European Commission

WEBINAR

Technical Working for Seveso Inspections (TWG 2)

Seveso Enforcement and Site Risk Management during the Covid-19 Pandemic

Organised by the EC-Joint Research Centre with the TWG 2 Steering Committee

9 February 2021, 13:00 – 17:00 CEST

The webinar will be open for participation at 12:30 for those who may need more time to set up access.

Moderator: Maureen Wood, EC-JRC-MAHB | **Co-Moderator: Simone Wiers, SZW, The Netherlands**

Introductory Session

• Welcome to the Webinar • Introduction to the Programme	Maureen Wood, EC-JRC and Simone Wiers, Ministry of Social Affairs and Employment (SZW), The Netherlands
• Summary of JRC Lessons Learned Bulletins and the TWG 2 Survey on the Covid-19 Pandemic and Seveso risk management and enforcement	Maureen Wood, EC-JRC

Session 1. Inspection of Seveso Sites during the Covid-19 Pandemic

• Inspections under COVID 19 – good practice by facility specific pandemic plans	Monika Ulshöfer / Stefanie Breitenberger, Regierungspräsidium Karlsruhe, Baden-Württemberg, Germany
• The new procedure for carrying out Seveso inspections during the pandemic in Italy	Fabrizio Vazzana, Environment Agency (ISPRA), Italy

- Discussion and examples from authorities: ***If you would like to ask a question or comment, please use the Zoom chat.***

Moderator: Maureen Wood, EC-JRC-MAHB | **Co-Moderator: Ragnhild Larsen, DSB (Norway)**

Session 2. Site risk management challenges during the Covid-19 pandemic

• Corporate leadership and the Covid-19 pandemic on hazardous sites	Charles Cowley, CCPS
• Some critical issues for SMS Managing in small-medium industrial sites during the COVID-19 Pandemic	Fausta Delli Quadri, Environment Agency (ISPRA), Italy
• Survey of Seveso sites on Covid-19 pandemic challenges	Ragnhild Larsen, Directorate of Civil Protection (DSB), Norway

Coffee break (20 minutes)

- Discussion: ***If you would like to ask a question or comment, please use the Zoom chat.***

Session 3. Maintenance and staff management challenges on Seveso sites during Covid-19

• Managing a refinery turnaround during the Covid-19 pandemic	Mark Hailwood, State Institute for Environment Baden-Württemberg, Germany
• Work reorganization measures and management continuity during the pandemic: Case studies from the process industry	Romualdo Marrazzo, Environment Agency (ISPRA), Italy

- Discussion and wrap-up. ***If you would like to ask a question or comment, please use the Zoom chat.***

End of webinar

Webinar on “Seveso Enforcement and Site Risk Management during the Covid-19 Pandemic”

TWG2, EC-JRC-MAHB, 09/02/2021

Work reorganization measures and management continuity during the pandemic: Case studies from the process industry

Romualdo Marrazzo

Service for Risks and Environmental Sustainability of Technologies, Chemical Substances, Production Processes and Water Services and for Inspections (VAL-RTEC)

ISPRA - Italian National Institute for Environmental Protection and Research

Program and themes

1. **New protocol for carrying out inspections in the COVID period**
2. **Information on the status of the establishment in pandemic conditions**
3. **Company measures for the prevention and containment of the virus diffusion**
4. **Conclusions and guidelines**

1. New protocol for carrying out inspections in the COVID period

SMS inspections vs COVID-19

- Health emergency from SARS - CoV - 2 has resulted in limitations in carrying out on-site inspections on the national territory
- ISPRA, National Fire Brigade (CNVVF), Safety at Work Institute (INAIL) and Ministry of Environment (MATTM), in compliance with LD 105/2015 (Italian implementation of the Seveso III directive), have introduced alternative methods for carrying out inspections
  - Possibility of performing some phases remotely
  - Identified what can be done through documentary examination and what must be done on site, with possible completion of documentary analysis

The new phases of inspections

1. Remote start of the inspection, with the collection of documentary evidence
   – Documentation made available with preliminary requests for inspection a/o sharing during VdC
2. On-site visit and inspection
   – Interviews with internal and external personnel, plant inspections and emergency drills
3. Ending the activity remotely
   – Inspection results with evidence of the non-compliances found

Process industry case studies (strategic activities):

- Crude oil extraction and process center
- Oil refinery

2. Information on the status of the establishment in pandemic conditions

Continuation of operational activities

- There were no interruptions to production processes or work activities
  - No consequences on the accident scenarios hypothesized in the Safety Report
- Confirmation of the implementation of the measures provided for in the Emergency Plan
  - The presence of figures with roles in the Internal Emergency Plan (IEP) is constantly guaranteed according to the responsibilities identified
  - Guaranteed the daily compositions of the emergency teams on the site, according to the scenarios from the Safety Report

Management continuity of the establishment

- No changes or additions to significant SMS procedures have been adopted
  - The documentation in compliance with the "safety at work" legislation has been updated, due to the new mode of staff presence on site
- Reduction of presence and activities carried out by third-party companies
  - Activities connected with the safe operation of plants were ensured

Process industry case studies (strategic activities):

- Crude oil extraction and process center
- Oil refinery

3. Company measures for the prevention and containment of the virus diffusion

Work reorganization measures

- The production operational staff, operating on 3 shifts of 12 hours, reorganized on shifts of 12 hours
  - Reduction of daily alternation in the plant and minimization of daily shift changes
  - Identification of homogeneous groups of shift workers (teams), isolated at home, as reserves in the event of infections of the groups remaining in shift
- Implementation of the teleworking method (smart working) extended to non-operating personnel
  - Management, executives and day workers (60% of the workforce)

Access procedures at the site

- Access to the site with dedicated entrance and exit routes, maintaining a distance of 1 m
  - Thermal scanner with no entry if temperature > 37.5 °
  - Separation of the changing area in the locker rooms
  - Diversification of access times to company canteens
  - Sanitation of environments and distribution of masks with procedure for maintaining their characteristics
  - Avoid face-to-face meetings (s.c. “in presence”) by using videoconferencing

Contrast and virus containment

- Application of COVID-19 protocol and “Contingency Plan” in agreement with the workers’ unions
  - Management of potential asymptomatic positive cases
  - Tracking close contacts in the company site
  - Carrying out screening for detection of potential cases of positive infection and prevention of possible infections
  - Possibility of “quick swab” for entry into the plant a/o for personnel from abroad (multinational company)
  - Ability to house staff, for the entire duration of the shift rotation a/o quarantine, at accommodation facilities in the nearby area (multinational company)

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

Sistema Nazionale per la Protezione dell'Ambiente

4. Conclusions and guidelines

Non-compliances issued from the inspections

- Respect of time frequencies for training and update sessions
- Explanation of the contents of training activities carried out in "remote" mode, with a final verification session ("in presence“)
- Consultation with worker representatives on mandatory documentation (MAPP, training program, IEP)
- Compliance with the timing and frequency of inspections on some critical technical systems, performed by staff of third-party companies
- Checks and controls subject to actual exercise

New inspection method: strengths

- The new inspection method ensured the continuation of the control activity
  - Complete preliminary document check
  - Push towards dematerialization
  - Bigger number of remote meetings with manager and company representatives (4/5 days)
  - More time available for drafting the final inspection report
  - Minimization of site visits and reduction of face-to-face meetings (1/2 days)
  - Guarantee of safety and health protection in compliance with the COVID-19 protocols
  - Economic and human savings for Public Administration and companies

Questions…???...

romualdo.marrazzo@isprambiente.it

Thanks for the attention!

The **31st** European Safety and Reliability Conference **(ESREL 2021)** will be held in Angers, France on **19 - 23 September 2021.**

For more than 30 years, ESREL has been one of the key annual events for meetings and knowledge exchanges for innovation in risk management and the performance optimization of socio-technological systems. ESREL is a real place of conviviality for our safety and reliability community.

In Angers, we want to continue in this tradition without forgetting quality, scientific relevance and innovative nature within your proposals.

Research and development practices in our fields are also faced to major change, particularly due to the digitalization boom. We, the organizers, wish to make this edition of ESREL 2021 a time and a place for exchanges on this general theme «Guaranteeing in our accelerating world».

ESRA: **esrahomepage.eu**

ESREL2021: **esrel2021.org**

esRel

19 / 23
Sept. 2021
ANGERS
.FR

European Safety and Reliability Conference

2020

2021

December 1: Submission for Special Session

January 15: Abstract Submission

February 28: Abstract Acceptance

March 30: Full Paper Submission

April 30: Notification of Acceptance & Registrations opening

May 20: Final revised full paper submission

July 31: Early bird registration deadline

APPLICATION AREAS

- Aeronautics and Aerospace
- Automotive Industry
- Autonomous Driving Safety
- Chemical and Process Industry
- Civil Engineering
- Critical Infrastructures
- Cyber Physical Systems
- Energy
- Healthcare and Medical Industry
- Information Technology and Telecommunications
- Land Transportation
- Manufacturing
- Maritime and Offshore Technology
- Natural Hazards
- Nuclear Industry
- Occupational Safety
- Oil and Gas Industry
- Renewable Energy Industry
- Railway Industry
- Security
- Smart Cities and Systems
- Socio-Technical-Economic Systems
- Supply Chains Management
- Water Transportation Systems
- Web Systems

METHODOLOGY AREAS

- Accelerated Life Testing
- Accident and Incident Modeling
- Asset management
- Economic Analysis in Risk Management
- Foundational Issues in Risk Assessment and Management
- Human Factors and Human Reliability
- Innovative Computing Technologies in Reliability and Safety
- Maintenance Modeling and Applications
- Mathematical Methods in Reliability and Safety
- Mechanical and Structural Reliability
- Organizational Factors and Safety Culture
- Prognostics and System Health Management
- Resilience Engineering
- Risk Assessment
- Risk Management
- Risk Scenario
- Softawre Reliability
- Structural Reliability
- System Reliability
- Uncertainty Analysis

Each abstract (and paper) will be evaluated for acceptance by peer reviewers. As customary, paid registration to the Conference is mandatory for abstract/paper acceptance (one registration per paper). Proposals for Special Sessions on complementary opening topics to the conference are welcome. Accepted papers will be published in open access conference proceedings by Research Publishing Services, Singapore, and be indexed.

An hybridation of the conference organization combining presence and virtual presentations will be proposed according to the evolution of public health rules related to the COVID-19 pandemic.

