

KLASS CONSOLES



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PURPOSE

The purpose of this presentation is to become familiar with the 5 KLASS consoles that will be used to launch the shuttle.

The 5 types of KLASS student consoles are:

1. SSME
2. ECLSS
3. ET
4. OBS
5. Weather

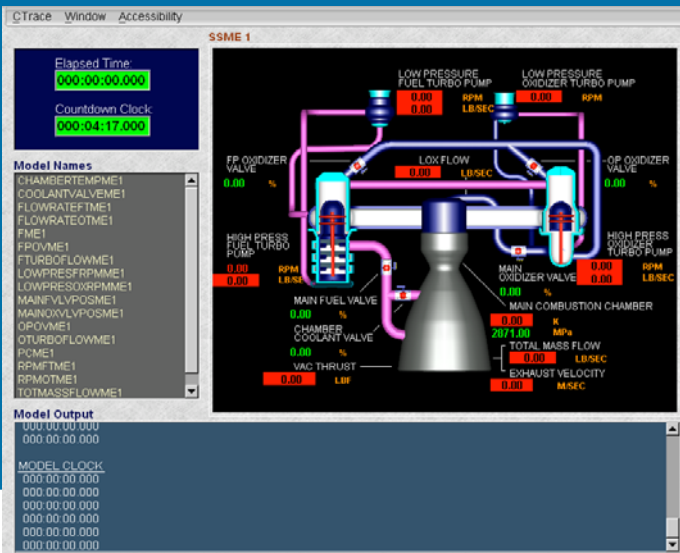


PHOTO CREDIT: NASA

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SPACE SHUTTLE MAIN ENGINE (SSME)

The SSME console monitors power output and propellant flow within the main engine. There are three SSME consoles, one for each of the Shuttle's main engines. From each of these consoles, a Shuttle engineer can adjust fuel and oxidizer valves in order to produce the required amount of thrust for the Shuttle.

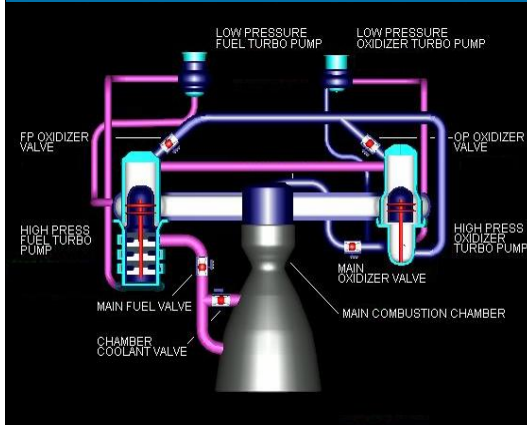


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MAIN ENGINE: OXIDIZER

Oxidizer from the external tank enters the orbiter's main propulsion system liquid oxygen feed line. Here it branches out into three parallel paths, one to each engine. In each branch, a liquid oxygen prevalue must be opened to permit flow to the low-pressure oxidizer.

The Low Pressure Oxidizer Turbopump (LPOT) is an axial-flow pump driven by a six-stage turbine powered by liquid oxygen. It boosts the liquid oxygen's pressure from 100 to 422 psia (pounds per square inch (actual)). The flow from the LPOT is supplied to the High-Pressure Oxidizer Turbopump (HPOT). During engine operation, the pressure boost permits the High Pressure Oxidizer Turbine to operate at high speeds without cavitating. The LPOT operates at approximately 5,150 rpm. The HPOT consists of two single-stage centrifugal pumps (a main pump and a preburner pump) mounted on a common shaft and driven by a two-stage, hot-gas turbine. The main pump boosts the liquid oxygen's pressure from 422 to 4,300 psia while operating at approximately 28,120 rpm. The HPOT discharge flow splits into several paths, one of which is routed to drive the



LPOT turbine.

