European Commission

JRC WEBINAR REPORT

Ageing and Primary Containment Maintenance on Seveso and other Hazardous Sites

Summary of webinar organised with the EU Technical Working Group on Seveso Inspections, 8 February 2022

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Foreword

This report summarizes the contents, discussion and survey results of a webinar on Ageing and Primary Containment Maintenance on Seveso and other Hazardous Sites, organised by the Major Accident Hazards Bureau of the EC-Joint Research Centre with the EU Technical Working Group for Seveso Inspections (TWG 2). The webinar was held virtually from the Joint Research Centre of the European Commission in Ispra on 8 February 2022.

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Authors

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Abstract

On 8 February 2022, on behalf of the EU Technical Working Group for Seveso Inspections (TWG 2), the Major Accident Hazards Bureau of the European Commission's Joint Research Centre organised a webinar on Ageing and Primary Containment Maintenance on Seveso and other Hazardous Sites. The purpose of the webinar was to present two recent TWG 2 publications supporting inspection of ageing and maintenance programmes on hazardous sites to Seveso and other hazardous site inspectors in EU, EEA, Enlargement and Neighbourhood countries. The webinar also included presentations on good practices and case studies from industry and Member States to illustrate the importance of the topic and provide additional insights on inspection and enforcement strategies. The webinar had an audience of over 280 participants from 21 EU and EEA countries and six EU Enlargement/Neighbourhood countries. This report summarises the presentations and main highlights of the webinar.

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1 Introduction: background and purpose of the webinar

Under the Seveso Directive, EU Member States and European Economic Area (EEA) countries are required to inspect Seveso sites within a certain time period [1]. Inspection, and follow-up enforcement actions that might ensue, is one of the most powerful oversight mechanisms available to competent authorities. The task of the inspector is to confirm that the site has demonstrated compliance with the Directive, in particular, the general obligation that the operator has taken "all necessary measures to prevent major accidents and to limit their consequences for human health and the environment". The inspector must be convinced that the site operator understands the chemical hazards present on the site and their risk potential, that the operator has accordingly established appropriate control measures to prevent and mitigate potential accidents related to these hazards, and that the operator has a safety management system in place that ensures these control measures operate as intended and are improved over time based on new information resulting from change or feedback from the system.

More than 100 types of diverse industry activities fall under the Seveso Directive and the diversity and number of substances that represent a potential accident risk are higher still. For this reason, for nearly two decades the EU Member States have provided strong support to an EU level technical exchange associated with Seveso inspection, managed by the JRC's Major Accident Hazards Bureau (MAHB). MAHB runs two related activities supporting the implementation of Seveso inspection obligations of Seveso implementing countries (which includes also EEA countries, Norway and Iceland). These activities include the Technical Working Group on Seveso Inspections (so-called "TWG 2") and the Mutual Joint Visit Workshop Programme for Seveso Inspectors (the "MJV Programme"), that is managed by MAHB in consultation with TWG 2. The exchange of information that takes place within these two activity spheres relates both to good inspection and enforcement practices as well as to good risk management practices that should be observed on Seveso and other hazardous sites.

In order to support the exchange of information annual meetings (either physical or remote) are being held among the TWG 2 and interested parties, where a thematic area is being discussed in order to communicate the most recent good practices on inspection strategies and establish a firm support network towards efficient risk management on hazardous sites.

The latest webinar held on February 8, 2021, was organised around the linked topics of ageing and maintenance on hazardous sites. Representatives from EC-JRC and the Center for Chemical Process Safety (CCPS) moderated the webinar and presented two recent publications of the TWG 2 for Seveso inspectors on this topic. Speakers from Germany, Italy, France, Hungary, and Norway made additional presentations of good practices and cases studies demonstrating the importance of the main theme to chemical accident prevention or giving examples of strategies for inspecting the ageing and maintenance programmes of hazardous sites.

The webinar was divided into three sessions: 1) TWG 2 Seveso Inspection publications on Ageing and Primary Containment Maintenance, 2) Practices and perspectives in the EU Member States, and 3) Inspection experiences on hazardous sites. In-between each session participants had the chance to discuss further and provide examples of their experiences on ageing inspection. Finally, at the end of the webinar, an online survey was conducted to evaluate the participants' satisfaction but also to allow participants to express their reflection on webinar's key takeaways and future thematic areas to address.

2 Agenda and format

The Major Accident Hazards Bureau, along with the support of TWG 2 and CCPS aims to bring together experts in Seveso inspections, and more specifically addressing strategies on ageing inspection and maintenance of primary containment systems within hazardous sites.

Table 1 shows the detailed agenda of the day, which lasted from 13:00 to 17:00 CEST. All speaker's presentations are available on the MAHB Minerva portal:
https://minerva.jrc.ec.europa.eu/en/shorturl/minerva/webinar_on_ageing_and_maintenance

Table 1. Webinar agenda

Time	Speaker	Content
Moderator: Maureen Wood, EC-JRC-MAHB Co-Moderator: Charles Cowley, CCPS		
Introductory Session		
13:00	Maureen Wood, EC-JRC	Welcome to the Webinar
	Charles Cowley, CCPS	Introduction to the Programme
Session 1. TWG 2 Seveso Inspection publications on Ageing and Primary Containment Maintenance		
13:10	Charles Cowley, CCPS	Summary of the Good Practice Report on Risk Management and Enforcement on Ageing Hazardous Sites
13:30	Maureen Wood, EC-JRC	Summary of the Common Inspection Criteria on Maintenance of Primary Containment Systems
Session 2. Practices and perspectives in the EU Member States		
13:50	Mark Hailwood, LUBW Baden-Württemberg, Germany	What is Ageing on a Hazardous Site?
14:10	Romualdo Marrazzo, Environment Agency (ISPRA), Italy	Analysis of accidents and good inspection practices for the management of ageing of industrial plants in Italy
14:30	Thibaut Marty, Ministry of Environment, France	National strategy on ageing and maintenance
14:40	Gauthier Vaysse, Ministry of Environment, BARPI	Ageing and maintenance – Recent accidents and near misses
14:55	Break	
15:15	Discussion and examples from authorities	

