VECOM

Global specialist

in metal surface treatment

ON-SITE SERVICES

METAL SURFACE TREATMENT

METAL SURFACE TREATMENT PRODUCTS

WASTE WATER TREATMENT

Vecom Group: **65 years** leading in metal surface treatment

On-site services

Worldwide chemical technical cleaning on location

For many years Vecom has been specialized in chemical technical cleaning and metal surface treatment. These activities are performed on sites all over the world.

Metal surface treatment

Waste water treatment

Metal surface treatment products

Vecom aims to be the best qualityservice provider in metal surface treatment by combining knowledge and experience with flexibility and operational excellence. Safety, people and the environment are of paramount importance.

Vecom can provide all the technical knowledge, skills and installations when it comes to metal surface treatment in order to deal with chemicals, metals and waste streams in a responsible way. The core activities of Vecom are metal surface treatment, on-site services, metal surface treatment products and waste water treatment.

Take advantage of over 65 years of our experience in maintenance and cleaning. Call or email us for tailored advice. Our people are ready to solve your challenges.

Vecom Group certifications:
ISO 9001:2015 ISO 14001:2015 VCA SIR

Vecom Sillavan Metal Treatment certifications:

ISO 9000:2015 0026

In this brochure we cover our on-site services. We are leading the way and we go the extra mile where others stop. Covering the total range of cleaning techniques, we explain what our specialty is and in which segments Vecom Sillavan Metal Treatment excels. We also reveal the sectors of the industry in which we regularly carry out assignments. This provides a fascinating insight into how we put our specialisms into practice on a daily basis. Where appropriate we are doing so in close cooperation with our Dutch colleagues of Vecom Industrial Services. This cross border cooperation and exchange of capacity is covered under the label of Vecom Projects.

The Vecom company name guarantees quality and reliability in international markets. An image that is based on an impressive global track record of both the company and its people.

Because of our exceptionally high level of knowledge of the specification of the chemicals required on one hand and the required method of operation on the other, highly respected national and international clients are happy to enter into a long-term relationships with us.

Want to know more about what we can do in the United Kingdom for your company in the area of chemical technical cleaning of your process and other installations? Contact us via telephone number 0161 797 6666 or via projects@vecom.co.uk.

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Vecom's **fabulous fourteen**

An overview of the marketsegments we serve

Overview of **cleaning techniques**

Cleaning inside of process- and technical installations

With chemical technical cleaning, cleaning fluids are circulated through a closed circuit. Often standard products and standard procedures are used by the contractor involved. These do not always give optimum results. Vecom Projects goes further where others stop. By applying bespoke processes and customer specific products and procedures, our clients are guaranteed an optimum result.

Of course we can offer "one-stop shopping" for the complete cleaning package if non-specialist activities form a limited part of the total project. In this way we remain competitive.

For the cleaning of internal parts of process and technical installations, roughly three techniques are used:

- **Mechanical cleaning**
  Mechanical cleaning (high pressure cleaning or grinding and polishing) are techniques that we have available if this work is a limited part of a more complex project., We do not perform such works as standard scope in our package of services.

- **Chemical mechanical cleaning**
  For chemical mechanical cleaning (decontamination), treatment methods with standard products such as those carried out by many companies in the cleaning industry are adequate in most cases. You can experience Vecom's added value when a degree of contamination has such characteristics that regular solutions no longer have an optimal and sustainable effect. In these cases we solve the problem with customer-specific formulae.

- **Chemical technical cleaning**
  Our greatest strength lies in chemical technical cleaning, where customer or process specific solutions are required in order to achieve optimum cleaning. A number of companies with a limited portfolio of resources and procedures also operate in this segment. Often a suboptimal end result is achieved using these techniques. It can then mean that cleaning and plant shutdown is more frequent and the costs of both the cleaning and downtime of the process can be more expensive.

Cleaning outside of process- and technical installations

Vecom Projects specializes in internal cleaning of process- and technical installations. It does not have external cleaning processes in its portfolio.

The **Vecom way**

The Vecom way - in practice

Vecom's core value is to be safe for people, the environment and metal. Vecom customers benefit from more than 65 years of leading experience in metal surface treatment and can feel 100% assured of the correct treatment of their precious metal parts, products and installations. The ultimate beneficiaries for whom we work directly or that we are serving as subcontractor of the main contractor often indicate that they would like to have their products and installations treated "the Vecom way".

"We develop client and process specific solutions."

The highest quality guaranteed for surface treatment

The Vecom way also means that procedures have been specifically made for our customers. This guarantees consistent results with the same metal contamination. When a new procedure is required, it is tailor-made.

A Metal Analyzer is used to research the meta alloy. The analysis of the nature and extent of the pollution is performed in the in-house Vecom laboratory. If there is no suitable cleaning product on the market, Vecom develops its own recipe, also in-house. This allows Vecom to deliver the highest quality time and again without exception.

A natural collaboration

More than 95% of Vecom's customers are long-term customers. Vecom gives its customers continuous insight into the progress and regards its customers as colleagues. Vecom works together with its customers to offer the best for them. Relationships are established quickly. Customers find Vecom's specialists particularly friendly and helpful. The collaboration is developed quickly.

Processing of chemical waste streams

Vecom understands chemistry. That is why Vecom acts responsibly. Vecom ensures that the waste streams (also on-site) are collected and processed in its own waste water treatment plant wheredetoxification, neutralization and dewatering are the main elements of the process. Vecom is authorized to act as a collector and processor of, among other things, various metallic acids and bases, waste water, rinsing water and pickling baths.

In-house laboratory

We take 100% responsibility for the chemistry used. Our in-house laboratory also works continuously on more sustainable and innovative cleaning products and we find a suitable solution for every challenge.

Certification from Vecom

Vecom customers can be confident that quality is guaranteed. We have various certifications including Quality ISO 9001:2015, Environment ISO 14001:2015, VCA * (equivalent to SHE checklist contractors) and SIR Certificate. In addition to that Vecom Sillavan Metal Treatment adds their relevant national certifications for projects in the United Kingdom.

Certified results

After carrying out a treatment such as pickling and passivation, it is possible to get a Vecom© certificate included. This certificate indicates the Vecom standards and procedures used and reports the test results.

Worldwide on-site **chemical technical cleaning**

The Vecom Group has been an expert in chemical technical cleaning on worldwide locations for more than 65 years. We can also arrange cleaning in our processing centers if required.

The vast majority of all conceivable "on-site" cleaning activities consist of regular activities without specific specialization. Vecom Projects, on the other hand, focuses on customer and process-specific solutions and thus operates in niche markets. We continue where others stop.

Of course we can offer "one stop shopping" for the complete cleaning package if non-specialist activities form a limited part of the total project. In this way we remain competitive.

For the cleaning of internal parts of process installations, roughly three techniques are used:

Mechanical cleaning

Mechanical cleaning (high pressure cleaning or grinding and polishing) are techniques that we have available if this work is a limited part of a more complex project. We do not perform such works as standard scope in our package of services.

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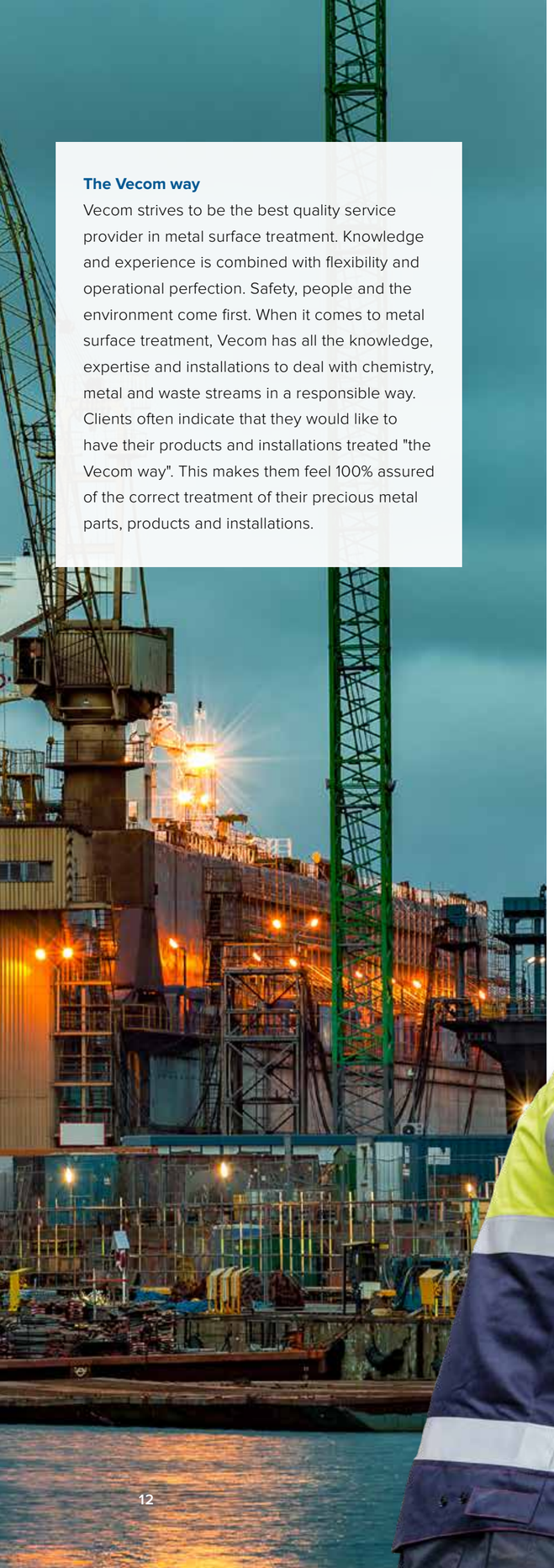
Chemical technical cleaning

Our greatest strength lies in chemical technical cleaning, where customer or process specific solutions are required in order to achieve optimum cleaning. A number of companies with a limited portfolio of resources and procedures also operate in this segment. Often a suboptimal end result is achieved using these techniques. It can then mean that cleaning and plant shutdown is more frequent and the costs of both the cleaning and downtime of the process can be more expensive.

Chemical technical cleaning services

Our activities focus on seven disciplines that are explained in more detail later in this brochure:

1 Pre-commissioning cleaning
2 Post-commissioning cleaning
3 Boiler cleaning
4 Cleaning of urea strippers
5 Pickling and passivation of stainless steel systems
6 Removing rouging
7 Pigging pipes



The Vecom way

Vecom strives to be the best quality service provider in metal surface treatment. Knowledge and experience is combined with flexibility and operational perfection. Safety, people and the environment come first. When it comes to metal surface treatment, Vecom has all the knowledge, expertise and installations to deal with chemistry, metal and waste streams in a responsible way. Clients often indicate that they would like to have their products and installations treated "the Vecom way". This makes them feel 100% assured of the correct treatment of their precious metal parts, products and installations.

Benefits

The chemical technical cleaning of your installations by Vecom Projects has many advantages:

- It is time efficient
- The highest quality is guaranteed
- Safety for people and the environment is guaranteed
- We offer a solution for every challenge on location

Time efficiency

To ensure that the installations can be put into operation as quickly as possible (again), we first agree what the most suitable process is for metal surface cleaning. Vecom never sacrifices quality due to time constraints. We always find a solution to ensure that there is minimal downtime for production.

For the chemical technical cleaning of two boilers, we clean them in one go so that minimal downtime is required. Less chemicals arerequired and less waste water remains. Apart from economic benefits, this is also beneficial to the environment.

Quality

Quality cleaning is an important part of maintenance to guarantee the efficiency of the machines, Increse the lifespan and minimise downtime.

When cleaning and maintaining machines and installations, however, increasingly complex issues arise, such as bacteria that are still unknown or new alloys that react differently to cleaning products. A small error therefore can have disastrous consequences, both for the health of employees and for the financial results. A production that stands still because the maintenance takes longer than planned; damage or contamination. The true value of maintenance only becomes clear when things go wrong.

