



Understanding the Impact of Balance of Plant Equipment on Liquid Fuel System Reliability

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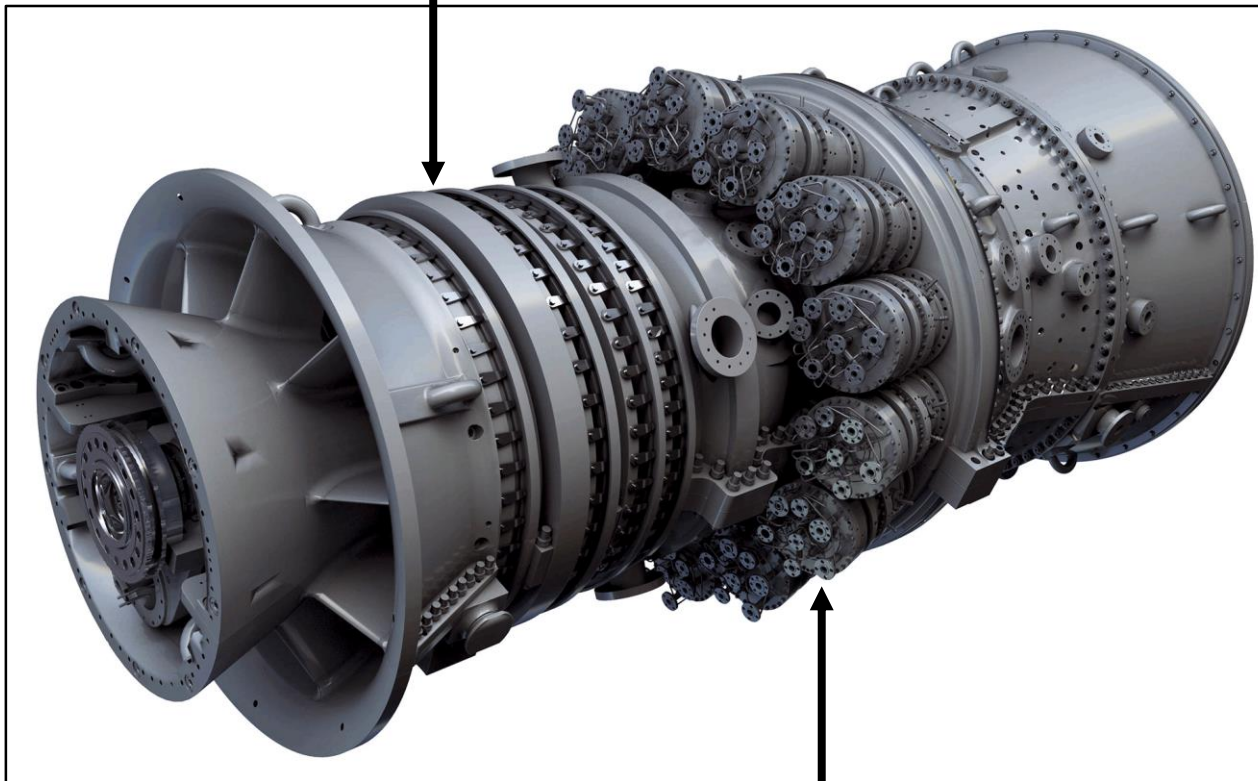
JASC 3rd Generation Fuel System Improvements _____



“Where JASC Performs”

Check Valves

3-Way Valves



Where you'll find
JASC Products



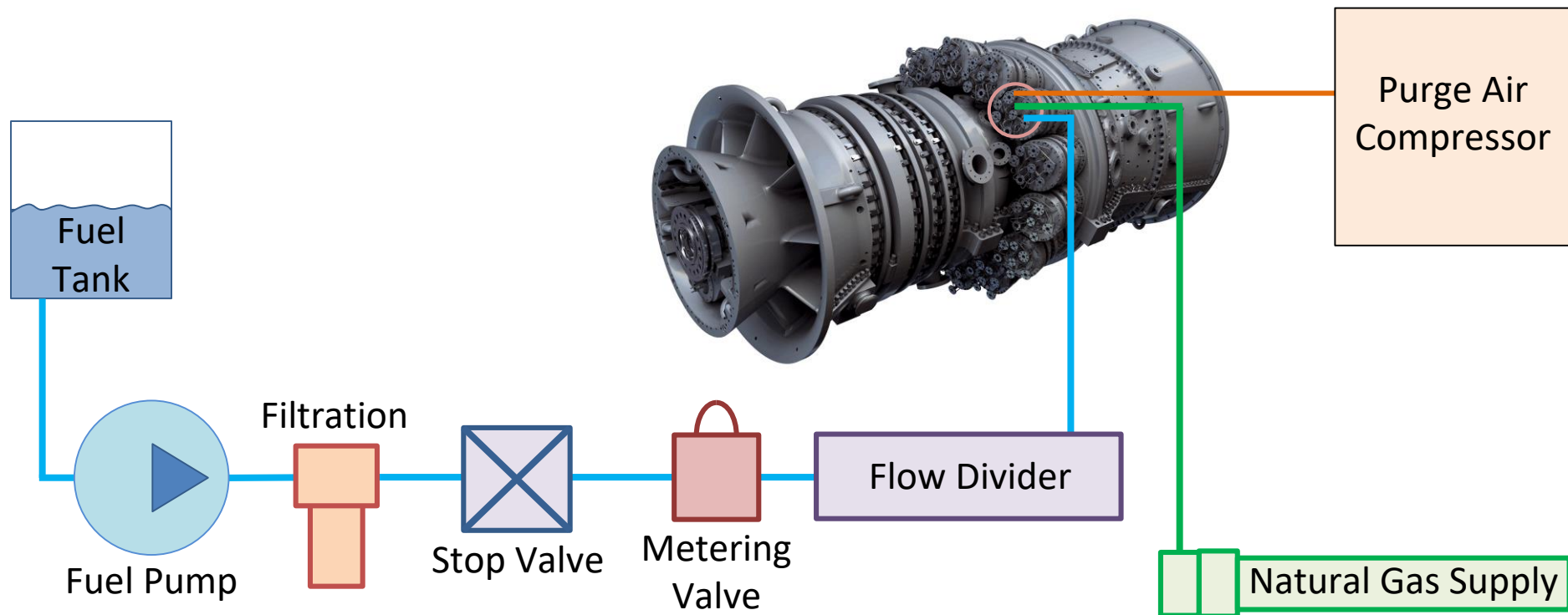
System Influence on Turbine Reliability



← CULTURE →

← FUNDING →

← KNOWLEDGE →



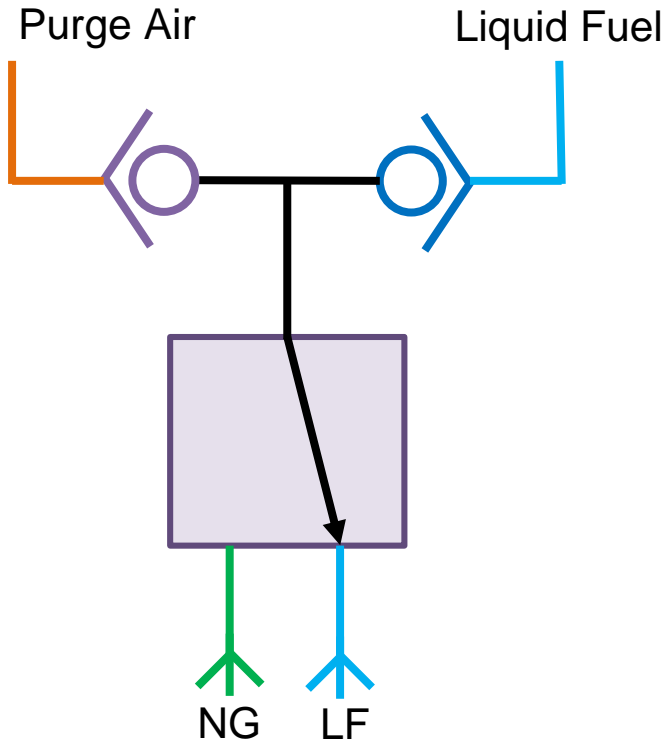
← MAINTENANCE & OPERATION →

System Influence on Turbine Reliability _____

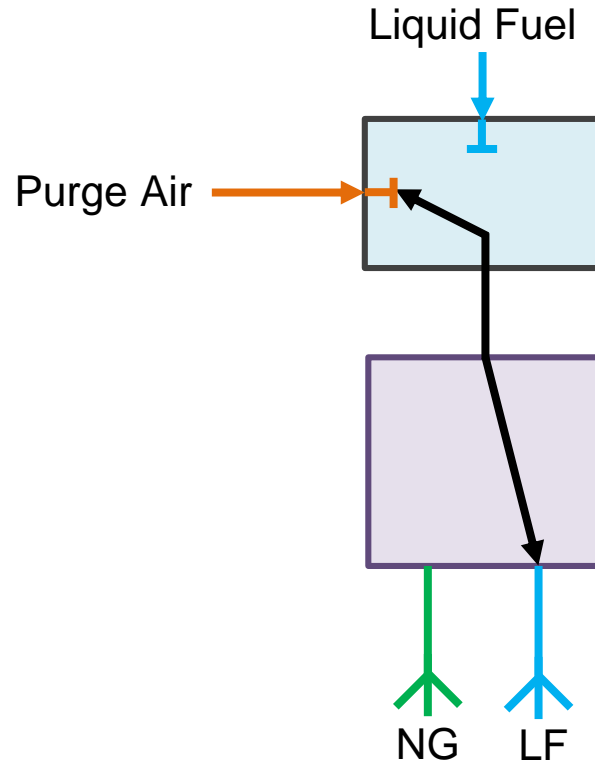


Valve Installation Overview

Check Valve Combustor Arrangement:



3-Way Valve Combustor Arrangement:

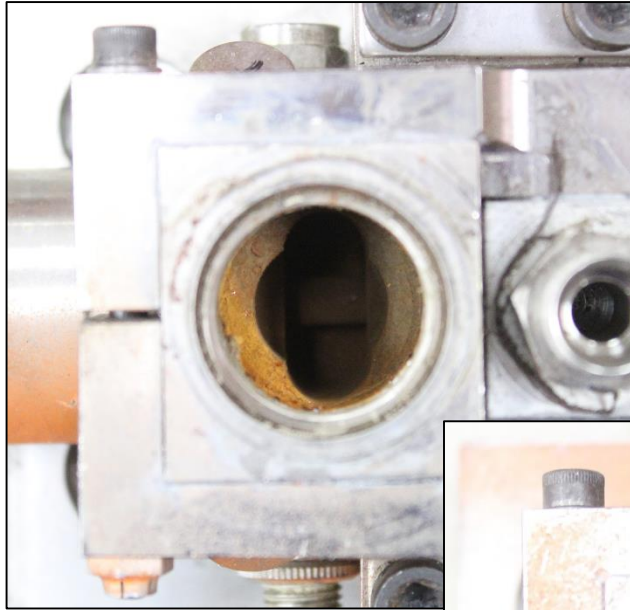


System Influence on Turbine Reliability _____

Upstream System Issues: Fuel System

- **State of health of the Overall Liquid Fuel System can be seen in the condition of the JASC Valves.**
- **All upstream components and operational conditions leave a signature in the JASC Fuel System Valves.**
- **Fuel and Purge Air for combustion success pass through JASC components.**
- **JASC will share operational findings of site components.**

