

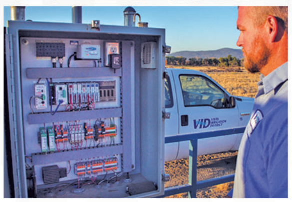


Case Study: American Metal Processing

Nation's largest rotary heat-treating facility improves reliability, alarming, operator control, traceability, and data logging with groov EPIC

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CASE STUDY: AMERICAN METAL PROCESSING

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Metal components used in products like cars, trucks, farm machinery, construction vehicles, and military equipment have to tolerate high friction, force, and temperature over a long lifetime. Design engineers specify various treatment processes for these components to improve properties such as wear-resistance, extending their lifetime and reducing cracking and fatigue.

Heat treatment is one of the most commonly requested processes for this purpose, and American Metal Processing (AMP) is one of the nation's foremost providers.

Established in 1945, AMP specializes in rotary heat treatment for deep case carburizing, carbonitriding, and neutral hardening ("quench and temper") processes and is the largest commercial provider in America. With 18 employees and seven furnace lines operating 24 hours a day, they are able to process millions of delicate parts (typically no larger than five inches) subject to some of the most extreme operating requirements.

Compared to competing methods, rotary heat treating yields tighter physical tolerances and greater uniformity through precise process control.

So, when AMP saw that its automation systems were reaching the end of their lives, it undertook the difficult task of modernization.

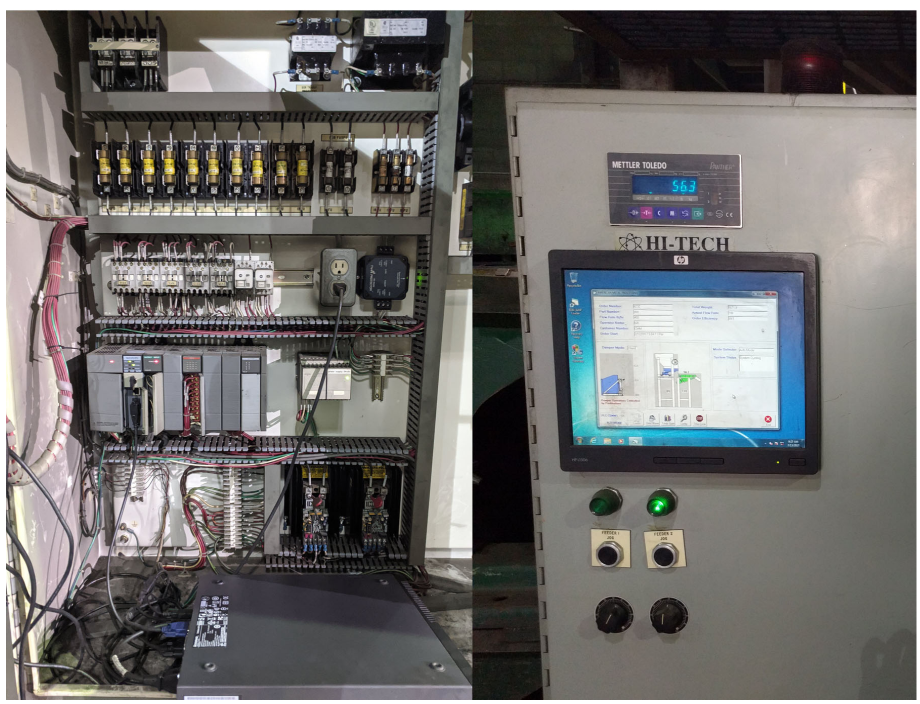
PROBLEMS AND OPPORTUNITIES

The first rotary furnaces introduced to AMP in the 1970s were controlled through precisely calibrated weights and scales. Computerized control was introduced in 1993 with a DOS-based control system and upgraded to PLC control in 2000, but these systems were aging poorly and had limited capabilities:

- Programmable logic controllers (PLCs) were experiencing regular failures and were limited to controlling the feed system.
- The operating system (OS) of the feeder system human-machine interface (HMI) was approaching its end of life, and AMP had no access to the HMI program source.
- The majority of system components were not integrated or automated beyond direct motor control.

"We were on borrowed time," says Grant Pinkos, president of AMP.