CONFERENCE GENERAL CHAIR:

Bruno Castanier
Laboratoire Angevin de Recherche en Ingénierie des Systèmes, Université d'Angers, France

CONFERENCE GENERAL CO-CHAIR:

Marko Cepin
ESRA Chairman, University of Ljubljana, Slovenia

TECHNICAL COMMITTEE CHAIR:

David Bigaud
Laboratoire Angevin de Recherche en Ingénierie des Systèmes, Université d'Angers, France

TECHNICAL COMMITTEE CO-CHAIR:

Christophe Bérenguer
GIPSA-Lab, Grenoble INP, France

14:40 Basma Khelfa and Antoine Tordeux
COMPARING RULE BASED AND DATA BASED APPROACHES FOR LANE CHANGE PREDICTION (abstract)
PRESENTER: Basma Khelfa

15:00-15:20 Coffee Break

15:20-16:00 Session Plenary V: Plenary Session

LOCATION: Plenary Room

15:20 Catherine Mouneyrac
Safer by design concept (abstract)

16:10-17:30 Session WE4A: Risk Assessment

LOCATION: Plenary Room

16:10 Cosetta Mazzini and Romualdo Marrazzo
CHALLENGES IN RISK ASSESSMENT FOR UNDERGROUND GAS STORAGE ACTIVITIES IN ITALY (abstract)
PRESENTER: Cosetta Mazzini

16:30 Sejin Baek, Gyunyoung Heo, Taewan Kim and Jonghyun Kim
Numerical Verification of DICE (Dynamic Integrated Consequence Evaluation) for Integrated Safety Assessment (abstract)
PRESENTER: Sejin Baek

16:50 Lucas L. Costa, Fabiano L. de Sousa and Milton de F. Chagas Junior
A RISK MATURITY LEVEL CONCEPT FOR CONCURRENT ENGINEERING ENVIRONMENT (abstract)
PRESENTER: Lucas L. Costa

17:10 Renan Maidana, Tarannom Parhizkar, Christoph Thieme, Marilia Ramos, Ingrid Utne and Ali Mosleh
Towards Risk-Based Autonomous Decision-making with Accident Dynamic Simulation (abstract)
PRESENTER: Renan Maidana

16:10-17:30 Session WE4B: Occupational Safety

LOCATION: ATRIUM 2

16:10 Vincenzo Nastasi, Giuseppe Giannelli, Antonino Muratore, Giuseppe Sferruzza and Giovanni Grillone
Index Method for Risk Assessment Using Load Lifting (Crane) and People Lifting (MEWP) Equipment (abstract)
PRESENTER: Vincenzo Nastasi

16:30 Marcello Braglia, Luciano Di Donato, Marco Frosolini, Roberto Gabbrielli, Leonardo Marrazzini and Luca Padellini
Critical assessment of the technical standards and regulations about the energy isolation and unexpected start-up in machineries (abstract)
PRESENTER: Leonardo Marrazzini

16:50 Luca Landi, Alice Buffi, Alessandro Stecconi, Mirko Marracci, Pasqualino Di Leone, Fabio Bernardini and Luciano Didonato
Localization systems for Safety Applications in Industrial Scenarios (abstract)
PRESENTER: Luca Landi

17:10 Antonino Muratore, Giuseppe Giannelli, Vincenzo Nastasi, Giuseppe Sferruzza and Giovanni Grillone
Risk assessment of pressure equipment during use phase (abstract)
PRESENTER: Antonino Muratore

16:10-17:30 Session WE4C: Petri Nets in reliability, safety and maintenance

LOCATION: ESPACE GRAND ANGLE2

16:10 Rundong Yan, Sarah Dunnett, Silvia Tolo and John Andrews
A PETRI NET METHODOLOGY FOR MODELING THE RESILIENCE OF NUCLEAR POWER PLANTS (abstract)
PRESENTER: Rundong Yan

16:30 Thomas Dosda and Jean-Yves Brandelet
DYNAMIC PROBABILISTIC SAFETY ASSESSMENT WITH PETRI NETS (abstract)
PRESENTER: Thomas Dosda

ESREL 31st European Safety and Reliability Conference
22 September 2021
Angers
France

"Underground natural gas storage - Guidelines for the evaluation of Safety Reports"

Challenges in risk assessment and the development of risk assessment guidelines for competent authorities for underground gas storage activities in Italy

Speakers:

Ms. Cosetta Mazzini
Regional Agency for Enviromental Prevention and Energy of Emilia Romagna

Mr. Romualdo Marrazzo
Italian National Institute for Environmental Protection and Research

Sistema Nazionale per la Protezione dell'Ambiente

ARPAE and ISPRA for industrial control

- ARPAE is the technical body supporting the Italian Regional authority of Emilia Romagna in Seveso issues:
  - Regional Laws
  - Cooperation in National Laws
  - Regional Inventory of establishments
  - Technical evaluation of safety reports
  - Safety Management System (SMS) inspections
  - External Emergency Planning (EEP)
  - Land Use Planning (LUP)
  - Collaboration with other Authorities competent for industrial risk

- ISPRA has a national role as a technical body supporting Italy's Ministry of Environment in the national implementation of the Seveso Directives (last: D. Lgs. 105/2015)
  - Laws and decrees
  - National Inventory of establishments
  - Safety Management System (SMS) Inspections
  - Support for international activities
  - Technical coordination of ARPA
  - Collaboration with other Authorities competent for industrial risk

arpae agenzia prevenzione ambiente energia emilia-romagna

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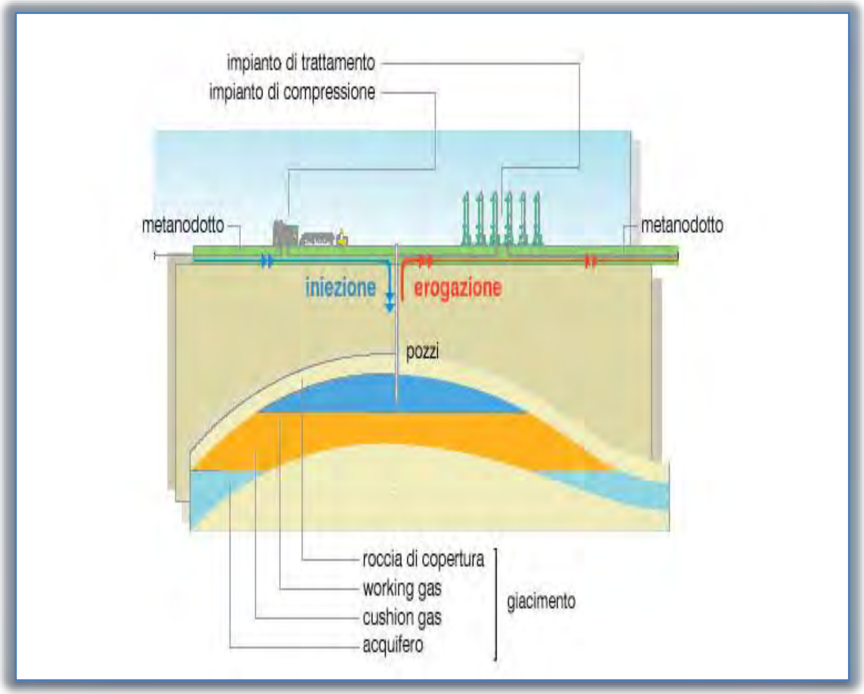
Introduction and background

The Italian situation: *underground natural gas storage sites*
Seveso sites- *upper tier*

✓ **12 underground natural gas storage sites** operating in 4 different regions: Lombardia, Veneto, Emilia Romagna, Abruzzo

Underground storage in Italy

The operating storage sites are *depleted gas production sites*: natural structures in which gas was trapped and which, once the primary exploitation phase was completed, were converted into storage



These establishments are:

- Surface plants (compressor and treatment units)
- Reservoirs (deposits - natural storage systems)
- Wells (connecting the reservoir with surface plants)
- Interconnecting flow-lines

The activity consists of the storage of natural gas in underground geological structures (injection) and subsequent distribution according to market demand and to guarantee the "strategic" supply in the country

Risk assessment and safety reports

- ***Risk assessment***

  The site operator produces a safety report with a description of a risk analysis and measures for the prevention of accident major hazards

- ***The competent authority is: the Regional Technical Committee***

  The Regional Technical Committee (CTR) consists of the National Fire Brigade (VVF), the Regional Environmental Agency (ARPA), the Safety at Work Institute (INAIL), Regional and Municipal Authorities, the Local Health Authority (ASL) and the National Mining Office (UNMIG)

  – The committee nominates a working group of representatives from VVF ARPA and UNMIG carries out the technical evaluation for the safety report with a multidisciplinary approach

  – The technical evaluation identifies accident scenarios, damage distances and frequencies of occurrence, as well as the safety measures adopted, for the purposes of External Emergency Planning (EEP) and Land Use Planning (LUP)

Guidelines for the safety report evaluation of underground natural gas storage: challenges, development and results

https://www.minambiente.it/sites/default/files/archivio/allegati/rischio_industriale/Linea_Guida_Stoccaggi_Gas_ottobre2018.pdf

Why the guidelines?

There are three main reasons why we wrote these guidelines

- *Establishments located in 4 different regions*
- *Discrepancies in the criteria to identify accident scenarios*
- *Discrepancies in consequence assessments (damage areas)*

Purpose ⟹

✓ To create shared guidelines in order to have uniform evaluation throughout the national territory of the risk analyses produced

Challenges ⟹

✓ To systematize the risk analysis experience gained over the years in the different regions

✓ To investigate rules and methodologies applicable to underground gas storage facilities

Who has drawn up the guidelines?

- In Italy there is a Coordination Table of Seveso Competent Authorities under the Ministry of the Environment (art. 11 L.D. 105/2015).
- The guidelines have been drafted by a specific working group which was nominated by the Coordination Table. This working group consisted of representatives from:
  - The Regional Environmental Agency (ARPA), The National Fire Brigade (VVF), the National Institute for Environmental Protection and Research (ISPRA), the Safety at Work Institute (INAIL), Region, the National Mining Office (UNMIG) and University
- The Guidelines provide technical indications for the evaluation of safety reports presented by the operators of underground natural gas storage sites

MULTIDISCIPLINARY APPROACH

Main contents of the guidelines

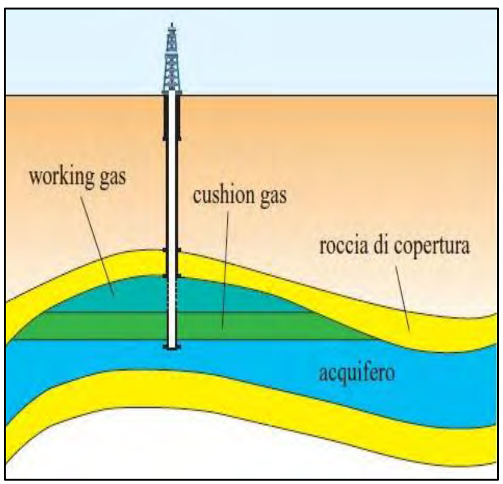
- **INFORMATION RELATING TO ESTABLISHMENT**
  - ✓ Activities: reservoirs; treatment units; clusters; isolated wells. Organizational structure.
- **ESTABLISHMENT CLASSIFICATION AND VERIFICATION SUBJECT TO SEVESO**
  - ✓ Quantities present: storage and hold up in reservoirs; surface plants; individual plants; other substances
- **SAFETY OF ESTABLISHMENT**
  - ✓ Risk: loss of integrity of reservoirs; wells Loss Of Containment (LOC); connecting flow-lines; formation of hydrates; Na-tech
- **IDENTIFICATION OF EVENTS AND ACCIDENT SCENARIOS**
  - ✓ Analysis of accident experience, preliminary analysis of critical surface plants
- **EVALUATION OF EVENTS AND SCENARIOS FREQUENCY**
  - ✓ Evaluation of frequency: events (fault tree and/or databases); scenarios (event tree)
- **CALCULATION OF CONSEQUENCES**
  - ✓ Identification of the source terms of the event; assessment of the release dynamics and calculation of the flow rate. calculation of consequences; evaluation of damage distances through mathematical models
- **SAFETY SYSTEMS**
  - ✓ Lightning protection measures; locking systems. fire prevention measures

