MEC (Extended SLOFEC) and UT External Pipeline Inspection Report

Client	**Client**
Facility	**Client's Gas Field**
Items Inspected	**12'' and 6'' Downstream Pipeline and Tie-in-Spool Sections**
Inspection Method	**MEC (Extended SLOFEC) and UT**
Date Commenced	**29th May 2013**
Date Completed	**1st June 2013**
Type of Report	**Final**
Report Number	**Kxxxx**

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PIPELINE

EXTERNAL INSPECTION REPORT

Using MEC and UT

Prepared for

Final Report: Kxxxx

Rev	Document	Author		Checked		Approved By		Date
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0	Issue to client for comment	TB		KR		AB		17/June/2012

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Disclaimer

Contents

1. Executive Summary

The inspection of the Client's offshore gas pipeline sections (XXX 5, XXX 4, ZZZ and YYY 2) has been carried out between the 29th of May 2012 and 1st of June 2012. No major defects have been detected. Three minor indications have been detected at the YYY 2 6'' Tie-in-Spool Section. All of them are pit-like and internal with a depth of close to 20 % wall loss.

2. Inspection Execution

2.1. Task

Innospection Ltd. has been asked by the Client to inspect several sections of the Client's offshore gas pipelines using the MEC (Magnetic Eddy Current) technology and ultrasonic testing (UT).

The inspected components are:

- XXX 5 12'' Downstream Pipeline Section (Priority 1)
- XXX 4 12'' Downstream Pipeline Section (Priority 2)
- ZZZ 12'' Downstream Pipeline Section (Priority 3)
- YYY 2 12'' Downstream Pipeline Section (Priority 4)

- ZZZ 6'' Rigid Tie-in-Spool (Priority 1)
- YYY 2 6'' Rigid Tie-in-Spool (Priority 2)

The main focus of the inspection has been laid on the detection of internal metal losses, e.g. caused by top-of-line corrosion. The MEC technology which is the next generation of fast corrosion mapping technique based on the further development of the SLOFEC technique was built into the MEC Combi Crawler tool (ref. 2.3) to allow for an external inspection of the subsea pipeline.

2.2. Inspection Objects

The inspected 6'' and 12'' pipeline sections are part of the XXX, YYY and ZZZ gas fields located offshore. The 12'' pipelines downstream of each inline tee exhibit a wall thickness of 18.1 mm and a 2.5 mm 3-layer-polypropylene coating.

The 6'' tie-in spools located at YYY and ZZZ exhibit a nominal wall thickness of 11 mm and a 2.5 mm 3-layer-polypropylene coating. The field joints of the pipelines are protected by heat shrink sleeve, allowing the tool to negotiate the circumferential welds.

For a detailed view of the inspection locations, see Figs. 1 – 3.

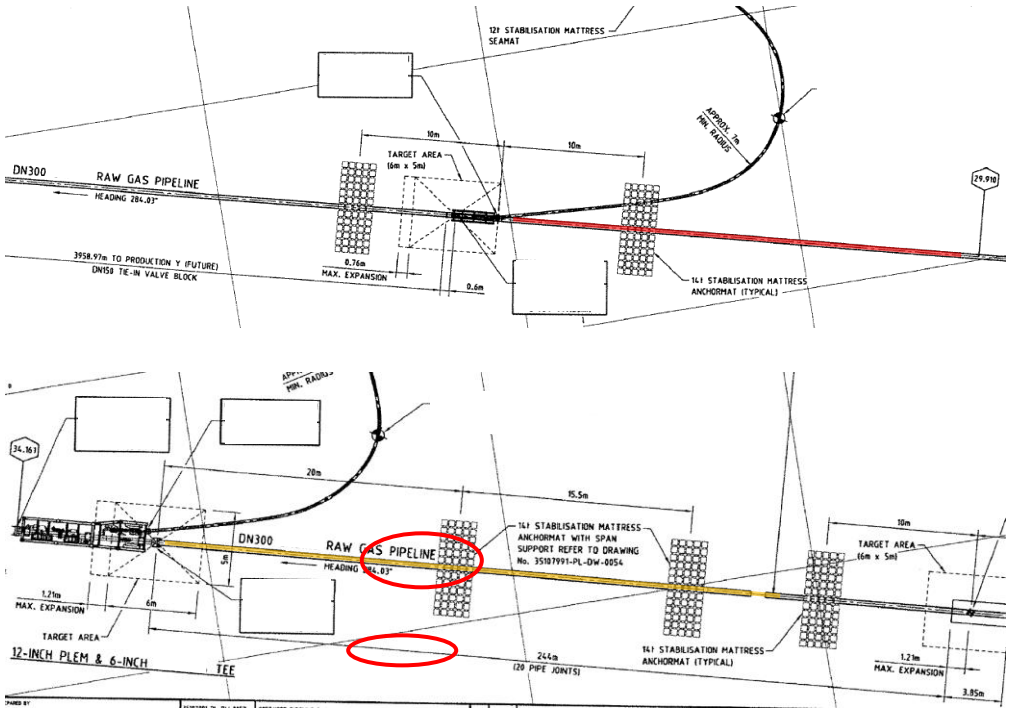


Figure 1: Inspection locations of the 12" downstream pipeline sections at XXX 5 (Priority 1) and XXX 4 (Priority 2).

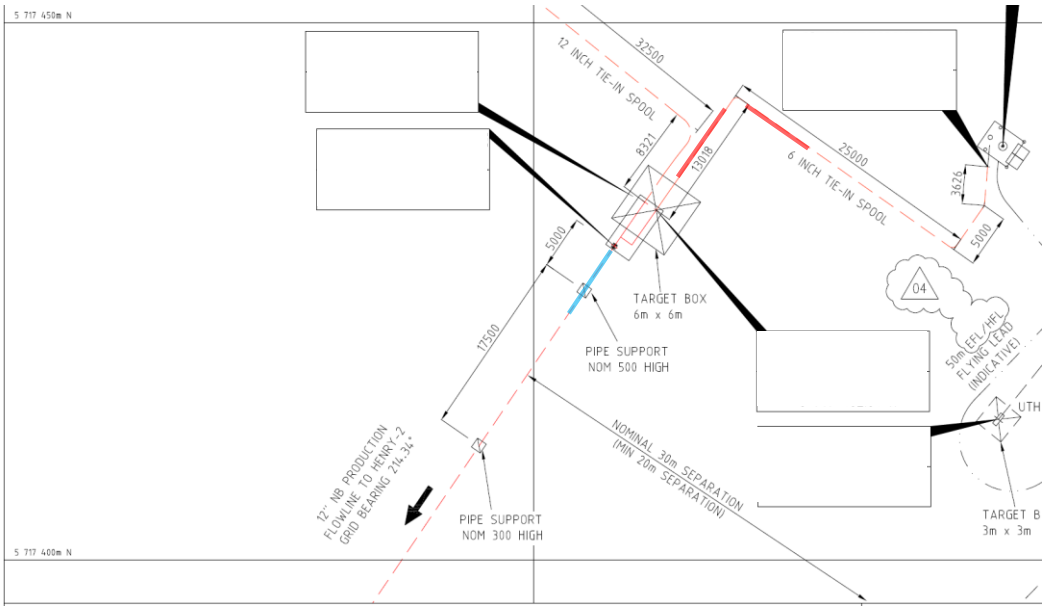


Figure 2: Inspection locations of the 6" (Priority 1) and 12" (Priority 3) pipeline sections at ZZZ.

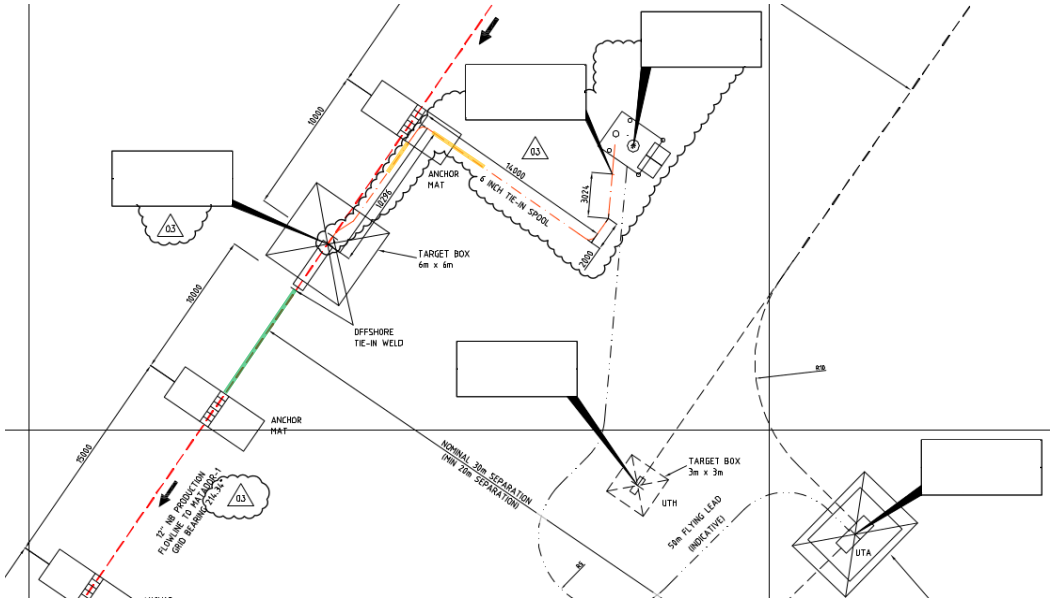


Figure 3: Inspection locations of the 6" (Priority 2) and 12" (Priority 4) pipeline sections at YYY 2.

2.3. Equipment

The MEC inspection technology was used. For the subsea deployment a suitable tool (MEC-Combi Crawler) was designed and built. The MEC-Combi Crawler tool has the following technical parameters:

MEC-Combi Crawler tool:	Hydraulically driven crawler to be attached to a horizontal or vertical pipe from the outside. The diameter is adjustable. The tool weight is 155 kg in air and 5 kg in water (adjustable by modular buoyancy). It has a length of 120 cm, a width of 60 cm and a height of 40.5 cm.
Sensors:	Eight Sensors of type FIT22. The unit covers a circumferential width of 180 mm.
Scanning Speed:	up to 30 m/min or 0.5 m/s
Eddy Current Instrument:	-IQ Data System
Software Version:	Innospectit Version 2.0

For more detailed information on the MEC-Combi Crawler system refer to Section 4.

2.4. Mobilisation and Preparation

Inspection Team

The inspection team was made up of the following people:

L x, Team Leader (Eddy Current PCN Level 2 - xx)
J x, NDT Technician (Eddy Current PCN Level 2 - xx)
M x, Electronic Support Technician
S x, Project Engineer

Mobilisation Dates

The equipment was mobilised on the 19th of April 2012. The inspection crew was mobilised from 13th of May to 3rd of June 2012. Upfront tests on site have been done on the 18th of May 2012. All tracks have been done from 29th of May 2012 to 1st of June 2012.

Cleaning

The cleaning of the inspected pipeline sections was done by the ROV operator (DOF Subsea) using a 3-brush system. The cleaning was successful allowing for a smooth movement of the MEC-Combi Crawler tool over the pipeline surface.

Procedure for Calibration and Set-up

The preparation and inspection of the riser was done according to Innospection's procedures

- Inno-PSloPIP-001-08 – MEC Inspection Equipment on External Pipe Applications – Current version
- Ultrasonic Inspection Procedure No. InnoUT-001-10 Current Version

The general test set-up was done prior to mobilisation in the workshop. Calibration pieces with artificial defects have been tested to allow for classification and sizing of defects. On site the tool was checked by the same procedure. All sensors have shown appropriate signals. A sheet of neoprene with a thickness of 3 mm has been used to simulate the coating of the pipeline. The settings were done accordingly before the tool was launched.

2.5. Execution and Performance

ROV Operation and Scanner Movement

The ROV (TRITON XLX Work Class) has been operated by DOF Subsea. The scanner has been positioned at the predetermined circumferential position on the pipeline by the ROV. Afterwards, the hydraulically powered drive unit enabled the scanner to crawl along the pipeline to carry out the inspection. The scanner moved smoothly on the pipeline with very little variation in velocity.

Figure 4 and Figure 5 depict the horizontal speed profiles for a top track (12 o' clock orientation) and a track with an orientation of 10 o'clock at XXX 5. The scanning speed is calculated by the sampling rate and the corresponding encoder values. The sampling rate is given by the electronics and is constant at all times. For the top track, the speed is at a very constant level of about 0.18 m/s. For the track at 10 o' clock, the speed profile results in a mean value of 0.075 m/s. There are no speed excursions that would compromise the quality of the inspection data.

After the MEC scanning of each section, additional UT wall thickness measurements of the pipeline have been performed each meter using the UT probe built into the MEC Combi Crawler tool. The results of these measurements are depicted in section 3 (colour-coded), an overview of the measurements is presented in Appendix 1.

