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THE ORBITER MATE/DEMATE DEVICE

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ABSTRACT

The purpose of this paper is to describe the numerous components and systems of the Orbiter Mate/Demate Device (MDD), with special emphasis on mechanisms and mechanical systems; to discuss in general their requirements, functions, and design; and, where applicable, to relate any unusual problems encountered during the initial concept studies, final design, and construction. The MDD and its electrical, machinery, and mechanical systems, including the Main Hoisting System, Power Operated Access Service Platform, Wind Restraint and Adjustment Mechanism, etc. were successfully designed and constructed. The MDD was used routinely during the initial Orbiter-747 Approach and Landing Test (ALT) and the more recent Orbital Flight Tests (OFT's) recovery and mate operations at the Dryden Flight Research Center (DFRC), Edwards Air Force Base, California.

INTRODUCTION

The Orbiter Mate/Demate Device is only one small part of NASA's overall Space Shuttle Program. However, at the time of its planning, development, design, and construction during the 1974 to 1976 period, it was of utmost importance. It was to be the only facility, at that time, capable of lifting and mating the Orbiter on the NASA 747 carrier aircraft and providing for all the numerous services and access requirements.

The firm of Connell Associates, Inc. was selected by NASA, Kennedy Space Center, Florida, to perform initial studies to develop, in a very limited amount of time (approximately 5 weeks), an acceptable MDD concept and, based on that acceptable concept, to provide the complete design. With the importance of the MDD in mind and aware of the very tight calendar time schedule, Connell Associates assigned its entire team of structural, machinery, electrical and mechanical engineers to the project to meet the challenge of developing an acceptable concept.

A schedule of mandatory coordination meetings, almost daily, between the engineering trades was initiated to expedite the concept design and to determine, as nearly as possible, the ideal geometry of the MDD structure and its principal components. An important design aid during this phase of the project was a scale model of the MDD which we made and continually revised as the concept was developed. The MDD model was constructed to the same scale as the model of the Orbiter, which was loaned to Connell Associates by NASA. The Orbiter model was mated on a plastic model of the Boeing 747 aircraft which we made from an "off-the-shelf" kit and then placed under the MDD model, thereby providing a three-dimensional view of the concept as it was being developed.

The concept design was successfully accomplished by preparing an Initial Studies Report and the model of the recommended concept and submitting them to NASA for review. After a few changes were incorporated into the design, the concept was approved and final design started. The on-going support, technical aid, and response provided by the NASA, KSC technical personnel of DD-MDD, DD-EDD, and DD-MED during all of the design phases were invaluable in helping to complete the project successfully and on schedule.

The MDD is a unique facility that could be classified somewhere between the categories of a conventional service structure and a fixed-frame multi-hook derrick. Its structure and components will be discussed in later paragraphs.

OUTLINE OF OPERATIONS, FUNCTIONS, AND SERVICE PROVIDED FOR ON THE MDD

The MDD is designed and constructed to routinely handle and accommodate the following operations, functions, and services:

1. Access to Orbiter jack points
2. Access to Orbiter fore and aft lift points
3. Hoisting the Orbiter high enough to allow a 747 aircraft to be positioned beneath it

4. Lowering the Orbiter and mating it with the 747 aircraft
5. Precise hoist load vertical positioning control system at each main hoist
6. Access for mating the Orbiter and 747 aircraft
7. Access for servicing each side of the Orbiter when it is in the following positions:
 - a. On jacks
 - b. Mated on 747
 - c. Secured for 40-knot wind while suspended from the MDD
8. Wind restraint and adjustment system to control positioning the Orbiter while it is suspended on the main hoists in winds up to 12 knots
9. Safety tie-down system to secure the Orbiter while suspended on the main hoists in winds up to 40 knots
10. Access/egress route to accommodate self-contained atmospheric protection ensemble (SCAPE)-suited personnel
11. All equipment/services are hazard proofed per KSC safety standards.
12. Accommodate services to the Orbiter such as APU hypergols and fuel cell gaseous oxygen and hydrogen. Requirements include cable trays, pipe traces, etc. for routing the services.
13. Installation of an airlock for access to the Orbiter crew hatch at on-jacks position and at the mated on 747 position.
14. Other components and systems provided or provided for on the MDD are the following:
 - a. Electrical systems such as electrical power service and distribution, lighting, receptacles, cable trays for GSE, fire alarm, obstruction lighting, and lightning protection
 - b. Mechanical (plumbing) systems such as compressed air system, wash-down stations, and personnel emergency shower system

GENERAL DESCRIPTION OF ORBITER/747 MATING OPERATIONS

The following events, in numerical sequence, are required to perform a typical Orbiter/747 mating operation at DFRC.

1. The Orbiter is towed into proper position at the mating device.
2. The Orbiter jack set is installed; connect hydraulic, cooling and electrical ground power lines; position Orbiter cabin access room.
3. Jack Orbiter to the "ground" service position (Orbiter ref: Zo = 400, 21'-1" above and parallel with ground surface).
4. Ingress ground crew and activate ECLSS, electrical power, and hydraulic systems.
5. Lower and position the power-operated access/service platforms to proper distance above the Orbiter (top of platform approx. 16'-1" above ground level) for servicing operations at the "ground" position.
6. Attach the fore and aft lifting slings to the Orbiter lift points.
7. Retract landing gear and doors.
8. Deactivate and secure system; egress ground crew.
9. Disconnect hydraulic lines and T-0 umbilical, and remove Orbiter cabin access room.
10. Prepare for hoisting Orbiter (detach jacks, etc.).
11. Retract (raise) the access/service platforms to proper position necessary.

