Rocket Propulsion Testing at NASA's John C. Stennis Space Center

Rocket Test Facility Operators Working Group

20-21 April 2005

Liquid Hydrogen Barge Vaporizers

Bob Schwer, Jacobs Sverdrup
NASA Test Operations Group
Phone: (228) 688-3278
Robert.Schwer@ssc.nasa.gov

Liquid Hydrogen Barge Vaporizers

Stennis Space Center

SSC

Introduction

- SSC Barge Usage

- Barge Refurbishment Efforts

SSC

Vaporizer Requirements

- Functionality
  - Pressures
  - Specification

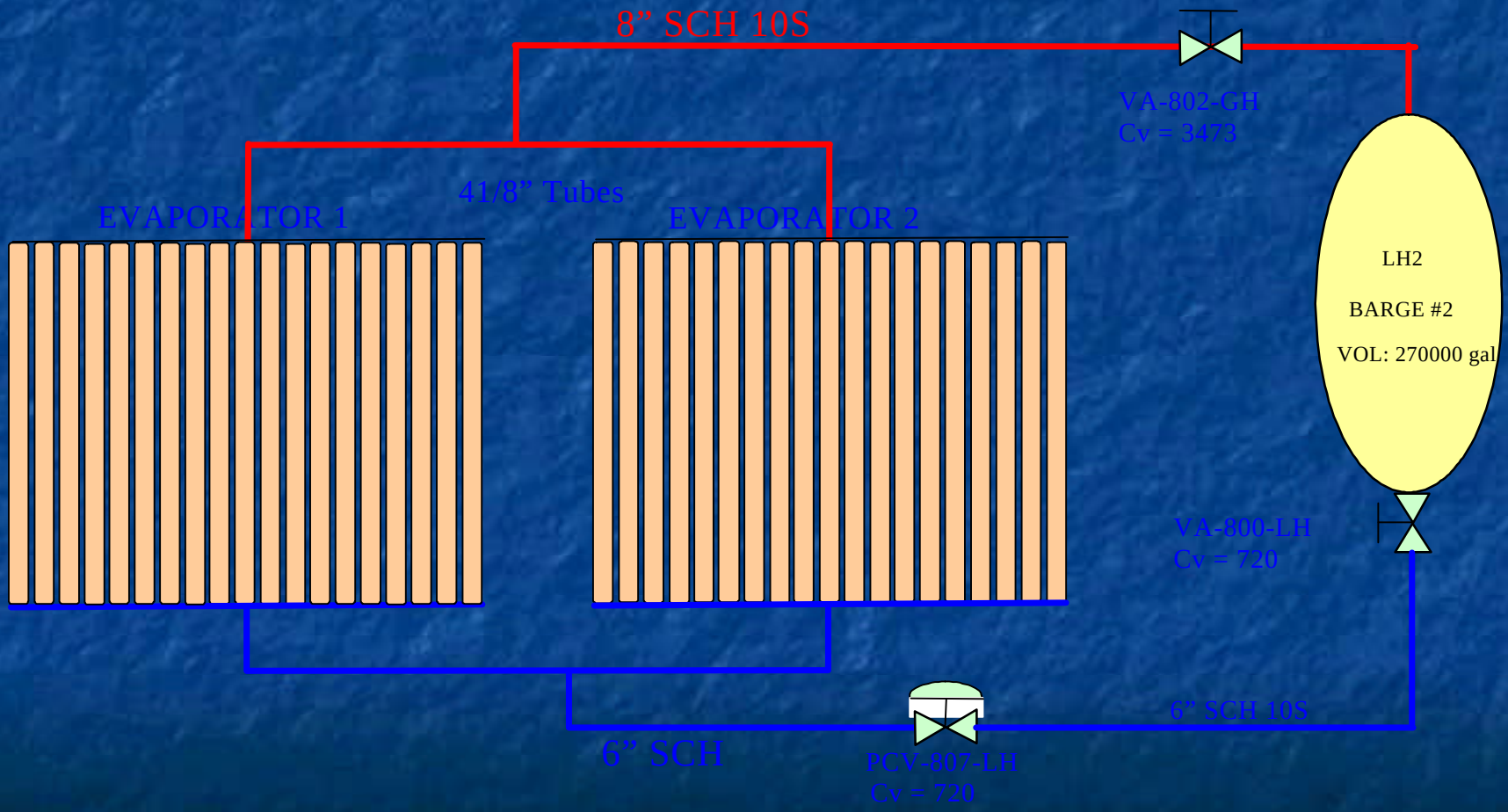
SSC

Vaporizer Design

- Three Designs
  - Original
  - Failed design
  - Redesign

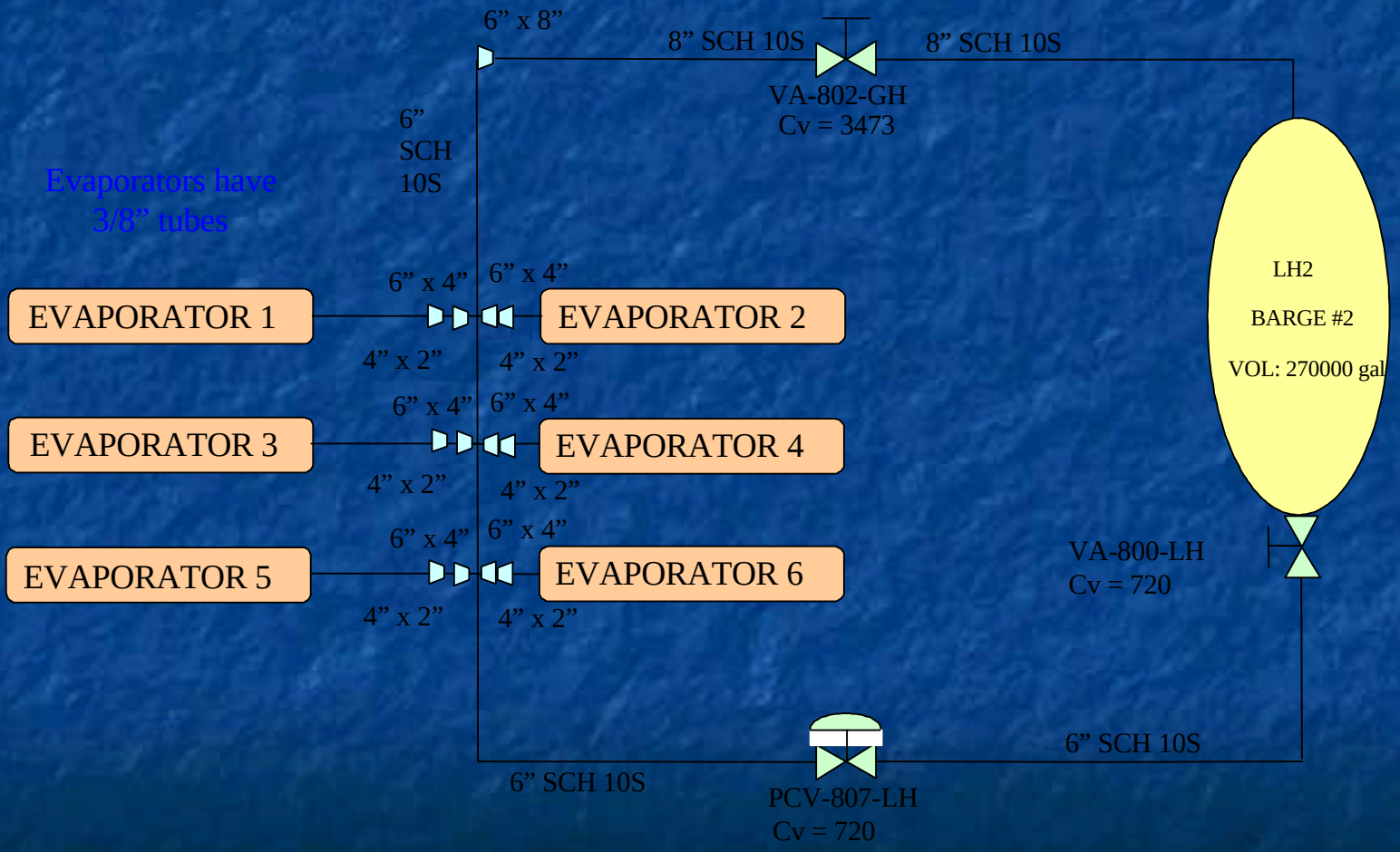
Design # 1 (Original Design)

