Combined Cycle Gas Turbine Severe Service Valves

A route map and summary of options available and the merits of each based on purchaser's unique circumstances

Table of Contents

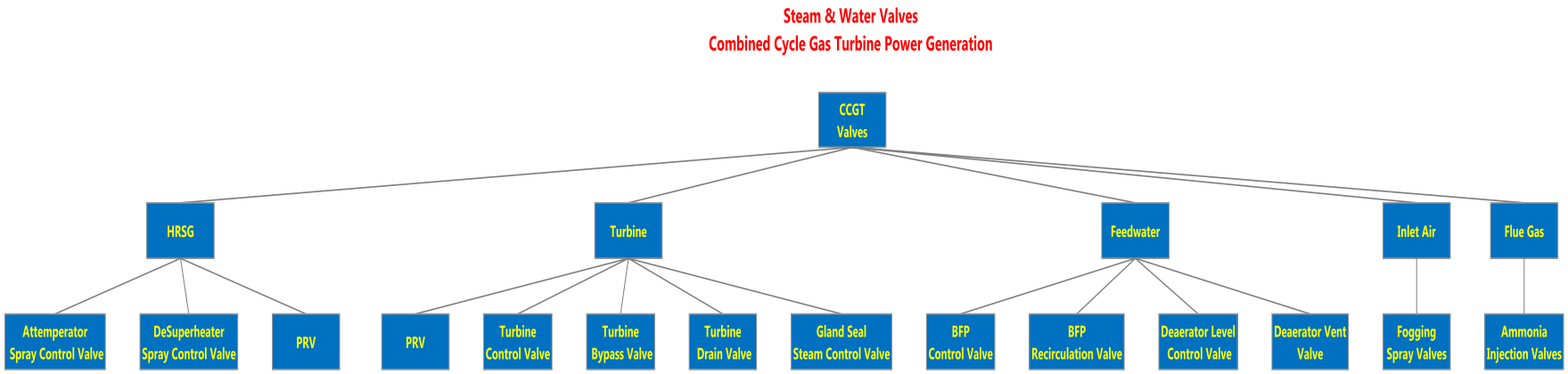
Program Outline

Users of this program on valves

- End-user power plants
- Consultants and engineering firms
- Suppliers of valves

Valve systems

- HRSG
- Turbine
- Feedwater system
- Inlet Air (fogging)
- Flue Gas
- See illustration



Gas Turbine Decision Program

Subject	Use
Decision Orchard	A website with articles, analysis, recorded webinars InterWEBviews™ and intelligence database which is continually updated (free to end users but not others)
Decision Guides	Route maps and summaries of decision paths for specific areas in the orchard
4As Operating System	The operating system for the decision orchard with **A**lerts, **A**nswers, **A**nalysis and **A**dvancement

CCGT Severe Service Valve Requirements Relative To Coal Fired Power

- Valve requirements for CCGT power generation are similar in many respects to conventional coal-fired power plants
  - Many of the same valve types are required including pressure relief valves, turbine bypass valves, turbine drain valves, attemperator spray valves, recirculation valves, and others
  - Severe service conditions will apply involving high temperatures, high pressures, high delta P's, and other severe service conditions
  - More **"cycling"** of valves may be expected in CCGT plants due to load variations for plants that are not purely base-load plants, or for plants that serve as peaking plants or backup for renewable power including solar and wind. This creates a special set of thermal and mechanical issues unique to CCGT power plants.

Severe Service definition

Severe Service Definition

- Cavitation potential exists (Water Valves)
- High vibration / noise expected (Steam Valves)
- Flashing service
- ΔP/P1>0.5
- Historical knowledge
- Needs continuous maintenance
- Plant manager knows about the valve

