NO ENTRY?

Camilla Marchi and Daniel Devò, Gerotto Federico S.r.l., Italy, look at robotic technologies for storage tank cleaning and imagine a future where unmanned technology is mandatory for high risk tank maintenance.

It is a well-known fact that maintenance of storage tanks in refineries and terminals is something that has to be performed with extreme attention and in strict compliance with safety regulations.

It is also true that, despite all these rules and precautions, storage tanks remain such dangerous environments that any mistake can result in a serious incident.

Sadly, it is quite common to read in the news about accidents due to explosions or fires which destroy entire storage tanks or plants, and harm people inside or in close proximity.

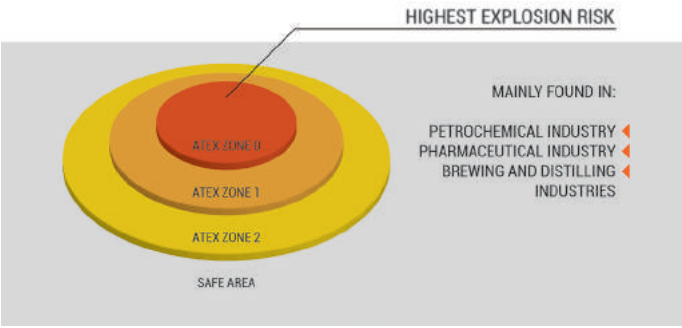

Figure 1. Classification of hazardous areas.

Some of the hazards associated with tank cleaning and inspection are:

- The presence of flammable materials and vapours, which could generate fires or explosions if ignited.
- Exposure to chemical substances, which could be inhaled, accidentally ingested or come into contact with skin or eyes, leading to intoxications, irritations or cancer (as a long-term effect).
- Oxygen deficiency, which could happen inside the tank or directly outside the manhole during the period it is open.
- Infections or allergic reactions, which can be caused by the presence of microbes that proliferate in the water settled on the bottom of tanks together with the sludge.
- The presence, in certain particular cases, of radioactive material.
- Slips, trips and falls, in addition to exposure to extreme climatic conditions (heat or cold), may have negative consequences on personnel entering the confined space of a tank, and first aid procedures would be long and difficult to carry out.

New approaches to tank cleaning

The traditional method for cleaning an aboveground storage tank follows these steps:

- Implementation of systems to ensure ventilation inside the confined space.
- Removal of the liquid part of the sediment by means of a vacuum truck or of ATEX-certified pumps.
- Entry of operators in the tank, wearing all required personal protective equipment (PPE) and using anti-spark manual tools and explosion-proof equipment to remove the solid sludge.
- Final washing of the tank by means of high-pressure water tools and solvents.
- Disposal and/or treatment for reuse of the wastewater and of the sludge.

Not all of the risks associated to storage tanks maintenance are 100% avoidable but at least one crucial factor can be eliminated: the presence of human operators inside the tank.

This is what many refineries and oil companies have tried to achieve in the last few years, installing automatic cleaning systems, e.g. rotary jet heads that use high-pressure water to clean the internal walls of a tank, or commissioning the maintenance of storage tanks to contractors who use robotic solutions.

Robotic solutions

Robots for tank cleaning operations are usually remote-controlled mini crawlers that can enter through the manhole with the use of a ramp. They are meant to be connected to the suction hose of a vacuum truck or to a pump, in order to suck up the sludge settled on the bottom of the tank.

Alternatively, some models have the possibility to mount a frontal shovel to push the sludge towards the suction hose or the pump, instead of carrying the hose around.

Powered by a power pack placed in a safe area, they are hydraulically driven through a distributor placed at a safe distance, to which they are connected through an umbilical and a retrieval rope for emergencies. They are usually equipped with:

- High-pressure water nozzles, which liquefy the sludge, making it easier to remove.
- Frontal accessories, such as shovels, rotating blades or particular suction nozzles to better suck up the sludge, depending on its viscosity or hardness.
- Special rubber or magnetic tracks, which are powerful enough to move forward in the sludge while carrying around the suction hose of the vacuum truck.
- Cameras and lights sending real-time images, which are used to monitor operations from a safe place.

Every component of the robot, as well as cameras and lights, has to be certified for working in potentially explosive environments: cables and electric devices must be intrinsically safe (meaning they have to be built in such a way to limit the thermal and electrical energy at a point that does not cause ignition) and the materials used for the machine's body have to be non-sparking and dissipative. The type of certification may vary, depending on the country where the technology is adopted, e.g. in Europe, equipment must be compliant with the ATEX regulations.

Regulations also define a classification of hazardous areas, starting from 'Zone 0', the most dangerous one, where an explosive atmosphere is constantly present, and going down to 'Zone 1' and 'Zone 2', where the explosive atmosphere occurs occasionally during normal operation or just rarely, respectively. The more dangerous an area is, the more stringent are the requirements for the machines that can operate inside of it.

