AIR TRAINING COMMAND

STUDENT STUDY GUIDE

OZR1821D/3121D-I-5

MISSILE AIRFRAME

19 June 1963

RESPONSIBLE AGENCY OF ATC

SHEPPARD TECHNICAL TRAINING CENTER
SHEPPARD AFB, TEXAS

DESIGNED FOR ATC COURSE USE ONLY

ABOUT STUDENT STUDY GUIDES AND STUDENT WORKBOOKS

Student study guides and student workbooks are designed by the Air Training Command as student training publications for use in training situations peculiar to courses of this command. Each is prepared for a particular Unit of Instruction as reflected in the course syllabus.

The **STUDENT STUDY GUIDE** *contains the specific information required in the Unit of Instruction or it will refer to other publications which the student is required to read. It contains the necessary information which is not suitable for student study in other available sources. The material included or referred to is normally studied either outside the classroom or during supervised study periods in the classroom. Also included are thought-provoking questions which permit self-evaluation by the student and which will stimulate classroom discussion.*

The **STUDENT WORKBOOK** *contains the specialized job procedures, important information about the job, questions to be answered, problems to be solved and/or work to be accomplished by the student during the classroom/laboratory, airplane/missile/equipment activity. It serves as a job sheet, operations sheet, mission card, check list or exercise to be performed during classroom or laboratory periods. Also included are questions which will aid the student in summarizing the main points of the Unit of Instruction.*

The **STUDENT STUDY GUIDE AND WORKBOOK** *is a training publication which contains both student study guide and student workbook material under one cover.*

Since this publication is DESIGNED FOR ATC COURSE USE ONLY and must not conflict with the information and/or procedures currently contained in Technical Orders or other official directives, it is updated frequently to keep abreast of changes in qualitative training requirements. Students who are authorized to retain this publication after graduation are cautioned not to use this material in preference to Technical Orders or other authoritative documents.

Missile Launch/Missile Officer (SM65E/F)
Atlas E/F Branch
Department of Missile and
Space Training
Sheppard Air Force Base, Texas

OZR1821D/3121D-I-5
Student Study Guide
5 June 1963

MISSILE AIRFRAME

INTRODUCTION

The Atlas missile airframe is that metal structure which supports and imparts velocity to the re-entry vehicle, contains the propellants necessary to produce thrust, and forms the basic framework to which controlling air-borne subsystems may be attached. It is divided into three sections: The re-entry vehicle adapter, the tank section, and the booster section.

The Atlas is designated as a one and one-half stage missile because it operates on a principle that compromises between the one stage and the two stage design. It carries one set of propellant tanks which form the longest part of the airframe. These two tanks contain about 30,000 gallons of propellants to be supplied to the five rocket engines (Figure 1). The sus-tainer and two booster engines furnish most of the thrust at launch, providing almost 390,000 pounds of thrust to lift the missile. Two vernier engines provide slight additional thrust, but are furnished primarily to give roll control during sustainer stage and to make final trajectory - velocity adjustments after sustainer cutoff.

Two propellants, liquid oxygen (LOX) and RP-1 (a hydrocarbon rocket propellant similar to JP-4), are used in the Atlas' Rocketdyne propulsion system. These are contained in the two integral propellant tanks which make up the basic airframe. The LOX tank is located forward of the RP-1 tank and contains 18,000 gallons. The RP-1 tank contains over 11,000 gallons.

REFERENCE SYSTEMS

Three reference systems are employed to facilitate location of missile components. They are stations, quadrants, and axes (Figure 2).

Stations

Station numbers are the arbitrary means employed to locate points along the length of the airframe. They are numbers corresponding to the distance

This publication replaces OZR1821B/3121B-4-I-5, dated 13 June 1962.

