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REMOTE MONITORING AND CONTROL OF SMALL DRINKING WATER PACKAGE PLANT SYSTEMS

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INTRODUCTION

Remote telemetry, metaphorically referred to as the "electronic circuit rider", offers an attractive alternative to an "on the road" operator. Substantial cost savings in addition to the improvement of drinking water quality can be achieved through the use of the remote telemetry. Using remote telemetry, an operator has the ability to call a remote data logger unit and review the operating parameters in "real time" of a plant within minutes using the central site personal computer. Likewise, several sites may be reviewed in this manner. An operator normally requires hours to physically visit the remote drinking water plant sites. Therefore, remote telemetry can significantly reduce operator time required to visit remote plants.

With remote telemetry, the operator has the ability to display the current operating parameters of a remote drinking water (DW) plant on the central site computer. The operator then, can prioritize the plant site visits accordingly. Also, immediate attention can be given to a drinking water plant with critical problems. Preventive maintenance can be scheduled for plants with operating parameters showing the need for maintenance. The overall effect from remote telemetry is an improvement in operator efficiency and hence a net improvement in water quality.

In addition to displaying parameters when the operator calls a remote site, the remote data logger unit has the ability to call the operator via a phone line to alert the operator of an immediate problem. Commercial remote sensing units have the ability to auto dial a pre-programmed phone number to alert an operator of site problems. This is typically referred to as "exception reporting." The operator defines the conditions which cause the remote unit to dial the pre-programmed phone numbers. The exception limits can be set for turbidity, pressure, flow, etc.. The operator of a specific plant defines the limits for the plant. Through exception reporting, water quality is improved by quickly alerting the operator of potentially harmful site conditions. Again, the net effect of remote telemetry is the improvement in operator efficiency thereby improving the overall, drinking water quality at the consumers tap.

METHODOLOGY

This project demonstrated remote telemetry using commercially available hardware and telemetry software. Specifically, a CUNO ultrafiltration drinking water package plant was remotely monitored and controlled. Monitoring consisted of permeate flow, pH, finished turbidity, hi and low trans-membrane pressure, chlorine residual, raw pressure, permeate pressure, reject flow, raw flow, and raw turbidity. Control of the plant via electrically actuated proportional valves included: raw water flow, hi trans-membrane flow, lo trans-membrane flow, and reject flow. The telemetry software allowed the "on line" data display, data analysis, trend reporting, and history reporting. Proportional control of the valves was accomplished via the remote telemetry software.

Remote telemetry hardware requirements include an Acromag Inc. remote data logger, a central site generic personal computer, a modem for communications, and selected monitoring instrumentation. The central site control and acquisition software is commercially available from Total Systems Resources (TSR). The process control and data acquisition software from TSR contain the hardware drivers necessary to communicate with the specific remote data logger used in this project.

Data Logger:

A commercially available remote data logger was purchased from Acromag Inc.. The data logger is a microprocessor unit with programmable memory, random access memory, a serial port, analog input/output and digital input/output. The remote logger is customized to a specific site. Information concerning the analog to digital conversions and the digital to analog control can be downloaded to the data logger's Electrically Erasable Programmable Read Only Memory (EEPROM) from the central site personal computer. Power failures will not cause the unit to loose specific site control information.

The data logger does not use electromechanical digital storage devices like disks or tapes for data or program storage. Read only memory (ROM) is used for CPU control and is hard coded at the factory. The ROM software controls the operation of the CPU. It is similar to a mini disk operating system (DOS). Commands are received in predefined format via the serial link, and appropriate actions are taken. Approximately seventy commands are available in the Acromag ROM system. The commands range widely in capability. The commands are as simple as "IS" which is identify station. And the commands are as complex as "LL" or log list all the data remotely stored.

The versatility of the microprocessor unit is a result of its field programmability. User field program control is stored in EEPROM. The field program control defines data collection rates, data channels to be collected, data channels to be used as analog outputs, communicates with the central site computer, and in general, controls the customization of the data acquisition and control of the remote data logger.

The microprocessor random access memory (RAM) stores data from the sensors. Approximately 9000 data points can be stored with the data logger used in this project. The data points are collected at user programmed data rates. The remote data logging is activated by the operator. The RAM is the internal buffer for the collected data. At operator selected intervals, remote data is downloaded from the data logger to the central site computer for display and time series plotting. After dumping the data to the central site, the RAM is free to start storing a new series of data points.

The microprocessor unit contains a serial communication link. It is through this link that the microprocessor receives control information and sends the collected information to the central site computer. The communication port is user programmable via the standard serial port capability. Programmability includes baud rate, parity checking, etc.. The microprocessor unit's serial link may be hardwired to a modem, radio transmission link, or other serial ASCII communication systems.

Data loggers typically have the ability to communicate with a variety of data acquisition modules. These include analog to digital (A/D) modules, digital to analog (D/A) modules, or digital input/output modules. As discussed earlier, the data logger is able to be customized to a particular site. System setup personnel customize the data logger to the site requirements. The customization is transparent to an operator. Data from the sensors will be numerically displayed as flow, pressure, turbidity, etc. on the computer display. All raw data transformations will be computed internally in the central site software. The transformations will be programmed by the setup personnel.

Most monitoring instrumentation can be specified with a 4 to 20 ma current loop interface. The 4 to 20 ma interface was chosen as the standard for this project. All instrumentation for the project was ordered with the 4 to 20 ma current loop interface. This included the "data in" as well as the "data out." The remote monitored parameters included chlorine, turbidity, pH, pressure, temperature, and flow.