Safety of Natural Gas storage establishments

Risk of loss of integrity of the reservoir
Geo-Mechanical Model

✓ There are two parameters for the safety assessment of the gas reservoir

Depth 1000-2000 m



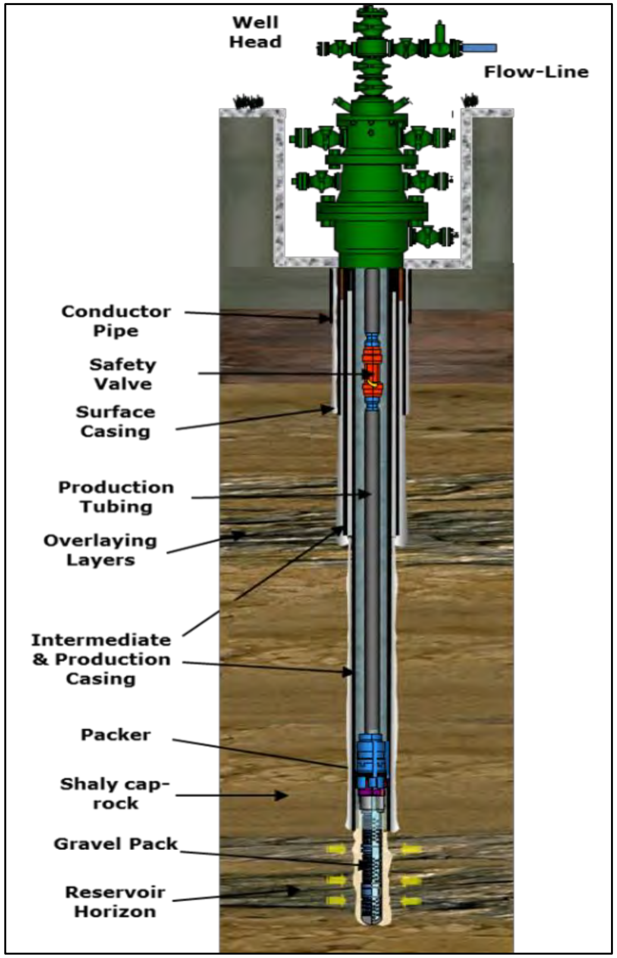
➢ The geo-mechanical model for the gas reservoir provides quantitative assessments of the limit pressure with which safe storage can be performed

➢ Monitoring of pressure, micro-seismicity and deformation of the soil indicate the maintenance of the state of the gas reservoir in conditions of safety during the injection and distribution activity

Safety of natural gas storage establishments

Risk of loss of integrity of the reservoir and the wells

Well safety



- ✓ The well consists of "casing", steel pipes and a cement filling
- ✓ Anomalies with gas leakage that can cause risks
  - ➢ Ineffective seal from the casing cementation of the well
  - ➢ Risk of eruption (blow out) of the well even during maintenance operations

Safety of natural gas storage establishments

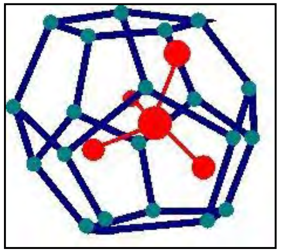
Safety of connecting flow-lines

✓ *Connection pipelines, outside the fences of the plants, between the well/cluster areas and the surface plants (compressor units)*

- In Italy the "methane pipeline" standard establishes the minimum safety distances from residential areas:
  - *100 m for pipelines with maximum operating pressures exceeding 24 bar*
- **(Guidelines) It is important to describe:**
  - ***routes and construction features; interception - blocking – safety systems***

Safety of natural gas storage establishments

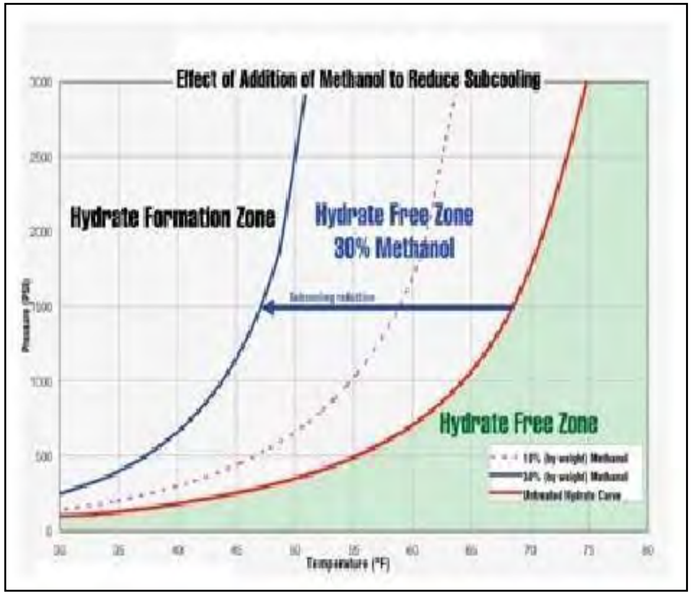
Safety of connecting flow-lines



Methane hydrate
(methane molecule is red)

- ✓ Hydrates are compounds of molecules of free water and/or condensation in the pipeline and natural gasses that crystallize in particular conditions of pressure and temperature

Block of methane hydrate obstructing pipeline



- ✓ To contrast the formation of hydrates, inhibitors such as methanol or glycol are used to move the stability curve

- ❑ **The guidelines give indications for the evaluation of hydrate formation in all plant conditions, that can lead to variations in pressure or temperature**
  - **normal operation, shutdown, maintenance activities**

Procedure for the formation of hydrates and emergency instructions to be implemented if the phenomenon occurs

Safety of natural gas storage establishments

Na-Tech safety

Geophysical and lightning events, hydro-geological instability

✓ A Na-Tech risk analysis shows, for example, if parts of the plant are not sufficiently safe

❑ **The Guidelines identify:**

- **the actions to be implemented through an adjustment plan to make the establishment safe**
- **to proceed with the risk assessment through the identification of possible accident scenarios and the related damage areas**
- **prevention/protection measures that ensure the safety of the installation**

Risk analysis for surface plants

Identification of event and accident scenarios
Historical experience, what-if analysis, FMEA-FMECA, HazOp

- ✓ Internal historical analysis
  - ➢ Causes of accidents, near-misses and anomalies that have occurred inside the plant
  - ➢ Fires, explosions, emissions of dangerous substances that have occurred, formation of hydrates
- ✓ External historical analysis of events which haveoccurred in similar establishments
  - ➢ Updated Databases (MHIDAS, FACTS, eMARS, etc.)
- ✓ Analysis of the historical experience of "delivery points" or "nodes" of the national natural gas distribution network
  - ➢ Located in areas adjacent to the establishment and with which they are closely interconnected

❑ **The guidelines give indications on all reference databases and plant and/or management measures to prevent events or limit their probability and consequences**

Risk analysis for surface plants

Evaluation of the frequency of events and scenarios

Rate of failure identification → Complex systems → Fault tree analysis

Rate of failure identification → "Random" failure of a single component (equipment, systems, pipes)

↓

Failure rates are taken from reliability databases
(Oreda, EIGIG, HSE, TNO Purple Book, EIGH, etc.)

- ✓ Limitation of the Database: attributing to a well-identified component the results found on other identical components, but whose use characteristics and operating environment conditions may be substantially different

- ❑ **The guidelines describe the reliability databases and suggests that it is important to show that data are representative of the specific plant and that the chosen failure rates can be considered conservative**

- ✓ In underground gas storage plants the random failure of the pipes is the basis (Top-Event) of the most significant events (more extensive damage areas)

Risk analysis for surface plants

General frequency values for pipe failure – examples

- Above-ground pipes

Diametri tubazioni / Diametri Rottura	0"-2"		2"-6"		6"-11"		11"-19"		19"-39"	
	HSE	TNO	HSE	TNO	HSE	TNO	HSE	TNO	HSE	TNO
Circa 1/9"	$1*10^{-5}$		$2*10^{-6}$							
1/6"					$1*10^{-6}$		$8*10^{-7}$		$7*10^{-7}$	
1"	$5*10^{-6}$		$1*10^{-6}$		$7*10^{-7}$		$5*10^{-7}$		$4*10^{-7}$	
10% DN		$5*10^{-6}$		da $2*10^{-6}$ a $5*10^{-6}$		$5*10^{-7}$		$5*10^{-7}$		$5*10^{-7}$
Rottura totale	$1*10^{-6}$	$1*10^{-6}$	$5*10^{-7}$	da $3*10^{-7}$ a $1*10^{-7}$	$2*10^{-7}$	$1*10^{-7}$	$7*10^{-8}$	$1*10^{-7}$	$4*10^{-8}$	$1*10^{-7}$

*HSE Failure Rate/TNO Purple Book 2005: General frequency values for pipe failure [occ/(y*m)]*

- **The guidelines make a comparison between databases (HSE Failure Rate/TNO Purple Book 2005)**
  - ✓ ***General frequency values for pipe failure***
  - ✓ ***Order in a range of 10^{-5} – 10^{-7}***

