CCI Nuclear Valve Resource Guide for Power Uprate and Productivity Gains

We Provide Nuclear Valve Solutions

Power uprate — Productivity gain — Plant life extension

CCI's world headquarters, Rancho Santa Margarita, California, USA

CCI's ASME-Certified facility, Winterthur, Switzerland

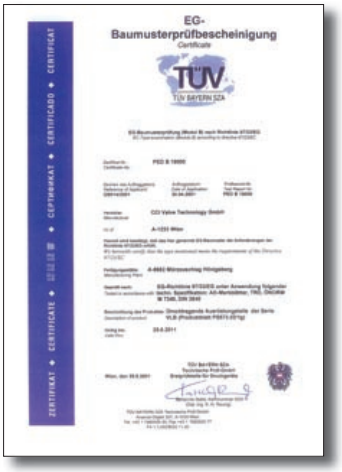
CCI — your proven source for innovative technologies needed to meet the ever-increasing demands of 21st century commercial nuclear power economics.

CCI nuclear valve technologies were developed to help commercial nuclear power plants stay competitive in today's changing power market. Power uprate, thermal performance gains and plant life extension are all available by using CCI severe service valves.

Brief refuel outage schedules no longer tolerate extensive valve maintenance or leak rate repair, and loss of thermal efficiency or an unplanned shutdown can mean the difference between profit and loss. Top-performing PWRs and BWRs around the world depend on CCI valves and people to keep them operating at the highest achievable levels. This guide describes the wide range of advanced valve technologies offered by CCI to increase plant productivity and earnings.

- **Severe Service Control Valves:** proven reliable in the most demanding high-differential pressure and thermal conditions
- **High Energy Isolation Valves:** providing tight shutoff with each cycle, preventing local leak rate test (LLRT) failures and related schedule delays
- **Fast-Acting Actuators:** relying upon system medium only for emergency operation, eliminates dependence upon troublesome air supply, nitrogen gas, hydraulic fluid or mechanical springs
- **Primary Overpressure Protection and Main Steam Safety Relief Valves:** ensuring repeatable lift set point performance within tolerance while eliminating simmering and seat leakage
- **Non-Slam, Reverse Flow Protection Check Valves:** fully guided for precision disc alignment and leak prevention
- **Solenoid Operated Process Control Valves:** incorporating power coil magnets rated for extreme temperature environment and extended Equipment Qualification life
- **Valve Position Indication System:** free of all electrical contactors or switches for positive valve position feedback in a harsh environment
- **Specialized Nuclear Technologies for High-Density Fuel Racks, ECCS Suction Strainers, Safety Relief Vent Resistor Silencers:** other applications contributing to plant productivity

CCI's history of innovation and quality manufacturing



In 1967, CCI introduced DRAG® velocity control technologies a revolutionary design capable of handling large pressure drops in high-pressure liquid and gas service. Since 1971, CCI has been supplying critical- to-safety, severe service DRAG® valves to the nuclear power industry and first received ASME N Stamp Certification in 1973.

DRAG® valves have routinely solved the most difficult steam and water flow control problems in primary and secondary systems. CCI's exclusive velocity control technologies are now contributing significant improvements to plant capacity factors and other performance indicators. The DRAG® valve also plays a major role in power update and plant life extension for nuclear plants around the world.

Today, CCI's nuclear technologies range from severe service control valves, engineered for long life in applications where conventional products experience infant failure, to advanced pressure relief and high-energy isolation valves that employ system medium actuation. CCI valves provide service life and reliability required to meet the demands of the emerging power market.

CCI remains committed to the success of commercial nuclear power. At a time when many ASME Certifications are not being renewed, CCI has doubled the capacity of its ASME-Certified manufacturing and engineering facilities in the United States and expanded its ASME N Stamp capability to include Europe. CCI technologies and people provide many of the resources needed by nuclear plants to be competitive far into the 21st century.