Pinkos also saw the opportunity to use this modernization project to make the system better than before. "The system was primitive by today's standards," he says. "We wanted it



One of the previous feeder system electrical panels and HMIs, circa 2000

> **"The [existing] system was primitive by today's standards. We wanted it to be more than a control system. We wanted it to be intelligent."**
>
> **- Grant Pinkos, president of AMP**

to be more than a control system. We wanted it to be intelligent."

Modernization would address the need for automated interlocking and alarm notification as well as reduce operator error through a rich HMI.

In addition to these improvements, AMP also wanted to address pressing needs around data integrity and connectivity. "We wanted a back end that would be on our network and which could be fully connected to our SQL database," Pinkos explains.

AMP's customers are typically Tier 1 and 2 suppliers to OEMs (original equipment manufacturers), and a majority of those work in the automotive industry. These customers require multi-year part traceability in case they need to investigate a particular lot.

Twenty years ago, AMP invested in a material tracking database for this purpose, which now contained billions of rows of data and had become important to process metrics and quality control. Integrating operations data into this database and eliminating double data entry became important goals of modernization as well.

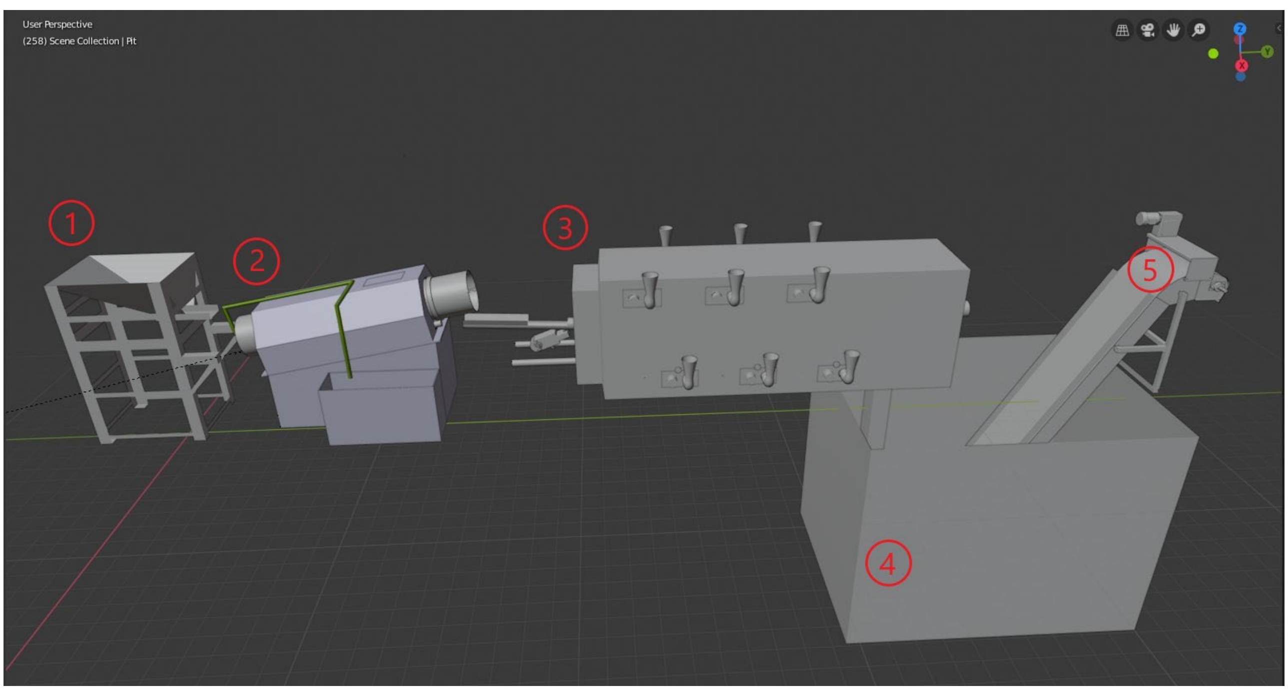
A final goal of the modernization project was to establish seamless process data integration. While purpose-built data logging systems are available for the heat treatment industry, they are usually sold as standalone systems, and AMP was uncertain of their ability to communicate with their lot tracking database. They decided to focus on upgrade designs that included integrated data logging as a feature of the system.

