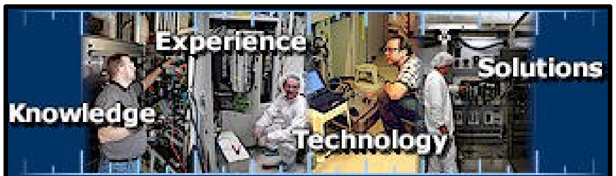

EPRI PEAC Corporation
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Compliance Specialist SM

Case Study: Vacuum Pump Performance Improved by using Capacitor Based Ride-Through Device

This Technical Case Study Provided by:

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EPRI PEAC is the worldwide leader in Power Quality services for the Semiconductor industry - Offering training, compliance testing, design consulting, and on-site plant audits related to the SEMI F-47 Standard "Specification for Semiconductor Process Equipment Voltage Sag Immunity". EPRI PEAC's goal is to solve Semiconductor tool voltage sag susceptibilities for our manufacturer and tool supplier clients to enable compliance with the SEMI F47 Standard and maximize process uptime.

In 2000, EPRI PEAC Corporation established the PQ Star^{sm} Program to test and certify manufacturer equipment per established power quality standards. PQ Star^{sm} certification for the SEMI F47 standard (Specification for semiconductor Processing Equipment Voltage Sag Immunity) is available for semiconductor equipment suppliers. EPRI PEAC utilizes the SEMI F42 test standard (Test Method for Semiconductor Processing Equipment Voltage Sag Immunity). With the PQ Star certification, EPRI PEAC Corporation offers a third party verification that the equipment tested meets this important new power quality standard.

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Background
Since the late 1980s, semiconductor chip manufacturers have become increasingly aware of the costly impact of minor power quality disturbances on ultrasensitive fabrication equipment. One voltage dip of just a few cycles can disrupt critical operations, such as occurred recently in a major semiconductor manufacturers diffusion furnace. Then end result irreparably damage hundreds of chips at a time which resulted in losses in millions of dollars. The manufacturer contracted with EPRI PEAC Corporation to test their equipment for voltage sag immunity and determine the most cost-effective solution.

Problem
Equipment shutdowns are often due to system incompatibilities with these power quality disturbances – components of the tool are not robust enough to endure the power variation. The SEMI F47 curve shown in Figure 1 resulted from industry-wide efforts to address the problem of voltage sags.