Upstream System Issues: Fuel System



System Influence on Downstream Devices



Upstream System Issues: Fuel Supply

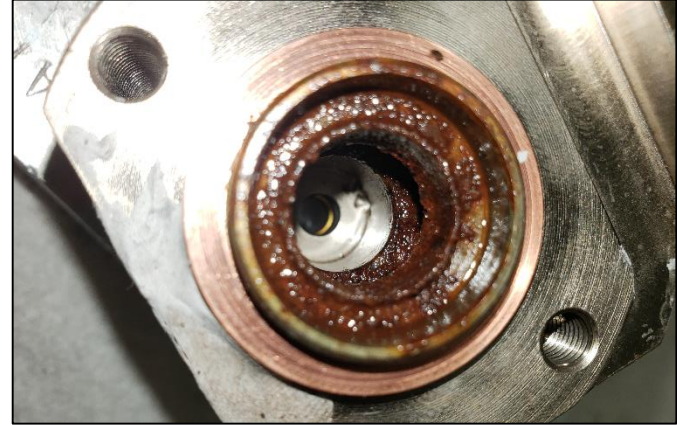
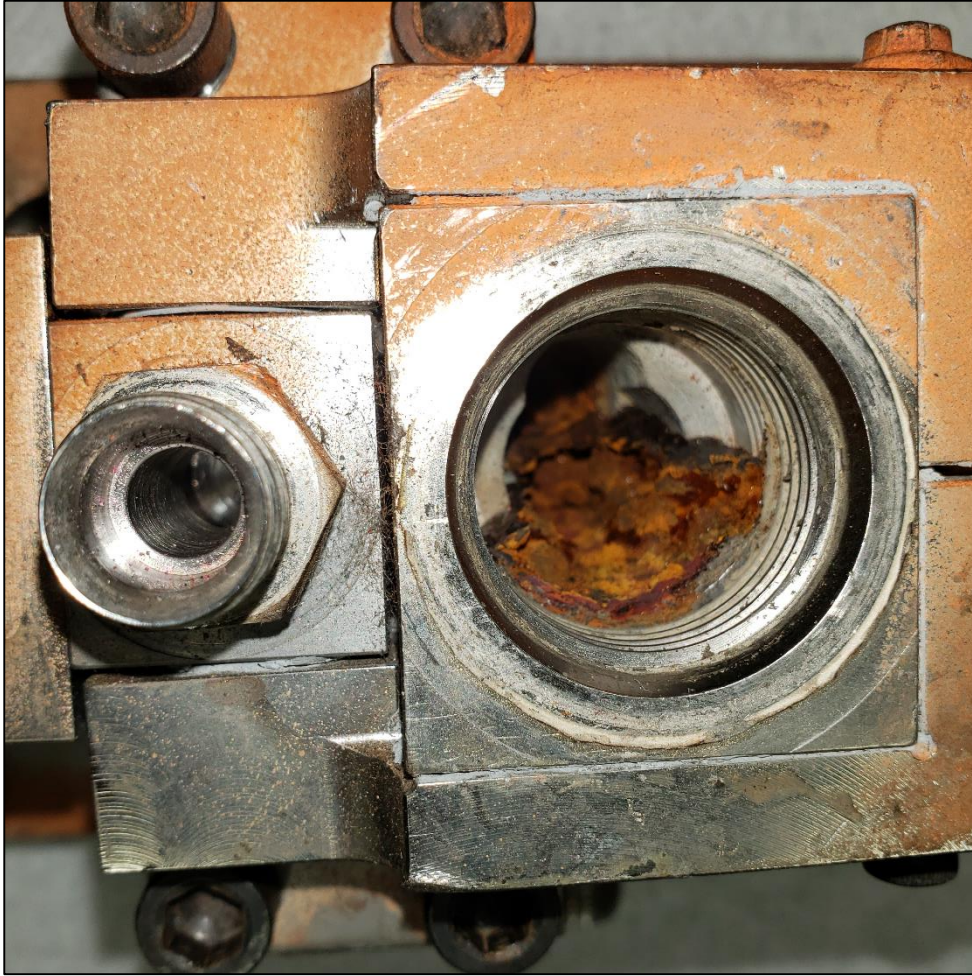


