Executive Summary

Regulatory compliance is an expensive and critical business issue for oil and gas pipeline operators. Any approach that expedites compliance efforts saves time and money and also improves safety. Computer-based simulators are seen by regulatory agencies as an effective tool for operators, and can help expedite regulatory compliance. This paper examines a range of simulator types and offers guidance for how controllers can be trained using such tools.
INTRODUCTION

Over time, government agencies that regulate oil and gas pipeline operational practices have developed a strong preference for computer-based simulation as an operator training and evaluation tool. Simulator tools vary in scope and function. A proper analysis needs to be made to verify how they can help meet operator and regulator safety and compliance goals.

A key factor is the ability of the simulator in question to provide a realistic replication of actual pipeline control. As a result, selection of the right simulation tool can impact not only controller effectiveness but the speed with which regulators grant compliance. In addition, regulators can prevent or stop pipeline operation if they feel requirements are not being met. For this reason, controllers need to be well trained by the pipeline operator.

Proper training is critical for the safe delivery of oil and gas to consumers. About 2.6 million miles of propane, gas and oil pipelines crisscross the United States alone. According to The Manhattan Institute for Policy Research, America has 175,000 miles of onshore and offshore petroleum pipeline and 321,000 miles of natural gas transmission and gathering pipeline. In addition, over 2 million miles of natural gas distribution pipeline send natural gas to businesses and consumers.1 A full 70% of crude oil and petroleum products are shipped by pipeline on a ton-mile basis and nearly all natural gas is shipped via pipeline. Regulators, pipeline operators, and consumers all want to make sure that pipeline controllers are offered the best training possible in order to avoid improper actions or accidents (see Figure 1).

Regulators expect that the pipeline controllers who are being trained can perform standard operating tasks such as opening and closing valves and starting and stopping pumps. In addition, pipeline controllers will also be expected to handle abnormal operating conditions such as events that may represent a condition exceeding design limits or resulting in hazards to people, property or the environment.

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<th>Year</th>
<th>Number</th>
<th>Property Damage (in millions)</th>
<th>Barrels Lost</th>
<th>Injuries</th>
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<td>701,092</td>
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Figure 1

Pipe line incidents and related injuries and fatalities over a 10 year period (2002-2011) – Courtesy of Manhattan Institute for Policy Research

1 Furchtgott-Roth, Diana, “Pipelines Are Safest For Transportation of Oil and Gas”, Manhattan Institute for Policy Research, Issue Brief 23, June 2013
Regulators are becoming focused on simulation (see Figure 2) as the primary training and evaluation tool for two reasons:

- Written and oral examinations do not allow evaluators the ability to observe how controllers execute the identification of and reaction to abnormal operating conditions in real-time. A controller can be trained to know the answer to a question but actual performance under realistic operating conditions is an entirely different situation.

- While tasks performed under abnormal operating conditions will be infrequent, the training and evaluation of controllers’ ability under these conditions must be extensive and repetitive. Such situations represent the highest risk (and highest cost) to all pipeline stakeholders. Crisis situations cannot be recreated in a safe or efficient manner through any on-the-job evaluation. In addition, deploying observers and trainers for on the job evaluations is an expensive option for operators, requiring significant staff resources.

In essence, computer-based simulator trainers are increasingly viewed by regulators and pipeline operators as essential tools in their controller evaluation process. As a result, utilizing these tools can offer an expedited path to regulatory compliance.

