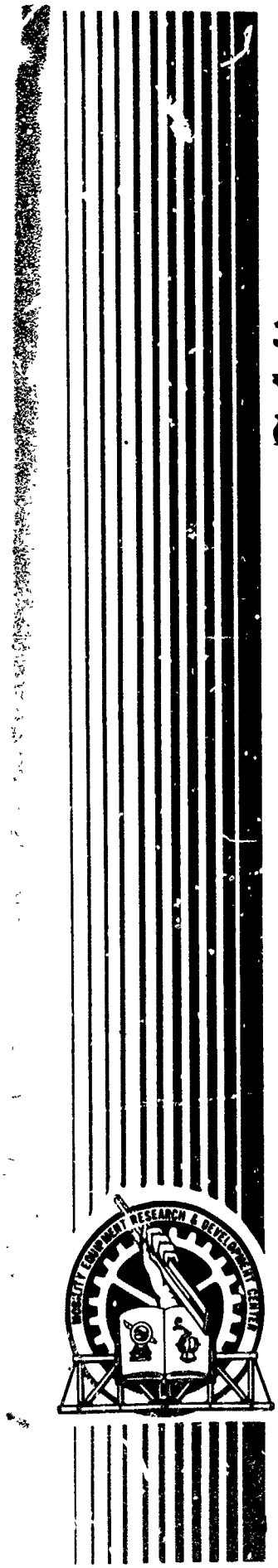

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Report 2025

REPAIR CLAMP, EMERGENCY, COLLAPSIBLE TANK, PETROLEUM

by

J. E. Christopher

February 1972

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U. S. ARMY MOBILITY EQUIPMENT RESEARCH AND DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

21

UNCLASSIFIED

Security Classification

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)*
Fuels Handling Equipment Division, Mechanical Technology Department, U. S. Army Mobility Equipment Research and Development Center, Fort Belvoir, Virginia

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
REPAIR CLAMP, EMERGENCY, COLLAPSIBLE TANK, PETROLEUM

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

5. AUTHOR(S) *(First name, middle initial, last name)*
James E. Christopher

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO. OF REFS
February 1972	22	

8a. CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	2025
c. Task 1J664717DL411	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	

10. DISTRIBUTION STATEMENT
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	USAMERDC Fort Belvoir, Virginia 22060

13. ABSTRACT

This report covers an investigation of deficiencies of mechanical repair clamps which provide an emergency repair of small fuel leaks in collapsible fabric fuel containers.

Manufacturing control of the clamp in accordance with specified design will eliminate the need for further design change.

The report concludes that:

a. A 3/16-inch-thick rubber gasket meeting the requirements for Class SB, Grade 5 B415A, E_6, E_7, L_1, B_8 will serve as an effective gasket.

b. Fabrication control of the clamp hinge joint is critical to maintain dependability of the clamp.

Details of illustrations in this document may be better studied on microfiche

DD FORM 1 NOV 68 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Repair Clamp						
Collapsible Tank						
Coated Fabric						
Fuel Containers						
Fuel Storage						
Maintenance						

U. S. ARMY MOBILITY EQUIPMENT
RESEARCH AND DEVELOPMENT CENTER
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Task 1J664717DL411

February 1972

Distributed by

The Commanding Officer
U. S. Army Mobility Equipment Research and Development Center

Prepared by

J. E. Christopher
Fuels Handling Equipment Division
Mechanical Technology Department

SUMMARY

This report covers: (1) An investigation of two deficiencies of a mechanical repair clamp, and (2) the actions taken to provide a solution for each deficiency. The clamp serves to provide an emergency repair of small fuel leaks in collapsible fabric fuel containers.

The clamp design was investigated. The only design change necessary to effect a leaktight seal was the addition of a gasket. No other design modifications are required. Manufacturing of the clamp must be in accordance with specified design, which will eliminate the need for further design change to overcome the deficiency related to fabrication errors.

FOREWORD

The investigation covered by this report and the tests conducted or design evaluation made to provide a solution for each deficiency were carried out by J. E. Christopher, Fuels Handling Equipment Division, Mechanical Technology Department. Technical assistance was provided by Philip Mitton, Fuels Handling Equipment Division, Mechanical Technology Department.

The work was performed from March 1970 to May 1970 under authority of Task 1J664717DL411.