Pre-upgrade System Description

AMP's hardener furnace lines consist of five primary components: feeder, prewash, retort furnace, quench tank, and conveyor.

Feeder

The heating process begins with a two-stage vibratory metering system with the feed rate controlled via an RS-232 connection from an Allen-Bradley programmable logic controller (PLC). Parts to be treated are fed through



3D rendering of one of AMP's furnace lines, consisting of 1) feeder 2) rotary prewash 3) rotary retort furnace 4) quench tank 5) conveyor

the prewash system and then the furnace at the rate specified by the operator at a Windows PC-based human-machine interface (HMI). The HMI provides visualization of the current feed rate and the weight of parts loaded on the scale.

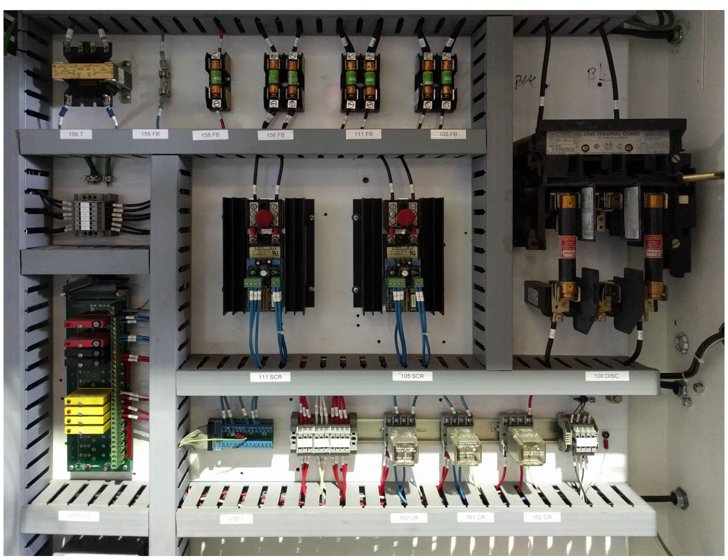
Prewash

Next, parts pass through a fixed-speed rotating barrel driven by a ½ HP 230V 3-phase AC motor and speed reducer. Parts are cleaned in a high-temperature spray on their way into the furnace.

Retort furnace

A rotating cylindrical retort conveys parts from one end to the other by slowly tumbling parts forward across a series of internal vanes. Internal temperature is maintained by Eurotherm 3204 PID controllers, and a two-position selector allows the operator to drive the furnace continuously in one direction or to select alternating back-and-forth motion when longer dwell times are needed.

The period of the alternating cycle is controlled by a dual-setpoint timer, and the rate of rotation is controlled by an Allen-Bradley PowerFlex 525 variable frequency drive (VFD) and a 1 HP motor through a 900:1 gear reducer. Operators manually set the output frequency of the drive via its integrated control panel.



Feeder system I/O panel with original Opto 22 I/O components, in operation since 1993

"Our process is something that can be sketched out on a whiteboard, and we believed the solution should be simple to implement and understand."

- Grant Pinkos, president of AMP

Quench tank

Parts fall from the end of the furnace through a chute into a 7,000-gallon tank where they are cooled in either water or oil. The quenchant is circulated constantly by a fixed-speed pump driven by a 30 HP 230V 3-phase AC motor.

Conveyor

Treated parts are removed from the quench tank by a conveyor belt driven by a 2.5 HP 230V 3-phase AC motor.

CONTROL PLATFORM EVALUATION

Given the scope of its controls upgrade—including computerized weighing, burner control, and drive control—AMP knew it would require a custom solution. After receiving quotes from several industry system integrators, it became clear to Pinkos that AMP had two options: "Either we pay someone $60K and give them the keys to the car, or we consider a homegrown solution."

Most of the companies that Pinkos contacted wanted to completely rebuild the feeder system electrical panels, including custom programming for new PLCs and accompanying HMIs, leaving AMP with no access to the source code unless they also paid for the required design software licenses. AMP wondered whether it could take on the job itself, potentially reducing costs and giving it the option of retaining full ownership of its control logic.

