# Understand the Instrumentation on your Heat Process

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## Part 1. Installed instrumentation.

The two articles that follow deal with items of good standard practice in process instrumentation including some tricks and traps.

While looking and poking around your physical plant and product you will be using two other levels of insight into the process.

**1. The installed instrumentation.** i.e. the meters, indicators, controllers, lights, recorders and screen displays that came with the process. These are used for day-to-day operation so should be within sight of the process.

**2. Test, investigation and trouble-shooting equipment** such as calibrators, multimeters, clamp-on ammeters, oscilloscopes and electronic thermometers.

**Operating instruments**

Temperature indicators and controllers: Insist on plant-wide agreement on usage of ºF or ºC. Totally purge the plant of one or the other or pay some day for scrap product, damage or accidents. Most instruments now are field convertible. The scale range and resolution usually determine accuracy so don't use a range greatly in excess of your working range. To avoid a dancing last digit, only use resolutions of 0.1 º or tighter if the process really needs it and is stable.

Liquid or gas-filled temperature indicators are usually too slow for prompt sight of process changes. A leaky bulb or capillary will default to low indication; another hazard.

Output indication: If your final control device is a valve or actuator, make sure that it feeds back a position signal and not a received control signal which you hope will be obeyed by the final control device. Note too that even valve position knowledge does not necessarily imply a corresponding flow - or any flow at all.

Heater ammeters: Moving iron ammeters are cheap and dependable. They also indicate the rms (heating effect) value even for severely phase-restricted SCR controlled loads. On such loads average responding meters (this includes most clamp meters) can indicate low by 50 or more percent though they are good on sinusoidal waveforms.

Analog ammeters can reveal erratic loads and trends better than digital meters and displays. They are also more sensitive indicators of control loop oscillation than the temperature indications. They do however lack the data-recording and heater malfunction alarm and action potential that DCS systems can provide.

For three-phase three-wire Y connected heaters I recommend an ammeter in each line. If you lose a heater or line fuse, one meter goes to zero and the other two will fall by about 13 percent For a delta connection put the ammeters inside the delta loop, one in series with each heater. Loss of any heater takes its meter indication to zero while the other two don't change. Loss of a line fuse gives the same result as the Y connection. Here, we assume balanced and reasonably constant resistance loads. When you know the load resistance can you readily work out the power as $I^2R$ (current squared times heater resistance) for each heater. Readers of a previous article on Heater Materials will recall how the severe resistance variation of resistance of some materials can upset your calculation.

Some controlling SCRs can put out a signal representing power, regardless of load resistance. These signals along with those from current transformers and from position feedback potentiometers can be fed into temperature controllers or DCS systems for indication and alarm action or process monitoring and record keeping.

You will sometimes see illogical combinations of readings, such as: Temperature high and

power stays on. Temperature high and power never on. Temperature low and power fails to increase. If you are there and alert you can diagnose and intervene but it is better to arrange for the measurement and control system logic to act for you.
**Convoluted key-handling.** There will be times when you have to make a quick and urgent adjustment to some control or alarm parameter and are defeated by the tricky button pushing sequence. Remember when you couldn't change the alarm time on your watch without reference to the manual? Make sure that operators take the time to become familiar with critical actions and refresh their training periodically. Favour suppliers who design clear and instinctive operator interfaces with the process.

## Part 2 Test instruments

At this deeper level of investigation you are probably investigating or trouble-shooting and there is danger. Chances are you will be opening enclosures without shutting your process down. If you are touching live wires and terminals with test probes make sure that you are qualified and competent to know where electric shock hazards lie. You will notice that the **top test equipment manufacturers** supply test leads that are covered (insulated) at the instrument terminals and have finger stops on the probes that prevent your fingers slipping onto the live probe tip. Alligator clip adaptors have a rubber sleeve over the clip to prevent finger contact. Better still gripping probes have a spring-loaded push action and retracting spring-wires at the live end. Multimeters have fuses at the input to avoid destroying the instrument or your eyeballs when you probe a line voltage with a current range selected. One manufacturer's meter will select a voltage range automatically if the user probes a hazardous voltage source with a resistance range selected.

Check that oscilloscopes have **floating input terminals**, i.e. neither terminal is connected to a metal case or ground. The modern LCD display scopes with plastic cases are good examples of safe design.
**Digital multimeters:** These are best choice for accuracy, resolution, high impedance and versatility. High end models can read RMS values, capture highest and lowest values and record time over the sampling period. Some have a bar graph or simulated pointer display that can make sense of a jittery signal. When the leads are lying unconnected or connected to two different points that are isolated electrically from each other you may see random voltage indications. This is due to capacitive coupling of nearby voltages through the leads into the meter's high impedance input. This is no cause for concern, a stable indication will return when you connect to a real source.

**Analog multimeters:** I refer to those without amplifiers and based on a moving-coil meter and an arrangement of resistors, rectifiers and rotary switches. The movement sensitivity can be as high as 50μA to minimise the loading effect on voltage ranges but they do not match digital meters in this respect. They have their advantages, being virtually immune from capacitive and noise interference. They are good for showing intermittent contact resistance say on wiring, relays, adjustable potentiometers and for observing jittery and suspect signals. They are not

sensitive enough to measure low millivolt signals like those from thermocouples or those from a high impedance source.
Clamp-on ammeters: The digital version is generally the most accurate and sensitive and comes in dc and ac-average or ac-rms responding versions. Max/min capture and sample-and-hold features are available. The analog moving-coil version is cheap and simple but accuracy is rarely better than 5% and only the ac, average-responding version is generally available. It will sample and hold by means of a thumb-operated pointer clamp. Good for locations where you can reach and clamp on to the conductor but cannot see the indication.

**Temperature Calibrators:** These can be anything from a small box with two output terminals and a rotary switch marked in steps of ºF or ºC, to a full service thermocouple/resistance thermometer /voltage/current source simulator with digital readout and continuous signal adjustment. All versions feed an accurate calibration signal into the temperature controller or indicator to simulate the installed sensor. They come with a small or large variety of sensor calibrations and are priced accordingly. An instrument calibration usually involves injecting five to ten signal levels throughout the range, including 0 ºC or 32º F. It is important to use connecting leads having wire that corresponds to the sensor. Often voltage, current and resistance ranges are included.
**Do you trust your temperature sensors?** A thorough on-process calibration calls for a look at them. They can be pulled from the process and inserted in a hot block or fluidised bed calibrator and compared, preferably at working temperature with a certified sensor.

**Digital thermometers:** These look like digital multimeters but indicate in ºF or ºC and have an input socket that takes a thermocouple which has a male connector. These are used for spot checks of process temperature. Some multimeters incorporate this function. They come with Immersion probes which work well. But rembember that surface temperatures do not transfer readily so very thin ribbon-type thermocouple probes have been designed to minimise this problem.
You can do a handy spot check of a controller's calibration (at the working temperature only) by clipping the digital thermometer's input leads to the thermocouple input terminals of the controller without disconnecting the wiring. To avoid cold junction errors use the correct extension cable with its wires soldered to the inside tip of the alligator clips that go to the controller. Keep your fingers off the clips.
**Sensor and wiring checks:** Most thermocouples have a resistance of less than one or two ohms but when you check from the controller terminals expect an additional up to one ohm per foot double run of extension cable. This varies greatly with material and wire gauge. Most indicators and controllers will tolerate up to 1000 ohm.
When checking RTDs you will expect 100 ohm at 0ºC and about an extra 38 ohm/100ºC. If you are checking at the instrument instead of at the probe head, expect an additional resistance for a double run of copper wire.