Fuel System Corrosion Passing from Tank to Flow Divider

System Influence on Downstream Devices _____

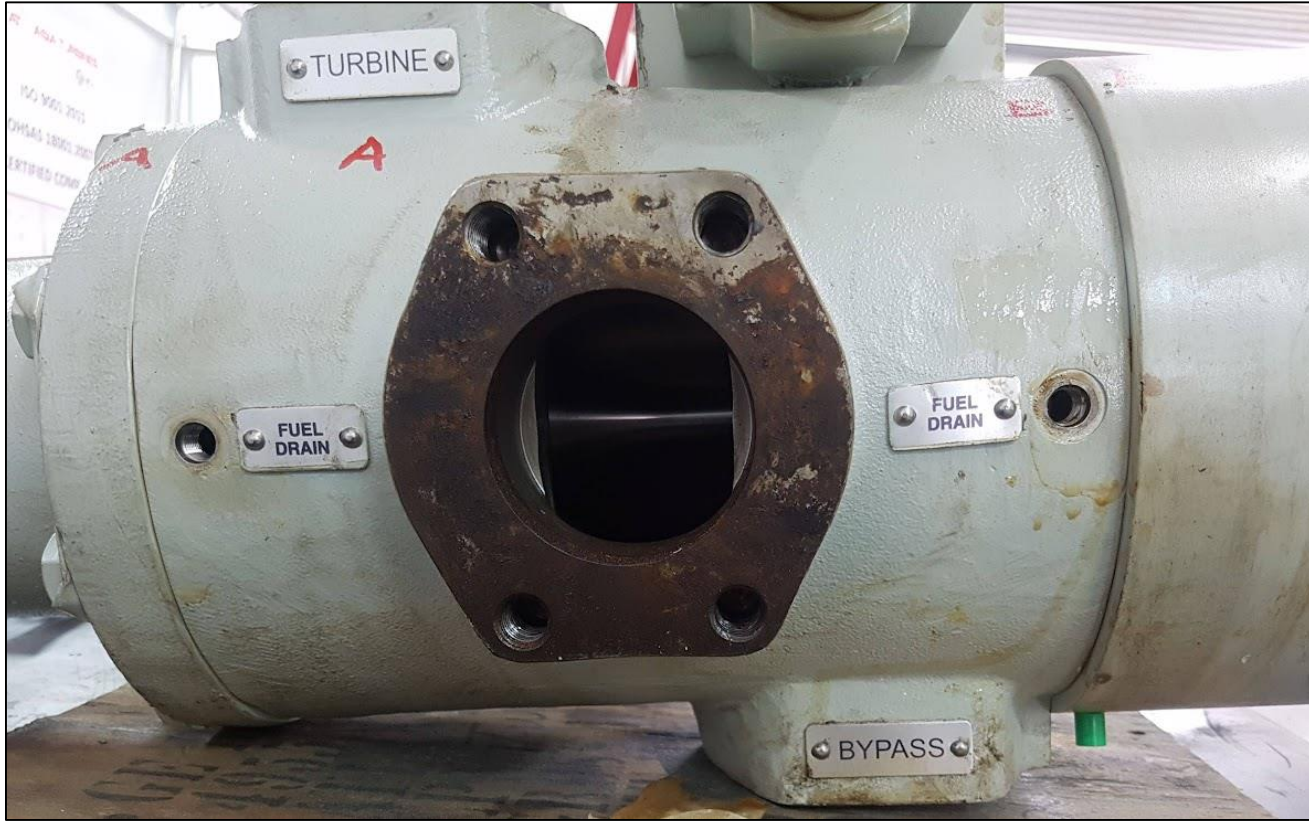


Upstream System Issues: Fuel System



System Influence on Downstream Devices

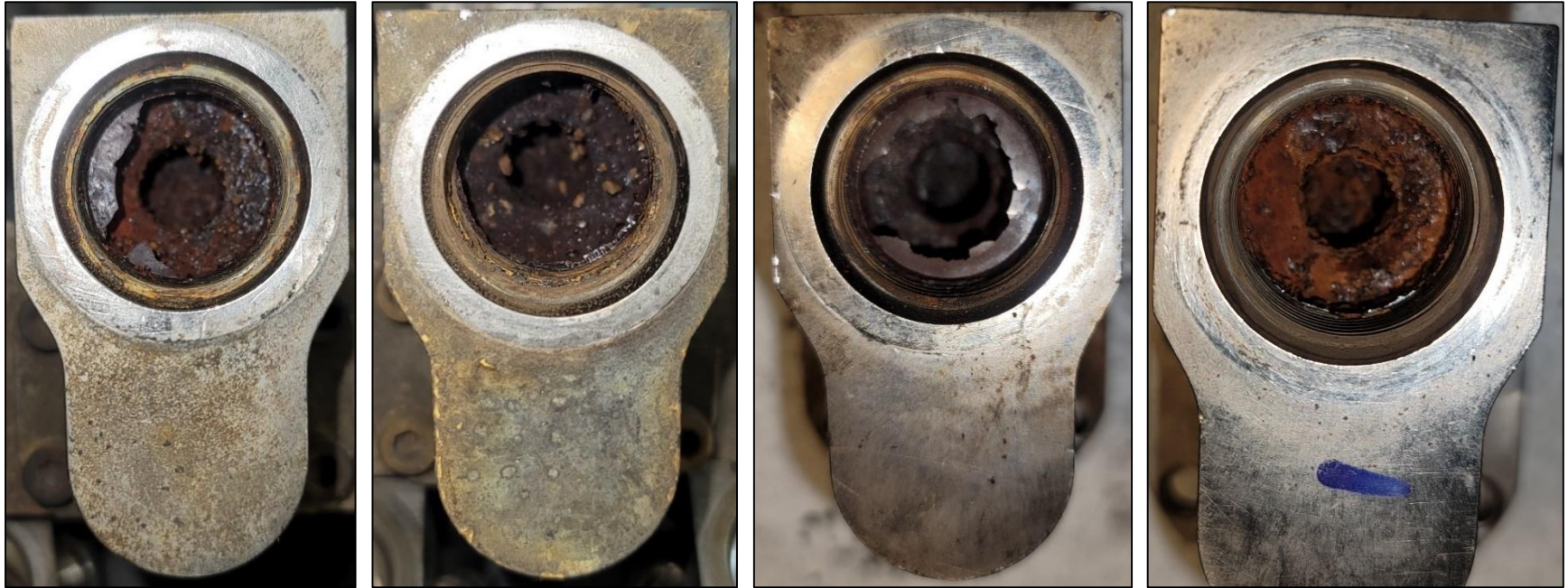
Upstream System Issues: Fuel Supply



System Influence on Downstream Devices



Upstream System Issues: Purge Air Supply

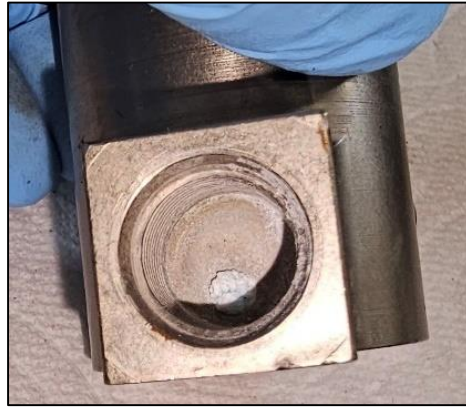


Oxidation and Deposition from Purge System

System Influence on Downstream Devices



Upstream System Issues: Pilot Air Supply



Contamination

System Influence on Downstream Devices



Evidence of Poor Thermal Management



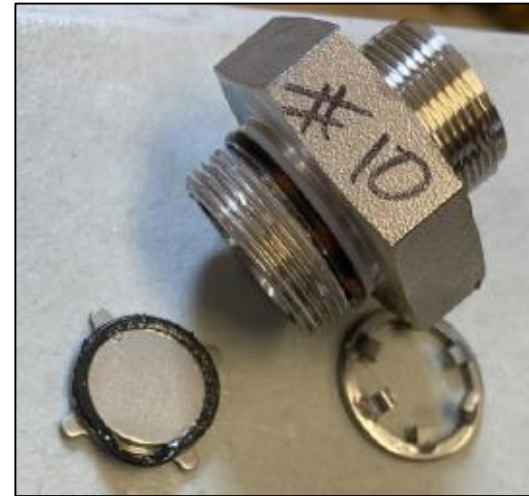
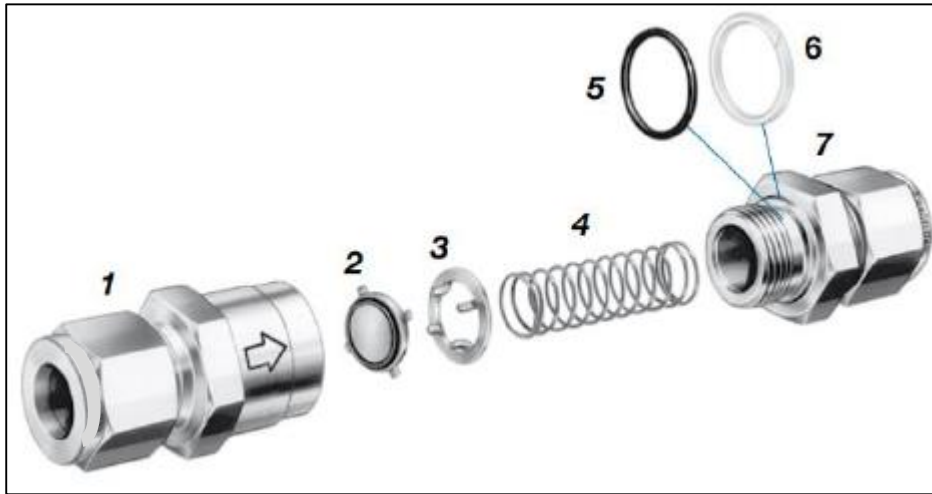
Coke Formation: Internal/External

System Influence on Downstream Devices



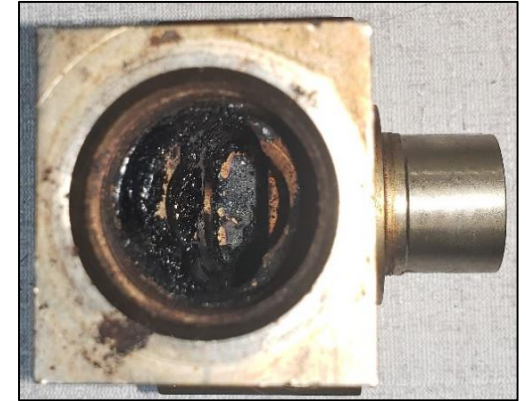
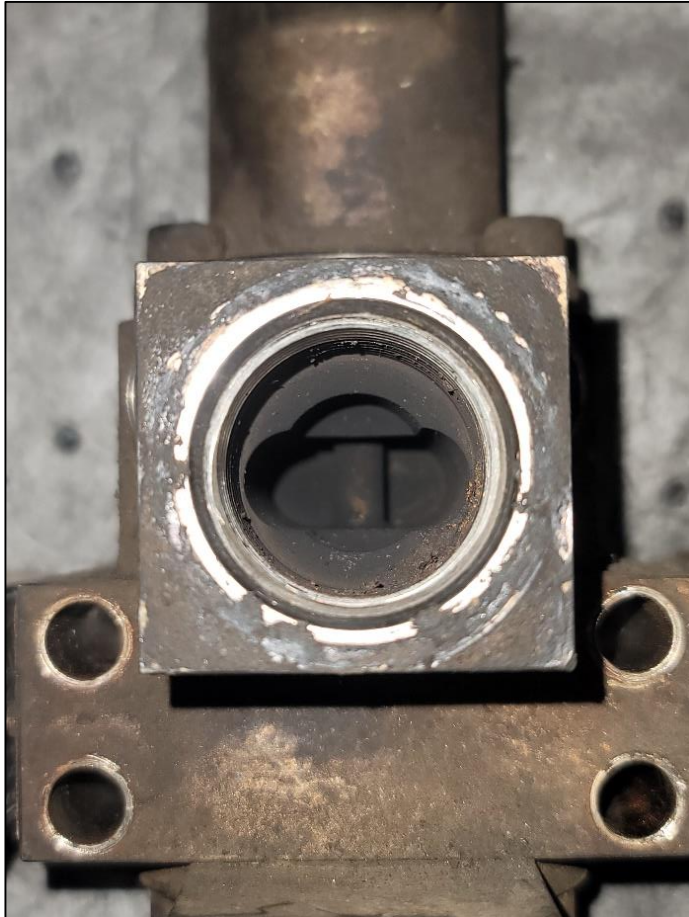
Catalog Check Valves

Not for the Turbine Environment



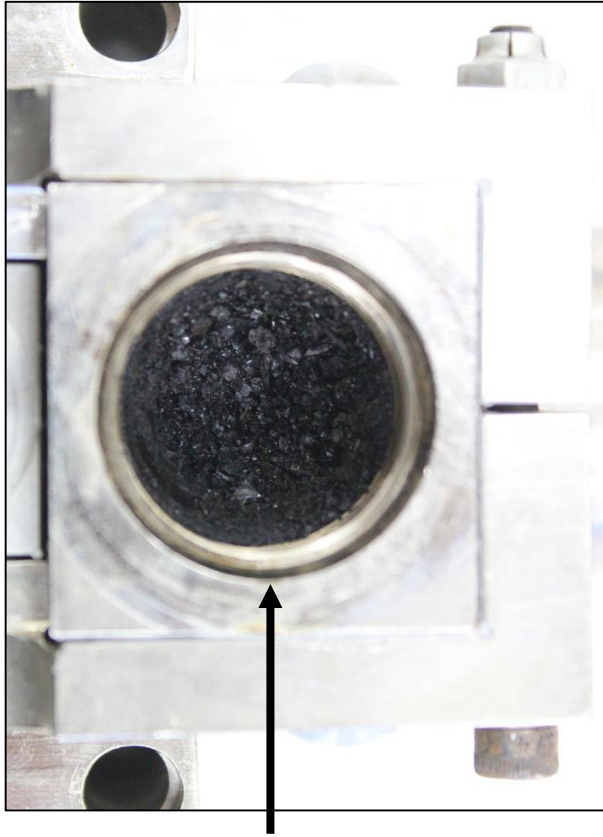
System Influence on Downstream Devices _____

Examples of Valve Coking During Service

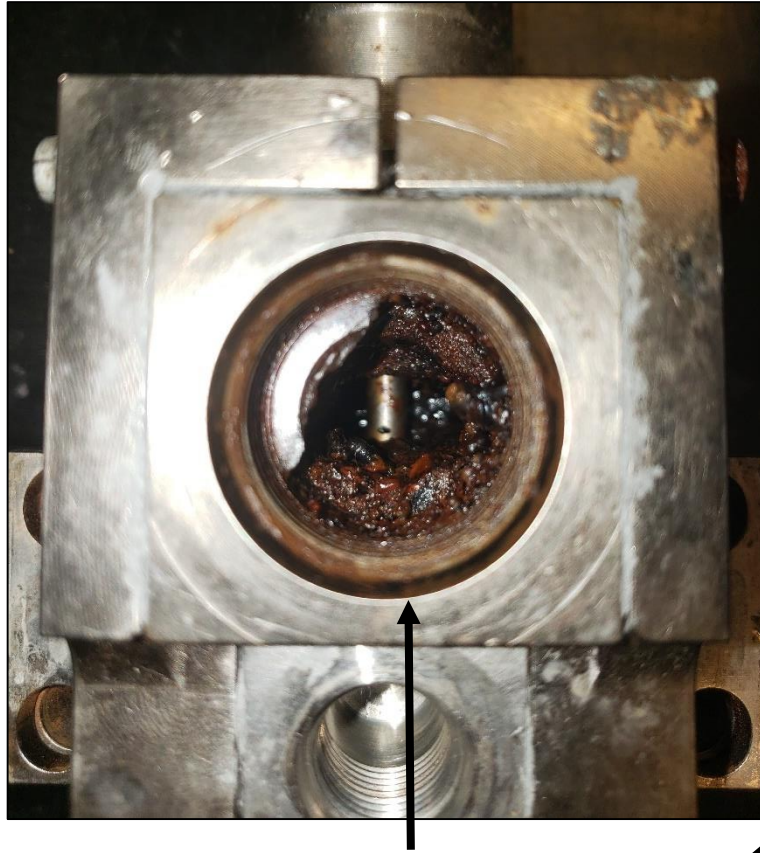


System Influence on Downstream Devices _____

Examples of Valve Coking During Service



Granular deposits
from external sources

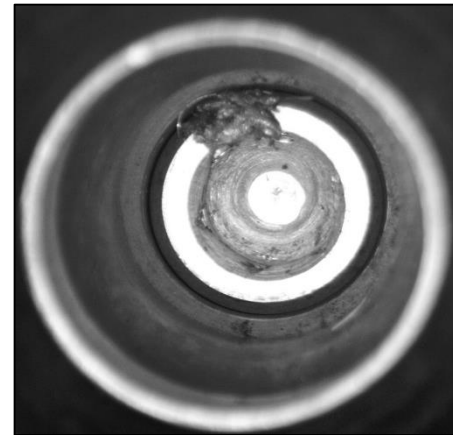
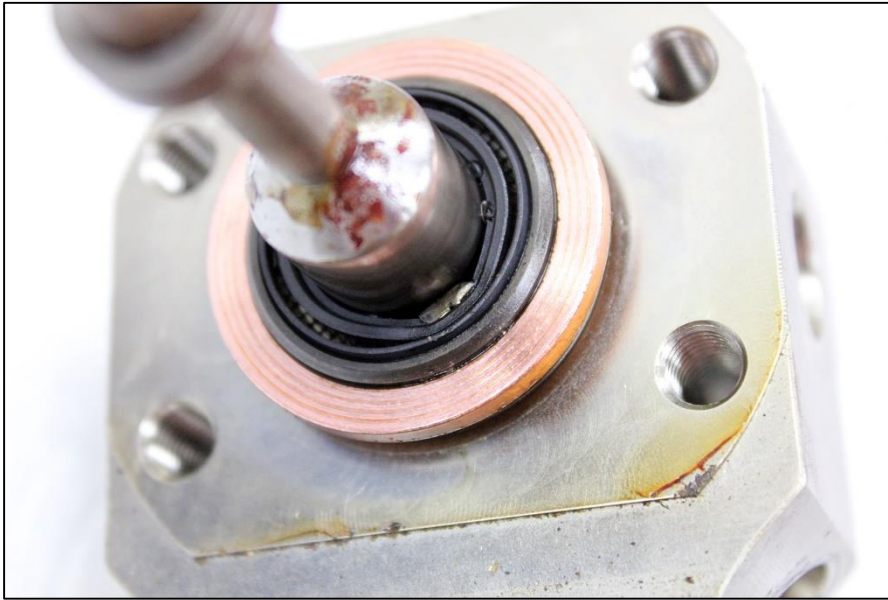


Coke from residual
stagnation



System Influence on Downstream Devices

Examples of Valve FOD In-Service



System Influence on Downstream Devices



JASC Best Practice Actions for System Reliability

Fuel Supply

- Eliminate stagnant fuel
- Eliminate water
- Eliminate bacterial/fungal growth
- Promote VOC cleaning action: circulate fuel
- Maintain filtration functionality
- Eliminate system FOD
- Prevent thermal degradation and coke formation