**REGULATORY COMPLIANCE CRITERIA**

Regulators consider several key elements when assessing the value of a simulator:

**Ability to replicate a full range of relevant tasks**

A simulation trainer and evaluation program is not effective if it can only simulate a portion of the tasks controllers will need to perform. A simulator that will pass regulatory review has to be able to provide simulation for each relevant task as outlined in the regulators qualification program. Examples of covered tasks include:

- Changing operation set points, such as delivery flows and / or pressures, or station discharge pressures
- Normal valve operations, such as batch cutting, shutting down delivery stations, or station bypass operations
- Pump starting and stopping
- Emergency shutdown

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2Chief US pipeline regulator, National Transportation Safety Board (NTSB)
Adequate replication of pipeline character

The simulator needs to replicate the physical characteristics of the pipeline, such as the type of product / substance flowing through the pipeline, geographic and climate influences (e.g., elevation changes), temperatures, and flow direction for example. All of these factors affect the dynamics of pipeline operation.

The simulation should also replicate the nature of the equipment and devices that act on the pipeline. This includes pumps, valves and even monitoring devices. These devices, and the way they interact with the pipeline, are essential to replicating the pipeline character.

Record of evaluations / qualifications

Accurate and thorough record keeping is also a key consideration for the regulator. A complete up-to-date record of qualified individuals must be kept including results from their latest evaluations. Regulators require this information and this data should also be accessible should an incident investigation occur. These records should include:

- Identification of all qualified individuals and the specific tasks they are qualified to perform
- Dates of all current qualifications
- Description of methods used to qualify individuals

Simulators can provide high accuracy electronic records in each of these areas, as well as information regarding how controllers were qualified. They also demonstrate that controllers have received updates regarding changes to pipelines that might affect their assigned tasks.

While written exam evaluations can provide a clear record of how and when a controller qualified for a specific task, they can’t provide any context that simulates realistic operation of the pipeline. Evaluations like demonstration tables or on-the-job observation can provide more of a realistic replication of pipeline operation. However, under these circumstances it is more difficult to establish a clear record on how the controller was qualified. It is also more difficult to demonstrate repeatable qualifying performances under abnormal conditions.

TYPES OF SIMULATORS

How do pipeline operators select the right simulation model? The scope of functionality of the simulator may differ based on the needs of the specific operator. The differences depend on the characteristics of the pipelines managed by the operator and the level of qualification needed to match the overall risk threshold. Three main types of simulator trainers exist: generic, full scope and partial scope.

Generic simulators

These simulators provide a realistic representation of key controller tasks through a set of common pipeline models. By design, these simulators do not incorporate the exact elements of the actual pipeline that controllers will manage. Therefore, generic simulators are one of the least expensive solutions for operators. They may be cost-efficient option for operators with straightforward and simple pipeline networks that do not require any unique requirements.

Full scope simulators

Full scope simulators are custom-built simulators that exactly replicate a pipeline model and configuration, as well as the supervisory control and data acquisition (SCADA) functionality and controller interface. These simulators (see Figure 3) provide the most realistic recreation of controlling
an actual pipeline scenario. They also provide the operator with the flexibility to utilize the platform for other functions such as validation of production leak detection systems. Other functions include verification of anticipated changes in the physical pipeline system, in control logic or operating components, and in SCADA configurations.

If trained in all these areas with a full scope simulator, controllers are better equipped to respond to these changes when they become a reality on their pipeline systems.

As a result of customization, full scope trainers are significantly more expensive. However these tools are better suited for operators with complex pipeline operations and low risk thresholds, or for operators who are faced with rigorous regulatory compliance standards.

Partial scope simulators

This category of simulator incorporates elements of both the generic and full scope simulators. These systems offer the flexibility and core elements of customization but at a lower price point than full scope trainers. Most partial scope trainers build in key elements of the operator’s pipeline, such as unique topography or particular flow conditions. However these simulators do not represent a full end-to-end replica of the pipeline network. They may also incorporate the pipeline model into a full-scope SCADA interface without building a full replica of the operator’s human machine interface (HMI).

Partial scope simulators also offer a set of different scenarios that can be played out through simulation with a configurable scenario builder. Partial scope trainers are useful as a universal option because they provide a realistic simulation without the full price of full scope simulators.