Severe Service = High Pressure Drop = High Velocity = ENEMY

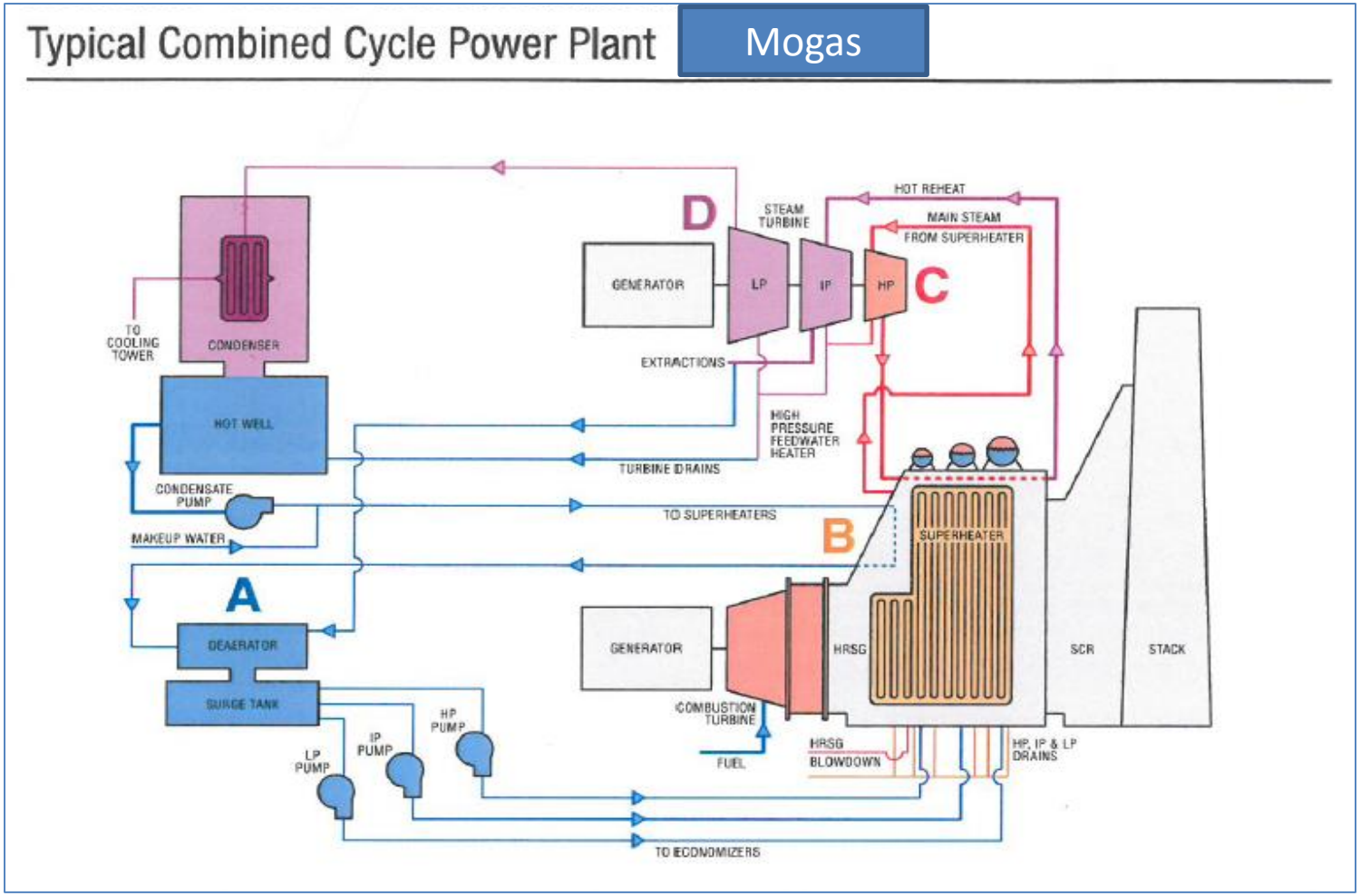
Combined cycle severe service applications

Common Severe Service Applications – Combined Cycle Power Plants

- Main Boiler Feedpump Recirculation
- Start-up & Main Feedwater Regulation
- Turbine Bypass Systems
- Attemperation & Spraywater Control
- Auxiliary Steam
- Vent Valves
- Condensate Recirc valves

Overview of CCGT Major Systems

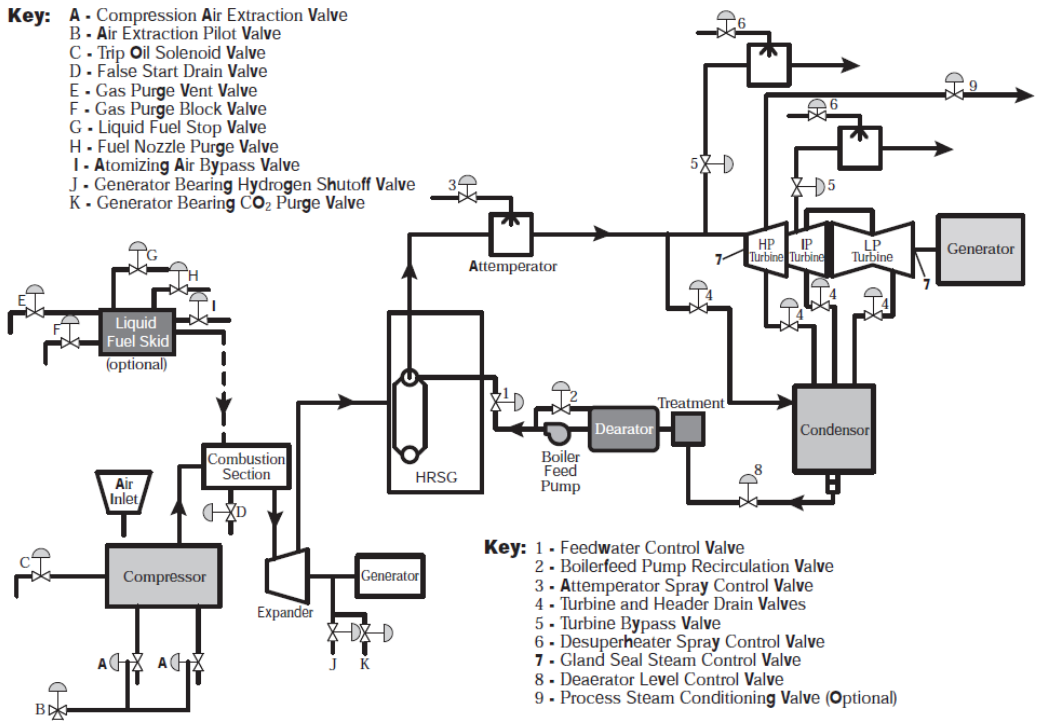
(Boiler Feed, HRSG, Turbine, Condenser, Flue gas, other systems)



Major Valves in CCGT Water & Steam Cycle

LESLIE CONTROLS, INC.
A subsidiary of CIRCOR International, Inc.

