



May 3, 2006
Gary Hopkins

STS-121

DESIGN CERTIFICATION

ERB REVIEW

ET GH2 Vent Umbilical
7-Inch GH2 QD
Ice Suppression Shroud
Modification

KSC
LAUNCH AND LANDING SITE

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Agenda

- **Objective/Scope/Purpose**
- **System Overview**
- **STS-114 Anomaly**
- **Ice Suppression Shroud Modifications**
- **Qualification Testing**
- **NSTS 7700 Volume X Paragraph Summary**
- **Design Products**
- **Schedule**
- **Summary**

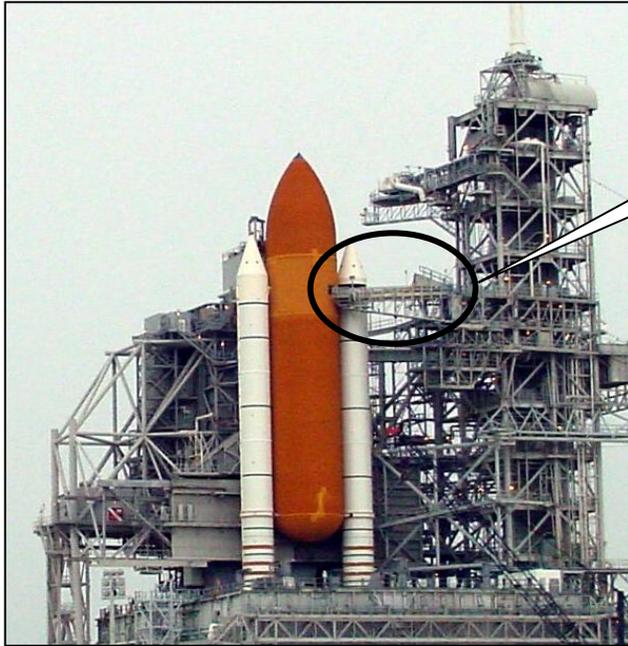
Objective / Scope

- The purpose of this briefing is to summarize the design certification results for modifications to Pad A & Pad B GH2 Vent System; U78-0102
- Modifications since STS-114 DCR
 - Ice Suppression Shroud

System Purpose

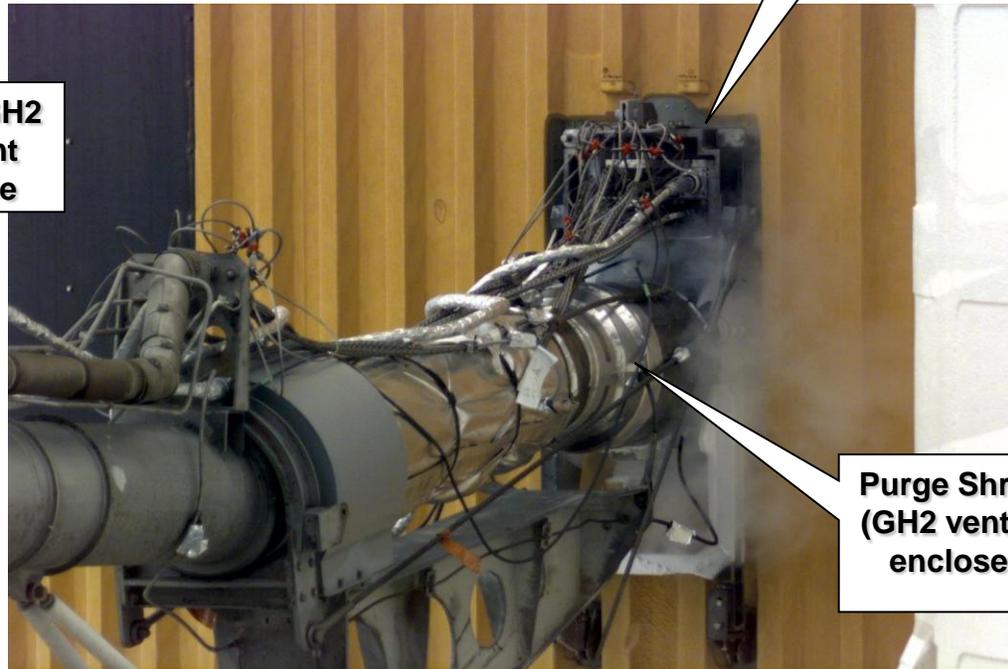
- The purpose of the ET GH2 Vent Umbilical is to provide a means of safely transporting hazardous gaseous hydrogen, vented during cryogenic loading through T-0, away from the ET to the facility vent system.
- The purpose of the shroud is to keep liquid air and/or ice from forming on the GH2 Vent 7-inch QD

