

# Actively Cooled Fuel Controls: Enhancing Liquid Fuel System Reliability

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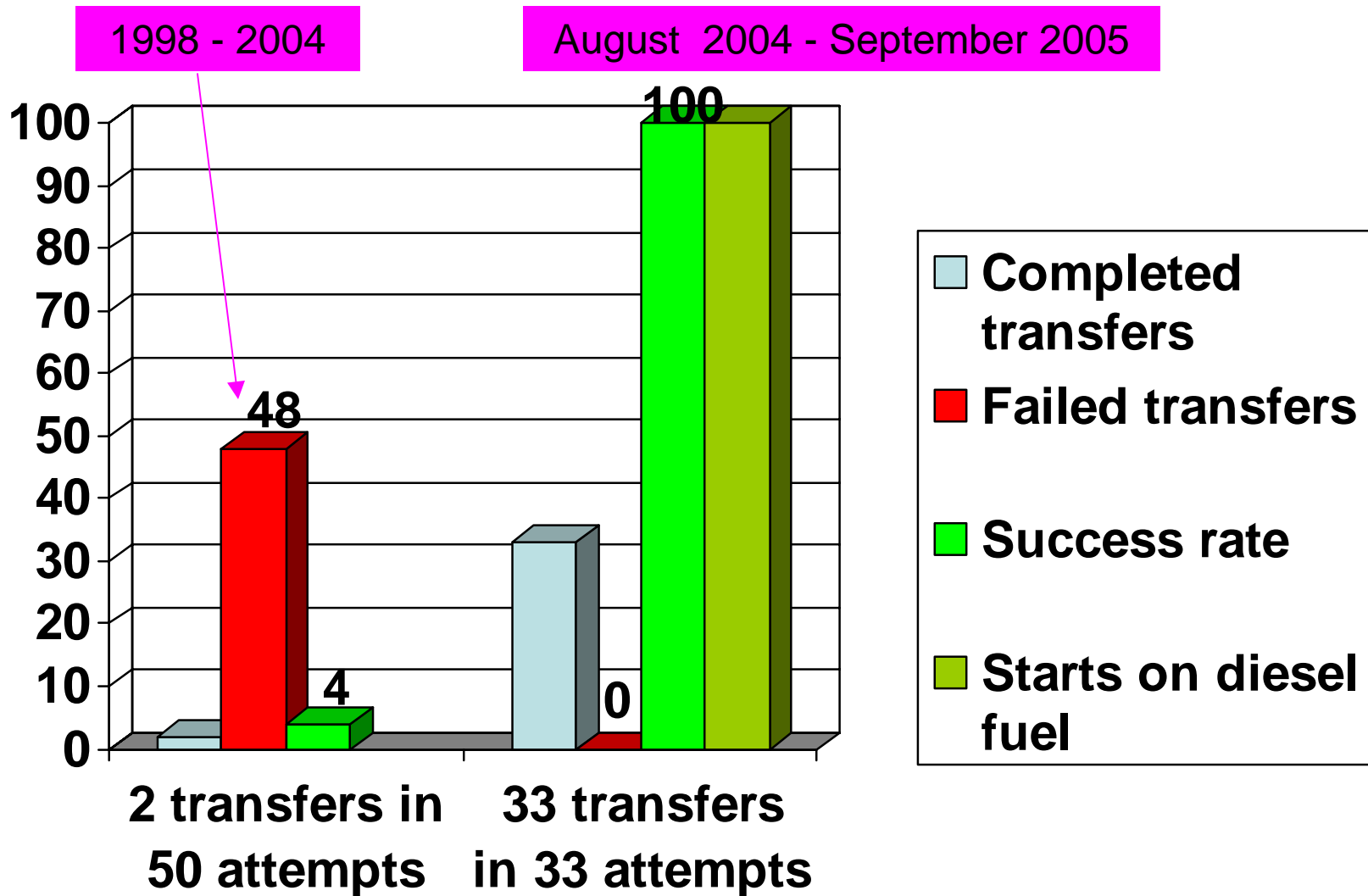
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**2500% improvement in transfer reliability rates. Successful transfer rate improved from 4% to 100% during the test period, August 2004 to September 2005.**



**8000+ hours of operation with WCLFCV's during 2005**

**96,000 cumulative hours of check valve operation without a failure**

# History of Check Valve Failures 1950- 1998

- 1. Different variations of Ball & Spring Check Valve designs utilized: All failed within 2 years of operation requiring fleet wide replacements for in-warranty units.**
- 2. Soft seat check valves: seal melts due to high temperatures, valves stick shut**
- 3. excessive leaks when particulates are trapped between ball and seat during fired shutdowns,**
- 4. ball and/or seat damaged by particles traveling through valve at high velocity,**
- 5. Flow Instability: High frequency oscillation at various pressures and flows; resulted in premature wear of valve internal components, hydraulic hammer caused cycle fatigue failures (breakage) of fuel tubing, resulting in turbine compartment leaks**