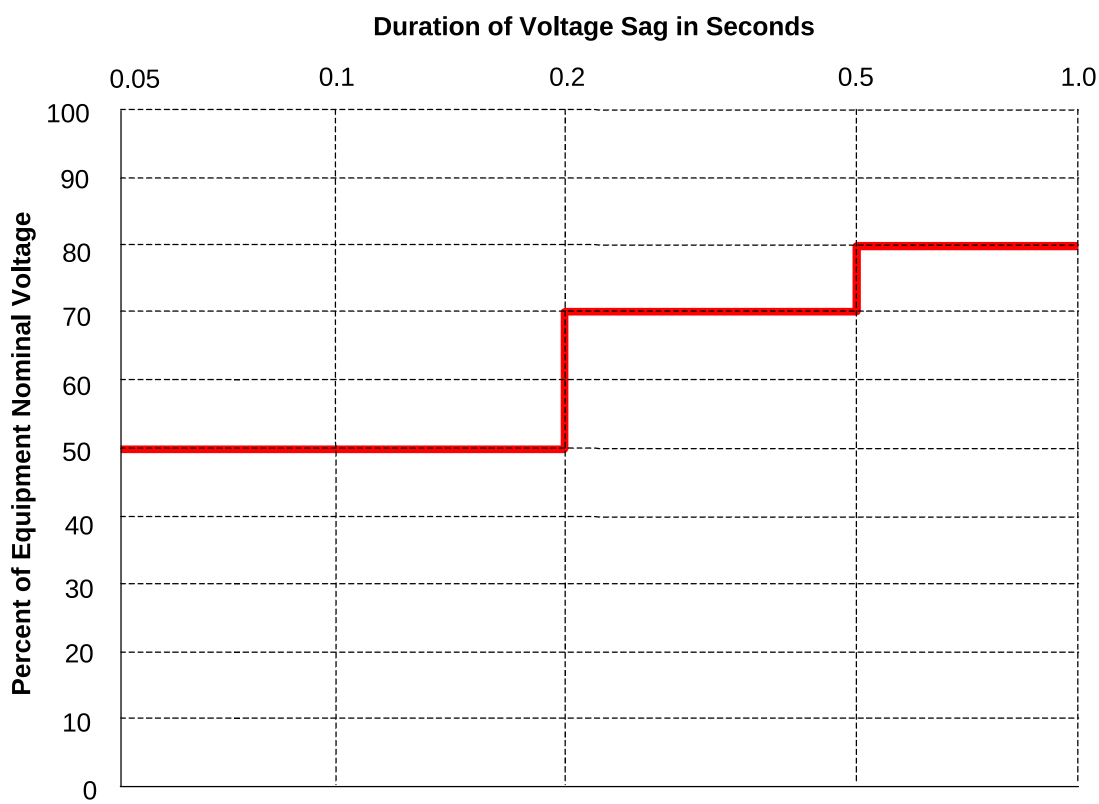

Figure 1. The SEMI F47 Curve

As most voltage sags in the United States occur in the area above and including the curve, any tool or component surviving voltage sags in this area would be considered compliant according to the SEMI F47 standard. Historic data of voltage sags experienced at the plant during a recent three-year period indicated that all but three severe sags did indeed occur near or above the SEMI F47 curve as shown in Figure 2.

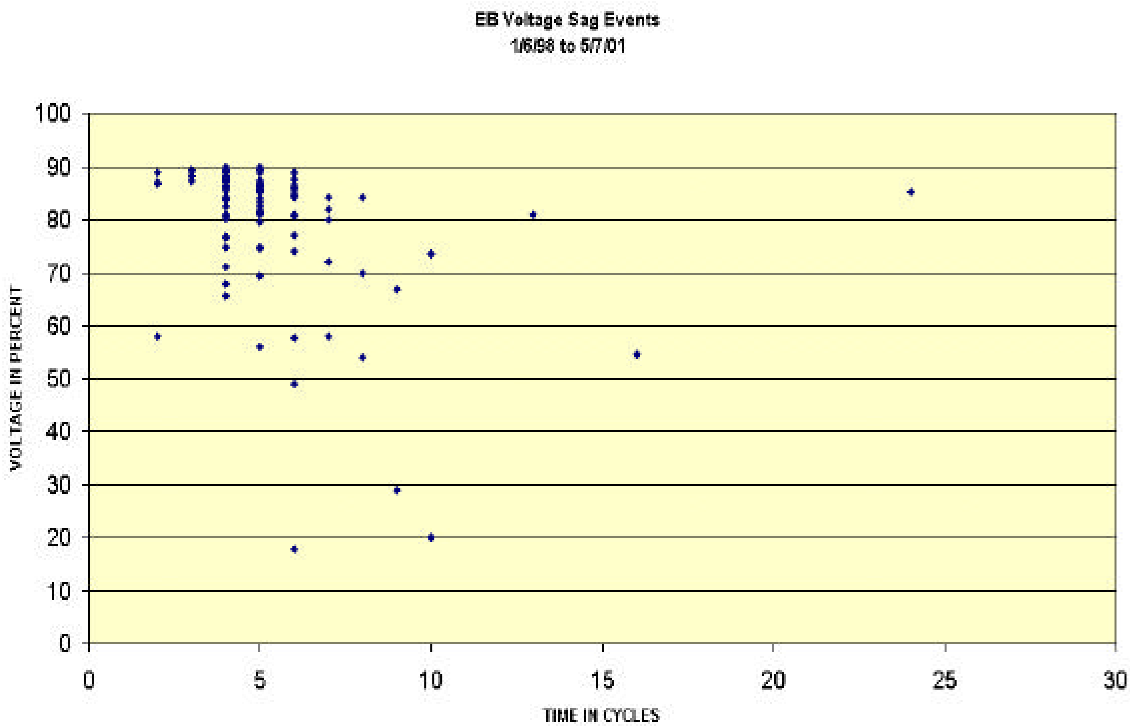

Figure 2. Facility Historic Voltage Sag Data

In this case, the furnace components could not ride through voltage sags common at the facility. While an uninterruptible power supply (UPS) protected the furnace controls as shown in Figure 3, the vacuum pumps themselves remained unprotected and shutdown after voltage sags. The resulting economic loss from contaminated wafers in the diffusion department could exceed three million dollars per sag!

