pipeline depends on the pipe material and surface condition, the hydrocarbon and type of ionic material present, the pipe diameter and length, metal-to-liquid surface ratio, and temperature and fluid velocity, it is conceivable that a substantial static charge could be generated along an inadequately grounded pipeline or system. Therefore, it is suggested that the recommendation outlined in paragraph 2.10.3d pertaining to grounding electrodes be incorporated in the draft technical manual as an added safety measure.

b. Operational performance confirmed all other safety characteristics of the test items. The collapsible tanks are capable of being operated without hazard to operating personnel, provided safety precautions contained in the draft technical manual as well as normal safety procedures for operating POL equipment are observed.

2.11 HUMAN FACTORS EVALUATION (ES)

2.11.1 Objective

To observe the effectiveness of the man-item relationship during operational use and to assess the degree of ease, simplicity, and effort in installing, operating, and maintaining the items in normal use.

2.11.2 Method

Throughout all testing, observations were made and recorded concerning the effort and ability of users to handle, install, operate, and maintain the test items. Safety features incorporated in the test items for the protection of operator personnel were thoroughly evaluated during the conduct of the test. Continually during the course of testing, operators' comments were recorded on a human factors rating sheet.

2.11.3 Results

a. Observations of engineering and service test teams revealed little difficulty in the operators' ability to install, operate, and maintain the test items, with the following exceptions:

(1) The tank was difficult to exhaust. Personnel were forced to vertically rotate the outlet hose and elbow. Further, the tank corners had to be lifted to draw product to the vicinity of the outlet.

(2) The tank fabric was difficult to grasp when shifting or rolling the tank.

(3) The single top crate portion made handling very clumsy for installation personnel.

(4) Difficulty was experienced in completely decanting the tank to prepare for relocation.

b. Personnel normally assigned to QM petroleum supply units could easily operate and maintain the tanks after one-half day of supervision and OJT.

c. Reaction time by operators in position to open valves was 10 seconds. Reaction time to close valves was 12 seconds.

2.11.4 Analysis

a. Simplicity in design and the use of common or standard manifold system components precludes complications in installation, operation, and maintenance of the tanks.

b. With approximately 3,000 to 4,000 gallons remaining in the tank, it became successively harder to decant product due to the fabric being sucked into the outlet elbow. By constantly moving the outlet elbow, additional product could be drawn. By lifting up or doubling back the tank corners, more product could be decanted. However, these procedures were not feasibly continued when approximately 500 gallons remained.

c. A metal stand-off basket installed under the tank closure plate would probably alleviate much of the problem of pump suction drawing the fabric into the outlet.

d. As service use of the tank increases, stretching of the fabric makes rerolling and repacking increasingly difficult. It was possible to reroll the tank on the mandrel, but recovering the crate was not possible.

e. Emptying the tank for relocation is somewhat difficult due to entrained air and vapor. Significant spillage and drainage must be expected.

2.12 VALUE ANALYSIS (ES)

2.12.1 Objective

To determine if the test item has any unnecessary, costly, or nice-to-have features which might be eliminated or redesigned to reduce cost.

2.12.2 Method

Throughout the conduct of the test, observations were made and users were questioned concerning features which could be eliminated or modified without compromising the operational performance, reliability, durability, or safety of the collapsible tanks.

2.12.3 Results

Based on observations by test team personnel, the tanks and their appurtenances have no unnecessary, costly, or nice-to-have features.

2.12.4 Analysis

Not applicable.

SECTION 3. APPENDICES

APPENDIX I. TEST DATA

APPENDIX I-A

INSTALLATION DATA

	Tank No. 1	Tank No. 2
(1) Site Preparation:		
Man-Machine Hours	10	10
Man-Hours (Manual)	12	12
Total Man-Hours	22	22
Slope:		
Existing Terrain	3%	3%
Prepared	.864%	0.976%
(2) Berm Construction:		
Berm Dimensions (ft)		
Length	125	125
Width	75	75
Height	5	5
Man-Hours	26	26
Man-Machine	10	10
Manual	16	16
(3) Tank Installation:		
Man-Hours	10	10
Manual	9.0	9.0
Man-Machine	1.0	1.0
(4) Manifold, Assembly of:		
Man-Hours	16	16
Manual	15	15
Man-Machine	1	1
Total Time All Operations		
Man-Hours (Manual)	104	(both test items)
Man-Hours (Machine)	44	

