General Specifications

eCUBE aqua

GS 34P03A31-01E

■ GENERAL

eCUBE aqua, a remote monitoring application, incorporates a wealth of maintenance know-how on water filtration equipment employing a Reverse Osmosis (RO) membrane, and runs on the STARDOM FCN/FCJ autonomous controller.

■ FEATURES

- Normalizes permeate flow and creates performance indicators of an RO membrane in a manner that is easily understandable for end users.
- Stores all measured and calculated data on the FCN/FCJ system card for 5 years.
- Predicts cleaning timing of an RO membrane based on the trend data of RO membrane performance indicator.
- Notifies the cleaning data via e-mail, so filter cleaning process can be easily added to the existing RO Equipments.
- Does not require special software, since a Web browser and Java applet are used for screen display.
- Allows remote monitoring and engineering.
- Has a PLC easy connection capability, can be easily added to the existing RO Equipments.
- Requires less programming.

■ OPERATING ENVIRONMENT

● eCUBE aqua System Development Environment

PC: Compatible with the operating environment for Logic Designer. Please refer to GS 34P02Q75-01E Logic Designer.

● Client PC

PC with Internet Explorer 6.0 (SP1, SP2)

● FCN/FCJ Autonomous Computer

CPU: FCN CPU module, or FCJ S2 (Style S2) or later

System Card: 512 MB

■ SYSTEM CONFIGURATION

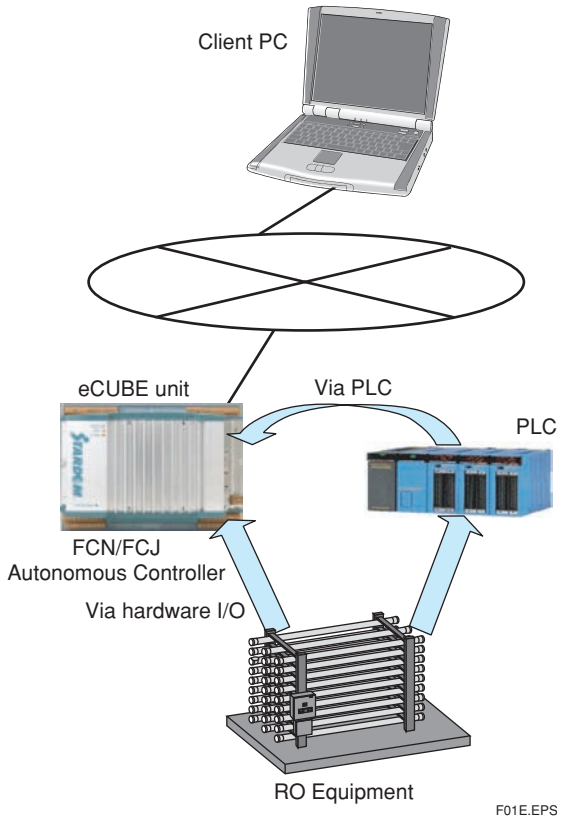

Figure eCUBE aqua System Configuration

■ CONNECTION TO RO EQUIPMENT

An eCUBE unit and RO equipment can be connected using any one or a combination of the following methods.

● Hardware I/O Connection

Collects data directly using 4 to 20 mA and 1 to 5 V signals.

● Ethernet Connection

Collects data from an existing PLC via Ethernet using the Modbus protocol.

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■ FUNCTIONAL SPECIFICATIONS

● Data Collection Function

Data is collected from the RO equipment periodically corresponding to the method of connection. The Web browser allows the collected data to be monitored as current value.

● Data Storage Function

The collected data is stored for 5 years or more as a CSV file on the system card of the eCUBE unit.

In addition to the function to store data at a certain time interval, there is a function to store data before and after a pre-specified event occurs. The stored data can be used for both preventive and breakdown maintenance.

● Alarm Notification Function

Alarm notification function informs the operator when the RO membrane cleaning time arrives or other preset conditions are met. Alarm can be notified by changing color on the Web browser screen or sending e-mail upon configuration.

