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CHECKOUT OF MERCURY-ATLAS LAUNCH VEHICLES

by

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# ABSTRACT

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A description is given of the Atlas in its original configuration and the changes necessary for use as a Mercury booster.

The Abort Sensing and Implementation System (ASIS) was added to trigger the escape mechanism prior to a catastrophic failure and is described. The parameters monitored by the ASIS are listed and discussed.

The test program described is basically limited to checkout at AMR. Those tasks performed at the factory are discussed that have a particular bearing on the AMR Operations. Added testing and philosophy changes made to increase the reliability are also discussed.

The Pilot Safety Program was implemented to insure that everything humanely possible would be done to provide the pilot with the maximum of safety.

The flight testing at AMR consists of unloading the airplane, laboratory checks, erection of the launch vehicle on the test stand, system checkout, tanking test, Flight Acceptance Composite Test (FACT), spacecraft mate and joint test between spacecraft and launch vehicle. A bar chart of the MA-8 countdown is included for reference.

A flow chart is used to show all test procedures in their ideal sequence. The highlights are pinpointed and discussed.

# INTRODUCTION

FIVE! FOUR! THREE! TWO! ONE! LIFTOFF! It is now 9:47:39 EST, the morning of 20 February 1962. The next five and one-half minutes held more tension and excitement for the Atlas launch crews at Cape Canaveral and the people of the free world than all other Atlas launches combined. John Glenn, his Mercury spacecraft, Friendship 7, and Atlas 109-D were then successfully in orbit.

The flight of Friendship 7 was the climax of months of painstaking testing and retesting. All of this meticulous checkout had been preceeded by years of planning, unmanned and manned Redstone flights, and unmanned Atlas flights, all from Cape Canaveral. The roar of the Atlas engines could just be heard over the cheers from the thousands of spectators on the beach. The roar from the engines and the cheers of the spectators on the beach were heard around the world.

This first orbital flight of an American in the Mercury Program will go down in history along with the flight by the Wright Brothers at Kitty Hawk and the suborbital flight of Alan Shepard in his Freedom 7 spacecraft aboard the Redstone rocket.

## PROGRAM DEFINITION

Project Mercury is the United States of America Man in Space Program managed by the National Aeronautics and Space Administration. The objectives of the Mercury Program are:

- 1. To place a manned spacecraft into orbital flight around the earth.
- 2. To investigate the capabilities of man in the new environment.
- 3. To recover successfully the spacecraft and its occupant.

The Atlas launch vehicle is furnished to NASA by the Space Systems Division of the United States Air Force. Aerospace Corporation provides technical assistance to all associate contractors via the USAF. General Dynamics/ Astronautics is the prime contractor for assembly, checkout and launch services in addition to supplying several electronic systems.

#### LAUNCH VEHICLE DESCRIPTION (Figure 1)

The Atlas was chosen for orbital flights since it was the most reliable vehicle available, capable of the mission, in the time span compatible with the Mercury Program. The launch vehicle consists of an airframe, propulsion system and equipment pods to protect the electronics equipment.

The airframe, less the payload, is approximately 75 feet long. The equipment pods are mounted on the outside of the tanks. The thrust section has a gradual taper from the equipment pods to a maximum diameter of 16 feet. The fuel and lox tanks, which are 10 feet in diameter, are constructed in a unique manner; there are neither internal framework nor stiffeners. The tanks depend on pressurization to retain their shape and rigidity. The entire tank section is constructed of stainless steel sheets varying in thickness to a maximum of 0.048 inches depending on the local stress conditions. A special welding technique and machinery were developed by General Dynamics/Astronautics and the welding industry for this task.

The propulsion system is furnished by the Rocketdyne Division of North American Aviation. The two booster engine thrust chambers have a thrust of approximately 165,000 lb. each. The booster thrust chambers, their turbo-pump power package, valves and piping are all mounted in the jettisonable booster section. The honeycomb Fiberglas constructed booster engine package is held in place by ten separation fittings. The single chamber, 60,000 lb. thrust sustainer engine and the turbo-pump power package, necessary valves and plumbing are completely surrounded by the booster section. The separation fittings are broken and the sustainer chamber is nulled at the precise moment after booster engine cutoff to allow the expended booster engines to slide free of the sustainer engine.

