BHDT Corrosion Inspection Services

at Nitrogenmuvek Zrt. Hungary Urea Plant

"First Time in the world and Fit for Purpose"

BHDT Service
Mr. Michael Simml

Contents

Summary

High Pressure Piping in the High Pressure synthesis section of a urea plant deserves the Best Quality and Maximum Reliability. The integrity of High Pressure Piping can be at risk due to internal and external corrosion phenomena. At regular time intervals corrosion inspections are advisable certainly in older age urea plants.
BHDT has the experience and Know How available to assure you Best Quality and Maximum Reliability. With BHDT Services, BHDT provides added value to its clients by offering Full Life Cycle support for the complete High Pressure Piping system. The activities of BHDT Service include all activities related to High Pressure piping systems during the complete lifetime of a urea plant; from Basic and Detailed Engineering, Installation services, Corrosion Inspections, Troubleshooting, Emergency supply/repair, Spare Parts Management up to Training Programs.
This paper describes the Digital Radiography Corrosion Inspection Services, which BHDT Service has provided to Nitrogénművek Zrt. in Hungary in April 2010. The corrosion analysis technique applied was a worldwide first time application of such a technique in a urea plant. This technique was considered by Nitrogénművek Zrt. very attractive as the internal corrosion phenomena could be analyzed while the plant remained in operation. The results were fit for purpose and provided Nitrogénművek Zrt. with the necessary information for the decision which piping needed to be replaced. Accordingly Nitrogénművek Zrt. could order the required material in time and replace the critical High Pressure piping in the scheduled turnaround of July 2010.

1. Introduction BHDT GmbH

BHDT (Best High Pressure & Drilling Technology) is a technologically qualified supplier and manufacturer of high pressure equipment and high pressure components for the chemical and petrochemical industry, as well as pumps generating pressures (up to 10,000 bar) for liquid media. We manufacture our products in co-operation with licensors of chemical processes using high-precision computer-controlled processing machinery and taking customer demands into account at the highest level of technological standards. Thanks to decades of experience, suitable materials and quality-assured order handling, we have gained an excellent position on the global market.

Picture 1: BHDT Headquarters in Kapfenberg, Austria

Decades of experience have made BHDT well known all over the world as a reliable manufacturer of high pressure valves (angle, globe, check, safety, analyzer, sample and control valves), all kind of fittings (tees, elbows, reducer, nipple, threaded flange, weld neck flange, weldolet, etc.) and prefabricated high pressure pipeline isometrics (spools) especially for Urea and Ammonia plants.

Special know-how in the field of material science (Austenitic stainless steel 316L Urea Grade and 25Cr-22Ni-2Mo, Duplex and Superduplex) for manufacturing of Fertilizer products in cooperation with all major licensors such as Stamicarbon, Saipem, TEC, KBR and Urea Casale assures high quality products.

Valves and fittings are made exclusively of forged material. The exact knowledge of process technologies guarantees optimum function and long service life of our products.

All connections can be produced to conform to all international standards including ANSI B 16.5, 1500#-2500#, DIN, IG, as well as customer standards. We also offer all kinds of actuators (gear, electric, hydraulic or pneumatic).

BHDT is not only producer of top-quality high pressure components but is also a supplier of complete customized high pressure systems for the Petrochemical Industry, and contractor for large industrial plants. BHDT has an excellent expertise because of decades of experience on the world market. Complex customer requirements are executed in the framework of an efficient, objective oriented project management.

2. BHDT Service: Best Quality and Maximum Reliability

The trends in project development of large capital projects like new ammonia/urea complexes show that the overall responsibility is shifting from contractors to operating companies. Also local engineering and local construction companies are becoming stronger, more experienced and more involved in these projects. BHDT has decided to intensify its services business in order to adapt to these trends and deliver more added value to contractors and operating companies.

BHDT Service mission is to:

- Offer Full Life Cycle support for all High Pressure Piping systems
- Learn & Improve via strategic partnerships with operating companies
- Become the One Stop Solution provider for all HP piping issues
- Offer Best Quality and Maximum Reliability

The activities of BHDT Service include all activities related to High Pressure piping systems in a urea plant; from Basic and Detailed Engineering, Installation services, Corrosion Inspections, Troubleshooting, Emergency supply/repair, Spare Parts Management up to Training Programs.

