UNECE

Safety guidelines
and good practices for the management and retention of firefighting water

UNITED NATIONS

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

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and good practices for the management and retention of firefighting water

UNITED NATIONS
Geneva, 2019

United Nations publication issued by the United Nations Economic Commission for Europe.

Photo credits: front cover, pages 15 and 50 - Ministry of Interior, Hungary;
page xiii - Fotolia; pages ix, xi, 1, 9, 16, 32 and 40 - iStock

ECE/CP.TEIA/40-ECE/MP.WAT/58

UNITED NATIONS PUBLICATION

Sales No.: E.19.II.E.29

ISBN: 978-92-1-117209-6

e-ISBN: 978-92-1-004290-1

FOREWORD

Over the past few decades, the level of safety at industrial facilities that produce, handle or store hazardous chemical substances has significantly improved in the United Nations Economic Commission for Europe (UNECE) region. Under the auspices of UNECE instruments,[1] frameworks and tools, many countries have stepped up their prevention, preparedness and emergency response measures regarding major accidents, in order to minimize the risks to people and the environment. However, preventing the release of contaminated firefighting water into the surrounding soil and water still presents a challenge, especially in the case of a major fire at an industrial facility. Extinguishing a blaze can take hours or even days, during which time a significant volume of contaminated firefighting water is produced and needs to be properly retained. If not, these discharges of polluted water can have devastating effects on humans and the environment, as demonstrated by several major accidents over the past 35 years.

A case in point is the Sandoz accident of 1986 — widely regarded as Europe's worst environmental disaster in decades. The lack of firefighting water retention facilities caused far-reaching transboundary water pollution across Switzerland, France, Germany and the Netherlands, affecting drinking water supplies and resulting in widespread ecological damage along the River Rhine for years. Despite the significant progress made in the field of industrial safety over the past few decades, the issue of firefighting water retention has still not been thoroughly addressed by countries across the region, meaning that a Sandoz-like disaster could happen today.

I am pleased that the Parties to two legal instruments serviced by UNECE — the Convention on the Transboundary Effects of Industrial Accidents (Industrial Accidents Convention) and the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) — have been working together to address issues related to accidental water pollution and the protection of watercourses, namely through the Joint Expert Group on Water and Industrial Accidents. Acknowledging the challenges that countries face and the lack of guidance in this field, the Joint Expert Group has developed safety guidelines and good practices — as contained in this publication — to assist countries in minimizing the risk of fire and safely retaining firefighting water, in line with Sustainable Development Goal 3 on healthy lives and well-being, Goal 6 on water, Goal 9 on industry, innovation and infrastructure and Goal 15 on life on land.

[1] Notably the Convention on the Transboundary Effects of Industrial Accidents (Industrial Accidents Convention) and the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention), serviced by the United Nations Economic Commission for Europe (UNECE).

I would like to encourage Governments, competent authorities and operators to make extensive use of the guidelines in order to enhance existing practices and promote harmonized safety standards. Joint bodies and international organizations should also support this work by promoting the guidelines and assisting competent authorities and operators in their application.

I look forward to the guidelines' successful implementation, so as to prevent the accidental release of firefighting water into surrounding soils and waters and to limit the consequences on human health and the environment, both within and across borders.

Olga Algayerova

Executive Secretary

United Nations Economic Commission for Europe

BACKGROUND AND ACKNOWLEDGEMENTS

In 1986, as a result of a fire at the Sandoz pharmaceutical facility near Basel, Switzerland, 30 tons of toxic chemicals were released into the Rhine River owing to the lack of firefighting water retention. This caused extensive transboundary water pollution, suspended drinking water supplies, devastated fish stocks in Switzerland, France and Germany and had effects reaching as far as the Netherlands (approximately 700 kilometres downstream).

On the occasion of the twenty-fifth anniversary of the Sandoz accident, a UNECE seminar was held in Bonn, Germany, on 8 and 9 November 2011.[2] The event was organized under the leadership of the Government of Germany, with the support of the secretariat of the UNECE Convention on the Transboundary Effects of Industrial Accidents[3] (Industrial Accidents Convention) and the Convention on the Protection and Use of Transboundary Watercourses and International Lakes[4] (Water Convention). The objectives of the seminar were mainly the following:

- To reflect on the work carried out and progress achieved in the area of prevention of accidental water pollution in the UNECE region;
- To examine existing deficits in the prevention of water pollution by chemical substances, and formulate the way forward to address these deficiencies.

Following the presentations by the seminar participants, it became evident that 25 years after the Sandoz accident a number of countries were facing significant challenges regarding fire protection and the containment of firefighting water to prevent the contamination of transboundary rivers. These challenges were faced not only at storage facilities but at all other on-site activities, in particular processing plants. Most countries lacked specific legislation and regulations regarding the retention of firefighting water and size requirements for retention basins remained inadequate. Several fire accidents or near-misses in recent years supported those findings. It was therefore recommended to address the issue jointly through the development of related guidance. To that end, the Bureaux to the Water Convention and the Industrial Accidents Convention endorsed a proposal for the Joint Ad Hoc Expert Group on Water and Industrial Accidents to develop safety guidelines and good practices for firefighting water retention.

As a first step, a questionnaire was sent to all focal points of the two conventions to identify needs and available expertise in this area. Under the leadership of the Joint Expert Group, a small group of international experts on firefighting water retention was then established

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2 For more information, please see http://www.unece.org/index.php?id=25376

3 United Nations, *Treaty Series*, vol. 2105, No. 36605.

4 United Nations, *Treaty Series*, vol. 1936, No. 33207.

and tasked with the elaboration of safety guidelines and good practices for the retention of firefighting water in the biennium 2017–2018. The present document contains these safety guidelines and good practices, which were developed by the Joint Expert Group in cooperation with the Expert Group on Fire-water Retention and supported by the UNECE secretariat. The Expert Group on Fire-water Retention held four meetings in 2017 and 2018[5] which were serviced by the secretariat. Previous versions of the safety guidelines were discussed at an international seminar on fire-water retention (Slubice, Poland, 5 September 2017)[6] and shared for comments with the focal points of the UNECE Water Convention and Industrial Accidents Convention, international organizations, industry associations and other partners in the last quarter of 2017. Their comments, inputs and feedback were considered by the expert group and, where feasible, included or otherwise addressed during the process of finalizing the guidelines. The Meeting of the Parties to the Water Convention at its eighth session (Astana, 10–12 October 2018) and the Conference of the Parties to the Industrial Accidents Convention at its tenth meeting (Geneva, 4–6 December 2018) took note of the guidelines and recommended their use and implementation by countries in order to prevent accidental pollution of soil and water, including pollution that could cause transboundary effects.

