



**STS-114 ET Vent Arm Umbilical Purge Shroud IFA Closure
Rationale, STS-114-I-014
&
Update ISPR-02
“ET Vent Arm System (ETVAS) Umbilical System
Malfunction”**

**CR# S050425DG
SICB**

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ETVAS Purge Shroud IFA Resolution Team



- **Jim Draus NASA / KSC Integration Office**
- **Mike Hartnett NASA / PH-Integration**
- **Fred Lockhart Lockheed Martin / External Tank Engineering**
- **Gary Hopkins USA / Ground Systems Design Engineering**
- **Andrew Knutson USA / Element Integration**
- **Nick DiBiase Boeing / Ground Systems Integration**

Background

- Excessive frost/ice at the GUCP to ice suppression shroud interface was noticed during tanking test #2 (reference IPR 114V-0361).
- During the STS-114 launch attempt on July 13, 2005, cryogenic liquid was seen flowing from the bottom of the GUCP ice suppression shroud starting at LH2 replenish when the LH2 vent QD is the coldest
- Ice was observed on the bottom of the shroud at the seam between the purge can halves
- During the STS-114 launch on July 26, 2005, the same problem was noted (reference IPR 114V-0472).
- IFA STS-114-I-014, LN2 DRIPPED FROM ET VENT LINE ICE SUPPRESSION SHROUD, assigned to KSC Integration (MK-SIO)
- LN2 liquefaction did not cause anomalies to SSV elements.
- Lien placed against ISPR-02 for LN2 Liquefaction

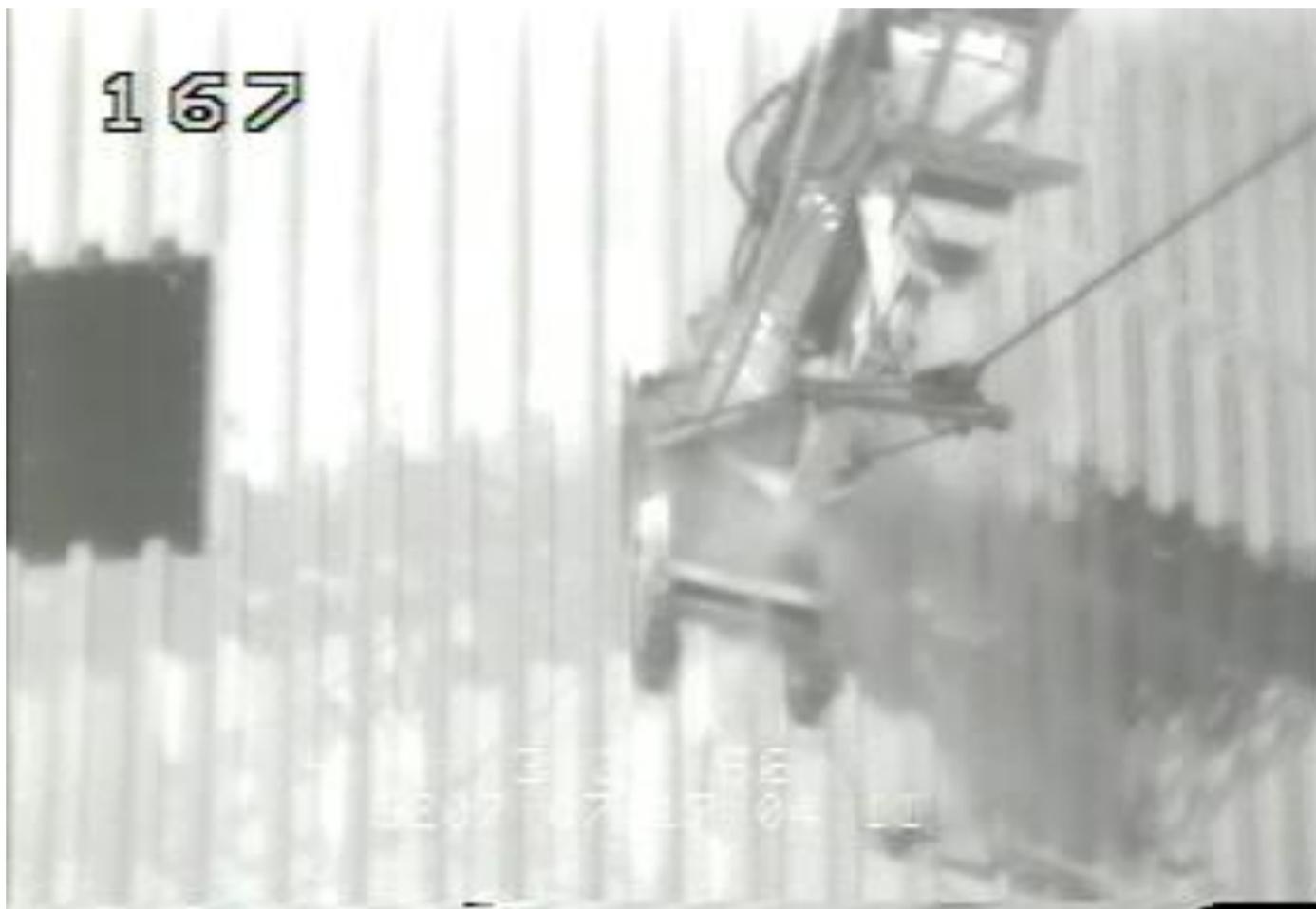
- LN2 Dripping onto SSV TPS, EB-3 and EB-7 attach points

