

A large industrial refinery complex is shown at dusk, with several tall distillation columns and a network of pipes and walkways illuminated by lights. The sky is a mix of blue and purple.

FLUID CATALYTIC CRACKING

At the corporate level, the standard business model for operating a plant focuses on reducing costs and increasing revenue. To achieve these high-level objectives, successful execution at the plant level is essential. Key areas for improvement often include safety, reliability, and environmental impact. In a refinery, optimizing the control of critical control valves is crucial to maximizing production. A well-designed plant modernization package ensures that all critical turbomachinery control elements work together seamlessly. This is accomplished through advanced control algorithms, precise measurement, and accurate actuation. Together, these technologies enable operations to effectively advance plant priorities.

Maximizing refinery profitability is key. Gasoline and diesel often account for a significant portion of a refinery's output, so having an efficient Fluid Catalytic Cracking (FCC) unit is essential for producing more of these high-demand products. This directly boosts the refinery's profitability. In summary, the FCC is vital for enhancing the economic value of refinery operations by optimizing the conversion of crude oil into high-demand products, increasing profitability, and providing greater operational flexibility.

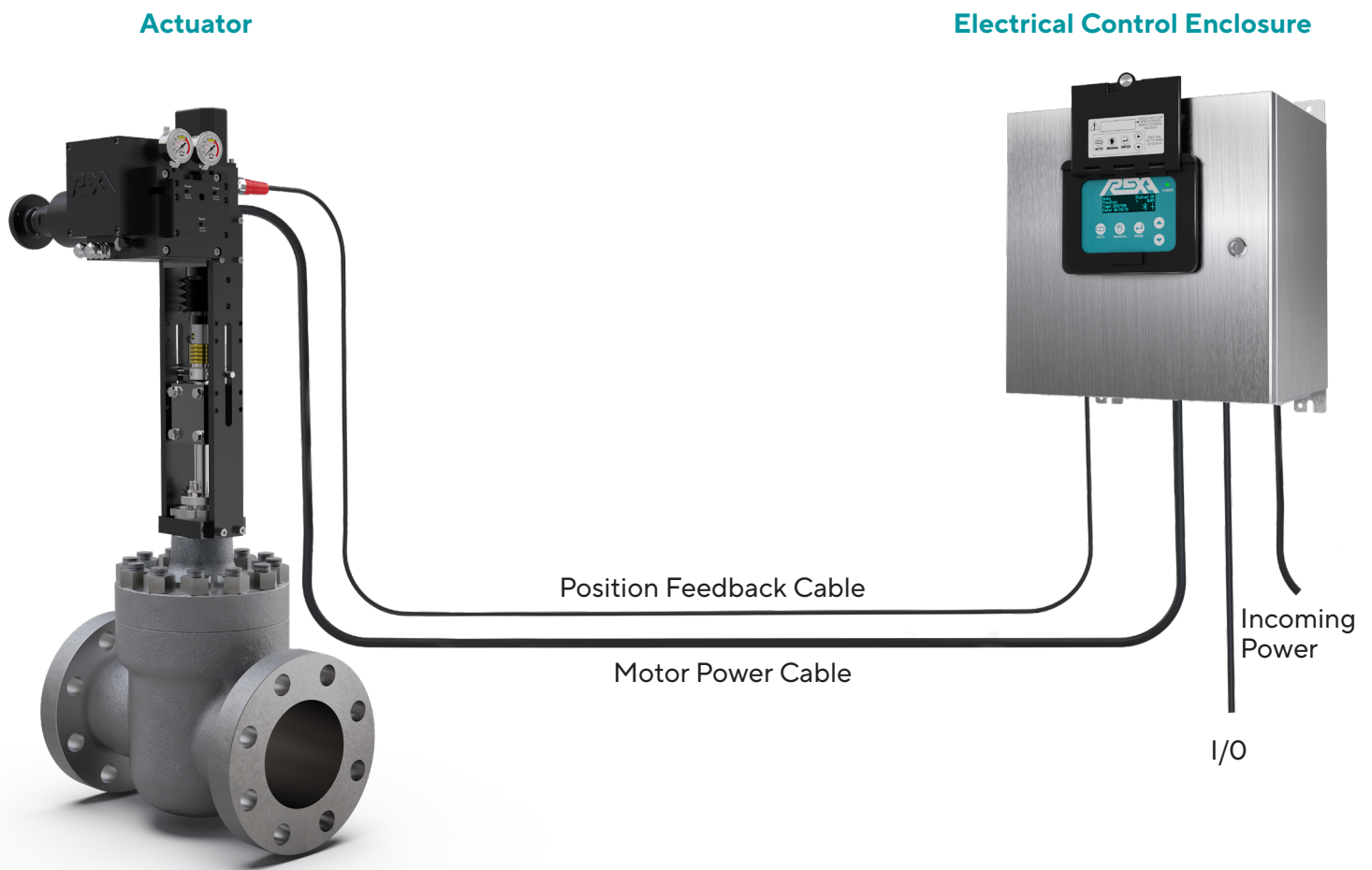
ELECTRAULIC™ ACTUATION

The REXA Advantage

At REXA, we have 30 years of experience in the petroleum refining market. We offer reliable, high quality low maintenance Electraulic™ Actuators that have been field-proven in some of the most critical and difficult applications.

The REXA XPAC Series 3 Electraulic™ Actuator is a superior positioning device well suited for critical control applications, such as those found in refineries. Our actuation technology reliably controls severe process conditions in harsh environments for a wide range of severe service applications. REXA Electraulic™ Actuators and Drives provide the final control element capabilities to match the most sophisticated instrumentation and distributed control systems.