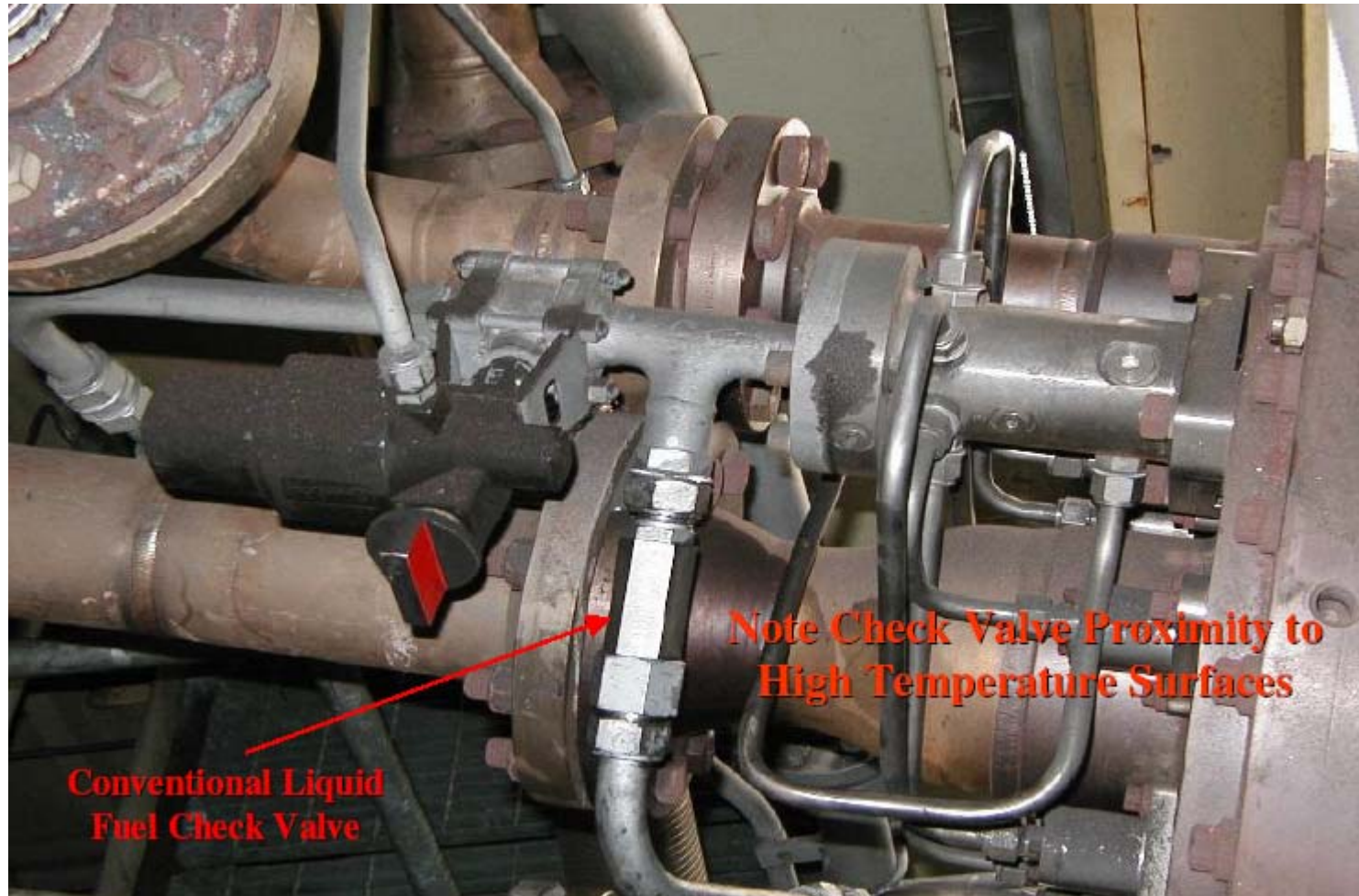
# JASC check valve design features

- 1. Flow stability addressed by incorporating Hem Holtz resonator circuit. This feature will dampen flow divider generated pressure signature of 90 psi pk-pk to 5 psi pk-pk for the entire flow range. Eliminates high frequency oscillation, hydraulic hammer and fatigue related tubing failures.**
- 2. Vespel seal material rated for continuous service of 575 degrees "F", can withstand short intervals of 700 degrees. Abnormal conditions which expose material to 1000+ degrees will only result in charring and cause material to crack. There is no risk of disintegration or material moving downstream to block nozzle orifices.**
- 3. Contamination tolerant design: Multiple injections of 480 grams of Arizona road dust failed to impact the check valve functionality. Feature allows valve to function properly in spite of catastrophic filter failure**
- 4. Knife edge seat decreases risk of particles being trapped between the poppet and seat . As little 5 psi of backpressure will embed particulate into the seat and allow the valve to close.**