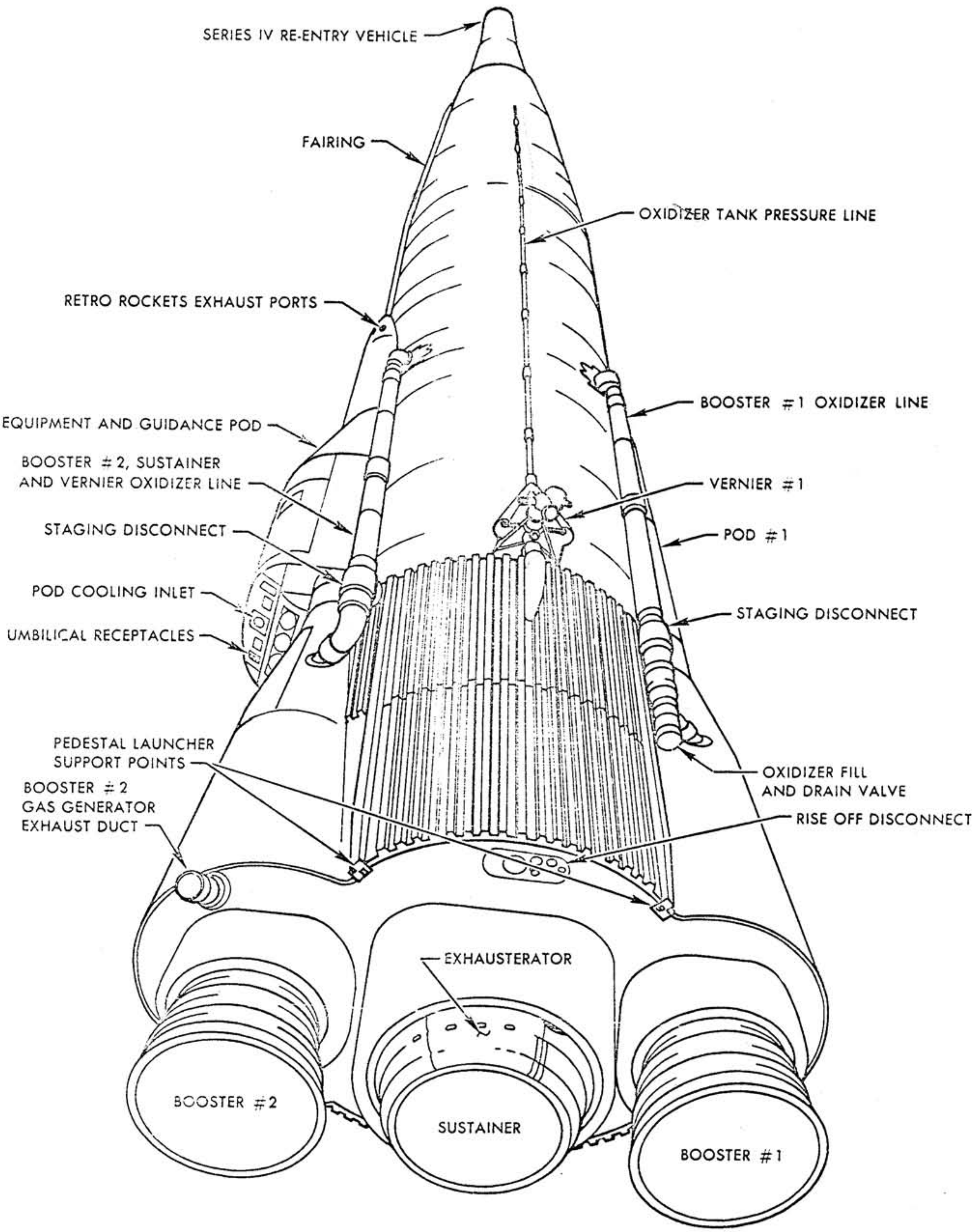


Figure 1 - Atlas Missile SM-65F

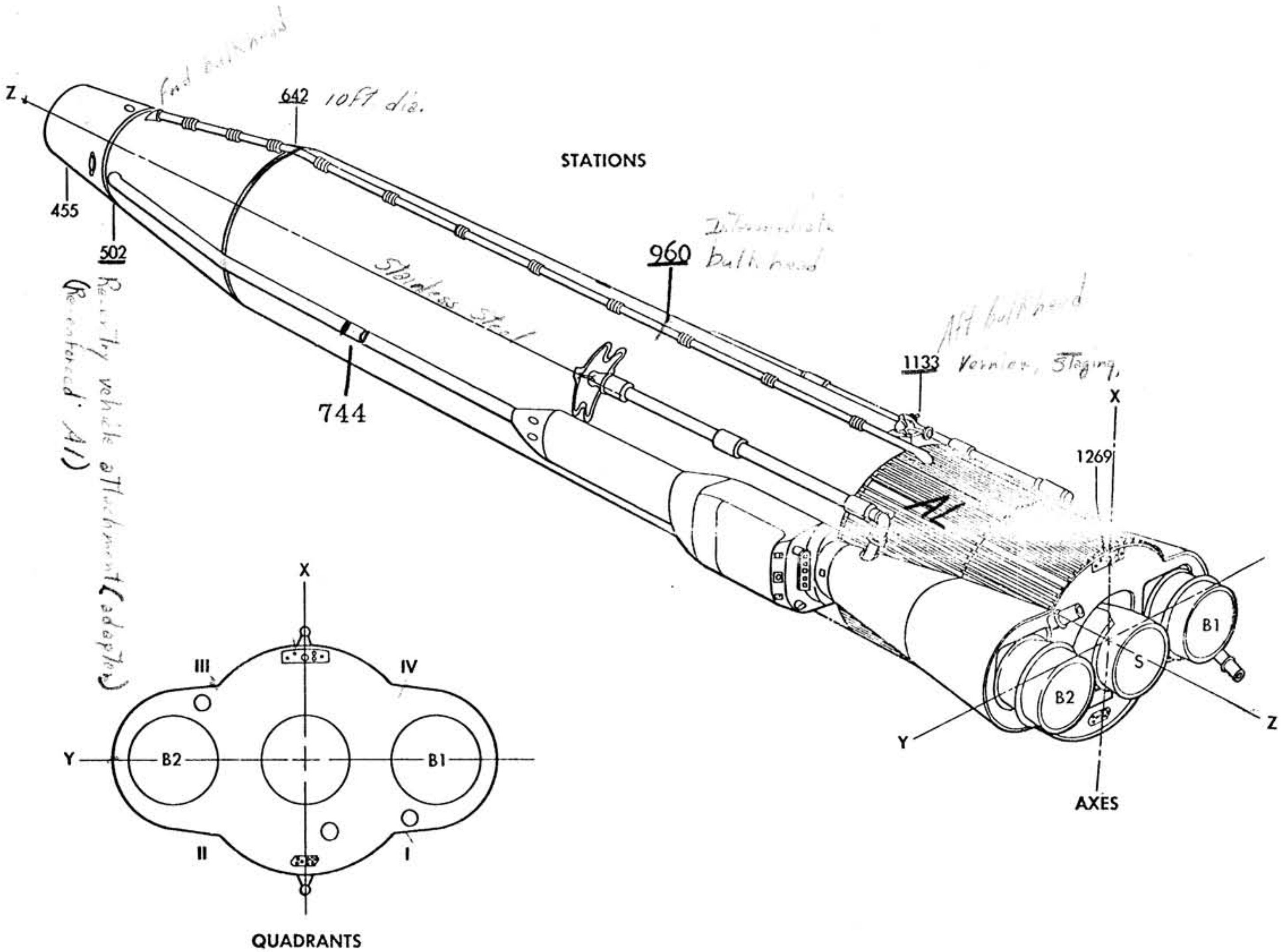


Figure 2 Missile Reference Systems

in inches from the arbitrary zero point which is far ahead of the foremost missile hardware. Important stations are shown in Figure 2.

Axes

The missile is further divided into sections for study and work projects by three orthogonal axes - the X, Y, and Z axes. The Z axis is the longitudinal axis of the missile. The Y axis seems, from the rear, to pass through the booster engine gimbal bearings, and the X axis seems to pass vertically through the vernier and sustainer engines. Of course, all axes meet at the center of gravity.

Quadrants

The quadrants into which the X and Y axes divide the airframe are designated numerically. When viewing the missile from the rear, Quad I is in the lower right. The other quadrants proceed clockwise, Quad II in lower left, etc.

CONSTRUCTION AND FABRICATION

Equipment Pods

Most missile subsystems, such as the battery, inverter, guidance, autopilot, etc., are mounted in the B-2 equipment pod (Figure 4), a fiberglass fairing which is mounted in Quads II and III at the rear end of the tank section. The rear of this pod contains the missile guidance system components.

The B-1 equipment pod is empty on operational missiles; it contains instrumentation and range safety equipment on research and development missiles.

Re-Entry Vehicle Adapter

The re-entry vehicle adapter is a truncated conical aluminum shell which mounts the re-entry vehicle to the missile (Figures 3 and 5). It tapers from about 4 feet in diameter at station 455 to about 6 feet at the missile interface, station 502. There is a re-entry vehicle cable and boiloff valve access door in Quad IV, and a LOX boiloff exhaust port in Quad II.

