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P - 13 DUAL AGENT APPLICATION

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ANSUL COMPANY
MARINETTE, WISCONSIN

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The two separate hose reel assemblies on the AS 32/P-13 were replaced with a single electric rewind reel containing 100 feet of twinned one inch hose. Agent discharge piping was rerouted to opposite sides of the hose reel and the agents are discharged through a dual agent nozzle assembly capable of being operated easily by one man. The existing two ball valve type nozzles are replaced with a single dual agent nozzle configuration capable of discharging dry chemical and Halon 1211. A standard electric rewind twinned hose reel was installed with attention to wiring		

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20. ABSTRACT (CONTINUED)

harness routes, power requirements and operation. The electrical requirements are within the present capability of the vehicle, and harness routing follows current vehicle specifications to prevent chaffing, weathering and other damage. The operating controls have been located to allow one man to energize the rewind mechanism and also guide the hose onto the reel.

The actuation systems of both units are combined to facilitate a one-person operation (movement of one lever opens all valves). This actuation lever is located at the rear of the vehicle in the vicinity of the dual agent nozzle. A provision was incorporated into the system to clear agents from the hose after use.

The dispensing system satisfies the flight and taxiing load requirements of MIL-A-8421.

The modified components of the vehicle can be discharged independently and simultaneously from their respective nozzles to insure satisfactory operation and conformance to the flow requirements.

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PREFACE

This final report was prepared by the Ansul Company, Marinette Wisconsin, under Contract F08635-80-C-0232 with the Air Force Engineering and Services Center, Tyndall Air Force Base, Florida. Job Order Number 2505-1002.

This report has been reviewed by the Public Affairs (PA) office and is releaseable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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SECTION I

INTRODUCTION

1. OBJECTIVE

The objective of this effort was to develop a dual fire suppression agent dispensing system for the AS 32/P-13 airfield ramp firefighting vehicle. That could dispense both dry chemical agent (PKP) and liquid vaporizing agent (Halon 1211) either singly or simultaneously from one nozzle. This dispensing system was also to satisfy the flight and taxiing load requirements of MIL-A-8421 and to be capable of being operated by one fire fighter.

2. BACKGROUND

The AS 32/P-13 vehicle was designed as a fast response vehicle for use as a standby and airfield ramp patrol vehicle to relieve some of the required duties of the primary aircraft crash rescue vehicles. The two auxiliary agents carried on the vehicle, Halon 1211 and dry chemical (PKP) have been shown to give the vehicle an advantage in fighting aircraft fires.

Halon 1211 (Bromochlorodifluormethane) is a "clean" agent capable of being used as a wet fire suppression agent without damage to aircraft components from chemical reactions and corrosion. PKP (potassium bicarbonate) is considered an excellent flame "knockdown" agent for class B fuel fires. This agent is utilized for all types of aircraft and ground fires not requiring a "clean" agent.

The AS 32/P-13 was designed to be operated by a two-person fire fighting crew. Increased costs and limited manpower make it an economically feasible alternative to change the present configuration to that of a twin-line, dual nozzle type dispensing unit which retains its proficiency, while being operated by one fire fighter.

3. APPROACH

The actuation system of the presently separate dispensing units were combined so that movement of one lever would open all valves and enable one person to operate a dual agent nozzle. The two separate hose assemblies were replaced by a single hose with a dual agent nozzle. A provision to clear agents from the hoses after use was also incorporated.

Modified components capable of being discharged independently and simultaneously from their respective nozzles were tested and evaluated to ensure satisfactory operation and conformance to flow requirements.

SECTION II

DISCUSSION

1. MODIFICATIONS

The AS 32/P-13 fire fighting vehicle previously designed for operation by two fire fighters has been converted to a one-person operation. The modified system can be either actuated manually as a separate unit or pneumatically for a dual system. The two separate hose assemblies were replaced with a single electric rewind reel containing 100 feet of twin agent hose with a single dual agent nozzle. The parts needed for this modification are listed in Appendix B.

The wiring harness routes from the electric rewind reel to the source of power are enclosed in a weather tight flexible conduit to prevent any weathering or chaffing to the wiring harness and can be disconnected at a weather tight box located on skid the unit.

The skid mounted system can be removed from the truck bed by disconnecting electrical wiring at the weather tight box and removing six bolts that fasten the skid to the truck bed. The skid unit is balanced so it can be lifted at the dry chemical tank eye hooks.

2. TESTING

Flow testing was done with 100 feet of twin agent 1-inch hose and dual agent nozzle assembly. The flow requirements for Halon 1211 were 5.0 to 5.5 pounds per second and an effective range of 40 feet. Discharge of the Halon unit was recorded on the Dynagraph. At 2/3 of 95 percent discharge time, the flow rate was 5.4 pounds per second. Prints of the nozzle assembly are attached. Flow rate on Purple-K agent was also recorded on the Dynagraph and the flow requirements were 6.5 to 8.0 lbs per second, using a converging/diverging nozzle. At the 2/3 of 95 percent discharge time, the flow rate of 7.5 pounds per second was recorded.

A problem that arose during the test program was sand in the Halon tank from previous sandblasting. During filling and discharge, sand would accumulate into the tank check valve, tank hose clean out valve, and tank outlet valve. All mentioned valves had to be replaced with new valves. The Halon tank was removed so the sand could be vacuumed out and piping to the valves was also cleaned. The sandblasting sand removal, eliminated the problem of scoring valve seats for leakage problems.

The tank hose clean-out valve and tank outlet valve were tested (N₂ at 200 psi and leak checked with soap solution) prior to

installation, with no visible leaks. Ball valves were installed on the unit in a closed position and the Halon tank was pressurized to 200 psi and let stand overnight. There was some pressure in the line to the nozzle.

Valves were then pressurized to 950 psi to square up the seat for more positive seal between the ball and the seat and then tested with a soap solution. There were no visible leaks. Valves were again pressurized to 200 psi and let stand with a soap solution. Again, there were no visible leaks. Valves were installed as per print 55660 with the threaded spacers as the inlet parts of the valve. The halon tank was pressurized with N₂ to 250 psi and left to stand with the hose clean out valve closed (normally closed) and tank outlet valve closed (normally closed). Again, there was some pressure to the nozzle. The Halon tank was then charged with 50 pounds of Halon 1211 to leak test valves with vapor pressure. All during the testing, the hose line was never purged with air so there probably was an accumulation of vapors in the nozzle.

Two new valves were sent from the Marpac Company with new seating material KEL-F and RTFE. The new material has a lower coefficient of expansion than the standard TFE material. Three Marpac valves with the three seating materials were installed on 2-1/2 pound shells charged with approximately 1 pound of Halon 1211 and pressurized to 240 psi. Units were leak tested at Systems Halon filling station with the Halogen leak detector. Results are:

- a. Standard valve P/N 54286 TFE seats leak rate .05 oz/yr no leakage.
- b. RTFE seats leak rate .05 oz/yr no leakage.
- c. KEL-F seats leak rate 0.05 oz/yr no leakage.

The Halon was dumped from the shells, recharged with 1211 and left unpressurized to simulate the P-13 unit. This method determined the amount of vapor lost per year.

- a. Results are TFE seats .25 oz/yr no leak.
- b. RTFE seats .05 oz/yr moderate.
- c. KEL-F seats .05/oz yr moderate.

Standard valve with TFE seats pressurized to 950 psi to square up the seat as per unit 36238 and then installed on 2-1/2 shell with 1211 and unpressurized, leak rate .05 oz/yr.

Aqueous film forming foam (AFFF) nozzle assembly P/N 54742 was converted for Halon 1211 had to have compression spring P/N

25786 changed to a heavier compression due to back pressure in the nozzle. The nozzle would not shut off. Standard compression spring P/N 25786 specifications are free length 1.350 inches to 1.380 inches, active coils 6, wire diameter .080 inches, compression 26.6 pounds at 1.0 inches. Replacement spring free length 1.300 inches, active coils 6, wire diameter .092 inches, compression 70 pounds at 7/16 inches.

3. EVALUATION

After modifications and testing, the following evaluations were made:

a. The nozzle with a new spring was tested on a 350 wheeled unit charged with water and cycled to determine shut off performance. The spring is capable of shutting off the nozzle with water or Halon.

b. The nozzle has been tested for both shutoff and sealing capabilities and has performed satisfactorily.

c. Manual and pneumatic actuation of the dual system is operationally satisfactory.

d. The operational discharge range of the dual agent nozzle is satisfactory.

SECTION III

CONCLUSIONS

The modification of the AS 32/P-13 fire fighting vehicle from a two-person configuration to one that could be operated by one person with no loss of proficiency was successful; see Appendix A. The unit was converted to a single electric rewind reel containing 100 feet of twin agent hose with a dual nozzle and an actuation system that can be operated manually or pneumatically.

Flow testing and effective range testing met the USAF requirements for Halon 1211 and PKP Dry Chemical agents.

The modified dispensing system satisfied the flight and taxiing load requirements of MIL-A-8421. All hose reel/hose reel base attachments to the mounting base were acceptable according to the procedures defined.

APPENDIX A

AIR TRANSPORTABILITY EQUATIONS

NOTE: Air transportability Equations are identical to those for the previous P-13 truck design, with the exception of the new fuel calculations. These calculations have been redone and are presented here.

HOSE REEL ASSEMBLY - SUB SECTION A

1. Calculation Set A - Fore and Aft (Figure 1)

These calculations will consider a force (F) equal to 3 g applied perpendicular and horizontal to the hose reel axis. Force can be fore or aft since stress loads (F_S) will be equal in either direction.