The XPAC Series 3 is comprised of the actuator and electrical control enclosure. The actuator consists of a double acting hydraulic cylinder, position feedback sensor and an Electraulic™ Power Module. The power module is a unique, self-contained, positive pressure-sealed hydraulic pumping system which manages oil pressure and flow to and from the cylinder. The electrical control enclosure consists of power supplies, motor drivers and a dedicated microprocessor. The combination of these mechanical, hydraulic, and electronic technologies ensures precise and repeatable control of refinery processes.

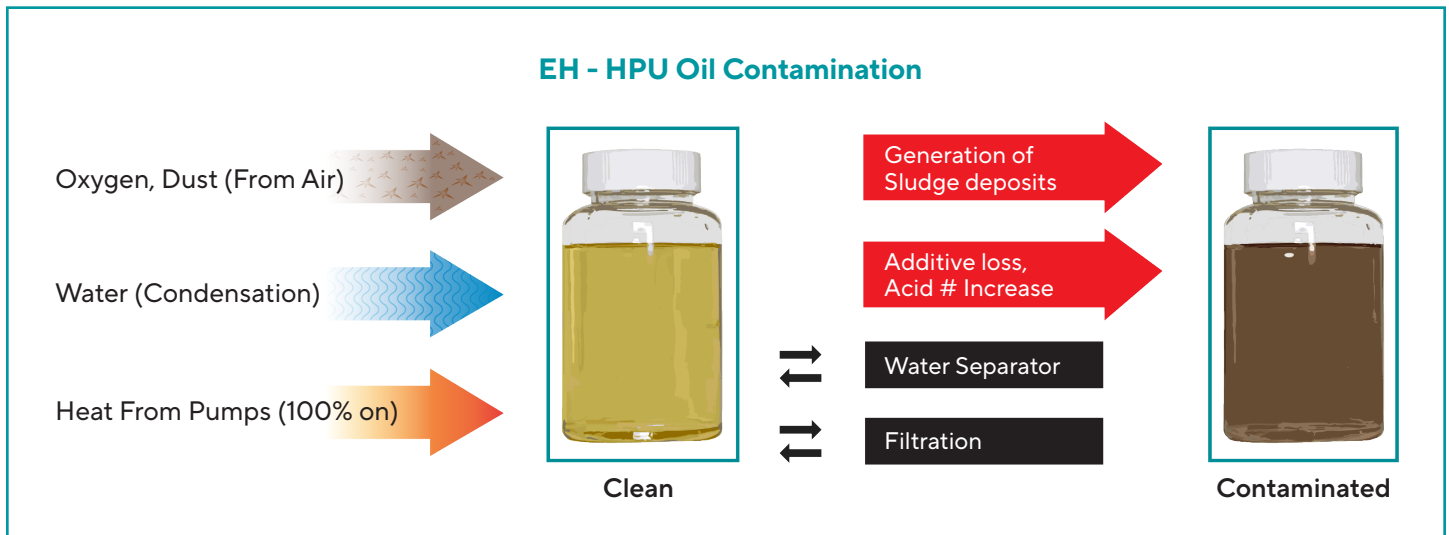


Limitations of Common Hydraulic and Pneumatic Actuation

Hydraulic Power Unit Actuation:

Traditional Hydraulic Power Units (HPU) are commonly used in critical severe service applications requiring position accuracy, speed, and response time. However, HPUs have numerous drawbacks associated with them, including:

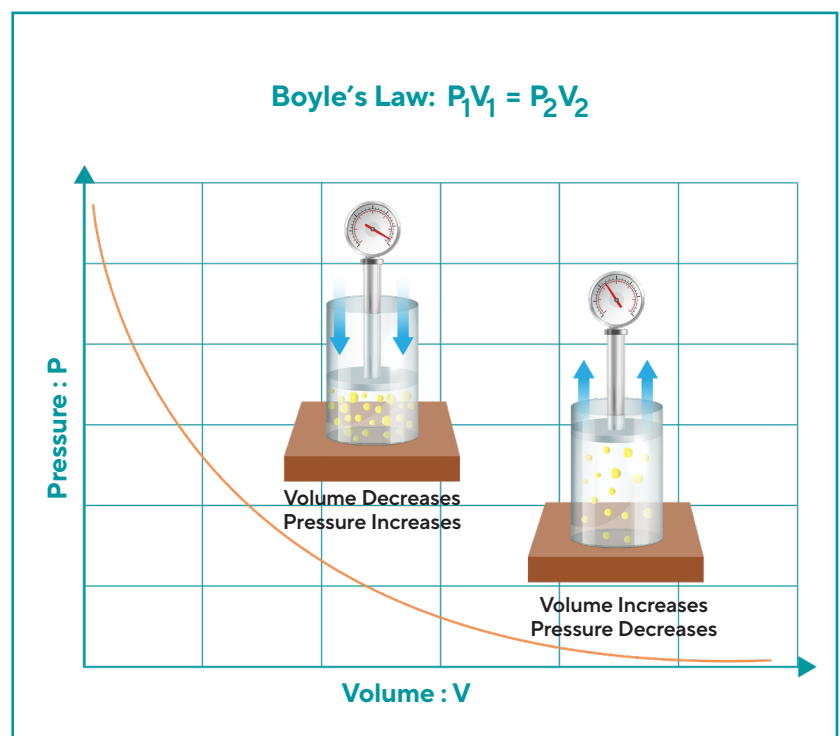
- Hydraulic fluid contamination
- Frequent fluid, desiccant and filter changes
- Expensive large volume of fluid
- Vented to atmosphere
- Continuously running pumps
- High electricity consumption



Pneumatic Actuation:

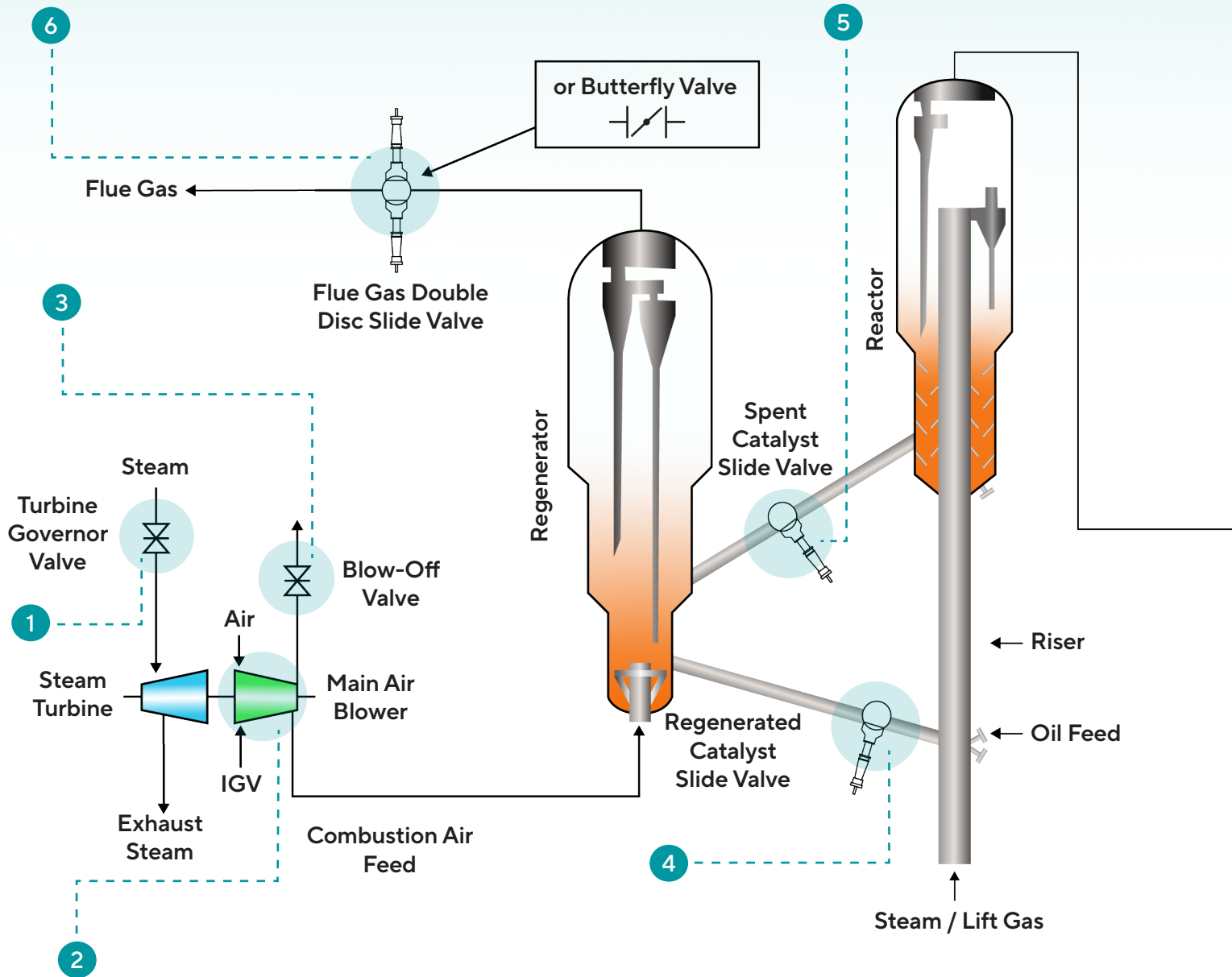
The inexpensive, familiar design of pneumatic actuators makes them the most common type of actuation technology where air is readily available. Though perceived as a low-cost solution, the true cost of pneumatics is often overlooked:

- Requires clean dry instrument air
- Costly compressor system maintenance
- Air compressibility causes poor position accuracy
- Static friction "stiction" impacts pneumatic actuator performance
- Smart positioners slow actuator response (deadtime)
- Volume boosters and quick exhaust required for speed
- Larger heavy actuators require structural support



Fluid Catalytic Cracking Process

Fluid Catalytic Cracking (FCC) is a critical conversion process in petroleum refineries, widely used to transform heavy oils into gasoline and lighter products, particularly propylene. The feedstock is injected into a riser, where it is mixed with hot catalyst from the regenerator. In the riser/reactor, large gas oil molecules, facilitated by catalyst, break apart into smaller molecules, which form gasoline and other valuable light products. To ensure efficient chemical reactions, the catalyst bed in the reactor is fluidized for optimal contact. The resulting gas exits the top of the reactor and is further separated in the distillation column.