The Vecom way also means that procedures are laid down for each customer. This guarantees consistent results with the same metal contamination. When a new procedure is required, it is tailor-made. Research into the pollution is done in the Vecom in-house laboratory. If there is no suitable cleaning product on the market, Vecom makes its own recipe, also in-house. This allows Vecom to deliver the highest quality without exception, every time.

"Every time a project is completed satisfactorily I am proud again."

Safety for people and the environment

Care for the environment is the focus in the entire process. For example, most process water is reused. Vecom packaging can be recycled.
Under our supervision, waste water is stored, processed and treated locally so that it is safe to discharge through the drain pipes. We take the chemicals with us and they are neutralized in our detoxification, neutralization and dewatering installation.
We continue to look for more people-friendly and environmentally-friendly solutions for chemical-technical cleaning. We are challenged daily at Vecom's in-house laboratory to develop safer and more friendly products and services.

Customer satisfaction

It is clear that Vecom is valued from the results of the customer satisfaction survey and from the reviews where Vecom is given an average of 8 on a scale of 10. These customers have been customers for more than 10 years on average.

Reference projects

Both in The Netherlands and abroad the Vecom specialists will appear on site for the execution for chemical technical cleaning assignments. Our experience has been called in and relied upon on a number of continents. On pages 46 and 47 a detailed summary of customers and locations are highlighted.

Target audiences

Within the process- and other industries we primarily focus on clients active natural gas extraction, production of fertilizers, production of plastics, pharmaceutical industry, blast furnaces, oleochemistry (processing of vegetable and animal oils and fats), oil refining, petrochemical, paper manufacturing, paint industry, food industry, water purification, shipbuilding and power plants. We have extensive references at home and abroad.

Pre-commissioning cleaning

Cleaning before commissioning

A newly built metal process installation, piping system, tank or power plant undergoes various processes, such as rolling, welding, grinding, etc. before it is ready for commissioning (pre-commissioning).

Through these operations, the (metal) surface is contaminated with all kinds of undesirable matter, including grease and oil, welding skin and blasting grit. In addition, these operations affect the temporary protective layer of the steel, causing (fly) rust. To obtain a clean, passive steel surface, chemical technical cleaning is often carried out prior to the commissioning of systems and installations, pre-commissioning cleaning. This prevents the medium that is to be stored or transported in the system from becoming contaminated.

Determining the correct cleaning method

There are various methods for removing the aforementioned contamination. You can read more about these later on. A project inventory is required to determine the correct cleaning method. During this step the cleaning method is determined on the basis of:

- Contamination present in the system
- Complexity of the system
- The material or materials the system consists of
- The desired cleaning result by the customer or manufacturer of the system

Pre-commissioning, the different methods

The most common cleaning methods for pre-commissioning are:

Method	Suitable for	Removes
Cleaning based on hydrochloric acid	carbon steel, copper	iron oxides (rust), welding skin, mill scale and annealing skin
Cleaning based on hydrofluoric acid	carbon steel, stainless steel, alloys with chromium or P91/92	iron oxides (rust), welding skin, mill scale, annealing skin & silicate compounds
Cleaning based on citric acid	carbon steel, stainless steel, alloys with chromium or P91/92	iron oxides (rust), at high temperatures or after adding of additional chemistry, also suitable for removing mill scale and annealing skin
Cleaning based on EDTA/Demclean 94	carbon steel, stainless steel, alloys with chromium or P91/92	iron oxide (rust) and very light grease / atmospheric contamination
Cleaning based on VPX One Step®	carbon steel, stainless steel, alloys with chromium or P91/92	iron oxide (rust)

The correct assessment for choosing a cleaning method and then its professional implementation, requires expertise.

This is the Vecom way.

Post-commissioning cleaning

In the majority of processes efficiency decreases due to contamination

A clean system is essential for installations and systems to function efficiently and for the long term. As the number of production years increases, all kinds of influences create contamination that has adverse consequences for the operation. By performing a periodic cleaning, the efficiency of the factory or production facility is guaranteed.

Back in operation as quickly as possible

To ensure that the installations can be put back into operation as quickly as possible, Vecom proposes the most suitable cleaning procedure. This is determined by:

- The metal type or types of the system to be cleaned
- The contamination present
- Complexity and construction of the installation
- Desired results and any (customer specific) regulations

Where possible, parts of (pipe) systems or several systems are connected to each other in the cleaning circuit in order to save time, chemicals and waste water with no compromises to human and environmental safety.

In general the cleaning process contains three steps:

- Degreasing
- Pickling
- Passivation

Post-commissioning, the different methods

The most common cleaning methods for post-commissioning are:

1. Cleaning based on hydrochloric acid
Suitable for: carbon steel, copper
Removes: iron oxides (rust), welding skin, mill scale and annealing skin

2. Cleaning based on hydrofluoric acid
Suitable for: carbon steel, stainless steel, alloys with chrome or P91/92
Removes: iron oxides (rust), welding skin, mill scale, annealing skin & silicate compounds

3. Cleaning based on citric acid
Suitable for: carbon steel, stainless steel, alloys with chrome or P91/92
Removes: iron oxides (rust), at high temperatures or after adding of additional chemistry, also suitable for removing mill scale and annealing skin

4. Cleaning based on VPX One Step®
Suitable for: carbon steel, stainless steel, alloys with chrome or P91/92
Removes: iron oxides (rust)

Boiler cleaning

Purity steam quality
is essential

Most new power plants based on thermal reaction today produce steam to drive a steam turbine that generates electricity through a generator. The purity of the steam quality in this production process is essential. If the steam contains impurities, these can deposit on the turbine blades and disturb the turbine's balance.

Cleaning type
To guarantee good steam quality, the cleanliness of the entire steam and water cycle is of great importance. Depending on the phase the power plant is in, Vecom can perform the following types of cleaning:

- Pre-commissioning
- Post-commissioning (maintenance phase)

Years of experience
Vecom has many years of experience in cleaning various types of power plants, (in both pre- and post-commissioning phase) including:

- Coal-fired power stations
- Gas plants
- STEG power stations (steam and gas turbine) by means of HRSG system
- Biomass power stations
- Waste incineration plants (waste-to-energy)

Cleaning methods
With boiler cleaning we can distinguish the following cleaning methods:

- Cleaning on the water and steam side in the pre-commissioning phase
- Cleaning on the water side in the post-commissioning phase
- Steam blowing after chemical cleaning
- Preservation after chemical cleaning (pre and post)

Vecom has the know-how and the materials

Vecom has invested in equipment and expertise for steam blowing. This equipment consists of:

- **Quench water (spray water) silencer**
- **Storage tank for demineralised water supply (30 m^3) and pumps suitable for high temperatures**
- **Condenser pot**
- **Temporary steam blow piping (up to DN450)**
- **Automatic target inserters**

“Everyone has their own input, we learn from each other. Not only very nice, but it also makes us strong.”

Pickling and passivation of stainless steel systems and installations

Prevent contamination of the process or medium in the installation or system

Stainless steel systems and installations are periodically cleaned before commissioning and in many cases to remove process contamination such as scale.

Metal surface treatment

Stainless steel must be chemically cleaned before use. The corrosion resistance of stainless steel is determined by a chromium-rich oxide skin. Once this oxide skin is formed, there is a passive surface.

Corrosion

Stainless steel is not completely resistant to corrosion. It is important that light corrosion is removed to prevent, among other things, pit corrosion with all associated negative consequences and to prevent contamination of the process or medium in the installation or system.

Why pickling and passivating?

During the installation of the stainless steel pipes in a system and / or installation, the surface is exposed to many mechanical and thermal treatments. This causes damage to and contamination of the protective oxide skin. This results in the loss of corrosion-resistant properties. The base material will therefore corrode faster. It is therefore very important that the chromium-rich oxide skin is intact and clean before the system or installation is put into use.

Pre-commissioning cleaning

Pre-commissioning cleaning of austenitic stainless steel generally involves three steps: degreasing, pickling and passivating. Degreasing is necessary to remove oil, grease and atmospheric contamination and to make the surface optimally accessible for the pickling agent. The pickling treatment removes iron particles and other contaminants from previous treatments on the material such as welding and handling. After pickling, the material is rinsed with low-chloride water to remove acid residues. The pickling treatment results in a chrome-rich surface.

Although the stainless steel will spontaneously passivate after pickling (forming a protective chromium oxide film) by exposure to sufficient oxygen in the outside air, closed systems are generally chemically passivated. The passivation fluid is circulated through the installation or system using acid-resistant pump units. The duration of this treatment depends on the type of stainless steel and the temperature. Analysis of the iron content and acid concentrations determine when the treatment is complete. The treatment is followed by rinsing, first with drinking water and then with demineralised water.

Cleaning of **urea strippers**

Deposition causes a less efficient production process

The urea substance is used, among other things, as fertilizer and raw material for the plastics industry. Urea is synthesized from carbon dioxide (CO_2) and ammonia (NH_3). A so-called "urea stripper" is used to complete the reaction.

A urea stripper is made of stainless steel alloy and consists of a vertical tube system where the reaction takes place on the inside of the tubes, while steam is introduced on the outside.

Reduced heat transfer

After some time, a typical deposit is formed in the urea stripper, consisting of iron III oxide (hematite) with admixtures of nickel, chromium and molybdenum oxides. This is usually gray to black in color. This deposit causes a reduced heat transfer, making the production process less efficient.

Specialist approach

Normally, iron oxide deposits can be easily removed from a stainless steel surface by pickling with an acid. However this also results in a very small portion of the base material being dissolved. This increases the roughness of the stainless steel surface, which is not desirable in urea strippers.

The solution

Research into an alternative cleaning method for removing the iron oxides and the possibility of minimizing damage has been carried out in collaboration with DSM and Stamicarbon.

A cleaning method based on EDTA appears to completely dissolve this deposit at high temperature and does not affect the underlying base material.

Vecom Projects specializes, among other things, in the thermal cleaning of urea strippers and has carried out successful cleanings at many urea production installations in recent years.

“Tried, tested and trusted by a large number of successful companies around the world. That forms our basis for further growth.”

De-rouging

Rouge formation can cause corrosion problems

Stainless steel is widely used in pharmaceutical applications. The cleaning of this stainless steel is very important because hygiene is a very high priority in the pharmaceutical industry.
One of the phenomena that occur with stainless steel, almost exclusively within the pharmaceutical industry, is rouging. Rouging is a red-brown film of iron oxides and iron hydroxides and is found in systems that come into contact with ultra pure water.

Conventional pickling can not be used

Conventional pickling will dissolve the passive layer and thus remove rouge, creating a clean surface. A disadvantage of this is that this process etches the surface, making it rougher and giving the finish a matt appearance.

Ra-critical components are destroyed in this way or need at least a further polishing treatment to obtain the correct surface roughness. Pickled surfaces will become rougher and therefore more susceptible to further rouging and fouling of other (process) contaminations.

Vecom has the right solution

Vecom has developed a cleaning procedure that removes the affected passive layer and removes the rouging without adverse effects, such as roughening of the surface and matt finish.

After this cleaning procedure (or any other), the system must be completely chemically passivated.