Tank Section

The tank section (Figure 3) is constructed almost exclusively

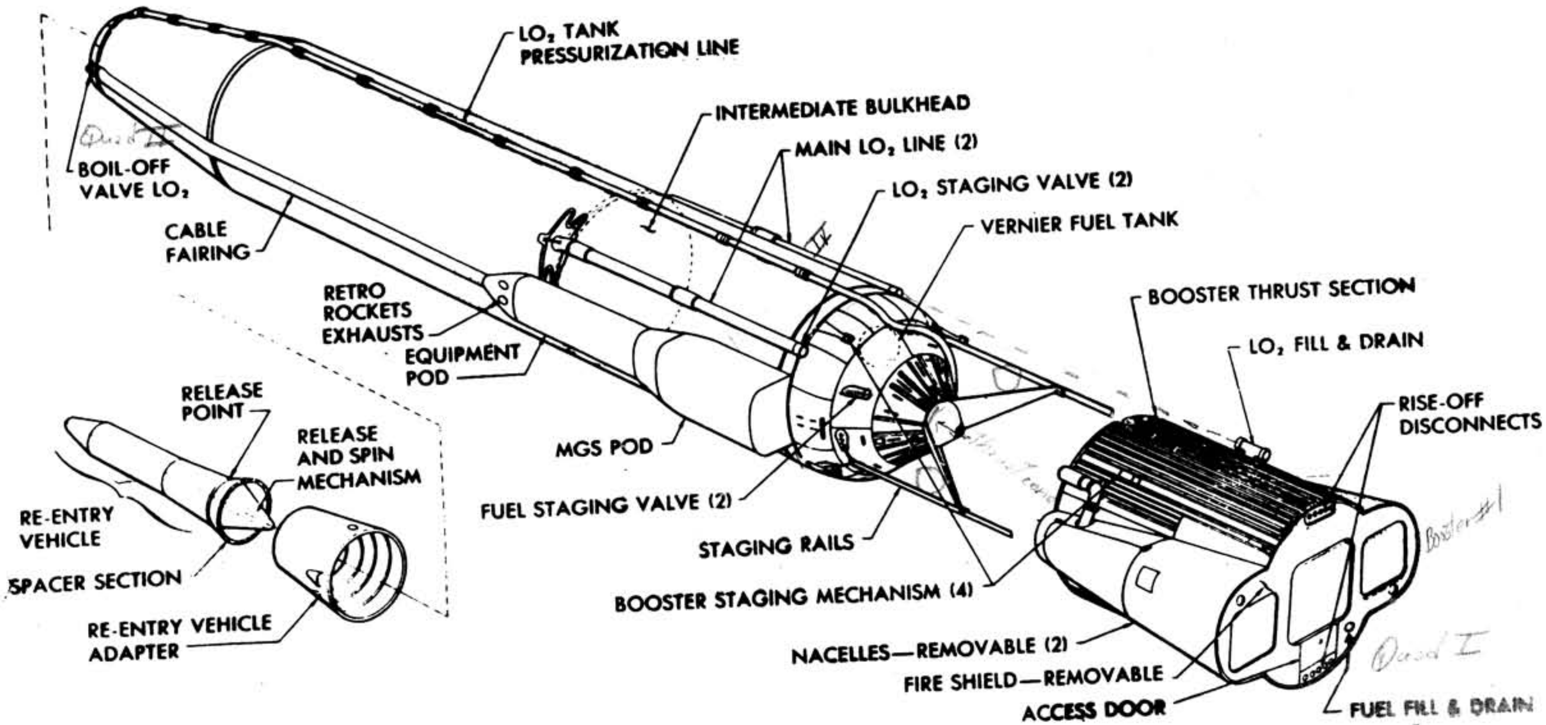


Figure 3 - Airframe Subassemblies

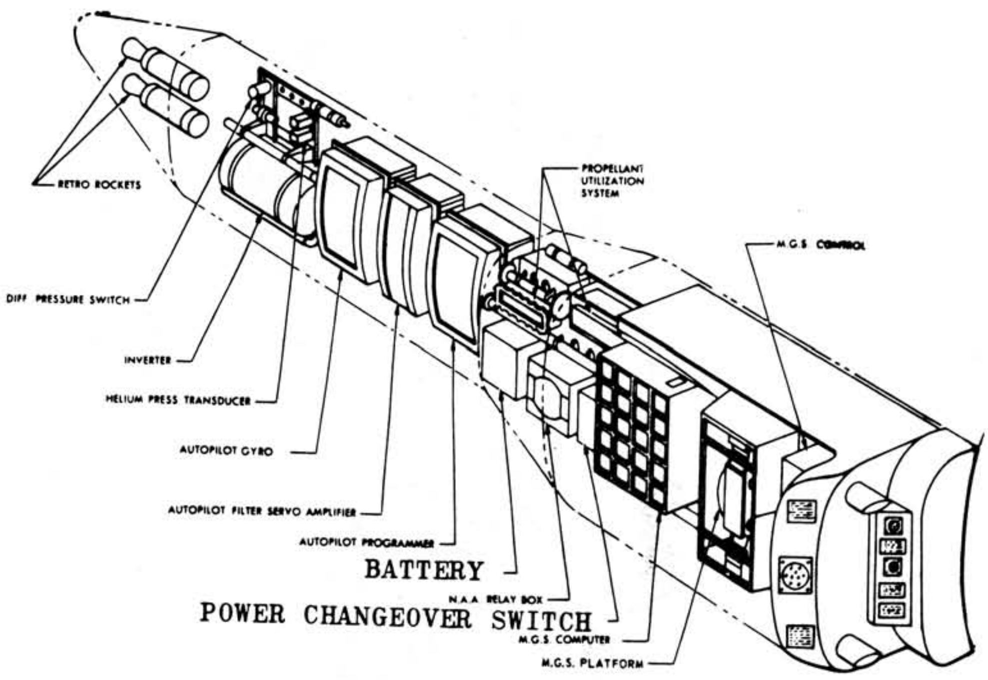
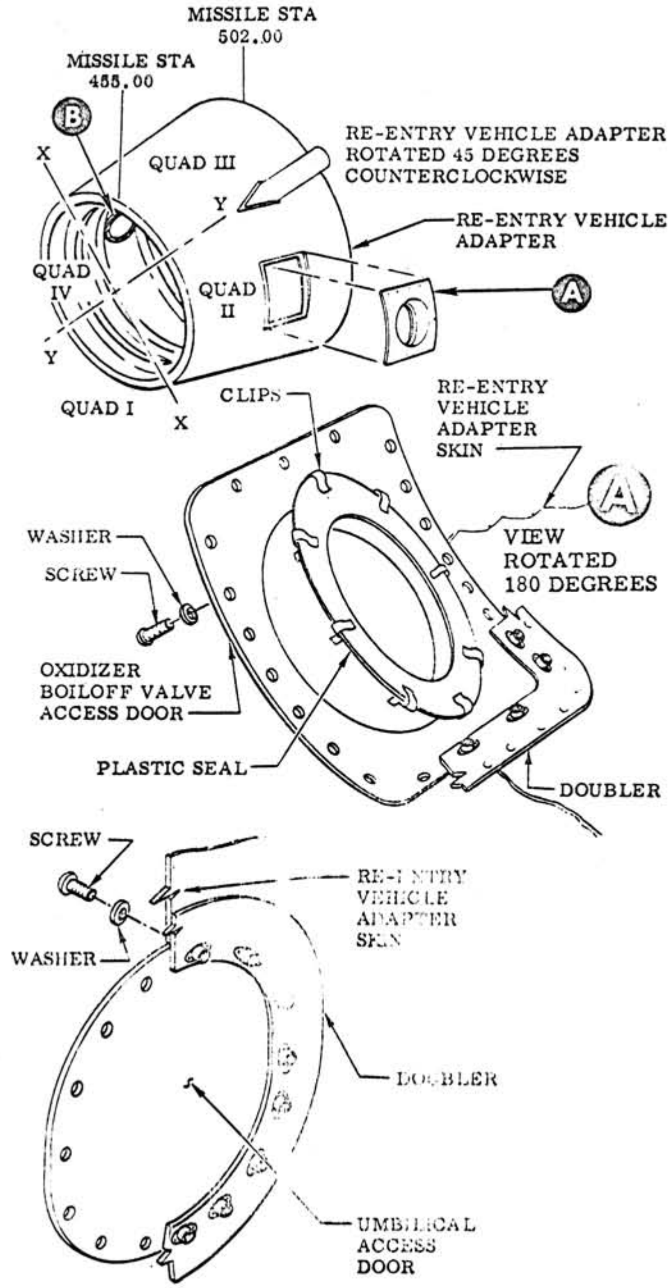


Figure 4 - Equipment and MGS Pod Interface with Missile



40.3-42

Figure 5. Re-Entry Vehicle Adapter Oxidizer Boiloff Valve and Umbilical Access Door Arrangement

of stainless steel. Its monocoque (single shell) construction makes it very light and strong. Its skin thickness nowhere exceeds that of a quarter, and in some places it is thinner than a dime. There are no internal supports in the Atlas airframe. Its strength depends entirely upon the internal pressures which keep its skin taut. Elaborate systems are provided to keep these pressures within prescribed limits and to provide an emergency protection to the tank in case of pressurization loss. This emergency backup is called "stretch", and is provided hydraulically by both the launcher and the missile handling trailer. Between 5,000 and 10,000 pounds of tension may be applied longitudinally to the airframe to maintain its rigidity.

The fabrication of the tank section is an interesting, unique, industrial process. It is essentially a ten-foot diameter welded tube with a tapering forward section. This tank section is constructed by welding strips of stainless steel into hoops which are stove-piped and spot-and-seam-welded into an integral tank skin (Figures 3 and 6). The front end of this tank section is closed off by a forward bulkhead; the LOX and RP-1 tanks are separated by an intermediate bulkhead; and the aft end of the RP-1 tank is closed off by a conical aft bulkhead.

Forward Bulkhead

The forward bulkhead (Figure 6) is constructed of thin stainless steel gore sections which are heliarc butt-welded into an ellipsoidal shape. The bulkhead is seam-welded into the front of the LOX tank taper section at station 502, sealing off the front of the tank. The forward bulkhead contains, at station 480, the LOX boiloff valve and an access door which allows personnel to enter the LOX tank.

Intermediate Bulkhead

The intermediate bulkhead separates the LOX tank from the RP-1 tank. It is an ellipsoidal stainless steel dome, ten feet in daimeter, located between stations 916 and 960.

Aft Bulkhead

The aft conical bulkhead assembly is a welded stainless steel structure composed of the following subassemblies:

1. The thrust ring (Figure 7) is a ten-foot diameter, cruciform cross-section machined stainless steel ring which distributes the thrust of all five engines to the tank skin.

