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Simulator Training Extends Its Role

Chemical makers now seek enterprise-wide and lifecycle opportunities

By Seán Ottewell, Editor at Large

The advent of new feedstocks, the increasing interest in making batch/specialty chemicals, the growth of cloud-based applications and the need for broader training strategies are creating greater-than-ever opportunities at chemical makers for training simulators, say vendors of such technology.

One vendor benefitting from these opportunities is AVEVA, Lake Forest, Calif., which earlier this year completed its merger with Schneider Electric's industrial software business.

Enterprise-wide needs increasingly drive the demand for operator training simulators (OTSs), according to Ian Willetts, AVEVA's vice president, simulation & training. "It's becoming more operator *and* training simulators," he says.

Willetts cites a recent example of this at a project carried out for Kuwait Oil Company (KOC), Ahmadi, Kuwait. For a number of years the company had used SimSci software to train control room workers. However, the need to improve overall operator training and also to effectively capture and transfer knowledge from older staff led KOC to select SimSci's EYESIM immersive virtual reality technology. The new training system connects all plant personnel with a high-fidelity 3D process simulation and virtual walk-through plant environment.

KOC already is seeing the results both in terms of fewer accidents and avoidance of costly plant shutdowns, notes Willetts.

While the "graying" workforce in developed economies presents one demographic challenge for operating companies, another comes from the young, largely unskilled workforces found in many less-developed economies.

"For example, a grassroots refinery in Nigeria needs trained staff to work not only as operators but also in maintenance, field engineering, [and] process engineering — in fact at every level in the facility. So, there is also a big new push on here for enterprise-wide training that brings simulation to a much broader audience," he explains.

The cloud also is positively impacting simulator training. A number of chemical companies, says Willets, are pursuing a strategy already taken by Arizona Public Service, the largest electrical utility in that state. Its generating plants are hundreds of miles apart but adopting a fully-cloud-accessed OTS has eliminated the need for operations staff to travel for training sessions. In addition, the entire training system powers up in just five minutes, so staff can begin training immediately.

"Once you open the door to a platform on the cloud, you can develop an open system which allows people from all across an enterprise to access the training they need," he adds.

A similar approach taken by Paris-based refiner and petrochemicals producer Total means that any engineer within the company can launch training simulations on both

TOTAL SITE
Figure 1. Any engineer at Paris-based company can launch training simulation for process or equipment. *Source: Total Group.*

processes and equipment using dynamic simulation at that person's site no matter where in the world it's located (Figure 1).

"One specific model we delivered for Total concerns compressors. They are such a crucial piece of equipment and a perfect example of something that must be thoroughly understood by new staff. The simulator is accessed through the company's learning management system, which Total now wants to open out to include other equipment. We are pursuing very similar projects with other process customers, too," comments Willetts.

Changing raw materials have opened up other opportunities. In the U.S., for example, the move to shale gas and natural gas liquids as feedstocks means that operators must have expert feedstock knowledge.

"Here, we have integrated FMC Technologies' Spyro furnace design and optimization software into our OTS, something that has never been done successfully before. It gives our users a much fuller understanding of feedstock parameters," he adds.

AVEVA also is pushing the importance of best practices via an experienced training services team. The goal is to help customers map its technology onto their own competency frameworks. This is critical for customer success, says Willetts, who notes that without it outcomes provide much less value. "It's a key differentiator for us and something we are carrying out for multiple clients."

THE VALUE PROPOSITION

Effective training prevents accidents from happening and reduces process challenges such as bottlenecks and equipment failures — so OTSs provide real value, stresses Dinu Ajikutira, senior director of product marketing at AspenTech, Bedford, Mass.

The technology has a proven track record, he says, with savings of up to $15 million per project that embraces an OTS.

As an example of such benefits, he cites a project with CEPSA, Madrid, which has two manufacturing sites, one in Spain and the other in China.

"They have about 46 operators at the two locations and wanted them to have identical training, for example at startup and shutdown, so as to develop similar skillsets and then be interchangeable between the two plants," Ajikutira explains.

AspenTech used HYSYS simulation software and the distributed control system operator workstations in the plants' control rooms. These were then connected to a hyperdynamic model in the Aspen OTS framework and 50 different disturbance scenarios were created.