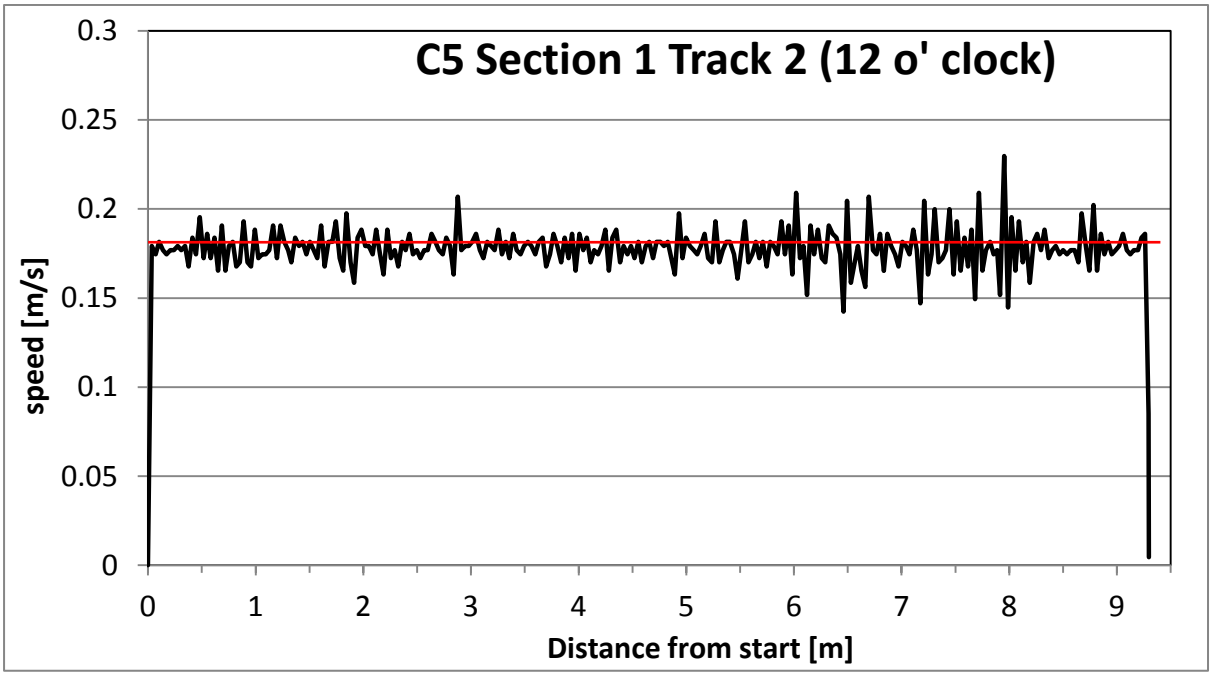


Figure 4: Speed profile of a top section (12 o' clock) track at XXX5.

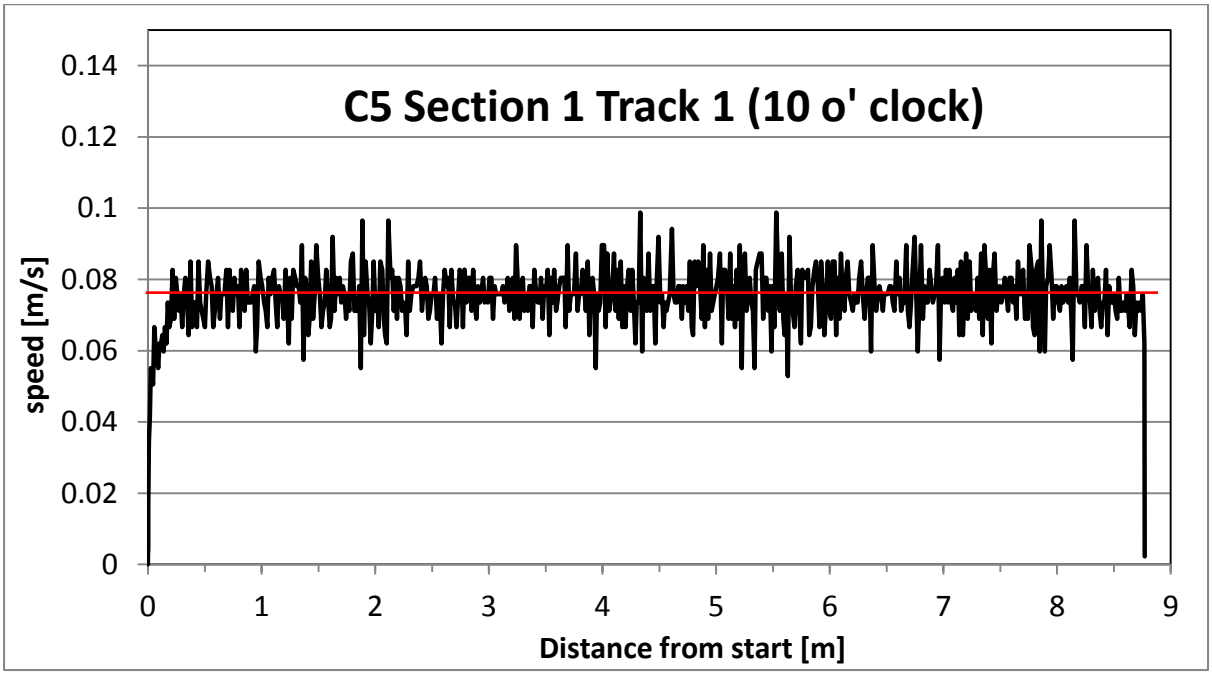


Figure 5: Speed profile of a track at XXX 5 with an orientation of 10 o' clock.

Tracks and Coverage

For all tracks, the datum point is the adjacent edge of the corresponding PLEM. All track positions given in this document are relative to this datum point.

XXX 5 12'' Downstream Pipeline Section (+3.5 m to +35 m from datum point)

A total of 9 track runs has been performed at this section. The pipeline section has been scanned with three tool orientations, resulting in a nearly 180° coverage of the top of the pipeline. See Table 1 for detailed track parameters.

Position from datum	*Track No.*	*File No.*	*Distance covered [m]*	*Orientation*	*UT lowest WT [mm]*	*comment*
+3.5m to +13.5m	*1*	*2012-05-29_07-59-26*	*8.8*		*17.4*	*weld at 9.5m*
	2	*2012-05-29_07-38-45*	*9.3*		*17.2*	*weld at 9.5m*
	3	*2012-05-29_08-10-59*	*8.4*		*17.0*	*weld at 9.5m*

+13.5m to +25m	*4*	*2012-05-29_15-03-46*	*10.6*		*17.35*	*weld at 18.5m*
	5	*2012-05-29_08-27-34*	*9.5*		*17.7*	*weld at 18.5m*
	6	*2012-05-29_15-40-40*	*10.1*		*17.6*	*weld at 18.5m*
+25m to +35m	*7*	*2012-05-29_16-01-15*	*10.4*		*17.85*	*weld at 31.9m*
	8	*2012-05-29_16-15-40*	*9.4*		*17.6*	*weld at 31.9m*
	9	*2012-05-29_16-32-07*	*10.1*		*17.9*	*weld at 31.9m*

Table 1: Overview of track parameters at XXX 5 12'' downstream pipeline section (+3.5 m to +35 m from datum point)

XXX 4 Downstream Pipeline 12'' Section (+6 m to +47.5 m from datum point)

A total of 4 track runs has been performed at this section. Only the top track (11 o'clock - 1 o'clock) has been inspected on this entire section. 39.25 metres in total was inspected over the section length of 41 metres. See Table 2 for detailed track parameters.

Position from datum	*Track No.*	*File No.*	*Distance covered [m]*	*Orientation*	*UT lowest WT [mm]*	*comment*
+6m to +12m	*1*	*2012-05-29_23-27-24*	*6.9*		*15.95*	
+14m to +25.5m	*2*	*2012-05-30_01-51-10*	*11.3*		*17.40*	*weld at 23.2m*
+27.5m to +37.5m	*3*	*2012-05-30_06-32-04*	*10.5*		*17.45*	*weld at 33.5m*
+37.5m to +47.5m	*4*	*2012-05-30_06-48-02*	*10.5*		*17.70*	*weld at 45.1m*

Table 2: Overview of track parameters at XXX 4 12'' downstream pipeline section (+6 m to +47.5 m from datum point)

ZZZ 12'' Downstream Pipeline Section (+7 m to +16 m from datum point)

A single track run of the top track (11 o'clock - 1 o'clock) has been performed at this section. See Table 3 for detailed track parameters.

Position from datum	*Track No.*	*File No.*	*Distance covered [m]*	*Orientation*	*UT lowest WT [mm]*	*comment*
+7m to +16m	*1*	*2012-05-30_23-27-22*	*8.91*		*17.7*	*Weld at 11.1m*

Table 3: Overview of track parameters at ZZZ 12'' Downstream Pipeline section (+7m to +16m from datum point).

YYY 2 12'' Downstream Pipeline Section (+1 m to +11 m from datum point)

A single track run of the top track (11 o'clock - 1 o'clock) has been performed at this section. The scan has been performed from +11 m on backwards. See Table 4 for detailed track parameters.

Position from datum	*Track No.*	*File No.*	*Distance covered [m]*	*Orientation*	*UT lowest WT [mm]*	*comment*
+1m to +11m	*1*	*2012-06-01_02-27-23*	*10.17*		*17.7*	*backwards scan* weld at 2.8m

Table 4: Overview of track parameters at YYY 2 12'' downstream pipeline section P2 (+1 m to +11 m from datum point)

ZZZ 6'' Tie-in-Spool Section (+6 m to +17 m from datum point)

A total of two track runs has been performed at this section. Only the top track (11 o'clock - 1 o'clock) has been inspected on this entire section. 8.2 metres in total was inspected over the section length of 11 metres. See table 5 for detailed track parameters. In the region of the bend, only UT measurements could be performed.

Position from datum	*Track No.*	*File No.*	*Distance covered [m]*	*Orientation*	*UT lowest WT [mm]*	*comment*
+6m to +12m	*1*	*2012-05-31_07-53-01*	*5.5*		*10.85*	*weld at 10.8m*
+12m to +13m					*11.8*	*only UT (bend)*
+13m to +17m	*2*	*2012-05-31_08-06-56*	*2.7*		*11.05*	

Table 5: Overview of track parameters at ZZZ 6'' rigid tie-in-spool pipeline section (+6 m to +17 m from datum point)

YYY 2 6'' Tie-in-Spool Section (+7 m to +18 m from datum point)

A total of two track runs has been performed at this section. Only the top track (11 o'clock - 1 o'clock) has been inspected on this entire section. 6.9 metres in total was inspected over the section length of 11 metres. See Table 6 for detailed track parameters. In the region of the bend, only UT measurements could be performed.

Position from datum	*Track Nr.*	*File Nr.*	*Distance covered [m]*	*Orientation*	*UT lowest WT [mm]*	*comment*
+7m to +10m	*1*	*2012-05-31_12-01-51*	*2.5*		*10.85*	
+10m to +13m					*12.3*	*only UT (bend)*
+13m to +18m	*2*	*2012-05-31_13-07-54*	*4.3*		*11.05*	*weld at 16.9m*

Table 6: Overview of track parameters at YYY2 6'' rigid tie-in-spool pipeline section (+7 m to +18 m from datum point)

UT measurements with standalone probe at elbow of Tees

Additional wall thickness measurements have been performed at the elbows of XXX 5, ZZZ and YYY 2 Tees using a standalone, ROV-mounted UT probe (Cygnus M5-ROV-048-M). A custom bracket with adjustable contact pressure has been designed for the UT sensor to be handled by the ROV manipulator. See Figure 6 for a detailed view of the tool. Wall thickness measurements have been performed at XXX 5 and YYY 2 outside of the tee elbows at the 12 o'clock position, as well as at ZZZ at the 8 – 9 o'clock position of the elbow.

At ZZZ tee, the inspection couldn't be performed at the 12 o'clock position due to obstacles caused by the PLEM structure and sacrificial anode. See section 3.7 for inspection locations and results of the performed measurements. At the time of inspection, no values of the corresponding nominal wall thicknesses of the elbows have been available.

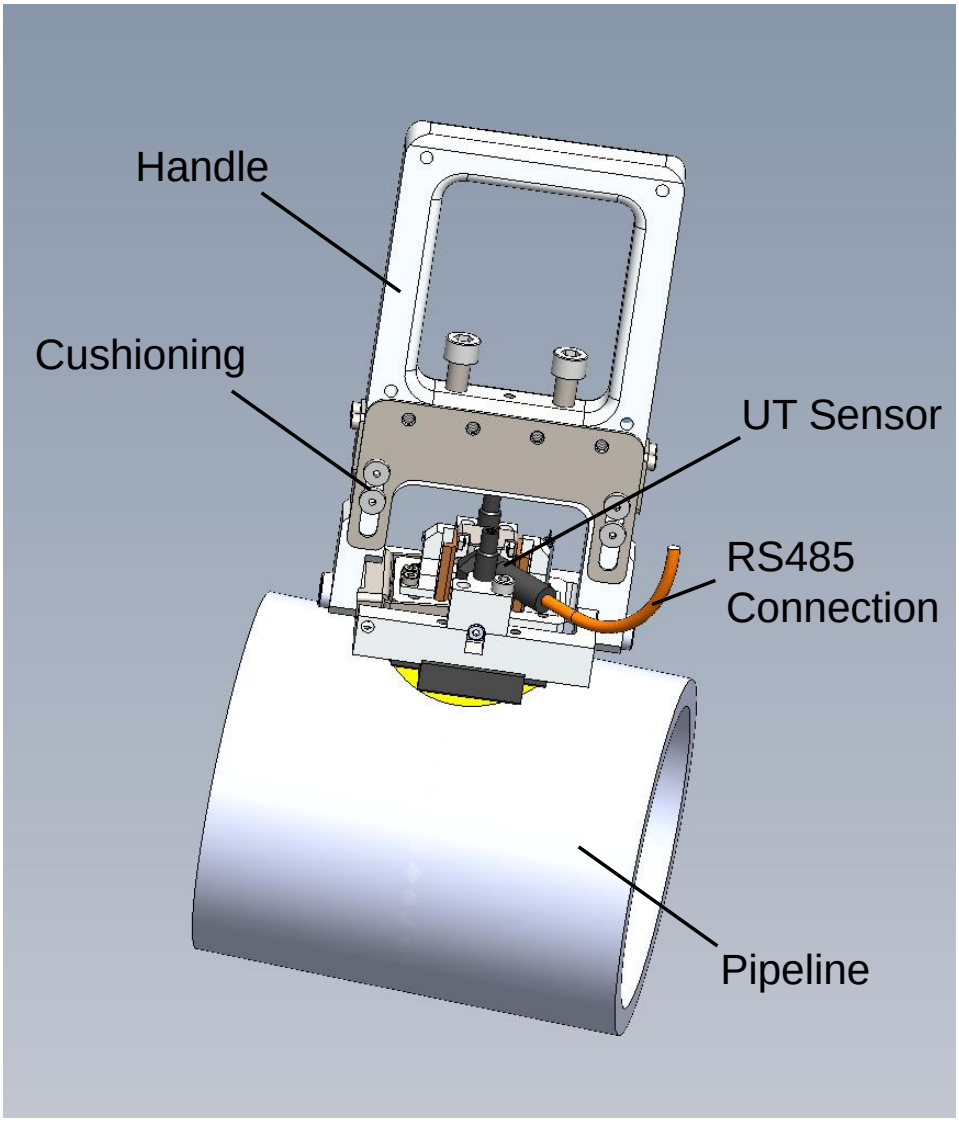


Figure 6: ROV-mountable UT probe with adjustable contact pressure.

