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EXTERNAL TANK PROCESSING FROM BARGE TO PAD

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ABSTRACT

The External Tank (ET) is off-loaded at the KSC Barge Turning Basin and towed to the Vertical Assembly Building (VAB), High Bay Transfer Aisle. It is erected vertically and placed in the ET Checkout Area of High Bay 2 or 4 for standalone checkout. At the completion of checkout the ET is transferred to storage or to the Integration Area of High Bay 1 or 3 for SRB and Orbiter Mate. A Systems Intergration Test is performed with the Orbiter and SRBs. Final movement is to the Launch Pad for final checkout and launch.

INTRODUCTION

The External Tank serves a dual role: to provide the structural backbone of the space Shuttle during launch operations and to contain and deliver liquid hydrogen (LH2) and liquid oxygen (LO2) propellants for the Orbiter's three main engines. The External Tank is 153.8 feet long and 27.6 feet in diameter (Figure 1). It weighs approximately 69,000 pounds empty and when loaded with propellants weighs approximately 1,660,000 pounds. The External Tank must accomodate the complex stresses created by its own weight and that of the Orbiter prior to launch. The flow of operations for the External Tank requires the precise accomplishment of delivery and launch readiness events in unison with other space Shuttle elements and the Orbiter turnaround schedule.

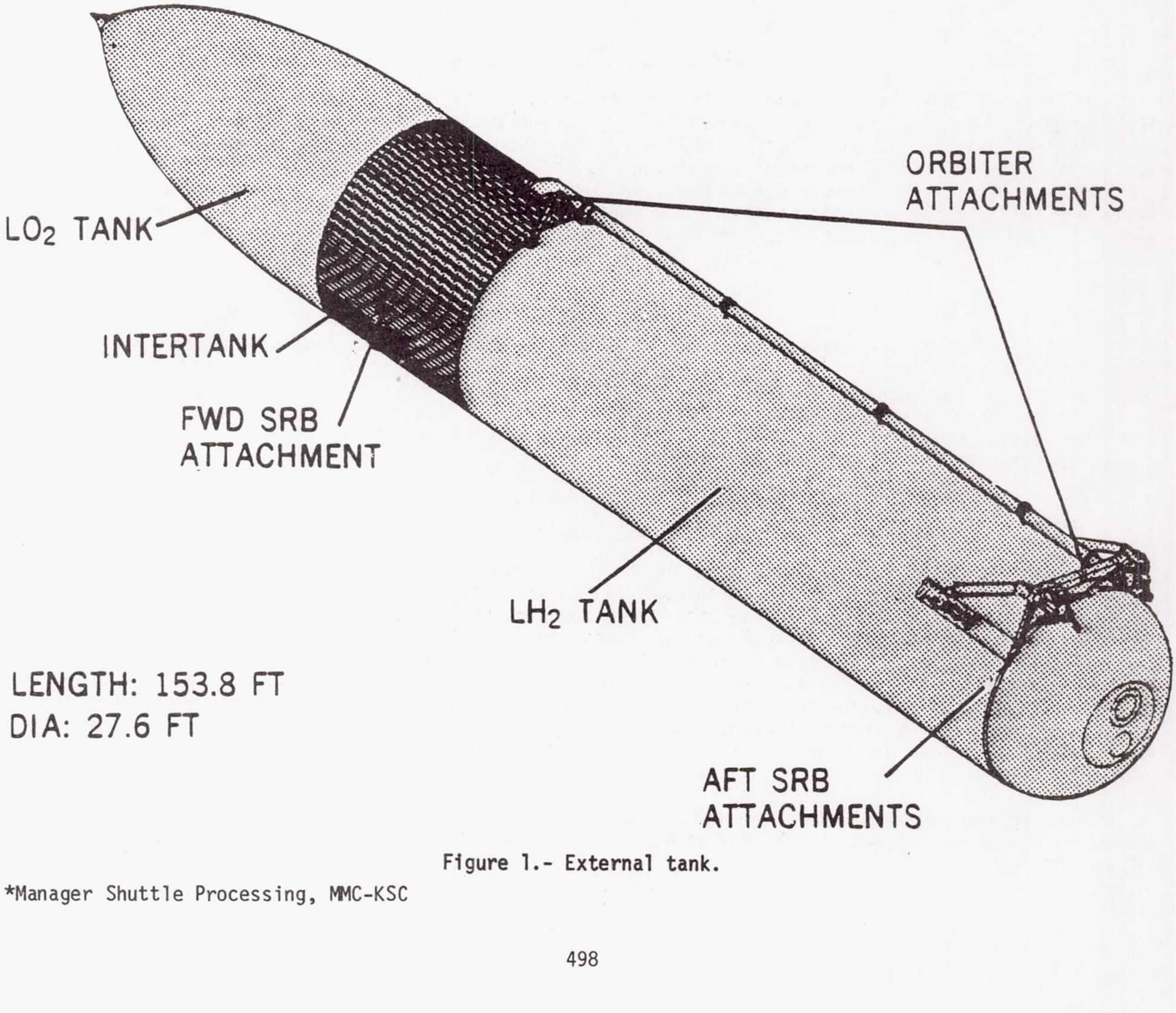

Figure 1.- External tank.

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ASSEMBLY AND DELIVERY

The External Tank is manufactured, assembled and given final acceptance testing at the NASA Michoud Assembly Facility (MAF) in New Orleans, Louisiana. The ET is mounted on an eight-wheeled (Modified Saturn SI-B) transporter at the Michoud Assembly Facility (Figure 2). This transporter serves as the means of moving the ET system to and from various points of activity during delivery, and remains with the system until it is moved into the VAB at KSC.

The ET and transporter are secured on a barge at Michoud Assembly Facility for delivery to KSC. The barge transportation system was developed to deliver NASA Saturn Stages to KSC, and has been modified for ET delivery. The ET is monitored during transportation by a sensitive instrumentation system. This system monitors the ET for pressures, humidity and acceleration.

Upon arrival at the KSC Barge Turning Basin the barge is secured and ballasted to dock level. The barge doors are opened and the ET and transporter are prepared for towing to the VAB. The transporter is secured for sea by four pedestals and tie down chains to the barge deck. After removal of the above and overall visual inspection of the ET and transporter for any apparent damage, the ET system is towed to the VAB and made ready for ET transfer into a checkout or storage cell.