"For a business like ours with less than 25 employees," explains Pinkos, "developing a solution in-house is inherently more attractive than paying an outside company, since it allows us complete control over the product and we can modify, adapt, or expand it as our needs change. Our process is something that can be sketched out on a whiteboard, and we believed the solution should be simple to implement and understand."

AMP began researching what a homegrown solution would require. It identified Opto 22 as a potential solution vendor while exploring a feeder system I/O panel dating back to 1993. "Opto 22 I/O modules were some of the few parts still working," according to Pinkos. "We got a quote for a *groov* EPIC system and were very impressed with the value and versatility offered."

With EPIC as a potential foundation for its new control system, AMP began mapping out a path to the goals it had identified using the content available through Opto 22's developer forum, training videos, and support channels. Pinkos, a chemical engineer by education, began learning Opto 22's free PAC Control programming software with guidance from sales and support staff.

The experience gave AMP the direction it needed, as Pinkos relates. "I could see the pieces coming together. Opto 22 does an amazing job of teaching people who don't have a background in programming. When I realized I could do data logging with *groov* EPIC, that checked another box for me. Once we found a way for our lot tracking database to use REST calls to extract data from the *groov* EPIC, then we had a complete solution. EPIC made it possible to create a homegrown system."

SYSTEM UPGRADE

AMP began developing its first *groov* EPIC system with a phased plan for upgrading each of its seven furnace lines. A month later, however, AMP suffered a critical PLC failure on one of its lines and decided to put an early version of the new system into service.

Built on the *groov* EPIC processor (GRV-EPIC-PR1), the first system incorporated the following I/O modules, each with channel-to-channel isolation, which allowed AMP to establish a basic control system:

- GRV-CSERI-4: 4-channel serial communication module
- GRV-OVMAILP-8: 8-channel V/mA analog output module with chassis-supplied loop power
- GRV-ODCIS-12: 12-channel simple discrete DC output module
- GRV-ITMI-8: 8-channel thermocouple/mV analog input module

New electrical panel layout with *groov* EPIC and accompanying *groov* View HMI

The feeder system scale was monitored through one of the system's serial inputs, with both vibratory stages controlled through 0–10 VDC outputs.

The retort furnace controls were integrated into the control program using one serial input channel to measure the rotational speed of the furnace, one analog output for setpoint control to the VFD, one discrete DC output to the VFD to control the direction of rotation, and four temperature readings of the furnace body and internal atmosphere.

The conveyor was integrated into the control program using an additional serial input to monitor the belt speed.

Finally, AMP's *groov* EPIC was connected to the company network, completing a basic design that laid the foundation for continuing enhancements.

Because *groov* EPIC uses a quad-core ARM processor capable of running multiple applications in parallel and includes additional software applications, control logic was just the beginning of AMP's modernization program.

OPERATOR INTERFACE

One of the software applications included with *groov* EPIC is *groov* View, an embedded visualization server for creating on-board, external, mobile, and desktop HMI displays. Along with duplicating the functions of the previous PC-based feeder HMI in *groov* View, AMP took the opportunity to integrate other control elements and create a unified operator interface.

