American Membrane Technology Association

America's Authority in Membrane Treatment

Membrane Facility Instrumentation and Controls

Overview

Membrane facilities by nature tend to be automated, typically requiring more instruments and control features than conventional water treatment technologies. Depending on the type of membrane and unit processes, the level of instrumentation and control devices varies significantly among membrane plants. This fact sheet will give a general description and discuss controls that are often common to many membrane facilities.

Reasons for controls in membrane plants

Typically membrane plants are too complex to be operated "In Hand" and require automated controls for:

- Process optimization
- Membrane system and process equipment protection
- Safety of operation
- Quick response time. Some critical controls require fraction of a second response time!
- Regulatory compliance, such as water quality reports, pressure decay tests and Log removal calculation

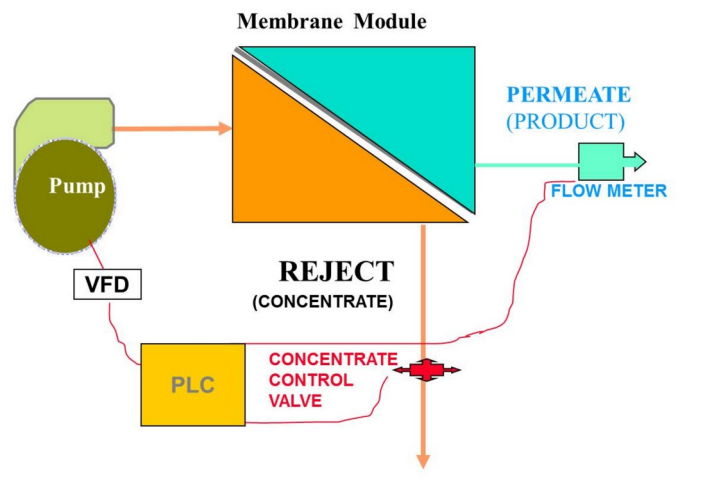

Figure 1: Example of a simplified RO skid control

Figure 1 shows a simplified single stage Reverse Osmosis (RO) skid control. The recovery and permeate flow are constant and set by the process design. The PLC will modulate the concentrate control valve to maintain the recovery. The PLC will ramp the feed pump VFD to maintain the permeate flow set point.

As facilities become more complex with multiple stages, passes and skids, the control systems become more complex.

Major components of plant control

Typical membrane plant control components are:

- Human Machine Interface (HMI): Desktop computers, printers and monitors
- HMI software
- Programmable Logic Controller (PLC)
- Wires, fiber optic, data cables, Ethernet cables
- Instruments
- Analyzers
- Remote I/O panels and communication cards
- Remote control panels: Other equipment PLCs
- Remote control devices: Variable Frequency Drives (VFDs), "smart chemical pump" and remote sub system PLCs or "mini-brains'
- Remote Telemetry Unit (RTU) and Supervisory Control Data Acquisition (SCADA) for remote sites and remote communication

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Instruments
The quantity and type of instruments varies widely among membrane plants. They vary by type of membrane system as well as system complexity and designer/operator preferences. For example, in low pressure membrane applications (MF/ UF/MBR) there may be more flow meters, while in high pressure membrane systems (RO/NF) there may be more pressure transmitters.

Generally these instruments can be divided in three categories:

1) *Hydraulic monitoring and controls:*
    - Pressure transmitters
    - Differential pressure transmitters
    - Flow meters
    - Level transmitters
    - Level floats
2) *Water quality monitoring and controls:*
    - Conductivity meters
    - Turbidity analyzers
    - Chlorine analyzers
    - Temperature sensors
    - pH monitors
    - Particle Counters
    - Specific chemistry analyzers such as Nitrate, Fluoride, etc.
3) *Safety devices and equipment protection:*
    - Low pressure switches
    - High pressure switches
    - Vibration sensors
    - Over-heat sensors
    - Oil monitors
    - Battery backed-up safe position valves
    - High/low level floats and switches
    - Emergency Stops

Overall Process Controls
The membrane process engineer will closely coordinate the type, location, material and ranges of all instruments as a function of water quality and process control needs. The process engineer will also be responsible for preparing the control description, establishing alarms and plant control response to the alarms. Then the process control engineer will prepare the Piping and Instrumentation Diagrams (P&ID). A combination of all the above will be used by the programmer to program the PLC.

Testing, Startup, and Commissioning
Although the entire control system and programming can be completed before plant start-up, many set points and programming functions such as reaction time and delays, have to be fine-tuned during testing. It is critical that plant process components be tested in sub-systems before trying to test the entire plant. Detailed testing protocols and procedures are often needed to ensure all features are tested in a safe manner and are well documented.

Security and Authorization
Generally 3-5 levels of permissions and authorizations are provided in the PLC program so only authorized staff who are very familiar with the process can change major parameters or set points. Parameters such as flux rate, recovery and alarm shutdowns will have a significant impact on the membrane and plant performance and should only be changed by staff who understand the impact of such changes. Certain safety features, such as high pressure shut downs, fall in the same category.

Performance Monitoring and Data Management
In addition to operational controls, membrane plants require data management and performance monitoring. These requirements can be met by utilizing the membrane manufacturer's tracking/normalization software, with customized Excel sheets with graphs and with XL-reporter and other custom databases. This detailed monitoring is required for:

- Regulatory compliance reporting
- Monitoring plant performance
- Knowing when feed water quality is changing
- Being proactive to prevent fouling and scaling
- Knowing when to clean the membrane
- Estimating the membrane life to plan for replacement
- Determining the effectiveness and understanding the performance of various plant chemical additions: (Coagulants, Scale Inhibitors)

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This material has been prepared as an educational tool by the American Membrane Technology Association (AMTA). It is designed for dissemination to the public to further the understanding of the contribution that membrane water treatment technologies can make toward improving the quality of water supplies in the US and throughout the world.

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