Assessing the Risk of Squeezing Activities

and Reviewing the Impact of Squeezing Polyethylene Pipe

For years, gas distribution operators have squeezed polyethylene (PE) pipe as a method of isolating a section of pipe or performing a branch installation. Modern testing and plastic pipe manufacturing techniques have alleviated many of the concerns that were associated with squeezing early generation pipe, such as slow crack growth (SCG) propagation. Still, while some operators are considering moving away from squeezing, others believe that squeezing is, and should remain, an acceptable practice.

The purpose of this paper is to:

- Show results of integrity testing of squeeze points on a PE pipe using microscopy.
- Compare the impact of properly versus improperly squeezing PE pipe.
- Examine and perform a risk assessment of the squeezing procedure using the "Strength of Defenses" model.
- Examine and compare the risk assessment of other isolation methods using the "Strength of Defenses" model.

This information may help you evaluate your current isolation methods and determine whether they align with your company's level of risk tolerance.

First, let's get a baseline: What kind of pipe are we talking about?

It is widely accepted in the industry that squeezing early generation PE pipe is not an acceptable practice. This is because it can increase the risk of SCG propagation, which can decrease the life expectancy of the pipeline. There are several Department of Transportation safety advisories (ADB-99-01, ADB-99-02, ADB-0-07) notifying operators that common PE pipes manufactured prior to 1983 (specifically Century Pipe, low-ductile Aldyl A and PE 3306) are susceptible to SCG propagation. Furthermore, these advisories suggest that performing squeezing activities on these pipes can accelerate SCG propagation.

For the purposes of this discussion, we will assume we are talking about squeezing newer pipe that is stronger and more robust than older pipe. Newer pipe is manufactured using a controlled polymer branching that generates a higher density pipe with longer Pennsylvania Edge-Notch Tensile (PENT) test results. Gas distribution operators are installing this kind of pipe in their networks today.

Is there a certain way that you have to squeeze the pipe?

The proper squeeze procedure is outlined in ASTM F 1041, which focuses on the rate of compression, the rate of release and using correct squeeze stops. Following this procedure and using proper squeeze tools that adhere to ASTM F 1563 is critical to maintaining the integrity of the pipe during a squeeze off. ASTM F 1041 suggests that the proper squeeze procedure is as follows:

- Squeeze at a rate of no more than 2 inches per minute.
- Release at a rate of no more than 0.5 inches per minute.
- Use correct stops to avoid over-squeezing.
- Use this squeeze procedure when temperatures are above freezing.

Citing test results and third-party data, most pipe manufacturers and squeeze tool manufacturers warn against deviating from the procedure and include the following notice in their operating manuals and on their websites:

> ***If the operator does not follow the approved procedure during a squeeze off, presume the pipe is damaged and replace or remove from service.***

With that information in mind, should you be worried that you are damaging the pipe during a properly executed squeeze off?

Absolutely not. There is no data suggesting that, when done properly, squeezing increases the risk of an incident or decreases the life of your pipeline. You simply must follow the procedure per ASTM F 1041 and use squeeze tools that are compliant with ASTM F 1563.

We decided to test this. We performed various squeeze offs on 4-inch medium density pipe and evaluated the impact on the pipe using microscopy.

We started with an ASTM F 1041-compliant squeeze. Then we performed a non-compliant procedure on a different piece of the same type of pipe, squeezing and releasing twice as fast as prescribed. After each squeeze off, we used microscopy to evaluate the stress on each of the squeeze points.