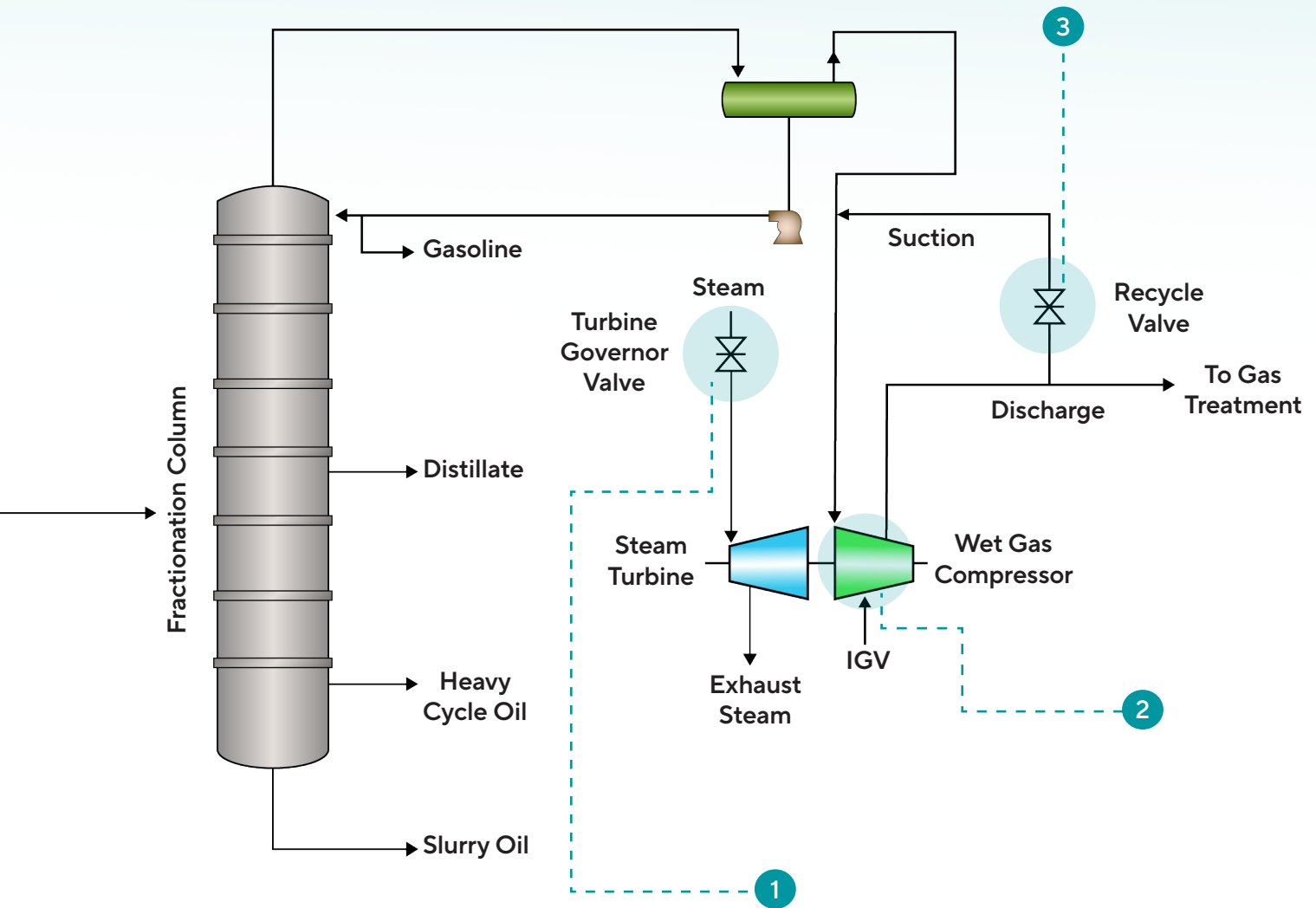


1 Governor Speed Control

2 Inlet Guide Vanes (IGV)

3 Anti-Surge

As the process continues, the catalyst particles in the reactor accumulate carbon deposits (coke), which reduce their ability to effectively crack the feedstock. To address this, the spent catalyst is transferred to the regenerator, where it is fluidized with hot air to burn off the coke, restoring the catalyst's cracking capability. The regenerated catalyst is then returned to the feed riser to repeat the process. Depending on the unit's capacity and the type of end products being produced, an FCC unit can have up to 250 control valves. The selection of globe or rotary valves often varies due to the erosive nature of the fluids in several applications. REXA has successful installations in many critical FCC applications that require high reliability and precise control.



4 Regenerated Catalyst Flow

5 Spent Catalyst Flow

6 Flue Gas Control

Regenerator Main Air Blower Blow-Off Valve

Application Purpose and Operating Conditions

- The FCC main air blower blow-off valve protects the main air blower by preventing surge
- Maintains minimum airflow and stabilizes the air system during process changes, startup, and upset conditions
- Main air blower trip must be avoided to prevent coke burning stoppage and reactor/regenerator heat balance collapse - often resulting in a FCC unit shut down

REXA Solution

- REXA actuation quickly opens the blow-off valve, acting as a relief mechanism, allowing the excess pressurized air to escape to atmosphere
- Quick response protects the blower's bearings and impeller from the severe stresses of surging
- Rapid valve response prevents the main air blower from entering an unstable operating zone, avoiding potential trips and unplanned shutdowns for the entire FCC unit
- FCC unit uptime and throughput are maximized



Regenerator Flue Gas Valve Control

Application Purpose and Operating Conditions

- Regulates the rate and direction of flue gas exiting the regenerator
- Helps maintain proper pressure differential between the regenerator and reactor
- Used for emergency isolation during upset conditions to prevent backflow
- Accurate flue gas valve control is critical to maintain FCC pressure differential in the cracking process
- During expander trip the flue gas valve must open reliably to divert gas directly to the stack preventing regenerator overpressure

REXA Solution

- In a recent installation success story REXA upgraded a refinery FCC by replacing a failing HPU actuator system
- REXA performance achieved through precise valve control with high reliability
- Less than 0.008% deviation between DCS output and actuator position

FCC Cost Of Downtime (Operations)			
Labor	Maintenance & Repair	Utilities	~\$500,000 per day



Linear Double Disk Slide Valve



Rotary Butterfly Valve(s) (recycle to expander)

Regenerator Main Air Blower Turbine Speed Governor

Application Purpose and Operating Conditions

- Regulate steam flow into the turbine to control blower speed and maintain the required air flow to the regenerator
- Stable air flow is essential to maintain coke combustion, regenerator temperature, and flue gas CO and O₂ composition
- A sticking actuator can lead to large speed swings (100–200 rpm), resulting in a process trip of the main air blower

