

# *SERVICE NEWS*

A SERVICE PUBLICATION OF LOCKHEED AERONAUTICAL SYSTEMS COMPANY-GEORGIA



**Fuel Venting**

PRESSING THE ADVANTAGE



J. A. Davidson

We at Lockheed Aeronautical Systems Company-Georgia are fortunate in having unique assets at our disposal. assets which are of immeasurable value to us in our airlift marketing program. One is the Hercules aircraft itself, the airlifter of choice in more than sixty nations. This extraordinary airplane continues to be in such consistent demand that we have every expectation that new production will extend well into the 21st century,

A second asset, no less important, is our distinguished world-wide team of Lockheed professionals who support the Hercules. They provide training, spares, maintenance assistance, ground handling equipment, and expert technical advice wherever and whenever they are needed.

Another special asset is the Hercules technical communications network, which includes aircraft manuals, service bulletins, newsletters, and our quarterly maintenance publication *Service News* magazine. This network ensures that a broad range of information on technical subjects, including maintenance tips, safety pointers, and servicing procedures will be readily available to all Hercules operators.

Perhaps the best part of having assets like these is that they are strengths which benefit everyone: the aircraft manufacturer, the operator, and the individual citizen who is the ultimate beneficiary of modern airlift capability. It is no coincidence that this is so.

To those of us in Marketing at Lockheed, our products, services, and support capabilities represent extensions of the Lockheed tradition, everyday manifestations of the individual commitment each of us at LASC makes to the satisfaction and success of every Lockheed customer. Even more important, to our customers they represent the tangible expression of what Lockheed is all about: quality and integrity in every phase of manufacturing, marketing, and product support.

Sincerely,

J. A. Davidson  
Vice-President, Airlift Marketing  
Lockheed Aeronautical Systems Company



A SERVICE PUBLICATION OF  
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Cover: SSgt Eugene Kaley, SSgt Tony Adams, and Lockheed Field Service Representative Dun Cox discuss C-130 maintenance at an inspection dock of the 94th TAW, Dobbins AFB, Georgia.

Photos (cover and page 3): John Rossino

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# *An Update On Fuel Venting*

When fuel vents overboard from a parked aircraft, the result is at best the loss of a scarce and precious commodity. At worst, the vented liquid may accidentally ignite and turn what was just a costly spill into a disaster.

That is why fuel venting always deserves to be taken **seriously**. When it happens, the interests of both safety and economy dictate that the causes of the problem be found and corrected as quickly as possible.

Before we look into the reasons why fuel venting occurs, let us first review the fuel tank arrangement on Hercules aircraft and note how the ventilation systems that serve these tanks are designed and function.

C-130 and L-100 airplanes are normally equipped with four main integral tanks, two in each outer wing. In addition, two bladder-type auxiliary tanks consisting of three interconnecting cells each are usually provided. These are installed in the right and left center wing section. Many Hercules models are also equipped with external pylon tanks mounted beneath the wings.

**Top-quality maintenance and a common-sense approach help CMSgt Buzz Sawyer of the 94th TAW minimize fuel system problems-even during hot Georgia summers.**



## FUEL TANK VENTILATION SYSTEM

Each fuel tank has a ventilation system which is designed to meet the particular requirements of that tank's construction and location. The basic purpose of a typical fuel tank ventilation system is to provide a controlled means of maintaining the desired pressure equilibrium inside and outside of the tank. The **system must be able to accommodate** changes in altitude and temperature; it also must be able to allow for changes in the volume of interior airspace when fuel is added or withdrawn. A fuel tank vent system has the additional function of providing a route by which excess fuel can escape in case the tank's capacity is exceeded because of overfilling or thermal expansion of the contents.

### Inboard Tanks

Three different types of ventilation systems are used on Hercules aircraft. The inboard main tanks and the auxiliary tanks are equipped with wrap-around vent systems. In this

type of system, open-ended vent lines are installed in the upper portion of each tank's interior space. The vent lines are connected to a vent tank which traps and stores any liquid fuel that enters the system. Air and fuel vapors can pass back and forth through the vent tank unimpeded. The vent system opens to the atmosphere through an overboard vent line that connects the vent tank to an outlet under the trailing edge of the wing. Any fuel trapped in the vent tank is automatically returned to the tank of origin whenever the associated fuel boost pump is in operation.

### Outboard Tanks

The outboard main tanks feature what is called an end-to-end system. This design uses what is essentially a long, straight vent line extending almost the length of the tank. Float-controlled valves are located in each compartment. A vent tank similar in construction and operation to the one used in the wrap-around system is installed in the main vent line near its inboard end. An overboard vent line connects the vent tank to an outlet below the trailing edge of the wing adjacent to that of the inboard main tank.

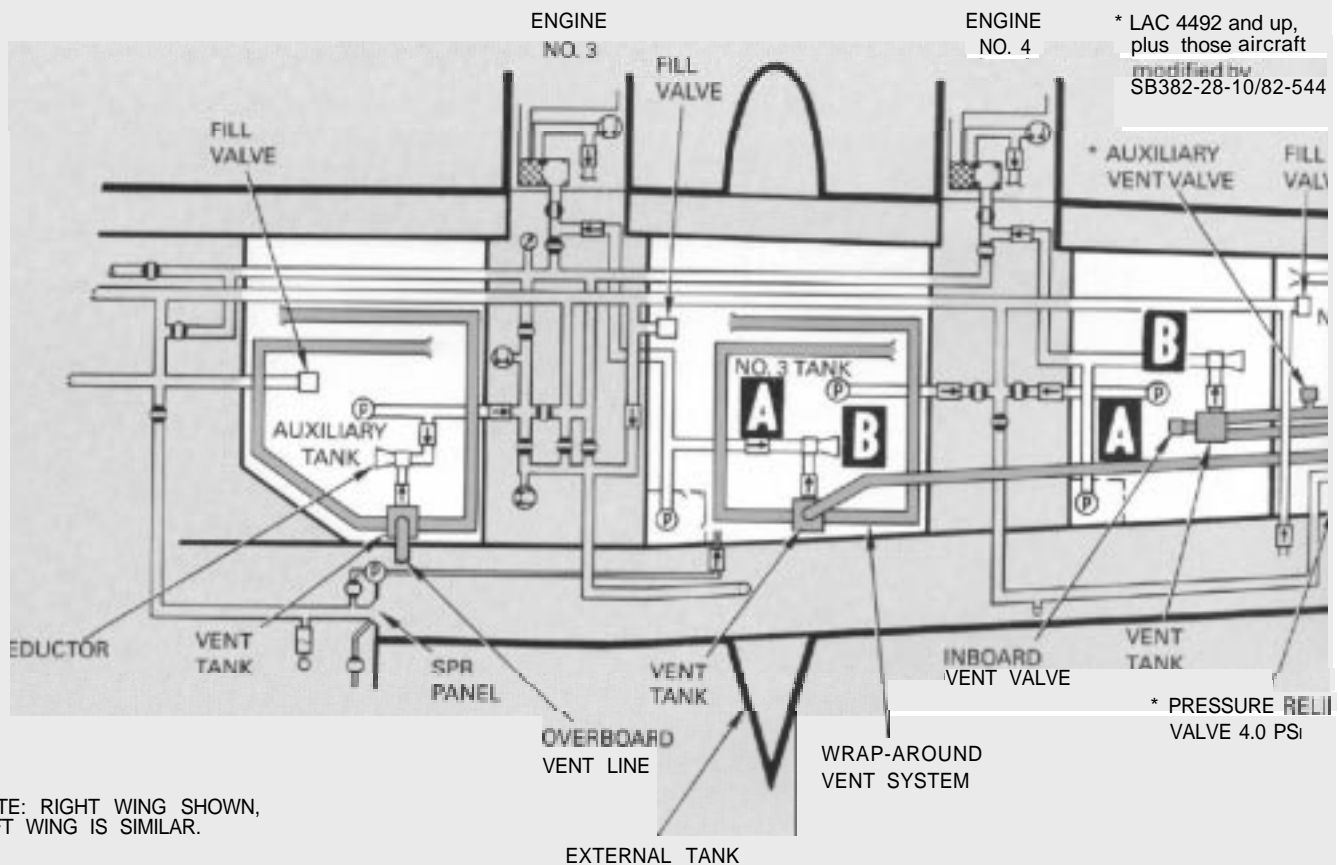
### External Tanks

Each of the two external tanks is vented to the atmosphere through a simple system that consists of a single vent line leading from the forward part of the tank, up through the pylon, and then to the trailing edge of the wing. This uncomplicated system is highly reliable. As a result, the external tanks are seldom involved in fuel-venting complaints. For this reason, they will not be considered further in the following discussion.