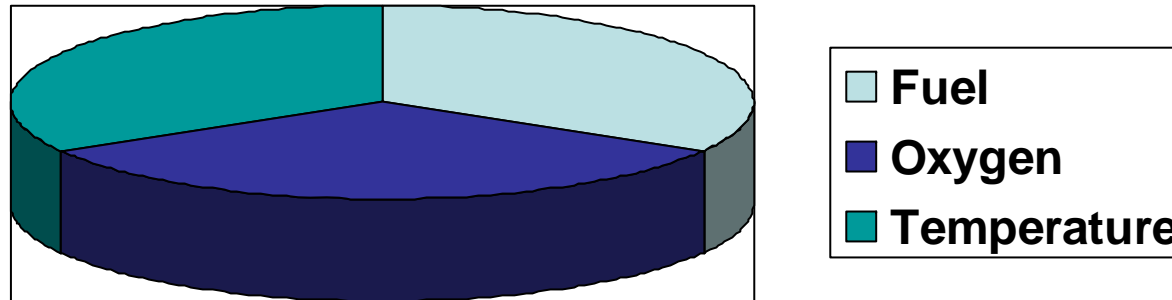
# Current liquid fuel system issues in dual fuel applications

1. **Transfer reliability impacted**
2. **Multiple start attempts required when firing on distillate**
3. **Excessive exhaust temperature spreads**
4. **Liquid fuel system pressurized by purge air/CPD**
5. **Check valve or 3-way purge valve refurbishment or replacement required after gas operation due to coking**
6. **Contamination related failures during commissioning**
7. **Coking of fuel lines**
8. **Liquid Fuel Thermal Expansion during gas operation**
9. **Complete evacuation of liquid fuel lines back to flow divider or beyond**
10. **Trips at load during transfer attempts**

## Standard Liquid Fuel Check Valve Installation



# High Temperatures cause coking!



When operating a dual fuel turbine on gaseous fuel the liquid fuel system is idle. Stationary fuel in close proximity to the combustor is exposed to high temperatures, above 250 degrees “F”, which oxidize the fuel and turn it into a hard substance which coats the internal surfaces of the check valve components, restricting their movement. Once this occurs the check valve will not open and close properly.

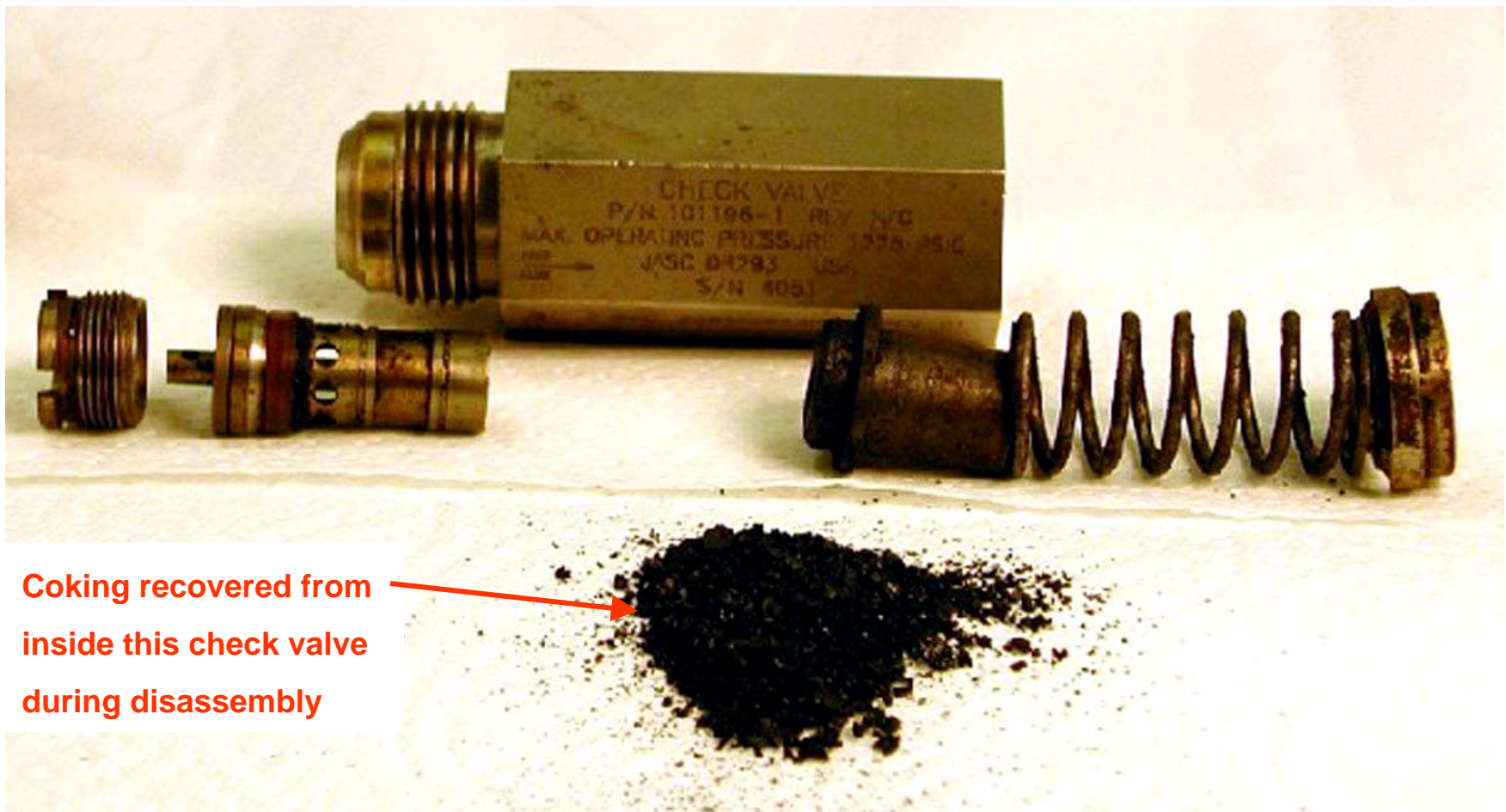
**Lower the temperature and eliminate coke formation!**

## Example of coking in ball & spring check valve design

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# Coking – Primary Cause for Failed Transfer



Coking recovered from  
inside this check valve  
during disassembly

A standard Liquid Fuel Check Valve showing the realized coking potential.