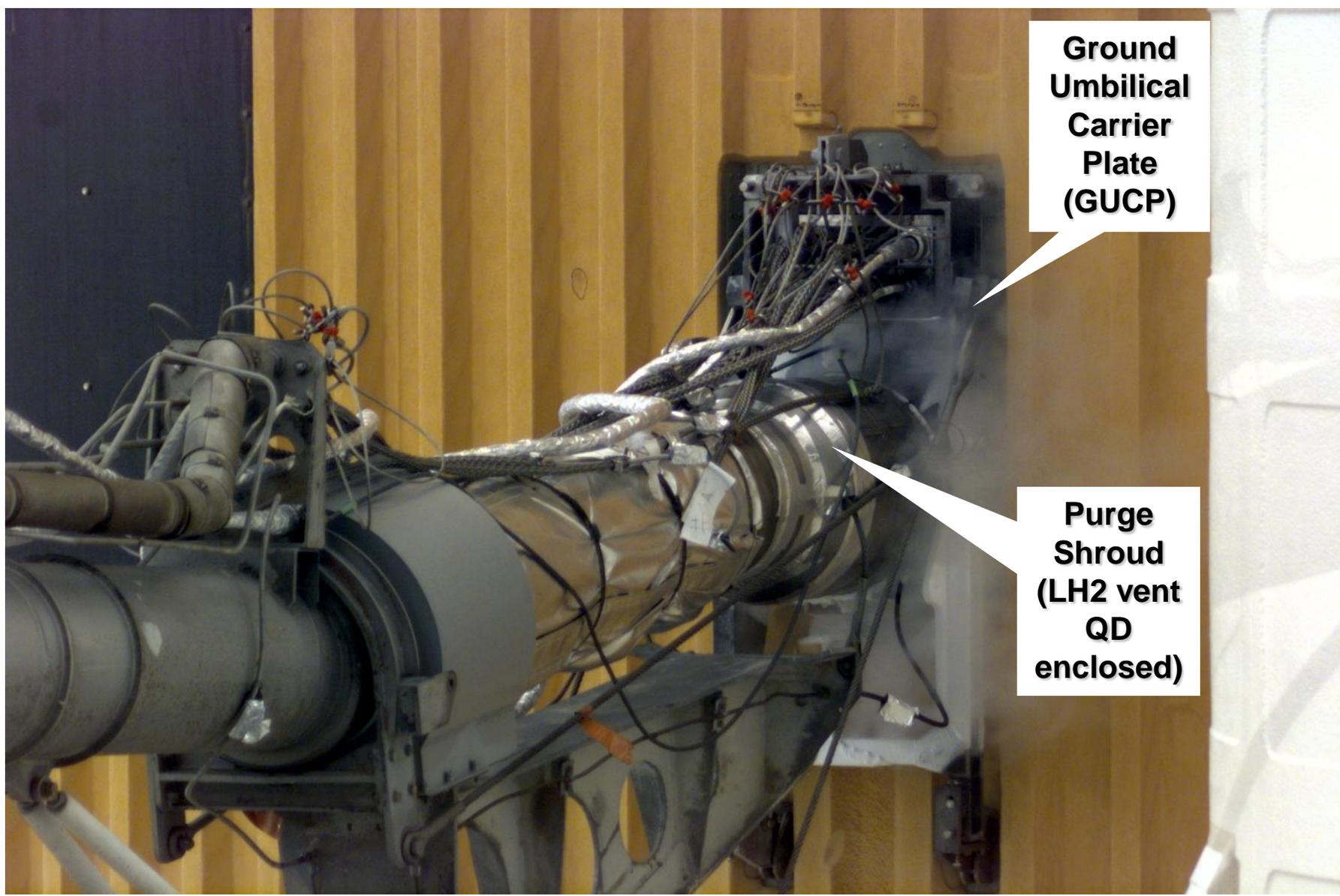
Source of LN2

EB-3, EB-7 attach points



Problem Description – LN2 formation video





Ground Umbilical Carrier Plate (GUCP)