● Web Browser Display Function

Web browser display function allows the user to monitor current value and alarm status, and make changes to the alarm settings. It also allows changes to be made to the analog alarm settings or event masking while the system is running.

● Configuration Function

With an eCUBE unit, configuration of monitoring logic and Web browser screen layout, etc. is not required. A system can be built only by assigning data addresses and defining alarm conditions for monitoring.

Tools provided include an eCUBE system definition tool, eCUBE configurator, and RO membrane diagnosis configuration page.

1. eCUBE System Definition Tool

Allows the eCUBE unit to define the attributes of collected data such as the connection destination, data type, collection criteria, and alarm conditions. The results of definitions are output as a CSV file.

As the measured data in eCUBE aqua is fixed configuration is simplified by copying a template with required data already included for each RO pass. User needs to only define where necessary.

2. eCUBE Configurator

Imports a CSV file that has been output by the eCUBE system definition tool and automatically generates software that runs on the eCUBE unit, a screen definition file, etc.

The automatically generated information consists of information that is needed to run the eCUBE unit or to collect data from the eCUBE unit for RO diagnosis.

The operating procedure of the configurator is simple and requires minimal time to perform.

3. RO Membrane Diagnosis Configuration

Web browser window is for setting RO membrane diagnosis data, including the number of RO pass, baseline data, and data for the prediction of cleaning times.

● Number of RO Equipment Pass

An eCUBE aqua application is capable of handling a total of 25 items of measured and calculated data in each RO equipment pass. An eCUBE unit handles four pass and each pass accommodates two banks.

Number of RO Equipment Pass	Number of Items of Data	Type of eCUBE Unit
1	25	SS
2	50	S
3	75	M
4	100	M

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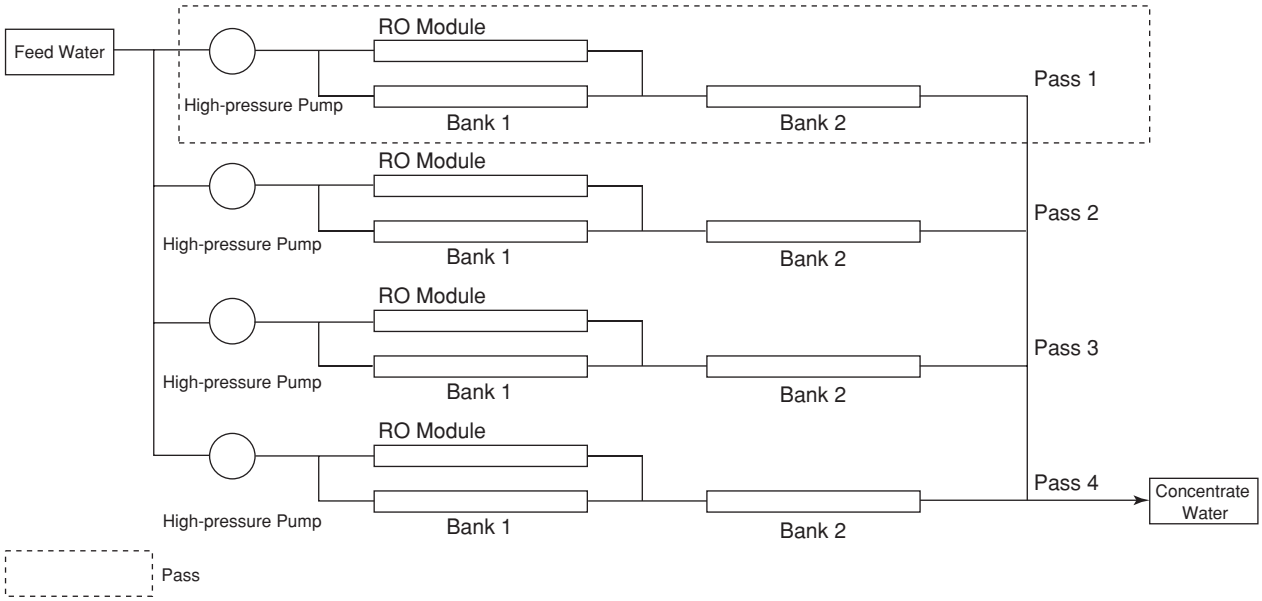

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Figure Example of RO Equipment Configuration

■ PRODUCT CONFIGURATION

The following products are required to run the eCUBE aqua application.

