Introduction

If a chain is only as strong as its weakest link, a pipeline is only as strong as its weakest weld. It's therefore not surprising that a huge amount of energy is expended on the process of welding pipes to tight specifications. This in turn can lead to bottle necks in the welding process if the specification cannot be easily met. OMS have worked with the industry owners, pipelay contractors and welders in order to develop solutions to these problems.

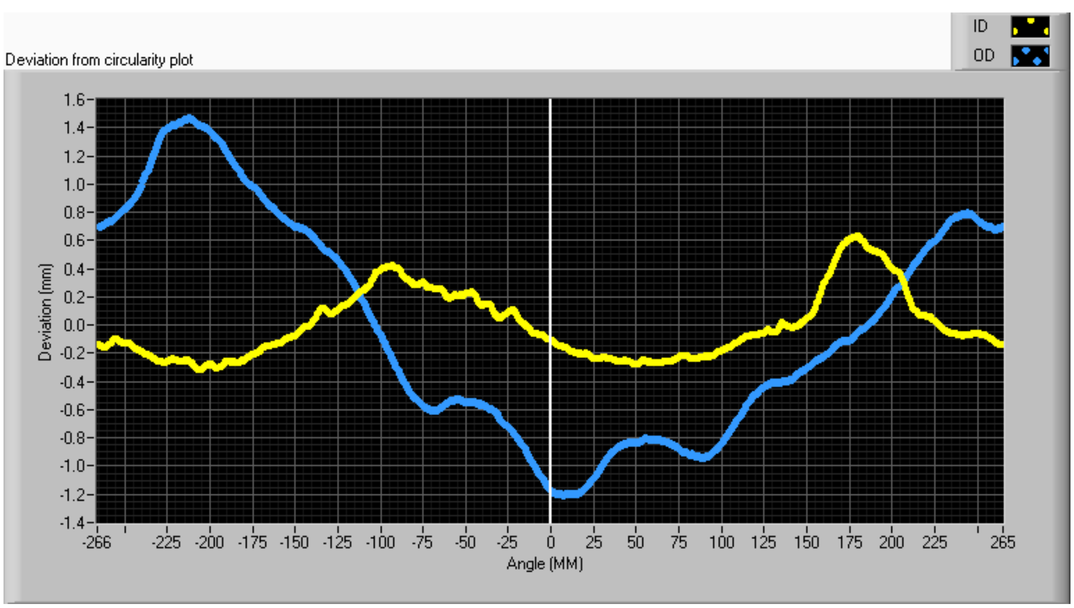
If pipes were round and of the same size there would be no fit up problems. Unfortunately pipes are manufactured by processes which are not perfect. The result is variations in size and shape. The knock on effect is problems in pipe fit up and hence problems with welding and fatigue life.

This problem has a solution, to be exact, a variety of solutions depending on the type of pipe and the clients requirements. These solutions have all been tried and tested on projects around the world from Africa and Brazil to theGulf of Mexico. Four examples are now given:

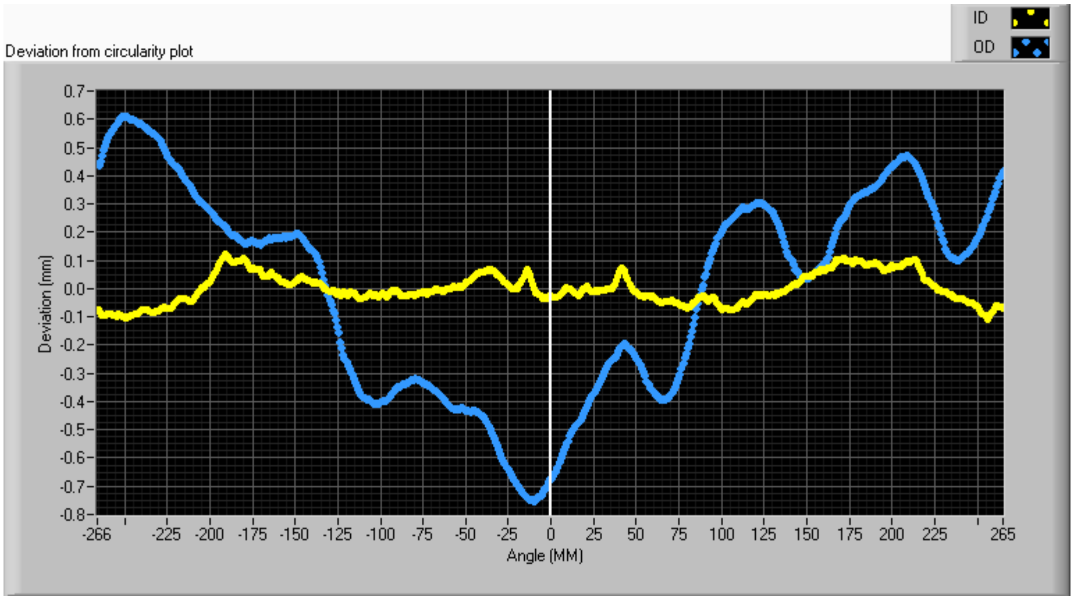
Example 1. Avoiding counterboring SCR pipes

