FX1000™

Paperless Recorder
At YOKOGAWA, we are committed to the “quality first, customer first” principle in all areas of our business, including product design, research and development, and sales and services. The new FX1000 paperless recorder exceeds customer expectations for quality, high performance and capability- at a price that meets the needs of a cost-sensitive market.

**Intuitive display, easy operation**
- 5.7-inch, high-precision, wide-viewing-angle color TFT LCD
- Many types of displays such as trend, digital, bar graph, overview, alarm, and historical trend
- Remote viewing of the FX1000 screen through the Internet
- Multi-functional panel keys

**Comprehensive selection of measurement types, and exceptional performance**
- Input types: DCV, TC, RTD, DI
- Scan interval: 1 s, 125 ms (fast sampling)
- Channels: 2, 4, 6, 8, 10, 12
- Measurement accuracy: ±0.05% of reading (DCV), ±0.15% of reading (TC, RTD)

**Reliable data storage**
- Large (400 MB) internal memory
- CF cards up to 2 GB (option)
- USB interface (option)
- Binary data storage
- Network enables data redundancy

**Support for a variety of applications**
- Power measurement recording (option)
- Vacuum pressure recording (Log scale, option)
- Flow rate summation (option)
- F value calculation (option)
- See “Applications” on the next page.

**Reliable design and construction**
- Space-saving design
- Waterproof and dustproof (IP65 compliant)

**Multi-Channel Measurement and Recording**
Universal input signal measurement

**Overview display**
Displays measurements and alarm statuses on all channels.

**Monitor display**
You can use the keys to switch to any of the operation screens. The operating states of memory sampling, alarms, key lock, computation, and other conditions are graphically displayed. Supports Chinese, English, German, French, and Japanese.

**Trend display**
Displays measured data as waveforms. Displays each channel’s scale value, industrial units, user messages, and other information.

**Digital display**
In addition to displaying measurements digitally, it displays channel tag, industrial units, and alarm statuses.

**High-capacity internal memory**
Standard 400MB non-volatile flash memory for secure, long-term recording

**Media FIFO function**
This function ensures that the CF card always retains the latest data when files are saved to it automatically. When the CF card is full, the oldest files are deleted to make room for the newest files. The media FIFO function allows you to use the FX continuously for long periods of time without having to change the CF card.

**Compact dimensions for easy panel & enclosure installation**
Shallow case depth behind the panel of 162 mm (6.4”)

**Water- and dustproof**
Complies with IEC529-IP65, except side-by-side mounting

**Intuitive operator controls**
The DISP/ENTER and arrow keys provide display mode and setting menu navigation. Clearly labeled menu, function, and record start/stop keys handle all setting and control operations.

**Overview display**
Displays measurements and alarm statuses on all channels.

**IE browser monitor screen**
FX screen monitoring and operation is made easy via Ethernet.

Bar graph, historical trend, and information displays (alarm summaries, message summaries, reports) are also included.
Secure Monitoring and Recording for a Wide Range of Applications

FX1000 combines a clear view of process data with highly reliable recording and efficient data access. Network file transfer and web browser viewing improves efficiency and saves time. Use the Power Monitor option to monitor and record energy consumption on equipment to learn true energy usage costs and for diagnostic and preventive maintenance purposes.

Temperature Recording/Monitoring for Aluminum Casting
Simplifies casting temperature quality management.
- Displays and records aluminum casting data
  Molten metal temperature
  Cooling water temperature
- Archives data upon alarm occurrence
  Analysis alarm data

Management of an Electrical Wire Coating Process
(Acquisition of Data on Wire Temperature and Outer Diameter)
Displays outer diameter and temperature in a electrical wire coating process for monitoring insulation quality.
- Select from a variety of inputs (universal input)
- Displays temperature and wire diameter simultaneously for monitoring of correlations
- On-site monitoring and recording of diameter, temperature, and alarms upon occurrence of abnormalities