Purge Air Supply

- Maintain moisture separation for dry air
- Reduce temperature as much as possible
- Maintain purge air compressor seals/oil seal leakage
- Maintain adequate pressure/flow

Pilot “Instrument” Air

- Maintain clean and dry

System Influence on Downstream Devices _____



3 Generations of JASC Liquid Fuel Components

GENERATION

FEATURES

1

**INTRO TO TURBINE
FIELD SERVICE**

-ANSI CLASS 6 SEATS
-DAMPING
-OPERATIONAL SURVIVABILITY
-DEDICATED DESIGN FOR POWER
GEN APPLICATION

2

**THERMAL
MANAGEMENT**

-ELIMINATION OF COKE
-INTRO OF WATER COOLING

3

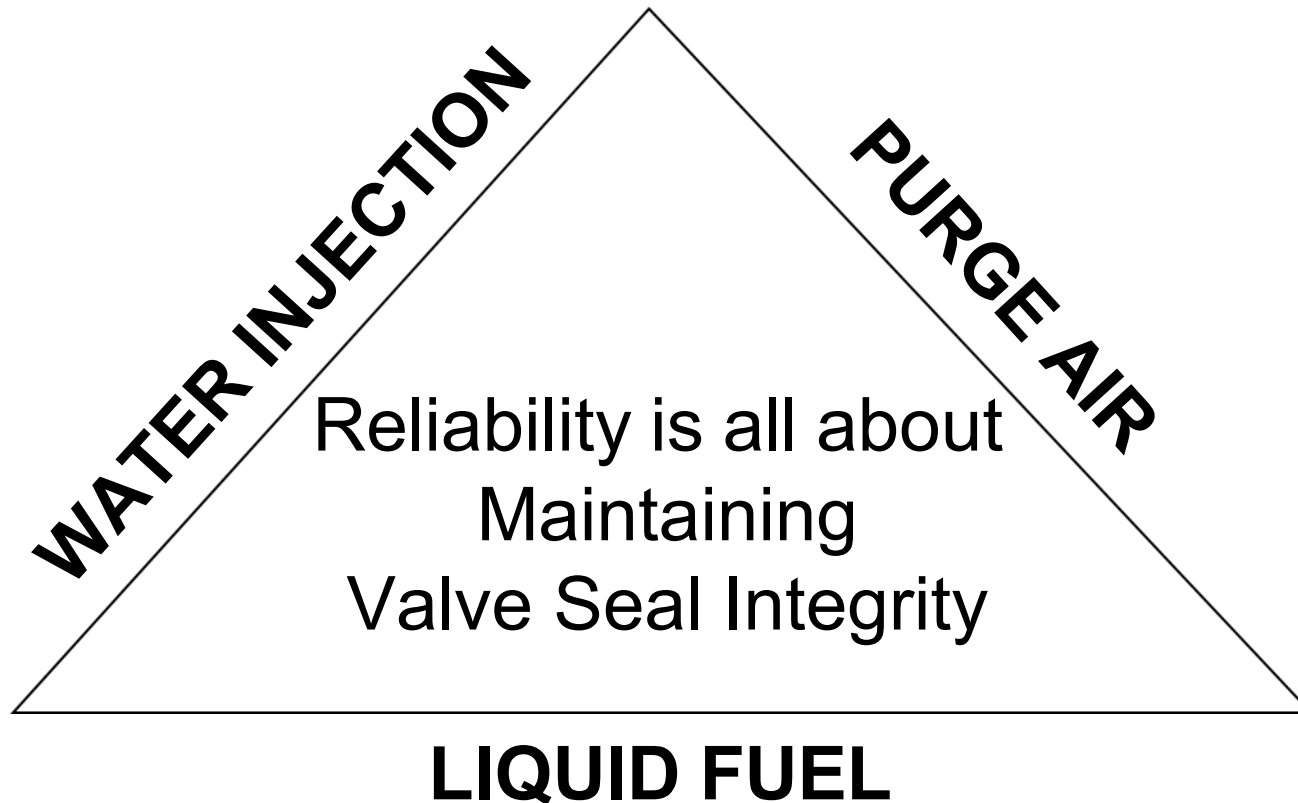
**EXTENSIVE USE OF
STAINLESS STEEL**

-ELIMINATION OF CORROSION IN
VALVES
-COOLING CLAMPS

JASC 3rd Generation Fuel System Improvements _____



Equally Reliable Systems Maximize Performance



Seal Leakage Cause and Effect

The leading causes for seal leakage are ineffective thermal management and FOD, which negatively impact turbine systems in different ways:

System	Effect
Liquid Fuel	Fuel Stop Valve Seal Unloaded Fuel System Evacuation Fuel Pump, Flow Divider, Fuel Filter Compromised Bypass Valve Oscillation Exhaust Temperature Spreads Out of Balance Limits Nozzle Coking
Purge Air	Compromised Valve Seal High Frequency Oscillation Nozzle Coking
Water Injection	Water System Evacuation High Frequency Oscillation

Dual Fuel Reliability: Optimizing System Capability for Reducing Fuel and Maintenance Cost

Predictable Start and Transfer Capability on Liquid Fuel Is Possible With:

- Normal Scheduled Annual System Maintenance
- No Annual Valve Replacement
- No Laying Up of the Liquid Fuel System
- No Weekly or Monthly Exercising of the Fuel System

JASC Product Design Performance

Where are we in 2024?

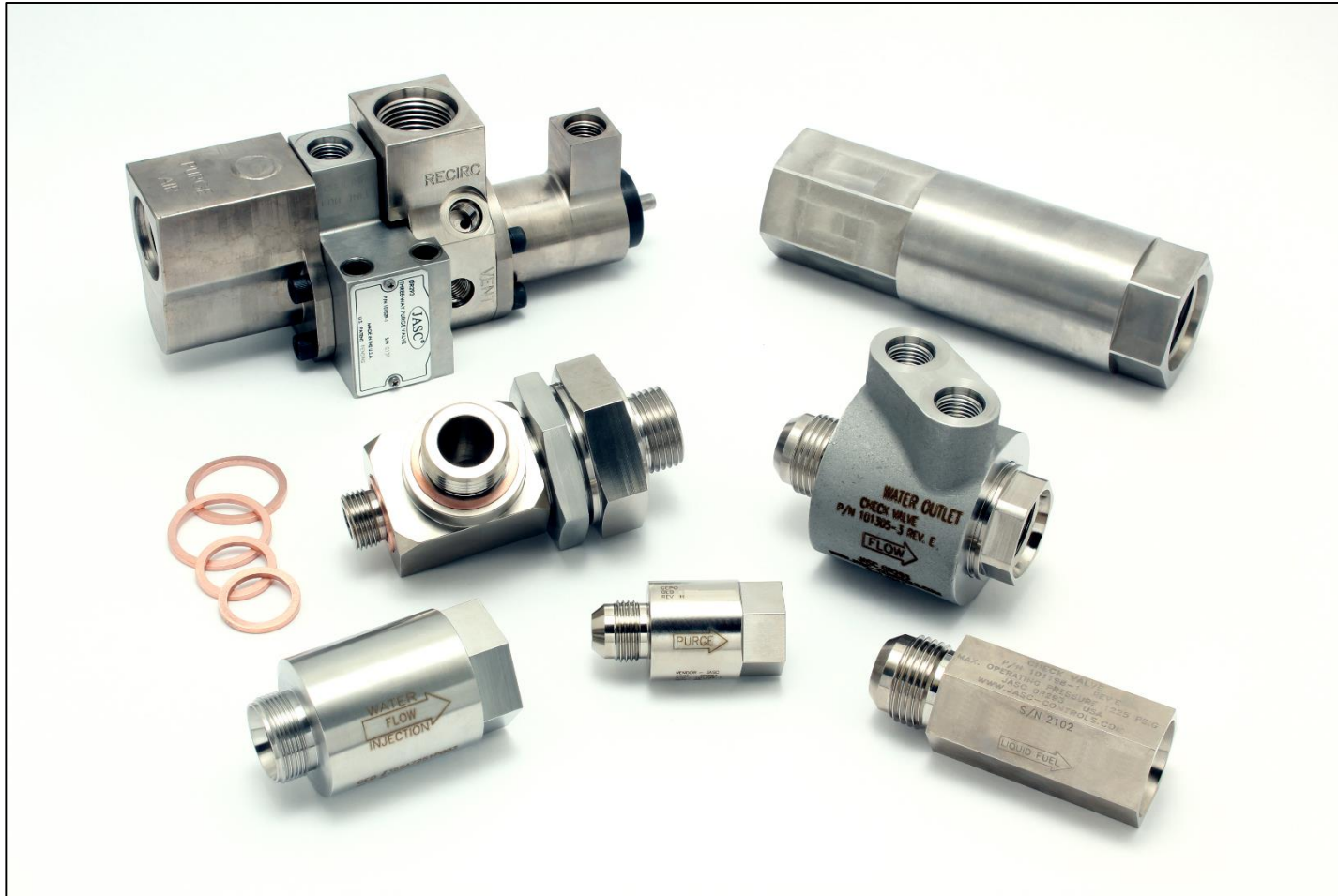
Accomplishments:

- **Liquid Fuel Starts and Transfers Improving Individual Site Historical Norms**
- **Purge Air Check Valve Operation with No Leakage During Liquid Fuel Starts or Transfers**
- **Reduced Check Valve and 3-Way Purge Valve Related Fault between Combustion Inspections Over Multiple Year Periods**
- **Water Injection Flow Proportioning Valve Operation Over Multiple Years for Thousands Of Hours on Natural Gas while the Liquid Fuel System is Inactive**
- **Valve Refurbishment at Scheduled Combustion Inspections**

JASC 3rd Generation Fuel System Improvements _____



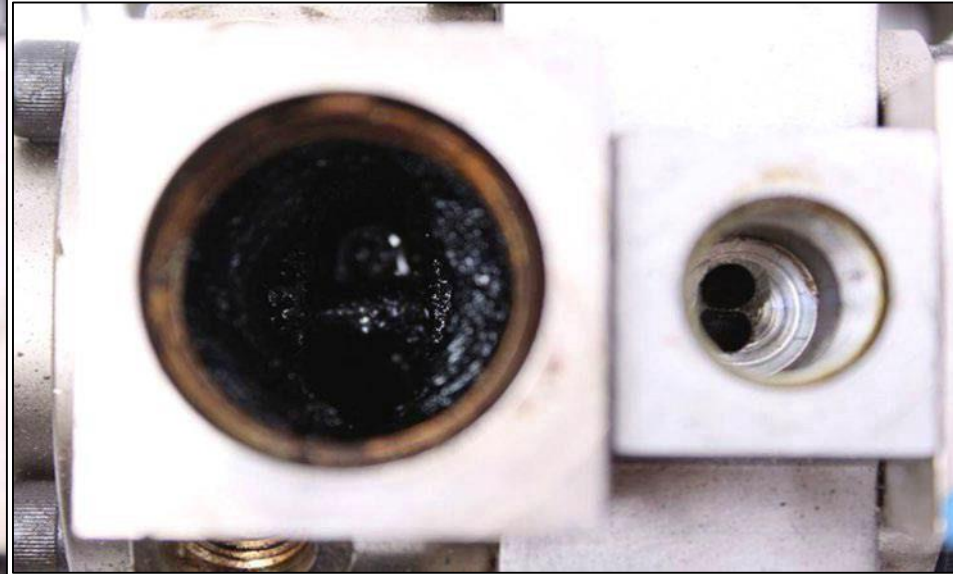
Products Developed Over The Past 20 Years to Improve Serviceability and Improve Reliability of Liquid Fuel, Purge Air and Water Injection Systems



