Comprehensive Management of Hydrocarbon Storage Tanks Ageing

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Abstract. Corrosion generates considerable material losses in industry and can result in irreversible damages to the environment and some times in losses in human lives. Hydrocarbon storage tanks are subject to various corrosion types like generalised corrosion resulting in large areas thickness reduction, or potentially dangerous local damage (pitting, crevice or craters) .
To keep safe storage conditions and save service life, it is essential:

- to identify the risks by taking into account the stored products, the storage type, the environmental factors, the type of coating and the storage history,
- to select the most appropriate NDT technique (acoustic emission, thickness ultrasonic measurement, TOFD, ACFM, visual inspection, remote UT ….) depending on the part to be inspected and on the expected type of damage,
- to propose the best solution for storage tank restoration (repair, improved protection…)
- to modify the operating conditions
- to define the NDT periodicity and the appropriate technique to apply according to the type of risks, to the former inspection results and to the regulation context,
- to determine the remaining life of storage tank.

This approach is named Comprehensive Management of hydrocarbon storage tank ageing. IS Services has developed a software called “AGIR” aiming at providing guidance and support to apply this approach.

1. Introduction

Each year, corrosion involves considerable material losses in industry. And furthermore, corrosion can involve irreversible damages to the environment and losses in human lives. Indeed corrosion can affect in-service devices and structures, provoking serious alterations such as thickness general diminution, production of pitting, crevices or craters, and moreover in the welded zones or in close proximity to them, stress corrosion cracking. That’s why, it is essential to identify and quantify the risks that could arise due to corrosion in order to control them.
An important field concerned involved there, is the maintenance of hydrocarbon storage tanks.

2 . Presentation of the AGIR Software

In order to assess the residual life of storage tanks (Fig 1), their inspection needs a comprehensive approach aiming at:

- identifying the risks by taking into account the stored products, the storage type, the environmental factors, the type of coating and the storage history,
- selecting the most appropriate NDT technique (acoustic emission, thickness ultrasonic measurement, TOFD, ACFM, visual inspection, remote UT ….)

depending on the part to be inspected and on the expected type of damage,,

- proposing the best solution for storage tank restoration (repair, improved protection…)

Fig 1 : General view of hydrocarbon tanks

- modifying the operating conditions ,
- defining the NDT periodicity and the appropriate technique to apply according to the type of risks, to the former inspection results and to the regulation context,

The AGIR data base has been developed by IS Services for that purpose. A questionnaire of more 100 key items must be filled. This questionnaire is based on our experience and the tank inspection checklist as per the API 653. Inspectors can follow the inspection checklist either on the paper, P.D.A. or Tablet PC. Inspectors follow questions on the list ensuring them not to forget an item to be inspected. The data base then will generate the immediate maintenance actions to carry out, the non destructive testing techniques recommended, the maintenance work to schedule for the next shut down, and a comprehensive assessment of the state of the inspected tank.