CONTENTS

REPAIR CLAMP, EMERGENCY, COLLAPSIBLE TANK, PETROLEUM

I. INTRODUCTION

1. **Background.** Collapsible bulk fuel containers designed for temporary storage of military liquid hydrocarbon fuels range from 10,000 gallons to 1,000,000 gallons in capacity. The containers are constructed of elastomeric coatings impregnating a reinforcing fabric. The coated fabric can be penetrated relatively easily by sharp pointed objects. If a container is accidentally punctured and the hole is not detected until liquid is pumped into the container, or if the container is punctured while filled with liquid, adhesive repair methods cannot be used because of the fuel leakage. The mechanical repair clamp was designed to provide an expedient temporary tank repair. If the hole is accessible, the tank does not have to be emptied for repair

Application of an undetermined number of clamps to repair leaks in collapsible fuel containers has revealed two clamp deficiencies.

2. **Scope.** This report covers an investigation concerning these deficiencies and results of a series of tests conducted to improve the sealing effect of the clamp. Requirements of the clamp are shown on Corps of Engineers drawing D13202E2370 (Appendix A). Equipment Performance Reports (STE Form 1025) from Field Test Units stated that difficulties were experienced in obtaining a seal when the clamps were used on 1250-, 5000-, and 25,000-barrel collapsible fuel containers. When attempts were made to tighten the clamp with a wrench to effect a seal, the threaded bolt that extends from a hinge joint attached to the lower half of the clamp sheared off at the hinge.

3. **Investigation.**

a. The original design of the clamp included a 60-durometer, 1/16-inch-thick nitrile rubber gasket installed on the lower half of the clamp. The gasket was bonded with an adhesive to the inside seal surface of the clamp. This gasket was deleted about 1964 because tank manufacturers decided that nitrile rubber-coated fabric tanks being manufactured at that time had enough rubber coating of sufficient softness and resilience to serve as a sealing gasket under the clamp. The clamp is equipped with a wing nut for "clamp up," and sufficient torque should be obtained to effect a seal by hand tightening the wing nut. Collapsible fuel containers are now being made of lightweight fabrics with a thin hard polyurethane coating which does not permit the present clamp, which does not have a gasket, to effect a seal when the clamp wing nut is tightened by hand. This problem is compounded when the clamp is installed partly over a fabric lap seam. Figure 1 shows two clamps, one being installed and one completely