# Water Cooling of Flame Detector

Extending Concept to Liquid Fuel Check Valves



# Installed in 6FA

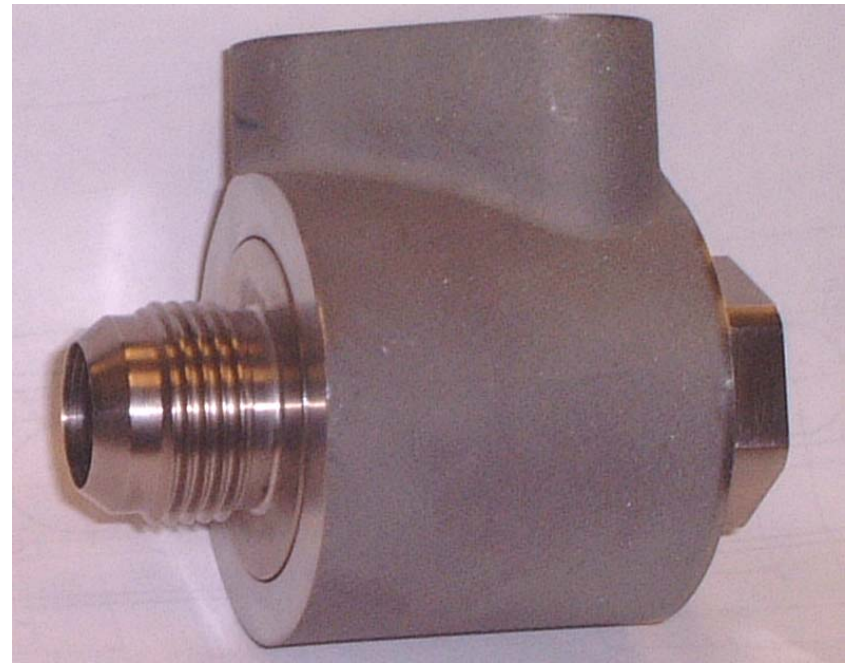
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- Design Benefits and Expectations
  - Low cost and ease of installation.
    - Added connections to cooling water supply and return.
    - Installed tubing distribution supply and return ring in turbine compartment.
    - Cooling requirement is .25 to 1 GPM per check valve.
    - 40 to 80 psi of water pressure.
    - No controls modifications needed.
  - Improved fuel transfer ability.
  - Improved start up reliability on diesel fuel.
  - Check valve life of 20 years or more

# Water Cooled Liquid Fuel Check Valve



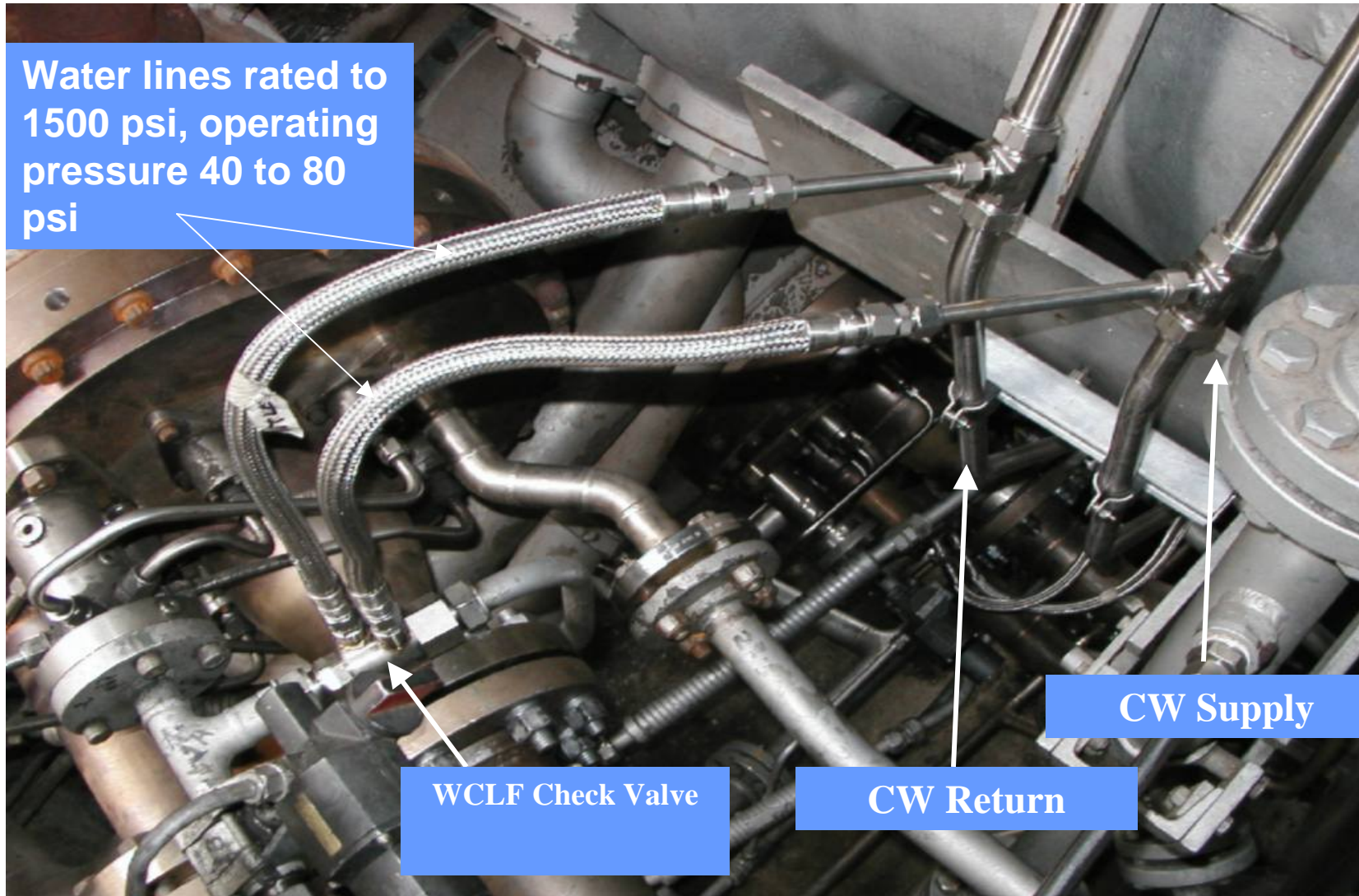
**Developmental Water Cooled LFCV with a welded sleeve**