In the period during which the guidance was elaborated, the Joint Expert Group was co-chaired by Mr. Peter Kovacs (Hungary) for the Water Convention and Mr. Gerhard Winkelmann-Oei (Germany) for the Industrial Accidents Convention. In addition to the Co-Chairs, the following experts actively supported the development of the safety guidelines by providing inputs: Mr. Claes-Hakan Carlsson (Sweden); Mr. Pavel Dobes (Czechia); Mr. Jesper Hansen (Switzerland); Mr. Lukasz Kuziora (Poland); Ms. Leighanne Moir (United Kingdom of Great Britain and Northern Ireland); Ms. Cornelia Sedello (Germany); Ms. Maarit Talvitie (Finland); Ms. Tuuli Tulonen (Finland); Mr. Bert van Munster (Netherlands); and Mr. Wolfram Willand (Germany). The Meeting of the Parties and the Conference of the Parties expressed their appreciation to the Joint Expert Group and the Expert Group on Fire-water Retention for having prepared the safety guidelines and good practices.

5 More information on these meetings is available at www.unece.org/index.php?id=44842, http://www.unece.org/index.php?id=45437, www.unece.org/index.php?id=45435 and www.unece.org/index.php?id=48199

6 For more information, see www.unece.org/index.php?id=45431

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EXECUTIVE SUMMARY

1. Contaminated firefighting water can cause severe environmental harm when released into the soil and water, not only within but also across countries. The Sandoz accident in 1986 was a tragic reminder of this fact when, owing to the lack of firefighting water retention during an emergency response to a major fire in an agrochemical warehouse at the Sandoz pharmaceutical company site near Basel, Switzerland, 30 tons of toxic chemicals were released into the Rhine River. This caused vast transboundary water pollution, suspended drinking water supplies, devastated fish stocks in Switzerland, France and Germany, and reached as far as the Netherlands (approximately 700 kilometres downstream).

Fire at the Sandoz agrochemical plant, Schweizerhalle, Switzerland, 1986

2. The management and retention of firefighting water is therefore crucial to prevent the pollution of the environment with contaminated firefighting water, which — as demonstrated by the Sandoz accident — can quickly affect other countries, even those which may initially appear to be far away from the accidental release. As such, it is evident that the management and retention of firefighting water is highly relevant in a transboundary context, and countries need to work together to prevent accidental (water) pollution with contaminated firefighting water.

3. Although the Sandoz accident triggered many improvements in United Nations Economic Commission for Europe (UNECE) countries in the area of industrial safety and transboundary cooperation, the issue of firefighting water retention has until now not been thoroughly addressed. In many UNECE countries, including European Union countries, there are gaps in the national legislation, and size requirements for firefighting water retention basins remain unclear. International and subregional regulations for the management and retention of firefighting water are lacking.[7] In addition, near-misses and accidents leading to the production of huge amounts of firefighting water for which insufficient retention volumes were available (see annex I) demonstrate the urgency for more regulation and additional preventive measures in this area. The threat is still real and accidents similar to Sandoz could still happen in the UNECE region today.

4. To avoid another such disaster, guidelines for the management and retention of firefighting water are strongly needed within the UNECE region and beyond to prevent transboundary pollution, notably water contamination. To this end, the present safety guidelines and good practices for the management and retention of firefighting water were developed to support governments, competent authorities and operators in

[7] From a regulatory perspective only 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 (Seveso III Directive) explicitly mentions fire-water retention as a major element to restrict the effects of a major accident (annex II, para. 5 (a)). However, no concrete regulation is outlined, either within the European Union and its member States or in other UNECE countries, with the exception of Switzerland, which has developed an inter-cantonal guideline for firefighting water retention for hazardous activities (see footnote 10).

applying measures and improving existing practices to prevent the accidental pollution of soil and water, including pollution that could cause transboundary effects. The key recommendations from both the general and the technical and organizational parts of the safety guidelines and good practices are summarized below:

(a) Firefighting water is hazardous to waters irrespective of the material burned. This means that, for example even burned packaging material and combustion products from building materials can contaminate firefighting water by turning it into a water-endangering agent. The development of huge amounts of firefighting water should therefore be avoided in the first instance. Firefighting water must be retained completely and disposed of adequately in order to prevent the contamination of water and soil, both within and across countries;[8]

(b) Governments should provide leadership and create suitable administrative and legal frameworks to introduce mandatory requirements for firefighting water management and retention in case of emergencies at all hazardous activities (i.e., not only at storage facilities);

(c) Retention capacities for firefighting water should be established at all hazardous facilities. They should be subdivided into fire compartment areas that are as small as possible. As an example for determining the retention capacities for firefighting water, the German VdS 2557 guideline[9] or the Swiss inter-cantonal guidelines[10] can be used in industrialized countries. For less industrialized countries, a quick, rough estimation based on a direct proportionality of the firefighting water retention volume needed compared with the largest fire-compartment area can be undertaken. Even a complete burn-down should be taken into account, if there is not sufficient retention capacity for firefighting water;

(d) These guidelines focus on water-based extinguishing strategies; however, differing firefighting strategies should also be considered. In general, the retention volume for firefighting water can be drastically reduced by implementing efficient measures to prevent fires from spreading, by using automated fire detection in combination with automatic extinguishing systems (sprinklers, deluge systems, high expansion foams and extinguishing gases) and by applying efficient firefighting techniques;

8 In accordance with the obligations under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) and the Convention on the Transboundary Effects of Industrial Accidents (Industrial Accidents Convention) to prevent accidental water pollution and its transboundary effects, contaminated firefighting water must be retained and disposed of adequately.