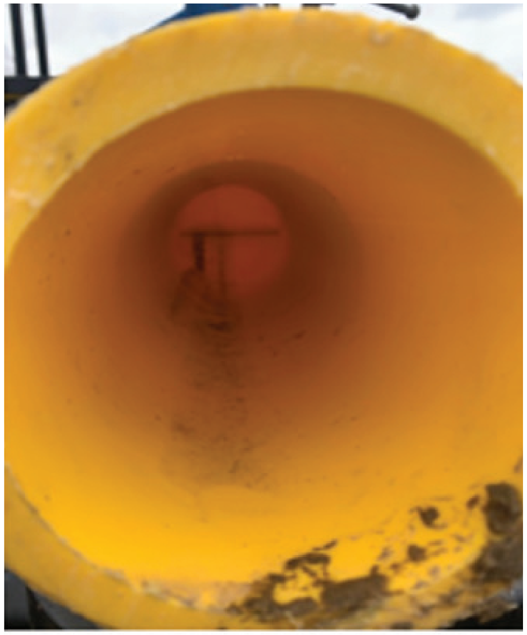


Fig. 1

The images and photos that follow are close-ups of a cross section of the pipe. You are looking down the pipe so you can see its inner wall and outer wall. See Figure 1 and Figure 2. The close-ups are at the 3 o'clock and 9 o'clock positions (i.e., the squeeze points). See Figure 3. This is the area of the pipe that absorbs the most stress during a squeeze off.

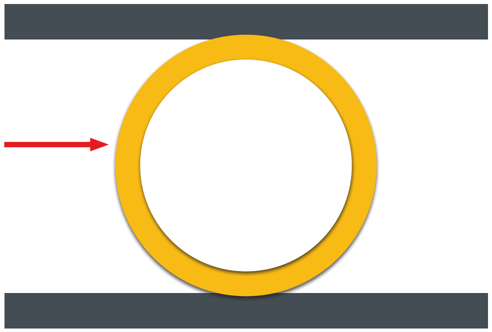


Fig. 2

Fig. 3

suggest that anything traumatic has affected the pipe, and it appears to be in acceptable working condition.

The picture below (see Figure 4) is a cross section of pipe that has not been squeezed. It looks as you would expect it to, with very smooth inner and outer walls and no visible deformities. Notice the fairly consistent wall thickness at various points on the pipe, roughly 10.8 mm. Consistent pipe wall thickness is critical to the structural integrity of the pipeline. Any significant decrease in wall thickness could constitute a weakness in the pressure properties and shorten the life of the pipeline.

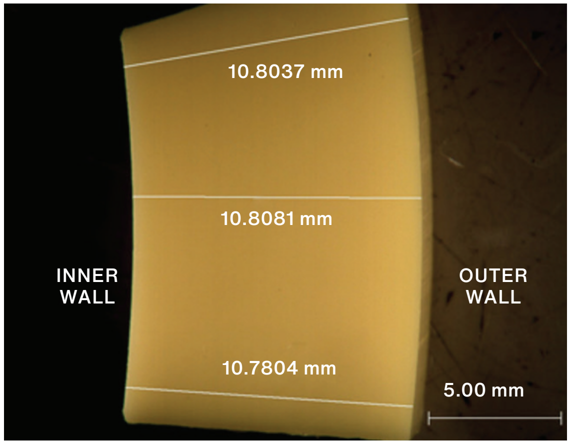


Fig. 4 Calibration 5x with 0.5x auxiliary lens

The next picture, Figure 5, shows a cross section of pipe that has been squeezed in conformance with ASTM F1041. Again, as in Figure 2 and Figure 3, you are looking down a cross section of the pipe so you can see the inner wall and outer wall.

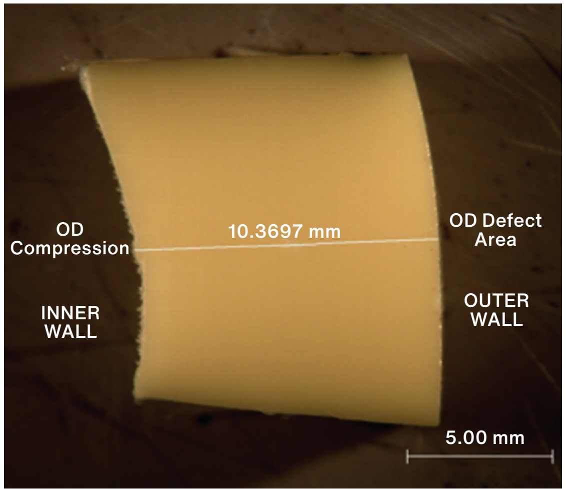


Fig. 5 Calibration 5x with 0.5 auxiliary lens

You can see a small amount of deformation on the inner wall. You can also see a slight decrease in the diameter, from about 10.8 mm to 10.4 mm, or roughly a 3.7% change in wall thickness. Nothing here would suggest that anything traumatic has affected the pipe, and it appears to be in acceptable working condition.