Purge Shroud (LH2 vent QD enclosed)

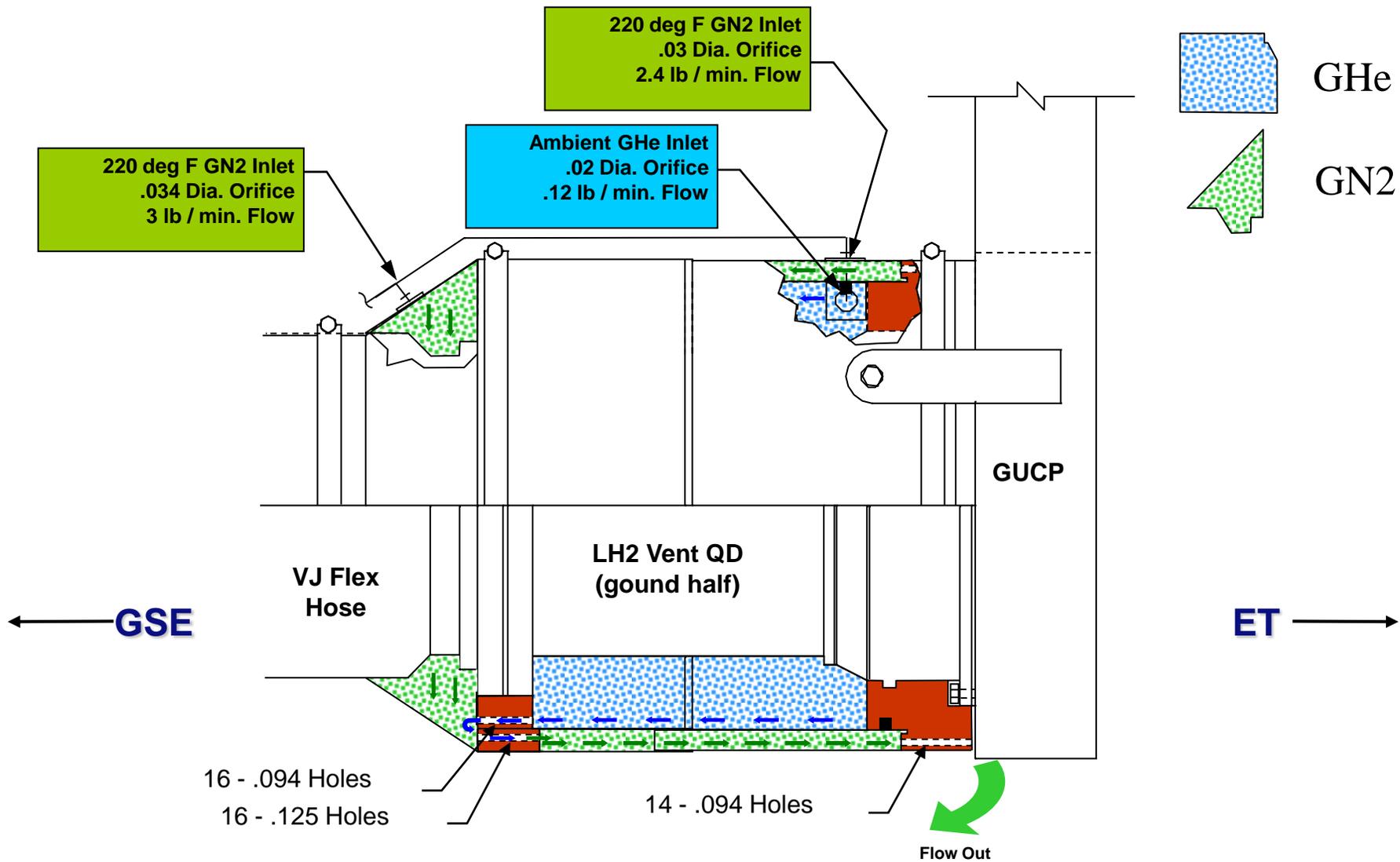
Purge Shroud Function

- The LH2 Vent QD is not insulated and will produce ice
- Prior to STS-26R the LH2 vent QD was wrapped in insulation and was prone to icing
- For STS-26R a purge shroud was developed to mitigate the ice formation using an enclosed purge system