1967	1973	1979	1997	1999	2003
Velocity Control DRAG© Introduced	ASME Certificate Received	Harsh Environment Pneumatic Actuator Introduced	Sulzer Acquired	BTG Acquired	Herion Acquired

CCI severe service DRAG® control valves for PWR productivity gains

Typical Applications for Pressurized Water Reactors

Application	Industry Problems	CCI Solutions
Feedwater Regulator	Wide pressure swings at SG inlet during valve actuation (15% ± @ 800 psig)	Rangeability available up to 300:1, providing precise flow control
	Poor control, small position changes in valve produce large changes in flow	Linear flow performance over full valve stroke range ensured by disk stack characterization
Feedwater Recirculation	Excessive vibration displacement	Radial pressure acting on plug is equalized
	Cavitation and flashing damage from excessive trim exit velocities	12-16 pressure drop stages control trim exit velocity to less than 75 ft./s (23 m/s)
Moisture Separator and Tank Level Control	Seat leakage and flashing damage	16 or more pressure drop stages, 75 ft./s (23 m/s) control trim exit velocity

PWR Severe Service Control Valves

PWRs employ a wide range of systems that require control valves designed for severe service. Severe service applications produce vibration, cavitation and excessive noise in control valves that are unable to tolerate moderate to high-differential pressure conditions.

Plant specific flow characterization

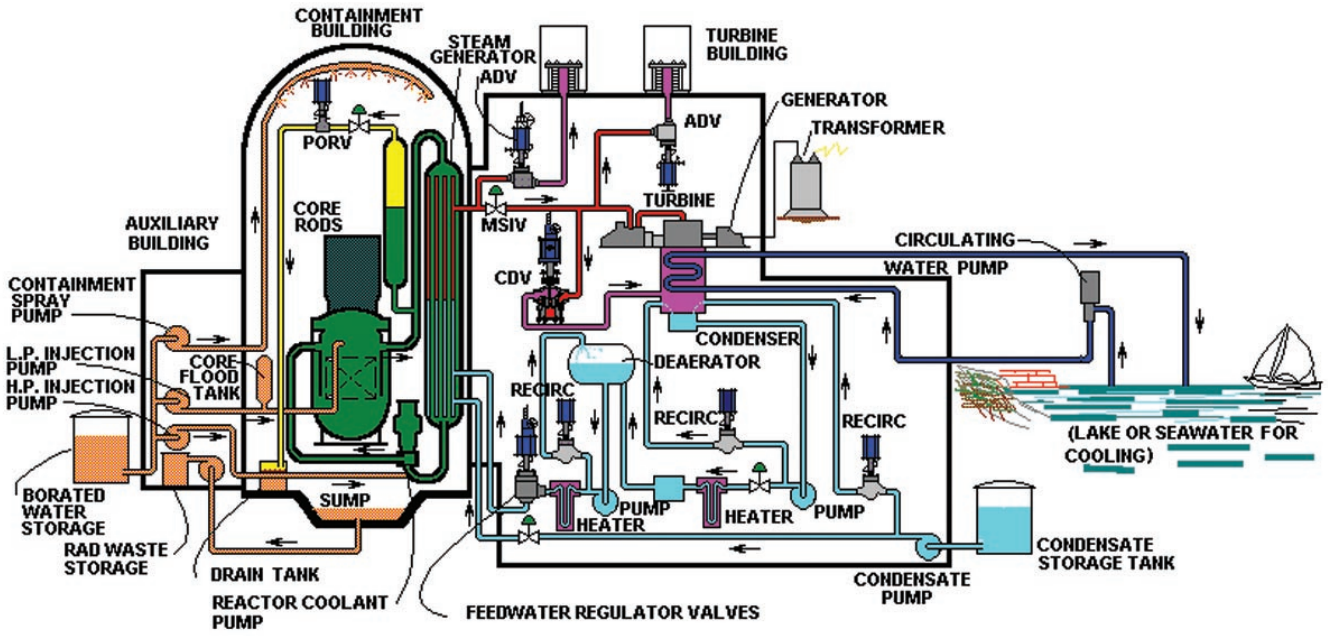
CCI's unique ability to characterize flow for linearity over the full stroke permits precise control and limits exit velocity to less than 75 ft./s (23 m/s) in all valve positions, thus mitigating cavitation and flashing damage.

Wide rangeability and precise control

CCI's valves eliminate feedwater flow regulation problems inherent to PWR single-stage, main feedwater regulating valves, including transmission of pressure oscillation to the steam generator inlet. CCI's DRAG® technology's exclusive rangeability up to 300:1 and application-specific characterization provide precise and stable flow control.