Time	Speaker	Content
Moderator: Charles Cowley, CCPS Co-Moderator: Maureen Wood, EC-JRC-MAHB		
Session 3. Inspection experiences on hazardous sites		
15:30	Fausta Delli Quadri, Environment Agency (ISPRA), Italy	Inspection experiences on ageing infrastructure and equipment control: case studies
15:50	Ivan Domjan, National, Directorate General for Disaster Management, Hungary	Hungarian evaluation method for the multi-aspect aging phenomenon
16:10	Vibeke Henden Nilssen, Directorate of Civil Protection (DSB), Norway	Ethylene gas release at a LDPE plant
16:30	Jasmin Pervaz, Bezirksregierung Arnsberg, Germany	Quick and unexpected ageing as a consequence of poor management of change *(Presentation not available to the public)*
16:50	Discussion and examples from authorities	
End of webinar		

All the presentations were given live while all Q&A sessions were conducted with the remote participation and replies of the experts.

3 Attendance

284 participants from 27 countries attended the webinar from various national organisations. Below are listed the details of the attendees (See Table 2.):

Table 2. List of attending counties and organisations

Country/Organisation	Participants
Germany	44
Croatia	27
Denmark	27
Sweden	23
Hungary	19
Austria	16
Belgium	15
Latvia	12
Lebanon	11
Ireland	10
Norway	9
Estonia	7
Ukraine	7
Cyprus	5
Czech Republic	5
Finland	5
Israel	5
Italy	5
Moldova	5
Serbia	5
Slovakia	5
European Commission	4
Palestine	3
AICHE - CCPS	2
Bulgaria	2
France	2
Netherlands	2
Lithuania	1
Malta	1
Total	284

A list of all stakeholders, authorities and organisations per country is available in Annex A.

4 Overview and key messages from the webinar

The webinar was divided into 3 sessions with a total of 10 speakers sharing their experiences and good practices on ageing inspection. Thematic areas included:

- Overview of available guidance resources - TWG 2 Seveso Inspection publications on Ageing and Primary Containment Maintenance
    - Good Practice Report on Risk Management and Enforcement on Ageing Hazardous Sites
    - Common Inspection Criteria on Maintenance of Primary Containment Systems
- Practices and perspectives in the EU Member States
    - Understanding what ageing is on a hazardous site
    - Accidents analysis and good inspection practices on management of ageing of industrial plants in Italy
    - National strategy on ageing and maintenance in France
    - Recent accidents and near misses related to ageing and maintenance
- Inspection experiences on hazardous sites
    - Case studies on inspection experienced on ageing infrastructure and equipment control
    - Multi-aspect aging phenomenon; the Hungarian evaluation method
    - Case study: Ethylene gas release at a LDPE plant
    - Quick and unexpected ageing; a consequence of poor management of change[1]

4.1 Overview of JRC technical resources – TWG 2 Seveso Inspection publications on Ageing and Primary Containment Maintenance

Within this session speakers presented an overview of the JRC's technical publications on ageing and maintenance of primary containment systems, currently available at the EC-JRC MAHB Minerva portal. Common inspection criteria series have been developed by EU Seveso inspectors to aid in sharing of good enforcement and risk management practices for the control of major industrial hazards in Europe and elsewhere. Common Inspection Criteria are produced by a team of Seveso inspectors from different EU and EEA countries based on the experiences and effective approaches used in their countries.

Similarly, the Good Practice Report is the product of exchanges that take place during the annual Mutual Joint Visit workshops for Seveso Inspections. MJV workshops have been, organised by the European Commission's Joint Research Centre with the TWG 2 since 1999, on a topic chosen for its importance and relevance for current challenges in the EU Member States and EEA. The Good Practice Report transforms the presentations and discussions into a technical document of good practices for conducting Seveso inspections on the topic.

To facilitate easy incorporation of the material into a site inspection, both the Common Inspection Criteria and the Good Practice Report contain a set of readily available tools for inspectors, such as checklists and sample inspection agendas.

4.1.1 Summary of the Common Inspection Criteria on Maintenance of Primary Containment Systems

The purpose of the Common Inspection Criteria on Maintenance of Primary Containment Systems [2] is to support EU Seveso Inspectors in verifying that an operator of a hazardous site has established a programme that is sufficient to control this type of risk. Good practices in managing maintenance of primary containment systems can help minimise the risk of loss of primary containment of hazardous materials (liquid leaks and gas releases) that could lead to a major accident. The CIC describes primary containment systems as the subset of safety critical elements (SCEs) that form the hardware components of preventive barriers, such as:

[1] This presentation is not available for distribution.

