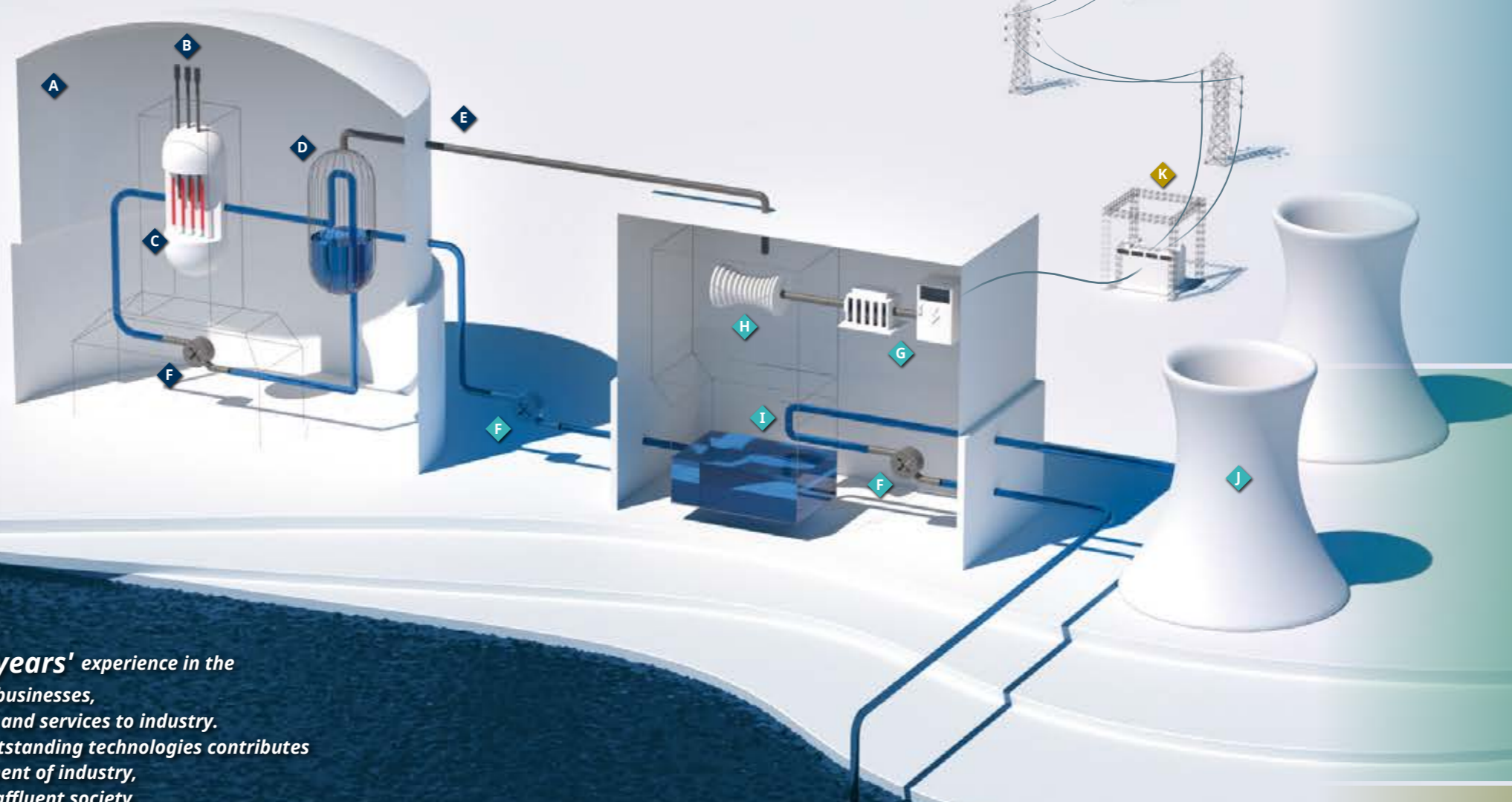


Yokogawa and the Nuclear Business

Highly reliable products for nuclear facilities

- A** Containment Structure
- B** Control Rods
- C** Reactor
- D** Steam Generator
- E** Steam Line
- F** Pump
- G** Generator
- H** Turbine
- I** Cooling Water Condenser
- J** Cooling Tower
- K** Transformers



Founded in **1915**,

Yokogawa Electric Corporation has over **100 years'** experience in the measurement, control, and information businesses, providing leading-edge products and services to industry.

The high added value created with its outstanding technologies contributes not only to the development of industry, but also to the realization of an affluent society.

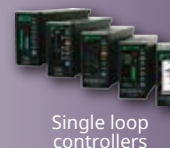
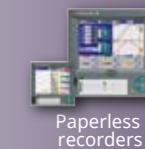
The company remains committed to achieving healthy and profitable operations.