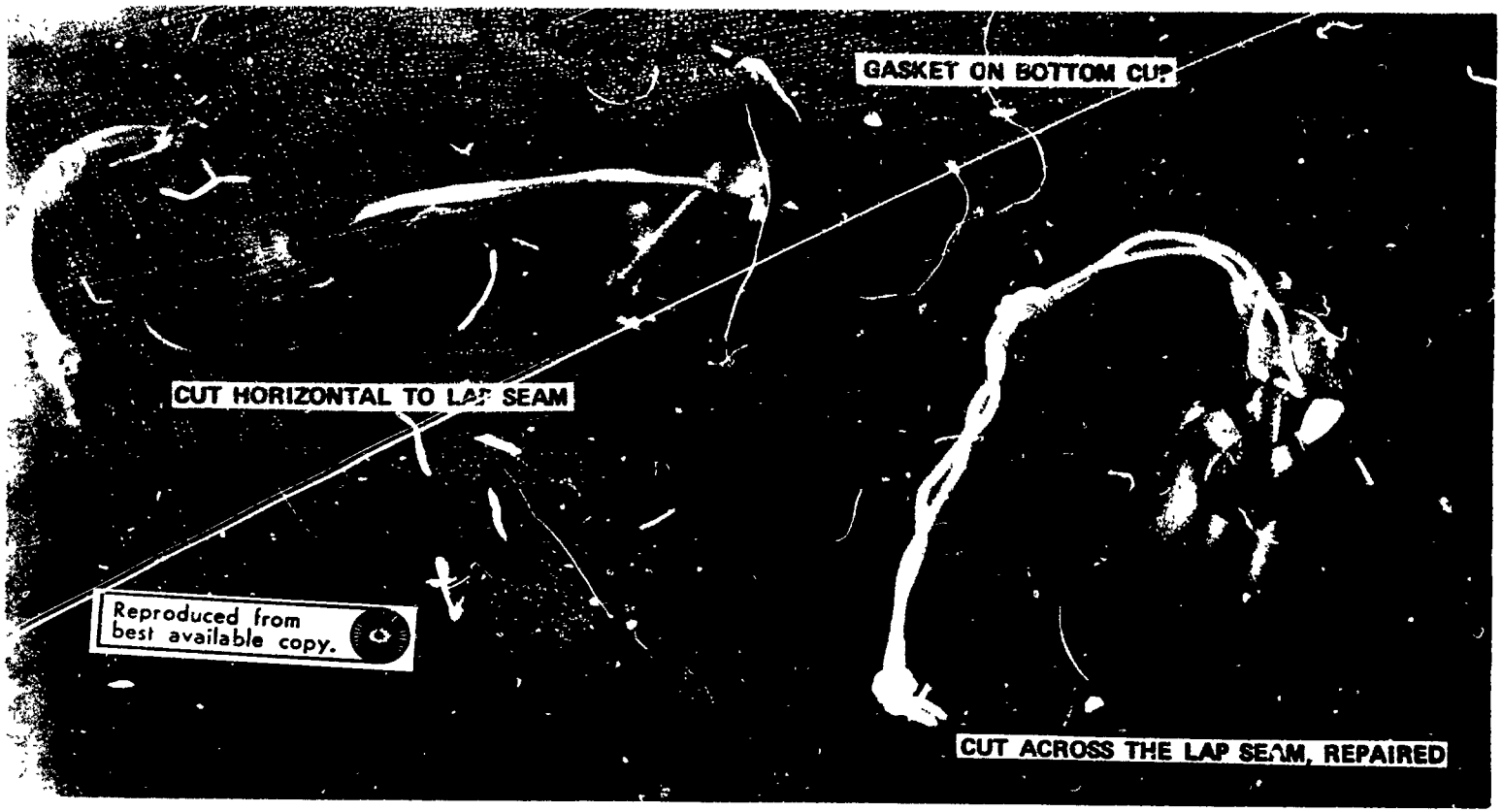


Fig. 1. Gasketed clamp installation over a fabric lap seam.

Installation Procedure:
- Step 1. Enlarge a small hole or tear in the tank fabric so that the bottom cup of the clamp can be inserted.
- Step 2. Insert the bottom cup and center it parallel to the tear.
- Step 3. While pulling upward on the clamp string, slip the top cup over the clamp stud.
- Step 4. Turn wing nut onto the stud and tighten the nut hand.

installed. On several occasions when further attempts were made to obtain seals using the ungasketed clamp by tightening the clamp wing nut with a wrench, the threaded stud sheared off. A separate gasket can be cut from suitable sheet stock and installed, but the additional step can be overlooked easily. A gasket not adhered to the clamp can rotate during clamp installation and thus be ineffective.

b. A comparative evaluation of the specification drawing for the standard clamp and several production items revealed discrepancies that contributed to the shearing of the threaded stud, especially in view of the torque requirements to effect a seal of thin-wall, coated-fabric tanks using clamps without a gasket. The hinge hole diameter in the stud of the clamp design analyzed is 0.036 inch larger than required by the drawing. The diameter of the rivet upon which the threaded stud pivots is also 0.036 inch larger than required by the drawing. The increase in hole diameter resulted in a reduction of steel between the outside edge of the hole and the stud threads over which the wing nut is tightened to secure the two halves of the clamp. The remaining metal thickness on each side of the stud hole is less than 3/64 inch, and the strength of the stud is critically reduced. The importance of effecting a seal by hand tightening the wing nut is emphasized because of the possibility that dimensional tolerances may not be controlled so that a torque greater than 30 inch-pounds can cause the threaded stud to twist off.

II. CORRECTIVE ACTION

4. Initial Tests Conducted.

a. Since the original clamp design called for a gasket installed on the lower half cup of the clamp, this design was re-evaluated. Two 5-inch standard repair clamps that did not have the weak stud deficiency were obtained and used as test clamps. Each clamp was equipped with a gasket which conformed to the original clamp specification drawing. The gaskets were bonded to the face of the bottom cups with a fuel-resistant rubber-to-metal adhesive. Figure 2 shows the gasket bonded in place. Tests were conducted to determine the sealing ability of each clamp. One clamp was employed to repair a cut in a normal area of tank fabric where no seam existed. The second clamp was employed to repair a cut parallel and adjacent to a fabric lap seam, with the clamp installed partly over the seam. A cut in the fabric coincident with a seam or fitting flange which occurs other than parallel is effectively sealed. The "clamp up" wing-nut on each clamp was hand tightened (hand tight is equivalent to 30 inch-pounds of torque).

b. The ability of each clamp to seal against liquid pressure applied to the back of the clamp and fabric was determined. The test fixture used to contain the