Let's compare this to what the pipe looks like after we applied a squeeze that deviated from the procedure outlined in ASTM F 1041. Remember, this time we squeezed and released faster than the recommended procedure. Again, you are looking down the pipe at a cross section and focusing on the corners of the squeeze point.

In the picture below, Figure 6, you can see significant plastic deformation on the inner wall of the pipe as well as a crack on the outer wall, indicated by the red arrow. The pipe's wall thickness has decreased from close to 10.8 mm to 9.6 mm, or about 11%.

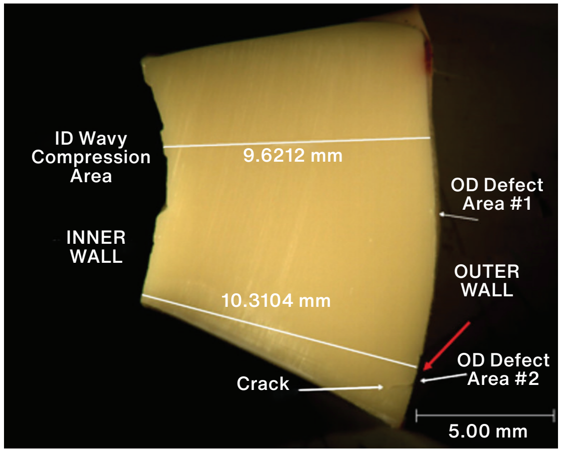
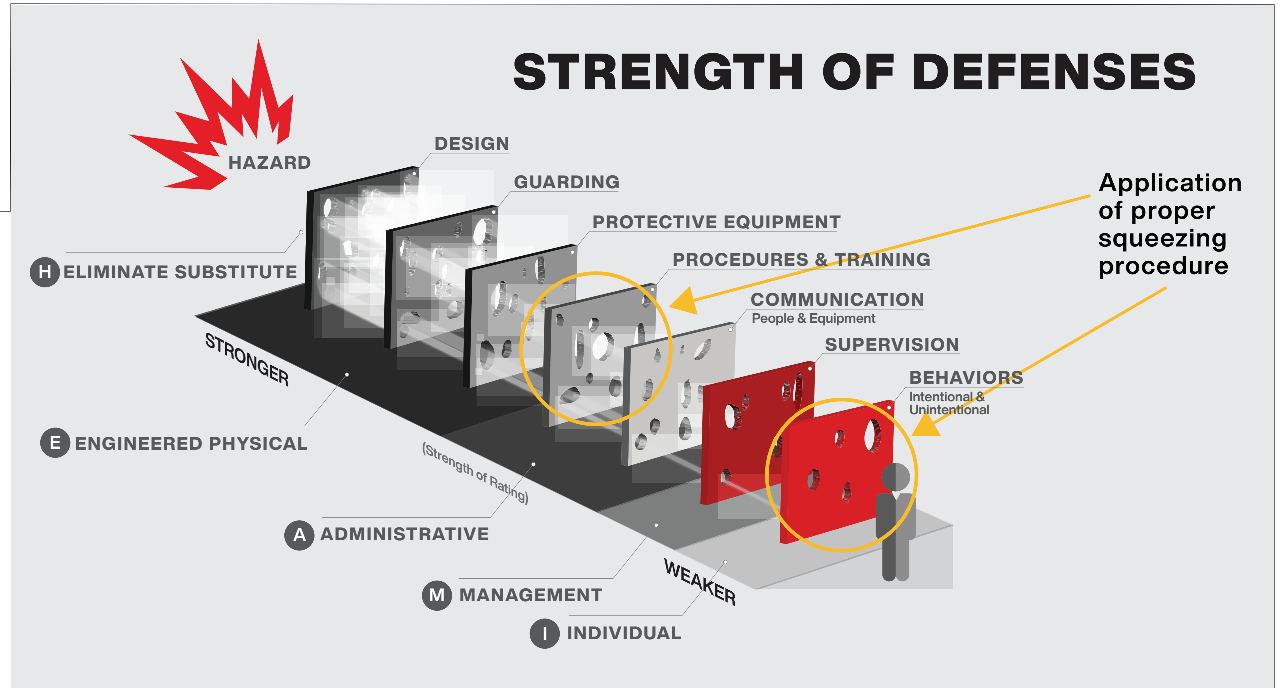