Weight of hose reel and components = 324#

The bearings are designed to withstand a radial load of 2,940 pounds. Therefore, the bearings are acceptable in the fore and aft direction since a force (T_t) of 480 pounds is applied to both bearings. Note that each bearing will share the total load equally.

All friction forces will be ignored as will the weight of the reel since this will provide for maximum stress loads.

a. Shear Load on Bolts (Figure 2)

Bolts are 3/8 - 16

$$F_y = 0$$

F_{SL} = Shear on left bolt

$$F_{SL} + F_{SR} - 3 (162) = 0$$

F_{SR} = Shear on right bolt

$$2 F_S = 3 (162)$$

$$F_{SL} = F_{SR} = F_S$$

$$F_S = 243 \text{ pounds}$$

$$\sigma = \frac{243}{A}$$

$$\sigma = \frac{243}{A} = \frac{4 (243)}{.2983}$$

σ = Shear stress
A = Area

$$\sigma = 3477 \text{ psi}$$

Shear stress is well below the yield shear stress of approximately 15,000 psi.

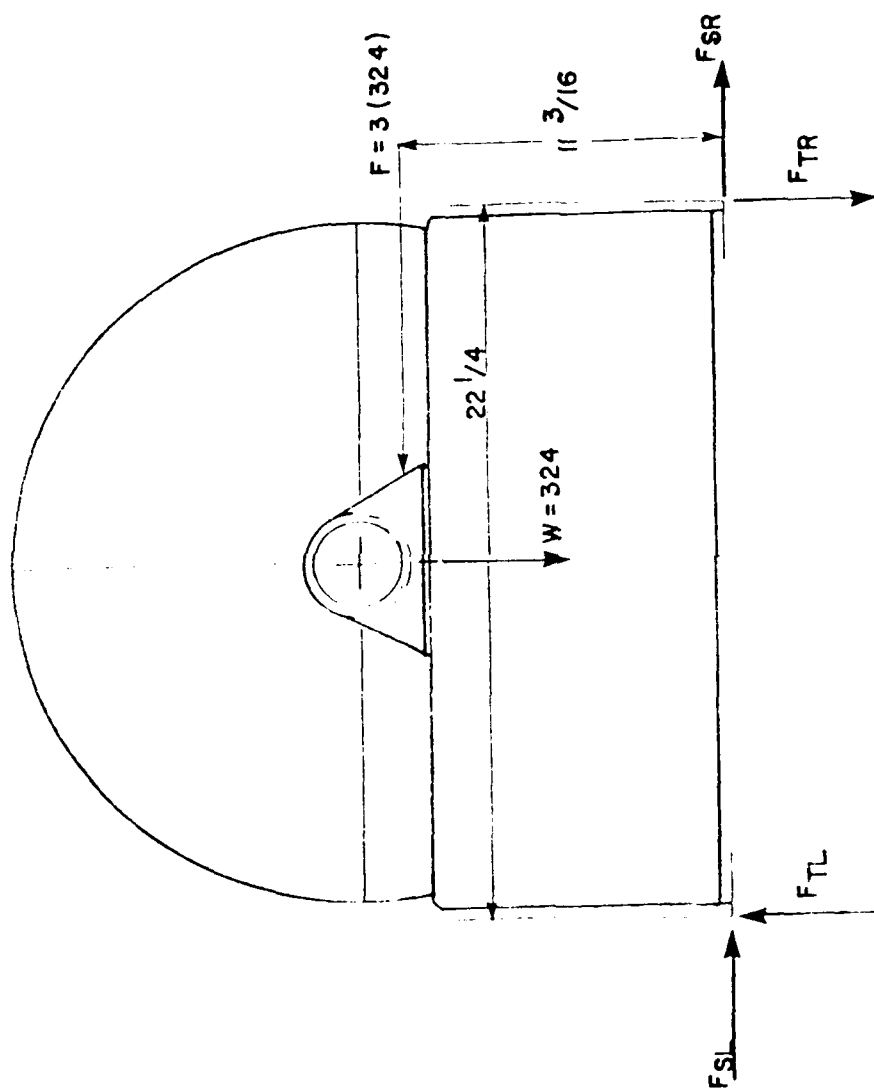


Figure-1 Calculation Set A-Fore and Aft

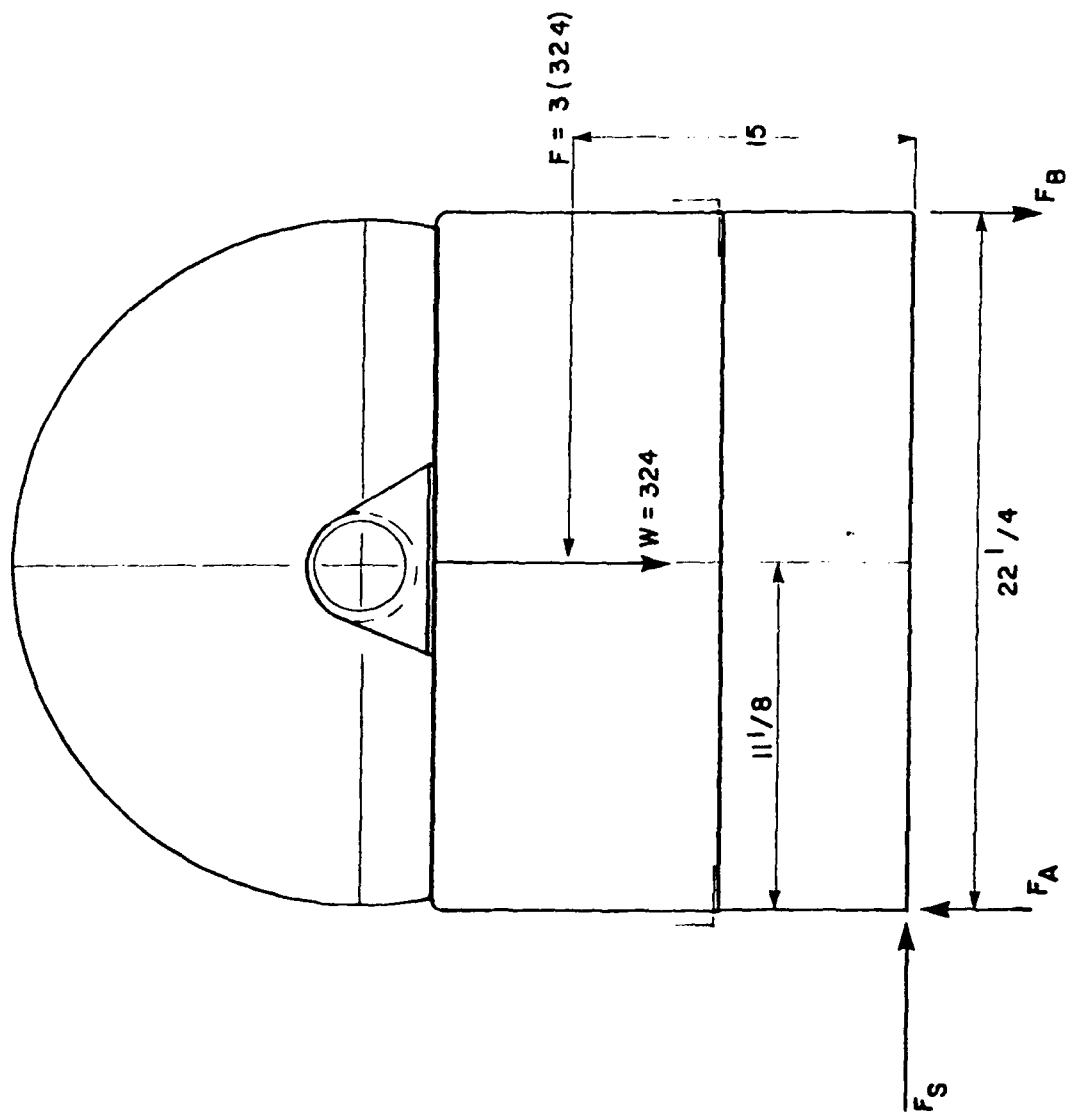


Figure-2 Shear Load On Bolts

b. Therefore, the tensile strength will now be examined (see Figure 2).

$$M_{\text{Left}} = 0$$

$$\text{bolt} \quad -(1)(3)(162) + 5(F_{TR}) = 0 \quad F_{TR} = \text{Tension load in right}$$

$$F_{TR} = 98 \text{ pounds}$$

$$\sigma = \frac{F_{TR}}{A_S}$$

$$A_S$$

$$\sigma = \frac{98}{.069}$$

σ = Tensile stress

$$\sigma = 1402 \text{ psi}$$

A_S = Stress area

The tensile stress is well below the 30,000 yield strength. Therefore, the bolts are satisfactory and acceptable.

c. The final area of concern in this calculation set is the legs on which the hose reel assembly are mounted (see Figure 1). These legs are constructed with 11 gauge (.120) carbon steel (1030). There is a shear force and a tensile force in this material (see Figure 3). Each leg is 20 - 3/4" long in the lateral direction.

$$F_x = 0$$

$$F_{SL} + F_{SR} - 3(324) = 0$$

$$F_{SR} = F_{SR}$$

$$2 F_{SR} = 3(324)$$

Where F_{SL} and F_{SR} are shear forces on each leg.

$$F_{SR} = 486 \text{ pounds}$$

$$F_{SL} = 486 \text{ pounds}$$

Therefore:

$$\sigma = \frac{F}{A}$$

σ = Shear stress

F = Shear force

A = area

$$\sigma = \frac{486}{(20.75)(.120)}$$

$$M_{\text{Left}} = 0$$

$$22.25 (F_{\text{TR}}) - 11-3/16 (3) (.324) 324 (11-1/8) = 0$$

$$22.25 (F_{\text{TR}}) - 10874.25 + 3604.5 = 0$$

$$F_{\text{TR}} = \frac{3590}{22.25} \frac{7269.75}{22.25}$$

$$F_{\text{TR}} = \underline{326.8 \text{ pounds}}$$

$$F_y = 0$$

$$F_{\text{TL}} - 324 - F_{\text{TR}} = 0$$

$$F_{\text{TL}} = \underline{324 + 326.8 = 650.8 \text{ pounds}}$$

Therefore:

$$\sigma = \frac{F}{A}$$

σ = Tensile stress

F = Tensile load

A = area

$$\sigma = \frac{650.8}{(.120)(20.75)}$$

$$\sigma = \underline{261.4 \text{ psi}}$$

Therefore, the shear and tensile stresses are well below yield point in shear (15,000 psi) and in tensile (30,000 psi) and are, therefore, acceptable. For the bolts which secure the legs, the force of 650.8 pounds (tensile in the leg) acts on four bolts (stress area 0.0773 per bolt) for a bolt shear stress as follows:

$$\sigma = \frac{650.8}{4(.0773)}$$

$$\sigma = 2104.8 \text{ psi}$$

Again, well below the yield point of 15,000 psi shear for the steel in question.