ET SUB-SYSTEM CHECKOUT

Operations for erecting the ET in the High Bay begins with positioning of mobile access platforms to facilitate visual inspection, disconnection of special shipping instrumentation, and attaching forward and aft hoist slings. The ET will be hoisted from its transporter by the 250 ton and 175 ton High Bay cranes and rotated to vertical for translation into a storage or checkout cell.

In the checkout cell, a complete receiving inspection is made of all Thermal Protection System (TPS) surfaces, the intertank and nose cone interiors, and all ground umbilical connections. Ship-loose items and Ground Support Equipment (GSE) and Launch Processing System (LPS) are connected.

ELECTRICAL SYSTEM CHECKOUT

The electrical system provides the Operational Instrumentation (OI) which includes instrumentation sensors, heaters, a tumbling subsystem and Range Safety System (RSS) (Figures 3-5). The electrical system also includes the ET cabling, Orbiter/SRB cabling, electromagnetic compatibility, and lightning protection. Electrical checks consist of installation of the RSS flight equipment, continuity and isolation checks, system power on, and an end-to-end systems test using the LPS to simulate Orbiter interfaces. This makes the checkout period as short as possible through the automated use of display consoles, computers, data transmission systems and associated computer programs.

PROPULSION SYSTEM CHECKOUT

The propulsion system serves the primary function of delivery oxidizer and fuel to and from the propellant tanks and Orbiter interface through 17 inch feedline disconnects. The complete system is comprised of LO2 feed system, LH2 feed system, LO2 and LH2 tank pressurization, vent/relief and tumbling system, intertank and tank environmental control systems, and ET intertank carrier plate assembly. Propulsion system checkout consists of tank and feedline leak checks, relief and vent valve checks and tank purge and environmental checks.

THERMAL PROTECTION SYSTEM (TPS) CHECKOUT

The External Tank Thermal Protection System is to maintain the primary structure and subsystem component within temperature limits during pre-launch and ascent phases. It serves the following functions: maintains LO2 and LH2 boil-off rates below the vent valves capabilities, contributes to loading accuracy and increased propellant densities, insures LO2 and LH2 specified temperatures at the Orbiter interface, minimizes air liquefaction on the LH2 tank, minimizes air formation on the ET surface and minimizes hard debris during ascent heating environment. Normal work on the above system at KSC is limited to closeout operations and minor repairs, although major modifications of repairs can be performed as necessary. Checkout cell TPS closeouts consists of the following: transporter attachment point, leak check ports, nose cone installation and closeout and Orbiter bipod jack pad closeout.

