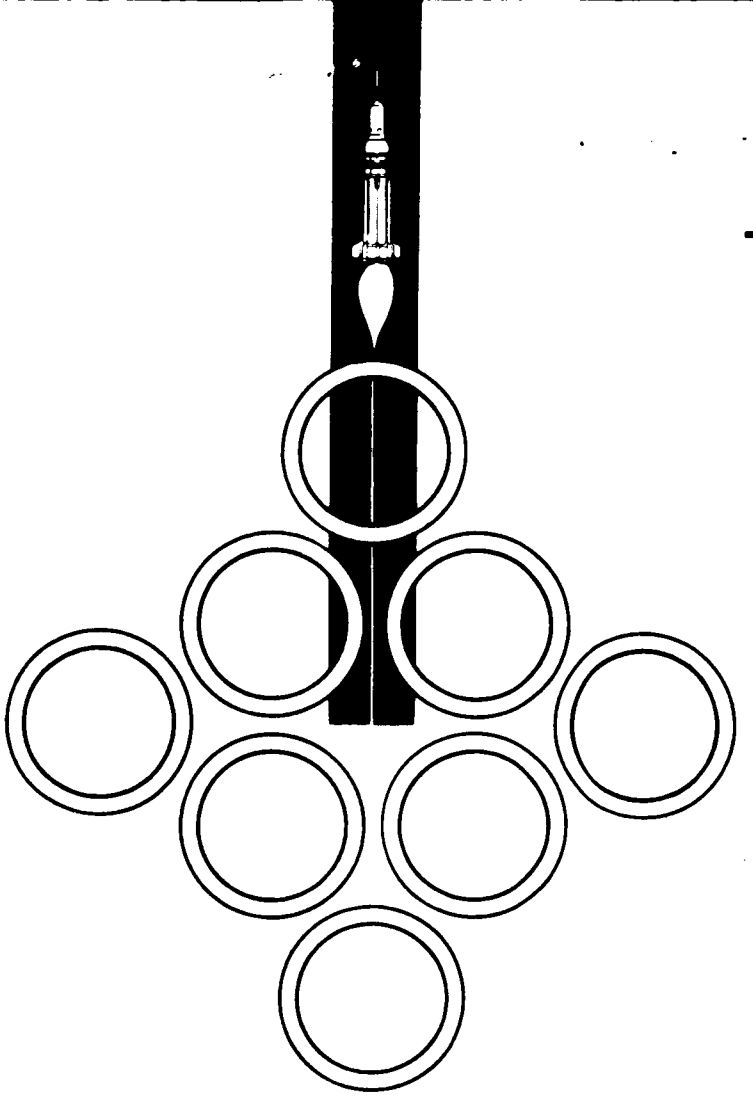

ENGINEERING DEPARTMENT

# TECHNICAL MANUAL

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# Saturn I

## LAUNCH VEHICLE SA-8 AND LAUNCH COMPLEX 37B FUNCTIONAL SYSTEMS DESCRIPTION

### Volume III

$LH_2$ FUEL SYSTEM FUNCTIONAL DESCRIPTION, INDEX OF FINDING NUMBERS, AND MECHANICAL SCHEMATICS



SPACE DIVISION CHRYSLER CORPORATION

SDES-64-414

# SATURN I
# LAUNCH VEHICLE SA-8
# AND
# LAUNCH COMPLEX 37B
# FUNCTIONAL SYSTEMS DESCRIPTION

## VOLUME III
## $LH_2$ FUEL SYSTEM
## FUNCTIONAL DESCRIPTION, INDEX OF FINDING NUMBERS, AND MECHANICAL SCHEMATICS

May 1964

CHRYSLER CORPORATION SPACE DIVISION - NEW ORLEANS, LOUISIANA

# FOREWORD

This volume is part of a ten-volume set that describes the mechanical and electromechanical systems of launch vehicle SA-8 and launch complex 37B that function either during the prelaunch countdown or in the event of a launch cancellation. The mechanical and electromechanical systems of the launch vehicle that function during flight are also described.

The ten-volume set is prepared for the Functional Integration Section, Systems Integration and Operations Branch, Vehicle Systems Division, P&VE Laboratory, MSFC, by Systems Engineering Branch, Chrysler Corporation Space Division under Contract NAS 8-4016.

This volume describes subsystems and components within launch vehicle SA-8 and on launch complex 37B that make up the $LH_2$ fuel system. The information is presented three sections: functional description, index of finding number, and mechanical schematics. The technical content reflects the functional system design information available on March 3, 1964.

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# SECTION 1

# FUNCTIONAL DESCRIPTION

## 1.1 INTRODUCTION

The $LH_2$ fuel system supplies fuel to the S-IV stage propulsion system. As shown in figure 1-1, a portion of the system is physically located within the S-IV stage, and the remaining portions are located on launch complex 37B. The launch complex portions of the system include an $LH_2$ fuel storage facility, transfer line control equipment, and equipment for controlling and monitoring fuel system operations. The S-IV stage portion of the system consists of a propellant tank that is divided into $LH_2$ and LOX containers; sensing elements for determining system pressures, temperatures, and $LH_2$ container levels; and other components for controlling system pressurization and $LH_2$ transfer between the launch complex and the S-IV stage.

Schematic diagrams are provided in section 3 to supplement the functional description of the system. The index of finding numbers in section 2 provides a physical and functional description of components identified on the mechanical schematics.

## 1.2 SYSTEM FUNCTIONS

Major functions of the $LH_2$ fuel system are: the storage of $LH_2$ to be used for filling the S-IV stage $LH_2$ container, the transfer of $LH_2$ between the $LH_2$ storage facility and the S-IV stage $LH_2$ container, and the utilization of $LH_2$ within the S-IV stage. Each of these functions is discussed in the following paragraphs.

1.2.1 $LH_2$ Storage - $LH_2$ storage is accomplished in three operations: storage facility purge, storage tank filling, and storage tank pressurization. The operations are initiated, controlled, and monitored at control equipment in the automatic ground control station (AGCS), launch control center (LCC), and the electrical equipment house (EEH).

Before the storage tank is filled with $LH_2$, the tank and associated lines are purged with $GN_2$ to prevent the formation of explosive mixtures of air and hydrogen. Following the $GN_2$ purge, the storage tank is purged with $GH_2$ and filled with $LH_2$ from mobile tankers.

The stored $LH_2$ remains in the storage tank until $LH_2$ transfer operations are initiated. During this storage period, storage tank pressure is maintained at approximately 4 psig. Excess pressure is vented to atmosphere.

1.2.2 $LH_2$ Transfer - Transfer operations include: prelaunch operations, postlaunch operations and launch cancellation operations. Prelaunch operations include S-IV stage LOX container pressurization, $LH_2$ storage tank pressurization, transfer line and S-IV stage cooldown, main fill, replenish, and final topping. Postlaunch operations include various operations necessary to depressurize the $LH_2$ storage tank and remove residual

$LH_2$ or $GH_2$ from transfer and storage facility lines. Since postlaunch operations are not part of the prelaunch countdown, they are discussed here only to the extent that they are employed in the event of a launch cancellation. Launch cancellation operations may be initiated during or after $LH_2$ transfer to the S-IV stage and include: storage tank venting, S-IV stage $LH_2$ fuel container pressurization, S-IV stage $LH_2$ container draining, transfer line warmup, and transfer line inerting.

1.2.2.1 Prelaunch Operations. Prelaunch transfer operations are performed to supply $LH_2$ to the S-IV stage fuel container. The operations are initiated, and monitored at the $LH_2$ control and $LH_2$ components panels in the LCC and are controlled by Douglas Aircraft Company (DAC) propellant loading control equipment. In a normal prelaunch countdown, the operations are sequenced automatically; however, mode selection capabilities at the $LH_2$ control panel enable manual sequencing or simulation of the operations.

The S-IV stage propellant tank and transfer lines are purged to provide an inert atmosphere within the S-IV stage and the transfer line prior to $LH_2$ transfer. The purge medium is helium (He) supplied from valve panel A (volume V). After passing through the stage and transfer lines, the purge supply is vented to the launch facility burn pond.

The S-IV stage LOX container is pressurized with He to approximately 48 psig to prevent collapse of the LOX/$LH_2$ bulkhead during $LH_2$ loading.

The $LH_2$ storage tank is pressurized prior to $LH_2$ transfer to provide the pressure head necessary for transferring $LH_2$ from the storage tank to the S-IV stage $LH_2$ container. Pressurization is accomplished by means of an $LH_2$ vaporizer that is supplied with $LH_2$ drawn from the storage tank and provides $GH_2$ for tank pressurization. The storage tank pressurization system maintains tank pressure at approximately 42 psig throughout $LH_2$ transfer.

Immediately following storage tank pressurization, cooldown of the transfer line and the S-IV stage is initiated. During this operation, a restricted $LH_2$ supply flows from the storage tank, through the $LH_2$ subcooler and transfer line and into the S-IV stage $LH_2$ container. The $LH_2$ flow precools the transfer line and fuel container to reduce $LH_2$ vaporization during subsequent $LH_2$ transfer. The cooldown $LH_2$ supply continues to flow until the S-IV stage $LH_2$ container is 15 percent filled.

When the S-IV stage $LH_2$ container is 15 percent filled, main $LH_2$ transfer is initiated automatically. An unrestricted $LH_2$ supply flows from the storage tank, through the subcooler and into the transfer line. The flow continues through the main fill transfer control and the S-IV stage fill and drain valve into the S-IV stage $LH_2$ container. Main fill continues until the DAC propellant loading control equipment senses that the $LH_2$ container is 92 percent full. At this point in the filling operation, the DAC equipment sends a signal that terminates $LH_2$ flow through the main fill control and initiates the replenish operation.

During replenish, $LH_2$ flows to the S-IV stage through the replenish control which regulates $LH_2$ flow to either 20 gpm or 500 gpm. The 500-gpm flow is maintained

until the $LH_2$ container is 99.25 percent filled as indicated by DAC propellant loading control equipment. At this indication, the replenish control reduces $LH_2$ flow to 20 gpm, which is less than enough to compensate for boiloff losses. When the $LH_2$ container fuel level falls to the 99-percent full level, the replenish control increases $LH_2$ flow to 500 gpm and maintains this flowrate until the $LH_2$ container is again filled to the 99.25-percent full level. The $LH_2$ container fuel level is repeatedly adjusted between 99.00 and 99.25 percent full until final topping is initiated at approximately T -140 seconds in the prelaunch countdown.

During final topping, the $LH_2$ container is filled to the 100-percent-full level and pressurized. $LH_2$ flow through the replenish control is increased to, and maintained at, 500 gpm until the container is 100 percent filled. DAC propellant loading control equipment then commands closure of the replenish control, the S-IV stage fill and drain valve, and $LH_2$ container vent valves. With closure of the replenish control, the transfer line vent valve is opened, and the transfer line between the replenish control and the vehicle is vented to the launch facility burn pond. The S-IV stage $LH_2$ container is then pressurized with helium routed from valve panel B (volume V) to the S-IV stage $LH_2$ container pressurization system. Final topping is complete at approximately T -90 seconds.

At liftoff, all ground connections to the vehicle are severed, and the umbilical housings are purged with helium.

1.2.2.2 Launch Cancellation Operations. Launch cancellation operations are performed to drain fuel from the S-IV stage and remove residual $LH_2$ or $GH_2$ from transfer and storage facility lines in the event of a launch cancellation.

When a launch cancellation is indicated, $LH_2$ transfer to the S-IV stage is halted and the $LH_2$ system is placed in standby status. To prevent further $LH_2$ transfer, the main fill and replenish transfer controls are closed, and the S-IV stage fill and drain valve is closed.

Upon initiation of S-IV stage $LH_2$ drain, the $LH_2$ storage tank pressurization supply is terminated and storage tank pressure is vented to the atmosphere. Simultaneously, the S-IV stage $LH_2$ container vent valves are closed and the container is pressurized with He. When the $LH_2$ container pressurization is complete, the S-IV stage fill and drain valve, main fill transfer control, and replenish transfer control are opened. The S-IV stage $LH_2$ container pressure forces $LH_2$ from the container, through the transfer line, and back into the $LH_2$ storage tank.

As $LH_2$ is drained, transfer line temperature is monitored as a means of detecting $LH_2$ flow. A temperature increase indicates a reduction of $LH_2$ flow and, consequently, depletion of $LH_2$ in the S-IV stage $LH_2$ container. When an increase in transfer line temperature is indicated, the line warmup operation is initiated. $LH_2$ transfer to the storage tank and further S-IV $LH_2$ container pressurization are terminated and the transfer line is vented to the launch facility burn pond. Venting is continued for 3 hours to allow complete vaporization of residual $LH_2$ and the dissipation of $GH_2$ vapors. Following line warmup, various manual valves are opened to admit a low-pressure $GN_2$ purge supply to the transfer line. The $GN_2$ purge eliminates any remaining $GH_2$ and provides an inert atmosphere within the lines.

1.2.3 S-IV Stage $LH_2$ Utilization - S-IV stage $LH_2$ utilization operations begin with RL10A-3 engine cooldown and terminate at engine cutoff. These operations include $LH_2$ container pressurization and $LH_2$ consumption.

## 1.3 SYSTEM DESCRIPTION

1.3.1 Storage Equipment and Subsystems - The major components and subsystems within the $LH_2$ storage facility are identified in figure 1-1. The more complex of these components and subsystems are described below; the remainder are described in the index of finding numbers, on system mechanical schematics and in descriptions of systems operations.

1.3.1.1 Pneumatic Control Console. The pneumatic control console receives 3500-psig $GN_2$ from the nitrogen and helium storage facility (volume IV) and provides $GN_2$ outputs of 750 psig and 25 psig. The 750-psig and 25-psig outputs are used to actuate various $LH_2$ storage facility control devices. The 25-psig $GN_2$ is also distributed through restrictive orifices for purging lines and electrical equipment cabinets.