Managing Sterilization of Food Industry
(Acquisition of Sterilization/Pasteurization Data)
MATH function (/M1, /PM1, /PWR1 options) enables recording (and F value calculation) of sterilization and pasteurization processes.
- Automatically computes F0 value according to temperature
- Computed results are recorded together with temperature and other parameters (Foodstuffs temperature, pressure, etc.)
- Measurement ON/OFF through external contact input (/R1, /PM1 options)

Display and Recording of Data from Environmental Testing Equipment
(Acquisition of Test Data from a Thermostatic Chamber)
Measures environmental testing data, and displays and records a variety of data in an easy-to-understand format
- Select from a variety of inputs (universal input)
- Automatically computes relative humidity from dry bulb temperature and wet bulb temperature (/M1, /PM1, /PWR1 options)
- Computed results are recorded together with temperature and humidity (pressure and current)

Vacuum Gauge Recording
Physical quantities of voltage converted to logs are input to the FX, and those physical quantities are displayed and recorded on the FX log scale.

Controlling Temperature and Pressure in Tire Manufacturing
(Vulcanization)
Measures and records mold temperature and pressure

Applications
Secure Monitoring and Recording for a Wide Range of Applications

FX1000 combines a clear view of process data with highly reliable recording and efficient data access. Network file transfer and web browser viewing improves efficiency and saves time. Use the Power Monitor option to monitor and record energy consumption on equipment to learn true energy usage costs and for diagnostic and preventive maintenance purposes.
### STANDARD SPECIFICATIONS

#### GENERAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>Mounting</th>
<th>Flush panel mounting (on a vertical plane) Mounting may be inclined downward up to 30 degrees from a horizontal plane.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel thickness</td>
<td>2 to 26 mm</td>
</tr>
<tr>
<td>Front panel</td>
<td>Water- and dustproof: Complies with IEC529-IP65 (excluding side-by-side mounting)</td>
</tr>
</tbody>
</table>

#### Power Supply

- **Voltage:** 90 to 132 or 180 to 250 VAC
- **Frequency:** 50/60 Hz ± 2%

#### Measurement Conditions

- **Temperature:** 23 ± 2°C
- **Humidity:** 55% ± 10% RH

#### Measurement Accuracy

- **DCA (with external shunt resistor attached):** ±(0.05% of rdg + 3 digits) 1 mV
- **DI (Contact input, TTL level):** ±(0.15% of rdg + 0.7°C)
- **RTD (Pt100, JPt100):** ±(0.15% of rdg + 0.3°C) 0.1°C
- **TC (R, S, B, K, E, J, T, N, W, L, U, WRe):** ±(0.15% of rdg + 1°C) 0.1°C

#### Measurement/Display Accuracy

- **Valid Operating Conditions:** Temperature: 23 ± 2°C; Humidity: 55% ± 10% RH; Allowable power supply voltage range: 90 to 132 or 180 to 250 VAC; Power supply frequency: 50/60 Hz ± 1%; Warm-up time: At least 30 minutes. Other ambient conditions such as vibration should not adversely affect the operation.

#### Inputs

- **Input Range:** DCV 1-5 V ±(0.05% of rdg + 3 digits) 1 mV
- **Thermocouple:** K ±(0.15% of rdg + 0.7°C) –200 to –100°C: ±(0.15% of rdg + 1°C)
- **RTD:** Pt100 ±(0.15% of rdg + 0.3°C) 0.1°C