With the completion of the above subsystems checkouts, the ET is removed from the checkout cell using the forward sling and the 250 ton crane, and is transferred to the storage or integration cell (Figure 6).

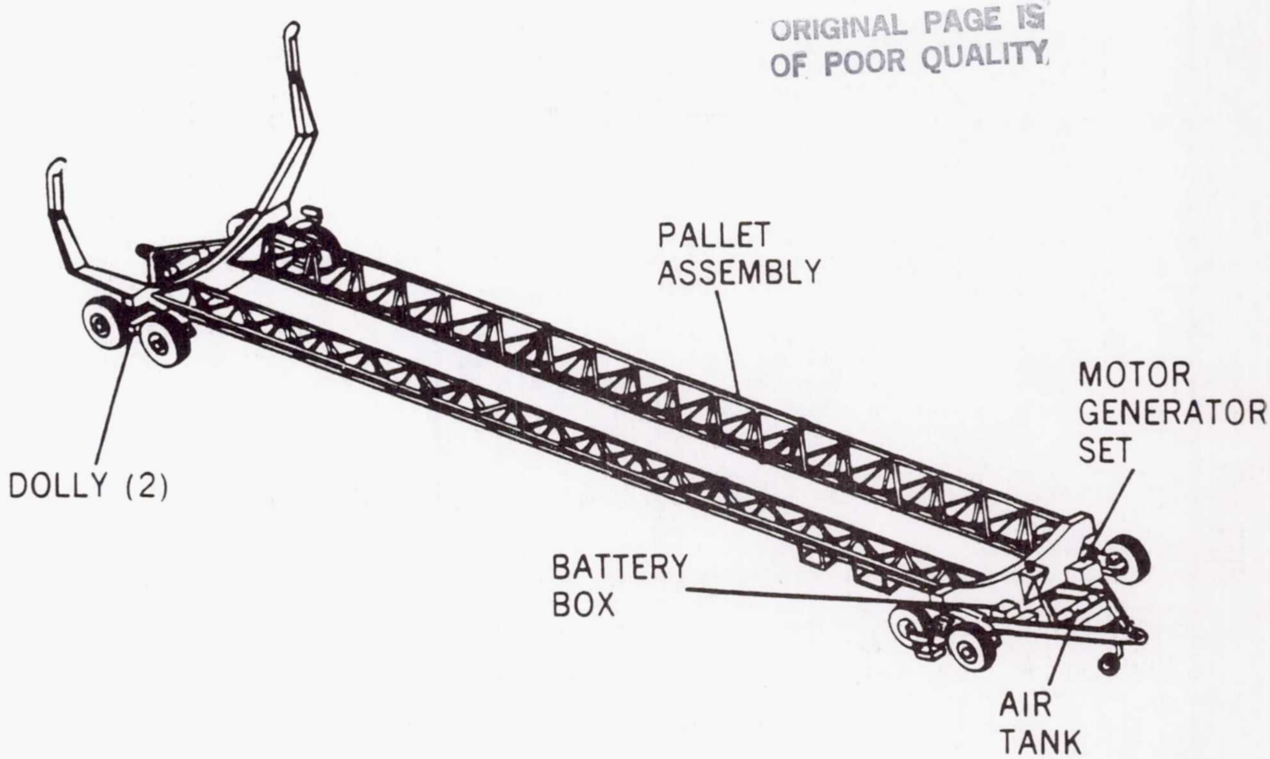


Figure 2.- ET assembly transporter.

ET TO SRB MATE

Upon transfer to the Integration cell, the External Tank is lowered into position for securing the ET/SRB forward support fittings (Figure 7). The ET is then lowered onto the SRB forward fittings. GSE guides and pins are used to facilitate final seating alignment, and are then replaced by the flight frangible bolt/nut assembly. At this point the ET is suspended entirely from the two forward attach points. When the forward fittings have been secured, the sequence of attaching the aft ET/ERB stabilizing struts begins. It begins with the attachment of the right and left diagonal struts to the ET upper fittings. One strut is preadjusted to length, the other is adjusted to fit. The upper lateral struts are assembled to the SRB's, adjusted to fit, and attached to the upper ET fittings. The lower struts are then similarly attached to the SRB's adjusted to fit, and bolted to the ET lower fittings. The ET/SRB mate is completed by mating the electrical pull-away connectors located on the two upper lateral struts, and by completing the electrical connections to the forward attach point frangible bolt.