Video Surveillance

The forward facing camera on the MEC-Combi Crawler tool worked at all times and has been used for orientation and documentation purposes. It also turned out to be useful to ensure a symmetrical cleaning of the pipeline.

Data Quality

The switching of the magnet worked without any problems. Also, the distance encoder worked at all times. The starting distances for the tracks were given by the ROV crew.

The overall signal quality is definitively good for the specified probability of detection for defects and complete data analysis.

3. Results

3.1. XXX 5 12" Downstream Pipeline Section (Priority 1)

3.2. XXX 4 12" Downstream Pipeline Section (Priority 2)

3.3. ZZZ 12" Downstream Pipeline Section (Priority 3)

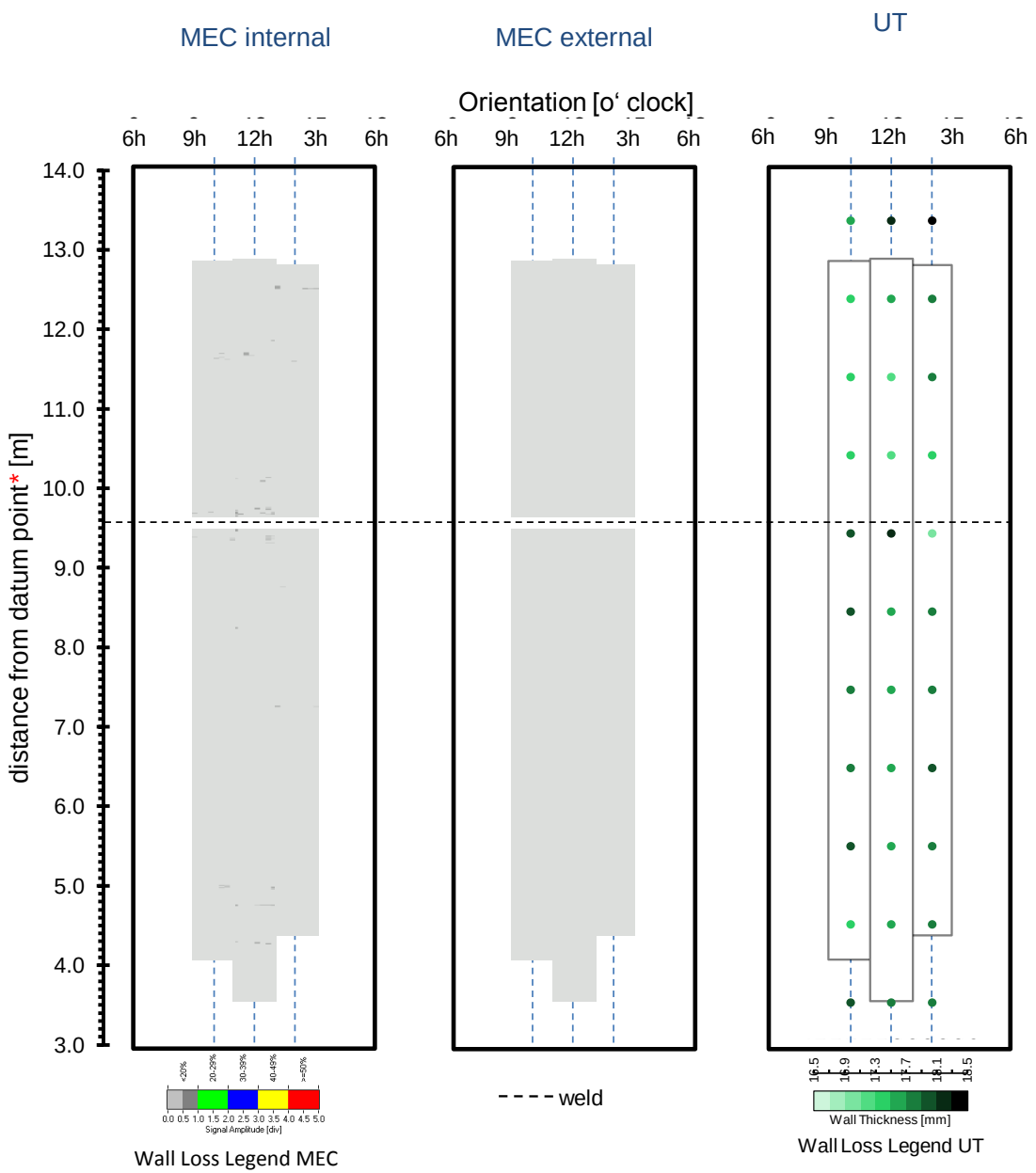
3.4. YYY 2 12" Downstream Pipeline Section (Priority 4)

3.5. ZZZ 6" Tie-in-Spool (Priority 1)

3.6. YYY 2 6" Tie-in-Spool (Priority 2)

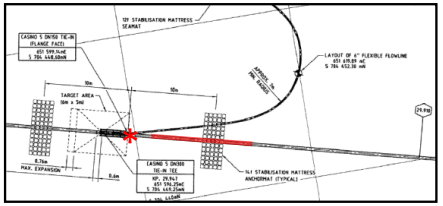
3.7. UT Measurements at XXX 5, ZZZ and YYY 2 Tee Elbows

3.1 XXX 5 12'' Downstream Pipeline (Priority 1) – Section 1 (+3.5 m to +13.5 m from datum point)



Remarks

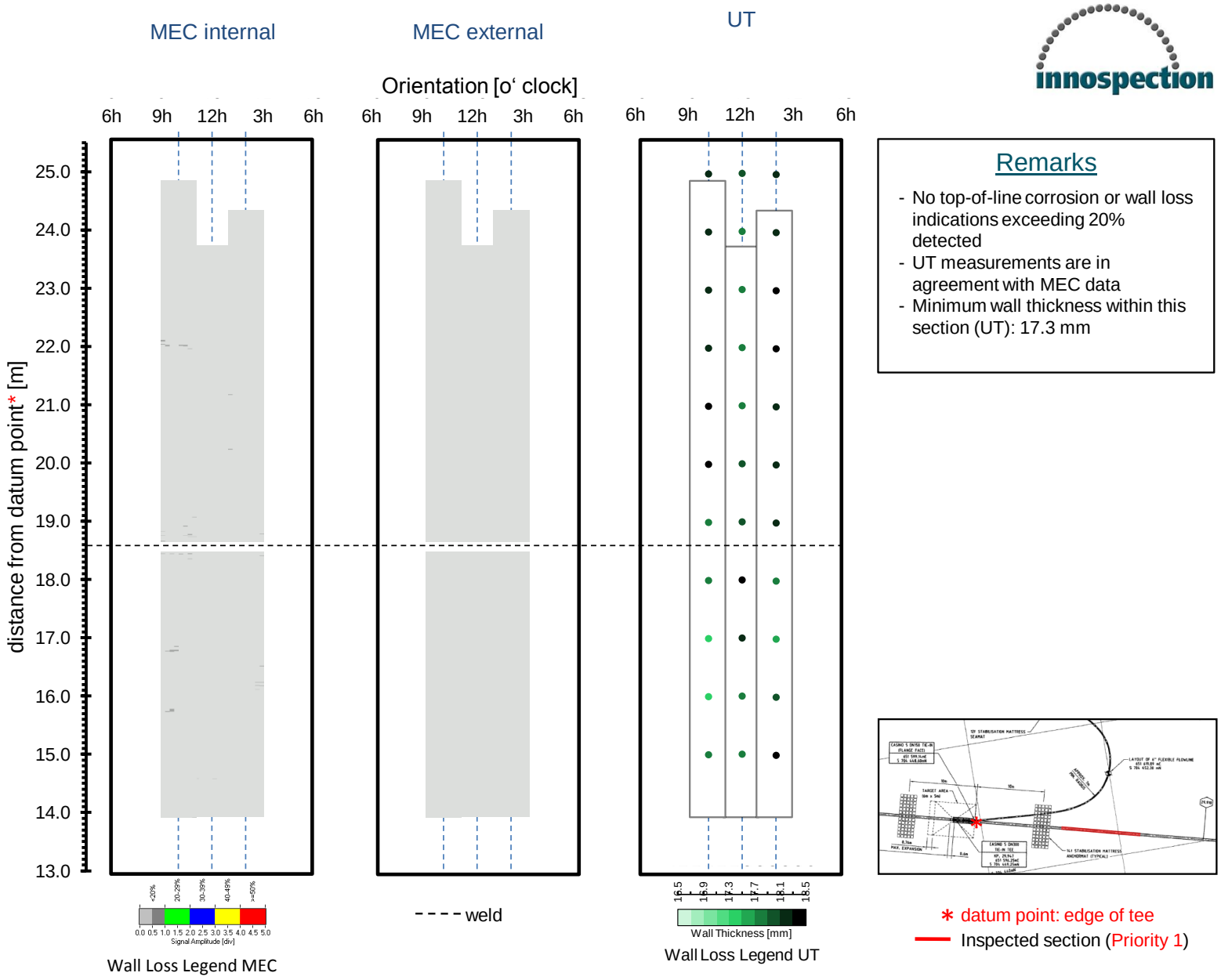
- No top-of-line corrosion or wall loss indications exceeding 20% detected
- UT measurements are in agreement with MEC data
- Minimum wall thickness within this section (UT): 17.0 mm



* datum point: edge of tee

Inspected section (Priority 1)

XXX 5 12'' Downstream Pipeline (Priority 1) – Section 2 (+13.5 m to +25 m from datum point)



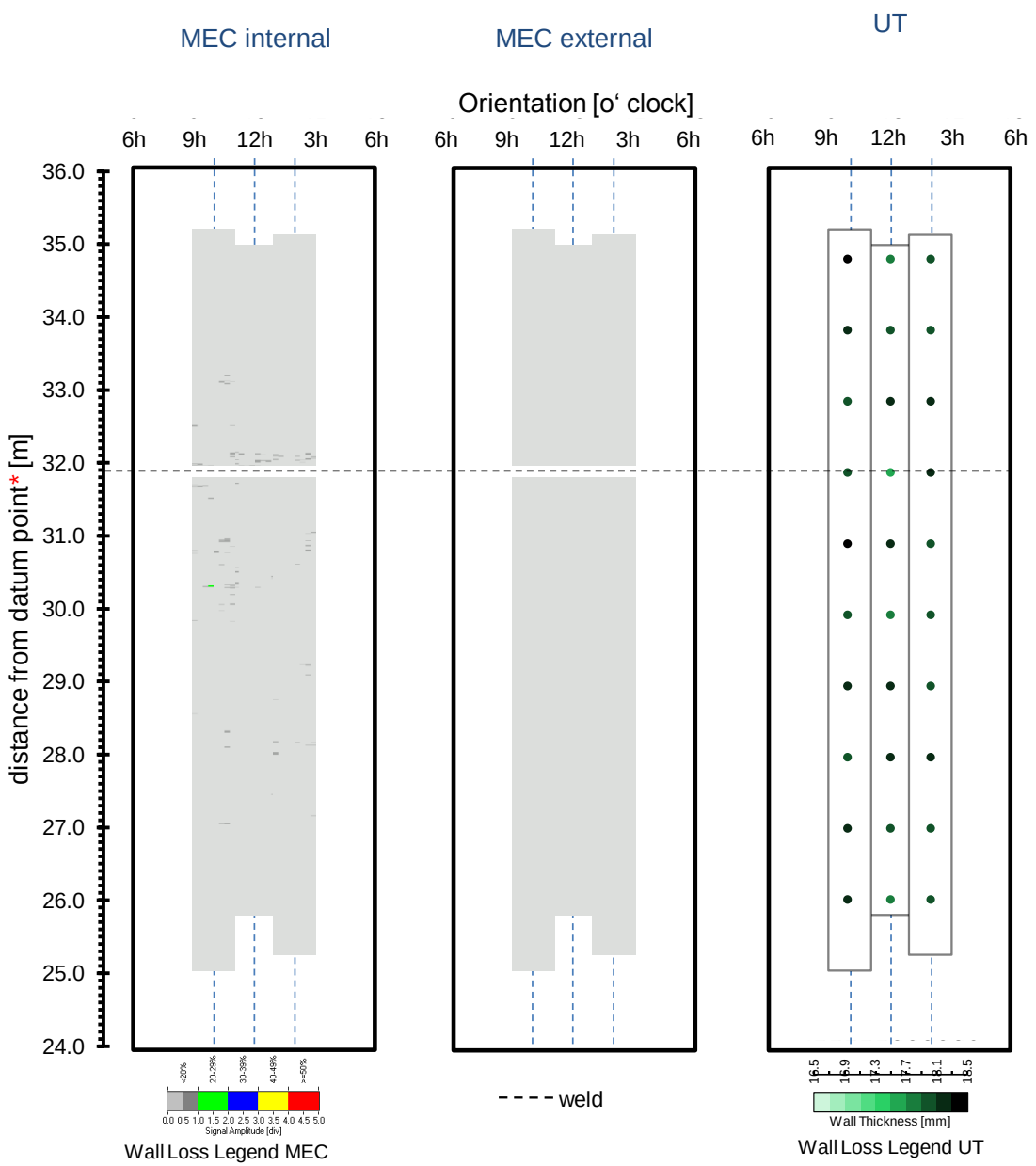
Remarks

- No top-of-line corrosion or wall loss indications exceeding 20% detected
- UT measurements are in agreement with MEC data
- Minimum wall thickness within this section (UT): 17.3 mm