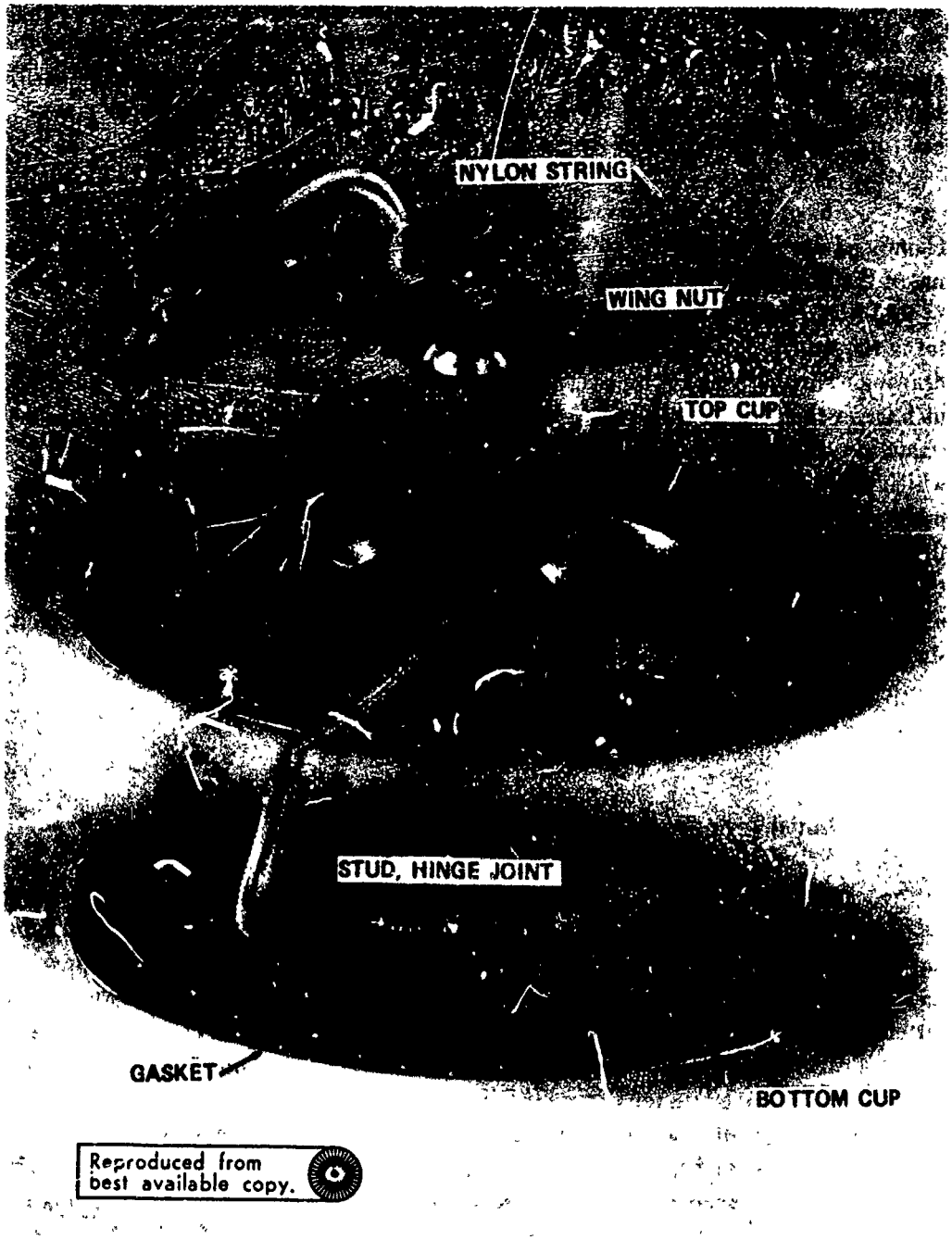


Fig. 2. Mechanical repair clamp equipped with a 40-durometer, 3/16-inch-th k gasket.

coated fabric to be repaired is identified as a fabric material test tub which measures 18 inches in diameter and 6 inches in depth and is equipped with a flanged top opening. With the fabric installed over the tub opening, clamped in the tub flange, the tub is pressurized to 0 psi, 3 psi and 5 psi to simulate different pressures in a fuel tank due to hydrostatic head of fuel and to achieve a curved fabric surface similar to that of a partly filled tank and a tank filled to its capacity. The clamp installed on a normal area of tank fabric where no seam existed provided a complete seal at 0 psi. When the test pressure was increased to 3 psi, a small leakage of the test liquid occurred. The clamp wing nut was torqued to 50 inch-pounds, and the leak stopped At a test pressure of 5 psi, another small leak developed. This leak continued although the clamp nut was torqued to 80 inch-pounds, at which time distortion of the top cup of the clamp was observed. The clamp installed partly over the fabric lap seam leaked at 0-psi test pressure. The leakage continued although the clamp wing nut was tightened until distortion of the clamp occurred. Due to these results, a task was undertaken to develop an effective gasket for the repair clamp.