Combined Cycle Power Plant (Gas and Steam Turbine Generator)



Severe Service Valves for GTCC

Summary

- Though small in number, severe service applications pose the highest challenges in the steam and water systems
- Each application should be reviewed and treated appropriately based on key application and process parameters
- Once severe service applications are identified the correct valve design needs to be applied to assure proper valve and plant performance
- ISA guidelines for sizing control valves are a great starting point: "Control Valves – Practical Guides for Measurement and Control" published by ISA

Babcock & Wilcox

Bailey

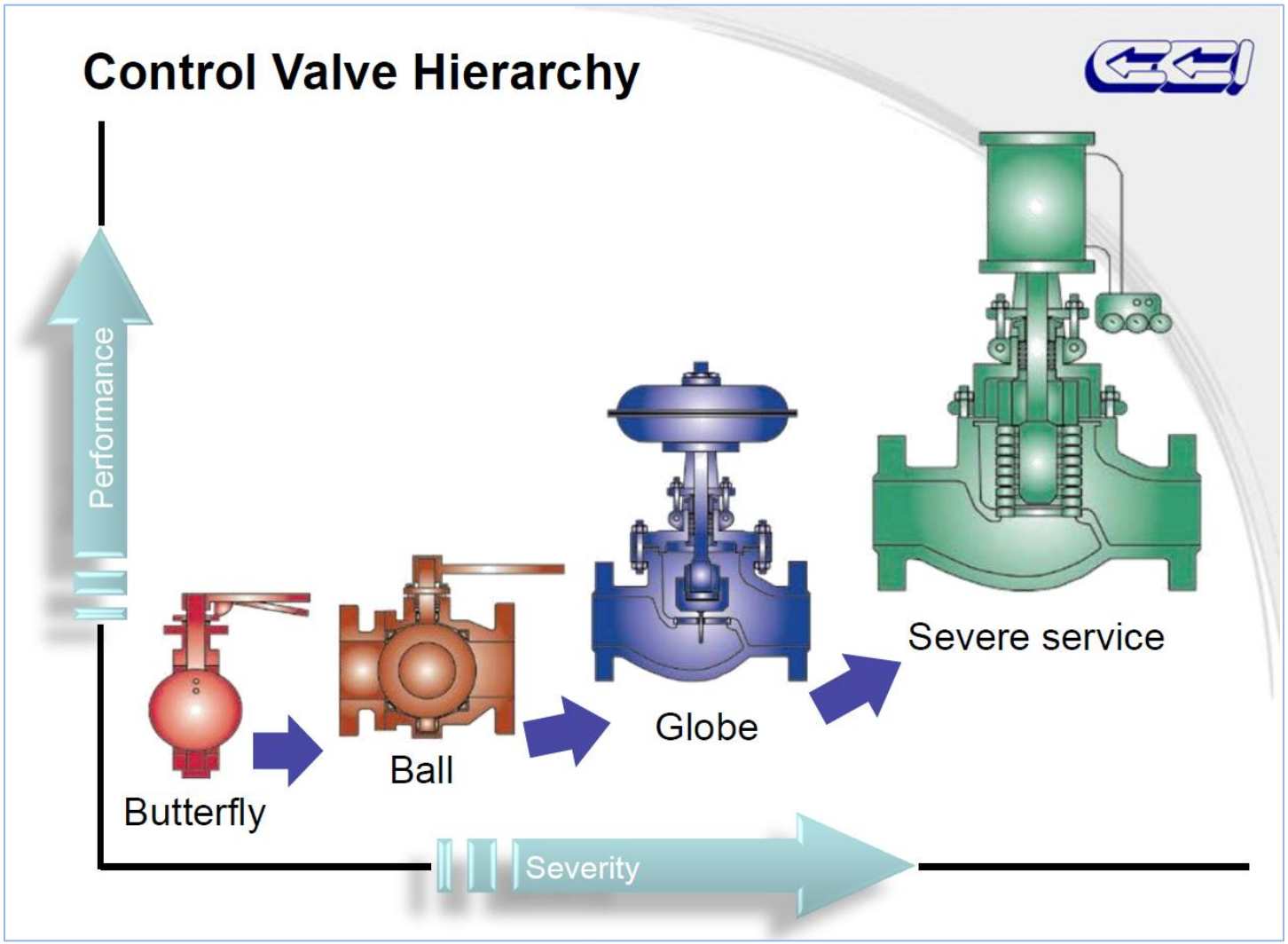
IMI

BTG

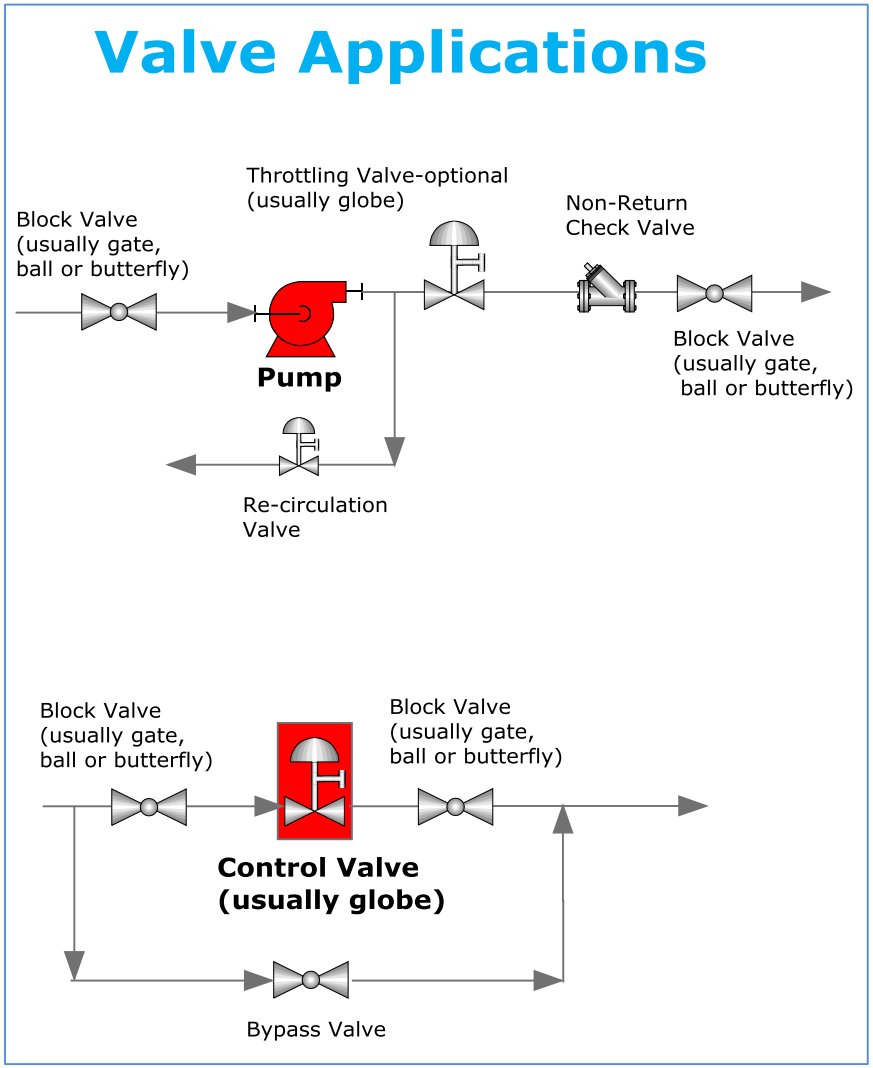
STI

FLUID KINETICS

Severe Service Hierarchy for Control Valves



Common Valve Groupings in CCGT



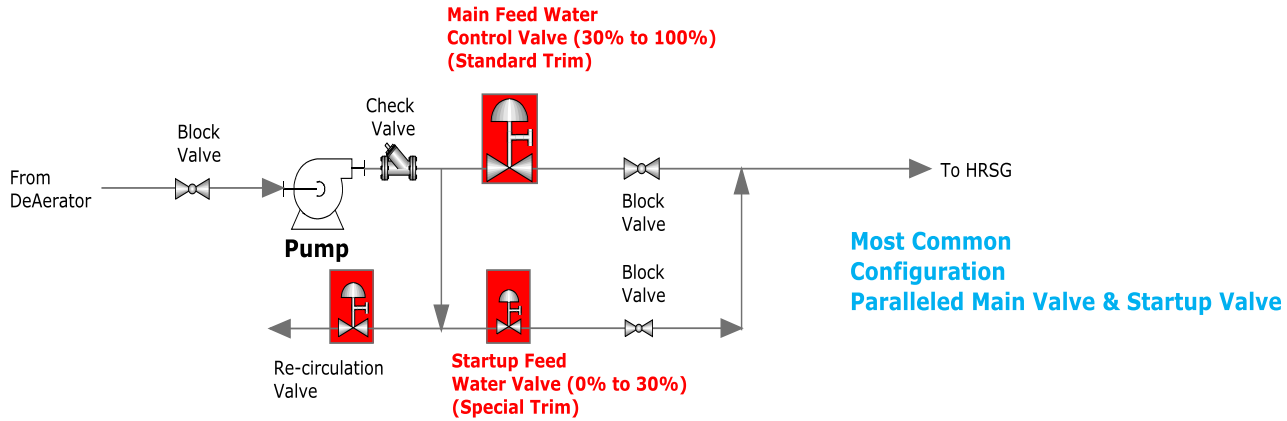
Specific Issues and Evaluation Considerations

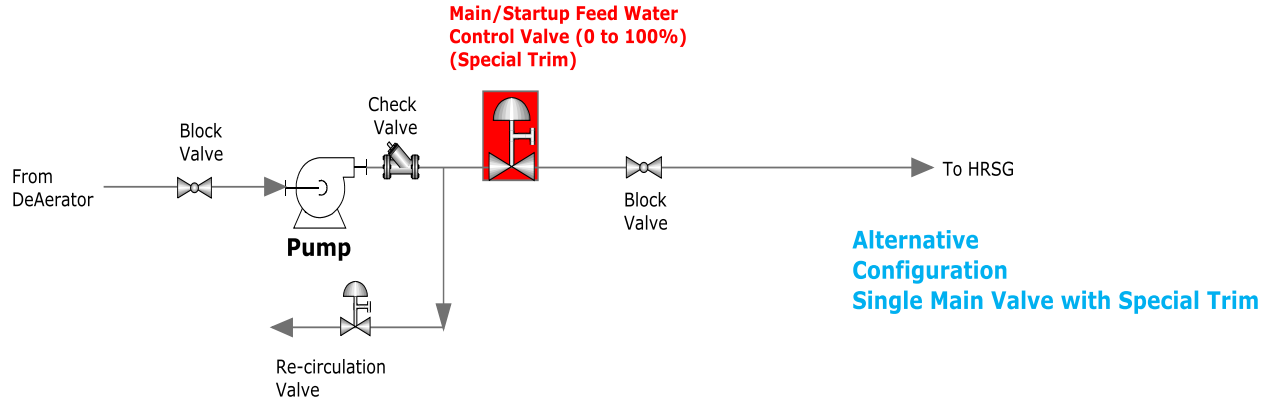
Application	Issues	Discussion
Boiler Feed	Single Valve or Dual Valve	Achieving the most economical and effective solution to boiler feed valving while avoiding cavitation and retaining startup and variable load performance
Turbine Bypass	Stellite Delamination	Mostly affecting steam valves in high pressure (hp) turbine bypass or hot reheat (hrh) lines; can result in valve damage/seat leakage or damage to turbine
Turbine Control	Cycling	More prevalent in CCGT plants than base-load coal-fired plants, and can require special valve capabilities for the increased thermal and mechanical stress
Hazardous Fluid Handling	Double Block & Bleed (Ammonia)	Hazardous fluids sometimes require double block & bleed compliant valves for maximum safety. Ammonia handling is one application in CCGT power plants.
Two-Seated Valves	Center cavity over-pressurization (CCOP)	Center cavity over-pressurization can be an issue with two seated valves, including double block & bleed valves
SCR	Anhydrous, aqueous, or urea	Ammonia for SCR NOx removal can be accomplished with anhydrous ammonia, aqueous ammonia, or urea with onsite ammonia production.
Inlet Air	Fogging Control	Generally advantageous in hot, dry climates to increase inlet air density and increase power output.