9 Verband der Schadenversicherer e.V. (Association of Non-Life Insurers) (VdS), *Planning and Installation of Facilities for Retention of Extinguishing Water: Guidelines for Loss Prevention by the German Insurers, No. VdS 2557* (Cologne, Germany, VdS Loss prevention GmbH, 2013). Available at https://vds.de/fileadmin/vds_publikationen/vds_2557en_web.pdf

10 Switzerland, Konferenz der Vorsteher der Umweltschutzämter der Schweiz (Conference of Chiefs of Environmental Protection Services), *Löschwasser-Rückhaltung – Leitfaden für die Praxis* (Firefighting Water Retention: A Practical Guide), 1st ed. (Zurich, October 2015). Available in French, German and Italian at https://www.kvu.ch/de/arbeitsgruppen?id=190

(e) These safety guidelines and good practices are intended to support governments, competent authorities and operators in applying measures and improving existing practices to prevent accidental pollution of soil and water, including pollution that could cause transboundary effects. Joint bodies, international organizations and other relevant actors could support this work by raising awareness about these guidelines and assisting competent authorities and operators in their implementation. The use of these safety guidelines will help develop a common safety level across the UNECE region. It will also support the implementation of the 2030 Agenda for Sustainable Development (notably the achievement of Sustainable Development Goal 6 on ensuring the availability and sustainable management of water and sanitation for all) and the four priorities of the Sendai Framework for Disaster Risk Reduction 2015–2030.

PART A

INTRODUCTION, SAFETY PRINCIPLES AND GENERAL RECOMMENDATIONS

I. INTRODUCTION TO THE MANAGEMENT AND RETENTION OF FIREFIGHTING WATER AND ITS TRANSBOUNDARY DIMENSION

5. Two UNECE treaties — the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) and the Convention on the Transboundary Effects of Industrial Accidents (Industrial Accidents Convention) — together provide a legal framework for addressing the risk of transboundary water pollution arising from industrial accidents. The Industrial Accidents Convention helps protect human beings and the environment against industrial accidents, especially those with transboundary effects, by preventing such accidents as far as possible, reducing their frequency and severity, and mitigating their effects. The Water Convention aims to prevent, control and reduce transboundary impacts by facilitating cooperation. Both conventions share a number of common principles and obligations, for example, the polluter pays principle[1] and obligations to prevent accidental pollution,[2] to inform potentially affected countries if an accident has happened[3] and to ensure joint contingency planning.[4] Issues related to the prevention of accidental water pollution are addressed under the Industrial Accidents Convention in close cooperation

1 The polluter pays principle contained in the Industrial Accidents Convention (ninth preambular para.) and Water Convention (art. 2, para. 5 (b)) is a general principle of international environmental law that aims to ensure that the final costs of pollution control and reduction are borne by the polluter.

2 According to the Water Convention (art. 3, para. 1 (l)), "the Parties shall develop, adopt, implement and, as far as possible, render compatible relevant legal, administrative, economic, financial and technical measures" in order to minimize the risk of accidental pollution. According to the Industrial Accidents Convention (art. 6, para. 1, and annex IV), "the Parties shall take appropriate measures for the prevention of industrial accidents, including measures to induce action by operators to reduce the risk of industrial accidents".

3 The Water Convention obliges Parties to inform each other about any critical situation that may have a transboundary impact and, if appropriate, establish joint warning and alarm systems (art. 14). In accordance with the Industrial Accidents Convention (art. 10, para. 2, and annex IX), in the event of an industrial accident, or imminent threat thereof, which causes or is capable of causing transboundary effects, the Party of origin shall ensure that affected Parties are, without delay, notified at appropriate levels through the industrial accident notification systems.

4 Parties to the Water Convention are obliged to take all appropriate measures to prevent, control and reduce pollution of waters causing or likely to cause transboundary impact (art. 2, paras. 1–2). Parties to the Industrial Accidents Convention have committed to establishing and maintaining adequate emergency preparedness to enable them to respond to industrial accidents (art. 8 and annex VII).

with the Water Convention through the Joint Expert Group on Water and Industrial Accidents (Joint Expert Group).

6. More than 30 years after the Sandoz accident, many countries still face a number of significant challenges with regard to the management and retention of firefighting water. An exchange on the legislative frameworks in those countries represented in the Joint Expert Group and the Expert Group on Fire-water Retention revealed that countries often lacked specific laws and regulations on firefighting water retention. Even in countries with basic regulations in place, these were often rather general and incomplete, e.g., only covering storage facilities but not production and processing plants.

7. In recent years, a number of accidents have occurred that led to a huge production of firefighting water, not necessarily at storage plants but, more frequently, at processing and production plants. Examples of some major accidents and near misses regarding firefighting water retention issues in UNECE countries, including their financial costs and a short description of what happened, are presented in annex I to these guidelines. The potential damages of such accidents can be severe and costly, not only within a country but also across borders. Often the companies involved are bankrupted by such accidents, and governments are left to take over the remaining costs for the accident and aftercare management, causing a huge financial burden for many years.

8. In order to avoid this financial burden arising from the negative effects of such accidents on human health and the environment, prevention is indispensable. Prevention is not only better than cure, it is also cheaper. To prevent accidental water pollution from happening, to minimize the risks of such accidents and to ensure an effective response in case such accidents should happen requires high quality work and coordination among all the relevant stakeholders at the national and cross-border levels. Only if all parties work together is prevention, minimization and effective response possible.

