GAUGING THE FUTURE

Geoff Wilkinson, Technical Director, Propipe, UK, **discusses the benefits of utilising SMART gauge technology in a complex multi-diameter pipeline.**

Advances in subsea recovery techniques allowing tie-in to existing subsea pipelines, mean that multi-diameter pipelines are now common practice for many offshore applications. These multi-diameter systems not only present a challenge from a pigging aspect, but also from a pipeline gauging perspective. The traditional approach to gauging, with a conventional aluminium plate, will not provide sufficient information on the as-built condition of a multi-diameter pipeline. As such, gauging enhancements must be made to keep up with the industry requirements.

Following construction of a pipeline, there are several further processes that are carried out to ensure the 'as-laid' conditions are acceptable. Operators usually undertake flooding, cleaning, and gauging operations to clean the asset

Table 1. Pipeline internal diameters / gauge system selection				
Pipe ID	**Length**	**Gauge diameter**	**System**	**FCG Pig#**
719 mm	**10 km**	**683 mm**	**30 in. Multi-Hit SMART gauge**	**1**
564/558 mm	**20km / 10 km**	**533 mm**	**24 in. Multi-Hit SMART gauge**	**2**
549.6 mm	**50 km**	**519 mm**	**24 in. aluminium plate**	**3**
All	**All**	**719 - 490 mm**	**Diameter measuring system**	**3**

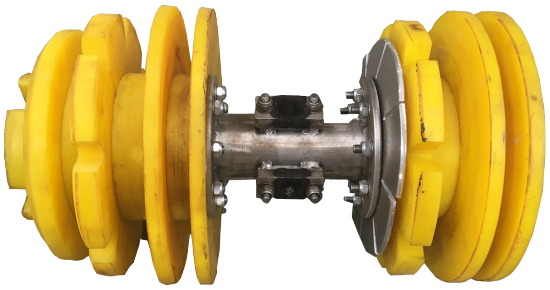

Figure 1. Conventional aluminium gauge plate.

Figure 2. Multi-hit SMART gauge system, 30 in.

from post-construction debris and verify that the line has been laid without significant defects. Pipeline pigging and gauging therefore play a key role in the pre-commissioning activities of a new pipeline.

Multi-diameter case study

A multi-diameter project located in offshore Middle East required gauging as part of the pre-commissioning campaign. The pipeline had an internal diameter range of 719 mm (30 in.) to 535 mm (24 in.) which equates to a 26% change. A three pig pre-commissioning pig train would run from onshore to offshore (1700 m water depth) to flood, clean and gauge the pipeline. Within the range of diameters, four main sections of pipeline with significant lengths would need to be gauged.

Typically, pipeline gauging involves using a pipeline pig with an aluminium plate fitted (Figure 1). This plate is generally sized at 95 - 97% of the pipeline minimum ID (depending on the specification used for sizing). Upon recovery of the pig, the gauge plate physical appearance is inspected for any deformation. In this case, because of the multi-diameter aspect, the size of the aluminium plate would be so small (being based on the minimum ID of the 24 in. section) that it would provide no information on the as-built condition of the larger (30 in.) sections at all – therefore a smarter approach to gauging would be needed for this project.

Gauging options

A range of SMART gauge technologies were required for the project to provide usable as-built information on the as-laid condition of each of the four main pipe sections. Through development, design and in-house testing Propipe provided a range of systems to gauge the pipeline. Table 1 summarises the gauge systems used for each section of pipeline.

'Hinged' gauge system

To achieve a gauge of the 719 mm 30 in. pipeline, the project required a plate with a diameter of 683 mm. This plate, if of standard (aluminium) construction would be damaged/destroyed in the 24 in. sections. Therefore, a mechanical 'hinged' gauge system was developed and deployed for use on the project.

The Propipe Multi-Hit SMART gauge system is designed to detect any gauge breaks in the 30 in. before collapsing to run through the 24 in. To achieve this, the gauge system uses multiple gauging arms with gauge tips. Each arm of the gauge system is spring loaded, and the position of the arm is continuously logged by onboard sensors. These onboard sensors are calibrated so that the deflection (in mm) of each independent arm can be reported at all points within the pipeline. This data is stored onboard the tool and downloaded for analysis on recovery.

The gauge tool arms were cleverly designed to allow the gauging of the 30 in. line with the 'tips', before switching over to a wheel when travelling in the 24 in. This wheel allowed for the physical appearance of the gauge tips to be inspected following the run. The project system was successfully run, picking up no deflections within the 30 in. line. The one deflection recorded on the tool was the transition from 30 - 24 in., shown in Figure 4.

Figure 3. Multi-hit SMART gauge system, 24 in.

Diameter measuring gauge system

Due to the significant change in internal diameter within the pipeline, wheeled suspension pigs were selected for use as the pig type for this multi-diameter project. This type of pig has an ability to maintain centreline running in all diameters, meaning it is a very effective carrier pig design for any SMART gauge system.