1.3.1.2 Storage Tank Pressurization Subsystem. The storage tank pressurization subsystem consists of an $LH_2$ vaporizer, pressure controllers, flow regulators and other associated control devices. The subsystem maintains storage tank ullage pressure at approximately 4 psig during steady state storage conditions and increases the pressure to approximately 42 psig during $LH_2$ transfer operations. During steady-state conditions, storage tank pressurization is accomplished through controlled venting of $LH_2$ boiloff within the storage tank. During $LH_2$ transfer operations, however, additional tank pressurization is provided by $LH_2$ Vaporizer A3754. (See figure 3-1.) The vaporizer receives $LH_2$ from $LH_2$ Storage Tank A3753 and provides $GH_2$ for storage tank pressurization. Excess pressure is vented to the storage facility burn pond. Major components associated with pressurization control are listed and described below.

a. Flow Regulator A3338 - Maintains storage tank pressure at approximately 4 psig during $LH_2$ storage and during storage tank filling operations by controlling the venting of $LH_2$ boiloff. The regulator is pneumatically actuated and its position is determined by the differential pressure applied across the regulator actuator.

   The actuator receives 25-psig $GN_2$ from the $LH_2$ pneumatic control console and a varying $GN_2$ supply from Pneumatic Controller A3551. The pneumatic controller increases control pressure from 3 to 15 psig as storage tank ullage pressure rises and thereby decreases the differential pressure across the regulator actuator. Regulator position is varied until venting is adjusted to maintain storage tank pressure at approximately 4 psig. When storage tank pressure exceeds 4 psig, venting control is transferred to main vent Pneumatic Valve A3304.

b. Storage Tank Pressurization Flow Regulator A3305 - Controls the flow of $LH_2$ to Vaporizer A3754 to maintain storage tank pressure at 42 psig during $LH_2$

transfer operations. Regulator position is determined by the differential between control pressures applied across the regulator actuator. The actuator receives a constant 25-psig $GN_2$ supply from the $LH_2$ pneumatic control console and a varying $GN_2$ supply from Pneumatic Controller A3544.

The pneumatic controller senses storage tank ullage pressure and varies differential pressure across the regulator actuator to increase or decrease $LH_2$ flow through the regulator. As storage tank pressure increases, differential pressure is decreased and $LH_2$ flow is reduced. When storage tank pressure reaches 42 psig, the regulator is closed to prevent further pressurization. Should the pneumatic controller malfunction, the regulator can be closed by the action of Solenoid Valve A3387 and Pressure Switch A3538. When storage tank ullage pressure increases to 55 psig, the pressure switch actuates and sends a signal that opens the solenoid valve. The solenoid valve vents control pressure from the regulator actuator and allows the regulator to close.

c. Relief Valve A3640 - Provides overpressure protection for the storage tank vent line by relieving excess pressure at 100 psig to the storage area burn pond.

1.3.1.3 $LH_2$ Subcooler Subsystem. The $LH_2$ subcooler subsystem is used to reduce the temperature of $LH_2$ being transferred to the S-IV stage and thereby reduce $LH_2$ vaporization within the transfer line. The subsystem consists of Subcooler A3752, Vacuum Pump A3751 and associated control and monitor networks. The major component within the system, Subcooler A3752, is a tube-and-shell heat exchanger installed in the main $LH_2$ transfer line. The subcooler coolant supply is $LH_2$ drawn from the transfer line. $LH_2$ being transferred to the S-IV stage is routed through the subcooler coolant by means of transfer tubes. The insulated annular space between the subcooler walls is evacuated to retard heat transfer between the inner and outer walls.

$LH_2$ supercooling begins when the S-IV stage $LH_2$ container is 92 percent filled. Vacuum Pump A3751 is started and subsequently reduces vapor pressure above the $LH_2$ coolant supply in the subcooler. The reduction in vapor pressure reduces the temperature of the coolant which, in turn, reduces the temperature of $LH_2$ in the transfer tubes to approximately - 426F. Other components functionally associated with subcooler operation are described below:

a. Liquid Level Probe A3509 continuously monitors the $LH_2$ coolant level within the subcooler and provides control pressure for regulating $LH_2$ coolant flow into the subcooler. The probe is mounted on top of the subcooler and extends downward between the inner wall of the subcooler and the transfer tubes. The probe is sealed at the bottom, and the upper end is connected to a pressure-tight chamber that is pressurized to 45 psig with $GH_2$.

Chamber pressure drops as the coolant level rises and increases as the coolant level drops. Thus, the chamber pressure is indicative of $LH_2$ level

and is used as a control pressure for regulating the flow of $LH_2$ coolant to the subcooler.

Two capacitance point level sensors, mounted near the bottom of the probe, sense $LH_2$ level and send signals to transducer cabinet indicators for local monitoring of $LH_2$ coolant levels. Level Sensor A3511 provides a high level indication when submerged in $LH_2$ and Liquid Level Sensor A3512 provides a low level indication when the $LH_2$ coolant level recedes below it. Liquid Level Sensor A3511 is also electrically interlocked with Solenoid Valve A3386. Actuation of Solenoid Valve A3386 closes pneumatic subcooler inlet Flow Regulator A3309 and shuts off $LH_2$ flow into the subcooler shell.

b. Pneumatic Pressure Controller A3513 and subcooler inlet Flow Regulator A3309 function together to maintain a constant $LH_2$ coolant level within the subcooler. The controller senses pressure variations in Liquid Level Probe A3509 and provides proportional increases or decreases in control pressure applied to the flow regulator. The flow regulator controls $LH_2$ flow from the transfer line into the subcooler. The pressure controller receives a 25-psig $GN_2$ supply from the $LH_2$ pneumatic control console and regulates control pressure applied to the flow regulator between 3 and 15 psig. An increase in $LH_2$ level reduces the pressure controller output pressure. The reduced output pressure increases differential pressure applied across the flow regulator actuator and thereby reduces $LH_2$ flow through the flow regulator. A decrease in $LH_2$ coolant level causes a corresponding decrease in the differential pressure applied to the flow regulator, thereby increasing $LH_2$ flow through the regulator. Thus, increases or decreases in $LH_2$ coolant level are compensated for by $LH_2$ flow regulation through the flow regulator.

c. Pneumatic Pressure Controllers A3515 and A3514 provide an alternate means for controlling the $LH_2$ coolant level adjustments through Flow Regulator A3309. These two pressure controllers substitute for Pressure Controller A3513 and Liquid Level Sensor A3509, which can be isolated by closing Manual Valve A3412. Pressure Regulator A3515 senses subcooler $LH_2$ level and regulates control pressure applied to Pressure Regulator A3514 which, in turn, regulates the positioning of subcooler inlet Flow Regulator A3309. Pressure Regulator A3515 senses $LH_2$ coolant level by sensing coolant differential pressure between upper and lower taps on the subcooler shell. Upper-tap pressure is applied to the pressure regulator through Manual Valves A3384 and A3406, and lower-tap pressure is applied through Manual Valves A3385 and A3407. In proportion to the applied differential pressure, Pressure Regulator A3515 reduces a 25-psig $GN_2$ supply from the $LH_2$ pneumatic console and provides a 15- to 3-psig control pressure for control of Pressure Regulator A3514. Pressure Regulator A3514 also receives a 25-psig $GN_2$ input from the $LH_2$ pneumatic control console and, in proportion to the control pressure applied from Pressure Regulator A3515, applies a 3- to 15-psig control pressure to Flow Regulator A3309.

d. Flow Regulator A3342 regulates $GH_2$ flow from the subcooler to Vacuum Pump A3751 during vacuum pump operation to maintain a set subcooler shell pressure. The flow regulator receives 25-psig $GN_2$ control pressure from the $LH_2$ pneumatic console and a variable control pressure of 3- to 15-psig $GN_2$ from Pressure Regulator A3554. The differential between these control pressures determines the regulator position.

The pressure regulator actuator senses, as control pressure, subcooler shell pressure over a range of 0 to 15 psig. In proportion to the applied shell pressure, the pressure regulator reduces 25-psig $GN_2$ from the $LH_2$ pneumatic console to a 3- to 15- psig control pressure for positioning Flow Regulator A3342. As Vacuum Pump A3751 reduces the subcooler shell pressure, the control pressure applied to the flow regulator is reduced, thereby reducing $GH_2$ flow through the flow regulator. Conversely, an increase in subcooler shell pressure causes an increase in $GH_2$ flow through the flow regulator.

e. Temperature Sensor A3585 and Indicator A3584 provide local monitoring of vacuum line temperature.

f. Temperature Sensor A3587 and Indicator A3586 provide local monitoring of vacuum pump inlet temperature.

g. Pressure Transducer A3547 provides subcooler pressure monitor signals to a vacuum indicator on the LCC $LH_2$ monitor panel.

h. Subcooler inlet Temperature Sensor A3574 measures line temperature upstream from Subcooler A3752. Measuring instruments associated with the sensor measure the vapor pressure inside the sensor bulb and provide a temperature indication as a function of vapor pressure. Temperature Indicator A3571 permits local monitoring of line temperature and is used for calibration of Temperature Transducer A3572. Temperature Transducer A3572 provides subcooler inlet temperature monitor signals to a temperature indicator on the $LH_2$ monitor panel. Temperature is measured over a range of -403 F to -430 F.

i. Subcooler discharge Temperature Sensor A3583 and Temperature Indicator A3582 function together to provide local monitoring of subcooler discharge temperature over a range of -403 F to -430 F.

j. Temperature Sensor A3580, Temperature Indicator A3576, and Temperature Transducer A3578 function together to monitor the transfer line discharge temperature. (See figure 3-2.) Temperature Indicator A3576 provides local monitoring of transfer line temperature and is used for calibrating Temperature Transducer A3578. Temperature Transducer A3578 provides transfer line temperature monitor signals to the LCC temperature recorder and a temperature indicator on the LCC $LH_2$ monitor panel.

1.3.2 Transfer Components - $LH_2$ transfer between the $LH_2$ storage facility and the S-IV stage $LH_2$ container is controlled by the main fill and topping control transfer-line valve complex. Major components within this valve complex are: main fill Pneumatic Valve A3911, replenish Pneumatic Valve A3910, transfer line vent Pneumatic Valve A3912, and helium heat exchanger $LH_2$ inlet Pneumatic Valve A3917 (See figure 3-2.). The pneumatic valves are controlled by individual solenoid valves that route 750-psig $GN_2$ control pressure from valve panel B (volume V) to the appropriate side of the pneumatic valve actuators. The solenoids are controlled by transfer sequence signals originated at $LH_2$ control equipment in the LCC and the AGCS. Each pneumatic valve is equipped with a position indicator switch that is electrically interlocked with an indicator on the LCC $LH_2$ components panel to provide continuous monitoring of valve position. Functions of major components within the main fill and topping control are described below:

a. Main fill transfer Pneumatic Valve A3911 - Opened during the main fill transfer operation and allows a 2000-gpm $LH_2$ flow to the S-IV stage $LH_2$ container.

b. Replenish Pneumatic Valve A3918 - A three-position valve that controls $LH_2$ transfer flow during the replenish operation. One valve position provides a 500-gpm $LH_2$ flow and the second valve position limits $LH_2$ flow to 20 gpm. During the replenish operation,the valve is alternately positioned to the 500-gpm and 20-gpm positions by Solenoid Valves A3923 and A3922 to maintain the S-IV stage $LH_2$ container between 99 and 99.25 percent full.

c. Pneumatic Valve A3917 - Directs part of the $LH_2$ supply being transferred to the S-IV stage to the helium precool heat exchanger (volume V) for use as a coolant supply.

d. Pneumatic Valve A3912 - Opened upon termination of $LH_2$ transfer operations to vent $GH_2$ from the transfer line to the launch facility burn pond. During $LH_2$ transfer operations, the valve remains closed.

e. Pressure Transducers A3900 and A3916 - Monitor main fill and topping control line pressure during $LH_2$ transfer operations and provide pressure monitor signals to pressure indicators on the LCC $LH_2$ monitor panel. Differential Pressure Transducer A3949 monitors the line pressure drop across Filter A3905 and provides monitor signals to a pressure indicator on the $LH_2$ monitor panel. The differential pressure ranges from 0 to 30 psig.

f. Relief Valve A3932 - Provides overpressure protection for the main fill and topping control lines by venting the lines to the launch area burn pond when line pressure reaches 92 (± 2) psig.

1.3.3 $LH_2$ Control Equipment and Subsystems

1.3.3.1 Launch Control Center Equipment. Propellant loading racks No. 6 and No. 7, located in the LCC, contain the panels and control equipment necessary for initiating, monitoring, and controlling $LH_2$ transfer operations. Equipment descriptions are provided below:

a. Relay Distributer Assemblies - A relay distributor assembly is mounted in each of the two propellant loading racks to provide a point for power distribution from the LCC to the storage and launch areas.

b. $LH_2$ Timer Assembly - Contains time relays for use in automatic sequences, and power switching relays for controlling system power busses and associated components.

c. $LH_2$ Control Panel - Used to initiate system operations and to provide visual monitoring of sequences for the performance or simulation of $LH_2$ transfer operations. Functional descriptions of control and monitor components located on the panel are as follows.

(1) Power ON-OFF Switch - Controls electric power to other $LH_2$ control panel components.

(2) Function Selector Switch - A four-position selection switch used for selecting one of four modes of system operation: off, operate, simulate, or manual. With the switch at the OPERATE position, the $LH_2$ system is set for automatic operation, which requires only the momentary depression of sequence buttons to initiate automatic sequencing of system operations. At the SIMULATE position, the switch again provides for automatic sequencing of system operations, but without $LH_2$ transfer. This mode is used only to verify the operation of system components. When positioned to the MANUAL position, the switch transfers individual control of system components to controls on the $LH_2$ components panel. At the OFF position, the switch inhibits all transfer operations.

(3) CONTROL RETURN Switch - Used to return control of transfer operations to DAC when required.

(4) Prerequisite Indicators - The indicators are mounted across the top of the panel. As each prerequisite is completed, a particular indicator will light. When all the prerequisites are met, and the S-IV stage $LH_2$ container is ready for filling, the STANDBY indicator will light in the FILL sequence group of indicators.

(5) FILL, SECURE, and DRAIN Pushbutton Switches - Used to initiate the fill, secure, and drain sequences as required. The fill sequence may be initiated only after the fill sequence STANDBY indicator and the prerequisite indicator lamps are lighted. Progress of the sequence may be monitored on indicators located to the right of the FILL pushbutton. The secure and drain sequences are initiated and monitored in a like manner.

d. $LH_2$ DC Power Panel - Provides d.c. power to propellant loading racks No. 6 and No. 7.

e. $LH_2$ Distributor Assembly - Contains the terminal connections which make cable connections and provide distribution points for lines entering the LCC.

f. $LH_2$ Monitor Panel - Provides ten gages for monitoring various system conditions in the storage facility, launch area, and the vehicle.