#### Display

- **Display:** 5.7-inch TFT color LCD (240 × 320 dots)
- **Display Color:** 5.7-inch TFT color LCD (240 x 320 dots)
- **Display Groups:**
  - Number of groups: 10
  - Number of channels that can be assigned to each group: Up to six
  - Display Color:
    - Channel: Select from 24 colors
    - Background: White or black (selectable)
  - Trend Display:
    - Layout: Vertical, horizontal, or wide
  - Bar Graph Display:
    - Direction: Vertical or horizontal (selectable)
  - Digital Display:
    - Update rate: 1 s
  - Overview Display:
    - Measuring values and alarm status of all channels
  - Information Display:
    - Alarm summary, message summary, memory summary, report, stacked bar graph, status, Modbus status
  - Modbus Log Display:
    - Displays the log in the log, error log, communication log (C2, C3, and C7), FTP log (C7), Web log (C7), e-mail log (C7), SMTP log (C7), and DHCP log (C7)

#### Error Handling

- **Tag Display:**
  - Number of displayable characters: Up to 60
  - Displayable characters: English, Japanese, and Chinese

#### Network

- **Protocol:** Dedicated protocol and Modbus protocol
- **Connection:**
  - EIA-422 (RS-422)/485 (RS-422/485)
  - Ethernet Communication Interface (/C7)
  - Modbus Communication Interface (/C7)

#### Normal Operating Conditions

- **Supply Voltage:** 90 to 132, 180 to 250 VAC
- **Rated Power Supply Frequency:** 50 Hz ±2%, 60 Hz ±2%
- **Ambient Temperature:** 0 to 50°C
- **Ambient Humidity:** 20 to 80% RH (at 5 to 40°C), 10 to 50% (at 40 to 50°C)

### OPTIONS

- **Alarm Output Relay:** (/A1, /A2, /A3, and /A4)
  - Action: Outputs relay contact signals from the terminals on the rear panel when alarms occur.
  - Number of Outputs: 2 (/A1), 4 (/A2), 6 (/A3), and 12 (/A4)
  - Relay Contact Rating: 250 VAC (50/60 Hz)/3 A, 250 VDC/0.1 A (for resistance load)
  - Output Format: NO-C-NC. Except /A4 option, NO-C- /A4A option
  - Relay Operation: Energized/de-energized, AND/OR, hold/non-hold, and refresh settings are selectable.
  - RS-232 Interface (/C2) and RS-422/485 Interface (/C3)
  - Connection: EIA RS-232 (RS-232) or EIA RS-422/485 (RS-422/485)
  - Protocol: Dedicated protocol or Modbus protocol
  - Setting/Measurement Server Function:
    - Operation, setting or output of measurement data are available by FX private protocol.
  - Modbus Communication:
    - Reading or writing of measurement data on other instruments are available by Modbus protocol.
  - Ethernet Communication Interface (/C7)
  - Conforms to IEEE 802.3 (Ethernet frames conform to the DIX specification)

#### Communication Interface (/C7)

- **Medium:** Ethernet (10BASE-T)
  - Protocol: Dedicated protocol as well as the TCP, IP, UDP, ICMP, ARP, DHCP, HTTP, FTP, SMTP, and SNTP, and Modbus protocols
  - E-mail Client: Automatically sends e-mail at specified times.
  - FTP Client, FTP Server, Web server, SNTP client, SMTP server, DHCP client, Modbus client, Modbus server

#### FAIL/Status Output Relay (/F1)

The relay contact output on the rear panel indicates the occurrence of CPU failure or selected status.
**Speciﬁcation • Performance**

- **Computation Function (Including the Report Function) (/M1)**
  - Used for calculating data, displaying trends and digital values, and recording calculated data assigned to channels.
  - Number of computation channels: FX1002 and FX1004: 12 channels, FX1006, FX1008, FX1010, and FX1012: 24 channels
  - Max. characters in formulas: 120
  - Operation: General arithmetic operations, relational operations, logic operations, statistical operations, special operations, conditional operations
  - Constants: Up to 60 (K01 to K60)

- **Report functions:**
  - Report type: Hourly, daily, hourly + daily, weekly + monthly

- **3-Wire Isolated RTD Input (/N2)**
  - All the RTD input terminals (A, B, and b) are isolated on each channel.
  - Applies to the FX1006, FX1008, FX1010, and FX1012