9. Operators should thus be encouraged to take measures to prevent any damage for which they will be held liable. Governments and competent authorities should put in place stringent regulatory frameworks to ensure that operators implement the necessary safety measures to prevent such accidents from happening. Emergency planners and responders should use these safety guidelines and good practices when developing a fire protection concept and on-site and off-site contingency plans that mitigate environmental harm (e.g., through an appropriate firefighting strategy). Joint bodies play a crucial role in cooperation in transboundary basins to reduce pollution, prevent accidental water pollution and ensure the sustainable and equitable use of waters by, among others, providing a platform for the implementation of harmonized safety standards and transboundary warning and alarm procedures.

10. The use of these safety guidelines will help develop a common safety level across the UNECE region. It will also support the implementation of the 2030 Agenda for Sustainable Development, notably the achievement of Sustainable Development

Goal 6 on ensuring the availability and sustainable management of water and sanitation for all, and the four priorities of the Sendai Framework for Disaster Risk Reduction 2015–2030.

1. DEFINITIONS AND TERMINOLOGY

11. Some general definitions, mainly based on the UNECE Industrial Accidents Convention and Water Convention, are listed below for the purpose of the present document:

(a) "Competent authority" means one or more national authorities designated or established by a country for the purpose of the Industrial Accidents Convention or the Water Convention;

(b) "Effects"[5] means any direct or indirect, immediate or delayed adverse consequence caused by an industrial accident on, inter alia:

(i) Human beings, flora and fauna;

(ii) Soil, water, air and landscape;

(iii) The interaction between the factors in (i) and (ii);

(iv) Material assets and cultural heritage, including historical monuments.

(c) "Firefighting water" means water that is used to extinguish a fire, including sprinkler and non-sprinkler water; this can also include firefighting additives;

(d) "Hazardous activity"[6] means any activity in which one or more hazardous substances are present or may be present in quantities listed in annex I to the Industrial Accidents Convention and that is capable of causing transboundary effects;

(e) "Industrial accident"[7] means an event resulting from an uncontrolled development in the course of any activity involving hazardous substances either:

(i) In an installation, for example during manufacture, use, storage, handling, or disposal;

(ii) During transportation as it is covered by paragraph 2 (d) of article 2 of the Industrial Accidents Convention.

(f) "JEG model" is the easy method used to roughly calculate the firefighting water retention volume (one square metre (m^2) fire compartment area requires one cubic metre (m^3) firefighting water retention volume). For more information see annex II of these guidelines;

(g) "Joint body"[8] means any bilateral or multilateral commission or other appropriate institutional arrangements for cooperation between the riparian countries;

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5 In accordance with the UNECE Industrial Accidents Convention.

6 Ibid

7 Ibid.

8 In accordance with the UNECE Water Convention.

(h) "Operator"[9] means any natural or legal person, including public authorities, in charge of an activity, for example, supervising, planning to carry out or carrying out an activity;

(i) "Advanced JEG model" is based on the JEG model (see (f) above) but takes into account advanced fire protection strategies (e.g., sprinklers). The retention volume calculated according to the JEG model can be reduced by 90 per cent owing to the reduced firefighting water needed. For more information see annex II of these guidelines;

(j) "Riparian countries"[10] means countries bordering the same transboundary waters;

(k) "Transboundary effects"[11] means serious effects within the jurisdiction of a country as a result of an industrial accident occurring within the jurisdiction of another country;

(l) "Transboundary waters"[12] means any surface waters or groundwaters that mark, cross or are located on boundaries between two or more countries. Wherever transboundary waters flow directly into the sea, these transboundary waters end at a straight line across their respective mouths between points on the low-water line of their banks.

12. While further terms and definitions related to the management and retention of firefighting water exist (e.g., in International Organization for Standardization standard ISO/TR 26368:2012,[13] etc.), these have not been included as the document serves as a guideline and national definitions may vary within and beyond the UNECE region.

2. SCOPE

13. These safety guidelines and good practices are intended for application at all hazardous activities, according to annex I to the Industrial Accidents Convention, including manufacture, production, storage and other activities. These safety guidelines and good practices could also be applied to hazardous activities outside the scope of the Convention.[14]

14. These safety guidelines and good practices focus on hazardous activities that have primarily water-based fire protection concepts. Alternative firefighting strategies using, for example, gas or carbon dioxide, can also reduce the dimensioning of firefighting water retention but are not considered in this document. The guidelines aim to protect people and the environment from fire accidents which may cause water and soil pollution.

9 In accordance with the UNECE Industrial Accidents Convention.

10 In accordance with the UNECE Water Convention.

11 In accordance with the UNECE Industrial Accidents Convention.

12 In accordance with the UNECE Water Convention.

13 Environmental damage limitation from firefighting water run-off. May 2012.

14 In accordance with its article 5, the scope of the Industrial Accidents Convention can be expanded.

15. Firefighting water can cause considerable damage if it enters surface water, infiltrates the ground, or contaminates groundwater. Substances or objects that are not harmful under normal conditions, like ammonium fertilizers, polyvinyl chloride (PVC), automobile tyres or elementary sulphur, can produce large amounts of toxic gases when burned, and cause highly contaminated firefighting water. Even burned packaging materials and combustion products from building materials can contaminate firefighting water. Therefore, as adverse effects on the properties of water bodies cannot be excluded, firefighting water should be prevented from entering surface water and groundwater as it is potentially hazardous to the environment irrespective of the substances involved in the fire.

16. These safety guidelines and good practices for the management and retention of firefighting water are derived from operational industry and firefighters' experience. This includes learning from history and the details of past major accidents and the remedial and prevention measures designed to prevent their recurrence or eventually to minimize their consequences.

17. These safety guidelines have been developed to minimize the risk of fire and to safely retain firefighting water. Cooling water that is unlikely to be contaminated and can be segregated may be treated differently, i.e., it can be used to prevent domino effects on neighbouring equipment, the facility or installations. However, cooling water is difficult to segregate and often picks up contamination from the site and should be contained where possible.

18. These guidelines recognize that different safety standards may already exist worldwide and that different approaches to safety exist with regard to production, storage and other activities, including the modes of transport and transport interfaces.