**Production Water Cooled LFCV using a cast sleeve**

**All variants of the Water Cooled LFCV use the same internal components as the standard LFCV**

# Installed in 6FA



# Uncooled vs. Cooled Check Valves

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Uncooled Check Valve



Less than 100 fired hours

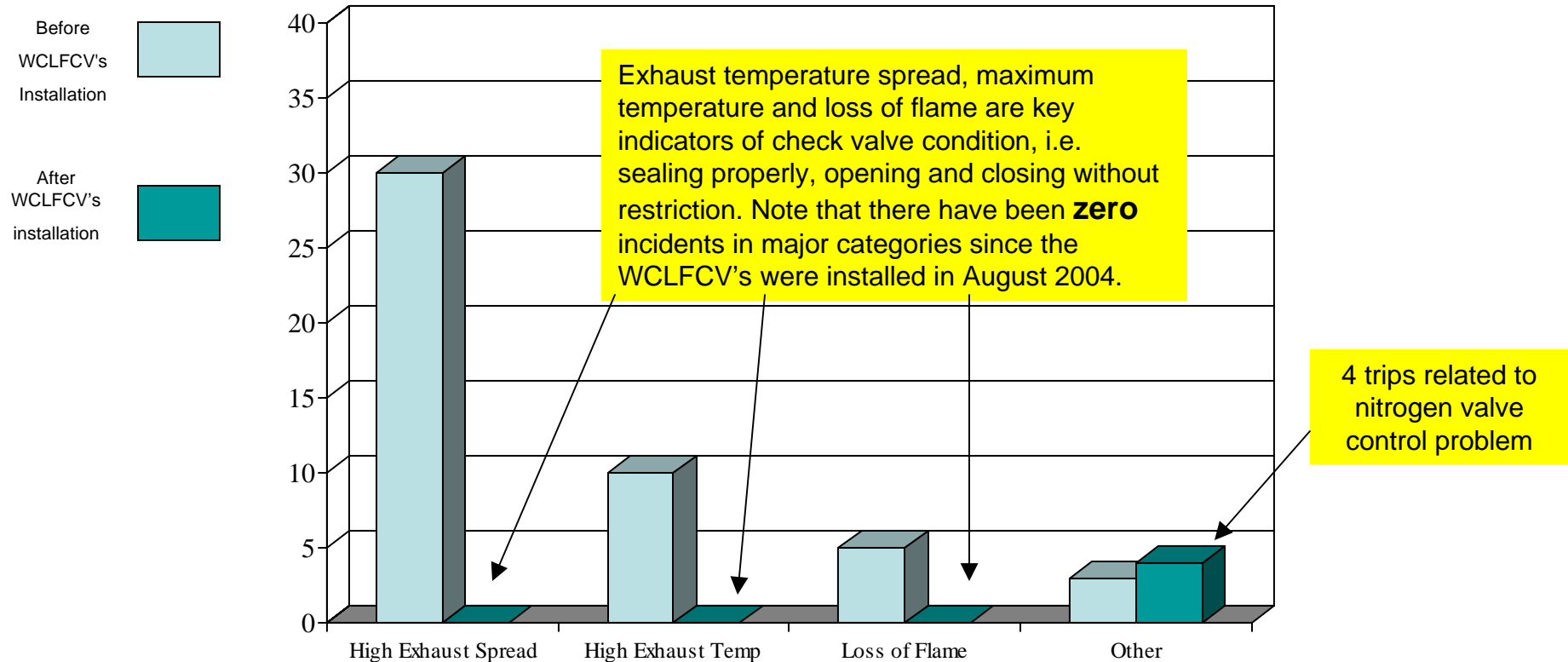
Water Cooled Check Valve



1,300 fired hours

# Failed Transfers - Trips

Typical gas turbine failure modes during transfer attempts



Most Common Trip During Transfer – High Exhaust Spread Temp.  
Cause – Stuck Liquid Fuel Check Valves due to coking.

