Case Study: Cold Storage Facility Management, Madrid, Spain

Optomation Systems modernizes cold storage control system at Mercamadrid, one of Europe's largest wholesale markets

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CASE STUDY: COLD STORAGE FACILITY MANAGEMENT, MADRID, SPAIN

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MERCAMADRID MARKET

Wholesale market Mercamadrid in Madrid, Spain, is one of Europe's largest wholesale markets for perishable food products. Spanning 547 acres (2,215,000 m_2), Mercamadrid contains separate installations for meat, fish, fruit, and vegetables, and serves as a daily trading hub for fresh food products for over 12 million people.

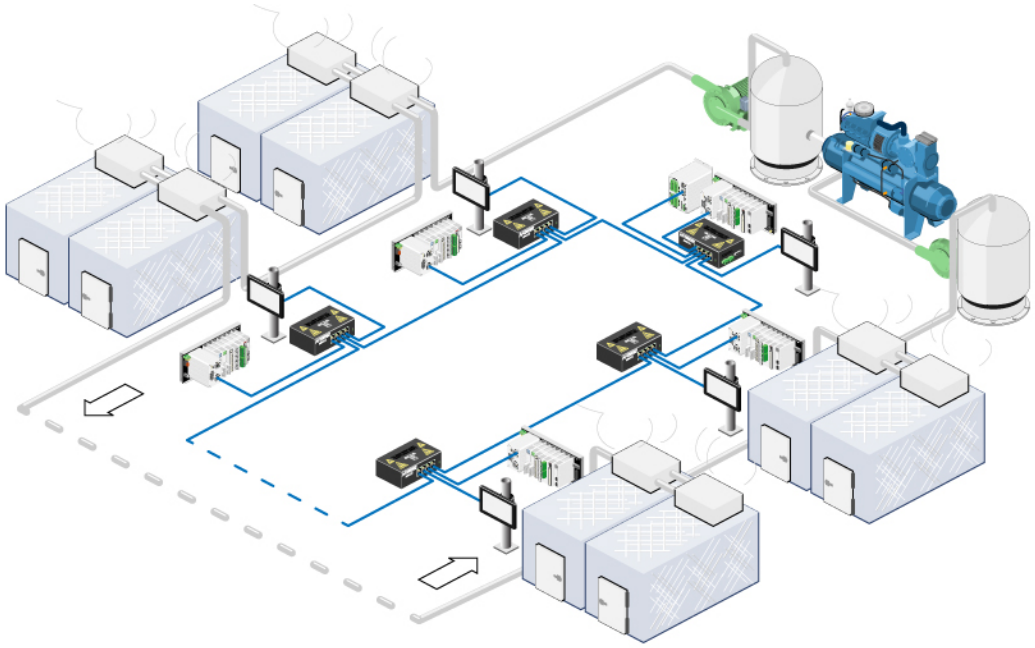
With all this fresh food, environmental control is key to Mercamadrid's success. One of the most environmentally controlled areas within Mercamadrid is the Central Meat Market, a processing, packaging, and distribution facility for meat and products derived from cattle, pigs, sheep, and other livestock. In this market, the top 25 distribution companies share an area of 10.3 acres (42,000 m_2) within a three-story building and deliver up to 136,760 tons (124,065 metric tonnes) of meat per year to a supply chain of local distributors, butchers, supermarkets, and restaurants.

Each distribution company at the Central Meat Market has its own infrastructure for its showcase and sales area, raw product warehouses, processing rooms, and final product storage, but they all share a common responsibility: delivering a quality product that fully complies with food storage, handling, and health regulations.

Perhaps the most important aspect of meat production is to ensure that the product is refrigerated correctly, not only during storage but also in all phases of product handling.

Cold Storage Control

The Central Meat Market's centralized cold production plant provides heat transfer fluids for each distribution company's refrigeration machines. The plant, powered by



At the Mercamadrid wholesale market in Madrid, Spain, a cold production plant at the Central Meat Market distributes refrigerant liquids to 26 refrigerated storage units used by individual meat distributors.

natural gas, is considered the most important installation of its kind in Europe.

Both ethylene glycol and liquefied ammonia are used for the refrigerant fluids based on the temperature required in individual cold storage areas. Refrigerant fluids are pumped through a pipeline manifold equivalent to 43 mi. (70 km) in length, forming a closed system that supplies all clients. The fluids travel to chiller units installed in the ceiling of each refrigerated space and then return to the production plant to start the cooling process again.