There are two vernier engines with a thrust of approximately 1,000 lb. each. The verniers are mounted on the aft end of the fuel tank and are canted at a 30 degree angle to protect the booster package from the flame impingement.

The D series Atlas was designed as a one and one-half stage missile with the advantage of the added reliability of starting all engines on the ground prior to release. Other inherent advantages of this design include the simplification associated with the requirement for only one fuel and one lox tank and a single pressurization system for each tank.

After booster engine cutoff, the in-flight steering is accomplished via a radio guidance system. The airborne system consists of a pulse beacon, rate beacon, decoder and antenna. The guidance ground station has a radar and digital computer. The radar and airborne components are designed and built by the General Electric Company. The computer was designed and built by the Burroughs Corporation. The guidance ground station is operated and maintained by the General Electric and Burroughs Corporations under the management of the United States Air Force 6555th Aerospace Test Wing. Aerosapce Corporation is the technical adviser to the Air Force on the guidance system as well as the launch vehicle.

# CHANGES TO THE LAUNCH VEHICLE FOR PROJECT MERCURY (Figure 2)

The Atlas weapon system was not designed with the reliability requirements imposed by Project Mercury. Therefore, NASA, the United States Air Force Space Systems Division, and General Dynamics/Astronautics made the decision to use the D series weapon system missile in its original configuration with only those changes necessary to (1) accomplish the mission, or (2) improve reliability. If a change was required for one of the above reasons, the USAF and General Dynamics/Astronautics required the new components to be flown on some other program prior to use in the Mercury Program. The changes required to accomodate the mission are:

- 1. Spacecraft adapter.
- 2. Wet start of engines.
- 3. Replacement of the telemetry package by an all transistorized lightweight telemetry system.
- 4. Removal of retrorockets.
- 5. Insulation of lox dome.
- 6. Deletion of vernier solo phase.
- 7. Three-second delay in range safety command destruct signals.
- 8. Addition of Abort Sensing and Implementation System (ASIS).

Those changes made to improve reliability are:

- 1. Boiloff valve.
- 2. Square autopilot.
- 3. Installation of baffle injector in booster engines.
- 4. Insulation bulkhead removal.
- 5. Guidance canister, Leap-frog philosophy.
- 6. Increase of skin thicknesses of the forward end of the lox tank.

## Mission Changes:

1. Spacecraft adapter. The adapter is a cylindrical section approximately five feet long and six feet in diameter which attaches the Atlas and spacecraft together for powered

flight. All adapters used in the Mercury Program are designed and built by the MacDonnel Aircraft Corporation. A special interface committee composed of NASA, Air Force, General Dynamics/Astronautics and MacDonnel coordinates the mechanical and electrical interfaces. The adapter is peculiar to the Mercury mission and could not be flown on other missions prior to use in the Mercury-Atlas series.

2. Wet start of engines. The water lead or "wet start" had been used in the earlier Atlas R&D flights but was discarded for operational missiles. It is accomplished by filling the fuel jacket of the thrust chambers with distilled water in the launch pre-count. This creates a slower thrust build-up, thus allowing lighter skin sections on the aft end of the missile tank. This saving of approximately 60 lb. allows the Atlas to carry an equivalent number of pounds of payload with no added flight complications.

3. Replacement of the telemetry package by an all transistorized lightweight telemetry system. The telemetry system was replaced by a transistorized telemetry system at a weight saving of 85 to 90 pounds, again allowing this much more added payload. This lightweight system was developed for the Centaur Program and has essentially the same measurement capability as the telemetry system on other Atlas launch vehicles.