Another path is routed to and through the main oxidizer valve and enters into the main combustion chamber. Another small flow path is tapped off and sent to the oxidizer heat exchanger. The liquid oxygen flows through an anti-flood valve that prevents it from entering the heat exchanger until sufficient heat is present to convert the liquid oxygen to gas. The heat exchanger utilizes the heat contained in the discharge gases from the HPOT turbine to convert the liquid oxygen to gas. The gas is sent to a manifold and is then routed to the external tank to pressurize the liquid oxygen tank. Another path enters the HPOT second-stage preburner pump to boost the liquid oxygen's pressure from 4,300 psia to 7,420 psia. It passes through the oxidizer preburner oxidizer valve into the oxidizer preburner and through the fuel preburner oxidizer valve into the fuel preburner.

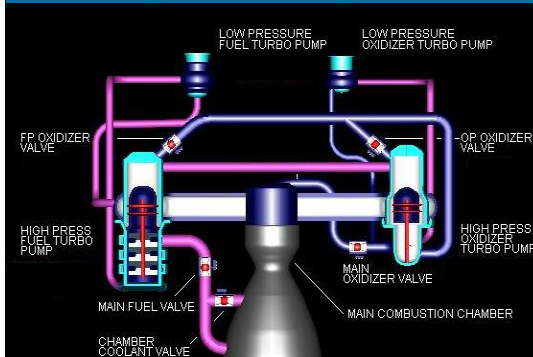
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MAIN ENGINE: FUEL

Fuel enters the orbiter at the liquid hydrogen feed line disconnect valve, then flows into the orbiter's gaseous hydrogen feed line manifold. Here the feed line branches out into three parallel paths to each engine. In each liquid hydrogen branch, a prevalve permits liquid hydrogen to flow to the low-pressure fuel turbopump when the prevalve is open.

The Low Pressure Fuel Turbopump (LPFT) is an axial-flow pump driven by a two-stage turbine powered by gaseous hydrogen. It boosts the pressure of the liquid hydrogen from 30 to 276 psia and supplies it to the High-Pressure Fuel Turbopump (HPFT). During engine operation, the pressure boost provided by the LPFT permits the HPFT to operate at high speeds without cavitating. The LPFT operates at approximately 16,185 rpm.

The HPFT is a three-stage centrifugal pump driven by a two-stage, hot-gas turbine. It boosts the pressure of the liquid hydrogen from 276 to 6,515 psia. The HPFT operates at approximately 35,360 rpm. The discharge flow from the turbopump



is routed to and through the main valve and then splits into three flow paths. One path is through the jacket of the main combustion chamber, where the hydrogen is used to cool the chamber walls. It is then routed from the main combustion chamber to the LPFT, where it is used to drive the LPFT turbine. A small portion of the flow from the LPFT is then directed to a common manifold from all three engines to form a single path to the external tank to maintain liquid hydrogen tank pressurization. The remaining hydrogen passes between the inner and outer walls to cool the hot-gas manifold and is discharged into the main combustion chamber. The second hydrogen flow path from the main fuel valve is through the engine nozzle (to cool the nozzle). It then joins the third flow path from the chamber coolant valve. The combined flow is then directed to the fuel and oxidizer preburners.

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MAIN ENGINE: PRODUCING THRUST

The fuel and oxidizer enter the preburners and are mixed so that efficient combustion can occur. The augmented spark igniter is a small combustion chamber located in the center of the injector of each preburner. The two dual-redundant spark igniters, which are activated by the engine controller, are used during the engine start sequence to initiate combustion in each preburner. They are turned off after approximately three seconds because the combustion process is then self-sustaining. The preburners produce the fuel-rich hot gas that passes through the turbines to generate the power to operate the high-pressure turbopumps. The oxidizer preburner's outflow drives a turbine that is connected to the HPOT and the oxidizer preburner pump. The fuel preburner's outflow drives a turbine that is connected to the HPFT.

The HPOT turbine and HPOT pumps are mounted on a common shaft. Mixing of the fuel-rich hot gas in the turbine section and the liquid oxygen in the main pump could create a hazard. To prevent this, the two sections are separated by a cavity that is continuously purged by the MPS (Main Propulsion System) engine helium supply during engine operation. Two seals minimize leakage into the cavity. Loss of helium pressure in this cavity results in an automatic engine shutdown.