APPENDIX I-B

FABRIC ANALYSIS

TEST CONDUCTED	SPECIFICATION/ METHOD	ORIGINAL PURCHASE DESCRIPTION REQUIREMENTS	GETA EXPOSED FABRIC VALUE		MERDC UNEXPOSED FABRIC VALUE		VARIANCE FROM ORIGINAL UNEXPOSED		% VARIANCE FROM ORIGINAL UNEXPOSED	
			TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM	TOP	BOTTOM
Weight Oz/Sq Yd	FTMS CCC-T-191b 5041.1		30.4	30.4	28.5	28.5	(+)2.0	2.0	7.0 (inc)	7.0 (inc)*
Thickness, Mils.	FTMS CCC-T-191b 5030.1		38	39	38	38	0.0	(+)1.0	0.0	2.7 (inc)
Abrasion Resistance Mg. Qms Loss/200 Cycles	FTMS CCC-T-191b 5306 and P.D.	(Top) Bottom +.0026 +.0014	7.1	8.8	2.6	1.4	(+)4.5	(+)7.4	dec 172	*dec 528
Blocking	Par. 4.24 P.D.	Shall Separate	Success		Fail	Fail				
Puncture	FTMS CCC-T-191b ERDL Method 5120		254	263	261	263	(-) (7)	(0)	dec 2.7	0
Tear Strength Lbs. Warp x Fill	FTMS CCC-T-191b 5134.1	Min. 55 x 55	37x40	26x24	31x27	32x29	(+) 6 (+) 13	(-) 6 (-) 5	Inc 19.4 inc 51.8	dec 19.9 dec 17.2
Breaking Stength Lbs. Warp x Fill	FTMS CCC-T-191b 5102.2	Min. 600 x 600	632 x 581	671x601	659x540	612x596	(-) 27 (+) 31	(+) 59 (+) 5	dec 3.9 inc 5.7	inc 9.6 inc .8
Mullens Burst Test	FTMS CCC-T-191b DIAPHRAM 5122.2		613	615	Not Conducted					
Puncture	MIL-T-6396c FTMS CCC-T-191b		177	149	261	263	(-)84	(-)114	dec 32	dec 43
Coating to Fabric Adhesion lb/in Ext-Ext Int-Int	FTMS CCC-T-191b 5970-2	Min. 15 Min. 15	25 18	26 20	72 75	85	(-)47 (-) 6	(-)59	dec 65 dec 10	dec 69
Peal Strength - End Seam lb/in	FTMS 601 Method 8011	Min. 15	53		59.5		(-) 6		dec 10	
Peal Strength - Body Seam lb/in	FTMS 601 Method 8011	Min. 15	35	40	27		(+) 8		inc 29	
Shear Strength - Body Seam	FTMS 601 Method 8311		532	613	655		(-)123		dec 19	
Vapor Transmission - Water Fl Oz/Sq Ft	Vapor Cup Method	Max. .025	0.140	0.145	0.0575	0.0620	(+).08	(+).08	inc 133	inc 133
Diesel			.098	.102	Not Conducted					
MOGAS			.054	.056	Not Conducted					
CITE			.033	.034	Not Conducted					
AVGAS			.007	.007	Not Conducted					
JP-4			.289	.311	Not Conducted					

*inc = increased; dec = decreased

APPENDIX I-C

SUMMARY OF MAXIMUM G FORCES FOR HUMPING TEST ON FLATCARS

(25 G full scale range setting was used to record shock forces during this test)

Run	Direction of Hump	Actual Car Hump Speed MPH	[a]Accelerometers on Flatcar			[a]Accelerometers on Test Item		
			Long	Trans	Vert	Long	Trans	Vert
1	[b]Fwd	1.97	3	2	4	3	1	3
2	"	3.98	8	6	7	4	2	5
3	"	5.77	8	6	5	5	1	6
4	"	5.82	7	6	7	5	1	4
5	"	5.72	7	7	5	6	2	6
6	"	7.90	7	8	10	9	4	9
7	"	8.00	8	7	9	10	3	9
8	"	8.08	8	8	11	11	2	9
9	"	10.63	8	8	12	13	3	12
10	"	10.30	9	9	12	14	3	13
11	"	10.45	10	8	12	15	3	13
12	[c]Rev	1.70	1	1	1	1	1	2
13	"	4.28	3	2	2	2	2	4
14	"	6.18	4	2	2	2	3	7
15	"	6.18	5	3	3	3	3	5
16	"	6.23	4	3	2	3	3	5
17	"	7.90	6	5	4	6	2	7
18	"	7.90	6	5	5	6	2	7
19	"	8.00	6	4	5	6	2	6
20	"	9.57	8	5	6	7	3	9
21	"	10.15	9	8	8	7	5	10
22	"	10.15	8	8	9	9	4	10

[a]The G forces were extracted from the tapes to the nearest whole figure.

[b]Runs 1 thru 11 were humped into cars having AAR couplers.

[c]Runs 12 thru 22 were humped into cars having foreign service buffers.