Control of the package plant is accomplished using 115 volt AC electrically actuated control valves. For proportional control, the actuator movement is initiated with the standard 4 to 20 ma current loop. Note that 4 ma. is the full closed control signal. And 20 ma. is the full open signal. Feedback potentiometers on the actuator control valves indicate the current position of the control valve. The feedback potentiometers will allow the current position of the valve to be displayed, upon system bootup. Control of DW site valves is accomplished via the remote control system. The operator may initiate a change in the process control, and instantly evaluate the effect of the process control change through the real time display of the monitored parameters.

Data acquisition and control software:

The central site software package, can communicate via modem, radio, or direct link with the remote data logger. The central site software provides a high level (mouse driven), sophisticated interface to the remote data logger. The software package used in this demonstration has extensive graphical capability which can provide complete monitoring and control information at a glance. The software is user friendly and can be easily applied to a variety of small drinking water package plant systems, nationwide.

The central site software communicates with the remote data logger by channels (one to sixteen). In this project, for standardization purposes, all Acromag units were programmed in a standard configuration. Channels 1 to 12 were defined as analog to digital modules. Channels 13 to 16 were defined as digital to analog modules. Channels 1 to 12 monitored remote parameters. Channels 13 to 16 controlled remote servo valves for process control.

All sites will require some customization of the software channels. Software channel 1 may be turbidity at site 1. Whereas at site 2 turbidity may be on channel 4. The system software setup personnel require some computer expertise. The computer expertise required is equal to a Harvard Graphics user or a Freelance Graphics user. For sites lacking "in house" computer expertise, the central site software vendor will gladly customize the software for a nominal fee.

In this demonstration, the software was partially customized by Drinking Water Research Division personnel. Customization by DWRD personnel included: adding the remote servo valves for variable flow rate control, adding a number of additional sensors not in the original system setup file. Modifying the graphics display to accommodate the additional sensors and control valves. Modification of the system was relatively painless. Sufficient technical support was obtained from both the software and hardware vendors.

CONCLUSIONS

As more small DW system operations utilize personal computers for billing, personnel tracking, etc., remote telemetry adds an additional cost benefit to the acquisition of a personal computer. The computer availability at the central office, in addition to attractive pricing of remote data loggers and data logger software makes remote "telemetry and control" an affordable option to a small systems operation. Cost of the remote data logger is under $5,000. Central site software is approximately $3,000 without customization. Sensors at the remote DW site usually have an option for an external computer interface (4 to 20 ma output). The external 4 to 20 ma interface is typically under $200. The fax can also function as a 9600 baud modem for data acquisition and control.

Computer expertise is probably the main impediment to remote telemetry. However, with each new generation, computers and computer control are becoming more commonplace. Remote telemetry and control is quickly coming into the reach of small system operations both from the standpoint of cost and personnel capabilities.

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CONTROL OF COPPER CORROSION OF HOUSEHOLD PLUMBING MATERIALS

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INTRODUCTION

The promulgation of the "Lead and Copper Rule" by the USEPA in 1991 has forced hundreds of water utilities nationwide to become concerned with controlling the uniform corrosion of copper plumbing materials. The exact extent of the problem is hard to quantify, but in the first round of monitoring by the large water systems (about 682), approximately 6 % exceeded the 1.3 mg/L action level according to an AWWA study. The highest copper levels for these utilities appeared to be in the southeastern and western regions of the United States, in utilities covering a considerable range of water qualities. The cuprosolvency problem apparently increases with decreasing utility size. When medium-sized water systems are included, large numbers of action level exceedences for copper occurred in the central and north-central midwest, implicating areas having hard and high alkalinity ground waters of approximately neutral pH. These water qualities are not those conventionally considered "corrosive".

Unfortunately, the regulatory monitoring data are of limited use for extracting details of copper chemistry behavior and understanding potential copper passivation strategies. Nonetheless, several interesting gross-scale trends have been discerned for large water systems. One example is that there is a poor correlation between 90th-percentile lead and copper levels. Another trend is that copper exceedences tended to be highest at very low alkalinities (<25 mg $CaCO_3$/L) and increasingly greater over 75 mg $CaCO_3$/L. Finally, no action level exceedences were reported for systems having a pH above approximately 8.

The data thus far suggest that cuprosolvency (copper solubility) will be a major concern across the United States, especially for smaller water suppliers that are less likely to employ corrosion control and use ground water sources. Further, the poor correlation between reported 90th-percentile lead and copper levels suggests that different control strategies for copper than those considered appropriate for lead may need to be developed or employed by affected utilities. Understanding how copper will respond to lead control measures and the results of other regulatory treatment requirements is therefore of considerable interest. Indeed, a response that effectively controls lead corrosion might exacerbate copper corrosion. Moreover, a utility must distribute aesthetically-pleasing water. A good example of the conflicts between control of corrosion of iron mains and reducing copper corrosion rates has been given for a study in Vancouver, BC.

In attempting to address some of the data gaps for cuprosolvency control by utilities, a variety of experimental systems have been constructed and operated in USEPA laboratories. During these experiments, some perplexing data was generated that appeared to either contradict some "conventional wisdom" on copper corrosion, or showed unexpected sensitivities to important water chemistry variables and experimental system operational protocols. These observations provided the motivation to begin