HALON PHASE OUT MANAGEMENT IN RTI/TRC/SONATRACH

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Abstract- Hydrocarbon pipelines transportation activity is an important part of SONATRACH business and where great care must be emphasised. The significance of hydrocarbons transportation is owed to its paramount role to link up-stream and down stream businesses, and on the other part; it guarantees products delivery to external. In order to ensure such a business continuity and face product delivery interruptions that may be caused by fire incidents or ignitions, especially in facilities where such incidents may partially affect business integrity, cause harm to employees, population, environment and facilities, TRC is using a Halon based fire fighting system for fire protection purpose of the floating roofs rim seals of oil storage tanks across its different regions.

The Halon use (except critical uses) is currently banned in non 5th Montreal Protocol's article parties, a delay has been granted to developing countries that will no longer be authorised to use Halon after 31st December 2010.

As the hydrocarbons sector, mostly, represented by SONATRACH, is the most important Halon user in Algeria, thus, SONATRACH is highly concerned by this issue. Under such pressures, it has been an emergent necessity to set up a Halon phase out management strategy

It is true that the origin of a such issue is purely an environmental concern that have been reinforced by a public policy, but other people and facilities safety matters, that have a considerable weight in the Halon phase out process, have to be highlighted and adequately managed.

Keywords: Halon, Ozone depletion, Risk assessment, waste management.

1. INTRODUCTION :

Under permanent legislature and business pressures, make a decision on a Halon phase out management strategy of the existing system is a delicate process, since alternative technologies and regulatory framework are changing so fast that the phase out process and the decision making is further complicated.

At this level, the Halon phase out process is not only a matter of a simple product (Halon) replacement, but it is rather about managing all the associated concerns, it is true that the origin of a such issue is purely an environmental concern that have been reinforced by a public policy (legislations), but other questions, that have a considerable weight in the Halon phase out process, have to be raised:

- What are safety issues that can be encountered during the phase out process?
- What are the most important factors on which the fire fighting system decision making has to rely?
- What will be the faith of the decommissioned Halon?
- In case where Halon system is still used (e.g. critical uses), what are practices to minimise Halon emission?

The aim of this project is to provide a guideline to the Halon phase out management that not only treat the environmental aspects of the issue but, put into light the hidden sides of the problem and its related safety issues.

In the end to achieve the stated aims, the followed objectives are plainly depicted in the following points:

- Understand ozone depletion concerns.
- Identify Halon role in this global environmental issue.
- Develop a general overview of the evolvement of international and Algerian position concerning the issues.
- Highlight how SONATRACH is the most implicated at the Algerian level, and why there is a need for immediate actions.
- Learn from other companies experience in this field.
- Set out a structured framework and strategy to face unforeseen events that could be linked to the Halon phase out process.

2. OZONE DEPLETION AND ITS RELATED ISSUES

2.1. The ozone layer

Ozone is a colourless gas that is a close chemical relative of molecular oxygen (O_2) having three oxygen atoms (O_3) in place of two. Most of the ozone in the atmosphere is found in a layer between 12 and 45 km above the earth surface, it reaches its maximum concentration at about 25 km in a region of the atmosphere known as the stratosphere.

The ozone layer is beneficial to life on earth, as it is a screen that absorbs the harmful ultraviolet (UV) radiation from the sun.

Under natural conditions, ozone in the stratosphere is continuously produced and destroyed, but at equal rates such that a stable ozone layer is maintained. But in recent years, a large "hole" in the ozone layer has opened over the Antarctic each spring, and a similar, but smaller size has been observed over the Arctic. A thinning of the ozone layer over mid-latitudes has also been recorded.

First in the early 1970s, Paul Crutzen, Sherwood Rowland and Mario Molina established a linkage between the breaking apart of chlorofluorocarbons (CFCs) in the atmosphere and the destruction of the ozone layer. Of all ozone-depleting substances, CFCs are the most extensively used by industry, finding applications in refrigeration, air conditioning, solvents, aerosols and foam blowing agents. Other ODS include carbon tetrachloride (a solvent used in electronics and chemical industries), methyl chloroform (also a solvent), Halons used in fire fighting agents, and methyl bromide used in pesticides [1].