System Overview



Ground Umbilical Carrier Plate (GUCP)

ET GH2 Vent Line



STS-114 Anomaly

- During STS-114 (Pad B) ET GH2 Vent Line Umbilical, Ice Suppression Shroud formed ice and had LN2 flowing from it.
 - Issue
 - Concern of Ice impacting the SSV
 - Concern of LN2 impacting the SSV
 - Program IFA STS-0114-I-014 (Closed @ ICB 4/25/2006)
 - KSC IFA STS-0114-K-001 converted to PR PV-6-428747

Source
of LN2

EB-3, EB-7
attach
points

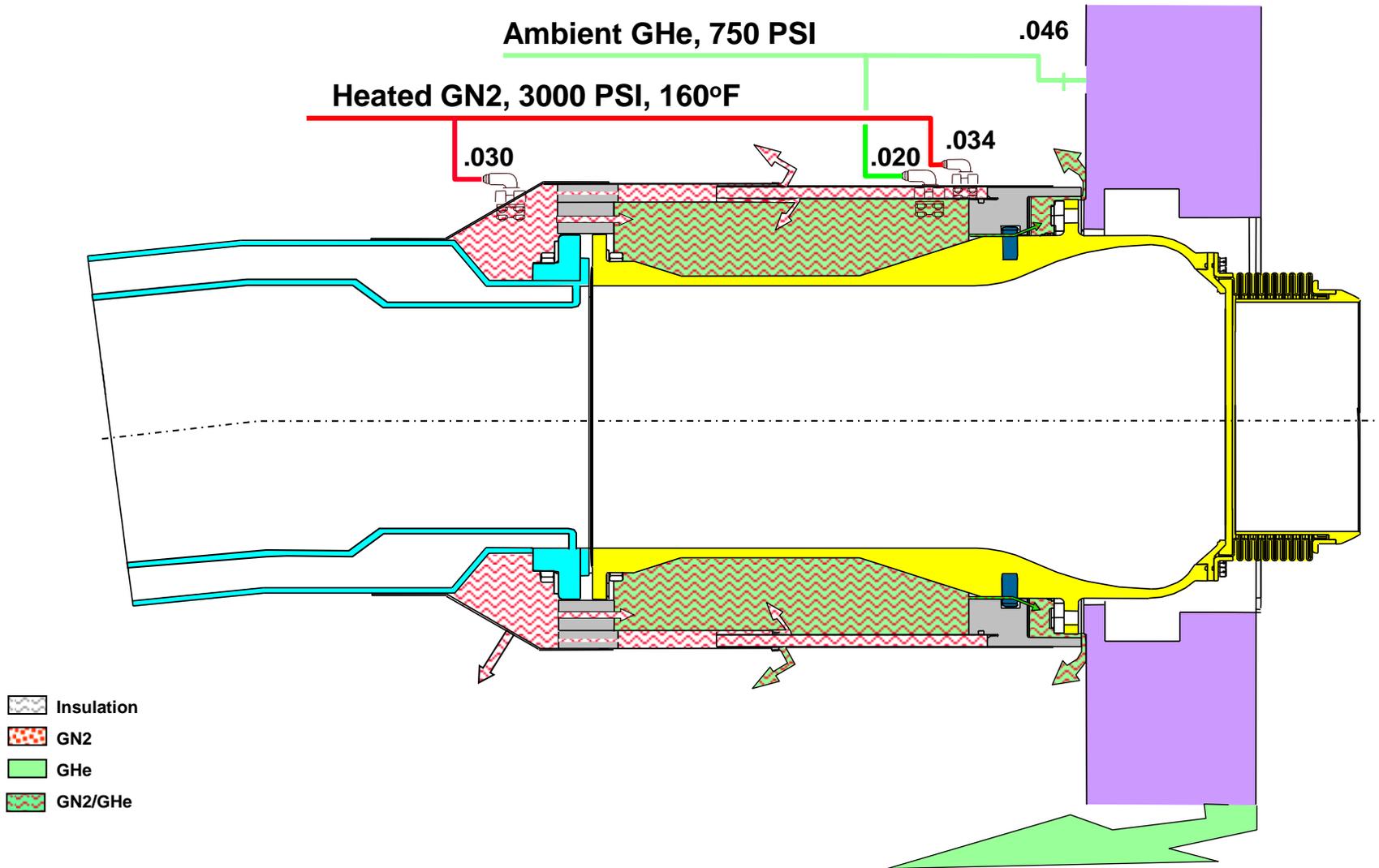


STS-114 Anomaly

- **Project/Test team concluded:**
 - **GN2 entered the GHe annulus due to the lack of seals in the GHe annulus. The GN2 liquefied and flowed from the shroud.**
 - **Ice formed on the shroud due to the lack of heated GN2 to the lower portion of the shroud.**
- **Other contributor, not cause:**
 - **Cold GUCP GHe purge (~-95°F) gas sweeping up and around the shroud cooling it.**