4. Removal of retrorockets. Since the spacecraft has posigrade rockets for separation from the launch vehicle, the Atlas retrorockets were removed. This allowed the spacecraft to have identical separation sequence on the Redstone flights and Atlas flights. The posigrade rockets are slung under the spacecraft inside the adapters in the same cluster with the retrograde rockets.

5. Insulation of lox dome. The top of the lox tank was insulated to shield the tank from the posigrade rocket blast at  $\omega$  separation and to protect the posigrade and retrograde rockets from extremely low temperatures of the lox tank. This insulation consists of a Fiberglas skull cap fitted to the lox dome.

6. Deletion of vernier solo. The vernier solo package was removed since the accuracy requirements for Mercury orbital launches are less than those for ballistic trajectory at ICBM ranges. The deletion of the vernier solo phase made the launch vehicle propulsion system less complicated by eliminating the requirement to refill and repressurize the vernier solo tanks in flight. Removing this equipment resulted in a significant weight savings on the launch vehicle which could be added to the spacecraft.

7. Three-second delay in range safety command destruct signals. In the event of a malfunction in flight requiring the Range Safety Officer to command a manual fuel cutoff and ultimately a destruct, a three-second delay between fuel cutoff and destruct was added to allow the spacecraft to separate a safe distance prior to destruction of the launch vehicle.

8. Abort Sensing and Implementation System (ASIS). The ASIS (Figure 3) was added to provide automatic protection for the astronaut in the event of a catastrophic failure of the launch vehicle during powered flight. It is designed to detect an impending catastrophic failure and trigger the spacecraft escape mechanism in time to afford the maximum of safety to the astronaut. The parameters monitored by the ASIS were selected on the basis of an analysis of data from all previous static and flight tests.

The launch vehicle was further analyzed for possible failures which had not occurred in previous flights or static tests but which could create a catastrophic condition. The parameters monitored are sustainer hydraulic pressure; fuel and lox tank differential pressure; lox tank pressure; 115 volt a-c, 400 cycle, Phase A; 28 volts d-c; continuity of the interface between the launch vehicle and spacecraft; missile pitch, yaw and roll attitude rates; and the fuel manifold pressures of the three main engines.

a. Sustainer hydraulic pressure. The sustainer hydraulic pressure measurement is an indication that the engine and plumbing are intact, the turbopump is still functioning and there is an adequate supply of hydraulic pressure to enable the autopilot to provide missile stability. b. Lox tank pressure. The lox tank must be pressurized to maintain structural integrity of the launch vehicle and provide the necessary static head pressure to the engine turbopumps.

c. Differential pressure. The fuel tank must be pressurized to maintain airframe integrity and provide the necessary head pressure to the turbopumps. In addition, the fuel tank pressure must be great enough to overcome the forces from lox weight, g-load and lox tank pressure on the pressure bulkhead. The requirement for monitoring the fuel tank pressure and differential pressure can be fulfilled by the bulkhead differential pressure measurement.

d. Four-hundred cycle, 115 volts a-c. This parameter must be monitored since the autopilot has three phase spin motors in the gyros and uses Phase A for all signals. The loss of Phase A would result in missile instability and ultimately breaking up.

e. Twenty-eight volt d-c. The 28 volt d-c is the primary missile power. The autopilot system used the 28 volts d-c to power all transistorized stages. The loss of d-c power followed by missile instability would result in a catastrophic condition.

f. Continuity of interface between the launch vehicle and spacecraft. The 28 volt signal through the interface between the launch vehicle and spacecraft is monitored. This indicates structural integrity of the adapter and forward section of the launch vehicle and the electrical interface is still capable of passing all normal or abort commands.

g. Missile attitude rates. The missile attitude rates; pitch, yaw and roll, are monitored for an over-rate condition. All previous flight failures have always been accompanied by excessive missile attitude disturbance prior to an ultimate failure. h. Booster one, booster two, and sustainer fuel manifold pressure. Analyses of the flight and static test data revealed that a major engine malfunction was always preceded by a decrease in at least one of the engine fuel injection manifold pressures.