2.2. CFCs and Halons

The CFCs, Chloro-Fluoro-Carbones, are artificial chemical components invented in 1930, they are obtained by replacing a part or all hydrogen atoms within a hydrocarbon molecule with one of the following halogens; F (Fluorine), Cl (Chlorine), Br (Bromine), I (Iodine) or At (Astatine). For instance; from methane (CH_4) which contains one molecule of hydrogen, we can obtain these two CFC variants:

- CFC 12 ($C\,Cl_2\,F_2$): where four hydrogen atoms are replaced by two Chlorine atoms and two Fluorine atoms (Totally Halogenated).
- CFC 22 ($C\,Cl\,F_2$): where only three hydrogen atoms are replaced by one atom of Chlorine and two Fluorine atoms (Partially Halogenated).

They are extremely stable components and inflammable, they are considered as non toxic chemical, so they can be safely handled, these facts makes them ideal products for industrial uses. On the other hand, their stability confers them a long life into the atmosphere without undergoing any degradation. Hence, once they are transported into the stratosphere they are bombarded by UV radiation giving rise to the destruction of the chemical links and releasing by the way Chlorine which is highly reactive and become rapidly ozone destructors [2].

However, Halon term is generic for a range of Halogenated Hydrocarbons, it belongs to the same family of CFCs.

Thus, in this case all the hydrogen atoms are replaced by halogens, for instance:

- Halon1211 (Bromo-Chloro-diFluoro methan, $C\,F_2Cl\,Br$), where Br Cl and F replace totally hydrogen atoms.
- Halon1301 (Bromo-TriFluoro methan, $C\,F_3\,Br$), where Br and F replace totally hydrogen atoms.

As well as CFC12, these agents are totally halogenated and will reach the upper stratosphere (troposphere) without undergoing any chemical degradation, where they will attack the ozone layer.

Developed in the late 1950s, Halon becomes the most popular fire extinguishing medium due to their unique properties, Halons cause minimum disruption, they are lowly toxic, highly effective on a wide range of fires, can be stored efficiently with low weight and space requirement, they are electrically non conductive, they are clean and do not cause secondary damages.

Modern society has, therefore, come to rely on Halon to protect valuable computer, telecommunication exchanges, electronic equipment and plants, archives and art collections, aviation and petrochemical industry. Halon systems are also used in places where there is risk of flammable liquids, such as pipeline pumping stations and transportation applications and it is still operational on some installations.

3. HALON PHASE OUT MANAGEMENT APPROACH

The use of Halon in Sonatrach is, mainly, restricted to extinguishment systems that ensure safety of facilities that are more or less critical. Hence, it is a must to work out a structured strategy that takes into account all the safety aspects and that makes use of all available resources in order to eliminate, mitigate, or avoid any source of risks to workers, population, environment and facilities as well.

Under Algerian regulations, it has been decided that Halon will no longer be used after 2010. Sonatrach being the first Halon user in Algeria with approximately 82% of the total Algerian Halon quantity [3], a great emphasis must be put on the oil and gas sectors, the use of an equivalent to more that 83000kg of Halon [3], have to be put under study in the end to decide which amount is to be decommissioned or to be classed as an essential use.

A Halon use is considered as "critical" when a need exists to minimize damage due to fires, explosions, or other extinguishing agents, which would otherwise result in serious impairment of an essential service to society or pose an unacceptable threat to life, environment, or national security even though all other appropriate fire protection measures have been taken [4], Critical users has been limited under EC2037/2000 regulations, as depicted on the following table.

TABLE.1. Halon critical uses[5].

Halon type	Critical users
Halon1301	in aircraft for the protection of crew compartments, engine nacelles, cargo bays and dry bays, in military land vehicles and naval vessels for the protection of spaces occupied by personnel and engine compartments, for the making inert of occupied spaces where flammable liquid and/or gas release could occur in the military and oil, gas and petrochemical sector, and in existing cargo ships, for the making inert of existing manned communication and command centres of the armed forces or others, essential for national security, for the making inert of spaces where there may be a risk of dispersion of radioactive matter, in the Channel Tunnel and associated installations and rolling stock.
Halon1211	in hand-held fire extinguishers and fixed extinguisher equipment for engines for use on board aircraft, in aircraft for the protection of crew compartments, engine nacelles, cargo bays and dry bays, in fire extinguishers essential to personal safety used for initial extinguishing by fire brigades, *in military and police fire extinguishers for use on persons.*

Before going any further in the proposed management approach it is important to have an overview of the available alternatives will be depicted in the following section.