5. **Procurement and Testing of New Gasket Material.** The Materials Research Support Division (MRSD) of MERDC compounded rubber sheets of different formulations, hardnesses, and thicknesses for test and evaluation of a suitable gasket. Table I gives technical data of the rubber materials. A Shore A hardness value for each gasket was selected on the basis of past experience. Application of the subject clamp to seal a rupture adjacent to or across a fabric lap seam with the clamp installed partly over the seam is the most difficult requirement for the repair clamp. Therefore, all subsequent gasket evaluations were made with gasketed clamps installed partly over a fabric lap seam as shown in Fig. 1. The sample of coated fabric used was identified as UniRoyal 938 construction, urethane-coated fabric that weighs 22 ounces per square yard and is used to fabricate 1250-barrel containers. The fabric thickness is 0.033 inch. The fabric lap seam width, including a gum strip, is 0.102 inch.

III. RESULTS OF TESTS

6. **Design Tests.** Table II presents data on each gasket tested, torque applied to the clamp nuts, levels of test pressure, and the results of each test. The gasket with 40-durometer hardness and 5/64-inch thickness permitted small leaks at the hand-tight torque of 30 inch-pounds at test pressures of 0 psi, 3 psi, and 5 psi. Double thickness of the 40-durometer gasket of 5/64-inch thickness (two gaskets together on each clamp) provided complete seals under 30-inch-pound torque against test pressures of 0 psi, 3 psi, and 5 psi. The 40-durometer gasket of 3/16-inch thickness provided complete seals under 30-inch-pound torque at test pressures of 0 psi, 3 psi, and 5 psi for periods up to 32 hours.

Table I. Low-Temperature Fuel-Resistant Rubber Compounds

Preparation of compounds meeting the requirements similar to those of Type I of MIL-G-2986D

Formulation No	7H23	7H24
Compound Ingredients	phr	phr
Herclor C[1]	100	100
NBC[2]	1	1
Zinc Stearate	0.75	0.75
Red Lead	5	5
EPC Black	5	25
Cab-o-Sil H-5[3]	10	–
KP-140[4]	2	2
DBP[5]	5	5
NA-22[6]	1.5	1.5
Hardness, Shore A	40	50
Cured 60 minutes at 320° F		

[1] An ECO rubber. Either Herclor C, manufactured by the Rubber Chemicals Division of Hercules, Inc., or Hydrin 200 manufactured by the B F. Goodrich Chemical Co. is satisfactory. ECO was selected as the base polymer to obtain the good balance of fuel resistance and low temperature serviceability that can be obtained with its use without the addition of large quantities of migrating plasticizers.

[2] NBC – Nickel dibutyl dithiocarbamate manufactured by Rubber Chemicals Division of E. I. duPont de Nemours Inc.

[3] Cab-o-Sil H-5 a colloidal silica manufactured by Cabot Corp.

[4] KP-140-Tributory ethyl phosphate manufactured by the Food Machinery Corp.

[5] DBP-Dibutyl phthallate obtainable from many sources including Union Carbide Co.

[6] Na 22 – 2-Mercaptiomidazoline manufactured by the Rubber Chemicals Division, E. I. duPont de Nemours, Inc.

Table II. Results of Gasket Tests

Thickness	Hardness Durometer Points	Torque[1] (In.-lb)	Pressure (Psi)	Results
1/8-inch[2]	50	30	0	No leak
		30	3	Large leak
		40	3	Small leak
		50	3	No leak
		50	5	Very small leak
5/32-inch[3]	50	30	0	No leak
		30	3	Large leak
		40	3	Small leak
		50	3	No leak
		50	5	Very small leak
3/16-inch[2]	50	30	0	No leak
		30	3	Large leak
		40	3	No leak
		50	3	No leak
5/64-inch[2]	40	30	0	Leaked
		Retightened to 30	0	Smaller leak
		20	3	Small leak
5/64-inch[3]	40	30	0	Leaked
		Retightened to 30	0	No leak
		30	3	Small leak
		30	5	Same leak
5/64-inch[2]	40 Double thickness gasket	30	0	No leak
		30	3	No leak
		30	5	No leak
5/64-inch[3]	40 Double thickness gasket	30	0	No leak
		30	3	No leak
		30	5	No leak

Table II (cont'd)

Thickness	Hardness Durometer Points	Torque[1] (In.-lb)	Pressure (Psi)	Results
1/8-inch[2]	40	30	0	No leak
		30	3	Leaked 13 drops/minute
		40	3	No leak
		40	5	No leak
5/32-inch[3]	40	30	0	No leak
		30	3	Leaked 36 drops/minute
		40	3	Leaked 5 drops then stopped
		40	5	No leak
3/16-inch[3]	40	30	0	No leak
		30	3	No leak
		30	5	No leak
3/16-inch[2]	40	30	3	No leakage during a period of 19 hours.
		30	5	No leakage during a period of 32 hours.
3/16-inch[3]	40	30	3	No leakage during a period of 19 hours.
		30	5	No leakage during a period of 32 hours.

