ATMOSPHERIC CORROSION
Preventive Measures
in Engineering and Construction phase

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Contents:

1. Introduction

From the cases of atmospheric corrosion and the conditions that are conducive to such corrosion we have formulated a number of preventive measures. They are taken at three different points in time, during the:

- Engineering phase;

- Construction phase;

- Maintenance phase (will be covered in a next paper).

2. Engineering phase

Preventive measures to be taken in the engineering phase are specified in a number of standards. In 1993, DSM reviewed its Standard EP 7-3.1 Surface protection; Measures to prevent external corrosion of metallic materials. This standard sets out, among other things, whether or not a protective coating should be applied depending on service conditions. An information sheet appended to it gives background information on the measures to be taken and on the requirements of the standard.

DSM Standard EP 7-3.1.2 (Surface protection, external; Selection table protective systems; List of protective systems) specifies what protective coating should be used depending on the service conditions such as the temperature and type of material of construction.

DSM Standard EP 3.13.2-1.1 (Thermal insulation; Equipment and aboveground piping) specifies how insulation is to be applied. In these EP's (Engineering Practices) general measures to reduce the risk of atmospheric corrosion are enumerated.
Measures to reduce the risk of atmospheric corrosion as mentioned in these standards are:

- Do not insulate if not necessary of process economics;
- Insulating material should be free of nitrates and chlorides;
- Use expanded polyurethane solely for cold insulation (with stable, non-corrosive flame retarding agents;
- Apply a water-tight finish of insulation jacketing;
- Do not affix chloride-containing stickers to (austenitic) stainless steel at temperatures exceeding 50 °C;
- Do not apply zinc, galvanized steel or zinc-containing paints etc. to stainless steel at temperatures higher than about 400 °C;
- Carbon steel skirts with fire protection should be given a protective coating;
- Pay attention to constructional aspects:
  - material selection,
  - crevice-free design,
  - weld design,
  - use of cover rings,
  - take use of spacers during installing of steam tracing;
- Un-insulated equipment in unalloyed and low alloy steel is always coated (mostly for reasons of aesthetics);

- Install steam tracing with use of spacers according to DSM standards EP 3.5.5-2.1 and EP 3.5.5-2.1/S002 (addition and amendments to EP 3.5.5-2.1)
- Additional measures should be taken for insulated vessels and pipe work likely to develop atmospheric corrosion:
  - apply a protective coating, (an)organic or metallic;
  - aluminium foil wrap;
  - shelter the apparatus;
  - apply mothballing system (cocooning).

AGI-Arbeitsblatt Q152 (Arbeitsgemeinschaft Industriebau E.V.) discusses a number of methods for preventing ingress of moisture through the cover sheeting (Figures 1 to 4).

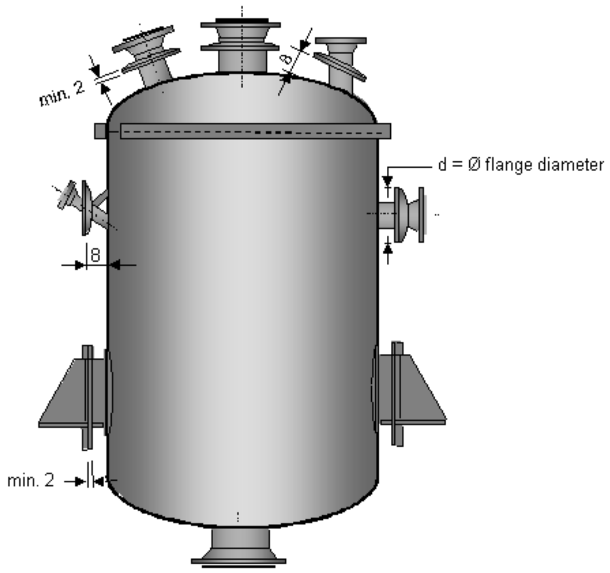


Figure 1: Cover rings on nozzles. (AGI Arbeitsblatt Q152)