An additional design requirement was that an erroneous abort signal could not be generated by a component failure within the ASIS. This protection is provided in two ways, first, by adherence to a rigid test program placed upon the ASIS and all of its components. All components used in the system had previously demonstrated their reliability through many R&D flights.

The second, and probably most significant self-protection scheme, is the redundancy designed into the system. Each of the parameters monitored has dual transducers or other devices to protect against single failures such as a pressure switch failure, broken wire, shorted diodes, etc. The circuitry within the Abort Sensing Control Unit (ASCU) canister was designed and constructed for maximum reliability. A diode matrix as shown in Figure 4 is a typical example of this design.

This redundancy proved itself in the flight of MA-7. The sense line to sustainer hydraulic pressure switch number two was apparently frozen during flight, decreasing the pressure applied to this switch and creating a single abort condition at four minutes and 25 seconds after liftoff. The ASIS properly interpreted this single ASIS malfunction and did not create an abort command as evidence by the successful three orbits of Scott Carpenter. Each new flight on an Atlas missile is analyzed to see if the parameters for ASIS would have been valid during that flight.

Reliability changes:

1. Boiloff valve change. The lox boiloff valve was changed from the weapon system valve to a type similar to that used in the C series R&D flight test program. The tradeoffs involved were a more reliable valve but with less capacity than the operational valve being developed, which would have better logistics. Further study indicated C series type valve had an ample capacity for the Mercury mission which is tanked at a slower rate than operational missiles.

2. Square autopilot. The autopilot change was created to replace the potentially unreliable Electro-Mechanical Programmer (cam and micro switches) with an all electronic transistorized programmer. The new autopilot consists of four square packages; programmer, gyro, servo, and rate gyro in place of the previously round canisters. The rate gyro package was moved forward on the tank section to a more sensitive location to compensate for the change in center of gravity which was a result of the heavy spacecraft being mounted on the forward end. Redundant rate gyros were added for the ASIS over-rate detection system.

3. Installation of baffled injector in booster engines. The rocket engines have shown traces of combustion instability at various times during the rocket engine and weapon system development programs. Rocketdyne's solution was the baffled injectors that are now installed in the booster engines to counteract this potential pressure instability. The baffled injectors were certified for use on the MA-8 mission and will be used on all subsequent Mercury missions as well as most other space programs using the Atlas. These baffles smooth out combustion pressure transients in the thrust chamber in the same manner fluid flow turbulence is controlled by baffles in a pipe.

4. Removal of insulation and insulation bulkhead. The insulation bulkhead is a layer of styrofoam located inside the fuel tank to minimize the heat transfer from the fuel to the lox. This insulation is supported by an aluminum bulkhead with a strength capability of support dry styrofoam with an adequate safety factor. The MA-6 launch was delayed to remove this insulation and supporting bulkhead when it was discovered that a small fuel seepage was wetting the styrofoam and reducing the dry weight safety factor. The MA-7 mission used a special tanking technique which further minimized the possibility of the insulation being wetted with fuel and jeopordizing the flight. The insulation was removed from MA-8 and subsequent Mercury missions to preclude the possibility of any further launch delays. This insulation was

not used during the A, B and C series R&D flights. It was added in the D series with the expectation of improving the launch vehicle performance. Data analysis subsequently showed the performance gained to be small in comparison to the added complexity, so the design was eliminated on E and F series missiles.

5. Guidance canisters, leap-frog philosophy. This plan involves the use of airborne equipment identified for Ground Test Only (GTO) in place of flight qualified Project Mercury canisters in all situations where the flight qualified equipment is not required. The GTO canister does not have to pass the flight certification but is electrically and mechanically equivalent in all other respects. There is no maximum hours limitation on the test canisters as long as they meet the same test parameters as the flight units. Mercury certified flight canisters are installed for all major composite tests.

6. Increase of skin thicknesses of the forward end of the lox tank. The skin thicknesses on the forward end of the lox tank were increased to provide adequate design safety factor for the heavy stress loads imposed by the spacecraft.

