Multi-Stage, Hierarchical System Supports German Region's Water Needs

Water Treatment & Distribution

In 1990, the water-works municipality of Leipzig, located in the former East Germany, invited tender offers for the building of a modern monitoring and control system for the area's water treatment, supply, and distribution. Organizations bidding on the offer faced several complicating factors while developing a solution.

Leipzig's water is derived from a variety of sources, and is distributed to homes and businesses across a relatively large 350-square kilometer area. In addition, the system employs a large number of pumping stations. ATR Industrie-Elektronik GmbH & Co. KG, of Viersen, Germany won the contract and has successfully implemented a multi-stage, hierarchical system whose main components are the PC-based Mistic industrial automation system supplied by Opto 22 and the FIX DMACS supervisory control system from Intellution, of Norwood, Massachusetts.

The Water-Works Municipality of Leipzig

The water-works municipality of Leipzig is responsible for the supply and distribution of 185,000 cubic meters of water daily to five townships — 26 communities — and serves nearly 550,000 inhabitants. The treatment and supply of water is accomplished via four large water-works, and numerous small- to medium-sized water-works. Additional water is supplied via long distance pipelines from sources in the fluvial plains of the river Elbe.

The ATR solution provides the means to control this resource, and also meets several other objectives stated in the original tender offer. For example, safety is improved through central monitoring of the water supply, plus reaction time to disturbances and accidents has been shortened, minimizing the consequences. Finally, the water-works municipality has realized a reduction in operating expenses and energy costs

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through optimal operation of water-works, pump stations, and pipelines.

The selection of the PC-based Mistic industrial automation system and FIX DMACS components was based on several important design characteristics. First, both vendors employ an open systems approach. The Mistic system is a combination of a processor (a high-speed 32-bit industrial microcomputer), intelligent analog and/or digital I/O bricks, and an object-oriented control language, Cyrano. It is very flexible and can be configured to utilize any combination of ARCNET, RS232, and RS485 communications. In addition, the Opto 22 equipment has proven to be very reliable in operation and in data transmission. The major components also communicate with standardized hardware (industrial PCs), operating systems (MS-DOS and MS-Windows), and Local Area Network (LAN) structures (Ethernet). The FIX DMACS is based on an industrial PC, the Texas Micro 486. The supervisory software is structured so that expansion is simply a matter of installing additional stations. Finally, the FIX DMACS has an online data transfer capability, which can be used to exchange data with industry-recognized application packages, such as spreadsheets or databases.

The new system is built with a hierarchy of control divided into several levels. Each level of control relates directly to the technological and business structure of the water-works municipality. At the base of the hierarchy are the sensors and actuators connected to pumps, motors, valves, tanks, filters, and other equipment. Local monitoring and control of these devices is furnished by intelligent remote I/O bricks. The next level of control provides coordination of groups of machines. Mistic G4LC32 processors from Opto 22 are used for this purpose. At the third level, single FIX DMACS stations are employed for plant control of water-works and large pump stations. The top of the hierarchy is a distributed control system for central supervisory control with FIX DMACS stations and Mistic G4LC32 processors as communication controllers. This portion of the system is located at a central control room in Leipzig.

Features For Phased Implementation

The open systems approach employed by Opto 22 and Intellution allowed ATR to develop a seamless, integrated system that is easily expandable. The system was built in stages, as a phased implementation was best suited to the technological and financial capabilities of the municipal water-works. During the first stage (1991-1992), data acquisition and monitoring was installed. At that time, four plants were brought online. Four FIX DMACS stations, four Mistic processors and 34 I/O bricks were utilized to measure and control 80 analog and 200 digital points. From 1993 to 1994, the control of plant and remote control equipment was added. Once completed, 17 plants with 250 analog and 1,100 digital points required 11 FIX DMACS stations, 23 Mistic processors, and 130 I/O bricks. A series of extensions performed in 1994 was even more ambitious. Twenty-four plants, with 400 analog and 1,500 digital points are now monitored and controlled via 15 FIX DMAC stations, 28 Mistic processors, and 150 I/O bricks.