3.1. Overview of alternative technologies:

During the last two decades, several fire professionals and chemical companies massively invested in Halon alternatives research, a general description of some alternatives are described below:

FM-100:

Great Lakes Chemical has introduced FM-100 (HBFC-22B1 bromodifluoromethane) as an environmentally better Halon alternative. The United States Environmental Protection Agency approved FM-100 for use in normally non-occupied space protection. Additional toxicity testing, allowed the expansion of the use of FM-100 to include selected occupied applications.Testing performed by the United States Navy confirmed the effectiveness of FM-100. The naval test of Halon 1211 and alternative extinguishing agents concluded that the fire suppression performance of FM-100 is equal or better than Halon 1211. However, it too has disadvantages. Because its ODP is still to high, FM-100 has been regarded as transitional product [6].

FM-200:

On August, 1991, Great Lakes announced the chemical formula and other important information on FM-200. Known as HFC-227 Heptafluoropropane surpasses the current environmental requirements. As a long term replacement agent, FM-200 is expected to meet future environmental requirements. Full scale fire testing has confirmed it has the potential to be a very effective replacement for Halon 1301, while the fire extinguishing capability of this agent appears satisfactory [7].

Foam:

Foams provide a unique agent for transporting water to inaccessible places; for total flooding of confined spaces; and for volumetric displacement of vapour, heat, and smoke.

Foam can be used on solid fuel and liquid fuel fires where some degree of in-depth coverage is necessary; it can provide quick and effective coverage of flammable liquid spills or some toxic liquid spills where rapid vapour suppression is essential. It is effective indoors and outdoors[8].

Carbon dioxide (CO_2):

Carbon dioxide is a colourless, odourless, electrically nonconductive inert gas. Liquid carbon dioxide forms solid dry ice when released directly into the atmosphere.

It extinguishers fire by reducing the concentration of oxygen, fuel vapour phase, or both to a point where combustion stops [9]. Some of its drawbacks is that the discharge of carbon dioxide in fire extinguishing concentration creates serious hazards to personnel, such as suffocation and reduced visibility during and after the discharge period.

3.2. HALON PHASE-OUT MANAGEMENT STEPS:

The Halon phase out management scheme that will be adopted and described throughout this thesis is summarised in the logical sequence of the following steps:

1. Conduct risk assessment.
2. Design and plan new system.
3. Halon decommissioning.
4. Halon wastes management and minimisation.
5. Emission reduction in the existing installation.

3.2.1. Conduct risk assessment:

An initial risk assessment and an extensive expertise process are essential to identify future requirement with accuracy. Risk assessment is typically applied as an aid to the decision-making process. As options are evaluated, it is critical to analyse the level of risk introduced with each option. The other purposes of a risk assessment is, first, assess the criticality of the facility (use), secondly, to provide information on a fire protection installation with respect to:

- Its identification;
- An assessment of its relevance (consistency with the owner's loss prevention and business policies);
- An assessment of its efficiency (fire prevention and fire protection).

Risk assessment is the process of gathering data and synthesizing information to develop an understanding of the risk of a particular activity. For that one must answer the following three questions:

- What can go wrong?
- How likely is it?
- What are the impacts?

Qualitative answers to one or more of these questions are often sufficient for making good decisions. However, as managers seek more detailed cost/benefit information upon which to base their decisions, they may wish to use quantitative risk assessment (QRA) methods

a. The risk assessment process:

To use a systematic method to determine risk levels, a quantitative risk assessment is usually performed. Within the frame of the precedent definition of QRA four basic elements are implicated [10]:

- **Hazard Identification:** determine the different scenarios that could lead to an incident. And hazards and hazardous events, and what could lead to them.
- **Frequency Assessment:** determine the frequency of occurrence of identified hazardous events.
- **Consequence Assessment:** to determine the extent of the consequences of the identified hazardous event.
- **Risk Evaluation:** to determine the risk level and prioritise further studies of risk and estimate their significance.