REXA Solution

- By maintaining precise speed control, REXA actuation prevents process oscillations and unplanned shutdowns of the entire FCC unit
- It acts as a controlled throttle during the startup, warm-up, and shutdown sequences, increasing the ramp rates of the turbine
- REXA hydraulic circuit design completely removes the need for filtration and requires no oil maintenance as part of a preventive maintenance plan



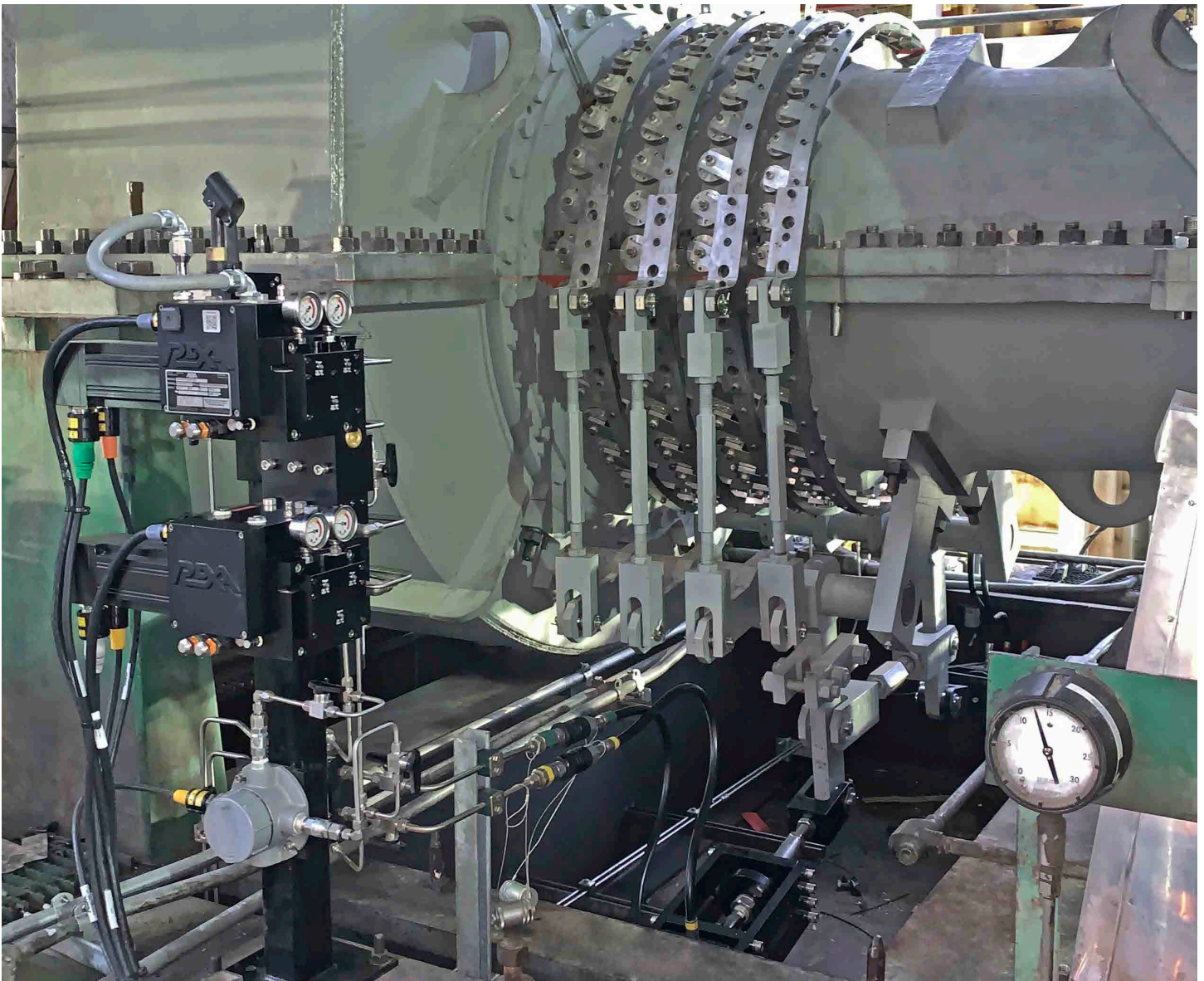
Regenerator Main Air Blower Inlet Guide Vanes

Application Purpose and Operating Conditions

- Inlet Guide Vanes (IGV) determine the airflow mass rate by adjusting the amount of air entering the compressor and optimizing performance across different operating conditions
- Airflow enters the compressor at the optimal angle, reducing the likelihood of flow separation, improving efficiency, and minimizing the risk of compressor surge or stall

REXA Solution

- REXA positions IGV to help match the airflow to the downstream load, allowing them to be more efficient at different position settings
- <100msec dead time
- Remote power module
- REXA has retrofit Inlet Guide Vanes that previously had pneumatic actuators which suffered from poor control with overshoot and undershoot



Regenerated Catalyst Slide Valve Control

Application Purpose and Operating Conditions

- Regenerated slide valves regulate the flow of regenerated catalyst to the riser
- Maintains the pressure head in the standpipe
- Protects regenerator from a flow reversal
- Catalyst slide valve stroke lengths can range between 8-28 inches
- Optimal slide valve operation is key to avoid pressure unbalances that could lead to inefficient process performance

REXA Solution

- State of the art actuation technology with unmatched performance
- Redundant construction options with hot swap capability for maximum reliability
- Declutchable manual override
- Accumulator fail-safe for loss of power trip conditions
- Adaptable to any slide valve



Spent Catalyst Slide Valve Control

Application Purpose and Operating Conditions

- Plays a crucial role in maintaining a catalyst barrier
- Stops hydrocarbons from the reactor from entering the regenerator
- Failure could pose safety risk of carbon containing gases to enter regenerator and flue gas system that can lead to ignition

