

## Ageing (- Seveso Installations) in the Netherlands

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At this point in time we have indications that ageing contributes to incidents in the field of the chemical industry. Due to ageing factors these installations can be more susceptible to failure, with incidents involving hazardous substances as a result. This aspect is named 'ageing' of the process industry. The paper is about the definition of ageing and how various players in the field, including the government and the Dutch (petro) chemical industry, address this phenomenon.

In the past years, various Dutch initiatives were started with a focus on ageing of installations. The RIVM has made an analysis of ageing factors that may have played a role in reported incidents involving hazardous substances. The Seveso Inspectorates have started a joint project to check compliance with legal provisions on ageing of Seveso installations. In the context of the current program Sustainable Safety in 2030, the government, chemical industry, and knowledge institutes have drawn up a roadmap for a sustainable asset integrity with zero chemical incidents in 2030, in which ageing of assets is one of the relevant items.

The RIVM has participated in the mentioned ageing projects and has made an overview of the aims and the results of the initiatives.

### 1. Introduction

The history of the chemical industry in the Netherlands dates back to the 19th century, yet most of the existing chemical plants were founded between the 1950s and the present years. During the past decades, new plants have been built, old installations have been modernized or they have been entirely replaced. Just like all chemical companies worldwide, the Dutch chemical industry has to deal with the processes of ageing and the effect that ageing has on its plants. In the worst-case scenario, unrecognized ageing processes could lead to failure, with incidents involving hazardous substances as a result. In order to maintain and reach a sustainable chemical industry with regard to safety, environment and the economy both in present times as well as the future, a systematic approach for ageing of assets is required. In 2012, the European Seveso decree, created to prevent hazardous incidents in high risk industries, states that companies should pay attention to the topic of ageing (EU-lex, 2012). In the Netherlands, this topic is addressed in the so called Brzo 2015 decree, which is the Dutch implementation of the Seveso III directive (Bottelberghs, 2000). The Dutch Ministry for Social Affairs and Employment wants to adapt ageing aspects in its occupational safety policy for companies in general, not only for Seveso companies. The Ministry has commissioned the Dutch National Institute for Public Health and the Environment (RIVM) to increase knowledge about ageing. Additionally, the BRZO inspectorates for environmental, occupational and fire safety (the co-operation between the three inspectorates is called BRZO+) want to monitor the compliance of the new provisions regarding ageing and have formed a project group on the topic of ageing. RIVM has joined this working group to provide knowledge of ageing and to gain insight of how Seveso companies deal with ageing aspects within their safety domain. Other initiatives, both governmental and by the chemical industry, are also ongoing to investigate the current knowledge regarding ageing and the aspects still needing to be researched in order to properly address the processes of ageing ensuring that chemical installations stay in safe conditions.

This paper will elaborate on the concept of ageing of chemical assets, including reasons why ageing is presently becoming an issue, what the definition of ageing is and how this definition has extended throughout the years. Furthermore, this paper will address the knowledge and experience that is already available on this topic and areas which still need to be covered by research.

## 2. The evolution of the concept of ageing of technical assets

Ageing is of all times, it is not a new concept. Yet, the concept of ageing has evolved during the past decade. At first, ageing of technical assets was primarily based on material degradation due to time-effects (ESReDA, 2010; OECD, 2017). The examination of ageing processes was part of the standard maintenance program. The knowledge of ageing in those times was based on the deviation of material properties, the status of operating and environmental conditions and the status of maintenance practices. In 2008, the attention for ageing of technical assets was given an impulse when the Health and Safety Executive (HSE) of the United Kingdom showed that ageing aspects also contributed to a large number of incidents (30%) involving hazardous substances in the chemical and offshore industry in the UK (Horrocks et al., 2010).

During later years the European Safety, Reliability & Data Association (ESReDA) defined a broader definition of ageing, which also includes obsolescence and ageing of organization and personnel (ESReDA, 2010). Obsolescence covers all aspects related to (unsuccessful) spare parts management for technical assets that are out of date. Obsolescence is also at play during design changes where out dated installations are (partially) replaced by new technologies and unexpected process failures arise as a result. Ageing of the organization and personnel includes 1) the whole range from maintenance of expertise that is necessary to safely operate installations, 2) keeping (Management of Change) procedures, documentation and instructions up-to-date and 3) the ageing of plant personnel themselves. This broader definition of ageing was later adopted by the European Commission, the Organization for Economic Co-operation and Development (OECD), and is currently also used for the Dutch BRZO+ ageing project (European Union, 2015; OEDC, 2017).