Velocity control

CCI's DRAG® technology achieves an 85% reduction in PWR main feedwater regulation control valve trim exit velocity when compared with a conventionally designed valve.



Additional PWRs Applications

Typical Applications for Boiling Water Reactors

Application	Industry Problems	CCI Solutions
Heater Drain	Poor control, small position changes in valve produce large changes in flow	Rangeability available up to 300:1 provides excellent level control
	Loss of steam cycle efficiency caused by seat leakage in normally closed, emergency heater to condenser drain valves	Pressurized seat design and high load actuator produces 1,000 PLI (175 N/mm) for superior seat loading shutoff
Feedwater Recirculation	High pressure drop to vacuum causes cavitation damage and massive internal leakage	Exit velocities limited to less than 75 ft./s (23 m/s), preventing fluid from dropping below vapor pressure

BWR Severe Service Control Valves

BWRs rely heavily on precise flow control and tight shutoff performance to be productive. CCI's DRAG® valve provides unmatched flow management while offering shutoff performance in accordance with stringent MSS-SP61 flow isolation standards.

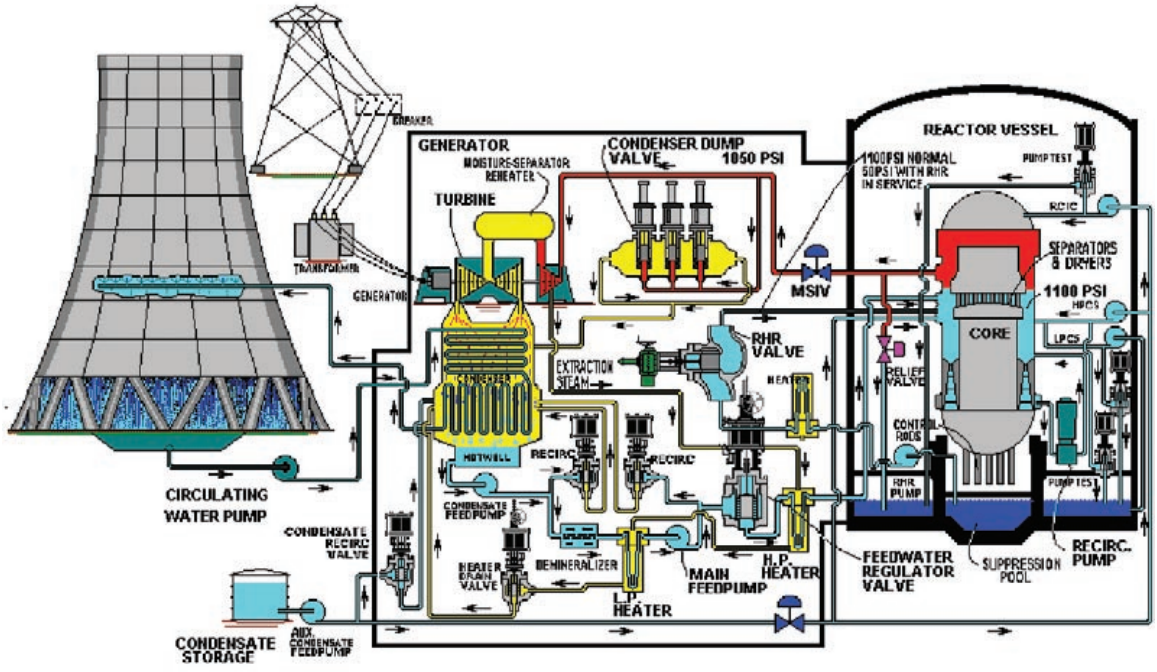
Performance gains

BWRs upgrading to DRAG® technology in feedwater recirculation application have reported as much as a 12-MWe gain in plant performance.

BWRs constructed with conventional control valves in feedwater recirculation have found two-stage, cage-type designs cannot tolerate the high pressure drop from 1200 psig (8.3 MPag) to the vacuum and extreme temperature conditions that exist in this severe service application. Cavitation problems and trim erosion due to flashing experienced by conventionally designed valves result in a substantial loss of energy and excessive maintenance.