With the completion of ET/SRB mechanical and electrical mate the upper lateral strut and forward attach point cable fairings are installed and TPS closeouts begin. TPS closeouts consist of TPS spray on the aft cable fairing and the associated area around the aft fairing area.

ET/ORBITER MATE

The Orbiter is erected and vertically aligned with the ET by means of a sling set and jacks attached to the Orbiter. The two aft ET/Orbiter structural interface points are attached first. Both attachment points are hemisphere (ET) to socket (Orbiter) interfaces with concentric, retaining bolt/frangible nut assemblies. The right interface is a fixed reference point; the left ET attach point is free floating laterally once the Orbiter socket has captured the ET hemisphere. Prior to this a temporary adjustable support strut is used to hold the left attach point in position. The two Orbiter supplied interface bolts are installed, but final torquing is deferred until the forward attachment is complete. Mating of the forward interface occurs by drawing the Orbiter, via the ET provided yoke fitting, onto the pivotal bipod. The strut flanged joints are then bolted together. One strut has an adjustable sleeve that is used to obtain the required lateral alignment tolerance (Figure 8).

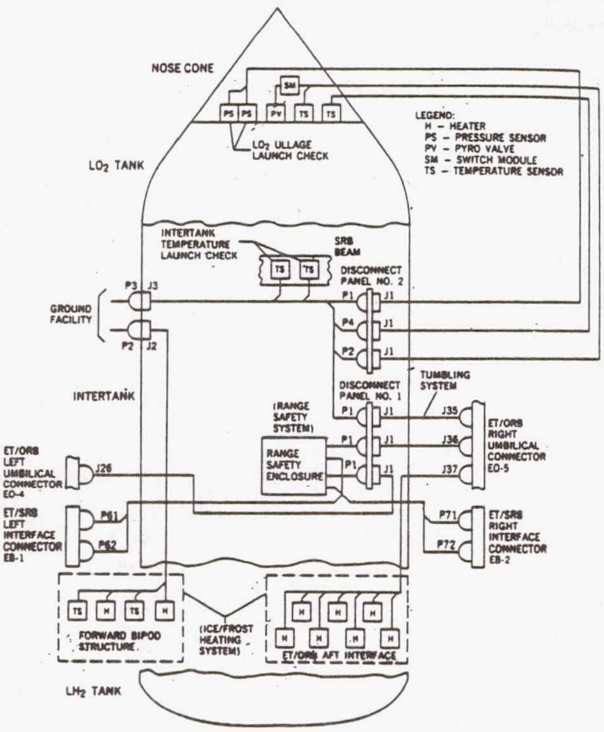


Figure 3.- Operational instrumentation systems components.

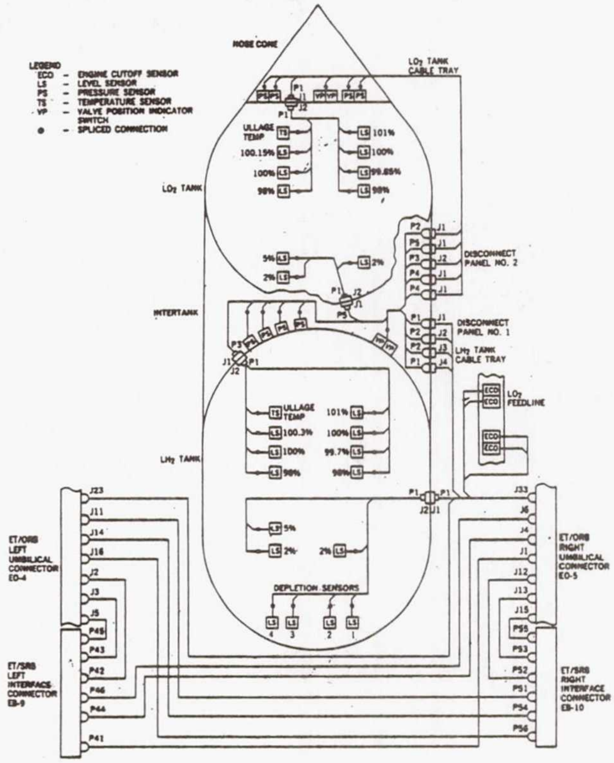


Figure 4.- Operational instrumentation sensors and switches.