'A pipe that is round with a constant wall thickness does not exist'. In looking at thousands of pipes of many different sizes and from many pipe mills, we have not seen one anyway. Out of round pipes will give welding engineers problems. There may be insufficient wall thickness to counterbore or the design engineers may wish to retain as much wall thickness as possible. If pipes cannot be counterbored, how can these pipes meet an exacting internal fit up specification when randomly bringing the pipes together would not achieve the required fit-up criteria (generally 0.5mm or less HiLo)?

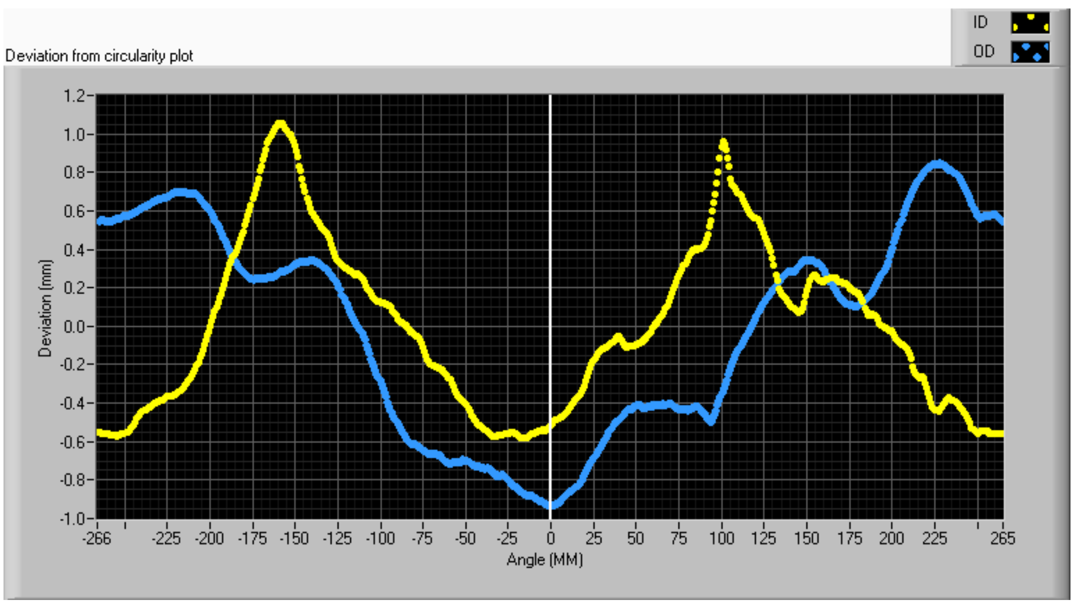
Some example pipe shapes are illustrated in the following graphs which are of pipes with average, maximum and minimum variations in the internal diameter from a set of pipes.



Average variation in ID (Yellow line) is illustrated in this graph by the yellow line. The blue line represents the relative difference in Wall Thickness. If two pipes of the same shape and size as this pipe were matched the result could be a HiLo of more than 0.85 mm.