Fig. 6 Calibration 5x with 0.5 auxiliary lens



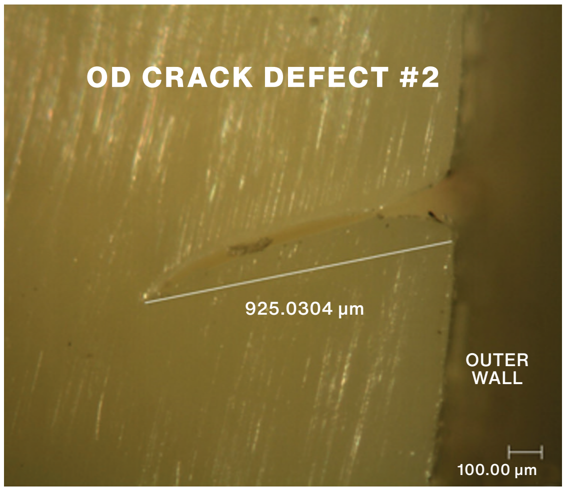


Fig. 7 Calibration 63x with no additional lens

The crack in the outer wall of the pipe ran 1.5 inches down the pipe wall and is approximately 1 mm deep, which is about 8.5% of the wall thickness of the pipe. See Figure 7.

In summary, after using the proper squeeze procedure, there appears to be a very slight deformation on the inner wall of the pipe with about a 3.7% decrease in wall thickness. There is no visible damage, and the pipe appears to be in an acceptable condition. When deviating from the procedure, however, there is significant deformation on the inner wall of the pipe, about an 11% decrease in wall thickness, as well as a significant crack on the outer wall that penetrates through 8.5% of the wall thickness and runs 1.5 inches down the pipe.

Knowing this, should squeezing be considered an unsafe practice?

No. There is no data suggesting that, when done properly, squeezing increases the risk of an incident or decreases the life of your pipeline. You simply have to follow the procedure.

Now let's look at a risk assessment of squeezing activities.

Many organizations have a risk assessment model. We will reference a couple of models here, but the primary one we will use is called the **"Strengths of Defenses"** model.

This model shows a potential risk and the various levels of risk mitigation that can be implemented to either eliminate the risk altogether or protect people or the environment from an incident. Weaker defenses consist of processes, supervision and human behaviors.

Medium defenses consist of protective equipment, training and communication, and the strongest mitigant consists of engineered physical solutions.

Theoretically, the farther up (or to the left) you go in the model, the more risk mitigation you have in place. Therefore, based on this model, safer solutions are those that have engineered physical design characteristics, then administrative controls, then management controls and, finally, individuals following proper training.

In the case of squeezing, the proper procedure according to ASTM F 1041, which can eliminate or mitigate the risk of damaging the pipe, is captured by the Procedures and Training wall of the model. The procedure is proven to be safe and effective in preserving the integrity of the pipeline.

However, as we demonstrated during testing, **following** the proper squeezing procedure is critical to the safety, integrity and life of the pipeline. It's up to the technician to perform the proper procedure in order to eliminate risk, relying on human behavior as the last line of defense before a risk is realized as an incident.

What are the risks associated with depending on human behavior to complete a squeeze off?

The safety and integrity of your pipeline are dependent on people, their behaviors and the application of proper procedures. The squeezing procedure is somewhat tedious and requires diligence to execute properly. It can be easy to unknowingly deviate from the proper procedure. The worker must be consciously monitoring timing during the squeeze and the release, and it can be easy to get distracted and lose track. It is also possible for the worker to use the incorrect stops on the squeeze machine, which could result in an improper squeeze off. Lastly, there is no way to test whether the pipe has been damaged during or after a squeeze off. Therefore, the integrity of the pipe is unknown, and the only way an operator would discover this integrity issue is from a leak at some point in the future. There is no way to test for this prior to an incident. It is the risk of the unknown that can be most catastrophic.

Does this mean that squeezing isn't safe?

No, squeezing is safe. By applying the "Strengths of Defenses" model, we show the risk of an incident is mitigated by the human behaviors of applying the proper procedure. However, we also show that this mitigation is the last line of defense against the risk being recognized as an incident. It's really about risk tolerance. The operator must decide if squeezing falls within the organization's risk tolerance.