### CAUSES OF FUEL VENTING

Fuel venting from an overboard vent line can have a number of possible causes. The most common are thermal expansion of the fuel supply, inadvertent overfilling, leaking vent tank check valves, and leaking vent line couplings.

FUEL AND VENTILATION SYSTEM SCHEMATIC



## Thermal Expansion

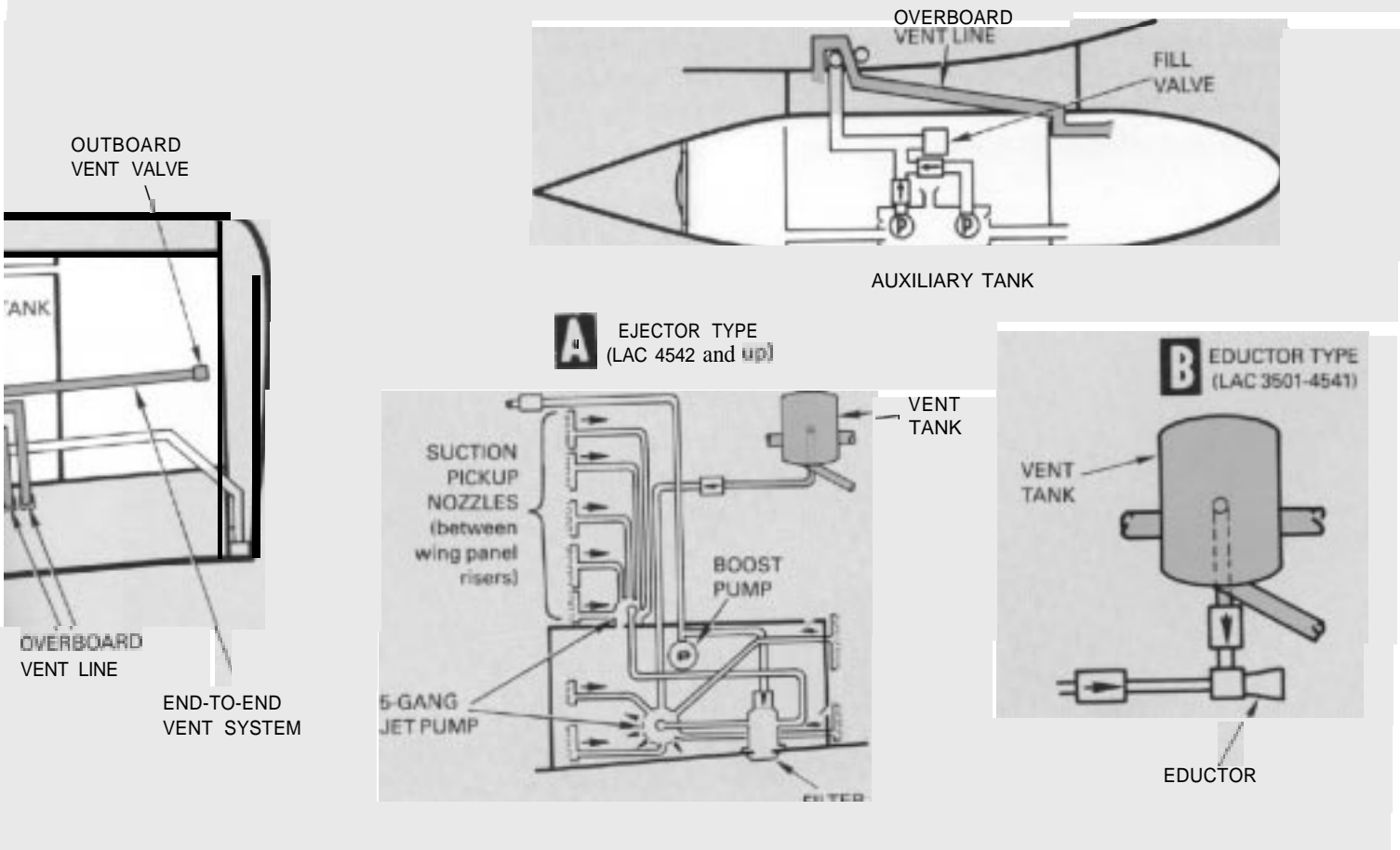
Thermal expansion of the fuel within an aircraft's tanks is probably the most common cause of fuel venting. Refueling activities are often carried out in the evening or early morning when ambient temperatures are likely to be relatively low. More often than not, the fuel is supplied from cold underground storage tanks. If an airplane whose tanks have been fully serviced during the cool hours is allowed to remain parked on the ramp long enough for the morning sun to warm it significantly, fuel venting may result. The cold fuel in the tanks will gradually absorb heat from the outside and expand. If the ambient temperature rises high enough, and the airplane is not flown or moved to a cooler area soon enough, the fuel may expand to a point where the tanks can no longer contain it.

Daily temperature changes are of course to be expected, and some allowance for thermal expansion must be included in tank design if fuel venting is not to become an everyday occurrence. The tanks in Hercules aircraft provide about 3 percent airspace above the top of the fuel when they are at normal full capacity. This is sufficient to

accommodate any thermal expansion that will usually be encountered in most climates,

But note that in some alpine and desert regions, daily temperature variations of more than 60 degrees F (15.6 degrees C) are occasionally experienced. Since JP-5, Jet A, and Jet A-1 increase in volume about 1 percent for each 19-degree F (10.5-degree C) rise in temperature, and JP-4 and Jet B expand about 1 percent for every 18.5-degree F (10.3-degree C) increase in temperature, a little quick calculation will show that it is entirely possible for thermal expansion to cause persistent fuel venting problems under such conditions. Even in more moderate climates, sudden extreme changes in temperature can and do occur. The possibility that such changes may affect tank capacity should always be considered when fuel loads are being planned.

It is also important to remember that the temperature of the ambient air is not the only source of heat energy which can have an effect on the temperature of fuel stored in aircraft tanks. Direct sunshine contains large amounts of radiant heat that is quickly absorbed by metal surfaces. A long expanse of aluminum wing can be a quite efficient



collector of this form of heat. In most aircraft, including the Hercules, these same metal wing panels are in direct contact with the fuel supply. It is thus quite possible to experience fuel expansion problems on what would appear to be only a pleasantly warm day. The temperature of the fuel, not the air, is the important factor, and direct solar radiation can play a key role in determining which of the two will be higher.

What can be done to control fuel venting due to thermal expansion? Once venting has started, the quickest way to put a stop to it is to run the fuel boost pump in the affected tank for a short period of time (a minimum of five minutes). This will clear the vent tank of accumulated fuel and keep it clear as long as the pump is running. Using the boost pumps to halt or prevent fuel venting is especially convenient when the aircraft has a scheduled flight within an hour or two.

Of course, the best way to deal with thermally induced fuel venting is to avoid having it happen at all. The only sure way to do this is the obvious one: make certain that the tanks always have enough airspace to accommodate any possible increases in fuel volume that might occur before takeoff. Some operators of Hercules aircraft have found that a 200-pound (30-gallon) reduction in the fuel load of each tank is sufficient to prevent fuel venting even under extreme climatic conditions.

