IADC SAFETY AWARD: REMEDIATION OF THE ACID TAR LAGOONS AT RIEME, BELGIUM

Each year the International Association of Dredging Companies (IADC) seeks to honor one of its member companies that has shown outstanding achievement in the area of safety. The IADC Safety Award is intended "to encourage the development of safety skills on the job and to reward those people and companies demonstrating special diligence in safety awareness in the performance of their profession". Companies are asked to recommend a project or ship for the Safety Award, and the IADC Board of Directors then chooses the recipient based on a thorough evaluation. Given the high standards that the IADC member companies set for themselves and for the industry, this is no easy task. The 2009 award has been presented to DEME Environmental Contractors (DEC), a subsidiary of DEME, the parent company of Dredging International and Decloedt Dredging. Through DEC these two dredging giants have combined their knowledge, technology and years of experience in sediment and sludge processing, soil and groundwater remediation and waterworks and landfill technology under one roof. The operation that DEC performed in the remediation of extremely toxic and dangerous acid tar lagoons demonstrates that the expertise developed by dredging and maritime construction companies is applicable in very unusual circumstances.

ACID TAR REMEDIATION PROJECT

Acid tar is a residue of the chemical refining of oils by means of oleum – concentrated sulphuric acid. In the early and middle 20th century, oleum was added to the oils in order to extract impurities and heavy molecules, which were trapped in a tarry product. After decantation of the tar, the oil was filtered over Fuller's earth to remove the residual tar and acid. Both the acid tar and used Fuller's earth were then commonly dumped in lagoons near the production site.

During this time, three large acid tar lagoons were constructed at Rieme, Belgium, nearby the Ghent-Terneuzen Canal. The composition of the acid tars in these lagoons varies in relation to the period of production and the age of the tars. The largest lagoon, an area of about 2 hectares, contained the oldest tars dating from before World War II. These are a mixture of solid and pasty tars. The other two smaller lagoons, both 0.5 hectare, contained liquid and viscous tars (Figure 1) In total, about 200,000 tonnes of lagoon material was present.

Above: The three acid tar lagoons at Rieme. Lagoon III (foreground) is the largest, covering about 2 hectares and contained the oldest tars dating from before World War II.

Elimination at Source

As the lagoons were not lined, they have caused a serious pollution problem to the subsoil and groundwater. Clearly, before any remedial action could be taken in the vicinity of the lagoons, the source itself needed to be eliminated. Therefore the client, who is legally the problem owner, together with the environmental consultant, decided to remove the content of all the lagoons, neutralise, stabilise and solidify the tars, and put the solidified material in a controlled containment cell on the former lagoon area.

Figure 1. A sample of liquid acid tar as found in the two smaller lagoons. Tar surfaces were covered with a lime slurry specially developed by DEC to prevent emissions of SO_2.

Once this source is removed, the second phase of the remediation will take place, that is, the treatment of contaminated soils outside the lagoon area and the third phase consisting of groundwater treatment in the vicinity of the lagoons. Thanks to their innovative approach with respect to execution of the remediation and approach to stabilisation, DEC NV was appointed as the contractor for the first phase of this remediation.

Within the boundary conditions of the remediation concept that was set up by the client and the environmental consultant, and agreed upon by OVAM (Environmental Agency of Flanders), DEC NV worked out the design for the remediation scheme, which mainly consists of:

1. Methodology of excavation of the lagoon materials taking into account the presence of unexploded ordnance (UXO) and high emissions of sulphur dioxide (SO_2).
2. Design of the mix formulation and design and build of the equipment for the stabilisation/solidification the lagoon materials to meet stringent geotechnical and chemical requirements imposed by the client and OVAM.
3. Design and build of the BATNEEC water treatment concept for lagoon water and groundwater.
4. Design and build of the controlled containment area for storage of the stabilised lagoon materials.

The design and pilot tests were conducted from April 2004 through end November 2005. Full-scale commissioning tests took place from March 2005 through February 2006. Immediately thereafter the full-scale execution began. It is scheduled to conclude at the end of 2009.

MAJOR RISK FACTORS

From a safety point of view, the remediation of the acid tar lagoons at Rieme posed a great challenge with many risk factors. These are:

• The content of the lagoons: The acid tar and the overlying lagoon water and the groundwater with a pH of about 2, conditions which are very unfriendly for both man and machine.

• The lack of stability of the lagoon dikes: Over time, the dikes of the acid tar lagoons were raised in order to increase the capacity of the lagoons. Because of restrictions and the vicinity of the terrain border, the dikes were not widened as they should have been, resulting in very steep and unstable slopes. This is a boundary condition to be reckoned with, because the consequences of a dike-failure could be catastrophic, especially in view of the nature of the products that are being contained by them.