Based on Yokogawa's vision for realizing the ideal plant, we develop products and solutions that ensure safety, make maximum use of plant assets, enhance production, and optimize operations over the entire plant lifecycle.

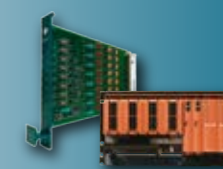
For the commercial nuclear power industry, we provide proven and highly reliable data acquisition, control solutions, sensors, and integrated systems for monitoring, control, recording, and testing. Thanks to their high reliability and availability, Yokogawa products and services are used in nuclear facilities all over the world.

Yokogawa is a leading control company and a pioneer in the development of distributed control systems for the monitoring and control of processes in a broad range of production facilities. Its comprehensive solutions range from sensors (such as pressure transmitters, flowmeters and analyzers) to control systems, software that improves productivity, and services that optimize plant lifecycle costs. Today, these solutions play a vital supporting role for our customers in diverse industries, encompassing electric power (including nuclear), oil, chemical, natural gas, iron and steel, pharmaceuticals, food, and other industries.

Data acquisition and controllers



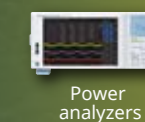
Control and safety systems



Field instruments and analyzers



Test and measurement





Data acquisition and controllers

Yokogawa paperless recorders and single loop controllers are ideal for plant operation. Highly reliable paperless recorders ensure stable plant monitoring and recording with low maintenance needs. Yokogawa single loop controllers can be used for various applications by running a user program, and offer high reliability, user friendliness, and expandability.

Data acquisition

Data acquisition is the measurement, recording, analysis, and presentation of real-world phenomena. It includes electrical measurements such as voltage, current, and power as well as measurements of temperature, etc. Yokogawa recorders are recognized for their industry-leading measurement accuracy, noise tolerance, and build quality.



DX1000

2 to 12 inputs
5.7-inch TFT LCD



DX2000

4 to 48 inputs
10.4-inch TFT LCD



Key specifications

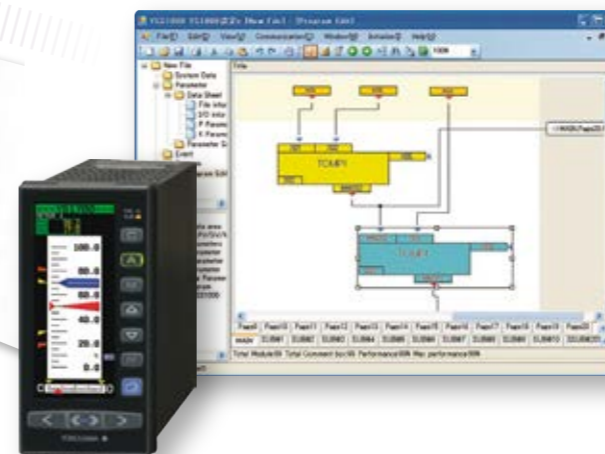
- Options and universal input to fit every need
- Secure and non-stop recording with high-capacity and non-volatile flash memory
- Powerful connectivity and convenient functions with Ethernet interfaces such as FTP, web server, and E-mail
- Logarithmic scale and exponential display
- Simulator function
- Access to all internal components from the front of the recorder (only for the DX1000N)

Major application

- Recording temperature and pressure in a turbine and the BOP area

Controllers

Robust and user-friendly controllers for a wide range of control applications ensure the highly reliable operation of production equipment and help improve product quality and productivity.



Key specifications

- Fail-safe thanks to dual CPU, "hard manual" operation available
- Nonvolatile memory for memory backup
- Easy connection to other devices through an Ethernet communication interface
- For basic type: FM nonincendive approved (Class I, Div. 2) and CSA safety and nonincendive approved (Class I, Div. 2)

Major application

- Turbine, BOP, and utility application control
- Simulator control

Key specifications

- 14-segment, active color LCD display
- Ladder sequence function
- Easy to operate with navigation keys
- Various built-in open network functions

Major application

- Turbine, BOP, and utility application control
- Simulator control



Note

Yokogawa products are used in nuclear facilities all over the world. Yokogawa offers various products as commercial products. Yokogawa recorders and controllers offer such high reliability and quality that they have been adopted by Element Nuclear* which is a leader in equipment qualification.

*Located in Huntsville, AL, Element Nuclear offers nuclear utilities and suppliers worldwide superior customer service in the provision of a full range of engineered services.