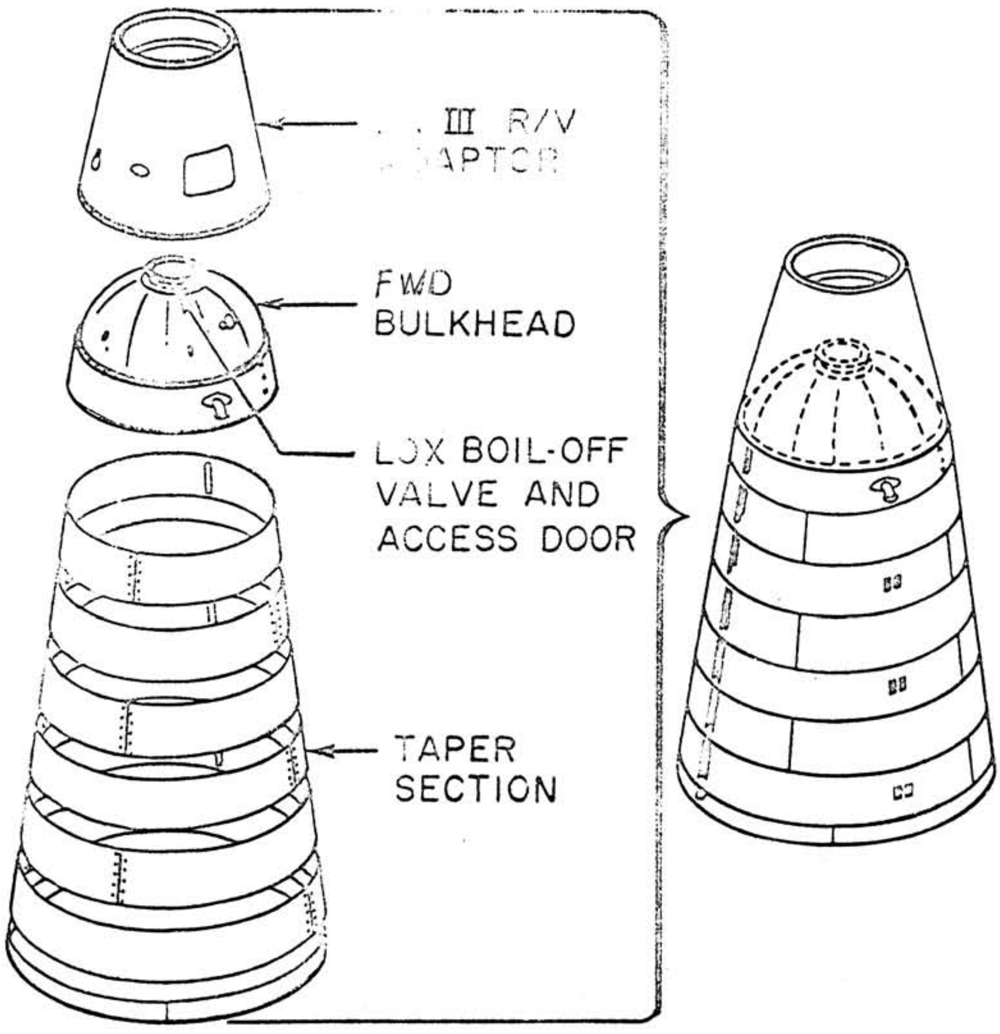


Figure 6 - Forward Bulkhead Assembly

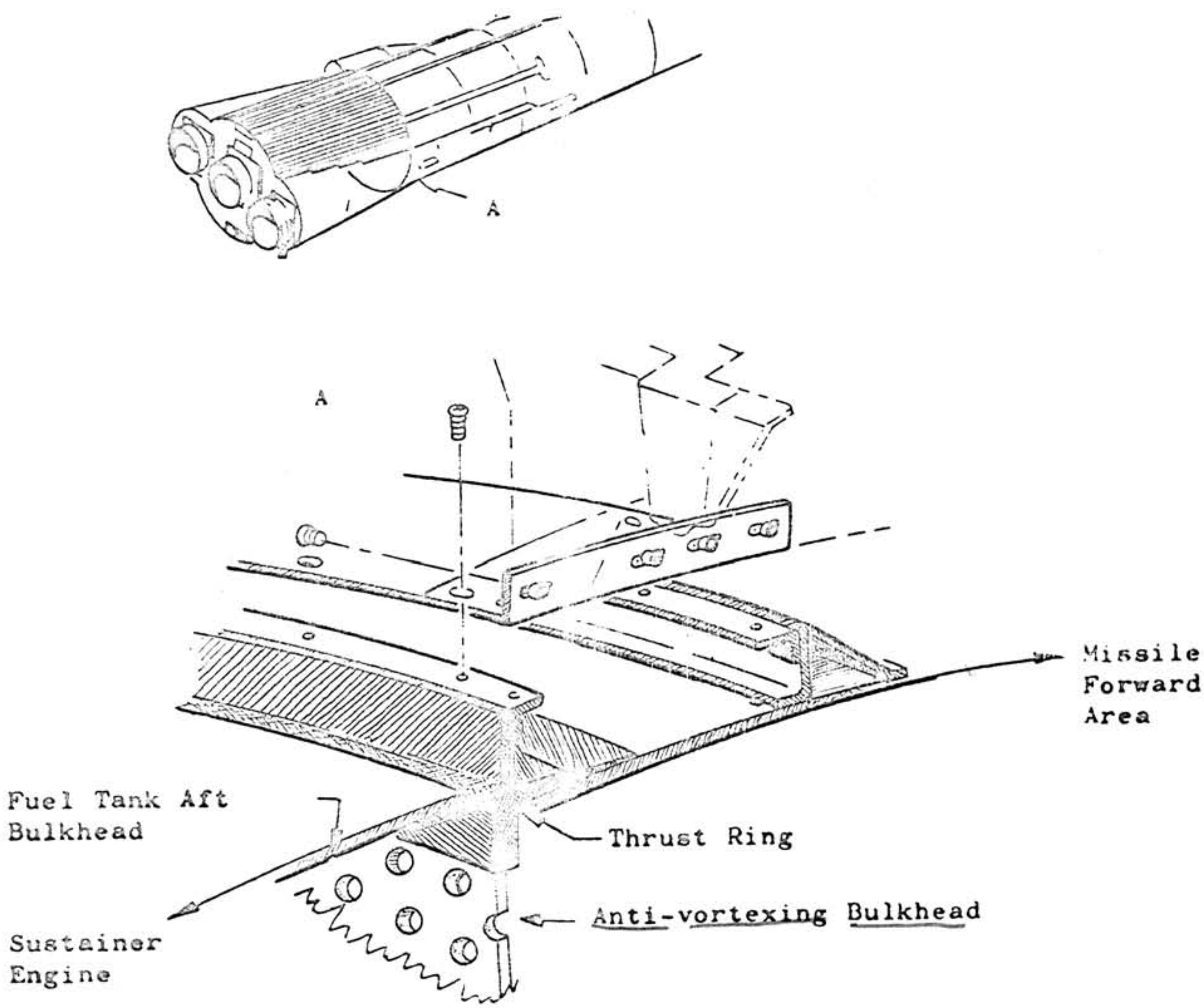


Figure 7 - Thrust Ring and Cableway Arrangement

2. The ellipsoidal gore section (Figure 8) is used to provide a smooth transition from the constant ten-foot diameter to the truncated conical shape that closes off the tank.

3. The intermediate cone (Figure 8) assembly is constructed of stainless steel, using the heaviest gauge skin on the missile. It provides outlet piping for booster engine fuel and an internal mount for the vernier solo fuel tank.

4. The aft cone subassembly (Figure 8) includes the only reinforced skin in the tank section. It is a truncated cone of stainless steel, reinforced by sections of steel spot welded to the outside surface. At the rear of this assembly is a 24 inch bolt ring for attaching the thrust cone (Station 1198).

These subassemblies are welded together as a unit, and the final welding process fastens the thrust ring to the last ten-foot diameter hoop at station 1133.

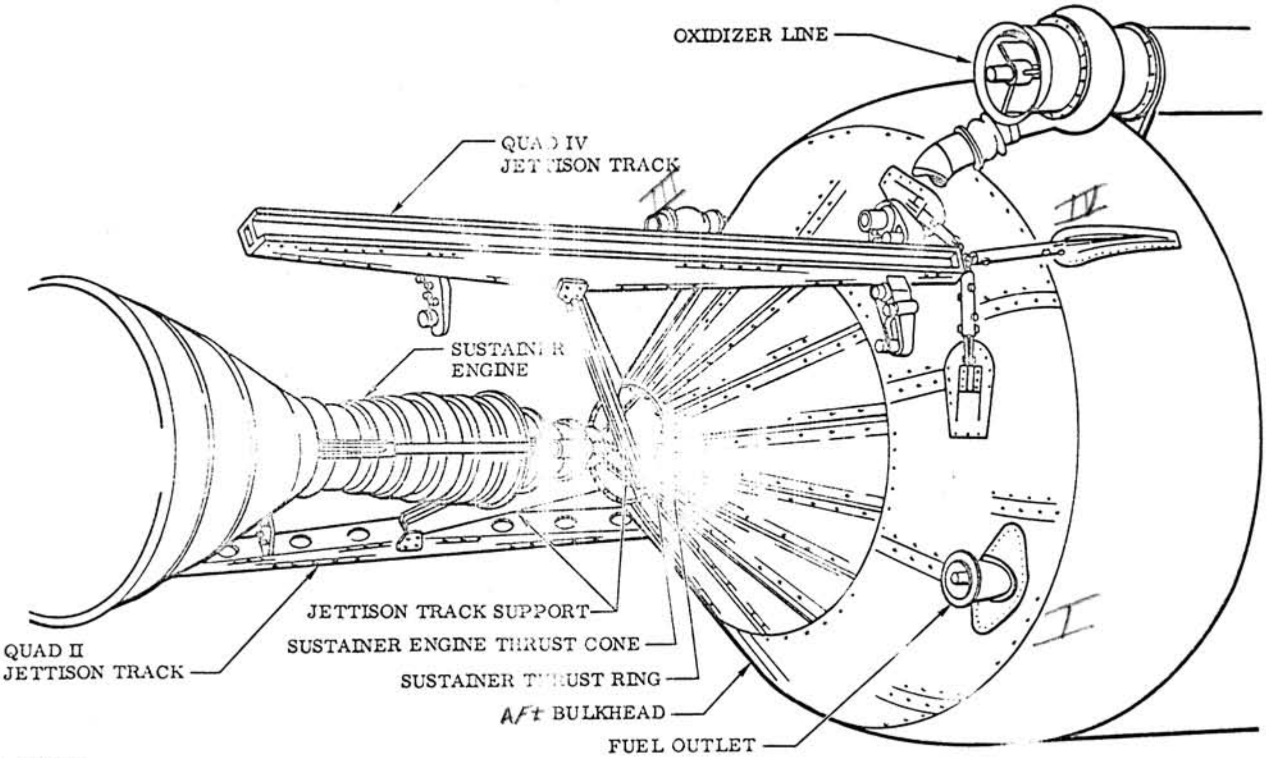
An aluminum forging called the sustainer thrust cone (Figure 8) is bolted to the 24-inch bolt ring mentioned above (Item 4) to provide a mount for the sustainer engine, an access door for the RP-1 tank, and a sustainer fuel supply port.

Flow Control

Two flow control devices are located in each main propellant tank.

In the LOX tank there is an anti-slosh structure. (Figure 9) This structure consists of eleven thin, four-inch wide, ten-foot diameter aluminum rings attached by clips to the tank skin. This structure helps prevent overworking of the flight control system by dampening LOX movement. Aft of the anti-slosh structure there are four vertical baffles mounted approximately 90° apart on the intermediate bulkhead. The baffles reduce vortexing in the LOX tank.

In the RP-1 tank the anti-vortexing membrane bulkhead is bolted to the thrust ring at station 1133. It is a ten-foot perforated aluminum disc which retards whirlpooling (vortexing) in the RP-1 tank, thereby preventing possible cavitation damage to the turbopumps. A two foot perforated disc is bolted to the sustainer thrust cone to reduce vortexing in the sustainer fuel line. This small disc is called the anti-vortex plate (Sustainer thrust cone membrane).