[1]30 inch-pounds torque is equivalent to finger tight.

[2]Gasket-equipped clamp installed in cut across the seam over the gum strip.

[3]Gasket-equipped clamp installed in cut parallel with and over the seam and gum strip.

NOTE: Results of tests conducted to determine a suitable gasket material for collapsible fuel storage tanks mechanical repair clamps. The gasket-equipped clamps were used to repair cuts at edge of a lap seam of nitrile coated fabric 0.033-inch thick. A gum strip had been placed over the edge of the seam.

IV DISCUSSION

7. Discussion.

a. The fuel-resistant rubber gasket materials tested were molded to two thicknesses from compounding ingredients that enabled two different levels of hardness. The hardness of the clamp gasket is significant for two reasons. First, it needs to be soft enough to fill in over a lap step-off of a tank seam, and second, it is easier to hand tighten the clamp to effect a seal when the gasket is soft. The formulations of the gasket compound No. 7H23 (Table I) were used for the purpose of this investigation. The properties of the rubber compounds to be used in production of gaskets for the mechanical repair clamp will be controlled by a specification which will require that the compounds be fuel-resistant; that the gasket contain only nonmigrating plasticizers, that it have a Shore A hardness of 40 durometer, and that it be serviceable in an arctic environment. The requirements for Type SB, Grade SF 415A, E_6, E_7, L_1, B_8 rubber as defined in Appendix B are considered satisfactory.

b. Reference is made to the hinge joint dimensional deficiencies and resulting stud failures. All stud failures that were reported occurred when a wrench was used to tighten the clamp wing nut. A wrench was necessary because a seal could not be obtained at lesser torques attainable by hand torquing. A wrench is not required to effect a seal using a clamp equipped with the proper gasket because an effective seal can be obtained by hand tightening the clamp wing nut; however, the incorrect joint dimensions which reduced the strength of the stud are considered serious. Users of the repair clamp will not always tighten the clamp nut by hand, and if a wrench is used, the nut can be over-tightened, which causes the stud to shear off. If the joint dimensions comply with those of the specification drawing, over-tightening the clamp nut will cause distortion of the clamp body before the stud shears. The distortion does not affect performance of the clamp.

