

ENHANCING PIPELINE WELDING WITH EXTRUDABLE PLUGS

By Michal Szczegolski, Aubin Group, UK

Executive Summary

During offshore pipeline installation welding engineers must find a solution to overcome the suck and blow effect of the gas in the pipeline. This effect can be removed by using temporary plugs. These plugs need to remain stationary in the pipeline to create a suitable environment inside the pipe to perform the welding operation.

In 2016 Aubin provided elastomeric plugs designed to resist a small pressure differential, to temporarily block the pipe, allow welding operations and then be extruded through a subsea discharge port.



Fig. 1: Extrusion of welding plug using 1.5" port from 4" pipe

Introduction

To achieve good quality joints between duplex pipes the weld needs to be performed in an environment free of atmospheric gases. Pipe purging dams (plugs) are the most commonly used, where two plug dams are placed either side of the weld. The space between the dams (Fig.2) is filled with inert gas that flushes out the air.

*"The presence of oxygen, and to a lesser extent nitrogen, around the molten weld can lead to wide-ranging defects. Discoloration is unsightly and in some instances might produce metallurgical imbalance, especially with some stainless steels. Gross oxidation inevitably results in reduction in mechanical properties and can cause catastrophic loss of corrosion resistance. Nitrogen contamination can result in brittleness. Gases in the weld may give rise to cracking during or after cooling."*¹

Over long lengths of pipe, temperature changes can cause pressure differentials in the pipe which can displace the inert gas, described as the "suck and blow effect".

During pipeline installation, the suck and blow effect comes from the reel side where air movement appears to be promoted by changes in temperature and from the subsea side where movement of the pipe in the catenary causes air movement (more prevalent in flooded or partly flooded pipe).

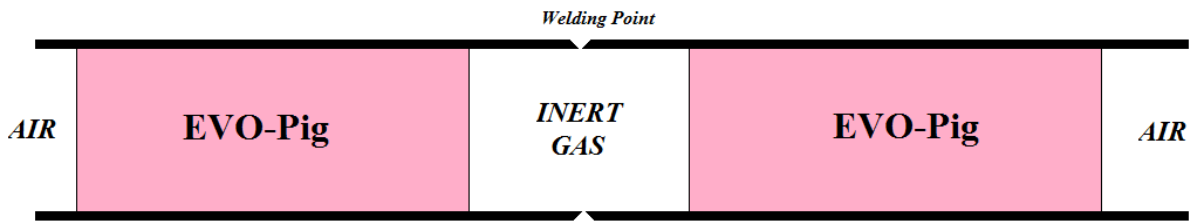


Fig. 2: The weld purge concept. Seal the pipe each side of the joint with dams and flush out the air with inert gas

Challenge

In 2016 Aubin received a request to create an extrudable plug in a 2" service pipeline to help perform a good quality weld on duplex pipe. In the absence of a receiving point, the intention was to extrude the plug through a 1" subsea port.

Criteria

The plugs were required to hold a differential pressure of approximately 0.5bar for 24 hours and withstand temperatures of up to 70°C generated by the welding operation. It was also hoped to be possible to displace and extrude the eight welding plugs during one operation through a small 1" port on the subsea manifold.

Additional requirements for the plugs included being quick and easy to insert mechanically, without a flanged connection and no contact between the duplex pipe and any metallic loading tools.

For testing purposes, the client provided a bare pipe (Fig: 3) and requested an extrudable plug which would hold minimum 0.5 bar differential.



Fig. 3: 2" Duplex service pipe

Description of Technology

Aubin proposed its elastomeric EVO-Pig as a potential solution to this challenge. The rubberized physical properties of EVO-Pig allow it to form an excellent hydraulic seal. EVO-Pig retains a “memory” of its original shape, so there is a restoring force constantly acting outwards onto the pipe wall. This restoring force creates a degree of friction on the pipe wall, with more severe restrictions requiring higher differentials to move the EVO-Pig. Upon reaching a threshold of shear for example when encountering a reduction greater than 50%, EVO-Pig tears apart with relatively low differential pressure. These properties were used to an advantage in this case study, with the EVO-Pig being extruded through a small 1” port on the subsea manifold.