Table 3. Technical and organisational measures to support inspections of ageing and maintenance of primary containment systems [2] [3]

Technical	
Maintenance programme strategy; *Optimize systems and process to ensure that equipment in operation is always fit for service and that degradation does not happen faster than it should.*	Asset registry with SCEs tag numbers, locations, operating limits, etc.
	Degradation mechanisms for each SCE
	Preventive maintenance plans
	Quality management protocols
	Records of all preventive and reactive maintenance
	Documentation justifying each SCE in-service
Operator inspection programme; *To have a documented inspection plan defining inspection intervals for each SCE.*	Risk-based periodic examination and assessment plan
	Established inspection intervals
	Systematic process and documentation for routine inspections of SCEs
	Involvement of the necessary competences in inspection of various SCEs
	Records of all examinations and assessments of each SCE
Competence of maintenance staff – including contractor personnel	Defined roles, responsibilities, accountability, authority and interrelation of all people
	Defined competence requirements of maintenance staff
	Records of competence assessments and skills development of maintenance personnel
Safe systems of work, integrating human factors good practice; *Standard safety practices are followed in all aspects of the maintenance work.*	Safe working practices, clear and accessible procedures and records for each job, developed with task performers
Organisational	
Define responsibilities and accountability, systems and processes for achieving the maintenance programme goals	Assignment of clear overall responsibility for asset integrity of the establishment to communicate, facilitate and ensure effective implementation
	Demonstration of compatibility and coherence with the safety management system
	Monitoring and oversight of asset integrity and maintenance operations

- Pressure vessels
- Atmospheric storage thanks
- Rotating equipment
- Piping systems and pipelines
- Technology specific containment systems (e.g., driers, condensers, refrigeration systems, etc.)
- Including all the subcomponents (valves, gaskets, flanges), supporting and connection structures, and relief systems.

Criteria focus on both technical and organisation measures to effectively support inspections:

4.1.2 Summary of the Good Practice Report on Risk Management and Enforcement on Ageing Hazardous Sites

The JRC Good Practice Report [3] covers all aspects of a hazardous site that may degrade due to forces of time or age prematurely due to excessive wear and tear. Ageing does not affect only "older sites", but "young" too, especially when maintenance and operation is not handled properly, management of changed is not addressed or due to misidentification of design or construction flaws. Control measures for ageing risk factors, should include: i) Asset integrity management of safety critical elements (SCEs), ii) Leadership and governance, iii) Use of available technical references (i.e., Common Inspection Criteria). Table 3 shows the breakdown of the components of a strategy for controlling risks on ageing hazardous sites as presented in the JRC Good Practice Report.

Ageing is not only about corrosion; other forms include:

Plant and equipment degradation

An efficient strategy towards plant and equipment degradation should take into account the identification of all SCEs using risk-based approach, maintenance and update of an asset register with all SCEs, their operating limits and minimum performance criteria while taking into account equipment-specific degradation mechanism and monitoring degradation rates.

Obsolescence of technology and procedures

Inadequate design should be addressed by routine plant design reviews against current standards. SCE procurement strategy should also include a routine review of availability and quality management of all parts and technical support. The frequency of the reviews should be determined on a risk basis.

A document management system for all safety-critical documentation should be in place to address ageing risks related to information sharing, auditing or procedures or incomplete/incorrect documentation.

People and organisation

Changes in ownership, loss of personnel or increased reliance on contractors are some of the organisational management of change aspects that should not be overlooked. Efficient resources management of safety critical roles such as plant operators, first line supervisors, operations managers along with effective leadership and governance are important to address ageing risks related to people and organisation.

Cybersecurity

Industrial automation and control systems (IACS) are increasingly web-dependant, thus susceptible to cyber-attacks while IT systems tend to age more rapidly than physical infrastructure. Addressing cyber threats efficiently requires effective management of IACS and IT integrity within the safety management system, but also reviewing IT-related systems to identify weaknesses and cyber-attack vulnerabilities.

4.2 Practices and perspectives in the EU Member States

An introduction of the definition of ageing on hazardous sites by a representative of Baden-Württemburg was presented during this session along with inspection practices and experiences of Italy and France. Outcomes of investigations on recent accidents and near misses related to ageing and maintenance issues were also presented.

4.2.1 What is Ageing on a Hazardous Site?

To establish effective control measures to manage ageing on a hazardous site, it is important to understand what is meant by ageing in this context and how it affects risk management. [6] Ageing can be described as the change in performance over time. It can have diverse effects on:

- Plants from mechanical (e.g., tanks, pipes, pumps, etc.) and civil engineering systems (concrete bunds, bridges, supports, etc.) to electrical/electronic systems (cables, switches and circuit boards, solder joints, etc.)
- Processes including procedures, documentation, communication, and software.
- People depending on the age of the workforce, knowledge, competence, and skills.

Management of ageing should be taken into consideration throughout the plant's lifecycle:

- Expected operating life and operating conditions should be assessed during the design phase.
- Validation of construction according to design and assessment of possible changes affecting the operating life-span should be taken into account during the commissioning stage.
- During the operation stage validation of the process intent (design) against operation is required. Moreover, possible deviations affecting the life-span should be assessed and proper inspection and maintenance need to be carried out, establishing maintenance and inspection records.

Since ageing cannot be prevented or eliminated completely, appropriate tools to support the management of ageing have to be deployed on a systems-based approach. These tools include:

- Managing obsolescence by assessing, as early as possible, the need to replace whole systems or pieces of equipment when they can no longer be maintained
- Adhering to the design specifications
- Following and reviewing (if necessary) the operating procedures
- Establishing inspection documentation and maintenance records
- Managing changes efficiently (MOC)
- Practicing systematic hazard identification and risk assessment (processes and results)
- Supporting training and information exchange (learning organisation)
- Involving workforce

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

The analysis of recent industrial accidents that occurred within the Italian national territory at "Seveso" establishments (refineries and chemical plants), provides insight on mechanisms of aging, both in technical and organisational terms, that can contribute to accident occurrences. [8] In particular, over time hazardous sites experience degradation in infrastructure and equipment These phenomena ultimately may change operating conditions on which risk controls are based.