• The potential emissions of SO_2, an irritating, toxic gas that is slightly heavier than air: To prevent the gas from escaping into the atmosphere, a water-lock had been kept on top of the lagoons. However, as soon as the water lock is removed or the acid tar is stirred, SO_2 is emitted. These emissions have to be dealt with adequately for the safety of the personnel working on site, the safety of the public, the minimisation of nuisance to the neighbours and the prevention of environmental pollution (SO_2 in the air gives rise to acid rain).

• The potential presence of UXO left from World War II when the area of the acid tar lagoons was a strategic target for German airplanes as well as the RAF and the USAF at the end of the war: UXO included mainly 500 and 1000 lbs aviation bombs, with some smaller 100 lbs bombs, artillery grenades and potentially bombs with chemical detonators.

• Nearby pipelines with inflammable and explosive products, above and below ground including high pressure gas pipe-lines, carrying hydrogen and natural gas.

• Nearby housing as the acid tar lagoons are located at the edge of the village of Rieme, with some houses located just outside the site fencing, and

• Neighbouring companies which are mainly (petro)chemical companies.

Although the risks are challenging individually, their tendency to interact can easily result in a cascade of catastrophic events. The particular cocktail of these risk factors thus renders the project extremely daunting: Acid tar itself, mixed with unstable dikes, combined with potential emissions of SO_2, with nearby private homes and UXO.

The potential presence of UXO is a challenge that is often faced on dredging contracts. But the presence of UXO with or without chemical detonators in combination with high pressure pipelines carrying hydrogen or natural gas only metres away gives an extra dimension to the problem. Add to that neighbouring (petro)chemical companies of Seveso class and potential doomsday scenarios easily spring to mind.

"FAILING TO PREPARE IS PREPARING TO FAIL"

To work safely within the boundary conditions stated above demanded a multi-level approach whereby the necessary preventive measures are incorporated in accordance with the hierarchy of prevention:

1. removal of the risk,
2. collective protective measures,
3. personal protective measures,
4. training of personnel, instructions and warnings.

As they say: "Failing to prepare is preparing to fail". Good preparation is always very important and in view of the potential disastrous outcome of any incident involving one of the major risk factors, failing was not an option.

A Team of Internal and External Specialists

Sound preparation absolutely required a team of experts who master their field and can find the best solutions for all the challenges at hand. DEC and DEME both have ample experience in environmental dredging, soil remediation, chemical immobilisation, geotechnical stabilisation, construction of controlled storage areas, dealing with gaseous emissions, water treatment and such. These specialists in each field were put on the job in the preparation phase. In the case of UXO, because it falls outside the core competences of DEC and DEME, specialist subcontractors were engaged. The scope of the operations with regard to UXO is two-fold: Detection work and approach and identification work (Figures 2 and 3).