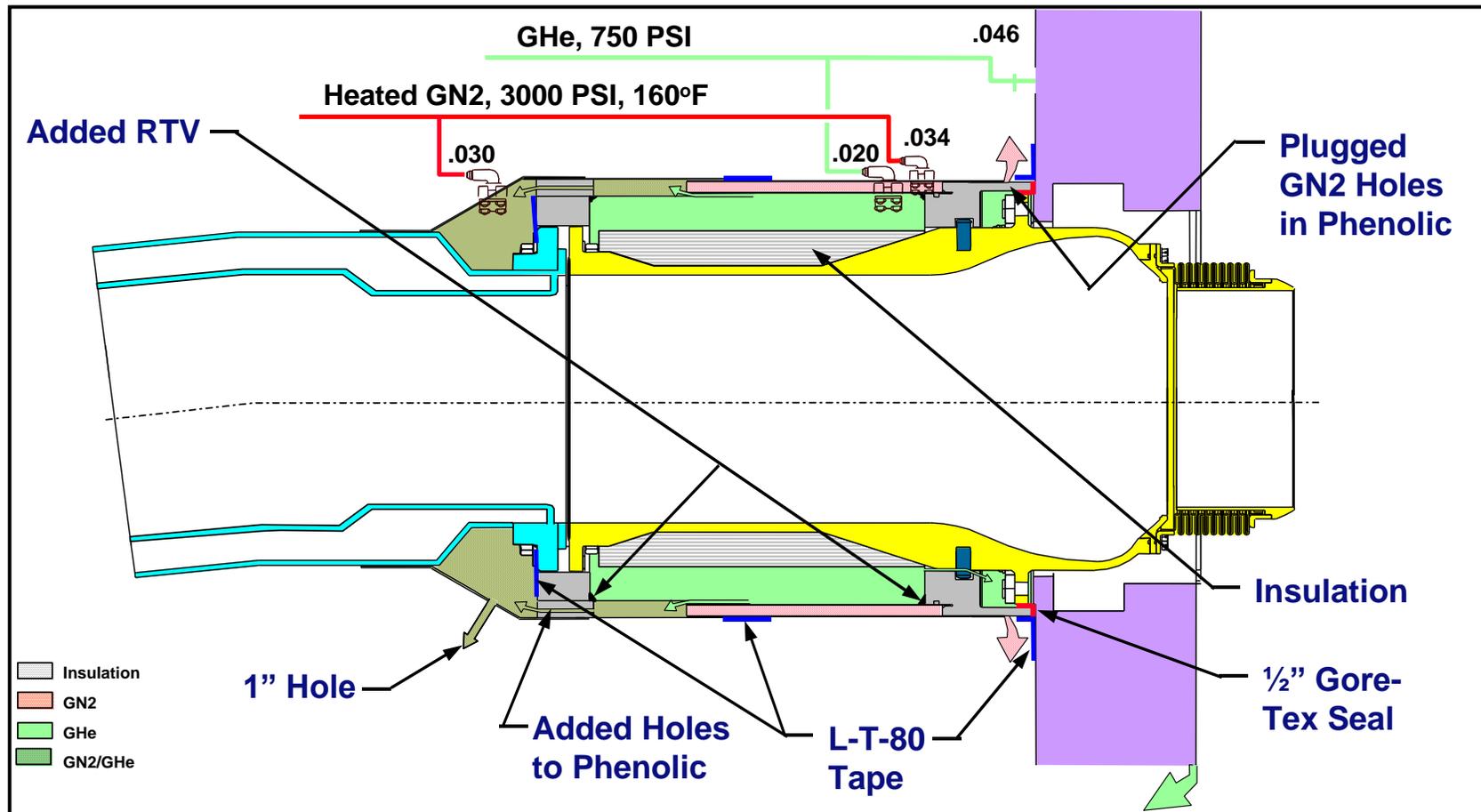
Old Shroud Purge Flow Path

STS-26R thru STS-114 Shroud Configuration



New Shroud Purge Flow Path & Modifications

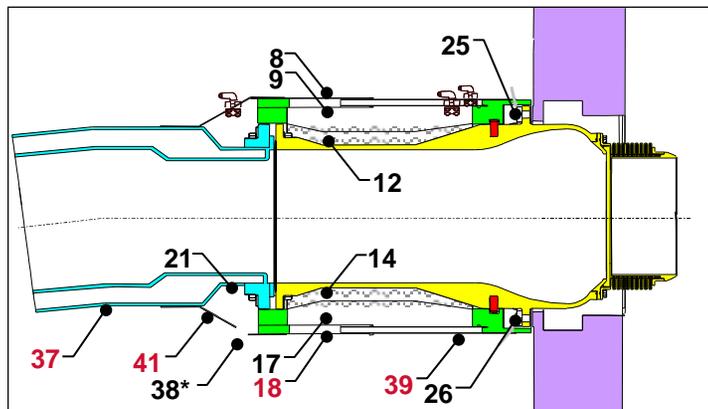
- Vent holes and seals added to redirect purges so:
 - GN2 does not come into contact with the QD and forming LN2.
 - OD of shroud is sufficiently warm to preclude ice formation



Qualification Testing

- **Ice Suppression Shroud required qualification testing to verify modifications eliminated LN2 and Ice formation.**
 - **Test fixture assembled at NASA Cryogenic Lab for LN2 development testing**
 - **Modified configuration developed**
 - **Test fixture moved to LETF for LH2 qualification testing.**
 - **Two 5-hour LH2 qualification tests of final configuration with misters were run.**
 - **Verified GN2 does not enter GHe annulus, therefore no LN2 formation**
 - **Verified shroud OD is sufficiently warm that no ice or frost can form**
 - **Testing requalified the Ice Suppression Shroud to support launch**
 - **Test Report KSC-5500-8111**

Qualification Test Data Summary



Description	Ambient Temperature (°F)	Humidity (%)	Wind (mph)
LH2 Test #3 @ LETF	64	59	0
LH2 Test #3 @ LETF w/misters	64	60	1