2. Calculation Set B - Lateral (Left or Right) (Figure 4)

These calculations will consider a load (F) equal to 3 g applied parallel and horizontal to the hose reel axis. Force considered can be left or right as each direction will produce equal stress loads (F_{SL} , F_{SR}).

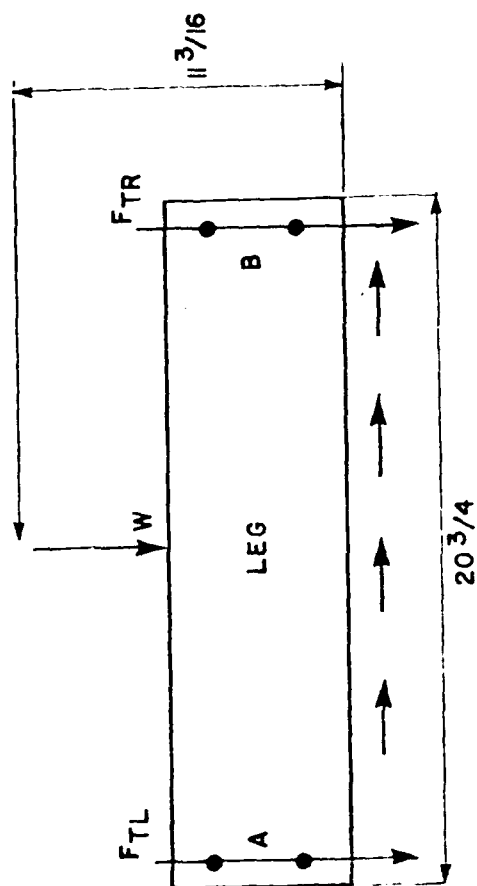


Figure-3 Legs To Mount Hose Reel Assembly

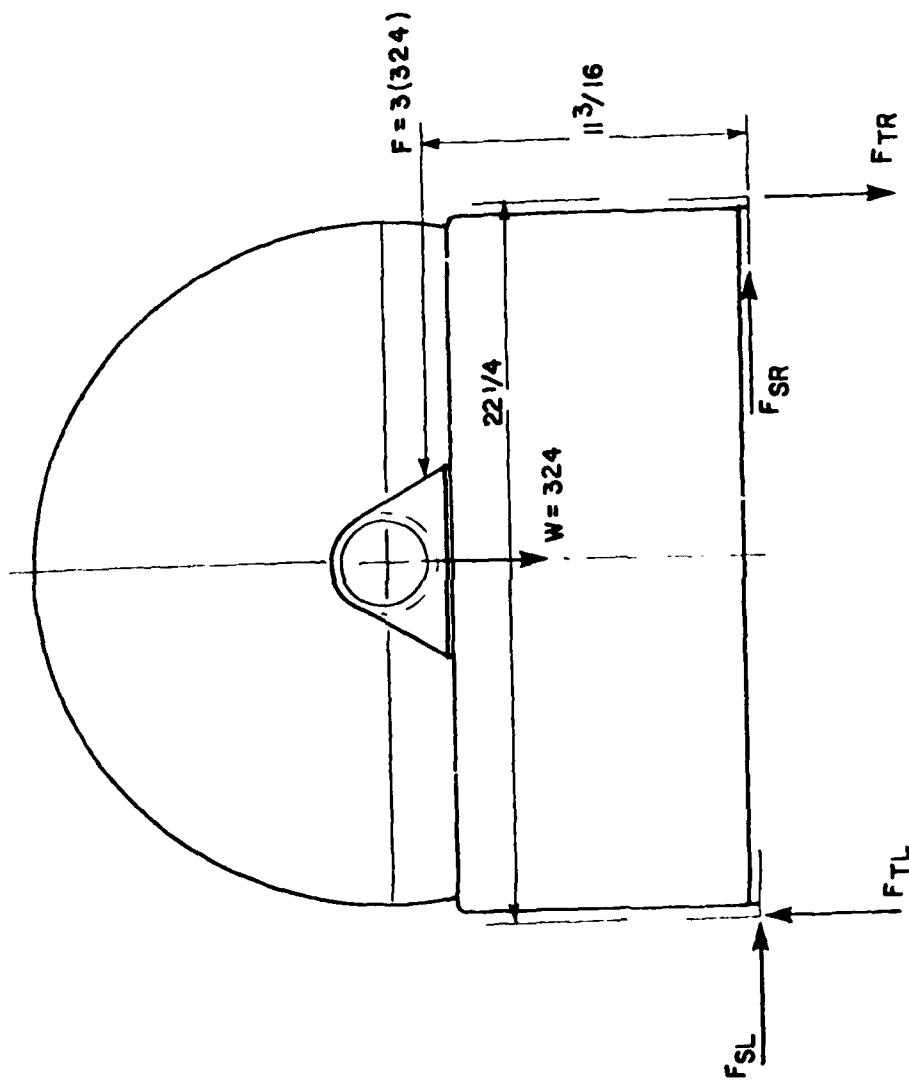


Figure-4 Calculation Set B-Lateral (Left or Right)

The bearings are designed to withstand an axial thrust of 588 pounds each. The total load on these bearings is equal to 3 (324)/2 or 486 pounds per bearing. Thus, the bearings can withstand the axial loading in the lateral direction.

The shear force in the lateral on the bearing bolts would be equal to the numerical value determined in Sub Section A.1.C. Therefore the bolts are satisfactory.

The remaining consideration in the lateral direction on the reel nose is the legs and the legs bolts (see Figure 4).

a. Shear Force on Leg

$$F_x = 0$$

F_s = Shear load on leg, but
there are two legs

$$3 (324) = 2 F_s$$

σ = Shear stress

$$F_s = \frac{486 \text{ pounds}}{2} = F_s/A$$

A = Shear area

b. Shear stress in the bolts will be:

$$\sigma = \frac{F}{A_s}$$

σ = Shear stress
F = Load = $F_{SR}/2$ since two

$$\sigma = \frac{486/2}{0.0773}$$

Bolts share the load

$$\sigma = 3143.6 \text{ psi}$$

A_s = Stress area

Therefore, the stress loads (tensile and shear) on the 3/8 - 16 bolts is well below the yield strength for stainless steel material. Thus, these bolts are acceptable.

c. Bolt attachments between base and skid (Figure 7)

3/8 - 16 bolts are utilized

$$M_A = 0$$

$$12 \frac{1}{2} (324) - 26.2 (3) (324) + 33 (F_B) - 7.5 (3) 243/4 = 0$$

$$F_B = \frac{26.2 (3) (324) - 12 \frac{1}{2} (324) + 7.5 (3) 243/4}{33}$$

$$F_B = 690 \text{ pounds}$$

$$F_y = 0$$

$$F_A - F_B - 324 = 0$$

$$F_A = 690 + 324$$

$$F_A = \underline{1014 \text{ lbs}}$$

$$F_x = 0$$

$$-3 \left(\frac{243}{4} \right) - 3 (324) + F_S = 0$$

$$F_S = \underline{1154 \text{ pounds}}$$

- (1) The force F_B is a tensile load on the bolts while the force F_A is a compressive force on the skid. Force F_B (690 pounds) is shared by four bolts. The tensile stress is:

$$\sigma = \frac{486}{0.120 (30.75)}$$

$$\sigma = \underline{132 \text{ psi}}$$

d. Shear Load on Bolts

$$M_A = 0$$

$$(30.75) (F_{TR}) + (15.375) (324) = 11.1875 (3) (324)$$

$$F_{TR} = \frac{10874.25 - 4981.5}{30.75}$$

$$F_{TR} = A_S$$

$$\underline{191.7 \text{ lbs}}$$

$$F_y = 0$$

$$F_{TL} + F_{TR} + 324 = 0$$

$$F_{TL} = -F_{TR} - 324 = 191.7 - 324$$

$$F_{TL} = A_S$$

$$\underline{515.7}$$

Therefore, the maximum load is on the bolts on the left end. There are two bolts per leg at each end and there are two legs. Therefore, the load is carried by four bolts. Thus:

$$\sigma = \frac{F_{TL}}{4A_S}$$

$$A_S = \text{Stress area} = .0773$$

$$\sigma = \frac{515.7}{4(.0773)}$$

$$\sigma = \underline{1667.85 \text{ psi}}$$

Again, far below the yield strength of 15,000 psi on 1030 steel.

