Attachment to downhole power unit helps large Middle East operator successfully perforate tubing in more than 300 wells without explosives.

### OVERVIEW

Before tubing can be replaced or pulled during workovers, it must be perforated to equalize pressure inside and out. A large Middle East operator used explosives to do that until recently. The explosives created risks and costs they wanted to mitigate. Logistical delays for permitting, transporting and storing the explosives – as well as bringing in an e-line crew to trigger them – all increased costs. Transporting and handling the explosives created additional risks.

With no reliable mechanical perforating alternatives in the market, in 2006, the operator approached Halliburton about developing a better solution. The DPU Actuated Tubing Perforator was the answer. After more than a year of development and testing, the operator used it in more than 300 wells with a success rate greater than 99 percent. The tool has reduced costs, simplified logistics and improved safety.

### CHALLENGE

<table>
<thead>
<tr>
<th>Logistics, costs and risks of explosives</th>
<th>DPU Actuated Tubing Perforator</th>
</tr>
</thead>
<tbody>
<tr>
<td>In many parts of the world, including the Middle East, the use of explosives during a workover creates additional costs and security risks while complicating logistics. Explosives require special permits, security, transportation, warehousing and crews.</td>
<td>The Halliburton DPU Actuated Tubing Perforator eliminates the need for explosives. It converts linear force generated by the DPU (downhole power unit) tool to lateral force. It then produces a hole in the tubing that allows pressure to equalize gradually – in a controlled fashion.</td>
</tr>
</tbody>
</table>

### RELIABILITY

<table>
<thead>
<tr>
<th>Reliability</th>
<th>Design as simple as a can opener</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to 2006, mechanical perforators in the market had only a 50 percent success rate on average. They could not work reliably in a wide range of tubing grades. Hard tubing could break the tools. Soft tubing was equally problematic but in a different way. It tended to deform rather than perforate.</td>
<td>The downhole power unit applies linear force against a blade, pushing it against the tubing like a can opener until the tubing perforates. This gradually produces a hole that can allow safe equalization of pressure. The design was more than 99 percent reliable in multiple grades of tubing.</td>
</tr>
</tbody>
</table>

### RAPID DEPLOYMENT

<table>
<thead>
<tr>
<th>Rapid deployment</th>
<th>No permitting or transportation security needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before the DPU Actuated Tubing Perforator was developed, a workover crew and offshore rig could sit idle for days while the operator mobilized an e-line crew, obtained permits for the explosives and transported the explosives to the rigsite.</td>
<td>Because the DPU Actuated Tubing Perforator is nonexplosive, the team can deploy immediately without arranging any special permits or transportation – as soon as they learn of the need to perforate. This tool has saved up to several days on each of its 300+ deployments to date.</td>
</tr>
</tbody>
</table>
THE MANY PROBLEMS WITH EXPLOSIVES

In many parts of the world, explosives are highly regulated and difficult to deploy. They require special security, permits, transportation and storage. They also require a specialized crew trained in the use of explosives to activate them. Arranging all this takes time while workover crews sit idle. To improve responsiveness, reduce costs and increase safety, this large Middle Eastern operator sought a nonexplosive way to perforate tubing.

Halliburton’s DPU® Actuated Tubing Perforator works much like a can opener. It applies an electromechanical force against the tubing wall until the wall perforates. This allows fluid pressure inside and outside the tubing to equalize gradually in a controlled fashion.

Because the DPU Actuated Tubing Perforator uses no explosives, it can be deployed rapidly without special permits, security, transportation or warehousing. The tool generates enough electromechanical force to punch a hole in tubing.

The DPU Actuated Tubing Perforator has penetrated J55, P110 and 13-chrome with 99%+ reliability. Halliburton can deploy the tool on slickline, e-line or coiled tubing.

Solving challenges.™
Explosive perforating poses many challenges
As long as operators have been doing workovers, there has been a need to perforate tubing. Perforation allows pressure from fluids inside and outside of the tubing to equalize. Explosives create a reliable perforation. But they also tend to create holes quickly. And if there is a large amount of fluid between the tubing and the casing, the sudden, radical pressure change can blow fluids up the tubing, creating a safety risk.

Moreover, many countries highly regulate the use of explosives. The operator’s home country requires permitting, special transportation and secure warehousing, all of which can be difficult to arrange in many locations. Offshore rigs could be idled for days while the operator worked out logistical issues. So the company had long sought an alternative to using explosives. However, there simply were no good mechanical alternatives in the marketplace.

High failure rate of early mechanical tools raised costs
Before 2006, the average failure rate of mechanical perforators approached 50 percent. As often as not, the operator would have to revert back to explosive perforating to finish the job. The company needed a reliable way to equalize pressure gradually, so that they could pump out fluids safely before work began.

The search for reliable alternatives leads to Halliburton
To improve safety, costs and logistics, in 2006, the operator asked Halliburton to develop a better mechanical alternative. At Halliburton’s Carrollton, Texas facilities, a handpicked crew of engineers began the search for solutions. Their efforts focused on adapting Halliburton’s field-proven DPU® (downhole power unit) tool to the task. In use since the 1990s, the DPU tool has proven its worth as a nonexplosive alternative to setting plugs worldwide. But could it be adapted to perforating?

Early development and testing points out challenges
The challenge was finding a way to convert linear force into lateral force – focused on a small point – that would open a hole in the sidewall of the tubing gradually.

Unique design harnesses linear force of the DPU tool
As a screw inside the DPU tool moves downward, it forces the tip of the blade – which rotates on a fulcrum – against the wall of the tubing. Eventually the tubing begins to perforate. Starting with a pinhole, the blade gradually enlarges the perforation to about one half-inch across. As the DPU tool continues to apply pressure against the blade, the blade flips over and retracts back into the tool so that the tool can be removed from the hole. The tool produces a puncture in the tubing within minutes.
Large Middle Eastern operator improves workover safety, costs and logistics with nonexplosive DPU® Actuated Tubing Perforator.

**Year-long collaborative design process**
More than a year’s worth of design went into this collaborative effort which tested different variables in multiple grades of tubing. Eventually, Halliburton engineers determined the right combination of properties to work in J55, P110 and 13-chrome.

**Used in more than 300 wells with a 99%+ success rate**
To date, the operator has deployed the DPU Actuated Tubing Perforator in more than 300 workovers for this operator. Their success rate exceeded 99 percent.

**Saves time and expense of mobilizing a specially trained crew**
The client has recognized significant cost savings by eliminating issues associated with provisioning, transporting and using explosives (including special crews needed to handle them) in this volatile part of the world.

**Works on any conveyance: slickline, e-line or coiled tubing**
The DPU Actuated Tubing Perforator saves the expense of mobilizing a second crew. One of the biggest time and money saving features is that it can be used on any slickline, e-line or coiled tubing unit at the rig site – whether it’s Halliburton’s or a competitor’s.

**Operator writes tool into operational specifications for all wells**
Because of the savings, the HSE benefits and rapid deployment, this operator now mandates that the DPU Actuated Tubing Perforator is available for all well operations. The company wrote the tool into the operational specifications for all of its wells.

**Recommended everywhere explosives pose concerns**
The Middle East is not the only part of the world with concerns about explosives. Any area with concerns about the security of explosives or stringent HSE regulations will find this nonexplosive alternative worth considering; it achieves a reliable tubing punch in a single run.