APPENDIX I-D

VESSEL HATCH AND BOOM DATA

Class	Clearance Under Hatch Girders Adequate	Hatch Size Adequate	Hatch Boom Adequate	Hatch Requiring Terminal Boom
Mariner	All	All. Loading into compartments 1, 2, 3, and 19 will require the draft to be lowered through the hatch in an inclined attitude.	All	None
Victory	All	All	All	None
Liberty	All	All. Loading into compartments 3, 4, 7, 8 will require the draft to be lowered through the hatch in an inclined attitude	All	None

APPENDIX I-E

Subject: Lift of Collapsible 5,000-barrel tank

Method:

The original crate was lifted one end at a time on to the bed of an M172 low bed semitrailer with a 10,000-pound yard lift, crane and one 1/2" x 14' chain. It was positioned lengthwise on the bed of the semitrailer and as far forward as possible. The crate was then tied down with one 1/2" x 14' chain and chain binder at each end of the crate.

The collapsible tank had been rolled up on a 6" pipe cut to fit the crate and snugged up with 1/4" rope to prevent unrolling. The tank was picked up with a 10,000-pound yard lift, crane using 2 each 1/2" x 14' chains fastened to the ends of the 6" pipe. The tank and pipe were positioned in the crate and tied down with the two 1/2" x 14' chains used for the lift and tightened with chain binders.

The truck was driven over a 4-mile course consisting of cross-country and dirt and hard surfaced roads and then returned to the original site. It was off-loaded with the same equipment and chain used in the loading operation.

Results:

Operation	No. of Men	Time Required
Load crate	2	6 Min.
Load tank	9*	18 Min. 20 Sec.
Unload tank	3	4 Min.
Unload crate	2	3 Min.

*6 Men were required to wrap and tighten the 1/2" rope around the rolled-up tank to prevent the tanks from unrolling.

Analysis:

No difficulties were encountered in loading, transporting, and unloading the collapsible tank and shipping crate. The 1/2" rope was capable of snugging the tank so it did not unroll; however, it is believed the nylon webb straps FSN 2540-930-9277 would be more suitable for such an operation.

APPENDIX II. FINDINGS

Approved Small Development Requirements 1250-, 2500-, and 5000-Bbl Collapsible Storage Tanks

SDR Reference	Small Development Requirement	Met	Not Met	Test Phase	Remarks and Paragraph References
Par. 2b(1)	Shall provide maximum safety possible consistent with the material and design used to personnel and equipment during operation, storage, transportation, and maintenance phases for the life of equipment.	X			Maximum safety will be enhanced with inclusion of a grounding kit (Pars. 2.6.3 and 2.10.3).
Par. 2b(2)	Shall be capable of utilization with 4- and 6-inch hoseline systems and with 4, 6, and 8-inch coupled or welded pipeline systems.	X			Compatible if proper adapters are supplied or available (Par. 2.6.3d).
Par. 2b(3)	Shall be capable of installation using equipment available in Engineer units.	X			Paragraphs 2.3.3a and 2.3.4a.
Par. 2b(4)	Shall be sufficiently rugged to withstand field service conditions normally encountered in this type of installation.	X			Paragraph 2.6.3.
Par. 2b(5)	Shall have a minimum operational life of 12 months and a shelf life or not less than 5 years.		-		Could not be determined due to limited test time (Par. 2.6.4d).
Par. 2b(6)	The minimum acceptable mission reliability is 96 percent. Reliability is defined as the probability of a tank successfully completing a mission of 12 months duration and is based on the assumption that the tank is expected to be in continuous use during this period of time.		-		96 percent reliability could not be determined due to insufficient number of test items (Pars. 2.9.3g and 2.9.4g).
Par. 2b(7)	Equipment and/or techniques shall be developed to enable the contents of the tank to be gaged.	X			These gaging systems applicable only for field estimations (Pars. 2.6.3e and 2.6.4a).

SDR Reference	Small Development Requirement	Met	Not Met	Test Phase	Remarks and Paragraph References
Par. 2b(8)	Shall continue to perform satisfactorily when exposed to flow fluctuations resulting from intermittent pump action or other causes.	X			Limited to 20 psi surges (Par. 2.6.3f).
Par. 2b(9)	The material used to fabricate the tanks shall be lightweight, high strength, with camouflage exterior, and resistant to water, and to all military liquid hydrocarbon fuels. The material shall be resistant to fungi, afford minimum loss of fuel by diffusion, and shall not adversely affect the fuel stored.	X			Paragraphs 2.5.1, 2.5.2, and 2.5.3.
Par. 2b(10)	The collapsible tanks, together with their repair kits, manifolds and appurtenances, shall be of minimum practicable overall dimensions and weight without compromise of primary functions.	X			Paragraph 2.2.3b and c.
Par. 2b(11)	Configuration of the collapsible tanks when filled shall be such that the installed facilities will present a silhouette not higher than six feet.		X		Performance not affected by overage (Par. 2.3.4e).
Par. 2b(12)	Collapsible tanks with appurtenances shall be individually transportable in standard military vehicles or trailers of appropriate capacity. Provisions shall be made to protect individual tanks and facilities handling during transport in the field.	X	-		Item transportable by appropriate capacity military vehicle (Par. 2.7.2.3c). Container modifications required to insure maximum protection and ease of handling by fork lift truck (Par. 2.7.2.4).