Classification	Product	Remarks
FCN/FCJ Hardware	FCN/FCJ autonomous controller	Select an FCN or FCJ depends on the number of hardware I/O.
FCN/FCJ Software	License for basic FCN/FCJ software (including Java functions)	
	Communication portfolio license	If PLC needs to be connected, select appropriate communication license.
	eCUBE unit portfolio license	Select according to the number of items of data.
	eCUBE aqua RO diagnosis portfolio license	License for RO membrane diagnosis
	eCUBE CSV Converter unit license	License for storing collected data as a CSV file on the system card.
Development Environment	eCUBE configurator license	
	FCN/FCJ Logic Designer license	
CD-ROM	FCN/FCJ software media	
	FCN/FCJ APPF software media	

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■ RO Membrane

An RO membrane has been developed for the purpose of converting seawater into fresh water. Its advantage lies in consuming less energy, since it is capable of separating salt from water without vaporizing it. The RO membrane is used for ultrapure water production for semiconductor manufacturing, in seawater desalination plants, in drinking water production plants, for pure water production for boilers, etc.

Generally, water treatment equipment consists of a combination of modules, such as microfiltration, removal filtration, RO membrane, ion exchange, and ultraviolet sterilizer, according to the target water quality. The RO membrane cost, along with the energy cost for a high-pressure pump, mostly accounts for water production, since the RO membrane is an article of consumption, which degrades in filtration performance over time as the result of the accumulation of impurities on the surface of the membrane.

● Basic Structure

RO equipment functions as a filter, which utilizes a semipermeable membrane that allows only water to pass through. When two volumes of water are separated with a semipermeable membrane, water will flow from the side of low solute concentration to the side of high solute concentration to equalize the solute concentrations on both sides of the semipermeable membrane. This phenomenon is called “osmosis” and the difference in pressure, at which the equalization of solute concentrations is reached, is called “osmotic pressure.” On the other hand, when a pressure higher than the osmotic pressure is applied to water on the side of high solute concentration, water will flow from the side of high solute concentration to the side of low solute concentration. This phenomenon is called “reverse osmosis.”

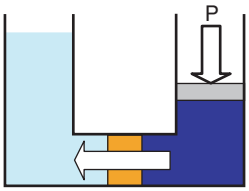

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Figure Reverse Osmosis

The following shows the basic structure of an RO system. Feed water, which is pressurized with a high-pressure pump, flows into the RO module. Water molecules and only a few impurities of the pressurized feed water flow through the RO membrane and come out as permeate water. Impurities and water that do not flow through the RO membrane come out as concentrate water. In pure water production, the permeate water is the product and in sugar and fruit juice concentrate plants, the concentrate water is the product.

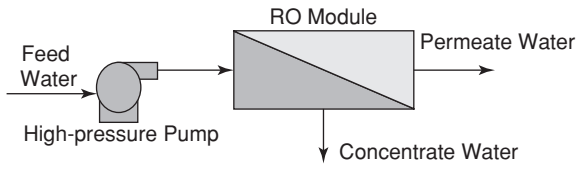

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Figure Basic Structure of an RO System

● Maintenance

The continued use of an RO membrane leads to fouling due to the accumulation of water impurities on the surface of the membrane on the feed water side, thus causing membrane clogging and performance degradation. Therefore, cleaning is required to remove fouling. To do so, stop the high-pressure pump and use cleaning chemicals, selected according to the types of feed water and fouling, to clean the surface of the membrane on the feed water side for a couple of hours.

Although cleaning recovers the performance of the membrane to a certain degree, the original performance is not recovered. This causes the membrane to degrade in performance over time until it finally reaches the end of its life span. If cleaning is late and the RO membrane is excessively contaminated, recovery rate declines and life shortens. Usually, it is desirable to clean the membrane, when the permeate flow rate declines by 10%. It is said that, if the permeate flow rate declines by 20%, there is a remarkable decline in the recovery rate. Regular monitoring of the state of an RO membrane and cleaning of it at proper intervals are required to continue using it until the end of its original lifespan.