An organization that applies even a broader definition of ageing as part of the (technical) asset management system, is the Dutch World Class Maintenance (WCM) organization. The WCM is a knowledge organization that develops, disseminates and brings into practice new, smart maintenance concepts for the Dutch industry. In the asset management system, ageing of the (technical) asset does not only relate to integrity, but also to the performance, functionality and costs of the asset. Figure 1 shows how the four ageing aspects in the TECC-driver model (Technical, Economic, Commercial and Compliance ageing) and how they can influence each other.

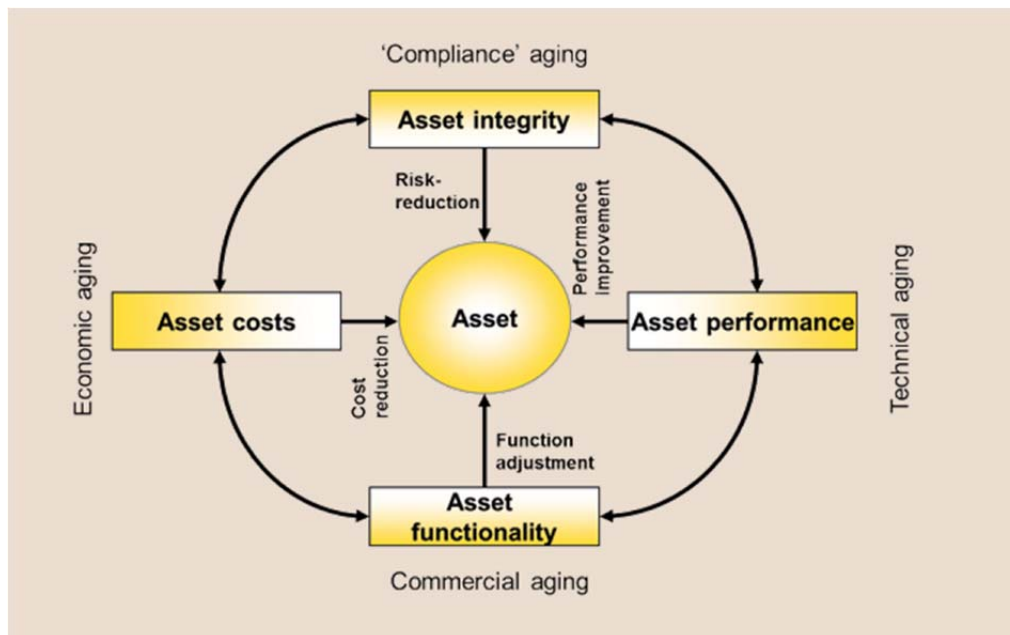


Figure 1: TECC-driver model, four ageing aspects of an (technical) asset. (Van Dongen, 2013).

## 3. Ageing in practice

Presently, there are various challenges related to creating more awareness regarding ageing and an implementation of a broader form of ageing. Up to date, both companies as well as inspectorates include the smaller definition of ageing, namely material degradation, in respectively their business processes and

inspections. Yet, the broader definition of ageing, including obsolescence and ageing of knowledge/personnel, still needs to gain momentum.

### 3.1 Study of the influence of ageing mechanisms on incidents

In 2016, the RIVM analyzed reported incidents on the presence of ageing related causes. This was done to obtain insight in the occurrence of ageing. Based on the incidents available in the Storybuilder database (Bellamy et al., 2013), a database used to analyze incidents in the Netherlands, the RIVM found that in 30% of the incident cases (91 of the 300 cases), ageing seemed to be a co-cause for failure of the installations (Geus and Kieskamp, 2018b).