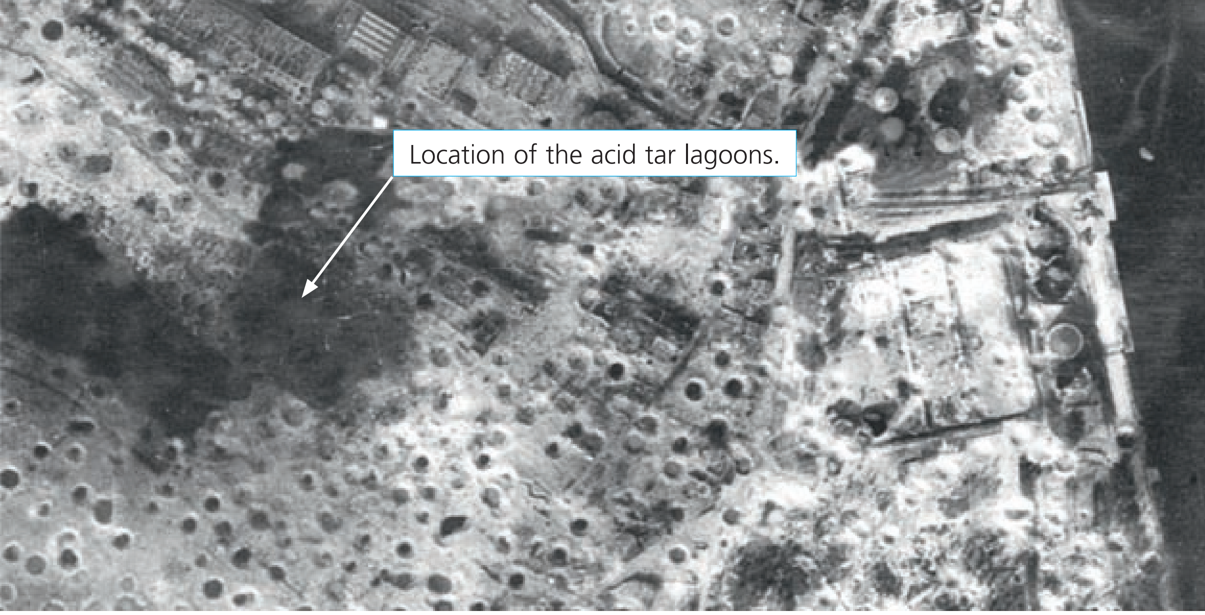

Figure 2. Left, An aerial view of the bombardments of the RAF and USAF in May 1944 and location of the lagoons. Statistically 10 to 20 percent of the total amount of bombs dropped can be expected to have failed to explode.

Figure 3. Right, An UXO expert identifies an UXO. The Belgian army and police are then immediately alerted to excavate and diffuse it.

Dry *versus* Wet Excavation

Given the terrain at the acid tar lagoons at Rieme, dredging techniques would normally be the obvious choice. At first sight dredging has many advantages: First of all, the water-lock is preventing massive emissions of SO_2. Secondly, large parts of the terrain become inaccessible for detection and excavation once the water is removed because of the liquid and pasty nature of the underlying lagoon content. These are very important stimuli to work with a dredging technique rather than a dry excavation method. Still, regardless of the technical difficulties that would have to be dealt with, DEC opted for the dry excavation method.

Why? Because the foremost concern was to develop an intrinsically safe work method and that meant knowing exactly what you are doing in these complicated circumstances. To know what you are doing you have to see what you are doing. DEC was convinced that dry excavation was by far the safest working method. This fundamental, far-from-obvious choice resulted in a number of very innovative solutions and broad know-how with regard to handling acid tar and particularly with regard to emission control.

Work Method Statements and Risk Analysis

Once a good and safe working method has been developed, it must be transformed in a detailed plan, known as the "work method statement". For the remediation of the acid tar lagoons at Rieme, the most important safety subjects are discussed below.

- *Dealing with potential emissions of SO_2*

This included the substitution of the water-lock in order to allow dry excavations; construction of purpose-built equipment and a FMEA (Failure Mode Effect Analysis) to ensure a safe design of the equipment. Other issues involved excavation front and excavation equipment; transport and transport equipment; treatment installation and off-gas treatment; and monitoring on the terrain, at the site perimeter and outside the site perimeter.

An extremely important safety decision involved the treatment process. Acid tar is a very unfriendly product both chemically and physically, both toxic and corrosive. For humans, the processing environment for the acid tars is lethal. Consequently, DEC reverted to a robust technical solution, fully automated and operated from an overpressurised control room, whereas the production hall itself was kept under constant underpressure. No people were allowed in the production hall in operation. If maintenance was required, the procedure for confined spaces was applicable. This was the most difficult solution from a technical point of view.

Although the treatment facility would only be temporary – it was built for the duration of the project only – great care was taken with the design of this complex installation and an elaborate HAZOP (HAZard and OPerability) study was used to optimise the safety of the entire concept.

- *Dealing with potential presence of UXO*

The first exercise with regard to UXO was the performance of a thorough historical investigation in order to obtain as much information as possible on the background of the lagoons and the types of UXO to be expected. Interviews with neighbours, former employees and former contractors were conducted and public archives as well as war archives, including those of the RAF in the United Kingdom were consulted. Statistically 10 to 20 percent of the total amount of bombs dropped can be expected to have failed to explode.

- *Dike stability measures*

In a more standard practice for a dredging contractor, stabilities of the dikes as they stood were calculated. From these calculations, it was obvious that the dikes were standing more out of habit than anything else. A work method statement was elaborated to lower and widen the dikes in a safe way, enabling access by heavy equipment.

- *Perform tests of various (unproven) techniques*

Various tests were conducted during the design and pilot phases of the project. With regard to safety, the main tests related to the preventive measures against potential emissions of SO_2. As regards other main risk factors, these were either common knowledge (e.g. dike stability) or un-testable (e.g. no UXO readily available). All tests were completed successfully and it was time for the full-scale execution.