Findings from the accident analysis confirmed that:

- Hazardous sites should analyse and document performance decay rates in order to plan adequate maintenance activities and identify the most suitable NDTs for assessing the damage.
- The importance of establishing an ageing management programme within the safety management system to ensure safe operational continuity of equipment.
- Asset management necessitates proactive prevention strategies, such as the application of risk-based inspection (RBI) and fitness for service (FFS) methodologies to establish inspection and maintenance schedules.

- Management of Change, a core element of the safety management system, is crucial, and requires that sites keep good keeping records of the operating history of critical safety equipment, including problems encountered over the life time.

The Italian legislation implementing the safety management system (Annex III of the Seveso Directive) specifically obliges Seveso sites to monitor and control risks related to ageing of equipment and systems that can lead to loss of containment of hazardous substances.. To support implementation of this legislation, the inspection authorities have developed a method for evaluating the adequacy of ageing consideration in a site's asset integrity management programme. Findings from inspections confirm that having a proactive and knowledge-based programme for managing mechanical integrity can prevent chemical incidents.

A possible approach to assuring mechanical integrity of critical safety assets could include:

- Defining the degradation mechanisms, including corrosion and other degradation mechanisms not related to corrosion
- Defining and assigning individual inspection technologies as appropriate to the equipment, such as liquid penetrant, magneto-scope, vacuum box, ultrasonic (long range), spark and acoustic emissions tests
- Determining the frequency of inspections based on a number of influential factors, such as construction and composition, repair techniques and materials, product stored, previous inspection findings, corrosion rates, presence and level of corrosion, prevention systems in place, potential contamination sources, double bottoms or other protective measures, and leak detection systems.

4.2.3 National strategy on ageing and maintenance

France has established a national strategy and modernisation plan to address the challenges of ageing hazardous sites. [9] The general methodology includes:

- Establishment of critical equipment inventory that could lead to a major accident in case of failure
- Assessment of equipment's initial state accompanied by all relevant documentation (operating conditions, photos, monitoring, etc.)
- Development and implementation of routine and reinforced inspection programme to be conducted by plant operators.
- Establish and maintenance of database to record inspection results
- Carrying out maintenance and repair actions

The modernisation plan also has specifically addressed ageing in regulations.. As in Italy, the law requires hazardous sites to monitoring and maintenance of ageing equipment and to include and ageing management programme in the safety management system. In addition, specific legal requirements have also been established for aboveground storage tanks, pipelines and pressure equipment. National working groups consisting of inspectors, experts and competed authorities have also been organised to provide specific national guidelines for implementing elements of the modernisation plan, e.g., identification of relevant equipment, possible failures and degradations, monitoring frequency, etc.

French inspection campaigns carried out in 2013-2017 provided useful feedback; on degradation mechanisms and were constructive in improving management of maintenance programmes on hazardous sites. On the other hand, inspections found that technical documentation was not always available or complete. Often, benchmarking of the progress of ageing was hindered because the equipment's initial state had been poorly assessed. Moreover, sites exhibited a high reliance on third-party contractors for maintenance and performance of maintenance tasks did not always fully result in the corrective action needed.

4.2.4 Ageing and maintenance – Recent accidents and near misses

The French Ministry of the Environment also conducted an analysis of nearly 400 chemical accidents and near-miss incidents in which equipment corrosion and fatigue were a contributing factor. [10] The study highlighted the following common causal factors:

- Failure to anticipate or detect /fatigue in a timely manner (sometimes in spite of many 'warnings')
- Defective equipment or incorrect assessment of ageing vulnerabilities during verification campaigns
- Insufficient temporary repairs or facility renovation programs scheduled too late
- Challenges with the large number of devices or piping involved on large-scale industrial platforms
- Lack of awareness of the full range of degradation possibilities and failure to identify all factors capable of accelerating the deterioration process.
- Lack of attention to known vulnerabilities
- Accessibility of equipment can hinder control and maintenance efforts

Several good practices also emerged from analysing lessons learned from these incidents, including:

- The importance of staff awareness and involvement in the design of the modernisation programme
- The importance of having increased risk control measures before and after plant shutdowns and turnarounds because of potential stress on ageing components
- The need to have knowledge about the main equipment types on the site to help implement a preventive maintenance plan supported by an efficient parts replacement and management programme
- The role of timely and thorough inspections in anticipating and preventing ageing and failure of equipment

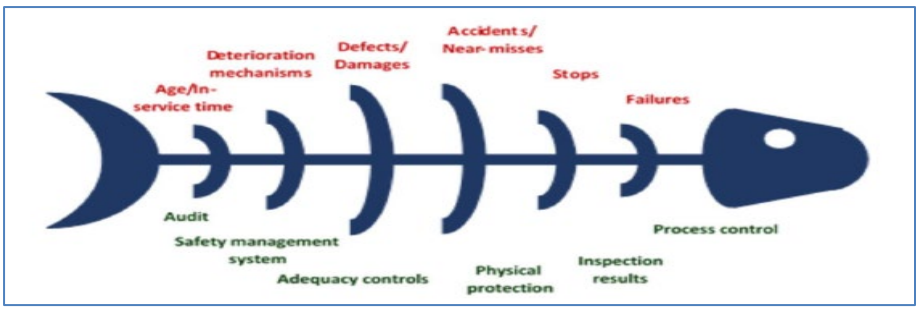
4.3 Inspection experiences on hazardous sites

Speakers from Italy, Hungary and Norway presented their in-depth inspection experiences on hazardous sites during this session.

