Table of Contents teaser: Today’s marketplace offers a wide variety of equipment for temperature monitoring and control. Cost, capabilities and ruggedness are major factors in deciding what type of system is best suited for a user’s particular application.

Fast Forward Bullet Points:

- Temperature measurement devices must be capable of providing reliable and accurate measurement in often hostile industrial environments
- Solutions should be scalable and integrate easily with existing plant-wide control and monitoring systems
- A Data Acquisition System (DAS) is the preferred option in many applications

Resource Box:

1. Fundamentals of Test Measurement

2. High Winds Tester
   [http://www.isa.org/InTechTemplate.cfm?Section=Archives4&template=/ContentManagement/ContentDisplay.cfm&ContentID=71521](http://www.isa.org/InTechTemplate.cfm?Section=Archives4&template=/ContentManagement/ContentDisplay.cfm&ContentID=71521)

3. Protection or Degradation
   [http://www.isa.org/InTechTemplate.cfm?Section=Archives4&template=/ContentManagement/ContentDisplay.cfm&ContentID=63839](http://www.isa.org/InTechTemplate.cfm?Section=Archives4&template=/ContentManagement/ContentDisplay.cfm&ContentID=63839)

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Selecting Temperature Measurement and Control Systems

How to get accurate data and perform reliable control from systems designed for the rigors of industrial applications.

By Steve Byrom, product manager, Network Solutions; Yokogawa Corporation of America

Measuring and controlling temperature is undoubtedly the most common measured parameter because it’s critical to so many operations and tasks. Accurate temperature measurement and control is vital to the quality of manufactured goods, such as finished metal components, and to the efficient and safe operation of a process or system.
In today’s market, there are myriad devices for monitoring and controlling temperature, ranging from simple temperature controllers to complex distributed control systems. Most temperature measurement and data acquisition products are well suited for the job for which they are intended, but care must be taken when applying them in harsh industrial environments.

Many low-cost monitoring and control devices and systems perform well in applications where they’re not exposed to environmental stress. While these lower-cost devices and systems may be well made for their intended purposes, they often won’t perform well in environments with excessive electrical noise or when exposed to over-voltage input conditions. Therefore, selecting the right equipment for the environment in which it will operate is critical for accurate and reliable performance.

The objective when selecting these temperature measurement and control systems is to find a product that provides very stable and reliable performance. The systems should also provide data in the form required by the application, such as for compliance reporting or mandatory plant data archiving. Depending on the application, these systems should be able to act as the data source for real-time operations, with their data serving as the front end of the plant control system. Finally, the systems should be cost-effective as well as rugged, with very long life spans.

**Ensuring Performance in Tough Conditions**
Finding the right type of device among the wide variety of temperature measurement and control systems can be daunting. Equipment selection begins with the ability to measure the required temperature sensor. Inputs that can measure thermocouples, resistance temperature detectors (RTDs) and DC voltage or mA outputs from temperature sensors or transmitters are a standard requirement.

Thermocouple sensors are commonly used and available in a variety of types and configurations to handle almost any application. Proven through decades of industrial service, thermocouple sensors are economical and physically rugged devices that provide accurate measurements for wide temperature sensing ranges. RTDs can provide even greater accuracy, but operate over more narrow temperature ranges and are more costly. Both sensor types can typically operate continuously in conditions of excessive temperature and vibration.

Temperature transmitters measure thermocouple or RTD sensors in the field close to the process, are usually hardened to operate outdoors and in combustible environments, and output temperature data in a variety of formats, ranging from 4-20ma to various digital data protocols such as HART. Smart transmitters can provide a wide variety of information in addition to the process variable sensor reading, including diagnostic and calibration data.

**Selecting the Right Solution**
A large process or test application may require hundreds of points or more of temperature sensor measurements. Operators will need to view this data, and a control system will need to act on many of these data points. The data commonly requires archiving for future review and reporting.
Modern plants and industrial sites have many methods for handling this sensor data, such as direct inputs to an existing control system—such as a distributed control system (DCS), a PID controller, a programmable logic controller (PLC) or a data acquisition system (DAS).

Determining the best solution is dependent on many factors including existing control system capacity, overall cost, and the ability to achieve the project goals. Adding direct inputs to the control system can be a viable option if the control system has available capacity and the ability to measure the required sensors. It should also be able to meet the planned requirements for operator display, control, data archiving, and reporting of the new measurement points.

Single-loop PID controllers can be the best choice for monitoring and controlling a limited number of temperature loops. These controllers provide local operator interface, excellent control performance and the ability to output the process value to plant information systems via analog retransmission or in a digital data format.

DASs and PLCs can be the best option when a large number of temperature points need to be measured and controlled. A DAS is well-suited for applications that require low-cost data display, storage and access to users via an economical interface, such as a web browser or very inexpensive or free PC-based software.

Extensive control needs are best achieved with a PLC system, but measurement-only and recording applications are best served by a DAS, which is available for a lower cost and optimized for temperature monitoring. In some cases, a DAS and PLC working together provide an extensive array of functions and can be the best choice at an attractive cost.

A modern DAS can also expand the capacity of and integrate with an existing plant-wide control system such as a DCS, by measuring many temperature sensor inputs and retransmitting the data to the DCS. In this manner, the DAS can act as a multiplexer, and be the data source for existing control and monitoring systems, often at a lower cost per channel than the existing system. Common serial and Ethernet protocols like Modbus RTU, Modbus TCP and EtherNet/IP provide built-in connectivity from the DAS to the control and monitoring system.