Cold is generated by 23 compressors, which are divided into four groups according to the temperature required:

- –43.6 °F (–42 °C)
- –25.6 °F (–32 °C)
- 5 °F (–15 °C)
- 21.2 °F (–6 °C)

For the two coldest groups, liquid ammonia is pumped directly to the clients' chillers. For the two warmest groups, ammonia in a primary compression circuit refrigerates the secondary circuit with ethylene glycol that is finally pumped to clients' chillers. (Ethylene glycol is used because ammonia will not remain liquid at those temperatures.)

Natural gas motors drive all compressors, which when running at maximum capacity deliver 5590 kW of cold energy and consume up to 22,954 ft_3/hr (650 m_3/hr) of natural gas.

Liquefied ammonia, ethylene glycol, and other fluids are pumped throughout the market using a pipeline manifold equivalent to 43 mi. (70 km).

The cold production plant also supplies other service fluids for each cold storage module, including hot ammonia and ethylene glycol to defrost the chillers, sanitary hot water, and hot water for office heating. The cold production plant includes an auxiliary boiler, now rarely used since the gas motor cooling system economically provides most of the heat required.

PROBLEMS WITH AN OBSOLETE SYSTEM

The control system for both the cold production plant and the 26 client modules dated from 1999 and was based on standalone PLCs, which were programmed using ladder logic and used Modbus-driven monochrome displays as operator panels. All the PLCs at the cold production plant and at each client module exchanged information and provided data to a SCADA system over an outdated Modbus Plus network.

Most of the existing control equipment was obsolete. PLC spare parts were hard to find at a reasonable price, and the SCADA and Modbus Plus interfaces had limited operating system support and hardware compatibility problems with present-day IT standards.

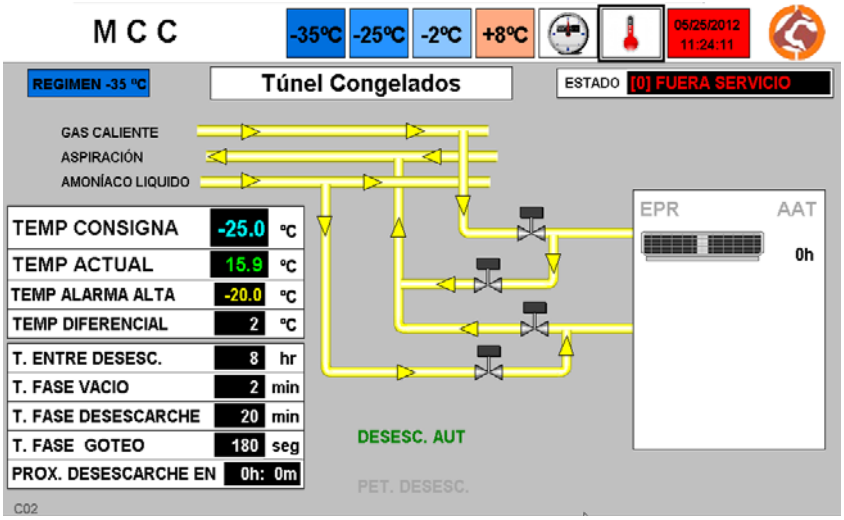
Problems with using the existing control equipment included the complexity of maintaining 27 separate control programs, the difficulties of using ladder logic to program communications or other advanced features, and the low 2 Mbps data throughput of the Modbus Plus network. These problems blocked any efforts to modernize the cold production plant and made it nearly impossible to implement control schemes to improve chiller COP (coefficient of performance) and reduce energy costs.

OPTOMATION SYSTEMS' CONTROL SOLUTION

System integrator and Opto 22 distributor Optomation Systems presented to Mercamadrid management a project to completely replace the existing control systems, from the temperature control in client modules right through to the control system in the cold production plant. All the buses used by control equipment would be replaced with a single Ethernet network, and new operator interfaces would be created to meet the requirements of end users.

IT Backbone

At the start of the project the decision was made that all client modules and the cold production plant would be



Temperatures, flow rates, and other parameters at the cold production plant are monitored and controlled using an HMI developed in Opto 22 PAC Display software.

connected together with a single high-speed, high-capacity IT-based network.

This network would not only need to handle the exchange of peer-to-peer control information between controllers, I/O, and data acquisition for a web-based management and control system, but also need to allow system maintenance from both centralized and offsite locations. Firmware updates, program corrections, software upgrades, and equipment diagnostics all needed to be done remotely without having a technician walk half a mile through freezing installations carrying a portable computer, manuals, cables, and other equipment.