LEARNING FROM EXPERIENCE

However good the preparation and however good everybody's intentions during execution, learning from experience is crucial. One way is to achieve this is to write method statements that allow some flexibility, i.e. that are not too rigid so absolutely no variation is possible. Method statements should already incorporate a learning process by fixing the principles to adhere to, but not necessarily the absolute values.

Drawing lessons from unsafe situations, near-misses and incidents is also essential to the learning process. At Rieme, every occurrence was analysed in order to find out its root causes. For complex situations, a fault-tree analysis approach was used. The basic principle for discovering all relevant information is to work by a "no-blame policy". Finding the root cause of an incident by interrogating all persons involved in a factual way and allowing people to admit a mistake without repressive consequences has very different results than blaming people or kicking workers off the site. Obviously, whenever bad intentions are involved, proper and severe consequences have to follow. Not to react in such cases would also be negligent and unsafe.

Whatever preventive measures are taken to limit the risks at the source and/or to provide collective protection, "rest-risks" still remain. These rest-risks can only be addressed by Personal Protective Equipment (PPE), monitoring equipment, and training and instructions to personnel. At Rieme in addition to the standard PPE, site-specific PPE such as chemical-resistant Tyvec coveralls, gloves and safety goggles in view of the acid conditions, as well as dust filters and safety goggles for operations where dust is a risk and personal gas masks, were provided. Also, personal SO_2 monitors to measure SO_2 levels were issued.

Monitoring equipment included portable gas detectors to perform measurements both within and outside the terrain border and permanent gas detectors were on the site perimeter, with permanent logging and connected to an automatic alarm system.

Training and instructions to personnel is always thorough, but at Rieme it was extensive. Everybody who starts to work at Rieme gets a site-specific introduction where all safety issues are addressed in an elaborate, comprehensive way.

Additional trainings are given to the excavator operators who perform the UXO excavation works under the supervision of the UXO expert. These trainings are given by instructors from the UXO expert and include an examination to make sure all instructions are clearly understood.

"Safety awareness" on site is always imperative. In general, within the company over 50% of the lost-time incidents are caused by slips, trips and falls. At Rieme this could be disastrous so addressing this was a top priority. Safety risks often lurk in very small corners, making on-site safety awareness always an important focus. To incentivise safety awareness, a system was put in place on the project and a trial period is now running. A "safety score" is kept and displayed on the digital display at the entrance of the site. The project started with 100 points. Positive marks that improve the safety level on site are awarded positive points. Violation of any safety rules or procedures results in a reduction of points. When the counter is above 100 after the end of the trial period, everybody on site receives an incentive.

Often it is difficult to get feedback for improvements or notifications on potentially dangerous situations from the workers on the work-floor. At Rieme, for the notification of potential improvements, a DEME S.H.O.C. (Safety Hazard Observation Card) is used. This is in itself a test to check out the system: in how far does the extra administration prevent a barrier and how can the system be kept as simple and efficient as possible.

The preliminary conclusions after two months of trial period were that the "safety counter" has a noticeable effect; by looking at the counter, employees are constantly reminded of safety and the safety awareness has been raised in a game-like fashion. The counter remains around 100, sometimes higher, sometimes lower. Till now, everybody has made an effort to keep the safety level high or get it higher. The conclusion: To keep attention elevated, any action or reminder is good, as long as it is brought in a positive way.

Communication with neighbours and relevant authorities is another area where a great deal of effort was invested. Clear and timely communication about what is going on, how the situation is being handled and how everything is absolutely under control is essential to ensure that the project remains acceptable to the neighbours, the general public and the authorities. Especially two "Open Days" one during the pilot phase and one prior to the full-scale work were a great success.

SETTING A GOOD EXAMPLE FOR THE INDUSTRY

Many topics such as zoning of the site in black (dirty) and white (clean) areas, the use of clean-dirty cabins, personal hygiene, smoking policy, traffic plan, working at height, lifting, electrical installations, work-permit system, waste-management and so on have not been discussed here. These procedures are always in place and very much attended to on this project. DEC and DEME are both VCA**, ISO 9001 and ISO 14001 certified companies, which is already a good indicator of the overall minimum safety level within the company. The safety measures described here are particular to this project and go well beyond the standard safety procedures.

Finally, the remediation of the acid tar lagoons at Rieme is unique by any global standard. Consequently DEC took the opportunity to organise an "Acid Tar Workshop". The aim of the workshop was to illustrate how acid tar can be dealt with safely and effectively. In total around 90 international and highly interested participants from various industries attended the workshop, learning from the DEC experience what elaborate safety measures are imperative for such a complicated project.