Pipe pigging

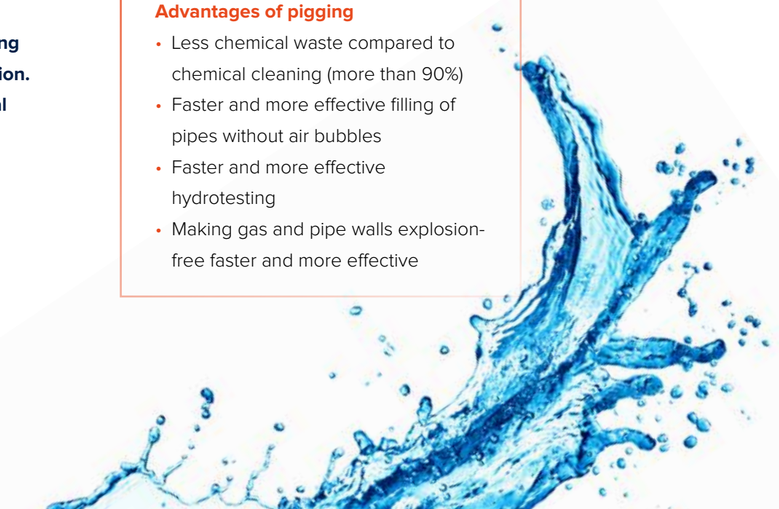
Environmentally friendly and effective **alternative**

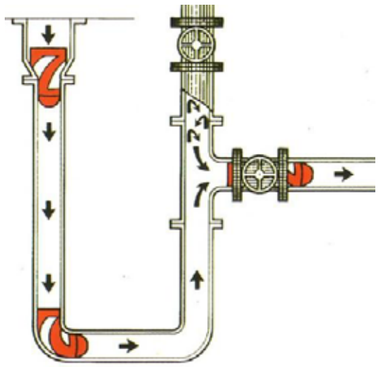
Every company with transport pressure piping in its production system is familiar with the problem of internal contamination and fouling in those pipes. This can lead to various problems, ranging from loss of efficiency to blockages and corrosion. A known cleaning method is chemical-technical cleaning where the pipes are cleaned with chemicals.

In some cases, however, the cleaning method by means of pigging offers an environmentally friendly and effective alternative.

Advantages of pigging

- Less chemical waste compared to chemical cleaning (more than 90%)
- Faster and more effective filling of pipes without air bubbles
- Faster and more effective hydrotesting
- Making gas and pipe walls explosion-free faster and more effective





The process

Pigging uses a flexible cleaning plug, the so-called "pig", which is pressed through the pipe with the help of a certain medium. The diameter of the pig is just slightly larger than the inside diameter of the pipe.

The pigs are always brought into the piping system to be cleaned from a "pig station" or launcher. The launcher contains at least one connection to the medium with which the pig is pushed forward. As a rule of thumb, this is a gas such as nitrogen or air, but it can also be a liquid such as water.

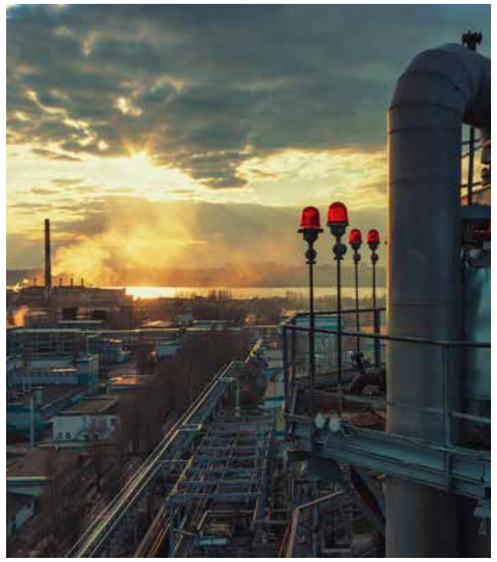
At the end of the pipeline, the pig and the medium are collected in a so-called "receiver", the second pig station. In the "receiver" the pig is separated from the medium. If the medium is water or product, this is separated with an additional connection. These pig stations can also be part of the fixed system or as mobile installations.

Application

There are various reasons for applying the pig method:

- Cleaning a pipe
- Emptying a pipe
- Inspection of pipes

Depending on the contamination, the material type of the pipe or the production purpose, the pigs have different sizes and are coated with a coating and/or are finished with a wire brush made of steel, stainless steel or teflon.



1 **Cleaning** a pipe

Cleaning of pipes by means of pigs can be done in different ways, depending on the contamination to be removed and the reason for the cleaning. To remove loose dirt and the like from a pipe, mechanical cleaning with 'brush' pigs is generally sufficient. Pigs are shot until the pigs look visually clean. Afterwards, a pipe is usually checked for cleanliness with a boroscope. Mechanical pig cleaning always takes place by propulsion with air or nitrogen. In order to be able to propel a pig, the volume of air or nitrogen is especially important.

Chemical cleaning with the help of pigs is often performed to save chemicals, thereby reducing the release of hazardous waste and evidently preserving the environment.
The process of chemical cleaning with pigs generally consists of several steps: degreasing, pickling and passivating, the so-called "cleaning train".

Construction of the "cleaning train" for stainless steel pipes

- Degreasing with a light alkaline cleaning agent
- Pickling with a strong acid based on nitric acid and hydrofluoric acid
- Passivation with a nitric acid-containing passivation agent

The pigs are used as a separation in this process, so that it is possible to alternate between the cleaning agent and demineralised water. Between the cleaning steps, a precisely matched amount of rinsing water will be used to rinse the metal surface of cleaning agents. At the end of the pipeline, the various chemicals are separated from each other and collected for waste processing.

Why a reduction of chemical waste by more than 90%
Thanks to this working method, the use of chemicals is handled sparingly (compared to circulation) and significant time savings can be made. For example, a 500-meter long DN250 pipeline has a capacity of 25 m^3. A chemical cleaning of this pipe, consisting of different phases and rinsing steps, would result in a waste volume of more than 125 m^3. A chemical "cleaning train" using pigs, limits the total amount of waste to 10 m^3. In short, a reduction of more than 90%.

Mechanical cleaning with pigs always takes place by propulsion with air or nitrogen. The volume of air or nitrogen is important to be able to propel a cleaning pig. Of course, tailor-made solutions are also possible for each specific project.

2 **Emptying** a pipe

Fixed transport pipes to tanks often contain standard fixed pig stations to completely empty the pipes during a product change, and possibly to clean them, before moving to another product load. This method prevents contamination of products in fixed transport lines.

3 **Inspection** of pipes

In places where inspection of pipes is not easy (for example, under the ground or under the sea surface), so-called "intelligent pigs" can be used. These type of pigs contain all kinds of measuring equipment enabling the pipe to be examined for wall thickness, corrosion, location, etc.

Vecom provides tailor-made solutions
Due to the flexibility of the pig, angle bends, T-pieces and other deformations are no problem. The diameter of the pipe system is also not an obstacle to working with pigs. By using a system that builds from soft to hard and pigs with different coatings increasing in diameter, almost all pipes can be safely, quickly and perfectly cleaned. The quality of pigging has proven itself in/at:

- **The chemical and petrochemical industry**
- **The food industry**
- **Drinking water companies**
- **Sewer pressure pipe management**
- **Offshore industry**

Technical bulletins

Vecom Projects is happy to share its expertise with its clients. The Technical Bulletin from Vecom examines the various aspects of metal surface treatment, cleaning and maintenance, among other things, and shows special projects that we have implemented. A selection of these bulletins is included in this brochure.

On the Vecom website you can register to receive future editions.

Pre-commissioning cleaning
Five standard cleaning methods

Installations (such as boilers, heat exchangers, cooling water systems and alike) are often cleaned prior to being put into use. This procedure is called pre-commission cleaning. Various procedures carried out on the installation will have resulted in it being contaminated with for example grease, oil and welding scale. The temporary protective layer of the steel will moreover have been corroded resulting in (fly) rust. There are various methods for removing these types of contamination chemically.

The method chosen will depend on the technical aspects (which materials have been used for the construction of the system and what is the extent of the contamination) and the requirements of the customer. The proper assessment of which cleaning method to apply and the subsequent implementation of it, requires expertise. The following restricts its attention to the cleaning of installations constructed from carbon steel (C-steel) and the various cleaning methods that Vecom is able to perform (on site). Five pre-commission cleaning methods are discussed in turn.

In general pre-commission treatment comprises:

Degreasing
A degreasing step during pre-commission cleaning procedure need not involve (in all cases) strong agents. Not only light oil and grease contamination from processing will be removed, but also atmospheric contamination.

Pickling
A pickling phase will remove iron oxide (welding scale, when present, also).

Passivation
The steel surface will be active after pickling, rusting (fly rust) immediately. To counter this, the steel is temporarily protected. This can be realized by passivation, a chemical treatment during which a stable gamma- ferric oxide is formed. A standard passivation is conducted in ammonium citrate with an oxidizer.

Cleaning on the basis of hydrochloric acid

Cleaning with inhibited hydrochloric acid is a method that is frequently employed. Hydrochloric acid will ensure that the material is pickled fully, removing rust welding and mill scale effectively. When in addition to fly rust older rust (Fe_2O_3) is also present, hydrofluoric acid or another additive is introduced to prevent corrosion by ferric ion (Fe^{3+}). A standard treatment with hydrochloric acid comprises: degreasing, rinsing, pickling, rinsing, passivation. Passivation is conducted with ammonium citrate and an oxidizer forming a (temporary) stable uniform gamma-ferric oxide film. During cleaning large quantities of waste water are released as a result of the intermediate rinse phases. This water can be processed applying the DND principle (Detoxification, Neutralization, Dewatering).

Advantages: also dissolves mill scale; very suitable for heavily rusted material; standard procedure (well-known); in some cases the only suitable method.
Disadvantages: large quantities of waste water; various corrosive chemicals required; more time consuming; less operator and environmentally friendly; when improperly applied risk of damaging base material. Not able to be used on all steel materials (for instance on P91 material, like steam lines and superheaters, HCl is not suitable).

Cleaning on the basis of hydrofluoric acid

Cleaning with inhibited hydrofluoric acid is most common practise for new build steam boilers. This method is also fully described by the VGB guide lines “internal cleaning of water-tube steam generating plants and associated pipeworks” (VGBR513e). Hydrofluoric acid cleaning will ensure the material is pickled fully, removing rust, welding and mill scale and silicate compounds. This method can also be safely applied to steel alloys containing chromium (and steam piping like P91/92). The use of hydrofluoric acid has a major advantage in the later part of the process: the effluent treatment. As the pickling solution is not drained (because of the formation of fly rust), but displaced with water, a passivation with ammonia/peroxide only is sufficient. In comparison with any other method the effluent treatment of this cleaning is relatively easy. Addition of lime precipitate the fluorides and iron as a sludge (DND method), which makes it possible to execute the waste water treatment on site. Most important value for discharging effluents after treatment is the chemical oxygen demand (or COD). This COD is directly correlated to the amount of organic contents of the water. Besides the inhibitor no organic compounds (like for instance citric acid) are used in this method, so relative low COD value of the effluent is met with this method.

Advantages: also dissolves mill scale and silicate (compounds); only suitable for power plants; standard procedure (VGB guide line); in some cases the only suitable method, easy to handle waste water treatment on site.
Disadvantages: large quantities of waste water; various corrosive and toxic chemicals required; very operator and environmentally unfriendly; when improperly applied risk of damaging base material.

Cleaning on the basis of citric acid

Cleaning with inhibited citric acid is conducted at a neutral pH. High temperatures are required however to remove the iron oxides. At elevated temperatures citric acid becomes more corrosive despite the neutral pH and inhibitors are required that may interfere with the second phase of the cleaning, passivation. Citric acid forms a strong complex with iron. Therefore the solution can be made alkaline without the iron precipitating as hydroxide. This means that with citric acid pickling and passivation can be conducted with one solution. When passivating, hydrogen peroxide or sodium nitrite is generally dosed. After cleaning, waste water is released that can be processed in a straightforward fashion by biological waste water purification or by the DND method.
Advantages: passivation with the cleaning solution; less waste water; method is suitable for removing copper.
Disadvantages: high operating temperatures; unable to remove mill scale in some cases; addition of chemicals during the passivation phase; less easy to treat effluent on site.