"For the operators, it meant that their training experiences were exactly as if operating one of the plants. We spent around 2,000 hours on training with them. CEPSA has since reported an increase in safety and a reduction in off-spec products at the two plants — although they are not keen to put a dollar value on these savings," he notes.

One of AspenTech's goals on this and similar projects is to promote an attitude of lifecycle dynamic modeling that leverages the same dynamic model for multiple applications. "Most companies do not focus on training the client on the dynamic model and instead focus on just delivering the turnkey OTS," emphasizes Ajikutira.

Another increasingly common use is after acquisitions or mergers where the enlarged company wants all the incoming operations staff to work to exactly the same standard operating procedures as its existing operators. Overall, the expectation these days is that new operators — whatever their backgrounds — should be up and running very, very quickly, he says.

Altered operational scenarios also open up opportunities. "In the real world, processes are changing — and more so than ever before. The move to shale gas as a feedstock is one example, but there is also the rise of batch/specialty chemical manufacturing. This is where the big margins are, but the products change rapidly in terms of raw materials, volume, product spec, etc., depending on demand. So, the OTS has to be bang up to date. There's absolutely no point in being trained on the wrong process," cautions Ajikutira.

He also points to the importance of the ongoing sustainability of an OTS technology during new builds: "There are many tools utilized throughout the entire project lifecycle to satisfy key requirements. By increasing our focus on the dynamic model lifecycle, we will provide tight integration between our core products at all project stages. Utilizing the same model from the beginning to end of the project lifecycle will reduce the amount of rework required and increase collaboration between different teams."

ACHIEVING GREATER SUCCESS

Lifecycle dynamic simulation is the key to achieving peak performance, believes Martin Berutti, vice president of process simulation, Emerson Automation Solutions, Chesterfield, Mo. "As the chemical industry has evolved from engineer-driven to operations-driven, shrinking workforces and global competition have pushed chemical organizations to run leaner and more efficiently. Plants want to make changes, but the risk of downtime frequently keeps them from making the changes that can deliver peak performance. Lifecycle dynamic simulation solves this problem by allowing organizations to better understand how operations and control strategies can be improved without requiring a shutdown or risking processes critical to the plant's bottom line."

Emerson incorporates its Mimic simulation and AspenTech's HYSYS Dynamics to deliver lifecycle dynamic simulation via DeltaV Simulate; this enables seamless leveraging from project design to successful operator training and long-term plant control and production (Figure 2).

Part of Emerson's strategy is to make the benefits of lifecycle dynamic simulation — using the digital twin approach — accessible and cost-effective regardless of a company's use case. Mimic's selective fidelity lets an organization move from low to medium to high fidelity to meet the specific and changing needs of its applications, cutting the cost of entry and the total cost of ownership.

In addition, a company using AspenTech's HYSYS and HYSYS Dynamics for modeling quickly can move to having a digital twin built at a low lifecycle cost, he says. This

LIFECYCLE USE
Figure 2. Dynamic model helps in project design, operator training, and long-term plant control and production. *Source: Emerson Automation Solutions.*

allows an organization to leverage existing data from process design for the OTS and then operations improvement, delivering value and return on investment across the plant lifecycle.

Using this approach, manufacturers throughout the chemical industry are reaping the benefits of lifecycle dynamic simulation, notes Berutti.

For example, he cites the recent case of a refiner that had great success with its OTS during a hydrocracker project. However, during training, the simulation revealed a problem with a feed to the hydrocracker's main fractionator. Upon investigation, this problem led directly to a process design issue that would have required a shutdown and change of piping directly after startup. "The project team caught the problem in time and was able to fix it before startup, saving the company millions of dollars," he says.

Similarly, an OTS used to deliver training to new operators on a greenfield project for an ammonia plant turned up a severe safety problem. While testing a training scenario, the digital twin predicted an explosive condition in the primary reformer. "When trainers notified the customer, the plant engineer realized that there was a process engineering issue missed in engineering design, leaving the organization with a serious explosion risk and putting personnel and the plant in jeopardy," Berutti explains. The company was able to fix the problem before startup and could move forward confident that no further issues would escape notice.