Prevention of cavitation

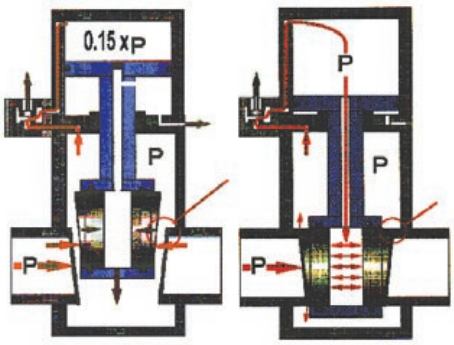
DRAG® feedwater recirculation valves employ 18 pressure drop stages to control trim velocity to below 75 ft./s (23 m/s). By limiting fluid velocities to this level or lower, the fluid is not allowed to fall below its vapor pressure. This prevents the formation of bubbles that result in cavitation and eliminates damage caused by water droplets being accelerated by flashing fluid.



Additional BWRs Applications

CCI high-energy isolation valves for tight shutoff

CCI high-energy isolation gate valve with system medium actuation for MSIV application



System medium actuator and pressure-activated disc control scheme

High-Energy Isolation Valves

CCI's innovative isolation valve technology provides positive solutions to long-standing nuclear isolation valve and actuator problems. CCI's isolation valve was developed, in part, to address the unique needs of supercritical fossil-fired power plants. A great deal was learned from dealing with the extreme process temperatures in these facilities. Preventing thermal binding and pressure lock conditions was of foremost concern in the design.

Pressure-assisted shutoff

CCI has applied its advanced pressure-activated disc technology to nuclear isolation gate valves. Upon reaching the fully closed position, the disc is pressurized internally to activate contact and increase load acting on the seat rings. This capability ensures tight shutoff and successful leak rate testing with each valve closure. For valve opening, pressure is vented and the disc collapses for frictionless movement across the face of the seat rings. Mitigating the potential for galling or binding. The disc is fully guided throughout the stroke to prevent misalignment during upset conditions such as high-energy line breaks. If the valve ever needs internal service, the seating elements can be replaced without welding. These advanced features have been thoroughly tested in simulated design basis conditions where cycle testing was specified by CCI to far exceed plant life expectancy.

Vibration mitigation

CCI's high-energy isolation valve family also includes advanced globe valves. CCI's globe valve is available in angle and Y patterns and is contoured to reduce pressure drop and increase flow capacity when compared with conventional globe-style MSIVs. The shaft and disc are protected from the flow and not susceptible to flow-induced erosion and vibration.

Simplified valve control

Critical system boundary isolation valves such as MSIVs and MFIVs have experienced high-frequency maintenance for various types of actuators, including electro-hydraulic, gas spring and pneumatic spring return. CCI has developed System Medium Actuators (SMAs) that rely upon system medium only for opening and fast closing. Many of the inherent failure mechanisms found on conventional fast-acting actuators, such as contact limit switches, stem packing and booster pumps, have been eliminated. CCI's SMA technology is available as an integral part of CCI's high-energy isolation valve or for upgrading original plant equipment.

CCI has completed over 140 MSIV and MFIV plant installations and upgrades around the world. Cost for upgrade is often offset in the near term by reduction in maintenance and elimination of leak rate anomalies.

CCI high-energy isolation valves for power uprate

Typical Applications for Pressure Boundary Isolation Valves

Application	Industry Problems	CCI Solutions
PWR MSIV	Frequent and costly electro-hydraulic actuator service	System medium actuator with eight to 10-year maintenance intervals
	Frequent repair of hardfaced disc and seating surfaces	Pressure-activated disc, frictionless cycling of gate valve
	Valve stem packing leaks and frictions	No stuffing box or stem packing
	Restricted flow	Reduced pressure drop, improved C_v
BWR MSIV	Flow-induced noise and vibration	Stable back seating of globe disc
	Erosion of stem and disc connection	Stem connection shielded from flow
	Turbulence generation	Internals contoured for improved flow
	Limit switch failure in steam tunnel environment	Induction coil position indication, remote adjustment from mild environment

MSIVs play an important role in plant performance. Most are subject to routine surveillance tests, such as LLRT, for leak rate integrity. Closing time in emergency mode must be less than five seconds.