Cleaning on the basis of EDTA, Demclean 94®

The Demclean 94® cleaning method is based on EDTA in pH neutral media (see also TB 2004-06 of March 2004). This method not only removes iron oxides, but also light oil, grease and atmospheric contamination. The rust (iron oxides) is dissolved with the formation of a strong iron-EDTA complex. This allows the pH to be increased after cleaning without the iron precipitating as ferric hydroxide. After this neutralization, the steel is passivated by dosing sodium nitrite. This means that only one solution is required for pickling and passivation with less waste water being released. The waste water released by this cleaning

procedure may be treated by biological water purification modified for EDTA processing.
Advantages: pH neutral cleaning agent; passivation with the cleaning solution; less waste water; not corrosive for other metals; time saving.
Disadvantages: addition of chemicals during the passivation phase; unable to remove mill scale; limited capacity for dissolving iron. Waste water can only be treated biologically.

Cleaning on the basis of VPX One Step®

The VPX One Step® process developed by Vecom consists of a cleaning procedure with a pH neutral solution, which dissolves the iron oxide allowing the underlying steel substrate to be phosphated. This process therefore pickles and passivates in one step. The fact that no other cleaning solution or addition of chemicals is required in order to passivate, is a major advantage because fewer environmentally harmful substances are used. VPX One Step® contains no toxic/corrosive constituents making this chemical cleaning procedure very environmentally and operator friendly. The waste phase is also free of problems. The waste water can be simply treated by the DND method. After cleaning a rinse phase is applied in which the waste released has a volume of twice the capacity. VPX One Step® will, thanks to its neutral pH, cause no problems when the installation incorporates also other metals such as copper, aluminium, zinc or stainless steel. VPX One Step® barely reacts with these metals, nor does it give rise to plating. VPX One Step® cannot be used to remove mill scale. A pre-treatment with hydrochloric acid should be used for that purpose.
Advantages: neutral; pickling and passivation in one step; operator and environmentally friendly; no reaction with other metals; fits in well with the boiler water treatment programme due to the presence of a phosphate film.
Disadvantages: process is not accepted worldwide; does not remove mill scale; removes very severe rust with difficulty; not cheap.

Conclusion

Each method has its advantages and disadvantages, the choice of method will be dependant very much on each process, type of installation, locality, budget, local regulations and even country. Every method should always be taken into consideration and discussed.

On the next page you will find a table with the various pre-commission cleaning methods.

	Demclean 94®	Hydrochloric acid	Hydrofluoric acid	Citric acid	VPX One Step®
Water consumption during cleaning	1 x system capacity	Pickling 1 X Rinsing 2 X Passivating 1 X Total 4 X capacity	Pickling 1 X Rinsing 2-3 X Passivating 1 X	1 X system	Pickling/passivating 1 X Rinsing 1 X Total 2 X capacity
pH cleaning solution	Neutral (5,0-5,5)	Acidic (< 1)	Acidic (1)	Acidic (3,0-3,5)	Neutral (6,0-6,5)
Operating temp. °C	50-60	40-50	50-70	70-80	40-50
Cleaning time (hrs)	24	48	48	24	15
Effluent treatment	Biological	DND, on site possible	DND, on site possible	DND/ Biological	DND
Corrosive constituents during pickling phase	None	Yes, hydrocholoric acid	Yes, and toxic	Yes, citric acid	No
Pickling	Iron oxides (rust) and very light grease / atmospheric contamination	Iron oxides (rust) and mill scale and annealing skin	Iron oxides (rust) and mill scale and annealing skin and silicates	Iron oxides (rust)	Iron oxides (rust)
Passivation / passivation solution	After NH_3 neutralization with nitrite 1 step	After rinsing with ammonium citrate / peroxide 2 steps	After displacement of the acid with ammonia and peroxide	After NH_3 neutralization with H_2O_2	No extra dosing required. Passivation by phosphate formation
Maximum iron concentration	4 g/l	10 g/l	10 g/l	10 g/l	7 g/l
Possible on steel alloys with chromium or P91/92 material?	Yes	No	Yes	Yes	Yes, for Cr alloyed steel (not tested on P91/92)
Cleaning possible when pipes present of: Copper Stainless steel	 No Yes	 Yes No	 No Yes	 No Yes	 Yes Yes
Accepted worldwide	Yes	Yes	Yes (VGB guideline)	Yes	No

Energy sector
Reference list

Location	Executed works
Amsterdam, The Netherlands	Chemical cleaning of cooling water systems
Diemen, The Netherlands	Pickling and passivation stainless steel
Koog aan de Zaan, The Netherlands	Removal of magnetite fromevaporator
Amsterdam, The Netherlands	Supply of effluent pit for chemical cleaning
Friedeburg, Germany	Chemical cleaning of fuel lines
Hengelo, The Netherlands	Pre-commissioning cleaning of water side of air cooler
Schoonebeek, The Netherlands	Pressure tests HRSG steam boiler parts
Europoort, The Netherlands	Delivery of 4.000 m^3 effluent pit for chemical cleaning
Ninzekamsk, Russia	Pre-commissioning cleaning of two steam lines
Sluiskil, The Netherlands	Pre-commissioning cleaning of one steamline
Dordrecht, The Netherlands	Pre-commissioning cleaning of two steam lines
Europoort, The Netherlands	Pre-commissioning cleaning of waste heat boiler and three heat exchangers
Moerdijk, The Netherlands	Pre-commissioning of three e economizers with VPX One Step Method
Botlek, The Netherlands	Pressure test steam boiler systems and removal and treatment of waster water
Moerdijk, The Netherlands	Pre-commissioning cleaning of steam lines
Bergen op Zoom, The Netherlands	Pre-commissioning cleaning of two steam boiler super heaters
Moerdijk, The Netherlands	Pre-commissioning cleaning of two heating crackers
Berlin, Germany	Cleaning of cooler banks (water side, removal of iron oxides)
Marsaxlokk, Malta	Boiler cleaning gas side
Cuyk, The Netherlands	Cleaning gas side Economizer

Pre-commission cleaning of 5 Heat Recovery Steam Generators

Cleaning before commissioning: two boilers in one shot!

A Combined Cycle Power Plant has two turbines. The first turbine is a gas turbine that is driven by burning, for example, natural gas. The second turbine is a steam turbine that is driven by the steam that is heated by the residual heat from the exhaust gases of the gas turbine (see the figure). Both turbines drive a generator where the electricity is produced. The electrical yield of this system is considerably higher (approx. 60%) than when only one turbine is driven.

The section where the steam is produced to drive the steam turbine is referred to as a Heat Recovery Steam Generator (HRSG); see photograph 1. An HRSG often has three sections: LP (Low Pressure), IP (Intermediate Pressure) and HP (High Pressure). Every section includes a steam drum and an evaporator section. Water is converted to steam in the evaporators. This steam will run through superheater sections where the temperature of the steam will be increased before it is led to the steam turbine.

Project in Oman

In Sur Oman (Arabian Peninsula), a Combined Cycle Power Plant has been built, consisting of 5 HRSGs. The configuration is 5 gas turbines and 3 steam turbines. Daewoo is the builder of the plant and Petron is the constructor of the boilers. The plant has five 250 MW (megawatt) gas turbines. The exhaust gases of each turbine will be led to its own HRSG. Using the steam of the five HRSGs, three times 300 MW steam turbines will be driven. The net capacity is, therefore, more than 2,000 MW.

Often chemical cleaning takes place before an HRSG is commissioned. This is referred to as pre-commissioning cleaning. The contaminants to be removed consist of loose contaminants (including sand), grease, oil, surface rust and welding scales. After the pre-commissioning cleaning, the water side of the HRSG will have a clean metallic surface and will have been completely passivated. When the HRSG is commissioned, a magnetite layer will form on the water side that protects the material against corrosion.

Vecom Cleaning Manual

Because the projects in the Middle East are often of this scale, Vecom has a joint-venture partner in Dubai UAE. Petron placed an order with Corodex/Vecom to carry out the chemical cleaning of the five HRSGs. Vecom has produced a Cleaning Manual for this purpose, based on the special inquiry to clean two boilers in one shot. A Cleaning Manual is a type of script in which the full chemical cleaning is described. It is exactly determined which sections of the HRSG must be cleaned and based on which flow charts this should be performed by using detailed P&IDs (Piping and Instrumentation Diagrams). This is referred to as Engineering. In addition, the full chemical procedure is also described in this manual.

Chemical procedure

Nowadays, many HRSGs are cleaned using hydrofluoric acid (HF), in particular in Europe. However, HF is a toxic acid that can cause serious burns. The five HRSGs in Oman have, for this reason, been cleaned by applying the citric acid method. Chemical cleaning with inhibited citric acid is a good alternative. However, a high temperature (80 – 90 °C) is required to ensure that the iron oxides are correctly dissolved. This can partially be compensated by adding ammonium bifluoride. This ensures that you can clean using a lower temperature. Hydrofluoric acid or ammonium bifluoride is also necessary for the removal of silicate deposits.

Before cleaning

After cleaning

Citric acid method

Chemical cleaning using citric acid includes the following cleaning steps:

- Pre-flushing at high speed to remove all loose contaminants (including sand).
- Degreasing phase: oil and grease contaminants are dissolved by using a detergent.
- Descaling phase: the inhibitor and the citric acid are mixed with the degreasing liquid (using a specific ratio). Next, ammonium bifluoride is added and the pH is slightly increased by adding ammonia to ensure the solution is less aggressive. A number of parameters are analysed continuously during descaling to determine the progress of the cleaning. The iron level and the citric acid concentration provide a picture of the cleaning progress. If this is stable, the descaling phase will be finished (see graph 1).
- Flushing phase at high speed to remove acid residue.
- Removal of flash rust: the flash rust that forms during draining and flushing is removed using a low concentrated citric acid solution.
- Passivation: the citric acid solution is neutralised using ammonia until a high pH is obtained. The passivation is started by adding an oxidator. Passivation involves oxidising the reactive iron surface to a (temporarily stable) uniform gamma-Fe_2O_3 layer.

Two boilers in one shot cleaning

An important new method was the cleaning of two HRSGs in one shot. For this, a special cleaning sequence has been engineered, also to limit the quantity of chemicals and wastewater.

All wastewater is stored in a temporary storage facility, a so called evaporation pit. The water evaporates, leaving a small quantity of sludge which is transported to a local processor. The method as it has been carried out in Oman by Vecom, generates considerably less wastewater than conventional cleaning methods. See the photographs for the cleaning result.

Temporary storage of waste water in an effluent pit

Storage of waste water on site with a very large storage capacity

Vecom has been carrying out boiler cleanings successfully for many years. When chemically cleaning, often large quantities of waste water are released that usually need to be stored quickly so that the following phase of the cleaning can start.

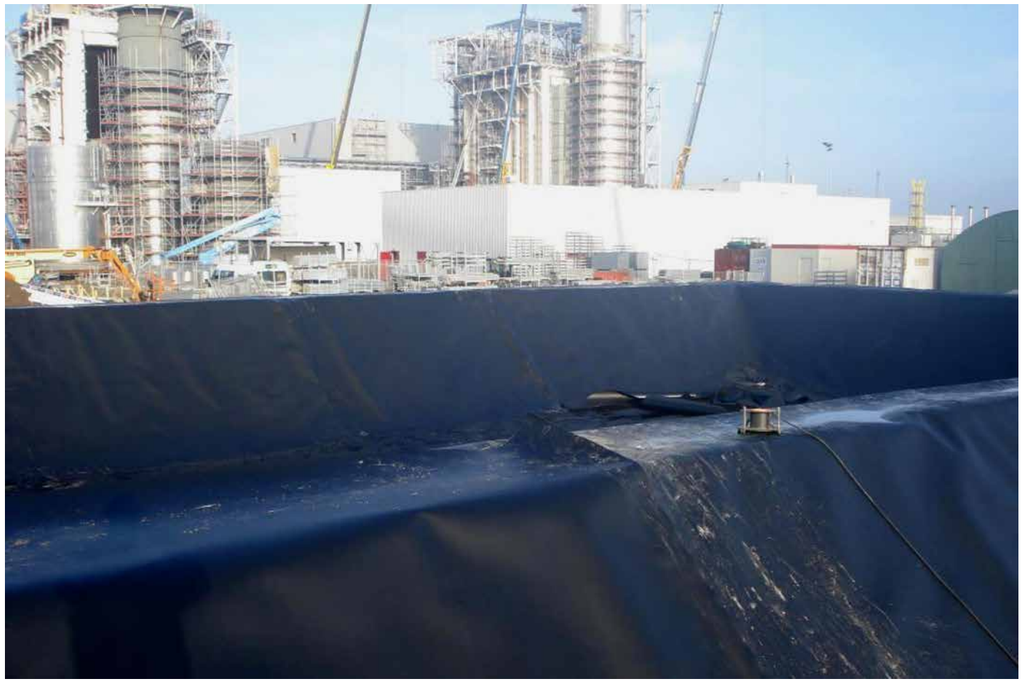
Waste water originating from chemical cleanings can be temporarily stored in different ways. Often IBC containers (1 m^3 per item) are used for small cleaning projects and tank vehicles (approx. 25 m^3) or temporary storage tanks (approx. 70 m^3) are used with larger cleaning projects. The disadvantage of these storage methods is the limited capacity when very large volumes are released during boiler cleaning. Quantities of more than 1000 m^3 are common with regard to boiler cleaning. Sometimes this waste water is temporarily stored in, for example, four temporary storage tanks (with a total of 280 m^3). They must, therefore, be emptied quickly using tank vehicles during cleaning before the following waste stream is released by the cleaning. This mainly has logistics disadvantages.