Qualitative methods of assessing frequency and consequence are satisfactory to enable the risk evaluation. In other cases, a detailed quantitative analysis is required. There are many different analysis techniques and models that have been developed to aid in conducting risk assessments. For each risk assessment step there are a bunch of considerations that have to be taken into account; these elements consist in what follow:

- The existing Halon system has originally been installed to meet specific fire protection needs. Verify that these needs still exist. Determine if alternatives to Halons could not provide the same fire protection.
- For each asset being protected against fire damage,

a) Determine the fire hazards threatening the asset;

b)Identify all risks to human health that may be present, including the exposure to combustion products in a fire situation;

c)Determine the value of the asset, in terms of costs of repair/ replacement and down-time consequences.

- Assess the effectiveness and reliability of the existing installation in terms of

a)history of false alarms and/or discharges;

b)Any failure to detect fire or discharge when properly required.

c) Changes to the protected asset and its physical environment from the time of initial installation.

- Identify conditions in the protected and adjacent areas that could trigger fire detectors (false alarms) and trigger the discharge of the Halon system.
- Compare the existing installation to current design practices with respect to compliance with the current codes and standards. Equipment, in particular, the means of detecting fire and initiating agent discharge, may require an upgrade to achieve optimum protection from false alarm sources.
- Evaluate suitability and adequacy of the different alternatives.

b. Set up of a risk analysis:

The goal of a risk assessment is to efficiently satisfy a particular need. the different elements of a risk assessment planning are described below:

- **Study Objective:**

It is as important as critical task, it consists, in brief, translate the needs and requirements into study objectives. For instance. For any risk assessment to efficiently produce the necessary types of results, the requirements must be clearly communicated through well-written objectives [11].

- **Scope:**

Establishing physical and analytical boundaries for a risk assessment is also a difficult task. Selection of an appropriate level of detail is the scope element that is most crucial to performing an efficient risk assessment. The use of approximate data and rough resolution during the early stages of the risk assessment should be encouraged. Once the areas that are the most significant to risk determined, a discriminatory application of more detailed effort to specific issues could be performed as the analysis progresses [12].

- **Technical Approach:**

Once the study objectives are defined the suitable technical approaches are selected. The methodologies to be used to recognise hazards and to evaluate frequencies and consequences should be defined. A variety of modelling techniques and general data sources can be used to target the desired results. The planned output from the assessment activities should also be described. An internal and external quality assurance review of the study should be conducted. Independent reviews of the risk assessment results can be helpful by presenting alternate viewpoints; outside experts (either personnel from another similar or different facility or consultants) should be included on the risk assessment review task. Finally it is important to formally document responses to any resulted recommendations [10].

- **Resources**:

Organizations can use risk assessments to study small-scale as well as large-scale problems, thus, the resources allocation depends mainly on the study objectives, a complete risk assessment could require as little as a few days to a few weeks of technical effort[13]. An appropriate blend of engineering and scientific disciplines must be assigned to the project. As the study involves an existing facility, operating and maintenance personnel will play a crucial role in ensuring that the risk assessment models accurately represent the real system. In addition to the risk analysts, a typical team may also require assistance from a knowledgeable process engineer, a senior operator, a design engineer, an instrumentation engineer, a chemist, a metallurgist, a maintenance foreman and/or an inspector. Unless a company has significant in-house risk assessment experience, it may be faced with selecting outside specialists to help perform the larger or more complex analyses.

3.2.2. Design and plan a new system:

a. System Design:

The design, installation, service and maintenance of extinguishing systems must be performed by those competent in extinguishing systems technology. Such firms should be able to:

- Show compliance with standards or specifications such as BSI, LPCB, NFPA …etc.
- use BS, LPCB ,UL , FM, or VDS listed equipment wherever possible.
- be full members of a recognised Fire Trade Association such as BFPSA, BASA.
- Comply with industry fire code of practice.

b. Design: mechanical:

The mechanical system comprises of one or several agent containers connected to pipework feeding nozzles within the area of hazard. The containers are fitted with valves that can be electrically, pneumatically or manually actuated.