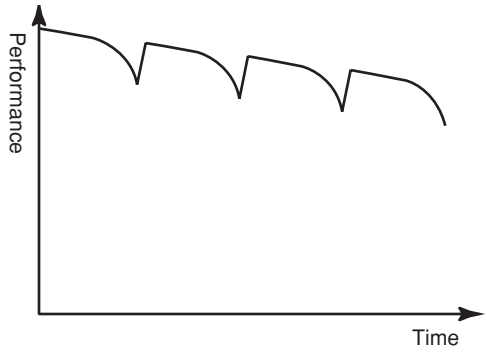

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Figure Example when Cleaned at the Right Intervals

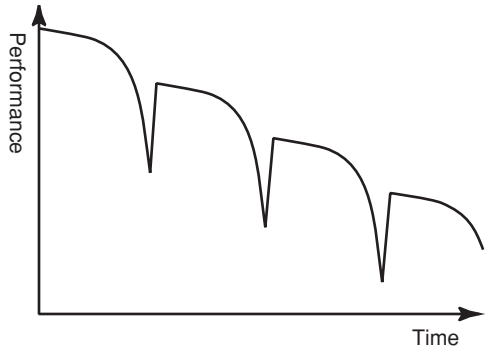

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Figure Example when Cleaned Late and Resulted in Rapid Degradation

■ RO MEMBRANE DIAGNOSIS FUNCTION

● Baseline Data

Baseline data showing the performance of a new RO membrane is required to evaluate the performance of an RO membrane. The eCUBE aqua application uses the following baseline data.

- Feed water temperature
- Temperature compensation coefficient
- Osmotic pressure at 25 °C
- Feed water pressure
- Permeate water pressure
- Differential membrane pressure
- Permeate flow
- Feed water conductivity
- Rejection
- Recovery

Usually, baseline data is available from the RO membrane manufacturer. Baseline data differs according to the type and size of an RO membrane or combination of RO membranes. If multiple pieces of RO equipment are installed, baseline data is required for each RO equipment.

● Measured Data

The following shows the data of an RO unit needed for RO membrane diagnosis. If the measurement of required data cannot be performed due to sensors are not mounted or defective, RO membrane diagnosis cannot be executed.

Table Measured Data

Data Name	Symbol	Description
Temperature	T	Mandatory
Feed flow	F1	Two of the three data items are mandatory.
Permeate flow	F2	
Concentrate flow	F3	
Feed water conductivity	uS1	Mandatory
Permeate water conductivity	uS2	Mandatory
Concentrate water conductivity	uS3	
Feed water pressure	P1	Mandatory
Permeate water pressure	P2	
Concentrate water pressure	P3	Any one of the two data is mandatory. Differential membrane pressure means the differential pressure between feed water and concentrate water.
Differential membrane pressure	DP	
Intermediate pressure	IP	If a process line consists of two banks and diagnosis is performed on each bank, one of the three data items is mandatory. (*1)
Upstream differential membrane pressure	P1-IP	
Downstream differential membrane pressure	IP-P3	
pH		(*2)

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*1: If there are no measured data, two banks are regarded as one bank.

*2: Although this data item is not mandatory for RO membrane diagnosis, it is included in the list of measured data because it is usually used as a water quality indicator of permeate water.