- Buried pipes

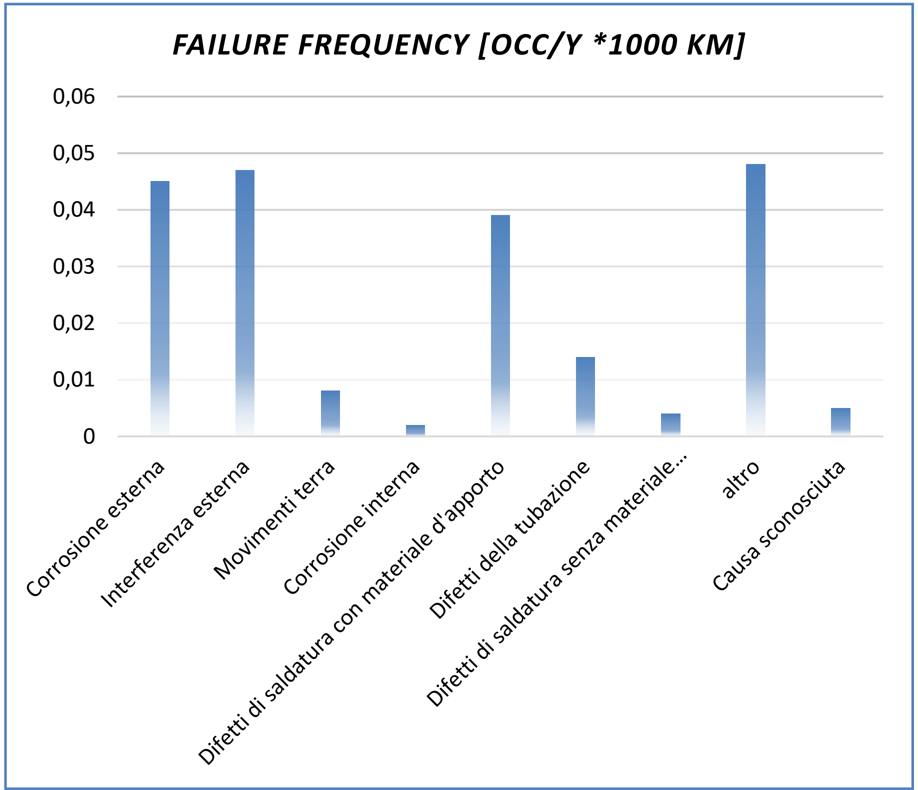
10° EGIG Report (2018): Frequency values for gas pipe failure

- **The guidelines suggest that failure frequencies indicated in the European Gas Pipeline Incident Data Group (EGIG) Report can be taken as a reference for natural gas pipes (buried or not buried, even within EST)**
  - ✓ ***Report RIVM On-site natural gas piping - scenarios and failure frequencies (2011)***

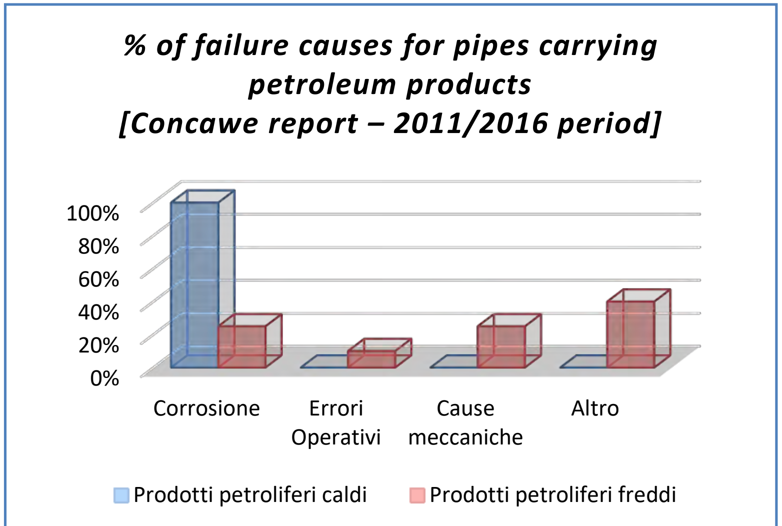
Risk analysis for surface plants

Incidence of the different failure causes on frequency

Data source	*Total rupture frequency (accidents/y*1000 km)*
UKOPA Report Pipelines of petroleum products in the UK during the period 1962-2016	0,212
CONCAWE Report Buried pipelines of petroleum products in EU during the period 1971-2016	0,46



Failure causes: external corrosion, external interference, internal corrosion, welding defects, piping defects, other



Failure causes: corrosion, operational errors, mechanical causes

Risk Analysis for surface plants

The API 581 standard: highlighted critical issues

- The API standard was developed by the American Petroleum Institute to define, implement and manage an inspection program based on risk analysis
  If this standard is used improperly and partially (Eg. taking into account in a generic way only of safety management system procedures) the results which are obtained will be wrong, because there will be a reduction by at least one order of magnitude of the general frequencies of equipment and pipes failure.
- **The guidelines suggest**
  - ✓ **the use of methodologies for the drafting of a risk-based inspection plan such as the API 581: 2016 standard**
  - ✓ **if an inspection plan based on risk analysis has been prepared, its effectiveness in preparing an integrated analysis can be taken into account in order to reduce the frequency of accidents**

IMPORTANT: The reduction of occurrence frequencies through an integrated analysis that combines risk analysis with the safety management system allows the quantification of the positive effects of the system in order to prevent major accidents

Risk analysis for surface plants

The integrated approach to risk assessment

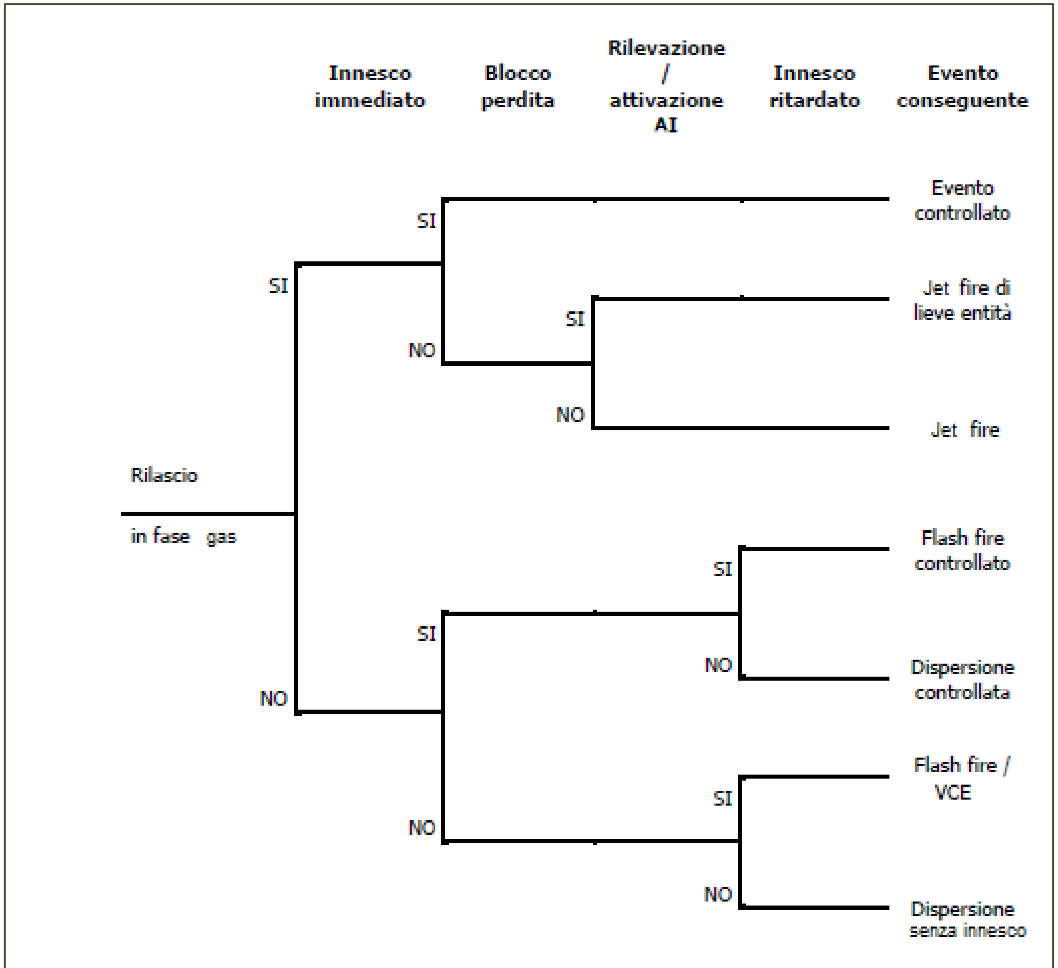
- **The guidelines describe the methodologies necessary for the integration of risk analysis techniques with benefits in terms of the reduction of the frequency of accidents deriving from the implementation of a safety management system (SMS)**
  - ✓ causes of failure, ways to prevent them and measures that can reduce the frequency of a particular cause and the subsequent total frequency

- “A quantified integrated technical and Management risk control and monitoring methodology” [EC Method (1999)]
  - ✓ It reduces the Top frequencies also for complex systems (Faul Tree Analysis)
- “The influence of Risk Prevention Measures on the Frequency of Failure of Piping” [International Journal of Performability Engineering (2010)]
  - ✓ Specific for random pipe failures

Eg. The Ukopa Report, the cause of main failure: external corrosion. The inspection plan aimed at this external corrosion reduces the frequency of pipe failure. The quantification of this reduction is obtained by applying the methods indicated above.

Risk analysis for surface plants

Evaluation of scenario frequencies (event tree)



Example of an event tree in case of fire safety systems and blocks

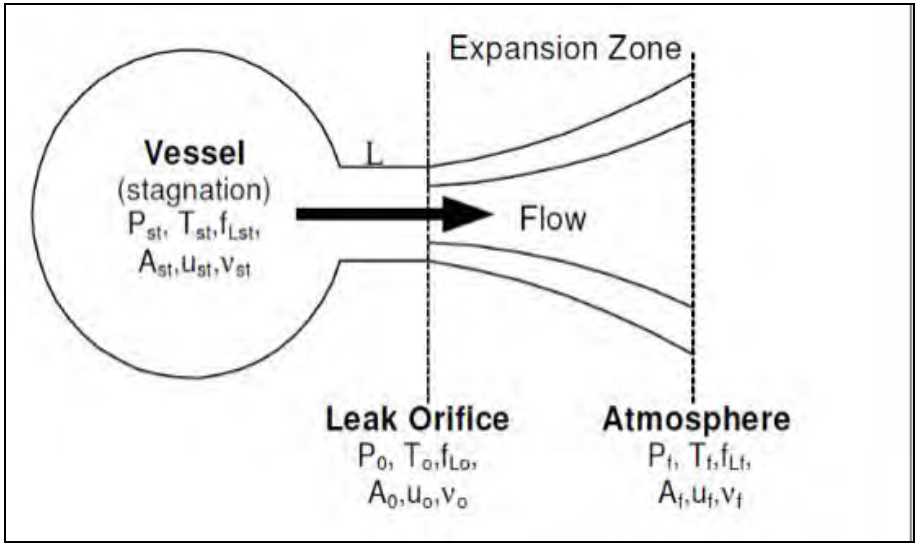
- ❑ **The guidelines highlight**
- ✓ **The trigger probability values to be reported in the event tree must be pertinent to the plant reality or cautiously estimated in favor of safety**
- ✓ **Methods for the calculation of the probability values of immediate/delayed triggering**

Ex: Purple Book 2005 "Guidelines for quantitative risk assessment" 2005; HSE 1997 "Ignition probability of flammable gas"