V. CONCLUSIONS

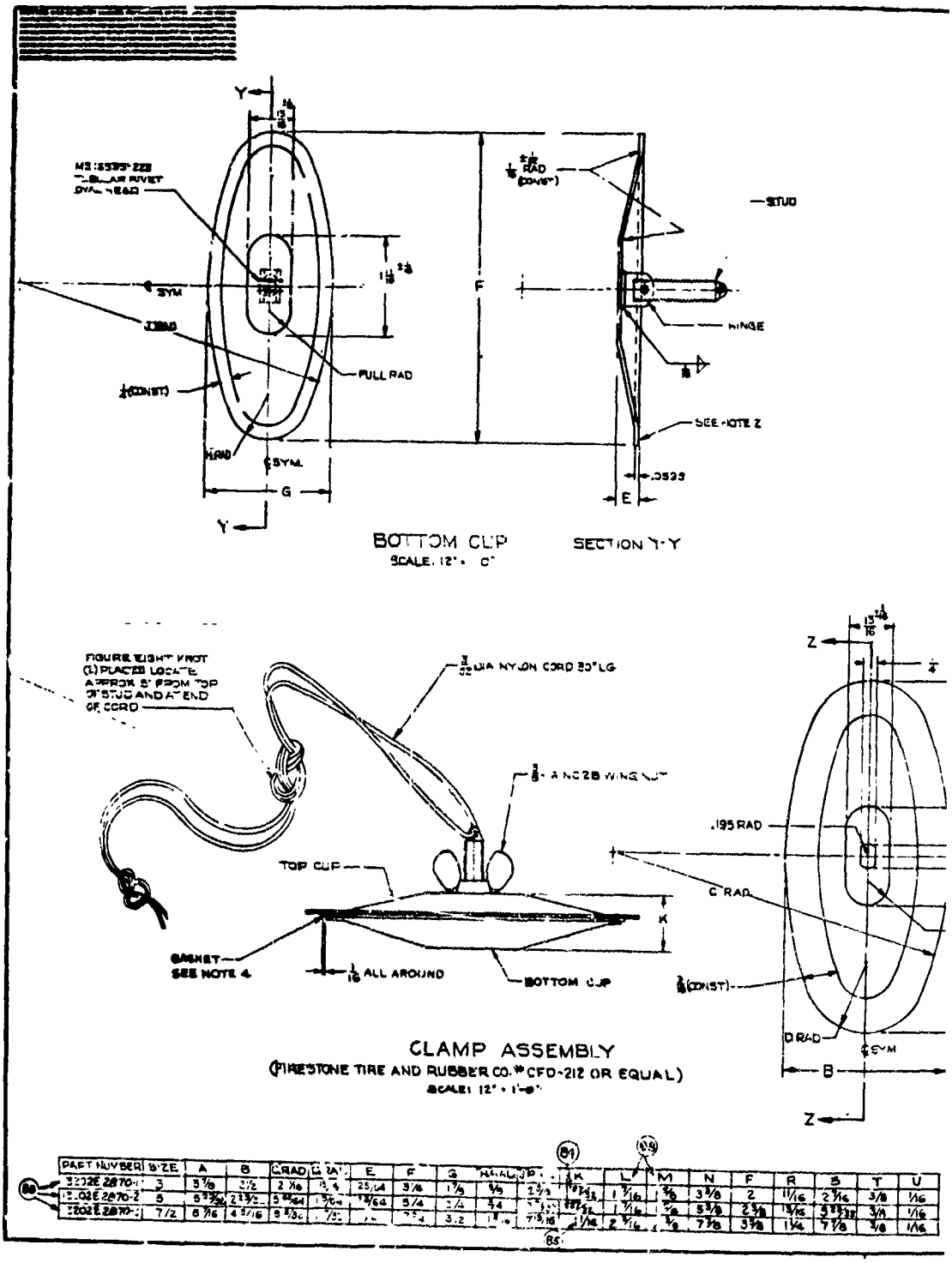
8. Conclusions. Based on the results of the design analysis and tests conducted, it is concluded that:

a. A 3/16-inch-thick rubber gasket of the design shown in Corps of Engineers Drawing 13202E2870 and meeting the requirement for Class SB, Grade SB415A, E_6, E_7, L_1, B_8 as defined by Appendix B will serve as an effective gasket for the mechanical repair clamp, and a new clamp design is not required. The addition of a gasket to the clamp will enable an effective seal in the field with hand tightening of the clamp nut.

b. The lack of fabrication control of the clamp hinge joint critically reduces the dependability of the clamp, and proper quality assurance must be followed to insure that manufacturers of the clamp comply with the requirements of the specification drawing.

APPENDIX A

REPAIR SEALING CLAMP ASSEMBLY
CORPS OF ENGINEERS DRAWING D13202E2870



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13202E2870-2	5	5 3/16	2 3/16	3 49/64	1 5/16	19/64	5 1/4	2 1/4	1/4	4 3/8	1 1/2	1 1/16	3/8	5 1/8	2 5/8	5/16	5 11/32	3/4	1/16
13202E2870-3	7 1/2	6 7/16	4 5/16	5 3/16	1 5/16	.406	7 1/4	3.2	1/4	7 15/16	1 1/16	2 1/16	3/8	7 1/8	3 1/8	1 1/4	7 1/8	3/8	1/16

B

MBLY
3202E2870

APPLICATION		REVISIONS			
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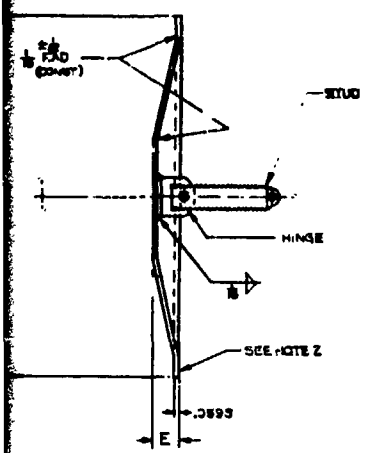

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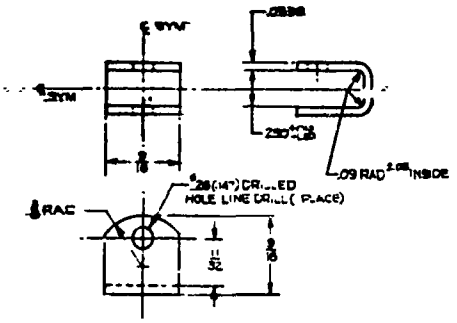