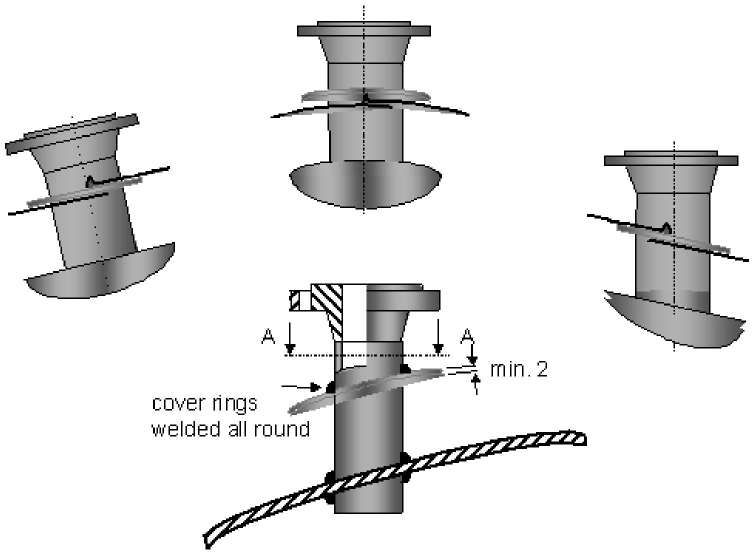


Figure 2: Positioning of Al sheeting at cover rings. (AGI Arbeitsblatt Q152)

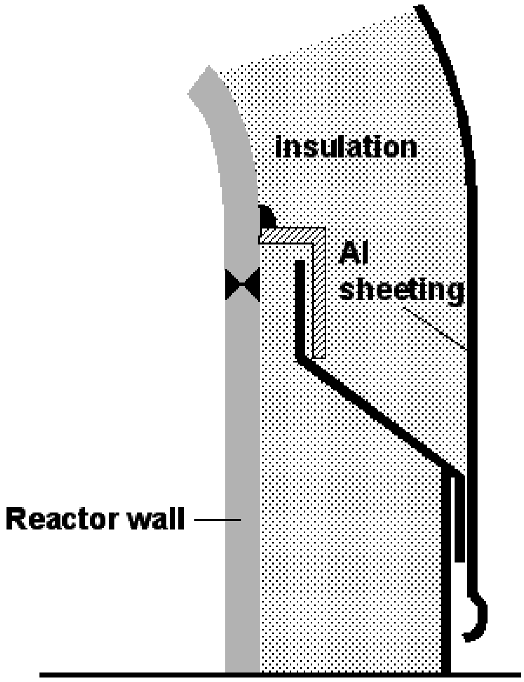


Figure 3: Positioning of Al sheeting at transition from dished head to cylindrical part. (AGI Arbeitsblatt Q152)

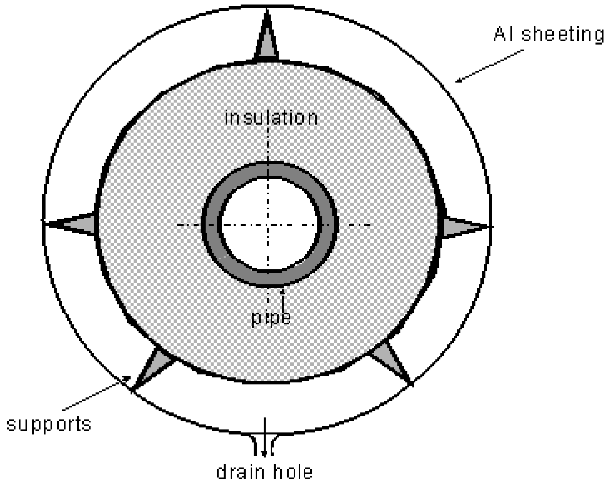


Figure 4: Positioning of support between Al Sheeting and insulation material. (AGI Arbeitsblatt Q152)

In the Netherlands, a committee (CINI) has been established whose objective it is to promote cost-effective insulation engineering in industry. The efforts of this committee, in which DSM participates, have meanwhile led to a CINI handbook giving recommended practices. Experience gained in the Dutch chemical industry indicates that the risk of atmospheric corrosion depends in large part on the quality of the cover sheeting.

