Pilot vs. Commercial Plant - part 3

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Thermowells and Flexible Lines in Pilot- and Commercial-Scale Plants

Thermowells

The overuse and over-specification of thermowells is one of the common errors we see in pilot-plant specifications, because they are so useful in commercial plants it intuitively feels right to extend the same philosophy to pilot plants. Clients commonly request that thermowells be included in process lines that requires temperature measurement because they know that when a thermocouple within a thermowell fails, the thermocouple can be easily replaced without the need for production interruptions and draining of the piping or vessel. However, this requirement comes from an understanding of commercial processes that run at equilibrium for long periods of time with very few changes in process conditions. In this environment, a thermocouple within a thermowell will accurately represent the process fluid temperature, but in a pilot plant where processes run for short times with multiple changes, this specification is inappropriate.

A large flanged thermowell will introduce residence time issues in pilot plants, which have smaller line sizes. Take for example, Figure 1a in which the pilot-plant piping needs to be expanded to accommodate the bulky thermowell. The configuration produces low process fluid velocities and a high volume relative to the flow rate. The fluid velocity within the assembly will be low, creating a laminar flow situation. Overall heat transfer coefficient is lowered as a result. In addition, the ratio of the relative amount of liquid and metal material that needs to be heated or cooled relative to the amount of heat coming in with the process flow is high. The net effect is that the time to achieve equilibrium following a temperature change will be significantly longer at the pilot-plant scale with this bulky assembly. Ultimately, this will adversely affect temperature and quality control.

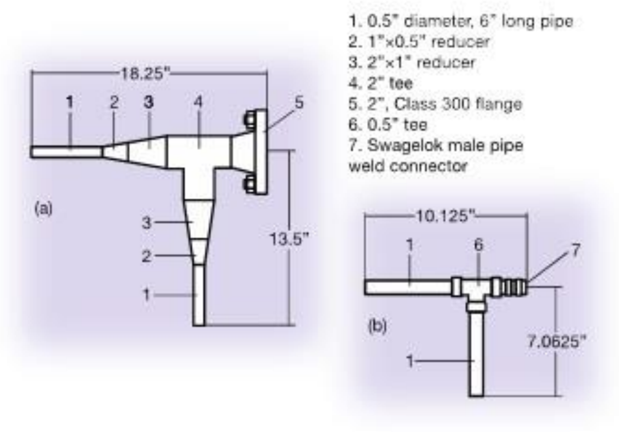

Figure 1. Large flanged thermowells (a) introduce residence time issues in pilot plants, which have smaller piping. Swaging the thermocouple directly into the process line (b) is a more appropriate and scale-specific method of temperature measurement that lowers residence time because of the smaller volume.

The best solution at this scale involves avoiding the use of a thermowell altogether. A thermocouple by itself can be used instead because non-functioning thermocouples can be changed out during a planned shutdown. If redundancy is required, a second thermocouple junction can be added within the same thermocouple sheath for little additional cost, avoiding the need to replace the thermocouple during any particular run. Figure 1b shows the thermocouple swaged directly into the process line, which is a more elegant, scale-specific method of temperature measurement. Temperature changes are more responsive and the smaller volume creates a lower residence time and better quality control.

There are instances where thermowells are useful at the pilot scale, but in these instances a more scale-appropriate tubing-style thermowell can be designed so that although an expansion in the tubing will still be required to accommodate the thermowell, it will not be as bulky as the expansion shown in Figure 1a.

Modification and Flexibility

Commercial-plant design specifications often call for the use of metal tubing and electrical conduit. The reason for this is that production plants need to be designed robustly to handle scenarios that are not common in pilot plants. For instance we have all heard about heavy-handed operators that have climbed up a wall of pipe and electrical conduit to reach an instrument or valve. Another scenario involves fork-trucks bumping into these lines. However, in a pilot plant setting metallic conduit and instrument air lines can be a case of over-design, bringing with it extra costs for no real benefit. Notably, plastic line systems are equally as safe as the metal line system. The scenarios outlined above are unlikely to occur in a pilot plant. Equipment is small enough to be installed economically within a structural steel framework. Electrical conduit, process tubing and utility tubing are well protected for potential contact with fork-trucks. Operators are not likely to scale a wall of tubing and conduit, since distances are much smaller on pilot plants, which can easily be laid out more ergonomically. One common objection to plastic lines is that they will melt in the case of a fire. But on further thought, if a fire were to occur in the plant, the plastic lines would melt, releasing air from the actuators and causing

the valves to fail to the safe position. However, the most important benefit of plastic lines in pilot-plant design is their flexibility, as they allow for the system to be reconfigured or modified quickly.
In the following figure, a bank of valves and instrumentation that are installed with metal tubing and electrical conduit (Figure 2a) is shown beside a bank of automatic valves that are actuated through plastic air lines and push-type quick-release fittings (Figure 2b). Comparing these two installations, you can see that the system with flexible lines will be far easier to modify.

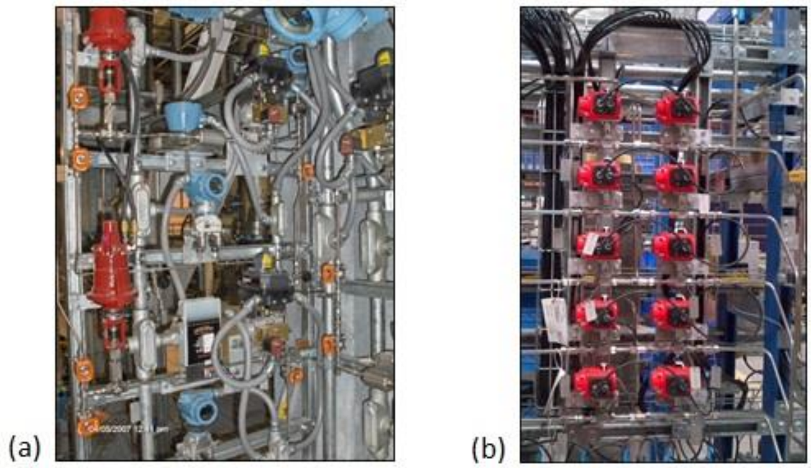

Figure 2. Banks of valves and instrumentation installed with metal tubing and electrical conduit are expensive and difficult to alter if additional equipment or connections are needed (a). Valves connected via plastic air lines and push-type quick-release fittings are less expensive, easier to install and change, and do not compromise safety (b).

Mechanical technicians can install flexible tubing lines in a fraction of the time it takes to install an equivalent metal line, which reduces cost and project schedule or maintenance time. If a new instrument were to be added to the assembly in Figure 2a, a stainless steel tubing line would need to be run between the air header and the new instrument, which would cost more and take more time to install compared to the assembly in Figure 2b.

Closing Thoughts

In this series of three articles, I have looked at the differences in objectives and criteria between production plants and pilot plants, as well as just a few examples of how commercial-scale specifications may be applied inappropriately to pilot plants. This is why it is imperative that before a pilot-plant project is initiated, the project management team review the objectives of the plant and choose criteria for specifications that are aligned to achieve those objectives. Ideally, specifications should be written specifically for the project. If that is not possible, the next best scenario is to exclude commercial specifications and follow codes, standards, and best practices, and incorporate only logical specifications that have solid support for inclusion. Applying these principles to your next pilot-plant project will reduce layout space, lower the cost, reduce schedule risk and improve overall performance.

References

Dukhedin-Lalla, L., “Pilot Plants — Part 2: Don’t Apply Commercial-Plant Specifications to Pilot Plants,” *Chemical Engineering Progress,* pp. 24–27 (Feb. 2005).