4.3.1 Inspection experiences on ageing infrastructure and equipment control: case studies

ISPRA (Italy) uses the fish-bone methodology (see Figure 1) to evaluate ageing accelerating and retarding factors associated with chemical accidents where ageing equipment was a causal factor. Accidents caused by poor ageing assessment and management have found to often be a combination of the score marking the presence of acceleration factors (negative score) and retarding factors (positive scored) (see Table 4).

Figure 1 Fishbone diagramme from Italian study [4]



Some examples of accelerating factors and failures in retarding factors identified in the cases studies include:

- Microbially influenced corrosion (MIC)
- Pause in operation of the equipment (e.g., temporary shutdown)
- Material fatigue
- Failures in risk analysis as part of the SMS
- Failures in corrosion control
- Inadequacy of physical protection (e.g., double bottom vessel)
- Equipment defects and damage (e.g., production defect in equipment)
- Deterioration of equipment under mechanical stress
- Inadequacy of quality control

Table 4. Accelerating and retarding factors in ageing evaluation [4]

Accelerating factors include:	**Retarding** factors include:
• Age/In-service time • Deterioration mechanisms • Defects/Damages • Accidents/Near-misses • Stops • Failures	• Audits • Safety Management System • Adequacy controls • Physical protection • Inspection results • Process control

4.3.2 Hungarian approach for assessing the multi-aspect ageing phenomena

Hungarian Department for Hazardous Establishments of the National Directorate General for Disaster Management has established an assessment model in an attempt to address ageing and implement corrective and preventive actions. [5] To develop the model, Hungary applied recommendations and practices identified in JRC exchanges and publications on ageing as well as the Hungarian guidance for ageing assessment. The model is based on the structure of the Swiss-Cheese model classifying negative and positive scoring factors to determine the level of degradation and rectifying measures (see Table 5).

Table 5. Positive and negative factors in ageing assessment [5]

Positive factors include:	**Negative factors** include:
Available layers of protection • Physical protection • Process monitoring • Keeping procedures up to date • Corporate memory & knowledge management Offsetting negative changes • Condition monitoring and maintenance • Tracking of equipment condition changes over lifecycle • Maintenance personnel expertise	Initial condition • Age and operating time of equipment • Safety inspection findings Signs of negative changes • Marking and labelling • Intermodal pipelines, supplement power sources • Physical degradation Efficiency • Stops • Failures

The summary of the results for each assessment is represented in an evaluation matrix in order to determine the necessary measures; results are classified among five levels of severity:

i. Severe *(Effective countermeasures need to be put in place without delay)*
ii. Deteriorated *(Relevant countermeasures are recommended)*
iii. Neutral *(Aggravating is expected over time, so protection is recommended to be strengthened)*
iv. Appropriate *(Protection is currently compensating for degradation, although susceptible to change over time)*
v. Excellent *(Recommended to share good practices with other organisations and authorities)*

4.3.3 Ethylene gas release at a LDPE plant

Norway has developed lessons learned for risk management on ageing hazardous sites from a recent accident at an ethylene gas release on one of its Seveso sites. [7] In September 2021, a release of ethylene gas took place at a Low-Density Polyethylene (LDPE) plant in south Norway. The gas leak occurred from a manual valve on the bottom outlet line on a high-pressure vessel. Gas detectors gave the alarm, the fire brigade was notified, and the control room initiated the emergency shutdown. Most probably the leak occurred due to incorrect installation of the packing material installed in the valve stuffing box by the vendor. This probably weakened the packing's ability to withstand pressure. As escalating effects, the blocked flare system and difficulties in accessing the valve to the flare system led to the release of approximately 800kg of ethylene gas.

Inspection of the accident also revealed that there had been an alteration in the original design and functioning of the plant's emergency response system that was not taken into account in risk management. The system had been modified and modernised by the installation of a remotely controlled flare valve. The valve experienced malfunctions over several years due to the harsh production conditions of high pressure and extreme temperature ranges. Moreover, the automated remote control valve to the flare, that constituted the emergency shut down function for the process, was switched off when it was determined that a manual valve upstream from the flare value should remain in a permanently closed position to protect it from wear and tear. As a result, the remotely controlled flare valve was not functioning either. These changes were performed without assessing their impacts on risk management using a proper Management of Change process.

The main findings from the accident inspection were:

- The system for safe operation had a significant shortcoming in that a critical safety function had been disconnected and shut down for a long time.
- The system for managing temporary changes was deficient.

The following lessons learned from the investigation were highlighted::

- Ensuring packing material should be installed correctly from vendor and might require a review of installation procedures
- The closing of the manual valve that was upstream of the flare valve is not recommended for any reason. Suitable valve installation for the process conditions must be followed so that important functions are intact and operational.