The logical choice for network communications was an Ethernet TCP/IP network that reached all client modules, the cold production plant area, and the maintenance control center. To minimize cabling costs due to the distances involved, Optomation Systems selected a ring topology with dedicated industrial Ethernet switches. A star topology would have required the use of costly fiber-optic networking.

The Ethernet switches used for the network automatically find the best path between any two points, and automatically use an alternative path if a connection fails due to hardware failure or cabling damage between contiguous switches. The switches have redundant power supplies, one using power available at the immediate location and one using power distributed over a centralized power ring, also monitored by the control system.

Cold Production Plant: The Classical Centralized System

The cold production plant controls the ammonia compressors, with primary/secondary circuits, associated duty/standby pumps, and control valves. A SNAP-PAC-S2 controller replaced the original Telemechanique TSX controller, and all control logic was rewritten using PAC Control software, maintaining original functionality and where possible improving the existing control strategy.

All compressors' standalone PLC controllers are now connected to a single SNAP-PAC-S2 using the Modbus RTU protocol, allowing start/stop commands and the setting of operational values according to an algorithm that constantly checks the refrigerant requirements of all clients.

One of the project's major technical challenges was to replace the control system while maintaining near-zero downtime. Due to its importance, the refrigeration control cannot be out of service for more than two hours at any time. In summer months, when outside temperatures easily reach 100 °F (40°C), this maximum permitted downtime is reduced to twenty minutes!

Optomation constructed special cables which allowed the switching of all digital and analog I/O between the existing PLC and its replacement SNAP-PAC-EB2 field I/O brain,

Original Telemechanique I/O hardware at the cold production plant was replaced with these smaller Opto 22 SNAP I/O products. Special cabling reduced changeover time between control systems to minutes.

filled with high-density SNAP modules, reducing any changeover time to minutes.

A local touchscreen based on an industrial panel PC running PAC Display provides a central HMI for the system.

Distributed Client Module Control: One for All, All for One

Each client module previously had its own PLC connected to a local display panel. That meant 26 different PLC programs and 26 different HMI configurations, even though they all essentially had the same basic functionality.

For maintenance engineers this was an inconvenience, but for software development it was a nightmare. Constant changes involved unnecessary effort, time, money, and mistakes. Further complicating the software was the fact that clients can actually change the functionality of individual storage modules to cater to product trends, requiring the subsequent changing of both control and HMI programs.

Optomation's approach was to create one program that would fit all the clients' module configurations, both for the controller and the HMI. Using advanced programming techniques and the built-in powerful features of the SNAP PAC controllers—including dynamic subroutines, object pointers, file manipulation, and XML parsing—

At each installation, each client can change setpoints, set alarms, and monitor temperatures for refrigerators and freezers using a local panel PC.

Optomation created a universal program for downloading to all 26 SNAP-PAC-R2 controllers installed in the clients' installations.

The specific parameters for each individual installation are defined by simple text files uploaded over the network by FTP into the SNAP-PAC-R2 controller, including the I/O definition and configuration; the number, type, and name of chambers; the number of chillers by chamber; and so on. The control program uses this information to adapt itself accordingly, similar to a batch production control program.

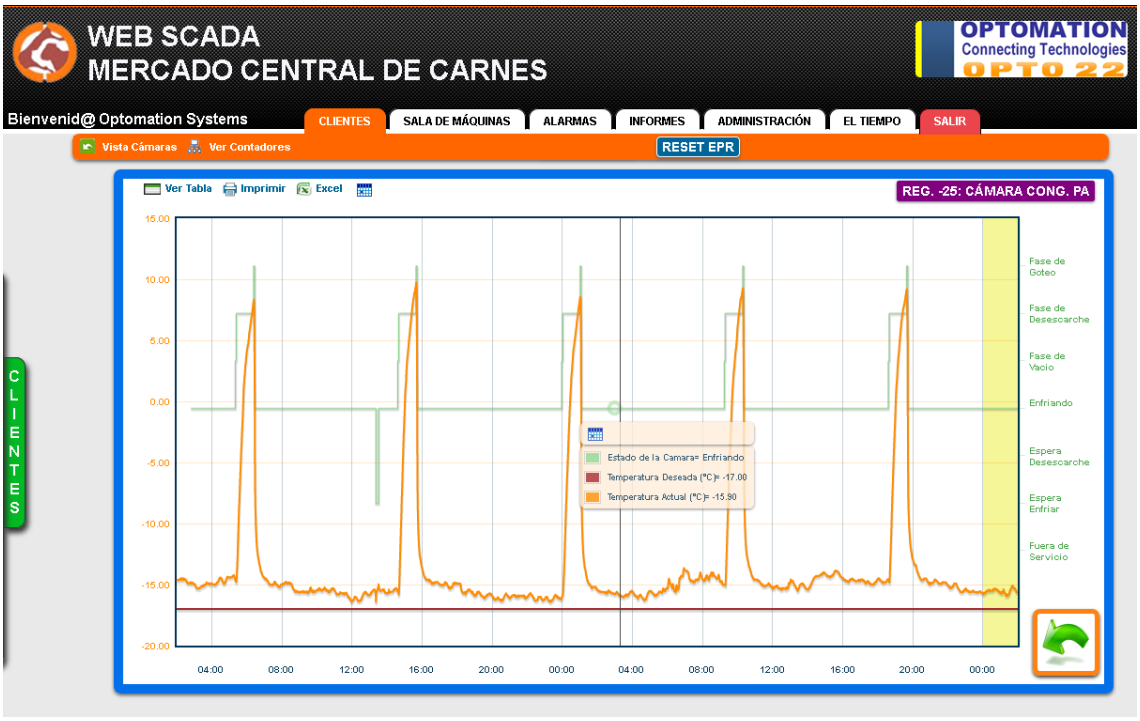
Each client installation has a local HMI, in this case an industrial panel PC with an 8 in. (20 cm) touchscreen running a common PAC Display project. This HMI "understands" the control program running in the controller and automatically modifies the operator interface to match the parameters at a specific installation, without a person needing to modify the display project.