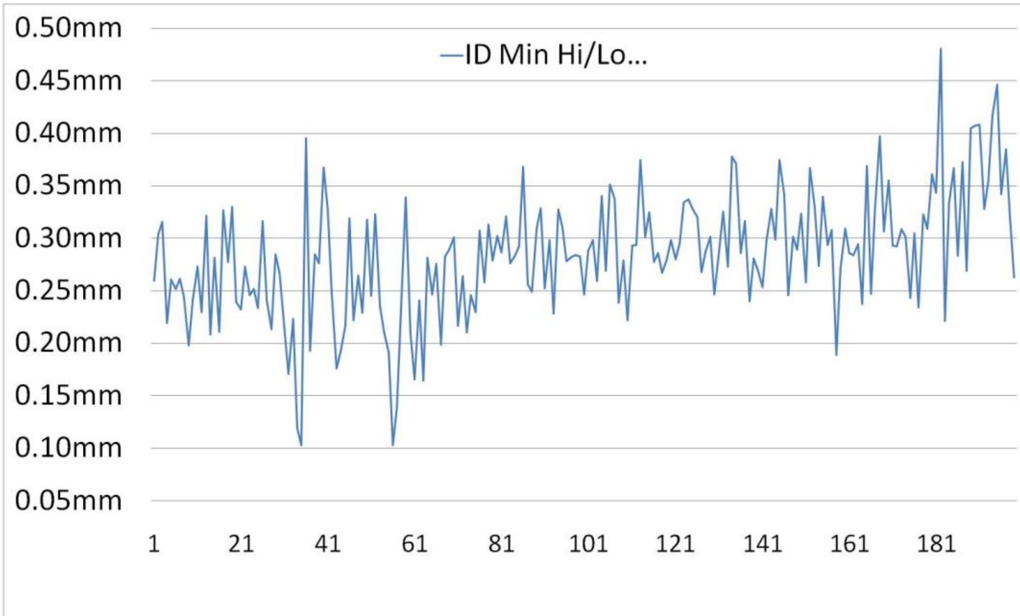
This graph illustrates the roundest pipe and the following graph illustrates the least round pipe.



This graph illustrates the least round graph with a variation in ID shape in excess of 1.6 mm.

The OMS solution to the problem presented by these pipes is to match the pipes together which are of the same size and shape. We have successfully managed a large number of projects, fitting together pipe which has not been counterbored, and have achieved fit-ups that have averaged better than 0.3 mm. Pipes can be used which have been cold end sized or directly without cold end sizing.

A typical HiLo maximum value graph is illustrated in the following figure.



In this case a HiLo average of around 0.3 mm was achieved. HiLo fit up average results between 0.25 mm and 0.35 mm are typical. A fit up of this level means that the pipes can be welded together with confidence that fit up will not be an issue for these pipes.

E.G. ATP Mirage, Callon - Entrada, BP - Greater Plutonio

Example 2. Avoiding wall thickness problems in SCR and Flowline pipe

Seamless pipes, by their nature, have very variable wall thicknesses. AUT (Automatic Ultrasonic Testing) requirements mean that the variability in the wall thickness in pipes can cause significant cost issues (i.e. if you are unable to construct a flowline or SCR with the minimum number of AUT scans). Furthermore, if the thick and thin parts of two pipes are brought together (pipes are usually lined up internally) then the outside of the two pipes will not match leaving an unacceptable HiLo difference (outside of the oil companies specification).

How has OMS solved this problem for its clients? There are a number of solutions. In one recent project in the US, the pipes were measured and sorted according to the required calibration blocks to be used for the AUT inspection. This sorting enabled the pipes that fell within a designated wall thickness range to be allocated to the more critical areas of the pipeline and the pipes that were more difficult to be fitted together were used in the less critical areas. A typical fragment of a SCR string with AUT cal block designations is shown in the following table.

