Yokogawa Solutions for Flue Gas Desulfurization and Denitrification
Yokogawa Solutions for Flue Gas

Yokogawa FGD solutions help optimize the operation of FGD systems and achieve the Sustainable Development Goals (SDGs) while minimizing running costs. A wide variety of solutions based on our extensive experience and track record all over the world ensure the ideal operation.

Proven control and monitoring system that digitizes the FGD system

Yokogawa, with its abundant experience in multiple FGD systems and providing control and monitoring solutions, has long played a key role in FGD system control. The service is not only for new power plants but is also ideal for retrofitting existing conventional systems. Digitized FGD systems with a retrofitted control system bring financial and safety benefits to customers.

Optimization of wet-scrubber FGD

With its optimization system, Yokogawa can minimize the total cost of ownership while keeping the FGD system with wet-limestone scrubbing in the ideal condition. The optimization system has been proven to perform well at large-scale coal-fired power plants in Japan; major improvements achieved include the following:

Cost reduction by optimizing pump operation
Yokogawa's FGD optimization system determines the optimum number of recirculation pumps required to run to keep the sulfur dioxide (SO₂) concentration in the outlet flue gas below the regulatory limit, thus reducing the consumption of electricity and limestone slurry and minimizing the cost of FGD operation.

Highly stable pH of slurry
The pH value of limestone (or lime) slurry is a key parameter that can be controlled to maximize the removal of sulfur oxides (SOx) while minimizing scale buildup, thus maintaining optimum FGD performance while avoiding unexpected problems. Yokogawa's optimization system stabilizes the pH of the slurry regardless of the process conditions.

Effective removal of SO₂ from flue gas
The primary objective of the FGD is to remove sulfur dioxide from flue gas. Yokogawa's FGD optimization system ensures that SO₂ emissions are kept below the regulatory limit at the lowest cost.
DeSOx and DeNOx

Field instruments

For accurate measurement with minimum maintenance, it is essential to select highly reliable field instruments.

**Pressure/differential pressure transmitters**
Yokogawa’s proven pressure and differential pressure transmitters can meet almost any process measurement needs. Silicon resonant sensors developed by Yokogawa ensure reliable measurement with high performance and robustness.

**Temperature transmitters**
Yokogawa’s temperature transmitters provide accurate and reliable temperature measurement.

**Electromagnetic flowmeters**
Yokogawa’s electromagnetic flowmeters are an excellent choice to measure and control the flow of abrasive and erosive limestone slurry to the sprayers, etc.

Flue gas analyzer system

Monitoring of FGD inlet and outlet flue gas is essential to measure the concentrations of SO₂ and other components. As the concentration of SO₂ in flue gas is a key index of FGD performance and compliance with emission regulations, a reliable online emission monitoring system is essential for ideal operation of an FGD plant. Yokogawa offers a flue gas analyzer system comprising a combination of high-end Yokogawa products with some third-party devices to deliver stable FGD control.

**pH analyzers**

Unstable pH measurement can have a significant adverse effect on the entire FGD performance, and so pH measurement is one of the critical parts of FGD control. Yokogawa’s pH analyzers developed based on its extensive experience and knowledge ensure accurate and stable pH measurement.
Distributed Control System (DCS) for FGD Control and Monitoring

**CENTUM VP**

Yokogawa’s CENTUM VP has a proven, ultra-high hardware availability better than “seven 9s” (99.999959%) thanks to its inherent dual-redundant design, non-stop controller technologies enabled by a “Pair & Spare” CPU configuration, the world’s fastest 1-Gbps control network (Vnet/IP), and online maintenance capability. CENTUM VP is ideal for FGD, whichever type of desulfurization system is adopted.

---

No. 1 market share (more than 60%) in Japan

The leader and pioneer of control solutions for all types of FGD at utility power plants in Japan

Yokogawa, the pioneer of FGD control with more than 40 years of experience, started providing control solutions to meet strict emission standards earlier than any other provider anywhere, including in Europe and North America!
**Turceni Thermal Power Plant (Coal-fired, 4 × 330 MW)**

Yokogawa’s integrated solutions for FGD process control at Romania’s largest power plant

The Turceni thermal power plant is the largest coal-fired power plant in Romania, belonging to the Romanian state-owned coal energy producer Complexul Energetic Oltenia S.A. When Romania joined the EU in 2007, it was required to bring the sulfur dioxide (SO$_2$) and dust emissions from its power plants into compliance with the EU environmental standards by 2011. At the Turceni power plant, it was decided that the installation of FGD systems for Units 3, 4, 5, and 6 would be financed by the Japanese government. Yokogawa provided its CENTUM VP integrated control system (PCS); field devices such as DPharp EJX pressure/differential pressure transmitters, ADMAG electromagnetic flow meters, pH analyzers, temperature transmitters; the Plant Resource Manager (PRM) integrated device management tool; the Exaquantum plant information management system (PIMS), etc.