32.123-36

Figure 8. Aft Bulkhead and Jettison Tracks

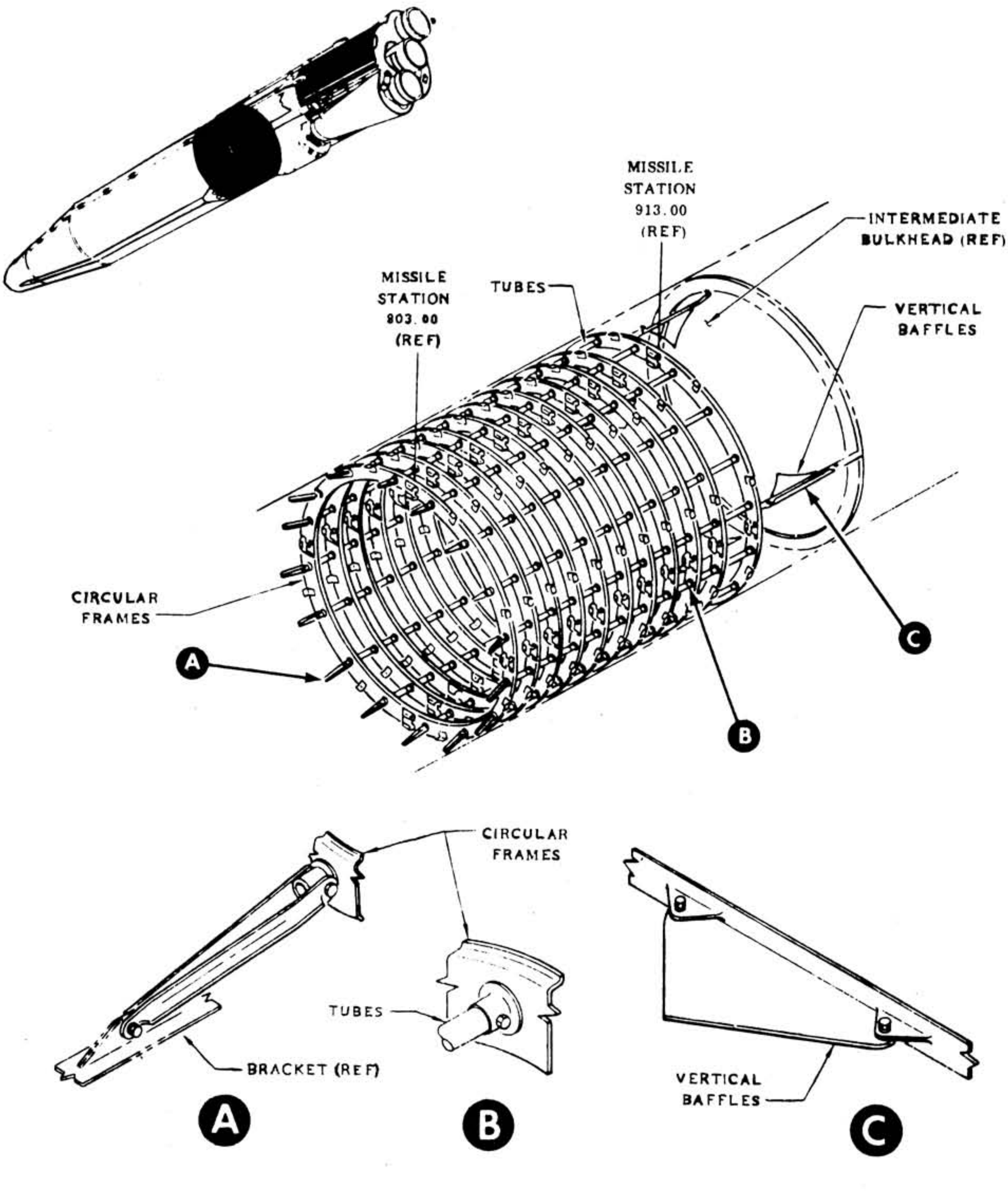


Figure 9 - Oxidizer Tank Baffles

Plumbing

All fluid piping on the Atlas missile is external to the propellant tanks (Figure 10). Outside the skin from station 950 back to the booster turbo-pumps, in Quads III and IV, are two 8-inch tubes carrying LOX to the booster and sustainer engines. A 2 3/4 inch LOX tank pressurization line is located between Quads III and IV. It extends from the booster section to station 506. A 2 1/2 inch RP-1 tank pressurization line is located between Quads I and II. It extends from the booster section to station 965.

Pressure sensing lines and re-entry vehicle electrical cabling are housed on the Quads II and III side of the missile in the re-entry vehicle cableway; a stainless steel half-cylinder extends forward from the B-2 equipment pod to the re-entry vehicle adapter. The pitch and yaw rate gyros are also located in this cableway at station 744.

Booster Section Construction

The booster section (Figure 11) is an aluminum built-up structure, constructed very much like a modern aircraft. Its major components are a thrust cylinder (a ten-foot diameter cylinder built up from three belt frames, four pedestal longerons, two booster thrust longerons, and a reinforced aluminum skin), a fireshield bulkhead, and nacelles. The fireshield bulkhead and nacelles are constructed of aluminum foil honeycomb with bonded fiberglass skins. The booster section houses and mounts the booster engines, all booster engine accessories, and the inflight pressurization system, allowing all excess and expended equipment to be jettisoned at booster staging.

The four pedestal longerons are used to support the weight of the loaded missile and for aligning the missile to the launcher.

This booster section structure distributes the 331,000 pounds of thrust produced by the two booster engines evenly around the thrust ring.

Separation Equipment

The booster section is held onto the tank section by four pneumatically operated latches which release simultaneously at staging (Figure 12) and allow the booster section to slide to the rear along two jettison rails, in Quads II and IV, and drop free without interference between the two sections. Fluid lines which allow flow between the booster and tank sections are separated by quick disconnects which automatically seal upon separation.