- **Extended Input (/N3F)**
  - This option allows the extra input types below to be added to the standard input types.
  - TC: Kp vs Au7Fe, PLATINEL, Pt100, W/Wh08, TypeE (AWS14), XX GOST RTD: N100 (SAMA), N100 (DIN), N120, Pt100 GOST, Cu100 GOST, Cu50 GOST, Pt100 (WEED)
  - DC/AC 24 V Power Supply (/P1)
  - Rated supply voltage: 24 VDC and 24 VAC (50/60Hz)
  - Allowable power supply voltage range: 21.6V to 26.4 VDC/AAC
  - Max. power consumption: 18 VA (24 VDC), 30 VA (24 VAC (50/60 Hz))

- **Remote Control (/R1)**
  - This option allows eight functions to be controlled remotely by a contact input.

- **24 VDC Transmitter Power Supply (TPS2 and /TPS4)**
  - Output voltage: 22.8 to 25.2 VDC (under rated load current)
  - Rated output current: 4 to 20 mA
  - Max. output current: 25 mA (overcurrent protection operation current: approx. 68 mA)

- **USB Interface (/USB1)**
  - USB port: Complies with rev. 1.1 and host function
  - Connectable devices: Keyboard complies with HID Class Ver. 1.1
  - External medium: USB flash memory

- **Pulse Input (/PM1)**
  - Accepts pulses via contact input or open collector signals to dedicated input terminals (remote input).
  - Pulse input option includes mathematical functions option (/M1) and remote control option (/R1).
  - Number of inputs: 3 (8 are available if using remote inputs)
  - Input format: Photocoupler isolation (shared common)
  - Isolated power supply for input terminal (approx. 5 V)
  - Input type: Voltage-free contact, open collector

- **Calibration Correction (CC1)**
  - Corrects the measured values of each channel using segment linearizer approximation.
  - Number of segment points: 2 to 16

- **Power Monitor (/PWR1)**
  - By including power measurement elements in an expression, you can measure a variety of power values.
  - Active power, regenerative electric power, reactive power, apparent power, voltage, current, frequency, power factor (LEAD: –, LAG: +), and electric energy (active energy, regenerative energy, reactive energy – LAG: +, reactive energy – LEAD: –, and apparent energy)
  - The MATH option (/M1) is included with the power monitoring option.

  - Phase and wiring system:
    - Single-phase two-wire system, single-phase three-wire system, and three-phase three-wire system
    - Frequency: 45 to 65 Hz
  - Rated input voltage:
    - Rated Voltage | Voltage Range (Variable) | Allowable Input Voltage
      | 120 V | 240 V |
      | 120 V | 240 V |
      | 150 V | 300 V |

  - Rated input current:
    - Rated Current | Current Range (Fixed) | Allowable Input Current
      | 1 A | 1 A |
      | 1.2 A |

- **Rated input power and measuring range:** The VT and CT's secondary side when using VT and CT.

  - **Single-phase two-wire system**
    - Input (AC) | Rated Power | Input Measuring Range
      | 120 V / 1 A | 100 W | -120 to 120 W |
      | 240 V / 1 A | 200 W | -240 to 240 W |

  - **Single-phase three-wire system**
    - Input (AC) | Rated Power | Input Measuring Range
      | 200 V / 1 A | 200 W | -240 to 240 W |
      | 240 V / 1 A | 400 W | -480 to 480 W |

  - The input measuring range when you are using a VT and CT is calculated using the following equation.
    - The measuring range must be within the input measuring ranges listed above, and the primary side input power must be less than 10 GW.
      - 1: Input measuring range (W) = Primary side input power in W × 2/VT ratio × CT ratio.
      - 2: Primary side input power = Secondary side rated power in W × 1.2 × VT ratio × CT ratio.