With the completion of mechanical mate the ET/Orbiter aft umbilical disconnects containing the electrical, pneumatic and fluid interfaces are mated. Interface protective covers are removed from the disconnect halves. The Orbiter halves of the umbilical plates are extended from their retracted position and aligned with the halves. They are secured using three flangible bolt/nut combinations per assembly.

At the completion of mechanical/electrical pneumatics and fluid mate, a leak check is performed on the pneumatic and fluid systems and a system integrated test is performed. The STS is now ready for pad roll out.

LAUNCH OPERATIONS

The complete Space Shuttle vehicle is moved from the VAB to the Launch Pad on the Mobile Launch Platform (MLP). The MLP is connected to the Launch Pad and its interfaces verified. Concurrently, facility interfaces are mated through the ET intertank Ground Carrier Plate Assembly (GUCA). The GUCA having been installed on the intertank during ET checkout, remains with the ET throughout the vehicle integration flow. Six fluid transfer lines, an electrical grounding cable, two disconnect lanyard cables, and two support lanyard cables emanating from the launch complex are permanently attached to the GUCA. The facility LO2 and LH2, and both ET tanks are purged with helium and sampled to assure an inert atmosphere for propellant loading.

FINAL COUNTDOWN

The Space Shuttle terminal countdown sequence begins at T-5 hours. Propellant loading is accomplished with vent valves open, loading from the facility through the Orbiter into the ET. Both LO2 and LH2 are loaded simultaneously, starting with a slow flow rate to precondition the lines, tanks and engines. The slow flow is continued until the 2% level is reached, at which time the flow rates are increased to the maximum of 12,000 gpm for LH2 and 5,000 gpm for the LO2 until each of the tanks contains 98% of its capacity. The flow rates are then reduced to provide a topping flow rate to 100% capacity, followed by a still slower replenish flow continues until the automatic sequence starts at T-9 minutes.

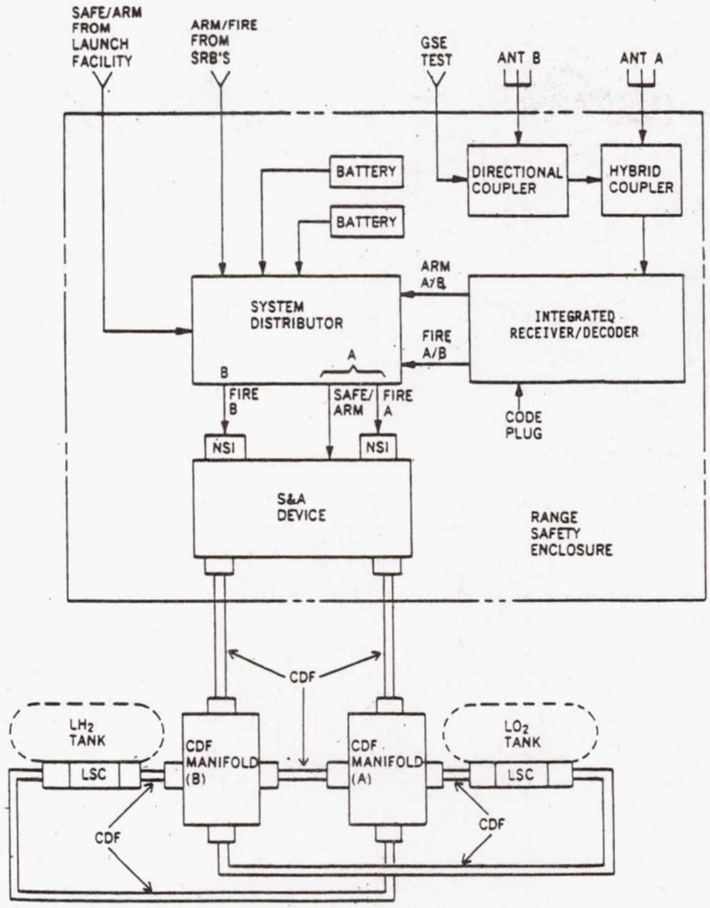
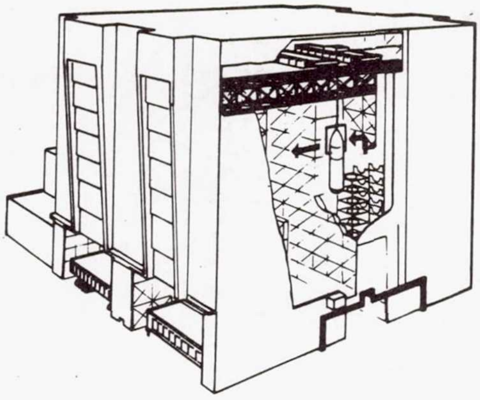


Figure 5.- Range safety system block diagram.