The speed of the HPOT and HPFT turbines depends on the position of the corresponding oxidizer and fuel preburner oxidizer valves. These valves are positioned by the engine controller, which uses them to throttle the flow of liquid oxygen to the preburners and, thus, control engine thrust. The oxidizer and fuel preburner oxidizer valves increase or decrease the liquid oxygen flow. This then causes increasing or decreasing preburner chamber pressure, HPOT and HPFT turbine speed, and liquid oxygen and gaseous hydrogen flow into the main combustion chamber. When this happens, it increases or decreases engine thrust, thus throttling the engine. The oxidizer and fuel preburner valves operate together to throttle the engine and maintain a constant 6:1 propellant mixture ratio. The main oxidizer valve and the main fuel valve control the flow of liquid oxygen and liquid hydrogen into the engine and are controlled by each engine controller. When an engine is operating, the main valves are fully open.

Each engine main combustion chamber receives fuel-rich hot gas from a hot-gas manifold cooling circuit. The gaseous hydrogen and liquid oxygen enter the chamber at the injector, which mixes the propellants. A small augmented spark igniter chamber is located in the center of the injector. The dual-redundant igniter is used during the engine start sequence to initiate combustion. The igniters are turned off after approximately three seconds because the combustion process is self-sustaining.

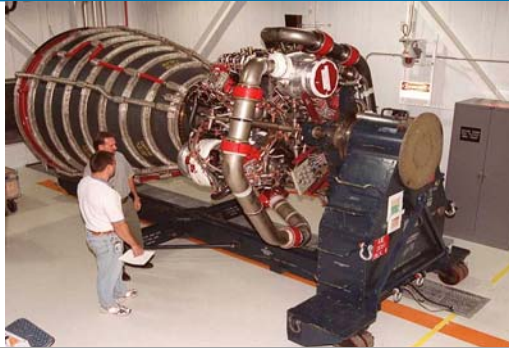
A blue button with the word "Next" in white text, surrounded by a grey, metallic-looking border with small circular details.

MAIN ENGINE: ADDITIONAL INFORMATION

The inner surface of each combustion chamber, as well as the inner surface of each nozzle, is cooled by gaseous hydrogen flowing through coolant passages. The nozzle assembly is a bell-shaped extension bolted to the main combustion chamber. The nozzle is 113 inches (2.9 m) long, and the outside diameter of the exit is 94 inches (2.4 m). Thermal protection for the nozzles is necessary at the nozzle/engine attach point because of the exposure that portions of the nozzles experience during the launch, ascent, on-orbit and entry phases of a mission. The insulation consists of four layers of metallic batting covered with a metallic foil and screening (part of the orbiter's heat shield).

The five propellant valves on each engine (oxidizer preburner oxidizer, fuel preburner oxidizer, main oxidizer, main fuel, and chamber coolant) are hydraulically actuated and controlled by electrical signals from the engine controller. They can be fully closed by using the MPS engine helium supply system as a backup actuation system. The main oxidizer valve and fuel bleed valve are used after shutdown off the SSMEs approximately eight and a half minutes after liftoff.