REXA Solution

- Full system redundancy with hot swap capability
- SIL 3 capability with 4oo4 solenoid configuration
- Online solenoid proof testing capability
- Declutchable manual override



Wet Gas Compressor Turbine Governor Speed Control

Application Purpose and Operating Conditions

- This compressor's major function is reactor pressure control by compressing low pressure gas that exited the fractionator, maintaining a stable differential pressure between the regenerator and reactor
- Reactor/regenerator differential pressure must be controlled within a relatively narrow range to permit stable catalyst circulation

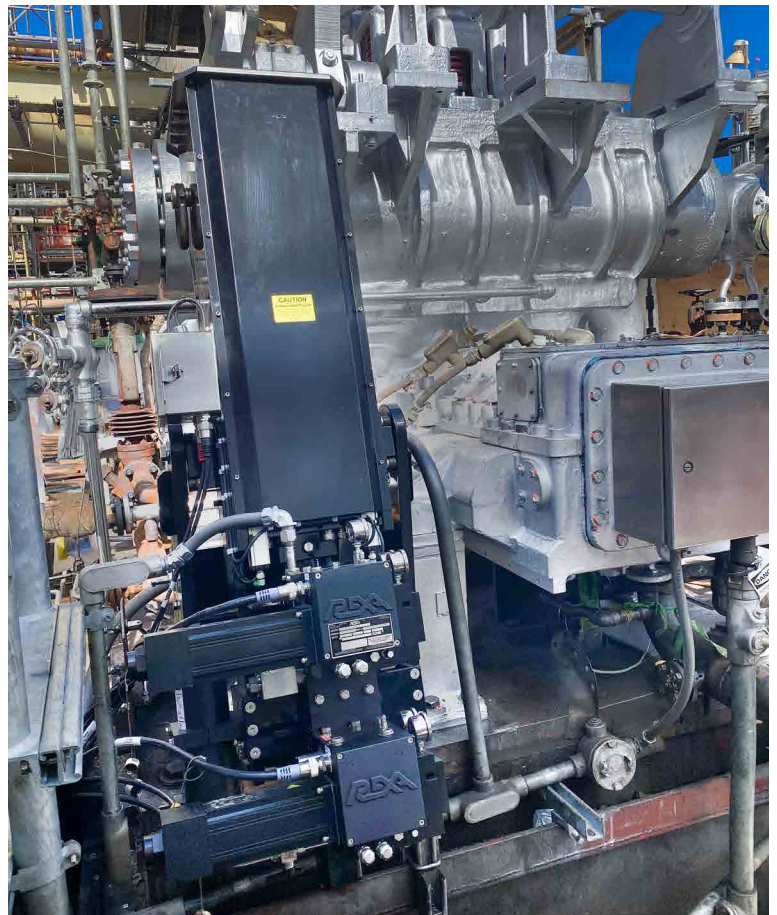
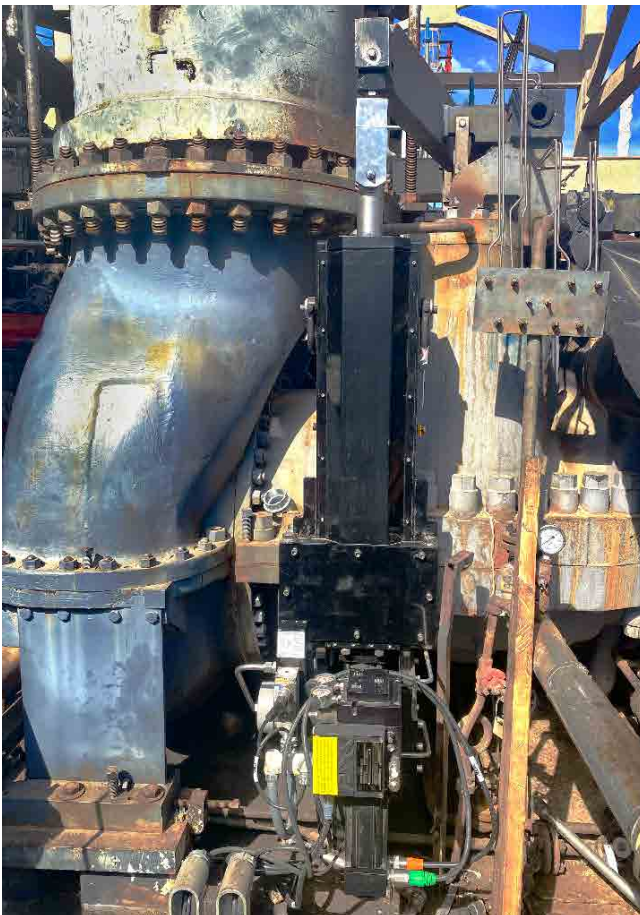
REXA Solution

- Accurately control turbine speed to ensure stable machine performance
- Significantly reduce refinery downtime to maximize revenue
- Precise and reliable positioning accuracy that addresses variability in main column overhead receiver
- Consistent governor position accuracy addresses variability in main column overhead receiver pressure and reduces risk of reactor pressure swings

FCC Cost Of Downtime (Gasoline Revenue Only)