12. Hoist the Orbiter to the "mate ready position" (to required elevation to provide clearance for 747).
13. Tow 747 into proper position beneath the Orbiter.
14. Utilizing the wind restraint and adjustment mechanism system, lower the Orbiter and mate to the 747.
15. Lower and position the access service platforms.
16. Remove the fore and aft lifting slings.
17. Complete servicing; perform final inspection and closeouts.
18. Retract (raise) the access service platforms to required height to clear Orbiter for tow away.
19. Perform pre-tow checklist.
20. Backtow 747 clear of mate/demate facility; tow to ramp area.

SPECIAL FEATURES

TRANSPORTABILITY OF THE MDD

A demanding feature of the MDD during the design and detailing was that all components of the facility, including the structural framing, platforms, machinery, electrical systems, mechanical (plumbing), etc., be designed and detailed for erection and disassembly into units for transport on either trucks or C5 cargo planes to relocation and routine reassembly at a different site. The structure, for example, consists of all-welded units which are sized to just fit in or on the carrier and to be reassembled using bolted connections. A similar solution is provided for the electrical system. A major portion of the electrical system's installation has been grouped together and mounted on a removable "ladder-like" substructure. The substructure and attached electrical installation is broken down into individual sections of nominal length and each section is independently bolted to the MDD main structure. The length of each section depends upon the spacing of the main members of the structural panel to which the section is attached. On one end of each section the wiring terminates in a large disconnect (splice box), and on the other end terminates with lengths of flexible conduit with circuit conductors extending from them. When in place on the MDD, one half of a union fitting on each flexible conduit of one section is joined with a matching half union fitting on the disconnect box of the adjacent section, and the circuit conductors are spliced to matching conductors inside the disconnect box. Each disconnect box is divided into two sections to isolate the control and power circuits as required by the code.

ACCESS/EGRESS ROUTE FOR SCAPE-SUITED PERSONNEL

An interesting requirement was to provide a safe method of access and egress from the ground level up to work positions at the outer end of the access service platform for personnel in heavy and cumbersome SCAPE suits. The SCAPE suit limits a person's movement and instead of stepping he must "shuffle along" at a slow pace, which could create a serious problem for the worker in an emergency situation when he needs to make a speedy exit. During the preliminary studies, several solutions were considered including using two mobile, self-powered, manually adjustable hydraulic platforms. However, after additional study, it was decided to provide a more conventional route of access and egress. Adjustable ramps are provided for access between the access service platforms and main level work platforms. For vertical transportation of the SCAPE-suited personnel, a personnel hoist is provided at the forward end of each of the two towers of the MDD. The personnel hoists are standard catalog units and have a cage size capable of accommodating several SCAPE-suited personnel at a time.

STRUCTURAL SYSTEM

The MDD structure is a fixed base (anchored) cantilevered-type space frame as indicated on plates 1, 2, 3, and 4. Its final size and geometry are the result of many trial concepts and provide the necessary horizontal and vertical clearance envelopes for accommodating the Orbiter and 747 aircraft and the numerous platforms and components required for the mating operations.

A strong effort was made during the design to keep the weight of the structure to a minimum due to the transportability requirement. Structural aluminum and also high-strength alloy steel were briefly

considered. However, these metals are not efficient when trying to limit deflection within that permitted by criteria; therefore, ASTM A36 steel was used for wide flange sections and ASTM A500, Grade B steel for the tubular steel members. The tubular steel sections, which have excellent torsion-resistant properties as well as efficient axial load members, were used throughout the structure for diagonal members. Wide flange sections were used for members subject to flexure and also for the main columns.

The structure is designed for universal-type loading criteria, including 125-mi/h hurricane winds, ar.J for Seismic Zone 4 (Z=1), the most severe earthquake loading. The space frame structure was designed by computer analysis using the MRI-STARZYNE III program.

MACHINERY

MAIN HOISTING SYSTEM

The main hoisting system is installed as an integral part of the MDD and is a special hoisting system consisting of three separate two-speed, 50-ton-rated hoist systems, each providing a separate pick-up point on the Orbiter. Each of the 50-ton-rated systems consists of a hoist machine, two deflector sheave blocks, a special three-sheave assembly, hook block with antifriction bearing swiveling safety latch hook, 50-ton hydra set unit, rope, and forged fittings. All of the above listed components for each system are identical for maximum interchangeability. The hoist machines are located at level 4'-0" in the base of the MDD towers. The deflector sheave blocks are located at approximate levels 80'-0" and 100'-0" and are at the top of the MDD towers and also at the top of the connecting framing between the towers. The three-sheave assemblies are located at level 100'-0" in the cantilever part of the MDD and are directly above the hook blocks. All three 50-ton-rated hoist systems are controlled from one plug-in portable operator-controlled station. There are two receptacles on the MDD that the operator control station can plug into, and these are located at level 5'-0" at columns 1A and 1D.

The operator control station controls all functions of the main hoisting system and has provisions for operating two or more of the 50-ton-rated hoists simultaneously. Also, each of the hoists can be operated separately and completely independently of one another. The operator control station controls the raising and lowering of the hook blocks in either of two fixed speeds and each speed has its own separate lever control. Each hoist has a control-on and control-off switch with a green light to indicate control-on condition. All hoisting controls have full inching capacity.

All hoist machinery for the main hoisting system is identical, and each consists of a 15/5 hp, 1800/600 rpm induction-drive motor; two fail-safe spring-set solenoid released shoe brakes immediately after the drive motor; double reduction Helical gear motor speed reducer; single grooving steel drum, wire rope, upper and lower geared limit switches; and a welded steel base. The total gear reduction is approximately 900:1, and all shafting is parallel. The drive motor is connected through a flexible coupling. The drive motor has discreet separate windings, one winding for low speed and one winding for high speed. Failure of either winding does not affect the use of the other speed.

Each of the three 50-ton-rated hoist systems is reeved 6 ps (6 parts single), and the wire rope is 1-1/8-inch diameter, improved plow steel, uncoated, bright, 6 x 19 IWRC, preformed, prestressed, with 56.5 tons breaking strength.