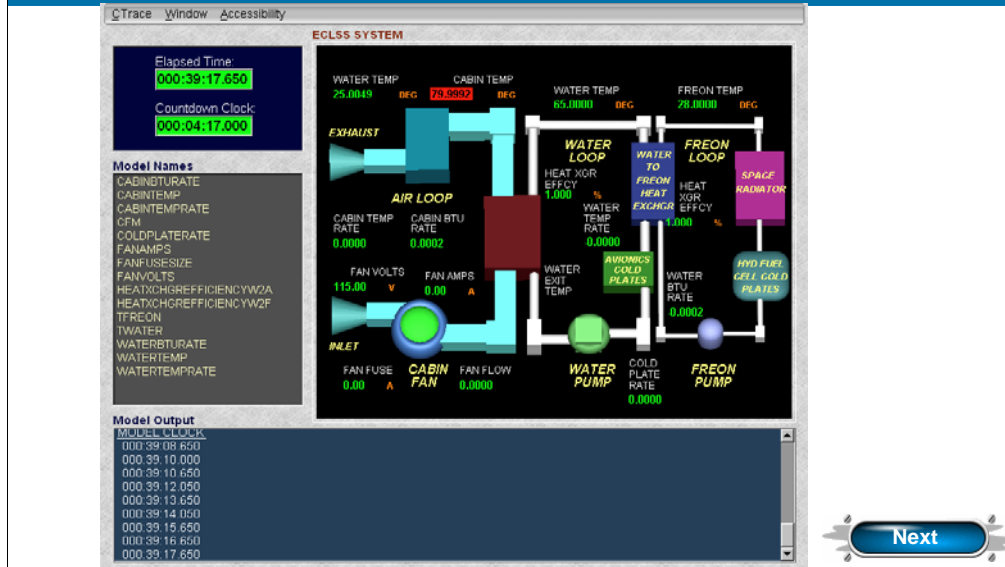
The main oxidizer valve is opened during a propellant dump to allow residual liquid oxygen to be dumped overboard through the engine, and the fuel bleed valve is opened to allow residual liquid hydrogen to be dumped through the liquid hydrogen fill and drain valves overboard. After the dump is completed, the valves close and remain closed for the remainder of the mission.



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ECLSS

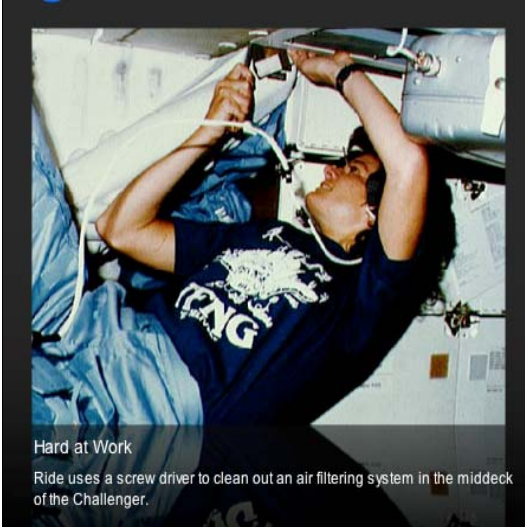
The ECLSS team is responsible for maintaining a comfortable environment for the astronauts while they are out of their space suits and in the Orbiter's cabin. The graphic below display shows the part of the ECLSS responsible for maintaining a comfortable air temperature.



ECLSS

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The environmental control and life support system (ECLSS) provides a pressurized and livable environment for the orbiter's crew. This environment is not only important for the crew, but it is essential to the protection and proper functioning of the onboard avionics. An additional function of the ECLSS is the management, storage, and disposal of water and crew waste. Below and to the left is a diagram of the orbiter and the individual parts that make up the ECLSS.



Hard at Work

Ride uses a screw driver to clean out an air filtering system in the middeck of the Challenger.

ECLSS: Four Main Sub-Systems

1. **Pressure Control System:** maintains a pressure of 14.7 psia of a breathable mixture of oxygen and nitrogen in the crew compartment. Nitrogen also is used to pressurize wastewater tanks.
2. **Atmospheric Revitalization System:** uses circulated air and water coolant loops to remove heat, control humidity, and purify the air in the cabin.
3. **Active Thermal Control System:** uses two Freon loops to collect heat from the orbiter's waste systems and transfer it overboard.
4. **Supply & Wastewater System:** stores water that is produced by the fuel cells for use by the orbiter crew (drinking, cooking, hygiene). It also stores liquid waste produced by the crew, as well as wastewater collected from the humidity separator. It has the ability to dump both supply and wastewater overboard.

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Environmental Control and Life Support Systems--better known by its acronym ECLSS (pronounced "EE-cliss").

ECLSS: Four Main Sub-Systems

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EXTERNAL TANK (ET)

The External Tank console monitors the flow of liquid oxygen and liquid hydrogen to the main engines.