* datum point: edge of tee

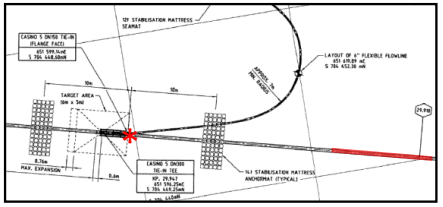
Inspected section (Priority 1)

XXX 5 12'' Downstream Pipeline (Priority 1) – Section 3 (+25 m to +35 m from datum point)



Remarks

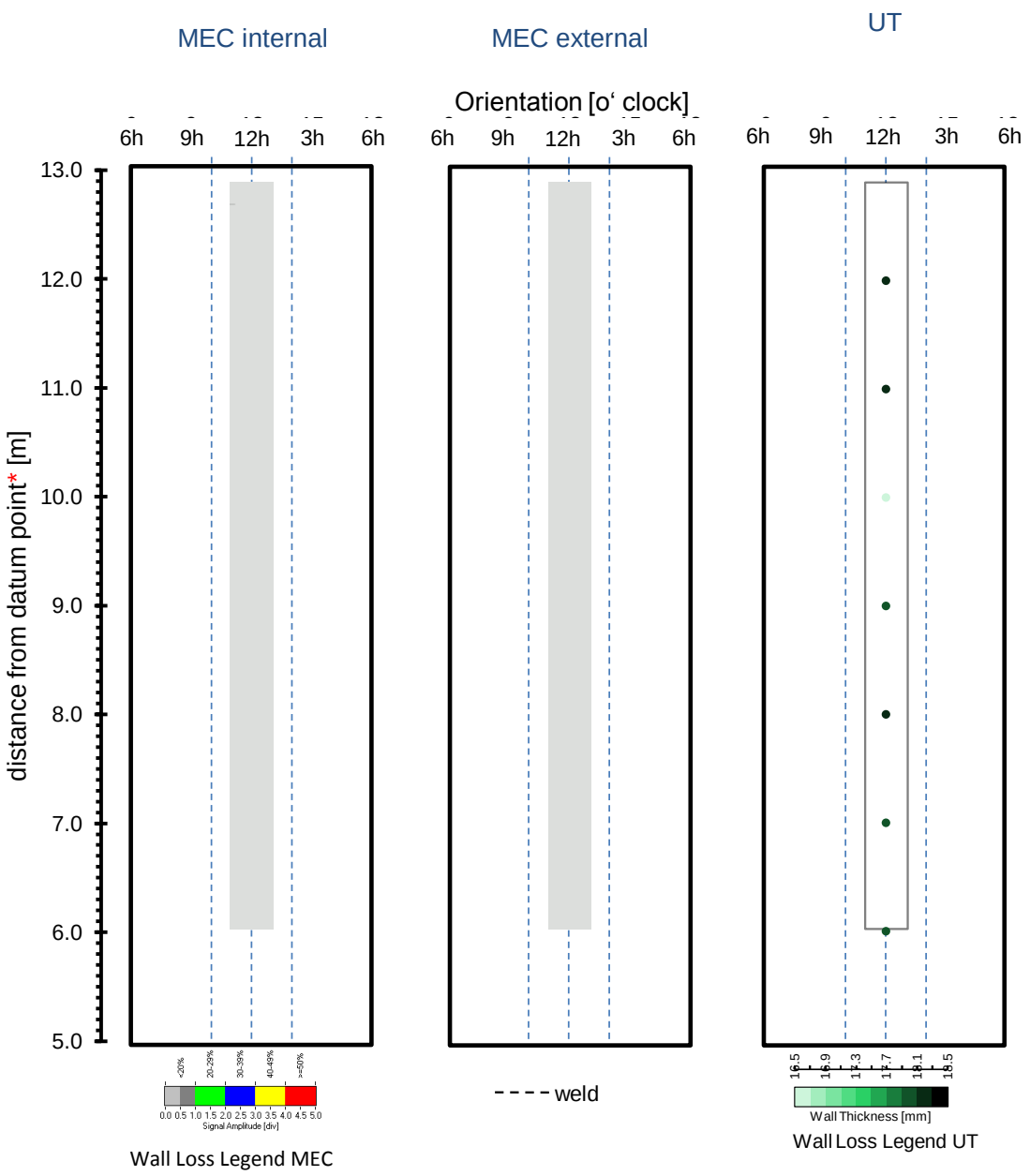
- No top-of-line corrosion or wall loss indications exceeding 20% detected
- UT measurements are in agreement with MEC data
- Minimum wall thickness within this section (UT): 17.6 mm



* datum point: edge of tee

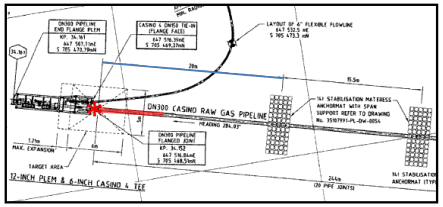
Inspected section (Priority 1)

3.2 XXX 4 12'' Downstream Pipeline (Priority 2) – Section 1 (+6 m to +12 m from datum point)



Remarks

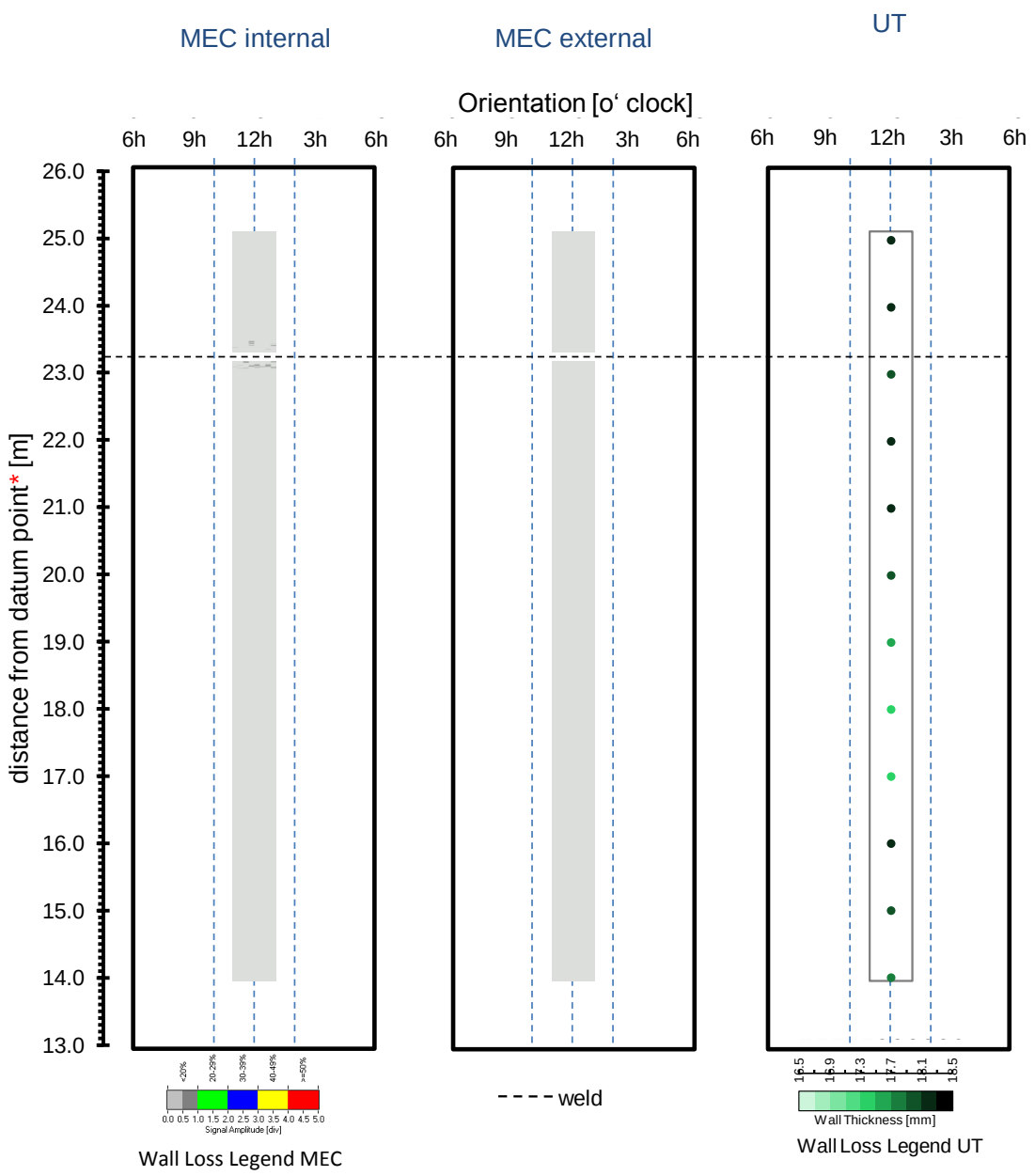
- No top-of-line corrosion or wall loss indications exceeding 20% detected
- UT measurements are in agreement with MEC data
- Minimum wall thickness within this section (UT): 16.0 mm



∗ datum point: edge of tee

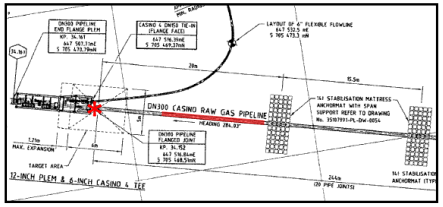
Inspected section (Priority 1)

XXX 4 12'' Downstream Pipeline (Priority 2) – Section 2 (+14 m to +25.5 m from datum point)



Remarks

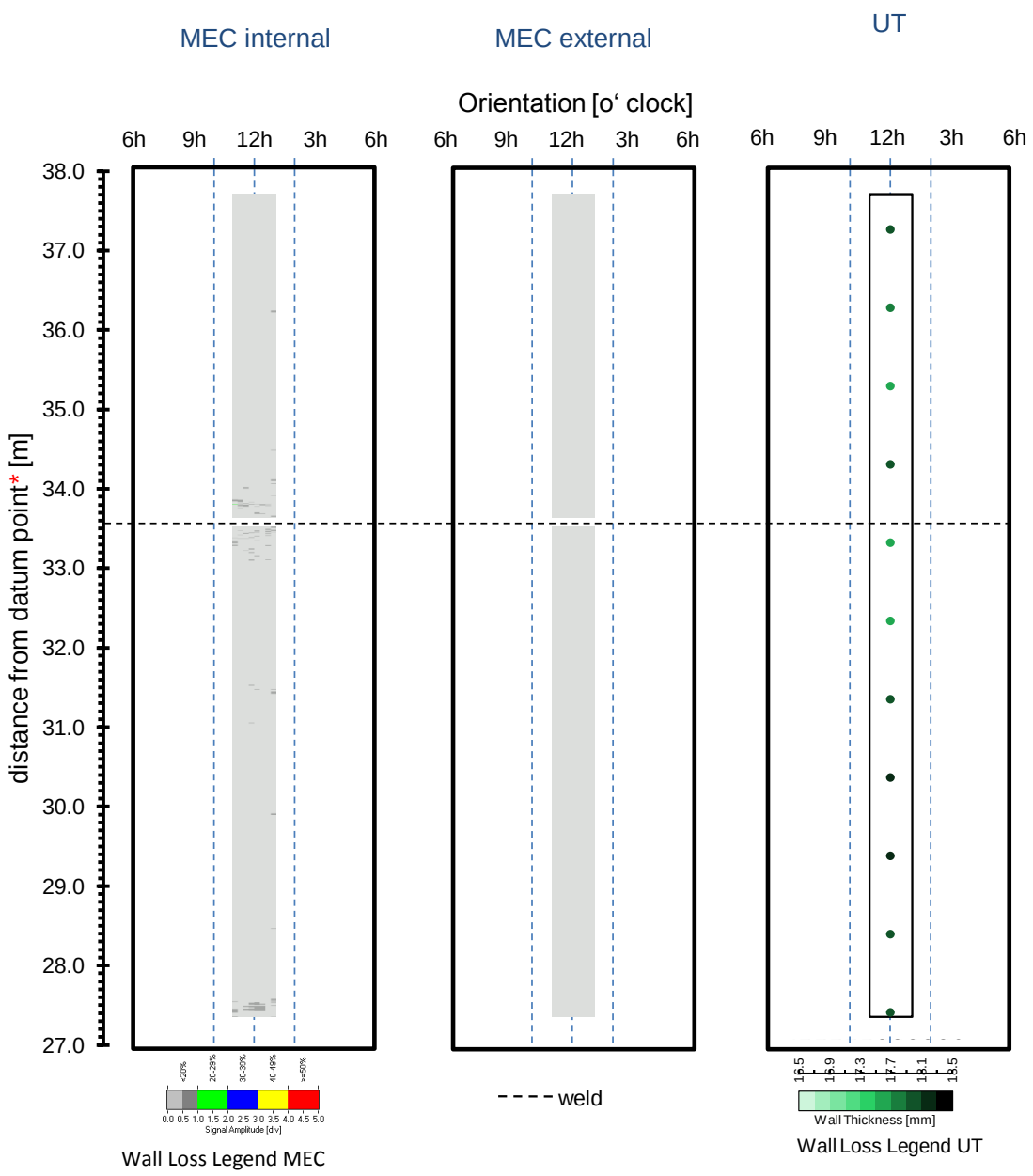
- No top-of-line corrosion or wall loss indications exceeding 20% detected
- UT measurements are in agreement with MEC data
- Minimum wall thickness within this section (UT): 17.4 mm