SSC



Design # 2 (Failed Design)

SSC

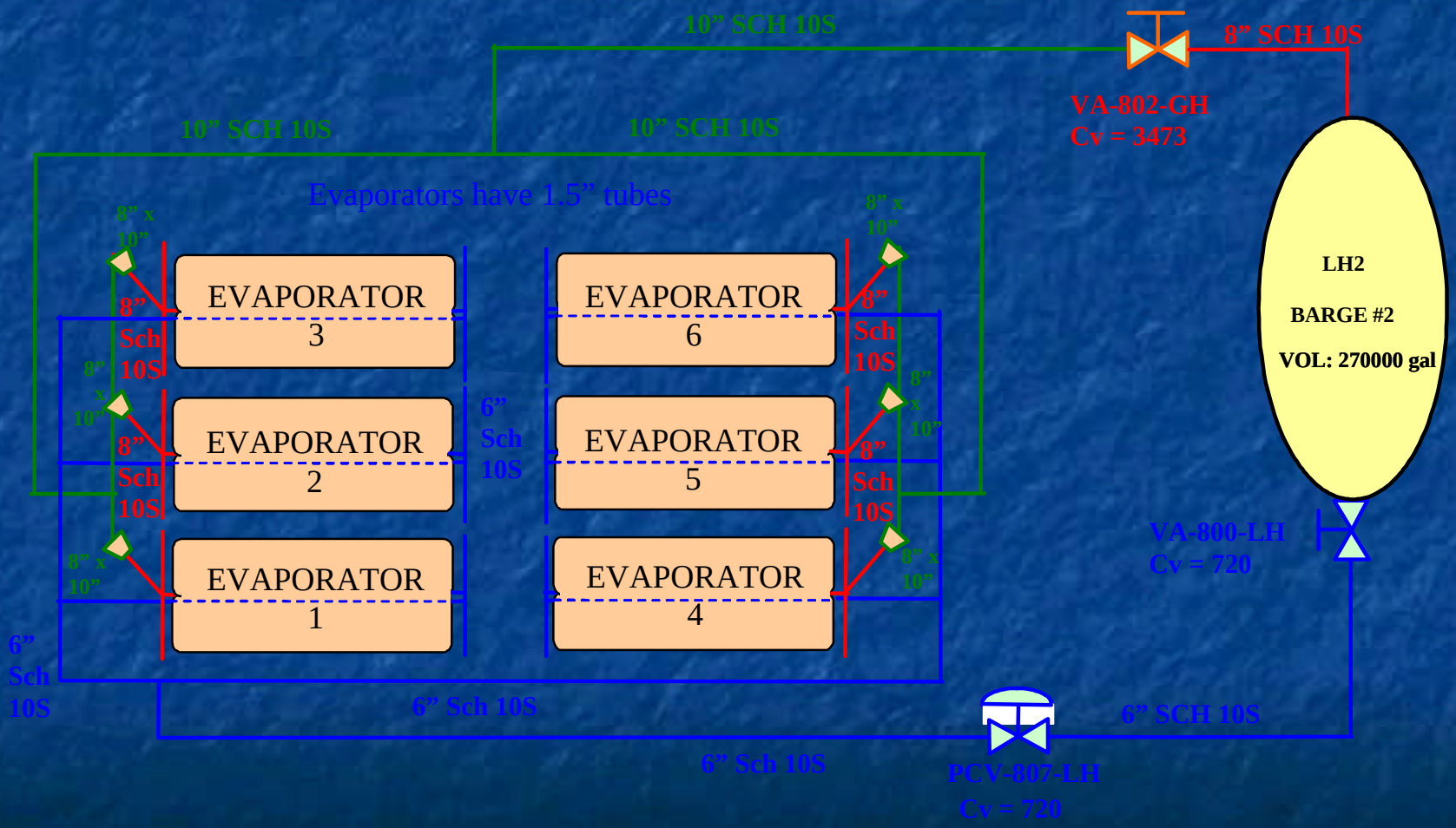


SSC

Vaporizer Design#1 (Failed Design)

Design # 3 (Redesign)

SSC



SSC

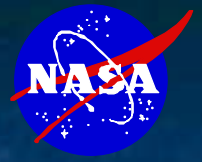
Vaporizer Design

- LOX Success
- LH Failure
  - Findings
  - Causes
    - Communication
      - Breakdown spanning several years
      - Inadequate specification to v
  - Analysis

LH2 # 2 Vaporizer Statistics

SSC

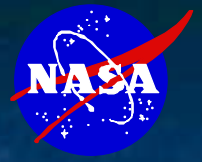
Variable	Current Design # 1	Failed Design # 2	New Design # 3
Cross Section Flow Area (ft^2)	3.36	0.05	3.09
		Failed Design # 2 Flow Area decreased by 85% from the current Design # 1	New Design # 3 Flow Area decreased by 8% from the current Design # 1
Volume (ft^3)	168.05	0.65	30.88
		Failed Design # 2 Volume decreased by 99.6% from the current Design # 1	New Design # 3 Volume decreased by 81.6% from the current Design # 1
Surface Area (ft^2)	2050	7200	12800
		Failed Design # 2 Surface Area increased by 351% from the current Design # 1	New Design # 3 Surface Area increased by 624% from the current Design # 1



SSC

Corrective Actions

- Factors
  - Schedule
    - Certification waiver of LH Barge pressure vessel
    - Gantt charge of milestones and critical path
  - Cost
  - Design requirements identification



SSC

Corrective Actions

- Actions Taken
  - Obtained 8-month waiver extension
  - Performed systems requirement review
  - Initiated redesign
  - Conducted vendor site analysis
  - Performed system analysis
    - Extremely low available head pressure

Corrective Actions