Using unmanned machines to perform tank cleaning is firstly a way to increase safety. With the introduction of remote-controlled robots, the operator can comfortably manoeuvre the machine from a safe control station, far from the potentially explosive atmosphere, by watching a real-time video feed

on a screen. Cameras and sensors constantly monitor the conditions of the environment inside the tank, warning the operator in case of malfunctions or dangers. Finally, should anything go wrong, only an inanimate machine would be involved in the accident.

Technology development

The development of robotic solutions for tank cleaning is one of the main activities currently carried out by Gerotto Federico S.r.l. The company started designing and producing the first tracked mini robot excavators in 2002, and is now working on some of the most cutting edge technologies to constantly improve its range of tank cleaner robots.

To develop these solutions, it is essential for companies to establish a close collaboration both with the final user of the robot, and with partner companies. The former, due to its experience on the field, knows exactly what the dangers and difficulties of its job are, and can give designers important advice to improve the machine. The latter, whether the company is a provider of components or a certification institute, can share its technical experience and provide the products or services to ensure full compliance with safety standards.

However, the advantages of no-man-entry solutions extend beyond safety. One benefit is the reduction of downtime for maintenance. Usually, when cleaning a tank in the conventional way, the plant has to be stopped for at least two months. That is because operators can only work inside the confined space for a few minutes. Due to the toxic atmosphere and extreme climatic conditions, they have to shift change with other operators in order to avoid dead time. Moreover, the sludge is often very thick and sticky, making it difficult to be removed by hand, and causing fatigue.

The adoption of mini robotic crawlers has proven to be a faster way of cleaning, taking just a few weeks, for example, to clean a 50 000 m^3 tank. In addition to this, the procedure to set up the equipment is very quick and only requires between 2 to 4 hours, depending on the configuration of the whole system (ie., if the robot is connected to a pump or a vacuum truck, containerised or skid-mounted control station, etc.)

Less downtime means the plant can be operative again sooner, so there is also an economic advantage for companies. Moreover, establishing a plan for regular tank cleaning operations would transform variable costs into fixed costs, so companies could allocate their budget annually to maintenance.

Conclusions

It is not a secret that some major oil companies, as well as companies who provide industrial cleaning services, are already investing in and implementing robotic technologies in terminals, refineries, and chemical plants. Using robots instead of manual labour offers advantages in terms of time savings, cost savings and, primarily, safety benefits. The technology has already been implemented in countries such as the Netherlands, Germany, the UK, Ireland, Belgium, France, Singapore and many others.

Even though manual cleaning is still widely adopted around the world, the spreading of 'no-man-entry' culture is an encouraging factor, which will hopefully, in the future, lead to specific regulations that make it mandatory to use unmanned technologies in such risky situations. T&T

Figure 2. Example of a tracked mini crawler to be attached to a suction machine.

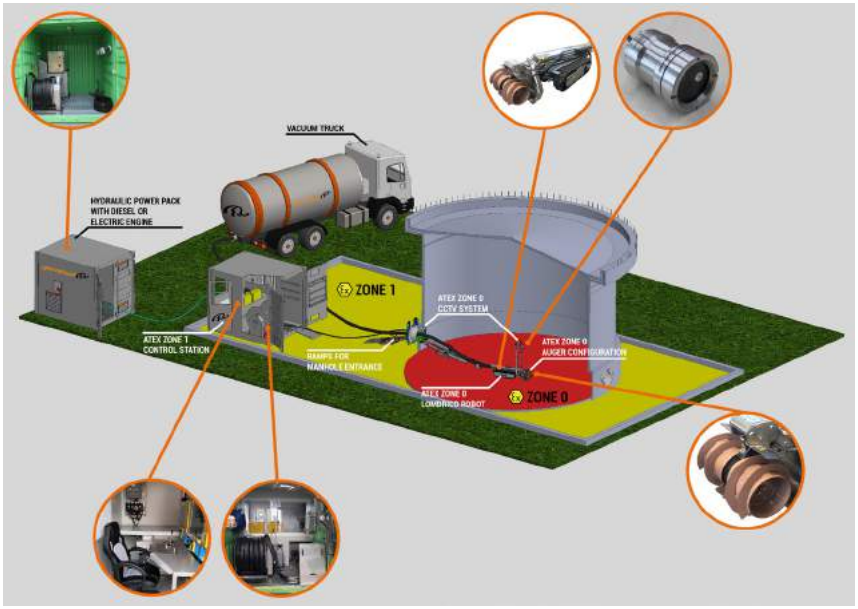

Figure 3. Example configuration of a tank cleaning system with containerised control room and power pack.