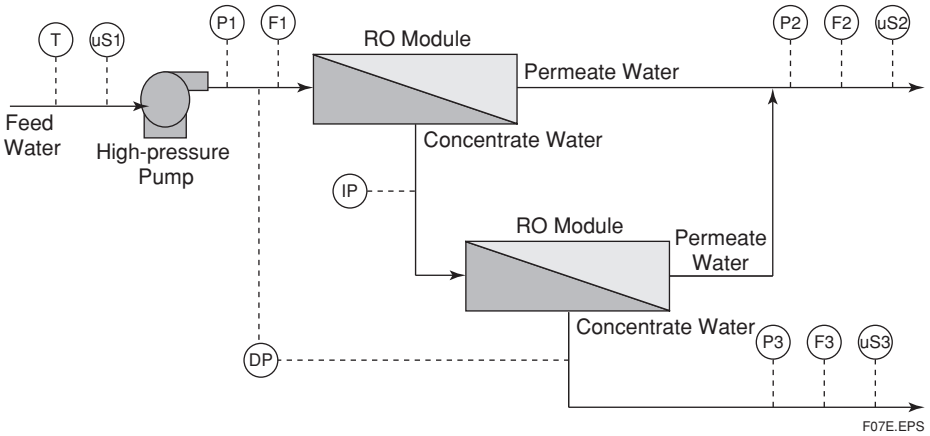

Figure Measured Data of RO Equipment

● Performance Indicators

The following three data items are used to evaluate the performance of an RO membrane.

- Permeate flow
  Flow through an RO membrane
- Differential membrane pressure
  RO differential membrane pressure between feed water and concentrate water
- Salt passage
  Concentration of salt contained in permeate water

These three data items are indicators showing the filtration performance of an RO membrane. The continued use of an RO membrane causes filtration performance to degrade over time.

The eCUBE aqua application creates the following performance indicators.

Table Performance Indicators

Data Name	Description
Differential membrane pressure	Measured data is used
Upstream differential membrane pressure	Only in case intermediate differential pressure is measured
Downstream differential membrane pressure	
Normalized permeate flow	Normalized data by baseline data such as temperature, pressure, and conductivity
Salt passage	Concentration of salt contained in permeate water, calculated from conductivity
Rejection	Concentration of salt rejected from feed water
Recovery	Rate of permeate water recovered from feed water

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Permeate flow is one of the indicators to evaluate an RO membrane. However, as permeate flow largely depends on circumstantial variable factors such as water temperature, measured data cannot be simply compared. To obtain a reliable performance indicator, temperature and pressure are corrected to be equalized all the time. This correction calculation is called “normalization.”

The eCUBE aqua application uses measured data obtained from the RO equipment to calculate normalized performance data. The normalization calculation formula is subject to the performance evaluation formula for an RO membrane, Standard D4516 defined by ASTM (American Society for Testing and Materials).

● Prediction of Cleaning Time

The future values for the three performance indicators are predicted based on the past trends of changes. The number of days until reaching the set value is calculated for each indicator. Out of the calculated values, the value that is closest to the present time is output as the cleaning time of an RO membrane. Furthermore, if the current value has already reached the set value, an alarm is generated to prompt cleaning to begin immediately.

For the eCUBE aqua application, if any of the following conditions is met, cleaning must be performed.

- Normalized permeate flow declines by more than certain percentage from the initial value.
- Differential membrane pressure increases by more than a certain percentage from the initial value.
- Salt passage increases by more than a certain percentage from the initial value.

The user can change a threshold value for each condition.

An RO membrane does not degrade linearly over the long run but largely depends on seasonal changes and feed water quality. If the environment changes, a predicted value calculated based on the latest data stored for a short period of time may be more accurate than that based on older data stored for a long period of time. For the eCUBE application, two predicted values are calculated based on data stored for 30 days and for 7 days. By comparing the two results, the value closer to the present date will be used as the predicted cleaning data.

■ RELATED DOCUMENTS

- GS 34P02Q01-01E “FCN/FCJ Autonomous Controller Functions”
- GS 34P02Q11-01E “FCJ Autonomous Controller Hardware”
- GS 34P02Q12-01E “FCN Autonomous Controller Hardware”
- GS 34P02Q75-01E “Logic Designer”
- GS 34P03A02-01E “eCUBE Unit”
- GS 34P03A03-01E “eCUBE Optional Packages”

■ MODEL AND SUFFIX CODES

		Description
Model	NT8870J	eCUBE aqua RO diagnosis portfolio license
Suffix Codes	-L	License
	W	Issued at Web
	1	Always 1
	1	Always 1
	A	Standard

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■ ORDERING PROCEDURE

Specify the model and suffix codes.

■ TRADEMARKS

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