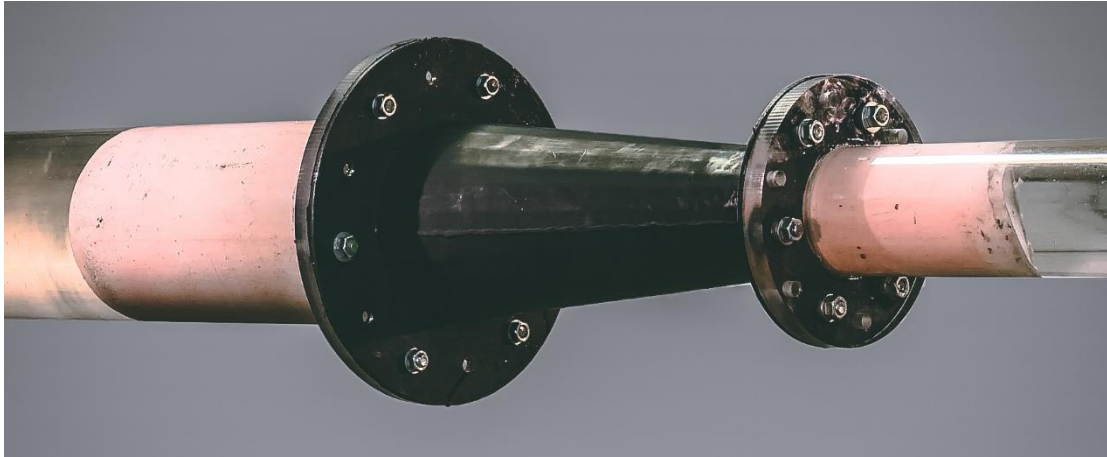


Fig. 4: EVO-Pig expanding from 4” to 8” in concentric reducer.

Design and Qualification

With confidence in the ability to extrude EVO-Pig (Fig.4) based on historical evidence, the development process mainly focussed on an investigation to determine how the oversizing of EVO-Pig governs the differential pressure required to move it. EVO-Pigs with different diameters and lengths were cast and placed separately into the 2” test pipes (as depicted in Figure 3) and the pressure required to move them from stationary position was measured.

The more challenging stage of this project was to develop a suitable inserting device able to meet all the design criteria. Based on a domestic silicone gun concept, Aubin designed and manufactured a plug cartridge dispenser as shown in Figures 5 and 6.