DISTINGUISHING CHARACTERISTICS

The simulator tool selected by the pipeline operator needs to accommodate the requirements laid out by the regulators. However, enhancement of the operational performance of the pipeline is also an important consideration. Listed below are a few key simulator characteristics that can help a pipeline operator achieve both of these goals:

Efficient hydraulic model - The hydraulic model is what drives the SCADA system in the training platform. If the hydraulic model doesn’t provide a realistic replication of the flow conditions in the actual pipeline, then the effectiveness of the simulator will be limited.

Realistic HMI - The Human Machine Interface (HMI) displays all the information that the controller will monitor. It also displays the actions the controller may need to take based on SCADA information displays. In a best case scenario, the simulator plugs into a replication of the actual SCADA system. However, when this is not the case, the simulator still needs to provide a realistic HMI experience in order to perfect controller recognition and response skills.

Flexible training conditions - To meet qualification requirements, training systems need to be updated and enhanced on a regular basis in order to reflect evolving norms and variations in controller experience. The simulator tool needs to be flexible
enough to define pipeline operating conditions (both normal and abnormal) so that a wide array of training scenarios can be created. Abnormal conditions that occur on pipeline systems can be caused by single point failures, multiple point failures, or by cascading failures. An effective simulator should accommodate any combination of these failure scenarios.

The flexibility needed also extends to the long term use of the simulator training system. The sophistication of the system has to grow with the experience level of the operators and with the pipeline technology it’s replicating.

**Evaluation and record keeping** - Some simulators utilize a Qualification Information System (QIS) to document all operations training that controllers have received. This documentation includes results of tests and all other relevant information used to manage a controller qualification. The QIS assists in helping to make training and testing fair and objective and defines the scope and expiration of current qualifications.

**Integration of equipment process logic** - While the hydraulic model replicates how product / substance is actually flowing through the pipeline, an essential element of pipeline operation is how the equipment controller affects product / substance flow. Equipment process logic includes building in the full communications logic in order to determine how the orders from the controller affect equipment action.

For example, when a controller sends an order from the SCADA interface, that order then goes to a remote terminal unit (RTU). The RTU then communicates that order out to a series of devices. In the case of starting a pump, that RTU might then send an order to not only start the designated pump but also open and close a series of valves. Because controllers may face an event where one of these valves fails to respond, simulators should be able to replicate at that level of detail. By building in the full equipment process logic, simulators can provide much more accurate scenarios that increase their utility to operators and their controllers.
CONCLUSION

Regulatory compliance is an expensive and critical business element for pipeline operators. Any solution that expedites compliance efforts in a cost-effective way is a great boon to operators.

Computer-based simulators for training and evaluation of pipeline controllers are key tools that help to improve operational safety and to meet regulatory requirements. Regulators have seen the value that simulators can provide above all other forms of evaluations and now consider them as the preferred training and evaluation tool. Therefore, choosing the right simulator can result in both more effective training and faster regulatory compliance.

The right simulator incorporates all the major elements regulators look for in an evaluation system, including replication of pipeline characteristics, replication of key trouble-shooting tasks, and an accurate record of controller performance evaluations. It is also prudent for operators to go beyond the simple replication of a pipeline flow model. Enabling the most realistic training experience is essential for both fast regulatory compliance and peace of mind. An advanced training includes creating a realistic HMI experience and incorporating elements of the equipment process logic which offers critical layers of detail to the simulation model.

Whether choosing a generic, partial scope or full scope computer-based simulator, operators need to select a method that not only supports and satisfies regulatory requirements, but also accommodates business goals and addresses the risk threshold they are willing to tolerate.

About the Author

Tony Collins is a simulation specialist for AVEVA. He has over 12 years’ experience designing and implementing SCADA systems for various applications. In addition, he has extensive project engineering and project management experience implementing real time pipeline modeling, leak detection and operator trainer in the oil and gas pipeline industry. Tony holds degrees in Electronics Engineering and Industrial Control Systems and Business Administration.