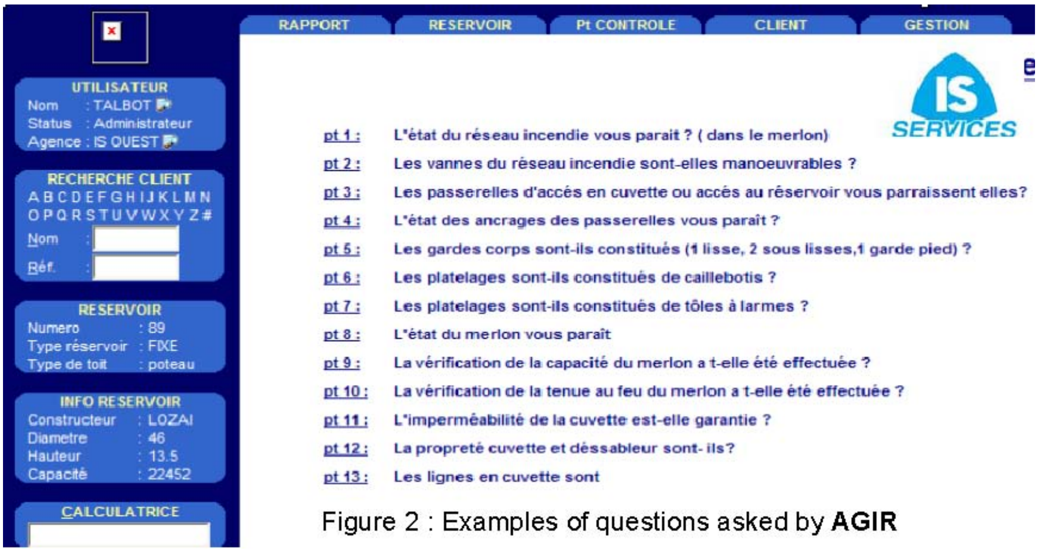

Figure 2 : Examples of questions asked by **AGIR**

3. NDT techniques to be applied for tank inspection

When the surface to inspect is accessible, and depending on the location of the area to be inspected, the following techniques can be applied (depending on presence and type of coating) :

- **for the whole inspection of the component:**
  - acoustic emission
- **for weld inspection:**
  - visual inspection ,
  - vacuum box testing,
  - penetrant testing ,
  - magnetic particle testing,
  - manual ultrasonic testing ,
  - TOFD ultrasonic testing,
  - conventional radiographic testing,
  - ACFM testing,
  - eddy current testing.
- **for detection of corrosion and quantification of remaining thickness**
  - ultrasonic thickness measurement,
  - ultrasonic expert inspection performed manually or with an imaging system

- TOFD
- eddy current testing with magnetic saturation or flux leakage : this last technique is particularly used for testing storage tank bottoms.

-An example of possible combination of NDT techniques to perform as per ageing comprehensive management following AGIR 4.1 software is illustrated in Figure 3.

Figure 3 : Comprehensive NDT solutions following AGIR 4.1 software

4. Examples of results obtained applying NDT

4.1 MFL inspection

MFL tank bottom inspection (see principle in Figure 4a) is generally carried out by using two different kinds of tools: the hand scan and floor map systems.