Risk analysis for surface plants

Calculation of consequences: physical phenomena of methane release

Modelling - High pressure methane release



Release phases of gas under pressure

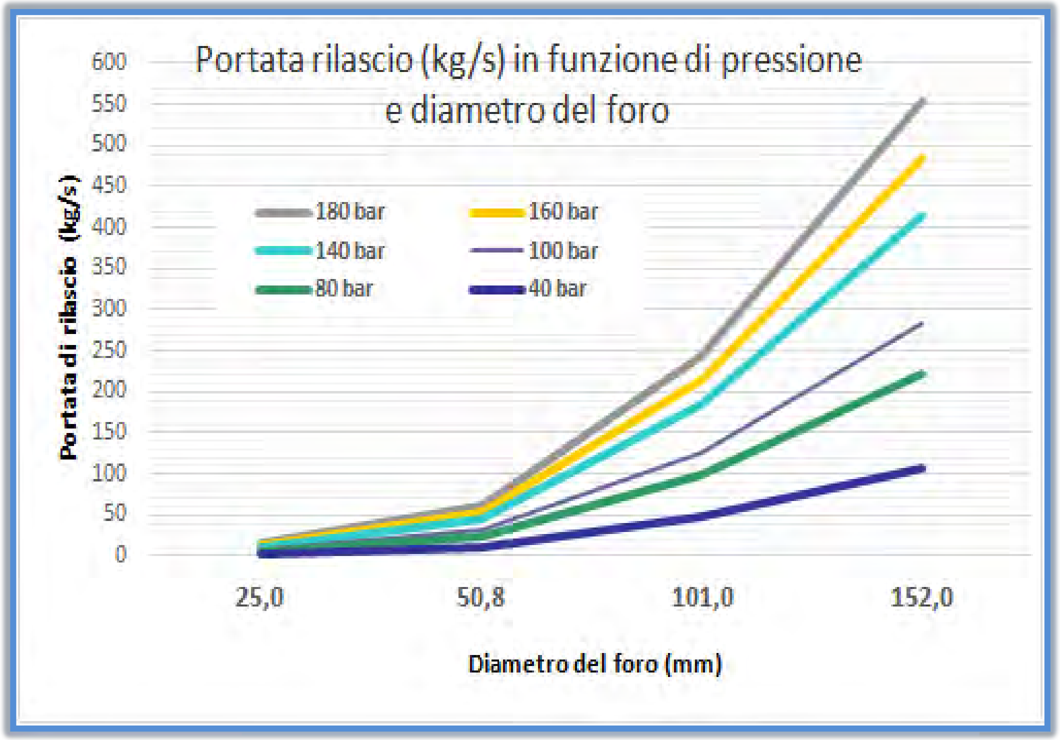
- **Phase 1: expansion from the initial pressure to the hole pressure**
- **Phase 2: expansion up to atmospheric pressure**
- **Phase 3: initial dilution**

Methane in supercritical conditions

- When a fluid is at a temperature and pressure higher than the critical ones it is in a supercritical state (no distinction between gaseous and liquid phase)
  - ✓ properties intermediate between those of a gas and a liquid and its density can be greater than that of gases in ordinary conditions

Risk analysis for surface plants

Calculation of consequences: gas density and release rate



Graph of the release mass flow rate as a function of the hole diameter for different pressure values in the range 40 -180 bar

✓ *The release flow rate varies according to the failure diameter and the pressure*

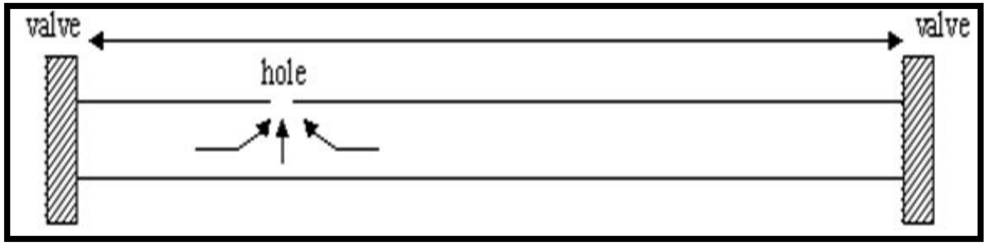
<u>Release evaluation</u>

- ➢ The density of methane proportionally affects the release rate
- ➢ The gas release rate must be calculated taking into account the gas density in supercritical conditions

Risk analysis for surface plants

Calculation of consequences: accident scenarios

- **Methane FLASH FIRE**
  - ✓ Fire of a flammable gas cloud that disperses into the atmosphere as a light neutral gas. The factors that affect modelling: density, weather conditions, release duration, cloud dilution, roughness



  - ✓ In case of interception systems, the duration of the release and the quantity released will be less. The frequency of the flash fire scenario could be reduced as the smaller cloud is less likely to run to a trigger source

- **The guidelines suggest that the intervention times assumed must be consistent with the emergency procedures and be verified by the working group with the plant personnel during field inspections**

Risk analysis for surface plants

Calculation of consequences: accident scenarios

- **A jet fire**
  - ✓ The release of a pressurized gas with immediate ignition and fire of a cloud. The factors that affect modelling: gas density, jet direction, release flow rate

- **The guidelines highlight that the jet fire damage areas identified are included within the damage areas for the corresponding flash fire scenarios. They must be considered especially for the purposes of evaluating a possible domino effect**

- **A Vapor Cloud Explosion (VCE)**
  - ✓ Confinement of the mass of flammable vapors mixed with air at the moment of ignition
  - ✓ It is necessary to assess whether the air/natural gas mixture can fall within the flammability range, calculating the amount of flammable mixture between LFL/UFL

Conditions that facilitate the occurrence of a vapor cloud explosion are releases in areas with a high degree of confinement or in closed environments

Risk analysis for surface plants

Calculation of consequences: comparison of models (i.e. Phast®-DNV GL, Effects®-TNO)

- **The guidelines show how using a computational model that does not take into account the "super critical conditions" of methane**
  - ✓ **some software does not automatically take into account the initial expansion and dilution of the methane jet**
  - ✓ **It is therefore necessary to apply a dilution factor to the release range (approx 1/10)**
  - ✓ **the value of the recalculated flow must be used as input data to any Gaussian dispersion model, since for this model the gas concentration is directly proportional to the release flow**
- **The guidelines highlight that the verification of the models chosen for the estimation of the consequences must be adequate to the physical phenomenon reality**

Phast®-DNV GL	***Effects®-TNO***
It takes into account the initial dilution of the cloud due to the high speed and therefore to the release turbulence (methane super-critical conditions)	*The Gaussian dispersion model does not take into account the initial dilution of the gas and therefore gives more conservative results*

Risk analysis for surface plants

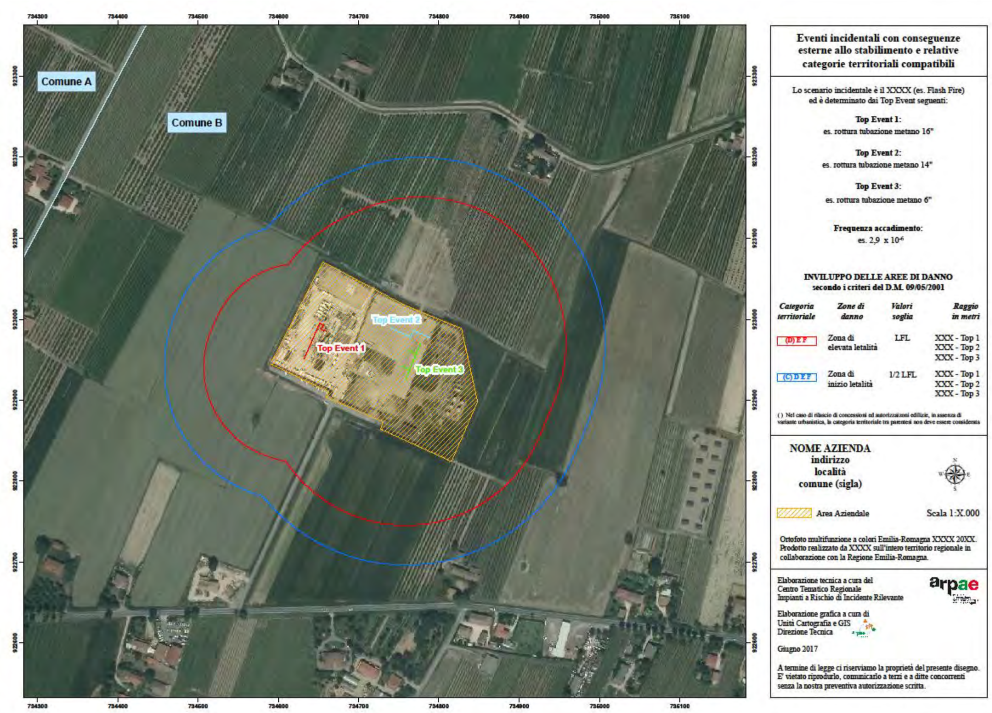
Safety systems

- **The Guidelines describe the main prevention and protection measures aimed at reducing the frequency and/or extent of the consequences of accident events**
  - **Locking systems to make plants safe**
    - **ESD (Emergency Shut Down)**: closing of all the plant sectioning valves and opening of the blow down valves with the consequent depressurization of the system
    - **PSD (Process Shut Down)**: production shutdown by closing the sectioning valves (SDV) and securing the unit
    - **LSD (Local Shut Down)**: blocking and securing of the unit, or the single equipment is intercepted and stopped
  - **Fire prevention measures and systems**

Safety report evaluation conclusions

Example of external emergency planning

- **Flash fire: geo-referencing of the consequence evaluation**
  - ✓ *Top-event: failure of a natural gas pipe (152 mm hole) at an operating pressure of 140 bar*



FLASH FIRE – Damage Distances (m)			
Hole Diamter [mm]	Pressure [bar]	Weather Conditions (D5)	
		LFL	½ LFL
152	140	284.91	435.88

Weather conditions in the area: atmospheric stability class of Pasquill D5 (neutral) with wind speed of 5 m/s

Conclusions and further developments

Guideline Conclusions

The aims achieved by the guidelines in the evaluation of safety reports

1. The identification of the standards applicable to natural gas storage establishments and the respective areas of application and methods of coordination
2. The identification of specific individual safety aspects relating to reservoirs, surface plants and flow-lines
3. Criteria for choosing state of the art accident databases and sources of reliability data
4. Conditions of feasibility of the API 581 standard (RBI) in the risk analysis of safety reports
5. Conditions of use for commercial computational models for the study of the consequences for methane releases in super critical conditions
6. Uniformity of risk assessment throughout the national territory

Guideline Conclusions

Here are our indications to improve the national regulatory framework

1. Define a validated methodology of integrated risk analysis in order to quantify the effect of the safety management system and also establish the procedures which are necessary both to reduce the probability of occurrence and to reduce the extent of the consequences of major accidents
2. Identify credibility thresholds for accident events, as in other countries in Europe
3. Recognize ways to carry out Na-Tech risk analyses
4. Put in place measures to contain methane emissions (greenhouse gas) in conditions other than normal operation

Thanks for listening!