19. These safety guidelines constitute a minimum set of good practices and recommendations to ensure a basic safety level. They aim at facilitating a harmonized level of major accident prevention, including firefighting water management and retention, and an acceptable level of risk within and beyond the UNECE region. These guidelines are intended to support existing requirements and recommend enhancement of practices, wherever appropriate.

3. BASIC SAFETY PRINCIPLES

20. Operators of hazardous activities have the primary responsibility for ensuring operational and process safety, the personal health of the operating staff and the prevention of contamination of the environment through released firefighting waters.

21. Technical and organizational measures in the case of an accident should be ensured. Therefore, contingency plans should be established by operators (on-site contingency plans) and by authorities (off-site contingency plans). These plans should be compatible with one another and regularly tested and updated. They should also include measures necessary for fire prevention, firefighting strategy and the management and retention of firefighting water to limit their potential consequences for human health and the environment.

22. Good storage practice for hazardous materials should be applied to minimize the risk of fire spreading, such as separation of combustible and non-combustible goods and the use of stable and water-resistant packaging materials to avoid the release of hazardous substances into firefighting water.

23. The accidental release of firefighting water can pose a potential risk to neighbouring countries sharing transboundary waters. In case of an accident, the governments concerned should inform each other of the measures taken or planned to be taken to retain and/or dispose of the firefighting water.

24. Past experience shows a high risk of groundwater and surface water contamination through the use of firefighting foams containing mixtures of perfluorinated and polyfluorinated Carbons (PFCs) or other persistent compounds with firefighting water. If there is a need to use such extinguishing agents, the potential environmental consequences should be carefully considered for each hazardous activity.

25. Regular exchange of information between operators, authorities and relevant stakeholders (e.g., firefighters, land-use planners, industry associations, insurance institutions, etc.) regarding good practices, improvement of safety, past accidents and near misses — including firefighting water management and retention issues — should be ensured.

26. Two independent power sources are required to provide for the power supply of automatically triggered firefighting water delivery systems, e.g., pumped deluge systems. For self-acting systems, e.g., systems that are operated pneumatically, hydraulically, or by gravitational force, a second independent power supply is not required.

27. A reliable high-integrity fire detection and suppression system should be installed to ensure the earliest possible detection and extinguishment of a fire. Account should be taken of factors that can influence rapid fire detection, such as the height of the room, subdivisions of the roof area (e.g., height of roof trusses), the condition of the environment and all possible sources that can result in false alarms.

28. An assessment of the required firefighting water quantity and the supply of the respective firefighting water must be undertaken.[15] During this assessment, the influence of differing firefighting strategies (controlled burn versus extinguishment, water sprays versus jets and fixed systems, etc.) should be considered.

29. The retention of any potentially contaminated firefighting water, including water that was not in contact with burning material but contains foam or wetting agents or released chemicals, is an essential component of an integral fire protection and safety concept.

30. For the retention of firefighting water, preference should be given to passive as opposed to active retention systems, i.e., self-acting, permanently installed, structural systems providing the required retention volume without any supplementary measures and being liquid-tight. A central or separately located retention system for firefighting water should be preferred over a local retention of firefighting water (e.g., in the building itself or at the point where the fire starts), to avoid hindrance to firefighters. However, where flammable liquids that are immiscible and less dense than water are involved, local containment may be required to reduce the risk of fire escalation.

31. Components of facilities for retention of firefighting water that could be exposed to a fire should be designed in such a way as to be resistant to the temperatures and heat radiation to be expected. Moreover, they should provide sufficient durability and resistance to other physical and chemical attacks during fire. Installations that penetrate a firefighting water retention basin should be avoided (e.g., plastic tubes) or otherwise designed so that they are able to withstand a major fire.

32. If firefighting water has the potential to mix with flammable liquids or if ignitable gas can be emitted, requirements for fire prevention and explosion protection (e.g., technical ventilation and air extraction) are to be met. Should a corresponding risk potential exist, it is strictly forbidden to use underground parts of the building, property sewerage systems (e.g., company-owned drainage systems), or other unprotected drains and shafts for retention and drainage of contaminated firefighting water.

33. All of the components of the retention system should ensure complete impermeability[16] until the disposal of any firefighting water retained. The requirement also applies to pipelines or other pipes leading to the retention reservoirs if they are also used for other purposes (e.g., for wastewater). Ensuring impermeability should take into account aggressive substances that may be present at hazardous activities or may occur in case of fire.

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[15] In accordance with the obligation under the Industrial Accidents Convention to undertake an analysis and evaluation of the hazardous activity to be able to take measures to prevent an industrial accident, including accidental water pollution and its transboundary effects.

[16] Impermeability criteria according to national requirements should be used as a basis.

II. RECOMMENDATIONS FOR THE MANAGEMENT AND RETENTION OF FIREFIGHTING WATER

34. These safety guidelines and good practices for firefighting water retention at hazardous activities contain recommendations and key elements for Governments (i.e., national governments), competent authorities and operators to take action to ensure a minimum level of safety for the prevention of an uncontrolled release of firefighting waters.

35. The safety guidelines are designed to prevent fire incidents at hazardous activities from happening and to limit the consequences for human health and the environment. They are based extensively on accepted and published good practice procedures to ensure conformity with international standards.

36. For the Parties to the UNECE Industrial Accidents Convention the need to take actions can be derived from their obligations under the Convention as well as from the general duty clause.[17] Non-Parties are also encouraged to take the necessary actions.