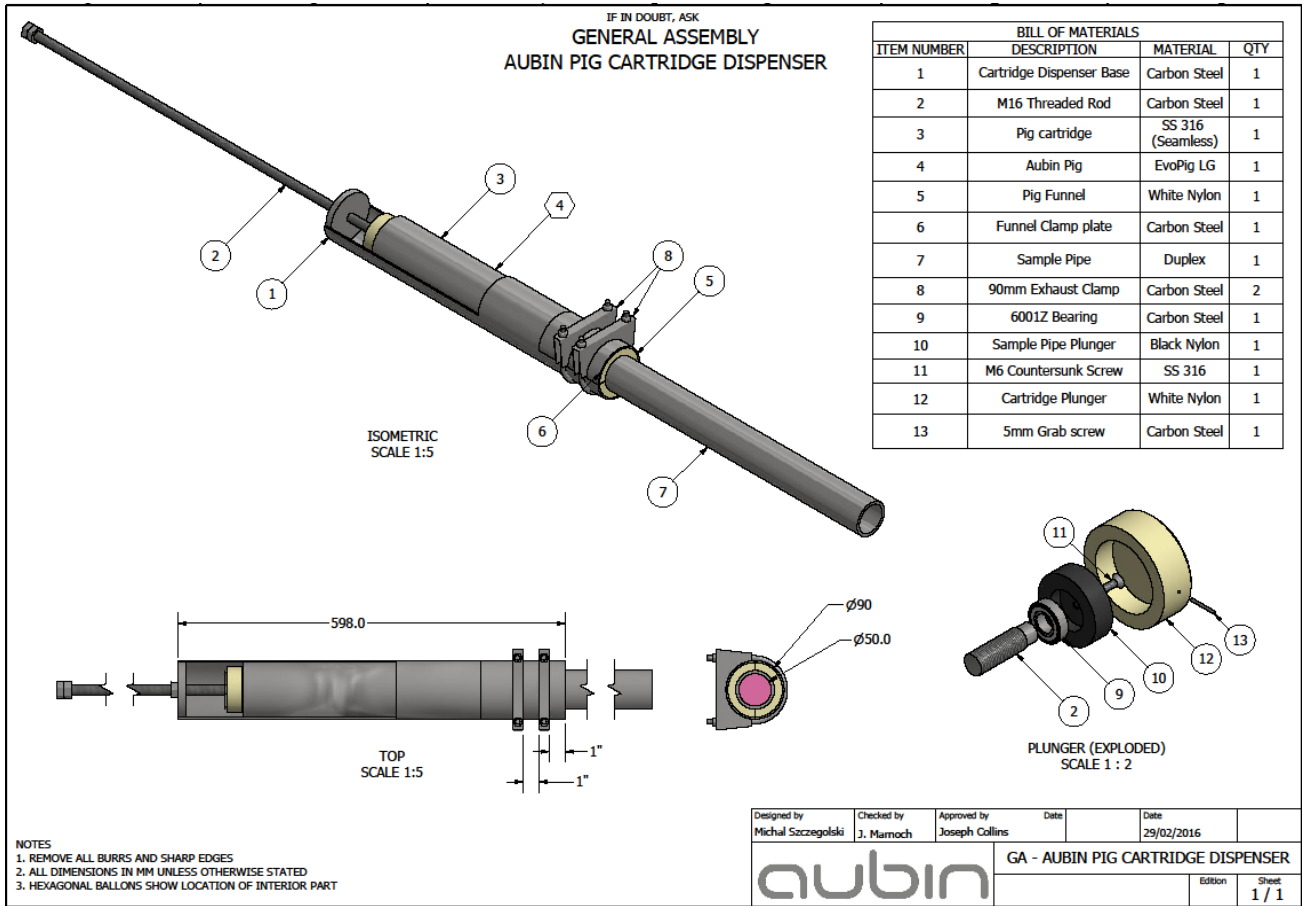


Fig. 5: Assembly drawing of plug dispenser

To accelerate the process of inserting the plug, an 18V cordless drill was used to rotate the threaded bar which pushed the EVO-Pig into the 2" pipe.

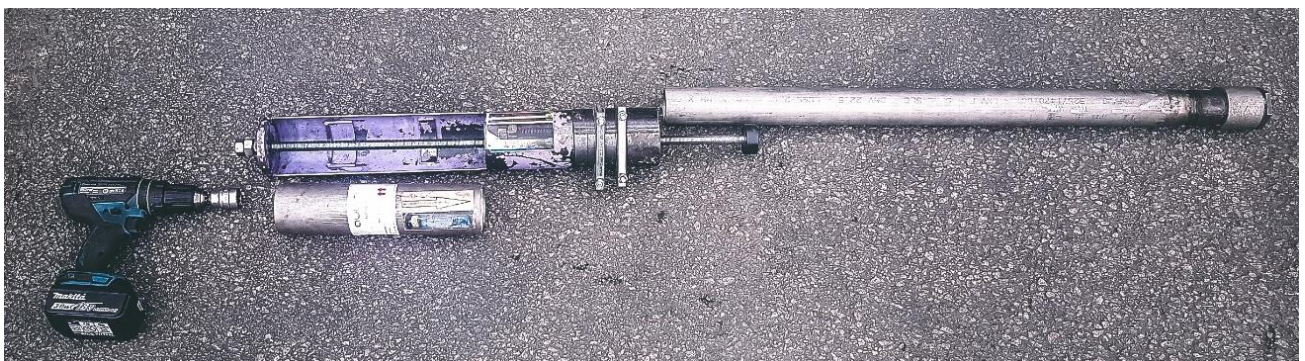


Fig. 6: Prototype plug inserting tool, utilised twice for offshore operations

This cartridge dispenser met all the requirements and allowed successful deployment of a plug in under 4 minutes.

Tests in 2" pipeline

It was observed that an EVO-Pig was capable of holding a constant 1 bar differential for 24 hours and 2.5 bar of pulse pressure in a 2" pipe (49.27mm ID) when oversized by 41%. Upon insertion into the 2" pipe the EVO-Pig deformed (Fig. 6) to occupy 450mm length. This temporary plug was then extruded through a 1" ball valve with 7 bar of pressure.



Fig. 7: Full size EVO-Pig and canister and EVO-Pig removed from 2" pipe after few weeks

After a few weeks (depending on the temperature) this EVO-Pig LG will deform permanently to the internal dimension of the pipe and will require much less pressure to remove from pipeline (fig.7).

Tests in 4" pipeline.

In a 4" pipe (92,1mm ID) EVO-Pig (fig. 8) was able to hold constant pressure of 2 bar for 48 hours and 4 bar of pulse pressure when oversized by 80% as shown in Figure 8. This plug occupied 1230mm length in the pipe. This above pig can be extruded through a 1" ball valve with 10 bar of pressure.



Fig. 8: Fresh EVO-Pig removed from manufacturing canister alongside 4" pipe

The temporary plugs were observed to extrude completely with no remnants left inside the pipe, as shown in Figure 9:



Fig.9: Extrusion of 4" diameter 1230mm long welding pig

Summary

Aubin qualified EVO-Pig for use as a temporary, extrudable welding plug. In the field these plugs performed perfectly, as per the testing phase. The plugs were inserted into three different dry lines, approximately 30Km long. The plugs were left in the lines for seven months, before being extruded through a 1" port subsea. The client is now considering using these plugs in other welding and plugging operations in 10"ID and 11"ID pipes, particularly where extrusion is the only method of exiting the pipe.

Valuable feedback from the client led to an improvement in the loading tool by using a trapezoidal thread to reduce wear compared to the M16 threaded rod.

References

1. <https://www.bssa.org.uk/cms/File/Huntingdon%20Fusion%20article%202.pdf>

Stainless Steel Pipe Fabrication Dr M J Fletcher, Delta Consultants, Rutland UK