APPENDIX II

SDR Reference	Small Development Requirement	Met	Not Met	Test Phase	Remarks and Paragraph References
Par. 2b(13)	The tanks, repair kits, manifolds, and appurtenances shall be designed to minimize the effects of corrosive action, deterioration and other chemical action resulting from a mixture of water, impurties and standard military liquid hydrocarbon fuels having an aromatic content not to exceed 40%.	X			Paragraph 2.5.2.
Par. 2b(14)	The overall dimensions of the largest tank packaged for shipment shall not exceed the allowable dimensions of the Berne International Loading Diagram. The collapsible tanks and accessory items shall be capable of transport by air in standard cargo aircraft.		-		Suitability for air transport not determined since no tiedown system has been developed (Pars. 2.7.1.3 and 2.7.5.3).
Par. 2b(15)	The tanks shall have a simple bottom water drain-off system.	X			Paragraph 2.6.3c.
Par. 2b(16)	The collapsible tanks shall incorporate design features to insure as much protection as possible from the effects of nuclear weapons. (Desirable)	X			Paragraph 2.8.3.
Par. 2b(17)	The tanks, with appurtenances as required, may be employed in hot-dry, warm-wet, and intermediate climatic zones.		-		This report covers testing for intermediate zone. Item is suitable for use under temperate climatic conditions (Par. 2.6.3).
Par. 2b(18)	Tanks shall have interchangeable components where possible.	X			Paragraph 2.6.3g.

SDR Reference	Small Development Requirement	Met	Not Met	Test Phase	Remarks and Paragraph References
Par. 2b(19)	Reid vapor pressure of fuel stored in these tanks shall not drop more than 2 psi after 60 days exposure as specified in AR 705-15 when tank is three-quarters or more full.	X			Paragraph 2.5.3.3.
Par. 2b(20)	The tanks should be capable of being made semi-fixed by a simple means utilizing tiedown eyelets and adjustable lines.		-		Item is inherently semi-fixed (Par. 2.3.4d).
Par. 2c(2)	Predicted servicing time is immediate, assuming no repairs are required. Service time is the time to service and check out the tanks for recommitment, beginning from the time the tank is emptied until it is ready for refilling, exclusive of transport and relocation time.	X			Paragraph 2.9.3.
Par. 2c(3)	Reaction time shall not exceed 1 minute. The time for the operator in position, to open and close inlet and/or outlet valves.	X			Paragraph 2.11.3c.
Par. 5a	These tanks shall be designed to require a minimum of operational and in-storage maintenance.	X			Paragraph 2.9.3.
Par. 5b	A repair kit consisting of all tools, gaskets, and patching materials shall be provided to permit field repairs of punctures and tears not in excess of 6 inches in length. The repair kit shall not use the vulcanization process.	X			Paragraph 2.9.4d.

APPENDIX II

SDR Reference	Small Development Requirement	Met	Not Met	Test Phase	Remarks and Paragraph References
Par. 5c	Test checkout methodology: (1) Allowable time for diagnosing failures will be such that 95% of all diagnoses will be accomplished as follows: (a) Organization Maintenance - 15 minutes (b) Direct Support Maintenance - None (2) Allowable time for making repairs will be such that 95% of all repairs will be accomplished as follows: (a) Organizational Maintenance - 2 hours and cure time (b) Direct Support Maintenance - None	X			Paragraph 2.9.3.
Par. 6a(1)	Identification of no-step and other areas that could possibly lead to injury of personnel and/or equipment.	X			Paragraph 2.10.3b and c.
Par. 6a(2)	Environmental conditions affecting human and/or equipment performance during installation and operation.	X			Paragraph 2.11.3a and b.
Par. 6a(3)	Information needed for operator decisions.	X			Paragraph 2.11.3.
Par. 6b	The tanks will be designed so that the average individual can operate and maintain them safely and adequately after one hour of preliminary supervised operation.	X			Paragraphs 2.3.3, 2.3.4, and 2.11.3b.