* datum point: edge of tee

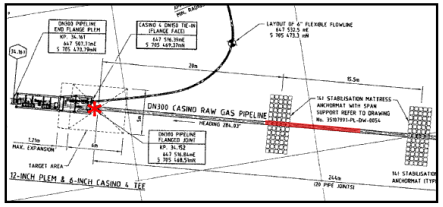
Inspected section (Priority 1)

XXX 4 12'' Downstream Pipeline (Priority 2) – Section 3 (+27.5 m to +37.5 m from datum point)



Remarks

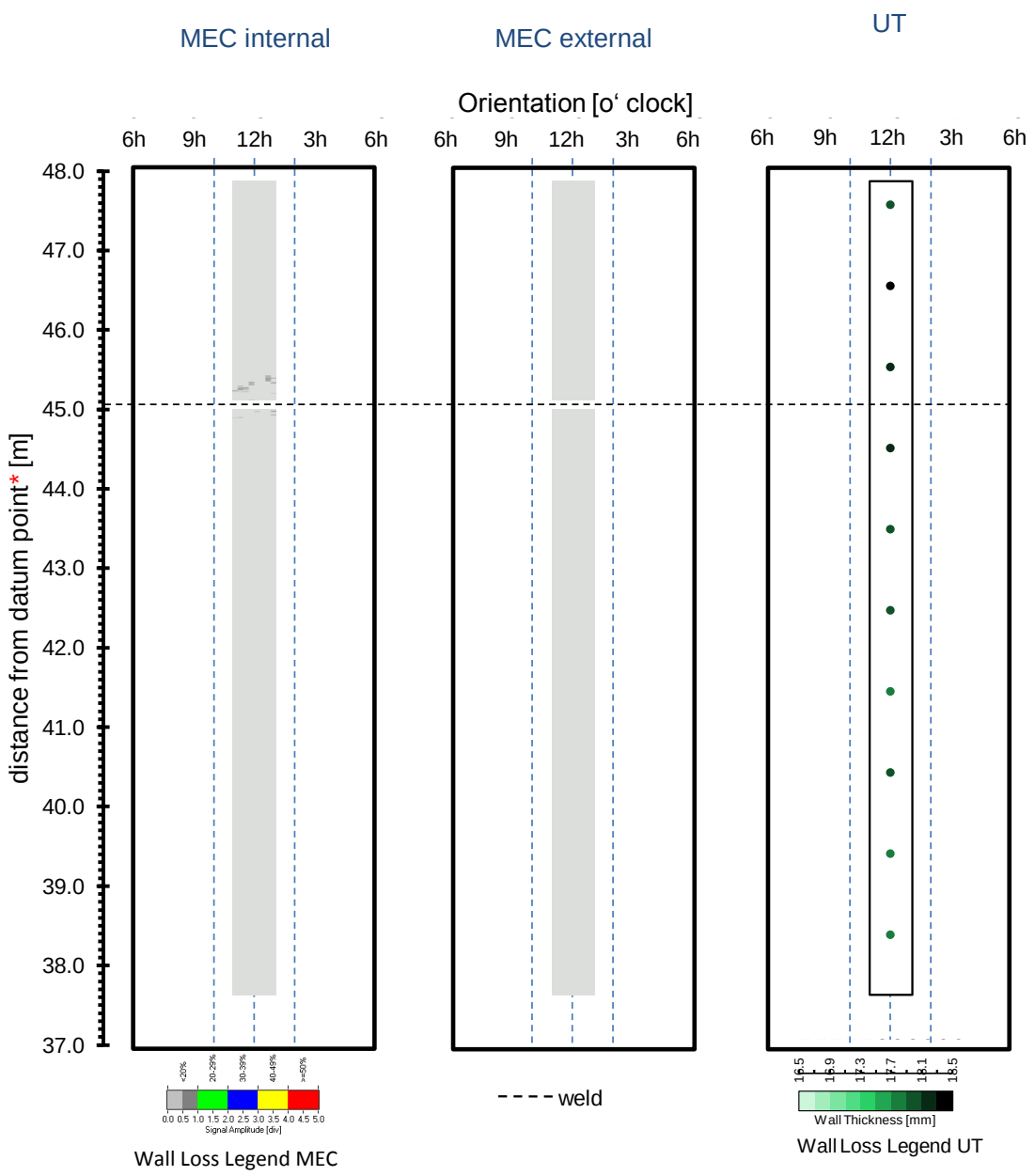
- No top-of-line corrosion or wall loss indications exceeding 20% detected
- UT measurements are in agreement with MEC data
- Minimum wall thickness within this section (UT): 17.4 mm



* datum point: edge of tee

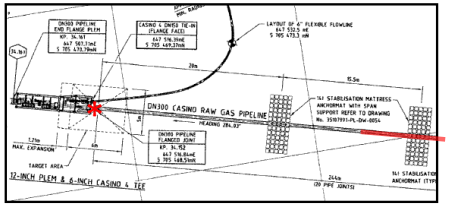
Inspected section (Priority 1)

XXX 4 12'' Downstream Pipeline (Priority 2) – Section 4 (+37.5 m to +47.5 m from datum point)



Remarks

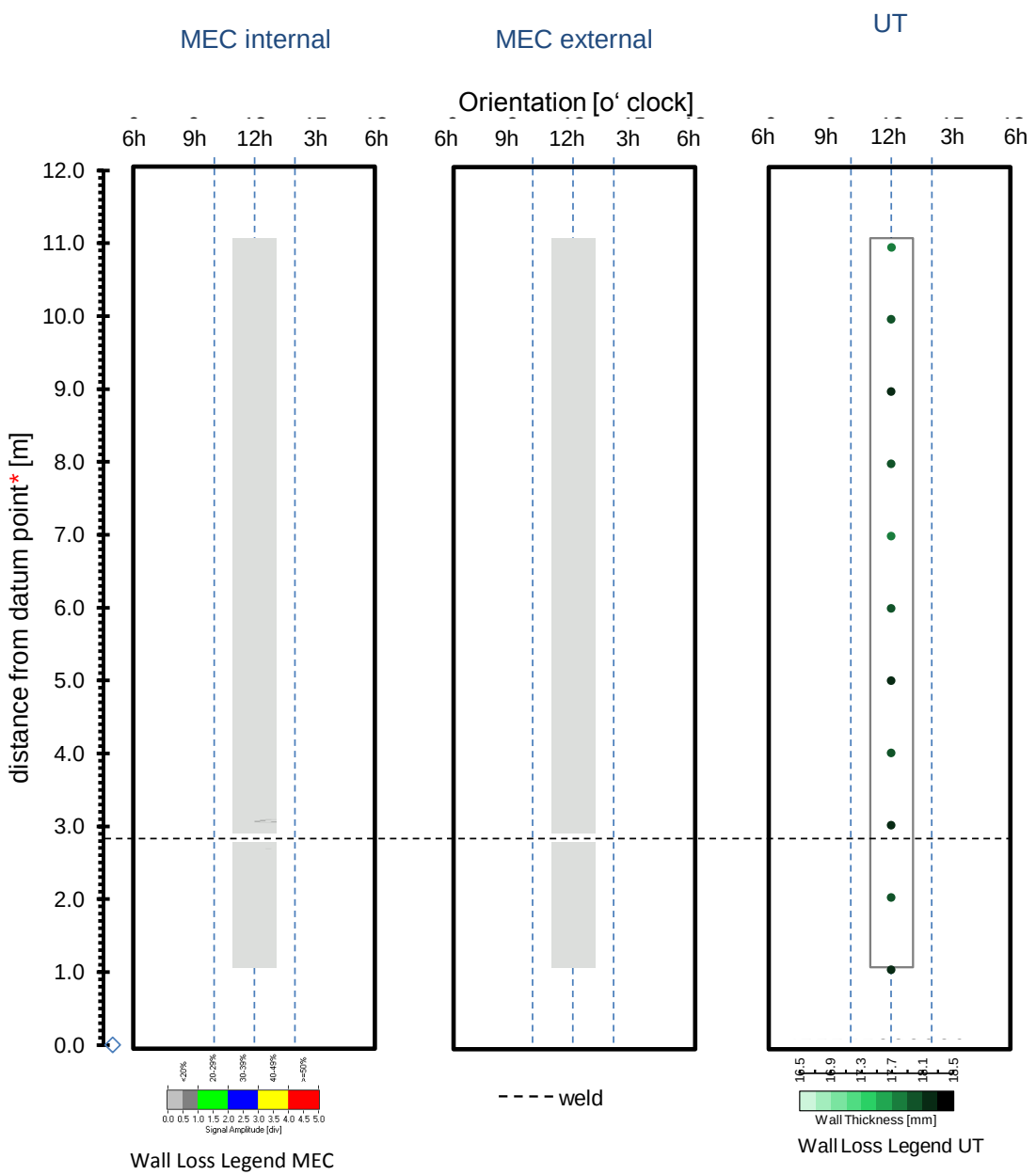
- No top-of-line corrosion or wall loss indications exceeding 20% detected
- UT measurements are in agreement with MEC data
- Minimum wall thickness within this section (UT): 17.7 mm



* datum point: edge of tee

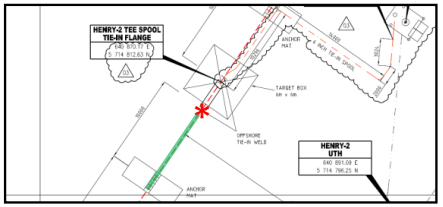
Inspected section (Priority 1)

3.3 ZZZ 12'' Downstream Pipeline (Priority 3) – Section 1 (+7 m to +16 m from datum point)



Remarks

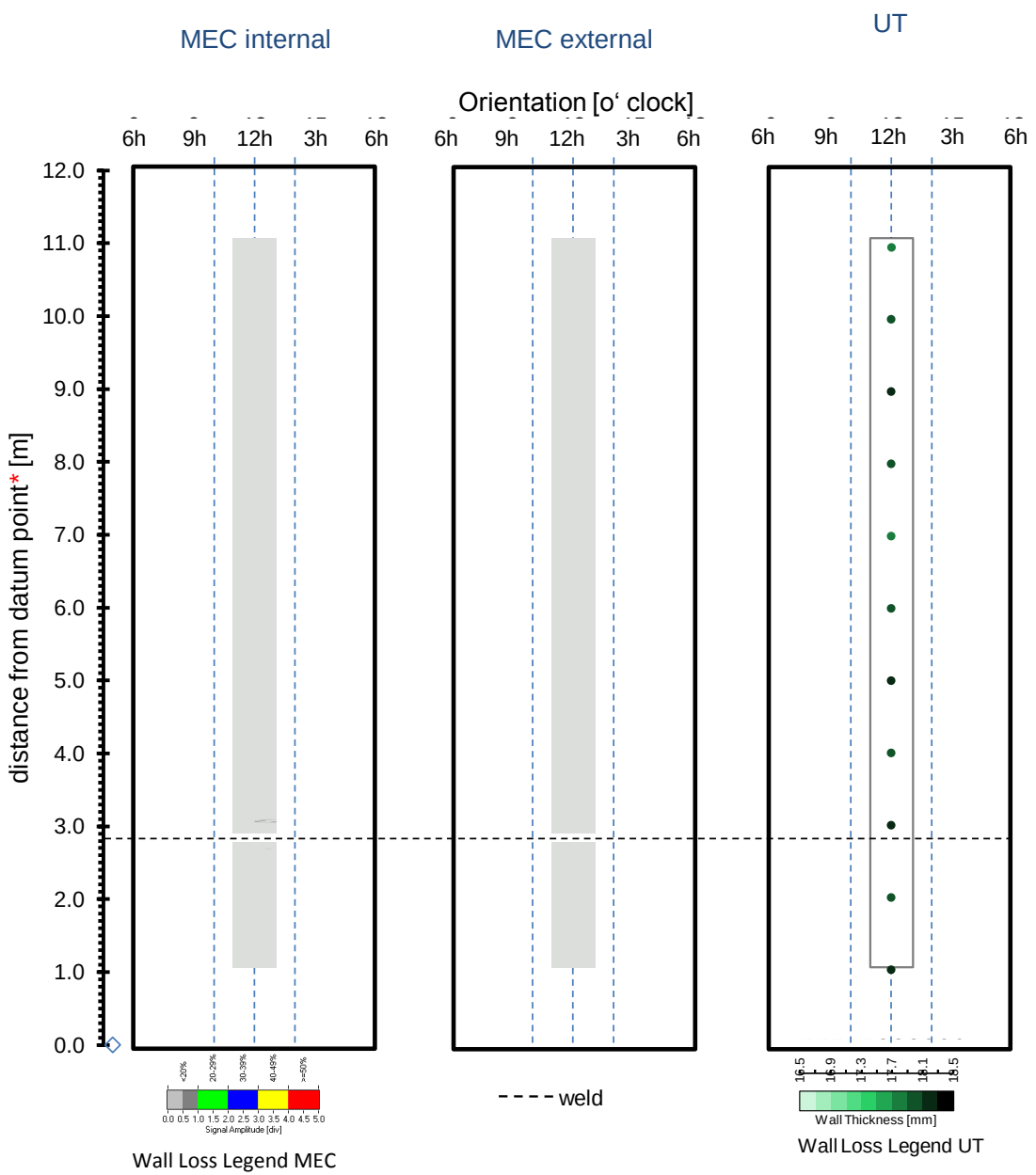
- No top-of-line corrosion or wall loss indications exceeding 20% detected
- UT measurements are in agreement with MEC data
- Minimum wall thickness within this section (UT): 17.7 mm