(1) Filter Differential Pressure Gage - Indicates the pressure drop across transfer line Filter A3905.

(2) Transfer Line Pressure Gage - Indicates the $LH_2$ pressure in the transfer line.

(3) Transfer Line Outlet Temperature Gage - Indicates the transfer line temperature of $LH_2$ leaving the storage area.

(4) Vehicle Vent Pressure Gage - Indicates the vehicle vent pressure in the vent stack.

(5) Subcooler Level Gage - Indicates the $LH_2$ coolant supply level in Subcooler A3752.

(6) Subcooler Inlet Line Pressure Gage - Indicates subcooler shell pressure being maintained by Vacuum Pump A3751.

(7) Subcooler Inlet Line Temperature Gage - Indicates the temperature of the $LH_2$ entering the tube side of Subcooler A3752.

(8) Storage Tank Level Gage - Indicates the level of $LH_2$ in Storage Tank A3753.

(9) Storage Tank Pressure Gage - Indicates the storage tank ullage pressure. The measurement range is 0 to 100 psig.

(10) Vehicle Tank Pressure Gage - Indicates the ullage pressure in the S-IV stage $LH_2$ container.

g. $LH_2$ Components Panel - Provides manual control and visual monitoring of remotely located $LH_2$ facility components. Manual control of components is attained by positioning the function selector switch on the $LH_2$ control panel to the MANUAL position. Indicator lamps on the panel show the condition or position of the various components.

1.3.3.2 Automatic Ground Control Station. $LH_2$ system equipment in the AGCS consists of an $LH_2$ DC power panel and an $LH_2$ control distributor, both of which are located in launcher accessories rack No. 1. Functional descriptions of the two components are given below:

a. $LH_2$ DC Power Panel - A rack-mounted assembly that contains indicating fuses for monitoring system power busses, and power switching relays for switching power to associated busses.

b. $LH_2$ Control Distributor - Contains the terminal distributors, cable connections, and circuit switching relays necessary to transfer power from the $LH_2$ DC power panel to remotely located valves.

1.3.3.3 Electrical Equipment House. $LH_2$ system equipment in the EEH consists of control distributors No. 1 and No. 2, an $LH_2$ DC power panel, and an $LH_2$ monitor panel, all located in rack No. 1. EEH equipment is described below.

a. Control Distributor No. 1 - Contains terminal connections and other equipment necessary to make cable connections and distribute signals along shielded lines to and from the LCC and storage area transducer cabinets.

b. Control Distributor No. 2 - Contains terminal connections and other equipment necessary to make cable connections and distribute signals along unshielded lines for operation of various control valves.

c. $LH_2$ DC Power Panel - A rack-mounted assembly that contains indicating fuses for monitoring system power busses, and switching relays for switching power to associated busses.

d. $LH_2$ Monitor Panel - Provides a means for visually monitoring liquid level and ullage pressure within the $LH_2$ storage tank. The three components mounted on the panel perform the following functions:

(1) Storage Tank Level Indicator - Indicates the level of $LH_2$ in Storage Tank A3753.

(2) Storage Tank Pressure Indicator - Indicates storage tank ullage pressure.

(3) Fill Valve Control Switch - Used to control the position of the storage tank fill Pneumatic Valve A3302 during tank filling operations.

## 1.4 SYSTEM OPERATIONS

1.4.1 Storage Operations - Storage operations include storage facility purge, storage tank filling, and storage tank pressurization.

1.4.1.1 Storage Facility Purge. The storage facility purge is initiated prior to storage tank filling to prevent the formation of explosive mixtures of air and hydrogen in the storage tank and associated lines. The purge requires external sources of $GN_2$ and $GH_2$. The $GN_2$ source is attached to storage facility couplings and is allowed to flow into the storage tank and associated lines. The storage tank is purged by repeatedly filling it with $GN_2$ and evacuating it until the oxygen content of the tank atmosphere is less than 1.5 percent per unit volume. The $GN_2$ purge is followed by a warm $GH_2$ purge which expels the $GN_2$ and provides a pure $GH_2$ atmosphere within the tank.

1.4.1.2 Storage Tank Filling. $LH_2$ is transported to the launch complex in mobile tankers and is subsequently pumped from the tankers into the storage tank. During the filling operation, storage tank pressure is maintained at approximately 4 psig; excess pressure is vented to atmosphere. The filling operation is continued until the tank contains approximately 125,000 gallons of $LH_2$.

1.4.1.3 Storage Tank Pressurization. After the storage tank has been filled, it is pressurized to 4 pisg with $GH_2$ and held at that pressure until the initiation of $LH_2$ transfer operations. Prior to the initiation of the main fill operation, however, the tank pressure is increased to, and maintained at approximately 42 psig. This increase in tank pressure is necessary to force $LH_2$ through the transfer lines and into the S-IV stage $LH_2$ container.

## 1.4.2 Preparation for $LH_2$ Transfer

1.4.2.1 Pre-Operational System Checkout. Following the storage tank filling operations and prior to the initiation of $LH_2$ transfer operations, a pre-operational check is made of the $LH_2$ pneumatic control console, storage facility purge supplies, and electrical power supplies. In addition, system manual valves are set up for $LH_2$ transfer operations.

a. Manual Valve Checkout. In preparation for $LH_2$ transfer to the S-IV stage, system manual valves are positioned as follows:

   (1) Storage tank vent Manual Valves A3324 and A3380 are opened.

   (2) Storage tank pressurization Manual Valves A3301, A3369 and A3370 are opened.

   (3) Subcooler inlet flow control Manual Valve A3412 is opened.

   (4) $LH_2$ transfer line Manual Valves A3303 and A3379 are opened.

   (5) Manual Valve A3372 is opened.

   (6) All other manual valves are closed.

b. $LH_2$ Pneumatic Control Console Checkout. (See figure 3-1.) The $LH_2$ pneumatic control console is placed into operation and checked out as follows:

   (1) Manual Valves A3712, A3713, A3714, A3715, A3720 and A3771 are opened.

   (2) Manual Vent Valves A3716, A3717, A3718, A3719, A3721, A3722, A3723 and A3724 are closed.

(3) Gages A3700, A3701, A3702, and A3703 must indicate 3500, 750, 720, and 25 psig, respectively. Downstream Pressure Regulators A3704, A3705 and A3706 may be adjusted to provide the correct gage indications of line pressure.

(4) With correct pressures indicated at the pressure gages, the operation of Pressure Switches A3725 and A3711 is verified at the LCC $LH_2$ control panel. Pressure Switch A3725 actuates on rising pressure of 600 (± 20) psig and lights the STORAGE FACILITY 750-PSI indicator on the $LH_2$ control panel. Pressure Switch A3711 actuates on a rising pressure of 21.5 (±0.5) psig and lights the STORAGE FACILITY 25-PSI indicator on the $LH_2$ control panel.

c. $GN_2$ Purge Supply Checkout. The S-IV stage and umbilical tower must be placed in a state of readiness for purging, and $GN_2$ purge supplies to various storage facility components must be pressure-checked and analyzed for oxygen content. Pressure checks are made with a portable manometer, and oxygen content is measured with a portable oxygen analyzer. Purge checks are made as follows:

(1) The vehicle vent stack purge is checked through Manual Valve A3375.

(2) The auxiliary vent line purge is checked through Manual Valve A3374.

(3) The launch area transducer cabinet purge is checked through a quick-disconnect fitting located in the top of the cabinet.

(4) The storage facility vent line purge is checked through Manual Valve A3366 and A3404.

(5) The storage tank steady-state vent line purge is checked through Manual Valve A3416.

(6) The subcooler transducer cabinet purge is checked through a quick-disconnect coupling located in the top of the cabinet.

d. Electrical Power Checkout. Electrical power must be available to $LH_2$ system equipment in the EEH, LCC, AGCS, and the storage area launch facility burn ponds. Power availability is indicated by various $LH_2$ control panel indicators as follows:

(1) The AGCS & STORAGE FACILITY indicator lights when ac power is available to AGCS and storage facility components.

(2) The STORAGE FACILITY, LCC, AGCS, TOWER S-IV & VEHICLE S-IV indicators light when d.c. power is available to areas that correspond with the indicator placards.

(3) The TOWER S-IV, S-IV 750 PSI, and STORAGE FACILITY 25 PSI & STORAGE FACILITY 750 PSI indicators light when pneumatic control pressure is available from the $LH_2$ pneumatic console. The availability of pneumatic control pressure also indicates the availability of power to EEH equipment.

(4) The STORAGE & LAUNCH FACILITIES indicator lights when power is available at the launch area and storage facility burn ponds.

1.4.2.2 S-IV Stage $LH_2$ Container and Transfer Line Purge. Following the pre-operational checkout, the $LH_2$ system is conditioned and powered for performance of the prelaunch countdown. A standby period is initiated to permit DAC checkout and He purging of the S-IV stage and the $LH_2$ transfer line. The sequence is as follows:

a. Control of transfer line vent Pneumatic Valve A3308 is transferred to DAC equipment from the LCC $LH_2$ control panel by setting the CONTROL RETURN switch. The function selector switch is turned to the MANUAL position. The S-IV status STANDBY light is lighted during this sequence.

b. The S-IV LOX container is pressurized with He to 29 (± 1) psia. This pressure is maintained until I $H_2$ container purging is complete to prevent collapse of the common bulkhead between the LOX and $LH_2$ containers.

c. During the standby period, $LH_2$ Container E102 and the I $H_2$ transfer line recieve a 50-minute He purge that is initiated by a solenoid valve in valve panel B (volume V). Helium flows from valve panel B into the S-IV stage $LH_2$ container through Quick-Disconnect Couplings A2653 and E250. From the $LH_2$ container, the He flows through fill and drain Pneumatic Valve E113, Couplings E100 and A3189, Pneumatic Valve A3150, Filter A3905, and to the He heat exchanger (volume V) and Subcooler A3752, through either main fill Pneumatic Valve A3911 or replenish Pneumatic Valve A3910. The He purge supply is vented to the storage facility burn pond through transfer line vent Pneumatic Valve A3308 and to the launch facility burn pond through the He heat exchanger and transfer line vent Pneumatic Valve A3912.

d. As the $LH_2$ container and transfer lines are purged, the $LH_2$ container vent line is purged with 50-psig He routed from valve panel A (volume V). The purge supply passes through the vent line and is vented to the launch facility burn pond through Check Valve A3376.

e. The umbilical vent line, $LH_2$ shutoff Pneumatic Valve A3950, and Quick-Disconnect Couplings A2389 and E105 are also purged with a 50-psig He supply from valve panel A (volume V). The umbilical line purge removes $LH_2$ boiloff during the cooldown operation and provides an inert atmosphere in the fill line. The quick-disconnect coupling purge displaces $GH_2$ which might escape during fill operations. These purges continue throughout the cooldown operation.

f. During the purge operations, the $LH_2$ transfer lines are checked for He content, and when they are found to contain 99 percent He, system control is transferred from DAC control equipment to ICC control equipment. The S-IV control return indicator on the $LH_2$ panel goes out to signal the transfer of system control.

### 1.4.3 Prelaunch $LH_2$ Transfer Operations

1.4.3.1 Initial Setup. Following DAC checkout and purge of the S-IV stage and transfer lines, $LH_2$ transfer operations are initiated at the LCC $LH_2$ control panel by setting the FUNCTION SELECTOR SWITCH to AUTO and pressing the FILL pushbutton. This setup initiates automatic sequencing of the prelaunch transfer operations described in paragraph 1.2.2.

1.4.3.2 System Interlocks. Various $LH_2$ system operations are interlocked such that a given operation or a given set of conditions automatically initiates another operation. These interlock functions are listed and described for reference. In subsequent descriptions of transfer operations the interlocks are referenced by number.

1. Transfer line fill Pneumatic Valve A3306 is closed unless transfer line outlet temperature is -406 F or less.

2. Transfer line fill Pneumatic Valve A3306, S-IV stage replenish Pneumatic Valve A3310 and S-IV stage main fill Pneumatic Valve A3911 are closed unless the S-IV stage LOX container is pressurized. A signal from DAC propellant loading control equipment indicates LOX container pressurization.

3. Transfer line fill Pneumatic Valve A3306 and transfer line cooldown Pneumatic Valve A3307 close with the opening of transfer line vent Pneumatic Valve A3308.

4. S-IV stage replenish Pneumatic Valve A3310 and S-IV stage main fill Pneumatic Valve A3911 close with an S-IV stage $LH_2$ container overpressure indication.

5. S-IV stage replenish Pneumatic Valve A3910 and S-IV stage main fill Pneumatic Valve A3911 close with an S-IV stage $LH_2$ container overfill indication.

6. S-IV stage umbilical line vent Pneumatic Valve A3912 is interlocked closed by DAC propellant loading control equipment with the opening of S-IV stage replenish Pneumatic Valve A3710, S-IV stage main fill Pneumatic Valve A3911, or S-IV stage fill and drain Pneumatic Valve E113.

7. Transfer line fill Pneumatic Valve A3306 is closed with the closing of S-IV stage vent Pneumatic Valves E114 and E115.

8. Transfer line He purge Solenoid Valve A3318 or transfer line high-pressure He purge Solenoid Valve A3344 are closed with the opening of either subcooler $LH_2$ inlet Pneumatic Valve A3309 or He heat exchanger $LH_2$ inlet Pneumatic Valve A3917.

9. $LH_2$ storage tank pressure less than 30 psig causes transfer line He purge Solenoid Valve A3318 or transfer line high-pressure He purge Pneumatic Valve A3344 to close.

10. $LH_2$ storage tank main vent Pneumatic Valve A3304 is closed when $LH_2$ storage tank pressure is equal to or less than 2 psig, or is interlocked closed with $LH_2$ storage tank pressurization Pneumatic Valve A3305 and transfer line fill Pneumatic Valve A3306.

11. S-IV stage $LH_2$ container pressurization Pneumatic Valve A2539 is closed unless the S-IV stage LOX container is pressurized.

1.4.3.3 S-IV Stage LOX Container Pressurization. When the FILL pushbutton is pressed, a command signal is sent to DAC equipment to initiate S-IV stage LOX container pressurization. The command signal also lights the $LH_2$ control panel PRESSURIZE LOX TANK indicator. LOX container pressurization to approximately 45 psia prevents collapse of the propellant tank LOX/$LH_2$ bulkhead as $LH_2$ is loaded into the $LH_2$ container. The $LH_2$ control panel PRESSURIZED COMPLETE indicator lights when pressurization is complete. ( Details of the LOX container pressurization sequence are covered in volume V ).