A small reduction in fuel load can also be helpful in cases where the No. 3 main fuel tank has proved especially prone to fuel venting. The No. 3 tank receives all of the fuel that is drained from the single-point refueling (SPR) man-

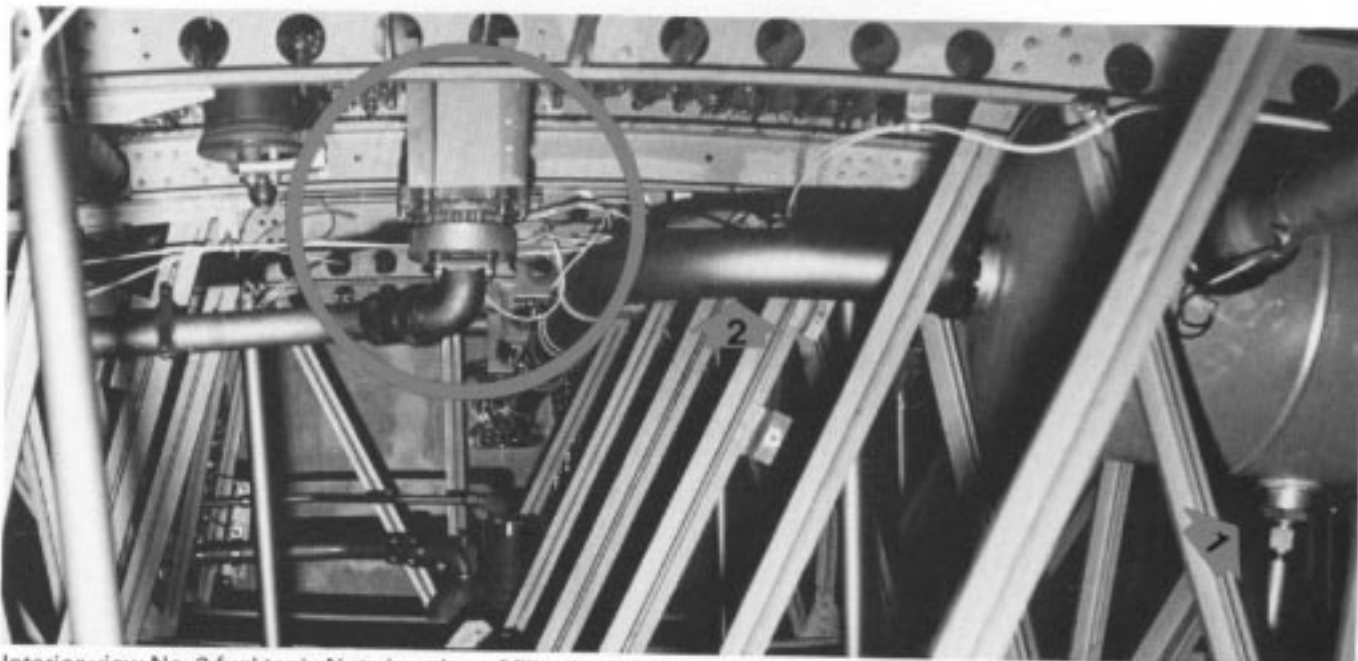
ifold after refueling is completed. The 26 or so gallons of fuel pumped from the SPR lines enter the No. 3 tank through an inlet which is not controlled by the tank's dual level control and shutoff valve (usually called simply the fill valve).

This means that if the tank is already full, the additional fuel from the SPR system represents a small excess over and above its normal capacity. As a result, part of the usual 3-percent minimum airspace in the tank will now be occupied by fuel. The No. 3 tank will therefore be a little less able to accommodate thermal expansion of its contents than the other tanks in the airplane. Not surprisingly, when conditions arise which favor thermally induced venting, the No. 3 tank is often the place where the problem shows up first.

An additional point that deserves to be mentioned is that the tank ventilation systems are best able to cope with thermal expansion of the fuel supply when the airplane is parked with the wings and fuselage level. Any other attitude, particularly one in which the nose is angled down, can predispose the aircraft to fuel venting problems when temperatures increase rapidly and the tanks are full. Level, and if possible sheltered parking areas will go **a long way** toward reducing the incidence of this kind of trouble.

#### Fill Valve Failure

Although many fuel venting problems can be traced either directly or indirectly to heat and thermal expansion, some are clearly due to other causes. Mechanical failure is



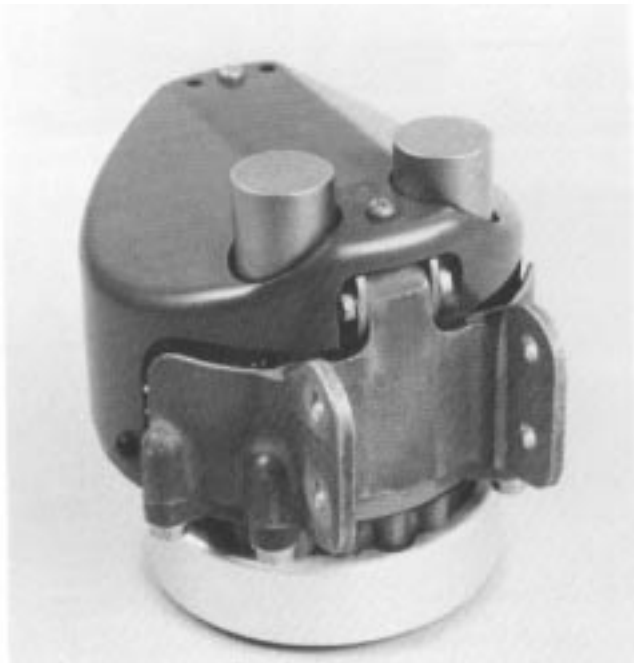
Interior view No. 3 fuel tank. Note location of fill valve (circle), the vent tank and the vent tank drain line (arrow 1), and the overboard vent line (arrow 2).

responsible for fuel venting in certain cases, and one possibility in this category is the inadvertent overfilling of a tank because of fill valve failure. Any tank can be overfilled through the SPR system if the fill valve in that tank malfunctions.

A fill valve is located near the top of each tank. The purpose of the fill valve is to shut off the flow of fuel automatically when the tank's full capacity is reached. In the Hercules aircraft, this means a level at which an airspace of about 3 percent still remains in the top of the tank to provide room for thermal expansion of the contents.

If a tank's fill valve fails in the open position, it will be possible to continue filling the tank until the remaining 3 percent of the airspace is completely occupied. Fuel will then enter the vent lines, flood the vent tank, and pour overboard from the vent outlet in a steady stream. Should the vent system for some reason be obstructed when this occurs, the fuel tank **could be overstressed or even rupture**.

The fill valves are designed in such a way that sudden, complete failure of the unit is uncommon. Each valve consists of a single housing which contains dual floats, dual diaphragms, dual pilot valves, and dual solenoids. The dual sets of components provide operational redundancy. In effect, primary and secondary systems within the valve act to back up each other. This helps to ensure that the fill valve will always close and shut off the fuel flow when the tank in which it is installed has reached its normal capacity. The proper operation of either the valve's primary or secondary



A dual level-control and shutoff valve (fill valve) is installed close to the top of each fuel tank.

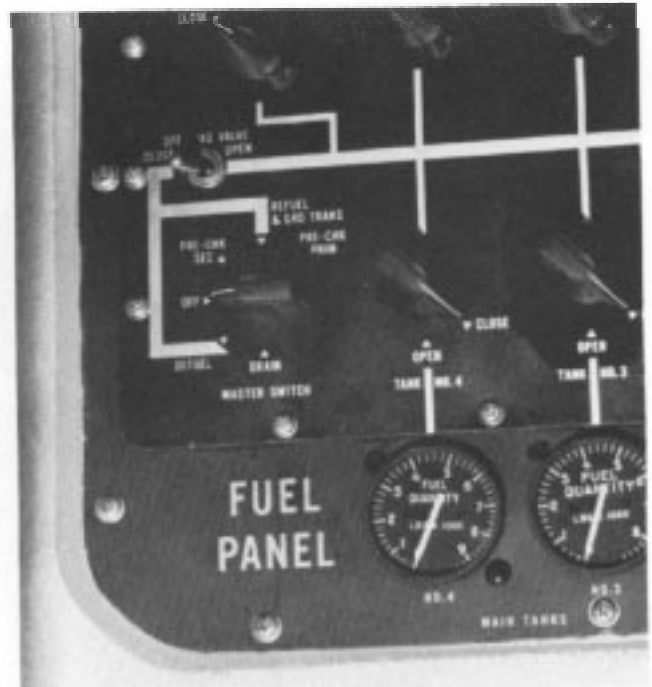
system will stop fuel from entering the tank once its maximum safe level has been reached.

### Fill Valve Operational Check

A reliable method of checking fill valve operation during refueling is provided on Hercules aircraft. The condition of the valves is normally checked each time the aircraft is refueled. To make this check, first rotate the master switch on the SPR panel to the PRE-CHK PRIM position. When the switch is in this position, electrical power is removed from the solenoid on the primary side of the fill valves in all tanks. This closes off the bleeding action across the primary diaphragms, which in turn should cause the fuel flow through the fill valves almost to stop. In PRE-CHK positions, fuel flow will not stop completely because a small amount of fuel continues to flow through other internal bleed passages.