3. Calculation Set C - Up

This calculation set will consider a force equal to 2 g acting perpendicular to the reel axis in the up direction. The load is equal to 2 (324) or 648 pounds. The bearings can each withstand 2,940 pounds of radial thrust. Thus, the bearings are acceptable for this loading condition.

- a. Each bearing is secured by two bolts (3/8 - 16) or four bolts restrain the 324 pound load. Thus:

$$\sigma = \frac{324}{4A_s}$$

A_s = Stress area

$$\sigma = \frac{320}{4(0.0773)}$$

σ = Tensile area

$$\sigma = 1035 \text{ psi}$$

Again, the stress is well below the yield point of 30,000 psi. Final consideration would be the bolts which secure the legs. However, these bolts are 3/8 - 16 as above, with eight bolts restraining the 324 pound load instead of four bolts as in the bearings. Therefore, these bolts are acceptable.

4. Calculation Set D - Down (Figure 5)

This calculation set will consider a force equal to 4 1/2 acting perpendicular to the reel axis in the down direction. The force is equal to 4.5 (324) or 1458 pounds. The bearings can withstand a force of 2940 pounds in the radial direction.

The legs are the only other support members to be considered in this calculation.

Thus:

$$\sigma = \frac{F}{8A_s}$$

σ = Shear stress

$$\sigma = \frac{1458}{8(0.0773)}$$

$$A_s = 0.0773$$

$$F = 1458$$

$$\sigma = 2357.8 \text{ psi}$$

Again, this shear stress is well below the shear yield strength of 15,000 psi.

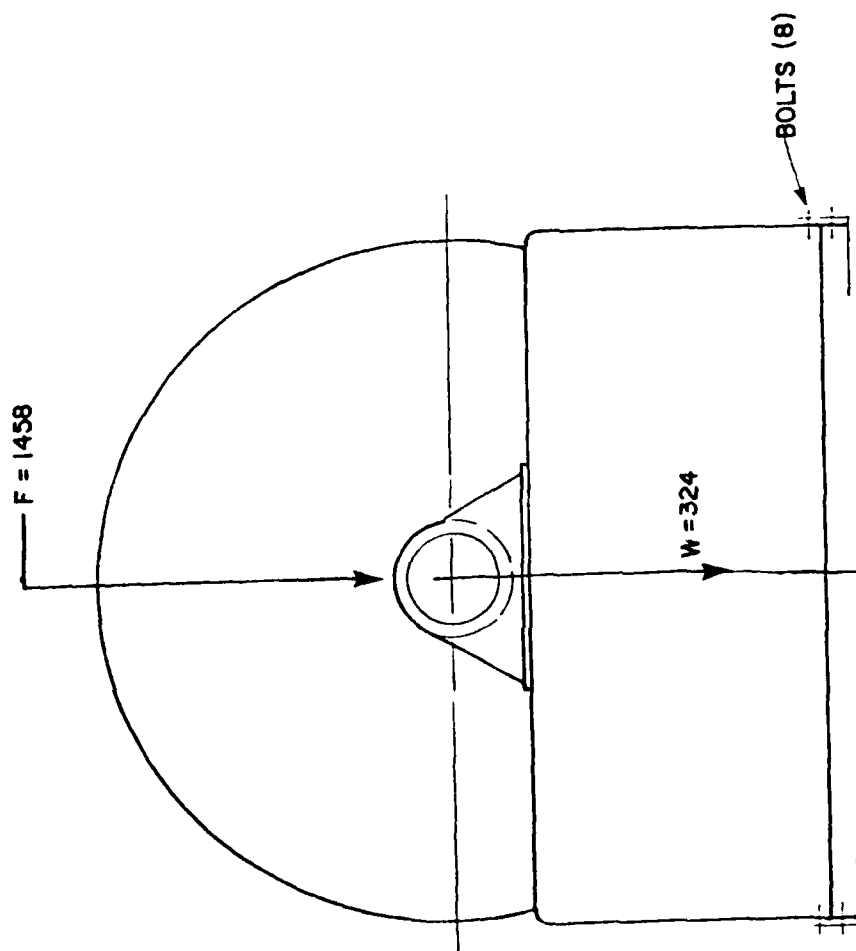


Figure-5 Calculation Set D-Down

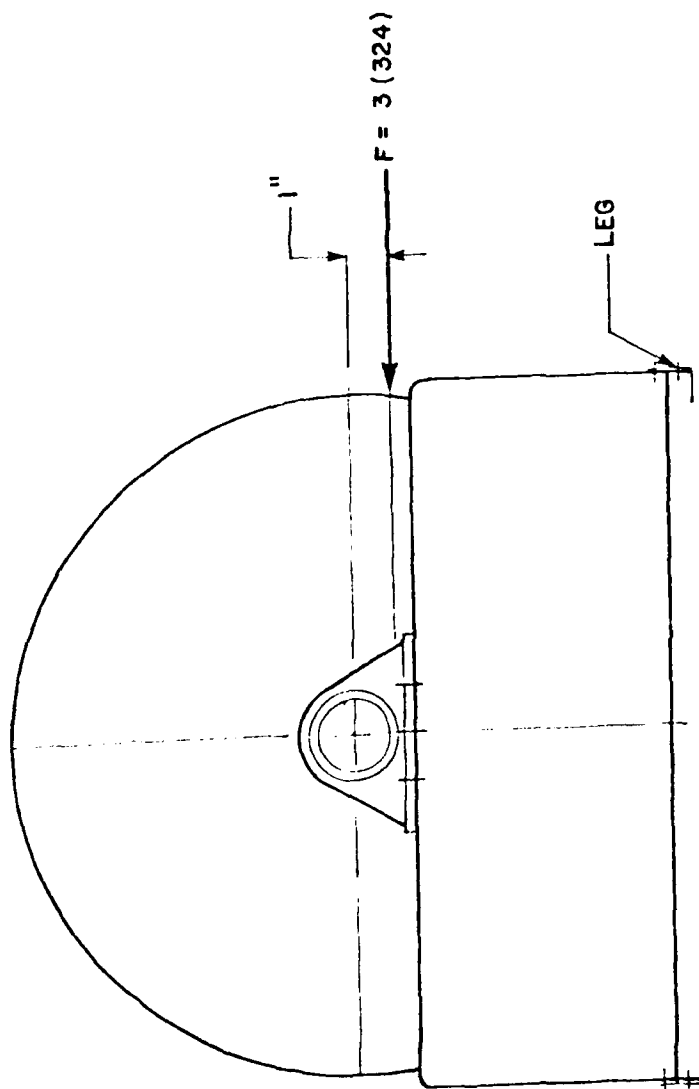


Figure-6 Bolt Attachment Between Reel and Base

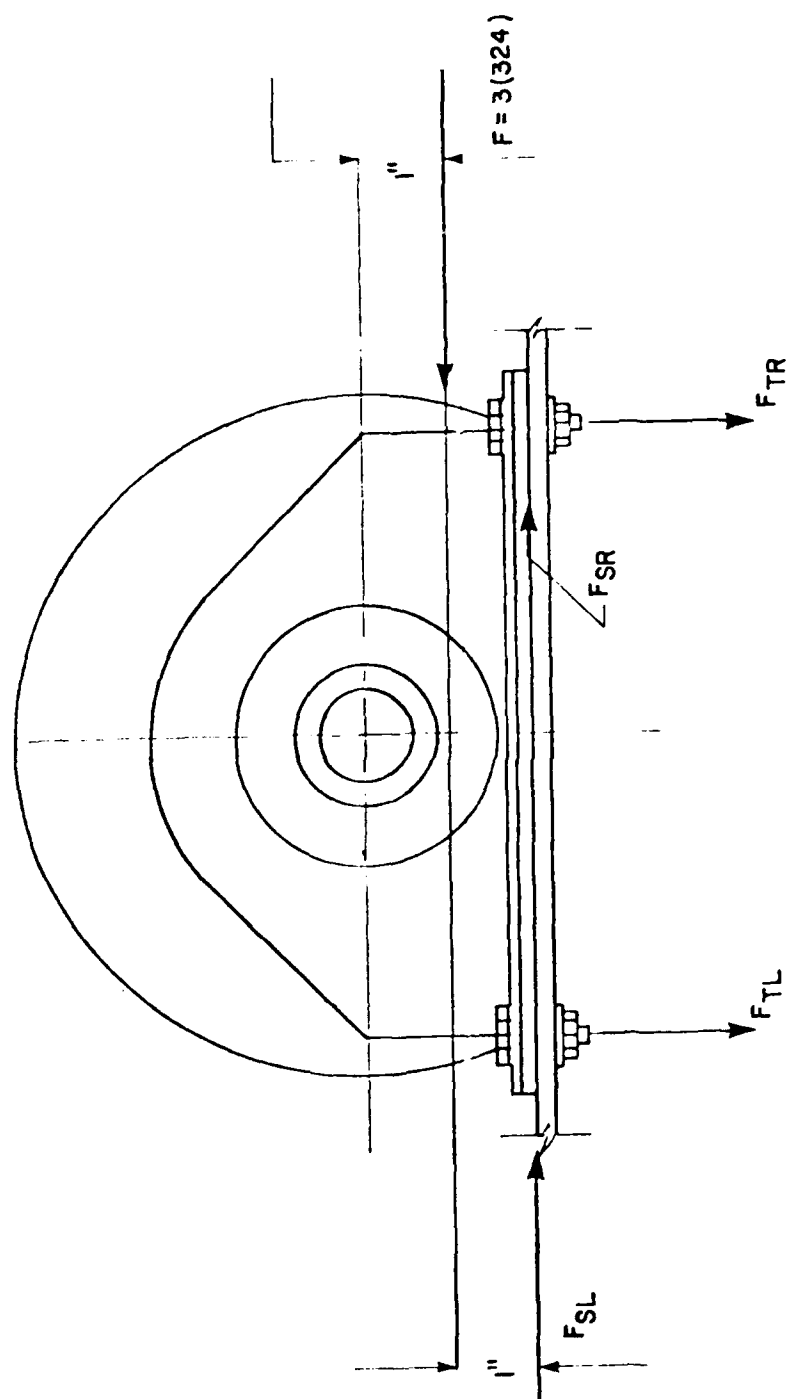


Figure-7 Bolt Attachment Between Base and Skid

Finally, the load is also supported by the leg. Therefore:

$$\sigma = \frac{F + W}{2(A)}$$

F = Force (1458)

W = Weight 324

A = Area

two legs

$$\sigma = \frac{1458 + 324}{2(20.75)(0.120)} = \frac{1782}{4.98}$$

$$\sigma = 357.85 \text{ psi}$$

Therefore, the leg design is acceptable.