Each hook of the three hoisting systems comprising the main hoisting system has a rated hook capacity of 50 tons and a rated maximum lift of 90 feet. Each hook has two fixed hoisting speeds: 1 fpm and 3 fpm, both raising and lowering.

Each of the three 50-ton-rated hooks is equipped with a 50-ton Hydra Set, which is positioned between the hook and the load. The Hydra-Set unit is a precision load positioner in the vertical axis and positions the load within 0.001-inch increments. The Hydra-Set unit works on the principle of a piston and cylinder, and during descent, oil is bled from the bottom of the piston; during ascent, oil is pumped to the bottom of the piston.

The MDD main hoisting system is designed to operate under the following duty cycle:

- a. Each hoist will raise and lower the specified rated hook load from ref. el. 0'-0" to 75'-10" for one full complete and continuous raising and lowering cycle at a sustained hook speed of 3 fpm.
- b. Two observer control stations, one port and one starboard, are provided at ground level with a "stop" button on a 100-foot cord plugged into a receptacle 5 feet above ground on the main structure. Operation of either "stop" button will trip the main hoist electric supply circuit

breakers, causing all three hoists to stop. The circuit breakers must be reset manually before any of the three hoists can be operated again.

POWER-OPERATED ACCESS/SERVICE PLATFORMS

The power-operated access/service platform system consists of two complete and identical, vertically adjustable, power-operated tilting platforms and their equipment, one on the port side and one on the starboard side of the MDD. This system provides the following:

- a. Access to the sides of the Orbiter above Orbiter wings and within longitudinal range of platform; access to the lift points and pins on the sides of the Orbiter; access for operation of the 50-ton Hydra Set precision vertical positioners; and all other access and service required within the operating range of the equipment.
- b. An adjustable pivoting ramp on the outboard side of the forward end of each of the two platforms. These ramps provide passageways for personnel and equipment to proceed on and off the platforms when the platforms are at their working positions.
- c. A manually operated ratchet hoist for each of the port and starboard side platforms to facilitate raising and lowering the small flip-down platforms positioned along the inboard edge of each of the two main platforms. The ratchet hoist positioned manually into and out of the row of pad eyes located along the center truss of each main platform.

Each of the two power-operated access/service platforms has its own separate operator control station located on the MDD tower on that platform side. Also, each platform has an observer control station provided with a "stop" button. Operation of the "stop" button will trip the access/service platform electric supply circuit breakers causing the platform to stop. The circuit breakers must be reset manually before the platform can be operated again.

The platforms have a vertical speed of 5 fpm both up and down, with full inching movement in both directions. Each of the two platforms is powered vertically by two self-locking worm gear hoisting systems, one hoisting the aft end of the platform. The two hoisting systems of any one platform can be run simultaneously or individually. When one hoist system of one platform is run individually, the platform will tilt, which is required to accommodate the various angular attitudes required of the Orbiter. When the Orbiter is in a tilt attitude, the power operated access/service platform has to be similarly tilted to provide the required access and service to the Orbiter. Each platform tilt is limited within a range of minus 5 degrees to plus 10 degrees, measured from horizontal in reference to the forward end of each platform. The platforms can be power hoisted in a tilted or horizontal attitude within the limits of the tilt.

Each platform is guided and supported by two sets of rectangular telescoping steel tubing. The aft set of telescoping tubes is connected to the top of the platform through a pivot pin joint, and the forward set of telescoping tubes is connected to the top of the platform through a link-pin joint. Through these two connections the platform can be tilted, within its tilt range, without binding the rigidly connected sets of telescoping steel tubing. All four sets of telescoping tubing assemblies are rigidly connected to the outside surfaces of the cantilever part of the MDD. A friction-type bearing for the sliding, telescoping tubing sections was selected instead of ball bearing. This was done to limit the freedom of the sliding action and with an average speed of 3 fpm (maximum of 5 fpm). This works well and produces a smooth running assembly. The antifricition bearing pads are preloaded with a precompressed silicone sponge rubber backing material. This produces an assembly with no shake and provides a cushioned and shock absorbing condition between the tubing sections.

The four self-locking worm gear hoisting machines are located on top of the 100-foot level of the cantilever part of the MDD. All are reeved 3 ps with 9/16 inch diameter wire rope, and the single part of rope proceeds from each hoist drum approximately horizontally to the side of the cantilever structure and in line with the vertically mounted, rectangular, telescoping steel tubing. At that point the rope is deflected through a double sheave deflector block vertically downward to a single sheave load block which is attached to the top of the inner section of the telescoping steel tubing. The rope then continues up to the double sheave and then down with dead end anchored to the single sheave load block.

Each platform is equipped with five, angled-arm-type limit switches mounted under the platform's personnel deck and arranged to prevent the extreme bottom outline of either platform from being less than 12 inches from the top of the Orbiter wing surface.

40-KNOT-WIND SAFETY TIE-DOWN SYSTEM

The Safety Tie-Down System is provided to secure the Orbiter while it is suspended on the main hoist hooks near level 60'-0" during strong wind conditions above 12 knots and to 40 knots maximum. The principal function of the wind ties is to limit horizontal or longitudinal movement of the Orbiter and prevent any damage to it due to contact with the MDD.

The tie-down system is symmetrical about the longitudinal centerline of the Orbiter and consists of anchorage mechanisms which secure the Orbiter's forward lift beam to the MDD and the aft lift beam to the access/service platforms. At the aft end, the anchorage mechanism consists of two assemblies extending horizontally at 45° from the access/service platform. Each of the assemblies consists of a combination tension-compression, barrel-enclosed spring assembly (8-1/2 ton rated), coupled to a reversible ratchet load binder. Each of these assemblies is rigid from end to end and provides push and pull capacity.

