# Laying of a duplex steel pipeline in the north of Germany

**An interview with Mr Moritz Fankhaenel and Mr Jan Holtvlüwer of PPS Pipeline Systems with Jürgen Krüger of Polysoude**

*Fig. 1: Mechanised orbital TIG welding of a Duplex pipeline*

## Introduction

The project to add a manifold to the existing pump station for storage facility water, at Rühlermoor in Lower Saxony (Germany) and to connect it to the station Adorf, by a 10.7 km long field pipeline, was completed in 2017, after a long period of complex preparations. As suggested by the name 'Rühlermoor', the area consists of moorland with swampy ground, ill-suited to moving heavy equipment. The pipeline had to cross a nature reserve, a circumstance which hindered the authorisation proceedings. In addition to the lengthy and complicated approval processes for this kind of construction work, specific licensing procedures and environmental impact assessments had to be carried out. Consequently, the time span allocated for the installation of the pipeline in the field was extremely short.

The client of the project, Exxon Mobil Production Deutschland GmbH, awarded the contract of the pipeline installation including the tie-in to the two related stations, to the company, PPS Pipeline Systems GmbH. Applied welding technology was key in this installation as the short delivery time required fast welding, whilst the delicate Duplex steel of the pipeline will only retain its mechanical characteristics and corrosion resistance when treated in accordance with the specified instructions. Furthermore, the material properties were such that any subsequent repair welding on the pipeline was ruled out. Above all it was clear from the very beginning that losses of the joint quality would not be acceptable.

PPS owns and operates modern welding equipment, which allows for improved productivity, when used in conjunction with Orbital TIG Welding to join pipes, whilst at the same time, maintaining extremely high joint quality. Unlike their competitors, PPS had already gathered a considerable degree of expertise in mechanised welding of Duplex steel pipes in the field: a similar project for Exxon had been finished successfully in the year 2015.

## Main features of the pipeline

### Characteristics of the pipeline

The pipeline is composed of pipes DN 200 (8"), PN 40, made of Duplex steel mat. 1.4462, heat insulated with PE casing pipe OD 315 x 12.00, it is designed for working temperatures between -10 °C and +80 °C and a working pressure of 40 bar. The longitudinally welded pipes with an OD of 219.1 mm and a wall thickness of 4 mm have a length of 12 m each, for zones with higher stability (e.g. street crossings) seamless tubes with a wall thickness of 5,6 mm and lengths between 6 and 8 m are used (the overall length of these tubes amounted to 2,000 m).

### Characteristics of Duplex stainless steel

Duplex stainless steel takes its name from a two-phase microstructure, in which small islands of austenit are embedded in a ferritic matrix, both phases at a ratio of roughly 50:50. This material is characterised by excellent strength, it shows good toughness and ductility and, depending on the grade, provides resistance against a wide range of corrosive media.

Welding of Duplex steel is generally possible, but the extraordinary properties of the material can be easily deteriorated by inexpert processing. In particular, the specific heat input and the interpass temperature are rigorously limited, if exceeded the resulting modifications of the material composition and the formation of coarse grain structures can cause disastrous consequences for the mechanical characteristics and corrosion resistance of the joints.

*Fig. 2: Pipeline laying in the field*

## Installation of the pipeline

### Flow of work in the field

Welding activities need to be protected against sand, dust, draught and humidity. In view of the unfavourable weather conditions in the north of Germany instead of the commonly installed tents for pipeline laying, a container had been selected and prepared as a welding booth.

The pipes were stored behind the welding booth (Fig. 2 left of the blue container). One after another, they were to be introduced through a hole in the back and aligned to the end of the last pipe of the already finished segment, which exited through an opposite hole in the front of the booth. The extremities of the pipes were butt welded together, then the segment was pulled out until the second end of the recently joined pipe arrived in the correct position and the entire procedure could be repeated.

The finished segment of the pipeline was supported by roller blocks (Fig. 2), as the interruptions of the insulation still had to be completed, before the structure could be lowered to its final position.

During the preparation of the path for the pipeline the fertile surface soil had been stocked separately (Fig. 2 right of the finished pipeline segment) from the sand which arose when the pipeline trench was dug. After laying, the pipeline had to be covered by at least a 1.2 m thick layer of sand before the post-construction restoration could be started.

## Welding technique

### Importance of the joining technique

The achievable progress throughout the whole pipeline laying process depends exclusively on the efficiency of the joining technique. Thus, the foremost goal of an operation of this type must be to establish a fast and reliable process which, when applied on site, is not susceptible to failure.

## Approval procedure

The approval procedure is a very important step to ensure the expected productivity of the welding operations on site. A realistic simulation of the working conditions allows operators and welding personnel to become familiar with the particular requirements of their mission. Welded coupons are visually inspected for the appearance of the welding seam, the weld geometry and the occurrence of coloration. Later on, the joints are examined for adequate mechanical properties and sufficient corrosion resistance. If the attained results meet the stipulated targets, the welding parameters can be optimised to reach highest efficiency. Although, at this stage, it is often a priority to increase the welding speed as far as possible, it should be taken into consideration that ultimately, a stable welding process is the main key to enhanced productivity. Even slightly reduced welding speeds are acceptable, if unintended interruptions of the weld cycles and time-consuming reworking can be eliminated.