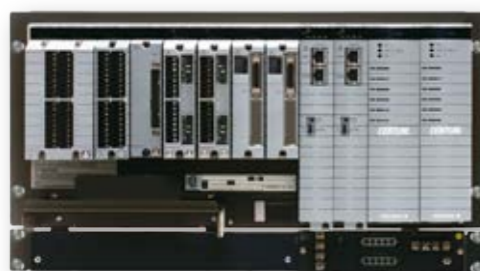


Control system

We provide our customers with a range of systems that support the safe and efficient operation of their plants. These include highly reliable production control systems for the control and monitoring of plant operations, safety instrumented systems that are fully integrated with plant production control systems to achieve the highest levels of safety, and network-based control systems that are both highly reliable and versatile.

DCS

Our distributed control system (DCS) enables automation and control of industrial processes and enhanced business performance. Over 30,000 systems use the Yokogawa DCS to achieve their production goals.



Key specifications

- High availability and reliability
- An upgrade path for each legacy system is always ensured when a new version is released
- Intuitive operating and monitoring environments
- Certified for ISASecure CSA Level 1

Major application

- Water treatment plant including condensate demineralizer
- Fuel pool demineralizer
- Post-event monitoring system
- Data recording and safety system for a nuclear fusion development plant

SCADA

CI Server is an open system that realizes a cross-platform supervisory control and information system integrating industrial control systems, sensors and artificial intelligence. This enables:

- Remote operation for operational efficiency
- Single process and wide-area process integration for grasping the wider supply chain
- Data-driven optimization leading to computer aided operation



Key specifications

- Two types of redundant configuration: high availability computing (HAC) and dual-redundant platform for computer
- Supports industrial standards such as OPC UA and ODBC, and communication drivers for Yokogawa products and third-party controllers
- Security features include IT security, encrypted communication, user management, and audit trails. Yokogawa's Endpoint Security Service can also be applied.

Major application

- Alarm system for a nuclear waste treatment plant
- HMI of the ProSafe-SLS and/or ProSafe-RS used for groundbreaking research of safety and shutdown systems or nuclear isotope production



Safety instrumented system (SIS)

Industrial processes and plants are increasingly concerned about potential incidents that could affect people, assets and the environment in and outside the plant. A SIS can dramatically reduce the risk of accidents in your plant. Yokogawa takes lifecycle management seriously and offers platforms for the industrial process safety sector which requires Safety Integrity Level (SIL) certification. ProSafe-RS is SIL 3 compatible and ProSafe-SLS is SIL 4 compatible, and both have obtained TÜV Rheinland certification.

SIS (up to SIL 3)

A SIS protects people, the environment and assets. Yokogawa's SIS and relevant safety solutions are widely used in applications for emergency shutdown, fire and gas system (FGS), burner management system (BMS), and high-integrity pressure protection systems (HIPPS).

Key specifications

- ProSafe-RS: Certified for TÜV SIL 3 and ISA Secure CSA 1.0.0 Level 1 (IEC 62443-4-2 and IEC 62443-4-1)
- Logic execution speed: Up to 50 ms
- Line monitoring function for safety loops

Major application

- Low-temperature tripping of trace-heating circuits for uranium enrichment process lines
- Replacement for obsolete PLCs for alarms
- Safety system for a nuclear fusion development plant



Solid-state SIS (up to SIL 4)

Yokogawa is unique in being able to offer highly diverse and modular analogue systems that employ magnetic elements to process the functional logic, making them inherently fail-safe, extremely fast, and highly reliable.

Key specifications

- Designed for highest safety integrity levels, safety certification by TÜV for SIL 4 based on IEC 61508
- Solid-state logic solver
- Self-testing technology
- 1 ms for IO scan and safety logic processing

Major application

- Research reactor: Hall isolation, basin isolation and HVAC
- Laboratory: Fueling machine and nuclear fuel rods





Field instruments and analyzers

We offer a full lineup of field instruments for use on production lines. These include transmitters and flowmeters that measure fluid pressure, temperature, and flow rate. We also offer analytical instruments such as pH and conductivity analyzers for measuring the concentrations of liquid constituents.

Transmitters

The accurate and stable measurement of process pressure with Yokogawa's pressure transmitters supports the safe, reliable and profitable operation of your plant.



Key specifications

- IEC 61508 certified and the results of Failure Modes, Effects, and Diagnostic Analysis (FMEDA) reported
- High accuracy of $\pm 0.025\%$ ensured (optional) and stability of $\pm 0.1\%$ of upper range limit (URL) per 15 years (for EJA Series)
- Response time of less than 90 ms (with optional quick response feature)
- Maximum working pressure of 250 bar
- Multi-sensing transmitters that combine differential pressure, gauge pressure, and temperature transmitter features into a single body
- Vibration effects less than $\pm 0.1\%$ of URL when tested per the requirements of IEC 60770-1 – Field with general application or pipeline with low vibration level (10-60 Hz 0.15 mm displacement / 60-500 Hz 2g)

Major application

- Measurement of the downstream flow rate of a feed water pump
- Measurement for power generation area
- Water pump pressure measurement
- Pressure measurement of air compressor
- Loop performance testing

Flowmeters

Yokogawa offers a wide range of flow measurement solutions with high quality, accuracy, and reliability. Today, Yokogawa's flowmeters are at work in harsh applications around the globe. With more than 100 years of flowmeter experience, we can provide the solution you need.