As well as the general measures mentioned before, specific measures should be taken if conditions are highly likely to cause atmospheric corrosion. In assessing this likelihood, the following aspects should be considered

(Table 1):

- the type of material of construction
- the most probable form of corrosion
- the service temperature
- the risk of ingress of moisture (indoor versus outdoor installation)

Specific preventive measures include the following:

- application of a suitable protective (organic) coating;
- wrapping with aluminium foil (for stainless steel lines);
- application of a metallic aluminium spray coating
- cocooning;
- sheltering the pipe or vessel.

Table 1: Assessing the risk of corrosion.

<table>
<tr><td colspan="2">In assessing the risk of corrosion, and thus the need for additional measures, the following aspects should be distinguished:

• Material for construction
• Likeliest form of corrosion</td></tr>
<tr><td>Carbon and low-alloy steel

• Overall corrosion (crater-like attack)
- service temp. –10 trough +140 °C
- cyclic temperature changes

• Stress corrosion cracking
- presence of NO_3^-
- service temp. > +50 °C (up to 240 °C)

• Hydrogen embrittlement
- high tensile steels
(> 1000 N/mm^2)</td><td>High-alloy steel

• Stress corrosion cracking of austenitic stainless steel in the presence of Cl^- at service temperature higher than +50 °C</td></tr>
</table>

DSM Standard EP 7-3.1.2 encourages the application of a protective organic coating. The selection chart (Figure 5) shows when coating is required.

As an alternative stainless steel pipelines can be wrapped with aluminium foil using the following procedure.

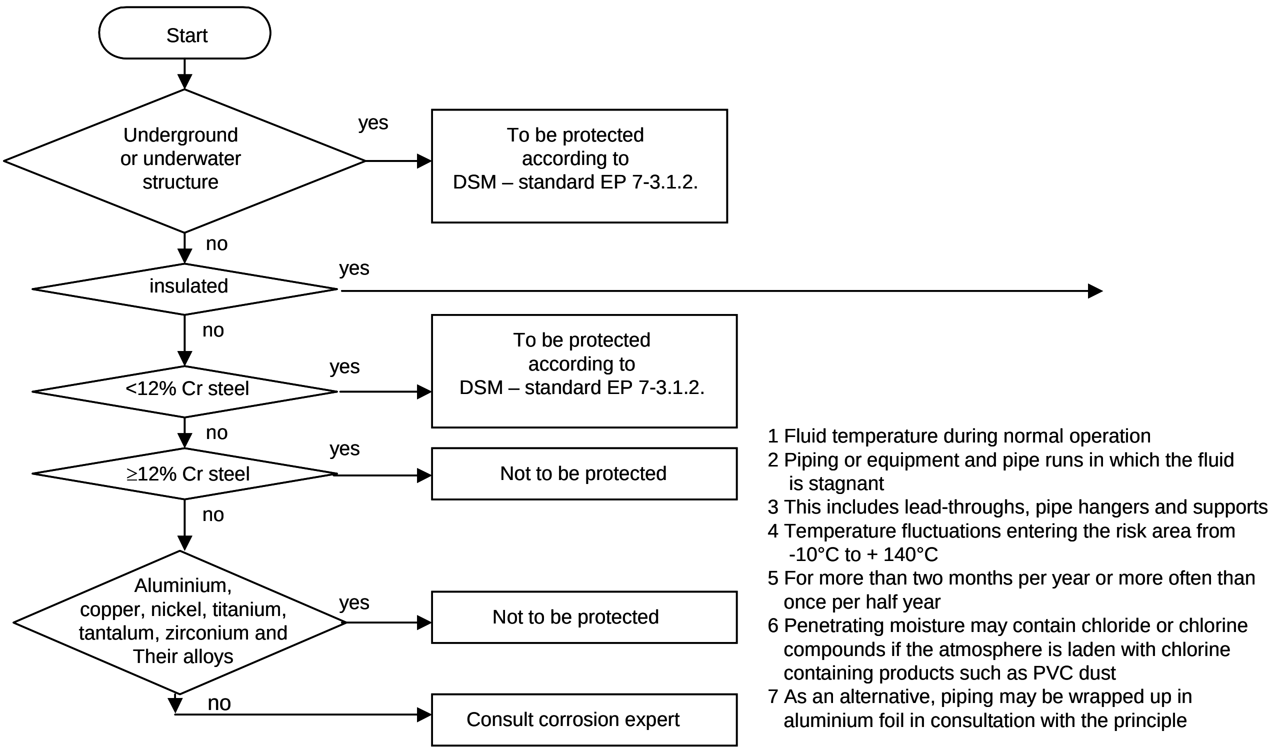
- The technique utilises aluminium rolls 0.05 mm thick, approx. 90 cm wide and 100 m long.
- Remove any adhering bits of insulation by brushing.
- Remove with hand tools all loose and/or thick corrosion products.
- Next, remove all dirt and grit.
- Conduct a visual inspection of the whole line and note observations in an inspection report.
- Measure the pipe wall thickness in heavily corroded areas.
- Cut strips of the aluminium roll measuring the outside pipe diameter plus 10 cm.
- Wrap the strips tightly around the pipe.
- Smooth down each wrap to remove wrinkles in and air pockets under the foil.
- See that the wraps overlap at least 5 cm.
- To prevent ingress of water, wrap vertical pipes in roof tile fashion, so from the bottom up.