…questions?...

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Hazards31

16–18 November 2021, Virtual conference

Suggested abstract topics

Assurance

Audits
COMAH & Seveso
Cyber security and cyber threats to process safety
Hazard and risk
Inspections
Legislation and compliance
Metrics
New codes of practice
Occupied buildings risk assessment
Oversight
Regulation & guidance
Safety case reviews
Other

Climate change, decarbonisation, new technologies

Carbon capture
Inherent safety
Managing the effect on existing infrastructure
Managing the impact of changing weather and extreme events caused by climate change (eg flood risk, natural hazards)
Managing the major hazard implications of new energies (eg H_2, LNG, CO_2, batteries, biomethane, unconventional gas, wind, solar)
Nuclear
Other

Engineering and design

Asset integrity and ageing plant
Chemical reaction and decomposition hazards
Digitalisation (eg cyber security, artificial intelligence, big data)
Dispersion modelling
DSEAR
Dust explosions
Energy storage
Fire and explosion hazards
Fire risk assessment
Functional safety & SIL
Hazardous area classification
Hazardous waste
Inherent safety
Pressure relief
Risk analysis
Toxic hazards
Other

Environmental protection

Air
Contamination and clean-up
Noise
Odour
Risk assessment
Waste
Water
Other

Human factors

Alarm management
Critical task analysis
Fatigue/shift patterns
Public impact
Safety psychology
Situational awareness
Unmanned plant
Other

Knowledge and competence

Analysis of losses
Big data
Case histories
Competencies
Condition monitoring
Consequence assessment and modelling
Education, training and communication
Failure data
Lessons from recent incidents and near misses
Process safety animations
Other

Safety culture

Corporate memory
Engaging business leaders
Safer plant operations
Safety leadership
Site safety culture assessment
Stakeholder engagement
Other

Systems and procedures

Construction of process plant
Decommissioning
HAZOP
Incident investigation
Integration of process safety management systems into existing business systems
LOPA
Maintenance
Management of change (MoC)
Management of non-routine operations
Operational risk assessment (business risk)
Permit to work
Process safety management
Risk assessments
Standard operating procedures
Other

IChemE Safety Centre

IChemE ADVANCING CHEMICAL ENGINEERING WORLDWIDE

Tuesday 16 November 2021

Hazards31

All times are Greenwich Mean Time (GMT)

09:30–09:45	Welcome from the conference chair	
09:45–10:40	**Plenary speaker**	*A Reflection of How the Downstream Oil Sector Responded to the Outbreak of COVID-19 and How that Response Mapped to Process Safety Management During the Ensuing Pandemic* Simon Wood, UK Petroleum Industries Association (UKPIA)

	Lessons Learned from the COVID-19 Response I Session chair: Trish Kerin	**Assurance** Session chair: Eamon Chandler	**Safety Culture I** Session chair: James Birch	**Modelling I** Session chair: Felicia Tan	
10:45–11:10	*Lessons Learned from the COVID-19 Pandemic* Keith Plumb, Integral Pharma Services, UK	*Process Safety Key Performance Indicators (API-754 Guidelines)* Ameer Hamza & Syed Salwat Hosain Rizvi, Engro Polymer & Chemicals, Pakistan	*Process Safety Site Visit to Improve PSM Culture* Ipek Isteben & Seçkin Gökçe, Tupras, Turkey	*Applying Standards and Transient Simulations to Find Root Cause of Fire Incident* Mira Ezora Zainal Abidin, Siti Fauzuna Othman & Zalina Harun, Petronas, Malaysia	
11:15–11:40	*Case Study – Design and Build of New Plant for Production of a Key Ingredient for a COVID-19 Vaccine* Carolyn Nicholls, RAS, UK	*Learning from Major Incidents Related to Process Safety Audits* Zsuzsanna Gyenes, IChemE Safety Centre, UK	*Influencing Improvements in Safety Culture Using Qualitative Research Methods: a Regulatory Perspective* Nick Shaw, Office for Nuclear Regulation, UK	*Advanced Methodology of Structural Redundancy Analysis for Optimising Passive Fire/Cryogenic Spill Protection* Hiroki Takahashi & Yoshinori Hiroya, JGC Corporation, Japan	
11:45–12:10	*Experiences and Lessons During COVID-19* Ellen Daniels, British Compressed Gases Association (BCGA), UK	*Integrated PHA approach for an Auditable Barrier Management Regime* Khama Matiti, Monaco Engineering Solutions, UK & Majid Siddiqui, North Caspian Operating Company, Kazakhstan	*Process Safety Cards "A Good Deal Safer"* David Hatch, Process Safety Integrity, UK	*Comparisons of the Predictions of the Dispersion Model DRIFT Against Data for Hydrogen, Ammonia and Carbon Dioxide* Graham Tickle, ESR Technology, UK	
12:15–12:40	Facilitated discussion	Facilitated discussion	Facilitated discussion	Facilitated discussion	
12:40–13:15					

13:15–14:15	Break	
14:15–15:10	**Plenary speaker**	*Cross Sector Learning – What the Chemical and Process Industries Can Learn from the Building Sector* Peter Baker, Health and Safety Executive, UK

	Cross-sector Learning Session chair: Ken Rivers	**Analysis of Losses** Session chair: Paul Coleman	**Risk Assessment** Session chair: James Fairburn	**Modelling II** Session chair: Diego Lisbona	**Process Safety Competencies** Session chair: Azzam Younes
15:15–15:40	*What the Processing Industry Must Learn from the Boeing 737 MAX Crashes* Richard Carter, ACM Facility Safety, Canada	*Trends in Offshore Process Equipment Leak Frequencies* Brian Bain, DNV, UK	*Cumulative Risk Model of Safety Barriers – Case Study* Yasser Fathy, Rashid Petroleum, Egypt	*Is Your Tank Inert? A Study into the Challenges of Ensuring Inert Atmospheres* Alan Collier & Stephen Puttick, Syngenta, UK	*Understanding Your Process Safety Competency* Trish Kerin, IChemE Safety Centre, Australia & Ken Gray, The Keil Centre, UK
15:45–16:10	*Thinking Outside the Box: Lessons and Experience that the Major Hazard and Nuclear Sectors Can Learn from Each Other* Ian Phillips, Office for Nuclear Regulation (ONR), UK	*Analysis of Accidents and Good Inspection Practices for the Management of Ageing of Industrial Plants* Romualdo Marrazzo & Fabrizio Vazzana, Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA), Italy	*Use of Live Barrier Models to Manage Risk* Rae Ann Joseph, Atlantic LNG, Trindad & Tobago	*Addressing the Unique Challenges of Hydrogen Gas Detection in 3D Fire and Gas Mapping* Khama Maiti, Chris Dysart, Alex Lebas, Lloyd Samaniego, Hasanah Shamsuri, Ahmad Muzammil & Filippo Derosa, Monaco Engineering Solutions, UK	*Practical Experience of Rolling out Process Safety Competency Assessments Across a Large Multinational Company* Graeme Ellis, Matthey, UK
16:15–16:40	*A Case Study of The Halo and Safety Culture in Motorsport* Andrew Laird & Dr Esther Ventura-Medina, University of Strathclyde, UK	Facilitated discussion	*Evaluation, Visualisation and Monitoring of Cumulative Risk Exposure Resulting from Safety Critical Hardware and Human Barriers Deviation* Tayo Olunsanya, Olu Adeyemi & Seyi Olusanya, Melios Ltd, UK	Facilitated discussion	*Linking Critical Competencies with Major Accident Hazards* Chris Proud, Andrew Lawson & Luke Butcher, ESR Technology, UK; Andy Brazier, AB Risk, UK
16:40–17:15	Facilitated discussion		Facilitated discussion		Facilitated discussion

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IChemE ADVANCING CHEMICAL ENGINEERING WORLDWIDE

Wednesday 17 November 2021

Hazards31

All times are Greenwich Mean Time (GMT)

09:30–10:25	**Plenary speaker**	*Keeping Risk in Perspective: Learning to Manage Black Swan Risks* Professor Atula Abeysekera, Imperial College London

	Lessons Learned from the COVID-19 Response II Session chair: Ken Rivers	Environment Session chair: Tony Clayton	Human Factors Session chair: James Birch	Process Safety Management Session chair: Laurence Cusco	Pressure Relief Session chair: Caroline Ladlow
10:30–10:55	*LOPA Versus Covid – Return to Sustainable Living* Ali Mokhber, Shivani Aggarwal & Pablo Garcia-Trinanes, University of Greenwich, UK	*Flood Risk Management – Are You Prepared?* Brad Eccles & Steve Fitzgibbon, ABS Consulting, UK	*The Impact of Cognitive Bias in Safety* Trish Kerin, IChemE Safety Centre, Australia	*Effective Field Engagement and Management of Higher Consequence Scenarios* Martin R Ovenden, ExxonMobil, UK	*Assessment of Operators' Response Time on Safe Operation of Distillation Columns: a Process Dynamic Analysis* Zalina Harun & Zulfan Adi Putra, Petronas, Malaysia ; Nik Abdul Hadi Md Nordin, Universiti Teknologi PETRONAS, Malaysia; Darmawan Ahmad Mukharror, PT Keselamatan Proses, Indonesia
11:00–11:25	*Lessons Learned and the Pros & Cons of Virtual HAZOP* Azzam Younes, AyEnergi Consulting, UK	*Guidance to Provide an Economic Value (or Series of Values) Which Can Be Applied When Undertaking a CBA Under Major Hazard Establishments for Environmental Purposes* Amaia O'Reilly, Energy Institute, UK	*Human Factors Issues in Turnarounds (TARs)* Jamie Henderson & Richard Marshall, Human Reliability, UK	*Applying Process Safety Experiences and Lessons Learnt to Achieve Improvements in Plant Up-Time and Stability of Production* Anees Iqbal Ansari & Mohammad Moonis, Pleiades Global, UK	*Mechanical Response of Shells to Tube Rupture in Shell-and-Tube Heat Exchangers* Colin Deddis, Greymore Engineering Services, UK; Mark Scanlon, Energy Institute, UK; Alan Clayton, Consultant, UK; Rob Kulka, TWI, UK
11:30–11:55	Facilitated discussion	*The Application of Satellite Data for Detection and Monitoring of Methane Emissions and the Integration Opportunities with Weather and Plant Sensor Data* Darren Steele, Stiperstone Analytics, UK & Dr Ian Spence, GHGSat, UK	*Managing Operator Fatigue – It's About More Than Just Sleep. Incorporating Lessons Learned from Offshore Wind into Process Safety in Onshore Major Hazard Facilities* Stefi McMaster, University of Hull, UK & Jenny Hill, RAS, UK	Facilitated discussion	*Detailed Analysis of Temperature and Pressure Behaviour During Reaction Runaway for Vent Sizing* Yuto Mizuta Turo, Motohiko Sumino, Hiroaki Nakata, Yuichiro Izato & Atsumi Miyake, Mitsubishi Chemical Corporation, Japan
11:55–12:30		Facilitated discussion	Facilitated discussion		Facilitated discussion