The screenshot displays the EXTERNAL TANK console interface. At the top, it shows system status: GOX RETR OFF, ARM Deg 90, CAP Deg 0, EXTD ON, RETR OFF, GOX RELF OFF, and 295.0 psi. The main display area features a central diagram of a rocket with the External Tank highlighted in green. Surrounding the diagram are several data panels:

- LO2 DEPLETION SENSORS:** SENSOR 1 ON, SENSOR 2 ON, SENSOR 3 ON, SENSOR 4 ON.
- LO2 LEVEL:** 1359135.30 LBS.
- LO2 FLOW:** 2555.24 LB/SEC.
- LO2 DEPLETED:** OFF.
- LH2 LEVEL:** 226235.70 LBS.
- LH2 FLOW:** 470.91 LB/SEC.
- LH2 DEPLETED:** OFF.
- TOTAL MASS FLOW:** ME1 738.48 LB/SEC, ME2 1079.00 LB/SEC, ME3 1007.34 LB/SEC.
- LO2 TURBO FLOW:** ME1 693.60 LB/SEC, ME2 929.38 LB/SEC, ME3 932.22 LB/SEC.
- LH2 TURBO FLOW:** ME1 118.79 LB/SEC, ME2 155.49 LB/SEC, ME3 154.94 LB/SEC.
- LH2 DEPLETION SENSORS:** SENSOR 1 ON, SENSOR 2 ON, SENSOR 3 ON, SENSOR 4 ON.

On the left side, there is a 'Model Names' list with various fuel and oxidizer flow and depletion sensors. Below that is a 'Model Output' section showing a list of timestamps from 008:20:07.050 to 008:20:15.050.

A 'Next' button is located at the bottom right of the console interface.

EXTERNAL TANK (ET)

The external tank (ET) is the largest of the three main parts of the shuttle system (ET, SRBs, orbiter). When fully loaded, it becomes the heaviest element of the shuttle as well, going from 66,000 pounds to 1,655,600 pounds.

The ET's liquid hydrogen (fuel) and liquid oxygen (oxidizer) supplies the three Space Shuttle main engines (SSMEs), located in the orbiter, during launch and ascent into space. Fuel from the ET begins to be consumed 6 seconds prior to launch of the Shuttle as the main engines power up to 90 percent. The ET continues to supply fuel to the SSMEs until all of the liquid fuel is consumed and the shuttle approaches its orbit, the ET is jettisoned off. As it passes back through the atmosphere, it begins to disintegrate. Any parts not completely destroyed falls into the remote parts of the ocean and are never recovered or reused.



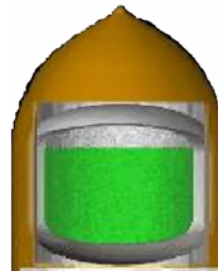
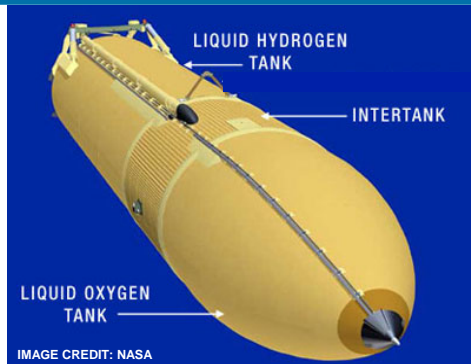
Three important components of the ET are the

1. oxygen tank
2. the intertank
3. hydrogen tank

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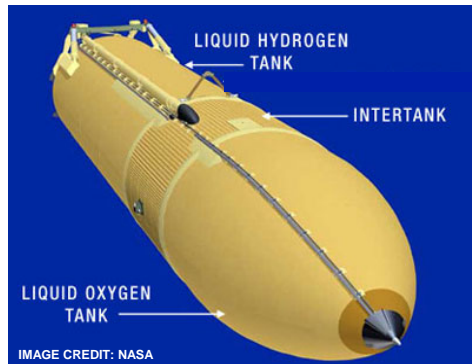
OXYGEN TANK