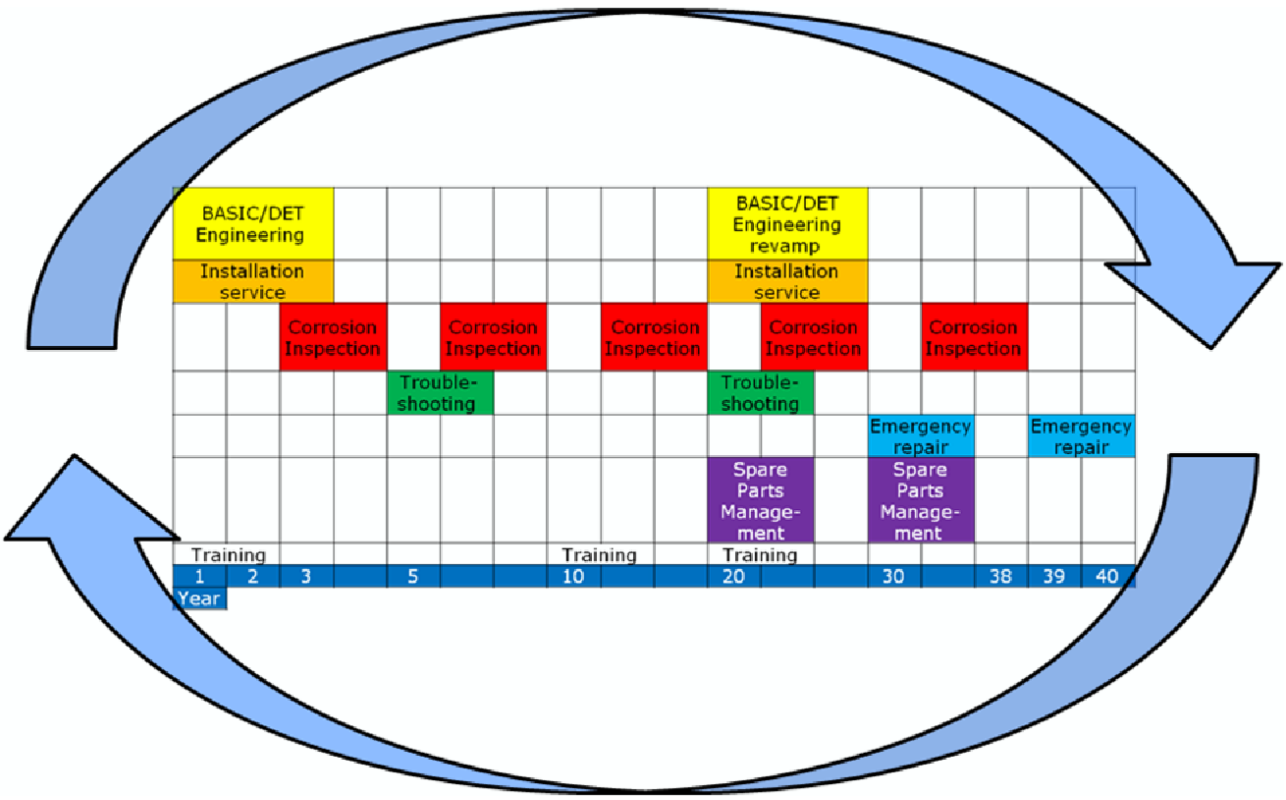
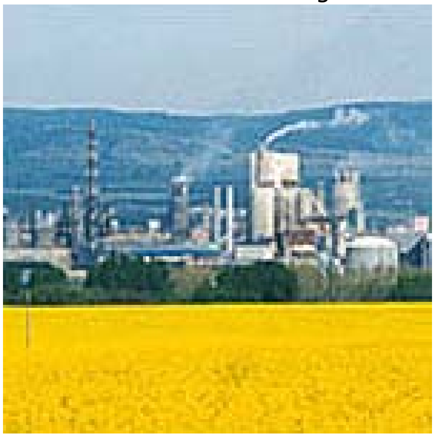


Figure 1: BHDT Service during the lifetime of a urea plant

The figure above shows that during the life time of a urea plant each of these services can and will become necessary. BHDT Service offers all these services; BHDT Service is the One Stop Solution provider for all your High Pressure Piping issues.