#### GENERAL TESTING PHILOSOPHY

Although the checkout, operating and maintenance procedures have always been scrutinized and revised when necessary, special Project Mercury review teams were formed at the factory, the complex and the guidance ground station. The only changes made were those necessary due to Mercury configuration differences; changes to increase reliability of testing, and changes to provide better documentation. To fulfill the added reliability requirements of the Mercury Program, General Dynamics/Astronautics created a new criteria for selection of critical items. These items are selected from the middle of the acceptable tolerance band allowable for other Atlas missiles. These components should neither be high nor low, and they should have a very minimum of rework.

An extensive indoctrination program for all General Dynamics/Astronautics employees and subcontractors working on Mercury components was instituted at the beginning of the program. This program consisted of educating all employees about t/ objectives and national importance of the Mercury

Program. As a reminder to the employee, a Mercury decal (Figure 5 and Figure 6) is attached to selected critical components during the manufacturing or checkout phase. These critical items receive additional care since each employee knows he is contributing to the safety of the astronaut. A similar indoctrination and identification program is used at General Electric. All flight certified guidance canisters are identified with a Project Mercury decal (Figure 7) and receive special attention during manufacturing, checkout, shipping and storage.

Prior to acceptance of a Mercury-Atlas launch vehicle at the factory, the missile history and open tasks are reviewed so as to assure General Dynamics/Astronautics and the customer that all tasks have been incorporated at the factory. This eliminates all modifications to Mercury-Atlas launch vehicles at AMR.

The checkout of the completed missile at AMR with a different crew and test equipment creates a redundancy in testing and essentially eliminates the acceptance of a faulty component in the field as a result of a personnel error or a malfunction in a piece of test equipment.

Component testing. Individual components are tested at the factory for conformance to specifications. Some critical items, i.e., gyros and regulators, are selected at the component level to a new criteria and decals are applied for identification. Special handling and documentation begins at this time and continues as long as the component is assigned to the Mercury Program.

Subsystem testing. During the assembly and testing of subsystems, autopilot canisters, propellant utilization canisters, etc., nominal subsystems are again selected. The pedigrees, histories and test data are reviewed for acceptability to Mercury standards. More rigorous testing is generally applied to the subsystem at this time. Once accepted an item is decaled for rapid identification.

those that are necessary because of the missile configuration differences and improved test equipment that has previously been used on other programs. An example of the latter is the manual gyro table which has been replaced by the new automatic gyro checkout set. The automatic test is more rigorous and has a test time of two hours as compared to approximately 24 hours on the old table.

All systems are tested individually for compliance to specifications. This includes tests similar to gyro torque rates, engine static gains, autopilot frequency response, missile electrical static and dynamic checkout, propulsion leak and functional test, ASIS harness and pressure switch checkout and pneumatic and hydraulic leak and dynamic test.

At the successful completion of all individual systems tests and an autopilot-guidance integrated test, the missile is subjected to a final composite test. During the composite, all missile systems are operating on internal power in as near a flight configuration as possible. Each system is exercised similar to a flight. Fuses are blown in place of pyrotechnic devices. The data is reviewed for compatibility and noninterference between systems and compliance to the system test parameters with slightly wider tolerance.

Search for Critical Weaknesses (SFCW). A new test has been devised for the Mercury Program and is named, search for critical weaknesses. The philosophy on this test is straight forward and consists of running a test to determine the weakest link in the chain. During this SFCW test, the components are exposed to excessive vibrations, temperatures, humidity, overvoltage, under-voltage, over-frequency, etc., until a failure occurs. The chain is made stronger and more reliable by finding the weak link, then strengthening this link. The SFCW test is run on all critical components and then must be repeated after any major redesign.

# PILOT SAFETY PROGRAM

A pilot safety program was devised and implemented by the Air Force and their technical advisors. This program consists of three basic parts, factory roll-out inspection, design review, and review of test procedures and documentation.