The liquid oxygen tank is made out of aluminum monocoque and operates in a pressure range of 20 to 22 psig (pressure per square inch-gauge). The tank contains anti-slosh and anti-vortex structures to reduce fluid motion during launch and ascent into space. The tank feeds into a 17-inch diameter line that transports the liquid oxygen through the intertank, then outside the ET to the SSMEs. The 17-inch-diameter feed line allows liquid oxygen to flow at approximately 2,787 pounds per second with the SSMEs operating at 104 percent (that is equal to a maximum flow of 17,592 gallons per minute). The liquid oxygen tank's double-wedge nose cone reduces drag and heating, contains the vehicle's ascent air data system, and serves as a lightning rod. The liquid oxygen tank's volume is 19,563 cubic feet (143,351 gallons) and is 331 inches in diameter, 592 inches long, and weighs 12,000 pounds empty (1,361,936 pounds full).



INTERTANK

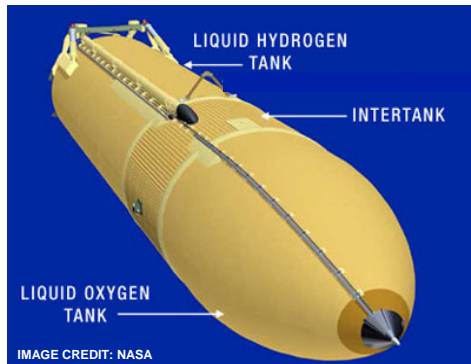
The unpressurized intertank is a steel and aluminum semimonocoque cylindrical structure that is joined on either end to the liquid oxygen and liquid hydrogen tanks. The intertank houses ET instrumentation components and contains an umbilical plate that allows for the detection (especially of hazardous gases) and release of excess gas supplies (mainly boiled of hydrogen). The intertank is 270 inches long, 331 inches in diameter and weighs 12,100 pounds.



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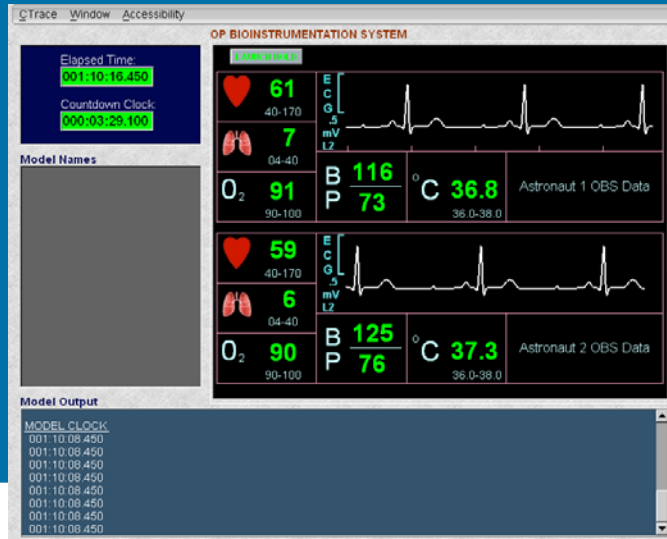
LIQUID HYDROGEN TANK

The liquid hydrogen tank is an aluminum semimonocoque structure with an operating pressure range of 32 to 34 psia (pounds per square inch-absolute). The tank contains an anti-vortex baffle and siphon outlet to transport the liquid hydrogen from the tank through a 17-inch line. The liquid hydrogen feed line flow rate is 465 pounds per second with the SSMEs at 104 percent (has a maximum flow of 47,365 gallons per minute). The liquid hydrogen tank is 331 inches in diameter, 1,160 inches long, and has a volume of 53,518 cubic feet (385,265 gallons). It has a dry weight of 29,000 pounds (227,641 pounds full).



OBS CONSOLE

The OBS console displays an electrocardiograph of two designated flight crewmembers. It also shows these astronauts' pulse, respiration, oxygen level, blood pressure, and temperature.



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WEATHER CONSOLE

The KLASS Weather Display console is a simplified version of the Kennedy Space Center's Meteorological Interactive Data Display System known as MIDDs. MIDDs integrates diverse weather data on a single display, including weather radar and lightning strikes. This data helps forecasters determine if weather and lightning avoidance criteria are met.