Make note of any tank in which the fuel flow is not cut off. Then rotate the master switch to the PRE-CHK SEC position. Now the secondary solenoids in all of the tank fill valves will be de-energized. This causes the bleeding action across the secondary diaphragms to stop, bringing fuel flow almost to a stop once again. Take note of any tanks in which the fuel flow does not cease.

Ideally, the primary and secondary sides of each valve in all tanks that are being refueled should operate properly during the precheck. If at least one side of every valve is



The master switch located on the single point refueling (SPR) panel.

shown to be functioning normally, refueling may continue, but the defective fill valve should be replaced at the earliest opportunity.

In cases where both the primary and secondary sides of a valve prove to be inoperative, the defective fill valve should be replaced immediately, if possible. If this cannot be done, it will be up to the refueling crew to make certain that the tank in question is not overfilled. Refueling should either be stopped well short of the tank's normal capacity, or if a main tank or an external tank is involved, the external filler port can be used. The location of the wing filler ports with respect to the tops of the tanks ensures that adequate airspace will remain when the tank is "full."

Fuel venting that occurs sometime other than during or immediately after refueling is not usually caused by a defective fill valve. If thermal expansion can also be ruled out, the trouble is probably due to a leak somewhere in the vent system.

## VENTILATION SYSTEM LEAKAGE

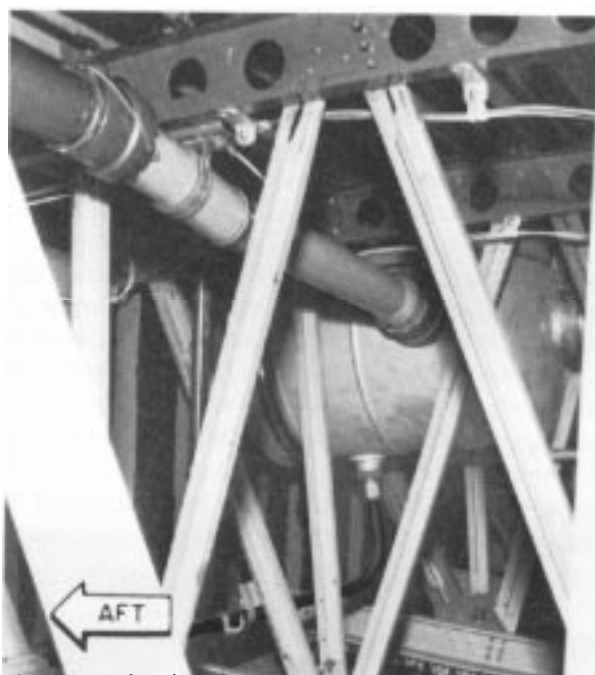
### Vent Valve

In cases where an outboard main tank is affected, one of the float-controlled valves on the main vent line may be leaking. Fuel venting through a failed vent valve is most often first noted when the aircraft has for some reason been parked on uneven ground where one wing is higher than the other.

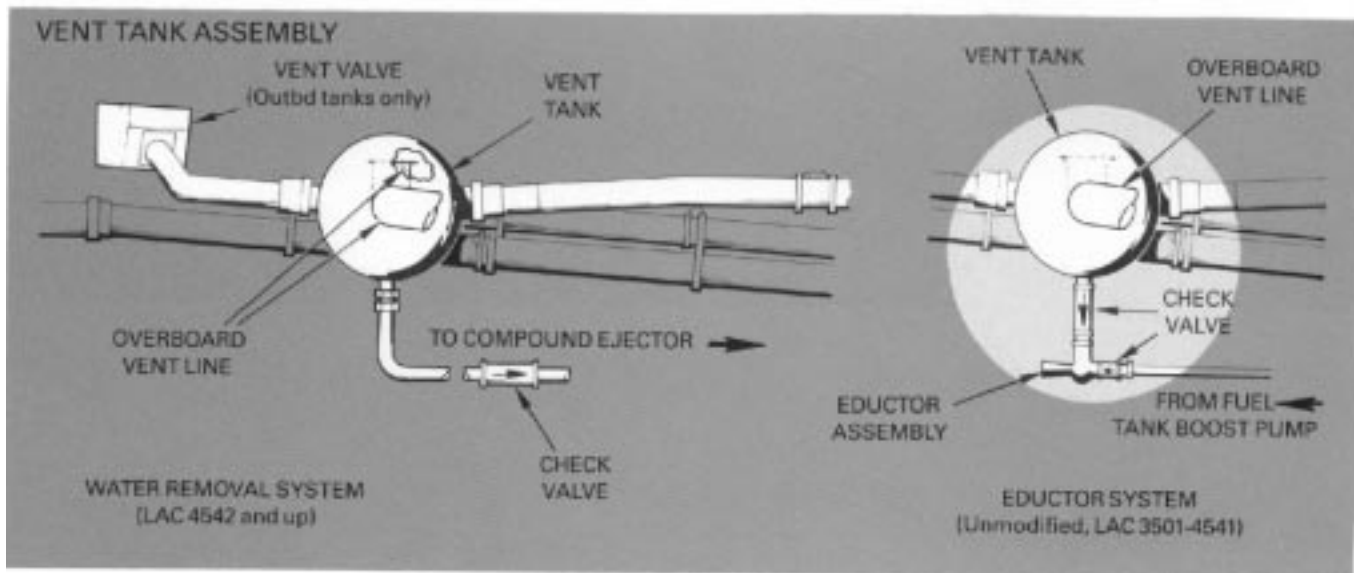
If the evidence points in this direction, there is little to do other than to remove the three valves from the leaking tank and check them. Procedures for doing this are covered in the maintenance handbooks.

### Check Valve

Another place where leakage has sometimes been discovered is at the check valve located in the vent tank drain lines of the main fuel tanks. The inboard tanks seem particularly susceptible. It appears that the flapper seal in the check valve in some cases swells enough in use to allow a slow bypass of fuel into the associated vent tank. Since the end of the overboard vent line inside the tank is slightly below the level of the fill valve, a leak through the check valve will cause the vent tank slowly to fill with fuel. The fuel will then move up the vent line to the outlet and drip overboard.



A check valve is located in the line from the vent tank to the ejector or eductor system.





The leakage through a defective vent tank drain line check valve is usually fairly slow; in one case it took 32 hours for enough fuel to seep through the valve for venting to begin. But if the check valve is installed incorrectly, overboard venting of fuel in quantity may occur much more quickly. Make sure that this valve is installed with the direction of the arrow away from the tank to allow fuel to flow from the vent tank to the eductor or ejector assembly.

A quick temporary solution to leakage through the vent tank drain line check valve is to lower the fuel level to a point where the open end of the overboard vent line is above the fuel level. Keeping the fuel load down to 6200 pounds in the inboard tanks and 6700 pounds in the outboard tanks should accomplish this.

Of course, the only real fix for a leaking check valve is to replace it. Once it is removed, the valve can be checked for leakage with a simple test: Obtain a 24-inch section of 1/2-inch straight pipe and provide it with a fitting on one end to adapt it to the check valve. Stand the assembly upright in a safe area and fill the pipe with fuel. The maximum amount of leakage allowed is ten drops per minute. If the valve fails this test, it must be replaced.

### Vent Tank

A problem that can produce symptoms similar to a leaking check valve is a crack in the welded seam of a vent tank. Metal vent tanks are used in the inboard and outboard main tanks. If one of them develops a small crack, the fuel may enter the vent tank at a rate quite comparable to the flow through a failed check valve.