Effluent pit

Another solution is an effluent pit. An effluent pit is constructed by creating a large pit with sand. Next, the inside and the sides are covered with foil. The foil can be rolled out manually or by using a crane (depending on the size of the pit and the available manpower). The foil is welded with a hot, round electrode and is, in a way, molten together. Since the welding seam is hollow inside, it is relatively easy to determine whether the welding seam leaks. To determine this, a thin needle is used to exert pressure on the welding seam. Next, a pressure gauge is used to determine whether the pressure remains constant for a specific period of time. When the pressure decreases, the welding seam leaks and it will be rejected. When welding an effluent pit, all welds are inspected and a record of this is also maintained. When the effluent pit is delivered, these certificates are also supplied.

An effluent pit after the earthworks (top) and the final result (bottom)

Applying foils using a crane: first the white protective foil, next, the black EPDM foil



Foil with in the background the HRSGs that have now been cleaned that are still partly being built

Foil

The foil that will be used will depend on different factors such as, for example, resistance to chemicals, mechanical strength, flexibility, etc. EPDM is often used for the storage of chemical waste. The specific advantages of EPDM are:

- EPDM has a high elasticity (up to 400%) over a large temperature range (-40 °C to 120 °C);
- EPDM has a good chemical, thermal and UV resistance;
- EPDM has a long service life (> 20 years; this will, of course, depend on the conditions and application).

This makes EPDM extremely suitable as storage resource for chemical solutions when there are high temperatures temporarily.

Often a soft protective blanket is placed under the foil. This protects the EPDM foil against any stones or other sharp objects that may be present.

Advantages of an effluent pit:

- Very high storage capacity;
- Economically more favourable in many cases with a longer working life;
- An effluent pit is also extremely suitable to treat waste water on site as the only storage method that offers this option;
- It is installed in accordance with the Kiwa guidelines with a certificate.

Practice

When constructing a power plant in the Rotterdam industrial and port area of Europoort, the customer chose to chemically clean the plant itself and to process the waste water on site. For this, a large storage capacity for a longer period of time was required. Therefore, they decided to store the waste in the aforementioned effluent pit. Vecom constructed an effluent pit for this project with an intermediate dike so that two different streams could be stored without the streams mixing.

The effluent pit was constructed in approximately 1 to 2 weeks. Next, the heat recovery steam generator (HRSG) was cleaned by applying the EDTA method. The waste water that was released during this treatment has been stored in the effluent pit. Next, the waste water was treated on site after which the residue was taken to a recognised waste water treatment facility using tank vehicles. The effluent pit was dismantled after seven months. The foil was cut loose and removed using a crane and manually. To conclude, the foil was taken to a recognised waste treatment facility.

Preservation of steam boilers

Protection of the boiler in case of extended period of decommissioning

Vecom Projects has carried out the chemical cleaning of various types of boilers over the last few years. This has been either a pre-commissioning cleaning or a cleaning of older boilers that experienced performance problems due to contamination (post commissioning cleaning). In the above cases the boilers will often be decommissioned for an extended period.

During a new construction project it could be that, due to circumstances, there is a substantial delay between finishing the construction and the start of the chemical cleaning of the boiler. This can vary from a few days to several months.

A long shutdown period is often chosen with older boilers that have to be cleaned due to contamination, in order to check all the ancillary installations for wear and the like. If such is the case, it could be that the boiler will have to be decommissioned for a longer time after the chemical cleaning.

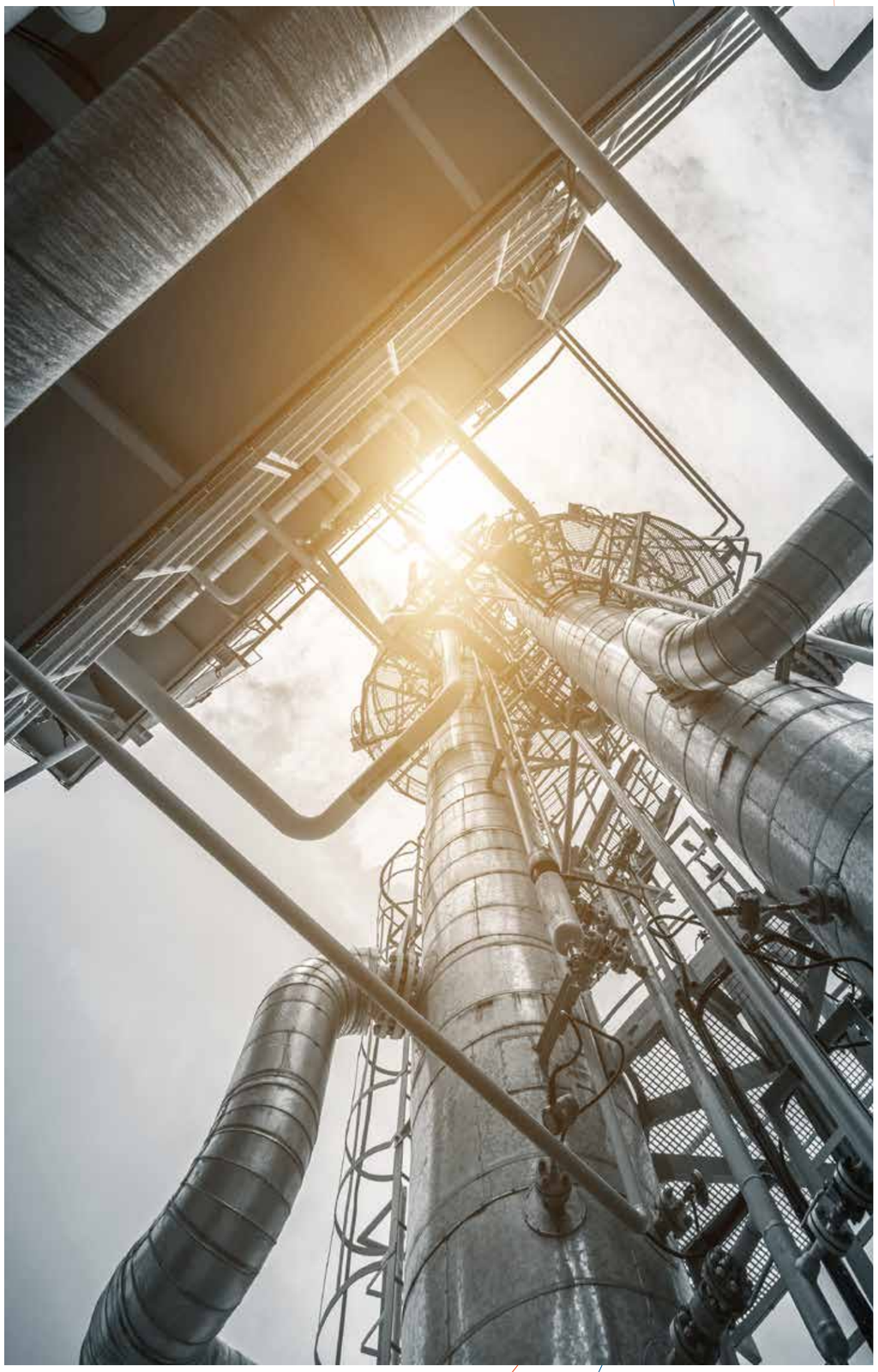
In these cases a fitting preservation of the boilers will have to be considered, as in time corrosion problems will occur in the internal parts of the boiler due to the action of oxygen. Consider here the most important parts of the boiler, such as the supply water pre-heater, the evaporator, the drum and the excess heater(s).

The preservation

Vecom defines preservation as the introduction of a high pH medium (pH 10-10.5) to the boiler. This can be done by adding trisodium phosphate to the demineralised water that is used to fill the boiler. The added phosphates will react with the surface of the steel. This will produce an iron phosphate layer, several microns thick. This will form a protective layer on the base material.
This layer could still be attacked by oxygen anyway, and it will therefore be necessary to add an oxygen binder to the preservative. Sodium sulphite for example is used for this purpose. Sodium sulphite takes oxygen out of the water and therefore prevents corrosion of the iron phosphate layer.

It is extremely important for all air to be removed from the boiler when it is being filled. It will however, due to its construction, not always be possible to actually fill a system completely with water. Also, there is always a chance that oxygen intrusion will occur because of a slight partial vacuum in the boiler, e.g. via leaking gaskets etc.
The boiler will have to be put under a slight excess pressure with nitrogen in order to expel these last remaining traces of oxygen and to prevent intrusion of oxygen from the atmosphere. An excess pressure of approx. 0.3 bar(g) nitrogen will already be sufficient.

Once the boiler is preserved it can theoretically be left for many months without corrosion occurring.
It will however still be necessary to check and record the pH at various points in the boiler at least twice a week. This is to detect premature deterioration of the preservation.
The nitrogen pressure will also have to be checked. A sudden increase in the nitrogen consumption can indicate a leak or loss of water from the boiler. If preservation water should after all be lost due to leaks or the incorrect emptying of the boiler, it will be necessary to refill the boiler with preserving liquid in the short term and to completely depressurise it again.



Steam blowing

Using the power and velocity of steam to remove impurities

Most new power plants nowadays are producing steam to run a steam turbine. A steam turbine is a sensitive system containing turbine blades. The steam quality is very important as impurities in the steam can deposit on the turbine blades and imbalance the turbine. To ensure good steam quality, the cleanliness of the system is of great importance, from the start of the erection of a steam generator of a new power plant.

The cleanliness of the steam and water parts of a steam generator is achieved by acid cleaning or boil-out combined with steam blow, the so called pre-commission cleaning. The reason a typical pre-commission cleaning of a steam generator consists of a chemical cleaning and steam blow, is the fact that mill scale/silicates are easier removed with chemical cleaning, which ensures less steam blow cycles are required in a later stage. This technical bulletin goes deeper into the methods of steam blow.

Steam blow operations

During the erection of new build steam generated power plants, it is impossible to prevent foreign matters remaining in the steam water cycle. And in addition, the steel of which the steam and water cycles are fabricated will be contaminated with corrosion products (iron oxides) due to heat treatments of the steel (annealing) or rust from environmental circumstances. Although strainers (filters) are placed in the system to prevent impact of materials on the turbine blades of a steam turbine, the steam system should be free of (large) particles, as strainers can be penetrated by particles and harm the turbine. A so called pre-commission cleaning of the steam and water cycles consist of a chemical cleaning and a steam blow. A chemical cleaning prior to a steam blow cleaning ensures the time and effort (and thus costs) of steam blow is reduced significantly, as a chemical cleaning will remove loose debris, iron oxides, mill- and annealing scales.