JASC 3rd Generation Fuel System Improvements _____



JASC Water Cooled 3-Way Purge Valve Fuel Inlet Filled with High Viscosity Fuel Migrating from Uncooled Fuel Supply Lines

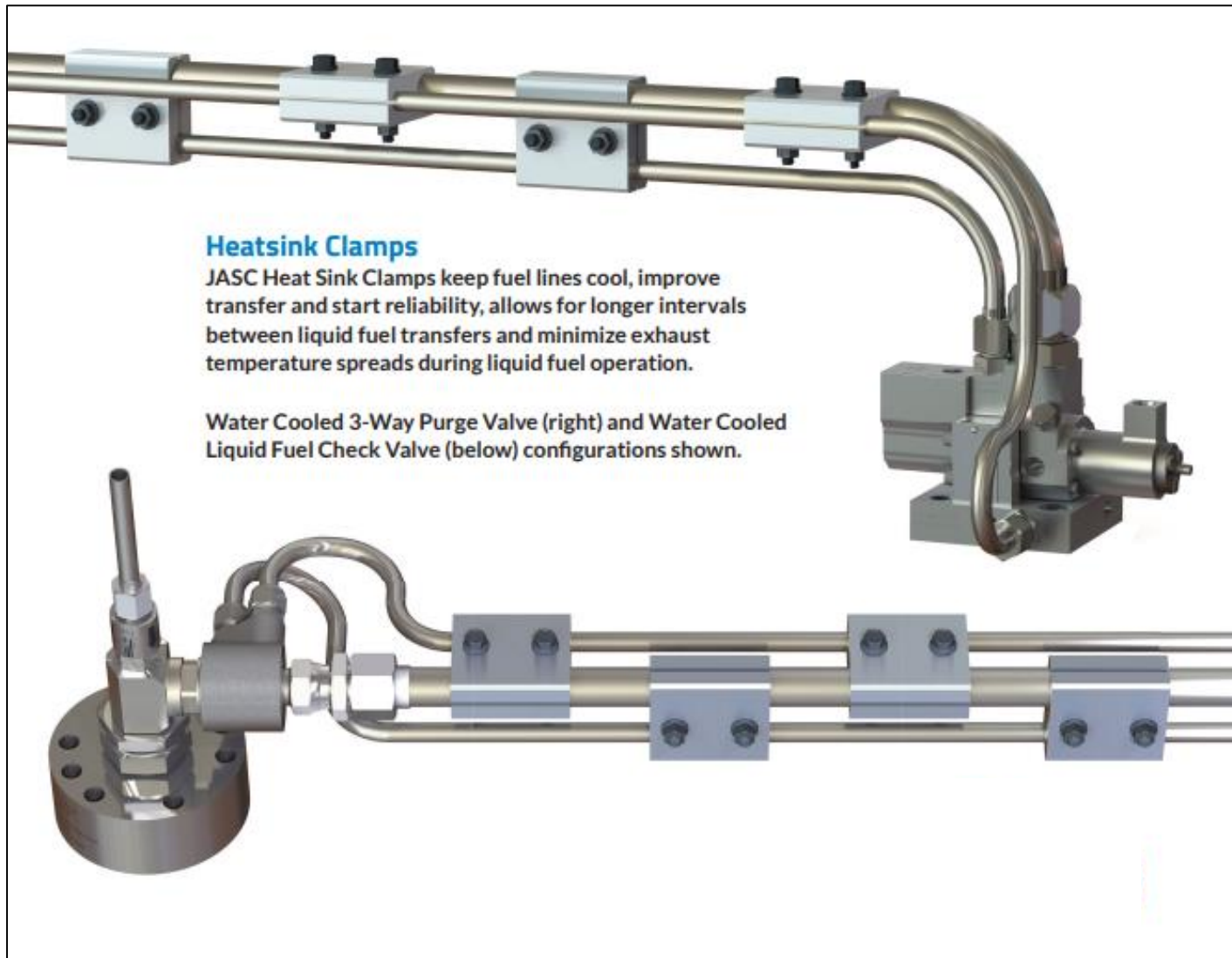


How do we prevent high compartment ambient temperatures from creating viscosity changes in stagnant liquid fuel supply lines?

JASC 3rd Generation Fuel System Improvements _____



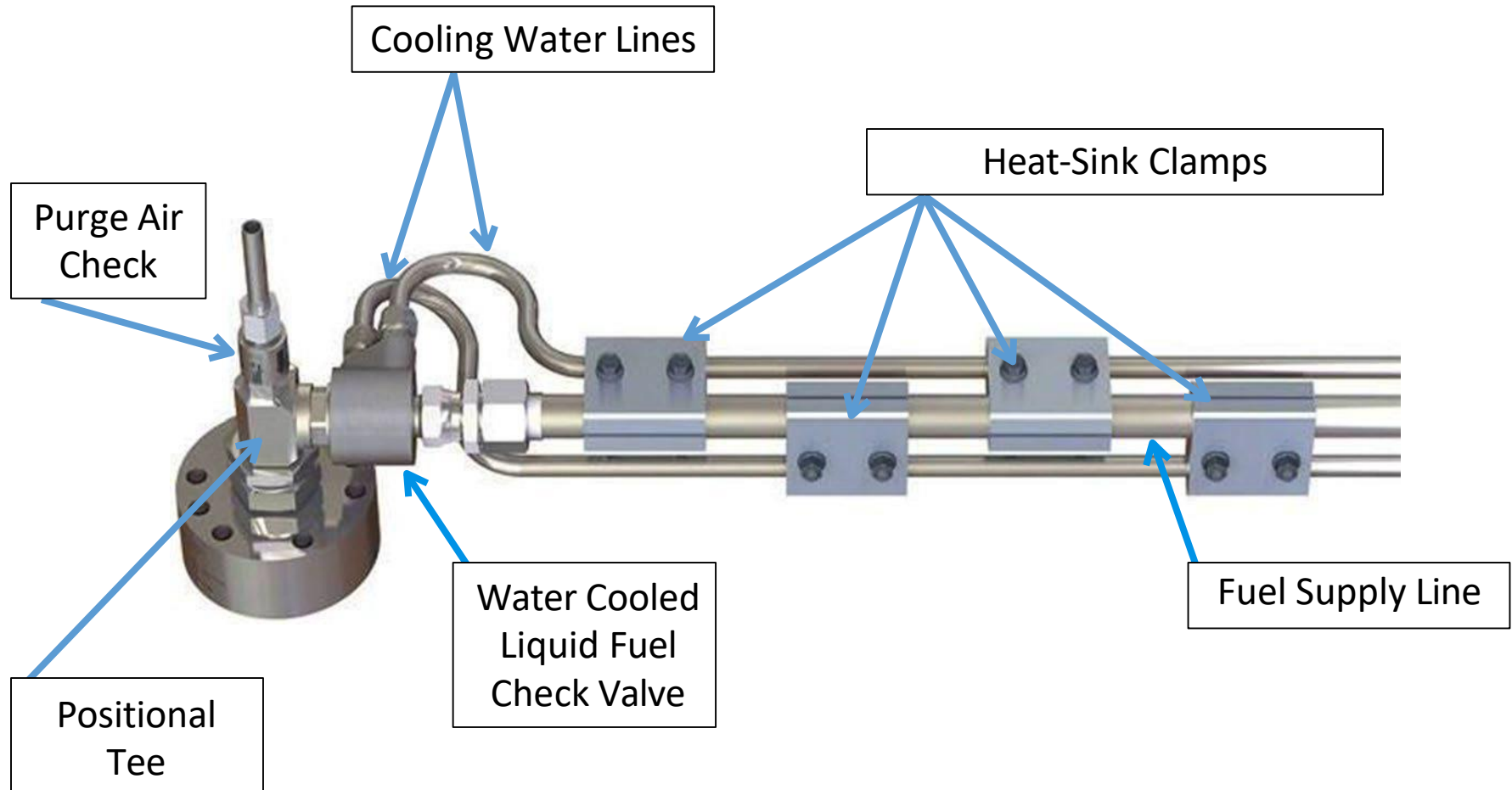
Thermal Management



JASC 3rd Generation Fuel System Improvements _____



JASC 3rd Generation Installation Configuration



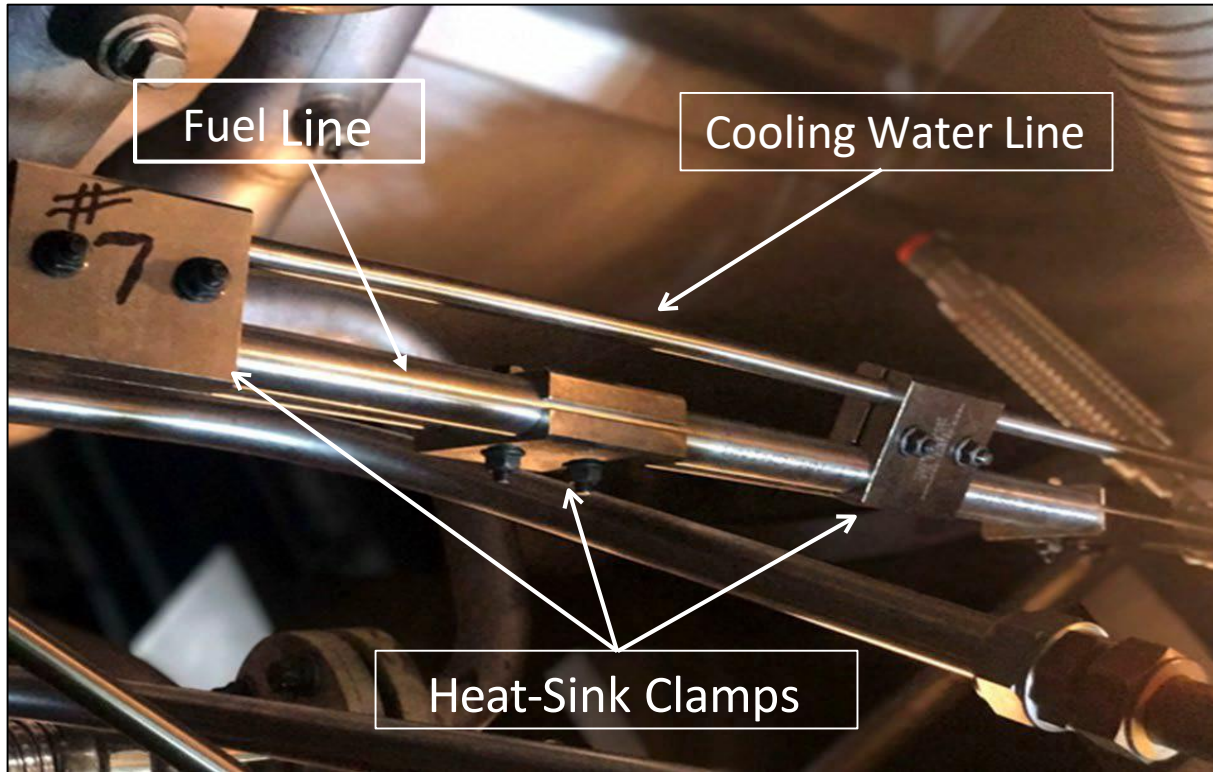
JASC 3rd Generation Fuel System Improvements _____



Dual Fuel Reliability:

Optimizing System Capability for Reducing Fuel and Maintenance Costs

Heat-Sink Clamps: JASC's turbine compartment solution

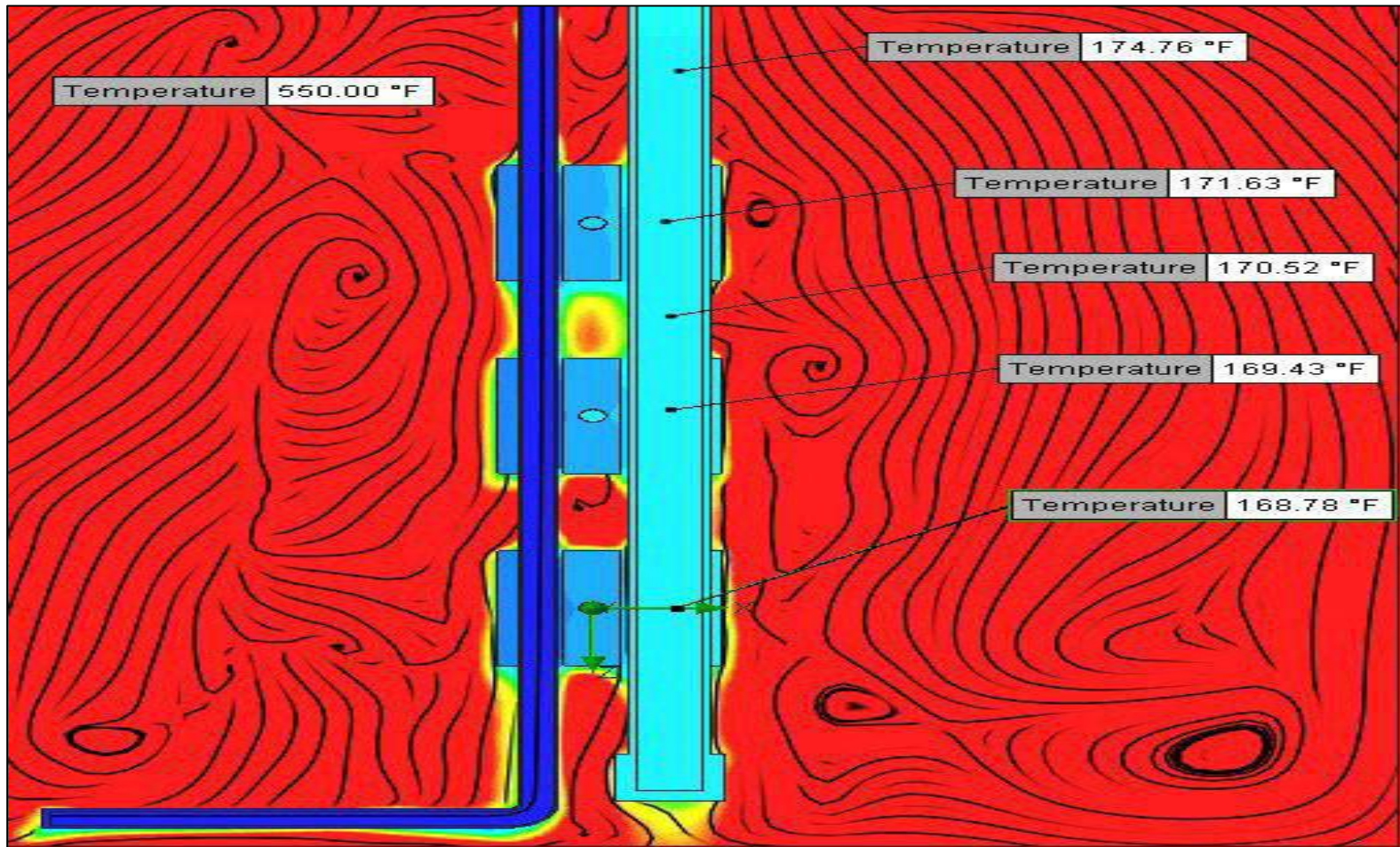


JASC 3rd Generation Fuel System Improvements



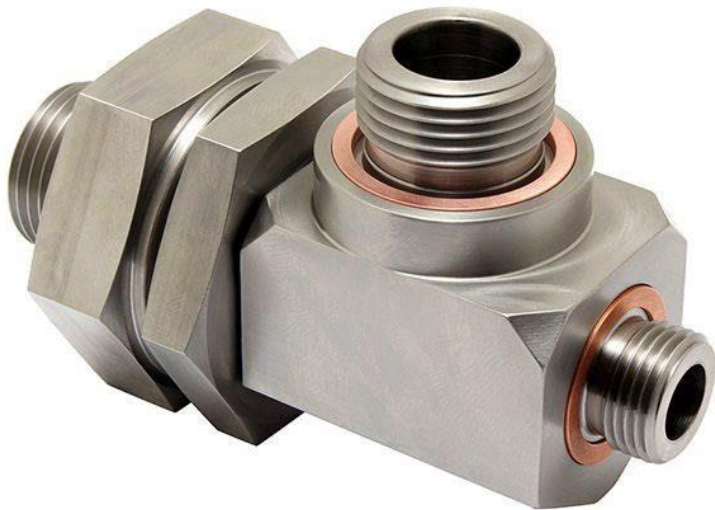
Heat-Sink Clamps

Prevent temperatures from exceeding 200°F, thus avoiding coking of both stagnant fuel or any residual fuel remaining on the piping inner diameter.



JASC Improvements 3rd Generation

Positional Tee Multiple-use crush gasket technology

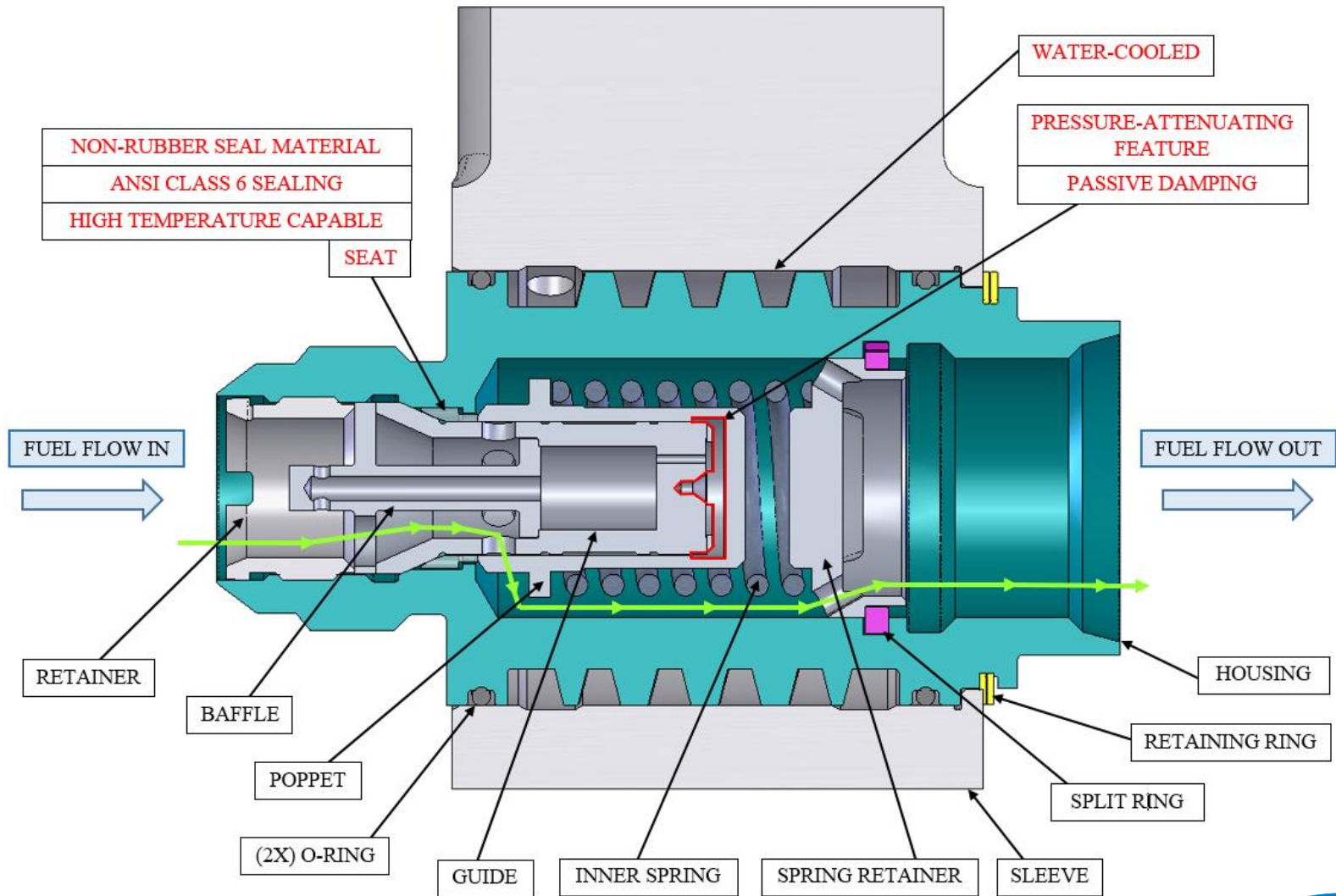


This design eliminates the opportunity for collecting stagnant fuel that exists within other tee configurations

JASC 3rd Generation Fuel System Improvements



Check Valves Designed for the Turbine Environment



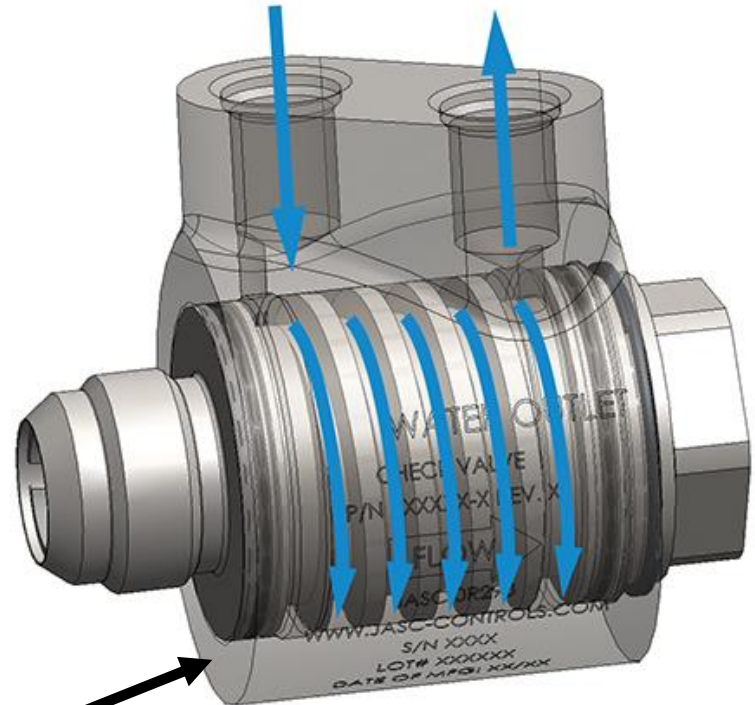
JASC 3rd Generation Fuel System Improvements



JASC 2nd Generation Improvements

Water-Cooled Liquid Fuel Check Valves

- 60 consecutive successful liquid fuel transfers over a 5-year period.
Site Demonstrated Improvement