1.4.3.4 $LH_2$ Storage Tank Pressurization. When the S-IV stage LOX container pressurization sequence is complete, the fill sequence automatically progresses to $LH_2$ storage tank pressurization. The sequence occurs as follows:

a. The $LH_2$ control panel PRESSURIZE STORAGE TANK indicator lamp lights.

b. Interlock functions 1 and 2 are in effect.

c. Pneumatic vaporizer inlet Flow Regulator A3305 is opened by Controller A3544 and Solenoid Valve A3387. Valve opening is monitored by the $LH_2$ components panel TANK PRESSURIZATION OPEN indicator. $LH_2$ from the storage tank passes through supply Manual Valve A3301 and pneumatic Flow Regulator A3305 to Vaporizer A3754 where it is converted to $GH_2$ for storage tank pressurization.

d. Relief Valve A3641 vents excess line pressure to the tank pressurization line, downstream from Vaporizer A3754, to maintain a maximum differential pressure of 20 psi across the vaporizer and pneumatic flow regulator.

e. Pneumatic Flow Regulator A3305 flow area is reduced by Controller A3544 as tank pressure rises. The flow regulator is completely closed when storage tank ullage pressure reaches 42 psig. Pressure Switch A3537 actuates and lights the LCC $LH_2$ control panel PRESSURIZATION COMPLETE indicator when storage tank pressure rises to 30 psig. Simultaneously, the PRESSURIZE STORAGE TANK indicator goes out. Pressure Switch A3538 actuates at an increasing ullage pressure of 55 psig to remove power from Solenoid Valve A3387. The closing of Solenoid Valve A3387 provides redundancy for Controller A3544 by ensuring that pneumatic Flow Regulator A3305 is completely closed.

f. A continued ullage pressure rise to 60 psig results in the actuation of Pressure Switch A3539. The switch supplies power to Solenoid Valves A3395 and A3396, which open Pneumatic Valve A3304. Excess tank pressure is vented through Pneumatic Valve A3304 and Check Valve A3365 to the storage facility burn pond. Ullage pressure is maintained at approximately 42 psig for the duration of $LH_2$ transfer.

1.4.3.5 Transfer Line and S-IV Stage Cooldown. Thirty seconds after Pneumatic Valve A3305 is opened, the transfer line and S-IV stage cooldown sequence is initiated automatically. The sequence is as follows:

a. The $LH_2$ control panel COOLDOWN FILL LINE indicator lights.

b. Interlock functions 1, 2, 3, 4, 5, and 6 are in effect.

c. Transfer line cooldown Pneumatic Valve A3307, subcooler inlet Flow Regulator A3309,and He heat exchanger inlet Pneumatic Valve A3917 are opened. $LH_2$ flows from Storage Tank A3753 through Manual Valve A3303, Pneumatic Valve A3307, the tube side of Subcooler A3752, and into the subcooler shell through Flow Regulator A3309. $LH_2$ flow through the subcooler continues through the transfer line and is admitted to the He heat exchanger (volume V) through Pneumatic Valve A3917. $GH_2$ vented from the helium heat exchanger is routed to the launch facility burn pond through Check Valve A3377.

d. Five minutes after Pneumatic Valves A3307, A3309, and A3917 are opened, main fill Pneumatic Valve A3911 is opened. Replenish Pneumatic Valve A3910, S-IV stage fill and drain Pneumatic Valve E113, and S-IV stage $LH_2$ container vent Pneumatic Valves E114 and E115 are opened when $LH_2$ is detected in the He heat exchanger. $LH_2$ then flows through the main fill and replenish valves and into S-IV stage $LH_2$ Container E102. $LH_2$ boiloff within the container is vented to the launch facility burn pond through vent Pneumatic Valves E114 and E115, Quick-Disconnect Couplings E105 and A2389, and Check Valve A3376.

e. The transfer line and S-IV stage cooldown continues until the $LH_2$ container is 15 percent filled. At this point in the sequence, DAC propellant loading control equipment generates a command signal that opens transfer line fill Pneumatic Valve A3306 and lights the COOLDOWN COMPLETED indicator on the $LH_2$ control panel. Simultaneously, the COOLDOWN FILL LINE indicator goes out. Transfer line fill Pneumatic Valve A3306 remains open as long as the S-IV stage $LH_2$ container is 15 percent filled.

1.4.3.6 Main Fill. The DAC command signal that lights the $LH_2$ control panel COOLDOWN COMPLETED indicator also initiates the main fill transfer operation. The sequence proceeds automatically as follows:

a. The $LH_2$ control panel MAIN FILL indicator lamp lights.

b. Interlock functions 1, 2, 3, 4, 6, and 7 are in effect.

c. Transfer line fill Pneumatic Valve A3306 is opened and transfer line cooldown Pneumatic Valve A3307 is closed. Valve positions are monitored by the pertinent OPEN and CLOSED indicators on the $LH_2$ components panel. $LH_2$ flows from Storage Tank A3553 through Manual Valve A3303, transfer line fill Pneumatic Valve A3306, Subcooler A3752, Manual Valve A3379, main fill and replenish Pneumatic Valves A3911 and A3910, Filter A3905, Quick-Disconnect Couplings A3159 and E100,and fill and drain Pneumatic Valve E113 into S-IV stage $LH_2$ Container E102. The filling rate is approximately 2000 gpm.

d. When the $LH_2$ container is 92 percent filled, DAC automatic circuitry initiates a start command to subcooler Vacuum Pump A3751 and subcooler Vacuum Pump Motor A3939. The 92% TANK LEVEL indicator on the $LH_2$ components panel lights and subcooler operations begin as follows:

(1) Solenoid Valve A3386 is opened and permits subcooler inlet Flow Regulator A3309 to function. Liquid Level Probe A3509 senses a low subcooler liquid level and supplies a high pressure signal to pnuematic Pressure Controller A3513. The controller output pressure passes through Manual Valve A3412 and opens subcooler inlet Flow Regulator A3309 to admit transfer line $LH_2$ to the subcooler shell. As the $LH_2$ level rises within the shell, Liquid Level Probe A3509 supplies a lower pressure signal to pneumatic Pressure Controller A3513. A drop in controller output, over a range of 15 to 3 psig reduces $LH_2$ flow through subcooler inlet Flow Regulator A3309, and thereby controls the amount of $LH_2$ admitted to the subcooler shell.

(2) Liquid Level Sensor A3511 actuates when the subcooler is overfilled, and energizes Solenoid Valve A3386. The Solenoid valve vents control pressure applied to Flow Regulator A3309, and the flow regulator is closed, thereby terminating $LH_2$ flow into the subcooler shell.

(3) Vacuum Pump A3751 reduces the subcooler shell pressure. The resulting pressure drop lowers the coolant temperature sufficiently to supercool transfer line $LH_2$ to approximately - 426 F.

(4) Main fill Pneumatic Valve A3911 is closed by Solenoid Valve A3906 when the $LH_2$ container is 95 percent filled. This action is initiated by a DAC command that energizes Solenoid Valve A3906 and lights the $LH_2$ components panel 95% TANK LEVEL indicator. Redundancy in terminating the main fill operation is provided by a circuit that delays the DAC command for 15 seconds and closes transfer line fill Pneumatic Valve A3306 if main fill Pneumatic Valve A3911 fails to close within 15 seconds after the DAC command is applied to Solenoid Valve A3906. The $LH_2$ control panel MAIN FILL indicator is lighted and the MAIN FILL indicator goes out when main fill Pneumatic Valve A3911 is closed.

1.4.3.7 Replenish. The replenish operation is initiated automatically with the closing of main fill Pneumatic Valve A3911. The operation proceeds as follows:

a. The $LH_2$ control panel REPLENISH indicator is lighted.

b. Interlock functions 1, 2, 3, 4, 5, 6, and 7 are in effect.

c. Replenish Pneumatic Valve A3910 and fill and drain Pneumatic Valve E113 are are held open by signals from DAC propellant loading control equipment. S-IV stage vent Pneumatic Valves E114 and E115 are held open by signals from Launch Operations Control (LOC) automatic circuitry.

d. $LH_2$ flows into S-IV stage $LH_2$ container E102 through Manual Valve A3379, replenish Pneumatic Valve A3910, Filter A3905, Quick-Disconnect Couplings A3933 and E100, and fill and drain Pneumatic Valve E113. $LH_2$ flow through the replenish valve is maintained at approximately 500 gpm until the $LH_2$ container is 99.25 percent filled.

e. When the $LH_2$ container is 99.25 percent filled, DAC propellant loading control equipment energizes Solenoid Valve A3922 and deenergizes Solenoid Valve A3923. The Solenoid valve action repositions replenish Pneumatic Valve A3910 to provide a 20-gpm $LH_2$ flow. Because the reduced replenish flow is less than the $LH_2$ boiloff rate, the container $LH_2$ level drops to the 99 percent full level.

f. When DAC propellant loading control senses this level drop, replenish Pneumatic Valve A3910 is repositioned to resume $LH_2$ replenish at 500 gpm. The replenish flow is repeatedly cycled between 500 gpm and 20 gpm until final topping is initiated.

1.4.3.8 Final Topping. $LH_2$ container final topping is initiated 10 seconds after the S-I stage firing command is given at T -150 seconds. LOX container pre-pressurization is initiated at T -150 seconds, and $LH_2$ container pre-pressurization is initiated at T -140 seconds. The topping operation occurs as follows:

a. System interlock functions 1, 2, 3, 4, 5, 6, and 7 are in effect.

b. $LH_2$ container vent Pneumatic Valves E114 and E115 are closed by Solenoid Valves E209 and E210 at T -140 seconds. Position-feedback signals from the pneumatic valves initiate a 50-to 500-psig He pre-pressurization supply from valve panel B ( volume V). The pre-pressurization supply is admitted to the $LH_2$ container through Quick-Disconnect Couplings A2653 and E250 and Check Valve E251 and subsequently increases container ullage pressure to approximately 36 psia.

c. Upon initiation of final topping, Solenoid Valve A3923 positions replenish Pneumatic Valve A3910 to provide a 500-gpm $LH_2$ flow into the $LH_2$ container.

d. At T -135 seconds, Solenoid Valve E211 is opened to ensure that vent Pneumatic Valves E114 and E115 are closed. The solenoid valve is again closed at T -130 seconds.

e. The S-IV stage $LH_2$ container is 100 percent filled at T -90 seconds. DAC propellant loading control equipment closes replenish Pneumatic Valve A3910 and fill and drain Pneumatic Valve E113. The $LH_2$ control panel REPLENISH COMPLETED indicator, and the $LH_2$ components panel 100% TANK LEVEL indicator are lighted.

f. When $LH_2$ container pressure reaches 37.25 (± 0.75) psia, Pressure Switch E276 actuates and provides a signal that terminates the He pre-pressurization supply from valve panel B. Switch deactuation at 35.75 (± 0.75) psia re-initiates the pressurization supply if $LH_2$ container pressure should drop before vehicle launch.

g. When the $LH_2$ container is completely filled and pressurized, transfer line vent Pneumatic Valve A3912 is opened by Solenoid Valve A3925. $LH_2$ in the transfer line is vented to the launch facility burn pond through Check Valve A3378.

h. The position feedback signal from transfer line vent Pneumatic Valve A3912 opens a solenoid valve in valve panel A (volume V) to initiate a 50-psig He purge supply that is coupled into the transfer line and the launch facility vent stack.

i. When DAC propellant loading control equipment senses that the $LH_2$ container is 100 percent filled, Vacuum Pump A3751 is stopped, subcooler inlet Flow Regulator A3309 is closed by Solenoid Valve A3386, and He heat exchanger $LH_2$ inlet Pneumatic Valve A3917 is closed by Solenoid Valve A3931. If the subcooler inlet flow regulator and the heat exchanger $LH_2$ inlet valve fail to close within 10 seconds after the closing command is given, transfer line fill Pneumatic Valve A3306 is closed to terminate $LH_2$ flow.

j. At vehicle liftoff, swing arms No. 2 and No. 3 disconnect all S-IV stage connections to ground complex fill, vent, and pressurization lines and the DAC propellant loading control equipment closes transfer line vent Pneumatic Valve A3912.

1.4.4 Launch Cancellation Operations - If a launch cancellation occurs during or after prelaunch $LH_2$ transfer, $LH_2$ is drained from the S-IV stage $LH_2$ container and transferred back to the $LH_2$ storage tank. The system prerequisites for draining are the same as the prerequisites for prelaunch $LH_2$ transfer with one exception; DAC propellant loading control equipment places the S-IV stage in a drain status. When the necessary prerequisites have been satisfied and the S-IV stage is ready for draining, the DAC automatic control circuitry generates a signal that lights the $LH_2$ control panel DRAIN STANDBY indicator. The drain sequence proceeds automatically when the $LH_2$ control panel DRAIN pushbutton is pressed. The DRAIN STANDBY indicator goes out and the DRAIN SEQUENCE indicator is lighted. The sequence occurs as follows:

1.4.4.1 Initial Setup. A DAC drain command signal is applied to Solenoid Valves A3386 and A3931 to close subcooler $LH_2$ inlet Flow Regulator A3309 and heat exchanger $LH_2$ inlet Pneumatic Valve A3917, respectively. If either A3309 or A3917 does not close within 10 seconds after the DAC command is applied, transfer line fill Pneumatic Valve A3306 is closed to prevent further $LH_2$ flow.

1.4.4.2 $LH_2$ Storage Tank Venting. Before $LH_2$ can be transferred from the S-IV stage to $LH_2$ Storage Tank A3753, storage tank pressure must be vented. The venting operation is initiated by the drain command and proceeds as follows:

a. The VENT STORAGE TANK indicator lamp on the $LH_2$ control panel is lighted.

b. Interlock function 6 is in effect.

c. Vaporizer inlet Flow Regulator A3305 is closed by Solenoid Valve A3387 to prevent further storage tank pressurization.

d. Replenish Pneumatic Valve A3910 is closed by Solenoid Valves A3923 and A3922 and main fill pneumatic Valve A3911 is closed by Solenoid Valve A3906. Closure of these valves prevents further draining of the S-IV stage $LH_2$ container. If closure is not effected within 15 seconds after the closing command is given, transfer line fill Pneumatic Valve A3306 is closed. Fill and drain Pneumatic Valve E113 is opened.

e. An S-IV stage $LH_2$ drain sequence secure signal is relayed to DAC control equipment, and an S-IV LOX tank pressurization signal is relayed to LOC control equipment.

f. A closed position feedback signal from Flow Regulator A3305 opens vent Pneumatic Valve A3304. The valve position is monitored by the appropriate indicator on the $LH_2$ components panel. The storage tank is vented to the storage area burn pond through Vent Valve A3304 and Check Valve A3365.

g. Pressure Switch A3535 actuates when tank pressure drops to 2 psig and lights the VENT COMPLETED indicator on the LCC $LH_2$ control panel.