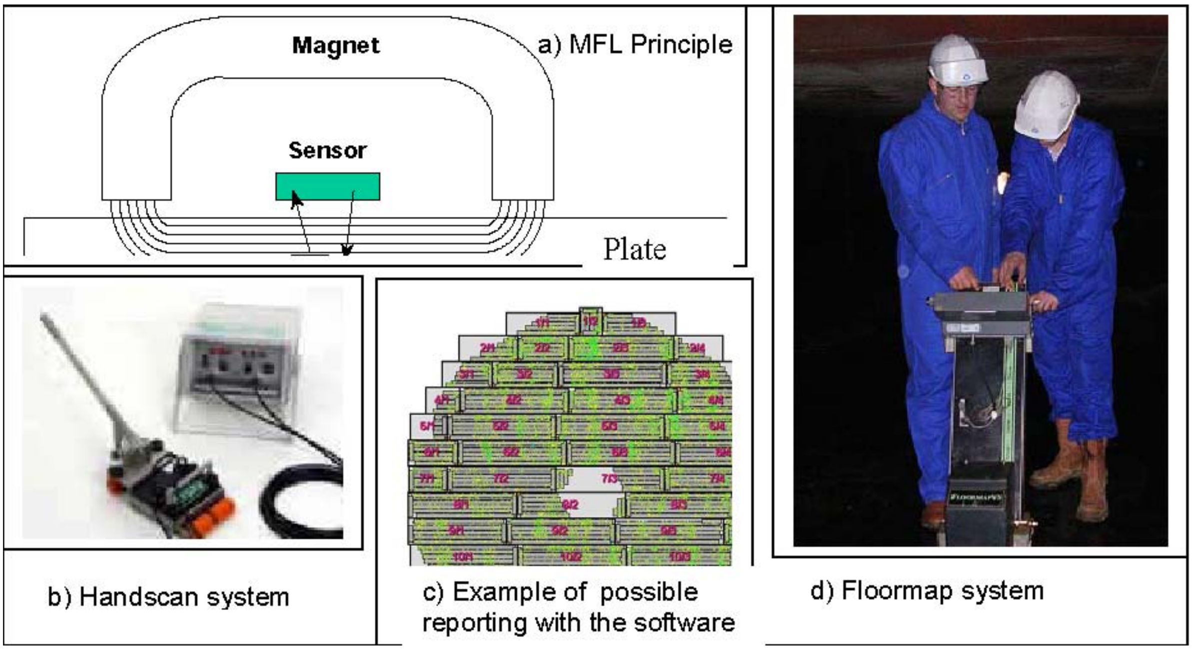

Fig 4 : principle, MFL tools and example of reporting

Hand scan (Fig4b) is devoted to the inspection of the annular ring due to it smaller size and to the bottom of the shell (external and internal inspection). Floormap (Fig4d) is used to inspect the plates at the bottom. A cartography of the whole tank bottom or plate by plate can be generated by the software (Fig 4c) with an histogram of the remaining thicknesses (after correlation with UT thickness measurement)

Important internal corrosion can generate a limit in the inspection of the bottom. Product deposits, dust or rust can deteriorate the result of control. Control can be carried out on thickness coatings lower than 4mm.(1mm coating on 10 mm thick sheets and having 3 to 4 mm on 6mm thick sheet). The maximum thickness to be tested in automatic mode is 10mm and 15 mm in manual mode. The system cannot detect cracks on plates. Tanks having re-heaters cannot generally be inspected with Floormap. A φ 36 m tank inspection requires only 4 days.

4.2 Acoustic emission

Metal vertical storage tanks of hydrocarbons, under atmospheric pressure, are an interesting case of application for acoustic emission. As a matter of fact, these tanks which diameter can reach more than 80 m, can present in service degradations by corrosion leading to leak. Acoustic emission is very useful for monitoring this kind of equipment in service, because this technique allows detecting leak and active corrosion UFIP : the French Union of Oil Industries (through their professional guidelines) is now taking into account the possibility to use acoustic emission for such inspection. Main benefits for using acoustic emission are given here after:

- the inspection of storage tanks often requires a complete draining, as well as a cleaning of the bottom before carrying out NDT techniques such as visual, MFL, ultrasonic thickness measurement …leading to possible long service interruption. Acoustic emission make possible the inspection in a very short time (service interruption lower than 24 H) according to criteria of standardized classification.
- acoustic emission provides a comprehensive diagnosis of the state of degradation of tank bottoms, allowing the owner to adapt his maintenance policy.

Acoustic emission of storage tanks requires adapted inspection conditions, to allow reliable result interpretation:

- quiet environment (no noisy work around),
- stopping of the agitators and closing of the valves to isolate the tank from outside ,
- favourable weather conditions (no rain, not too much wind),
- mechanical stability of the tank.
- if condensation occurs, an optimised instrumentation shall be set
- a very good knowledge of the operating working conditions of the tanks, their history and condition of manufacturing, and the risk of in service degradation.
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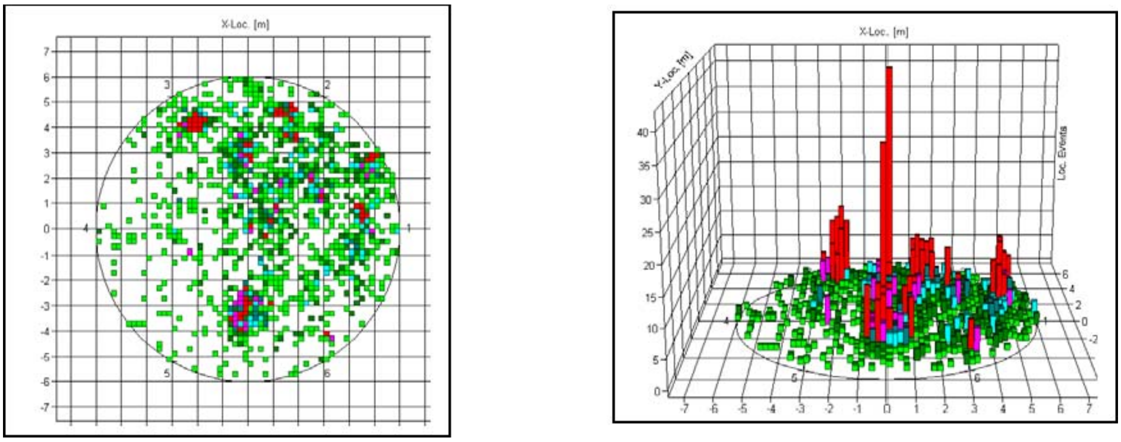