Self-adhesive aluminium tape may facilitate application here, but note that such tape is temperature resistant only up to 80 °C. The wraps will be kept in place by the insulation yet to be applied. Pipe hangers and supports, including penetrations through the insulation, should also be wrapped.

- Tees and other complex geometries should be wrapped as tightly as possible, covering the entire surface. Any application problems encountered should be resolved in consultation between the contractor and MPS.
- Apply a thermal insulation system in accordance with DSM standard EP 3.13.2-1.1 “Thermal Insulation”.
- Note in the inspection report all relevant particulars observed during application. The report should also state the pipe material specifications, operating temperature, pipe fluid.

- For the next five years, conduct random inspections once a year on direction of a materials engineer and note the results.

Recently also the application of metallic coatings is introduced to combat atmospheric corrosion of carbon steel.



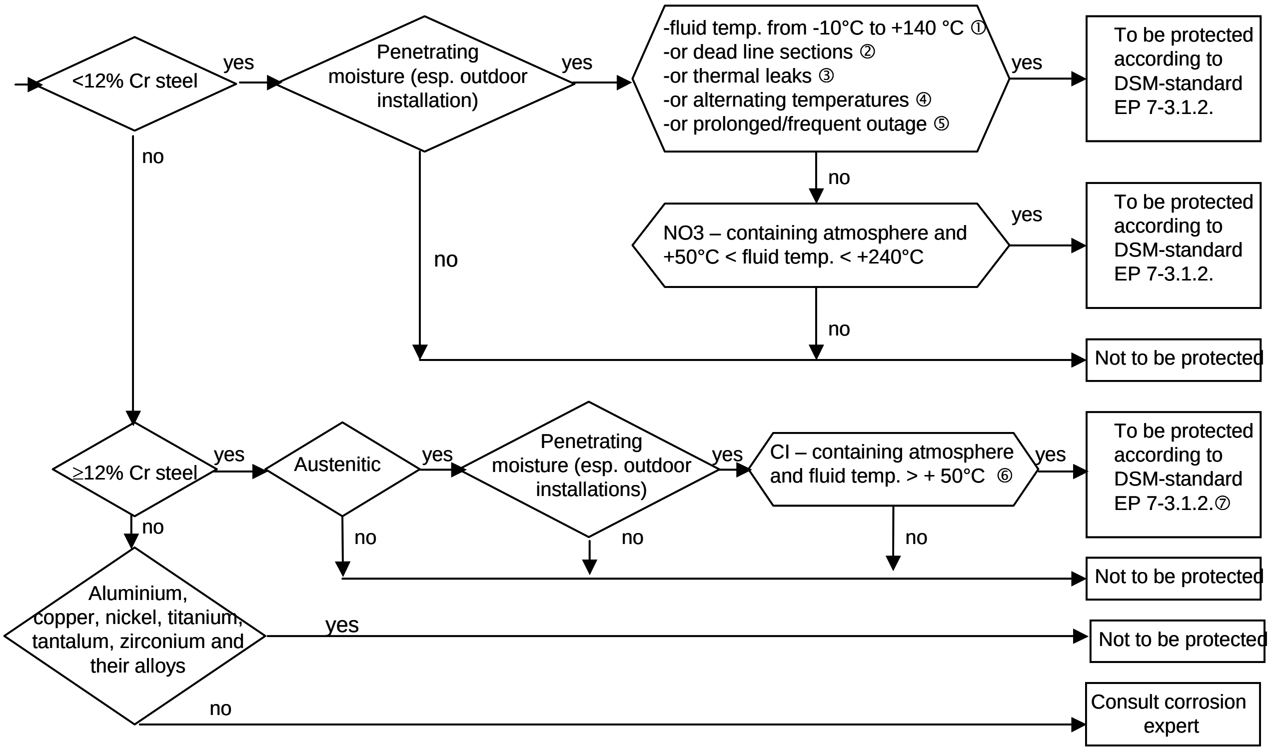


Figure 5: Selection diagram coating system.

3. Construction phase

Protective coatings and insulation, often included in the scope of work for the piping contractor or equipment supplier, do not always get as much attention as they deserve. Sometimes, these jobs come last on the list of priorities. Painting and insulation inevitably come last in any project, when time often is tight.

3.1. Protective coatings

Methods of inspection for quality assurance of protective coatings are specified in DSM Standard EP 7-3.2.2 (surface preparation), ED 7-3.3.2 (Implementation paint application) and ED 7-3.4.2 (Inspection paint application). A specialist firm should be hired for guidance and control of coating operations.