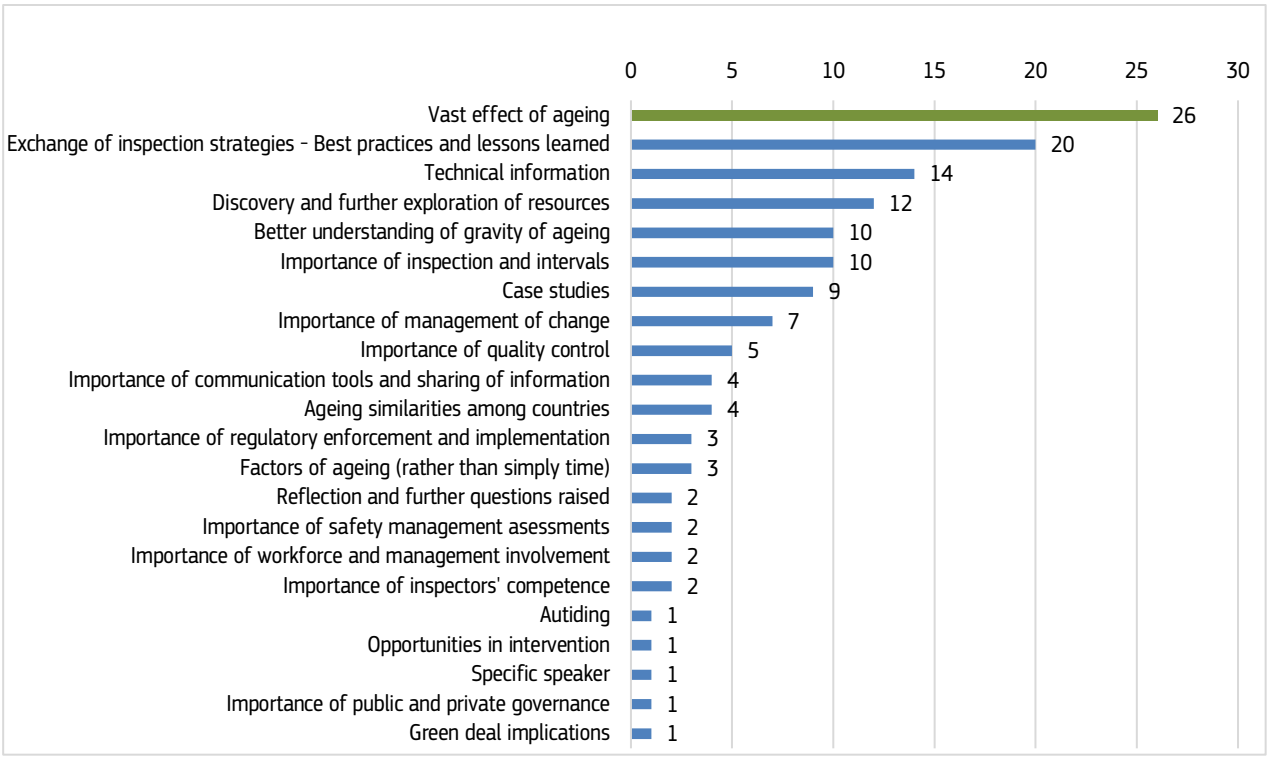
5 Survey and results

Shortly after the webinar, the participants were invited to provide their feedback on the webinar along with any reflections or recommendations. More than 50 attendees participated in the survey sharing which included four questions targeting the key takeaways for the attendees, possible questions on the matter and their suggestions for future webinars on other thematic areas. Participants were asked if they had any key takeaways or new information from the webinar. They also were asked whether they had additional questions that had could be explored in future.

5.1 Webinar key takeaways according to the survey participants

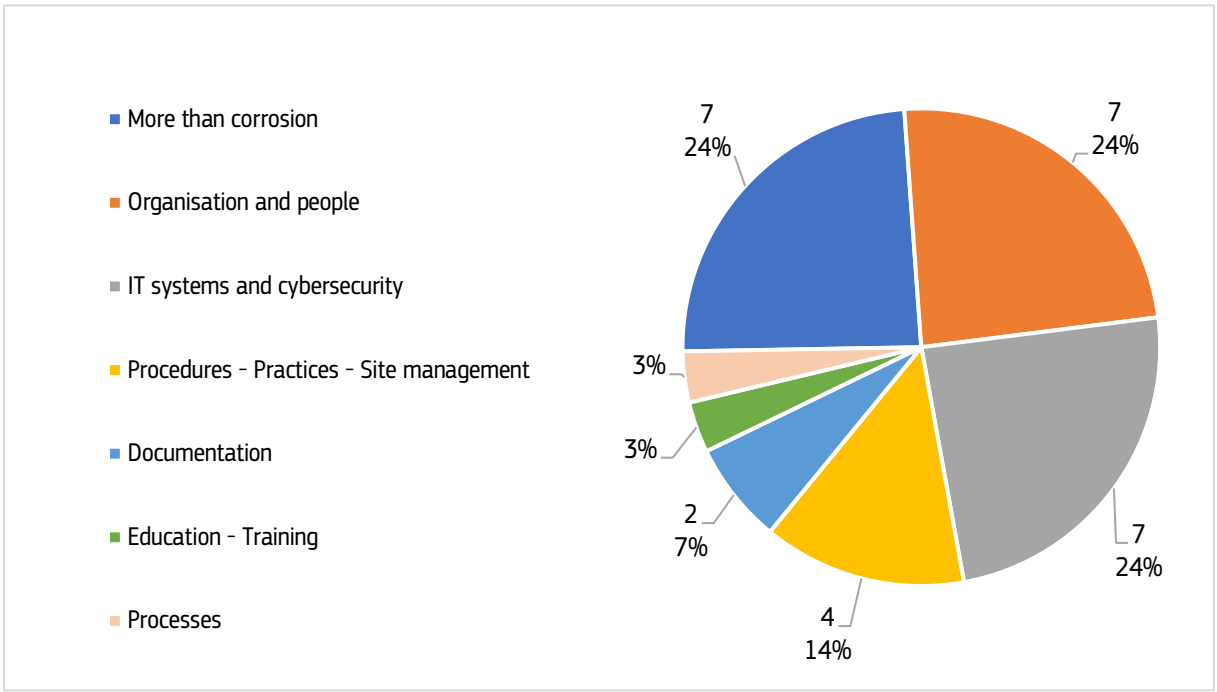
One of the most important takeaways as described by the survey participants was the understanding of ageing vast effects. As presented by the speakers, ageing is not simply related to corrosion and can affect more than just equipment, construction elements and the plant. Almost half of the survey participants (26 or 49%), identified that ageing can have diverse effects on plants as key takeaway of the webinar as shown in Figure 2 below.