As an addition to the gauging tools already presented, a diameter measuring gauge system was developed to deliver an average internal diameter of the pipeline. The concept behind the system is to utilise the wheeled suspension system of the pig and measure the diameter the wheels are on throughout the pipeline run. Sensor systems embedded into the wheel technology allowed the system to provide a continuous change in diameter of the pipeline to an accuracy level of +/- 0.25 mm.

The diameter measuring system was added to Pig#3, together with the standard aluminium gauge plate. The results from the actual pipeline run far exceeded the expectations following the trials conducted at Propipe prior to field use. Examples of data:

- Figure 5 shows the transition of the pig from 719 - 564 mm through the pipeline reducer.
- Figure 6 shows the diameter measuring system recording the three variations of 24 in. pipeline after a transition from the 30 in. section.
- Figure 7 is a good example of how sensitive the system is to a change in diameter, as it shows the ability to detect a weld bead between pipe joints.

Data and technology

In addition to the SMART gauge OR diameter measuring technology, embedded inertial measurement sensors combined with pressure and temperature sensing provide a full picture of the internal pipeline condition to be built up. The example shown in Figure 8, shows the ability of the SMART gauge to detect weld beads and more specifically the difference between 'Factory' and 'Field' welds of the double pipe joint construction method used on the project.

All systems provided on the project were also SMART in the way they start-up and conserve battery life during operation. This is a key consideration when designing new products, as most of the time pipeline pigs are loaded weeks/months prior to offshore operations. All Propipe products can activate

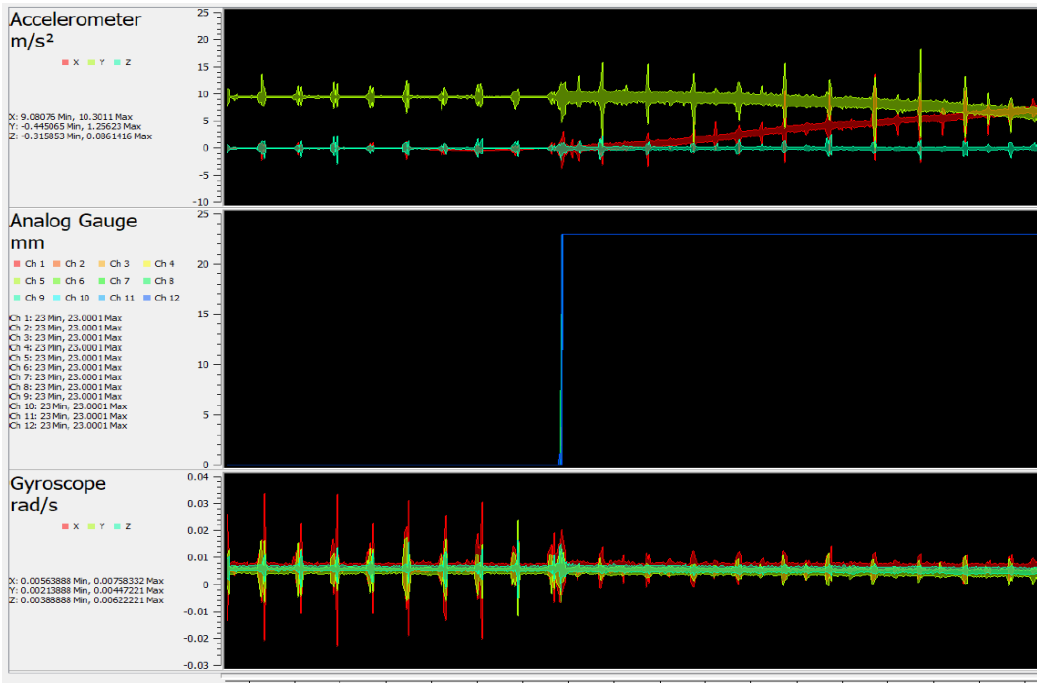

Figure 4. Transition data 30 x 24 in.

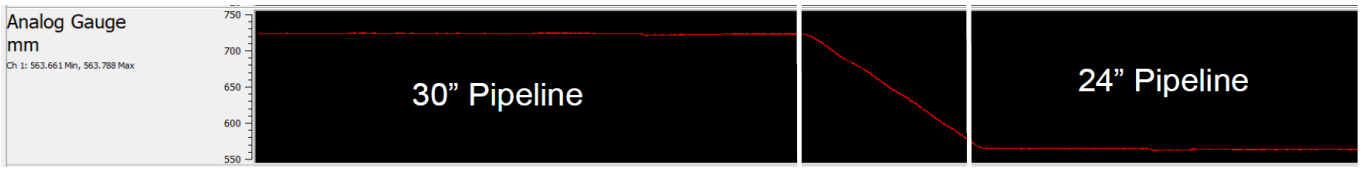

Figure 5. 30 x 24 in. transition data.