The benefits of lifecycle dynamic simulation extend beyond greenfield projects, he stresses. For example, a multinational chemical manufacturer needed to perform a shutdown procedure but hadn't run either a startup or shutdown in a very long time. Using dynamic simulation to train for the procedure, the organization discovered that interlocks in the control system made startup almost impossible. "Had the organization performed a shutdown without realizing this problem, it would have suffered an extended outage that would have potentially cost millions of dollars. By catching the interlock problem with the simulator, the organization was able to keep its scheduled outage on schedule," he notes.

In another case, a specialty chemical plant that was underperforming due to poor batch control design wanted to develop, test and fine-tune new designs without impacting production. Its engineers initially dismissed the idea of simulation as a solution due to anticipated high costs of high-fidelity models. However, the team discovered that selective model fidelity available with lifecycle dynamic simulation would allow use of medium-fidelity modeling for the entire plant, with high fidelity necessary only for the reaction models. "The cost savings of selective fidelity coupled with the production benefits prompted the organization to pursue the option of implementing simulation organization-wide," says Berutti.

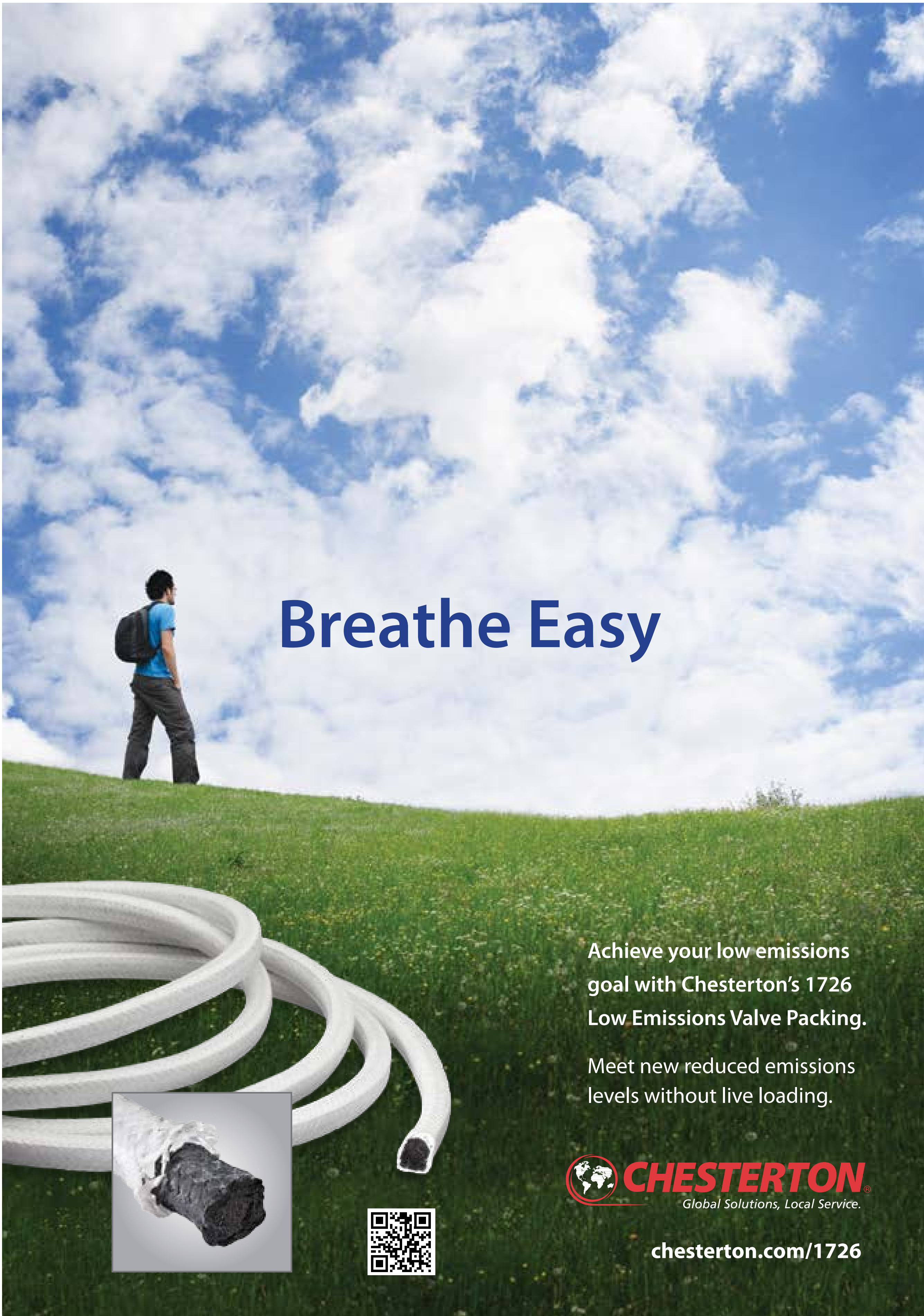
DUTCH DEVELOPMENT

Long-established vendors don't have the market to themselves. For instance, one newcomer, virtual reality development and performance data analytics specialist Serious VR, Enschede, The Netherlands, recently started working with AkzoNobel, Amsterdam, on the development of virtual training applications using Serious' in-house virtual reality (VR) technology. This follows a two-year period of development with a sister company on how to do use 3D animations in an e-learning environment to ensure that operators fully understand how to carry out critical procedures on chemical plants.

"One of the most important reasons that our clients work with us and with the VR technology is because drastic cost reductions can be made, especially in the time spent by operators on plant maintenance or other technical procedures. This means the ROI [return on investment] can be calculated by measuring the extra uptime in the production, resulting in a higher production or lower plant downtime. The safety aspect, i.e., reducing incidents, is also a critical reason to start using both VR and augmented reality (AR) in operator training," explains company co-founder Ton Kuper.

As well as being flexible — operators can be trained anywhere at any time — Serious VR's learning management system captures training data that allow measuring and optimizing the progress of operators.