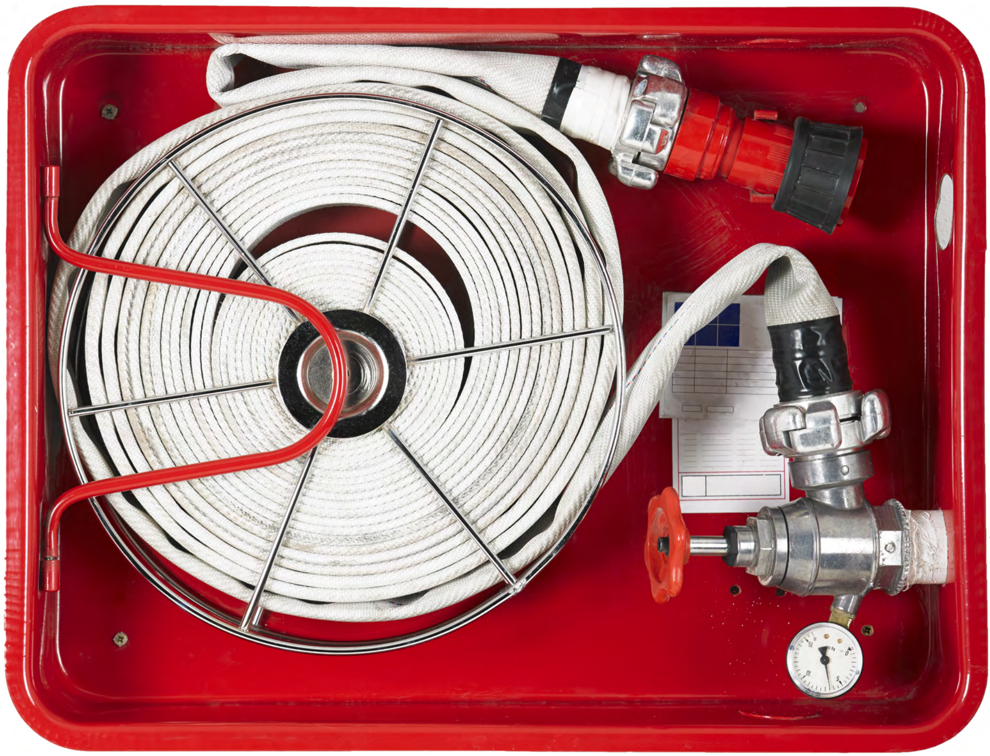
37. When using these guidelines, competent authorities and operators must ensure that national requirements are met. These guidelines constitute a minimum set of good practices to ensure a basic level of safety in this respect. Alternative approaches by applying different policies, measures and methodologies are possible, provided they achieve at least an equivalent level of safety.

1. RECOMMENDATIONS TO GOVERNMENTS

38. Governments should provide leadership and create suitable administrative and legal frameworks to establish the need for firefighting water management and retention in case of emergencies at all hazardous activities.

39. Governments should adopt policies for the safety of hazardous activities, including concepts for fire protection and the retention of firefighting waters. They should raise

17 The general duty clause aims to establish the principle, as a matter of law in most countries, that operators of hazardous activities have the responsibility for the safe operation of their facility. Further information about the general duty clause can be found in the United Nations Environment Programme flexible framework guidance: *A Flexible Framework for Addressing Chemical Accident Prevention and Preparedness: A Guidance Document* (Milan, Italy, 2010).



awareness and share experience and good practices through educational or training programmes and other means.

40. Governments are responsible for initiating the development and subsequent implementation of technical rules for firefighting water retention. Such firefighting water protection plans should be obligatory in relevant facilities.

41. Governments should encourage operators to provide details of the fire protection measures when applying to operate a hazardous activity.

42. Governments should set up policies on insurance, civil liability and compensation for damage caused by the local and/or transboundary effects of industrial accidents. The UNECE Protocol on Civil Liability and Compensation for Damage Caused by the Transboundary Effects of Industrial Accidents on Transboundary Waters[18] could be used as a reference.

[18] This joint protocol to the Industrial Accidents Convention and the Water Convention was adopted and signed by 22 countries at the Environment for Europe Ministerial Conference in Kyiv, Ukraine, on 21 May 2003. Two more countries signed the Protocol later in 2003. The Protocol has been ratified by Hungary and is not in force.

43. National legislation regarding fire protection should be clear, enforceable and consistent with the requirements of the Industrial Accidents Convention in order to facilitate international cooperation in, for example, the development and implementation of off-site contingency plans.

44. One or more competent authorities dealing with the management and retention of firefighting water should be designated. Governments should aim at designating such authorities at the national level and, where feasible, at the appropriate regional or local levels so that they have the necessary competence to ensure adequate monitoring and control of hazardous activities. The independence and objectivity of the competent authorities should be ensured.

45. Governments should ensure that the competent authorities are legally empowered and adequately resourced to be capable of taking effective, proportionate and transparent enforcement action, including, where appropriate, to cease operations in cases of unsatisfactory safety performance and environmental protection.

46. Governments should establish a system to ensure that information about fire incidents is evaluated on the national level and, if appropriate, basin level, to follow-up on lessons learned. Descriptions of lessons learned should be freely available to all stakeholders.

47. Governments should create joint bodies where these do not exist already for jointly managing their transboundary watercourses (in accordance with article 9 of the Water Convention). They should also establish international warning and alert systems in the framework of existing joint bodies to be able to cope with and counteract industrial accidents occurring in transboundary river catchments, including those with firefighting water emissions.

48. Governments should work, including through joint bodies, to raise awareness about the risks of accidental water pollution posed by firefighting water emissions, including the potential transboundary consequences, and to support the implementation of harmonized safety standards and approaches between riparian countries to prevent accidental pollution through firefighting emissions.

49. Governments should enhance international cooperation on mutual assistance, research and development and the exchange of information and technology in the field of industrial accident prevention, preparedness and response.

50. Governments should inform potentially affected riparian countries without delay in case of an accident that could cause transboundary effects, including through firefighting water emissions, using their bilateral or multilateral agreements, if any, and early warning systems according to their national regulations.[19]

[19] In accordance with article 10 of the Industrial Accidents Convention, the Parties must provide for the establishment and operation of compatible and efficient accident notification systems at appropriate levels to inform neighbouring countries. This can be ensured by using the UNECE Industrial Accident Notification (IAN) System, the European Union Common Emergency Communication and Information System (CECIS) and the alert systems of river basin commissions. The Parties to the Water Convention, in accordance with article 9, paragraph 2 (g), are required to establish warning and alarm procedures. This is assured in several international river basin commissions by their jointly established and regularly tested warning and alarm plans.