Steam blowing is a cleaning operation which uses the power (energy) and velocity of steam to remove impurities from boiler parts and additional pipelines, and differences in temperatures during steamblow operation will remove mill scale, due to expansion and contraction of the steam piping. Almost always a turbine manufacturer demands a steam blow cleaning to a certain cleaning criteria.

Steam blowing for a steam generating plant requires careful planning and the establishment of a steam blow program, a so called pre-engineering. One of the important parts of the engineering is the determination of the velocity of the steam inside the system. This is called K-factor. Only from a certain velocity or K-factor the steam has sufficient energy to remove the particles from the system. The K-factor is dependent on the dimensions of the boiler like production of steam, pressure, temperature, diameter of the steam lines and length of the steam lines. When the K-factor is known, the dimensions of the temporary piping and silencers can be determined. The turbine itself will of course not be a part of the steam blow and will be bypassed with the temporary steam blow lines. Steam blow operations have to be monitored. As the size and number of particles are important, these are measured using “target plates”. These plates are mirror like steel (or other prescribed materials) plates, which are placed in the temporary steam lines. The target plates are inspected regularly during operation. The size and number of particles on the mirror plate are a part of the cleanliness criteria.

To reach the K-factor during steam blowing, there are two types of steam blow methods:

1. Shock blow
2. Continuous steam blow

Shock blow

With shock blow, the pressure inside the steam generator is raised to a certain maximum and reaching the required pressure, a temporary sacrificial valve is opened quickly. During this pressure release the K-factor or steam velocity is reached, but for a short period of time. Due to release of the pressure and temperature, the steam generator has to start again. The steam blowing operation described should last approximately four to six hours, including start-up and shutdown of the steam generating plant. Normally not more than one steam blowing operation should be effected daily in order to ensure adequate cooling of the system.

Continuous steam blow

With continuous blow there is no pressure build up, but after calculations, the K-factor is reached continuously. During the continuous steam blow the target plates are checked on impacts of particles.

Noise reduction

High pressure/temperature steam is actually water with enormous amount of energy. Releasing steam to the atmosphere with such energy gives a lot of mist formation and noise. To reduce noise levels to acceptable values, steam has to be cooled by condensation. There are two types of noise reduction methods. One is the classical silencer or knock out pot, which works like a type of cyclone; the increasing of the surface area will cool the steam. The second type of noise reduction works like spray water inlet in normal steam operations. At the end of the temporary steam blow pipe, water is introduced to cool down the steam and at the end of the line there is a condensate pot to collect the condensate steam. From this temporary condenser the water is used again for spray water inlet.

Continuous steam blowing has certain advantages in comparison with shock blowing. Specially in combination with noise reduction by means of spray water inlet (so called quenching). As the K-factor is most important for a good steam blow result, continuous steam blow has the advantage to measure this factor for a longer period, as with shock blow the K-factor is reached for a short period. Second, the amount of demineralised water required for continuous steam blow is much less than with shock blow. Finally, in combination with spray water inlet noise reduction, the temporary pipe work of continuous steam blow will receive a max pressure of approx. 10 bar, which enables to use less expensive temporary piping. For shock blow the temporary piping up to the silencer is PN40 at least.

In the table on page 45, the differences between shock blow and continuous steam blow are given.

Vecom offers continuous steam blowing

Vecom has invested in the equipment and expertise for steam blowing. This equipment consists of:

- Quench water (spray water) silencer
- Demin storage tank (30 m³) and hot water pumps
- Condenser pot
- Temporary steam blow piping (up to DN450)
- Automatic target inserters

The differences between shock blow and continuous steam blow.

	Continuous Blowing process to atmosphere	Shock Steam blow process
Measures for noise reduction	Quenching No pressure loss Temporary piping PN16	Silencer/Sound absorber High pressure loss Temporary piping PN63 (max 58 bar at 400 °C) or PN100
Scope/Application areas	- Removal of mill-scale as well as loose particles in steam parts of the boiler. - Design gradients of the boiler and steam lines are not exceeded. - Can still be used in case of load-restrictions of the boiler.	- Removal of mill-scale as well as loose particles in steam parts of the boiler. - Design gradients of the boiler and steam lines are exceeded. - The plant/system must be pickled.
Steam Blow-out procedure	Operation of the boiler in sliding-pressure against the atmosphere. Steam-pressure emerges from loss of pressure of the super-heater system and the temporary steam blow piping system. Operating parameters: Steam-pressure between about 15 and 35 bar. Steam blow temperature should be between 480 and 525 °C. During steam blowing, the temperature quenching should be between 250 and 480 °C. Boiler load of about 20% to 40% Boiler superheater and steam line are fully open during the entire operation. Duration of the blow-out operation is about 3 to 6 hours (demin water storage capacity). Steam blowing can be finished in a time of 4 to 5 days.	Start-up of boiler at about 50% operating-pressure (about 68 bar). Pressure-accumulation through throttling of the temporary blow-out valve (time for open/close < 10 second). 2 to 5 actions of steam blow per day are possible with the shock blow procedure. For each blowing step the combustion/heating must be put out-of-action, because the water level in the steam drum increases outside of the visible area. Adjusting the secondary-feed regulator in such a fashion that at the end of the pressure-impact/surge the water level in the drum is within visible range. The number of blow-out operation is dependent on the rate of the cleanliness during erection. Steam blowing time is incalculable.
Advantages and disadvantages	System-friendly. Gradual and uniform increase of pressure and temperature.	Not system-friendly due to rapid decrease of pressure and temperature.
	Uses less demin water in total.	Uses more demin water in total.
	Possibility to enhance the K-factor variably.	Difficult to reach/achieve the K factor 1,2
	Level of noise can be controlled by water injection.	Level of noise can be controlled by silencer.
	By means of lower blow-out pressure and substantially reduced steam temperature, temporary steam blow lines with smaller wall-thickness and low-alloyed steel is possible to use. Quick operating valves are not required.	Steam blow lines with larger wall-thickness and high-alloyed steel have to be used due to greater pressure and steam temperatures during steam blow. Quick operating valve are expensive.
	Large diameter for the steam blow lines after injections/spraying.	Consistent diameter of steam blow lines up to silencer.
	Build-up of exhaust vapour (mist) at silencer due to water quenching.	Possibility of saving process water, because no quench water is required.

Locations

Chemical cleaning

AkzoNobel · ArcelorMittal · B&W · bam · BASF The Chemical Company · Bayer · bp · Cargill · Damen · Dow · DSM · Hero · Jansens & Dieperink · John Cockerill · Koninklijke Marine · Kraft foods · lyondellbasell · Marine Contractors · Q8Oils · Sabic · Shell · Siemens · SPIE · Stork A Fluor Company · Tata Steel

ENGIE · ExxonMobil · FrieslandCampina · GDF Suez · GE · Grolsch · Heineken · McDermott · NAM · Nederlandse Energie Maatschappij · Neste The only way is forward · Nouryon · Petro-Canada · Petron Fuel Success. · thyssenkrupp · Total · Unilever · urenco · Vattenfall · wolter & dros TBI techniek · Yara

Veclean LowCOD

Specially developed for the removal of heavy oils and grease

Vecom developed the product Veclean LowCOD. This is a very powerful cleaning product based on natural raw materials, emulsifiers and special surface-active substances. The product has been specially developed for removing heavy oils and greases, black tar, bitumen, distillation residues and many other contaminants.

Due to its special composition, it is many times more effective than alkaline products and offers an effective substitute for conventional solvents like petroleum and white spirits in almost all cases. A 5% Veclean LowCOD emulsion in water alone is even much more effective than most undiluted solvents. Veclean LowCOD is excellently suitable as a circulation medium as usually used in industrial cleaning and tank and bulk cleaning.

Waste

The emulsion that results after a cleaning with Veclean LowCOD can be easily processed. When heated to a specific temperature, the emulsion separates within a few hours into an oil and a water phase. The water phase will contain very little organic material, so that requirements relating to waste water can be fulfilled. The Chemical Oxygen Demand (C.O.D.) will be less than 5,000 mg/l O2 and the water will contain less than 200 mg/l mineral oils. This separation process is reversible. In other words: after cooling of the emulsion, for example during transport or storage, the emulsion is heated to a specific temperature and after a few hours, the wastewater will separate again into a water phase and an oil phase.
Depending on the starting concentration of Veclean LowCOD, the quantity of waste can be limited to 95%. The remaining 5% oil waste should be disposed-of as oil waste.

Since the wastewater can meet very stringent requirements after separation, it is possible for Vecom to accept Veclean LowCOD waste and to process it in one of the Vecom waste processing installations.

Separation of Veclean LowCOD into an oil and water phase

Practical example

Vecom Projects has carried out a number of successful cleaning operations using Veclean LowCOD. Two different types of cleaning operations using Veclean LowCOD will be explained here.

1

At the company Shell, a small heat exchanger of approximately 1 m^3 capacity, contaminated with cokes and bitumen, was cleaned. This contamination was present at the product side of the heat exchanger. The cleaning was done using circulation and with heating, using a 10% Veclean LowCOD solution.
The Veclean LowCOD emulsion was treated in a wastewater treatment installation at the Vecom works after the cleaning. The oil phase and the water phase gets separated after heating to a specific temperature. In order to determine whether the water phase is really clean, the Chemical Oxygen Demand (COD) can be determined. This provides an indication of the organic substances present in the water. In addition, the content of mineral oil is determined. These are the main parameters for determining whether the separation has taken place sufficiently or not.
Ultimately, 93% of ‘clean’ water was obtained from the emulsion and 7% oil waste was left over.

The analysis results have been presented in the table below.

Table 1:
Results of the analysis of the water layer after separation with Veclean LowCOD

Parameter	Content av.
Chemical Oxygen Demand (COD)	4300 mg/l O2
Mineral oils	70 mg/l
Heavy metals: Cu, Ni, Zn, Pd & Cr	< 0,5 mg/l

2

At Corus in IJmuiden a lub oil tank with a volume of 25 m^3 was cleaned in collaboration with Mourik Services B.V. The installation consisted of a steel tank in which the oil is heated with 95 °C water. The installation was heavily contaminated with residues of old oil and was fully cleaned with circulation at a relatively low temperature (50 °C). It was, however, not possible to fully fill the installation with cleaning medium and as a result, the ceiling of the tank could not be cleaned with circulation. The results can be clearly seen from Photo 3: the bottom has been thoroughly cleaned. The contamination is still visible in areas which Veclean LowCOD was not able to reach.

Where earlier several persons had to use high pressure water jets for several days to clean the installation, it now is possible to obtain better results within a few hours using circulation with Veclean LowCOD than ever before.

The use of Veclean LowCOD provides major advantages in the field of environment and safety: it is now no longer necessary for several persons to enter the tank to remove the contamination, thereby reducing the risks of accidents as well as the cleaning time, enabling the production process to be restarted sooner.

Lub oil tank (25 m^3) after cleaning

Treatment of very large stainless steel heat exchangers

Flexibility and well-planned logistics make the difference

Industrial heat exchangers exist in many forms, with a wide range of applications. The most common heat exchangers are the pipe and plate heat exchangers. There are forms in which the tube is coiled in a spiral enclosed in a casing. Another form is a combination of a straight tube exchanger fitted perpendicularly to a spiral coil tube, the so-called "spiral coil type exchanger". Another concept is the "heat train" in which several tube heat exchangers are fitted in series in one casing.

The choice of metal for this equipment depends on the process, medium, temperature, pressure, tension and corrosion resistance. Materials such as construction steel, stainless steel, duplex steel, Inconel, Hasteloy, etc. can be used. Depending on the material, the processes such as rolling and welding and the environmental surroundings of the process, the valuable equipment must be protected in an optimum manner against corrosion, in order to achieve the optimum life span.
The Vecom group's Service Business Units have broad experience in the recovery of corrosion resistance by means of pickling and passivation of the many types of stainless steel processed in both small and large heat exchangers.