APPENDIX III. DEFICIENCIES AND SHORTCOMINGS

1. DEFICIENCIES

Deficiency	Suggested Corrective Action	Remarks
1.1 Vent pipe was submerged in pool of water because of heavy rainfall and product (MOGAS) had seeped from tank through vent pipe.	Use of lighter vent pipe or off-setting vent pipe from center line of tank.	Considered a safety hazard in that product was exposed. However, no product was lost since leakage was confined on top surface of tank.

2. SHORTCOMINGS

Shortcoming	Suggested Corrective Action	Remarks
2.1 Various pinhole leaks were detected on upper and under surface of tank.	Increase in manufacturer's quality control.	This should prevent flaws in fabric such as imbedded foreign matter and slight punctures.
2.2 Numerous wet spots appeared on tank especially at corners and along seams.	Improvement in impermeability of tank fabric coating compound.	Wet spots did not affect performance of item; increased during warm weather, decreased during cold weather.
2.3 Cap screws on closure plate and vent pipe flange of the items could not be adjusted as specified in the DTM and on the labels on the test items.	Issue of an inch-pound torque wrench with the item or provision to using organization.	None.
2.4 Shipping container was received in damaged condition from what appeared to be handling by forklift truck.	Modify lower portion of crate to adapt it to handling by forklift.	Ability to move the containerized item by forklift will greatly enhance its shipping adaptability. Strengthening the flooring of the container will prevent damage to the box and its contents during attemps in the field to lift the item by this means when cranes are not available.

APPENDIX III

Shortcoming	Suggested Corrective Action	Remarks
2.5 No means of securing the test item during air transportability was developed during test and evaluation by the appropriate agency.	A tiedown method should be developed.	Air transportability cannot be fully determined until the appropriate agency develops an adequate means of securing the item for air movement.

3. CORRECTED DEFICIENCIES AND SHORTCOMINGS

Deficiency	Corrected Action	Remarks
3.1 Leakage occurred around bolts fastening locking insert to oval closure plate.	Inlet/outlet closure plate with locking insert from 2500-bbl test item was substituted on 5000-bbl tank.	Closure plate on 5000-bbl tank is slightly different from that included with 2500-bbl tank.

APPENDIX IV. MAINTENANCE EVALUATION

APPENDIX IV-A

MAINTENANCE PACKAGE LITERATURE CHART

INSTRUCTION SHEET - DESCRIPTION

COLUMN

1. Give Army or manufacturer's publication or draft manual number.

2. Number of copies received. Insert "O" if none were supplied. Use Para III i, Chapter 9, of AR 310-3 as a guide to determine those manuscripts and publications that should accompany the test item. Manuscripts and publications contained in the maintenance package should cover operations and functions through general support maintenance and should specify the categories involved.

3. Complete title.

4. Fill in date manuscript (MSS) or publication was received.

5. Fill in date test item or materiel was received.

6. Insert "X" in appropriate block. Minor errors on 1598 forms are not in themselves sufficient reason to term a manuscript inadequate. Evaluation may be omitted if fewer than 25% of the specified maintenance operations were performed.

7. Insert date 1598 form was forwarded and 1598 form reference No.

8. In addition to appropriate remarks, explain if manuscript was not evaluated.

APPENDIX IV-A

MAINTENANCE PACKAGE LITERATURE CHART

Manuscript			Date Received		Evaluation		Form 1598	
Number	Qty	Title	Lit	Materiel	Adqt	Inadqt	Reference No. and date fwd	Remarks
1	2	3	4	5	6	7	8	9
DTM 5-5430-202-12	1	Draft Technical Manual Operator and Organizational Maintenance Manual (including repair parts), Tank, Collapsible Self Supporting 1250-2500 and 5,000 Bbl. Capacity, Fuel Storage (including manifold assembly)	Mar 67	Mar 67	X		None	Adequate with Supplement No. 1
DTM 5-5430-202-12 Supplement No. 1	1	Supplement No. 1	Jun 67	Jun 67	X		None	None

5,000 Bbl Tank

APPENDIX IV-B

MAINTENANCE AND RELIABILITY ANALYSIS CHART

INSTRUCTION SHEET - DESCRIPTION

COLUMN

1. Functional group number as indicated in the Maintenance Allocation Chart (ref AR 310-3) of the assembly or subassembly. The sequence number of the maintenance operation is in parenthesis below the group number.

2. Component and related operations as indicated in the Maintenance Allocation Chart. Operations assigned to depot level maintenance are not shown.

3. Maintenance Level, Prescribed. The maintenance level prescribed by the Maintenance Allocation Chart or the parts manual, whichever is appropriate, is indicated using the following code: C - Operator/Crew; O - Organizational; F - Direct Support; and H - General Support.

4. Maintenance Level, Recommended. Use the code letters, C, O, F or H to indicate the level of maintenance recommended by the test agency.