LH2 Test #4 @ LETF	71	59	5
LH2 Test #4 @ LETF w/misters	68	58	2

38* is Exist Gas Temperature. Not on Shroud

Measure Number	Measure Location Description	LH2 Test #3 @ LETF	LH2 Test #3 @ LETF w/misters	LH2 Test #4 @ LETF	LH2 Test #4 @ LETF w/misters
8	OD Shroud Rear 12:00	81	68	90	68
9	ID Shroud Rear 12:00	48	46	53	43
12	OD of QD Rear 12:00	-407	-409	-404	-406
14	OD of QD Rear 6:00	-406	-407	-404	-405
17	ID Shroud Rear 6:00	58	61	61	53
18	OD Shroud Rear 6:00	62	74	71	63
21	OD Flex Hose In Conical 6:00	-28	-28	-27	-25
25	QD Flange Surface 12:00		-364	-360	-362
26	QD Flange Surface 6:00		-385	-382	-383
37	OD Flex Hose 6:00	65	60	67	61
38*	Conical Portion Vent Gas	37	39	35	29
39	OD Shroud Front 6:00	82	96	92	82
41	OD Conical Portion 6:00	68	69	70	65

Requalification Issue

- Added insulation and colder GHe gas at QD flange could cause GUCP to be colder
 - Excessive Ice seen on GUCP Legs during 5-hour LH2 tests.
 - Most likely cause is test conditions – tested for 4-hours with misters on test article.
 - Flight side QD and vehicle vent line insulated – Nominal inter-tank temperature is 80°F
- Lockheed Martin up-dating analysis to determine if there is any issues