3. Corrosion Inspection at Nitrogénművek Zrt.

As a member of the Bige Holding Group, Nitrogénművek Zrt. is the only fertilizer producer company in Hungary having complete chain of nitrogen fertilizer production, meaning that the most important substrates for the fertilizer production, ammonia and nitric acid, are also manufactured by the company.



Picture 2: Nitrogénművek Zrt.

The portfolio of Nitrogénművek Zrt. is highlighted by the production and sales of fertilizers, particularly of those containing nitrogen-based agents.The main products of the company has kept on to be the CAN, ammonium nitrate, urea and UAN.
From 2003 the company started to market its fertilizer product under the brand name of Genezis.
In 2005 the company started an investment program of several years, including the production of a new acid plant, a granulation plant, a packaging plant, a neutralization plant and a dolomite mill.

The distribution of the different chemical by-products - nitric acid, liquid ammonia, calcinol, AN-solutions, industrial gases - forming during the process of fertilizer production still took only a minor part in the sales of the company.

Nitrogénművek Zrt. operates a Stamicarbon CO_2 stripping plant in Petfurdo, Hungary with a design plant capacity of 600 metric tons per day. The plant was constructed in 1975 by Coppee Rust in Belgium. After some 34 years on-stream time the owner noticed severe corrosion problems in several High Pressure Pipelines.

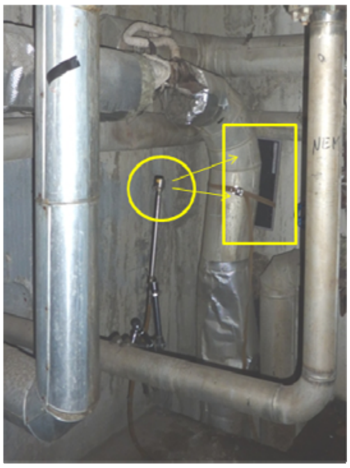
A small part of the High Pressure Pipelines was replaced. However, the owner needed a complete corrosion inspection to assure the integrity of the High Pressure Pipelines in the synthesis section.

In February 2010 Nitrogénművek Zrt. contacted BHDT Service with the request to perform a corrosion inspection on the process side of the High Pressure Pipelines. The results from the inspection were needed as soon as possible in order to replace the critical pipelines during the Turnaround, which was already scheduled for July 2010. Furthermore, no shut down of the urea plant was acceptable.

Picture 3: The civil structure of the high pressure synthesis section at Nitrogénművek Zrt. urea plant in Hungary

3.1 Digital Radiography

BHDT Service recommended to perform the corrosion inspection according to the Digital Radiography technique. Although this technique was not been proven in urea plants yet, its features were very attractive as this technique allowed a corrosion inspection of the pipelines while the urea plant remained in operation.
For the execution of this corrosion inspection, BHDT Service did co-operate with Applus RTD, from the Netherlands, who is specialized in non - destructive testing (NDT) and inspection solutions for both standard and customized inspections.



With Digital Radiography a radio-active source is used to take a digital picture of a certain part of a pipeline. Picture 4 shows the radio- active source (in this case Iridium) pointing to a pipeline behind of which a receiving panel is mounted on which the digital picture will be developed.

Via computer software the radiography film (X-ray picture) is digitalized and visually analyzed on a computer screen located in a small mobile trailer (refer to picture 5).

Picture 4: Iridium source

Picture 5: Mobile trailer

The Digital Radiography Technique has the following advantages:

- Inspection during operation is possible
- Preparation time will be available for repair/replacement during turnaround
- Digital Image processing
- Up to 90% dose reduction
- Onsite interpretation
- Look under pipe supports
- Look inside insulation
- No chemicals / no darkroom needed

3.2 Scope of Inspection

The corrosion inspection at Nitrogénművek Zrt. in Hungary was performed in a limited period of only three days (April 7-9, 2010). The figure below shows the process flow scheme of the synthesis of the urea plant of Nitrogénművek Zrt. The scope of inspection being four major High Pressure Pipelines are indicated with a brown circle.

