SSV Launch Monitoring Strategies: HGDS Design Implementation through System Maturity

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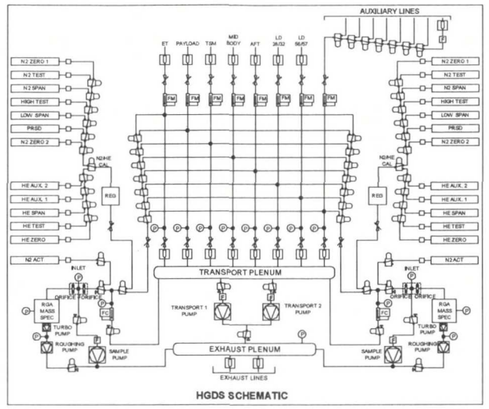
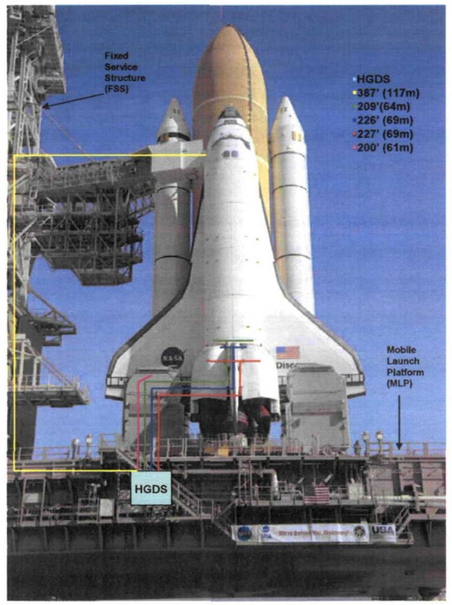


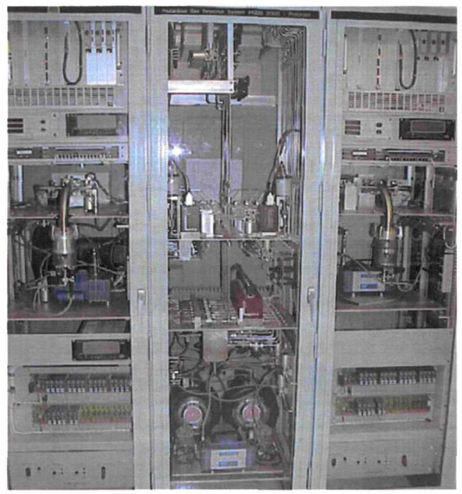
HGDS SCHEMATIC

The Hazardous Gas Detection System (HGDS) is comprised of three different subsystems, a sample delivery system (SDS) and two redundant *mass spectrometer systems (System A and System B). The HGDS monitors* the Orbiter Aft, Orbiter Midbody, Orbiter Payload Bay, External Tank Intertank, and Liquid Hydrogen Tail Service Mast for Hydrogen and Oxygen leaks during ET Cryogenic Fuel Load through Launch. Additionally, each system (A and B) has seven nitrogen cylinders used for calibrations.



The transit times for a sample from each area are as follows:

- **External Tank Intertank (Yellow) - ~50 seconds.**
- **Orbiter Aft (Red) - Typically ~13 seconds.**
- **Orbiter Midbody (Green) - Typically ~15 seconds.**
- **Orbiter Payload Bay (Blue) - Typically ~15 seconds.**
- **Requirements for the orbiter sample lines are less than 30 seconds.**



2001 – Original Hazardous Gas Detection System configuration.

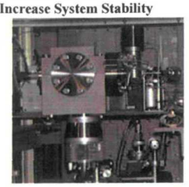
The HGDS has been through several modifications since the original prototyping and installation.

- **Inlet and High Vacuum Chamber Modification**
- **Turbo Backing Pump Modification**
- **Several Software Upgrades**
- **NIST Certified Calibration Bottles**
- **Sample and Transport Pump Modification**
- **Turbo Pump Upgrade**
- **Exhaust Modification**
- **Launch Commit Criteria Revisions**
- **Validation/Operating Procedures Revisions**

2010 – Current Hazardous Gas Detection System configuration.