At the forward end, the anchorage mechanism consists of a single assembly similar to the assemblies at the aft end except it is an 8-ton tension type, connected directly to the adjacent MDD column at one end and to the Orbiter lift beam at the other end. It is designed and installed to pull parallel with the centerline of the Orbiter lift pin. Also, at the forward end and as part of the tie-down system is a mechanism which anchors the forward end of the access/service platform to the MDD main column. This mechanism includes two assemblies, one from each corner of the access/service platform to the connection plate at the column. Each assembly consists of a reversing ratchet and integral handle and has a 28-ton-rated capacity. This portion of the tie-down system pulls a wedge seat, provided on the forward end of the access/service platform, into and snug against a tapered wedge lug on the MDD and secures the platform to the structure.

PERSONNEL HOISTS

Two personnel hoists are provided, mainly for use by SCAPE-suited personnel. These personnel hoists are standard catalog units regularly manufactured for a variety of industrial uses. A personnel hoist is located next to the extreme forward side of the stairs of each of the two towers. The two personnel hoists are identical; each is a counterbalanced rack and pinion drive type. The hoisting pinion drive machinery is located in the cage, and the rack is attached to the mast. Each hoist has a single speed of 160 fpm raising and lowering and a live load capacity of 5,000 pounds.

A complete operator control panel is located inside the cage, and all control of the personnel hoist system is from within the cage, with the exception of a safety stop switch located on top of the cage (required by ANSI A10.4-1973). All cage gates and locks and all hoistway gates and locks are operable only from within the cage, with the exception of the lowest landing, and these have an exterior key lock in compliance with ANSI A10.4-1973.

A separate cage safety mechanism, a part of each cage hoisting machinery, tracks the primary hoisting rack attached to the mast. The cage safeties are of the rack and pinion type. A second pinion, running on and driven by the rack, is assembled together with the overspeed governor and the safety brake to form an integral unit. The governor, on the same shaft as the pinion, senses when the pinion exceeds normal rated speed and sets the safety brake. The safety brake, in turn, applies a retarding force on this shaft and, therefore, on the pinion gear, stopping the cage.

WIND RESTRAINT AND ADJUSTMENT MECHANISM

The wind restraint and adjustment mechanism is an integral part of the MDD and provides the following:

- a. Restraint to the movement of the Orbiter when suspended from the main hoisting system during a maximum 12-knot wind. The restraint provided is not 100%, but it reduces the amount of Orbiter movement to a workable and safe degree while it is being hoisted from the jacked position to the mated position. The restraint equipment provides a stiffness factor in the horizontal plane to the rope-suspended Orbiter and does not detract from the smooth and precise vertical positioning requirement. When the Orbiter is in the mating mode the restraint equipment prevents the Orbiter from excess movement that would bring it into contact with the access/service platforms and the MDD.
- b. Six-inch plus or minus adjustment of the Orbiter in the X-axis and the Y-axis horizontal plane when Orbiter is suspended from the main hoisting system. The adjustment is required for minute movement of the Orbiter during the process of mating and attaching the Orbiter to the pylons of the 747 and during the reverse process of demating the Orbiter from the pylons of the 747.

The wind restraint and adjustment mechanism is one complete system, and each of the two functions is achieved with the same equipment and simultaneously. At the same time that adjustment is being accomplished, restraint is inherent and automatic. The wind restraint and adjustment mechanism consists of four telescoping square steel tubing assemblies; fourteen universal joints; four ball joints; three 10-ton electric motor driven, machine screw, self-locking worm gear actuators, each with fail-safe motor brake and extreme travel, geared limit switches; three welded steel brackets for actuator mounts; two links; and one operator control station. The telescoping tube assemblies are mounted vertically, and the top end of each assembly is attached to the MDD at the approximate 100-foot level. A universal joint is provided between the top end and the 100-foot level connection. The lower end of each telescoping tube assembly is attached through ball joints to one of the two main hoisting system spreader bars. The spreader bars are part of the hoisting equipment between the Orbiter and the Hydra Set/hook assemblies. Two telescoping tube assemblies are vertically located in the Y-axis line of the Orbiter at X₀582 and the forward main hoisting hook, and two telescoping tube assemblies are vertically located in the Y-axis line of the Orbiter at X₀1307 and the aft main hoisting hooks.

The wind restraint and adjustment mechanism operates and produces adjustment of the Orbiter in a horizontal plane through the horizontally mounted, motor drive, screw actuators. The displacement of the actuators in the X and Y axes at the approximate 80-foot level is transmitted to the Orbiter through the telescoping steel tubing assemblies which are connected to the Orbiter lift system spreader bars. Because the tubing telescopes, the actuator movement at the 80-foot level can be transmitted to the Orbiter at any elevation within the range of the equipment. Wind restraint is simultaneously and automatically achieved with the same equipment used for Orbiter adjustment and restraints at any elevation within the range of the equipment. When the actuators are inoperative, the system equipment in a horizontal plane is rigid and provides the required wind restraint. Due to the telescoping capability of the tubing assemblies, precision vertical movement of the Orbiter is accomplished while horizontal wind restraint is functioning.

One operator control station controls all adjustment functions of this system. Each actuator has a separate and complete set of controls, and there is no provision for simultaneous control of any of the actuators. All movement controls have complete inching capacity and are "dead man" type of controls which return to "off" position when released.

MATING ACCESS SYSTEM

The mating access system provides access to the forward and aft attach points of the Orbiter to the pylons of the 747. The aft equipment portion of this system is government furnished equipment (GFE), consists of two manually adjustable hydraulic platforms, and is cataloged under KSC P/N 79K05143. One platform is required for the port pylon, and one is required for the starboard pylon.

The equipment that provides access to the single forward attach point pylon consists of two manually operated rolling platforms. One is located in the port side MDD tower, and the other is located in the starboard side MDD tower, both of which are at the approximate 35-foot level. The two forward rolling platforms are similar, one right hand and one left hand.