The approval procedure is generally accompanied by the final release of the qualified welding procedures for production, given by an independent supervisory body. The outcome is a document with exact and complete instructions as to how to carry out the welds; this WPS (Welding Procedure Specification) must be applied with binding effect by everybody involved in the joining process.

## Welding equipment

Besides the experience of the engineering department, the competence of the welding personnel and the skills of the operators, the suitability of the welding equipment plays a significant role during approval and production. For the Rühlermoor project, PPS had selected an Orbital TIG welding installation, which had been designed and manufactured by the French company Polysoude, a global leader in the area of automated TIG welding and cladding technologies.


*Fig. 3: Power source P6 for orbital TIG welding*

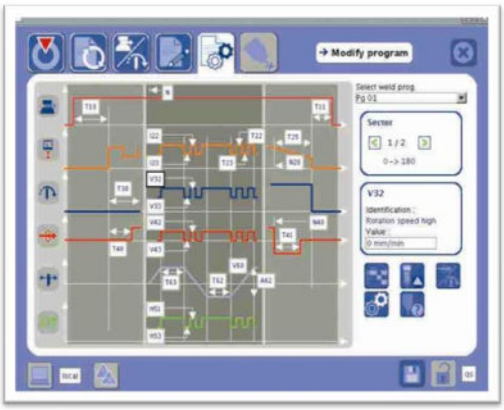


*Fig. 4: Intelligent graphic user interface of the power source*

For easy communication, the power sources of the P6 series (Fig. 3) provide an intelligent graphic user interface (Fig. 4). Empowering search functions help to find appropriate weld cycles with proven parameters in the integrated data base or, as in the case of the Rühlermoor project, well-tried welding programs from former applications can be modified to fit the actual conditions.

To accelerate the phase of development, the whole range of welding parameters is presented in a clear and comprehensive manner, all are easily accessible and, within the limits of the installation, they can be modified as required. During a welding cycle, the incorporated real-time data acquisition system indicates the relevant welding parameters on the screen, modifications are monitored immediately and their effects on the welding result can be evaluated by the experts.

In the production mode, the real-time welding parameters are monitored as well, but only a few selected values can be modified by the operator. Thus, in case of an incident, he can react on his remote control pendant and try to avoid an interruption of the welding cycle in progress, but he will always remain within the permissible limits specified in the WPS.

The orbital welding head (Fig. 5) is a device which is fixed on the pipe by a clamping system with the intention of guiding the welding torch along its circumference. The name "orbital welding" stems from the circular movement of the welding tool on an orbit around the workpiece.

*Fig. 5: Orbital TIG welding head in action with pulsed current; during the phase of high intensity (pulse current) full penetration is achieved*

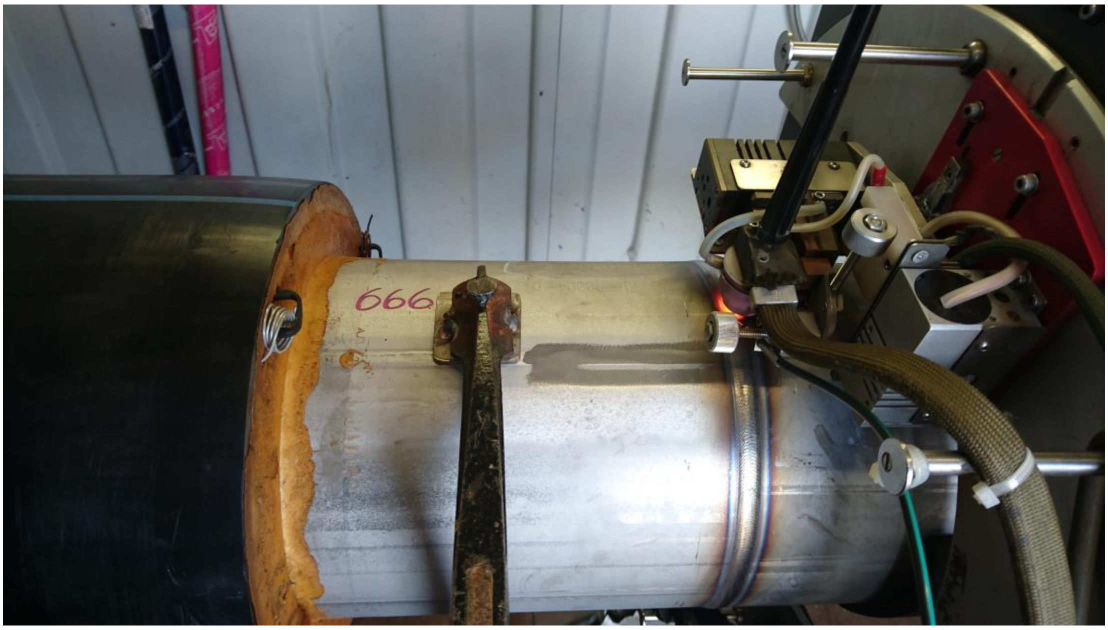


*Fig. 6: Orbital TIG welding with pulsed current, during the phase of low intensity (background current) the weld pool is stabilised*