1.4.4.3 S-IV Stage $LH_2$ Container Pressurization. As the $LH_2$ storage tank is being vented, the S-IV stage $LH_2$ container is pressurized. When the storage tank pressure drops to 8 psig or less, as sensed by Pressure Switch A3536, the following sequence occurs:

a. The PRESSURIZE S-IV TANK indicator on the $LH_2$ control panel is lighted.

b. Interlock functions 3, 6 and 11 are in effect.

c. Vent Pneumatic Valves E114 and E115 are closed to prepare the $LH_2$ container for pressurization. A closed position feedback signal from the vent valves energizes a solenoid valve in valve panel B to initiate a 50-to 500-psig He pressurization supply. The pressurization supply enters the $LH_2$ container through Quick-Disconnect Couplings A2653 and E250 and Check Valve E250.

1.4.4.4 $LH_2$ Container Draining. $LH_2$ container draining is initiated when container ullage pressure increases to a minimum of 17 psig. The $LH_2$ control panel PRESSURIZED COMPLETE indicator lights, and the drain sequence occurs as follows:

a. Interlock functions 3, 6, and 11 are in effect.

b. Main fill Pneumatic Valve A3911 and fill and drain Pneumatic Valve E113 are opened. If closed, transfer line fill Pneumatic Valve A3306 is also opened.

c. The $LH_2$ control panel DRAIN indicator is lighted.

d. $LH_2$ flows from the S-IV stage $LH_2$ container through fill and drain Pneumatic Valve E113, Quick-Disconnect Couplings E100 and A3933, Filter A3905, main fill Pneumatic Valve A3911, Manual Valve A3379, Subcooler A3752, transfer line fill Pneumatic Valve A3306, and into the storage tank through Manual Valve A3303.

e. Temperature Switch A3575 actuates when transfer line temperture increases to -406 F and signals the completion of draining. Temperature switch actuation lights the $LH_2$ control panel DRAIN COMPLETED indicator.

1.4.4.5 Transfer Line Warm-up. Transfer line warmup is initiated when the transfer line inlet temperature increases to -406 F. The sequence occurs as follows:

a. The $LH_2$ control panel LINE WARM-UP indicator is lighted.

b. Interlock functions 3, 6, and 11 are in effect.

c. Transfer line fill Pneumatic Valve A3306 and main fill Pneumatic Valve A3911 are closed.

d. System control is returned to DAC propellant loading control equipment when a closed position feedback signal is received from main fill Pneumatic Valve A3911.

e. The $LH_2$ container prepressurization supply from valve panel B is terminated.

f. Transfer line vent Pneumatic Valve A3308 is opened to vent the transfer line to the storage facility burn pond.

g. Vent Pneumatic Valve A3304 is closed by the position feedback signal from transfer line fill Pneumatic Valve A3306, or when the storage tank ullage pressure drops to, or below, 2 psig.

h. The transfer line is vented for 3 hours before transfer line vent Pneumatic Valve A3308 is closed.

i. Automatic sequencing terminates at this point in the sequence, and the $LH_2$ control panel LINE WARM-UP indicator lamp goes out.

1.4.4.6 Manual Inerting. Manual inerting of the transfsr line and $LH_2$ storage facility is initiated at the closure of transfer line vent Pneumatic Valve A3308. The READY FOR INERTING indicator on the $LH_2$ control panel is lighted and the sequence occurs as follows:

a. Solenoid Valve A3318 is closed manually from the $LH_2$ components panel.

b. Manual Valves A3301, A3303, and A3343 are closed.

c. Manual Valves A3336 and A3337 are opened to supply low pressure $GN_2$ to the transfer line. The $GN_2$ supplied at Coupling A3937 passes through Manual Valve A3337, Orifice A3606, and Manual Valve A3348 to the transfer line.

d. Helium heat exchanger $LH_2$ inlet Pneumatic Valve A3917 is opened for 1 hour. Subcooler inlet Flow Regulator A3309 is opened for 5 minutes. The He heat exchanger and Subcooler A3732 are purged by $GN_2$ supplied to the transfer line. Pneumatic valve and regulator positions are monitored by indicators on the $LH_2$ components panel.

e. Steady-state vent Flow Regulator A3338 is opened by Pressure Controller A3551 to vent Storage Tank A3753. Tank pressure may be maintained at a positive pressure of approximately 0.5 psig by adjusting Pressure Controller A3551.

1.4.5 S-IV Stage $LH_2$ Utilization

1.4.5.1 $LH_2$ Container Pressurization. $LH_2$ container pressurization provides necessary structural integrity to the S-IV stage propellant tank and provides a net positive $LH_2$ suction head to the RL10A-3 engine fuel pumps. During the period between $LH_2$ replenish operations and RL10A-3 engine shutdown, the $LH_2$ container receives four levels of pressurization.

a. The S-IV stage $LH_2$ Container E102 is pressurized to a nominal pressure of 36.5 psia during $LH_2$ replenish operations. Pressurization is initiated by DAC propellant loading control commands when the $LH_2$ container is 95 percent filled. Immediately prior to liftoff, Pressure Switch E278 signals inadequate tank pressure for liftoff if tank pressure drops to 33.5 ( ± 0.5) psia, and the launch is halted. However, if pressure is 34.5 ( ± 0.5) psia, the pressure switch signals minimum pressure for liftoff and the launch operations are continued. To maintain container pressure between 37.25 (± 0.75) psia and 35.75 (± 0.75) psia, Pressure Switch E276 controls the opening of a prepressurization solenoid valve in valve panel B.

b. $LH_2$ container pressure remains substantially constant during S-I powered flight until the $LH_2$ pre-start command is initiated. An appreciable pressure drop occurs however, during $LH_2$ chilldown of the RL10A-3 engine. Pressure Switch E277 opens Solenoid Valve E257 and E255 to admit make-up pressure to the $LH_2$ container from the S-IV stage control pressurization system if pressure drops to 30.5 ( ± 0.5) psia. He at 3000 psig, supplied through Solenoid Valve E257, Check Valve E258, Orifice E259 and E253, Solenoid Valve E255, and Orifice E256, increases tank pressure to 31.5 ( ± 0.5) psia and make-up pressurization stops. Pressure Switch E277 controls container pressurization between 30.5 (± 0.5) psia and 31.5 ( ±0.5) psia until chilldown operations are completed. A system interlock function at T +4.6 seconds renders the make-up pressurization system inoperative for the remainder of S-IV stage powered flight.

c. When RL10A-3 chilldown is initiated, additional $LH_2$ container pressurization is provided, as required, by the action of $LH_2$ container Pressure Switch E279. Pressure Switch E279 actuates Solenoid Valve E254 at a container ullage pressure of 27.5 ( ± 0.5) psia and remains operative until the propellant utilization system commands Solenoid Valve E254 to remain open during the latter period of S-IV stage powered flight. The pressure switch is rendered inoperative as long as the ullage pressure remains above 29.5 ( ± 0.5) psia. Solenoid Valve E254 provides He for container pressurization until T +4.6 seconds, when the make-up pressurization system is rendered inoperative.

d. After engine ignition, $LH_2$ container pressurization is supplied by 340-psia $GH_2$ from RL10A-3 engine $LH_2$ container pressurization lines. The pressure is reduced to approximately 34 psig by Orifice E253 to maintain adequate tank pressure as $LH_2$ is depleted. Electropneumatic Valve E255 supplies additional He to the $LH_2$ container through Orifice E256 upon receipt of a command signal from Pressure Switch E277 that indicates a container pressure drop below 30.5 ( ± 0.5) psia. Pressure Switch E277 controls the opening and closing of the electropneumatic valve to maintain $LH_2$ container pressure at 30.5 ( ± 0.5) psia until approximately 370 seconds after RL10A-3 engine ignition.

e. Additional $LH_2$ container pressurization is required during the last 100 seconds of powered flight to ensure that a net positive suction head is maintained at the RL10A-3 engine turbopump inlets. At approximately 370 seconds after RL10A-3 engine ignition, a propellant utilization system command opens Electropneumatic Valve E254 to admit additional $GH_2$ from the engine $LH_2$ container pressurization lines to the $LH_2$ container. $GH_2$ at approximately 340 psig is applied to Orifice E252, and the flow through the orifice increases container pressure approximately 10 psig. For the remainder of S-IV stage powered flight, $LH_2$ container pressurization is maintained by Electropneumatic Valve E254 and Orifices E252 and E253.

f. Differential Pressure Switch E275 prevents the possible collapse of the $LH_2$/LOX bulkhead should $LH_2$ container pressure exceed LOX container pressure during flight. When $LH_2$ container pressure exceeds LOX container pressure by 1 ( ± 0.1) psid, Differential Pressure Switch E275 actuates and sends a signal that energizes Solenoid Valve E209. Control pressure flow through the solenoid valve opens vent Pneumatic Valve E115, thereby reducing $LH_2$ container pressure.

g. Vent Pneumatic Valves E114 and E115 provide $LH_2$ container overpressure protection by relieving excess pressure at 44 psia. The valves reseat at 41 psia.

1.4.5.2 $LH_2$ Consumption. $LH_2$ consumption is initiated during RL10A-3 engine chilldown. The fuel inlet shutoff Pneumatic Valves E1 ( volume IX) are opened during SI/S-IV stage separation to supply $LH_2$ to the RL10A-3 engines. $LH_2$ flows from the $LH_2$ container, through each of six suction lines and fuel inlet shutoff Pneumatic Valves E1 to each RL10A-3 engine turbopump inlet. During engine operation, the $LH_2$ mass flow to each engine is approximately 5.88 pounds per second. Sensor E107 senses $LH_2$ container $LH_2$ level and provides continuous monitor signals to the S-IV stage propellant utilization ( PU) system. When $LH_2$ depletes to approximately 83 pounds of residual fuel, the S-IV stage PU system initiates engine cutoff.

## SECTION 2

## INDEX OF FINDING NUMBERS

This section contains an alpha-numerical list, by finding number, of $LH_2$ fuel system components that function during a prelaunch countdown, during vehicle flight, or in the event of a launch cancellation. The finding numbers listed identify components on system schematic diagrams provided in section 3. Additional columns in the index of finding numbers provide such pertinent information as component description and function, part number, and the supplier's name and part number. A break will occur in the alpha-numeric sequence of finding numbers when a component or component series is non-functional during the countdown, functional only in the event of a malfunction, functional only during a maintenance operation, or part of another functional system.

The letter prefix of a finding number identifies the component with either the launch complex or an area of the launch vehicle. The area associated with each prefix is noted below.