Specific Issues and Evaluation Considerations

(Feedwater Valving)

Boiler Feed Valve Configurations





Application
Boiler Feed
Turbine Bypass
Turbine Control
Hazardous Fluid Handling
Two-Seated Valves
Inlet Air

Specific Issues and Evaluation Considerations

(Stellite Delamination)

- Stellite liberation from large valves installed in high-pressure (HP) and hot reheat (HRH) steam systems serving F-class combined cycles has emerged as an important industry concern. Tight shutoff of parallel-slide gate and non-return globe valves has been compromised in some cases, based on feedback from plant personnel; steam-turbine components also have been damaged.
- EPRI has established a committee on "Cracking and Disbonding of Hardfacing Alloys in Combined-Cycle Plant Valves" to dig into the details. The work, funded by several sponsors, began early this year. John Shingledecker (jshingledecker@epri.com), the technical manager for this program, said the project timeline is estimated at 14 months. The first formal review of industry experience is incorporated into the program for the upcoming EPRI Fossil Materials and Repair Program Technology Transfer Week, June 24-28, in Destin, Fla.
- Owner/operators, valve manufacturers and service organizations, and other interested parties expect one outcome of the R&D effort will be a more reliable process for the bonding of stellite to discs, seats, and slides for valves subjected to steam temperatures approaching 1100F, as well as to rapid quenching caused by improperly operating desuperheaters and/or drain systems. The solution also may require changes to current industry inspection, operating, and maintenance procedures

Application
Boiler Feed
Turbine Bypass
Turbine Control
Hazardous Fluid Handling
Two-Seated Valves
Inlet Air

Specific Issues and Evaluation Considerations

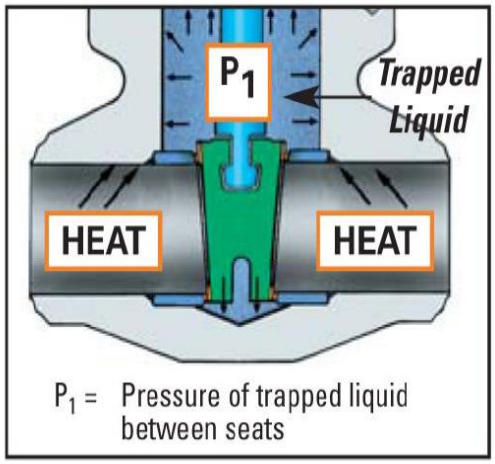
(Center Cavity Over-Pressurization, CCOP)

Prevention of *Center Cavity Overpressurization* & Thermal Binding

Center Cavity Overpressurization (CCOP) & Pressure Locking

Applicability and Definitions

CCOP may be defined as a build-up of pressure in the center cavity of a valve (having two seats) caused by the heating of fluid which has been trapped between the seating surfaces. Such pressure may make opening the valve more difficult, and in extreme cases, render the valve inoperable.



Velan Publication *VEL-PS*

WEIR POWER & INDUSTRIAL

Application
Boiler Feed
Turbine Bypass
Turbine Control
Hazardous Fluid Handling
Two-Seated Valves
Inlet Air

Specific Issues and Evaluation Considerations

(Center Cavity Over-Pressurization, CCOP)

Prevention of *Center Cavity Overpressurization* & Thermal Binding

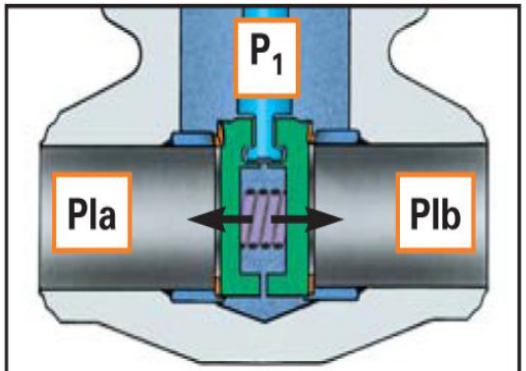
Center Cavity Overpressurization (CCOP) & Pressure Locking

Applicability and Definitions

Pressure locking may be defined as a decrease in upstream (Pla) and/or downstream (Plb) pressure, where the resultant increase in differential pressure (center cavity vs. upstream and/or downstream bores) is high enough to preclude the valve from opening.

ASME B16.34 (para. 2.3.3) assigns responsibility to the ***Owner or his designee*** to advise the Valve manufacturer of the potential for CCOP or pressure locking and specify a method to preclude occurrence.

These methods are as summarized herein.



P_1 = Pressure of trapped liquid between seats

Pla & Plb = Line pressures

Velan Publication *VEL-PS*

WEIR POWER & INDUSTRIAL

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Specific Issues and Evaluation Considerations

(Center Cavity Over-Pressurization, CCOP)

Prevention of Center Cavity Overpressurization & *Thermal Binding*

SUMMARY

- Prevention or elimination of center cavity overpressurization and/or thermal binding are key considerations in power plant operation.
- All valves with two seats are subject to CCOP and/or pressure locking
- There are a number of methods to guard against CCOP and pressure locking. Choose the most effective for your plant piping system needs.
- It is the Owner's (or designee) responsibility to identify the potential for CCOP and thermal binding.
- Because of design features, parallel slide valves are not subject to thermal binding.