Feed Oil x Crack Spread x Gas Yield = Total Cost

$$135\text{K B/D} \times \$0.59 \times 50\% \times 42 = \$1.7\text{M/D}$$



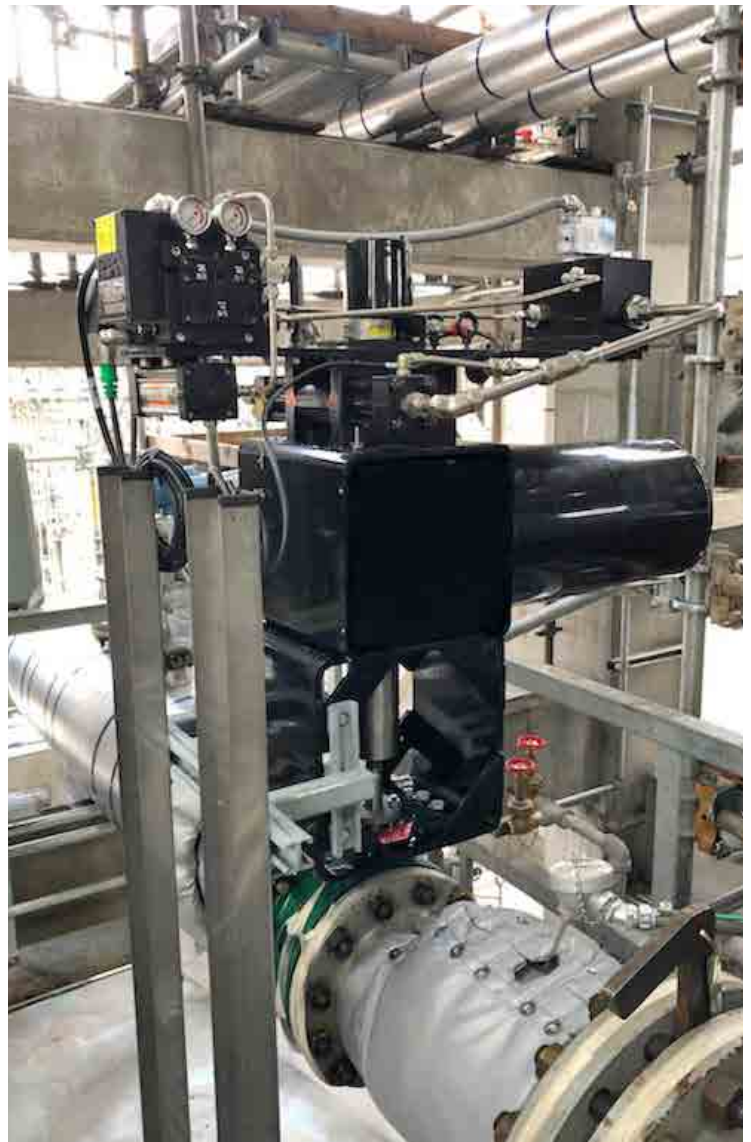
Wet Gas Compressor Anti-Surge Control

Application Purpose and Operating Conditions

- Used to recycle gas to ensure inlet gas flow rate is maintained above the minimum flow to protect the compressor from surge or choke
- Anti-Surge valve provides throttling control to recycle a portion of the discharge flow as the compressor is brought up to normal operation
- Legacy actuation (pneumatics) are prone to particulate and moisture ingress reducing performance and reliability

REXA Solution

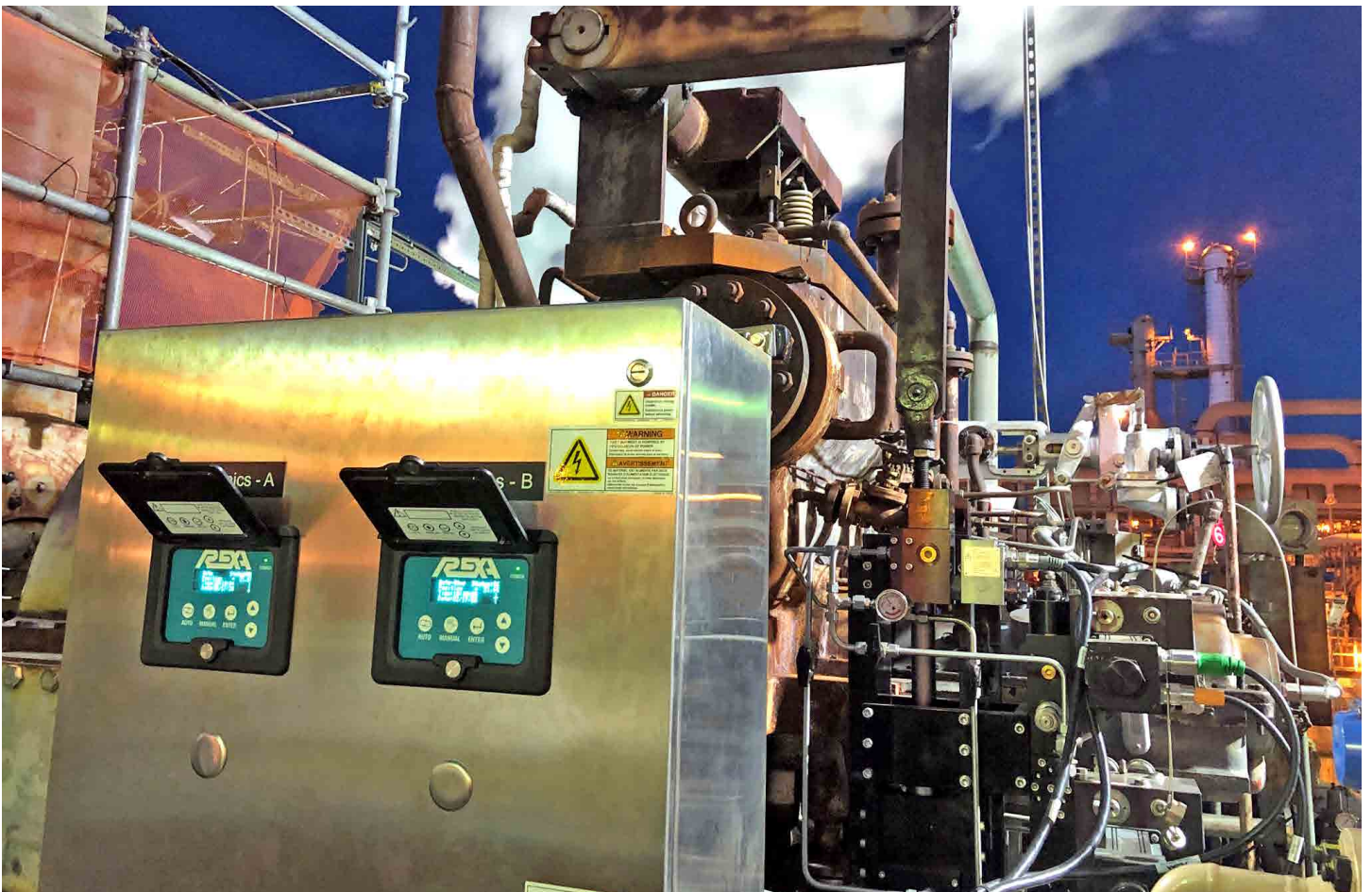
- Hydraulic driven with (non-compressible)
- Minimal deadtime (~70ms) and no overshoot
- Fast stroking speed (<2 seconds) for repeatable and reliable flow control
- Spring or accumulator fail-safe for power loss and trip conditions
- Adaptable to any Anti-Surge valve