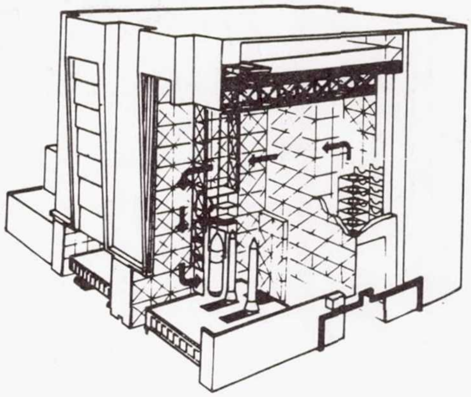
The L02 vapors generated during the loading and conditioning process are vented through vent louvers in the nose cone and facility line carrying G02 to the umbilical tower. LH2 vapors are vented directly to a burn pond through a ET/facility vent system via the intertank ground umbilical carrier assembly. This assembly also provides connections to the pneumatic lines for conditioning the nose cap and intertank cavity, monitoring the hazardous-gas detection system, and for the actuation of the vent valves. The L02 and LH2 tanks are then pressurized, with pressurization occurring for the L02 tank at T-155 seconds and at T-106 seconds for the LH2 tank.

REFERENCES

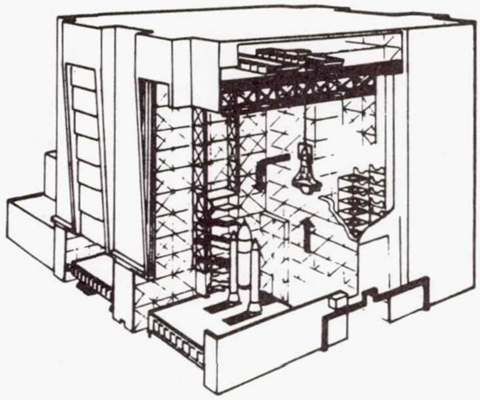
1. Manual System Definition Handbook, Space Shuttle External Tank, MMC-ET-SE25-0, August 1980.



ET leaving checkout cell



ET mating integration cell



Orbiter mating operation

Figure 6.- ET leaving checkout cell.

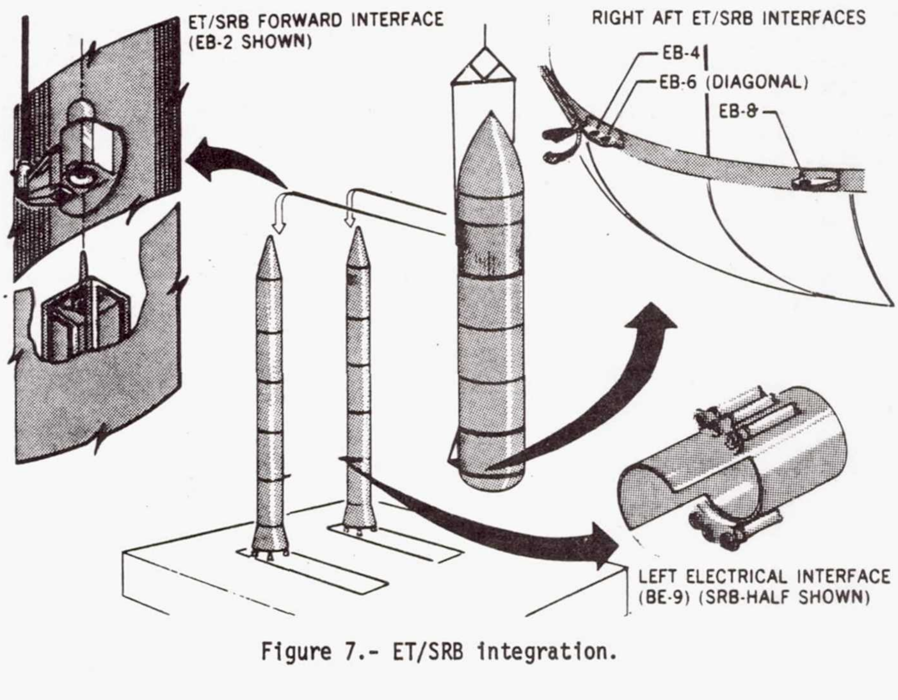


Figure 7.- ET/SRB integration.