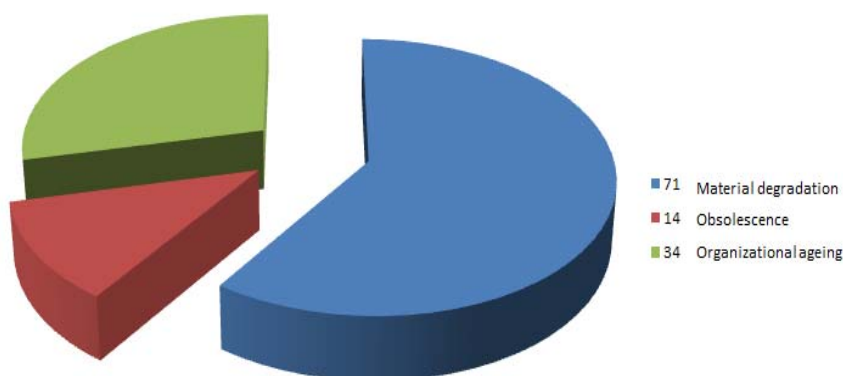


Figure 2: Distribution of ageing types found amongst the 91 ageing incident cases. An incident can have multiple ageing aspects as co-causes (Geus and Kieskamp, 2018b).

As Figure 2 shows, in 71 of the 91 analyzed 'ageing' incidents, a material degradation mechanism like corrosion, erosion or fatigue was a co-cause of the incident. To a lesser extent, obsolescence (14 incidents) or ageing of the organization (34 incidents) were co-causes. In some incident cases, two to three ageing aspects played a role at the same time (besides also other non-ageing causes). We must be aware that the subject of ageing was not explicitly included in the accident investigations in the period under review (2004-2016). Additionally, the broader elements of ageing are difficult to recognize at an accident investigation. Therefore, certain ageing aspects might not have been recognized and reported as such.

To provide detailed insight in the three different forms of ageing, descriptions of a typical material degradation, obsolescence and organizational ageing incidents are presented below. These incidents were obtained from the RIVM rapport (Geus and Kieskamp, 2018b):

- A typical example of an ageing incident due to material degradation mechanisms is a leakage of hazardous substances from vessels or pipelines caused by corrosion of the material of the containment or of the appendices. In some cases, the corrosion mechanism was not recognized as a possible failure cause in design, safety or maintenance studies. In situations where the company did recognize corrosion as a possible failure cause, the corrosion damage was not detected on time due to an insufficient inspection and maintenance frequency. The lack of or ineffective maintenance is an important factor of failure.
- A typical example of an ageing incident due to obsolescence (using outdated technology) is a leakage in a 30 years old pipeline belonging to an ammonia cooling installation. The pipeline was constructed as a combined pipeline consisting of two concentric inner and outer pipelines. The inner pipeline was used to transport cold, melted water. The outer pipeline was used to transport ammonia gas of high temperature and high pressure. The wall between the inner and the outer pipeline burst, causing high-pressure ammonia to enter the inner pipeline and pushing out the content and the leaked ammonia. In modern ammonia cooling installations combined pipelines are not allowed anymore. Cracking of the inner wall cannot be detected on time. The incident would not have happened if the old double walled pipeline had been replaced by two separated pipelines, according with the actual safety standards.

- A typical example of an ageing incident due to ageing of organizational aspects is an incident in a congested pipeline for Sulphur dichloride. The pipeline was cleaned incorrectly resulting in a violent chemical reaction and an explosion. The company had faced congested pipelines in the past and had researched the best way to tackle this problem. However, the newly responsible manager did not have the knowledge of these new procedures. So, the knowledge had faded away with the departed employees.

Some lessons learned from the RIVM study of the contribution of ageing of technical assets to accidents with dangerous substances (Geus and Kieskamp, 2018b), are:

- Although for many chemical plants corrosion is a well-known problem, attention should still be given to this ageing aspect. When carrying out a risk assessment, one should take into account that corrosion hazards in installations are not always visible or are difficult to inspect. For instance, corrosion underneath insulating material or pipelines located at high altitudes.
- Follow maintenance procedures according to the best insights. For example, comply with the current knowledge of the effects of degradation mechanisms.
- Exchange best and worse maintenance practices between Seveso plants.
- Be aware that knowledge in the organization may age or drain. This particularly applies to installations that are nominated for disposal. Do not let knowledge of the specific risks of an installation drain away, especially when an installation is at its final stages.

Additionally, The Dutch Safety Board has carried out an investigation regarding the control of the process safety of chemical installations at a large industrial complex in the Netherlands (Dutch Safety Board, 2018). The reason was a series of incidents where hazardous substances were released. They also gave various recommendations for the field of ageing of safety critical installations for both companies and government.