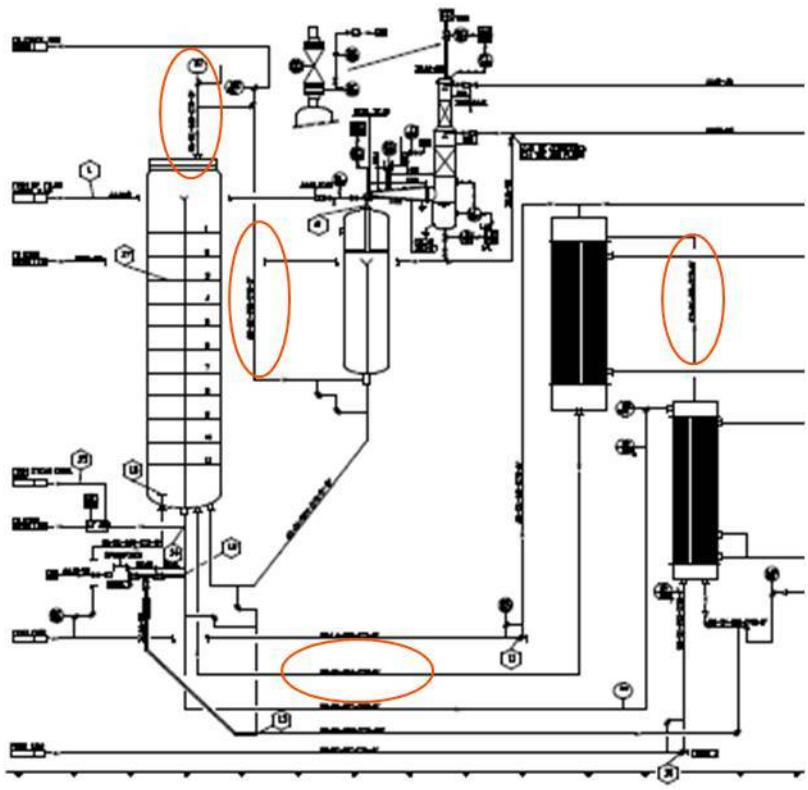


Figure 2: Flow scheme of synthesis section of Nitrogénművek Zrt.

The four lines are:

1. Gas line from High Pressure stripper to High Pressure Carbamate Condenser: a 6” line with a length about 38 m and with a steam tracing
2. Gas line from the reactor to the High Pressure scrubber: 3” line with a length of about 24 m with a steam tracing
3. Gas line from the reactor to the stack: 2” line with a length of about 6 m with a steam tracing
4. Gas/liquid line from the High Pressure Carbamate Condenser to the reactor: a 8” line with a length about 12 m and with a steam tracing

With Digital Radiography a length of approximately 10-15 m could be covered in one day. For this reason it was necessary to make priorities and to select those areas where highest corrosion rates were expected based on the different possible corrosion phenomena. For liquid lines these areas are for example at the outer radius of bends and the weldolets and for gas lines these areas are at locations where condensation corrosion can occur (areas with bad insulation, flanges and Tee’s)