  - VT ratio/CT ratio: By setting the VT and CT ratios, input to the FX is converted to the primary side input value before the VT/CT and displayed.

  - Low cut power function:
    - A power measurement element is included in which power below a specified value is treated as 0.
    - This is used when calculating power as watt hours.

  - Setting range: 0.05 to 20.00% of the rated power

  - Update interval: 1 sec.

  - Power computation:
    - With TLOG, SUM, or the report function, you can measure watt hours (active watt hours, regenerated energy, var-hours (LAG: +), var-hours (LEAD: -), volt-ampere-hours).

  - Measurement accuracy:
    - | Item | Measurement Accuracy (Instantaneous Values)
      | Active power (W) | ±1.0% of Range
      | Voltage (V), current (A) | ±1.0% of Range
      | Apparent power, reactive power, power factor | Value calculated from the measured value ±1 digit
      | Frequency | ±1.0 Hz

  - **Log Scale (LI1)**
    - Function: A logarithmic voltage that has been converted from a physical value is applied to the FX, and then the FX’s Log scale (logarithmic scale) is used to display and record the physical value.
      - Input type:
        - Log input: Logarithmic input (LogType1)
        - Log linear input: Input that is linear on a logarithmic scale (LogType2)
      - Range: 20 mV, 60 mV, 200 mV, 2 V, 6 V, 20 V, 50 V, and 1 V
    - Unit symbol: Any character string up to 6 characters in length

  - **Scalable range:**
    - Log input (LogType1)
      - 1.00E−15 to 1.00E+15 (15 decades maximum)
      - Lower limit mantissa range: 1.00 to 9.99.
      - Upper limit mantissa range: 1.00 to 9.99.
      - Scale: L = Scale_U
      - If the lower limit mantissa is 1.00, the difference between the exponents must be 1 or more.
      - If the lower limit mantissa is a value other than 1.00, the difference between the exponents must be 2 or more.
      - Log linear input (LogType2)
        - Lower limit mantissa range: 1.00 to 9.99.
        - Upper limit mantissa range: N/A (the value is the same as the lower limit mantissa).
        - If the lower limit mantissa is 1.00, the difference between the exponents must be 1 or more.
        - If the lower limit mantissa is a value other than 1.00, the difference between the exponents must be 2 or more.

  - **Alarm:**
    - Kind: High limit, low limit, delay high limit, and delay low limit
    - Range: 1.00E−16 to 1.00E+16, mantissa: 1.00 to 9.99
    - Hysteresis: 0% (fixed)

  - Color scale band range: 1.00E−16 to 1.00E+16, mantissa: 1.00 to 9.99

  - The display position lower limit must be less than the display position upper limit.

  - Number of mantissa display digits: 2 or 3
Terminal Arrangement

This is the arrangement of the terminals for models and options. For combinations of models and options, see the chart of models and option codes.

Symbols such as "NC" indicate the terminal functions.
- Alarm output, FAIL, Status
  - NC : Normally closed
  - NO : Normally opened
- Remote control input
  - 1 to 8 : Remote control terminal number
  - C : Common
- Pulse input
  - H and L
- Transmitter power supply output
  - + and -

A terminal that is not used.

Arrangement of the Input Terminals

<table>
<thead>
<tr>
<th>CH2</th>
<th>CH1</th>
<th>CH6</th>
<th>CH5</th>
<th>CH4</th>
<th>CH3</th>
<th>CH2</th>
<th>CH1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Input terminal block of the FX1002

<table>
<thead>
<tr>
<th>CH2</th>
<th>CH1</th>
<th>CH6</th>
<th>CH5</th>
<th>CH4</th>
<th>CH3</th>
<th>CH2</th>
<th>CH1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Input terminal block of the FX1004

<table>
<thead>
<tr>
<th>CH2</th>
<th>CH1</th>
<th>CH6</th>
<th>CH5</th>
<th>CH4</th>
<th>CH3</th>
<th>CH2</th>
<th>CH1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Input terminal block of the FX1006