# Actively Cooled Fuel Controls: Enhancing Liquid Fuel System Reliability

1. **JASC water cooled liquid fuel check valves addresses all previous failure modes and the most recent, coking.**
2. **Eliminate high exhaust temperature related trips due to sticking check valves.**
3. **Refurbish and perform maintenance on liquid fuel check valves every 4 or 5 years during scheduled major outages.**
4. **Eliminate the need for multiple starts in order to purge air from your liquid fuel system.**
5. **Low installation costs, readily applied to all frame sizes.**
6. **No controls modifications required.**
7. **Simple to assemble or disassemble before and after scheduled maintenance.**
8. **Ability to exercise your liquid fuel system regularly without worrying about the condition of your fuel controls.**

# The future of Actively Cooled Fuel Controls: Enhancing Liquid Fuel System Reliability

- Water Cooled Combining valve design features
  - Replaces liquid fuel check valve
  - Replaces purge air valves
  - Replaces fuel distributor valve
  - Integral strainer to eliminate contamination failures
  - Eliminate coking and leak related issues on all 3 major components

# The JASC Water-Cooled Combining Valve

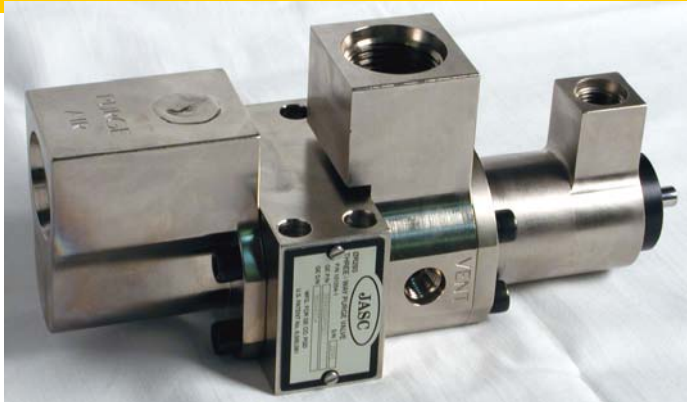
## 3-Way Purge Valve Overview:

Replaces Liquid Fuel & Purge Air Check Valves

Over 3000 Units in Field Operation

No Active Water Cooling (currently) -  
Units in High-Temperature Locations  
are Prone to Internal Coke Formation

No Particle Trap - Seals are Typically  
Damaged During Initial Firings Due to  
Large Particulate Contamination of  
the Fuel



## The Water-Cooled Combining Valve:

Valve is Designed to Emulate Functions of  
Current OEM Fuel Distributor Valve

Addresses Specific Issues of Current Valves  
to Improve Overall Liquid Fuel System  
Reliability:

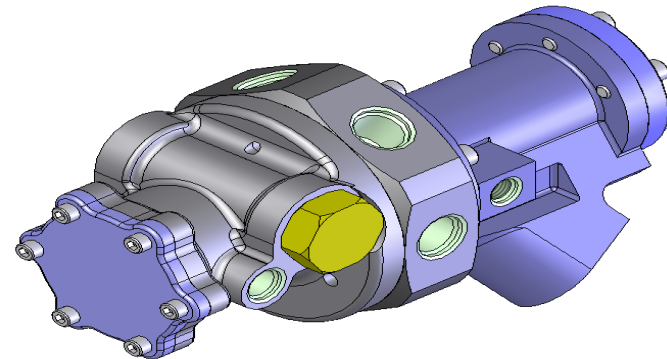
- Effective Water-Cooling Design

- Staged Fuel Delivery

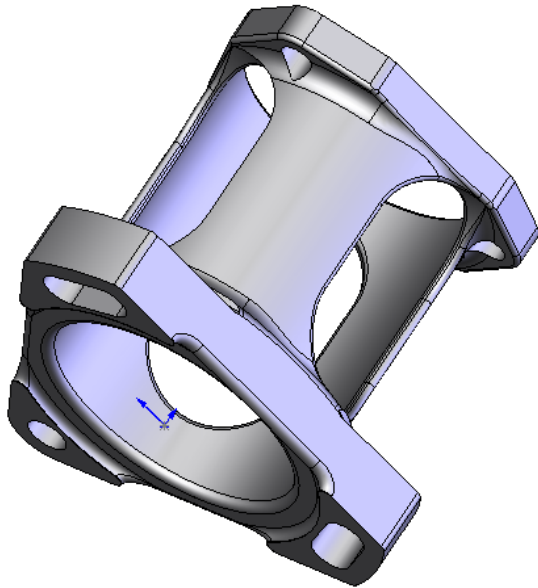
- Small Quiescent Internal Fuel Volume

- Removable Fuel Inlet Screen

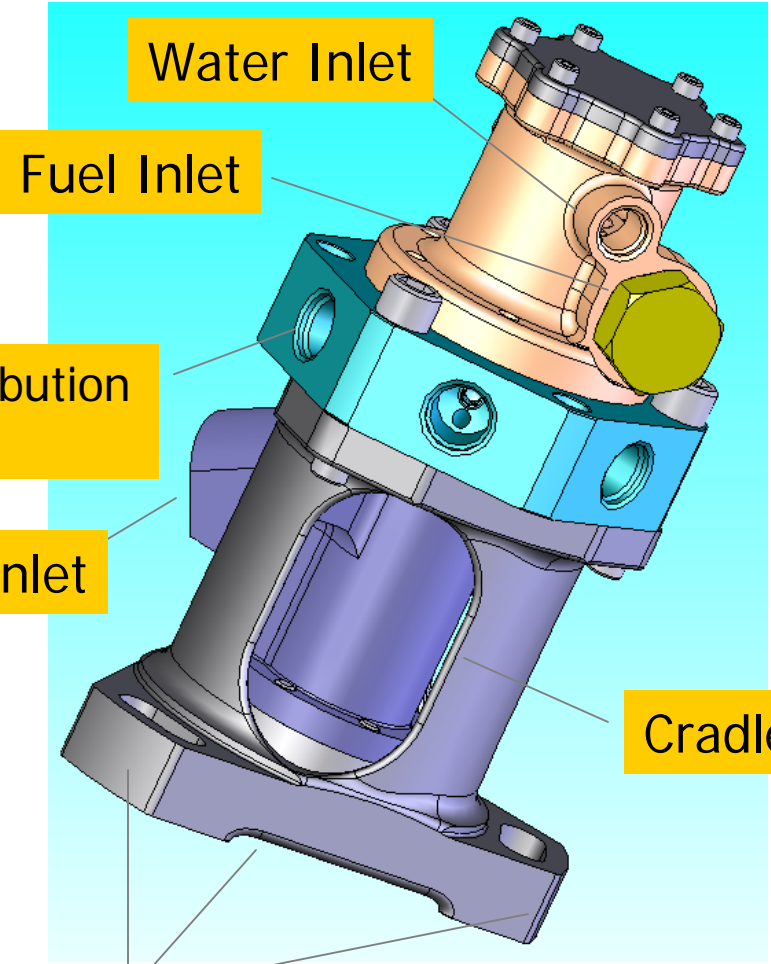
- Pilot Air Actuation can be Incorporated  
(if required)