Successful orbital welding depends on a reliable control of the bath of molten metal during the whole weld cycle, taking into account the influence of the continuously changing position of the torch and the increasing temperature of the pipes. The most effective measure to keep the control of all weld positions during the orbital weld cycle is to use pulsed weld current where the current intensity switches periodically between two different levels. During a specified time period the weld current remains at a high level (pulse current), the volume of the weld pool increases to its maximum and the desired penetration can be achieved (Fig. 5). Afterwards the current intensity is reduced to a lower level (background current), the weld pool cools down and its volume decreases to a minimum, so that any adverse gravitational effects can be mitigated. (Fig. 6).

## Joint quality

A great deal of attention must be paid to producing an excellent root pass, as this not only serves as the foundation for subsequent filler passes, but is also in direct and continuous contact with any aggressive medium passing through it. The recommended pipe end preparation for Orbital welding is a J-Preparation (Fig. 7).

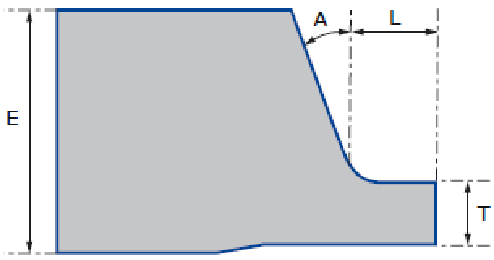


*Fig. 7: Recommended J-preparation of the pipe ends for successful Orbital TIG welding of the root pass*

The geometry of the J-preparation can be perfectly adapted to the requirements of the process, the thickness T of the lip is chosen to allow full but not excessive penetration of the weld in all positions. By means of mobile cutting machines, the pipe end preparation is carried out on site just before the welding operation begins (Fig. 8), so that any subsequent contamination of the welding gap can be excluded.

*Fig. 8: Correct pipe end preparation is carried out on site before the welding operation and checked by means of a template*

In the case of stainless steel, heat tint of the welds is a serious concern, as it can considerably lower the corrosion resistance of the material. The coloration of the Heat Affected Zone (HAZ) at both sides of the weld seam (Fig. 6) on the outside of the pipeline is tolerated, as it can be removed completely, by means of a specially designated wire brush.

However, in the interior of the pipeline the occurrence of any coloration or heat tint is not acceptable. The welds must present a blank metallic surface, in accordance with the rest of the pipes. Therefore, a backing gas chamber is installed inside the pipes, the entire area which is heated up during the weld, is protected by a flow of pure argon gas. The resulting smooth surface of each joint welded is documented by video. (Fig. 9).

After the removal of the backing gas chamber there remains no possibility for further gas protection from the inside of the pipeline, for this reason the need for any subsequent repair welding must be eliminated, as was the case at Rühlermoor.


*Fig. 9: Capture from a video of the blank metallic surface at the inside of the joint (welding shown in Fig. 6)*

**Productivity**

For the entire Rühlermoor project, 1,035 welded joints had to be realised; 877 of which were produced by mechanised welding. The joints of the pipes with a wall thickness of 4 mm are composed of the root pass, three filler passes and a cap pass. For the filler passes and the cap pass torch oscillation has been applied. Besides visual controls a 100 % video documentation of the inside of the roots and a 100% x-ray examination were carried out.

The planning period of 13 months was followed by 8 months of work on site, the installation of the pipeline started on 14 March 2017 and finished at the end of October of the same year.

To carry out the welds, two welding teams were employed, which had at their disposal two Polysoude power sources of the type P6 and two MU-type Orbital welding heads (as shown in Fig. 5).

The arc time to complete a joint between the pipes with a wall thickness of 4 mm amounted to one hour approximately; generally, during an 8-hour shift 6 welds were produced.

## Conclusion

In most cases, the installation of pipelines has to be carried out under tremendous time pressure. Mechanised welding is not dependent on the availability of skilled welders, so a more accurate planning of the work progress is possible. Orbital TIG welding is renowned for outstanding quality and high reliability even under harsh environmental conditions. Due to the commonly achieved result of 100 % defect-free welded joints, unintended interruptions of the work and time-consuming reworking can be eliminated.

The final success of the Rühlermoor project was achieved due to a sound contractor with efficient engineering, experienced welding experts, skilled operators and sturdy state-of-the-art welding equipment.

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Author: Jürgen Krüger

- Interviewees Mr Moritz Fankhaenel (On-site welding manager) and Mr Jan Holtvlüwer (project manager)
- All photos are courtesy of PPS Pipeline Systems GmbH