Figure 2. Webinar key takeaways (N=53, combination of three entries per response)



Of the 26 participants acknowledging the vast effect of ageing, 23 (or 89%) classified this takeaway as quite important placing it first out of three responses. As stated, ageing can have serious effects on IT, people, organisation, cybersecurity and more acknowledging that it is not related strictly to equipment and material or associated only with corrosion.

Figure 3. Complexity of ageing effects as perceived by the attendees (N=26)



Attendees considered really important that other effects of ageing should not be overlooked. As shown in *Figure 3* seven of the 26 responses pointed that more issues than corrosion should be inspected, while seven more stressed the importance of ageing consequences on organisation and people; from loss of knowledge or loss of workforce to insufficient organisational recondition. IT systems and cybersecurity were deemed highly important areas of concern against ageing among the first responses too; 24% of the participants clearly acknowledged the necessity to keep all IT systems up to date, while establishing and maintaining efficient protection against cyber-attacks. Managing ageing on procedures and good practices related to site management was the key takeaway for four participants while four more identified the need to maintain and update properly the documentation and training programmes while reviewing plant processes against ageing.

The second most important takeaway as described by participants' responses (20 or 38%) shown in Figure 1 is related to information exchange; more specifically the exchange of inspection strategies along with the best practices shared stemming from the lessons learned of the presented case studies.

Technical information provided throughout the webinar was well perceived, ranking third (14 participants or 26%) in participant responses, mentioning:

- Forms of corrosion (e.g., bacterial)
- Piping vulnerabilities
- Ageing of IBC containers
- Material fatigue
- Ageing of reactor components (e.g., agitation)
- Root cause analysis (e.g., fishbone diagram) and qualitative risk analysis

Importance of guidance material and resources was also common among responses with 12 participants (23%), referring to:

- Minerva portal resources, tools, and functions
- Common Inspection Criteria
- Good Practice reports
- Translation function (guidance in HTML format)
- Checklists
- Accident databases (e.g., eMARS, ARIA)
- Experience of inspectors in applying available resources

Other responses were related to:

- Better understanding of gravity of ageing; the seriousness of its effects and the causality in accidents (10 participants or 19%)
- The importance of inspection strategy and inspection intervals (10 participants or 19%)
- Case studies and usefulness of practical examples (9 participants or 17%)
- The importance of management of change against ageing effects (7 participants or 13%)

5.2 Did you obtain any new ideas for your inspection system? If so, what?

It was common among attendees' responses that ageing can be identified with efficient inspection. All the inspection resources were deemed useful while responders shared their reflection on certain areas:

Ageing affects various aspects and not only equipment thus, **expanding the focus areas of inspection** should be considered in:

- IT and maintenance of primary containment systems
- Electrical/electronic infrastructure and means of communication
- Old equipment and material fatigue
- Equipment or components that may not operating continuously
- Ageing plant management and technical issues

Many responders also acknowledged the need to **review their national inspection practices** related to:

- Management of change and ageing inspection checklists
- Electrical/electronic systems and technology update requirements
- Request of ageing plan from operators
- Assessment of the initial state of plant and equipment and established processes to identify degradation mechanisms
- P&ID inspection
- Primary containment systems maintenance

Sharing of information on how other countries deal with ageing inspections, responders identified the need for modernisation of their inspection plan. Reviewing and expansion of the inspection checklists was also common among responders while reflection upon the available shared inspection tools and practices could facilitate this effort.

5.3 Are there any additional questions about this topic that you would have liked to discuss, or you would like to discuss in future? If so, what?

Responders were keen in receiving more information on:

- Different countries' strategies, legislation, and implementation
- Systems' integrity assessment
- Guidance resources (i.e., checklists)
- Electrical/electronic systems
- Good lessons learned following the presented strategies
- Regulations on mandatory replacement of old parts?
- Case studies
- Dealing with public governance

5.4 Please provide any suggestions that you might have for a future webinar (topics, arrangements, format, etc.)?

Responders expressed their interest in other thematic areas for a future webinar related to:

- Common inspection criteria and tips for implementation
- Risk assessment and functional safety
- Checklists and questions for inspectors
- Integrating ageing to legislation
- Exchange of information on how different organisations and countries deal with ageing inspections
- Inspection of biogas plants
- Inspection of hazardous waste sites
- Emergency management
- Cyber security inspection
- Lessons learned from recent accidents
- Land use planning
- Learning from incidents and risk analysis methods

6 Conclusions

The webinar on ageing and primary containment maintenance on Seveso and other hazardous sites was a good opportunity to bring together experts, Member States and interested parties to share experiences and guidelines in order to support inspection strategies. It was one of the series of seminars and webinars organised by EC-JRC MAHB and the TWG 2 aiming towards communication of guidance resources and sharing of experiences and good practices. Several topics were addressed, such as the diversity of ageing effects on sites, gaps presented during inspections as well as the correlation between recent accidents' causality and ageing. The webinar was greeted with broad acceptance and satisfaction by the attendees according to the conducted survey, while any recommendations made are vital to the organisers in pursuing high standards for future seminars/workshops. Any suggestions for future thematic areas will be evaluated to address the needs of risk management and inspectors' community.