2. RECOMMENDATIONS TO COMPETENT AUTHORITIES

51. Competent authorities should ensure within their organization that they have expertise related to:

(a) Accident prevention (i.e., fire protection), emergency preparedness and response;

(b) Inspection and audit;

(c) Permitting requirements for the operation of hazardous activities (fire compartment areas).

52. Competent authorities should carefully consider the fire risk and firefighting water management when issuing a licence for operating a hazardous activity. The licensing or permitting authority should thoroughly examine the capability of the operator to ensure the continuous, safe and effective operations under all reasonably foreseeable conditions.

53. Competent authorities should require the operator to ensure that its analysis and evaluation of the hazardous activity considers also retention capabilities for firefighting waters and a firefighting strategy. The competent authority should thoroughly assess the operator's analysis and evaluation before approving it. It may also require the operator to provide any additional information necessary to enable it to fully assess potential accidents. The competent authority's approval of the analysis and evaluation does not imply any transfer of responsibility for the control of major hazards from the operator or the owner to the competent authority.

54. Competent authorities should set up a system of inspections or other control measures in order to ensure that operators meet the legal requirements.

55. Competent authorities should be empowered to conduct legal inspections. They may also set up a system for certified, independent experts to undertake the inspections of facilities. When competent authorities use independent experts for inspections, they remain responsible for assessing the competence and accountability of the experts and for the effectiveness of the inspection process.

56. The inspection regime of hazardous activities, as defined by the competent authorities, should include at least the following:

(a) The hazard potential;

(b) The operator's analysis and evaluation of the hazardous activity;

(c) The potential effects and the proximity and pathways to sensitive environments or communities;

(d) A fire protection concept,[20] including the respective equipment and installations for the retention of firefighting water;

(e) The previous inspection and performance records of the operator;

(f) The historical accident and incident record at the hazardous activity.

57. Competent authorities should ensure that operators:

(a) Draw up on-site contingency plans, including a fire-brigade response plan, and put them into effect without delay when an accident occurs;

(b) Supply them with the necessary information to enable the competent authorities to draw up off-site contingency plans.

58. Competent authorities should ensure that the operator provides training to the on-site personnel on how manually activated firefighting systems work and should be used (including systems for firefighting water retention). Training on this issue should be undertaken on a regular basis and at least once a year in cooperation with the fire brigade in charge.

59. Competent authorities are responsible for establishing permit conditions based on internationally accepted safety standards and sound fire protection systems.

60. The competent authorities should approve remediation plans for fire and explosion scenarios for hazardous industries.

3. RECOMMENDATIONS TO OPERATORS

61. The operator is liable not only for its operational risks following the polluter pays principle but can also be held responsible as a proprietor for consequential loss due to the fire brigade action and potential emissions of firefighting waters.

62. The operator must ensure the safe performance of the hazardous activity and is responsible for the implementation of a safety management system. In case of damage or an accident, it is the operator's responsibility to assess the situation and to initiate emergency measures and countermeasures as required.

63. All parts of a facility for the retention of firefighting water and its triggering devices (e.g., automatically shutting valves) should be installed so that they will not be damaged by operational activities. The devices should be installed in such a way to ensure their accessibility at any time for maintenance purposes and in the case of danger, such as a fire. This may include the need for remotely activated systems.

[20] The fire protection concept should include a firefighting strategy and a firefighting water retention concept. For further information and specific recommendations and good practices, see Part B (the technical and organizational recommendations) and Annex II of the safety guidelines.

64. Should parts of the sewerage system or other pipelines be used for the discharging of firefighting water into collecting facilities, the impermeability,[21] in particular the chemical resistance, of the corresponding section of the sewer or pipeline should be proven and ensured through long-term control and maintenance by the operator.

65. If the section for the sewerage system used to drain firefighting water into a retention facility also serves for the drainage of operational wastewater, this should be taken into account in the design and dimensioning of connected volumes of retention. The inlet into the pipeline or the sewer should be designed in such a way that burned material or other coarse debris do not block the inlet pipe or enter into the pipe. Immersion tubes or inlet structures with coarse screens can be installed to this end.

66. Firefighting water and combustible liquids may be mixed in the on-site sewerage system only if appropriate measures have been taken to ensure that this will not result in an explosive atmosphere in the sections of the sewers used. Appropriate measures should be taken to prevent the ignition of liquids in the retention system.

67. The locations of installation and triggering devices for the firefighting water retention facilities are to be marked on the ground plans for use by the operator's fire brigade and the public fire brigade.

68. Firefighting water retention facilities that need to be started manually should be inspected at least monthly to prove their functionality and ensure their operability in case of emergency. Inspections of all fire and retention systems should be carried out as laid down in the maintenance instructions by the manufacturer and/or installer. The operator is responsible for the observance of the inspection and maintenance intervals.

69. Firefighting equipment for open-air facilities should be constructed in such a way as to ensure its operability under the most severe expectable meteorological conditions (extreme temperatures, strong wind, heavy rain, flood, etc.).

70. The personnel should be instructed and trained on how the firefighting water retention systems work and how they should be used. Instruction and training should be repeated regularly, and at least yearly for all systems (automatic and manual).

71. The facility for the retention of firefighting water should be inspected regularly to ensure its proper structural condition and integrity. This will include at least a visual inspection of the surface of all parts and areas that will be exposed to firefighting water. Should defects be detected, e.g., separation in the area of joints, more detailed inspections will be necessary.

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[21] Impermeability criteria according to national requirements should be used as a basis.

72. Operators should apply good housekeeping practices and ensure that their premises are kept clean to avoid, for example, the blockage of sewers or other retention facilities. Regular checks for potential blockages should be carried out.

73. Connections, seals, and other wear parts are to be exchanged or replaced to the standard and at least as frequently as recommended by the manufacturer. All inspection and maintenance work, including the details observed are to be recorded. All defects are to be remedied immediately.

74. The operator should perform a periodic control of the impermeability[22] and the operational reliability of the safety equipment. The periodic control should be mainly focused on:

- **(a)** Visual inspection of the retention basins;
- **(b)** Control of the pollution control valves in terms of impermeability at least once a year;
- **(c)** Control of the operational reliability of valves, pumps, alarms and additional devices.