**Tachibanaawan Thermal Power Plant (Coal-fired, 2 × 1,050 MW)**

Integrated system for environmental control facilities at one of the largest coal-fired power plants in Japan

The Tachibanaawan thermal power plant is one of the largest coal-fired generation units in Japan consisting of two 1,050 MW units. The plant is well known not only for its stable electricity supply but also for its environmental protection measures of removing nitrogen and sulfur oxides (NOx and SOx) emissions and ash dust, and recycling fly ash. The environmental control facilities at this plant include FGD, electric precipitator, coal handling, ash handling, and wastewater treatment systems. This large application with more than 30,000 data items is monitored and controlled by Yokogawa’s CENTUM CS integrated control system. Since entering commercial operation in 2000, the environmental control facilities at the Tachibanaawan Power Station have been managed effectively by the CENTUM CS, achieving a stable supply of electricity with minimal impact on the environment.
Optimization system for the best FGD performance

Yokogawa’s FGD optimization system is best suited for wet limestone scrubbing among all types of desulfurization process. The typical configuration shown below can continuously adapt to varying process and plant conditions and maintains optimal FGD performance at all times.

**Model Predictive Control (MPC)**
- Optimized slurry flow calculation
- Optimized pH calculation

**Process Value Prediction**
- \( \text{SO}_2 \) concentration prediction
- Calcium carbonate (\( \text{CaCO}_3 \)) conc. prediction
- pH bias prediction

**Enhanced Regulatory Control (ERC)**
- Pump operation optimization
- Slurry flow setpoint calculation
- pH setpoint calculation
- Feedforward control for abnormal cases

**Normal-state control by DCS**
- Slurry flow control
- pH control

Yokogawa’s optimization system:
- Effectively keeps \( \text{SO}_2 \) concentration in flue gas below regulatory limit
- Reduces load of recirculation pumps by optimizing the number of pumps in use
- Optimizes limestone slurry consumption
- Achieves stable control of slurry pH
- Enables the FGD system to adapt to various types of coal and coal-oil mixture firing
- Adapts to changes in line with plant aging
- Adapts to changes in load and other process conditions
Success at 700 MW coal-fired power plant in Japan

Yokogawa’s FGD optimization system has significantly reduced costs and improved performance at large coal-fired power plants in Japan. As an example, the trend graph below shows the operation data with and without optimization at a 700 MW coal-fired unit that uses Yokogawa’s optimization system.

### 8 hours with optimization disabled vs 8 hours with optimization enabled

- **Absorber pH**
- **Absorber inlet SO2**
- **Number of recirc. pumps in use**
- **MW load**
- **Slurry flow**
- **Absorber outlet SO2**

8 hours with optimization disabled:
- All five recirculation pumps are in use despite low absorber inlet SO2 level.
- Unnecessarily large margin compared to the target value.

8 hours with optimization enabled:
- Change in coal type to high sulfur coal raised inlet SO2 concentration.
- Number of recirculation pumps in use was reduced by two despite the increase in inlet SO2 concentration.
- Outlet SO2 is reasonably lower than target.

### Reduced costs by US$700–900k per unit per year and in-plant load by 12.4%

Note: This result was achieved in a 700 MW coal-fired power plant in Japan assuming operation for 300 days per year and electricity cost of US$0.08 per kilowatt.

Yokogawa’s FGD optimization system keeps FGD plant facilities operating in the ideal state by means of stable control of slurry pH, a key parameter in FGD plant control. The pH is adaptively controlled within the allowable range under varying process conditions such as load changes.

### 300 MW coal-fired plant without FGD optimization system vs 1000 MW coal-fired plant with Yokogawa’s FGD optimization system

- **300 MW load change (1000+600 MW)**
- **1000 MW load change (1000+600 MW)**

300 MW (full load):
- Big deviation from pH control range and large pH fluctuation.

1000 MW (full load):
- Stably controlled pH in both normal condition and at load changes.

**Best condition with stable control of slurry pH**
There are many important processes in an FGD plant. Adequate FGD control and monitoring requires highly reliable field instruments for accurate measurement of various process values with minimum maintenance. Yokogawa offers a broad range of field instruments to optimize the performance of FGD operation.

