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# Analysis A1 and B2 Methods of Hydrostatic Testing Applied at Gas Pipeline; Cause Study A1-Method

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***Abstract*— in this paper we will analyze methods of hydrostatic testing applied in Trans Adriatic Pipeline Project. According to DVGW469 test methods applied in this project we have: A1, A2 and B2.**
***We will analysis the A1 Test Method ,which is applied to sections that are subject to be re-tested after being laid in final position as part of the main line testing, e.g. HDD crossings, RDX, RVX,AGI etc..***
***Another method for testing pipeline is A2 Test Method, which is applied to exposed sections and is the final hydro test and are not subject to be re-tested again.***
***Also another method that we will be apply in this project is B-2 Test Method that is applied to buried sections and no access over the whole section for visual leak.***
***Our study consist in Pre-test Horizontal Direction Drilling Section in SEMAN River Crossing at Kp198 using A1 method ,the outside diameter of this section is 48" ,wall thickness 24.9 mm, length 1129.94 mm, volume 1219.56 m$^3$. After filling the section with water we start pressurization no more than 3 bar/min, where pressure is meassured by dead weight tester and indiceted by pressure recorder.***
***The minimum test pressure was 123.5 bar, max test pressure 152 bar and strength test pressure 144 bar.***
***After pressure in the section reaches test pressure we start stabilization time. When pressure reached 144.170 bar, no leak was founded during the visual check after 4-hour pressure holding time. When the holding time is up, we start depressurization by no more than 3 -5 bar/min after this test came to an end. Finally, we accepted this pre-test because in the best test period chosen we had a differences on the temperature of -0.6454 °C, for a temperature decrease we must have a pressure decrease, in our test period we have a pressure decrease of -0.59 bar, which means that a correct ΔP/ΔT behavior for the section tested. In addition, for this test section we have a maximum ΔP/ΔT= 1.3494 Bar/°C. The ΔT of the test period is -0.6454 °C, where the allowed pressure decrease is -0.8709 Bar, at the final of the test period we received a ΔP of -0.59 bar which's is less than 0.8709 bar, the test is between the accepted ranges. As result test is accepted.***

*Index Terms*—**DVGW469, A1 Test Method, HDD section, Dead Weight Tester, Pressure Recorder.**

## I. DESCRIBE METHODS OF HYDROSTATIC TESTING APPLIED AT GAS PIPELINE

We will describe A1 and B2 methods of hydrostatic testing based on to DVGW G469.

***A 1 METHOD***

The test pressure is defined by the DVGW Technical Rules applying to the pipeline or installation. The Test pressure shall be specified prior to testing but must not exceed 95% of the minimum proof stress Rt 0.5 of the pipelines and/or installation components as per DIN 30690 Part 1 at the lowest point of the pipeline. The test pressure shall be at least 1.3 times the maximum permissible operating pressure at the highest point of the pipeline. After filling and de-aeration (cf. 3.3), the test pressure shall be applied with a pressure increase of up to 3bar/min max., and shall, as a general rule, be held for 3 hours in pipelines and installations. The holding time may be reduced for installation assemblies in accordance with DIN 30690 Part 1 and pipelines in accordance with DVGW Code of Practice G 496. During the holding time, in particular the connections and fixtures (flanges, socket joints, fittings, etc.) of the pipeline or installation assemblies shall be tested for tightness. The A 1 method is one pressurization interval+ 4-hour leak test. Test Method is applied to sections which are subject to be re-tested after being laid in final position as part of the main line testing, e.g. HDD crossings, RDX, RVX).
The hydro test is carried out before the section is laid in final position to verify the section has passed the strength test and is free of leaks. The pre-hydrostatic strength test and leak test pressure shall be slightly higher than the test pressure at the location when re-tested during the main line testing. The 4-hour leak test may be continued at the strength test pressure carried out at a reduced pressure as long the test pressures are higher than the expected test pressure when re-tested. Volume controlled pressurization is only required when the test pressures raise above 95% SMYS. Section can be water filled with the free-flooding method providing the air can be vented-off at a high point, or one bi-direction pig is pushed with water for air free water filling of the section. Air entrapment

calculation is not required. The acceptance criteria: No leak is found during the visual leak check after the 4-hour pressure holding time.