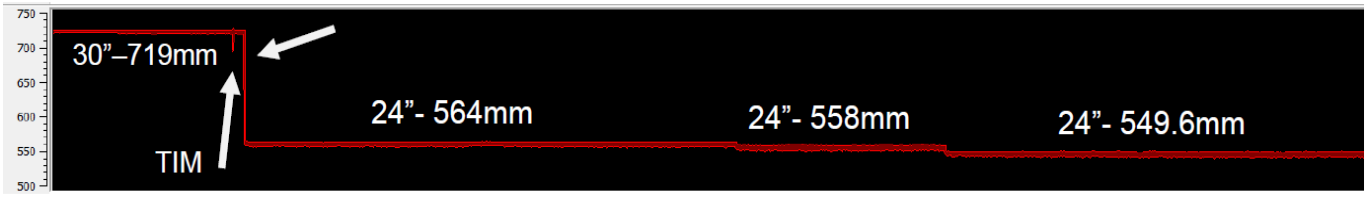

Figure 6. 2 in. pipeline sections.

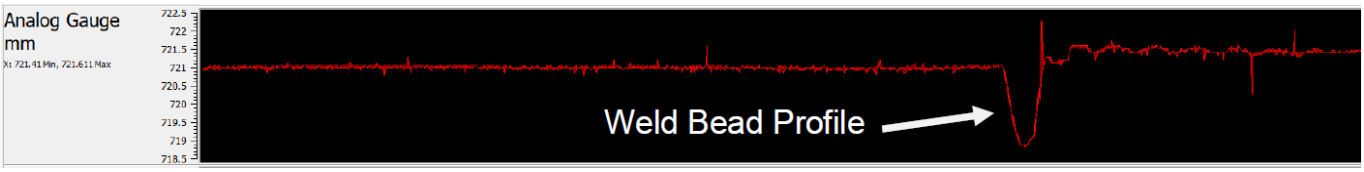

Figure 7. Weld bead profile.

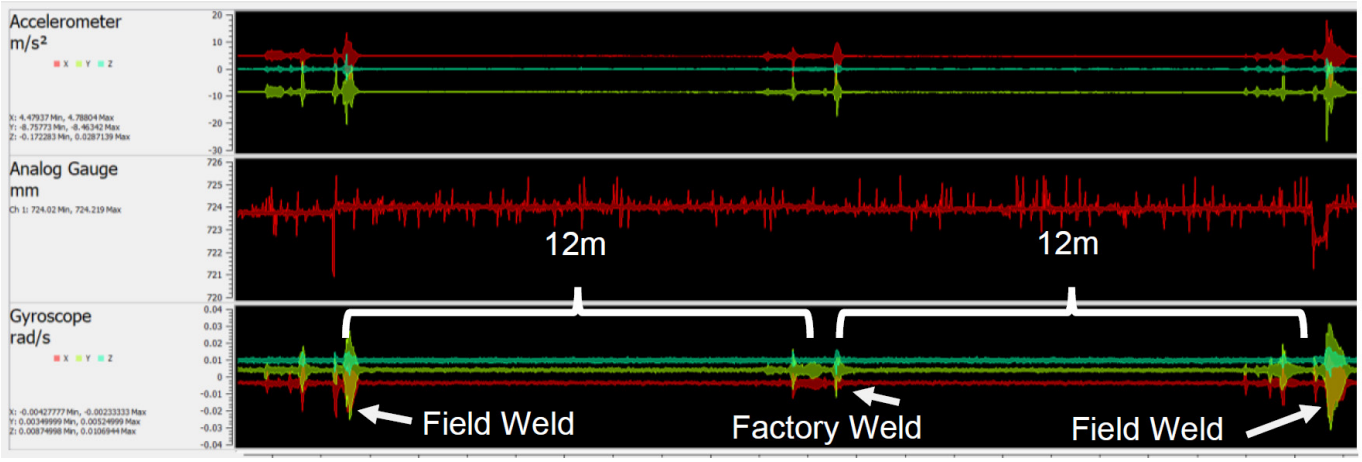

Figure 8. Field vs factory weld.

by pressure, water, timer delay, magnet – which mean the equipment is in an ‘OFF’ state during times when recording is not required. Furthermore, once the unit turns ‘ON’, battery life can be conserved further by only recording when the pig detects motion. All of this leads to a significant improvement in the battery life and the reliability of gathering data on even the more challenging projects.

At the end of the gauging run, all of the data is stored onboard the tool. Once recovered, the data can be analysed quickly using the dedicated PigView Analytics app. For some subsea operations, the recovery of the PLR is not immediate, which could be problematic. Whilst the full data cannot be communicated through the pipe, a ‘GO / NO-GO’ signal can. This signal can be delivered using either Acoustic OR Electromagnetic technology which is set to trigger on a pre-determined threshold.

Continued success

This example project shows the benefits of utilising such SMART gauge technology in a complex multi-diameter pipeline. The use of multiple technology within the same pig train, yielded the best possible data on this newly constructed pipeline. The selection of technology meant that systems overlapped, giving a 100% confirmation of the as-built condition.

The introduction of the diameter measuring tool provided success beyond all expectations, to the point that subsequent runs with the tool were completed during the dewatering operation after several new features had been added to this system.

Propipe continues to develop the Trident range and plans to introduce new technology to further support the industry, ensuring the ability to gauge pipelines that are currently beyond reach of existing technology.