The NPDGamma Liquid Hydrogen Target Failure Mode Testing in MPF-35

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The March 9, 2006 Readiness Review of the NPDGamma test setup at MPF-35 requested the collaboration to create a plan for failure mode testing of the LH2 Target system at MPF-35.

After consulting the NPDGamma Failure Analysis Table, we concluded that the major failures of the target system can be listed as;

1. *Rupture of the LH2 vessel*
2. *Rupture of the LH2 vessel and vacuum jacket*
3. *Lost of the isolation vacuum*
4. *Lost of electrical power*
5. *Lost of heater in the cryo cooler head*
6. *Operator error*

Rupture of the LH2 vessel
will lead to high pressures in the LH2 vessel and in vacuum. The relief system and lines are sized for this event. A direct test of this failure mode is not possible with a simple experiment.

Rupture of the LH2 vessel and consequently vacuum jacket
will cause the hydrogen to enter the room and cause serious consequences. By design and engineering the probability of this failure is very very small. We do not want to test this failure mode directly.

Lost of the isolation vacuum
will lead to fast boil off of the liquid hydrogen in the LH2 vessel. The relief system is sized for this event. Testing of this failure mode is easy and we are going to do it at MPF-35. We will spoil the vacuum by dumping helium/argon mixture to the vacuum. This fast spoil of the vacuum has been built into the system for emergencies.
The proposed test is described as a Step in the IWD # 0003501 "Functionality testing of the NPDGamma Liquid Hydrogen Target". The test will verify the calculations used to size the relief system and vent stack. This is an opportunity to study the reliability of the engineering calculations.
The Reviewers stated: "*Functional testing in MPF-35 is the only opportunity to test and time the emergency venting of the hydrogen target due to loss of vacuum before the target installed is installed in ER2. The committee felt it was advisable to conduct this test prior to target installation in ER2. Action: P-23/NPDG Team – Add this to planned testing and ensure it is covered in the IWD.*"
The collaboration fully agrees with this recommendation.

Lost of electrical power
will stop the two cryo coolers and the target starts slowly to warm up. The relief system will easily handle the vaporizing hydrogen gas. This failure mode is easy to test, we need only to stop the cryo coolers and record evolution of the hydrogen pressure. We will perform this test. This failure mode has been already tested with neon gas.

Lost of heating in the cryo cooler head
will lead to cool down of the target and sub atmospheric hydrogen pressure in the target which in present of a leak will condense air to the target. This will be tested by turning off the two heaters one by one and record the hydrogen pressure.

Operator error
several of them, have been taken place during the previous cryogenic tests of the system without hydrogen. These errors will be minimized by the use of the operating procedures. Two-person rule will also minimize operator errors.