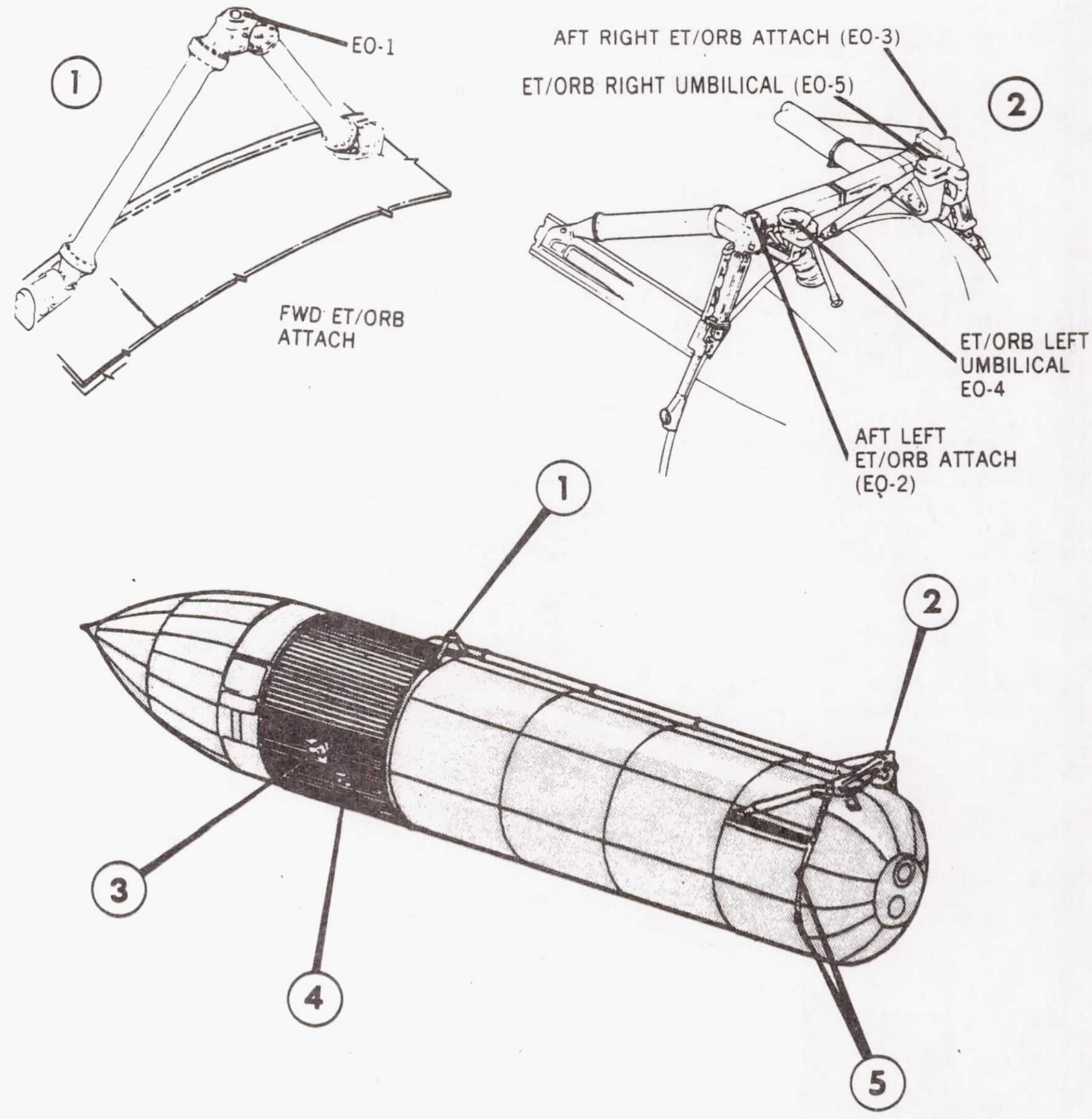


Figure 8.- ET interface configuration.