Figure 4 : results obtained by AE on a tank bottom exhibiting major damages

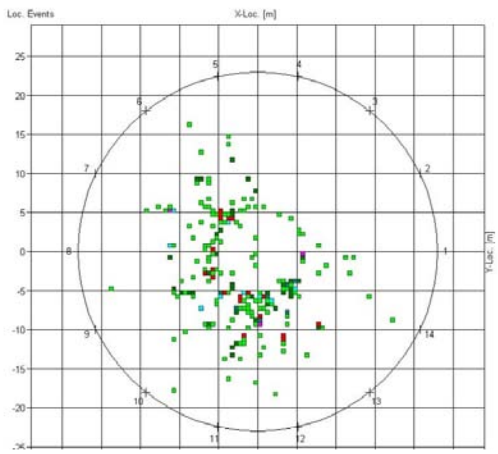

Figure 5 : results obtained by AE on a tank bottom exhibiting minor damages
Figures 4 and 5 show a typical example of results obtained on storage tanks exhibiting minor and major damages.

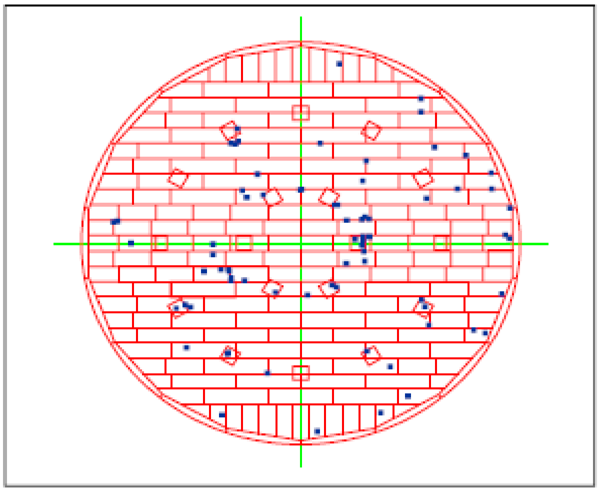

Figure 6: results obtained by MFL on the same tank (see figure 5)

Figure 6 shows results obtained by MFL on the same (figure 5). Areas having a loss of thickness ≥ 40% are marked on that figure and a satisfactory correlation is observed.

4.3 Remote UT inspection

Figure 7: UT remote inspection of a tank roof (Scorpion system)

The crawler used is a rugged remote access ultrasonic crawler designed to allow cost effective ultrasound thickness measurements on tank shell without the need for costly scaffolding or on roof keeping safe work.

The crawler uses a dry coupled wheel probe eliminating the need for traditional couplant. Strong magnets are used to maintain the crawler attached to the wall to be inspected. The distance between the magnet and the wall is determined to allow the crawler to move up to a speed of 1,5 m/mn. This allows the crawler to travel vertically, horizontally or even inverted whilst still fully functional.

The system is used with a conventional ultrasonic system or with an imaging equipment. In that last case it is possible to produce B-Scan imaging corresponding to a profile of remaining thickness on a line.. The system is battery operated and is powered by the battery pack which is capable of 8 hours operation on a single charge.

5. Conclusions

Maintenance of hydrocarbon tanks needs a comprehensive approach leading to associate knowledge of NDT specialists and corrosion experts, and people specialised in tank maintenance. A software such as AGIR is a very good tool to optimise the maintenance of hydrocarbon tanks.

Acoustic Emission is the only NDT technique providing a whole inspection of a tank and is very useful to prevent leaks. The benefits of acoustic emission compared with the other NDT techniques are to get a whole diagnosis of the tank and to minimize service interruptions.