Old Purge Shroud Operation

- (reference figure next page)
- GHe enters the shroud into the space between the inner shroud wall and the LH2 Vent QD.
- Heated GN2 enters a cavity that is created by the shroud inner and outer wall.
- The GHe migrates towards the back of the shroud into the aft cone section mixing with the GN2 to be heated
- Both gases migrate along the lower outer wall toward the front of the shroud and exit through holes along the front surface up against the GUCP.

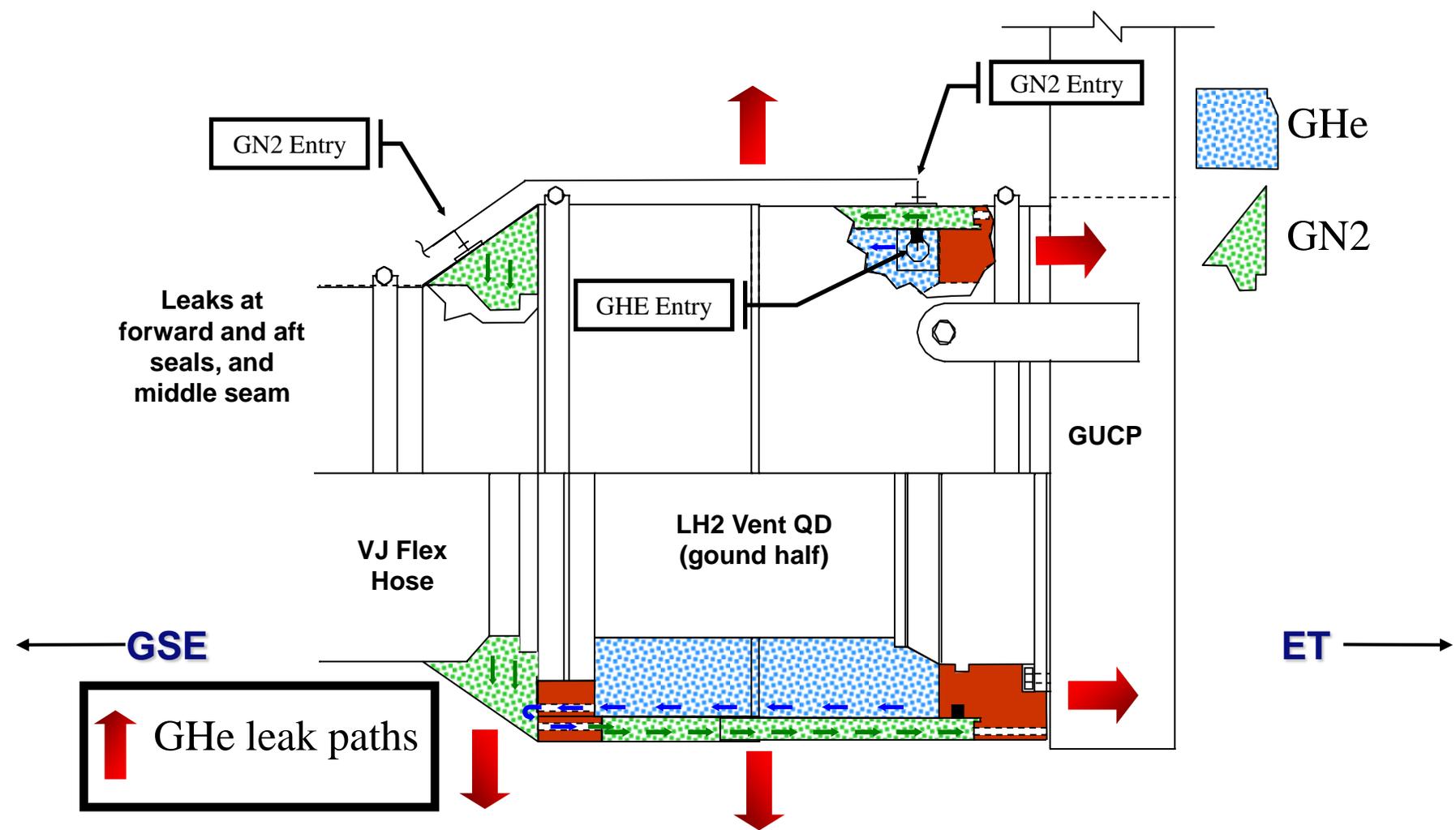
Old Purge Shroud Operation



Cause of LN2 formation

- (reference figure next page)
- Gap between the LH2 vent QD and the phenolic ring at the GUCP interface allowed venting of GHe
- GN2 intrusion into the inner cavity due to evacuating GHe
- The GN2 liquefy's due to contact with the LH2 Vent QD.