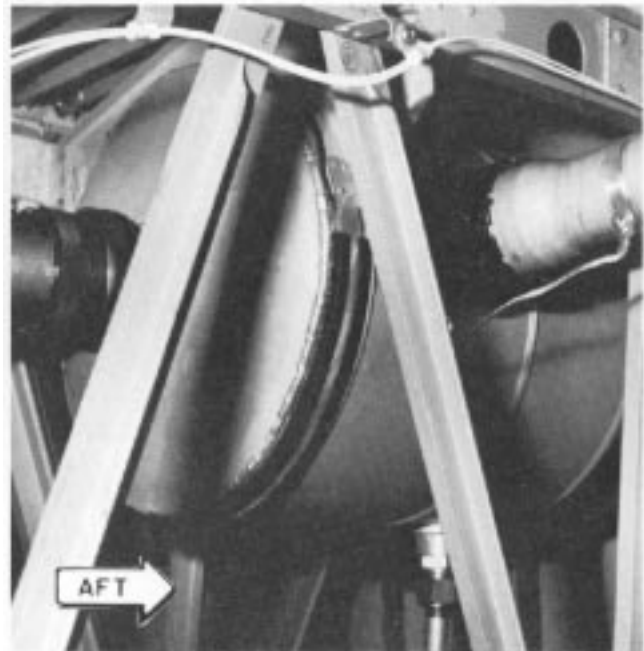
Vent tanks are not easy to test with certainty because a defective tank that is not under stress may appear to be sound. A crack may open up, however, just as soon as stress is applied—as it is when the vent tank is partially submerged in a full tank of fuel.

### LOCATING LEAKS

An excellent way to leak-check an entire fuel tank ventilation system—vent tank, vent lines, and couplings—is to pressurize the system with air. This may be done for any of the main fuel tanks, but the affected tank must be drained and purged first.

#### CAUTION

**Do not pressurize auxiliary tank vent systems.**



A crack in the welded seam of a vent tank can cause fuel to be vented overboard.

### Ventilation System Layout

Note that before attempting to pressurize a tank ventilation system to locate leaks, it is a good practice to review the applicable vent line routing schematics. Vent system leaks can be deceptive, and having a good mental picture of the layout of the vent line plumbing could help save a lot of time and trouble.

One point in particular to remember is that the overboard vent line for an inboard tank is routed through the outboard tank on the way to its vent outlet. This means that when fuel shows up at the vent outlet of an inboard tank, it may in fact have originated in the outboard tank. The leak could be in the inboard tank's vent line somewhere along its route through the outboard tank.

A quick way to determine which tank is the source of the leak is to drain the fuel from the inboard tank; any leakage originating in that tank will then cease. If the fuel venting continues, leakage into the portion of the vent line that passes through the outboard tank is indicated. In this case, it will be necessary to drain and purge both the affected inboard and outboard tanks in order to locate the leak by pressurizing the vent system.

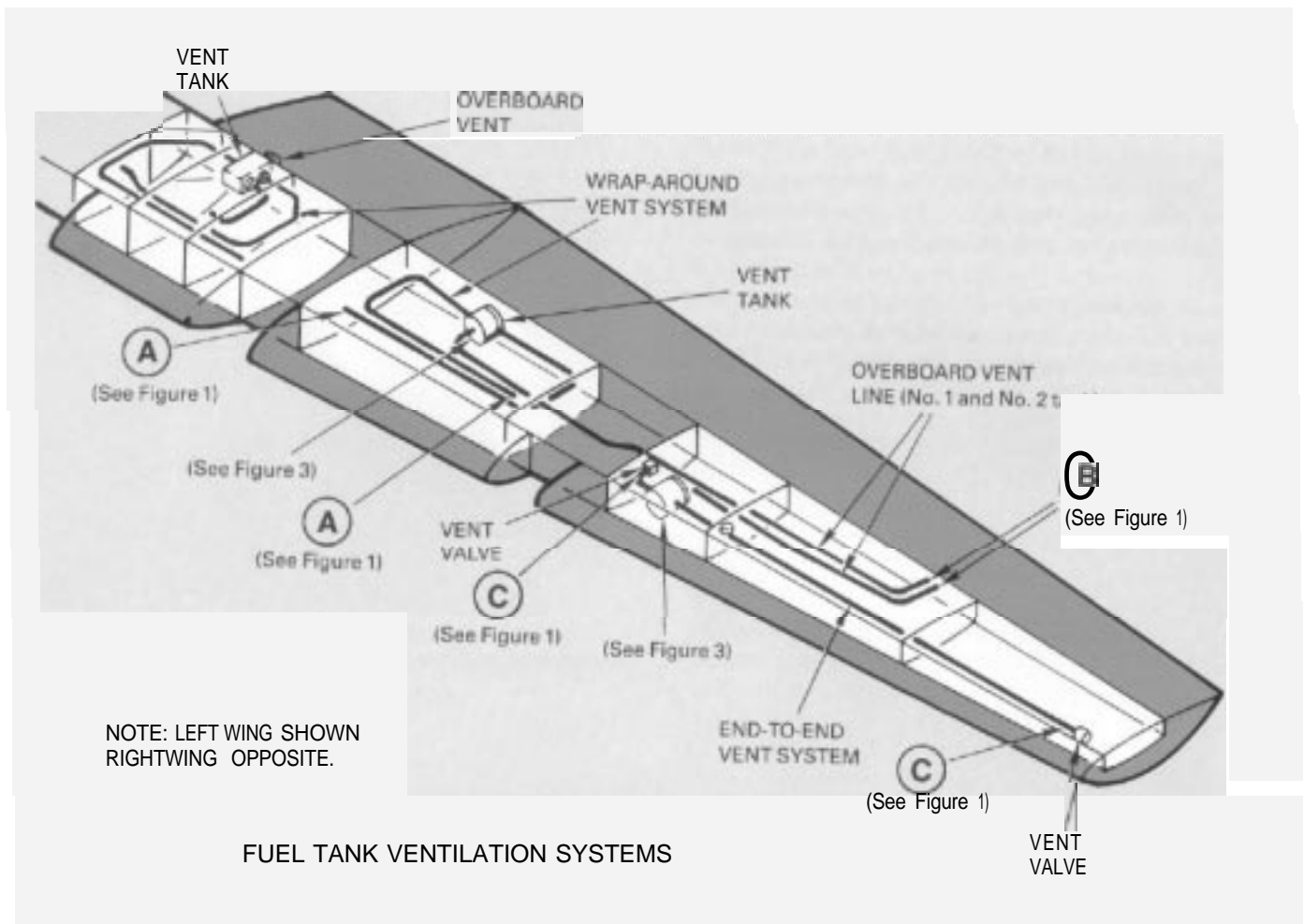


Figure 1. Locally manufactured items used in pressurization of the vent system.