Leak tight shutoff

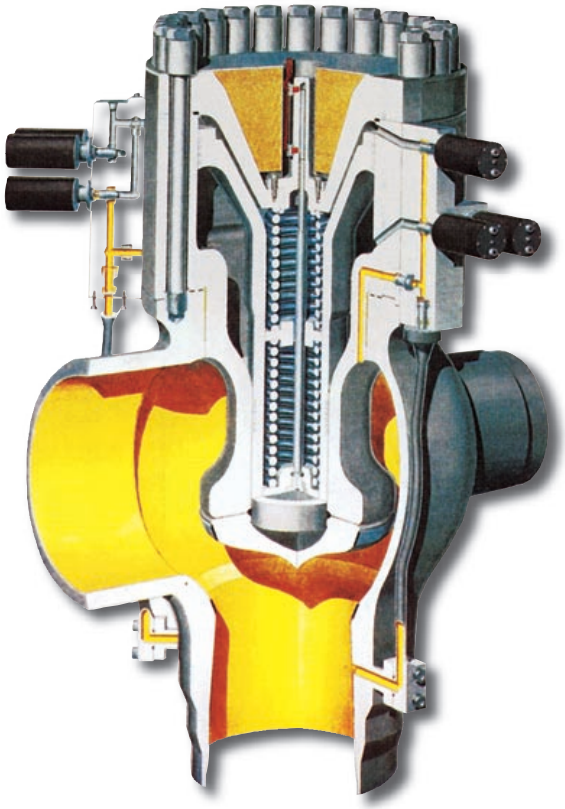
Today's demands for cost-competitive power generation require a pressure boundary valve to provide positive, leak-tight performance with each cycle. Disassembly for leak rate repair can mean failing to meet the goals of an outage schedule.

Power uprate

MSIVs can also limit production capacity by restricting flow and producing turbulence. Reducing differential pressure contributed by the MSIV can increase plant capacity by as much as 5 MWe. Resulting laminar flow downstream of the MSIV further supports power uprate goals.

Many conventional MSIVs have proven to produce noise from vibration. Erosion problems have caused separation of stem and disc, resulting in plant trip.

CCI's high-energy isolation valve provides solutions for MSIV and actuator reliability and performance problems while increasing available flow and improving flow characteristics.



CCI high-energy isolation globe valve sectional view with system medium actuation

CCI advanced safety and pressure relief valves for performance reliability

Main steam safety relief valve with optional electric motor override feature

CCI DRAG® atmospheric steam dump, power-operated relief valve

Advanced Pressure Relief Valves

CCI is a leading supplier of safety and pressure relief valves for nuclear applications. CCI has developed advanced safety valve technologies that provide positive solutions for PWR and BWR pressure relief concerns. The CCI safety valve has proven stable and leak-tight in all operating modes.

Valve simmering problems typical of spring-loaded safety valves are caused by the balancing of system pressure below the disc with spring closing force acting above the disc. As system pressure approaches lift set point, spring-loaded safety valves grow unstable, producing seat leakage and loss of plant efficiency. The closing force acting above CCI's main disc is produced by system pressure and is a minimum of twice the force acting below the disc until lift set point is fully reached. This principle of operation ensures stable valve performance and eliminates simmering and the potential for damaging valve chatter when subjected to high-pressure, low-flow conditions.

CCI's advanced safety valve operates on the principle of pressurization. Fluid or steam flow in the pilot control area is limited and velocity is controlled to prevent erosion and leakage.

PWRs employing CCI's safety valve for pressurizer primary overpressure protection have found they do not need to thermally soak (stabilize) the valve during power ascension and can therefore ramp up at a faster rate without concern for seat leakage.

For BWR and PWR main steam safety valve applications, CCI's safety relief and main steam isolation valves can be integrated in one module to minimize plant space requirements as well as reduce plant construction scheduling and costs.

CCI's DRAG® valve is in use for PWR main steam power-operated atmospheric relief around the world. CCI's exclusive velocity control technology is ideal for controlling steam venting when plant operations call for a minimum valve open position. CCI velocity control technologies are also used for silencing relief exhaust vent systems to satisfy hearing protection standards.