5. TM Instructions, Adequate. An X in this column indicates the TM instructions covering this maintenance action are adequate.

6. TM Instructions, Inadequate. When the TM instructions are considered inadequate, insert the test agency reference number used on the DA Form 1598.

7. Active Maintenance Time. Man-hours and clock hours required for the maintenance operation to the nearest tenth of an hour. If the operation was not actually performed but was reviewed, the estimated active maintenance time is indicated by using the prefix E. (Unusual differences in maintenance times for the same operation should be explained in the body of the test report.)

8. Life. The number of operational hours (essential) and miles, events, etc., as required in the test plan, accumulated during the test prior to the occurrence of the malfunction or scheduled service. (Under the life figure enter in parenthesis the sequence number for which that particular operation was last performed followed by the appropriate life unit; i.e. M, H, etc.) "S" will be placed in this column if the operation was performed on a sampling basis and not because of an actual failure.

MAINTENANCE AND RELIABILITY ANALYSIS CHART

INSTRUCTION SHEET (Cont'd)

COLUMN

9. Reason Performed. The symbol "Unscd" will be shown in this column if this operation was performed as a result of unscheduled maintenance. If the operation was performed and recorded as a required portion of a scheduled maintenance service, the symbol "Scd" will be used. If the operation was performed only to verify procedure and tool requirements, not to correct a malfunction, the symbol "Sim" will be used.

10. Remarks. If the operation was not performed as a result of using the sampling technique authorized by AR 750-6, one of the following remarks will be entered:

a. Reviewed - not performed.

b. Neither reviewed nor performed due to No TM's or insufficient service test time.

c. Other as appropriate.

If an EPR is related to the operation, the EPR reference number will be shown. When the operation was performed to correct a failure as defined in this regulation, it will be indicated by the word "Failure" in this column.

APPENDIX IV-B

MAINTENANCE AND RELIABILITY ANALYSIS CHART

GROUP NO.	COMPONENT AND RELATED OPERATIONS	MAINT LEVEL C-OPER/CREW O-ORGZN F-DIRECT H-GENERAL		TM INSTRUCTIONS		ACTIVE MAINTENANCE TIME		LIFE H-HOURS M-MILES	REASON PERFORMED	REMARKS
		PRE-SCRIBED	RECOM-MENDED	ADE-QUATE	INADE-QUATE	CLOCK HOURS	MAN-HOURS			
1	2	3	4	5	6	7		8	9	10
55	Pumps									
5518	Manifold Assembly									
	Inspect	C	C	X		0.2	0.2	"S"	Sim	
	Replace	C	C	X		4.4	4.4	"S"	Sim	
	Repair	C	C	X		E 2.0	E 2.0			Reviewed-not performed
	Coupling; Hose; Pipe									
	Replace	C	C	X		0.2	0.2	"S"	Sim	
	Gasket Tube									
	Replace	C	C	X		0.2	0.2	"S"	Sim.	
	Valve									
	Replace	C	C	X		0.5	0.5	"S"	Sim	
	Repair	O	D	X		E 0.5	E 0.5			Reviewed-not performed
80	Storage Equipment Components									
8000	Storage Tank Collapsible:									
	Inspect	C	C	X		0.2	0.2	"S"	Sim	
	Replace	O	O	X		0.9	18.9	"S"	Sim	21 men were used to perform this task.
	Repair	C	C	X		0.1	0.1	"S"	Sim	Sealing clamp was used

APPENDIX IV-B

MAINTENANCE AND RELIABILITY ANALYSIS CHART

GROUP NO.	COMPONENT AND RELATED OPERATIONS	MAINT LEVEL (C-OPER/CREW, O-ORGZN, F-DIRECT, H-GENERAL) PRE-SCRIBED	RECOM-MENDED	TM INSTRUCTIONS ADE-QUATE	INADE-QUATE	ACTIVE MAINTENANCE TIME CLOCK HOURS	MAN-HOURS	LIFE H-HOURS M-MILES	REASON PERFORMED	REMARKS
1	2	3	4	5	6	7		8	9	10
	Caps, Vent and Pressure Chain Assy, Drain Assemblies Elbow and Flanges:									
	Inspect	C	C	X		0.1	0.1	"S"	Sim	
	Replace	C	C	X		0.3	0.6	"S"	Sim	
	Gaskets, Inlet-Outlet Assembly									
	Inspect	C	C	X		0.1	0.1	"S"	Sim	
	Replace	C	C	X		0.8	0.8	"S"	Sim	
	Packing, Preformed, Plates									
	Replace	C	C	X		0.6	0.6	"S"	Sim	
	Repair Kit									
	Inspect	C	C	X		0.1	0.1	"S"	Sim	Repair kit inspection is required to verify expiration date of glue (cement).
	Replace	C	C	X		Not applicable				5000 Bbl contains sealing clamps only.