The factory roll-out inspection is a refinement of the missile acceptance used throughout the R&D flight test program. More emphasis is placed on a completed launch vehicle, complete and adequate documentation, complete testing and data evaluation.

The design review is a more complete analysis of proposed design changes by the associate contractors.

Probably the most significant contribution to the success of the Mercury Program is the review of test procedures and documentation. The test procedures are continually being reviewed by working teams for complete and meaningful testing. The completed test procedures are reviewed by this same working team for compliance, complete documentation and any trend in the test data that might indicate an impending failure. The working team is composed of a contractor's system engineer, Aerospace system engineer, the Air Force Project Officer and USAF quality control. These working teams were formed as a technical organization but have contributed even more by creating the team spirit in all members.

The working teams report to the Active Review Team. The Active Review Team either accepts or rejects the recommendations of the working teams. If the contractor has not taken the required action as recommended by the working team, then the Active Review Team can give the necessary Air Force direction. The Active Review Team has one member each from the 6555th ATW, USAF quality control, and Aerospace Corporation. The chairman is the Aerospace representative.

#### FACTORY ROLL-OUT INSPECTION

After the completion of a composite test at the factory, the General Dynamics/Astronautics data evaluation group in San Diego reviews the data to determine if the composite is acceptable or not acceptable. If the composite is acceptable to General Dynamics/Astronautics, San Diego, the data is turned over to the USAF quality control for review. After the data is accepted by Air Force quality control, the roll-out inspection team, composed of USAF-SSD, Aerospace and General Dynamics/Astronautics, is convened in San Diego for the following purposes:

- 1. Audit all open tasks.
- 2. Review the composite test data.
- 3. Perform a physical inspection of the missile.
- 4. Review the pedigree of all selected critical components assigned to the Mercury Program.

The missile is prepared for shipment to AMR when all conditions are satisfactory to the roll-out inspection team.

# FLIGHT TEST

The flight test philosophy used in the Mercury Program is very similar to the test program used during the R&D Atlas development program. More emphasis has been placed on documentation, data analysis and availability of backup spares. The autopilot and ASCU canisters are removed from the missile at AMR and placed in the autopilot and ASCU laboratories for retesting individually and as a married set; rate gyros are married to ASCU overrate detectors. This retesting at AMR with a different crew, on a different (but identical) test set, and with a different data evaluation group, essentially eliminates the possibility of passing a faulty component as a result of a faulty test set or human error. The autopilot and ASCU procedures used at San Diego and AMR are identical and the testing is performed on identical test sets in order to make a comparison of field and factory data for trends.

There are normally three sets (called the flight set, the first back-up set, and the second back-up set) of critical canisters: autopilot, ASCU, propellant utilization, telemetering and guidance associated with each missile at AMR. The flight and first back-up sets undergo a complete checkout in the laboratories and on the launch vehicle at the complex at AMR. The first back-up set is then stowed in a bonded area for use in the event of a flight component failure. The third set, or second backup set, normally only has passed the laboratory checkout in San Diego and AMR. The reason for performing a checkout on the back-up canisters is to minimize the amount of delay in the launch date if a canister fails.

The Mercury launch team was selected from General Dynamics/Astronautics and associated contractor personnel. Only the most qualified engineers, technicians and mechanics are assigned to Project Mercury. A special security background investigation is required for all employees to assure the maximum of security to the launch vehicle and supporting Aerospace Ground Equipment (AGE).

Upon arrival at AMR, the missile is unloaded from the airplane and transported to the hanger assembly area. The missile is lifted from the trailer used for air transportation and placed in a different type of trailer for erection at the AMR. The air transport trailer is air-delivered back to San Diego.

The launch vehicle is completely inspected for damage during transit. An inventory of all components is performed. Those items removed for air transit are installed prior to launch vehicle erection at the complex. Concurrently with this inspection and installations in the hanger assembly area, the complex is being prepared for launch vehicle erection and the autopilot and ASCU canisters are being tested in the laboratory area.