The manufacturer contracted with EPRI PEAC to conduct voltage sag tests using its Process Ride Through Evaluation System (PRTES) to help determine effective solutions for the voltage sag problem.

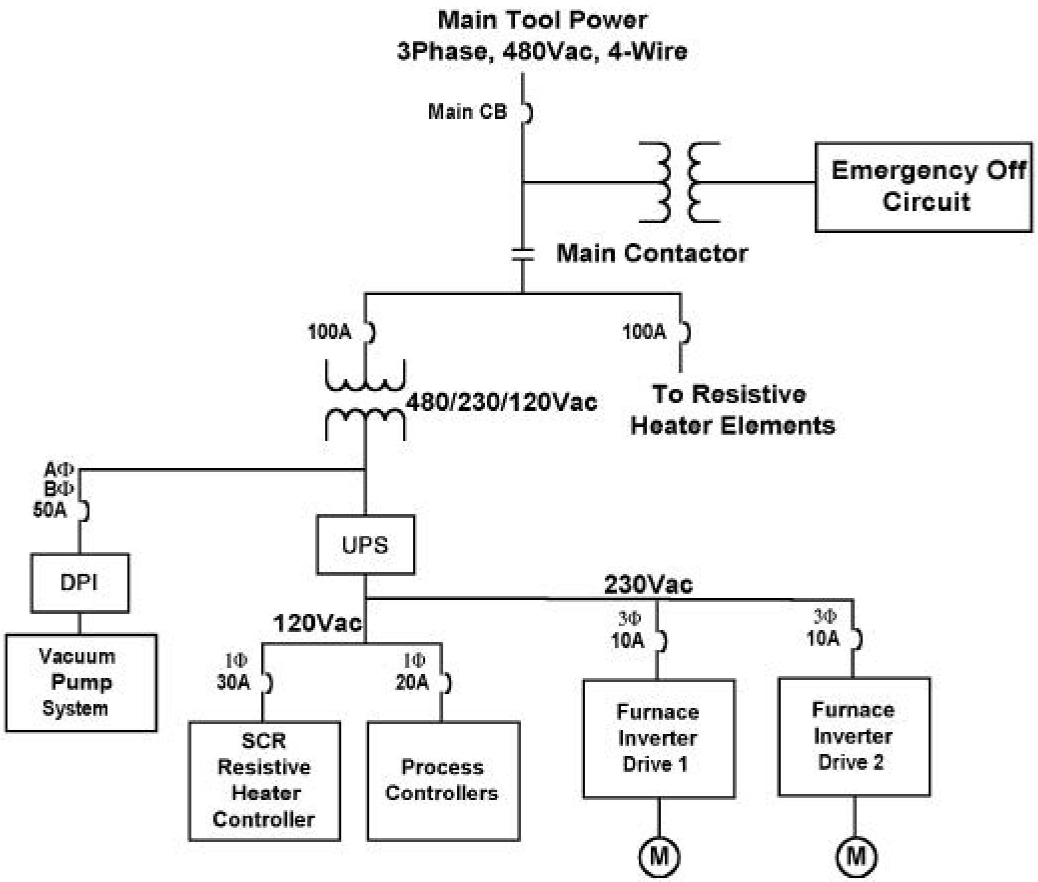

Figure 3. Furnace Schematic with PRTES

Test Objective

The objective of voltage sag testing was to identify the sensitive components that caused the vacuum pumps to drop out and not function according to the SEMI F47 curve. Once these "weakest links" could be identified, possible solutions could then be recommended.

Test Setup

With the portable voltage sag generator connected as shown in Figure 4, testing began. To characterize the performance of the system accurately and to identify sensitive components, voltage sag testing would occur first without any voltage sag protection on the vacuum pumps. The next sequence of tests would be performed with a Dip-Proofing Inverter (DPI) protecting the vacuum pumps (www.measurlogic.com).