Local Control

The entire water supply depends upon reliable local control of wells, filters, water tanks, pump stations, and pipelines. The basic components for the complete monitoring and control system are the decentralized, intelligent Mistic I/O bricks. The I/O bricks are used for typical tasks such as data acquisition — which includes measuring values, receiving digital signals, and monitoring equipment. Opto 22 has designed ASIC chips for both digital and analog I/O units, creating intelligent, multifunction I/O capable of reacting to events in the field immediately. This is critical to meeting the safety and reaction time objectives of the plant. Installed in a cabinet or near the wells, the local controls system in this configuration now provides all of the functions necessary for safe operation. Each group of I/O bricks is connected via a standard communication network (RS485 or fiber optics) or by modems to a Mistic processor. This high-speed controller is based upon the 32-bit 68020 microprocessor coupled with a

68881 floating point math co-processor. It handles serial communications, supports industry-standard networking, and many more tasks. The Mistic system can support more than 10,000 I/O points per processor. ATR has taken advantage of the I/O brick's design to employ much of the existing cabling, minimizing expenses. For distances less than 3,000 meters, twisted-pair or fiber optic cables were used to link the I/O bricks to the processor. For distances greater than 3,000 meters, standard, off-the-shelf modems were used.

What ties this incredible amount of computing capability together is Opto 22's Cyrano control software. Cyrano is a highly intuitive, object-oriented programming tool. Applications are created by drawing flowcharts in a mouse-driven environment. Boxes, known as "operation blocks," contain a list of actions to perform, such as "open a valve," or "turn on a pump." Boxes referred to as "condition blocks" contain one or more conditions to test. Connecting the boxes allows developers to indicate the sequence of execution. I/O configuration is accomplished by identifying each external device (such as a valve) and assigning it a name in the software. Cyrano handles floating point, integer, and ASCII string values. These features combine to create a tool that presents developers with a clear visual representation of logic that is self documenting, and multitasking. Again, Cyrano employs an open communications protocol, which simplifies linking its function to the supervisory system.

Coordination Control and Local Monitoring

Plant operations must be adjusted to meet changing levels of consumption throughout the day. This requires the coordination of control functions, such as managing groups of wells, pumps, filters or valves. For this purpose, ATR engineers again employed the Mistic G4LC32 processor. The Mistic system supports industry-standard networking via ARCNET, and the engineers use this feature to organize multiple controllers into distributed systems. Communication between the local FIX DMACS operator stations and the distributed control system is performed by a Mistic processor. It is also used for data transmission to the central supervisory control system, located in a room in central Leipzig.

The FIX DMACS operator stations provide the man-machine interface for the plant level coordination and control, as well as for the central control room monitoring. It is a distributed supervisory control and data acquisition (SCADA) system with software that provides graphical status representation of individual equipment. Further, the operator can see a real-time view of the entire plant with process displays shown on a PC. These can be overviews, as well as detailed pictures of individual wells, filters, groups of wells, pump stations and other equipment groups. The FIX DMACS displays include real-time process values of flows, levels, pressures, and energy consumption, plus the current status of switches and valves. The software also provides monitoring and alarming functionality, calculation of variables (such as daily consumption or operating hours) reporting, and trending of both historical and real-time data.

In the local control rooms, information from the plants is aggregated and combined for continuous reporting of the status of the connected plants. An operator may intervene in the local control process to initiate manual control operations — closing valves, switching pumps, turning on motors, and so forth — by interacting with the system at a FIX DMACS station.

Central Supervisory Control System

One of the most important features built into the Leipzig water system by ATR is the ability to monitor and control operations from a single control room located in central

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Leipzig. In this room, the central supervisory control system collects information from the local and remote monitoring and control systems via modems in four Mistic systems. The other key component of the central supervisory control system is a network of FIX DMACS, consisting of two SCADA-nodes, two VIEW nodes, one SCADA/VIEW-node as an engineering station and one file server. The stations and the fileserver are connected via an Ethernet-LAN.

The SCADA and VIEW nodes provide general monitoring of all water-works and pipeline systems in the Leipzig area. Operators navigate through overviews and detailed displays of pipeline systems and water-works based upon on-line values, real-time and historical trends, and archiving of measured values. Additionally, operators in the central control room may also navigate through displays via the SCADA software to monitor operations on the plant level. The central supervisory control system also generates reports on the system's alarms, shift activities and daily operations.

Individual pumps and valves are also operated from the central control room. This eliminates the expense of dispatching a crew each time an isolated piece of equipment requires adjustment.

The Future

Prior to the system developed and installed by ATR, the only automatic control functions in the water-works municipality of Leipzig were provided by a few scattered Programmable Logic controllers (PLCs). Now the area's water needs are well-served by a modern, complex monitoring and control system with a multilevel hierarchical structure. Also, the use of major components which employ an open systems approach and utilize industry standard networking protocols facilitates easy expansion of the system to meet increased requirements. Finally, the computer control at the local level in the hierarchy permits resources to be shifted and reallocated without replacement or reconfiguration of hardware.

The flexibility and power provided by the Opto 22 Mistic system and the Intellution FIX DMACS combination have convinced ATR that the water control system is a tool that will also be successfully applied in the waste-water treatment and chemical processing industries

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