The forward access rolling platform is special, and each platform consists of a rolling platform, four vertical support roller assemblies, four horizontal side guide roller assemblies, one hand-operated winch and stand, 1/4"-diameter wire rope, three wire rope sheaves, two sheave brackets, one wire rope anchor bracket, forged fittings, ladder and landing to the rolling platform; two horizontal support beams that the platform rolls within.

Operation of each rolling platform is manual through the operation of a 1-ton hand winch. The winch has a gear ratio of 10.5:1; the rolling platform rolls on and is side guided by antifriction roller-bearing rollers.

Each of the rolling platforms is reeved 1 ps (one part single) with 1/4"-diameter, fiber-core pre-formed wire rope. This results in a safety factor of 1.74. The wire rope is one continuous piece and has three turns around the drum for good traction. A turnbuckle is provided in the reeving to maintain proper rope tension. Each rolling platform rolls out to the centerline of the MDD, and the two platforms provide 360-degree access to the forward pylon attach point to the Orbiter.

NOSE PLATFORMS WINCH SYSTEMS

A winch system is provided to raise and lower the nose platforms and the hinged access stairs at the 15'-7" level of the MDD. There are two winch systems, and they are similar -- one being left hand and one right hand. One is located in the port side MDD tower, and one is located in the starboard side MDD tower. Both systems are manually operated, and each winch system consists of two 1-ton hand-operated winches on one common stand, 1/4"-diameter wire rope, five snatch blocks, two swiveling safety

latch hooks, forged chain, fittings, and pad eyes. All components of both port and starboard winch systems are identical for interchangeability. The winches and stands are located on the 20'-10" level, and all pad eyes are located just under the 40'-0" level. When platforms are in the raised position, they are secured in a vertical position by safety chains.

ELECTRICAL SYSTEMS

The major electrical system installations provided on the MDD are electrical power service and distribution, lighting, receptacles, cable trays for GSE, fire alarm, obstruction lighting, and lightning protection. In addition to meeting their basic functional requirements, the design of the above installations includes special provisions for:

- a. Operation under hazardous conditions
- b. Demountability of electrical installations
- c. Minimum power operation

ELECTRICAL POWER SERVICE AND DISTRIBUTION

The electrical power service and distribution installation provided for the MDD is designed to receive a 480-volt, 3-phase, 3-wire electric service from the site on which it is erected; to distribute this 480-volt power to all 480-volt loads on the MDD and to several loads located on the site immediately adjacent to the MDD; to produce 208Y/120-volt, 3-phase, 4-wire power and distribute it to all 120-volt loads on the MDD; and to provide capacity for the future addition of a nominal amount of electrical load. The electric service from the site interfaces with the MDD at the line side connections of the main circuit breaker in a power panelboard on the outboard side of the MDD's port leg. This main breaker serves both as the service overload protection and disconnect. The breaker is equipped with a shunt trip coil controlled by a momentary contact switch located separately above the panelboard to permit rapid removal of all power from the MDD without having to open the panelboard enclosure. The electric service from the site must have a capacity of not less than 400 amperes at 480 volts. The total connected MDD load is 352 kVA with an estimated maximum concurrent demand of 282 kVA. Power is distributed to all 480-volt loads from two 480-volt distribution panelboards, one on each side of the MDD at ground level. The panelboards are located at ground level because the larger 480-volt loads are all at that level and also to allow ready access to the panelboards. Spare capacity has been provided in all panelboards in the form of spare circuit breakers and spaces for future circuit breakers.

LIGHTING

The lighting installation is designed to provide task and area illumination during MDD operational periods and minimum access illumination during nonoperational periods. Task and area lighting consists of floodlights mounted on poles that are separate from the MDD structure. This method was selected to permit locating the luminaires outside of the hazardous area of the MDD, thereby utilizing higher efficiency, nonexplosive-proof-type light sources. Supplementary floodlighting is provided on the two access/service platforms and nose platforms to provide a high level of illumination for localized work areas where the general task lighting may be inadequate. These floodlights are tungsten-halogen type, explosion proof because of their location on the MDD.

FIRE ALARM

The fire alarm system provided on the MDD comprises only one zone of a complete system for the entire Shuttle approach and landing test (ALT) facilities. The central control for this system is located in the nearby maintenance hangar and shops. One alarm-initiating circuit is extended from the system control panel to the MDD. This circuit is provided with manual stations and water flow switches. The flow switches are located upstream of the manual deluge valves and will operate upon opening of the respective valve. An alarm-sounding circuit is extended from the system control panel to the MDD. This circuit is provided with an alarm-sounding bell on the stairway for each of the MDD legs.

OBSTRUCTION LIGHTING

Obstruction lighting is provided on the MDD because its normal location will always be close to an operating airstrip. The obstruction lighting system is equipped with photoelectric control, mounted at the top of the MDD to automatically control the lights. A manual bypass switch is provided at ground level to override the photo control.

LIGHTNING PROTECTION

The lightning protection system is designed to provide protection for the entire structure and for personnel on the platforms and catwalks. The system design is based on the "cone of protection" concept using cones of 1 to 1 for a single point, and 2 to 1 between two adjacent points.

MECHANICAL (PLUMBING) SYSTEMS

COMPRESSED AIR SYSTEM

The air system is designed to supply shop air to pneumatically operated tools and purging air to electrical equipment located in a hazardous environment. The air system capacity will serve up to seven pneumatic tools in simultaneous operation and also provide a cubic-foot-per-minute airflow to 82 purging enclosures for a total air supply demand of approximately 115 cubic feet per minute. The air compressor is a self-contained factory package unit. The belt-driven air-compressor electric motor, starter, air receiver, and refrigerated air dryer are mounted on a common base and located at ground level, forward of the structure to avoid purging requirements of its electrical components due to the hypergol environment. The electrical components selected for the design are suitable for outdoor use.