CCI's wide range of safety and pressure relief designs allow applying the best technology for an application, including:

- BWR and PWR main steam safety relief
- PWR main steam power-operated relief
- PWR primary over-pressure protection
- RHR over-pressure protection

CCI advanced safety and pressure relief valves for tight shutoff

Typical Applications for Safety Relief Valves

Application	Industry Problems	CCI Solutions
PWR Pressurizer Safety	Seat leakage during plant heat up	No thermal soaking required to achieve tight shutoff, no costly loop seal required
	Potential for chattering in low-flow, high-pressure conditions	Stable valve performance when subjected to two-phase flow or low-flow transient
PWR Main Steam Safety	Simmering and leakage at normal operating pressures due to balancing system pressure with spring force	Leak-tight shutoff at normal operating pressures due to stable disc contact force regardless of system pressure
	Steam cutting and erosion of disc and seat	Stable disc contact force prevents steam cutting
	Set point test deviations	Repeatable test performance within required tolerance
BWR Main Steam Safety Relief	Sticking/ bonding of pilot disc to seat, causing set point test deviations	Proper geometry of pilot disc to mitigate sticking/ bonding
	High velocity flow in pilot stage during main valve lift, causing erosion and leakage of control elements	Velocity controlled in pilot stage during main valve lift, preventing erosion of control elements

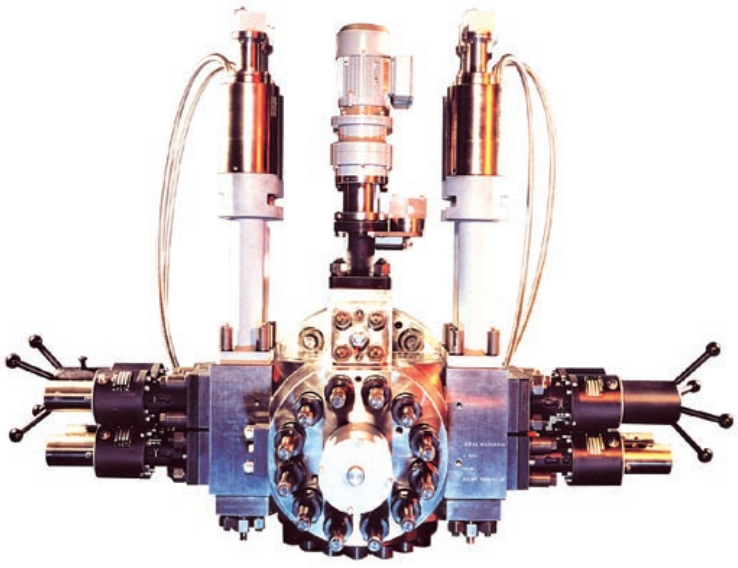
Most of today's spring-over-disc and pilot-operated safety valves found in critical nuclear overpressure protection applications are adaptations of conventional power designs. CCI's advanced safety and pressure relief valves were developed specifically for nuclear application.

Nuclear power plants continue to experience lost productivity from pressurizer and main steam safety valve seat or pilot leakage. Set point lift test deviations cause expensive delays in in-service test programs and drive up maintenance costs.

Dependable set point performance

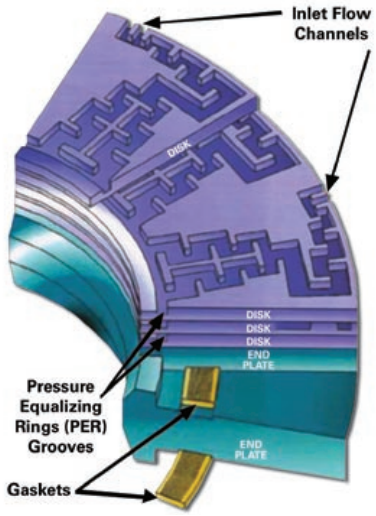
CCI's advanced nuclear overpressure protection technology has proven to solve the seat leakage and set point deviations problems inherent in spring-over-disc safety valves and early generation pilot-operated safety valves using the depressurization principle of operation.

CCI offers exclusive dual-function pressurizer and main steam safety valve features, including integral electric motor actuation for bleed and feed and low-pressure condition override.