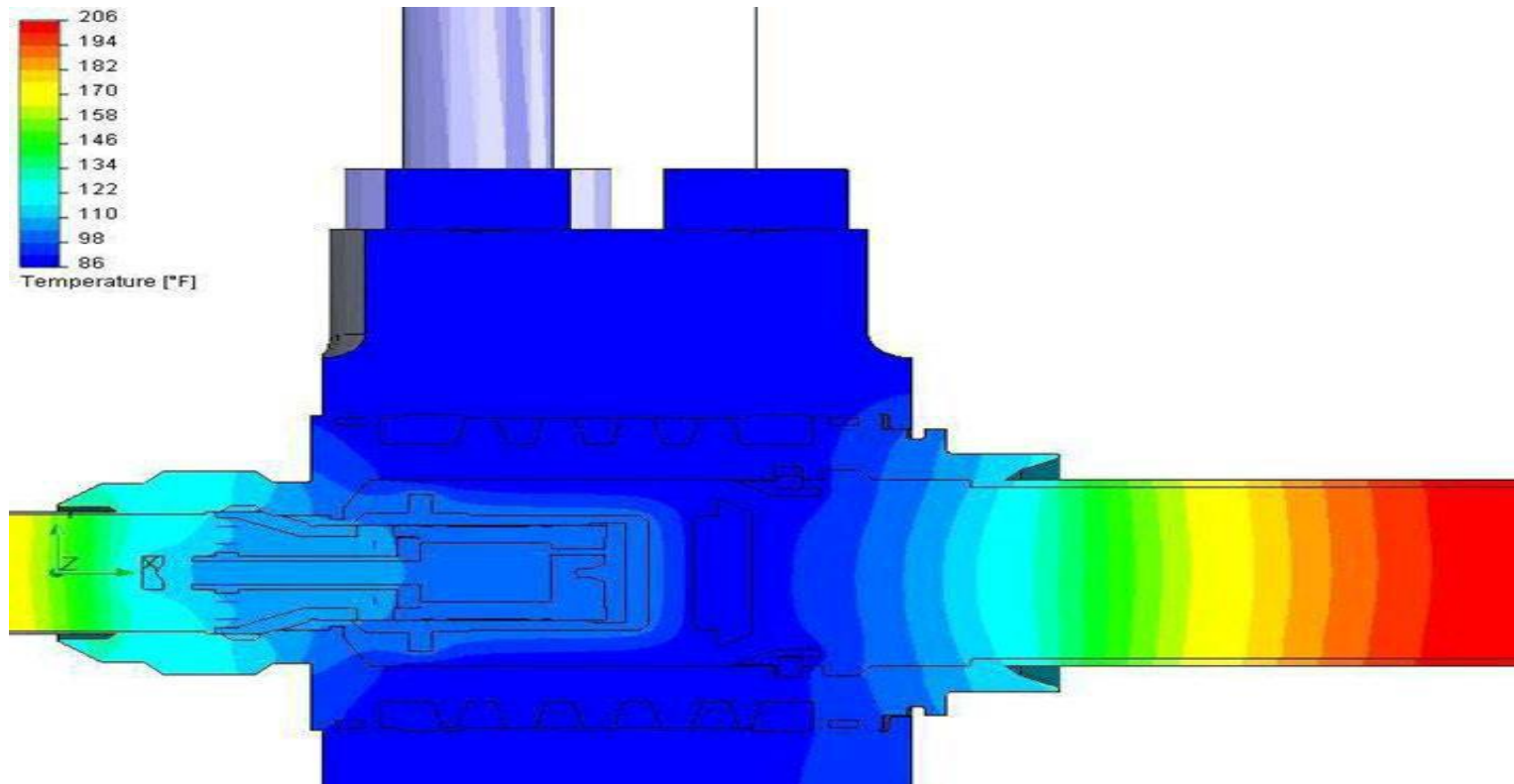


Water jacket added to the standard liquid fuel check valve design to eliminate coking on valve internals

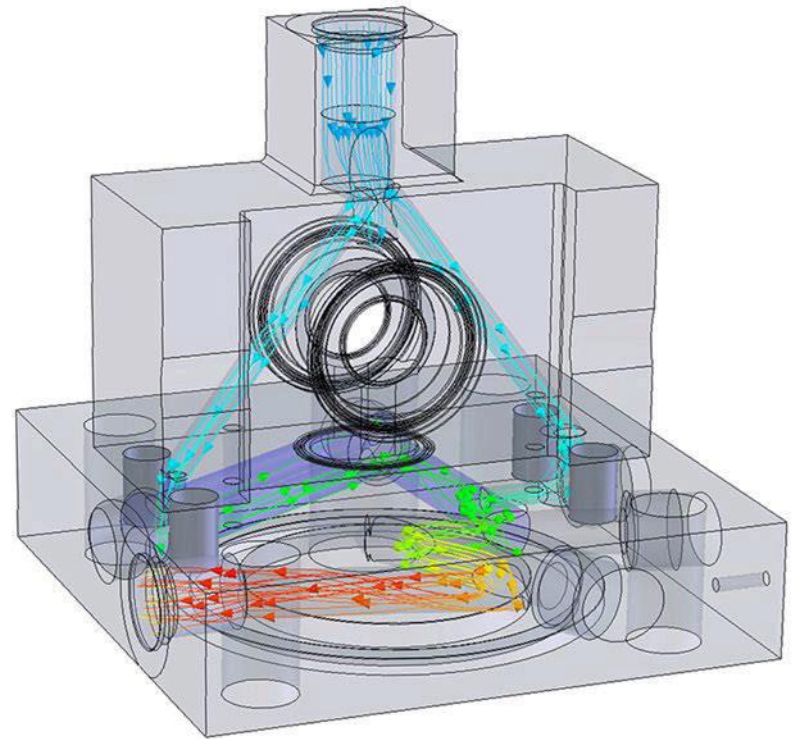
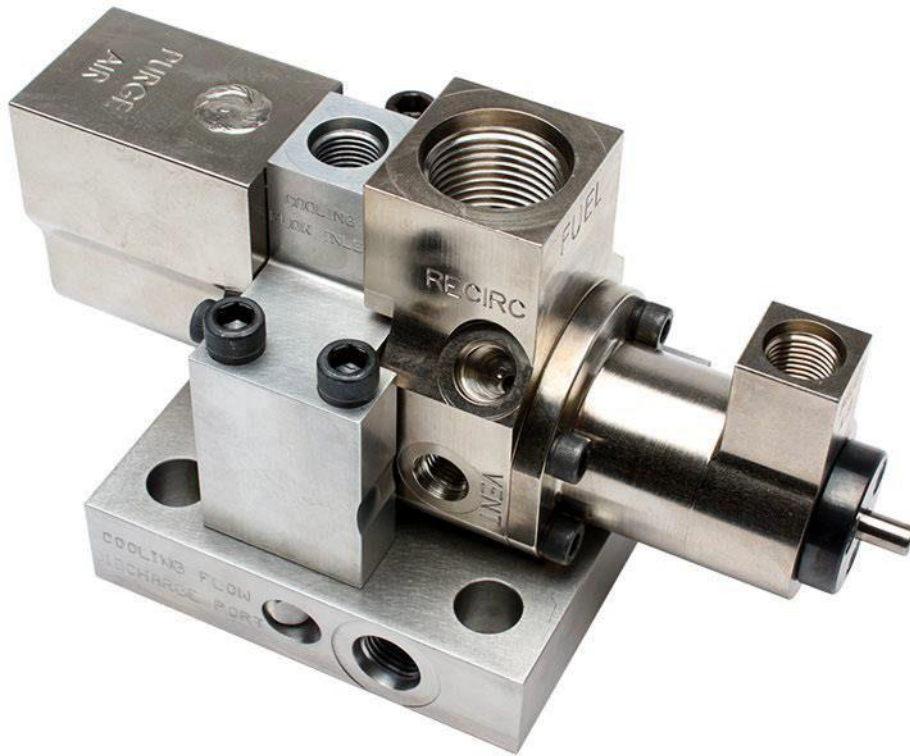
JASC 3rd Generation Fuel System Improvements