Example Installations



Compressor Anti-Surge Valve Control

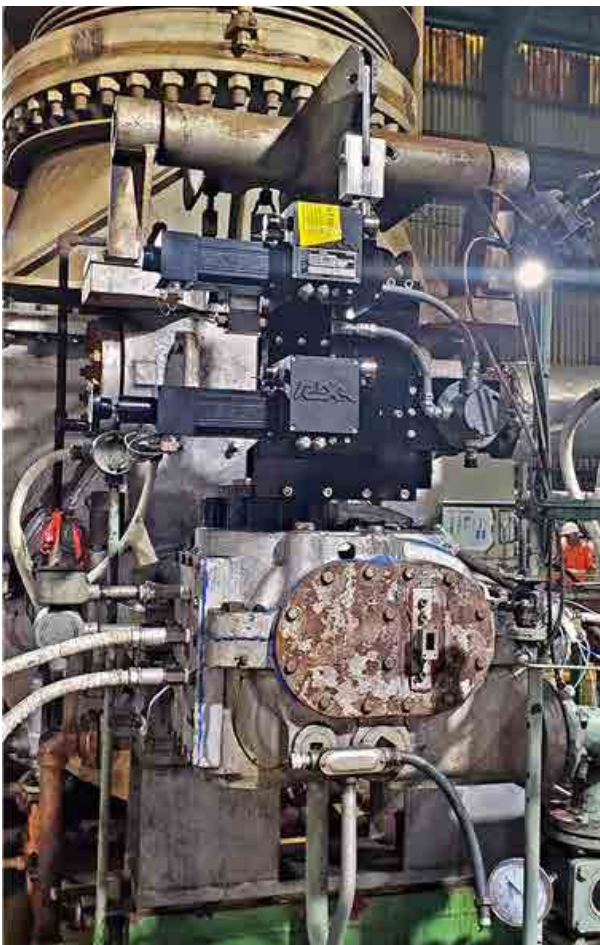


Steam Turbine Governor Control

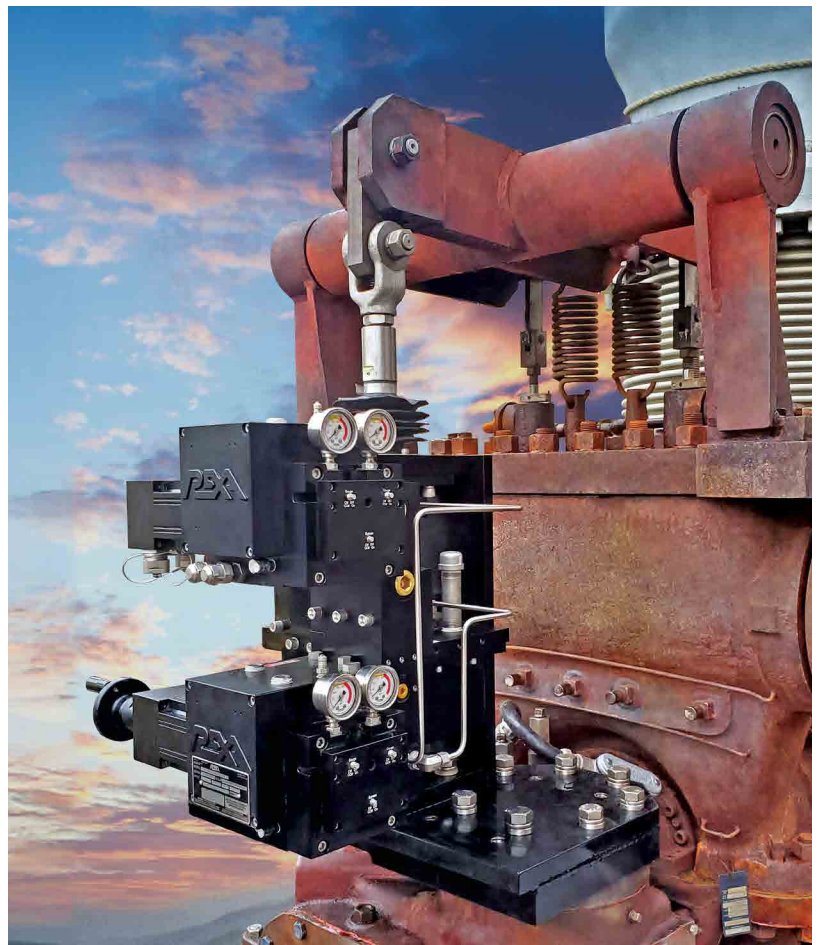
Example Installations



Compressor Inlet Guide Vane Control



Steam Turbine Governor Control





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