03150_B	03042_A	Aut Cal Block Group B
03042_B	03074_A	
03074_B	03424_B	
03424_A	03533_A	
03533_B	03561_B	
03561_A	03260_B	
03260_A	03364_B	
03364_A	03152_A	
03152_B	03545_A	
03545_B	03485_A	
03485_B	03089_A	
03089_B	03060_B	
03060_A	03172_B	
03172_A	03292_B	
03292_A	03509_B	
03509_A	03471_A	
03471_B	03433_A	
03433_B	03427_B	
03427_A	03432_B	
03432_A	03516_A	
03516_B	03096_A	
03096_B	03443_A	
03443_B	03134_B	
03134_A	03149_B	
03149_A	03452_A	
03452_B	04326_B	
04326_A	03456_B	
03456_A	03411_A	
03411_B	03408_B	

03408_A	03121_A		
03121_B	03489_B		
03489_A	03507_A		
03507_B	03144_B		
03144_A	**03174_A**	Aut Cal Block Group A	Critical
03174_B	**03448_B**		
03448_A	**03618_B**		
03618_A	**03660_B**		
03660_A	**03655_A**		
03655_B	**03635_B**		
03635_A	**03546_A**		
03546_B	**03634_A**		
03634_B	**03624_B**		
03624_A	**03453_A**		
03453_B	03263_A		
03263_B	03049_B		
03049_A	03212_B		
03212_A	03276_A		
03276_B	03019_B		
03019_A	03233_A		
03233_B	03428_A		
03428_B	03543_A		
03543_B	03295_A		
03295_B	03499_A		
03499_B	03488_B		
03488_A	03204_B		
03204_A	03258_A		
03258_B	03457_A		
03457_B	03380_A		
03380_B	03283_A		

This identification meant that there was the least possible disruption to the fit-up process.

Another example involved assessing pipe dimensions in real time and marking pipes accordingly so that problem pipes were welded onshore and not offshore where they could have delayed production.

This example is illustrated in the figure above where a colour code end marking has been put onto the pipes. In this case the dual markings are because the pipe was measured at both 20 mm and 100 mm into the pipe and indicate that these pipes can be segregated into a pile where these pipes can be used both offshore and onshore.

Yet another example utilised the OMS visualisation software in the firing line to simultaeously optimise both the ID and OD fit-up between the pipes.

E.G. Petrobras - Cascade Chinook, BP Thunderhorse, Shell BC 10.

Example 3. Avoiding bad fit up delays on board “J-lay” vessels

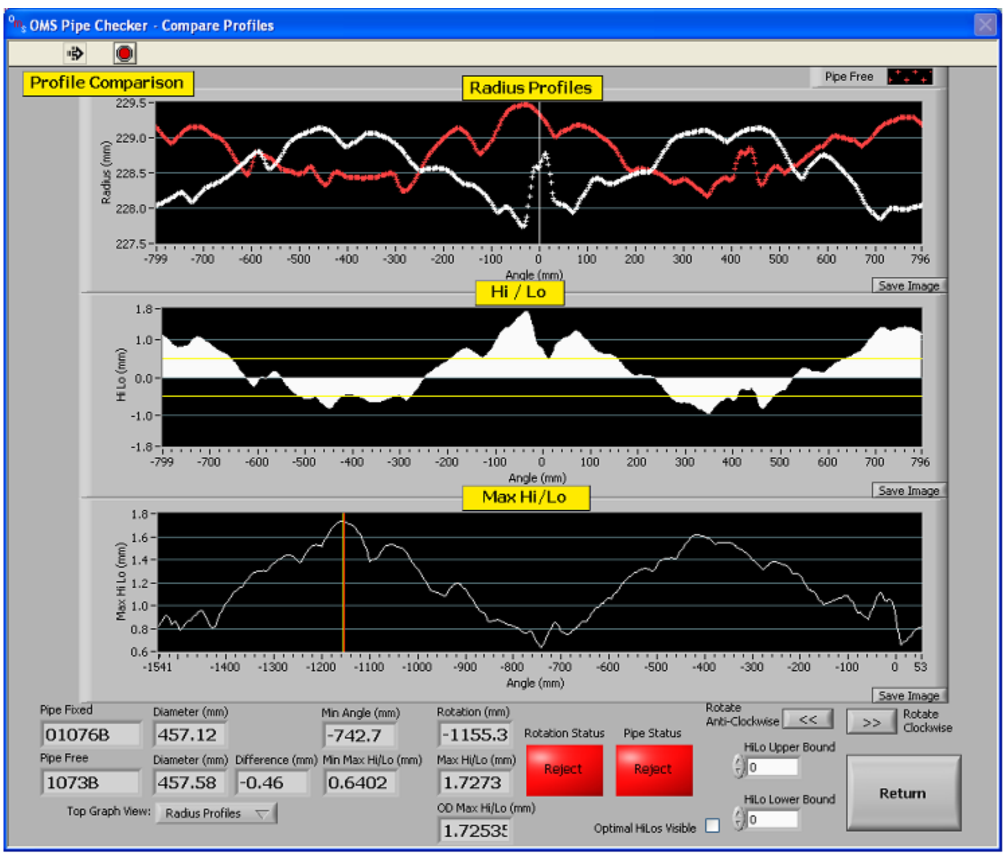
When a quad, quin or hex is raised in the tower and butted onto the previous set of pipes (that has been lowered into the water) the weld must to be completed as quickly as possible to maintain the pipelay schedule. When a pipe does not make the HiLo requirement it may have to be lowered back to the deck and a replacement pipe used. Alternatively the pipe may have been be welded and then the hi/lo is measured and then a cut out may result due to the excessive HiLo.