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Photos from LETF Testing

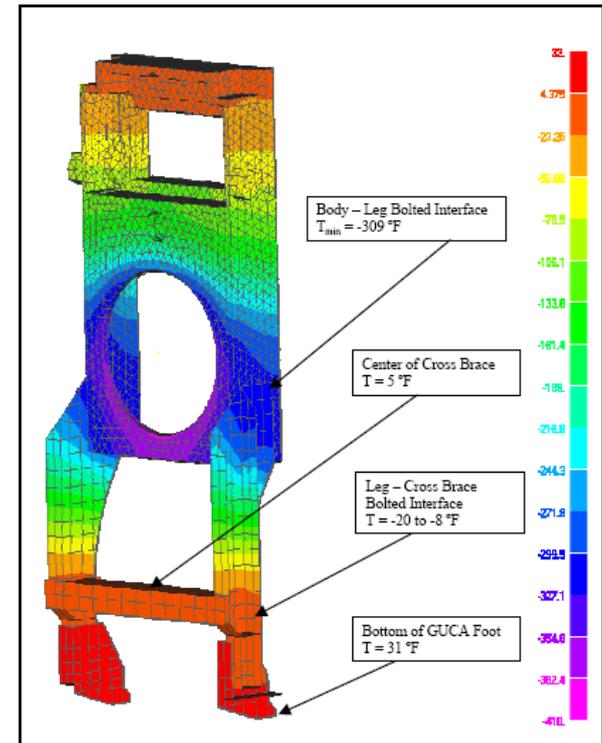
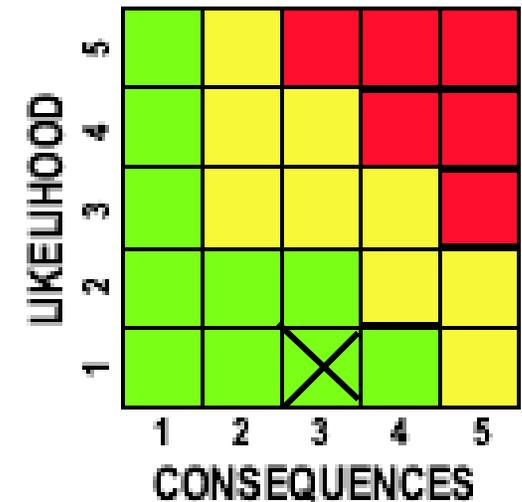
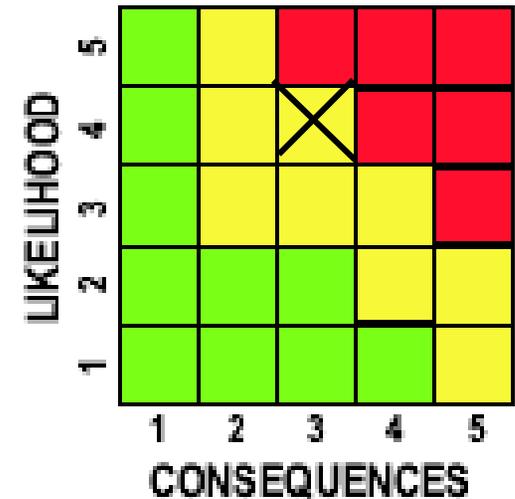


Figure 9: GUCA Steady-State Temperature Profiles
Existing LM Analysis

Requalification Issues

- Without Changes
- Risk Scorecard – Yellow
 - Likelihood (4) Likely - Could happen in the life of the program. Controls have significant limitations or uncertainties.
 - Consequence (3)
 - Supportability - Temporary usage loss of major element(s) of flight vehicle
 - System Safety - Damage to major element(s) of flight vehicle
 - Schedule - Greater than 7 day slip in an SSP Milestone
- Modifications to be incorporated before RTF

- With Changes
- Risk Scorecard – Green
 - Likelihood (1) Highly Unlikely - Extremely remote possibly that it will happen in the life of the program. Strong controls in place.
 - Consequence (3) See above



Controls and Verifications

- **OMI – Visual Inspection of Installation with engineering sign-off**
 - Aerogel Insulation
 - Gore-Tex Seal
 - L-T-80 Tape
 - Heated GN2 & GHe purges activated
- **ICD – IRN KO-2125 (CR S063347) Controls:**
 - Aerogel Insulation
 - Gore-Tex Seal
 - L-T-80 Tape
- **Hazard Report ISPR-02 Up-Dated (CR S050425DG)**