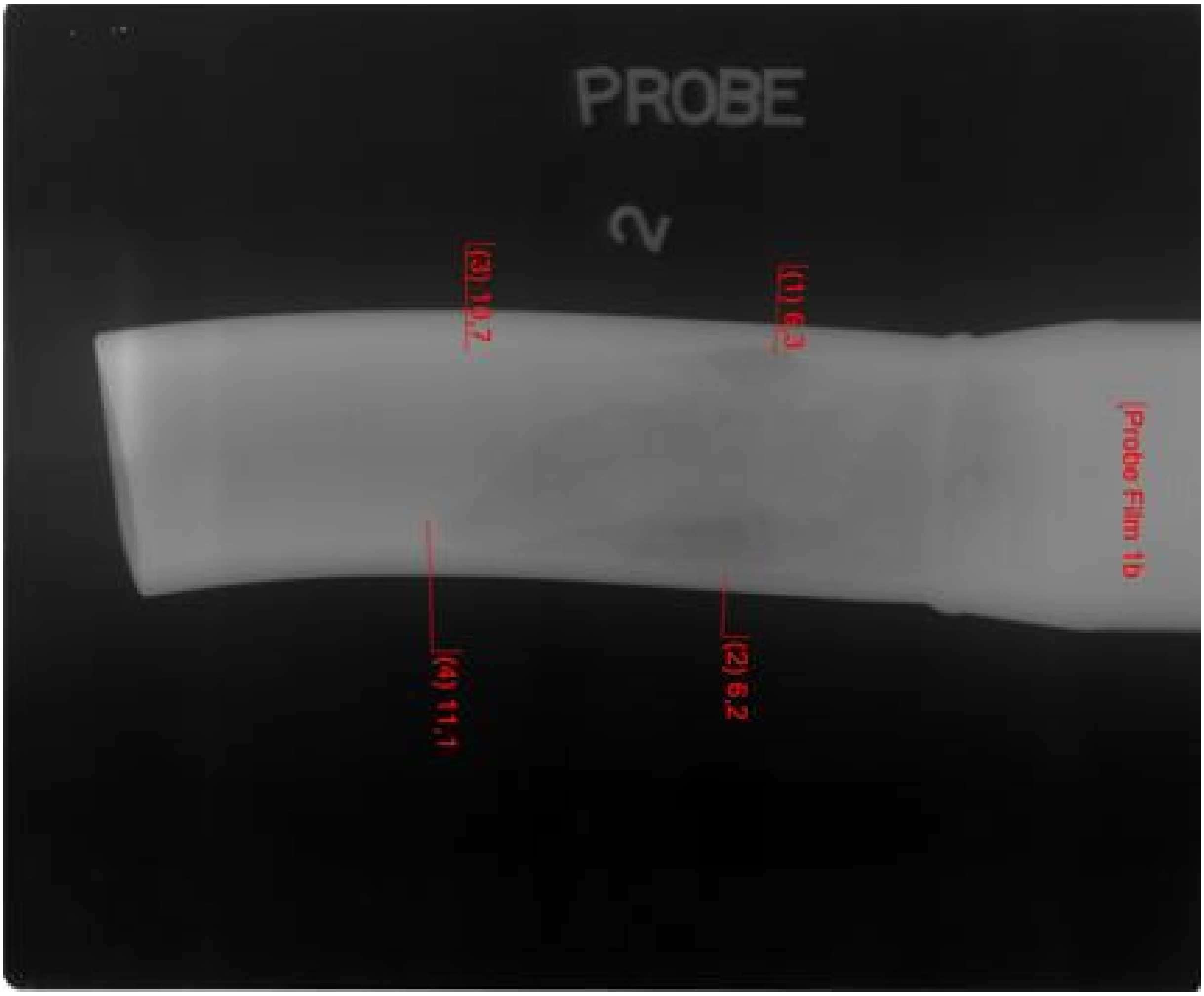
Several high pressure pipelines were badly insulated which is very common in 35 year old plants and although the synthesis section of the plant was located in a close concrete building (refer to Picture 2) condensation corrosion in gas pipelines was an area of concern and a point of special attention during the inspection.

3.3 Validation

Although Digital Radiography is an attractive and promising inspection technique, it was never before applied in a high pressure section of a urea plant. Important therefore was a validation of the technique against traditional inspection techniques. Fortunately the owner had available a 3” High Pressure pipeline part with corrosion attack, which could be used for the validation.

Picture 6a/b: The corroded 3” pipeline used for validation of the Digital Radiography Technique

The pictures above show the 3” pipeline part, which was replaced earlier due to heavy condensation corrosion. It is a 3” high pressure pipeline, material of construction 316L UG with the following dimensions 88,9 X 11,13 mm. Ultrasonic wall thickness measurements showed a minimum thickness of 3 to 4 mm with an accuracy of ±1 mm.
The picture below shows a Digital Radiography film of this pipeline part.