**DAS or PLC?**

PLCs, with their inherent and almost limitless flexibility and wide ranging application capabilities are the clear choice for complex control applications. PLCs have similar temperature measurement performance to most DAS equipment, but they may not support certain types of thermocouple or RTD sensors. In addition, PLCs sometimes deliver inferior measurement of electrically noisy sensor inputs. Furthermore, most PLCs don’t have local data recording capability.

If PLC limitations are a hindrance for the particular application, a modern data acquisition/data logging system is a logical choice. Oftentimes a DAS can work with a PLC, by doing what the PLC may not be able...
to do—such as measuring unusual input sensors, providing more accurate measurements, and providing backup data recording along with quick access to historical data.

Since there’s a lot of overlap in the measurement capability of a PLC versus DAS, choosing one over the other will be based on many other factors. This may include the presence of and preference in using an existing vendor’s PLC system. If the plant can cost-effectively plan a new system that meets all objectives using their preferred PLC vendor, that can be the best choice.

A DAS, however, can be the best choice when control is not the main requirement, and when the plant does not have established PLC expertise and support. The combination of excellent measurement performance, easy to use and inexpensive software, web browser access and readily available connectivity to other plant systems via common protocols makes a DAS an attractive solution for many applications.

**Advanced DAS Features**

A basic DAS is typically connected to a PC, with the PC being used for operator display and data logging. A more capable system may incorporate built-in data logging functions that allow it to record data. This provides redundancy and the convenience of stand-alone operation. With universal inputs, users can assign any channel to measure any input signal type, and fully configurable recording and display functions in the PC software or the unit itself allow it to be tailored for each application requirement.

High speed DASs can capture many thousands of data samples per second per channel, but temperature is generally a slow-changing parameter that does not require this level of performance. Depending on the manufacturer, a wide of DASs may be offered, ranging in size from portable hand-held devices, to large standalone systems that can easily handle hundreds or even thousands of inputs.

DASs, with their multiple capabilities, can handle a wide range of monitoring, control and data logging functions. Some of the newest DASs include embedded control functions that can provide up to 500 lines of logic. This lets them perform many of the same control functions as a separate temperature or process controller.
Data Acquisition System (DAS)

Data acquisition systems can combine monitoring, control, display and data handling in a single unit.

Considerations When Choosing a DAS Solution

In general, DAS are used for two distinct purposes: testing/laboratory applications and industrial applications. A lower-end, less robust DAS will often work well in a clean lab environment, but that same DAS won’t be able to perform in a harsh industrial environment, such as a petrochemical plant.

DASs for test laboratory and industrial process environments both have their own performance challenges. Some test applications require temperature measurements of energized components or circuits where the thermocouple sensor is in direct contact with high AC voltage. Successful measurement under these conditions requires differential inputs with high common mode voltage and noise rejection specifications, as well as robust channel-to-channel and channel-to-ground isolation. A low cost single-ended measurement circuit will fail under these conditions in the worst case, and often provide noisy and unusable data.

Industrial settings can present other challenges with the added demands of coping with ambient temperature extremes, dirt, vibration and moisture. A well-engineered system must survive and provide stable and accurate measurements in these applications and environments.

Image 2, Signal Input Circuit Diagram:

**DC voltage and thermocouple inputs are channel-isolated to ensure stable, reliable measurements**

Products built for industrial environments should have dust- and splash-proof front panels, preferably that are compliant with IEC529-IP65 and NEMA4 standards, and the ability to retain data during power failures of any duration in non-volatile memory not requiring a battery protection circuit.

Measured and calculated data should be continuously saved to a secure, non-volatile flash memory. At scheduled intervals, the files in the memory can be automatically copied to another flash memory, and these files can be copied and archived to an FTP server. These features enable three copies of the same data file to be stored at the same time in different locations, providing redundant and highly secure data storage.

A DAS should also be highly scalable to expand as needed. This can be done by adding input modules, or by connecting to expansion hardware via a serial or Ethernet connection using a protocol such as Modbus, which can enable users to add hundreds of input channels to the base unit.

Data Display and Manipulation

Operators need a method to observe data and interact with the DAS. This can be a PC display showing the DAS software screens, a web browser or a built-in color LCD at the DAS. Typical displays include trend, digital and bar graph screens—with the ability to build custom displays that suit the needs of the
user. Users should be able to review historical data with date and time calendar search functions. The DAS should also contain reporting templates, such as an Excel report template that enables reports to be created easily and automatically.

Network connectivity ties everything together. The goal of any DAS is to deliver sensor data for reporting and analysis. The ubiquitous Ethernet interface is a DAS requirement, connecting the DAS to the plant network and into the PC world. Multiple protocols are typically available, such as FTP for file transfer, Modbus TCP and EtherNet/IP, web browsing, email messaging and OPC server support. When standard industry protocols are supported by the data acquisition equipment, data can be seamlessly exchanged with virtually any other control or computing system in the enterprise.

Touchscreens interfaces are the next step in streamlining DASs. Newer systems offer improved ergonomics and operator interface, going from the buttons and panel key navigation to only one or two buttons and a touchscreen operation interface that has many of the characteristics of a modern smartphone or iPad interface.

A modern DAS can serve multiple functions: monitoring and control, local operator display, redundant data recording, and multiplexed data source to a plant-wide control and monitoring system. When an application demands all or most of these functions, a DAS can be the best fit, offering a highly reliable and economical solution.

Table 1: Considerations for Choosing the Right DAS

1. Built to withstand harsh environmental conditions such as high voltage, temperature extremes, etc.
2. Ability to reject signal noise and perform stable measurements
3. Scalability to protect investment
4. User-friendly operator displays
5. Networking capabilities