1. Pressurization to 80 % of Test Pressure
2. 20 min stabilization
3. Pressurization to 100% of Test Pressure
4. Minimum 4 hours holding time and Perform Visual Check
5. Depressurization

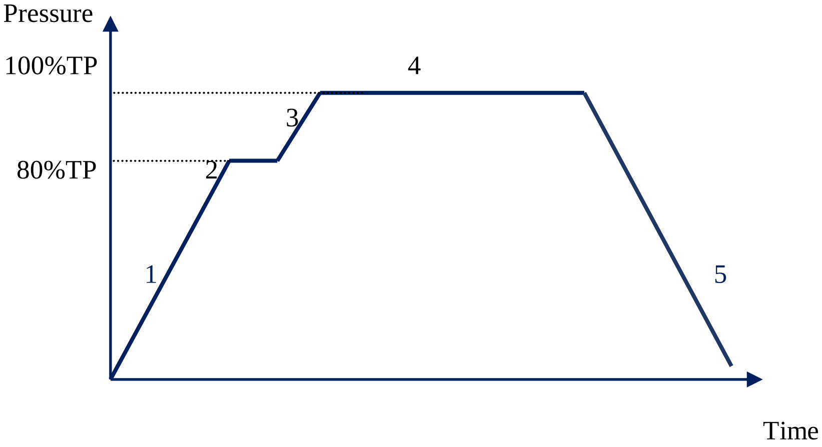


**Fig 1: Pressurisation Sequence Method A-1**

***B 2 METHOD***

Testing Method: Two Pressurization Intervals + 24-hour leak test.

The B-2 Test Method is applied to buried sections. It applies to sections with no access over the whole section for visual leak. The tightness of the test section is checked by evaluating the temperature-dependent fluctuations in pressure compared to the measured pressure differences over a minimum of 24-hour continuous testing time. The maximum strength test pressure is equivalent to ≤ 95% of SMYS with the exception in higher elevated areas to <100% SMYS pressure but shall never be less than 1.3 x MOP of each pipe at the location. The minimum leak test pressure is ≥1.1 x MOP but shall not exceed the strength test pressure applied to this section. After completion of water filling and sufficient time allowed for water temperature stabilization Test section is ready for pressurization. Pipeline temperatures will be obtained for proof of stabilization of filling water temperature and for calculating the theoretical volume necessary for raising 1 bar pressure.

The maximum test pressure is equivalent to <100% SMYS (E.g. 99.9%).At test pressures exceeding 95% SMYS, a quick-pressure-release-valve is installed in the pressurizing system which can be remote opened if necessary, e.g. in the unlikely event of pipe yield.

***1st Pressurizing Interval***

The pressurization shall be at a rate of not exceeding 3 bar per minute and stop at 100% test pressure. The pump rate, once established, shall be maintained to avoid pressure surges in the test section which can cause instable pressure/volume readings. The test pressure is held for 90 minutes. During this time the test pressure is logged every 15minutes and pressure values are transferred on a pressure decay plot. Upon completion of the 90-minute pressure holding time, the test pressure is decreased at a rate not exceeding 3-5 bar per minute to a pressure not lower than 2-5 bar at the high point.

***2nd Pressurizing Interval***

Same method is followed as during the 1st pressurization interval.

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***Determine Air Content***

The air contend is calculated during the pressurization to test pressure by comparing the theoretical Volume vs actual volume injected per pressure increase at 80% test pressure. The actual injected volume is measured by a high precision flow meter and transmitted to the test control cabin.The difference between the actual and theoretical data shall no exceed the factor 1.06 (6%).Optional a "Drain-Test" can be used for determine the air content. The Test pressure is recorded during all time on end-less paper roll by means of a mechanically clockwork operated pressure recorder. Pressure gauges are installed inside and outside the test cabin and indicating at all time the pressure status of the test section.