"Both VR and AR technologies will find their way in a training environment because lots of procedures need both approaches to get the best possible output of how operators successfully do their job," Kuper believes.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Deftly Deal with Distillation Performance

Several issues contribute to water hammer and leakage of condensate

By Earl Clark, Energy Columnist

Jake recently had graduated college and started his first job. His new company assigned him to one of its large sites. There, Jack, a senior engineer who had been at the site his entire career, would mentor Jake.

One of the areas both were responsible for was a methanol distillation or finishing process. Methanol, created in previous steps, was pumped to this final refining area to produce product for customers. Because it was a very-low-pressure distillation process, the temperature of the steam and condensate in the reboiler also were low. Earlier in the process, heat recovered from the reformers generated steam. Then, the steam was let down through several stages of power generation to provide the boil-up for the distillation operation. Condensate from the process then was sent to the process sewer.

WINTER WOES

The small amount of flash steam created hazards during winter weather. In light of a national energy crisis at the time, an energy conservation push closely targeted any losses. Installing a flash cooler on the line to the sewer resolved the hazard issue. Engineers put in a used heat exchanger at ground level with the condensate line piped to the exchanger. (For more on heat exchanger commissioning, check out "Keep Out of Hot Water," http://bit.ly/2KSrQyH.) And, then, problems started.

When the heat exchanger began banging and jumping, Jack was called to the site. Eventually, the movement caused the inlet piping to fail; the condensate spilled into the area, resulting in even more problems on that cold day. Jack had the condensate diverted back through the original sewer dump while he began to deal with the water hammer issue. Because Jake had just graduated, Jack asked him to do a little research on water hammer and directed him to some of the company's resources on the subject.

It was a great learning experience for a young engineer.

In the meantime, Jack went back to finding a quick solution. He installed a sparger into the inlet line and piped cooled condensate to the sparger. Weld repairs were made and the heat exchanger returned to service. Jack gradually introduced condensate into the sparger and reached an equilibrium point where the banging and shaking stopped. It was temporary — but it solved the problem for the time being.

