National Aeronautics and Space Administration

SPACE LAUNCH SYSTEM

Overview of the SLS Core Stage Thrust Vector Control System Design

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Agenda

- **Core Stage Thrust Vector Control (TVC) System**
  - Hydraulic Supply, Return, Case Drain, Fluid
  - Gas System
  - Actuators and Controllers
  - Hydraulic Cross-Strapping
  - Thermal Management
- **Core Stage TVC Components**
  - TVC Actuator
  - TVC Actuator Controller (TAC)
  - Core Auxilliary Power Unit (CAPU)
  - Main Pump
  - Filter Manifold
  - Reservoir
  - Supply/Return Accumulator
  - Circulation Pump
  - Exhaust Gas Heat Exchanger (EGHE)
- **Questions**

Core Stage TVC System

- **Hydraulic Supply, Return, & Case Drain**
  - Major Components
    - Main Pump
    - Circulation Pump
    - Filter Manifold
    - Accumulators and Reservoir
    - TVC Actuators
  - Ancillary Components
    - Tubing
    - Flex-hoses
    - Fittings
    - Quick Disconnects
- **Hydraulic Fluid**
  - MIL-PRF-83282
    - Standard hydraulic fluid used in military and commercial aircraft
  - NASA Micronic 882
    - Adds additional cleanliness and testing to MIL-PRF-83282 requirements
- **Gas System**
  - CAPU & CAPUC
  - Tubing
  - Flex-hoses
  - Filters
  - Check valves
  - Exhaust duct

Core Stage TVC System (Cont.)

- **TVC Actuators and Controllers**
  - 4 TACs connected to the Flight Computers over MIL-STD-1553
  - 8 TVC actuators
    - 2 per RS-25 engine
    - Aligned in the vehicle Pitch and Yaw planes
- **Hydraulic Cross-Strapping**
  - TVC Actuators have primary and secondary hydraulic connections
  - If primary pressure is lost, a valve inside the actuator switches from primary to secondary source.
  - Each CAPU/Main Pump is connected to 4 TVC Actuators (2 primary, 2 secondary)
- **Thermal Management**
  - Circulation Pump is used to move hydraulic fluid during cryo-load to keep the systems warm
  - Line heaters and insulation are employed in dead headed lines
  - EGHE uses CAPU exhaust to cool hydraulic fluid in flight

Core Stage TVC Components

- **TVC Actuator**
  - 4 channel, majority vote, servo-hydraulic actuator
  - Servo-valve dynamic pressure feedback – hydraulic load resonance compensation
  - Servo-valve delta-pressure sensors – telemetry and fault detection
  - Mechanical piston position feedback – closes piston position control loop
  - Piston position sensor – telemetry
  - Hydraulic locking valve – locks actuator in place below certain pressure
  - Hydraulic switching valve – switches from primary to secondary hydraulic supply in the event of a pressure loss
- **TAC**
  - Generates servo-valve current from Flight Computer commands
  - Performs fault detection and correction based on servo-valve delta-pressures
  - Telemeters servo-valve currents and delta pressures and actuator positions

Core Stage TVC Components (Cont.)

- **CAPU**
  - Cold gas (GHe – ground, GH2 – flight) spun turbine
  - Heritage from Shuttle Orbiter and Solid Rocket Booster (SRB)
    - Heritage APUs used gas generated via hydrazine decomposition over a catalyst bed
  - Gear box used to reduce shaft speed to Main Pump operating speed
- **CAPUC**
  - Performs turbine speed control based on Magnetic Pickup Units (MPUs) mounted on turbine shaft
  - Commands Propellant Supply Valve (PSV) and Speed Control Valve (SCV) to maintain turbine speed
  - Telemeters speed and valve positions to Flight Computers

Core Stage TVC Components (Cont.)

- **Main Pump**
  - Pressure Compensated, Variable Displacement, Axial Piston Pump
  - CAPU Turbine provides driving torque
  - Based on F-14 heritage
  - Identical pump used on Space Shuttle SRB
    - Similar design on Space Shuttle Orbiter
  - ~3000 psig nominal output pressure
  - Provides hydraulic flow to meet the demand of up to 4xTVC Actuators + 1 RS-25 Hydraulic Actuation System (HAS) in off-nominal scenarios
  - Electro-Depressurization Valve
    - Solenoid Valve used to reduce load on CAPU at startup
- **Circulation Pump**
  - Heritage hardware from Space Shuttle Orbiter
  - Electric Motor Driven Gear Pump
  - Used to circulate fluid for thermal management during cryo-load

Core Stage TVC Components (Cont.)

- **Filter Manifold**
  - Routes fluid from Main Pump and Circulation Pump to hydraulic system
  - Provides filtration
  - Contains check valves, relief valves, and pressure transducers
- **Accumulators and Reservoir**
  - Gas pre-charged, welded metal bellows devices
  - Supply and Return Accumulators have sealed gas pre-charge
  - Reservoir has adjustable pre-charge pressure for possible use during hydraulic system fill and bleed
  - Reservoir has bellows position (volume), pressure, and temperature sensors for telemetry
- **EGHE**
  - Shell and tube cross flow heat exchanger
  - Uses cold gas exhaust from CAPU
  - Passive device with no flow controls on the gas or hydraulic side
  - Routes hydraulic return flow through EGHE back to Reservoir

Questions