Minimize Purging, Venting, Cleaning During Turnaround

Space Propulsion Technology Assessment Workshop

April 2001

Current Baseline
Minimize Purging, Venting, Cleaning During Turnaround

- LOX/hydrogen engines produce steam from the preburners downstream
    - When the engine is shutdown, water vapor, and later condensed water, is trapped in the engine
    - The engine also ingests humid ambient air when shut down and open to the atmosphere
    - During conditioning prior to start the water and water vapor can become ice and block passages and/or produce pieces of ice which can be a concern for items such as turbine blades
    - Possible use of oxygen/hydrogen for OMS and RCS engines will increase the problem

- Consequently, significant effort and timeline is expended to dry the engine before conditioning and start
    - And purges are used during shutdown to minimize the problem
        - Inert gases, i.e., separate fluids

Potential Solutions
Minimize Purging, Venting, Cleaning During Turnaround

- Goal is to have no problem with ice, not necessarily to have no water
- Goal is to have minimum impact on turnaround labor and timeline
- Primary places of concern
  - Injector orifices
  - Cooling passages
    - Plugging
    - Film reducing heat transfer
  - Drain lines, particularly turbopump seal drains
- Approach is to
  - Design engine to minimize water and ice effects
  - Self purge engine at shutdown
  - Address water ingestion during reentry
  - Address storage on ground
  - Address any engine not sealed while on ground

Technologies to Implement Solutions (TRLs)
Minimize Purging, Venting, Cleaning
During Turnaround

- Self purge engine at shutdown
  - One method (4)
    - Close tank pressurization lines from fuel and ox side of engine
    - Open valve in bypass line, which also has a check valve, from each pressurization line to engine
    - As pressure decays, tank pressurization gas will provide gas purge
    - Close valve in bypass line to end purge
  - Alternately (4)
    - Use gas from accumulator in integrated OMS/RCS/MPS system if present
      - This accumulator was already filled by the fuel and ox pressurization lines from the engine
      - Higher pressure purge available

Technologies to Implement Solutions (TRLs) (Cont'd)
Minimize Purging, Venting, Cleaning
During Turnaround

- During reentry
    - Purge from pressurization gases or accumulator (4)
  - or
    - Use very specific heating of the parts of components which could produce a problem (3)
    - Finish with purge as above to blow out water vapor

- Transition between landing and throat plug
  - Either an inert purge or continue the component heaters until the throat plugs are inserted

- Storage on ground
  - Probably only simple solution is throat plug and slight overpressure in engine (9)
    - Does require a GSE or vehicle supplied inert purge gas
  - Works for MPS and OMS because not many engines and easily verifiable
  - More difficult for RCS
    - Many more of them and harder to access
    - Can be addressed as part of start sequence
  - Drain lines must be valved

Technologies to Implement Solutions (TRLs) (Cont'd)
Minimize Purging, Venting, Cleaning During Turnaround

- During Start
  - Only RCS engines need to be addressed
    - Will also work for OMS if throat plug not used
  - Pressurization gases from engine are warm gases and can be designed to be hot gases if useful
  - Use one of two ways
    - Route pressurization lines by the components (e.g., injectors) that need to be free of ice (3)
    - Use pressurization gases to run small turbogenerator (4)
      - 140 Horsepower available from 0.7 lbm/sec at 3,000 psi and 490 R
        - 1,500 psi still available downstream
        - 60 lbm and 0.5 cubic feet produces about 40 Kwe
      - Use to power resistance (or other type) heaters

Turbine					
N, rpm	Pressure Ratio	P_{exit}, psi	Dia, inches	Weight, lbm	Shaft HP
35,000	2	1,540	4	~23	139
35,000	5	616	4	~30	222
50,000	2	1,540	4	~20	166
50,000	5	616	4	~28	289

- Example Generator
  - Generator – 38 KW_e; Weight – ~38 lbm; Envelope ~4" Dia, 3" Length plus 8" cube
  - Generator Weight ~ 1 lbm/KW_e

Cost to Mature Technology
Minimize Purging, Venting, Cleaning During Turnaround