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Ageing of hazardous installations as a potential contributor to major accidents: some events occurred at chemical and petrochemical Italian establishments

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Introduction and Background

The role of ISPRA for industrial risk control

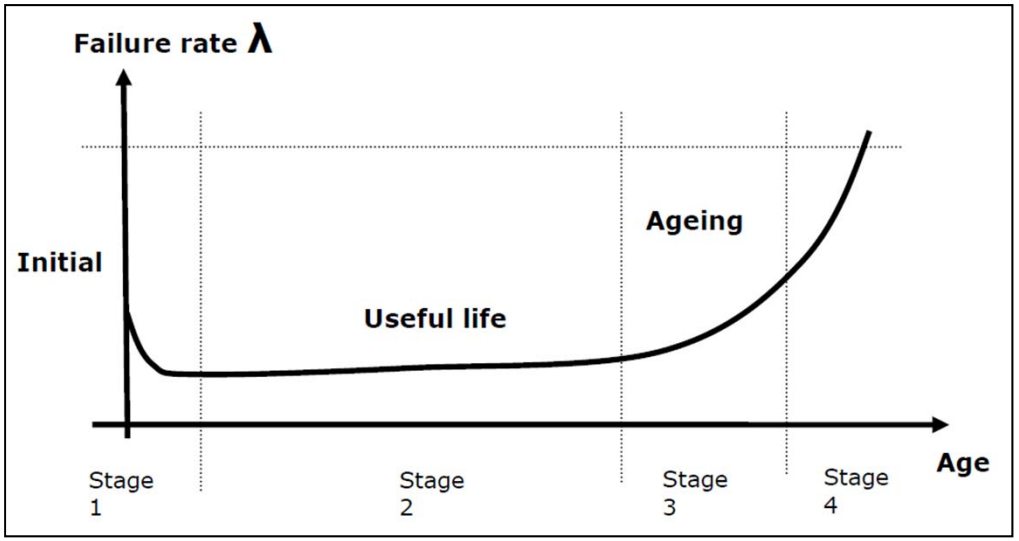
- ISPRA has a national role as a technical body supporting the Ministry of Environment in the national implementing of the Seveso Directives (last: D. Lgs. 105/2015)
  - Definition of technical contents of laws and decrees to control Major Accidents
  - Set-up of the National Inventory of major accident hazards establishments and other related data-bases
  - Inspections of upper-tier establishments SMS on regular basis or after an accident
  - Support for international activities (EU, OECD, bilateral cooperation)
  - Technical coordination and addressing of Regional Agencies for the Protection of Environment (ARPA)
  - Collaboration with other Authorities competent for industrial risk (Ministry of home affairs – National Fire Brigades; Department of civil protection; Ministry of infrastructures)

The control of the risks related to ageing in D. Lgs. 105/2015

- ***Annex 3 (information on the SMS-PMA)***
  - Operational control issue is among the elements to be taken into account for the purpose of implementing SMS: ...management and control of the risks associated with ageing equipment installed in the establishment and corrosion...
- ***Annex B (GL for SMS-PMA implementation)***
  - Among technical content of SMS, operational control is a key element: ... In addition, plans for monitoring and controlling the risks of ageing (corrosion, erosion, fatigue, creep) of equipment and installations, that can lead to LOC of dangerous substances, must be provided, including necessary corrective and preventive measures ...
- ***Annex H (Criteria for conducting inspections)***
  - Check-list for SMS-PMA inspections ("ageing" item)

The state of the art: the concept of ageing (HSE-UK)

- Ageing is not related to the age of the equipment, but to its changes over time, in terms of deterioration and/or damage degree
  - These factors are more likely to cause failures in the lifetime of the equipment, but are not necessarily associated with it
  - In the case of equipment or installations, ageing can lead to significant deterioration and/or damage to initial conditions, which may compromise functionality, availability, reliability and safety



Some industrial accidents occurred at chemical and petrochemical Italian establishments

Raffineria ISAB Impianti Nord – Refinery plant, Priolo Gargallo (SR)