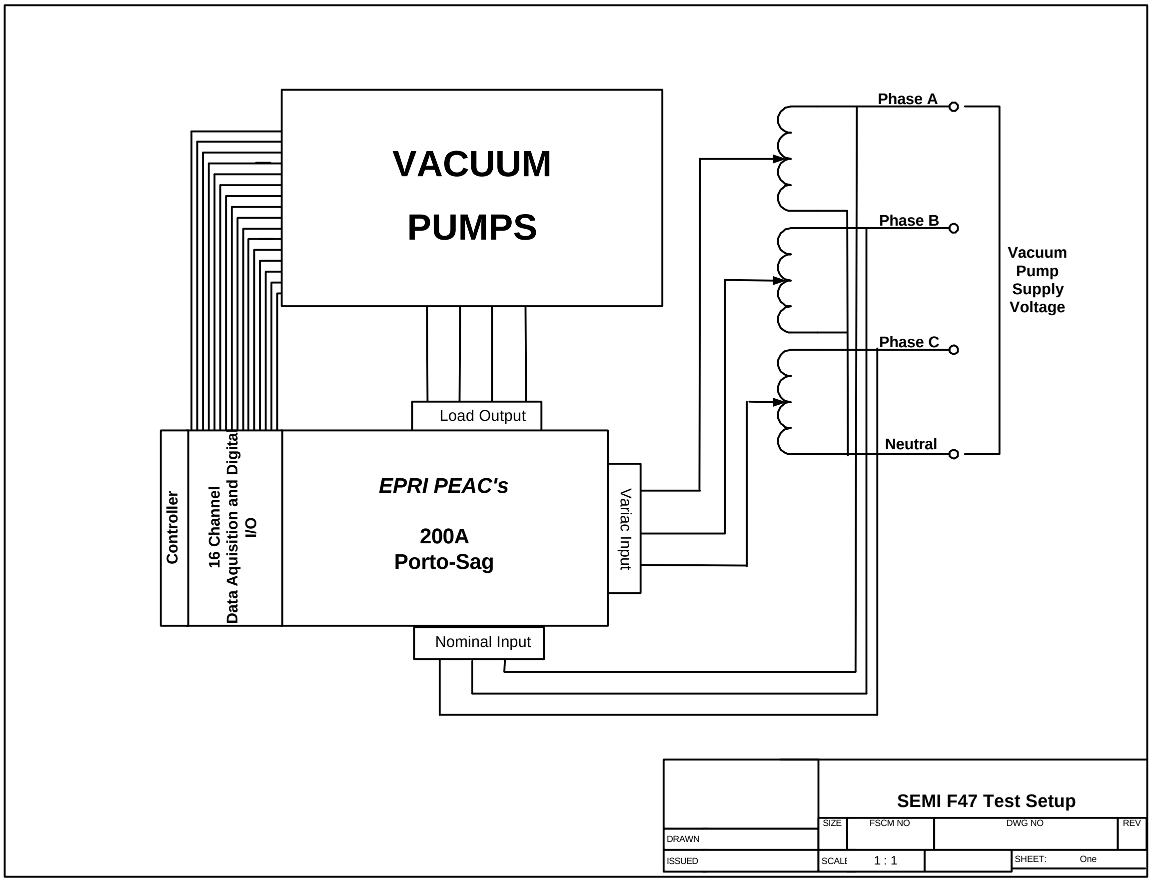

Figure 4. Test Setup

The vacuum pumps were connected across phases A and B; therefore, voltage sags testing would only involve phases A and B for the vacuum pumps.

Test Results

Testing without any voltage sag protection revealed that a relay within the Vacuum Pump System opened or chattered at a voltage sag of 60% of nominal for 0 to 5 cycles, thus causing the Emergency Motor OFF (EMO) relay to open and shut down the pumps. This result is shown in Figure 5.