| FINDING NUMBER PREFIX | DESIGNATED AREA |
|---|---|
| A | Launch complex |
| B | S-I stage |
| E | S-IV stage |
| G | Instrument unit |
| H | Payload |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3150 | 1 | Valve, Pneumatic | Shutoff | Hadley Valve | A75M-05605 | |
| A3151 through A3158 are not functionally applicable to this system. | | | | | | |
| A3159 | 1 | Coupling, Quick-Disconnect | $LH_2$ supply | | D57M-04852 | |
| A3160 through A3165 are not functionally applicable to this system. | | | | | | |
| A3166 | 1 | Valve, Check | Helium purge | | 3871261-501 | |
| A3167 | 1 | Orifice | Valve purge | | 75M06713-2 | |
| A3168 | 1 | Orifice | Coupling purge | | 75M06686-3 | |
| A3169 through A3300 are not functionally applicable to this system. | | | | | | |
| A3301 | 1 | Valve, Manual | 3 in. | Pacific Valves, Inc. Model G-710YJ-10K-WE | 10464405 | |
| A3302 | 1 | Valve, Pneumatic | 2 in., NC | The Annin Co. Model 1720 | 10464408 | |
| A3303 | 1 | Valve, Manual | 6 in. | Pacific Valve, Inc. Model G-710YJ-10K-WE | 10464407 | |
| A3304 | 1 | Valve, Pneumatic | 8 in., NC | The Annin Co. Model 1620B | 10464411 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3305 | 1 | Regulator, Flow | 1-1/2 in., NC;<br>25 psig actuator pressure,<br>3 to 15 psig signal pressure | The Annin Co.<br>Model 1760 | 10464410 | |
| A3306 | 1 | Valve, Pneumatic | 6 in., NC | Pacific Valves, Inc.<br>Model G-710YJC-10K-WE | 10464401 | |
| A3307 | 1 | Valve, Pneumatic | 1-1/2 in., NC | The Annin Co.<br>Model 1720 | 10464402 | |
| A3308 | 1 | Valve Pneumatic | 1-1/2 in., NC | The Annin Co.<br>Model 1620 | 10464403 | |
| A3309 | 1 | Regulator, Flow | 1 in., NC,<br>25 psig actuator pressure,<br>3 to 15 psig signal pressure | The Annin Co.<br>Model 1760 | 10464416 | |
| A3310 through A3317 are not functionally applicable to this system. | | | | | | |
| A3318 | 1 | Valve, Solenoid | 2-way, 2-position;<br>NC | Marotta Valve Corp.<br>Model MV-185 | 10464427 | |
| A3319 is not functionally applicable to this system. | | | | | | |
| A3320 | 1 | Valve, Manual | 2 in. | The Annin Co.<br>Model 1710 | 10464409 | |
| A3321 is not functionally applicable to this system. | | | | | | |
| A3322 | 1 | Valve, Manual | 1/2 in., shutoff | Hills Mc Canna Co.<br>Model S-303-S6-T | 10464552 | |
| A3323 | 1 | Valve, Manual | 3 in., shutoff | Hills Mc Canna Co.<br>Model S-303-S6-T | 10464562 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3324 | 1 | Valve, Manual | 6 in., shutoff | Vacuum Research Co. Model VG-6N5 | 10464550 | |
| A3325 | 1 | Valve, Manual | 1/2 in., NC, shutoff | Vacuum Electronics Engr. Co. Model L62P | 10464551 | |
| A3326 | 1 | Valve, Manual | 1/2 in., NC, shutoff | Vacuum Electronics Engr. Co. Model L62P | 10464551 | |
| A3327 | 1 | Valve, Manual | 1/2 in., shutoff | Hills Mc Canna Co. Model S-303-S6-T | 10464552 | |
| A3328 | 1 | Valve, Manual | 1/2 in., shutoff | Hills Mc Canna Co. Model S-303-S6-T | 10464552 | |
| A3329 | 1 | Valve, Manual | 1/2 in., shutoff | Hills Mc Canna Co. Model S-303-S6-T | 10464552 | |
| A3330 | 1 | Valve, Manual | 2 in. | The Annin Co. Model 1710 | 10464404 | |
| A3331 | 1 | Valve, Manual | 2 in. | The Annin Co. Model 1710 | 10464404 | |
| A3332 | 1 | Valve, Manual | 2 in. | The Annin Co. Model 1710 | 10464404 | |
| A3333 | 1 | Valve, Manual | 2 in. | The Annin Co. Model 1710 | 10464404 | |
| A3334 | 1 | Valve, Manual | 1/2 in., vent | Vacuum-Electronics Engr. Co. Model L62P | 10464551 | |
| A3335 | 1 | Valve, Manual | 1/2 in., NC, drain | Hills Mc Canna Co. Model S-303-S6-T | 10464552 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3336 | 1 | Valve, Manual | 1/2 in., shutoff | Hills Mc Canna Co. Model S-303-S6-T | 10464552 | |
| A3337 | 1 | Valve, Manual | 1/2 in., shutoff | Hills Mc Canna Co. Model S-303-S6-T | 10464552 | |
| A3338 | 1 | Regulator, Flow | 3 in., NC; 25 psig actuator pressure, 3 to 15 psig signal pressure | The Annin Co. Model 1660 | 10464418 | |
| A3339 is not functionally applicable to this system. | | | | | | |
| A3340 | 1 | Valve, Manual | 1/2 in., shutoff | Hills Mc Canna Co. Model S-303-S6-T | 10464552 | |
| A3341 | 1 | Valve, Manual | 1/2 in., NC, vent | Hills Mc Canna Co. Model S-303-S6-T | 10464552 | |
| A3342 | 1 | Regulator, Flow | 2 in., NC; 25 psig actuator pressure, 3 to 15 psig signal pressure | The Annin Co. Model 1760 | 10464417 | |
| A3343 | 1 | Valve, Manual | 1/2 in., NC | Hills Mc Canna Co. Model S-303-S6-T | 10464552 | |
| A3344 | 1 | Valve, Solenoid | 2-way, 3-position; NC | Marotta Valve Corp. Model MV-182C | 10464421 | |
| A3345 | 1 | Regulator, Pressure | 1/2 in.; 50 psig input, 2 psig output | Fisher Governor Co. Model 45-L | 10464420 | |
| A3346 | 1 | Valve, Manual | 1/4 in., NC, vent | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3347 | 1 | Valve, Manual | 1/4 in., NC, vent | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3348 | 1 | Valve, Check | 1/2 in., 2 psig cracking pressure | William Powell Co. Model 70-2341-KD | 10464553 | |
| A3349 | 1 | Valve, Check | 2 in., 0.05 psig cracking pressure | Chapman Valve Mfg. Co. Model PD-117948 | 10464554 | |
| A3350 | 1 | Valve, Manual | 1/4 in., NC, vent | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3351 | 1 | Valve, Manual | 1/4 in., NC, shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3352 | 1 | Valve, Manual | 1/4 in., NC, shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3353 | 1 | Valve, Manual | 1/4 in., NC, shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3354 | 1 | Valve, Manual | 1/4 in., NC, shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3355 is not functionally applicable to this system. | | | | | | |
| A3356 | 1 | Valve, Manual | 1/4 in., NC, vent | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3357 | 1 | Valve, Manual | 1/4 in., N.O., shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3358 | 1 | Valve, Manual | 1/4 in., N.O., shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3359 | 1 | Valve, Manual | 1/4 in., N.O., shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3360 | 1 | Valve, Manual | 1/4 in., N.O., shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3361 | 1 | Valve, Manual | 1/4 in., N.O., shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3362 | 1 | Valve, Manual | 1/4 in., N.O., shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3363 | 1 | Valve, Manual | 1/4 in., N.O., shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3364 | 1 | Valve, Manual | 1/4 in., N.O., shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3365 | 1 | Valve, Manual | 8 in., 1 psig cracking pressure | Chapman Valve Mfg. Co. Model PB-117946 | 10464555 | |
| A3366 is not functionally applicable to this system. | | | | | | |
| A3367 | 1 | Valve, Manual | 1/4 in., NC, vent | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3368 | 1 | Valve, Manual | NC, shutoff | | | |
| A3369 | 1 | Valve, Manual | 1/4 in., N.O., shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3370 | 1 | Valve, Manual | 1/4 in., N.O., shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3371 | 1 | Valve, Manual | 1/4 in., NC, vent | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3372 | 1 | Valve, Manual | 1/4 in., N.O., shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3373 | 1 | Valve, Manual | 1/4 in., NC, shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3374 and A3375 are not functionally applicable to this system. | | | | | | |
| A3376 | 1 | Valve, Check | 10 in., 2 psig cracking pressure | Chapman Valve Mfg. Co. Model PB-117408 | 10464556 | |
| A3377 | 1 | Valve, Check | 8 in. | Chapman Valve Mfg. Co. Model PB-117946 | 10464555 | |
| A3378 | 1 | Valve, Check | 2 in. | Chapman Valve Mfg. Co. Model PB-117948 | 10464554 | |
| A3379 | 1 | Valve, Manual | 6 in., N.O. | Pacific Valves, Inc. Model G-710YJ-10K-WE | 10464424 | |
| A3380 | 1 | Valve, Manual | 6 in. | Vacuum Research Co. Model VG-6N5 | 10464550 | |
| A3381 | 1 | Valve, Manual | 1/4 in., NC, vent | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3382 | 1 | Valve, Check | 3 in. | Chapman Valve Mfg. Co. Model PB-117947 | 10464563 | |
| A3383 | 1 | Valve, Check | 1 in. | William Powell Co. Model 70-2341 | 10464564 | |
| A3384 | 1 | Valve, Manual | 1/4 in., shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3385 | 1 | Valve, Manual | 1/4 in. , shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3386 | 1 | Valve, Solenoid | 3-way, 2-position; NC | Marotta Valve Corp. Model MV-74TB | 10464413 | |
| A3387 | 1 | Valve, Solenoid | 3-way, 2-position; NC | Marotta Valve Corp. Model MV-74TB | 10464413 | |
| A3388 | 1 | Valve, Solenoid | 3-way, 2-position; NC | Marotta Valve Corp. Model MV-74TB | 10464413 | |
| A3389 | 1 | Valve, Solenoid | 3-way, 2-position; N.O. | Marotta Valve Corp. Model MV-74TB | 10464413 | |
| A3390 | 1 | Valve, Solenoid | 3-way, 2-position; NC | Marotta Valve Corp. Model MV-74TB | 10464413 | |
| A3391 | 1 | Valve, Solenoid | 3-way, 2-position; N.O. | Marotta Valve Corp. Model MV-74TB | 10464413 | |
| A3392 | 1 | Valve, Solenoid | 3-way, 2-position; NC | Marotta Valve Corp. Model MV-74TB | 10464413 | |
| A3393 | 1 | Valve, Solenoid | 3-way, 2-position; N.O. | Marotta Valve Corp. Model MV-74TB | 10464413 | |
| A3394 | 1 | Valve, Solenoid | 3-way, 2-position, NC | Marotta Valve Corp. Model MV-74TB | 10464413 | |
| A3395 | 1 | Valve, Solenoid | 3-way, 2-position, N.O. | Marotta Valve Corp. Model MV-74TB | 10464413 | |
| A3396 | 1 | Valve, Solenoid | 3-way, 2-position, NC | Marotta Valve Corp. Model MV-74TB | 10464413 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3397 | 1 | Valve, Solenoid | 3-way, 2-position, N.O. | Marotta Valve Corp. Model MV-74TB | 10464413 | |
| A3398 | 1 | Valve, Solenoid | 3-way, 2-position, N.O. | Marotta Valve Corp. Model MV-74TB | 10464413 | |
| A3399 | 1 | Valve, Manual | 1/4 in., N.O., shutoff | Robbins Aviation, Inc. Model SSKG 250-4T | 10464559 | |
| A3400 is not functionally applicable to this system. | | | | | | |
| A3401 | 1 | Valve, Manual | 1/4 in., N.O., shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3402 | 1 | Valve, Check | 1/2 in., cracking pressure -0.1 psig | Circle Seal Products Inc. Model 119T-4PP | 10464566 | |
| A3403 | 1 | Valve, Manual | 1/4 in., NC, vent | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3404 is not functionally applicable to this system. | | | | | | |
| A3405 | 1 | Valve, Manual | 1/4 in., NC, shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3406 | 1 | Valve, Manual | 1/4 in., NC | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3407 | 1 | Valve, Manual | 1/4 in., NC | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3408 | 1 | Valve, Manual | 1/4 in., NC, vent | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3409 | 1 | Valve, Manual | 1/4 in., N.O., shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3410 | 1 | Valve, Manual | 1/4 in., N.O. vent | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3411 | 1 | Valve, Check | 3/4 in. | Circle Seal Products Co. Inc., Model 859T-12BB | 10464565 | |
| A3412 | 1 | Valve, Manual | 1/4 in., NC, shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3413 | 1 | Valve, Manual | 1/4 in., NC, shutoff | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3414 | 1 | Limiter, Differential Pressure | 1-1/2 psid set pressure | | 10466187 | |
| A3415 | 1 | Valve, Manual | 1/4 in., 3-way, 2-position, shutoff | | 10466188 | |
| A3416 | 1 | Valve, Manual | 1/4 in., NC, drain | Robbins Aviation, Inc. Model SSKG250-4T | 10464559 | |
| A3417 | 1 | Valve, Manual | 1/2 in., NC, drain | Hills Mc Canna Co. Model S-303-S6-T | 10464567 | |
| A3418 through A3501 are not functionally applicable to this system. | | | | | | |
| A3502 | 1 | Transducer, Differential Pressure | 0-1 psid nominal range | | 10465305 | |
| A3503 is not functionally applicable to this system. | | | | | | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3504 | 1 | Gage, Liquid Level | 125,000 gallon normal indication, 0-130,000 range | Barton Model 199 P Unit Model 200 indicator | 10466009 | |
| A3505 | 1 | Level Indicator | 0 to 100 percent range | | 10464724 | |
| A3506 | 1 | Gage, Compound | 30 in. Hg vacuum, 60 psig range | | 10466007 | |
| A3507 | 1 | Transducer, Pressure | 0-50-psig range | Fairchild Controls Corp. Model 990550-2 | 10465306 | |
| A3508 is not functionally applicable to this system. | | | | | | |
| A3509 | 1 | Probe, Liquid Level | 10 to 40 psig internal pressure, 100 to 0 percent subcooler $LH_2$ level | | 10462814 | |
| A3510 is not functionally applicable to this system. | | | | | | |
| A3511 | 1 | Sensor, Liquid Level | Actuates at 100 percent $LH_2$ level | | 10466011 | |
| A3512 | 1 | Sensor, Liquid Level | Actuates at 0 percent $LH_2$ level | | 10466011 | |
| A3513 | 1 | Controller, Pressure, Pneumatic | 10 to 40 psig input, 15 to 3 psig output | Bristol Series 624 | 10466004 | |
| A3514 | 1 | Controller, Pressure, Pneumatic | 13 to 15 psig input 15 to 3 psig output | Bristol Series 624 | 10466017 | |
| A3515 | 1 | Controller, Pressure, Pneumatic | 100 to 0 percent $LH_2$ level, 2 to 0 in. $H_20$ actuating press., 3 to 15 psig output | Barton Model 274 Transmitter Model 199 P Unit | 10466010 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3516 through A3531 are not functionally applicable to this system. | | | | | | |
| A3532 | 1 | Gage, Pressure | 0 to 100 psig range | | 10466006 | |
| A3533 | 1 | Transducer, Pressure | 0 to 100 psig range | Fairchild Controls Inc. Model 990550-2 | 10465306 | |
| A3534 is not functionally applicable to this system. | | | | | | |
| A3535 | 1 | Switch, Pressure | Actuates at 2 psig decreasing pressure | | 10466005-1 | |
| A3536 | 1 | Switch, Pressure | Actuates at 2 psig decreasing pressure | | 10466005-2 | |
| A3537 | 1 | Switch, Pressure | Actuates at 2 psig increasing pressure | | 10466005-3 | |
| A3538 | 1 | Switch, Pressure | Actuates at 55 psig increasing pressure | | 10466005-4 | |
| A3539 | 1 | Switch, Pressure | Actuates at 60 psig increasing pressure | | 10466005-5 | |
| A3540 | 1 | Switch, Pressure | Actuates at 15 psig increasing pressure | | 10466024 | |
| A3541 is not functionally applicable to this system. | | | | | | |
| A3542 | 1 | Transducer, Pressure | 0 to 20 psig range | Fairchild Controls, Inc. Model 990550-2 | 10465306 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3543 is not functionally applicable to this system. | | | | | | |
| A3544 | 1 | Controller, Pressure, Pneumatic | 0 to 100 psig input, 15 to 3 psig output | Bristol Series 624 | 10466001 | |
| A3545 and A3546 are not functionally applicable to this system. | | | | | | |
| A3547 | 1 | Transducer | 0 to 20 psia range | Fairchild Controls, Inc. Model 990550-2 | 10465306 | |
| A3548 and A3549 are not functionally applicable to this system. | | | | | | |
| A3550 | 1 | Gage, Pressure | 2 psig normal reading, 0 to 60 psig range | | 10466027 | |
| A3551 | 1 | Controller, Pressure, Pneumatic | 0 to 4 psig actuating press., 25 psig input. | Bristol Series 624 | 10466003 | |
| A3552 | 1 | Snubber | Set at 10 psig | Sprague Eng. Corp. Model S-214-10 | 10466014 | |
| A3553 is not functionally applicable to this system. | | | | | | |
| A3554 | 1 | Controller, Pressure, Pneumatic | 0 to 15 psia input, 3 to 15 psig output | Bristol Series 624 | 10466002 | |
| A3555 through A3570 are not functionally applicable to this system. | | | | | | |
| A3571 | 1 | Indicator, Temperature | Pressure operated, 0 to 150 psia range; -430 F to -403 F range | | 10466008 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3572 | 1 | Transducer, Temperature | Pressure operated, 0 to 150 psia; -430 F to -403 F range | Fairchild Controls Inc. Model 990550-2 | 10465306 | |
| A3573 is not functionally applicable to this system. | | | | | | |
| A3574 | 1 | Probe, Temperature | | | 10466016 | |
| A3575 | 1 | Switch, Temperature | Pressure operated, actuates at 100 psig increasing pressure-equivalent to -406 F | | 10466025-1 | |
| A3576 and A3577 are not functionally applicable to this system. | | | | | | |
| A3578 | 1 | Transducer, Temperature | Pressure operated, 0 to 150 psia; -430 F to -403 F range | Fairchild Controls, Inc. Model 990550-2 | 10465306 | |
| A3579 is not functionally applicable to this system. | | | | | | |
| A3580 | 1 | Probe, Temperature | | | 10466016 | |
| A3581 is not functionally applicable to this system. | | | | | | |
| A3582 | 1 | Indicator, Temperature | Pressure operated, 0 to 50 psia, -430 F to -403 F range. | | 10466008 | |
| A3583 | 1 | Probe, Temperature | | | 10466016 | |
| A3584 | 1 | Indicator, Temperature | Pressure operated 0 to 150 psia, -430 F to -403 F range | | 10466008 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3585 | 1 | Probe, Temperature | | | 10466023 | |
| A3586 | 1 | Indicator, Temperature | Pressure operated, 0 to 150 psia, -430 F to -403 F range | | 10466008 | |
| A3587 | 1 | Probe, Temperature | | | | |
| A3588 through A3600 are not functionally applicable to this system. | | | | | | |
| A3601 | 1 | Orifice | 0.228 in. dia., 20 scfm flowrate | | 10464423-1 | |
| A3602 | 1 | Orifice | 0.052 in. dia., 1 scfm flowrate | | 10464423-2 | |
| A3603 | 1 | Orifice | 0.182 in. dia., 20 scfm flowrate | | 10464423-3 | |
| A3604 | 1 | Orifice | 0.116 in. dia., 8 scfm flowrate | | 10464423-4 | |
| A3605 | 1 | Orifice | 0.116 in. dia.. 5 scfm flowrate | | 10464423-4 | |
| A3606 | 1 | Orifice | 0.228 in. dia., 20 scfm flowrate | | 10464423-1 | |
| A3607 | 1 | Orifice | 0.037 in dia., 0.5 scfm flowrate | | 10464423-5 | |
| A3608 | 1 | Orifice | 0.037 in. dia., 0.5 scfm flowrate | | 10464423-5 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3609 | 1 | Orifice | 0.037 in., dia., 0.5 scfm flowrate | | 10464423-5 | |
| A3610 | 1 | Orifice | 0.0156 in. dia., 0.1 scfm flowrate | | 1046118 | |
| A3611 through A3620 are not functionally applicable to this system. | | | | | | |
| A3621 | 1 | Indicator, Vacuum | | | | |
| A3622 | 1 | Transducer, Vacuum | | | 10466012 | |
| A3623 | 1 | Transducer, Vacuum | | | 10466012 | |
| A3624 | 1 | Transducer, Vacuum | | | 10466012 | |
| A3625 through A3639 are not functionally applicable to this system. | | | | | | |
| A3640 | 1 | Valve, Relief | Relieves at 100 psig | Manning, Maxwell, & Moore, Inc. | 10464412 | |
| A3641 | 1 | Valve, Relief | Relieves at 20 psid | Manning, Maxwell, & Moore, Inc. | 10464415 | |
| A3642 | 1 | Valve, Relief | Relieves at 100 psig | Manning, Maxwell, & Moore, Inc. | 10464414 | |
| A3643 | 1 | Valve, Relief | Relieves at 100 psig | Manning, Maxwell, & Moore, Inc. | 10464414 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3644 | 1 | Valve, Relief | Relieves at 100 psig | Manning, Maxwell, & Moore, Inc. | 10464414 | |
| A3645 | 1 | Valve, Relief | Relieves at 5 psig | Manning, Maxwell, & Moore, Inc. | 10464419 | |
| A3646 | 1 | Valve, Relief | Relieves at 100 psig | Manning, Maxwell, & Moore, Inc. | 10464414 | |
| A3647 | 1 | Valve, Relief | Relieves at 100 psig | Manning, Maxwell, & Moore, Inc. | 10464414 | |
| A3648 through A3699 are not functionally applicable to this system. | | | | | | |
| A3700 | 1 | Gage, Pressure | 3500 psig normal reading, 0 to 10,000 psi range | U. S. Gauge Company | 10437648 | |
| A3701 | 1 | Gage, Pressure | 750 psig normal reading 0 to 1500 psi range | U. S. Gauge Company | 10437688 | |
| A3702 | 1 | Gage, Pressure | 120 psig normal reading 0 to 300 psi range | U. S. Gauge Company | 10437687 | |
| A3703 | 1 | Gage, Pressure | 25 psig normal reading, 0 to 60 psi range | U. S. Gauge Company | 10437686 | |
| A3704 | 1 | Regulator, Pressure | 3500 psig inlet, 750 psig outlet | Grove Valve & Regulator Co. Model No. 94X | 10437651 | |
| A3705 | 1 | Regulator, Pressure | 120 psig inlet, 25 psi outlet | Grove Valve & Regulator Co. Model No. 94 X | 10437651 | |
| A3706 | 1 | Regulator, Pressure | 120 psig inlet, 25 psi outlet | Moore Products Co. Model 42H50 | 10437679 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3707 | 1 | Filter | 10 Micron | Permanent Filter Corp. P/N 10813 | 10437650 | |
| A3708 | 1 | Valve, Relief | Cracks at 900 ( ± 50) psig, reseats at 750 psig min. | Republic Manufacturing Co. P/N 625B-9-6 | 10437652 | |
| A3709 | 1 | Valve, Relief | Cracks at 120 psig, reseats at 100 psig min. | Republic Manufacturing Co. P/N 625B-3-6 | 10437680 | |
| A3710 | 1 | Valve, Relief | Cracks at 35 ( ±5) psig, reseats at 25 psig min. | Republic Manufacturing Co. P/N 625-2-8 | 10437681 | |
| A3711 | 1 | Switch, Pressure | Actuates at 21.5 ( ± 0.5) psig, deactuates within 1.5 psig of actuation press | Southwestern Industries, Inc. P/N PS-3700A-4 | 10437682 | |
| A3712 | 1 | Valve, Manual | 5/16 in., shutoff | Robbins Aviation P/N SSNA-375A-6T | 10437684 | |
| A3713 | 1 | Valve, Manual | 5/16 in., shutoff | Robbins Aviation P/N SSNA-375A-6T | 10437684 | |
| A3714 | 1 | Valve, Manual | 5/16 in., shutoff | Robbins Aviation P/N SSNA-375A-6T | 10437684 | |
| A3715 | 1 | Valve, Manual | 5/16 in., shutoff | Robbins Aviation P/N SSNA-375A-6T | 10437684 | |
| A3716 | 1 | Valve, Manual | 1/4 in., NC, vent | Futurecraft Corp. P/N 30205 | 10437647 | |
| A3717 | 1 | Valve, Manual | 1/4 in., NC, vent | Futurecraft Corp. P/N 30205 | 10437647 | |
| A3718 | 1 | Valve, Manual | 1/4 in., NC, vent | Futurecraft Corp. P/N 30205 | 10437647 | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3719 | 1 | Valve, Manual | 1/4 in., NC, vent | Futurecraft Corp. P/N 30205 | 10437647 | |
| A3720 | 1 | Valve, Manual | 5/16 in., shutoff | Robbins Aviation P/N SSNA-375A-6T | 10437684 | |
| A3721 | 1 | Valve, Manual | 1/4 in., NC, vent | Futurecraft Corp. P/N 30205 | 10437647 | |
| A3722 | 1 | Valve, Manual | 1/4 in., NC, vent | Futurecraft Corp. P/N 30205 | 10437647 | |
| A3723 | 1 | Valve, Manual | 1/4 in., NC, vent | Futurecraft Corp. P/N 30205 | 10437647 | |
| A3724 | 1 | Valve, Manual | 1/4 in., NC, vent | Futurecraft Corp. P/N 30205 | 10437647 | |
| A3725 | 1 | Switch, Pressure | Actuates at 600 ( ± 20) psig, deactuates at 50 psig less than actuation pressure | Southwestern Industries P/N PS-5100A | 10437683 | |
| A3726 through A3749 are not functionally applicable to this system. | | | | | | |
| A3750 | 1 | Pump, Vacuum | 8 in. bore, 5 in. stroke | F. J. Stokes Model 412-10 | | |
| A3751 | 1 | Pump, Vacuum | 8 in. bore, 5 in. stroke | Air Products & Chemicals Inc. | 10463950 | |
| A3752 | 1 | Subcooler | Supercools $LH_2$ from -423 F to -426 F | | | |
| A3753 | 1 | Storage Tank, $LH_2$ | 125,000 gallons capacity | Air Products & Chemical Inc. | | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3754 through A3770 are not functionally applicable to this system. | | | | | | |
| A3771 | 1 | Valve, Manual | 5/16 in., shutoff | | | |
| A3772 through A3899 are not functionally applicable to this system. | | | | | | |
| A3900 | 1 | Transducer, Pressure | 1/4 in.,<br>0 to 100 psia range | Douglas Aircraft Co.<br>P/N 7870467-511 | | |
| A3901 | 1 | Transducer, Vacuum | 0 to 1000 Microns<br>Hg | Douglas Aircraft Co.<br>( DAC)<br>P/N 1A36723-1 | | |
| A3902 through A3904 are not functionally applicable to this system. | | | | | | |
| A3905 | 1 | Filter | 4 in.; 98 percent of 72 micron particles, 100 percent of 125 micron particles | Douglas Aircraft Co.<br>1A38763-1 | | |
| A3906 | 1 | Valve, Solenoid | 1/4 in.;<br>4-way, 2-position, NC<br>750 psig | Douglas Aircraft Co.<br>P/N 3863940-501 | | |
| A3907 | 1 | Transducer, Vacuum | 0 to 1000 microns,<br>Hg | Douglas Aircraft Co.<br>P/N 1A36723-1 | | |
| A3908 and A3909 are not functionally applicable to this system. | | | | | | |
| A3910 | 1 | Valve, Pneumatic | 2 in., 3-position,<br>NC | Douglas Aircraft Co.<br>P/N 7864354-1 | | |
| A3911 | 1 | Valve, Pneumatic | 4 in., NC | Douglas Aircraft Co.<br>P/N 7864253-1 | | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3912 | 1 | Valve, Pneumatic | 2 in., NC | Douglas Aircraft Co. P/N 7864252-1 | | |
| A3913 through A3915 are not functionally applicable to this system. | | | | | | |
| A3916 | 1 | Transducer, Pressure | 1/4 in., 0 to 100 psia range | Douglas Aircraft Co. P/N 7870467-511 | | |
| A3917 | 1 | Valve, Pneumatic | 1-1/2 in., NC | Douglas Aircraft Co. P/N 7866052-1 | | |
| A3918 through A3921 are not functionally applicable to this system. | | | | | | |
| A3922 | 1 | Valve, Solenoid | 1/4 in., 4-way, 2-position; NC, 750 psig | Douglas Aircraft Co. P/N 3863940-501 | | |
| A3923 | 1 | Valve, Solenoid | 1/4 in., 4-way, 2-position; NC, 750 psig | Douglas Aircraft Co. P/N 3863940-501 | | |
| A3924 | 1 | Transducer, Vacuum | 0 to 1000 microns Hg | Douglas Aircraft Co. P/N 1A36723-1 | | |
| A3925 | 1 | Valve, Solenoid | 1/4 in., 4-way, 2-position; NC, 750 psig | Douglas Aircraft Co. P/N 3863940-501 | | |
| A3926 | 1 | Transducer, Vacuum | 0 to 100 microns Hg | Douglas Air craft Co. P/N 1A36723-1 | | |
| A3927 through A3929 are not functionally applicable to this system. | | | | | | |
| A3930 | 1 | Transducer, Vacuum | 0 to 1000 microns Hg | Douglas Aircraft Co. P/N 1A36723-1 | | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3931 | 1 | Valve, Solenoid | 1/4 in., 4-way, 2-position; 750 psig | Douglas Aircraft Co. P/N 386940-501 | | |
| A3932 | 1 | Valve, Relief | Relieves at 92 ( ± 2) psig. reseats at 84 ( ± 2) psig | Douglas Aircraft Co. P/N 3865757-1 | | |
| A3933 | 1 | Coupling | | | | |
| A3934 | 1 | Orifice | 0.052 in. dia., 1 scfm flow rate | | 10466186-2 | |
| A3935 | 1 | Orifice | 0.052 in. dia., 1 scfm flow rate | | 10466186-2 | |
| A3936 | 1 | Coupling | | | | |
| A3937 | 1 | Coupling | | | | |
| A3938 | 1 | Motor | 15 hp. | U.S. Electrical Motors, Inc. Type J | 10462945 | |
| A3939 | 1 | Motor | 15 hp. | U.S. Electrical Motors, Inc. Type J | 10462945 | |
| A3940 | 1 | Coupling | | | | |
| A3941 | 1 | Coupling | | | | |
| A3942 | 1 | Coupling | | | | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| A3943 | 1 | Coupling | | | | |
| A3944 | 1 | Snubber | 1/2 in. | Douglas Aircraft Co. | | |
| A3945 | 1 | Pressure Switch | | Douglas Aircraft Co. | | |
| A3946 | 1 | Coupling | | | | |
| A3947 | 1 | Coupling | | | | |
| A3948 | 1 | Coupling | | | | |
| A3949 through E99 are not functionally applicable to this system. | | | | | | |
| E100 | 1 | Coupling | | Douglas Aircraft Co. P/N 7851805-1 | | |
| E101 is not functionally applicable to this system. | | | | | | |
| E102 | 1 | Container, $LH_2$ | 4274 cu. ft. | Douglas Aircraft Co. | | |
| E103 and E104 are not functionally applicable to this system. | | | | | | |
| E105 | 1 | Coupling, Quick-Disconnect | | Douglas Aircraft Co. P/N 7851802-1 | | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| E106 | 4 | Vortex Eliminator | 100 and 150 mesh | Douglas Aircraft Co. P/N 5851798-1 | | |
| E107 | 1 | Sensor | | Douglas Aircraft Co. | | |
| E108 through E112 are not functionally applicable to this system. | | | | | | |
| E113 | 1 | Valve, Pneumatic | 3 in. NC | Douglas Aircraft Co. P/N 7851806-501 | | |
| E114 | 1 | Valve, Pneumatic | NC, 475 ( ± 25) psig, vent | Douglas Aircraft Co. P/N 7851795-1 | | |
| E115 | 1 | Valve, Pneumatic | NC, 475 ( ± 25) psig, vent | Douglas Aircraft Co. P/N 7851795-1 | | |
| E116 through E208 are not functionally applicable to this system. | | | | | | |
| E209 | 1 | Valve, Solenoid | 3-way, 2-position, NC | Douglas Aircraft Co. P/N 7851827-1 | | |
| E210 | 1 | Valve, Solenoid | 3-way, 2-position, NC | Douglas Aircraft Co. P/N 7851827-1 | | |
| E211 | 1 | Valve, Solenoid | 3-way, 2-position, NC | Douglas Aircsaft Co. P/N 7851827-1 | | |
| E212 through E249 are not functionally applicable to this system. | | | | | | |
| E250 | 1 | Coupling, Quick-Disconnect | | Douglas Aircraft Co. P/N 7851861-1 | | |