Dual-function PWR pressurizer overpressure protection safety relief valve

Conventional valve trim destroyed by high velocity-induced cavitation



Exclusive flow channels equalize unbalanced pressures to prevent vibration

More on Velocity Control

High fluid velocities passing through the control element are a root cause of control valve failure. The damaging effects of cavitation, erosion, abrasion, high noise and vibration are signs that velocities are not being controlled. These high velocities can quickly destroy a conventionally designed valve. In the period before catastrophic failure occurs, excessive noise, severe vibration and poor process control reduce power plant performance.

In a conventional control valve, process fluid flows through some version of a single or multiple-hole orifice. The resulting high-pressure drop produces uncontrolled velocities. These high velocities, the unwanted side effects of pressure reduction, are not treated as a design criteria by many valve manufacturers. Instead, harder trim, pipe lagging and downstream diffusers are used. All are costly attempts to treat the symptoms rather than the real cause of the problem.

CCI's DRAG® technologies prevent development of high velocities and flow-induced problems. At the same time, they satisfy the true purpose of a final control element: to effectively control system pressure and flow rate over the valve's full stroke. CCI's DRAG® disk stack design permits application-specific characterization of the trim to achieve optimum valve performance and reliability. The DRAG® valve's rangeability performance up to 300:1 or greater is unmatched. CCI's DRAG® technology is available for upgrading many conventional design valves.

In addition to long life, nuclear power plants are concerned with valve shutoff performance. CCI's DRAG® valve includes pressurized seating that, when combined with high actuator force, delivers tight shutoff each and every cycle. CCI's DRAG® valve performs to stringent MSS-SP61 shutoff standards.

CCI has applied DRAG® technologies to improving nuclear plant performance for over 30 years. Although the experience list is extensive, the following are samples of applications where DRAG® increases plant performance and reliability:

- Main and auxiliary feedwater control
- Feedwater bypass
- Feedwater pump recirculation
- High-pressure safety injection (HPSI) and low-pressure safety injection (LPSI) control
- Power-operated relief valves
- Temperature control, decay heat removal
- Chemical volume control valve (CVCS) letdown and charging control

KC Check Valves

- Integral damping
- Non-slam performance
- Induction position indication

IEEE and KTA Qualified Solenoid Operated Valves (Herion)

- Extended life Class C coil
- Bolted bonnet construction
- ON/OFF and modulating models

IEEE and KTA Qualified Induction Position Indicators

- Remote adjustment
- No reeds or contact points
- Upgrades most brands of check valves

BWR ECCS Suction Strainers

- Enlarged suction surface
- Anti-clogging feature
- Turn-key plant modification engineering

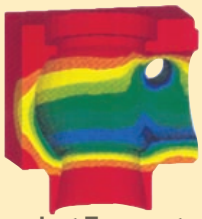
High-Density Fuel Racks

- Increased storage capacity
- Enhanced lifting and handling
- Dry and wet storage

Atmospheric Resistor Silencer

- Supports OSHA noise standards
- Upgrades existing vents
- Zero maintenance, compact design

Engineering and Field Services



Transient Temperature Distribution Inside a Nozzle

Studies and Calculations

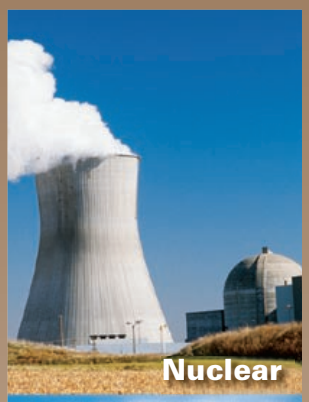
- Structural mechanics
- Fluid dynamics
- Life cycle analysis/prediction
- Aging management

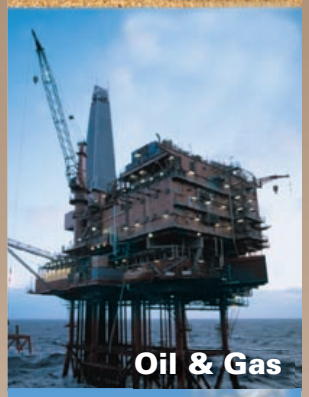
Nuclear Field Services

- Valve and control upgrades
- Scheduled maintenance
- 24-hour emergency services

Professional Consulting Engineers

- Plant optimization
- Component reliability
- Seismic requalification





Throughout the world, companies rely on CCI to solve their severe service control valve problems. CCI has provided custom solutions for these and other industry applications for more than 80 years.

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