- **Thank-you……..**

WEIR POWER & INDUSTRIAL

Application
Boiler Feed
Turbine Bypass
Turbine Control
Hazardous Fluid Handling
Two-Seated Valves
Inlet Air

Specific Issues and Evaluation Considerations

(Erosion/Corrosion Related Damage)

Velocity Related Damage Mechanisms

- **Cavitation** damage varies as a 5th to 6th power of velocity
- **Erosion** damage varies as a 2nd to 4th power of velocity
- Control valve **noise** varies as logarithmic with mach
- **Vibration** is caused by excessive fluid velocities & turbulence
- **Corrosion** is accelerated by velocity & fluid turbulence

Application
Boiler Feed
Turbine Bypass
Turbine Control
Hazardous Fluid Handling
Two-Seated Valves
Inlet Air

Other Valve Considerations

(Click here for hyperlink to documents)

- **Resource Title:** Article: From Coal to Combined Cycle
- **Keyword:** Forged
- **Discussion:** With coal use facing gradual reduction in the U.S. and natural gas fueling the next generation of power production, valves and other process equipment must be designed to address specific conditions of the changing environment. Power professionals worldwide seek to assure their operations are increasingly efficient. But productivity gains come at a cost because increases in plant cycling, temperatures and pressures place additional burdens and stress on the equipment. Consequently, valve users seek solutions that are reliable, safe and, above all, efficient to meet the energy needs of an increasingly-demanding nation. Forged and cast valve solutions alike meet this need in the harsh environment, while offering users the quality and dependability commanded by the ever-dynamic industry.


From Coal to Combined Cycle

Published on Tuesday, 28 October 2014 13:13

Written by By Steve Brown

Other Valve Considerations

(Click here for hyperlink to documents)

- **Resource Title:** How to Avoid, Fix Problems with Boiler Feedwater Valves
- **Keyword:** Feedwater
- **Discussion:** Combined-cycle power plants offer a great deal of operating flexibility, typically having the ability to respond to changing load demands much faster than large fossil-fired steam stations. So it is not surprising that in competitive power markets combined cycle facilities are experiencing more operating cycles than owners planned for at the design stage. While the ability to cycle a large combined-cycle plant is ideal for fleet flexibility, frequent startups and shutdowns strain many critical components and limit their effective lifetimes.

How to avoid, fix problems with boiler feedwater valves

By **John Wilson,** Fisher Controls International LLC

Combined-cycle powerplants offer a great deal of operating flexibility, typically having the ability to respond to changing load demands much faster than large fossil-fired steam stations. So it is not surprising that in competitive power markets combined-cycle facilities are experiencing more operating cycles than owners planned for at the design stage.

While the ability to cycle a large combined-cycle plant is ideal for fleet flexibility, frequent startups and shutdowns strain many critical components and limit their effective lifetimes. Witness the relatively common boiler tube failures caused by flow-accelerated corrosion (FAC) and the premature failure of steam-turbine bypass valves. Such problems can bring a plant down for extended periods, often without warning.

Another maintenance issue, one that has not received much publicity to date, has to do with valves in the boiler feedwater system. The design of boiler feedwater systems varies somewhat from plant to plant, but the valves used are fairly repeatable.

The number of valves depends on the design of the steam turbine and the heat-recovery steam generator (HRSG). If the turbine and HRSG are of the multi-pressure type, the number of valves increases. To illustrate: For multi-pressure HRSGs, drum level may be controlled by a one-valve or two-valve arrangement. Depending on plant design, there may be between two and six drum-level control valves. In addition, for each boiler feedpump (most plants have two per HRSG), there is a recirculation valve that recycles a portion of feedwater flow back to the low-pressure (l-p) drum or deaerator to prevent the boiler feedpump from overheating and potentially cavitating.

Similar problems with feedwater valves have been experienced at several combined-cycle plants with different types of steam turbines and HRSGs. The most common issue noted is excessive leakage. With leakage comes damage to the internal throttling and seating surfaces of the valve. This damage often is incorrectly attributed to faulty design or misapplication. In many cases the resultant leakage damage can be traced to frequent cycling of the unit. It is not uncommon for a combined-cycle plant to experience over 250 starts per year. This is more than the number of starts that most large coal-fired plants experience in a lifetime.

Given that there are up to eight critical boiler feedwater valves per HRSG, maintenance or replacement of these valves can be very expensive. The cost of feedwater valves for a two-on-one combined cycle can run more than $100,000. While many problems can be traced to frequent cycling, there are other reasons for valve damage as detailed below. It is important to understand the type of damage and its cause before the proper replacement or fix can be applied.

What causes feedwater valves to leak? The first indication of leaking feedwater valves normally is an increase in drum water level. After you determine which valves leak, they must be opened for inspection to determine the root cause. Below are six reasons for leakage and what to do when you isolate the problem.

1. Insufficient information to guide valve selection

Valve leakage often can be traced back to the engineering and design phase of the project. It is at this time that operating data are specified and equipment is selected based on preliminary heat-balance information. Only two or three operating conditions normally are provided and these are intended to encompass the entire range of conditions that the valves will experience. Many times operating conditions are specified before the feedwater pumps have been purchased, making it very difficult to predict the output-pressure and flow data needed for proper valve selection.