* datum point: edge of tee

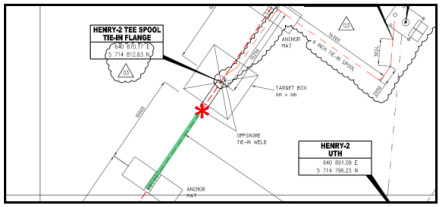
Inspected section (Priority 4)

3.4 YYY 2 12'' Downstream Pipeline (Priority 4) – Section 1 (+1 m to +11 m from datum point)



Remarks

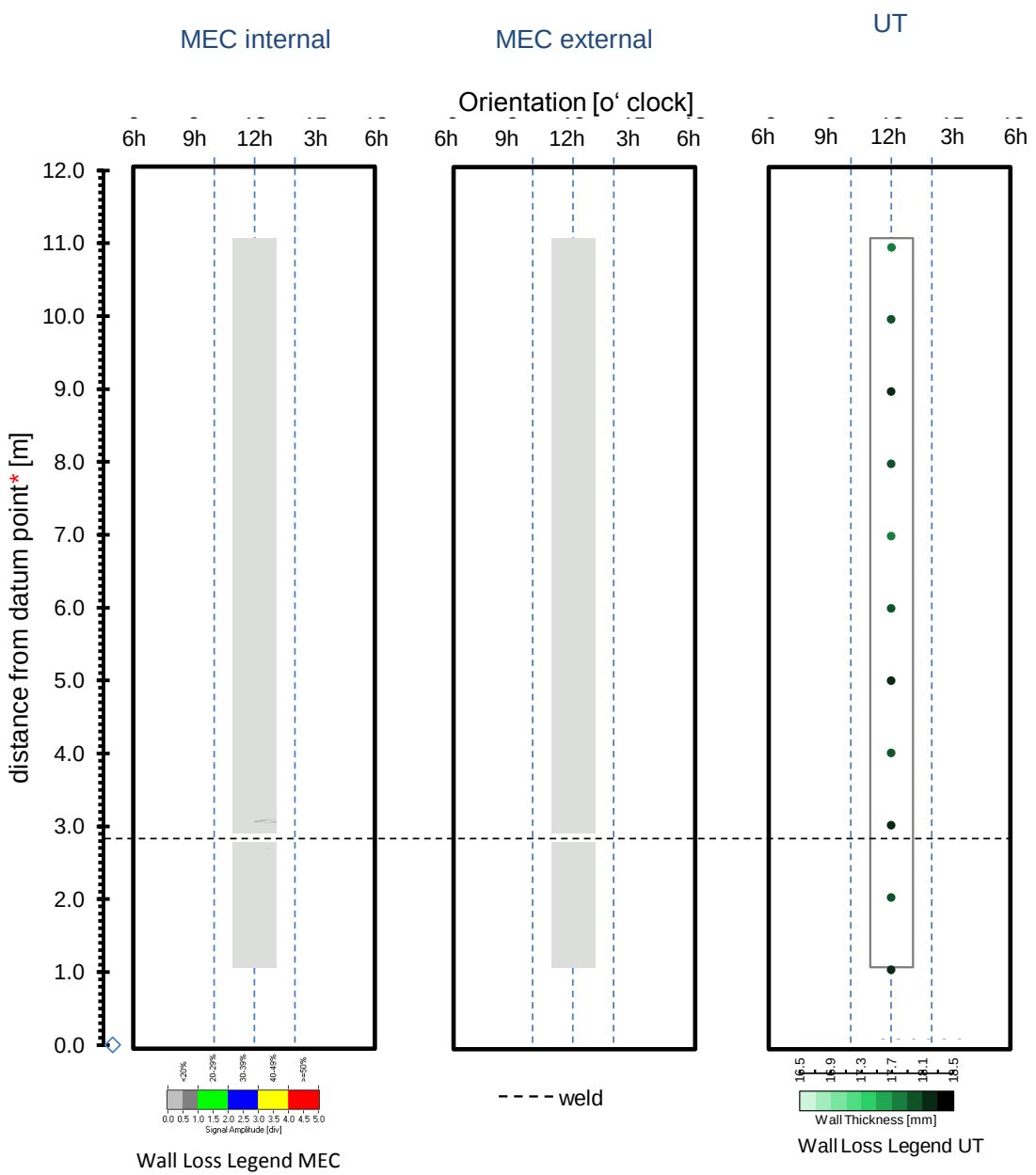
- No top-of-line corrosion or wall loss indications exceeding 20% detected
- UT measurements are in agreement with MEC data
- Minimum wall thickness within this section (UT): 17.7 mm



* datum point: edge of tee

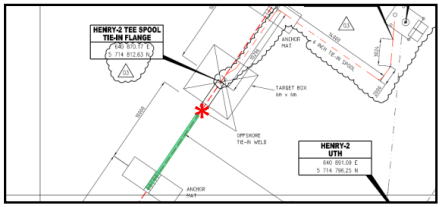
Inspected section (Priority 4)

3.5 ZZZ 6'' Rigid Tie-in-Spool (Priority 1) – Section 1+2 (+6 m to +17 m from datum point)



Remarks

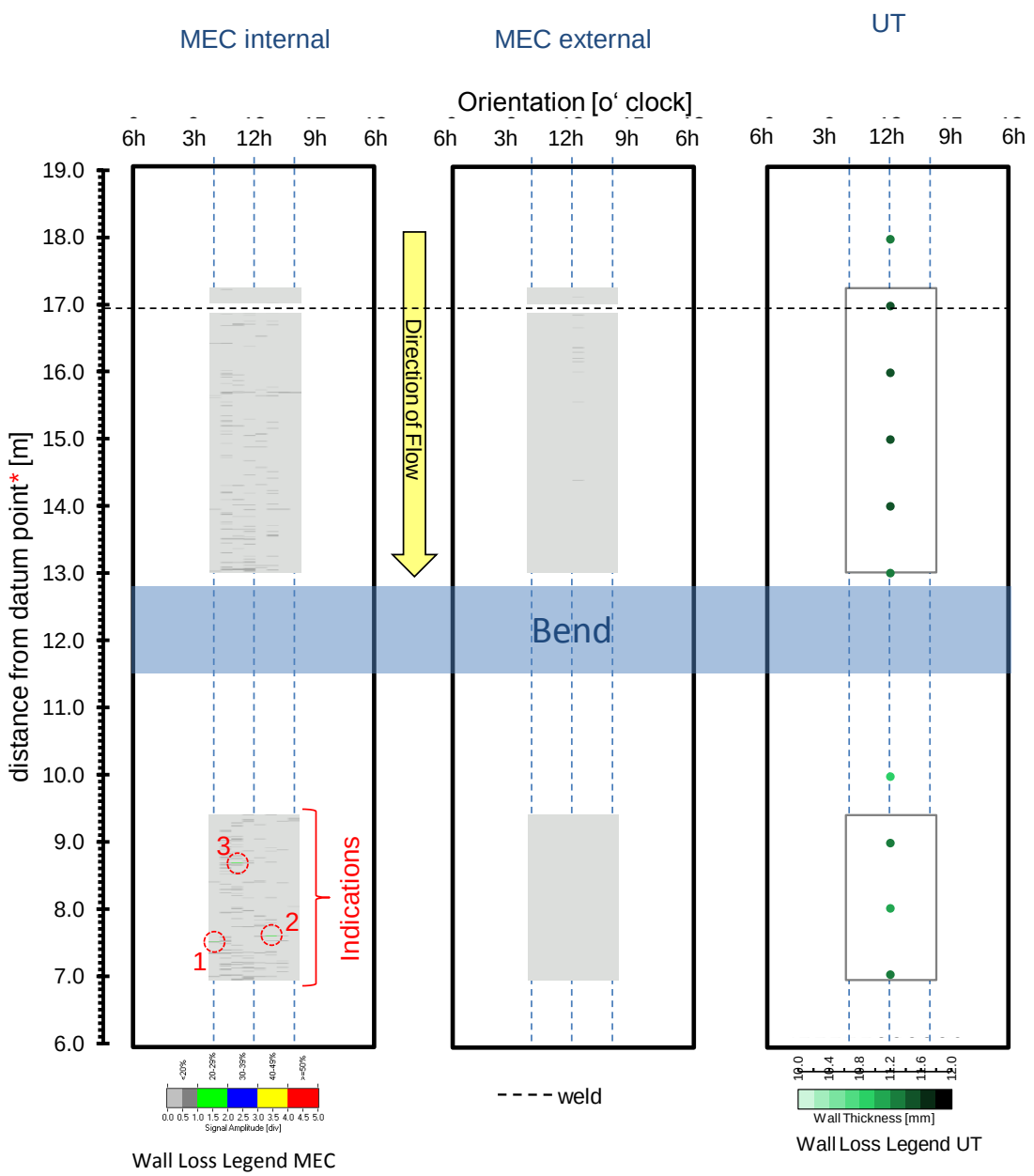
- No top-of-line corrosion or wall loss indications exceeding 20% detected
- UT measurements are in agreement with MEC data
- Minimum wall thickness within this section (UT): 17.7 mm



* datum point: edge of tee

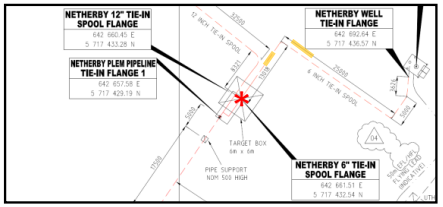
Inspected section (Priority 4)

3.6 YYY 2 6'' Rigid Tie-in-Spool (Priority 2) – Section 1+2 (+7 m to +18 m from datum point)



Remarks

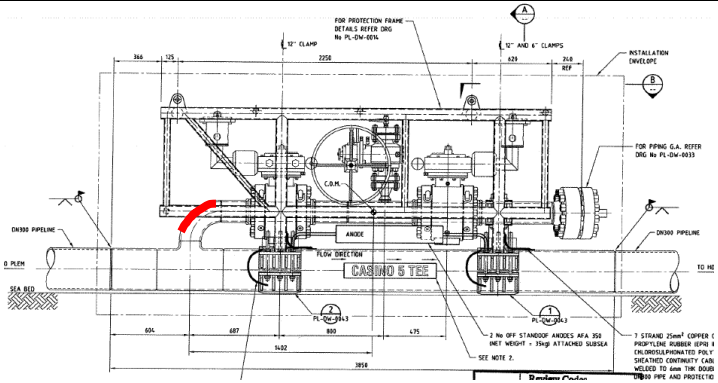
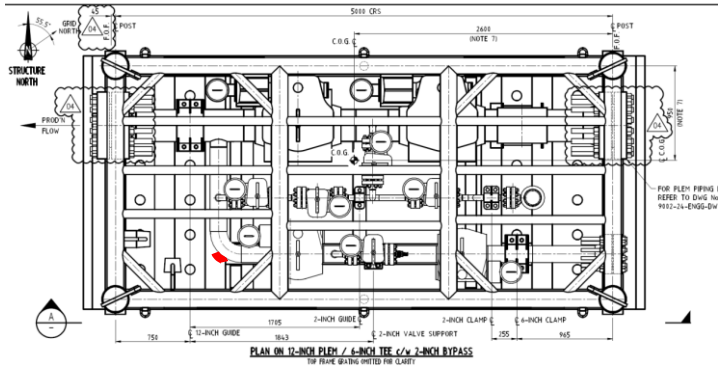
- 3 indications close to 20% wall loss detected at 7.45m, 7.55m and 8.7m relative to datum point.
- UT measurements are in agreement with MEC data
- Minimum wall thickness within this section (UT): 10.8 mm



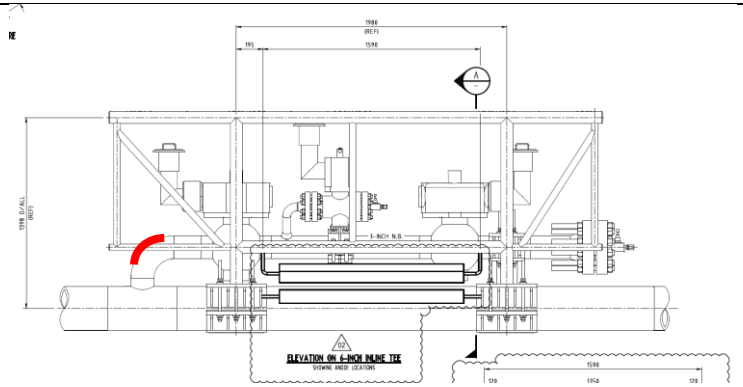
∗ datum point: edge of tee

Inspected section (Priority 2)

3.7 UT Measurements at XXX 5, ZZZ and YYY 2 Tees

Inspection Location (marked in red)	UT Wall Thickness Measurement [mm]	Comments
XXX 5 Tee Elbow		
	11.1 – 11.8	Measurements performed at outside of elbow, 12 o'clock orientation
ZZZ Tee Elbow		
	13.2 – 13.9	Measurements performed at outside of elbow, 8 to 9 o'clock orientation (12 o'clock not accessible due to obstacles)

3.7 UT Measurements at XXX5, ZZZ and YYY 2 Tees

Inspection Location	UT reading of Wall Thickness [mm]	Comments
YYY 2 Tee Elbow		
	13.9 – 15.0	Measurements performed at outside of elbow, 12 o'clock position

3.8. List of MEC Indications

Three minor indications have been detected at the YYY 2 6'' Tie-in-Spool Section (see Section 3.6). All of them are pit-like and internal with a depth just slightly close to 20 % wall loss. See Table 7: Features of the individual indications.