An idealized test sequence chart used on Missile 113-D (MA-8) is shown in Attachment A and covers all General Dynamics/Astronautics test procedures required for checkout of a launch vehicle.

A normal checkout consists of testing each system (autopilot, guidance, ASIS, etc.), in a manner very similar to the test performed in San Diego. A different checkout procedure is used since the launch AGE is used. However, the parameters tested are identical to those used in San Diego except for wider tolerances.

In addition to airborne systems checkout, all AGE undergoes a checkout either before erection or with the launch vehicle after erection. A booster flight acceptance composite test (B-FACT) similar to the San Diego composite test is performed on the vehicle after the satisfactory completion of all individual systems tests. Flight components are used in all systems except fuses are substituted for pyrotechnic. The B-FACT consists of running a short countdown similar to the launch countdown, testing of all electrical-electronic systems on external power, switching to internal power, proceeding through a simulated engine ignition, umbilical ejection and allowing all RF systems to perform with the range and guidance ground station in a manner similar to the launch operations. The guidance ground station sends all discrete commands close to the nominal flight times. The objectives of the B-FACT are to prove compatibility and noninterference between systems on internal power with the umbilical removed and that neither the propulsion nor other airborne systems will shut down at umbilical ejection and that all systems will go through a normal flight sequence. After the successful completion of a B-FACT, the spacecraft can be mated to the launch vehicle.

The Mercury Program is different from other programs using the Atlas launch vehicle in requiring a completion of all launch vehicle testing prior to mating of the payload. This policy makes it possible for the launch vehicle personnel to support the spacecraft testing with a minimum of interference and delay. At the completion of the Joint-FACT, the worldwide tracking network and ocean-going vehicles are deployed, thus the maximum of testing should be completed prior to this time.

On some Mercury launch vehicles a flight readiness firing (FRF) is required. If required, this task is also performed after B-FACT but prior to spacecraft mating. The test procedure used is essentially identical to the last 150 minutes of a launch countdown, except for astronaut insertion and spacecraft testing. The engines are run for 10 seconds.

The spacecraft installation is composed of two parts: adapter installation atop the launch vehicle, and physical mating of the spacecraft to the adapter. Prior to spacecraft installation, an interface inspection is performed to assure all agencies concerned of the cleanliness, mechanical and electrical integrity of all components in the adapter area.

The countdown used during the launch is similar to countdowns used in other Atlas test programs. A bargraph for MA-8 is included as Attachment B. The major differences are spacecraft checkout, astronaut insertion and complete launch vehicle checkout before and after astronaut insertion. This repetitive testing is to assure a minimum amount, if any, of hold time after the astronaut has been inserted in the spacecraft. The autopilot-guidance loop test is rerun after astronaut insertion but immediately before tower removal. In event of a failure of either the guidance or the autopilot system during the loop test, the components can be changed without requiring the added delay of returning the service tower around the launch vehicle.

The astronaut enters the spacecraft at approximately minus 140 minutes in the launch countdown. At any time prior to tower removal, minus 50 minutes, the pilot could egress to the service tower in event of any emergency in the spacecraft or launch vehicle.

The astronaut may egress one of three ways after tower removal. If there is an emergency in the spacecraft, a bascule can be lowered to a position by the spacecraft. The door can be blown off by the pilot or rescue team or wait on the removal of the hatch depending on the condition of the astronaut and the urgency of the situation.

If the mission is delayed for weather, spacecraft, launch vehicle or tracking network troubles, the gantry would be returned around the Atlas. The spacecraft service crew would remove the bolts securing the hatch in place and the astronaut would egress on the service tower.

The third method of escape used to protect the astronaut is by separation of the spacecraft from the launch vehicle. The spacecraft escape rockets are armed at gant ry removal and may be fired from the Atlas Test Conductor Console at Blockhouse 14, Mercury Control and by the astronaut in the spacecraft. Parallel paths for the Atlas Test Conductor are provided through umbilicals (hardwire) and via a radio link from the range.