A brief description of pickling and passivation

The most important reason for pickling stainless steel is for removal of welding discolouration. These heat-affected areas have virtually no corrosion resistance. In addition, the pickling dissolves all foreign iron and chloride particles. These particles also have a harmful effect on the corrosion resistant chromium oxide film of the stainless steel. By means of chemical passivation, the chromium oxide film is built up more quickly and the stainless steel achieves an optimum corrosion resistance in the shortest possible time. For further background information about pickling and passivation of various types of stainless steel, please refer to our other Technical Bulletins on www.vecom-group.com.

In practice

Vecom Projects received a request from Spain to pickle and passivate five very large stainless steel 304 "heat train" heat exchangers. The heat exchangers were destined for a bio-ethanol factory under construction in China and weigh 65 to 150 tonnes. The exchangers were transported by ship and temporarily offloaded in Middelburg, where Vecom was given 7 to 10 days to pickle the entire interior and exterior up to the facing of the pipes in the pipe plates. During the initial discussions it was decided that the heat exchangers needed to be set up indoors due to the environmental temperature (December), the environment, soil protection and to prevent the pickling agent from being blown away into the surroundings. A large shed was rented, heavy cranes were ordered for loading and unloading and the five heat exchangers were set up on stands on soil protecting sheets.
The Vecom degreasing solution was applied to the material using spray equipment, after which the heat exchangers were rinsed with high-pressure water hoses.
Next, Vecom Low NOX spray pickling solution was applied to the entire degreased metal surface. Following a reaction time of several hours, the metal surface was rinsed with water from high-pressure hoses, whilst pH paper was used to ensure that the metal remained pH neutral. The entire heat exchanger was then rinsed once more with demineralized water. This was done to ensure that there were no more chlorides present on the metal and that the stainless steel can build up its protective chromium oxide film. Vecom Projects was able to complete this project to the satisfaction of its Spanish client within the set delivery time, including the removal of waste.

Another example

At the Vecom location in Maassluis, Vecom Projects treated a 60 tonne stainless steel heat exchanger. This heat exchanger is fitted with welded pipes in the pipe plates. In order to achieve optimum corrosion resistance, it is essential for this type of heat exchanger to treat the internal chrome-depleted material on the welding sites with pickling solution. In order to achieve this, a temporary circulation system is fitted to the cooler and according to the protocol degreasing, rinsing, pickling and rinsing fluids are circulated. The exterior was treated with Vecom spray pickling solution. This project again included heavy goods transport, heavy cranes and well-planned logistics.

Before pickling

After pickling

Cleaning of urea strippers

Deposition causes a less efficient production process

The substance urea is employed for, among other purposes, artificial fertilizer and raw material for the plastics industry. Urea is synthesized from carbon dioxide (CO_2) and ammonia (NH_3). This chemical reaction does not provide immediately a 100% yield. In order to complete the reaction a so-called "urea stripper" is employed. Urea strippers are manufactured from stainless steel alloy and consist of vertical tubes with the reaction progressing on the interior of the tubes while steam is introduced on the exterior of the tubes. After a period of time a deposit develops in the urea stripper.

A typical deposit in a urea stripper consists of ferric oxide (hematite) with admixtures of nickel, chromium and molybdenum oxides and is generally grey to black in colour. This deposit causes reduced heat transfer resulting in a reduction of production process efficiency.

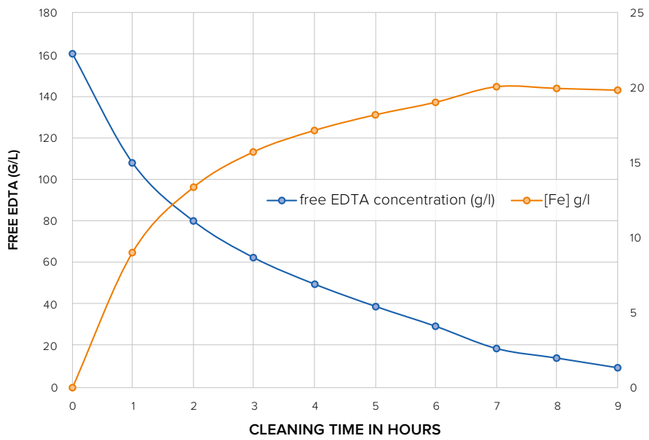
Iron oxide deposits can generally be removed readily from a stainless steel surface by acid pickling. This however also results in a very small portion of the base material being dissolved. This in turn increases the roughness of the stainless steel surface. This so-called acid corrosion can be slowed down by addition of inhibitors (pickling inhibitors), but this in itself will be insufficient to protect the stripper completely from material loss. It is not acceptable for part of the base material to be exposed to any corrosion.

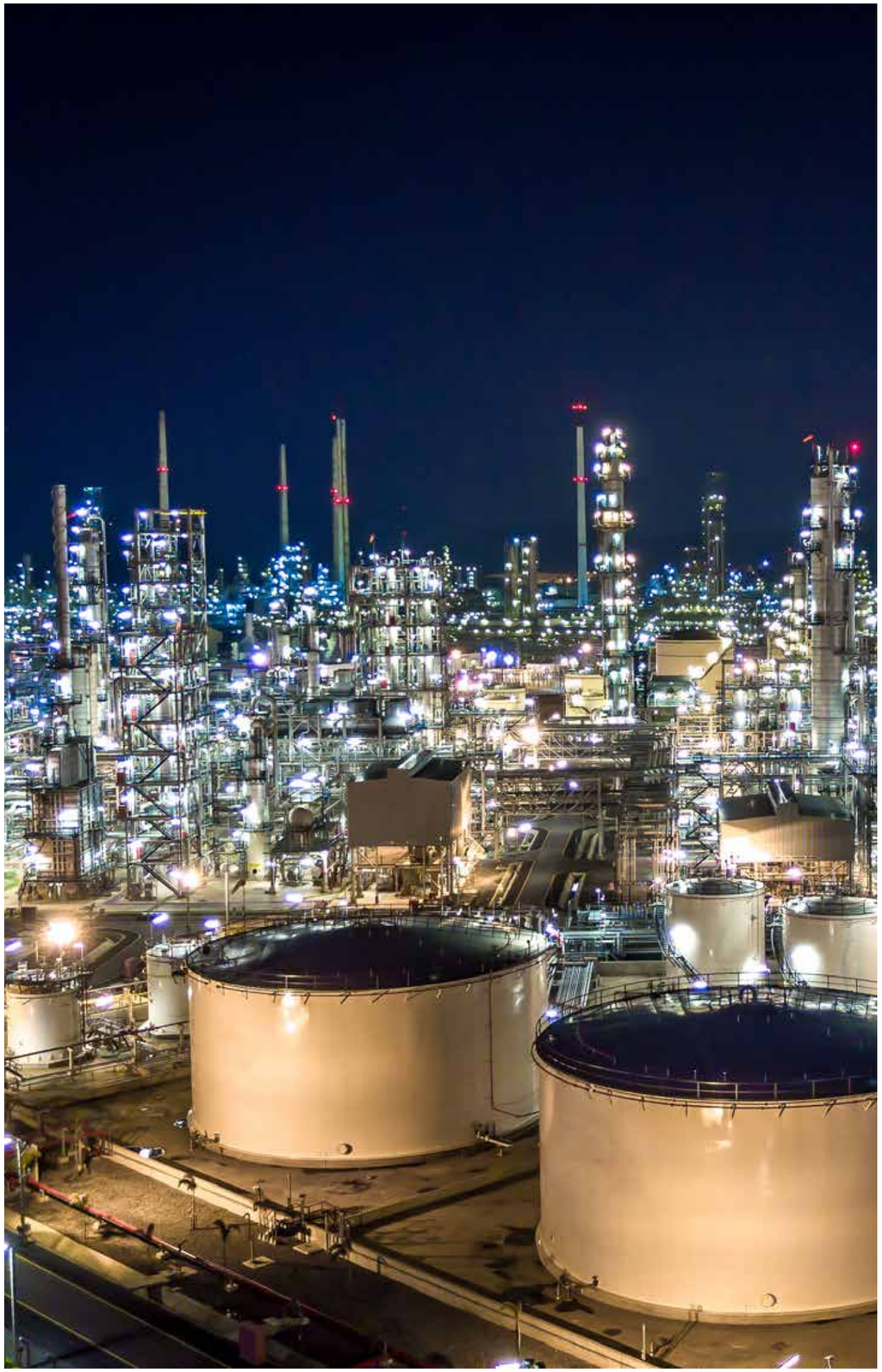
Research into an alternative cleaning method for the removal of the iron oxides involving the possibility of minimum corrosion were carried out in collaboration with DSM and Stamicarbon.
A cleaning solution based on EDTA appears to dissolve this deposit completely at high temperature without corroding the base material. In a pH neutral medium the iron oxide will dissolve forming an iron -EDTA complex.
The cleaning temperature is selected to maximize the reaction of the EDTA with the iron oxides. During cleaning the free EDTA and dissolved iron levels are continuously monitored in order to provide insight into the progress of the cleaning process.
Prior to cleaning the total quantity of EDTA and the number of batch treatments required are determined on the basis of the quantity of deposit and the size of the Stripper. Cleaning is carried out in batches employing a "Fill & Soak" method, in which nitrogen gas is used as agitation agent. Pump circulation is not possible due to the high temperature at which cleaning is conducted.

Vecom Projects specializes in, among other activities, the chemical cleaning of urea strippers and has during the past years cleaned successfully many urea production installations.

In the graph below the progress of a of urea stripper cleaning session is displayed.

Upper surface of a urea stripper in Iran





Rouging - cleaning and removal

Rouge formation can cause corrosion problems on stainless steel

Stainless steel is widely used in pharmaceutical applications. The surface treatment of this stainless steel is very important, as in the pharmaceutical industry, hygiene aspects are priority. From several studies it shows there is a relation between surface roughness and the ability to clean and the ability of micro organisms to attach to the surface.
The lowest surface roughness can be achieved by (electro) polishing.

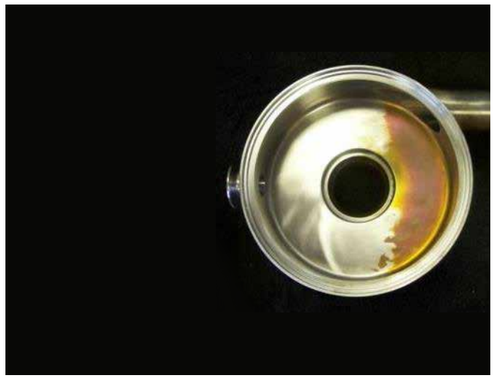
Pump casing with rouging before treatment

One of the phenomena that occurs on stainless steel, almost exclusively within the pharmaceutical industry, is rouging. Rouging is a reddish brown film of iron oxides and hydroxides and is found in ultra-pure water systems. The rouging film mainly contains iron (ferric) oxides but also can contain chromium and nickel compounds which can give different colours to the rouge. It seems AISI 304 (EN 1.4301) stainless steel is more sensitive to rouging than AISI 316 (EN 1.4401). It has been observed that an electropolished surface is less susceptible to this phenomenon than a mechanically polished one.

Mechanisms

One of the main properties of stainless steel is its passive chrome oxide film, which protects the underlying steel. Formation of this chrome oxide film is spontaneous with oxygen from the air and stainless steel has therefore the ability to repair itself and form this film after being damaged. In order to form this film, the stainless steel surface has to be uncontaminated as contaminants can disturb the formation of the chrome oxide film.
In an ultra-pure water environment this protective chrome oxide film can be attacked (See figure 1 on the next page). As ultra-pure water lacks any ions, the strength to pull ions into the solution is so strong it can dissolve the protective chrome oxide and leave an active and unprotected stainless steel surface. As chrome and nickel ions can dissolve in water at neutral pH, iron ions dissolve at pH three or higher, and is deposited as iron hydroxides on the active stainless steel surface as it repassivates. Iron hydroxides will oxidize to ferric oxide which is red (rouge). This passivation and repassivation process can cycle which results in various different colours.
Formation of rouge can be dangerous for stainless steel. Under deposits, a micro environment can be formed with a total different chemistry than the bulk. When for instance, sulphides (compound of a stainless steel alloy) react with this micro environment, pitting corrosion can be initiated.

