

NASA Summary

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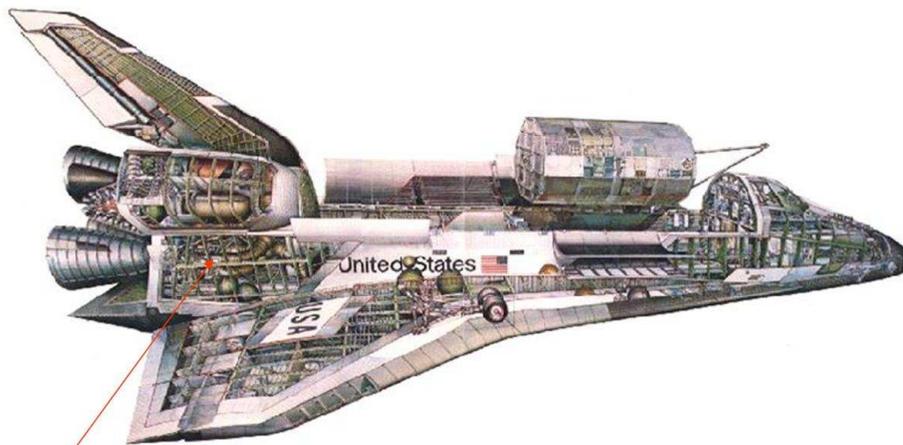
SUMMARY SHEET

February 2009

Gaseous Hydrogen Flow Control Valves

Gaseous Hydrogen (GH2) flow control valves are part of the main propulsion system on the space shuttle. There are three valves within the system, one dedicated to each of the shuttles main engines. The valve's function is to regulate the flow of gaseous hydrogen from the main engines to the external fuel tank so the tank will maintain structural integrity and deliver liquid hydrogen to the engines at the correct pressure. The GH2 flow control valve has two flow positions, high and low. During ascent, the valve moves between the two positions about 15 times.

During ascent, the external fuel tank supplies the main engines with liquid oxygen and hydrogen propellants. As the engines consume propellant, the liquid level within each tank drops and causes an empty space above the liquid. To fill the void within the liquid hydrogen (LH2) tank, the engines turn LH2 into gaseous hydrogen and return this gas to the external tank. The role of the GH2 flow control valves is to regulate the amount of gaseous hydrogen that is returned to the tank.



GH2 Flow Control Valve Location



For the shuttle engines to run correctly and for the hydrogen tank to maintain structural integrity, the LH2 tank pressure is regulated to 33 psi. For single flow control valve failures, the other two valves can compensate by moving to either the high or low flow position as required. In some cases, the other valves can not compensate and the tank pressure can reach 35 psi. In this event, a vent valve on the tank can open to relieve the pressure.

GH2 Flow Control Valve Poppet Failure

During space shuttle Endeavour's STS-126 mission in November 2008, flight controllers identified that GH2 was flowing from one of the shuttle's engines at a higher than normal rate. To compensate, the other two gaseous hydrogen flow control valves reduced the amount of their flow and there were no issues during launch. After landing, the main propulsion system was inspected and engineers discovered the GH2 flow control valve poppet on the suspect line was cracked and a small piece was missing. The poppet on the valve acts like a pop-up on a sprinkler to let the GH2 flow.

The damaged valve was removed from Endeavour and shipped to the vendor (Vacco) for disassembly. It was then sent to the Boeing Co. in Huntington Beach, Calif., where engineers determined that the crack was caused by fatigue. The concerns are whether a failed poppet or poppets could cause:

- 1) a rupture in the gaseous hydrogen line, resulting in loss of pressure to the external tank's hydrogen tank. This could result in a main engine shutdown.
- 2) an over pressurization of the hydrogen tank, forcing open a vent line that could expel hydrogen into an oxygen-filled area.

During shuttle Discovery's STS-119 Flight Readiness Review on Feb. 3, 2009, managers determined that more data was needed on the flow control valve issue before proceeding to launch.

Since finding the failure, an expert team of engineers has been assembled to understand what caused the fatigue. As part of the investigation, the flow control valves from all three shuttles and three flight spares were subjected to a rigorous inspection. The results of these inspections are still being evaluated. The team also is working to understand the risk imposed to the shuttle in the event another poppet breaks and a piece comes off. Impact testing was conducted at multiple NASA centers including Glenn Research Center, Cleveland; Stennis Space Center, Miss.;

and White Sands Test Facility, Las Cruces, N.M. Additionally, engineers at Marshall Space Flight Center, Huntsville, Ala., are constructing computer models in order to better understand the conditions that would result in a fatigue failure.