HOSE REEL ASSEMBLY ATTACHMENT MOUNTING BOLTS - Sub Section B

1. Calculation Set A - Fore and Aft Direction

A force equal to 3 g will be applied to the hose reel assembly perpendicular to the reel axis of rotation in the horizontal direction fore or aft. Calculation will be done in the fore direction with numerically equal results in the aft. There are two sets of mounting bolts to consider --- one set attaches the reel assembly to the hose reel base (see drawing 36225 and Figure 6) and the other attaches the hose reel base to the skid (see Figure 7).

The base will carry the load of two hose reels. We will assume the hose reels are free standing and will ignore the added strength of the rapid piping.

2. Bolt Attachments Between Reel & Base (Figure 6)

3/8 - 16 bolts are utilized

$$M_{\text{Left}} = 0$$

$$25 (F_{TR}) - 11\text{-}3/16 (3) (324) + 324 (12 \text{ } 1/2) = 0$$

$$F_{TR} = \frac{10875 - 4050}{25}$$

$$F_{TR} = 273 \text{ lbs}$$

$$F_y = 0$$

$$F_{TL} - 324 - F_{TR} = 0$$

$$F_{TL} = 324 + 273$$

$$F_{TL} = 597 \text{ lbs}$$

$$F_x = 0$$

$$F_{SL} + F_{SR} - 3 (324) = 0$$

$$2F_{SR} = 3 (324)$$

$$F_{SR} = F_{SL} = 486 \text{ pounds}$$

$$F_{SL} = F_{SR}$$

Where F_{SL} and F_{SR} are
shear forces on each
bolt.

a. The load F_{TP} is a tensile load on the bolts while F_{TP} is a compressive load on the base stand. The load F_{TP} (273 pounds) is shared by two bolts. Thus:

$$\sigma = \frac{F}{A_s}$$

$$\sigma = \frac{273/2}{.0773}$$

$$\sigma = 1765.9 \text{ psi}$$

σ = Bolt tensile stress
 F = Bolt load $F_{TP}/2$

A_s = Stress area = 0.077

The shear stress on the bolts is:

$$\sigma = \frac{F_s}{S A_s}$$

σ = Shear stress
 F_s = Shear force

8 bolts share load

$$\sigma = \frac{1154}{8 (.0773)}$$

$$\sigma = 1853 \text{ psi}$$

Therefore, the stress loads (tensile and shear) on the 3/8 - 16 bolts is well below the yield strength for stainless and steel material. Thus, these bolts are acceptable.

b. Shear and Bending of Hose Reel Base

Ignoring the added strength of the rigid piping, we will examine the vertical members of the hose reel base assembly for shear and bending.

We will assume the shear force on the members is identical to the bolt shear force of 577 pounds. Two angles will absorb each force. Therefore:

$$\sigma = \frac{F}{A} \quad \frac{SL}{A}$$

$$\sigma = \frac{577}{2 (.94)}$$

σ = Shear stress
 A = Shear area of angle
 $\sigma = 307 \text{ psi}$

- c. For bending stress we will assume each angle to be a cantilever beam supporting the weight of the hose reels and the base assembly. Four (4) beams will support the total weight.

$$S_B = \frac{M}{4Z}$$

$$\begin{aligned} S_B &= \text{Stress in bending} \\ M &= \text{Moment} \\ Z &= \frac{I}{C} = \text{angle properties} \end{aligned}$$

$$M = 0 \quad M = 15 (3) (324) - 7.5 (3) \quad 243/4 = 0$$

$$\underline{M = 15946 \text{ in pounds}}$$

- d. Shear stress in the bolts will be:

$$\sigma = \frac{F}{A_S}$$

$$\begin{aligned} \sigma &= \text{Shear stress} \\ F &= \text{Load} = F_{SR}/2 \text{ since two} \end{aligned}$$

$$\sigma = \frac{486/2}{0.0773}$$

$$\begin{aligned} &\text{bolts share the load} \\ A_S &= \text{Stress area} \end{aligned}$$

$$\sigma = \underline{3143.6 \text{ psi}}$$

Therefore, the stress loads (tensile and shear) on the 3/8 - 16 bolts is well below the yield strength for stainless steel material. Thus, these bolts are acceptable.

- e. Bolt attachments between base and skid (Figure 7)

3/8 - 16 bolts are utilized

$$M_A = 0$$

$$\frac{12 \frac{1}{2} (324) - 26.2 (3) (324) + 33 (F_B) - 7.5 (3)}{243/4} = 0$$

$$F_B = \frac{26.2 (3) (324) - 12 \frac{1}{2} (324) + 7.5 (3) \quad 243/4}{33}$$

$$\underline{F_B = 690 \text{ pounds}}$$

$$F_y = 0$$

$$F_A - F_B - 324 = 0$$

$$F_A = 690 + 324$$

$$F_A = 1014 \text{ lbs}$$

$$F_x = 0$$

$$-3 \frac{243}{4} - 3 (324) + F_S = 0$$

$$\underline{F_S = 1154 \text{ pounds}}$$

- (1) The force F_B is a tensile load on the bolts while the force F_A is a compressive force on the skid. Force F_B (690 pounds) is shared by four bolts. The tensile stress is:

$$\sigma = F/A_S$$

$$\sigma = \text{Bolt tensile stress}$$

$$\sigma = \frac{690}{.0773/4}$$

$$F = \text{Bolt load} = F_B/2$$

$$A_S = \text{Stress area} = B0.0126$$

$$\sigma = 2231.5 \text{ psi}$$

$$S_B = \frac{15975}{4 (.25)} = 15946 \text{ psi}$$

This is the highest stress produced through out the assembly and still well within the properties of the steel.

3. Calculation Set B - Lateral Direction: Left and Right

These calculations will consider a load equal to 3g applied parallel to the axis of rotation of the hose reel --- force can be applied either left or right directions without changing the maximum numerical stress. There are two sets of mounting bolts to consider --- one set attaches the reel assembly to the hose reel base (see drawing 36225 and Figure 8) and the other attaches the hose reel base to the skid (see Figure 9).

4. Bolt Attachments Between Reel and Base (Figure 8)

3/8 - 16 bolts are utilized

$$M_A = 0$$

$$14.5 (324) - 29 (F_B + 14 (3) (324)) = 0$$

$$F_B = \frac{(14) (3) (324) + 14.5 (324)}{29}$$

$$F_B = 631.3 \text{ pounds}$$

$$F_y = 0$$

$$F_A + W - F_B = 0$$

$$F_A = 631.3 - 324$$

$$F_A = 307.3 \text{ pounds}$$

$$F_X = 0$$

$$F_X - 3 (324) = 0$$

$$F_S = 972 \text{ pounds}$$

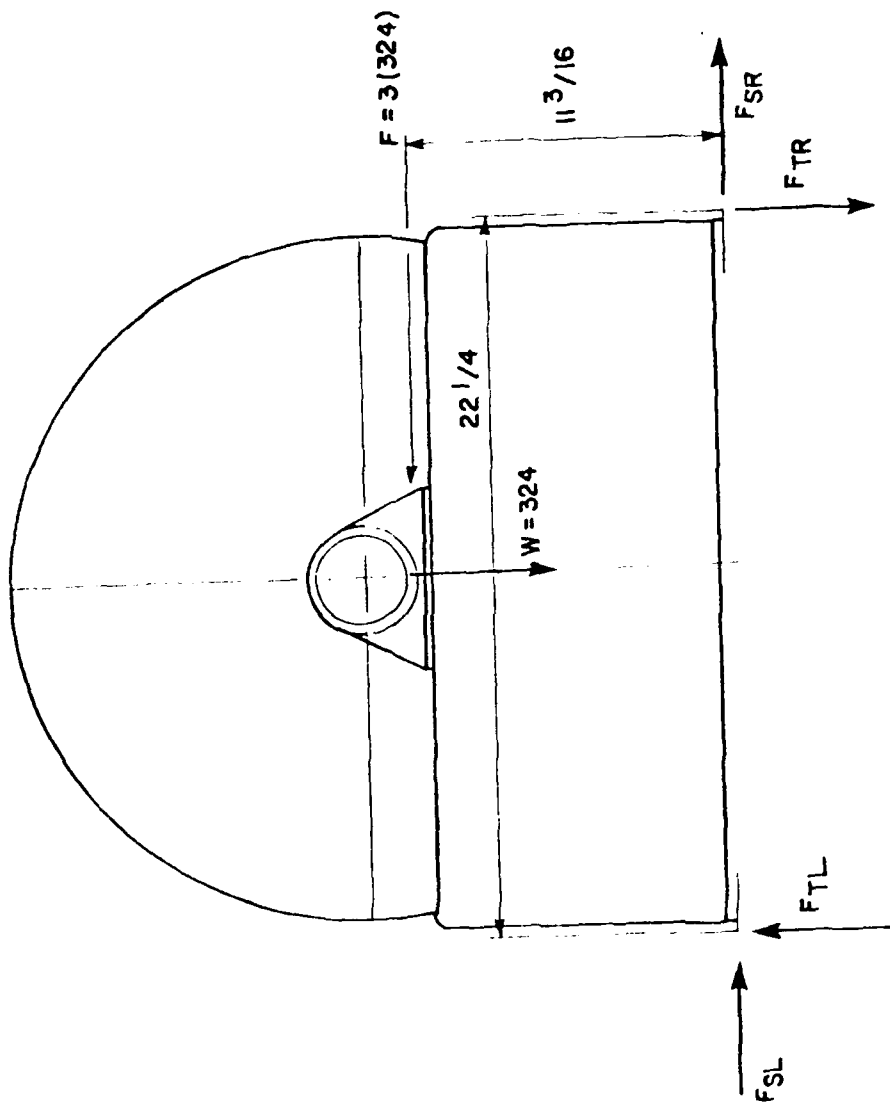


Figure-8 Bolt Attachment Between Reel and Base

- a. The force F_A is a tension force applied to the bolts while F_B is a compressive force on the base. Therefore, the tensile stress on the bolts is:

$$\sigma = \frac{F}{A_S}$$

σ = Bolt tensile stress

$$\sigma = \frac{307.3/2}{0.0773}$$

$F = F_A/2$ (force on each bolt)
 A_S = Stress area

$$\sigma = \underline{1988 \text{ psi}}$$

- b. Shear stress is:

$$\sigma = \frac{F_l}{A_S}$$

σ = Shear stress
 $F_l = F_S/4$ (4 bolts are sharing shear load which is F_S)

$$\sigma = \frac{972/4}{0.0773}$$

A_S = Stress area

$$\sigma = 3143.6 \text{ psi}$$

Therefore, both the shear stress and the tensile stress on the 3/8 - 16 bolts are well below the yield strength of stainless steel.

5. Bolt Attachments Between Base and Skid (see Figure 9)

3/8 - 16 bolts are utilized

$$M_C = 0$$

$$29 (324) + 14.5 (324) + 26.2 (3) (324) + 7.5 (3) 24-3/4 = 0$$

$$F_D = \frac{29 (324) + 14.5 (324) + 26.2 (3) (324) + 7.5 (3) 24-3/4}{29}$$

$$F_D = \underline{1411 \text{ pounds}}$$

$$F_y = 0$$

$$F_C + 220 - F_C = 0$$

$$F_C = 1411 - (324 + 243/4)$$

$$\underline{F_C = 1026 \text{ pounds}}$$

$$F_x = 0$$

$$F_{S1} - 3 (324) - 3 (243/4) = 0$$

$$\underline{F_{S1} = 1154 \text{ pounds}}$$

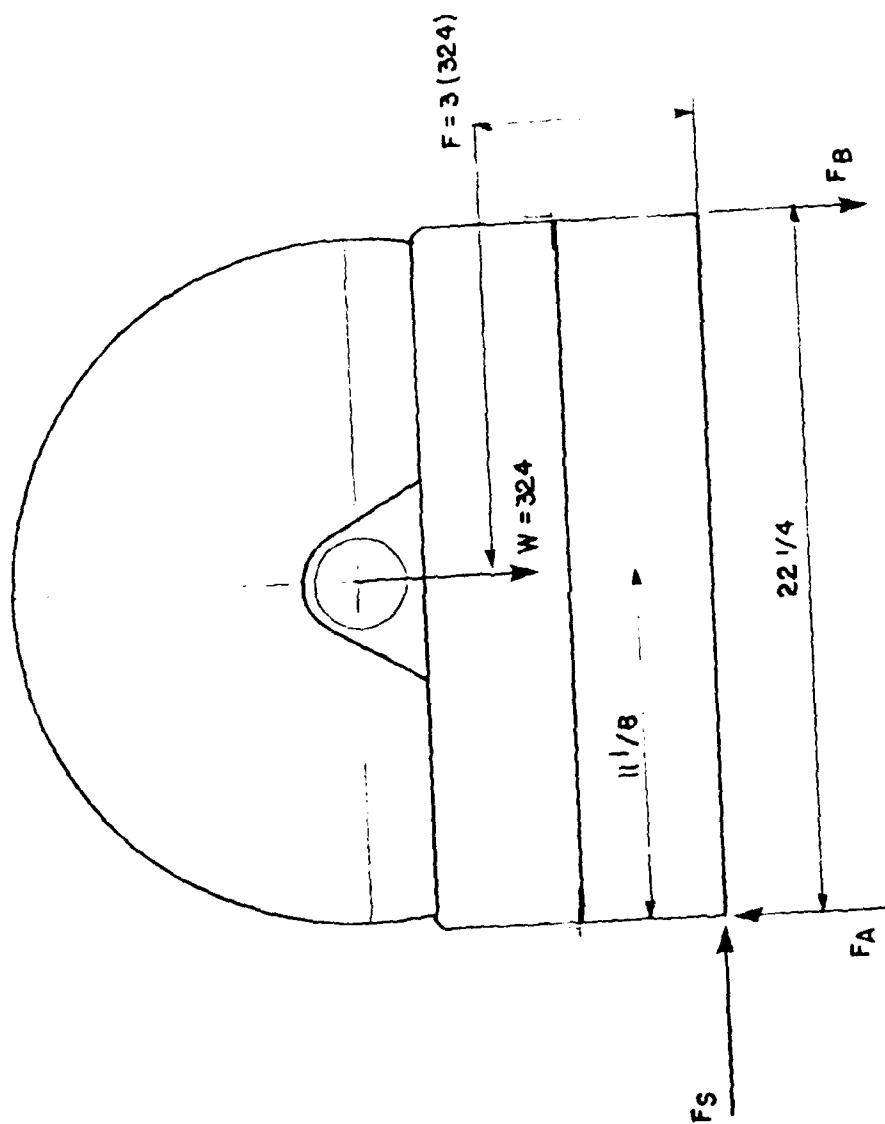


Figure-9 Bolt Attachment Between Base and Skid

- a. The force F_D is a compression force on the skid and the force F_C is a tensile force on the 3/8 - 16 bolts. Therefore, the maximum tensile stress on the bolts assuming only two will hold the entire unit is:

$$\sigma = F/A_S$$

$$\sigma = \frac{1026/2}{.0773}$$

$$\sigma = 6636.5 \text{ psi}$$

$$\begin{aligned} \sigma &= \text{Bolt tensile stress} \\ F &= F_C/2 \text{ (force on each bolt)} \\ A_S &= \text{Stress area} \end{aligned}$$

- b. Shear stress is:

$$\sigma = F_1/A_S$$

$$\sigma = \frac{1154/8}{.0773}$$

$$\sigma = 1866 \text{ psi}$$

$$\begin{aligned} \sigma &= \text{Shear stress} \\ F_1 &= F_{S1}/8 - 8 \text{ bolts are sharing} \\ &\quad \text{shear load which is } F_{S1} \end{aligned}$$

Therefore, both the shear stress and the tensile stress on the 3/8 - 16 bolts are well below the yield strength of stainless steel. The shear and bending loads on the vertical base members will be identified to the fore and aft calculations, Section II, Calculations Set A.

6. Calculation Set C - Up Direction

These calculations will consider a load equal to 2 g applied perpendicular to the axis of rotation of the hose reel in the up direction. There are two sets of mounting bolts to consider --- one set attaches the reel assembly to the hose reel base (see drawing 36225 and Figure 10) and the other attaches the hose reel base to the skid (see Figure 11).

- a. Bolt Attachments Between Reel and Base (Figure 10)

3/8 - 16 bolts are utilized.

Since the force is applied at a center of gravity which is equal distance from the four bolts, the bolts will share the load equally. Therefore:

$$F_y = 0$$

$$F_{\text{Bolt}} = \text{Load on four bolts}$$

$$F_{\text{Bolt}} + 324 - 2(324) = 0$$

$$F_{\text{Bolt}} = 324 \text{ pounds}$$

$$\sigma = \frac{324}{4A_S}$$

$$A_S = 0.0773$$

4 bolts

$$\sigma = 1048 \text{ psi}$$

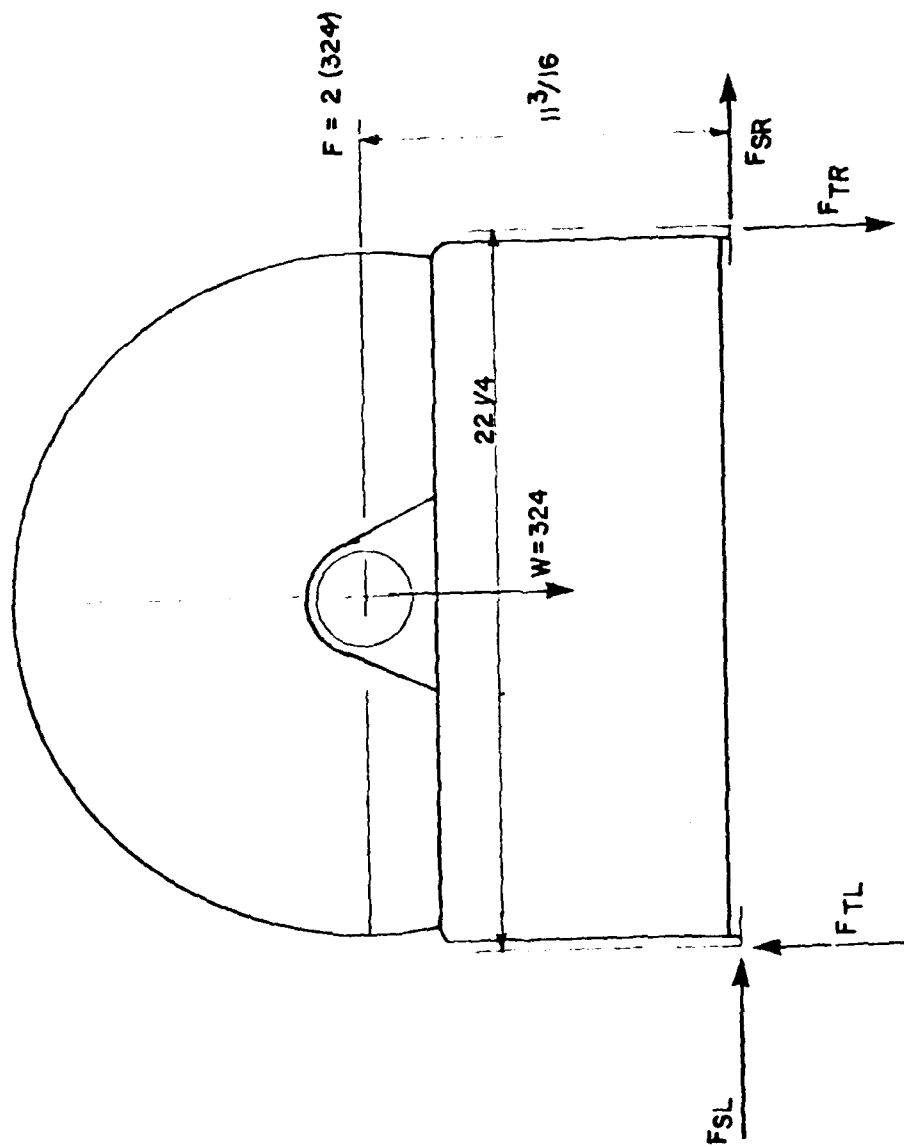


Figure-10 Bolt Attachment Between Reel and Base

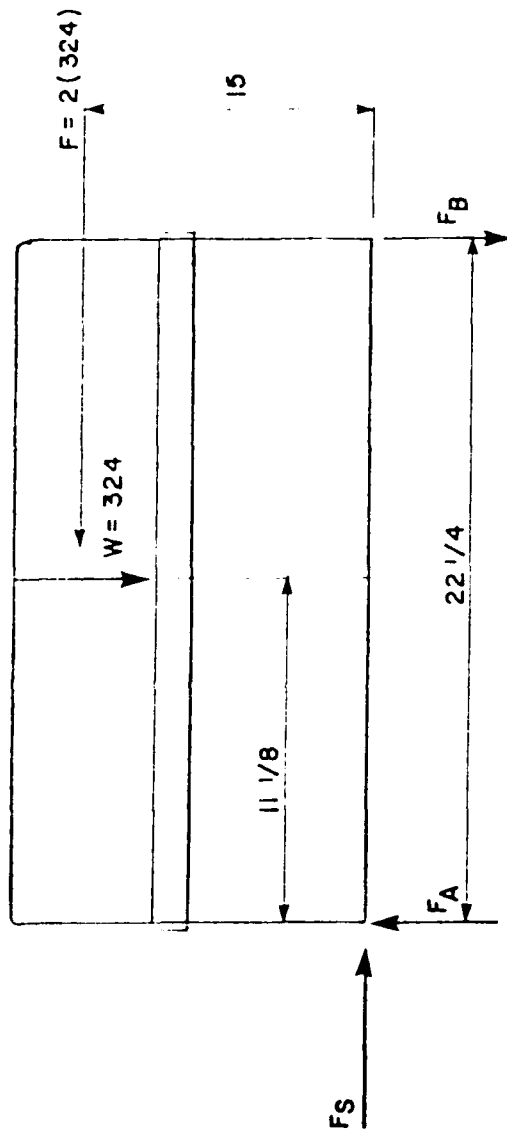


Figure-11 Bolt Attachment Between Base and Skid

b. Bolt Attachments Between Base Skid (Figure 11)

3/8 - 16 bolts are utilized.

Since force is applied at a center of gravity which is equal distance from the eight bolts, the bolts will share the load equally. Therefore:

$$F_y = 0$$

$$F_{\text{Bolt}} = 385 - 2 (385) = 0$$

$$F_{\text{Bolt}} = 385$$

$$\sigma = \frac{385}{8A_s}$$

$$A_s = .0773$$

8 bolts

$$\sigma = \underline{622 \text{ psi}}$$

Therefore, the tensile stress on the 3/8 - 16 bolts is well below the yield strength of stainless steel.

7. Calculation Set D - Down Direction

A force equal to 4 1/2g will be applied to the unit in a down direction perpendicular to the agent tank base plate. This force direction does not exert any forces on the bolt attachments, and therefore, is not a factor in the calculations required by MIL-T-83303A.

APPENDIX B

PARTS INDEX

Parts needed for modification of the AS 32/P-13

55589 350 PKP dry chemical 500-Halon 1211 skid ass'y - modified
one man operation (USAF P-13 skid ass'y).

2372 1/8" x 1" flat steel (3)
36237 Skid frame
19124 3/8 x 1-1/4 bolt s.s.
16580 6" x 10.5 lb/ft channel (82" lg) (2)
17469 4" x 5.4 lb/ft channel (44" lg) (6)
16365 "X" frame
2987 2" x 2" x 1/4" angle (44" lg)
2987 2" x 2" x 1/4" angle (18" lg)
8988 1/4" x 2" flat steel (6" lg) (2)
8988 1/4" x 2" flat steel (12-1/2" lg)
8988 1/4" x 2" flat steel (6-1/2" lg)
23845 1/2" x 2" flat steel (17-1/4" lg)
23845 1/2" x 2" flat steel (15" lg)
36228 Paint specifications
36234 Dry chemical tank and piping
29924 Vendor's tank
19404 Collar (Ansul supplied)
29922 Gas tube assembly (Ansul supplied)
2431 1/2" wrought steel pipe (5" lg)
29921 Gas Tube
29920 Pipe (Drilled)
2462 1/2" wrought steel
pipe (15" lg)
3288 Clamp
25508 Disc
3287 Valve rubber
10935 1/2" Malleable tee
2462 1/2" Wrought steel pipe
(12-1/2" lg)
26312 Indicator fill cap
16090 1" x 5" lg nipple (2)
19962 1/2" tee (2)
16088 1/2" x 4" lg nipple (2)
16198 1/2" close nipple
26001 1/2" ball valve (2)
26013 Safety valve
23850 Ring pin bracket assembly
1133 1/4" Lockwasher
18107 1/4" - 20 Hex nut
1132 1/4" - 20 x 3/4" lg rd head machine screw
2985 1/2" sq. steel (1-1/2" lg)
2986 1/8" x 1/2" flat sheet (6-1/2" lg)
36228 Paint specifications
19838 1/2" x 90° street elbow (2)
19836 1/2" x 1-1/2" lg. nipple (2)
19872 1" tee
31782 1" x 90° union elbow
26002 1" ball valve
26000 1/4" ball valve

19190	1/4" close nipple
19994	Bracket nameplate
19992	Bracket nameplate
19993	Bracket nameplate
598	Ring pin (4)
2367	Safety chain (4)
25540	Pop rivet (6)
25464	1/2" x 1/4" reducing bushing (2)
36228	Paint specifications
16196	1/2" union elbow
19873	1" x 1/2" reducing bushing
19958	1/2" pipe (23" lg)
197	Lead and wire seal (4)
55660	Halon 1211 tank and piping
36229	Vendor's tank
54286	3/4" Ball valve
30263	Fill gage
26001	1/2" ball valve (2)
26000	1/4" ball valve
16198	1/2" close nipple (3)
19836	1/2" x 1-1/2" nipple (2)
25464	1/2" x 1/4" reducing bushing
28124	1/2" cross
26013	Pressure relief valve
19833	3/4" x 90° elbow (3)
19853	3/4" pipe (5" lg)
19853	3/4" pipe (8-1/4" lg)
19116	3/4" close nipple
19853	3/4" pipe (13-3/8" lg)
19853	3/4" pipe (6" lg)
19846	3/4" x 3/4" x 1/2" reducing tee
16196	1/2" union elbow
19993	Bracket nameplate
19994	Bracket nameplate
19992	Bracket nameplate
598	Ring pin (3)
2367	Safety chain (3)
25540	Pop rivet (6)
19838	1/2" x 90° street elbow (2)
19958	1/2" pipe (17-1/4" lg)
26031	1/2" charging coupling
26148	Dust cap
19772	1/2" check valve
19962	1/2" tee
16195	Union elbow
19190	1/4" close nipple
36228	Paint specifications
197	Lead and wire seal (3)
19853	3/4" pipe (2-1/2" lg)
1738	2" pipe plug (2)
55588	Hose reel base assembly
36037	Hose reel base