The supply air piping system is divided at ground level for separate routing of shop air supply and purging air is reduced to 55 psig. The piping is routed through the tower to serve shop air outlets and purging enclosures on the left and right sides of the tower ("fixed levels") and, for shop air only, on left and right sides of the access/service platforms.

EMERGENCY SHOWER AND EYE/FACE WASH FIXTURES

A combination emergency shower and eye/face wash fixture is located on each side of the MDD "fixed" platforms at levels 20' and 40'. An eye/face wash fixture is located on each access/service platform. These units will serve as temporary relief for accidental spillage of hazardous or irritating fluids. The showers are designed for deluge type flow for full decontamination.

WASHDOWN STATIONS

The washdown stations will enable washing of inadvertent fuel spill on the Orbiter or adjacent areas. The stations are located on the access/service platforms and consist of a 40'-long, retractable water hose reel. The terminal fitting provided is a standard adjustable-type fog nozzle.

PERSONNEL SHOWER SYSTEM

A deluge-type shower system is designed for personnel protection against hypergol spills and ground level fire. The personnel shower system requires manual activation via two butterfly valves. Dual butterfly valves are used to preclude system flow by accidental opening of one valve. Manual activation will require two observers stationed on each side of the towers "fixed" level (either level 20 or level 40, depending on location of the access/service platform).

Each access/service platform has 30 spray nozzles. In addition, deluge-type sprinkler heads are located on the "fixed" levels to provide full egress protection between access/service platforms and "fixed" level stairways. Three additional spray nozzles are located on the access/service platform and are aimed toward the Orbiter's gaseous hydrogen and hydrazine servicing interfaces.

The entire system is supplied from an 8-inch underground main, reduced to 5 inches for routing to four separate manually controlled deluge stations located on the tower. Each control station (dual butterfly valves) has a waterflow detecting device electrically wired to an alarm system.

PIPING SPECIALTIES

The shop air, fire line, and potable water supply between the "fixed" level and access/service platform is supplied through flexible rubber hoses. The hoses must be disconnected when raising or lowering the access/service platform and reconnected to the applicable level (20 or 40) when the access/service platform is positioned at the desired level.

Swivel joints are located on the access/service platforms in order to maintain a vertical position at the hose connections while the access/service platforms are in variable tilting positions. This eliminates undue stress on piping and hoses.

Safety flow-cutoff valves are located in the air supply immediately upstream to the air hoses. These valves will automatically stop airflow in the event of hose rupture and eliminate hose whiplash.

CONCLUDING DISCUSSION

The Orbiter Mate/Demate Device at the Kennedy Space Center, Florida, is basically a twin facility to the MDD at DFRC, Edwards AFB, California, which is the subject of this paper. The two facilities have identical and interchangeable components and systems for mate and demate operations; however, some of the functions and services provided for at DFRC were not required for the design at KSC, such as the following:

- a. Access/egress route for SCAPE-suited personnel
- b. Personnel hoists
- c. Compressed air system
- d. Emergency shower and eye/face wash fixtures
- e. Washdown stations
- f. Personnel shower system

Both of these facilities have been used for each of NASA's Space Shuttle Orbiter's successful series of Orbital flight tests (OFT), with the recovery and mating operation at the MDD at DFRC and the demating operation at the MDD at KSC, where the Orbiter is prepared and readied for each of its space flights.

Related to the MDD's at DFRC and KSC is NASA's Orbiter Mate/Demate Stiffleg Derrick facility at the White Sands Missile Range, Northrup Strip, New Mexico (secondary landing site) (foundation and site design by Connell Associates under direction of NASA, KSC). It is designed and constructed to handle and accommodate the necessary operations, functions, and services for deservicing and mating the Orbiter for its return to KSC. This facility was recently used to recover the Orbiter after one of its OFT return flights and safe landing at WSMR.

In addition to the Orbiter mate/demate facilities at DFRC, KSC, and WSMR, to ensure safe landing, proper servicing, and quick turnaround for the next scheduled space flight, contingency landing sites (CLS's) have been selected by NASA around the world in case the Orbiter needs to make an emergency landing. The CLS's are located at the following airfields:

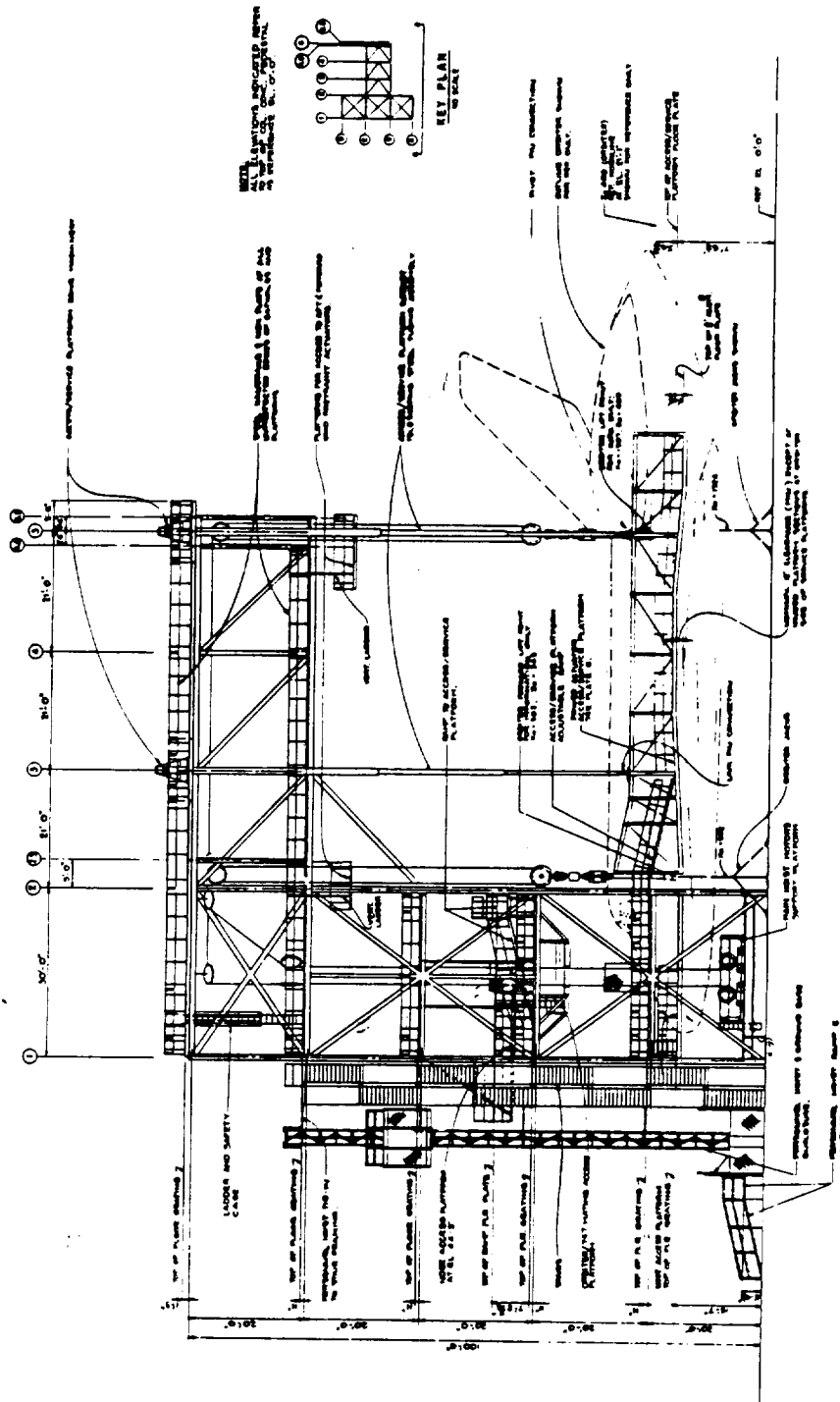
Naval Station, Rota, Spain
Kadena Air Base, Okinawa, Japan
Hickam AFB, Oahu, Hawaii
Dakar, Senegal

A Mate/Demate Stiffleg Derrick Universal Foundation has been designed for each of these sites to accommodate installation of the stiffleg-derrick system (GFE) and the forward and aft guy systems (GFE). All items needed to construct the facility, except for concrete and reinforcing steel, will be provided in a "fly-away foundation kit" which is GFE. Actual construction at any of the sites will not begin until an actual emergency landing of the Orbiter occurs at that particular site and the "go" signal is given by NASA.

REFERENCES FOR ADDITIONAL INFORMATION

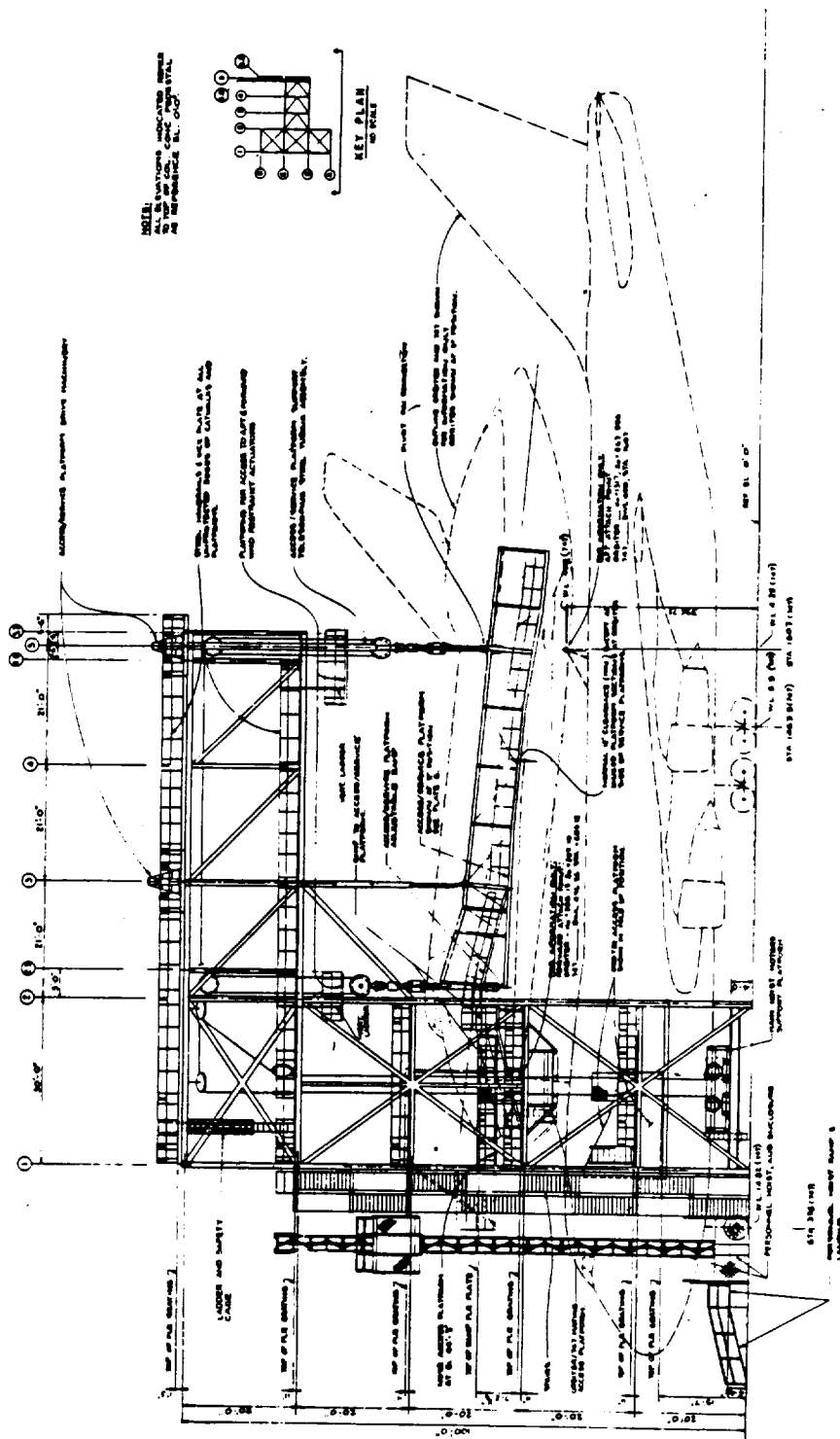
1. NASA Technical Report TR-1355, July 1975, Design Data Manual - Orbiter Mate/Demate Device, prepared by Connell Associates, Inc.
2. NASA Drawing No. 79K05459, Orbiter Mating Device, NASA DFRC, Edwards AFB, California (July 1975)
3. NASA Drawing No. 79K08112, Orbiter Mate/Demate Device, NASA, Kennedy Space Center, Florida (December 1976)
4. NASA Drawing No. 79K16871, Mate/Demate Stiffleg Derrick, White Sands Missile Range, N.M. (June 1979)
5. NASA Drawing No. 79K021033, Mate/Demate Stiffleg Derrick, Naval Station, Rota, Spain (March 1981)
6. NASA Drawing No. 79K21097, "Fly-Away" Foundation Kit CLS (A7D-0873)