12:30–13:30	Break	
13:30–14:25	**Plenary speaker**	*Dropped in the Deep End – a Personal Senior HSE Management Journey* Terry Cooper, Offshore Petroleum Regulator for Environment and Decommissioning (OPRED), UK

	Identifying & Embedding Good Practice in Process Safety Session chair: Paul Kenny	Clean Technologies – Hydrogen I Session chair: Ashley Hynds	DSEAR Session chair: Andy Mackiewicz	Process Hazard Analysis Session chair: Diego Lisbona	
14:30–14:55	*The Message from Losses – What You Need to Know and Learn From to Prevent Major Accidents* Phil Hewer & Scott McNeil, Marsh, UK	*Hydrogen Projects – Business as Usual?* Clare Dunkerley, Otto Simon, UK	*Application of Functional Safety to a Burner Management System – How to Avoid Common Pitfalls* Michael Scott, aeShield, USA	*Latest HAZOP Practice* James Fairburn, Chevron, UK	
15:00–15:25	*Why Did They Do That? How To Conduct A Human Factors Incident Investigation* Steve Cutchen, retired Incident Investigator, Chemical Safety Board (CSB), USA	*Ammonia, Methane, Hydrogen Oh My! Understanding Hazards from Alternative Power to Gas Options* Darren Malik & Kelly Thomas, BakerRisk, USA	*The Role of an Innovative Approach to DSEAR in Accelerated Early Career Development* Rebecca Phillip & Adriana Reyes Cordoba, Atkins Global, UK	*Hazard Identification and Risk Assessment for Smaller Changes: Tips and Tools for Avoiding Misses and Improving Quality* Jody Olsen, JE Olsen Consulting LLC,USA	
15:30–15:55	*Embedding the Lessons of Hard Knocks–Trying Not to Repeat Our Mistakes Time and Time Again* Ken Patterson, Consultant, UK & Gillian Wigham, Synthomer, UK	*Developments and Uncertainties in Hydrogen Fuels Risk Assessment* Michael Moosemiller, Baker Engineering & Risk Consultants, USA & Rob Magraw, BakerRisk Europe, UK	Facilitated discussion	Facilitated discussion	
16:00–16:25	*Identifying and Embedding Good Practice in Process Safety – Safety Culture/Leadership* Peter Culbert, Exida, Ireland	*Quantification of the Risks Associated with a Hydrogen Gas Distribution Network* Andrew Phillips, Mike Acton & Ann Halford, DNV, UK; R Oxley & D Evans, Northern Gas Networks, UK			
16:25–17:00	Facilitated discussion	Facilitated discussion			

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IChemE Safety Centre

IChemE ADVANCING CHEMICAL ENGINEERING WORLDWIDE

Thursday 18 November 2021

Hazards31

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09:30–10:25	**Plenary speaker**	*Managing Cyber Security Risks: a Regulator's Perspective* Sarabjit Purewal, Health and Safety Executive, UK

	Digitalisation I Session chair: Matt Clay	**Clean Technologies – Other** Session chair: Rob Magraw	**Safety Culture II** Session chair: Trish Kerin	**Mist Hazards** Session chair: Diego Lisbona	**Risk Analysis** Session chair: Andy Crerand
10:30–10:55	*Best Practices to Optimise Management ofChange System and Manage the MOC Digital Transition* Hussain Alabduljabbar, Saudi Aramco, Saudi Arabia	*Managing the Major Accident Potential of Carbon Capture and Storage CO_2* Hamish Holt & Michael Simms, DNV, UK	*The Safety Culture of the Regulator* Marc McBride, Office for Nuclear Regulation, UK	*Demystifying Mist Explosion Hazards* Stephanie El–Zahlanieh, Idalba Souza Dos Santos, Hugo Tostain & Olivier Dufaud, University of Lorraine, France; Alexis Vignes, INERIS, France; Simon Gant, Health and Safety Executive, UK	*Preliminary Hazard Analysis and Mitigation for the Prevention of Catalyst Regeneration Vessel's Catastrophic Rupture* Manesha Thiyaga Rajan, Noor Arnida Abdul Talip & Hasnor Hassaruddin Hashim, Petronas, Malaysia
11:00–11:25	*Improving Loss Prevention in High Hazard Industries Through the Evaluation of Safety Culture and Error Traps from Structured and Unstructured Data Using Machine Learning* Gus Carroll & Dr Nyala Noe, Empirisys, UK; Dr Mike Orley, Centrica Storage, UK	*Smoke, Sparks, Flames or Explosions? An Experimental Study into How Lithium-ion Cell Failure Varies in Open Field* Katie Abbott, Jonathan Buston & Jason Gill, Health & Safety Executive, UK	*Leadership Matters – Real World Examples of Process Safety Leadership Good Practice* Ashley Hynds & Colin Chambers, WSP, UK	*Ignitability of Diesel Fuel Mists over a Vertical Distance* Louise O'Sullivan & Dr Richard Bettis, Health & Safety Executive, UK; Dr Anthony Giles, Cardiff University, UK	*New International Failure Frequency Database for High Pressure Gas Installations* Mike Acton, C Humphreys & Z Wattis, DNV, UK; H Olafsen, Energinet, Denmark
11:30–11:55	*Cyber Attacks on Process Plants and Understanding What is Needed* Clive de Salis, Dekra, UK	*Experimental Understanding of Displacement and Forces Generated Due to Swelling During Lithium-ion Pouch Cell Failure* Gemma Howard, Jason Gill & Jonathan Buston, Health & Safety Executive, UK	*From Zero Accidents to Safe Sustainable Production* Urbain Bruyere, Environmental Resources Management (ERM), UK	*Flammability Testing for Heavy Oil Mists* Hannes Engel, Gexcon, UK	*Assessing the Risks When Expanding Process Plants or Building New Units on Compact Sites* Robert Canaway, Suregrove, UK
11:55–12:30	Facilitated discussion	Facilitated discussion	Facilitated discussion	Facilitated discussion	Facilitated discussion

12:30–13:30	Break

13:30–14:25	**Plenary speaker**	*Engineering X Safer Complex Systems – Learning Through Case Studies* Professor Brian Collins CB, UCL, UK & Dr Steve Gwynne, Lund University, Sweden

	Digitalisation II Session chair: David Hatch	**Clean Technologies – Hydrogen II** Session chair: Andy Crerand	**Fire and Explosion Hazards** Session chair: Chris Tighe	**Case Histories** Session chair: Zsuzsanna Gyenes	
14:30–14:55	*Treating Data as an Asset – Experiences of the Early Adopters* Brad Eccles, ABS Consulting, UK; Henrique Paula, Steve Arendt & Matt Mowrer, ABS Group, USA	*Review of the Current Understanding of Hydrogen Jet Fires and the Potential Effect on PFP Performance* Michael Johnson & Robert Crewe, DNV, UK; Graham Boaler & John Evans, Thornton Tomasetti, UK	*Fight or Flight: What's your Fire Response?* Kristen Graham & Karen Vilas, Baker Engineering & Risk Consultants, USA	*Human-Factors and Automation-Related Accidents in the Railway Industry* Mona Ahmadi Rad, Lianne M Lefsrud, Michael Hendry & Daniel Blais, University of Alberta, Canada	
15:00–15:25	*Using Artificial Intelligence and Machine Learning Techniques to Analyse Incident Reports* Fereshteh Sattari, Daniel Kurian, Renato Macciotta & Lianne Lefsrud, University of Alberta, Canada	*Maximum Overpressure and Flame Velocity of Methane/Hydrogen Layers Vented Deflagrations in a Large-Scale Enclosure* David Eduardo Torrado Beltran, James Fletcher, Andrew Tooke & Philip Hooker, Health & Safety Executive, UK; Thomas Isaac, Progressive Energy, UK; Dave Lander, Consultant, UK	*SafePool* Seckin Gokce, Ahmet Can Serfidan, Eyup Azizoglu & Gokhan Gedik, Tupras, Turkey	*Investigating Unusual Powder Decomposition Incidents* Stephen Rowe, Clive de Salis, Simon Gakhar & Andrew Jennings, Dekra Organisational & Process Safety, UK	
15:30–15:55	*Practical Guidance for Applying Data Science Techniques in Health & Safety* Scott Kimbleton & Graziella Caputo, IBM, USA	*Assessment of Enclosure Ventilation Safety for Hydrogen Fuelled Gas Turbines* Tristan Vye & Aidan Wimshurst, Frazer Nash Consultancy, UK	*The Use of Ester Based Transformer Liquids for Reduced Fire Risk and Lower Costs* James Reid, M&I Materials, UK	*Investigation into a Microbiologically Induced Corrosion (MIC) Failure of an Onshore Pipeline* Keith Birkitt, Aneta Nemcova & Ian Chapman, Health & Safety Executive, UK	
16:00–16:25	*How is Cybersecurity Changing Process Safety?* Patrick O'Brien, exida, USA	*The Use of CFD for the Design of Hydrogen Bulk Storage Areas* Michael Bristow, Pablo Giacopinelli, Graham Morrison & Gary Pilkington, Gexcon, UK	Facilitated discussion	Facilitated discussion	
16:25–17:00	Facilitated discussion	Facilitated discussion			

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ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

Sistema Nazionale per la Protezione dell'Ambiente

Hazards31. IChemE

16-18 November 2021, Virtual conference

Analysis of Losses. 16/11/2021

Analysis of accidents and good inspection practices for the management of ageing of industrial plants

Romualdo Marrazzo

Service for Risks and Environmental Sustainability of Technologies, Chemical Substances, Production Processes and Water Services and for Inspections (VAL-RTEC)

ISPRA - Italian National Institute for Environmental Protection and Research

The role of ISPRA for industrial control

- ISPRA has a national role as a technical body supporting the Ministry of Environment in the national implementing of the Seveso Directives for the prevention of major accidents
  - 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)

Program and themes

1. **Introduction**
2. **Industrial accidents and plant aging**
3. **Italian law, national standards and guideline**
4. **An approach to good practices**
5. **The analysis of inspections**
6. **Conclusions**

- Introduction and background
- Risks related to ageing

1. Introduction

Introduction and background

- The Italian implementation of the Seveso III directive (2012/18/EU) is the D.Lgs. 105/2015, aiming at the prevention of major accidents involving dangerous substances
  - Site Operators are obliged to take all necessary measures to prevent major accidents a/o limit their consequences for health and environment
  - Depending on the amount of dangerous substances present, establishments are categorized in lower and upper tier