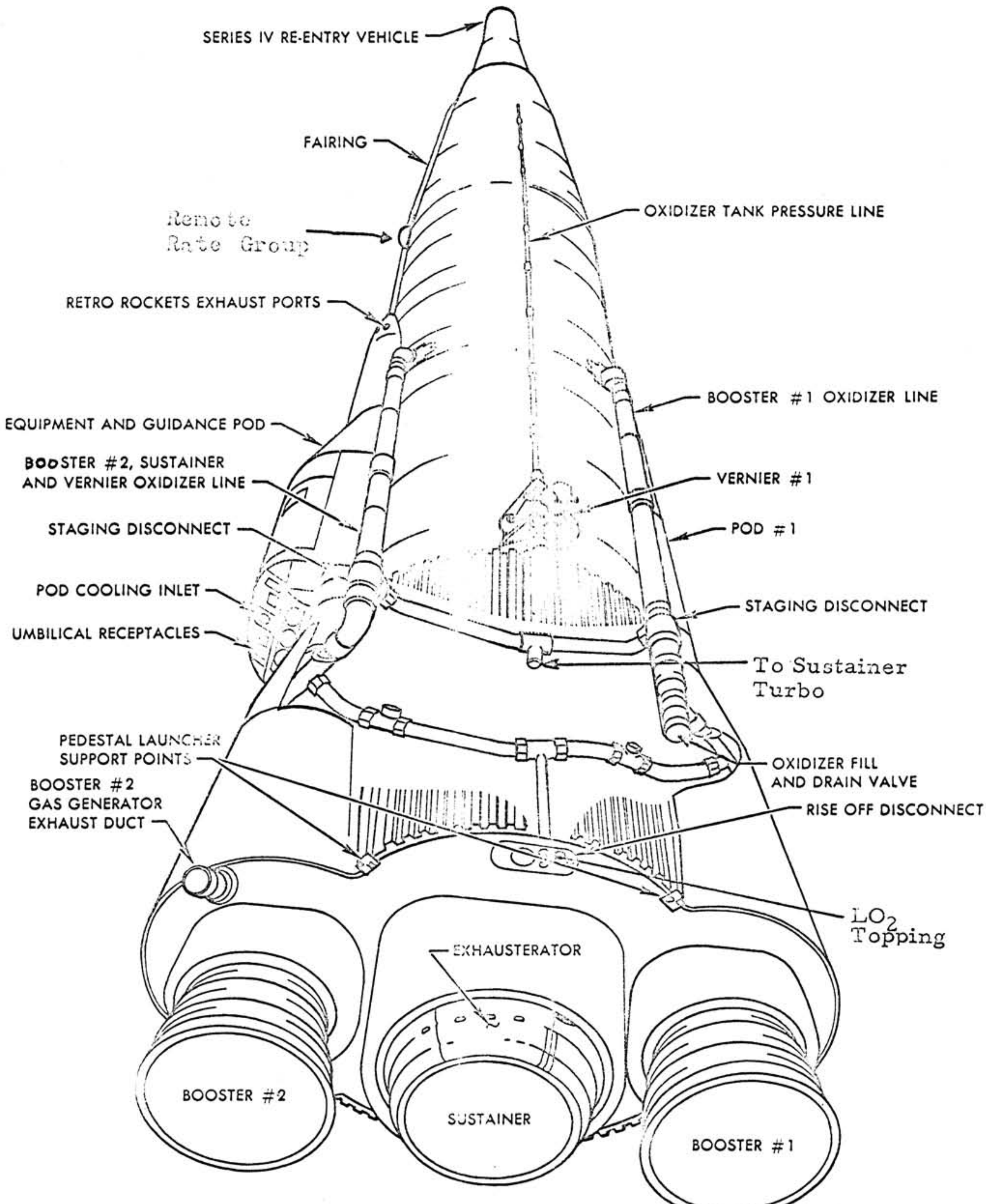
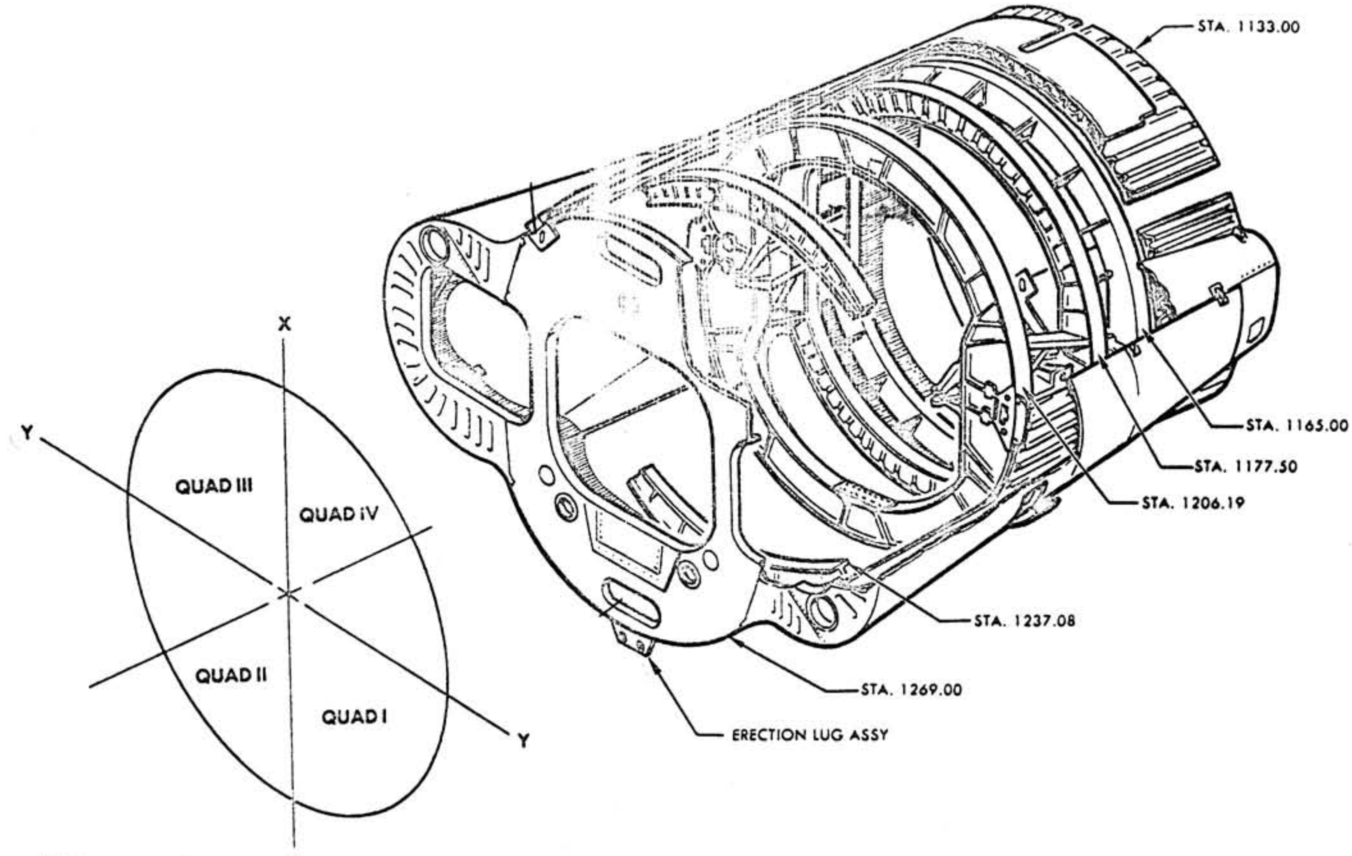
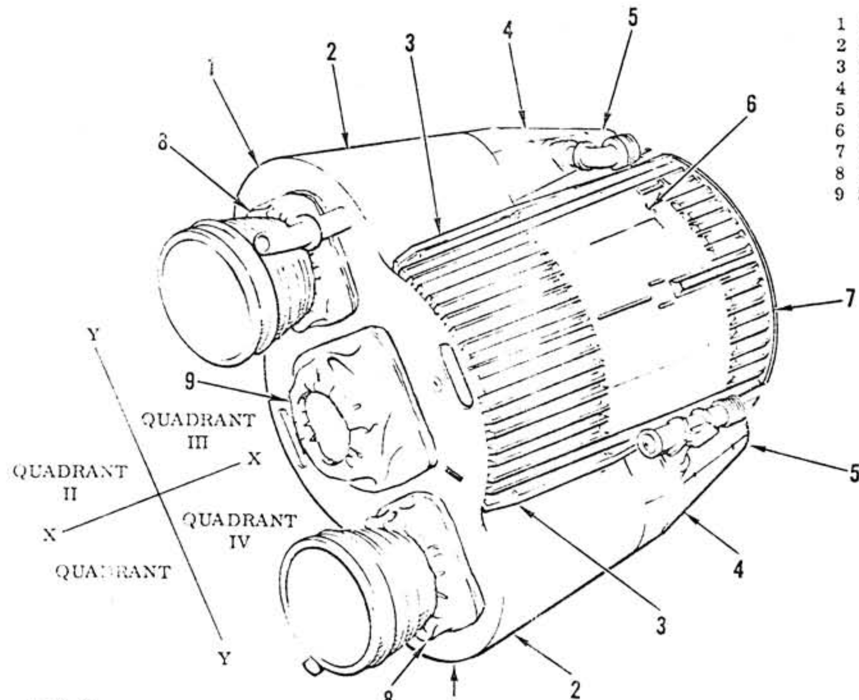


Figure 10 - SM65F Airframe Plumbing



42.2-42A



1 BOOSTER RADIATION SHIELD
2 AFT NACELLE
3 MISSILE SUPPORT LONGERON
4 FORWARD NACELLE DOOR
5 FORWARD NACELLE
6 VERNIER ENGINE RADIATION SHIELD
7 THRUST CYLINDER
8 BOOSTER ENGINE RADIATION BOOT
9 SUSTAINER ENGINE RADIATION BOOT

40.3-36

Figure 11. Booster Section

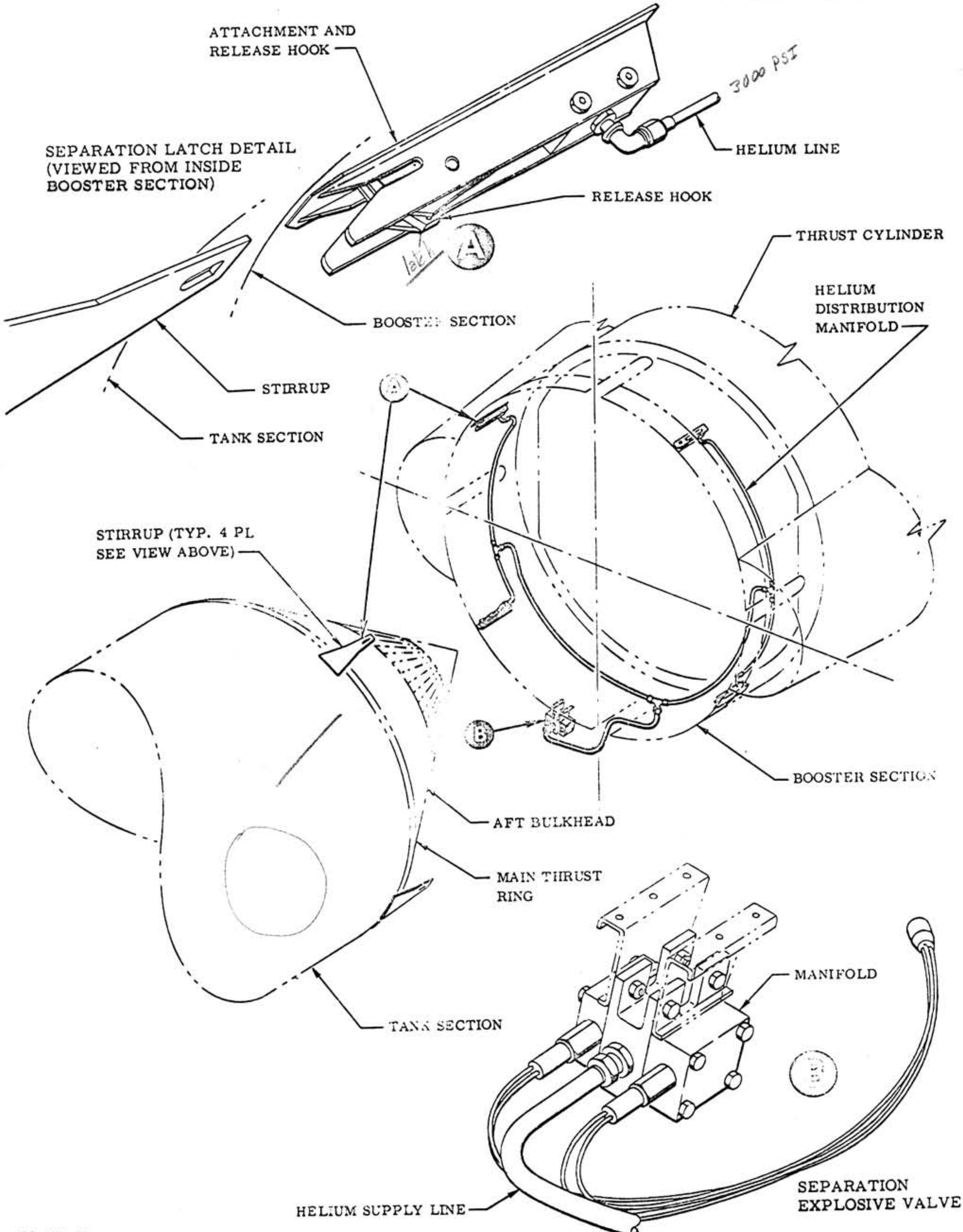


Figure 12. Booster Section Separation System

Missile Aft Support Sockets

Aft support points for the missile are provided by two sockets (Figure 13) machined into the frame at missile station 1206.00. The aft support sockets are located 30 degrees from the Y-Y axis in quadrants I and II. The aft support sockets are used to support the aft end of the missile in the missile semitrailer. The booster section attach fitting located on the missile semitrailer fits into the aft support socket, and the missile is secured to the semitrailer using four quick-release pins.