Water Cooled Liquid Fuel Check Valve Thermal Mapping



3rd Generation Water Cooled 3-Way Purge Valve



JASC 3rd Generation Fuel System Improvements _____



Frequent Coking Condition of 3-Way Purge Valve: Non-Cooled

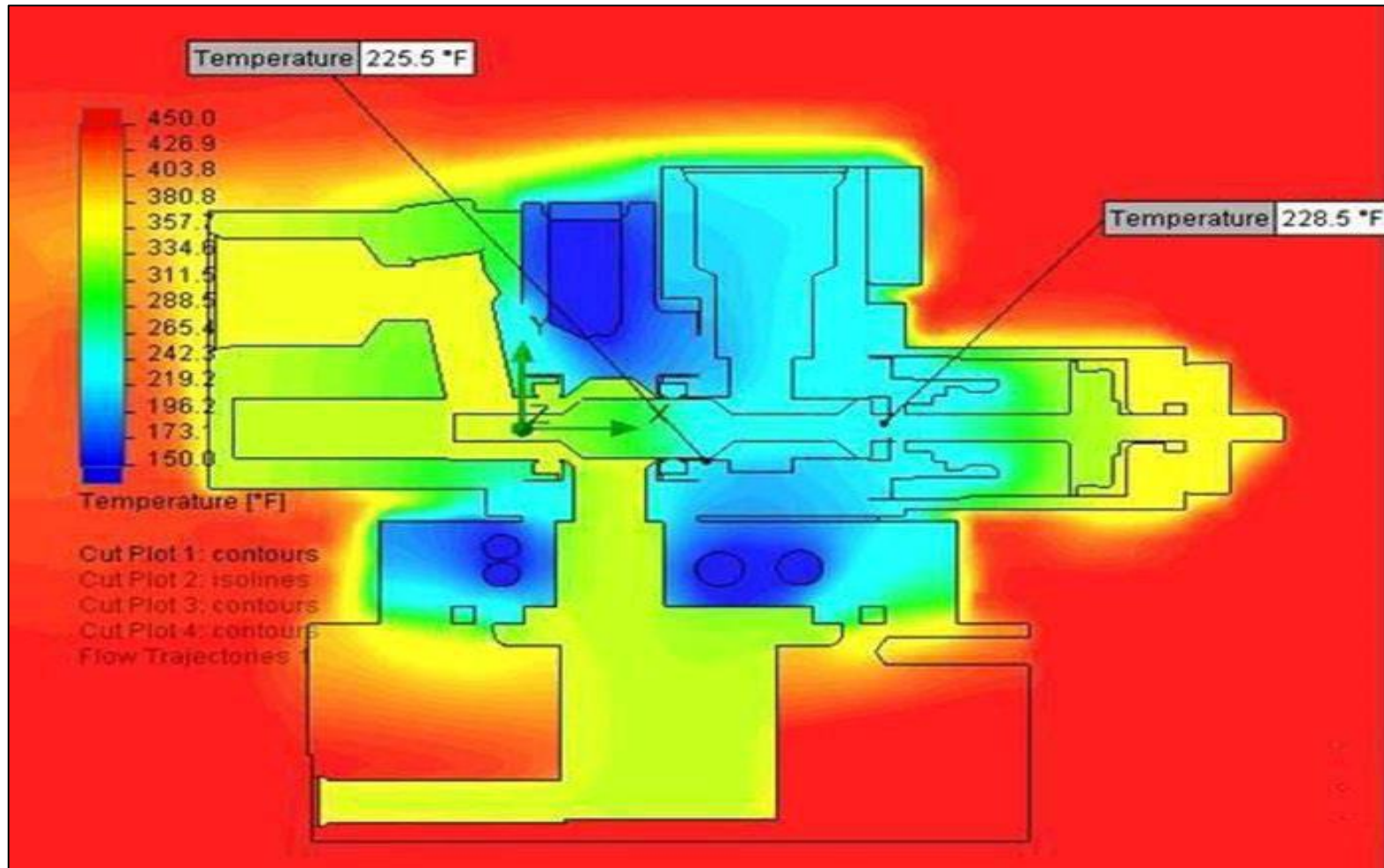


3-way purge valve spools and fuel ports after operation without cooling

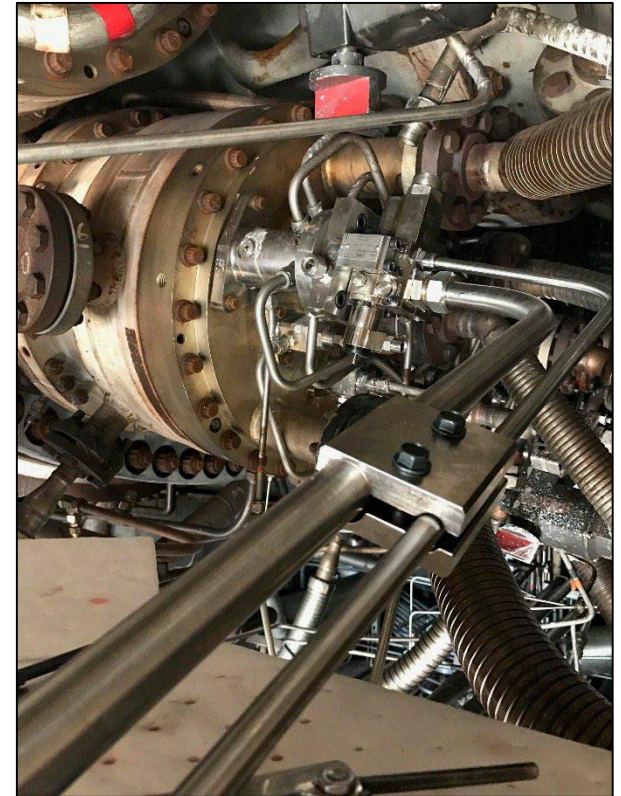
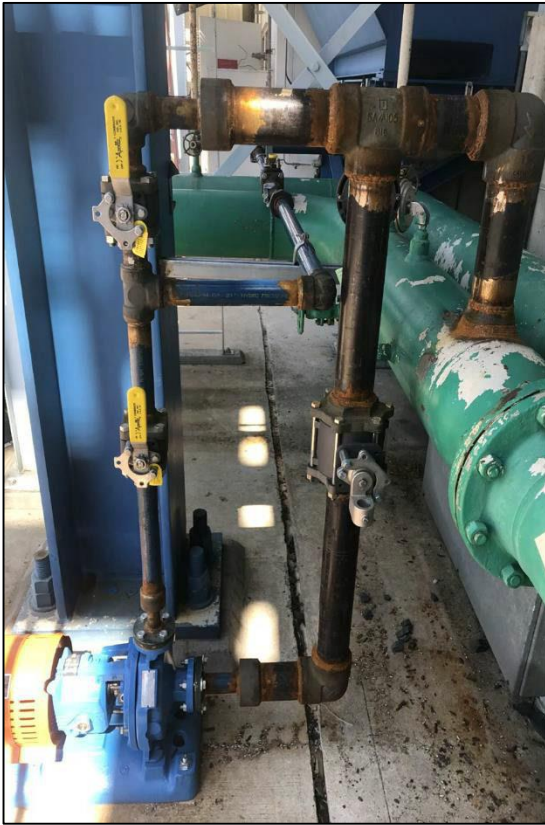
JASC 3rd Generation Fuel System Improvements _____



Water Cooled 3-Way Purge Valve CFD Analysis Thermal Mapping



Perryman GT-51 Fuel System Upgrade to Water Cooled 3-Way Valves: A Case Study

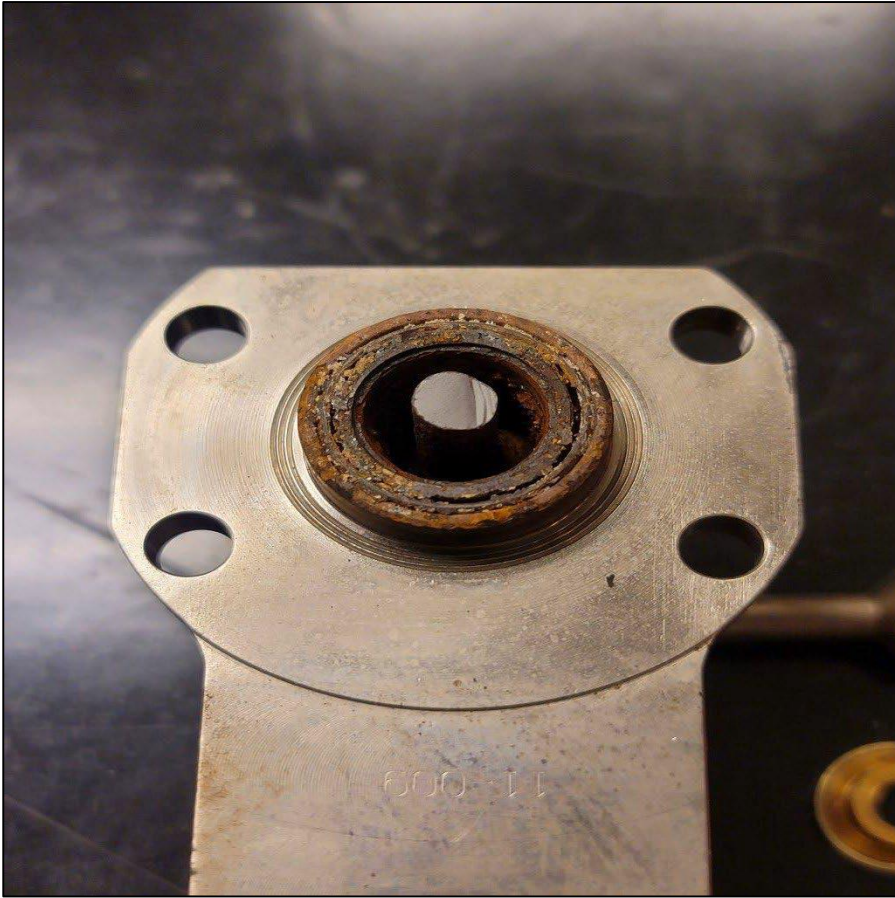


Fuel System Improvement Summary/Lessons Learned _____



JASC 3rd Generation Improvements

Seal Condition After One Year Of
Operation Using Plated Steel Non-Water
Cooled System Design



Seal Condition After 4 Years Of
Operation Using Stainless Steel
Water Cooled System Design



Fuel System Improvement Summary/Lessons Learned _____



Perryman GT-51 Example of Water Cooled 3-Way Purge Valve after 3 Years of Operation



Fuel System Improvement Summary/Lessons Learned _____



Perryman GT-51 Examples of Fuel Nozzle Condition during Borescope



2016



2021

Fuel System Improvement Summary/Lessons Learned _____



Problems That Sites Were Experiencing in 2016 before Upgrading to Water Cooled 3-Way Valves?

- Inability to start reliably on liquid fuel
- 3-Way Purge Valve porting/shuttling affected by coke
- Fuel system evacuation during gas operation
- Coked fuel distributor valves
- Clogged/coked liquid fuel cartridges in nozzles
- Forced outages for fuel nozzle repair
- Exhaust temperature spreads when operating liquid fuel
- Lost profits due to inability for seamless transition from gas to liquid fuel operation
- Annual fuel system maintenance required
- Flow divider issues
- Fuel system layup for gas operation

Fuel System Improvement Summary/Lessons Learned _____



Perryman GT-51 Run Data from 2016 to March of 2021

Total Fired Hours: 4,394

Total Starts: 481

Perryman-51: Liquid Fuel Operation Overview

Year	Unsuccessful Starts	Total Runs	Rate of Success
2016	4	144	97.2%
2017	2	74	97.3%
2018	5	104	95.2%
2019	1	86	98.8%
2020	2	73	97.3%

Most trips were the result of other balance of plant issues

Fuel System Improvement Summary/Lessons Learned _____



User Site Improvements from 2017 to 2021 after Upgrading to Water Cooled 3-Way Purge Valves

Liquid fuel operational difficulties:

- Inability to start reliably on liquid fuel
- 3-way purge valve compromised functionality
- Fuel system evacuation during gas operation
- Clogged/coked liquid fuel cartridges in nozzles
- Forced outages for fuel nozzle repair
- Exhaust temperature spreads when operating on liquid fuel
- Flow Divider issues
- Annual fuel system maintenance
- Lost opportunities due to inability for seamless transition from gas to liquid fuel operation

Resolved

No valve issues since 2017

Resolved

No cartridge issues since 2017

No forced outages for nozzle repair

Resolved

Resolved

Process cost significantly reduced

Significantly improved transfers without tripping

The most frequent, labor intensive, and expensive liquid fuel operational issues have been either eliminated or drastically reduced.

Fuel System Improvement Summary/Lessons Learned _____



User Site Experience from **2022 to 2023** after Upgrading to Water Cooled 3-Way Purge Valves

Liquid fuel operational difficulties:

- Inability to start reliably on liquid fuel
- 3-way purge valve compromised functionality
- Fuel system evacuation during gas operation.
- Clogged/coked liquid fuel cartridges in nozzles
- Forced outages for fuel nozzle repair
- Exhaust temperature spreads when operating on liquid fuel
- Flow Divider issues
- Annual fuel system maintenance
- Lost opportunities due to inability for seamless transition from gas to liquid fuel operation

Resolved

Multiple faults

Resolved

Experienced issues in 2023

Forced outages for nozzle repair

Problem returned

Resolved

Process cost increased

Investigation of system degradation revealed that **Thermal Expansion Relief Valve** was not operating. Inability to open when pressure of idle fuel system reached 45 psi allowed fuel system pressure to relieve through the valves and into the fuel nozzles.

Solution: Replace the TRV

Note: Valve repair 12/15/23. Performance data collection in progress...

Fuel System Improvement Summary/Lessons Learned _____



Optimizing System Reliability for Reducing Fuel and Maintenance Costs

- Water cooled fuel components demonstrate the ability to maintain sealing that keeps the fuel system primed from the stop valve to the fuel controls.
- Water cooling prevents stagnant diesel fuel in the turbine compartment from experiencing fuel viscosity changes which foul fuel valves and seals. Time and temperature will transition fuel into solid coke during extended operation on natural gas.
- Heat-sink clamps provide effective use of water and thermal management of fuel:
 - Eliminate diesel fuel viscosity changes
 - Increase intervals for turbine operation on natural gas
 - Keep fuel lines primed from the stop valve to the fuel control
 - Eliminate opportunities for coke formation inside fuel lines

Fuel System Improvement Summary/Lessons Learned _____



Liquid Fuel Reliability: Understand and Address Upstream System Issues

- JASC offers proven solutions for enhancing backup liquid fuel operation.
- Both Check Valve and 3-Way Purge Valve designs have demonstrated the ability to offer predictable performance between Combustion Inspections.
- JASC provides upgraded hardware to improve O.E.M. installed systems.

**Innovation is our foundation.
Excellence is our goal.
Flow control is our specialty.**

Contact JASC for your most challenging process control situations.

Fuel System Improvement Summary/Lessons Learned _____





Do Not Let System Inadequacy Dictate Your Outage Schedule!



**Non-water cooled 3-Way Purge Valve
spool after less than 1 year of operation**



**Water cooled 3-Way Purge Valve
spool after 3 years of operation
with an optimized system**

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Image References

7F Combustor:

<https://www.gevernova.com/gas-power/products/gas-turbines/7f>

JASC Heatsink Clamps:

Combined Cycle Journal

JASC Spools (Non-water cooled vs. water cooled):

Combined Cycle Journal Issue #66, Pg. 11

<https://www.ccj-online.com/ccj-issue-66/>