Date: 30/04/2006	**Title**: Fire and explosions in piping	
Synthetic description: Release of crude oil from transfer pipe in the underpass of the road that crosses the plant, that developed a fire by accidental triggering which subsequently involved the adjacent piping and then a series of explosions		
Causes: Age (over 25 years) and state of preservation of the pipe in relation to the progressive corrosion phenomena, which led to the pipe drilling		
Organizational factor / Description	**Actions taken**	**Expected / Planned actions**
Emergency planning - Consequences analysis, planning and documentation	Internal emergency plan activation with major risks emergency forwarding. Intervention of refinery and neighboring establishments fire departments and local Fire Brigade	Internal emergency plan check
Identification and evaluation of major hazards – Planning for plant and management compliances to risk reduction and updating	Investigation to find out the causes of the accident. Visual inspection and basic design of corrective actions. Necessary reconstruction activities	Specific risk analysis. Planned and/or required compliances following CA examination. Check of the pipeline inspection plan

Fires and explosion at the refinery plant

The pipeline rack after the event

ENI Raffineria – Refinery plant, Taranto

Date: 01/05/2006	**Title**: Leakage through the tank bottom		
Synthetic description: Leakage of oil through a large lesion at the bottom of a floating roof tank and subsequent release of a significant amount of oil inside the containment basin			
Causes: High corrosion and deteriorated area			
Organizational factor	**Description**	**Actions taken**	**Expected / Planned actions**
Operational control - Identification of installations and equipment subject to maintenance plans	Release of oil inside the containment basin	Tank insulation. Covering the spilled oil with foam to limit the vapor emission. Transferring the product to another tank with temporary pipes	Tank out of service. Carrying out the remediation and maintenance of the basin and the tank. Double bottom insertion

The containment basin after the event: the rupture area

The lesion at the tank bottom

ENI Raffineria – Refinery plant, Taranto

Date: 25/03/2007	**Title**: Breakdown of the hydraulic guard on the torch		
Synthetic description: General interruption of refinery process plants, due to lack of electrical energy, resulting in a plant depressurization to the torch. Later there was a mechanical breakdown of a vessel (one of the two hydraulic guards at the base of the hydrocarbon torch). Following this breakdown, a flammable gas portion was released, which was triggered resulting in a fire at the vessel			
Causes: Corrosion of the steel sheet of the hydraulic guard due to prolonged contact with water, which has reduced the thickness so as to render it insufficient to contain overpressure			
Organizational factor	**Description**	**Actions taken**	**Expected / Planned actions**
Operational control - **Identification of installations and equipment subject to maintenance plans**	The sea water level of the hydraulic guard maintained at a height greater than that of the "gunite" anti-corrosion coating (spritzbeton)	Fire extinction. Hydraulic guard put out of service. Checks on pipes, vessels and structures affected by the event	Replacement of the hydraulic guard redesigned with the following precautions: 1) increase the "gunite" inner coating; 2) realization of the end of the coating with inclined geometry to prevent water stagnation: 3) increase the equipment corrosion overlay from 3 to 6 mm

Polimeri Europa - Petrochemical plant, Gela (CL)

Date: 26/04/2007	**Title**: Leakage of ethylene on the connecting line		
Synthetic description: Leakage of process flammable gas mixture (mainly ethylene) at the coupling flange on the line that connects the compressor with the heat exchanger			
Causes: Abnormal deterioration of the seal in the coupling flange. Loss of sealing capacity			
Organizational factor	**Description**	**Actions taken**	**Expected / Planned actions**
Operational control – 1) Operating procedures and instructions in normal, unexpected and emergency conditions. 2) Identification of installations and equipment subject to maintenance plans	Leakage of process flammable gas mixture at the coupling flange	Stopping the plant with conditions checking by DCS. Control room aeration system interruption. Reactors inerting	Review the purchase procedure and the assembly instructions for critical technical systems (i.e. coupling flange). Monitoring the sealing condition (subject to wear). Review the inspection and control planning for critical lines, and related training activities.
Emergency planning - Consequences analysis, planning and documentation		Gas detectors and system for vapors dilution. Emergency team intervention. Operational and emergency connections with the neighboring refinery	Specific risk analysis of the event. Exchange of information with the neighboring establishments