Inspection Object	Item	Position from datum [m]	Orientation [o' clock]	Depth [%] (±10%)	Approx. Length [mm]	Approx. Width [mm]	Description
YYY 2 6'' Tie-in-Spool	1	7.45	2	20	20	20	internal metal loss
YYY 2 6'' Tie-in-Spool	2	7.55	11	20	20	20	internal metal loss
YYY 2 6'' Tie-in-Spool	3	8.7	1	20	20	20	internal metal loss

Table 7: Features of the individual indications

A more detailed view of the indications is depicted in Figure 7. It shows a zoomed view of track 1 (12 o'clock position) recorded at the first section of the YYY 2 6'' tie-in-spool. The right-hand-side of the figure shows the corresponding phase angle diagrams of the indications. The vertical orientation of the signals indicates an internal wall loss. The amplitude in both directions barely reaches the green-marked area which highlights the wall loss region of 20 – 29%.

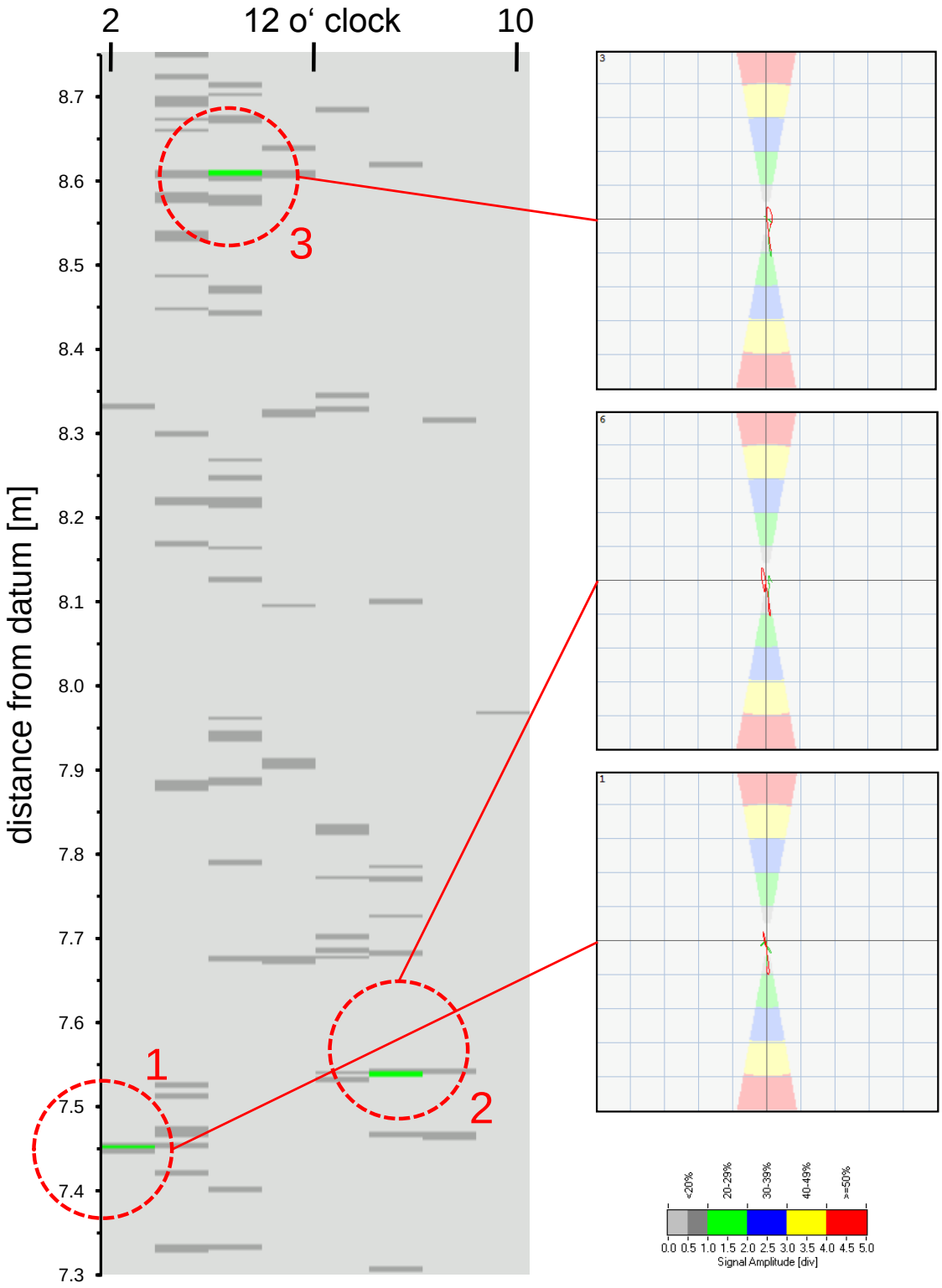


Figure 7: Detailed view of the positions and phase angles of the indications 1-3 detected at the YYY 2 tie-in-spool.

3.9. Conclusion

Three MEC-related indications have been found within the scanned areas of the individual pipelines. All of them are located at the first section of the YYY 2 6'' rigid Tie-in-Spool. They are isolated and only seen on a single sensor at the internal scan, giving a size estimate of about 20 x 20 mm. The depth of the indications is close to 20% of wall loss.

Due to their small size and depth, the indications can be classified as minor.

The spot-like UT wall thickness measurements performed with the UT probe integrated into the MEC Combi Crawler tool are in agreement with the MEC measurements. The maximum wall loss reading obtained with the UT tool is 12%, measured on a single spot at the top track of the XXX 4 12'' downstream pipeline in a distance of 10 m from the datum point.

Top-of-the-Line corrosion, characterised by a chain of deep pitting concentrated near the 12 o'clock position, has not been detected.

4. Technical Details of the Instrumentation

4.1. Description of the MEC (Extended SLOFEC) Technology

Standard eddy current instrumentation is only sensitive to the surface of a metallic material. Even this can be quite a benefit for the inspection of flexible riser pipe. However, modifications of the standard eddy current technologies allow for the inspection of deeper structures. At Innospection magnetically biased eddy current has been found to be a versatile method for the inspection of ferritic steel structures. The technology is also known under the trade name of SLOFEC. The SLOFEC technology has been further developed into the MEC (Magnetic Eddy Current) technique.

Specifically developed Eddy Current sensors able to generate a higher density Eddy Current field for the increased defect detection sensitivity are used on the ferromagnetic material and to magnetise the section of ferritic steel components at the same time. The magnetisation has several effects. It changes the permeability of the material. Hence, the penetration depth increases. At the same time changes in permeability due to different flux distribution become visible. With these effects also defects embedded in the material can be picked-up with eddy current sensors. The principle is shown below.

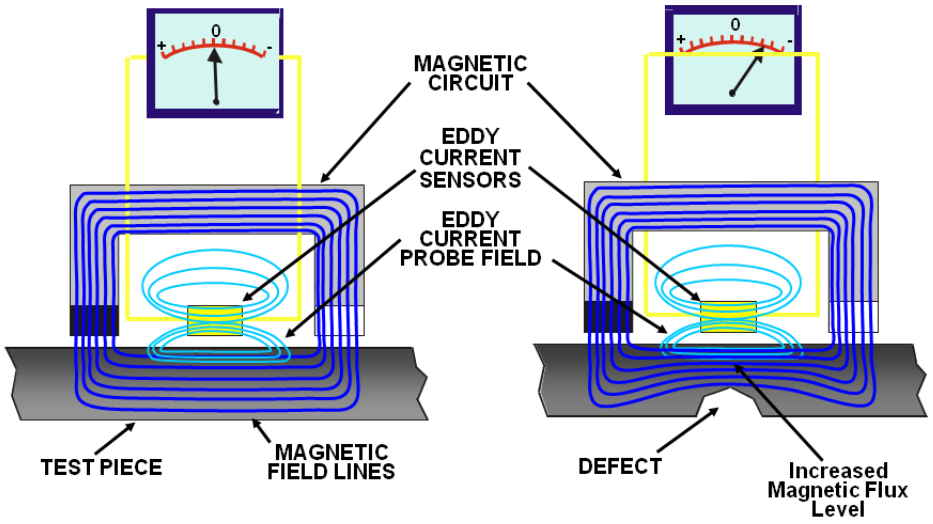


Figure 8: Principle of Eddy current measurement

The principle of measurement is related to MFL-measurement, but the set-up works at lower magnetisation levels. Since only moderate levels of magnetisation are required, the method works to higher wall thickness pipe, or through several millimetres of coating thickness.

Obviously one difference to MFL is that the level of magnetisation should be adjusted. In contrast in MFL the magnetisation level should always be as high as possible.

4.2. Equipment Calibration

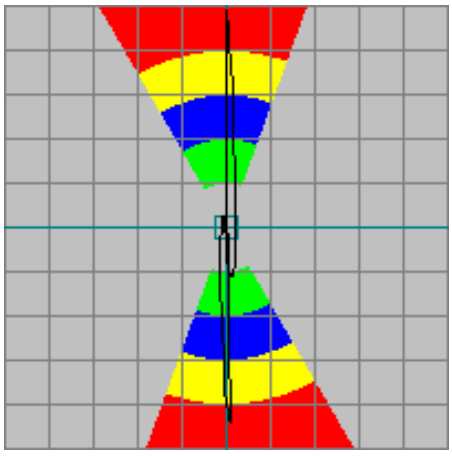
For external corrosion detection, the differential mode was used. The frequency setting used for channel 1-8 (differential mode) was 70 kHz.

The amplitude of the signals was set so that the artificial reference defect (Ø 25mm 60% depth) was set to 5 screen divisions. This is only classed as the initial pre-calibration setup and may then be further adjusted when the first true indication is detected and evaluated for depth, this by utilising the ultrasonic pulse echo technique.

Optimum signal/noise ratio and signal phase separation between the internal defect indications and other indications were considered when selecting a suitable test frequency.

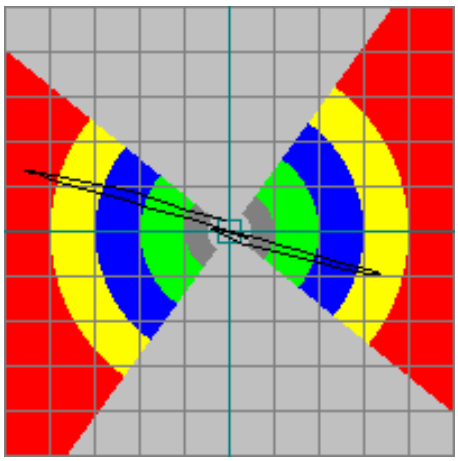
The differential channels of all the sensors were set so that internal defects were indicated in the vertical signal phase direction as shown in the diagram below. By moving the scanner in the reverse direction, the internal defect signal would show the first peak down, followed by the second peak up with an upward movement.

Sample signal display of internal defect

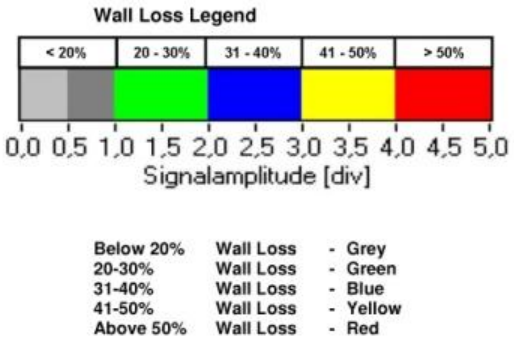


Subsequently external defects are indicated in the horizontal signal phase direction as shown below. Moving the scanner in the reverse direction, the external defect signals have the first peak left followed by a right movement with the second peak right.

Sample signal display of external defect



The general overview of the inspected areas with its results is presented in the attached colour scan reports with wall loss represented in colour classes as below. The applied colour code is shown on the report sheets.