**Pressure and differential pressure transmitters**

**Temperature transmitters**

**Magnetic flowmeters**

**Coriolis mass flowmeters**

---

**YOKOGAWA SOLUTIONS FOR FLUE GAS DeSOx and DeNOx**

Field Instruments

Pressure and differential pressure transmitters  
Temperature transmitters  
Magnetic flowmeters  
Coriolis mass flowmeters
The SO₂ concentration in flue gas is a key index since the objective of FGD is to remove SO₂ from flue gas to meet the regulatory target for SO₂ emissions.

As a specialist supplier of sensors and analyzers, Yokogawa supplies an integrated FGD flue gas analyzer system which combines sophisticated Yokogawa products and some third-party devices to ensure stable FGD control as per the customer’s requirement.

Our extensive experience and knowledge bring the following benefits to customers:

- Flexibly tailored, integrated analyzer system according to each customer’s requirements with a combination of Yokogawa products and third-party devices
- O₂ correction function built into Yokogawa infrared flue gas analyzers
- Dedicated after-sale service to customers after delivery

Yokogawa has over four decades of experience in providing tailored and packaged analyzer solutions to customers in various industries such as power, water, oil and gas, petrochemicals and chemicals. For the wet-limestone scrubbing type FGD, pH measurement is critical for control as unstable pH measurement can severely affect the entire FGD performance.

Therefore, reliable and accurate pH measurement is mandatory to keep the FGD system running optimally as the consumption of desulfurizing agent (lime or limestone) is controlled using online pH analyzers. Yokogawa’s pH analyzers incorporating extensive experience and knowledge ensure accurate and stable pH measurement of FGD.

- High reliability
- Tailored pH analyzer system for each application as per the customer’s requirement
- pH sensors with self-diagnostics
- Digital communications (HART, FOUNDATION Fieldbus and PROFIBUS PA)
- Dedicated after-sale service to customers after delivery
Powerful ultraviolet rays in sunlight cause a photochemical reaction of nitrogen oxides (NOx) in exhaust gas from power plants and factories, producing toxic photochemical oxidants such as ozone. This is the primary cause of photochemical smog which is harmful to most living creatures including humans. NOx in the air also reacts with water vapor to form nitric acid, which oxidizes water in lakes, rivers, and soil and also causes acid rain, which is harmful to plants and animals. NOx removal catalysts and denitrification (DeNOx) systems render NOx harmless via a decomposition reaction with ammonia, reducing atmospheric pollution.

In the typical processes of selective catalyst reduction (SCR) and selective non-catalyst reduction (SNCR) for denitrification, however, the release of ammonia gas into the atmosphere (ammonia slip) can occur due to incomplete mixing of the ammonia reagent with the NOx or excessive ammonia injection. As ammonia is a toxic gas and depletes the ozone layer, its release must be minimized. Yokogawa's holistic control, monitoring, and measurement solutions help minimize ammonia slip while maximizing DeNOx performance.

Yokogawa's Tunable Diode Laser Spectrometer (TDLS) is an ideal analyzer for ammonia slip monitoring. It measures the concentration of a gas using laser absorption spectroscopy without the need for preconditioning of the gas, unlike many similar analyzers used in a continuous emissions monitoring system (CEMS). This makes the TDLS ideal for harsh applications that require in-situ, precision, and fast-response measurement.

Tunable Diode Laser Spectrometer for Flue Gas DeNOx

Precision, Fast-response Ammonia Slip Monitoring

The American Electric Power (AEP) Clinch River power plant started operating in 1958 and is located near Cleveland, Virginia. In 2006, AEP Clinch River installed tunable diode laser (TDL) analyzers to measure ammonia slip from the SNCRs. However, these analyzers, which came from another vendor, did not provide sufficient availability to ensure that the compliance monitoring requirements could always be met. High maintenance costs and the accuracy of their readings were issues. After evaluating several vendors' TDL analyzers mounted on-site for several months, AEP decided to install nine Yokogawa TDLS analyzers to improve its monitoring of ammonia slip.

Thanks to having a more powerful laser light source than competing products, the TDLSs are able to measure ammonia slip in the flue gas of a coal-fired power plant, which is known as an extremely challenging application for analyzers of this type because of the inevitable high dust (fly ash) loading.

Since installation, the TDLS analyzers have been working efficiently and effectively. AEP now finds it much easier to meet and comply with national NH₃ regulations.