Control of the risks related to ageing

- As part of the implementation of the Safety Management System for Prevention of Major Accident (SMS-PMA), the D.Lgs. 105/2015 imposes
  - Monitoring and control of risks related to ageing of equipment and systems that can lead to loss of containment of hazardous substances, including the necessary corrective and preventive measures

- Ageing mechanisms as potential contributors
- Some national cases

2. Industrial accidents and plant aging

Ageing mechanisms as potential contributors

- Main results of the analysis of some industrial accidents, which recently occurred on the national territory at "Seveso" establishments (refineries and chemical plants), identified
  – Mechanisms related to aging, as significant causes, both in technical and organizational terms

Fire and explosions in piping

Description	Causes	Actions	Expected/Planned
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** belonging to different operators and then **a series of explosions** (Domino Effect)	**Age (over 25 years)** and state of preservation of the **pipe** in relation to the **progressive corrosion** phenomena, which led to the pipe drilling	**Visual inspection** and **basic design** of corrective actions. Necessary **reconstruction** activities.	Specific **risk analysis**. Planned and/or **required compliances** following Competent **Authorities** examination. Check of the **pipeline inspection plan**

Leakage through the tank bottom

Description	Causes	Actions	Expected/Planned
Leakage of **oil** through a large **lesion** at the **bottom** of a floating roof **tank** and subsequent **release of the total amount** of oil inside the containment **basin**	High **corrosion** and **deteriorated** area	Tank **insulation**. **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



Spill of sulphuric acid from a supply pipe in an underground channel

Description	Causes	Actions	Expected/Planned
A **spill** occurred in the **buried channel** housing the **pipeline connecting 6 storage tanks** of sulphuric acid. This spill of **H_2SO_4 in the subsoil** caused the structural **failure of one tank** and the relative **rotation of the base** of the containment **basin**	Advanced **corrosion** in a section of this **pipeline not accessible** to the controls. It has been supposed a **duration of the spill** in the subsoil of about **40 days**, for a total of H_2SO_4 spilled from the pipe equal to **about 45 t**	H_2SO_4 **tank emptied** of the product. Supply **lines intercepted** and further **tank isolated**. Monitoring and **verification of the deformation** of structures. The **perimeter wall** of the containment **basin** has been **reinforced**, in order to ensure the seal of the basin itself	Scheduled **maintenance on H_2SO_4 tanks**. **Monitoring of corrosion** of these tanks and of the loading pipes, for the **calculation of the corrosion rate** in the short and long term and of the **residual life** (new procedure)

Presence of diesel in piezometers near a storage tank

Description	Causes	Actions	Expected/Planned
Following the **sampling at 2 piezometers**, located near a **storage tank** containing **diesel**, the presence of a **supernatant hydrocarbon** product of the same type in the tank was found. Spill of about **1000 cubic meters of diesel in the subsoil**, following a **leak** from a storage tank	**Corrosion in the single bottom** of the tank, although this had been subject to **maintenance work on the bottom in the previous 2 years** (application and welding of **overlapping sheets** on the existing bottom)	Construction of a **draining trench** north of the tank and commissioning of **new piezometers**. Update of the **operational protocol** for the hydro-chemical and piezo-metric **monitoring of groundwater**	Implementation of the **double bottom on all tanks of hydrocarbon** products, with **viscosity** lower than 12 ° E at 50 ° C, with a single bottom. **Review of the aging management program** of the tanks

- National and technical standards
- Supporting for ageing evaluation

3. Italian law, national standards and guideline

National and technical standards

- Tools for the implementation of an effective SMS (UNI 10617, 10616, 10672, 1226)
  - "State of the art" in the D.Lgs. 105/2015 and meet the requirements of the law and the ISO standards
- Technical standards, specific for pressure equipment (UNI/TS 11325-8, 11325-9)
- Risk Based Inspection (RBI) and Fitness For Service (FFS) methodologies
  - A targeted planning of maintenance operations and accurate monitoring

Supporting for ageing evaluation

- Development of a method for a base evaluation of the adequacy of ageing consideration in the frame of the asset integrity management
  - It is useful for site managers (qualitative assessment) and for inspectors (evaluation of the implementation)
  - Role of Public Administration in addressing the control of risks associated with aging

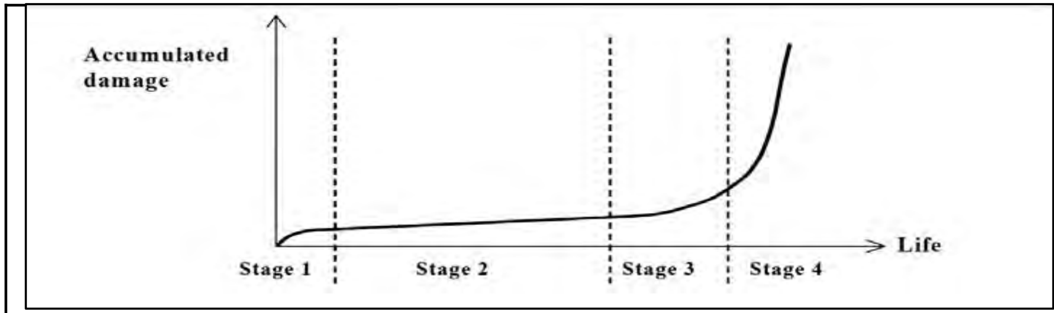
- Implementation of maintenance standards
- Influence of ageing on equipment
- The primary containment system

4. An approach to good practices

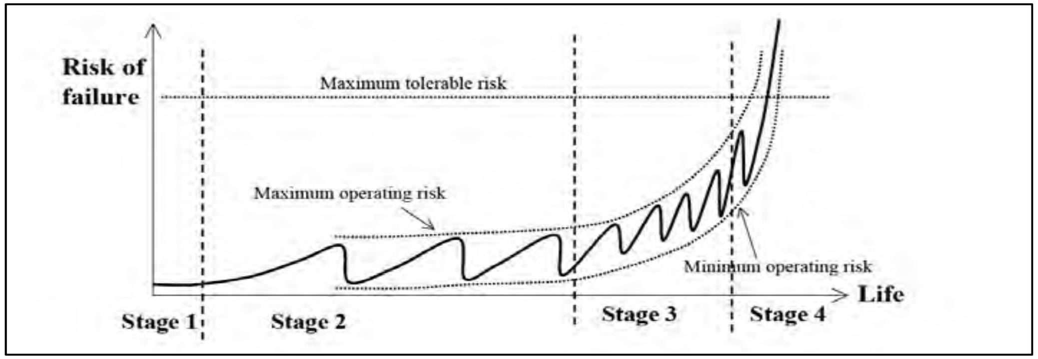
Implementation of maintenance standards

- Preventive, scheduled, or corrective maintenance of critical equipment or lines may be performed in accordance with the Risk Based Maintenance (RBM) Policies/Practices
  - They shall minimize the risk of loss of functionality
- Ageing is not strictly related to the age of the equipment, but to its changes over time
  - It can lead to significant deterioration and/or damage to initial conditions, compromising functionality, availability, reliability and safety

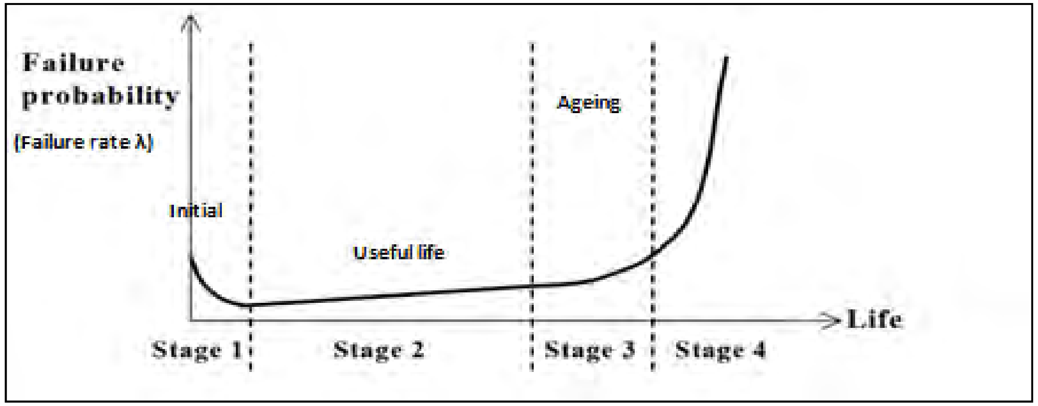
Influence of ageing on equipment



Variation of accumulated **damage during the service**



Effect of **periodic maintenance** on the risk of failure, varying **between tolerable risk and operating risk**



Model for the **probability of failure** of a population of equipment: the **"bathtub curve"** shows the typical **four stages of the progressive ageing**

The primary containment system

- A possible approach to ensure mechanical integrity
  i. Defining the degradation mechanisms
    - ✓ *Corrosion / Mechanisms not related to corrosion*
  ii. Defining and personalizing inspection technologies
    - ✓ *Liquid penetrant testing / Magneto-scope test / Vacuum box test / Ultrasonic (long range) / Spark test / Acoustic Emissions*
  iii. Determining the frequency of inspections
    - ✓ *Construction / Repair techniques and materials / Stored product / Previous inspection / Corrosion rates / Corrosion prevention systems / Potential contamination / Double bottoms or other systems / Leak detection systems with operating tanks*
- In addition, the "Management of Changes" is crucial
  – It is important to keep records of the operating history and problems encountered during the life

- Non-compliances found on SMS

5. The analysis of inspections

Non-compliances found on SMS

- The main findings of the inspections on the SMS, conducted in the last three years in Italy
  - Critical issues emerged regarding the aging and asset integrity problems of industrial installations
    - ✓ *Need to consider and analyze the problems of ageing (corrosion, erosion, fatigue) of equipment (no procedure)*
    - ✓ *No evidence of a plan for monitoring the ageing, unless it is in accordance with law obligations*
    - ✓ *Developed a well-structured Asset Integrity Management procedure, but partially implemented (no evidence)*
    - ✓ *Lack of a specific procedure containing: Analysis of degradation mechanisms; A fixed-term monitoring plan; Preventative and corrective actions*

- Risks of plant ageing and SMS implementation

6. Conclusions

Risks of plant ageing and SMS implementation

- Plants are subject to degradation phenomena and the effects of operational changes
  - It is useful to know the performance decay rates to plan adequate maintenance activities, and to identify the most suitable NDTs for assessing the damage
- The correct implementation of the SMS plays a considerable role, in order to ensure safe operational continuity of equipment
  - The RBI and FFS methodologies can constitute a valid response in the management of asset integrity issues and its correlation with aging phenomena

Questions…???...

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Thanks for the attention!