Picture 7: Digital Radiography film of the 3” pipe part

After taking two films with Digital Radiography the minimum measured wall thickness was 6.2 mm, while after four films the minimum measure wall thickness found was 4.6 mm (accuracy of ±5%).

The following conclusions can be drawn from this validation:

1. Differences in darkness qualitatively indicate a decrease in wall thickness
2. In case of a local attack several Digital Radiography films are needed to find the minimum wall thickness.
3. Know How of corrosion phenomena is therefore vital for correct position of source and film

3.4 Inspection results

With the Iridium source the 2″ and 3″ High Pressure Pipelines could be inspected, however for the 6″ and 8″ High Pressure Pipelines, which have a larger wall thickness the stronger Cobalt source was needed.

2″ gas line from the reactor to the stack (4 locations were inspected with the Iridium source):

- No abnormalities were found as this line is not in operation continuously.

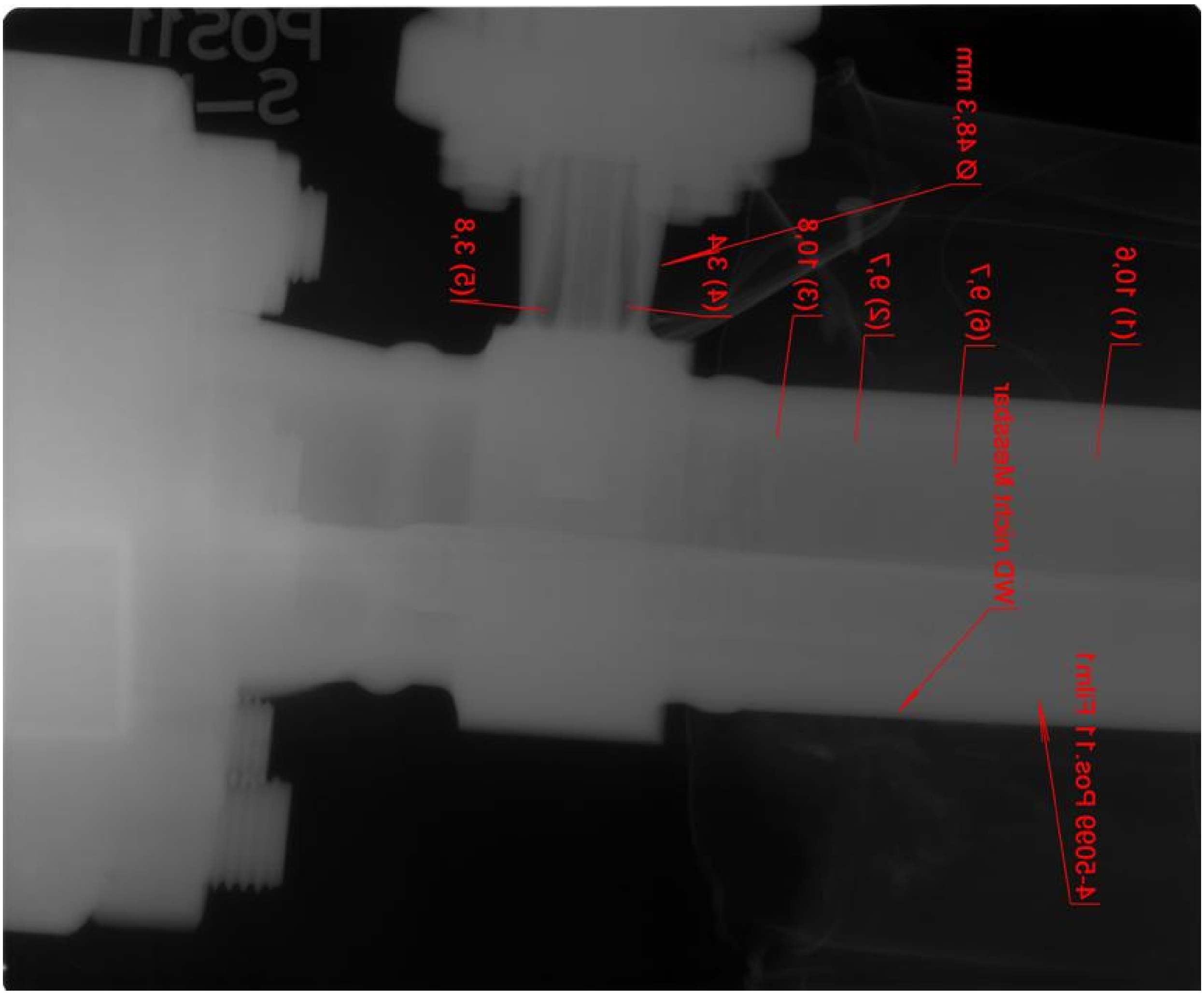
3″ gas line from the reactor to the High Pressure scrubber (8 locations were inspected with the iridium source):