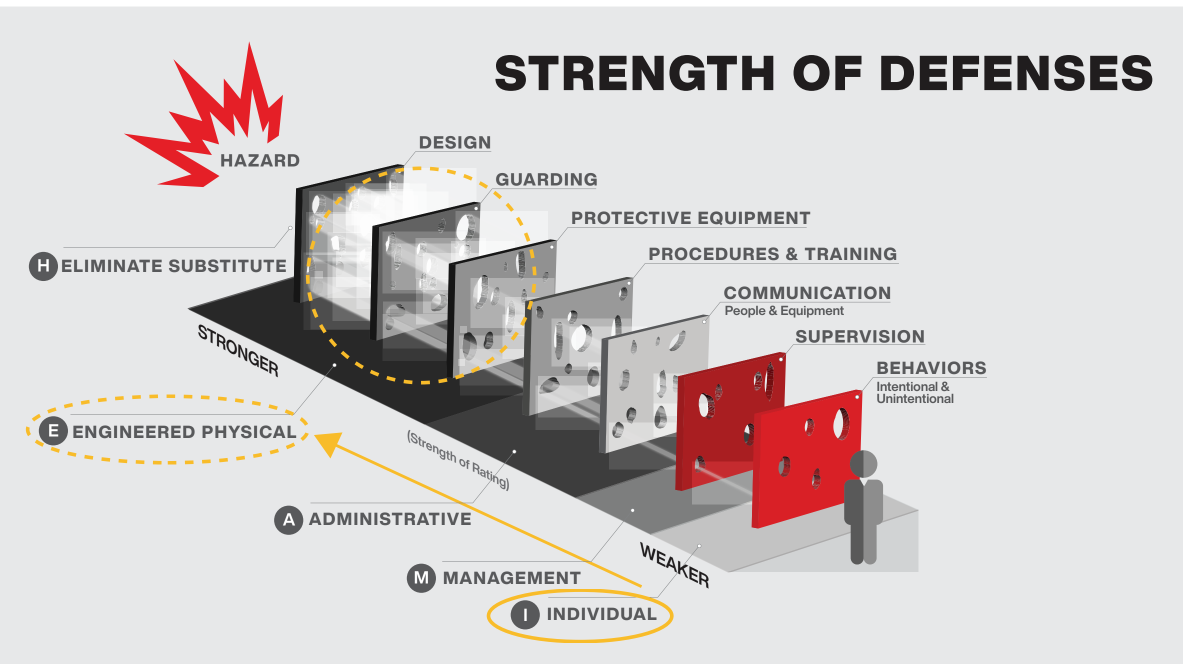
How does the loss of experienced personnel affect risk?

As we have identified, following procedures is very important during a squeeze off. So it begs the question, from an industry perspective, how have we been so successful and safe performing squeeze offs for the last 40 years? The answer is simple: because of our workforce. Pipeliners who have been serving this industry for decades are the best in the world at what they do. They've seen it all.

This is not to say there have not been incidents. We're always learning, always trying to get better. But the men and women who have been working on these pipelines have been doing it right for a long time.

With "The Great Crew Change" and "The Great Resignation" impacting our industry, a very real concern is what will happen when seasoned employees are no longer on the job. We have management, training and administrative controls in place, but when the men and women with the tribal knowledge walk out the door, this will be tough to overcome.

Considering the challenges involved in squeezing, the significance of deviating from procedures, the risk of not knowing about pipe damage and the loss of key personnel, is it time for the industry to move further up the model and find an engineered physical solution to help mitigate risk?