VERNIER SOLO TANKS

The purpose of these tanks is to furnish propellants to the vernier engines after sustainer engine cutoff. The LOX vernier solo tank is mounted to the Quad IV staging rail and the RP-1 vernier solo tank is mounted inside the aft bulk head in Quad IV.

INFLIGHT HELIUM BOTTLES

The ambient helium bottle is mounted to the Quad II staying rail. Heluim from this bottle is used to operate the staging latches and vernier control valves, pressurize the vernier solo tank, and purge the booster turbopumps.

The shrouded (chilled) helium bottles are mounted to the booster sections. The main purpose for these bottles is for inflight propellant tank pressurization.

MAINTENANCE

It is imperative to keep the missile in a "first readiness" state. To meet this need, it is necessary to perform maintenance on the missile airframe at all times. Maintenance procedures for the missile airframe are as follows:

1. Monitoring missile tank pressures.
2. Propellant tank dew-point measurement.
3. Pressure and leak testing propellant tanks.
4. Missile airframe cleaning procedures.

Monitoring Tank Pressures

During ground transportation the main tanks are pressurized automatically

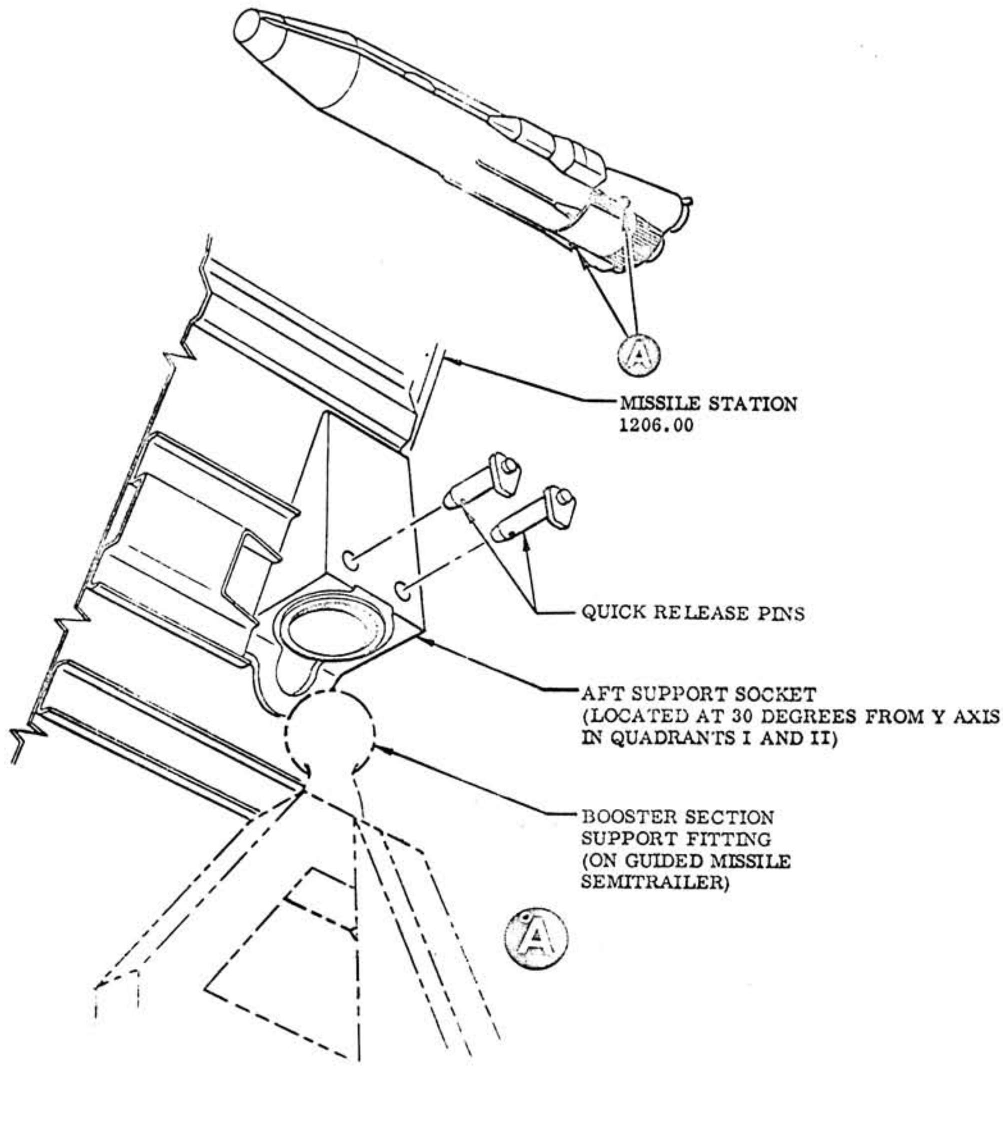


Figure 13. Missile Aft Support Sockets

on gage pressure by the trailer mounted Pressurization Control Unit (PCU). This system will automatically maintain the proper pressures, always keeping more pressure in the fuel tank than in the LOX tank. The supply of GN_2 for this control system is 8 "K" bottles on the forward end of the trailer.

Air Transportation

The missile is not on gage pressure during air transportation. It is switched to absolute pressure, and the missile tank pressure is automatically controlled by the air transportation pressurization control unit (PCU), The unit is monitored constantly during air transport, and has a manual override valve connected to the automatic systems for regulating of tank pressures during climbout and letdown.

Launcher

Pressures maintained in the missile tanks while on the launcher are:

1. 4 PSIG in LOX tank (standby pressure)

2. 12 PSIG in RP-1 tank (standby pressure)

Correcting Propellant Tank Pressures:

1. On the trailer

Correct fuel and oxidizer tank pressure must be maintained on the trailer. If tank pressures are not within prescribed ranges, propellant tank pressures must be corrected.

WARNING

Do not increase propellant tank pressures while unauthorized personnel are in immediate area of missile. Rupture of missile skin may cause injury to personnel.

NOTE

While using pressurization unit manual controls, fuel tank pressure must be at least 2.0 PSI higher than oxidizer tank pressure.

Propellant Tank Dew Point Measurement

The temperature at which the vapor becomes saturated and begins to condense is called the dew point (condensation temperature). The Alnor dew pointer, in conjunction with the Alnor dew point calculator, is used to check the dew point temperature in the propellant tanks whenever the tanks are vented. Dew point temperature in the tanks must be less than 30° F to prevent water vapor from accumulating in the tanks.

Propellant Tank Leak Tests

Fuel Tank

Fuel tank leak tests consist of adding a tracer gas to the fuel tank, setting up the leak detector, performing the leak tests and repressurizing the tanks at the conclusion of the tests. Leak tests are conducted under the following conditions:

1. Malfunctions

2. Acceptance inspections

3. Periodic inspection

Freon 12 gas is stored at the squadron maintenance area (SMA) and is used as a tracer gas in the fuel tank only.

WARNING

Use freon in well ventilated area only. Excessive freon in area may asphyxiate personnel.

A leak test of the fuel tank is accomplished by slightly increasing the missile tank pressure, and introducing "freon 12" gas into the tank. A "sniffer" (a mechanism which will detect freon 12 in the air) probe is passed around all seams of the fuel tank. When freon 12 is detected by the sniffer the area will be marked. After completing the sniffer test a liquid soap test is made in order to pinpoint the leak.

Liquid Oxygen Tank

Freon 12 will not be used to leak test the oxidizer tank because it becomes a solid at liquid oxygen temperatures. This could cause considerable damage to the missile. Liquid soap is used for leak detection.

Leak Testing Intermediate Bulkhead

The intermediate bulkhead shall not be leak tested unless there are definite indications that a leak exists; for instance, continuous dropping of fuel tank pressure accompanied by rising oxidizer tank pressure. If the intermediate bulkhead must be leak tested, the procedure consists of a preliminary leak test, applying stretch to missile, removing the oxidizer tank access plate, locating leaks, performing repair, and reinstalling oxidizer tank access plate.

A preliminary leak test consists of depressurizing the missile oxidizer tanks, disconnecting the pressure line and inserting the sensing tube of the leak detector test gun into the pressure port. If leak test indicates presence of tracer gas, continue with intermediate bulkhead test. If no leak is detected, discontinue tests and return the oxidizer tank to standby condition.

CAUTION

If oxidizer tank is depressurized, tank must be vented to atmosphere. If it is not, temperature change can cause tank to collapse.

A leak test of the intermediate bulkhead is performed by entering the oxidizer tank through the access door. Then, by placing the leak test detector around the entire structure of the intermediate bulkhead and along seams of individual sections , a leak may be detected. If a leak is detected perform the soap test as described in leak test of the fuel tank.