Assuming the plant lay-out allows good accessibility for coating, proper performance will be obtained only if coating selection, surface preparation and application are geared to one another (Figure 6).

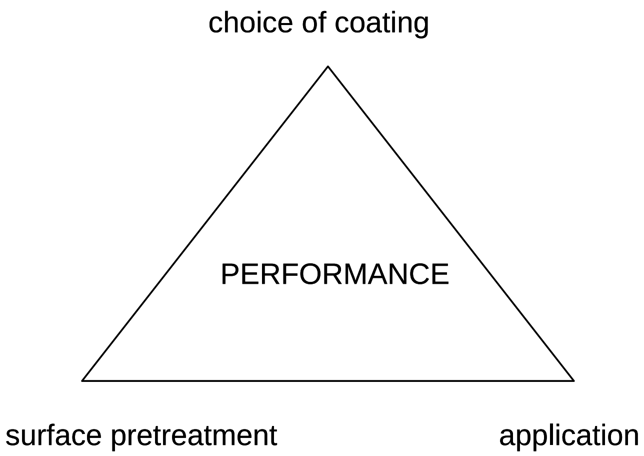


Figure 6: Essential factors for obtaining a protective coating system with an optimum life / performance

Coating selection

Coatings are selected using the selection chart in DSM Standard EP 7-3.1.2 (Table 2). A description of the protective coatings is presented in Table 3. The following factors should be considered: the type of material of construction, the metal temperature, the environment (e.g. above ground, underground or submerged in water) and the presence or absence of insulation.

Remarks

(1) Objects in a highly aggressive environment shall be treated with the duplex system according to DSM standard ED 7-3.807 (hot-dip galvanizing and painting). See also (5)

(2) System ED 7-3.426 is used predominantly for objects to be given safety colours.

(3) System ED 7-3.323 applies to objects with heating-up rates of > 60°C/min. (The first time that heating-up to the maximum process temperature takes places).

(4) Systems ED 7-3.324 and ED 7-3.325 apply to objects with heating-up rates ≤ 60°C/min. (The first time that heating-up to the maximum process temperature takes place).

(5) Alternative systems can be used after consultation with the principal.

(6) The principal shall be consulted for use of systems ED 7-3.323 in a fire hazardous area, in connection with possible damage as a result of zinc in the paint.