Note that for a grassroots combined-cycle plant using F-Class combustion-turbine (CT) technology and supplemental duct firing, feedwater pressures can be as high as 3000 psig. If newer steam-cooled CTs are specified, feedwater pressures can climb to 3500 psig. Repowering projects present a wide array of feedwater pressures with some climbing above 4000 psig.

It is important to know pump performance details before selecting a control valve. Reason is that with such high feedwater pressures comes the potential for valve cavitation. If the pump characteristics of head loss with increasing flow are not properly understood

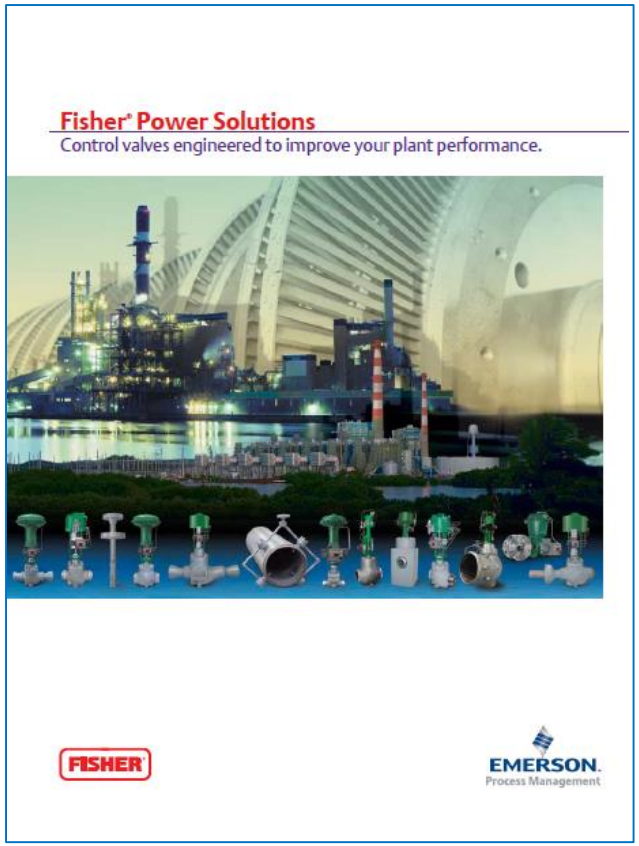
FISHER

EMERSON. Process Management

Other Valve Considerations

(Click here for hyperlink to documents)

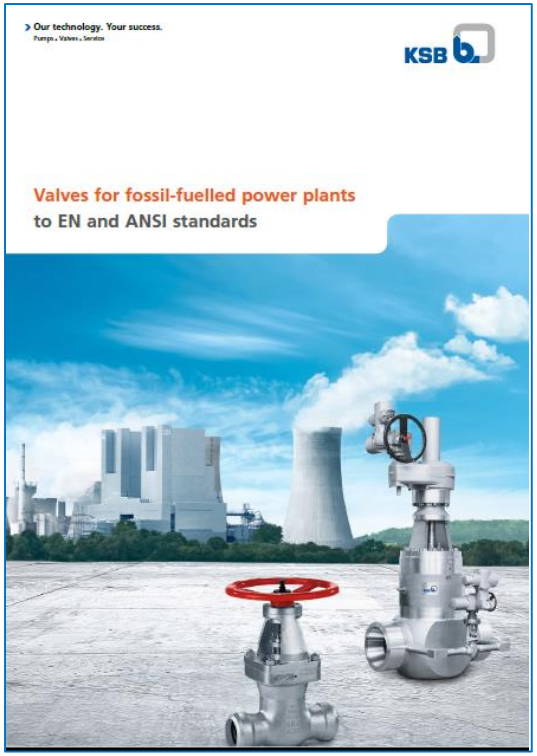
- **Resource Title:** Fisher Control Valves Engineered to Improve Your Plant Performance
- **Keyword:** Feedwater
- **Discussion:** In the normal range of plant operation, the boiler feed water regulator experiences high flow rates with low differential pressure. However, during startup, this valve experiences low flow rates with very high differential pressure, which can cause severe cavitation damage. Some feedwater systems are designed using one valve to handle startup and normal operating conditions. Others are designed using a separate small startup valve to handle low flow, cavitating conditions and a second larger valve to handle high flow rates required for normal operation.



Other Valve Considerations

(Click here for hyperlink to documents)

- **Resource Title:** KSB Valves for Fossil Fueled Power Plants
- **Keyword:** Standards
- **Discussion:** The demands placed on components in power plant applications are immense. This is particularly the case for valves that are used to reliably shut off water and steam. These must withstand enormous heat and pressure and have to fulfill the exacting requirements of standards and codes such as DIN / EN, ASME / ANSI or IBR.



Decision Route – Application Specific Issues

Webinars (Protected)

Date	Recording Title
June 2, 2011	**Valves for Power Plant Steam and Cooling Water** 104 minutes

InterWebViews™ (Free)

Date	Topic

Intelligence System Key Words

Search Category	Key Words
By App	
By Site Specific Issue	
By Product	valve
By Company	
By Person	

Choices

options

- Single or dual valves for boiler feed
- Replacement or repair of hp bypass valves to address possible stellite delamination*
- Special purpose valves with enhanced cycling capability for turbine control
- Special block & bleed valves for hazardous fluids