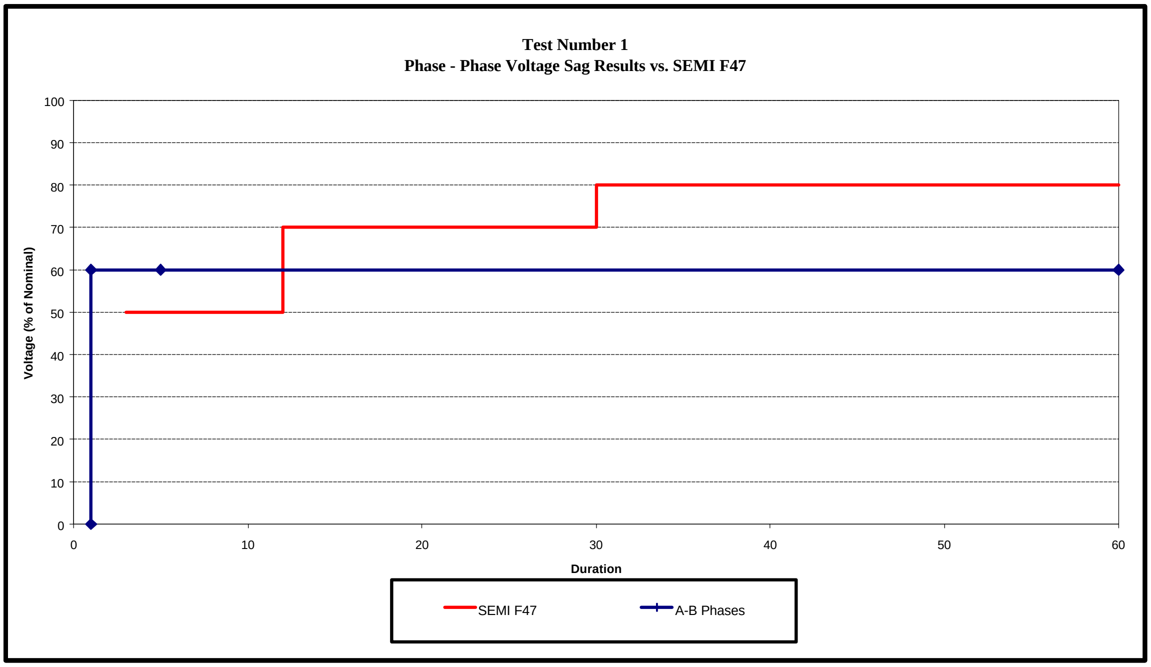

Figure 5. Test Setup

If the vacuum pumps system could be made more robust in this interval of 0 to 12 cycles, then the system would be SEMI F47 compliant. One possible solution to this problem would be to install a Dip-Proofing Inverter (DPI) ahead of the vacuum pumps. Although the square-wave output of a DPI may be incompatible with some electronic components, it will suffice for the relays used in the control circuitry of the vacuum pumps. The size of the DPI necessary to support the connected load would be 500VA.

With the 500VA DPI inserted ahead of the vacuum pumps as shown in Figure 6, the pumps successfully rode through voltage sags according to the SEMI F47 standard.