- Inspection of the critical areas of the 3″ pipeline shows that at several locations severe condensation corrosion has taken place.
- The corrosion rate is questionable since this type of corrosion is a result of bad insulation.
- The measured remaining wall thickness is at several locations lower or close to the minimum required wall thickness.
- In some occasions the steam tracing impaired a correct wall thickness measurement.

The picture below shows one of the Digital Radiography films of the 3″ gas line from the reactor to the High Pressure scrubber.

Clearly one is able to see the flange with the bolts and nuts and the two steam tracing lines. Please remind the line is in operation and the insulation is in place.
A little more difficult but still clear enough (certainly on the original film) also one can see the areas in the 3″ line with a darker grey/black color showing the areas with a smaller wall thickness. 6.8 mm is measured as the minimum wall thickness on one of these areas, which corresponds to the minimum required wall thickness of a 3″ High Pressure Pipeline under these operating conditions.

Picture 8: Digital Radiography film of the 3″ pipe line

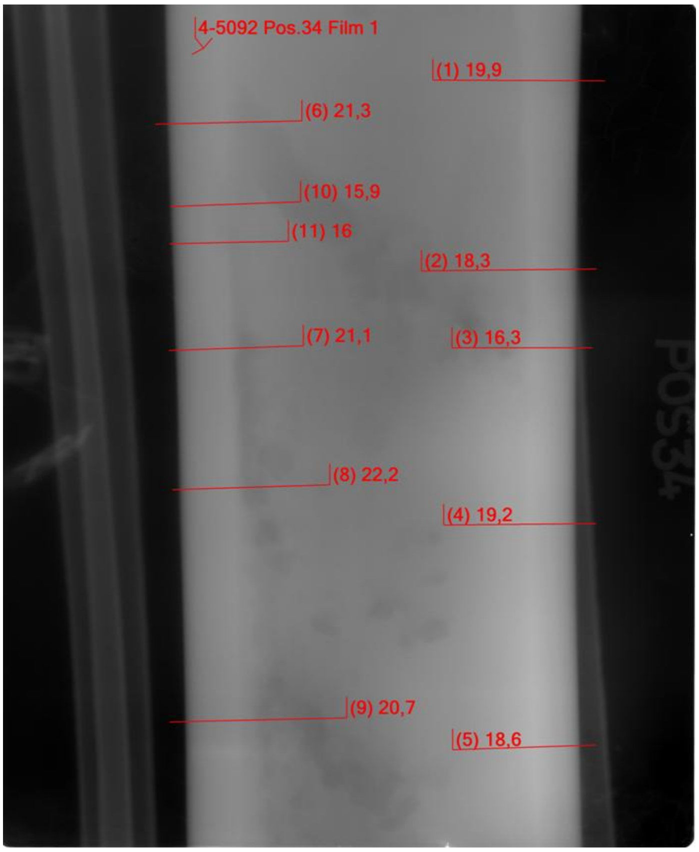


Picture 9: Digital Radiography film of a Tee of the 3” pipe line

The picture above shows the Digital Radiography film of another part of the 3” pipeline. Here one can see a serious wall thickness reduction of the wall of the Tee to a level of 3.4 to 3.8 mm. Condensation corrosion has taken place as such a Tee can easily act as a cold spot area.