2987 2 x 2 x 1/4 angle (12-3/4 lg) (4)
 2987 2 x 2 x 1/4 angle (45-1/2 lg) (2)
 2987 2 x 2 x 1/4 angle (18-1/4 lg) (2)
 8988 2 x 1/4 flat stock (22-1/4 lg) (2)
 8988 2 x 1/4 flat stock (46 lg) (2)
 8988 2 x 1/4 flat stock (12-3/4 lg) (2)
 2985 1/2" square stock (3/4 lg) (2)
 2987 Angle
 36228 Paint specifications
 55674 Hose reel ass'y
 55595 Electric hose reel
 19273 Hose reel
 12532 Swivel adaptor union
 16159 Swivel adaptor union
 19861 1-1/2 x 1 reducing bushing (2)
 36228 Paint specifications
 55659 Roller base assembly
 55658 Roller base
 2396 3/8 x 3 flat
 55655 channel
 8940 2 x 1 x 1/8 hot rolled mild steel
 channel
 55656 channel
 8940 2 x 1 x 1/8 hot rolled mild steel
 channel
 36228 Paint specifications
 17586 Hose roller assembly
 55624 Hose confiner
 19939 1/2 aluminum rod
 36228 Paint specifications
 16121 1/2" lockwasher ss (4)
 16119 1/2" hex nut ss (6)
 19124 3/8 x 1-1/4 bolt (4)
 14928 3/8 hex nut ss (6)
 14929 3/8 lockwasher ss (6)
 16618 3/8 flat washer (6)
 19686 Hose clamp (4)
 2538 1/8 x 1-1/4 flat steel
 1132 1/4 x 3/4 screw (8)
 1133 1/4 lockwasher (8)
 18107 1/4 hex nut (8)
 55709 Halon 1211 hose assembly
 31213 1" I.D. x 50' hose
 55708 1" hose coupling
 55859 D.C. hose assembly
 11384 hose
 2131 male coupling
 55708 Hose coupling
 19428 Clip - crank handle (3)
 3855 #10 Screw (3)
 14235 #10 Lockwasher (3)
 14732 #10 Hex Nut (3)

36231	100 cu. ft. nitrogen cylinder	
	197	Lead and wire seal (2)
	17262	Valve locking assembly
	1625	Tag wire
	15389	Tag
	1423	D.O.T. caution tag
	11391	Label
	25128	Label
	3477	Label
	2367	Chain (20 links)
	52698	Charged nitrogen cylinder
	19897	Cable tie
	36228	Paint specifications
36230	300 cu. ft. nitrogen cylinder	
	36043	Charged nitrogen cylinder
		25125 Quick Opening valve
		11453 Shipping Plug
		11392 N ₂ cylinder cap
		28281 Nitrogen Cylinder
	197	Lead and wire seal (2)
	17262	Valve locking assembly
	11391	Label
	2367	Chain (20 links)
	15389	Tag
	19897	Cable Tie
	1625	Tag wire
	1423	D.O.T. caution tag
	25128	Label
	12011	Label
	36228	Paint specifications
25462	Nitrogen hose (L.P.) (2)	
7787	Nitrogen hose (H.P.)	
3382	Nitrogen hose (H.P.)	
4070	Patent plate	
687	Drive pin (2)	
55620	Valve handle	
	2186	Valve handle machined
		12283 handle casting
3112	Valve extension rod bushing	
3113	1/2" conduit lock nut	
2537	1/2" D. Rod (62" lg)	
598	Ring Pin	
2367	Safety Chain	
15609	#4 - 40 x 3/4" Lg. Hex Head Screw	
197	Lead and Wire Seal	
14798	Regulator (2)	
	25590	Stud (2)
36239	Cylinder Roller (3)	
	19940	Ball Transfer (2)
	25540	Pop Rivet (4)
	2396	3" x 3/8" Flat Steel (9-1/4" Lg)
	36228	Paint Specifications

36045 Cylinder End Plate
 16166 8" x 1/4" Flat Steel (10-1/8" Lg)
 36228 Paint Specifications
 36044 Cylinder End Plate
 16166 8" x 1/4" Flat Steel (11-21/32" Lg)
 36228 Paint Specifications
 16121 1/2" Lockwasher (S.S.) (8)
 16119 1/2" - 13 Hex Nut (S.S.) (10)
 16512 3/8" - 16 x 1-1/2" Lg Cap Screw (S.S.) (12)
 14928 3/8" Hex Nut (S.S.) (16)
 14929 3/8" Lockwasher (S.S.) (16)
 16618 3/8" Flat Washer (S.S.) (36)
 26520 3/16" x 5/16" Lg Pop Rivet (S.S.) (8)
 17281 1/2" x 3/8" Reducing Bushing (2)
 30245 1/2" x 45° Elbow (2)
 25582 Swivel Adaptor Union (2)
 16117 1/2"-13 x 1-1/2" Lg Hex Head Bolt (S.S.) (8)
 17486 1/2" Flat Washer (S.S.) (8)
 16514 1/4"-20 x 1-1/2" U Bolt (S.S.) (7)
 1133 1/4" Lockwasher (S.S.) (6)
 18107 1/4"-20 Hex Nut (S.S.) (6)
 19853 3/4" Pipe (49" Lg)
 19875 1" Pipe (26" Lg)
 19958 1/2" Pipe (27-3/4" Lg)
 36042 Nameplate
 34709 Nameplate
 34708 Nameplate
 36227 Nameplate
 36226 Nameplate
 19958 1/2" Pipe (58" Lg)
 36038 Cylinder Roller (3)
 19940 Ball Transfer (2)
 25540 Pop Rivet (4)
 2396 3" x 3/8" Flat Steel (10" Lg)
 36228 Paint Specifications
 36235 Nameplate - Identification
 36236 Nameplate - Transportation
 36036 Nameplate - Warranty
 26147 Recharge Carton
 26072 Charging Valve (2)
 16122 1/4" x 2" Lg Nipple (2)
 36041 Machined Tee (2)
 36228 Paint Specifications
 19124 3/8" x 1-1/4 Bolt (8)
 55502 Actuation Line Assembly
 32739 Remote Actuator
 For balance of details see actuating
 device shipping assembly, 32739
 19112 1/4" O.D. PVC Covered Copper Tube
 55472 Valve Actuator
 36228 Paint Specifications
 16477 1/4 Tube x 1/4 NPT Male Connector (6)

19173	1/4 Tee (2)
11580	Hose (2)
11160	Quick Opening Valve Actuator (2)
	Refer to accessories index Page 56 for details
16645	1/4 x 90 Street Elbow
13797	Safety Relief Valve
55686	Oil Hole Cover
19407	Elbow
11718	Male Elbow
19111	Bushing
1732	1/8 NPT Poppet Valve
19968	1/4 Elbow Brass (2)
16138	1/4 Brass Pipe 15" Lg
16138	1/4 Brass Pipe 8" Lg
19172	1/4 x 1-1/2 Lg Brass Nipple
16138	1/4 Brass Pipe 2" Lg
55469	Twin Agent Nozzle
55875	D.C. Nozzle Sub-Assembly
55874	Nozzle Body, Coated
	53084 Nozzle Body, Machined
	55819 Hard Lube Coating Specifications
55873	Trigger Assembly
	55872 Trigger Coated
	53455 Trigger Machined
	54010 Trigger Casting
	55819 Hard Lube Coatings Specs.
	53848 Pins (2)
	For balance of details refer to over/under twin agent nozzle assembly (commercial) 54735
53091	Insert
13903	O-Ring
8105	Gasket (3)
55706	Nozzle Body, Coated
	55503 Nozzle Body
	31844 Aluminum Rod
	55819 Hard Lube Coating Specifications
55878	Bent Pipe, Coated
	54281 Bent Pipe
	53086 1" Sch. 40 Aluminum Pipe
	55819 Hard Lube Coating Specifications
24713	Coupling (S.S.)
54864	Set Screw (2)
55718	Halon Nozzle Sub-Assembly
	55717 Compression Spring
	55858 Nozzle Body, Coated
	53088 Nozzle Body, Machined
	53010 Nozzle Body, Casting
	55819 Hard Lube Coating Specifications
53909	Shaft - Chrome Plate
	53085 Shaft
	9515 Chrome Plate Specifications

55873 Trigger Assembly
 55872 Trigger Coated
 53455 Trigger Mounted
 54010 Trigger Casting
 55819 Hard Lube Coating Specs.
 53848 Pin (2)
 For balance of details, refer to
 Mobil Oil twin agent nozzle assembly,
 53082 D.C. nozzle P/N 53083
 55848 Halon Nozzle Body - Coated
 55621 Nozzle Body - Machined
 31844 Aluminum Rod
 55819 Hard Lube Coating Specifications
 55856 Barrel, Coated
 55596 Barrel
 55819 Hard Lube Coating Specifications
 3902 Adaptor
 26144 Free Swivel Adaptor
 55587 Adaptor Coated
 55622 Adaptor
 55819 Hard Lube Coating Specifications
 42397 O-Ring #126
 55545 Bracket
 18105 1/4 x 1/2 Lg Hex Socket Cap Screw (2)
 55544 Adaptor
 55543 Bracket
 55542 Adaptor
 22438 3/8 x 1/2 Hex Cap Screw (2)
 55594 #10 x 3/8 Lg Socket Hd Cap Screw (4)
 15990 Grommet
 55687 Conduit Clip (9)
 18105 1/4 x 1/2 Lg Hex Hd Bolt (11)
 11334 1/4 Stop Nut (11)
 55688 Switch Box Assembly
 55689 Switch Box - Machined
 54481 Switch Box
 27024 Terminal Board
 30824 Pop Rivet (2)
 17873 Solderless Terminal (4)
 55690 Sealtite Connector (5)
 55691 Grounding Ferrule
 19926 Grommet
 55692 Sealer
 19922 1/2" Sealtite Conduit (22 ft. approximately)
 19921 #4 Gage Electric Wire (25 ft. approximately)
 19920 #16 Gage Electric Wire (25 ft. approximately)
 19929 Terminal (5)
 17873 Terminal (7)
 19931 Terminal
 55623 Rollpin
 51656 Nozzle Support
 36228 Paint Specifications