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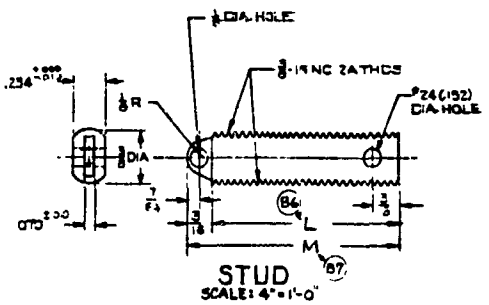

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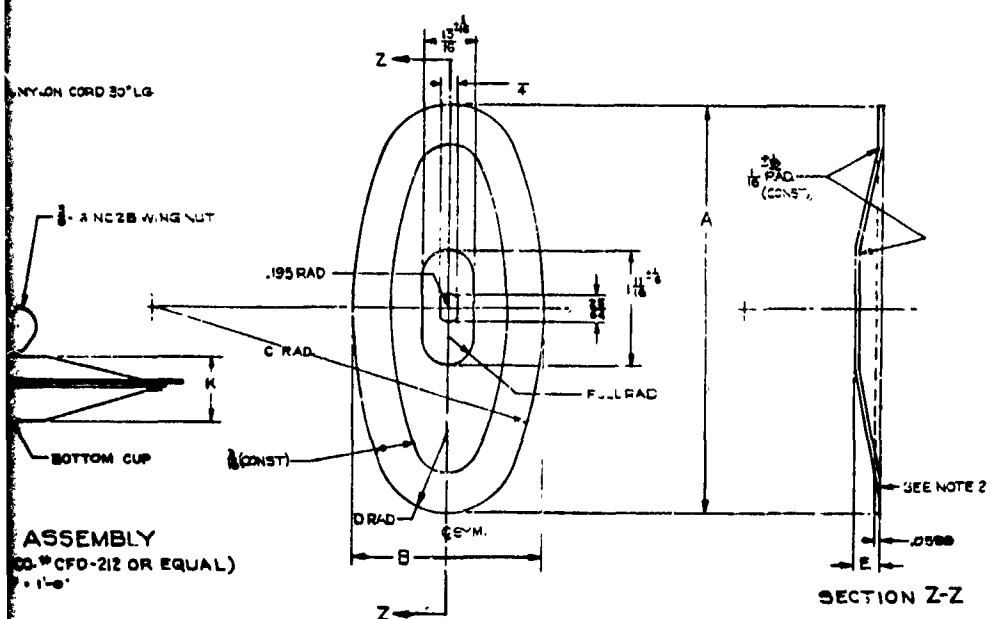

ASSEMBLY
CO. CFO-212 OR EQUAL)
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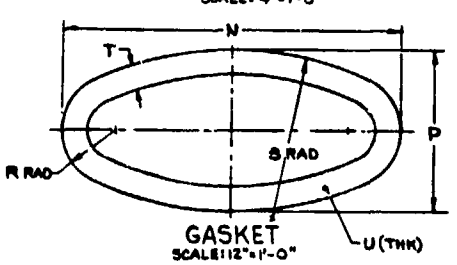
SECTION Z-Z



GASKET
SCALE: 12"=1'-0"

NOTES:
1. FINISH: CADMIUM PLATED .0005 MIN.
2. THIS SURFACE TO BE FLAT AND SMOOTH TO WITHIN .015 TIR.
3. THIS DRAWING IS REFERENCED IN MIL-P-[illegible], MIL-D-[illegible], AND MIL-T-14399 (C)
4. GASKET MATERIAL TO BE A RUBBER COMPOUND WHICH MEETS THE REQUIREMENTS OF 2BG(B)EG1 OF ASTM D2000. THE GASKET SHALL BE BONDED TO THE BOTTOM CUP ONLY, WITH A GASOLINE RESISTANT, RUBBER-TO-METAL ADHESIVE.

SIZE	RAC	K	L	M	N	F	R	S	T	U
[illegible]	2 3/8	[illegible]	1 7/16	1 5/8	3 1/8	2	11/16	2 7/16	3/8	1/16
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7/8	7 1/16	1 1/16	2 7/16	2 1/8	7 1/8	3 1/8	1 1/4	7 1/8	3/8	1/16

TOP CUP
SCALE 12"=1'-0"

MATERIAL: 1010 CRS	REPAIR SEALING CLAMP ASSEMBLY 3, 5, & 7½ IN. SIZES	U.S. ARMY ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES CORPS OF ENGINEERS FORT BELVOIR, VA.	D 13202E2870
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