Inlet and High Vacuum Chamber Modification to Reduce Oxygen Drift and Increase System Stability

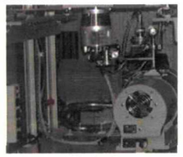
Original Inlet and High Vacuum Chamber



Current Inlet and High Vacuum Chamber - Installed 2004

Turbo Pump and Turbo Backing Pump Modifications to Increase Efficiency, Decrease Maintenance Efforts, and Address Obsolescence Issues

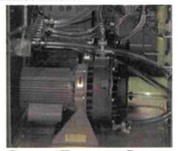
Original Turbo Pump and Turbo Backing Pump



Current Turbo Pump and Turbo Backing Pump – Modified 2003; Upgraded 2009

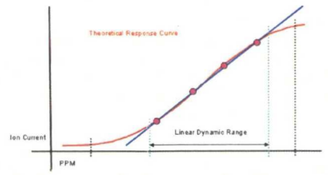
Sample and Transport Pump and Exhaust Modifications to Address Debris Issues, Increase Efficiency, and Decrease Maintenance Efforts

Original Transport Pumps



Current Transport Pumps - Installed 2008

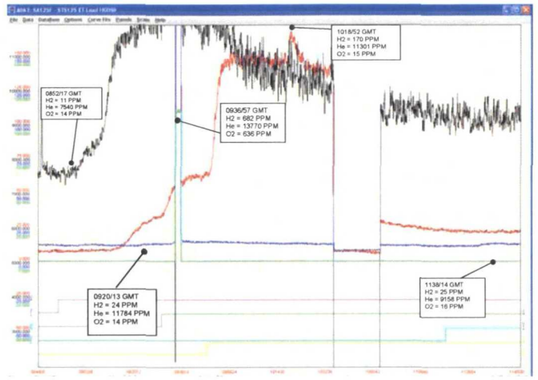
Launch Commit Criteria Revisions and Validation/Operating Procedures Revisions to Improve System Confidence and System Accuracy in the Range of Interest



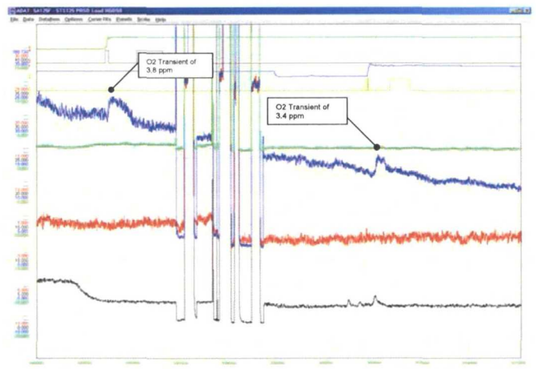
Linear Dynamic Range. *Using the system in multiplier mode and focusing on the bottom part of the linear dynamic range with NIST certified calibration cylinders has significantly improved the limit of detection and the resolution of the HGDS.*

$$LOD = (3 * TC) * \left| \frac{TSTD}{TA - LA} \right| \quad (1)$$

TC = Certified Concentration of 'Test' Calibration Gas
TSTD = Measured Standard Deviation of Minimum of 30 Data Points on 'Test' Calibration Gas
TA = Measured Average of Minimum of 30 Data Points on 'Test' Calibration Gas
LA = Measured Average of Minimum of 30 Data Points on 'Low' Calibration Gas



Dynamics in the Orbiter Aft During External Tank Loading. *(a) The blue line represents oxygen, Red represents Hydrogen, Green represents Argon, and black represents Helium as read by the HGDSB plotted with ppm on the y-axis vs. time on the x-axis. Other significant ET load events are plotted as well. (b) The plot shows the various levels of the different gas species present in the orbiter aft during ET load. (c) With HGDSA still monitoring, HGDSB had to perform a test gas check to verify the accuracy of the readings, causing an interruption in monitoring on the aft for system B as seen at 0936 GMT reading.*



Transient Leaks Observed on HGDS During PRSD Load. *(a) The blue line represents oxygen as read by the HGDS plotted with ppm on the y-axis vs. time on the x-axis. Red represents Hydrogen, Green represents Argon, and black represents Helium. (b) The following was calculated for the system H2 Resolution = 2.10 PPM and O2 Resolution = 0.90 PPM.(c) With the low LOD and resolution of the HGDS, the system was able to distinguish a 3.8 ppm and 3.4 ppm transient oxygen leak during load.*