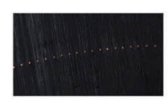


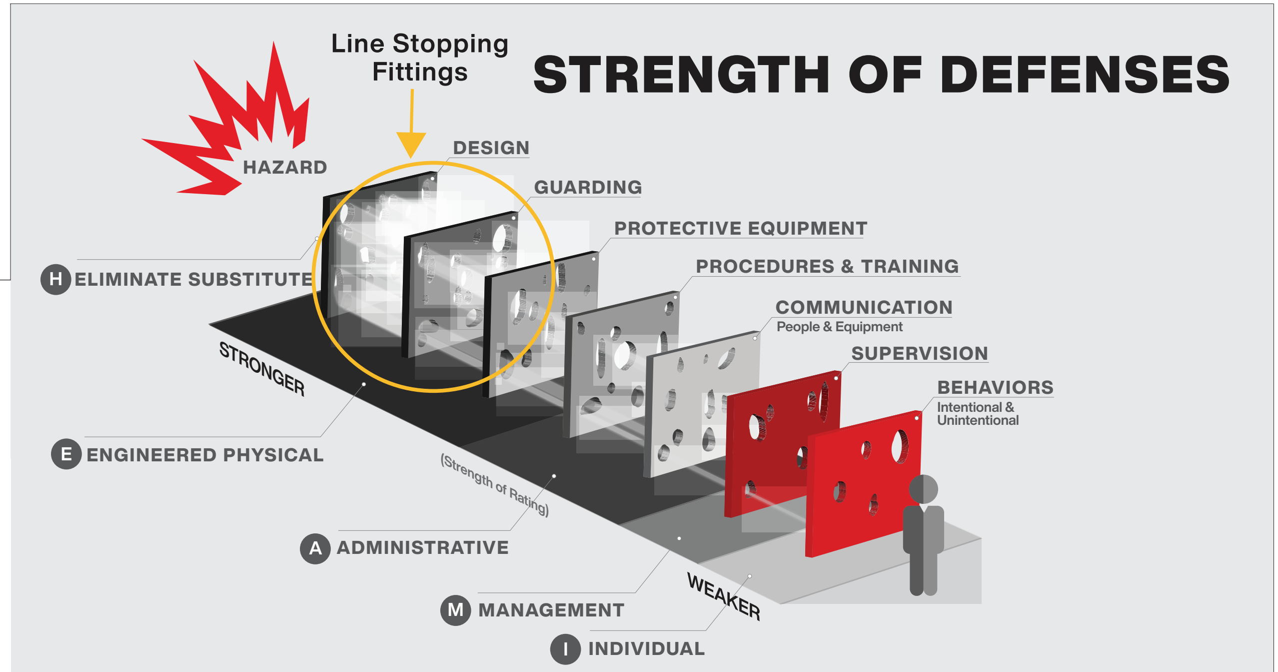
What are examples of engineered solutions from a hot tapping and plugging standpoint?

From an isolation and branching standpoint, the electrofusion fitting is an example of an engineered solution. This is based on several key elements, the first being the fusion process.

When a fitting is fused to the pipe, the fusion area becomes as strong as, if not stronger than, the pipe itself. The interweaving of the polyethylene molecules increases the pressure properties and tensile strength of the pipe. Once the fusion is complete, the fusion area is leakproof. The fitting and the pipe become one, and no gas can escape.

Each fitting is marked with bar codes that are scanned to tell the fusion machine the correct voltage and amperage to send to the fitting, so the fusion is successful. Once the fusion is complete, the machine generates a report or record confirming the fusion results. Lastly, and perhaps most importantly, the fusion can then be tested with a test cap prior to any tapping or penetration of the pipe. If, for some reason, the fusion was unsuccessful, the operator will know about it before commencing the tapping operation. This is a key feature that allows the operator to know if any quality issues have occurred during the fusion process. Going back to the risk of the unknown, this feature eliminates that risk.





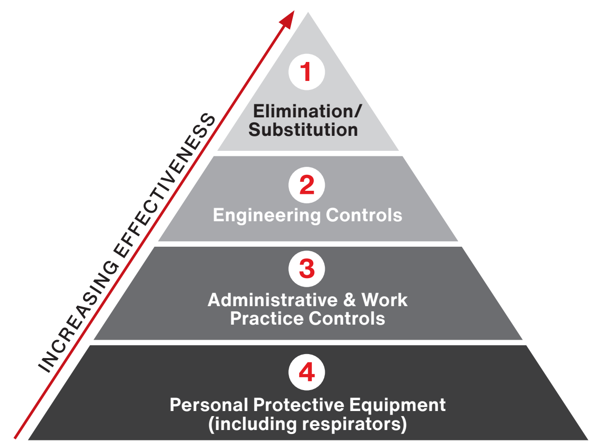
Are there procedural risks associated with using line stop fittings similar to those during squeezing?