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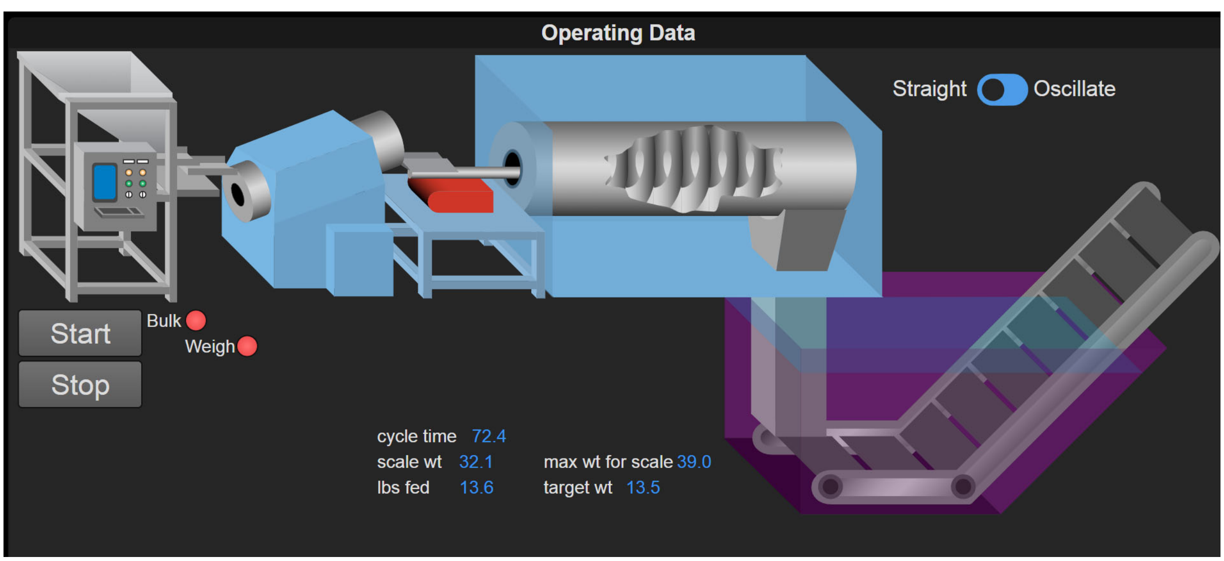
Furnace temperature, retort speed (which corresponds to dwell time), and quench tank temperature were added to the existing feed system readings, while the manual furnace timer and rotational direction selector components were replaced with HMI control gadgets. The result was a logically arranged operator interface "that anyone could understand," according to Pinkos.

To enhance the interface even further, AMP utilized previously installed IP cameras directly above the feeder hoppers so that operators could observe the level of parts in each, which they did 3-4 times an hour. AMP used the *groov* View camera gadget to add these camera feeds directly to the main HMI display, allowing operators to verify the hopper level at a glance and manage equipment from one location.

All HMI screens and camera feeds are available to operators from an external display connected to the *groov* EPIC's HDMI port. And since *groov* View also supports mobile displays, Pinkos is able to supervise operations from his smartphone.



***groov* View HMI—operator controls and process read-outs**

***groov* View HMI—camera feed of feeder hopper level**

"The new system is easy to understand and even easier to visualize, which builds confidence with existing customers and helps attract new ones," says Pinkos.

Alarming

A controlled, multi-stage, high-temperature process like AMP's involves various safety and productivity risks, so AMP also used *groov* EPIC's toolset to add layers of protection.

In PAC Control, AMP implemented overfeed and underfeed monitoring along with process logic to interlock the upstream feeder and prewash systems should any of the downstream systems stop. It also designed an emergency oscillation routine for the furnace in the case that either the quench pump or conveyor motor stopped unexpectedly. This gives the system a way to safely hold parts while downstream maintenance occurs.

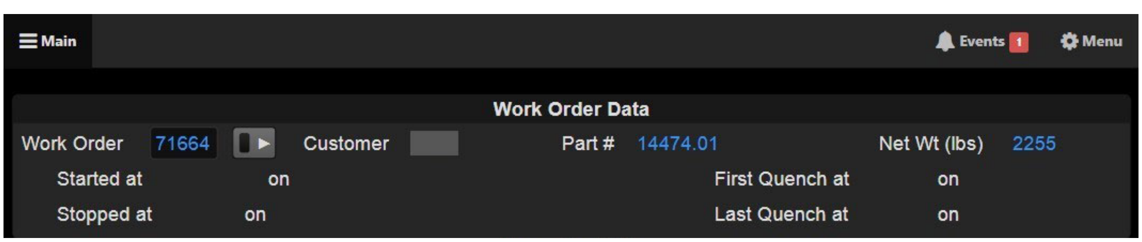
For operator safety and responsiveness, AMP added lights and sound beacons around the furnace perimeter. They added a discrete AC output module to the *groov* EPIC controller and wrote additional logic to drive the alert system whenever an alarm occurs. AMP configured event monitoring in *groov* View so any of these alarm occurrences would also be recorded in the HMI's operator log.

As a final measure, AMP used another of *groov* EPIC's embedded applications to interact with the company PA system. Node-RED is a visual event-driven programming language from IBM for connecting data from across the internet. It includes a library of functions for designing transactions with databases, web services, and networked devices.