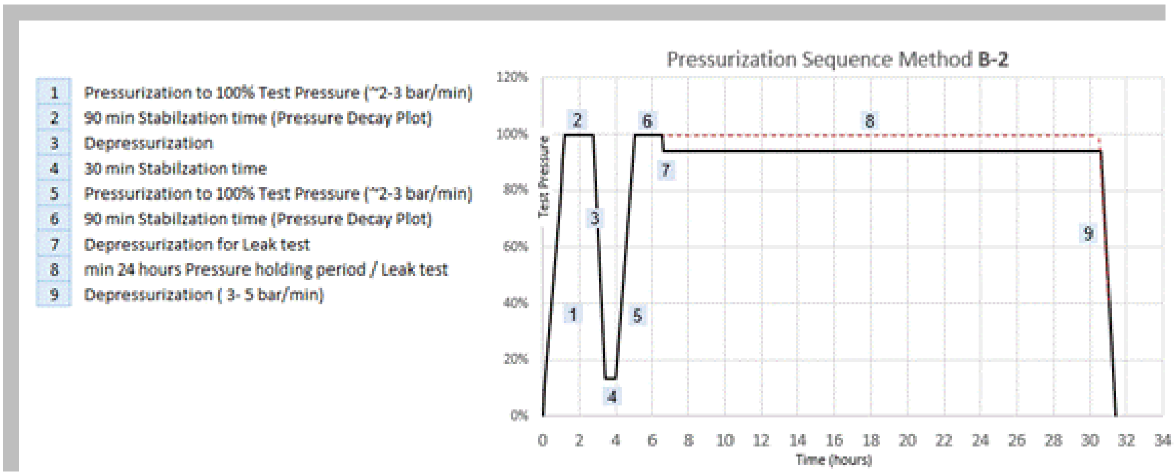


**Fig 2: Pressurisation Sequence Method B-2**

***Leak Test***

Pressure Holding Period for Leak Test

After completion of the second 90-minute holding time the Test Engineer shall decide whether to continue with the leak test at the same pressure (strength test pressure) or at a lower pressure.

A lower test pressure shall consider the head pressure to the high point and the expected effect of temperature change on test pressure, to ensure that the leak test pressure is not falling below the minimum test pressure at the section high point.

The minimum leak test pressure is 1.1 x DP at the high point.

Once the leak test has commenced the test data shall be recorded for a minimum continuous time of twenty-four (24) hours.

***Acceptance Criteria***

The permissible unaccountable volume change is regulated by the equation: $4xV_{ri}/3000=$ litre/hour

The maximum value is limited to 4 litre/hr regardless of the Section volume.

If the temperature corrected pressure loss is greater than the unaccountable, an assessment will be conducted to determine if there is a leak. This may be achieved by continuing the assessment of the test over a longer period of time. If a leak is determined, the location will be identified and repair undertaken.

## II. A1 METHOD-CAUSE STUDY

***Pipeline Details***

| **Subject** | **Detail** |
|---|---|
| Service | HP Gas Pipeline |
| Nominal Pipe Size / Outside Diameter | 48" / 1219 mm Outside Diameter |
| Nominal Wall Thickness | 17.5mm / 21.0mm / 24.9mm / 30.9mm |
| Design Pressure | 95 bar |
| Inside Diameter | 1184.0mm /1177.0mm /1169.2mm /1157.2mm |