Table 2: Selection chart coating systems

Objects (1)	Wall temperature ((C)	Protective system standard ED 7-3....	
		non-insulated	insulated
ABOVE GROUND Piping, equipment and steel structures			
Unalloyed and low - alloy steel (1)	-20 to + 120 + 120 tot + 500 -20 to + 400	425 - 426 324 (4) 323 (3) en (6)	427
High -alloy steel	+ 50 to + 500	325 (4)	
ABOVE GROUND Storage tanks			
Unalloyed and low - alloy steel	-20 to + 120	425	427
Rail tankers and gas - cylinders			
Unalloyed and low - alloy steel	- 20 to + 120	446	427
UNDER GROUND Piping and storage tanks			
Unalloyed, low-alloy and high-alloy steel	-20 to + 30 + 30 to + 60	065 (5) 428 (5)	
UNDERWATER Piping and steel structures			
Unalloyed, low-alloy and high-alloy steel	0 to + 30	065 (5) or 428 (5)	

Table 3: List of protective systems.

No. ED 7-3..	Undercoat		Top coat			
		Dry film thickness		Dry film thickness	Film thickness total system	Colour
042	Rust-resistant, elastic, waterborne primer and finish, HB, for blast steel Rust-preventive, elastic water-borne paint	100(m 200µm	Water-borne finish	50µm	350µm	white
323	Alkyl silicate zinc dust paint, heat resistant	50µm	Alkyl silicate finish, single component, heat-resistant.	50µm	100µm	grey
324	Not applicable		Silicone/titanium ester resin finish, heat resistant, HB	100µm	100µm	alum. grey
325	Not applicable		Silicone/titanium ester resin finish, heat resistant, HB	100µm	100µm	alum. grey
425	Rust-preventive epoxy primer, HS, low in solvents	100µm	Epoxy finish, HS, low in solvents	100µm	200µm	optional
426	Rust-preventive epoxy primer, HS, low in solvents	125µm	Urethane finish, chemically resistant	35µm	160µm	optional
427	Rust-preventive epoxy primer, HS, low in solvents	100µm	Epoxy finish, HS, low in solvents	200µm	300µm	optional
428	Rust-preventive epoxy primer, HS, low in solvents	100µm	Epoxy finish, HS, low in solvents	350µm	450µm	optional
446	Rust preventive epoxy primer, HB, lead and chromate	50µm	Urethane finish, HB Urethane finish,	50µm 35µm	135µm	White

	free		chemically resistant			
807	Hot-dip galvanized Rust-preventive epoxy primer, HB. lead and chromate free	70µm 50µm	Epoxy finish, HS, low in solvents	200µm	320µm	optional
065	Asphalt bitumen		Nom. pipe diam. ≤150mm. 1. asphalt bitumen + glass mat 2. asphalt bitumen + glass mat 3. Lime coat Nom. pipe diam. > 150mm: 1. asphalt bitumen + glass mat 2. asphalt bitumen + glass mat 3. Lime coat		4.5 mm 6 mm	white white

Surface preparation

Requirements regarding surface preparation are mentioned in DSM standard EP 7-3.2.2.

After weld spatter has been removed and sharp edges blunted, the surface should be cleaned and roughened. Blasting to a cleanliness of Sa 2.5 to ISO 8501-1 is much to be preferred over manual de-rusting.

Where blasting is impracticable, de-rusting can best take place by means of portable power tools. Cleanliness should be at least St 2 to ISO 8501-1.

Application

Requirements regarding implementation of paint application and inspection of paint application are mentioned in DSM standards ED 7-3.3.2 respectively ED 7-3.4.2. Painters should know the specifications for paint application, usually to be found in the product information sheet. It is essential that due account be taken of the correct mixing ratio, dilution, methods of application, curing times, atmospheric conditions (relative humidity and temperature and the like).

If we equate the performance of a coating to 100%, the coating selection accounts for 25% and the surface preparation and operational damage for the remaining 75%. It will be clear, then, how important it is to supervise the work. Experience shows that the service life of a coating is dependent on the frequency and thoroughness of inspection during surface preparation and application. Supervision during the work and final inspection are complementary functions. In actual practice, circumstances may make it very difficult indeed for such inspections to be organized and carried out.

Sometimes, it is a tough job to meet the requirements specified in our standards. Cases in point are the relative humidity and grit blasting. Consequently, it seems to me that more research efforts are needed for developing coating systems that are easier to apply.

As mentioned before, recently also the application of metallic coatings is introduced to combat atmospheric corrosion of carbon steel. Especially large surfaces are suitable for the aluminium thermal spray technique. The aluminium layer thickness is 150 to 185 μm.