The authority for activating the abort or escape mechanism is assigned to the Atlas Test Conductor from T minus 55 minutes through plus 10 seconds. Mercury Control has the authority from plus 10 seconds through powered flight. The pilot has capability for creating an abort from liftoff until separation but does not have the authority for acting except as a backup for the Atlas Test Conductor or Mercury Control. After careful consideration of all Atlas systems the parameters listed in Attachment C were selected for monitoring at the times indicated.

# SUMMARY:

The most significant contributions to the success of the Mercury Program are:

- \* Selection of nominal components.
- \* Incorporation of modifications to improve reliability.
- \* Selection of launch crews.
- No modifications at AMR.
- \* All flight components have established reliability from other flight test programs.
- \* Complete systems testing at factory and retesting at AMR.
- \* Emphasis on documentation.
- \* Team spirit by all agencies.
- Complete launch vehicle testing prior to spacecraft mating.
- \* Interface inspection.

Each of the changes in hardware, testing and testing philosophy have been analyzed and adapted to other programs in the manner best suited to the needs of these programs. Identical procedures are used on Mercury, Ranger and Mariner missiles except for mission pecularities. The Ranger-Mariner series does not require complete launch vehicle testing prior to payload mating. Their missions require meeting short launch windows while Mercury has no launch windows but must minimize the time the world wide network re on station.







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ATTACHMENT A

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. 9	s	LANDLINE							
10	ĸ	LOS CONTROL	FILL LE2 HEAT EX		LO2 PREP	LOS TATKIN	G		
10	L	FUEL CONTROL	F & D CHEDOK						
10	×	PRESSURIZATION	STAGE I			STACE II			п
10	N	PREUMATICS		ELIUM PREPARATION	HELI	um storage			
10	٩	WATER SYSTEM					ALL PO	MPS ON	110
10	U	MISSILE RECTRICAL							
11	T	GROUND SUPPORT	STOURE WEITE ROOM	TOWER FREP TOW	ER REMOVAL	1			
				60 	45	30	15	1	1

FOWLER-14 ⊳ DIVISION OF GENERAL DYNAMICS CORPORATION GENERAL DYNAMICS/ASTRONAUTICS GENERAL DYNAMICS/ASTRONAUTICS ATTACHMENT C AMR OPERATIONS ABORT PARAMETERS Page 1 MISSILE FOR Prepared by 113D Site Manager 0 Complex 14 Ģ Fowler ç PNEUMATIC CONSOLE PARAMETER TIME HOW REPORTED TANK PRESSURE Uncontrollable loss or rise T-45 min. thru lift-off and Report condition to Test in fuel or LO2 tank pressure plus time in case of a launch Conductor. abort. PERISCOPE PARAMETER TIME HOW REPORTED M'ssile Structure T-45 min. to T  $\neq$  10 seconds Report condition to (a) Any abnormal condition Test Conductor. (b) Tank Integrity (c) Pod Doors (d) Nacelle Doors T.S. Integrity (e) (f) Adapter Integrity Missile Attitude T-45 to lift-off and plus (a) Any deviation from Report condition to vertical time in case of launch abort. Test Conductor. (b) Missile falling T-45 to  $T \neq 10$  seconds or Report as "Abort" Astronaut egress in case of Launch Abort Missile Fire T-45 to T-0 (a) Smoke from pods Report condition to Test Conductor. (b) Smoke or fire from T.S. T-45 to T-0 Report condition to Test Conductor. (c) Abnormal after fire in case Leunch Abort only Report condition to of launch abort after ignition Test Conductor. (d) Abnormal flame pattern Lift-off to T/10 sec. Abort (e) Fire in T.S. Lift-off to T/10 sec. Abort RECORDER COMPLEX 14

FIRE IN T.S.

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t.

P1673T, P1674T, P1675T, Abrupt Rise & Recorder going off Scale T-45 to lift-off or plus time in case of launch abort. Report condition to Test Conductor.