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| | |
|---|---|
| Pipeline Material | Carbon Steel |
| Material Grade | X70ME / L485ME |
| Specified Minimum Yield Strength(Rt0.5) | 485 N/mm2 |
| Specified Maximum Yield Strength (Rt0.5) | 605 N/mm2 |
| Specified Minimum Tensile Strength (Rm) | 570 N/mm2 |
| Specified Maximum Tensile Strength (Rm) | 690 N/mm2 |
| Design Pressure | 95 bar |
| Design Temperature | Minimum -20°C / max. + 60°C |

| HDD Section | Approx. Length (m) | Approx. Volume (m) |
|---|---|---|
| HDD Semani River (KP 198) | 1111.74 | 1194.4 |
| HDD Semani River (KP 198) with test headers | 1123.74 | 1206.64 |

***Test pressure***

Minimum test pressure = 1.3 x Design Pressure=1.3 x 95 Bar=123.5 Bar (on the highest point of the section)
Maximum test pressure = ((2 x Minimum Yield strength x Wall thickness)*0.95) / ED= ((2 x 486 x 24.99)x0.95)/1219.2)x10=189.2 bar (on the highest point of the section).
Depends on the start time of the test, should be between the maximum and minimum at the highest point of the test section.

***Test instrumentation***

- 1 Dead Weight Tester (Budenberg 5400 EP)
- 2 Dial Pressure Gauge ( Anti parallax mirror) 0-250 Bar
- 2 Magnetic Pipe Temperature Sensors
- 1 Ambient temperature thermometer