Design Certification Requirements – NSTS Paragraph Summary

	Volume X Paragraph No.	Method of Compliance	Status
1	3.2.1.2.2 Launch and Recycle **	Testing/Similarity	Verified
2	3.2.1.2.11 Pad Stay Time **	Similarity/Analysis, Inspection of drawings	Verified
3	3.2.1.2.14 Debris Prevention **	Testing/Analysis, KSC-5500-8111, & -8194	In-Work
4	3.2.1.2.14.1 Launch Holds **	Testing/Analysis, KSC-5500-8111, & - 8194	In-Work
5	3.2.2.2 Ground System Design (Natural Environments) **	Testing/Analysis, KSC-5500-8111, & - 8194	In-Work
6	3.2.2.2.2 Ground Support Equipment	Similarity	Verified
7	3.5.1.2.1.1 GSE Fail Safe	Similarity/Analysis,SAA09VE44-001 Rev. C	Verified
8	3.5.1.2.2 GSE Failure Protection	Similarity/Analysis,SAA09VE44-001 Rev. C	Verified
9	3.5.2.3 Ground System Maintainability	Similarity/Analysis, Inspection of drawings	Verified
10	3.5.2.3.1 Turnaround Support (3.5.3.1)	Similarity/Analysis, Inspection of drawings	Verified
11	3.5.2.3.2 Turnaround Flow	Similarity/Analysis, Inspection of drawings	Verified
12	3.5.3.1 Design-Life	Similarity /Testing/Analysis, Inspection of drawings	Verified

** Note: These paragraphs also satisfy Combined Element requirements

Design Certification Requirements – NSTS Paragraph Summary

	Volume X Paragraph No.	Method of Compliance	Status
13	3.5.4.2.1 Facilities and Non-flight Equipment	Similarity/Analysis, SAA09VE44-001 Rev. C	Verified
14	3.5.4.2.6 Air Liquefaction	Testing/Analysis, KSC-5500-8111	Verified
15	3.6.5.2.1 Corrosion Protection	Similarity/Analysis, Inspection of drawings	Verified
16	3.6.10 Drawing Standards	Analysis, Inspection of drawings	Verified
17	3.6.13 Traceability	Similarity/Analysis, Inspection of drawing	Verified
18	3.7 Quality Assurance	Analysis, Inspection of drawings Based on existing GSE mod process and data package	Verified

3 Paragraphs In-Work (ECD 5/26/2006)

System Design Products

- **Certification Requirements (CR) Plan**
 - **KSC-5500-8192 (ECD 5/17/2006)**
- **DESIGN DRAWINGS**
 - **80K51096 Revision C (ET GH2 Vent QD Ice Suppression Shroud Assy & Insulation) (ECD 5/12/2006)**
- **SAA09VE44-001 Revision C – No Change**
- **Certification Approval Request (CAR)**
 - **KSC-5500- 8193 (ECD 5/17/2006)**
- **OMRSD File VI - No Change**
- **Documents**
 - **KSC-5500-8110; LETF Test Requirements (ECD 5/26/2006)**
 - **KSC-5500-8111; LETF Test Report (ECD 5/26/2006)**
 - **KSC-5500- 8194; Shroud Thermal Analysis Report (ECD 5/26/2006)**
 - **KSC-5500- 8191; NASA Cryogenic Lab Test Report (ECD 7/14/2006)**

Summary

- **Ice Suppression Shroud modified and successfully tested**
 - Open issue of excessive Ice on GUCP (Lockheed Martin analysis in-work)
- **Dev to OMI to ensure proper installation of modified shroud (ECD 5/12/2006)**
- **Modifications to Pad A & Pad B Shroud**
 - Machine new phenolics eliminating instrumentation holes (Pad B Complete)
 - Shroud Reassembly (Pad B Complete)
 - New seal and insulation materials available
- **All shroud modifications will be complete, certified, and ready to support STS-121 processing, tanking test and launch**

Back-Up

Weather Rules

NSTS 16007 Section 4 Weather Rules, Paragraph 1.1.B.2 From Start of ET Cryogenic Loading to Exiting the Last Hold Prior to Auxiliary Power Unit (APU) Start.

- The SSV shall not be launched if the ambient temperature (T_{amb}) is lower than the minimum temperature limit (T_{min}) (Table 1.1A), for more than 30 consecutive minutes unless the Preplanned Contingency Procedure (PCP) indicates recovery from the low temperature excursions that caused the Launch Commit Criteria (LCC) violation. The minimum temperature limits are specified in Table 1.1A as a function of wind speed and relative humidity. The 0-64% column of Table 1.1A shall be used to specify minimum ambient temperature limits if relative humidity instrumentation is non-functional.

Wind Speed (knots)	Minimum Ambient Temperature (Deg F), T_{min}				
	Relative Humidity				
	0-64%	65-74%	75-79%	80-89%	90-100%
0-1	48	47	46	45	44
2	47	46	45	44	43
3	41	41	41	40	39
4	39	39	39	39	38
5-7	38	38	38	38	38
8-14	37	37	37	37	37
>14	36	36	36	36	36

Table 1.1A