- Cost considerations
  - New design not best value
    - High cost to fabricate and install
    - Scope growth hard to control
  - Best value – reuse original vaporizers

Corrective Actions

- Repair of Original Vaporizers
  - Damaged during hurricane preparation activities
    - Planned for salvage
  - Performed pressure leak checks
  - Certified weld procedures and welders for copper
  - Repaired leaks by welding
  - Replaced bent tubing
  - Pressurized and leak checked
  - Cleaned for hydrogen service
  - Replaced drip pans
  - Installation and checkout ongoing

SSC

Lessons Learned

- Incorrect assumptions can be extremely costly
- Communicate – Communicate – Communicate
  - Loss of continuity during contract changes
  - Changes in personnel assigned to task
  - Ensure adequate documentation
  - Involve users for requirement identification
- Value of a good specification
- Technical reminders
  - Hydrogen head pressures are unforgiving
    - Extremely light liquid
    - Pressure drops change significantly with temperature
  - Use system approach analysis

Lessons Learned

- Incorrect assumptions can be extremely costly
- Communicate – Communicate – Communicate
  - Loss of continuity during contract changes
  - Changes in personnel assigned to task
  - Ensure adequate documentation
  - Involve users for requirement identification
- Value of a good specification
- Technical reminders
  - Hydrogen head pressures are unforgiving
    - Extremely light liquid
    - Pressure drops change significantly with temperature
  - Use system approach analysis