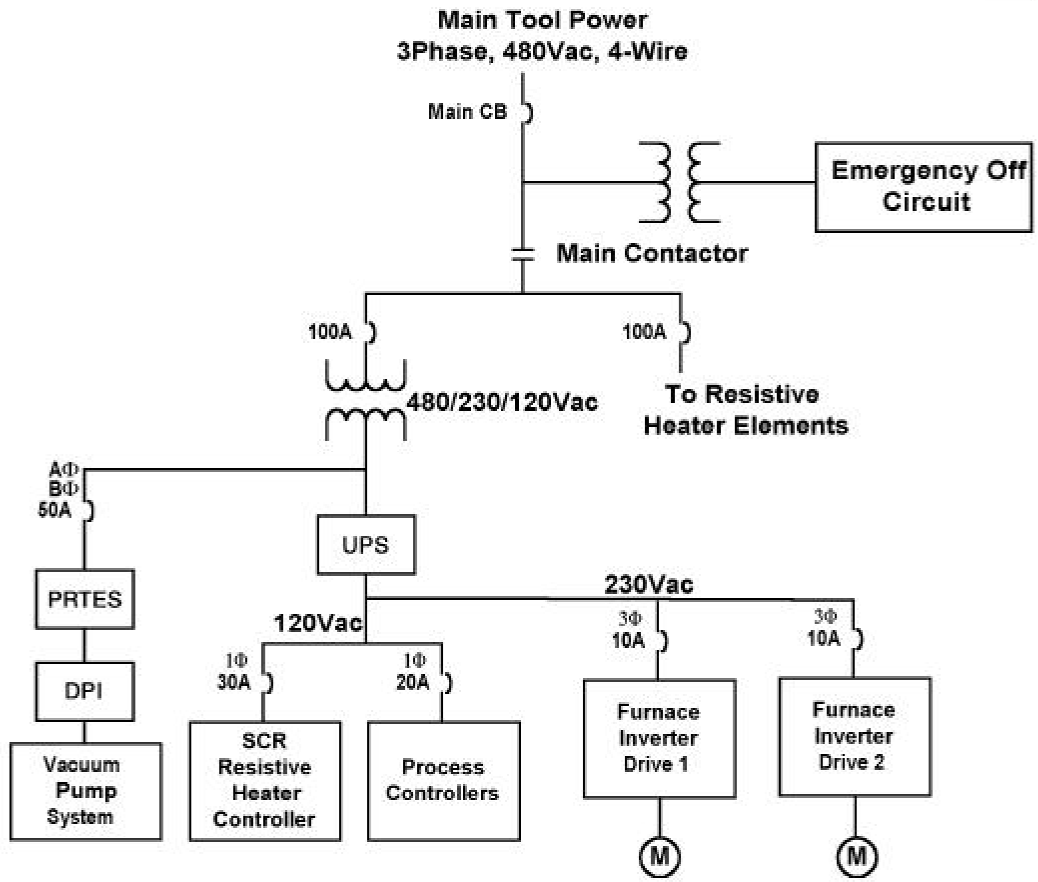

Figure 6. Test Setup with DPI

Testing with the DPI protecting the vacuum pumps resulted in the pumps passing all SEMI F47 points as shown in Figure 7 with no change in pressure. Further, the pumps sustained a complete outage for 60 cycles (one second) without failing or experiencing a change in pressure!

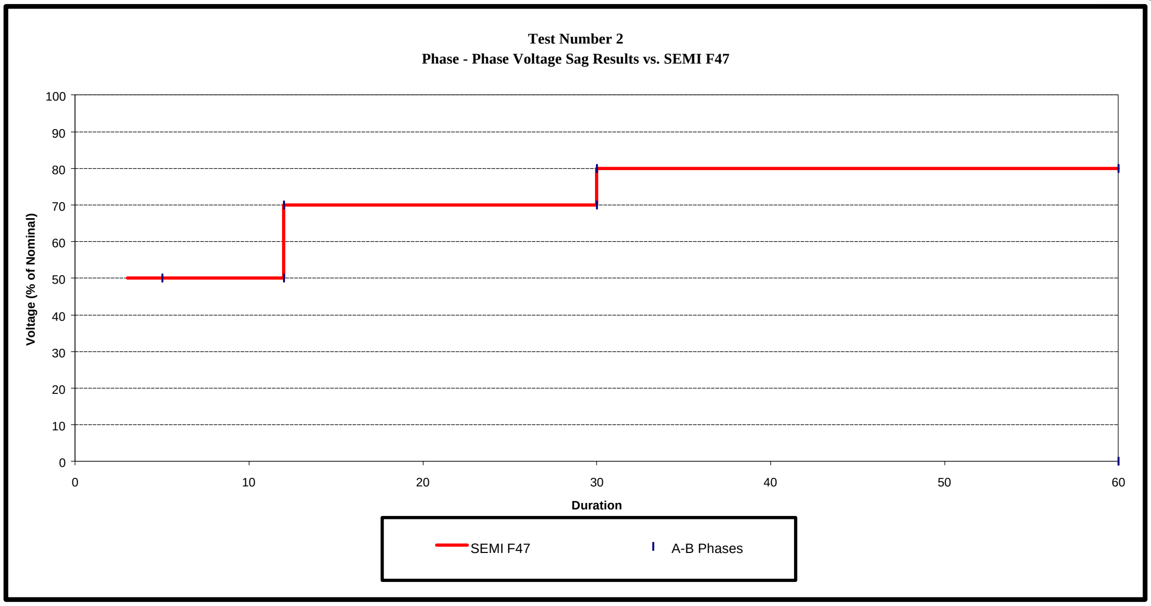

Figure 7. Test Results with DPI

Discussion

A particular solution may not work best in all cases. Why prefer the DPI solution to one using a UPS or a Constant Voltage Transformer (CVT)? Unlike a UPS, the DPI does not use a battery. Thus, no regular, costly battery maintenance is required for the DPI to remain effective. The inrush currents caused by the relays in the vacuum pump load may cause a CVT to fail just when it is needed. Therefore, should the load be compatible with its square-wave output, the DPI remains the better choice in this case. Testing proved that the control systems for the vacuum pumps were compatible with the Square-wave output of the DPI.

Significance

The manufacturer implemented the recommended solution on thirty diffusion furnaces at a cost of around $1,500 per furnace. While this expense, a total of around $45,000 in all, was significant, it could not compare to a possible loss of many millions. Indeed, soon afterward, the whole plant suffered a voltage sag that affected all processes *except* those protected with DPIs in the diffusion department!

Due to the great success of the targeted solution for the diffusion furnaces, other plant areas expressed interest in similar solutions for their vulnerable processes.

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