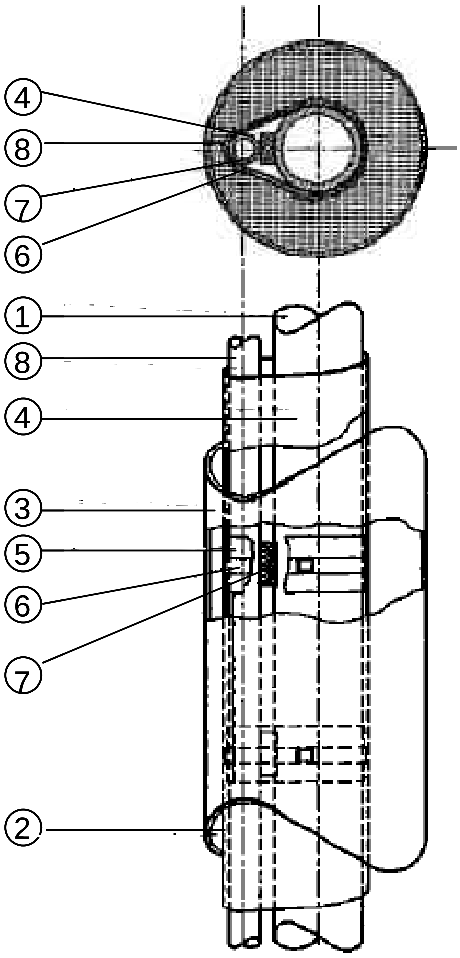
Experiences show that with this type of coating less maintenance is required.

Despite higher investments costs it is expected that in many cases the life cycle costs are lower. For that reason application of thermal spray aluminium coating is promoted more and more to combat atmospheric corrosion of carbon steel piping and equipment.

3.2 Installing of steam / hot water tracing

At locations of touching steam / hot water tracing there is an increased risk of atmospheric corrosion . To minimize the risk of atmospheric corrosion it is strongly recommended to install steam / hot water tracings with spacers according to the DSM standards EP 3.5.5-2.1 and EP 3.5.5-2.1/S002 (additions and amendments to EP 3.5.5-2.1). Plastic spacers (packing blocks) shall be used at temperatures up to 200 ^{0}C. Nitrile rubber of hardness Shore A-90 may be used at temperatures up to 115 ^{0}C.

The order of assembly and the item list of steam / hot water tracing is illustrated in Figure 7.

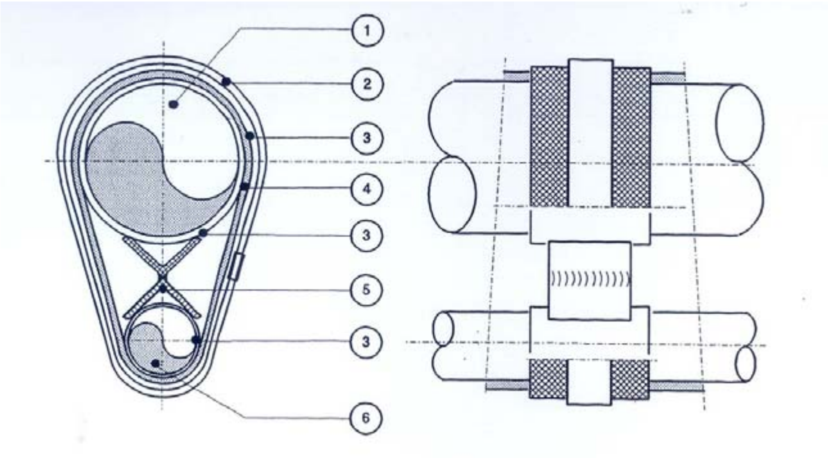


Order of assembly:
- Position tracer
- Position spacers and wrap tracer and product line with one layer of ladder (glass fibre) tape
- Secure tracer with Band-It
- Wrap with 0.05 x 50 mm aluminium film with overlaps not less than 500 mm.
- Insulate the assembly

Item list:
1. Product line
2. Insulation
3. Jacketing
4. Aluminum film
5. Ladder tape
6. Band-It with clip
7. Spacer
8. Tracer

Figure 7: Order of assembly and the item list of steam / hot water tracing.