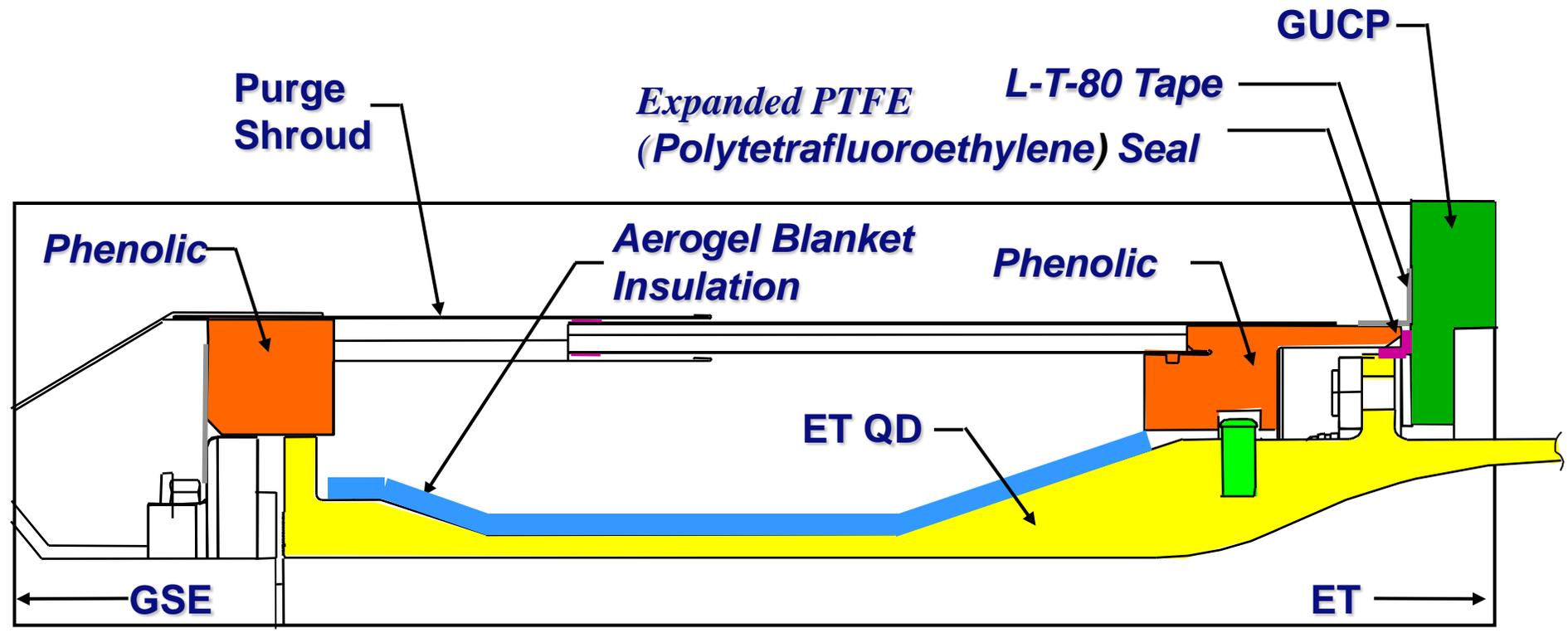
Cause of LN2 formation



GH2 Vent QD Shroud Cut-Away (suspected leak pattern)