APPENDIX IV-C

PARTS ANALYSIS CHART

INSTRUCTION

GENERAL: This chart is a list of the parts which were used in maintaining the test item. Parts will be grouped in this chart by functional groups and in Federal Stock Number (FSN) numerical order within each group.

COLUMN	DESCRIPTION
1.	Group Number (Sequence Number). Parts usage by maintenance operation is indicated by cross referencing the group number and sequence number in Column 1 of the Maintenance and Reliability Analysis Chart.
2.	Federal Stock Number. Record the Federal Stock Number, Technical Services Part Number, Manufacturer's Part Number, or Drawing Number in this order of preference.
3.	Noun Nomenclature. Self-explanatory.
4.	Maintenance Level, Prescribed. The maintenance level prescribed by the parts list under review. Use the code: C - Operator/Crew; O - Organizational; F - Direct Support; H - General Support.
5.	Maintenance Level, Recommended. The code symbols C, O, F or H indicate the maintenance level recommended by the test agency.
6.	Part Life. The number of operating hours (essential) and miles, rounds, effects, etc., as required by the test plan, accumulated by this part. This is True Part Life and should agree with the part life reported on the EPR. Each entry in this column is followed by the appropriate life unit symbol; i.e., H, M, or R, etc.
7.	Reason Used. The symbol "Unscd" will be shown in this column if this part was replaced as a result of unscheduled maintenance. If the part was replaced as a required action of a scheduled maintenance service, the symbol "Scd" will be used. If the part was consumed to verify procedures or tools, not to correct a malfunction, the symbol "Sim" will be used.
8.	Remarks. If an EPR is related to the part used, the EPR reference number will be inserted in this column. When the part was replaced to correct a failure, as defined in this regulation, it will be indicated by inserting the word "Failure" in this column.

APPENDIX IV-C

PARTS ANALYSIS CHART

GP NO. CROSS REF	FEDERAL STOCK NUMBER	NOUN NOMENCLATURE	MAINTENANCE LEVEL C - Operator/Crew O - Organizational F - Direct H - General		PART LIFE M - Miles H - Hours	REASON USED	REMARKS
			Prescribed	Recommended			
1	2	3	4	5	6	7	8
80	5340-591-6864	Clamp Assy Sealing 5" (81336) 13202E 2870-2	C	C	Unknown	Unscd*	Maintenance was performed during Engineering Test.
80	5340-591-686	Clamp Assy Sealing 5" (81336) 13202E 2870-2	C	C	Unknown	Unscd*	Same as above

*This was only unscheduled maintenance performed on tank and was performed at operator/crew level maintenance.

APPENDIX IV-D

RECORD OF COMMENTS ON PUBLICATIONS
(AR 310-3)

DATE: 21 October 1968

SUBJECT: 5,000-Bbl Tank, Collapsible, Self-Supporting, USATECOM Project No. 7-7-0887-01

REVISION NOTES FROM: DTM 5-5430-202-12, Operator and Organizational Maintenance Manual

ITEM NR	PAGE	PARAGRAPH	LINE*	COMMENT (Exact wording of recommended change must be given)
1	1	2	2	Delete: "period"; add: "by using authorized tools." Explanation: Safety, Reference TM 10-1101, Petroleum Handling Equipment and Operations, Page 1, Safety Precaution 3.
2	2.3	2.4	4	Add after "screws": "to 20-30 inch-pounds with an inch pound torque wrench." Explanation: Labels on the tank and instruction figure 2-4, Step 2. Torque cap screws 20-30 inch-pounds require this wrench.
3	2.15	2.7b(1)		Add illustrations showing step by step folding of the tank. Explanation: Present illustrations are not clear and definite.
4	3.1	3.1		Change paragraph to read as follows: "One special tool, and inch-pound torque wrench required by organizational maintenance personnel for maintenance of the self-supporting fuel storage tank." Explanation: It is essential that a torque wrench be used to perform the required maintenance actions (torqueing cap screws) to prevent damage to the test item.
5	3.1	3.4	1	Add after "inspection": "and monitoring with a vapor tester (explosimeter)." Explanation: Visual inspection of a full tank is difficult, because of the configuration, maintenance personnel have to crawl on the ground to observe ground to tank contact area. A vapor tester with probe would be a better and more reliable method of checking for leakage.
6	B.4	Group No. 3200		Add: "½-inch drive, inch-pound torque wrench." Explanation: Instructions for maintenance require use of this tool which is not available at organizational level and is, therefore, recommended for issue with each test item or be made available to the using organization.
7	B.4	3200		Add: "Ready-made signs, as approved from recommendations". Explanation: Additional safety will be provided if safety signs are made part of basic issue items and are available for immediate field use.
8	C.7	5518	4	Delete "C" in column H for valve replace; add "O". Explanation: Test mechanics recommendation.
9	C.7	5518	4	Delete "O" in column I for valve repair; add "D". Explanation: Test mechanics recommendation from field experience.