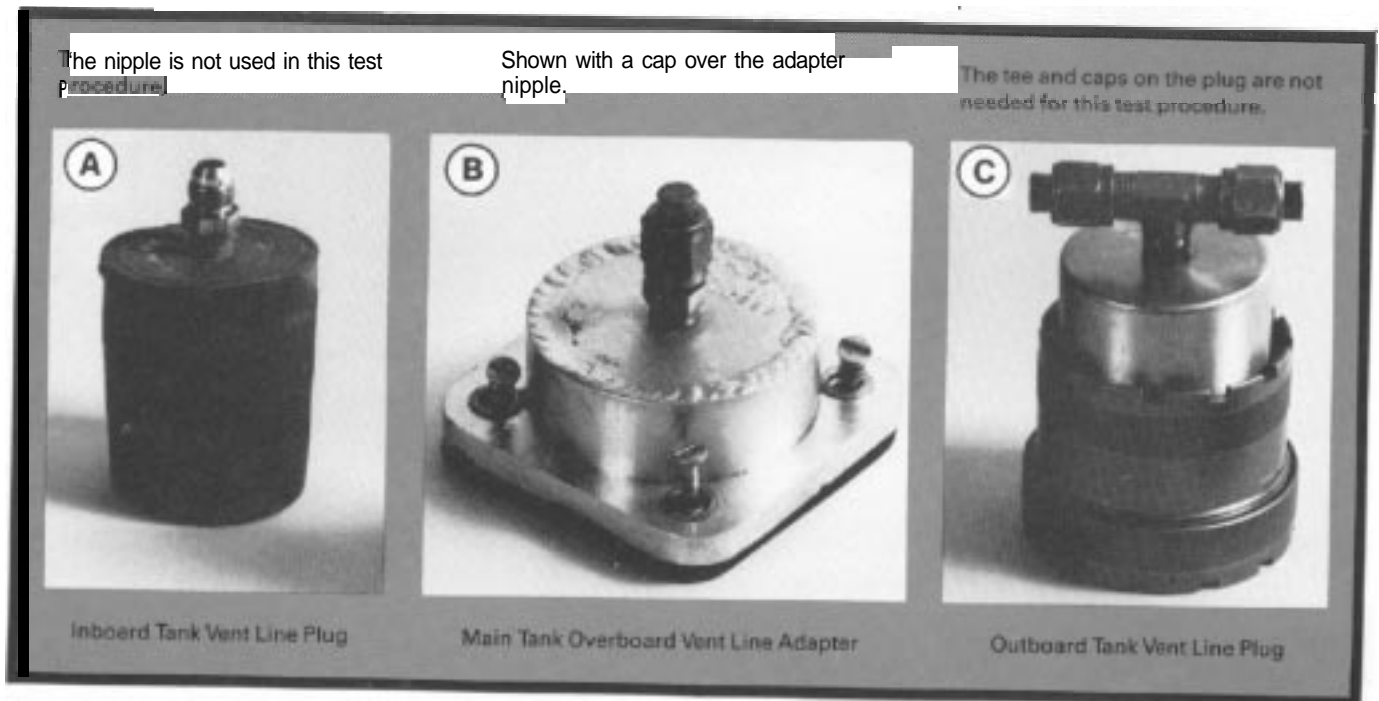
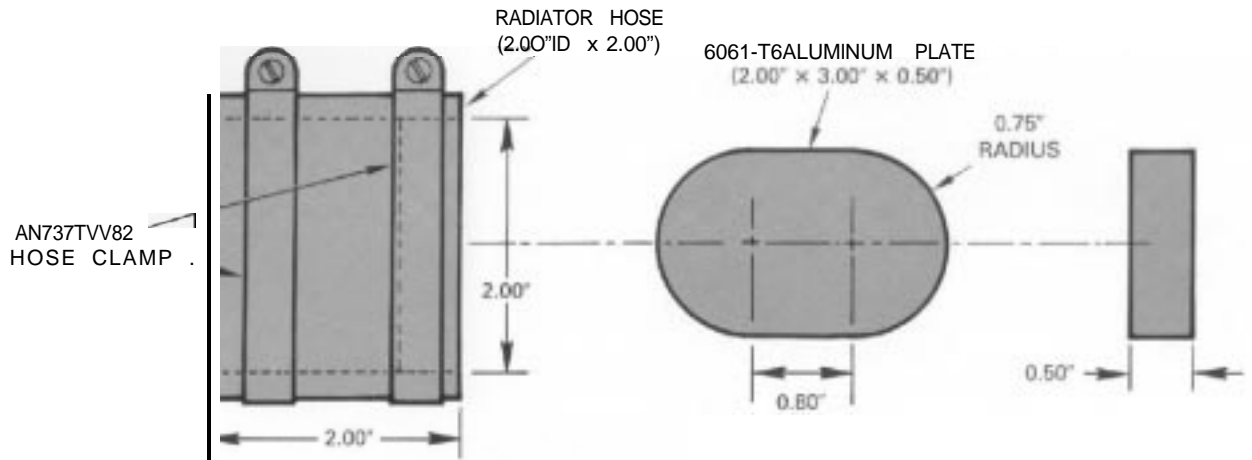


Figure 2. Inboard tank vent line plug.



### PRESSURIZING THE SYSTEM

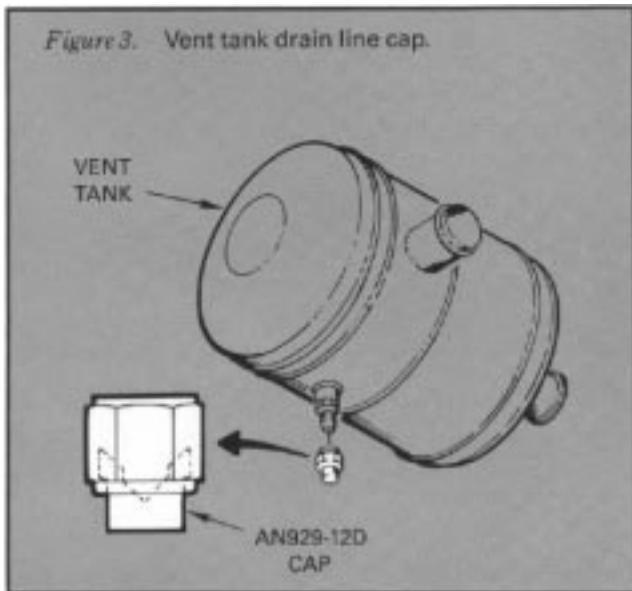
To pressurize the vent system of an inboard or outboard main tank, an AN929-12D cap is needed, and an adapter and plugs will have to be locally manufactured.

#### Inboard Tanks

An inboard tank will require two identical plugs (Figure 1A), each of which can be made as follows. Fabricate an oval-shaped aluminum plate (as shown in Figure 2), and insert it into a short length of rubber hose or tubing (such as an automobile radiator hose) that will withstand a pressure of 10 psi. Seal the mating surfaces per best shop practice to hold a minimum air pressure of 5 psi and secure it with an AN737TW82 clamp.

To install the plugs on the inboard tank vent system, simply slide the hose end of one of the plug assemblies over each of the two vent line openings inside the tank and tighten with another AN737TW82 clamp. Be careful not to crush the vent line while tightening the clamp.

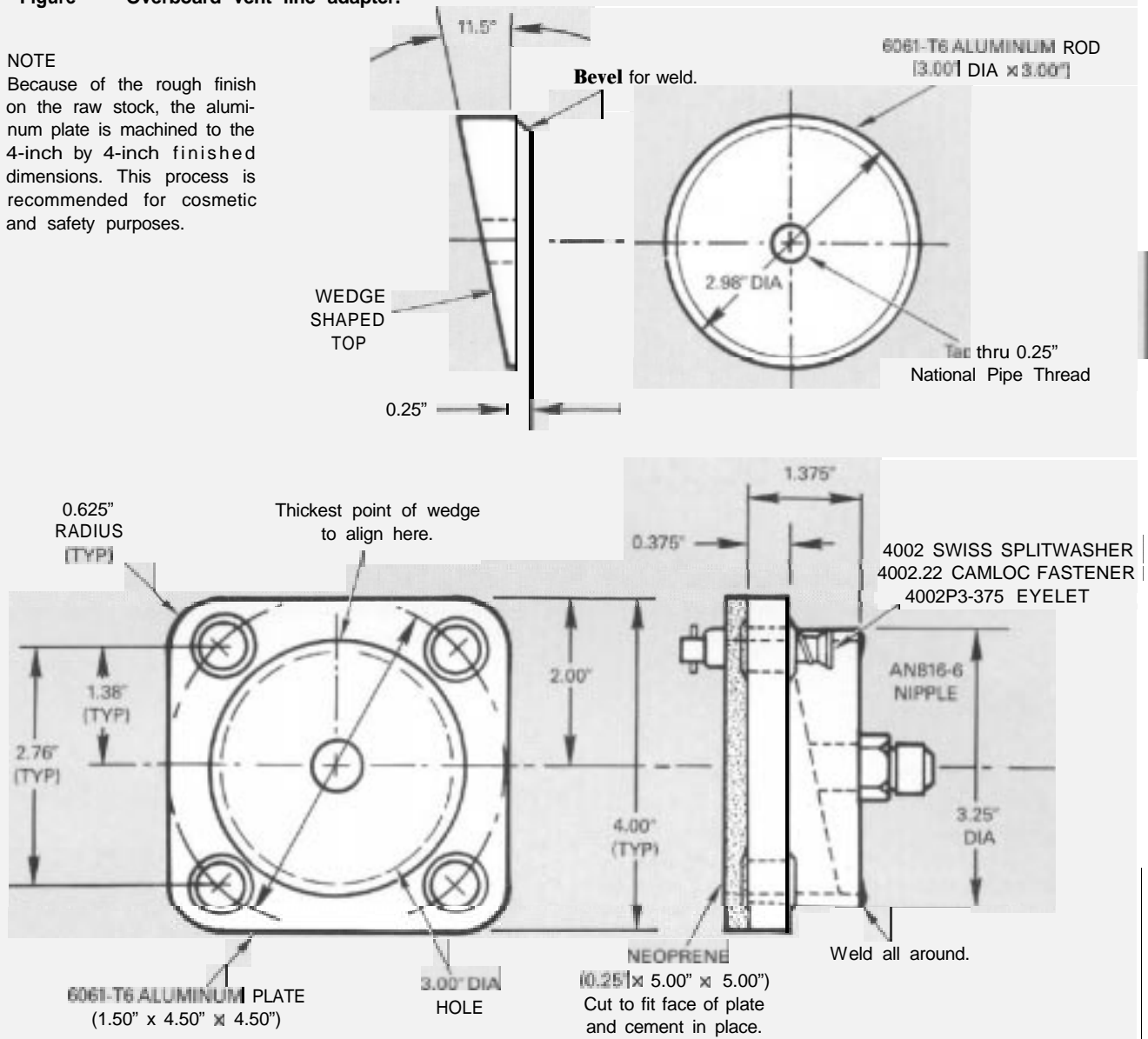
An obstruction in the vent system can cause serious damage to the tanks-see Figure 6.