<table>
<thead>
<tr>
<th>CH2</th>
<th>CH1</th>
<th>CH6</th>
<th>CH5</th>
<th>CH4</th>
<th>CH3</th>
<th>CH2</th>
<th>CH1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Input terminal block of the FX1008

<table>
<thead>
<tr>
<th>CH2</th>
<th>CH1</th>
<th>CH6</th>
<th>CH5</th>
<th>CH4</th>
<th>CH3</th>
<th>CH2</th>
<th>CH1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Input terminal block of the FX1010

<table>
<thead>
<tr>
<th>CH2</th>
<th>CH1</th>
<th>CH6</th>
<th>CH5</th>
<th>CH4</th>
<th>CH3</th>
<th>CH2</th>
<th>CH1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Input terminal block of the FX1012

<table>
<thead>
<tr>
<th>CH2</th>
<th>CH1</th>
<th>CH6</th>
<th>CH5</th>
<th>CH4</th>
<th>CH3</th>
<th>CH2</th>
<th>CH1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Arrangement of the Optional Terminals

<table>
<thead>
<tr>
<th>/A1</th>
<th>/A2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm output 02</td>
<td>Alarm output 01</td>
</tr>
<tr>
<td>NO</td>
<td>C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>/A3</th>
<th>/A4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm output 04</td>
<td>Alarm output 01</td>
</tr>
<tr>
<td>NO</td>
<td>C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>/C3</th>
<th>/F1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm output 06</td>
<td>Alarm output 07</td>
</tr>
<tr>
<td>NO</td>
<td>C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>/PM1</th>
<th>/R1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse input</td>
<td>Remote control input</td>
</tr>
<tr>
<td>L</td>
<td>H</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>/TPS2</th>
<th>/TPS4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter power supply output</td>
<td>Transmitter power supply output</td>
</tr>
<tr>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>/PW/R1</th>
<th>/A1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current input</td>
<td>Alarm output 02</td>
</tr>
<tr>
<td>IL</td>
<td>LS</td>
</tr>
</tbody>
</table>

Alarm output
CF card capacity is subject to change.

Opening FX1000 Manuals (1), CF card (512MB; On FXs that have a CF card slot (suffix code and Installation Guide (1), How to Use the CD Installing FXA120 DAQSTANDARD and Mounting brackets (2), FX1000 DAQSTANDARD/Manuals CD (1), FX1000 Safety Precautions

Note: To load data, the FX must be equipped with a communication interface (/C2, /C3, or /C7

*10 The three options /TPS2, /PWR1, and /A1 cannot be specified together.

*9 If /PWR1 is specified, /A3, /A4A, /F1, /R1, /PM1, or /M1 cannot be specified.

*8 If /PM1 is specified, /A4A, /M1, /R1, /TPS2, /TPS4, or /PWR1 cannot be specified.

*7 If /TPS4 is specified, /TPS2, /A2, /A3, /A4A, /F1, /R1, or /PM1 cannot be specified.

*6 If /TPS2 is specified, /TPS4, /A2, /A3, /A4A, /F1, /R1, or /PM1 cannot be specified.

*5 If /R1 is specified, /A4A, /TPS2, /TPS4, /PM1, or /PWR1 cannot be specified.

*4 /N2 cannot be specified for FX1002 and FX1004.

*3 If /A3 or /A4A is specified, /F1 cannot be specified.

*2 /C2 and /C3 cannot be specified together.

*1 Any combination of /A1, /A2, /A3, and /A4A cannot be specified together.

Before operating the product, read the instruction manual thoroughly for proper and safe operation.

VigilantPlant is Yokogawa’s automation concept for safe, reliable, and profitable plant operations. VigilantPlant aims to enable an ongoing state of Operational Excellence where plant personnel are watchful and attentive, well-informed, and ready to take actions that optimize plant and business performance.