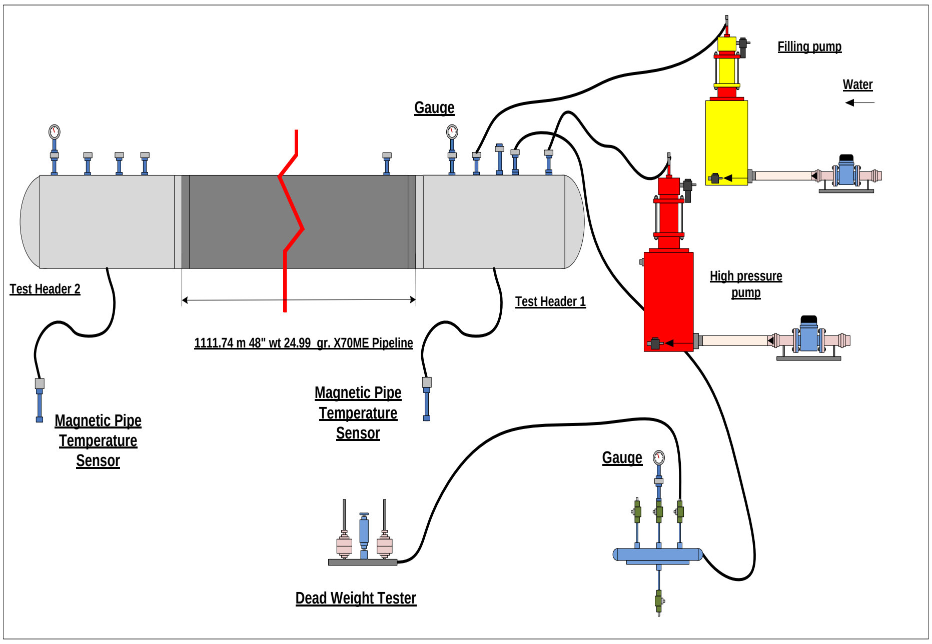


**Fig 3: Instrument scheme**

***Results of the Test:***

Graph Pressure vs Time

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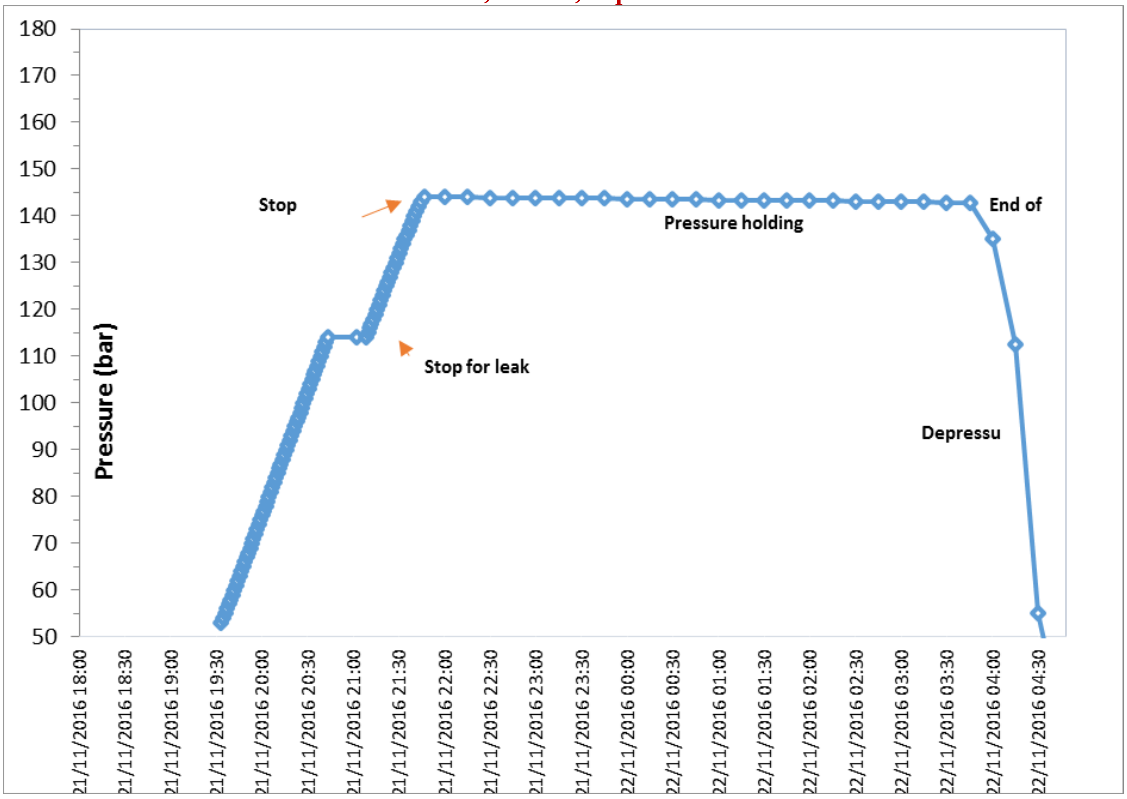