| Finding Number | Reqd | Component | Remarks | Vendor | Drawing Number | Elec. Sym. |
|---|---|---|---|---|---|---|
| E251 | 1 | Valve, Check | 1 to 2 psig cracking press. | Douglas Aircraft Co. P/N 7851859-1 | | |
| E252 | 1 | Orifice | 0.457 in dia. | Douglas Aircraft Co. P/N 4884302-1 | | |
| E253 | 1 | Orifice | 0.271 in. dia. | Douglas Aircraft Co. P/N 4884302-503 | | |
| E254 | 1 | Valve, Electropneumatic | | Douglas Aircraft Co. P/N 7851858-1 | | |
| E255 | 1 | Valve, Electropneumatic | | Douglas Aircraft Co. P/N 7851858-1 | | |
| E256 | 1 | Orifice | 0.162 in dia. | Douglas Aircraft Co. P/N 4884302-501 | | |
| E257 | 1 | Valve, Solenoid | 2-way, 2-position, NC | Douglas Aircraft Co. P/N 7851825-1 | | |
| E258 | 1 | Valve, Check | 5 to 10 psig cracking press. | Douglas Aircraft Co. P/N 7851822-1 | | |
| E259 | 1 | Orifice | | Douglas Aircraft Co. P/N S-4851838-4 | | |
| E260 through E274 are not functionally applicable to this system. | | | | | | |
| E275 | 1 | Switch, Differential Pressure | Actuates at 1 ( ± 0.3) psid | Douglas Aircraft Co. P/N 7851831-1 | | |
| E276 | 1 | Switch, Pressure | Actuates at 37.25 ( ± 0.75) psia, deactuates at 35.75 ( ±0.75) psia | Douglas Aircraft Co. P/N 7851860-501 | | |