To measure ammonia across the entire width of a flue gas duct, insertion tubes were installed on both the launch and detector units. This shortens the section of the long optical path length that is exposed to particulate-laden process gases, which can decrease measurement accuracy. The insertion tubes are air-purged to keep the laser windows clean and prevent the entry of fly ash which can cause additional signal degradation and maintenance issues.
Yokogawa Solutions for Flue Gas Desulfurization and Denitrification

With the adoption of the Paris Agreement at the 21st Framework Convention on Climate Change (COP21) and the Sustainable Development Goals at the United Nations Sustainable Development Summit, momentum is building in the global effort to achieve a sustainable society. In light of these developments, in August 2017, Yokogawa released a statement on its aspiration for sustainability and established three sustainability goals. These aim to make the world a better place by means such as enabling the use of low-carbon energy sources and the recycling of materials. As described below, the Company is committed to transforming itself in several key ways to better position itself to achieve these goals.

Statement on Yokogawa's aspiration for sustainability

Yokogawa will work to achieve net-zero emissions, make a transition to a circular economy, and ensure the well-being of all by 2050, thus making the world a better place for future generations.

We will undergo the necessary transformation to achieve these goals by 1. becoming more adaptable and resilient, 2. evolving our businesses to engage in regenerative value creation, and 3. promoting co-innovation with our stakeholders.

Three sustainability goals

**Environmental**

Achieve net-zero emissions

**Social**

Ensure well-being

**Economic**

Make transition to circular economy

Achieve net-zero emissions; stopping climate change

Climate change is an urgent issue that requires a global response. We aim for net-zero emissions, which means that the greenhouse gas concentrations in the atmosphere do not rise due to the balance of emissions and the absorption of greenhouse gases, which can be accomplished through the introduction of renewable energy and efficient use of energy. We are also working to reduce the impact of natural disasters and respond to biodiversity issues.
Yokogawa's recent fossil fuel fired power plant projects

- Poland: 5 x 215 t/h coal-fired, FGD
- Bulgaria: 4 x 177 MW coal-fired, FGD
- Bosnia and Herzegovina: 500 MW coal-fired, FGD
- Spain: 800 MW CCPP
- Italy: 400 MW CCPP
- Algeria: 169 MW, IWPP
- Egypt: 2 x 150 MW oil-fired
- Saudi Arabia: 4 x 730 MW Supercritical oil-fired
- Tanzania: 2 x 120 MW, CCPP
- Indonesia: 3 x 400 MW Supercritical coal-fired
- Mongolia: 8 x 420 t/h coal-fired
- China: 500 MW coal-fired, FGD
- Korea: 1 x 356 MW coal-fired, FGD
- Japan: 900 MW coal-fired, FGD
- Japan: 3 x 700 MW, 2 x 1,000 MW coal-fired, FGD
- Japan: 2 x 1,800 MW coal-fired, FGD
- Taiwan: 2 x 550 MW coal-fired
- Vietnam: 2 x 600 MW coal-fired
- Australia: 4 x 720 MW coal-fired
- Japan: 900 MW coal-fired, FGD
- USA: 1 x 480 MW, CCPP
- Canada: 117 MW, CCPP
- Venezuela: 460 MW, CCPP
- Peru: 530 MW, CCPP
- Brazil: 500 MW, CCPP
- Tanzania: 2 x 120 MW, CCPP
- Spain: 800 MW CCPP
- Italy: 400 MW CCPP
- Algeria: 169 MW, IWPP
- Egypt: 2 x 150 MW oil-fired
- Saudi Arabia: 4 x 730 MW Supercritical oil-fired
- Tanzania: 2 x 120 MW, CCPP
- Indonesia: 3 x 400 MW Supercritical coal-fired
- Mongolia: 8 x 420 t/h coal-fired
- China: 500 MW coal-fired, FGD
- Korea: 1 x 356 MW coal-fired, FGD
- Japan: 900 MW coal-fired, FGD
- Japan: 3 x 700 MW, 2 x 1,000 MW coal-fired, FGD
- Japan: 2 x 1,800 MW coal-fired, FGD
- Taiwan: 2 x 550 MW coal-fired
- Vietnam: 2 x 600 MW coal-fired
- Australia: 4 x 720 MW coal-fired
- Japan: 900 MW coal-fired, FGD
- USA: 1 x 480 MW, CCPP
- Canada: 117 MW, CCPP
- Venezuela: 460 MW, CCPP
- Peru: 530 MW, CCPP
- Brazil: 500 MW, CCPP