Modification of GH2 Vent QD Purge Shroud

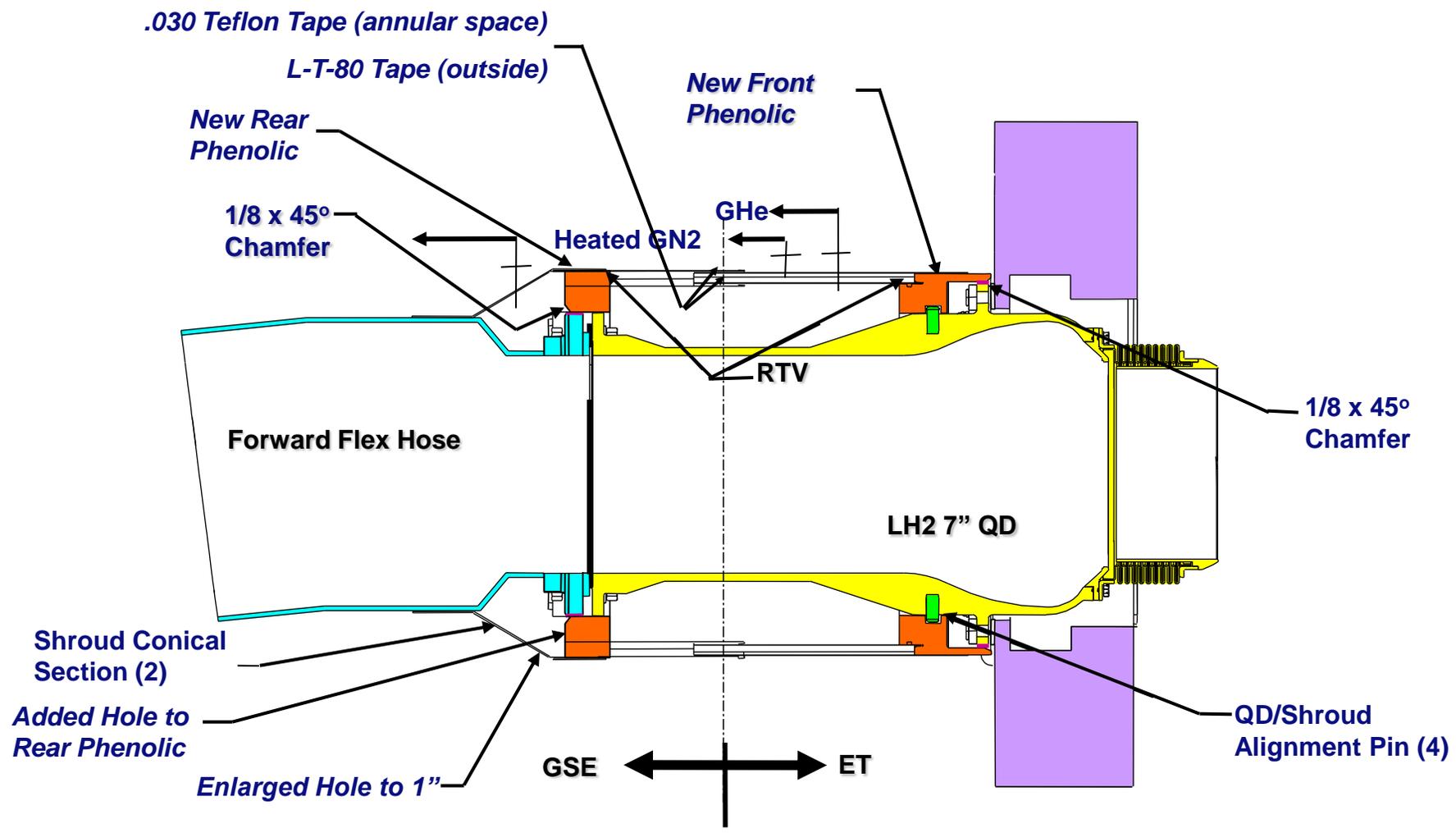
- Figure showing new components (*italics*)



GH2 Vent QD Shroud Cut-Away
(upper half detail)

Modification of GH2 Vent QD Purge Shroud

- Figure showing new components (*italics*)



GH2 Vent QD Shroud Cut-Away

- Qualification testing is complete and successful at the KSC Launch Equipment Test Facility using LH2.
 - No frost formation on the shroud
 - No LN2 formation produced during testing.