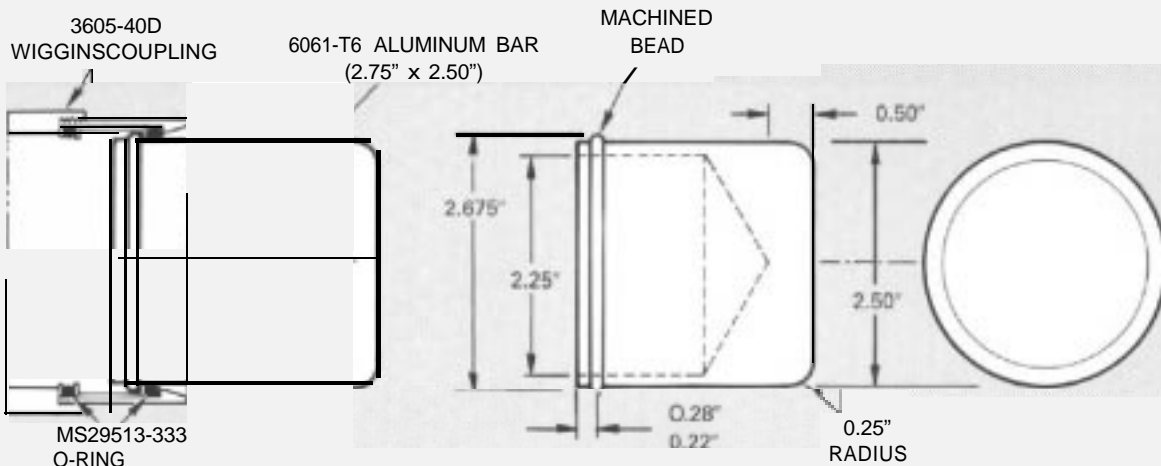
**Figure Overboard vent line adapter.**

**NOTE**

Because of the rough finish on the raw stock, the aluminum plate is machined to the 4-inch by 4-inch finished dimensions. This process is recommended for cosmetic and safety purposes.



**Figure Outboard tank vent line plug,**



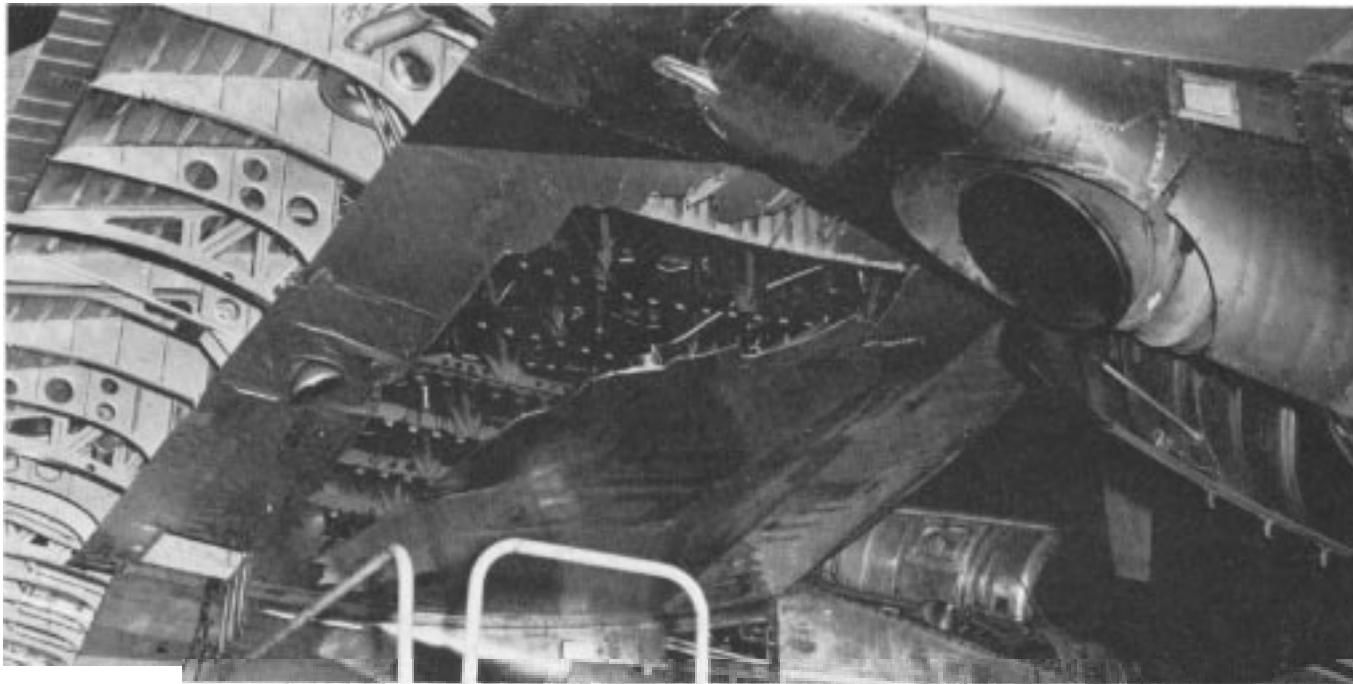


Figure 6. A plastic bag left in the vent system caused this tank to rupture during refueling.

When the plugs are in place, disconnect the line between the vent tank and the ejector or ductor system and cap the opening at the bottom of the tank with the AN929-12D cap (Figure 3).

An adapter (Figure 1B) equipped with a nipple that will accept an air line fitting must be installed over the outlet of the overboard vent line. To manufacture this, machine an aluminum plate to the specified dimensions (see Figure 4) and insert a camlock in each corner. Install the wedge-shaped top, with the thickest point centered between any pair of camlocks.

Weld the contact area between the plate and the top, keeping in mind that the mating surfaces must be airtight. Install the AN816-6 nipple, then glue a Y-inch neoprene gasket to the bottom of the plate.

Pressurize the vent system to approximately 3 psi and allow five minutes for temperature stabilization. During the next 20 minutes, no leakage should occur. If the pressure decreases, indicating that leakage is present, brush the vent tank and all couplings with a leak detector solution to locate the leaking coupling or cracks.

### Outboard Tanks

An outboard main tank will also require the AN929-12D cap, the adapter, (Figure 1B) and two plugs (Figure 1C); the plugs must be fabricated as follows.

Machine an aluminum bar to the dimensions given in Figure 5, carefully forming a bead. To install on the tank ventilation system, remove the clamp securing vent system tubing at outer wing station 526.8. Disconnect the Wiggins coupling just inboard of the vent valve and lower the vent line. This should allow room to install the first plug. Now disconnect the coupling outboard of the inboard vent valve, and then install the second plug. Pressurize the system and check for leaks as above.