6” gas line from High Pressure Stripper to High Pressure Carbamate Condenser (4 locations were inspected from various angles with the Cobalt source):

- Digital Radiography films show serious reduction of wall thickness at numerous areas.
- In about half of the films the remaining wall thickness is at minimum required level of 13 mm. In other half the minimum measured wall thickness is at 16 mm.
- The decrease in wall thickness is 7 to 10 mm! This condensation corrosion mainly occurred since the moment that the insulation has been in bad condition.
- Line is badly insulated.



The picture on the left shows one of the Digital Radiography films of the 6″ gas line from the High Pressure Stripper to the High Pressure Carbamate Condenser.
Clearly one is able to see again the steam tracing lines. Also one can see the areas in the 6″ pipeline with a darker grey/black color showing the areas with a smaller wall thickness. 15.9 mm is measured as the minimum wall thickness on one of these areas, which means a reduction of the original wall thickness of more than 6 mm.

Picture 10: Digital Radiography film of the 6″ pipeline

8″ gas/liquid line from the High Pressure Carbamate Condenser to the reactor (3 locations were inspected from various angles with the Cobalt source):

- No abnormalities were found

3.5 Conclusions

With an Iridium source High Pressure pipelines in the high pressure synthesis of a urea plant up to 3″ can be inspected with Digital Radiography. Judgment of the remaining wall thickness by means of a Cobalt source of 6″ and 8″ lines in liquid as well as gas lines appeared to be possible. Gas lines show better results.

Validation with a 3″ validation pipe piece showed that Digital Radiography is able to determine qualitatively the corroded areas. Difference in darkness qualitatively indicates decrease in wall thickness. In case of local attack, several Digital Radiography shots are needed to find the minimum wall thickness. Know How of corrosion phenomena is therefore vital for correct position of source and film.

Inspection of the critical areas of the 3″ gas pipeline from the Reactor to High Pressure Scrubber and the 6″ gas pipeline from the High Pressure Stripper to the High Pressure Carbamate Condenser showed that at several locations severe condensation corrosion has taken place. The corrosion rate is questionable since this type of corrosion is a result of bad insulation. It was strongly advised to replace these pipelines completely at the first opportunity, i.e. July 2010. The Digital Radiography Corrosion Inspection of the 2″ and 8″ High Pressure pipelines showed no abnormalities. The 2″ gas pipeline is in service temporarily only and the 8”pipeline contains liquid/gas mixture which is less vulnerable for condensation corrosion.

4. Overall conclusions

High Pressure Piping in the High Pressure synthesis section of a urea plant deserves the Best Quality and Maximum Reliability. The integrity of High Pressure Piping can be at risk due to internal and external corrosion phenomena. It is advised to perform at regular time intervals corrosion inspections certainly in older age urea plants.

Digital Radiography is a very promising and attractive corrosion inspection technique as it is possible to do the inspection while the plant is in operation. This enables the plant owner to prepare the replacement of the critical High Pressure Piping before the scheduled turnaround. BHDT Service did co-operate with Applus RTD in the Netherlands, who is specialized in non - destructive testing (NDT) and inspection solutions for both standard and customized inspections. It was the first time in the world that this inspection technique was applied in a urea plant and has proven to be very successful; it accommodated fully the needs of Nitrogénművek Zrt.

The material quality certificates of the High Pressure Piping material are important in order to know the actual mechanical and corrosion properties, which enables an accurate determination of the minimum allowable wall thickness.

With an Iridium source High Pressure Pipelines up to 3” can be successfully inspected with Digital Radiography. Judgment of the remaining wall thickness by means of a Cobalt source of 6” and 8” lines in liquid as well as gas lines appears to be possible; presence of liquid influences the accuracy of the measurement; gas lines show better results. For larger wall thicknesses new inspection techniques need to be developed.

Validation with a 3” pipe part showed that the digital radiography is able to determine qualitatively the corroded areas. Difference in darkness qualitatively indicates a decrease in wall thickness. In case of local attack, several Digital Radiography films are needed to find the minimum wall thickness. Know How of corrosion phenomena is therefore vital for correct position of source and film.