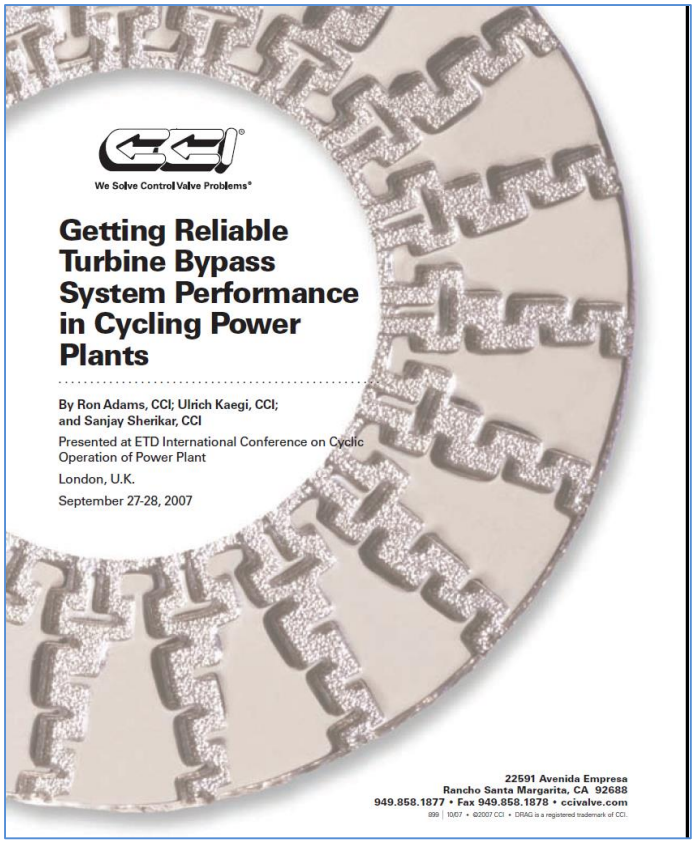
Power points and authors

Topic	Reference
Boiler feed valving	Fisher Controls, Experitec
Stellite delamination	Kim Bezzant
Valve cycling	Conval
Hazardous fluids	CCJ OnLine

* If repairs are needed, or if you're buying a new valve, it would be prudent to specify a limit on base-metal dilution into the first layer of hard facing of between 10% and 20%, based on what investigators have learned to date. Minimizing base-metal dilution should reduce the hardness levels in the first layer of hard facing and reduce the potential for disbonding. Qualify a prospective valve supplier or repair services provider by specifying a demonstration to prove their welding process can minimize dilution.

Decision orchard (Click here for hyperlink to documents)

- **Resource Title:** CCI Getting Reliable Turbine Bypass Performance in Cycling Power Plants
- **Location:** GdPS for CCGT Valve Selection
- **Keyword:** Turbine-Bypass
- **Discussion:** Contributing factors to problems in turbine bypass systems were traced to faulty control algorithms, over-sized spray water valves, leaking spray water lines, thermal shock, and improper system layout.



Decision orchard (Click here for hyperlink to documents)

- **Resource Title:** EPRI Valve Maintenance Guides Developed for Combustion Turbine Combined Cycle Plants
- **Location:** GdPS for CCGT Valve Selection
- **Keyword:** Valve-Maintenance
- **Discussion:** As U.S. utilities curtail operation of older coal-fired plants, CTCC plants are increasingly being run at higher capacity factors, putting new stresses and pressures on plant equipment. This trend, in turn, requires crews to re-evaluate their inspection and maintenance practices. At the same time, advanced new equipment is finding its way into plants, adding greater complexity to the maintenance process

Valve maintenance guides developed for combustion-turbine combined-cycle plants

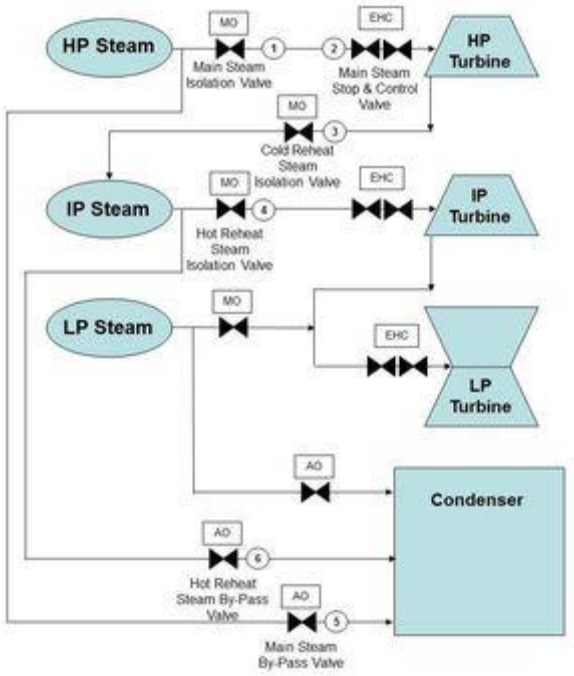


Figure 1.

Decision orchard

(Click here for hyperlink to documents)

- **Resource Title:** Mogas Ball Valves for Power Generation Severe Service Applications
- **Location:** GdPS for CCGT Valve Selection
- **Keyword:** Delamination
- **Discussion:** With the integration of two powerful movers – both gas turbine engine and steam turbine engine – the combined cycle power plant has the capacity to produce tremendous amounts of power on short notice. Quick start-ups, however, can be brutal on a turbine valve population and ultimately cause the breakdown of surface coatings. MOGAS understands the unique challenges of the combined cycle plant and has done extensive research to better understand how the thermal power cycle affects turbine valve components. It was realized that the mechanically bonded coatings, such as HVOF applied Chrome Carbide, had a tendency to crack and flake off causing leak-by and possibly lock-up. Innovations were then made to fuse our coating to the base material creating a metallurgical bonded coating. Since this, we have enjoyed flawless performance and extended longevity.