**Fig 4:Pressure vs Time**

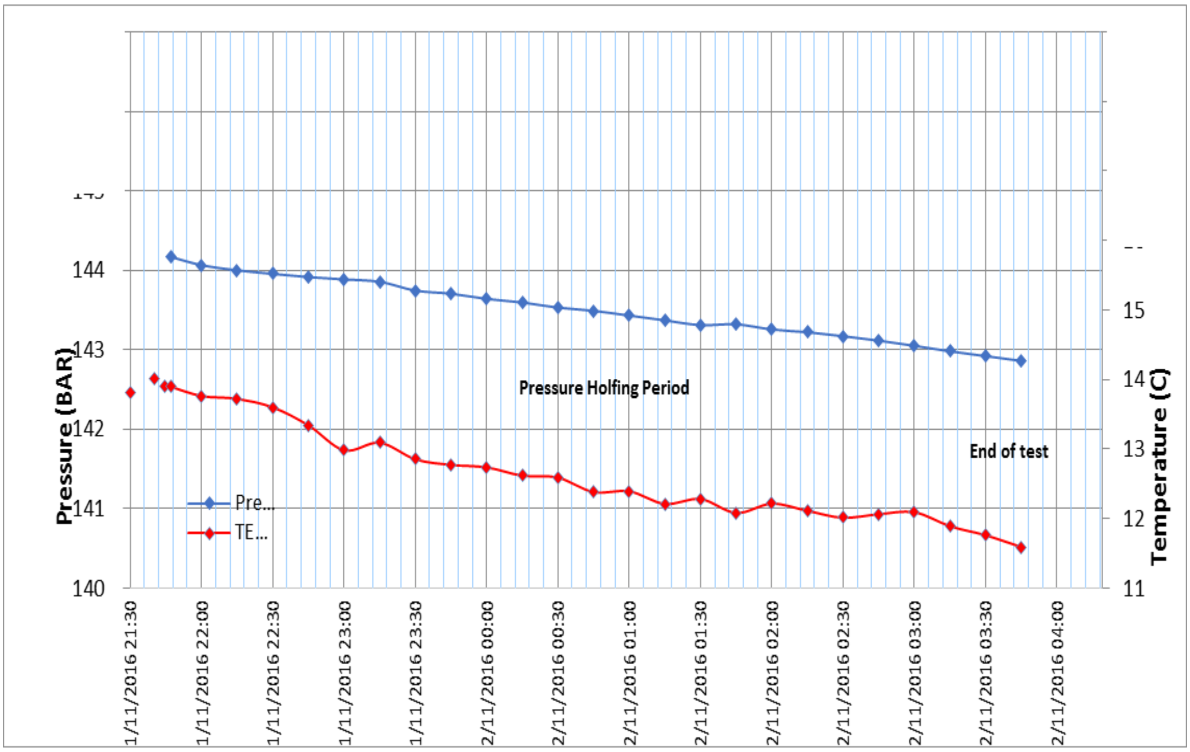


**Fig 5: Graph: Pressure vs Average Wall Temperature**

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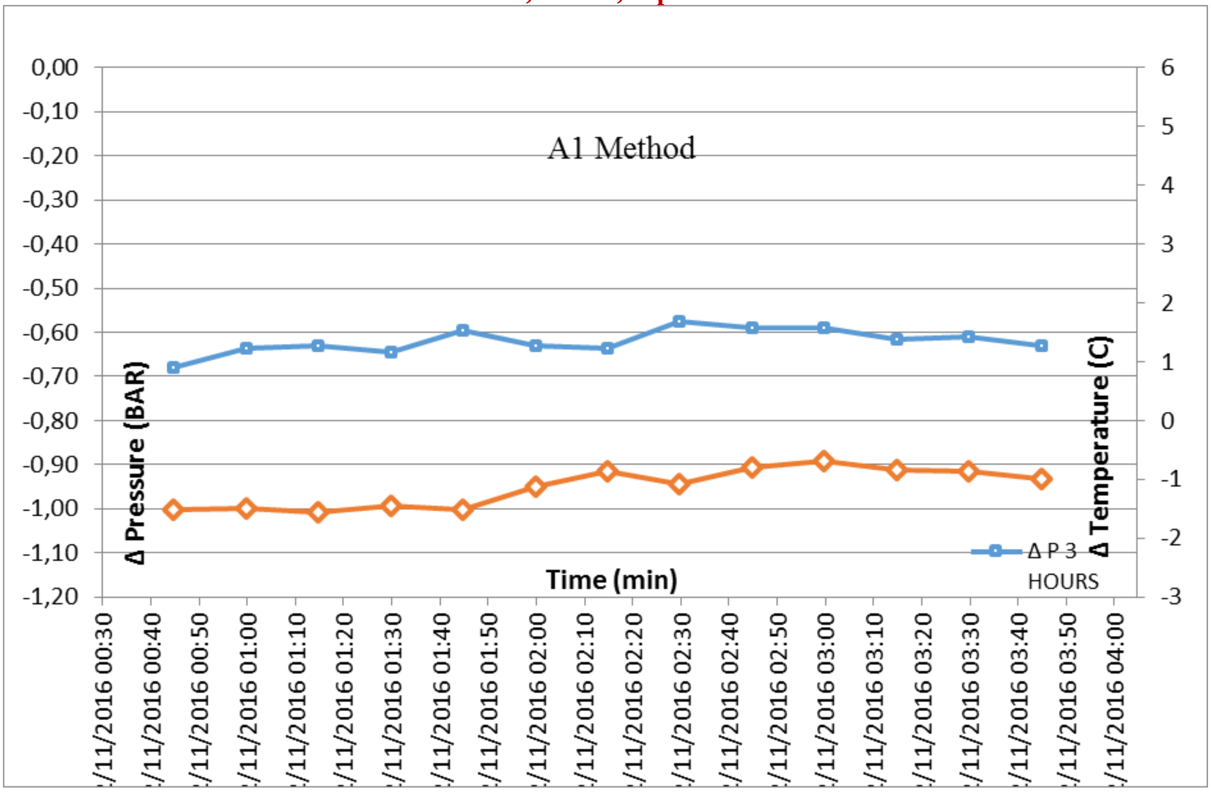