At temperatures exceeding 200°C packing crosses (material: austenitic stainless steel) shall be used with assembly as shown in Figure 8.



Item	Description
1	Run pipe
2	Band-It band
3	Glass fibre tape, width 50 mm
4	Aluminium foil
5	Cross, long 30 mm, from 20x20x3
6	Tracer

Figure 8: Assembly of steam tracing at temperatures > 200 ^{0}C.

3.3. Insulation system (DSM standard EP 3.13.2-1.1)

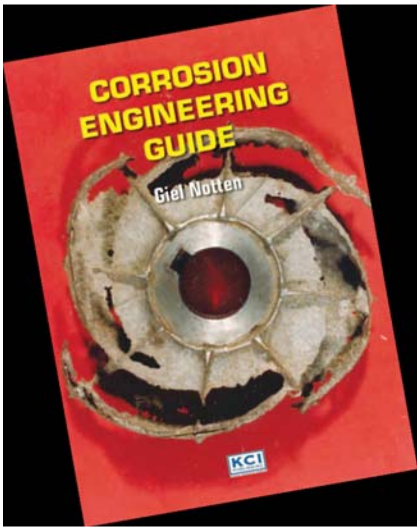
Check, before the insulation system is applied, whether the materials that make up the insulation meet the quality requirements in terms of, for instance, compressive strength and the absence of corrosion-inducing materials. The materials should be labeled stating all relevant data. Also, the materials should be properly stored, without the risk of, for instance moisture ingress. Finishing materials such as mastic should be stored in frost-free conditions. Test reports should be available concerning the thermal conductivity at the mean service temperature. The insulation material should be applied in accordance with good workmanship. In particular, the aim should be not to create too many seams and that the insulation material is suitably applied in the pipe bends.

Cover sheeting should be fastened in such a way as to preclude ingress of water.

An insulation expert should be hired for proper guidance and control of the insulation work.

This paper is part of Giel's Corrosion Engineering Guide, a valuable asset for any engineer working in a urea plant.

This guide is available via:
http://www.stainless-steel-world. com/
Please find the Table of Content of this Corrosion Engineering Guide herebelow.



About Giel Notten

Giel is a true materials and corrosion expert who, before his retirement in 2004, spent thirtyeight years working with DSM in The Netherlands. After gaining his Engineering degree at the Higher Technical School of Heerlen, The Netherlands, he joined DSM's central laboratory.
He was to remain with the company for the rest of his career and held several positions as a materials and corrosion expert there. For the last twenty years before he retired, Giel worked in the Corrosion Department as Managing Senior Corrosion Engineer. He has further participated in numerous conferences spreading the word about his broad experiences as a corrosion and materials specialist in chemical process plants.
For Stamicarbon, a subsidiary company of DSM, and licensing DSM's know-how, he set up programmes for lifetime extension studies in urea and ammonia plants and supervised them.
He was also involved in the development of Safurex®, the super-duplex stainless steel grade (developed by Sandvik in cooperation with Stamicarbon) for application in Stamicarbon urea plants.
Giel has always enjoyed teaching so, after only five years working in the field at DSM, he already began to develop a Corrosion Engineering course. Since then he has taught many young engineers from both inside and outside DSM about the ins and outs of corrosion control in chemical plants. He was also a board member of NACE Benelux and a member of the Contact Group Corrosion of the Dutch Chemical Process Industry and the Studiekern Corrosion of the Dutch Corrosion Society (NCC).
Since his retirement from DSM, Giel Notten has remained active as a corrosion engineering consultant. He has devoted much of his time to passing on his extensive knowledge and experience on the complicated topic of corrosion engineering to a new generation of engineers.
He has done this in the form of numerous corrosion courses and workshops.
Alongside his professional career, Giel has been very active in local societies and has been a Rabobank board member for about thirty-five years, twenty-five years of which as Chairman of the Board. Furthermore, he is an active cyclist. Together with his wife, Lianne, he has made trips up to 2500 km by bicycle to Santiago de Compostela, Spain and Rome, Italy.

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