IFA STS-114-I-014 Closure Recommendation

- **SICB issue a directive to MP-71 to close PRACA STS-114-I-014 with the following rationale;**
 - **LN2 liquefaction did not cause anomalies to SSV elements.**
 - **Cause of problem is corrected through modification.**
 - **Qualification testing at LETF successful.**
 - **Shroud performance to be monitored during S0007**
 - **IRN, KO-2125, Change GH2 Vent Line Ice Suppression Shroud Configuration, will update ICD-2-0A002 with the new interface configuration.**



Update ISPR-02

“ET Vent Arm System (ETVAS) Umbilical System Malfunction”

CR# S050425DG

Revision based on IFA STS-114-I-14 “LN2 DRIPPED FROM ET VENT LINE ICE SUPPRESSION SHROUD”

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Objective

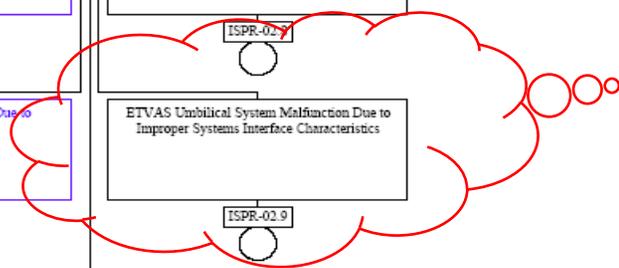
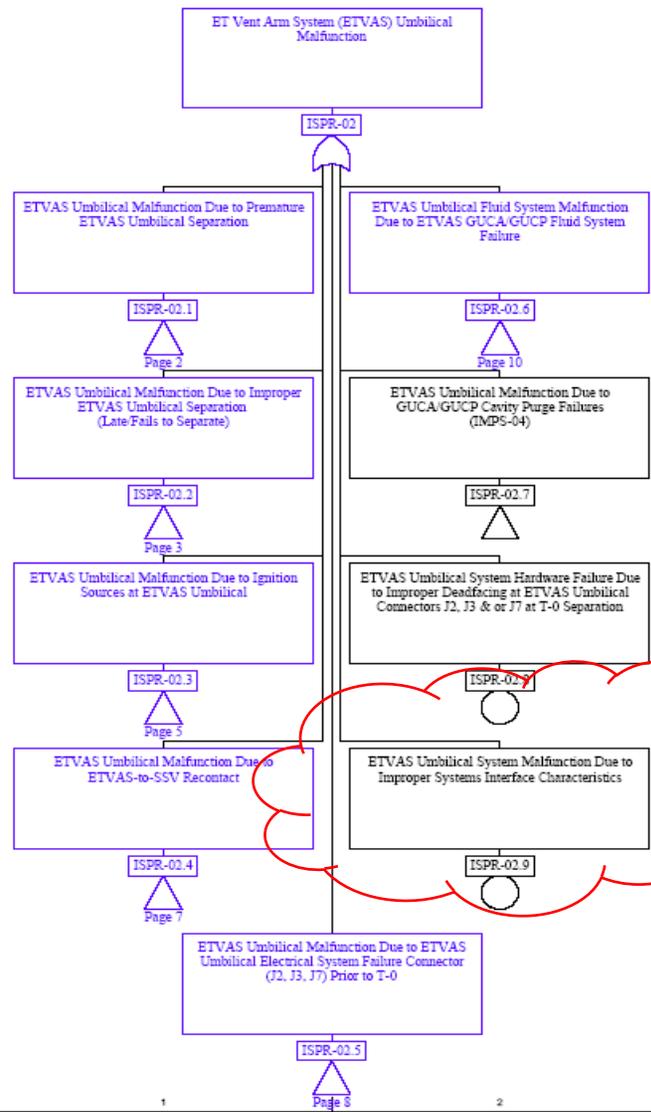
- Approve the update to ISPR-02 integrated hazard report (IHR) and fault tree based on STS-114-I-014 In-Flight Anomaly.
 - Add new fault tree block ISPR-02.9, “ETVAS Umbilical System Malfunction Due To Improper Systems Interface Characteristics”
 - Add cause “ETVAS Umbilical System Malfunction Due To Improper Systems Interface Characteristics”
 - ISPR-02-AQ and fault tree block ISPR-02.9
 - Adds controls and verifications for the purge shroud
 - Purge activation
 - Forward expanded PTFE seal, L-T-80 tape, phenolic ring, and Aerogel Blanket insulation at ice suppression shroud
 - Risk classification remains “controlled”

ISPR-02 IHR Update

- ISPR-02 update documents the controls and verifications which mitigate the following hazardous conditions
 - Ice formation that presents a potential debris hazard.
 - Hazardous concentrations of H₂ that present a fire/explosion hazard.
 - LN₂ formation and subsequent dripping from the purge shroud which could potentially causes damage to SSV structure, TPS, and electrical components during pre-launch cryogenic loading.
- During the STS-114 launch on July 26, 2005, cryogenic liquid was seen dripping from the bottom of the ET Vent Arm Ground Umbilical Carrier Plate (GUCP) ice suppression shroud.
 - Reference: IPR 114V-0472
- The program placed a lien against ISPR-02 with the action to investigate interface characteristics that control the LN₂ dripping.
 - Reference: IFA STS-114-I-14 “LN₂ DRIPPED FROM ET VENT LINE ICE SUPPRESSION SHROUD”