**Fig 6:Graph :Delta P vs Delta T**

| Pipeline Details | | | | Pressure Test Parameters | |
|---|---|---|---|---|---|
| | | Length (m): | 1129,94 | Strength Test Pressure Bar: | 144 |
| | | O.D. (inches): | 48 | Minimum Test Hold Period: | 3 hours |
| | | I.D. (mm): | 1169,4 | Leak Test Pressure KPa: | - |
| From KP: | 198+000 | To KP: | 199+130 | Minimum Test Hold Period: | - |
| Weld No.: | KP 198/J-1 | Weld No.: | KP 198/J-60 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Pressurization Start: | Date: | 21/11/2016 | Time: | 19:33 | Pressure: | 50 Bar |
| 100% Test Pressure Attained: | Date: | 21/11/2016 | Time: | 21:47 | Pressure: | 144.170 Bar |
| Strength Test Hold Period Commenced: | Date: | 22/11/2016 | Time: | 00:00 | Pressure: | 143.745 Bar |
| Strength Test Hold Period Completed: | Date: | 22/11/2016 | Time: | 03:00 | Pressure: | 142.920 Bar |
| Depressurization Commenced: | Date: | 22/11/2016 | Time: | 03:45 | Pressure: | 142.860 Bar |

## III. CONCLUSION

We accepted this pre-test because no leak founded during 4 hours holding time and in the best test period chosen we had a differences on the temperature of -0.6454 °C, for a temperature decrease we must have a pressure decrease, in our test period we have a pressure decrease of -0.59 bar, which means that a correct ΔP/ΔT behavior for the section tested. In addition, for this test section we have a maximum ΔP/ΔT= 1.3494 Bar/°C. The ΔT of the test period is -0.6454 °C, where the allowed pressure decrease is -0.8709 Bar, at the final of the test period we received a ΔP of -0.59 bar which's is less than 0.8709 bar, the test is between the accepted ranges. As result test is accepted.

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[3] EN12327:2000 - Gas supply systems - Pressure testing, commissioning and decommissioning procedures. Functional requirements. Remark: The German standardEN12327 is referring to the DVGW Regelwerk G469 and this is referring to VdTÜV Merkblatt 1060.

[4] DVGW Regelwerk G469: 2010 – Druckprüfverfahren – Gastransport/Gasverteilung.

[5] ISO 3183: (last edition), Petroleum and natural gas industries – Steel pipe for Pipeline transportation systems; EN 12327: (last edition) Pressure Testing, functional requirements.

## AUTHOR BIOGRAPHY

**Alfred HASANAJ** was born in Fier Albania in 1988. He earned the MSC degree from the University Polytechnic University of Tirana majoring in “Mechanical Constructions and Moving Vehicles”, 2012.He was graduated from Northumbria University Newcastle Upon Tyne, United Kingdom in Pipeline Integrity Management, and currently he is following the PhD studies topic: "Assessment integrity of gas pipeline –Cause study TAP-Project ". At the preset he works as Hydro test Engineer at Trans Adriatic Pipeline Project. He is continuing research on the mechanics specifically in gas pipe related fields.