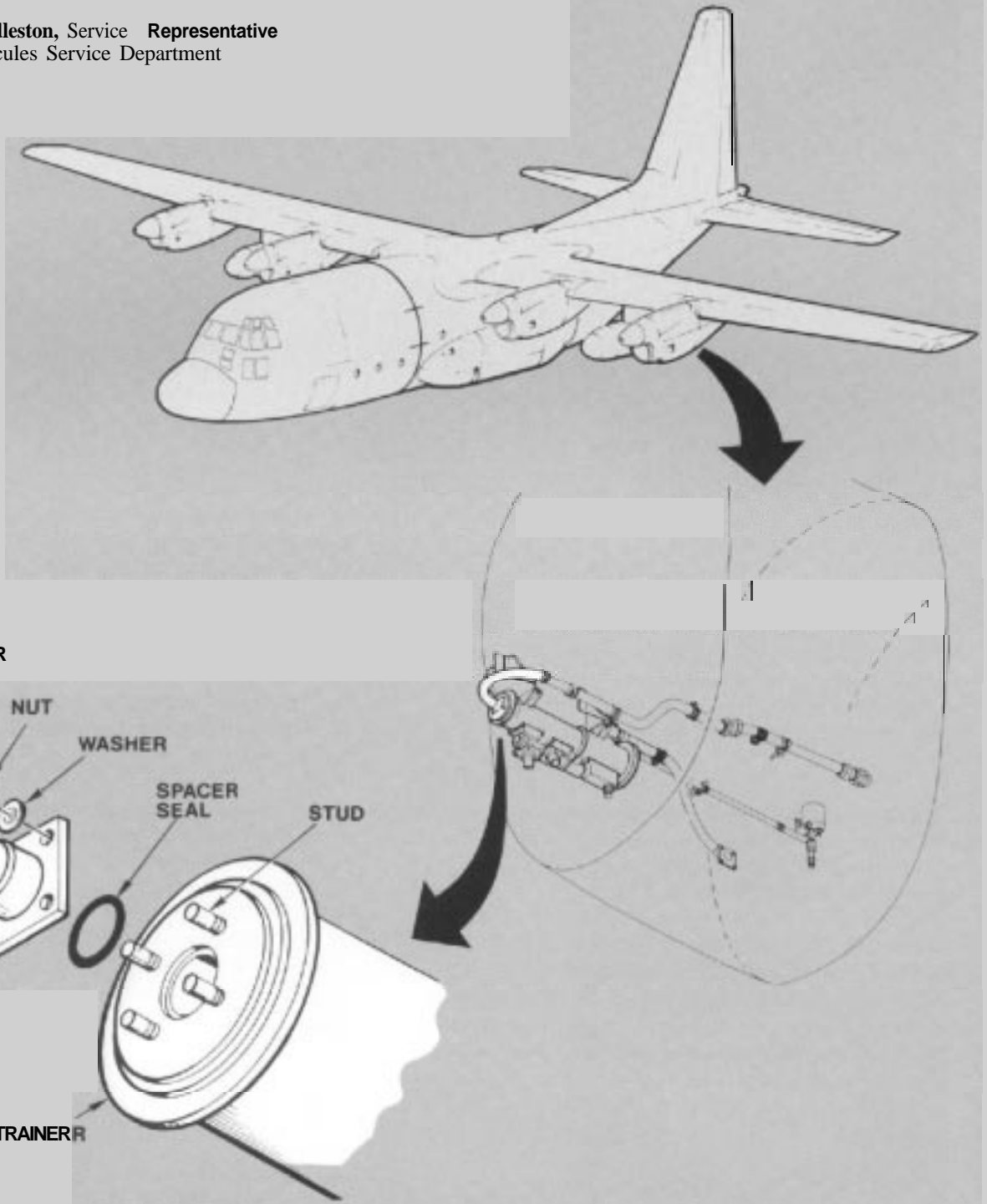
After any problem areas have been located, reduce pressure to atmospheric; remove the cap, plugs, and adapter, and restore the vent system to normal. When repairs have been completed, visually inspect the vent system before tank closure and before refueling. Figure 6 shows what may happen if anything is left in the line that can plug the system.

The efficient use of fuel is on top of everyone's list. The solutions offered here for overboard venting should help save precious fuel and help avoid the safety hazards that fuel spills invariably entail.

**SERVICE  
NEWS**

# Fuel Strainer Inlet Assembly Installation

by **T. E. Huddleston**, Service Representative  
C-130/Hercules Service Department



**Figure 1.** Connecting the fuel strainer inlet tube to the engine fuel heater and strainer.

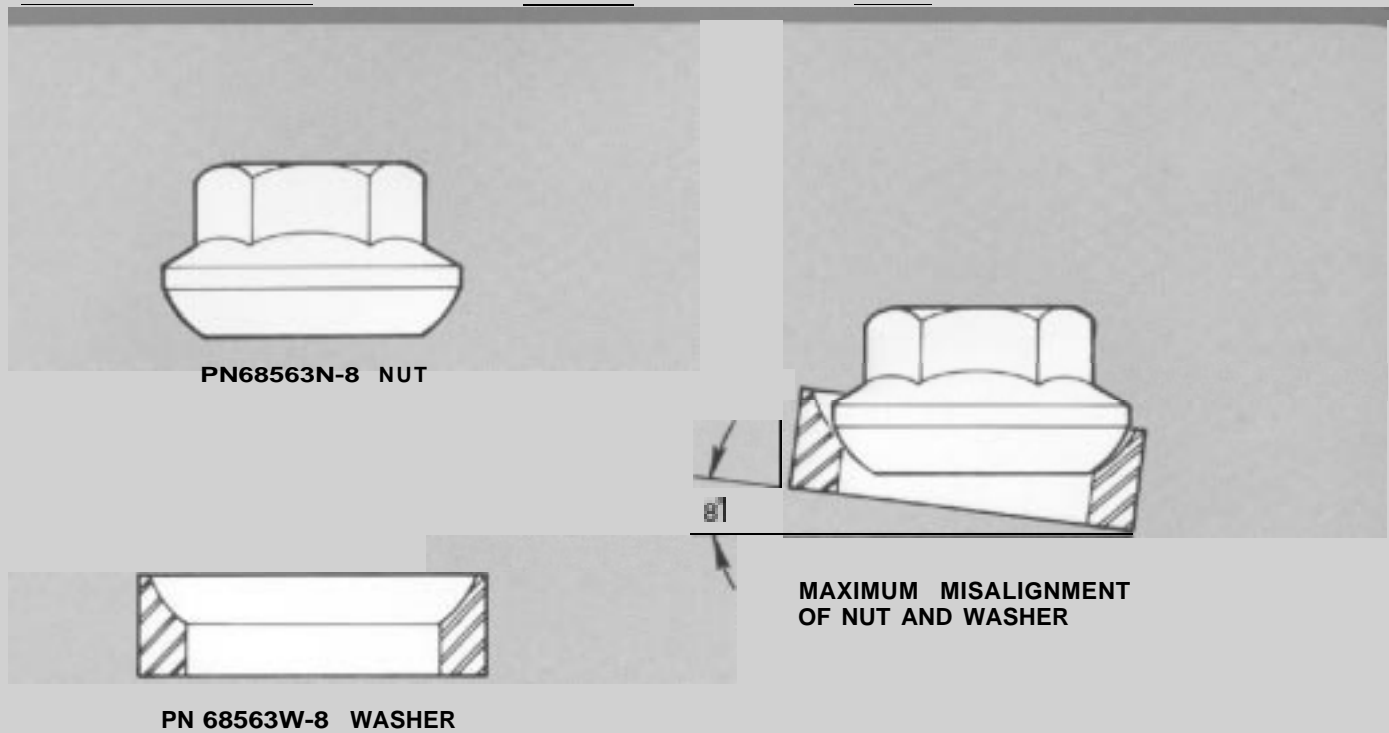


Figure 2. Self-aligning swivel-base nut and washer.

When the fuel strainer inlet is connected to the engine fuel heater (Figure 1), it is important that appropriate care be used in tightening the retaining nuts.


Reports from the field indicate that excessive torque is sometimes used to tighten the four inlet assembly retaining nuts against the clamp flange of the tube assembly, deforming the clamp flange and causing the studs on the fuel heater to bend outward.

Deformation of the clamp flange can result in a mismatch between the clamp flange and the machined end of the tube, requiring replacement of the tube inlet assembly. Since the presence of a deformed clamp flange usually also means that the fuel heater studs have been bent out of alignment, disassembly of the affected components can be difficult.

Be sure to review the correct procedure in the authorized maintenance manual before attempting to connect the fuel inlet tube assembly to the engine fuel heater and strainer. It is particularly important that the retaining nuts be installed on the studs of the engine fuel heater to 25-35 inch-pounds of prevailing torque, and that the torque values be measured with a torque wrench certified to be accurate.

Self-aligning swivel-base nuts and washers can also help. Lockheed Engineering recommends that PN 68563N-8 swivel-base nuts and PN 68563W-8 washers conforming to MIL-N-25027 (see Figure 2) be considered for use in place of the original nuts to reduce the tendency of the fuel heater studs to bend in response to deformation of the strainer assembly clamp flange.

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