Signal Y-component /angle analysis window set for indication of internal defects with approx. depth information

Eddy Current inspection is an evaluation method of NDT; hence all results obtained are based upon the test piece used. Material and wall thickness of the test piece should be as near as reasonably practicable to the item under inspection. Artificial defects should be as near in size and shape as to the type sought.

Because MEC signal amplitudes are an indication of defect depth and volume, the defect depth analysis by signal amplitude can only be done in comparison with varying depth artificial reference defects.

4.3. Analysis Procedure

Once the data of an inspection job is received all sensitivities and phase angles are adjusted.

For the analysis the data is exported as bitmaps. These bitmaps are used for an exact arrangement of the tracks. The arrangement can be made rather fine using circumferential weld signals. Once the exact arrangement is established, a track overview is generated, showing the exact coverage of the inspected object.

The inspected object usually is split up into sections. Even if the object is scanned in one run, it is advisable to split the data up into shorter sections. The data displayed in bitmaps will not reveal anything if too long distances are shown. A typical section length is 10 m. For these sections bitmaps are arranged to show the mapping of data in a position versus orientation coordinate system. This is done for the two phase directions and, if available, for the UT sensor data. It yields three mappings of the object. The bitmap with horizontal phase displays the outer layer of the object, whereas the bitmap with vertical phase displays the inner surface. Different types of defects may appear in different shape and size.

4.4. Description of the MEC-Combi Crawler Tool

The MEC-Combi Crawler pipe scanner is designed and built for high performance inspection applications. Based on the **M**agnetic **E**ddy **C**urrent technique (MEC), the pipe scanners allow the detection of internal and external corrosion in thin and thick walled piping/vessel components. This dynamic inspection technique utilises Eddy Current in combination with a magnetic field. With the superimposed DC-magnetisation, the depth of penetration is increased to such an extent that the internal corrosion attack (metal loss) can be detected from the external surface. It also allows the detection of small volumetric internal and external defects. Additionally, the tool is equipped with a UT sensor allowing scattered measurements of the wall thickness.

The scanner head with a multiple sensor array covers 180 mm circumferentially, meaning that a number of axial runs are to be taken with overlap to have 360° coverage of the full pipe. For a 6" pipe with ~200 mm diameter this would require four scans to complete the full 360° coverage. Several views of the tool are shown in Figure 9, Figure 10 and Figure 11.

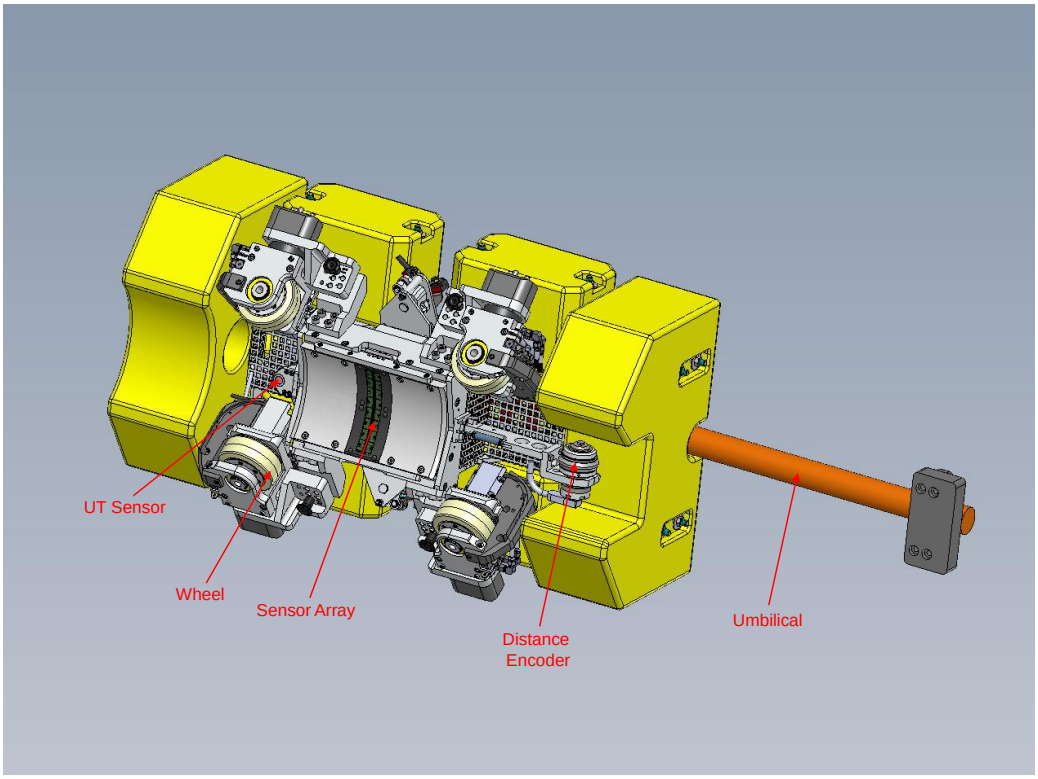


Figure 9: The MEC-Combi Crawler tool for the inspection of pipelines for top-side deployment (bottomside view).

The distances driven are measured with an encoder-wheel. An umbilical is connected to the tool for supply of electrical and hydraulic power by the ROV. In addition the eddy current and UT signals are routed to a top-side data-acquisition system via the ROV umbilical.

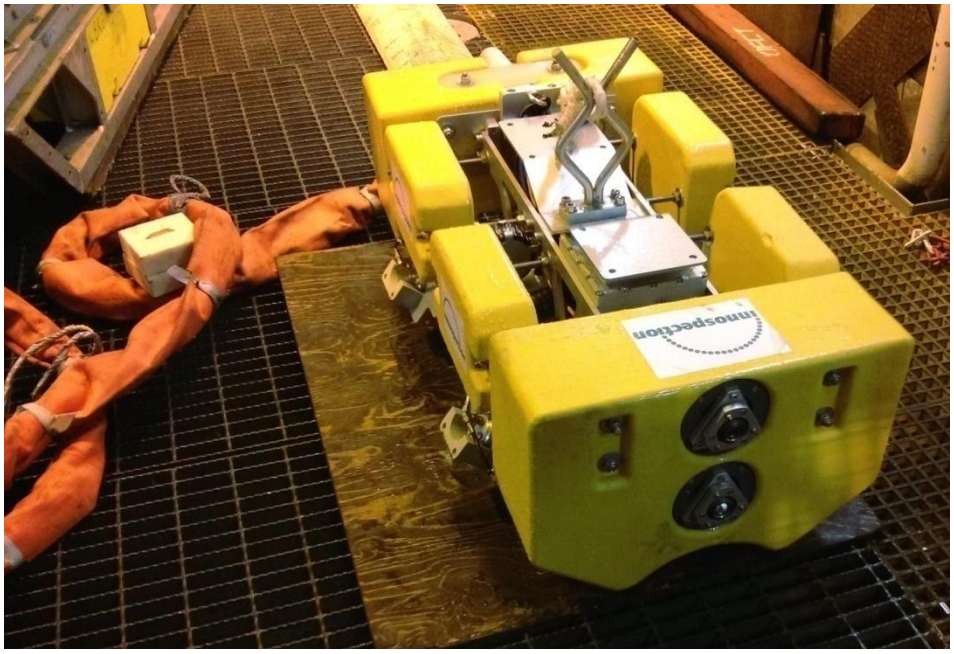


Figure 10: The MEC-Combi Crawler on site.

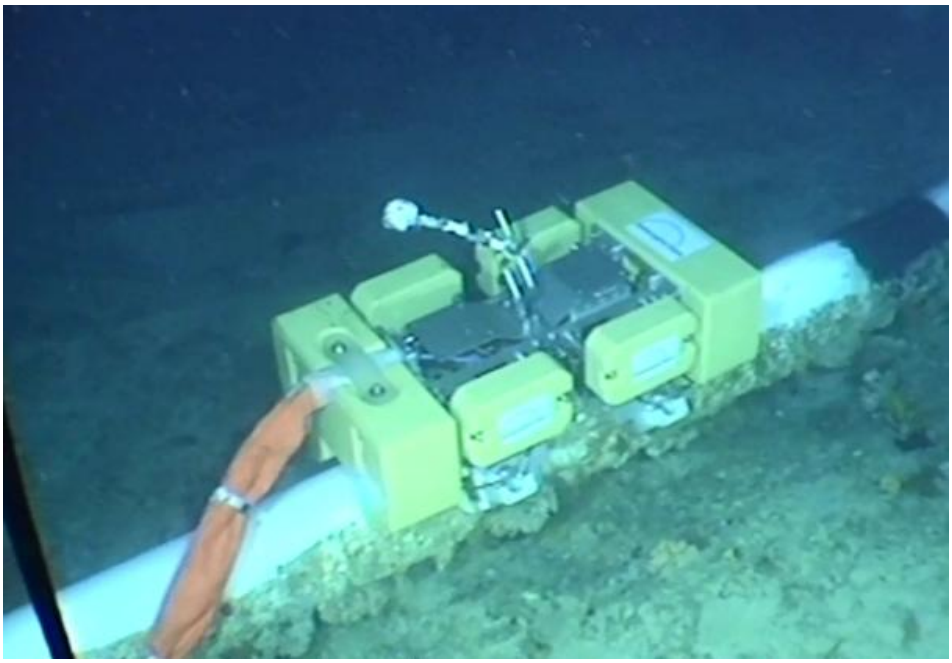


Figure 11: The MEC-Combi Crawler in operation scanning part of the XXX 4 pipeline section.

Appendix 1: UT measurements performed with the crawler-integrated UT probe

XXX 5 12'' Downstream Pipeline			
	Track 1 (10 – 12 o'clock)	Track 2(11 – 1 o'clock)	Track 3 (1 – 3 o'clock)
Distance from datum point [m]	UT reading [mm]	UT reading [mm]	UT reading [mm]
3.50	17.9	17.8	17.9
4.50	17.4	17.6	17.7
5.50	18.0	17.6	17.7
6.50	17.8	17.6	18.0
7.50	17.8	17.6	17.9
8.50	18.1	17.7	17.7
9.50	18.1	18.2	17.0
10.50	17.4	17.2	17.3
11.50	17.5	17.2	17.7
12.50	17.4	17.7	17.7
13.50	17.6	18.2	18.3
15.00	17.6	17.8	18.3
16.00	17.5	17.8	18.0
17.00	17.4	18.2	17.6
18.00	17.6	18.4	17.8
19.00	17.7	17.9	18.1
20.00	18.4	17.9	18.1
21.00	18.3	17.7	18.2
22.00	18.1	17.7	18.3
23.00	18.2	17.8	18.3
24.00	18.2	17.8	18.1
25.00	18.2	18.0	18.2
26.00	18.1	17.8	18.0
27.00	18.2	18.0	17.9
28.00	18.0	18.2	18.2
29.00	18.1	18.1	18.0
30.00	18.0	17.8	17.9
31.00	18.3	18.2	18.0

32.00	17.9	17.6	18.2
33.00	18.0	18.2	18.1
34.00	18.2	18.0	18.0
35.00	18.3	17.8	18.0

XXX 4 12'' Downstream Pipeline

Track 2 (11 – 1 o'clock)

Distance from datum point [m]	UT reading [mm]	Distance from datum point [m]	UT reading [mm]
6.00	17.9	27.50	18.0
7.00	18.1	28.50	18.0
8.00	18.2	29.50	18.2
9.00	17.9	30.50	18.1
10.00	16.0	31.50	18.0
11.00	18.2	32.50	17.6
12.00	18.2	33.50	17.5
		34.50	18.0
		35.50	17.6
14.00	17.8	36.50	17.8
15.00	17.9	37.50	17.9
16.00	18.1	38.50	17.7
17.00	17.3	39.50	17.7
18.00	17.6	40.50	17.9
19.00	17.4	41.50	17.8
20.00	17.6	42.50	17.9
21.00	18.2	43.50	18.0
22.00	18.2	44.50	18.2
23.00	17.9	45.50	18.2
24.00	18.1	46.50	18.5
25.00	18.1	47.50	17.9

ZZZ 12'' Downstream Pipeline		YYY 2 12'' Downstream Pipeline	
	Track 2 (11 – 11 o'clock)		Track 2 (11 – 1 o'clock)
Distance from datum point [m]	UT reading [mm]	Distance from datum point [m]	UT reading [mm]
7.00	18.2	1.00	18.2
8.00	18.2	2.00	18.0
9.00	18.2	3.00	18.1
10.00	18.0	4.00	18.1
11.00	18.2	5.00	18.2
12.00	18.1	6.00	18.0
13.00	18.0	7.00	17.8
14.00	17.7	8.00	18.0
15.00	17.7	9.00	18.2
16.00	17.7	10.00	18.0
		11.00	17.7

ZZZ 6'' Rigid Tie-in-Spool		YYY 2 6'' Rigid Tie-in-Spool	
	Track 2 (11 – 11 o'clock)		Track 2 (11 – 1 o'clock)
Distance from datum point [m]	UT reading [mm]	Distance from datum point [m]	UT reading [mm]
6.00	11.1	7.00	11.2
7.00	11.0	8.00	11.1
8.00	10.9	9.00	11.3
9.00	11.1	10.00	10.9
10.00	11.0		
11.00	11.0		
12.00	11.0	13.00	11.3
13.00	11.1	14.00	11.4
14.00	11.1	15.00	11.4
15.00	11.1	16.00	11.4
16.00	11.1	17.00	11.4
17.00	11.2	18.00	11.1