Altair Chimica – Chemical plant, Volterra (PI)

Date: 31/01/2008	**Title**: Leakage of hydrochloric acid (HCl) through the hydraulic guard of tank		
Synthetic description: Leakage of HCl through the overflow and the relative hydraulic guard placed at the bottom of a tank, with subsequent release of a HCl cloud			
Causes: Bad housekeeping of storage tanks. Effects of some past over-fillings that compromised tank sealing. High corrosion development was found			
Organizational factor	**Description**	**Actions taken**	**Expected / Planned actions**
Organization and staff - **Human factors, operator-plant interface**	Human error of the operator that did not follow the procedures for HCl loading in the tank. For a process problem at another installation, the operator who followed the transfer has gone away. The filling tank overflowed and the HCl released	The event was immediately reported by the shift supervisor activating the External Emergency Plan. The loss of the HCl aqueous solution was minimal, as the shift supervisor immediately intercepted the acid supply line to the tank	Fulfillment of the manual control tank filling procedure with constant presence of the operator. Editing a procedure for hazardous substances loading and unloading. Updating documentation and staff training
Operational control - **Operating procedures and instructions in normal, unexpected and emergency conditions**	Lack of high and very high alarms on all HCl tanks. The containment basins free of base, with possible leakage of product into the soil	Inside the tanks has been made a natural rubber tire	Installation of a pump dedicated to the tank loading, free from the truck loading. Installation of a 1st level switch on the tank, with local and check room acoustic alarm. Installation of a 2nd level switch that determines the tank loading pump stop and the closing of an on-off automatic valve on the supply line of the tank

Conclusions and guidelines

Ageing mechanisms as potential contributors to accidents

- Presentation of some industrial accidents, that occurred at chemical and petrochemical Italian “Seveso” establishments, where ageing mechanisms have been identified as a significant cause
- The analysis of technical and organizational factors of such events highlights problems of asset integrity of hazardous installations
  - Deterioration and degradation caused, over time, by corrosion, erosion, fatigue (stress, strain)
- Corrective actions taken by the authorities and the operator
  - Internal emergency plan, investigation and risk analysis, checks on installations and plants (pipeline, tanks, basins, pumps, etc.)
- Methods used to assess industry’s response to ageing issues
  - Remediation and maintenance, updating management procedures and operational instructions, specific monitoring and control plan for critical technical systems

Knowledge of degradation phenomena and related controls

- Plants are subject to degradation phenomena based on the level of static/dynamic stresses and the effect of materials compatibility with operating conditions
  - Knowing performance decay rates is useful for scheduling maintenance interventions with a correct frequency input
- The Seveso operator to comply with the regulatory requirements must consider the equipment changes in terms of deterioration and/or damage degree
  - The preservation of an equipment is related to the likelihood that a damage may occur
  - It’s necessary to know the damage mechanisms in order to identify the best “non destructive control method” suited to prevent them

Management of the risks associated with plant ageing

- For Seveso establishments, it's basic to control and maintain risk at acceptable levels through proper management of equipment maintenance activities
  - Aimed at ensuring operational continuity
  - Ensuring the stability conditions to prevent LOC that have humans and/or environment effects
- It's necessary to adopt risk assessment methods, maintenance-specific, to monitor and manage safety and reliability parameters
  - Risk Based Inspection (RBI): Inspections according to the actual operating conditions of the equipment, in order to allow a targeted planning of the maintenance interventions

An example of correct SMS procedure: the implementation of Asset Integrity Management for a Seveso establishment

- Upgrading the management system policy with AIM development, including identifying and monitoring KPIs
- Setting up and preparing an Asset Register, based on controls systems and software, documents, etc
- Identifying Integrity Critical Elements (ICE) through RBI: SCE (Safety Critical Elements) and OCE (Operational Critical Elements)
- Elaboration and preparation of Performance Standards for ICE
- Highlighting within the inspection/maintenance systems of all ICE
- Fulfillment of inspection and maintenance plans and defining Asset Integrity plans
- Implementation of prevention and mitigation measures for SCE

Thanks for the attention!

Any question…?

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