Small systems (generally single containers) may be pre-engineered so that no flow calculations and specific nozzle sizing is required. However most systems will be engineered systems where the sizing of pipework and nozzles are calculated to ensure the right amount of agent is distributed to all parts of the enclosure within the required discharge time.

c. Design codes

A number of extinguishing system design codes are available, and which compliance must be checked:

- 'BFPSA Code of Practice for Gaseous Fire Fighting Systems', British Fire Protection Systems Association (BFPSA), 1995;
- 'BS DD233:1996, Code of Practice for Gaseous Fire Fighting Systems';
- 'NFPA 2001 Standard on Clean Agent Fire Extinguishing Systems', 1996 edition.
- A European standard, based on the ISO draft, is in its final stages of ratification.
- NFPA 12, Standard on carbon dioxide extinguishing systems. NFPA 11A, Standard for Medium- and High-expansion Foam systems.

d. Documentation

With each facility a fire protection logbook should be maintained. Mainly, the most important documents that should be provided by the system suppliers, and included in the fire protection log book:

- Scaled plan and section drawings of the hazard area, showing the agent distribution pipework, containers and nozzles;
- The occupancy, the particular agent used and its concentrations;
- Details of the containers, nozzles, pipes, valves and fittings, pressurisation and vent calculations;
- Details of fire detection and control;
- Calculations for the amount of agent provided;
- Pipe and nozzles flow calculations;
- User instructions (testing, maintenance, and inspection schedule).

3.2.3. Halon decommissioning:

Halons are pressurised gases. Therefore, the cylinders containing them are under pressure and must be handled with great care. If the pressure is released in an uncontrolled way, the cylinder will become a projectile and can cause serious injury or death to people working on the cylinder, or to bystanders and even installations. It is of utmost importance that proper safety procedures be followed at all times when handling Halon cylinders.

The existing Halon systems components (in TRC) have been manufactured there was over 15 years. In 1992, when the system was installed, it was under the charge of facilities protection department, and some engineers and technician have been trained (by the manufacturer) on its commissioning, maintenance and testing, but, there was a couple of years, the system has been placed under the responsibility of HSE department, this last one has been subject to no training. Because of this, it can be difficult to know exactly how a particular valve or mechanism does works or not, or the proper procedures for safe decommissioning. This can be true even for contractor/professional that may do not encountered such a design before. Under such conditions a systematic approach should be adopted to ensure workers' and installations' safety and by the same way make certain that no accidental releases will occur, by focusing on the different decommissioning tasks and identifying the associated risks, a countermeasures and precautions could be set. For this purpose a Job Hazard Analysis (JHA) is suitable to examine in detail the safety and environmental considerations.

A JHA is a systematic method of identifying jobs and tasks, a way of highlighting their associated hazards, and developing procedures that will help reduce or eliminate identified risks.

The job is broken down into its individual steps [14]. Jobs that involve many quite different tasks should be handled by analysing each major task separately. It can consider risks both to the workers involved, and to the system. Risk controls for both approaches such as the Scenario and "What If" tools can contribute to the identification of potential hazards [15].

3.2.4. Halon waste management & waste minimisation:

All industrial, commercial and governmental operations produce waste to a greater or lesser degree. The management of waste is important from the point of view of minimising risks to personnel, the environment, profitability and even the continuing existence of the organisation.

Waste Management Hierarchy:

The waste management hierarchy went back to the 1970s, the disposal-based waste management begun to be criticised by the environment movement. Thus, In lieu of regarding wastes as a homogenous mass that should be buried, they argued that it was made up of several materials that have not to be treated in the same way, some have to be reused, some recycled, and others have to be burnt or buried [16]. Pollution prevention refers to the elimination, change or reduction of operating practices which result in land, air or water discharges. This approach should be included into the design and management of facilities and the planning of associated activities. If elimination of a waste is not possible, then minimising the amount of waste generated should be investigated. Responsible waste management may be accomplished through hierarchical application (Figure.1), it means:

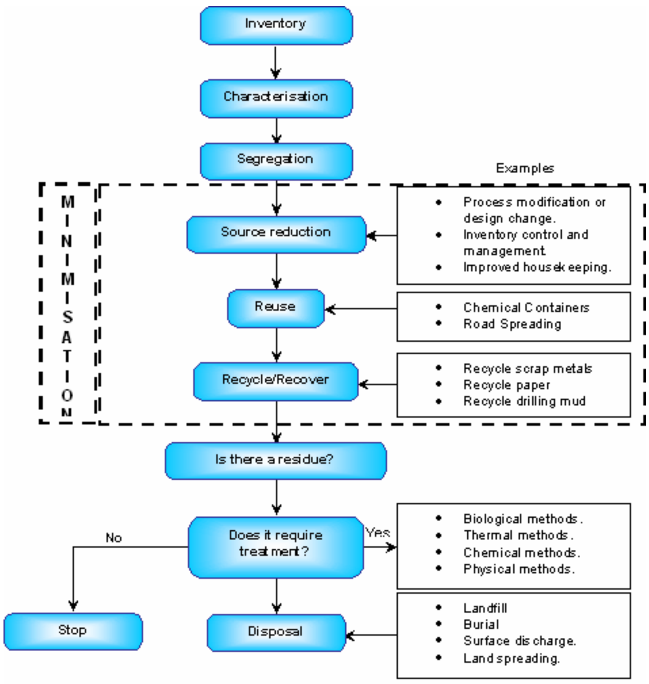
- Source reduction, (more efficient practice that produce less wastes).
- Reuse (the use of materials or products when possible).
- Recycling/recovery.
- Treatment (the destruction, detoxification and/or neutralisation of residues).
- Responsible disposal

3.2.5. Emissions reduction in existing installations:

Emission reduction means the avoidance of any unexpected Halon releases in the existing installation. In RTI at least two unexpected releases was recorded, the first one is due to human error when maintenance were performed on the floating roof of the tanks, and the other was due to a system failure, thus, in order to minimise Halon releases it is of utmost importance to ensure Halon system reliability.

the reliability analysis have to influence overall the performance of an item or equipment, the performance of an item can be described by four elements:

Item's ability to satisfy its functional needs.



- Efficiency or the item's ability to effectively its supply of energy.
- System ability to start or continue to be operational.
- Item's ability to be quickly operational following its failure.

One of the methods that have shown a high effectiveness, and which is widely used in system reliability analysis is FMECA (Failure Mode Effect Criticality Analysis), FMECA is an inductive reasoning approach that is best suited for reviews of mechanical and electrical hardware systems. The FMECA technique considers how the failure mode of each system component can result in system performance problems and ensures that appropriate safeguards against such problems are in place. This technique is applicable to any well-defined system, but the primary use is for reviews of mechanical and electrical systems (e.g., fire suppression systems, vessel steering/propulsion systems). It also is used as the basis for defining and optimising planned maintenance for equipment because the method systematically focuses directly and individually on equipment failure modes[18].

4. CONCLUSION

It has been clear from this study that there is an urgent necessity to phase out the existing Halon in RTI. It can also be conclude that the best environmental friendly option that could be adopted as a Halon "drop in" alternative for the RTI specific case is a first shot foam system combined with the installation of rim seals fire retardant, this option can be easily undertaken because the availability and the facility of installing a fire retardant could be envisaged.

Sonatrach has expressed agreement and willingness toward finding solutions to Halon issue, this fact is, clearly, demonstrated by the different seminars that had been held, efforts and time spent in coordinating with other organisations and structures such ENGI (National Company Of Industrial Gases) and the Algerian ozone bureau to put in place a Halon bank in order to recycle and manage the decommissioned Halon from the different user in Algeria.

Through this project, a structured sequential methodology has been proposed, and well thought steps has been, individually, described, through which the following tasks has been performed:

Assessment of the different available environmental friendly technologies and alternatives to Halon.

Evaluation and assessment of different risks and threads that could lead to business interruption.

Highlight safety issues related to Halon decommissioning, and describe an approach to set measures to avoid/reduce incidents.

It has been demonstrated that great care must be given to the post-decommissioning phase; especially that Halon will be considered as special waste, with focus on storage, transportation, recycling/destruction and the traceability of these steps.

Finally, in cases where the Halon will be judged as indispensable, an efficient inspection, maintenance, and testing (using environmental friendly methods) schedule must be programmed.

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