# SECTION 3

## MECHANICAL SCHEMATICS

This section contains mechanical schematics that reflect all $LH_2$ fuel system components that function during a normal countdown sequence. For a definition of the mechanical symbols used, see MSFC-STD-162.

# APPENDIX A

## LISTING OF LAUNCH VEHICLE SA-8 AND LAUNCH COMPLEX 37B VOLUMES

| Volume | Title |
|---|---|
| I | RP-1 Fuel System |
| II | LOX System |
| III | $LH_2$ Fuel System |
| IV | Nitrogen and Helium Storage Facility |
| V | Pneumatic Distribution System |
| VI | Environmental Conditioning Systems |
| VII | Launch Pad Accessories |
| VIII | H-1 Engine and Hydraulic System |
| IX | RL10A-3 Engine and Hydraulic System |
| X | Separation and Flight Termination Systems |

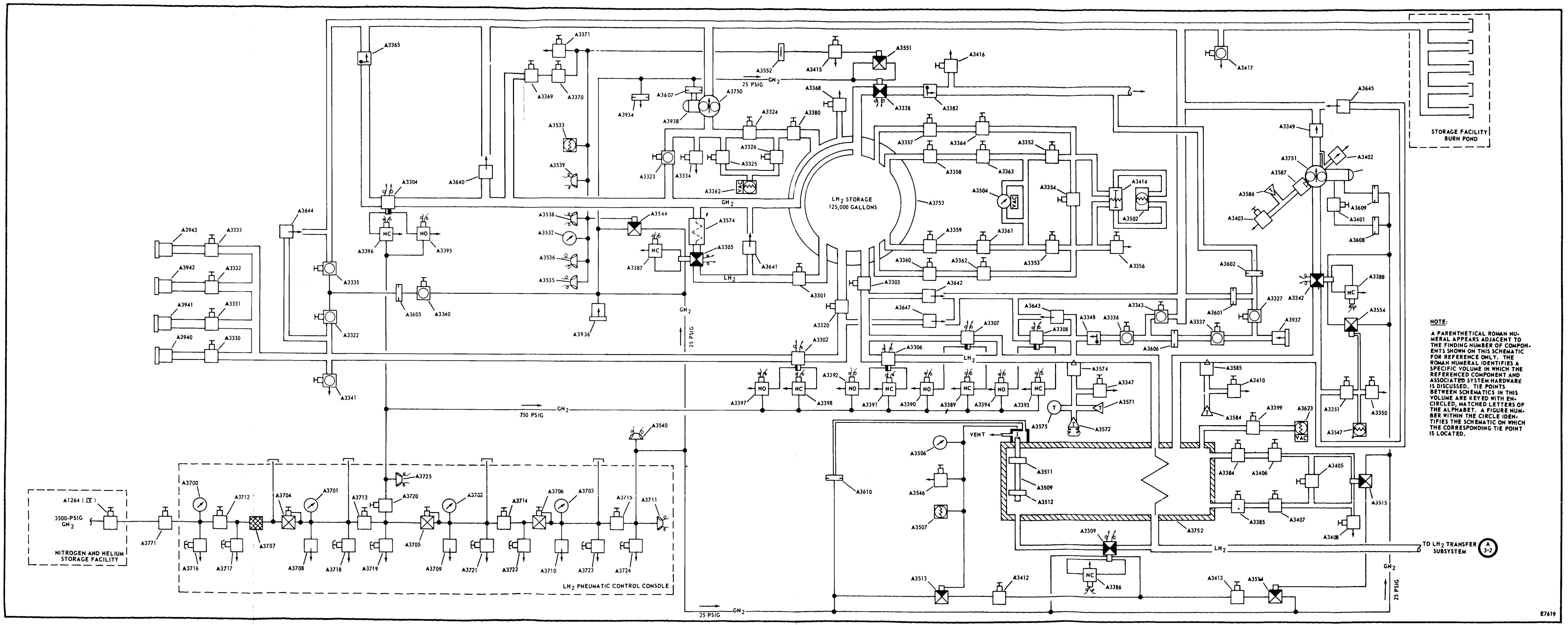


Figure 3-1. Launch Complex 37B $LH_2$ Fuel Storage Facility - Mechanical Schematic

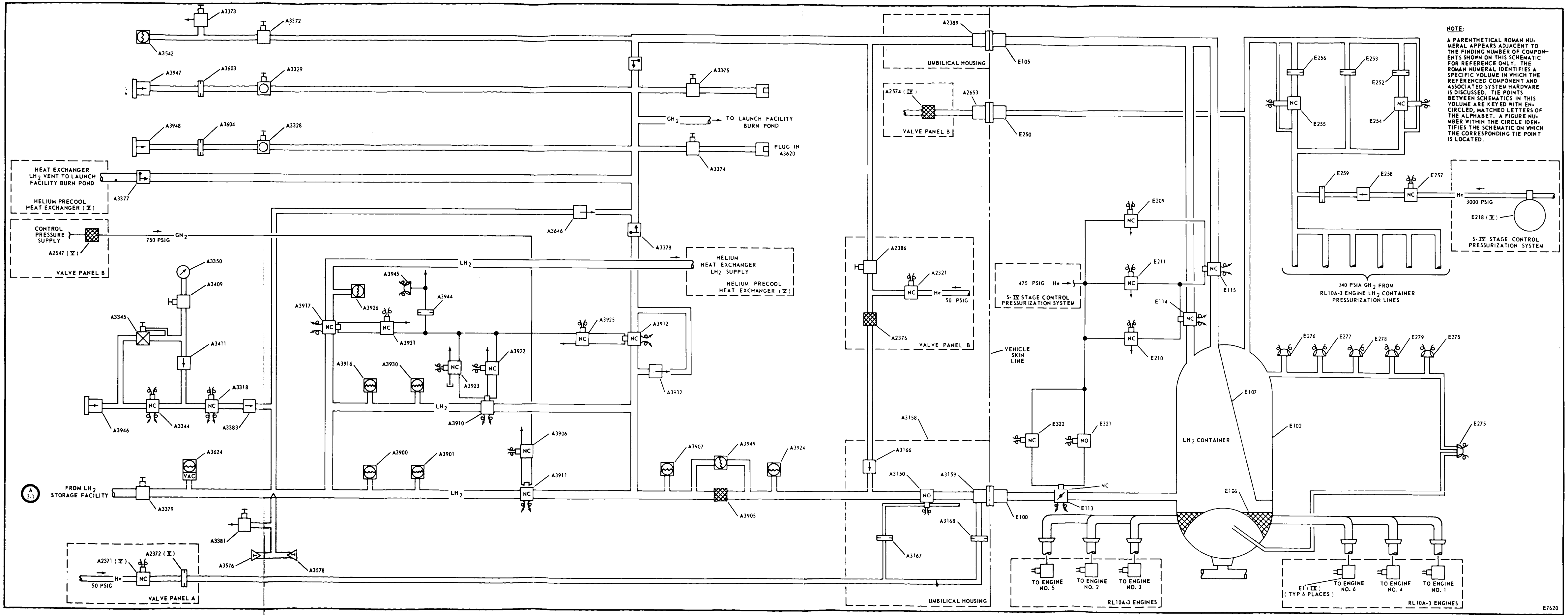


Figure 3-2. Launch Complex 37B $LH_2$ Transfer Subsystem and S-IV Stage $LH_2$ Subsystems - Mechanical Schematic

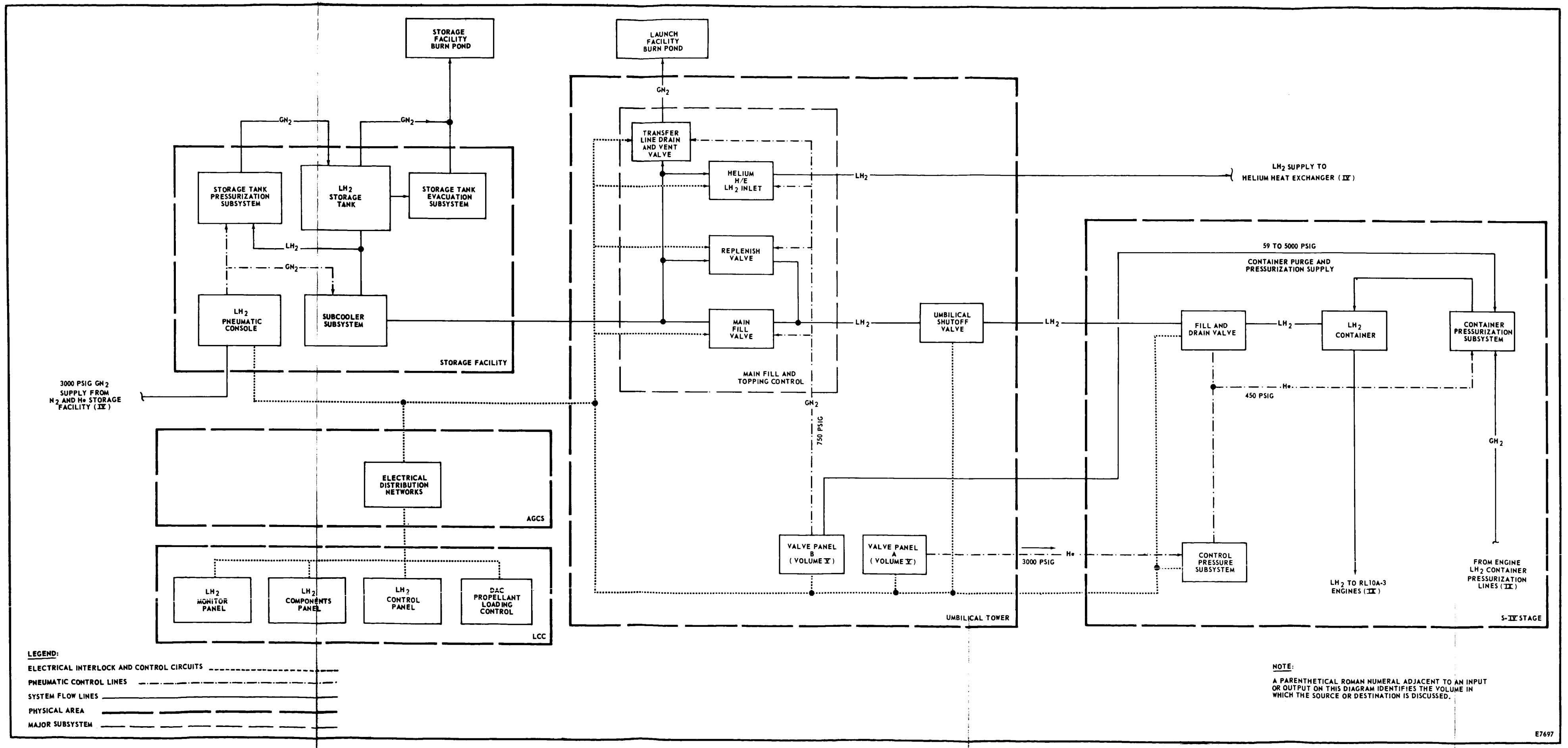


Figure 1-1. Launch Vehicle SA-8 and Launch Complex 37B $LH_2$ Fuel System - Block Diagram