MULTIPLE ISSUES DISCOVERED

Jake had begun researching the water hammer issue. Jack had sent him to one of the corporate experts who showed Jake where to find the information as well as how to begin the manual calculation and modelling process. Jake began the calculations but ran into a problem due to lack of information for the model; Jack filled in the missing data. Together, they worked through the complex analysis until they had a clear picture of what was happening. Through this experience, Jake learned not only how to perform the analysis but also how to be a mentor to a younger engineer.

So, what did they discover? First, the heat exchanger was oversized. It was bought cheap but resulted in too much capacity, causing flash steam in the condensate to quickly condense leading to the severe water hammer. Second, the piping to the heat exchanger had been sized according to the inlet to the exchanger rather than for the actual flow of condensate. This led to a large cross section with the pipe operating much like a drain with only partially filled conditions. As it entered the heat exchanger, a rise in elevation then closed off the pipe, capturing flash steam in a bubble that then collapsed, further aggravating the water hammer problem. Third, river water was used as condensing medium. The water was fairly warm in the summer but when winter rolled in the temperature difference along with the oversized heat exchanger resulted in major bubble collapses within the heat exchanger.

And finally, while the sparger could mitigate the problem, it required constant modulation based on multiple variables including process rate, river temperature, ambient temperature, etc.

They developed a solution but, unfortunately, the cost was not in the budget. The plant had been scheduled for shutdown three years before Jake arrived; however, operation continued because the facility set to replace it experienced start-up delays, forcing the older plant to continuing operating at low rates. Nevertheless, it was a great learning experience for a young engineer both from a technical perspective as well as forming one of the bases for future mentoring. (For more on mentoring and sound advice from the field, visit www.ChemicalProcessing.com/voices/field-notes/.)

Grasp the Nuances of Level Measurement

The differences in the way devices work can profoundly affect readings

By Andrew Sloley, Contributing Editor

To truly understand what your process is doing, you must understand how you are measuring its performance. Process instruments provide readings on a variety of physical characteristics, including integer measurements (e.g., batches run, items made, bales processed), continuous measurements (e.g., temperature, pressure, flow, level) and discrete measurements (e.g., weight of product in a container). In all cases, the accuracy of the measurement depends upon the device used. Potential production and safety problems from inaccurate measurements and how the device responds to unusual process events also vary with the type of instrument. To illustrate these points, let's look at three common methods for measuring liquid level: differential pressure devices, displacers and floats.

Figure 1 shows a schematic of these devices installed for measuring liquid level. The differential pressure device is placed directly on the vessel. The displacer and the float are put in a stilling well attached to the vessel. The intent of the stilling well is to keep streams entering the vessel from directly hitting the measurement device.

A differential pressure measurement converts a pressure difference into a height of liquid, *h*, assuming you know the density difference between the liquid and vapor:

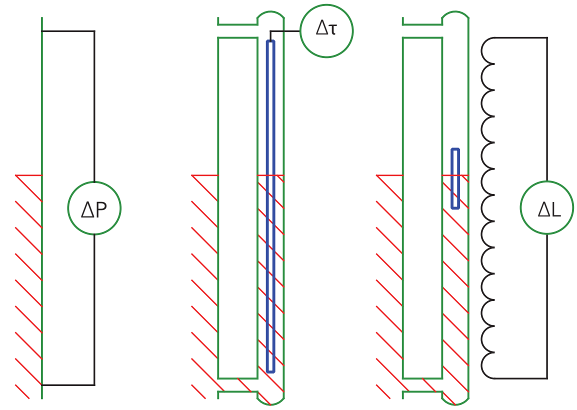
$$h = \frac{\Delta P}{g(\rho_l - \rho_v)}$$

where g is the gravitational constant.

In most applications, the density of the liquid is far higher than that of the vapor.

Hence, the vapor density often is ignored. However, in some cases, the vapor density can be important.

A displacer doesn't measure pressure. Instead, it measures torque, τ, generated by buoyant force. The displacer is a modern application of the phenomenon that led Archimedes to exclaim "Eureka." As the liquid level increases, the displaced liquid appears to make the displacer weigh less. This weight change equals the weight of the displaced liquid. If the density and cross-sectional area of the displacer are known, the change in torque directly translates into liquid level.



LIQUID LEVEL MEASUREMENT
Figure 1. Methods rely on different variables to come up with a reading.