### 3.2 Compliance with the new ageing provisions

In 2017, the Dutch Seveso inspectorates working together in the so called BRZO+ organization started a project to monitor the compliance with the new ageing provisions. In this ageing project the Seveso inspectorates investigate how Seveso companies include ageing of its technical assets in their safety management system. During the inspections, specific attention was given to corrosion under insulation (CUI) and ageing of firefighting systems.

Right before the BRZO+ ageing project was established, the RIVM provided an insight of the status of the (petro) chemical companies regarding ageing. A baseline measurement was conducted in 2016 amongst branches of the chemical and petrochemical industry dealing with ageing of installations. Using a questionnaire insight was unlocked regarding the awareness of and actions taken by the companies in relation to the broader form of ageing. The main conclusion of this study was that during the end of 2016, many companies were still in the early stages of implementing ageing in their processes (Geus and Kieskamp, 2018a). Not all sectors included ageing explicitly in their risk management at that time, yet aspects were discussed internally for the majority of the organizations. Additionally, companies used various definitions of ageing.

The conclusion of the baseline measurement study of the RIVM, is supported by general research and analysis of the 283 inspections of 2017 that the Seveso inspectorates have carried out. Firstly, the Seveso inspectorates noticed that there is a lack in definition of ageing across the various stakeholders (Ministerie van Infrastructuur en Waterstaat, 2018). This makes it difficult to tackle the broader version of ageing. Secondly, companies have formed their ageing policy in different ways. Often companies rely on the preventive maintenance of installations, while a complete inventory of degradation mechanisms is lacking. As it is assumed that ageing is recognized by performing maintenance on installations, no separate policy has been described in, for example, the Major Accident Prevention Policy (MAPP), procedures or checklists. Nevertheless, some companies have developed ideas to deal with the broader form of ageing, but have not yet fully developed or implemented these ideas. Additionally, few companies actually have a documented and suitable system including the aspects relating to ageing of installations, procedures and retention of knowledge.

The Seveso directive nor its implementation into Dutch legislation, i.e. Brzo2015, provide a definition of 'ageing' (EU-lex, 2012). Also, there are no clear standards on how ageing should be tackled. It is desirable to work towards an unambiguous definition of ageing and to better formulate what requirements can be imposed on ageing aspects in the safety policy of a company.

#### 4. Current and future developments in the field of ageing

Various projects by various players in the field are currently ongoing to create awareness of and knowledge about ageing, to implement strategy including the ageing aspect and to investigate and monitor ageing from the policy side.

The RIVM will focus its efforts in 2019 on obsolescence and the ageing of knowledge.

TNO is producing tools to identify ageing risks caused by reduced mechanical integrity, obsolescence and ageing of organization (securing knowledge to operate the installation safely). These tools will be available at the end of 2018. The checklists to identify the risks of ageing will be supplemented with examples for solutions. In 2019, TNO will start a new research project to develop a model based on the Safe-by-Design principle, including the risks of ageing mechanisms.

The Seveso inspectorates will continue the ageing project in 2019. The topics will be the ageing of pressure equipment (compliance with the regulations for pressure equipment), the quality and completeness of the inventory of possible degradation mechanisms of their ageing plants and the ageing of passive fire-fighting measures. Additionally, the BRZO+ ageing project group will focus on increasing the practical knowledge that inspectorates have of ageing. Various courses on the recognition of material degradation mechanisms and of ageing in installations and (passive) firefighting provisions will be given in 2019. Furthermore, the BRZO+ project group will continue to increase awareness and discuss practical strategy.

The joint Program Sustainable Safety by all stakeholders of the (petro-) chemicals industry, governments and expertise institutes has as an ambition to achieve zero incidents in 2030 in the Netherlands. One of their current projects is the Roadmap to a sustainable asset management for the chemical and petrochemical industry in the Netherlands (DV 2030, 2018). Part of this roadmap is to assess the current situation of how companies consider and manage ageing of its installations. The first global results will be presented in 2019.

Other initiatives focused on sharing of knowledge and increasing awareness regarding ageing range from workshops, symposia and courses. For example, various joint workshops are conducted by the national inspectorates to inspire knowledge sharing on inspection of installations between the labour inspectorate, environmental and transport inspectorates, offshore installations inspectorate, nuclear installations inspectorate and telecom inspectorate. Additionally, ageing is an often programmed topic on many relevant safety congresses.