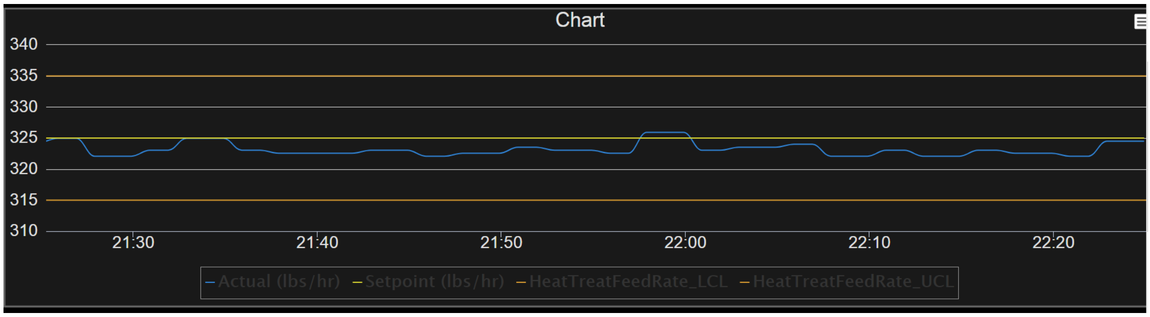
AMP used Node-RED to query the company's operations database for alarm occurrences, generate a string representation of each, for example "Temper furnace 204 overtemp alarm," and send the string to a text-to-speech (TTS) function. Each EPIC stored a copy of this program, which executed in a browser on the company's PA-management computer, creating unique audio announcements any time an alarm was triggered. Instead of an operator having to follow his ears to identify the location of an alarm, announcements direct him to the specific piece of equipment, so he can deal with the situation promptly.

Lot Tracking and Data Logging

In addition to providing traceability of all the parts that AMP processes, the company's SQL database stores various heat-treating recipes and essentially serves as an ERP system. Previously, operators had to look up the appropriate recipe parameters in the database, input those



***groov* View HMI—work order data interface**



***groov* View HMI—feed rate trend plot**

into the feeder system HMI as well as other furnace controls, and record work order information in the database prior to each run.

To reduce the possibility of human error, AMP integrated all of those tasks into a common interface. Now, the controller queries the company database via Node-RED and transmits recipe parameters (feed rate, retort speed, temperature, oscillation period and more) to variables in the PAC Control strategy. Work order information is recorded and sent to the database from the Work Order Data section at the top of the main HMI display. Operators can also use that interface to query the database for information on previous runs.

AMP enhanced its basic work order tracking by configuring periodic data logging of multiple process variables, including feed rate, VFD output and current draw, rotational direction, conveyor status, and various temperature readings. A 24-hour trend of key data was added to the main HMI display with the complete data set residing in the company's database for long-term storage.

"The pace of advancement is quite good," says Pinkos. "Having a data logger is essential, but usually that's a separate system with its own set of logic and alarms. Now operators can instantly see the feed direction and feed rate for real-time feedback. I can go back and change things

One of the upgraded furnace lines showing the new HMI at far left

based on their feedback. And I can do that a few times a week. Our OEE will likely improve over time."

WHAT'S NEXT?

According to Grant Pinkos, AMP's control system modernization project with *groov* EPIC has yielded tighter process control, multiple levels of error-proofing, better traceability, and historical data retention. But they aren't done yet.

There are still many opportunities for improving and expanding basic control system functions. For instance, quench tank level management, like the feeder hopper, currently relies on operator observation. AMP would like to automate this and many other functions around the shop, says Pinkos. "I look around and I see all these fans, motors, cooling water pumps and temperature systems being controlled and think if I could just whittle away 2% or something, which I think is achievable, the investment would pay for itself. It's like LED lighting. Why wouldn't you do it?"

Pinkos also has plans to create a more connected, distributed IT infrastructure. AMP will be migrating its SQL database to a cloud hosting provider that will securely communicate with the *groov* EPIC units in the plant. And Pinkos would like to take advantage of *groov* EPIC's virtual private networking (VPN) client to enable remote monitoring and control system management.

AMP is also in the early phases of planning furnace control and automation for a recently acquired sister company that offers heat treating using batch furnaces. It intends to base these upgrades on *groov* EPIC, as well Opto 22's *groov* RIO edge I/O module.

For more information on American Metal Processing, visit ampht.com or call **(586) 757-7337.**

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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