Both the differential pressure device and displacer measure a physical variable that requires a value for density to convert the measurement into a level. As long as you use the actual density, the measurement is accurate. If the density assumed is wrong or changes, then the level measurement is inaccurate. Assuming too low a density will give a level less than expected while assuming one too high will lead to the opposite result.

Two extreme cases deserve mentioning.

In foams, densities may be dramatically lower than expected. The foam level may be many times higher than the liquid level. Foam can end up in vapor lines and cause significant downstream problems.

The second extreme case is if the actual density is lower than the assumed density and the liquid level goes above the span of the instrument. In such cases, a level instrument may continue to show a liquid level less than 100%; any level changes calculated from the instrument reading are due to density changes in the liquid, not level changes in the vessel. This was a small, but real, contributing factor to the infamous BP Texas City refinery disaster on March 23, 2005. Operators saw changes in level but the liquid level actually was well above the displacer. The changing level reflected falling liquid density as the tower heated up.

Texas City brings up a second point about displacers. They are not the same as floats. The buoyant body in the torque displacer shown doesn't move very much. It isn't floating on the liquid. In contrast, a float eventually will reach the top of the range, even if mis-calibrated.

Figure 1 also shows a float — in this case, a magnetic float without direct contact between it and the sensing element. The signal going to the control system is a direct measurement of the float's position, which isn't necessarily the same as the liquid level. The float's submergence will change depending upon the liquid density. The lower the liquid density, the more the float will sink into the liquid, and vice versa.

Many people confuse displacers with floats. Indeed, one source of misunderstanding in Texas City was lack of appreciation of the differences between these two devices. I've gone into some detail about these differences in a previous column, "Interpret Level Readings Right," http://bit.ly/2N9cHpw, but it's worth briefly reviewing them.

Changes in levels reported with changes in liquid density differ dramatically between these instruments. The error in level reading with changes in density for the differential pressure measurement and the displacer is a percent of the level. For differential pressure and displacer measurements, the reading shifts by a percent of the reading.

In contrast, with a float, errors in readings are a percent of the float dimension. A short float would have small errors. A longer float would have larger errors. Errors in density cause an offset in level readings. The measurement is off by a fixed percent of range set by the float dimension independent of the level reading.

The most effective plant engineers understand the physics of what's being measured by the instrument. They know how this gets converted to common control room readings. And they grasp how to use this knowledge to troubleshoot and run the plant better.

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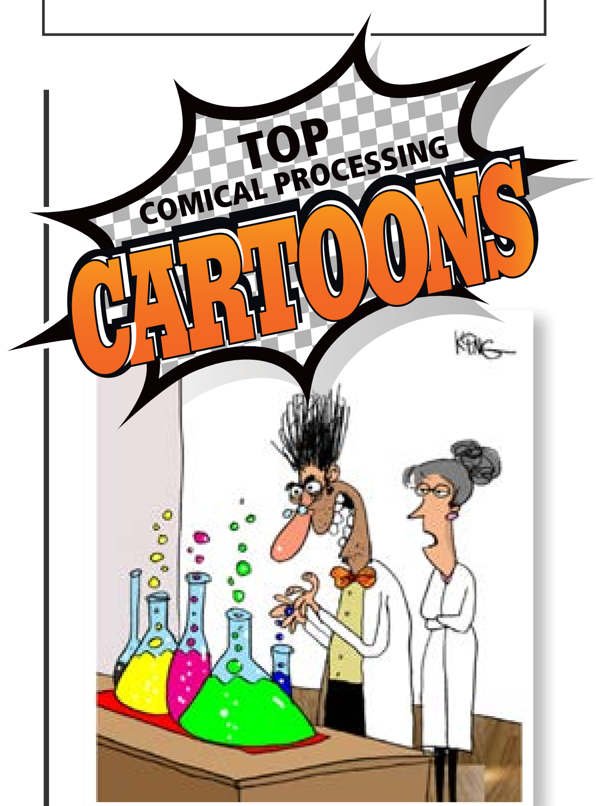

Visit the lighter side, featuring drawings by award-winning cartoonist Jerry King. Click on an image and you will arrive at a page with the winning caption and all submissions for that particular cartoon.