The OMS solution is to measure the pipes onshore and then give the client software which enables them to visualise the fit up before they put the pipes into to the firing line. A rotation of the pipe can be performed to gain the best fit possible or, if a fit-up is not possible at all, the pipe can be put to one side and a better candidate selected. Our clients report that this methodology has completely solved all welding and fit-up problems for them on board the pipe lay vessels.

The system works by knowing what the fit up problems are likely to be before you have them and then offers a solution to deal with them. In our experience most fit ups can be dramatically improved by early identification of shape and by rotating the pipes in respect to each other. OMS software identifies the rotation required and the pipe just needs to be rotated to the correct rotation before welding. This scheme works well for oval pipes as you just match the two ovals together to solve the problem. It also works for other misshapen pipes. In the few cases that this solution will not work – for example when you are trying to match a round pipe and an oval pipe or when the pipes are both different in size and shape - the pipe is held back until it can be fitted up to a similar pipe. It is only pipes which are damaged or have a serious manufacturing defects that cannot be used at all.

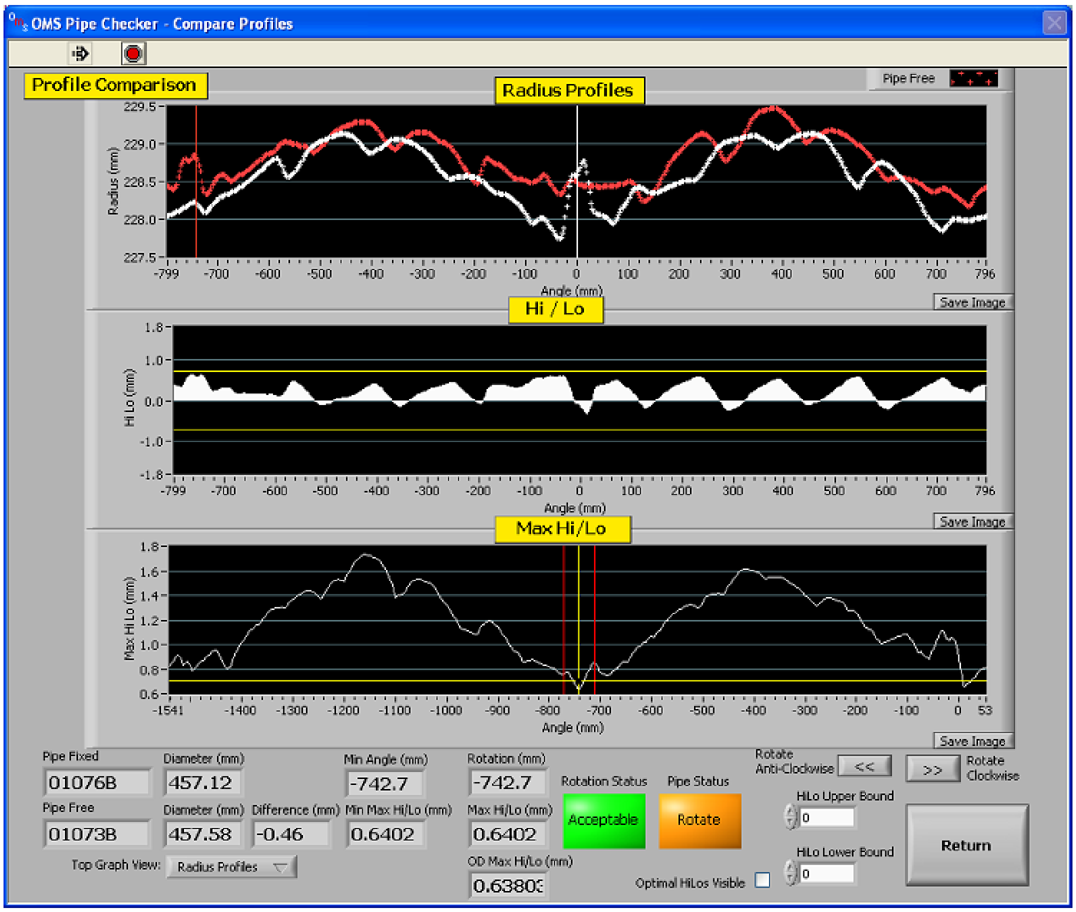
How can you never introduce a fit up problem to the firing line? The following two graphs explain the process:

The first figure illustrates the worst case fit up of two 18” pipes.



The top graph is the radial distance from the centre of the pipes – both of them are oval. The middle graph is the HiLo fit up plot showing that mismatch between the pipes would be more than 1.7 mm.

The next graph show what happens when you rotate the two pipes into the best rotation position.



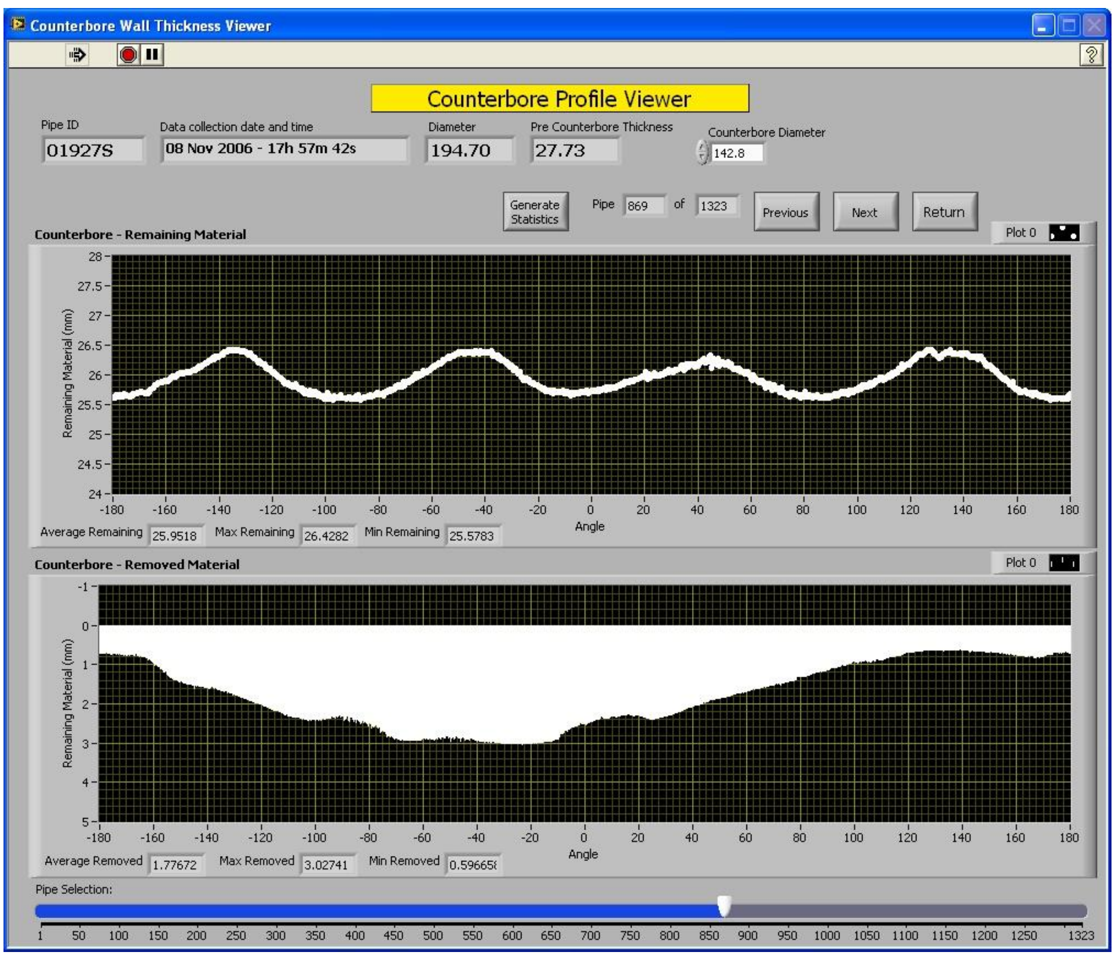
Here you can see that the two pipes are now meshed together and the maxim HiLo anywhere around the pipe could be as small as 0.7 mm. Much of the HiLo is caused by the difference of 0.46 mm between the two diameters of the pipes.