Key specifications

- SIL 2 certified based on IEC61508
- High accuracy of $\pm 0.1\%$ ensured for liquid flow measurement (Rotamass TI Coriolis flowmeter)
- Advanced verification tool function built into all series models
- All series models have an alarm (abrasion, adhesion, vibration, etc.) detection function
- Replacement retrofitting parts available for old series

Major application

- H₂ concentration measurement of turbine generator cooling
- Steam mass flow measurement in turbine gland seal flow system

Liquid analyzers

Liquid analyzers are used for monitoring process chemistry including water quality, providing process optimization and control.



Key specifications

- High flexibility thanks to modular design with replaceable sensor modules
- Ambient temperature range of -20 to 55°C for 4-wire multichannel transmitter/analyzer
- Certified intrinsically safe types: ATEX, IECEx, FM, CSA and NEPSI, and nonincendive of FM and CSA for 2-wire dual channel transmitter/analyzer

Major application

- Measurement of pH, oxidation-reduction potential (ORP), conductivity, resistivity, inductive conductivity, percent concentration, dissolved oxygen
- Conductivity and pH monitoring of effluent and domestic water
- pH monitoring of boric acid
- pH monitoring of demineralizer





Test and measurement

Yokogawa has been developing measurement solutions for nearly 100 years, consistently finding new ways to give R&D teams the tools they need to gain the best insights from their measurement strategies. As well as offering a broad product lineup and an extensive range of calibration and other services, the company has pioneered accurate power measurement throughout its history, and is the market leader in digital power analyzers.

Yokogawa instruments are renowned for maintaining high levels of precision and continuing to deliver value for far longer than the typical shelf-life of such equipment. Yokogawa believes that precise and effective measurement lies at the heart of successful innovation, and has focused its R&D on providing the tools that researchers and engineers need to address all kinds of challenges.



Data acquisition

Yokogawa's ScopeCorder product family provides flexible and high-performance multi-channel test instruments by combining a variety of signal conditioning input modules, onboard calculations, and deep data acquisition storage into an off-the-shelf data acquisition solution.



Key specifications (DL350)

- CE mark obtained
- Sampling rate of up to 100 MS/s
- Battery power for 3.5 hours
- Choose from 20 different input modules to measure voltage, temperature, strain, acceleration, and more

Major application

- Testing in laboratories
- Maintenance work

Power analyzers

Yokogawa, the world's largest manufacturer of power analyzers and meters, provides a broad choice of digital power analyzers to satisfy all requirements.



Key specifications (WT5000)

- High accuracy of 0.03%
- Seven slots for user-swappable power elements and diverse options enable expansion and reconfiguration of the WT5000 to meet changing application needs
- 10 MS/s, 1 MHz power bandwidth, 18-bit resolution
- 10.1-inch WXGA touchscreen environments

Major application

- Testing in laboratories

Portable and handheld instruments

Yokogawa's portable and handheld instruments address diverse testing needs of customers from simple measurement to high-precision power quality analysis and pressure calibration.



Key specifications (CA500/CA550)

- Multi-function support with accuracy of 0.015% (DC current), 0.020% (resistance), and 0.3°C(RTD)
- Long battery life (up to 16 hours) for long-term field use
- CE mark for design, EN61010-1, EN61010-2-030 to 032 for safety, and EMC for some models

Major application

- Testing in facilities
- Maintenance work

Remarkable experience

Research Institute Delft (RID)



Plant Information

Location: Delft, Netherlands
End user: Delft University of Technology
Reactor type: Research reactor
Completion: 2020



Delft University of Technology is the oldest and most prestigious technical university in the Netherlands. The Nuclear Reactor Research Institute runs the OYSTER (Optimized Yield – for Science, Technology and Education – of Radiation) program, and is conducting groundbreaking research. Since 2018, Yokogawa has been supplying safety systems, control systems, field devices, and recorders to the OYSTER program. After the Fukushima nuclear accident, national safety regulations became stricter, and the relay based protection system was revised to comply with them. Yokogawa's safety system ProSafe-SLS is a highly reliable system that has obtained the highest safety level of SIL 4. The control range of ProSafe-SLS is reactor shutdown, hall isolation, basin isolation, HVAC, and information is monitored by the CI Server SCADA software. The safety system was introduced in the nuclear reactor upgrade and renewal in 2020. Yokogawa products will continue to support nuclear power research.

<https://www.yokogawa.com/industries/power/nuclear/>



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