New Fault Tree block to IHR ISPR-02

- Add new fault tree block ISPR-02.9, “ETVAS Umbilical System Malfunction Due To Improper Systems Interface Characteristics”



ISPR-02.9



Recommend adding an Improper Systems Interface Characteristics Cause to IHR ISPR-02



- New Cause ISPR-02-AQ
 - ETVAS Umbilical System Malfunction Due To Improper Systems Interface Characteristics
 - Ground supplied Helium (GHe) and heated Nitrogen (GN2) is supplied to the GUCA ice suppression shroud. An off-nominal purge to the GUCA ice suppression shroud during pre-launch cryogenic loading may fail to prevent the formation of flammable concentrations of GH2 in the event of a leak or to preclude ice formation around the umbilical. Hazardous concentrations of H2 present a fire/explosion hazard. Ice formation presents a potential debris hazard. Any of these failures could result in loss of SSV and crew.
 - Failure of the forward expanded PTFE seal or phenolic ring can allow GHe to escape out of the shroud cavity allowing GN2 intrusion from the shroud outer annulus into the shroud cavity surrounding the ET Vent quick disconnect. The GN2 will liquefy due to temperatures being below the GN2 liquefaction temperature. The LN2 will exit the shroud through the leak path and potentially damage SSV structure, TPS, and electrical components.
 - Severity: Catastrophic
 - Likelihood: Improbable
 - Classification: Controlled

- New Cause ISPR-02-AQ has strong Controls and Verifications
 - See Redline IHR for Cause “ETVAS Umbilical Malfunction Due To Improper Systems Interface Characteristics” for details
 - Controls:
 - Ice Suppression Shroud Design and Operations
 - ICD documenting the configuration of the phenolic, Aerogel insulation, and expanded PTFE seal
 - Validation/Verification Test at LETF
 - NSTS 07700, Vol X requirements
 - System Assurance Analysis documented on operations
 - Element Hazard Report on purge shroud documenting that strong controls are in place
 - Verifications:
 - OMRSD to verify gas purity and purge operations for GHe and GN2 fluids
 - LCC to verify GN2 purge active to T-31 sec

- After review of ISPR-02 based IFA STS-114-I-14, the ISPR-02 risk classification remains “Controlled”.
- Change IHR to:
 - Update background to reflect IFA STS-114-I-14 resolution.
 - Add cause ISPR-02-AQ with controls and verification identified
 - Title: “ETVAS Umbilical System Malfunction Due To Improper Systems Interface Characteristics”
 - Update Risk Matrix from 13 to 14
 - Revise Flight Effectivity to STS-121 and STS-115
 - Add to Cause Summary
 - Update Fault Tree section description Revision Letter
 - Update Signature Page
 - Add new fault tree block ISPR-02.9, “ETVAS Umbilical System Malfunction Due To Improper Systems Interface Characteristics”
 - Update Revision Letter



ISPR-02 Change Request Recommendation

- Recommend approval of the updated ISPR-02 Integrated Hazard Report with the changes described previously.
 - The risk classification for this hazard report revision remains “Controlled”.
- Flight Effectivity:
 - STS-121 and STS-115

Closure Summary

- During the STS-114 launch attempts on July 13 and July 26, 2005, liquid nitrogen was seen flowing from the bottom of the GUCP ice suppression shroud
 - LN2 formed as the result of GN2 mixing with GHe due to a lack of positive GHe purge in QD cavity
- GH2 vent shroud configuration modifications have been made to provide for a positive pressure in GHe cavity to prevent/mitigate the formation of LN2:
 - Phenolic rings redesigned
 - expanded PTFE seals added
 - L-T-80 Tape added
 - Insulation added to GH2 QD
- Close lien against ISPR-02, and update ISPR-02
- Close IFA STS-114-I-014.



Background





ISPR-02 Verification Tracking Log

IHR	Description	Effectivity	Impact Assessment	Closure/Status Date
ISPR-02	Purge Shroud qualification testing	STS-121	Incorporate purge shroud qual testing report title, number, and results	Open