Besides the rouging by ultra-pure water, rouging can be formed by external compounds in a water environment. One common source is ferrous bicarbonate. This is commonly used to soften hard water (lower calcium concentration). By means of several chemical reactions and with or without chlorine disinfection, iron hydroxides and ferric oxides are formed and deposit as rouge. Dissolved carbon dioxide gas also contributes the formation of rouge in ultra-pure water systems.



Pump casing after (partially treated)

Cover plate before

Cover plate after

Impeller plate before

Impeller plate after

Classification

Rouging has been categorized in three types:

Class I

This type class rouge comes from an external source. Deposited rouge particles on the stainless steel surface are easily wiped off and the stainless steel surface itself is not corroded. The most common source is carbon steel materials in the system, where pumps etc are most suspicious.

Class II

Iron compounds originated in-situ by ultra-pure water or improperly passivated stainless steel surfaces.

Class III

This type of rouge is coloured darker (purple/black) and forms in the presence of high temperature steam. The ratio iron/chrome in the protective passive film is altered as the amount of ferric oxide (typical black magnetite) is formed.

Cleaning and removal of rouging

Rouging will contribute to iron release into the ultra-pure water. Even small amounts of other compounds as chrome and nickel might dissolve. Although there is no consensus of the fact how it interferes in a process, it seems the common practise is to prevent or minimize rouge and perform a chemical cleaning to de-rouge and passivate the stainless surface.

Procedure for chemical cleaning

There are various ways in which rouging can be removed from an affected system. Conventional pickling will dissolve the passive layer and strip back the rouge, leaving a clean surface. The negative side is that this process will etch the surface of the steel, roughening and dulling the finish. Ra-critical components will inevitably be ruined or at the very least, require further polishing to achieve the correct surface smoothness. Surfaces that have been pickled will subsequently become rougher and therefore more susceptible to further cases of rouging.
Where possible, (i.e., in vessels, etc.) mechanical polishing can also remove this contamination. This is however an extremely expensive and time consuming process which is very dirty and will require extensive cleaning operations afterwards. It is also impossible to perform this process on the more commonly affected parts (pumps, pipework, valves, etc.).

Vecom have developed a chemical formula that will remove the affected passive layer and remove the rouging with no detrimental effect.
Our sulphuric / phosphoric based solution can be easily pumped through a pharmaceutical system with minimum disruption to the plant, leaving no mess, totally removing all traces of rouging and most importantly, not affecting the Ra finish of the parts.

After this cleaning operation (or any other), the system should be fully repassivated. Vecom are able to offer this service using either a nitric acid based passivating solution, or a more environmentally / operator friendly citric acid based one.

Note

http://corrosionlab.com/Failure-Analysis-Studies/rouging.htm

http://www.corrosion-doctors.org/MatSelect/rouging.htm

http://www.ispe.org/

Pipe pigging
James Bond's favourite cleaning method

Every company with pressurised piping in its production system is familiar with the problem of internal contamination and accumulation of material on the inside the pipeline. This can cause various problems, from a loss of efficiency to blockages and corrosion. A common cleaning method is chemical technical cleaning where the piping is cleaned with chemicals. In some cases, however, the 'pipe pigging' method is an environmentally friendly and effective alternative. This Technical Bulletin takes a closer look at this cleaning and inspection method that has even made the big screen.

The pig

Pigging uses a flexible cleaning plug, the so-called 'pig', that is forced through the pipe by a particular medium. The diameter of the pig is slightly larger than the inside diameter of the pipe. As a result, the pig scrapes the pipe wall clean and carries the contamination to the end of the pipe. The first documented use of this technique dates from around 1870, when a crude oil pipe of Colonel Drake in Titusville (Pennsylvania) began to silt up after two years in use. At the time, use was still being made of a plug consisting of rags bound together. Later the rags were replaced by leather. The cleaning pig owes its name to the screeching sound that can be heard when passing through the pipe. From approximately 1960 developments with the introduction of the 'polly pig' progressed quickly. This is a spherical plug of strong but easily deforming polyurethane. Various sizes and types are available nowadays: covered with a special coating or finished with a steel, stainless steel or Teflon wire brush. Which type is most suitable depends on the pipe material and the contamination.

Installation

The pigs are always introduced into the piping system to be cleaned from a pig station or launcher. The launcher has at least a connection for the medium with which the pig is pushed forward. Normally this is a gas such as nitrogen or air, but it can also be a liquid such as water. At the end of the pipe the pig and the medium are collected in a so-called receiver, the second pig station. The pig is separated from the medium in the receiver. If the medium is water or product, this is separated with an extra connection.
These pig stations either form part of a fixed system or mobile installations that can be connected.

Pig launcher

There are different reasons for using the pig method:
1. Cleaning a pipe,
2. Emptying a pipe,
3. Inspecting a pipe.

1. Cleaning a pipe
Cleaning piping using pigs can be done in different ways depending on the contamination to be removed and the reason for cleaning. To remove loose dirt, etc. from a pipe mechanical cleaning with 'brush' pigs is in principle adequate. Pigs are pushed through until the pigs appear clean. Then, the pipe is usually checked for cleanliness with a boroscope. Mechanical pig cleaning is always done with propulsion by air or nitrogen. To propel a pig it is particularly the volume of air or nitrogen that is important.

Chemical cleaning using pigs is often carried out to save chemicals, to reduce the release of hazardous waste and to protect the environment.

Stainless steel piping is often chemically treated with the purpose of removing undesired weld discolouration and hence restore corrosion resistance. This is normally done by chemical cleaning consisting of different stages; degreasing, pickling and passivation. Degreasing takes place with a slightly alkaline cleaning agent, pickling stainless steel is done with a highly acid cleaning agent based on nitric acid and hydrofluoric acid, whilst passivation takes place using a passivating agent containing nitric acid.
Such cleaning in stages can also take place with a so-called chemical 'cleaning train' whereby the pigs are used to complete the separate stages individually. The chemical cleaning agent is applied between the different pigs, with sufficient water between the different cleaning steps to rinse the chemicals off the surface. The pushing medium for such chemical cleaning is preferably demineralised water. The chemical is introduced in the pipe with the pig launcher. After the introduction of the pig the chemical cleaning agent is pumped into the pipe with a pump. The next pig is then inserted with a certain quantity of rinsing water before the next cleaning chemicals can be introduced. This is how the chemical 'pig train' originates. At the end of the pipe the different chemicals are separated and collected in waste containers. Analyses of the medium give a picture of the progress of the chemical cleaning.
Large quantities of chemicals can be saved using this method. A 500 metre-long DN250 pipe has a volume of 25 m^3. Chemical cleaning of this pipe in different phases and rinsing stages could result in a waste quantity of over 125 m^3.
A chemical train using pigs reduces the total quantity of waste to 10 m^3, which is equivalent to a reduction in waste of over 90%.

2. Emptying a pipe
Fixed pipes to tanks often have standard fixed pig stations to fully empty the piping with a product change, with possible cleaning before a different product load is transported. This method prevents the contamination of products in fixed piping.

3. Inspecting a pipe
So-called 'intelligent pigs' can be used in places where the inspection of piping is difficult (for example under the ground or below the sea surface). These types of pigs contain various kinds of measuring equipment with which, for example, the wall thickness, corrosion and location can be examined.

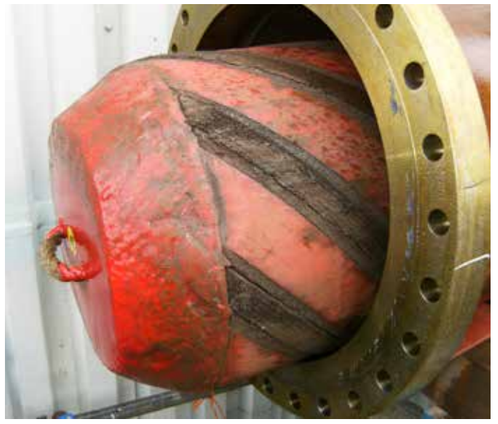
Restrictions

Not all piping can be treated using the pig method. If a pipe has too many or too long branches there is the likelihood that the pig will become stuck. Short branches are not a problem for the pig (see illustration on page 58). The pipe must also have the same diameter along its whole length. If a pipe narrows it cannot be pigged. Narrowing can occur because the pipe is made up of sections with different diameters, or because the pipeline contains thermowelds or orifices, for example. The pipe must only contain full-passage valves. Butterfly valves will block a pig.

Vecom and pigging

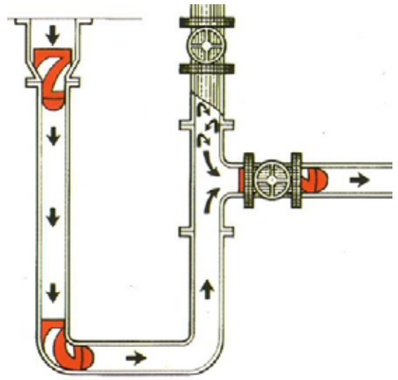
Besides the technical chemical cleaning we are all familiar with, Vecom Projects also offers pigging as a cleaning service worldwide. The basis here is offering a client-specific cleaning solution. Vecom deploys the following procedure:

1. Laboratory analysis of the contamination to be removed and determining the appropriate cleaning products;
2. Analysis of the system to be cleaned, determining the cleaning circuits, pig types and engineering documents including safety aspects;
3. Course of the offer;
4. Carrying out the cleaning;
5. Removal and processing of the resulting waste material flows and used pigs;
6. Inspection of the cleaned piping and reporting on the cleaning.



Pigging on the big screen

A pipe pig has appeared in a James Bond films no fewer than three times. The first time was in ‘Diamonds are Forever’ in which James Bond removes a pig to be able to escape from a pipe. Then in ‘The Living Daylights’ the Russian general Georgi Koskov (indeed played by Jeroen Krabbé) was smuggled on a pig through a gas pipeline under the Iron Curtain. And in ‘The World is Not Enough’ a pig was used again, this time to smuggle nuclear weapons through a pipe. So we can see how a specialised cleaning method can enjoy the wide attention of a large audience.



Pigging
Reference list

Location	Executed works
Vlaardingen, The Netherlands	Pigging stainless steel lines
Dendermonde, Belgium	Pigging gas fuel lines
Vlissingen, The Netherlands	Piggingstainless steel for oxygen clean purposes
Veendam, The Netherlands	Pigging several 8" lines
Rotterdam, The Netherlands	Pigging several lines 1" to 6"
Rotterdam, The Netherlands	Pigging of stainless steel lines 8"
Zwijndrecht, The Netherlands	Pigging of stainless steel lines 12"
Geel, Belgium	Pigging/degreasing stainless steel pipes 1" to 4"
Moerdijk, The Netherlands	Pigging 24" steam line including endoscopic inspection
Veendam, The Netherlands	Pigging several lines
Rotterdam-Pernis, The Netherlands	Pigging of production lines
Petrobrazi, Romania	Drying of stainless steel heating coils after pickling
Geel, Belgium	Pigging several lines
Eemshaven, The Netherlands	Pigging cargo lines on a chemical tanker ship
Den Helder, The Netherlands	Pigging hydraulic lines on HMS Jacob van Heemskerk

Vecom - Global specialist in metal surface treatment

Vecom Sillavan Metal Treatment Ltd

Wood Street,
Bury, BL8 2SL
United Kingdom

+44 161 797 6666
www.vecom.co.uk
www.vecom-group.com