Yes. Before a fitting can be properly fused onto the pipe, pipe preparation is required. Most notably, the pipe must be peeled, or scraped, to remove any oxidation on the outermost layer of the pipe. This is an important step and ensures the quality of the fusion between the fitting and the pipe. Other than using an approved peeling tool, this step is fairly straightforward and is not complicated or difficult to perform.

If there were ever a scenario where the pipe was not peeled, this would most likely be an intentional decision not to prepare the pipe appropriately as compared to a squeeze operation where deviation from the procedure is more likely to be unintentional. Intentional actions are much easier to correct and control than unintentional actions.

Furthermore, regardless of whether the pipe was prepared properly or not, if there are any issues with the quality of the fusion area, they will surface during the pressure test with the test cap. Because of the ability to test the fitting before commencing with the job and the physical change that occurs during the fusion process, the electrofusion fitting is a good example of an engineered solution that will help mitigate risk during and isolation of branching application.

In addition to the Strength of Defenses model, another tool, called "Hierarchy of Controls," also shows how engineered solutions are more effective at mitigating or eliminating risks than other controls, including work practices. For example, to ensure pipeline integrity, applying a physical change such as the fusion of a fitting is more effective at reducing risk than requiring a worker to do something like following a procedure.



1. Eliminates the exposure before it can occur
2. Requires a physical change to the workplace
3. Requires worker or employer to **do** something
4. Requires worker to **wear** something

Assessing the Risk of Squeezing Activities

and Reviewing the Impact of Squeezing Polyethylene Pipe

CONCLUSION

It is important to remember that squeezing is safe. There is no data to suggest that if you follow the proper squeezing procedures and use the proper squeeze tools, you will damage the pipe during a squeeze off.

However, the integrity of the pipeline is dependent on the application of a correct procedure and therefore depends on people and “Behaviors.” Based on the “Strength of Defenses” model, this is the last line of defense that can mitigate a potential risk from coming to fruition, possibly harming a person or the environment.

Referencing the “Strength of Defenses” model, you should consider “Engineered Physical” solutions that will reduce the risk of an integrity issue caused by a deviation from proper squeeze procedures. If squeezing is your preferred method, there are hydraulic squeeze tools that have engineered features such as a needle valve and double-acting hydraulic cylinders that can help reduce the risk of releasing too fast. This will help eliminate some of the risks associated with squeezing.

From a hot tapping and plugging perspective, an example of an “Engineered Physical” solution is an electrofusion fitting. Since they are an engineered solution, designed to physically become part of the pipeline, and can be tested prior to performing work, electrofusion fittings would fall near the top of the “Strength of Defenses” model. Therefore, this should be considered a safe alternative to squeezing for those operators looking to mitigate the risk of integrity issues on their pipeline networks.

Author

Ryan Ragsdale
Senior Product Manager
6801 South 65th West Ave
Tulsa, OK 74131
+1-918-447-5538

www.tdwilliamson.com
North & South America +1 918 447 5000
Europe / Middle East +32 67 28 36 22

The TDW Solution to Squeezing

A TDW Alternative

With these challenges and safeguards in mind, TDW developed an intervention and isolation system that eliminates the risks associated with squeezing PE pipes.

Introduced to the gas distribution market in 2020, the POLYSTOPP® Quick Connect system is an ideal alternative to squeezing.

Servicing a range of sizes from 4-inch to 8-inch, the POLYSTOPP® Quick Connect system is designed to withstand pressures up to 10 bar (150 psi) and is capable of covering multiple standard dimension ratios. It also has a feature that allows for a 2-inch bypass.

POLYSTOPP® was designed with a two-stroke tapping machine that significantly increases the speed of the overall tapping procedure, offering efficiency and time savings. Additionally, the machines are pressure-balanced to eliminate resistance during operation, enhancing the ease of use and operational smoothness. A bar locking feature is incorporated to increase safety, ensuring secure operations during use. Moreover, the cutter is meticulously designed to capture shavings, providing a clean plugging service inside the pipe.

With its revolutionary connection design, the POLYSTOPP® Quick Connect system makes it easy to safely perform hot tapping, plugging and branching on PE pipelines — and to do it faster than with any other isolation technology.