ORIGINAL DRAWING
OF POOR QUALITY

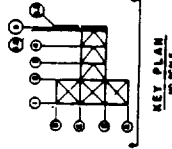


ORBITER MATING DEVICE
SIDE ELEVATION
ORBITER POSITIONED ON JACKS
PLATE NO. 1

CROSS SECTION OF POOR QUALITY

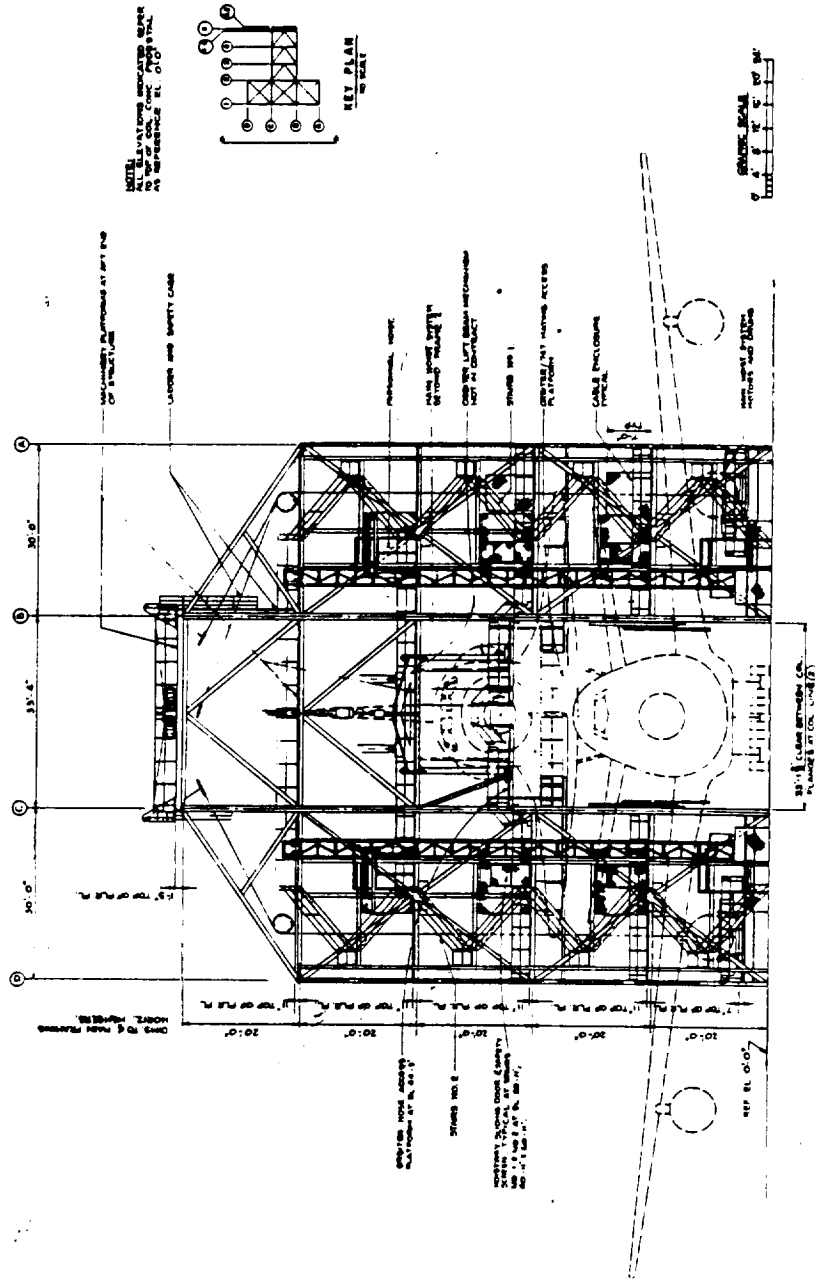


NOTE:
ALL DIMENSIONS INDICATED HEREIN
ARE TO CENTER UNLESS OTHERWISE SPECIFIED.



ORBITER MATING DEVICE
SIDE ELEVATION
ORBITER POSITIONED ON 747
PLATE NO. 2

ORIGINAL FRONT ELEVATION
OF POOR QUALITY



ORBITER MATING DEVICE
FRONT ELEVATION
ORBITER POSITIONED ON 747
PLATE NO. 3

ORIGINAL DRAWING OF OF POOR QUALITY