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Annex 1. List of all stakeholders, authorities, and organisations per country

Country	Department/organisation
Austria	Fire Department Vienna
	Kärtner Landesregierung
	Magistrat Linz
	Ministry of Environment
	Salzburger Landesregierung
	Steiermärkische Landesregierung
Belgium	Afdeling Handhaving
	Brussels Environment
	Federal Public Service Employment Labour and Social Dialogue
	Flemish Government
	Flemish Government – Department Environment
	Flemish Government – Department Environment - Enforcement Section
	FOD WASO ACR
	Ministry of Environment Walloon region
	SPFETCs (Labour inspection)
	Vlaamse Overheid, Milieuhandhaving, TZR
Croatia	State Inspectorate
Czech Republic	Brand & Redning MidtVest
	Brno University of Technology
	DWEA (Danish Working Environment Authority)
	Environmental Protection Agency

Denmark	Fire & Rescue
	Greater Copenhagen Fire Department
	Mendel University in Brno
	Ministry of the Environment
	Municipality of Copenhagen
	Nordvestjyllands Brandvæsen
	Vestsjællands Brand
	VŠB University Ostrava
Estonia	Consumer Protection and Technical Regulatory Authority
	Estonian Rescue Board
Finland	Tukes (Finnish Safety and Chemicals Agency)
France	Ministry for environment
Germany	Bayerisches Staatsministerium für Umwelt und Verbraucherschutz
	Behörde für Umwelt, Klima, Energie und Agrarwirtschaft Immissionsschutz und Abfallwirtschaft (Hamburg)
	Bezirksregierung Arnsberg (NRW)
	Bezirksregierung Köln (NRW)
	Bezirksregierung Münster (NRW)
	Freie und Hansestadt Hamburg, Behörde für Umwelt, Klima, Energie und Agrarwirtschaft
	LUBW State Institute for Environment Baden-Württemberg
	LUNG M-V
	Ministerium für Umwelt, Landwirtschaft, Natur- und Verbraucherschutz des Landes Nordrhein-Westfalen
	Regierung der Oberpfalz (Bayern)
	Regierung Oberbayern (Bayern)
	Regierung von Mittelfranken (Bayern)

Germany	Regierung von Schwaben (Bayern)
	Regierung von Unterfranken (Bayern)
	Regierungspräsidium Darmstadt
	Regierungspräsidium Karlsruhe, Referat 54.1
	Regierungspräsidium Karlsruhe, Referat 54.2
	Regierungspräsidium Karlsruhe, Referat 54.4
	Regierungspräsidium Stuttgart, Referat 54.3
	Staaliches Amt für Landwirtschaft und Umwelt Westmecklenburg
	Staatliches Gewerbeaufsichtsamt Hildesheim (Niedersachsen)
Hungary	Baranya County Directorate for Disaster Management
	Budapest Directorate for Disaster Management
	Hajdú-Bihar County Directorate for Disaster Management
	Heves County Directorate for Disaster Management
	Komárom-Esztergom County Directorate for Disaster Management
	National Directorate General for Disaster Management
	Nógrád County Directorate for Disaster Management
	Pest County Directorate for Disaster Management
	Somogy County Directorate for Disaster Management
	Szabolcs-Szatmár-Bereg County Directorate for Disaster Management
	Tolna County Directorate for Disaster Management
	Vas County Directorate for Disaster Management
	Zala County Directorate for Disaster Management
Ireland	Health & Safety Authority
Israel	HFC, IDF
Italy	ISPRA

Latvia	State Environmental Service (Kurzeme region)
	State Environmental Service (Latgale region)
	State Environmental Service (Riga region)
	State Environmental Service (Supervision Department)
	State Environmental Service (Vidzeme region)
	State Environmental Service (Zemgale region)
Lebanon	Syndicate of chemist
Lithuania	Fire & Rescue Department under the Ministry of the Interior
Malta	OHSA
Netherlands	Ministry of Social Affairs and Employment
	Safety Region Zeeland
Norway	Norwegian Directorate of Civil Protection
	Petroleum Safety Authority Norway
	The Labour Inspection Authority
Palestine	Environment Quality Authority (E.Q.A)
Republic of Moldova	Agency for Technical Supervision
	ICS DANUBE LOGISTICS SRL
	Inspectorate for Environmental Protection
	Technical University of Moldova
Serbia	Ministry of Environmental protection
Slovakia	Ministry of Environment of the Slovak Republic
	Slovak Environment Agency
Sweden	County Administrative Board
	County Administrative Board of Blekinge
	County Administrative Board of Dalarna

Sweden	County Administrative Board of Gävleborg
	County Administrative Board of Jönköping
	County Administrative Board of Norrbotten
	County Administrative Board of Skåne
	County Administrative Board of Västmanlands
	Gotland Country Administrative Board
	Länsstyrelsen
	Länsstyrelsen Västra Götaland (County Board of Administration Västra Götaland)
	Swedish Civil Contingencies Agency, MSB
Ukraine	Ministry of Ecology and Natural Resourses of Ukraine
	SESU

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