CAUTION

Before entering the oxidizer tank, special clothing and head covering must be worn by personnel to avoid contamination of the tank interior. After completion of tests, oxidizer tank must be left completely clean. Impurities may combine with oxygen to form explosive mixture.

Airframe Cleaning

Preparation for Cleaning

1. Make sure the necessary cleaning materials are available.

2. Be sure proper clothing is available. This will include the following items:

   a. Full face shield

   b. Rubber apron

   c. Oil-resistant boots

   d. Rubber gloves

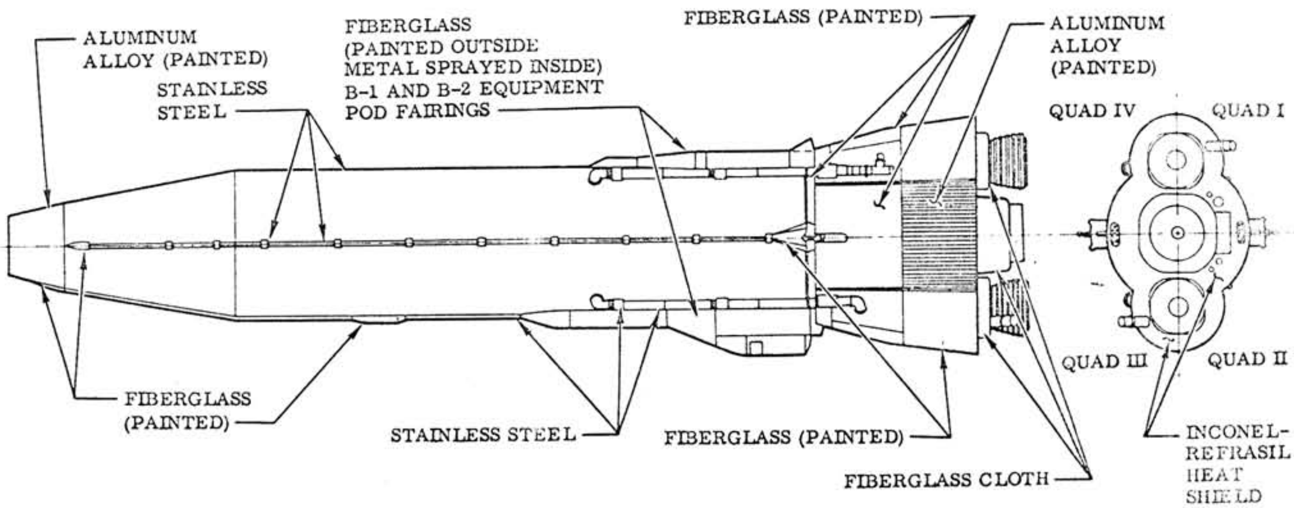


Figure 14. Composition of Missile Airframe Components

Cleaning Stainless Steel Surfaces (Figure 14)

CAUTION

Close all access openings to the missile tank and seal crevices with waterproof tape.

1. Clean all exterior surfaces of the missile tank sections with distilled or deionized water. If large amounts of distilled or deionized water are not available for cleaning, tap water may be used, provided the application is followed by a distilled or deionized water rinse. Dry areas completely after cleaning.

WARNING

Assure adequate ventilation when using trichloroethylene, MIL-T-27602. Use in small quantities and avoid prolonged breathing of vapors and contact with skin to prevent nasal and skin irritation.

CAUTION

Exercise care to prevent trichloroethylene from spilling, dripping, or otherwise coming in contact with painted surfaces. Failure to comply will cause removal of airframe protective coating.

2. Remove exessive soil accumulations from unpainted stainless steel surfaces with trichloroethylene, applied with a clean cloth. Rinse the cleaned surfaces with distilled water and dry with a clean dry cloth.

3. Remove light stains and deposits from cleaned stainless steel surfaces with pumice. After allowing pumice to dry to a powdery state, polish with a dry cheesecloth.

CAUTION

Use of abrasive paper without water or the use of abrasive paper coarser than 600 grit is prohibited. Failure to heed caution may result in damage to equipment.

4. Remove heavy stains and deposits from cleaned stainless steel surfaces with NO. 600 grit abrasive paper and water. After polishing with abrasive paper, wipe area free of residues with clean dry cheesecloth.

5. Applying Protective Coating

CAUTION

Apply protective WD-40 in a single coating only, leaving no visible film on surface. Guard against unnecessary buildup on protruding areas or dripping and spilling around maintenance areas. Protect switches, terminal posts, electrical plugs, and other wiring in the equipment pods and thrust section. Do not apply WD-40 to fiberglass surfaces. Failure to heed caution may result in damage to equipment.

Apply protective coating of WD-40 material NO. 900388 (Aerosol) or 900213 (bulk) to clean stainless steel surfaces of tank section as follows:

a. Mask off edges of pod doors and areas around thrust ring with vaporproof barrier tape or other suitable waterproof barrier material.

b. Be certain that all openings or accesses to interior of propellant tanks are sealed.

c. Apply WD-40 by wipe-on, wipe-off procedure. Spray application may be used if apparatus is adjusted to produce a thin coat of WD-40.

d. Apply thin coat of WD-40 to all exterior metallic tank surfaces with clean, lint-free cloths or fine spray. Avoid running or dripping, and wipe off excess with dry cheesecloth, leaving a thin, almost invisible coat of WD-40.

e. Remove all barrier tape from joints, being certain that no adhesive material from the tape has adhered to the airframe.

f. After completing cleaning and protective coating procedures, remove cleaning equipment from area to appropriate storage location.

NOTE

Stainless steel surfaces of the missile shall be checked periodically for evidence of excessive soil accumulation or staining. The coating of WD-40 shall be removed using trichloroethylene, MIL-T-7003, and a new coat of WD-40 shall be applied. When periodic checks reveal only small isolated areas with staining of soil accumulation, these individual areas shall be spot cleaned and a thin coat of WD-40 applied over them.

Cleaning Re-Entry Vehicle Adapter, Vernier Engine Fairing and Booster Section Aluminum and Glass Cloth Laminate Surfaces (Figure 14)

Clean these structures with Tec 901 in accordance with the following procedures:

1. Using a soft cotton cloth, apply cleaning solvent to the exterior surface by hand.

2. Apply the solvent in long strokes to remove all foreign deposits and accumulations of grease and grit.

3. Use undiluted solvent sparingly, covering an area of approximately 4 SQ FT with each application of solvent.

4. Do not wipe the surfaces dry. Use a fresh application of solvent on a clean cloth, squeezing the cloth as dry as possible for the final wipe. The applied solvent requires approximately 2 MIN to evaporate.

5. Exact methods for cleaning and repainting these sections are given in the appropriate T. O.

SUMMARY

The Atlas missile airframe is a stainless steel and aluminum structure, ten feet in diameter and over seventy feet long, and is composed of three sections. The re-entry vehicle adapter is an aluminum spacer that allows the re-entry vehicle to be bolted to the missile. The tank section is a stainless steel monocoque shell providing tank space for 30,000 gallons of propellants and structural support for the re-entry vehicle, as well as mounting points for all major subsystem components. The booster section consists of an aluminum cylinder constructed of belt frames, longerons, and a reinforced skin, with nacelles and fireshield of aluminum-fiberglass honeycomb. The Atlas airframe provides an optimum design compromise between low weight and high strength which has proven itself to be dependable and effective.

The missile tank internal pressure must be monitored for the proper pressures. This monitoring is accomplished at varying intervals depending on the situation. If the pressure is outside the required limits, it can be corrected, depending on its location, from the trailer pressurization unit, the launch control console, or the PCU. To prevent condensation, and thus corrosion in the missile tanks, it is necessary to keep a check on the propellant tank dew point. If the dew point is too high, the tanks must be purged. It is also necessary, on occasion, to check the tanks for leaks. At certain times, or when needed, the airframe will be cleaned and a protective coating applied.

REFERENCES:

TO 21-SM65E-2FJ-2-1

TO 21-SM65F-2-1

REVIEW QUESTIONS

1. What are the major sections of the missile airframe?
   a) Re-entry vehicle adapter
   b) Tank
   c) Booster

2. What reference systems are employed on the missile?
   a) Stations - [illegible] zero point
   b) Quadrants - lower right going clockwise I - IV
   c) Axes - Z - longitudinal ; X - vertical ; Y - horizontal

3. How are the missile propellant tanks prevented from collapsing if pressurization should fail? By using stretch

4. What separates the missile propellant tanks? Intermediate bulkhead.

5. What are the major components of the booster section? [illegible]
   a) Thrust cylinder - AL - 10' dia. - has [illegible] 4 pedestal longerons, 2 B. [illegible]
   b) Fireshield bulkhead - Al [illegible]
   c) Nacelles - [illegible]

6. Give an example of equipment located in the B-2 equipment pod. [illegible] I & II
   a) Guidance - [illegible]
   b) Battery
   c) Inverter
   d) Pwr changeover sw.

7. Is pressure monitored during ground transportation of the missile? yes
While pn the launcher? Yes
GN_2 used to pressurize tanks. LOX [illegible] } stand by
RP-1 [illegible]

8. Why is freon 12 introduced into the RP-1 tank? So sniffer can be used to test for leaks.

9. If a leak is detected with the sniffer, what procedures must be followed?
a) Perform soap test
b) [illegible]

10. What is dew point? Temp at which H_2O vapor starts [illegible]