Internationally, cooperation on the topic of ageing occurs between the Dutch players and international organisations. The RIVM, for example, provides various presentations for our international counterparts, such as the Flemish Seveso Authority in 2018. Additionally, the RIVM is one of the Dutch representatives in an international working group, The OECD Working Group on Chemical Accidents (WGCA).

#### 5. Conclusions

At this point in time we have indications that ageing contributes to incidents in the field of the chemical industry. We also know that companies do and have focussed on the material degradation side of ageing, but that obsolescence and ageing of personnel and knowledge are still in the shadows. The Seveso directive nor its implementation into Dutch legislation provide a clear definition of 'ageing'. This makes it difficult to determine when a company has paid sufficient attention to ageing of the installation. Broadening the definition of and the discussion regarding ageing, opens up possibilities to shed a light on practices which up to date might have been under investigated. By understanding these concepts through various ongoing projects, we might get closer to develop new practices, which in turn can lead the chemical industry to more sustainable and safer practices regarding ageing.

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#### References

- Bellamy L.J., Mud M., Manuel H., Oh J.I.H., 2013, Analysis of underlying causes of investigated loss of containment incidents in Dutch Seveso plants using the Storybuilder method, *Journal of Loss Prevention in the Process Industries*, 26, 1039-1059.
- Bottelberghs P.H., 2000, Risk analysis and safety policy development in The Netherlands, *Journal of Hazardous Materials*, 71, 59-84.

- Center for Chemical Process Safety (CCPS), 2018, Dealing with aging process facilities and infrastructure, American institute of Chemical Engineers, New York, USA, Wiley-AIChE online publishing.
- Dutch Safety Board, 2018, Summary Chemistry in cooperation- Safety at the Chemelot industrial complex, Dutch Safety Board, the Hague, the Netherlands.
- DV 2030, 2018, Duurzaam Assetmanagement, Duurzame Veiligheid 2030 <[www.dv2030.nl/duurzaam-assetmanagement](http://www.dv2030.nl/duurzaam-assetmanagement)> accessed 11.10.2018. (in Dutch)
- ESReDA, 2010, Ageing of components and systems, Report European Safety, Reliability & Data Association.
- EU-lex, 2012, Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC Text with EEA relevance, European Union Law < [www.eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0018](http://www.eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0018)> accessed 11.10.2018.
- European Union, 2015, Lessons Learned Bulletin No. 7: Major accidents related to ageing, Security Technology Assessment Unit, Institute for the Protection and security of the Citizen, European Commission, Ispra, Italy.
- Geus E.C.J., Kieskamp K.K., 2018a, Aandacht voor 'ageing' binnen de chemische industrie. Bedrijven over de risico's als gevolg van het verouderen van chemische installaties, De invloed van veroudering van installaties ('ageing') op de oorzaak van ongevallen met gevaarlijke stoffen, RIVM report, National Institute of Public Health and the Environment, Bilthoven, the Netherlands. (in Dutch)
- Geus E.C.J., Kieskamp K.K., 2018b, De invloed van veroudering van installaties ('ageing') op de oorzaak van ongevallen met gevaarlijke stoffen, RIVM report, National Institute of Public Health and the Environment, Bilthoven, the Netherlands. (in Dutch)
- Horrocks P., Mansfield D., Thomson J., Parker K., Winter P., 2010, Plant Ageing Study, Phase 1 Report, Research Report 823, Health and Safety Executive, Warrington, UK.
- Ministerie van Infrastructuur en Waterstaat (IenW), Ministerie van Sociale Zaken en Werkgelegenheid (SZW), Ministerie van Veiligheid en Justitie (VenJ), 2018, Staat van de Veiligheid majeure risicobedrijven 2017, Ministerie van Infrastructuur en Waterstaat, the Hague, the Netherlands. (in Dutch)
- OECD, 2017, Environment Directorate, Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology, 2017, Ageing of hazardous installations, Series on Chemical Accidents No. 29., Organisation for Economic Co-operation and Development, Paris, France.
- Van Dongen, R., 2013, Lifetime extension is key in the next decade, Maintworld, 3, 28-30.