# Valve / Bracket Assembly



Bracket Only



Water Inlet

Fuel Inlet

Fuel Distribution Ports

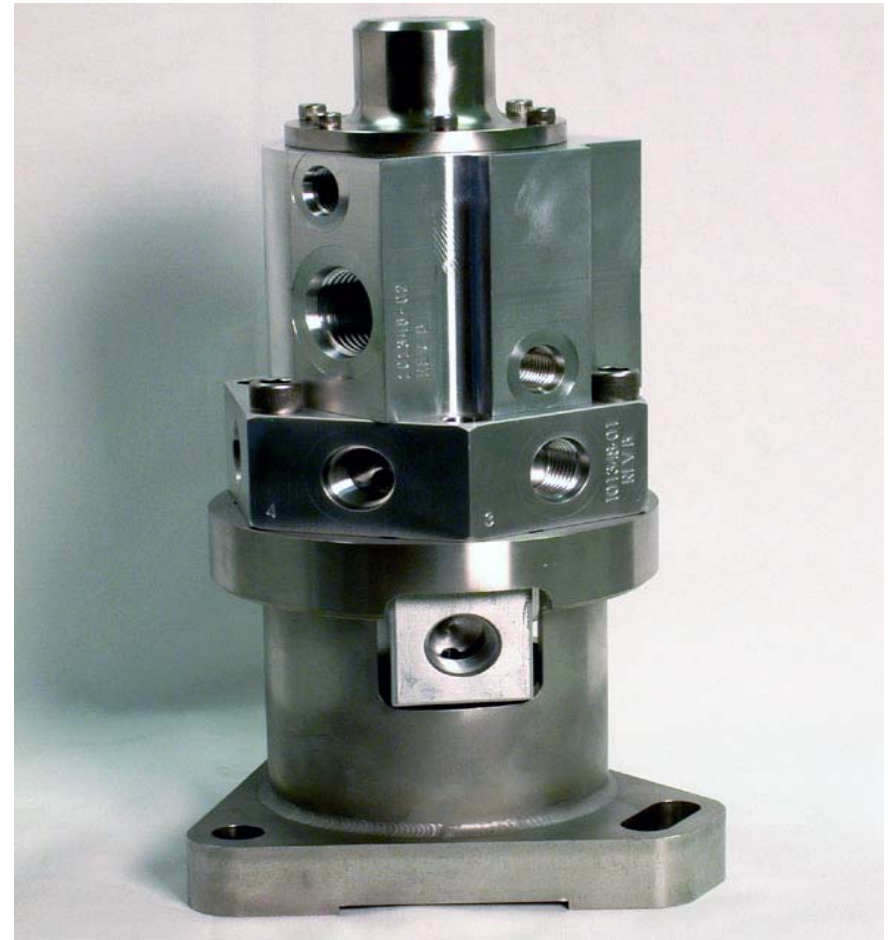
Purge Air Inlet

Cradle

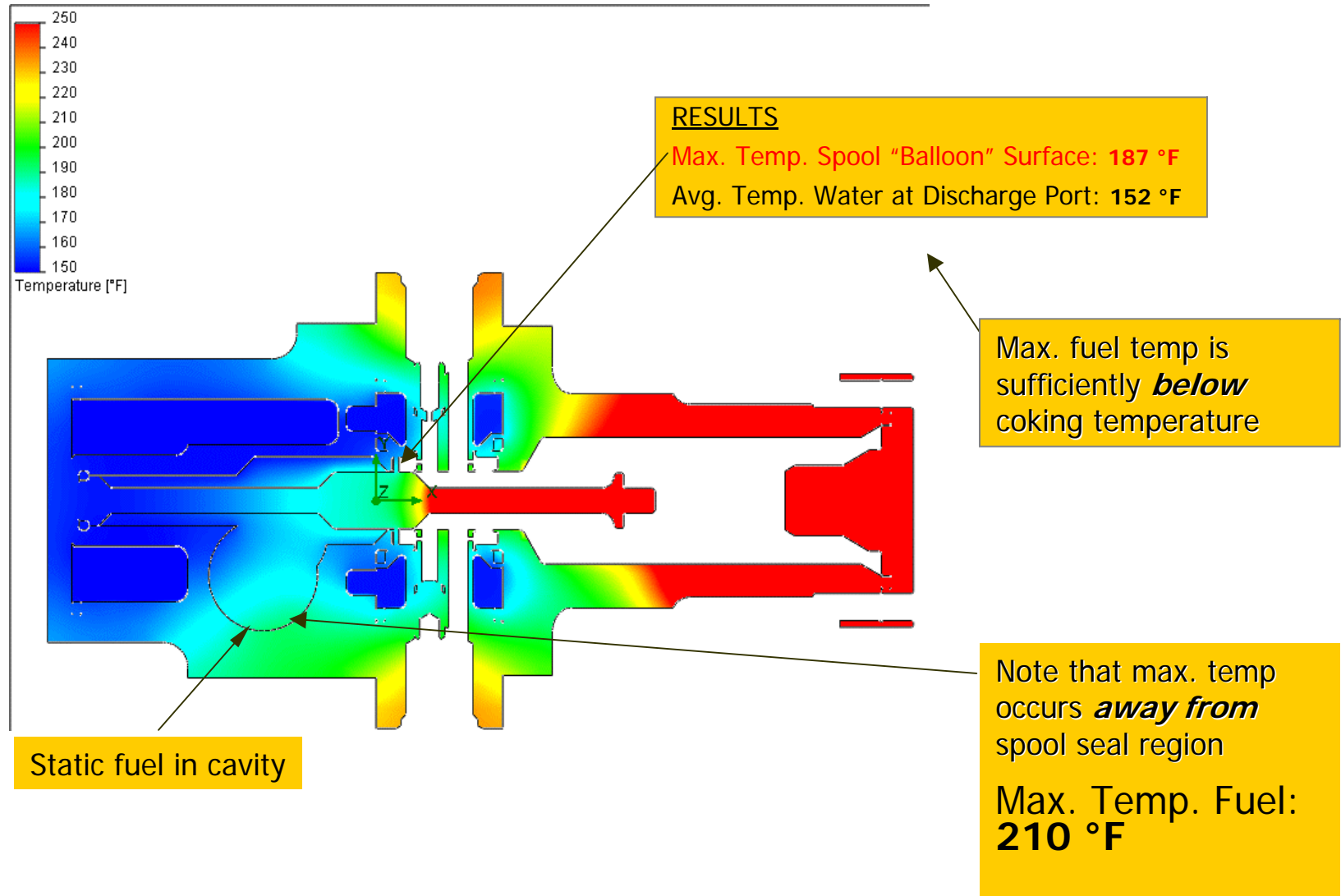
Mounting Surfaces

# Water Cooling has arrived!

- Combining Valve design used for DLN applications
- Bolt-on configuration
- Technology can be readily applied to all dual fuel gas turbine applications



# Water Cooling Thermal Analysis, Current Valve @ 1.5 GPM Worst Case Boundary Conditions



# Cost Analysis Considerations

- Installation of both systems is relatively simple
- Tap into existing water system
- Maintenance only required during major outages
- Significantly improved Transfer reliability
- Elimination of coking related failures
- Elimination of contamination related failures
- Enhanced start capability on liquid fuel
- Elimination of trips associated with high exhaust temperature spreads

# Summary

- JASC has had great success developing complete systems or integral components which resolve process control problems in a variety of industries and applications.
- Continuous improvement of existing designs provides our customers with products which exceed all expectations.
- Our goal is to provide our customers with a level of service which is unparalleled.
- We actively seek opportunities to apply our problem solving ability to your issues.

# JASC Contact Information

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