* Reference to line number within the paragraph or subparagraph.

DA FORM 1 DEC 55 1598

U. S. GOVERNMENT PRINTING OFFICE: 1958 O-[illegible]

APPENDIX V. REFERENCES

1. Letter, AMSTE-GE, subject, "Test Directive, USATECOM Project No. 7-7-0887-01 through 04, Integrated Engineering/Service and Environmental Tests of Tank Collapsible, Self-Supporting, 5000 Barrel."

2. DA Approved Small Developments Requirement (SDR) for Tanks, Collapsible, Self-Supporting, 1250, 2500 and 5000 Barrels, dated 21 Feb 1966.

3. Developer's Safety Statement, dtd. 22 March 1966.

4. Recommendation for Safety Release," USAGETA, USATECOM Project No. 7-7-0887-01, Tank, Collapsible, Self-Supporting, Fuel Storage, 5000 Barrel Capacity, dated 8 March 1968."

5. Military Specification (MIL-F-8901A) Filter/Separators, Aviation and Motor Fuel, Ground and Shipboard. Use, Performance Requirements and Test Procedures for, dtd 11 June 1963.

6. DA Pam 39-3, "Effects of Nuclear Weapons," dated April 1962.

7. TM 5-343, Military Petroleum Pipeline Systems, August 1962.

APPENDIX VI. DISTRIBUTION LIST

USATECOM PROJECT NO. 7-7-0887-01

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Director Development Center Marine Corps Development & Education Command Quantico, Virginia 22133	1		1	1

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Commander Defense Documentation Center for Scientific and Technical Information ATTN: Document Service Center Cameron Station Alexandria, Virginia 22313				20
Commandant U. S. Army Engineer School Fort Belvoir, Virginia 22060	1			1

AD Accession No.

U. S. Army General Equipment Test Activity, Fort Lee, Virginia

INTEGRATED ENGINEERING AND SERVICE TEST OF TANK, COLLAPSIBLE, SELF-SUPPORTING, 5,000-BARREL (TEMPERATE) by 1LT Richard H. Stetzer, Daniel S. Gafford, and C. Miguel Duncan, December 1968, 87p., -tables, -illus.; 6 Appendices p59-87 (TECOM Project No. 7-7-0887-01) Unclassified Report

An Integrated Engineering and Service Test of Tank, Collapsible, Self-Supporting, 5,000-Barrel (Temperate) was conducted during the period March 1967 - October 1968 to determine technical performance and safety characteristics of the tank and its associated tools and equipment as described in the SDR and the technical characteristics, and as indicated by the particular design, and to determine the suitability of the item and its maintenance package for use by the Army.

It was concluded that: the tank meets the requirements of the SDR except as indicated in paragraph 1.4a and is

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1. TANKS (CONTAINERS)
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suitable for use by the U. S. Army under intermediate climatic conditions; technical performance characteristics are satisfactory; the mission of handling POL product was adequately demonstrated, maintenance features of the tank are compatible with TOE organizational capabilities, no contingencies arose in transporting the crated test item and accessories by railcar, appropriate standard military vehicles, or oceangoing vessels, safety aspects of the test items were confirmed, and the test item is capable of being relocated once during its service life.

It is recommended that: the Tank, Collapsible, Self-Supporting, 5,000-Barrel, be considered suitable for use by the U. S. Army in the intermediate climatic zone, deficiency and shortcomings (App. III) be corrected; suggested revisions to the manual be incorporated as stated in Appendix IV-D; quality control of the tanks during manufacture be increased; a torque-wrench be included in the tank maintenance package, stand-off device be provided at tank inlet; suitable means of restraining the crated item for air transport be developed; and responsible agencies be requested to prepare appropriate instructions for transporting the test item in accordance with transportability findings contained in this report.

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DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Department of the Army U. S. Army General Equipment Test Activity Fort Lee, Virginia 23801	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

Integrated Engineering and Service Test of Tank, Collapsible, Self-Supporting, 5,000-Barrel (Temperate)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report

5. AUTHOR(S) (Last name, first name, initial)

STETZER, Richard H., 1LT; GAFFORD, Daniel S.; DUNCAN, Miguel S.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
December 1968	87	7

8a. CONTRACT OR GRANT NO. b. PROJECT NO. USATECOM 7-7-0887-01 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

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