One Web Interface: Anytime, Anywhere, Any Data

The old existing SCADA, an Intellution FIX, was also replaced by Optomation's Web Portal software. This software uses the network to collect data from all SNAP PAC controllers, in the cold production plant and in all client modules, in order to fill an SQL database with current and historical data. A custom web server tool based on the latest web standards connects to the database to generate dynamic web pages, displaying realtime data, web objects, historical trending, alarms, and reports for all parts of the installation. No client software is required beyond an internet browser.

The web portal acts just like any other restricted website, providing the same level of access within the local intranet network as it does offsite via the internet, through a secure router gateway and firewall protection.

A variety of users with diverse requirements can remotely access the portal to obtain information for which they are authorized. One client may want to check the temperature fluctuation in a module over the last 12 hours, while an external maintenance company may want to compare the performance of identical chillers installed in different clients' installations. Site maintenance may want to check overnight alarm data from the common cold production plant through a smartphone, while a quality department may access and download historical sampling data into Microsoft Excel for regulatory purposes.



Optomation Systems' Web Portal software provides each refrigerated storage unit a custom, web-browser-based interface that displays temperature history and equipment status.

Information publicly available from the internet—such as weather forecasts, wholesale meat prices, and energy costs—are mixed in with live site data, integrating everything in a single web portal.

Software engineers can even change chambers and module configurations, remotely downloading them into the SNAP-PAC-R2 controllers, while Optomation can remotely connect to the site to check Opto 22 hardware or discuss observed instrumentation or control problems, without having to drive to Mercamadrid's location.

ABOUT OPTOMATION SYSTEMS

Working from its centralized offices in Madrid, Optomation Systems has been the exclusive distributor for Opto 22 for Spain, Portugal, and North Africa since 1996. The company is responsible for the commercialization, distribution, installation, and after-sales support of Opto 22 products in this area.

Optomation has developed a complete support network, including integrators, consultants, and suppliers that offer services, local support, compatible technologies, and products that complement those of Opto 22.

ABOUT OPTO 22

Opto 22 was started in 1974 by a co-inventor of the solid-state relay (SSR), who discovered a way to make SSRs more reliable.

Opto 22 has consistently built products on open standards rather than on proprietary technologies. The company developed the red-white-yellow-black color-coding system for input/output (I/O) modules and the open Optomux® protocol, and pioneered Ethernet-based I/O.

In early 2013 Opto 22 introduced *groov* View, an easy-to-use IoT tool for developing and viewing mobile operator interfaces—mobile apps to securely monitor and control virtually any automation system or equipment.

Famous worldwide for its reliable industrial I/O, the company in 2018 introduced *groov* EPIC® (edge programmable industrial controller). EPIC has an open-source Linux® OS and provides connectivity to PLCs,

software, and online services, plus data handling and visualization, in addition to real-time control.

All Opto 22 products are manufactured and supported in the U.S.A. Most solid-state SSRs and I/O modules are guaranteed for life.

The company is especially trusted for its continuing policy of providing free product support, free training, and free pre-sales engineering assistance.

For more information, visit opto22.com or contact **Opto 22 Pre-Sales Engineering**:

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