When required OMS can take this process as step further and create a SCR (HiLo < 0.5 mm) quality fit up for large UOE pipes by additionally sorting the pipes into sizes and shapes that will match together almost perfectly consider the pipe shape variations. Complete critical SCR pipes or fatigue sensitive pipes have been laid using this method with Hi/Lo's achieved of 0.5mm or less.

E.G. Shell Amberjack, Technip PDET and Simian Sapphire

Example 4. Avoiding pipe geometry problems by counterboring

The ultimate method of solving pipe geometric problems, which by now the reader will have gained an understanding are both common and expensive, is to take the step of attempting to create a perfectly round pipe. This is typically achieved by counterboring the pipes to a specific size. You would imagine that this would be an easy process, however reality is that pipes not only vary in shape but also in size. As a consequence, counterboring to one size might mean that considerable sections of some pipes would be missed and not be conterbored at all whilst in other pipes it might mean that the wall thickness was reduced too much (resulting in the pipe being out of specification). Neither situation is acceptable. What OMS provides is the measurement and analysis solution that removes minimal wall thickness (by producing counterbore groupings) so that no partial counterbore or wall thickness problems occur. Our extensive experience of undertaking this type of work has resulted in a system that has been proven to give maximum utilisation of the pipe material for each pipe.



This figure give an indication of the material that would be removed from a pipe during counterboring. The amount of material varies from a little more than 0.5 mm in one location on the pipe to as much as 3 mm in one area. The resulting wall thickness of the pipe varies by less than 0.8 mm after the machining process has been completed. OMS tools can be used to measure the pipe shape before counterboring in order to determine the right counterbore group size and then to measure the pipes after counterboring in order to ensure that the counterbore tool performed correctly.

E.G. Chevron/Subsea7/Petrology Blind Faith and Shell/Subsea7/Petrology BC10

Conclusion

OMS specialise in providing value added solutions to the pipe laying process. We additionally supply tools to measure a wide variety of dimensional features on pipes. For more information regarding our pipe measurement technology and/or if you would like a discussion regarding any fit-up issues please contact:

sales@optical-metrology-services.com

Denise Smiles
Optical Metrology Services Limited
11 Twyford Business Centre
London Road
Bishops Stortford, Herts CM23 3YT

Tel +44 1279 656038
Cell +44 7943 810118

Marcus Janes
Optical Metrology Services USA LLC
17421 Village Green Drive
Houston
TX 77040

Tel +1 832 230 0153
Cell +1 832 654 7551