75. In addition, the staff need to be instructed about the actions and behaviour that should be employed during a fire.

76. Operators should work out a firefighting water retention concept as part of the on-site contingency plan, containing also measures for the timely disposal of firefighting water. These plans should be developed in cooperation with the competent authority and the responsible fire brigade.

22 Impermeability criteria according to national requirements should be used as a basis.

PART B

TECHNICAL AND ORGANIZATIONAL RECOMMENDATIONS

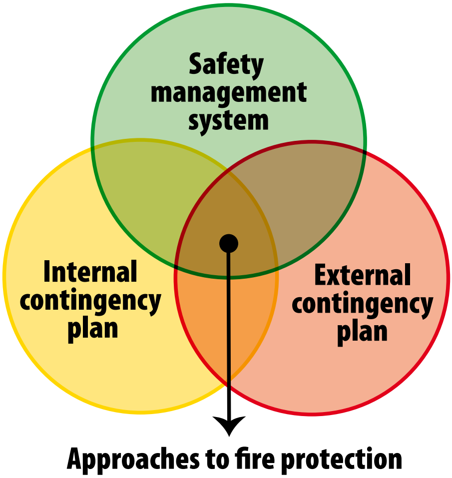
I. INTRODUCTION TO THE TECHNICAL AND ORGANIZATIONAL ASPECTS OF THE MANAGEMENT AND RETENTION OF FIREFIGHTING WATER

1. Since firefighting water, irrespective of the material burned, is hazardous to water, the occurrence of fires should be prevented. Where, despite stringent safety measures, a fire occurs, it must be detected quickly. Facilities should be designed so as to prevent the further spread of a fire and staff should know how to react and, specifically, to operate the fire-related equipment in the event of an emergency. These and other measures are part of the sound fire protection strategy that should be in place. In particular, fire protection for hazardous activities is composed primarily of the following elements:

- **(a)** Active fire protection, which may include manual or automatic fire detection systems and fire suppression;
- **(b)** Passive fire prevention, which includes compartmentalization of the overall site, e.g. through the use of fire-resistance-rated walls and floors. Organization into smaller fire compartments comprising one or more rooms or floors prevents or slows the fire's spread from the room in which it originated to other building spaces, limits building damage and gives the occupants more time to evacuate the building or reach an area of refuge.

2. Fire protection also entails minimizing ignition sources and training the facility's occupants and operators in the operation and maintenance of fire-related systems so that they can ensure their correct functioning and activation in an emergency. The correct procedures, such as notification of the fire response service and emergency evacuation, should be followed and fire protection should be addressed as part of the safety management system and contingency planning (see figure 1 below), based on the fire brigade response plan and the firefighting water retention strategy.

FIGURE 1 APPROACHES TO FIRE PROTECTION



II. APPROACHES TO FIRE PROTECTION

3. As part of the on-site contingency plan, operators should elaborate and implement a sound approach to fire protection, which should be adjusted to technical and organizational needs and new developments. The personnel should be trained in using this concept on a regular basis.

4. This approach may be both general and specific and may include structural and plant-specific fire protection measures which, taken together, make the occurrence of a fire a low probability and allow for earlier detection and suppression so that the minimum quantity of firefighting water is required.

5. The approach should include a firefighting strategy, a procedure for the retention of firefighting water and the following organizational plans:

(a) A wastewater and rainwater sewage plan, including points of intervention and of discharge into surface waters or public sewer systems;

(b) An on-site contingency plan, including alarm and evacuation organization;

(c) A fire brigade response plan, including, among other things, firefighting techniques, firefighting water management strategies, emergency contacts, access routes, floor plans and chemical inventories.

6. The approach to the retention of firefighting water should comprise documentation of the facility's layout, dimensioning, and all measures implemented by the operator in order to adequately retain the firefighting water used.

1. GENERAL MEASURES

7. In light of the environmental impact of accidents, the role of emergency planners and emergency responders should also be recognized and contingency plans (e.g., an appropriate firefighting strategy) developed in order to mitigate environmental harm.

8. Where an adequate defensive fire protection system (including adequate intervention time, an appropriate class of fire brigade and local knowledge) exists, the installation of a fire detection and fire alarm system and the resulting early detection of a fire can limit the extent of a fire, and thus the quantity of firefighting water required.

9. The use of non-combustible building materials also reduces the fire load and spread, and thus the quantity of firefighting water required to extinguish the fire. For this reason, non-combustible and heat-resistant building materials should always be used and the area should be divided into fire compartments separated by fire-resistant materials.

10. By means of automatic extinguishing systems (sprinklers, deluge systems, high expansion foams and extinguishing gases), a fire can be extinguished or its spread stopped at the earliest stage, perhaps even without additional firefighting water being used by the fire brigade). The quantity of firefighting water required may be up to 10 times less than in the absence of an extinguishing system. However, while fixed systems can often reduce firefighting water volumes effectively, these arrangements can potentially fail. Thus, for contingency planning at high-hazard sites, worst case scenarios should be considered if escalation of the fire would require a significantly larger volume of firefighting water.

2. SPECIFIC MEASURES

11. The specific fire protection measures include:

- **(a)** Constructional measures;
- **(b)** Fire detection and notification facilities;
- **(c)** Mobile and stationary firefighting equipment (operator and external fire brigade);
- **(d)** Provision of suitable firefighting agents and water in adequate quantities, including high-volume pumps;
- **(e)** Administrative measures such as storage facility regulations, fire prevention plans and training of personnel;

(f) A well-trained and -equipped fire brigade that is familiar with the fire protection plan and the specific nature of the hazardous activity, e.g., a fire in a pesticide storage facility;

(g) Facilities and measures for the retention of contaminated firefighting water (both installed and mobile systems).

3. STRUCTURAL FIRE PROTECTION

12. Constructional measures seek to contain fires within a limited area of the facility.

13. Fire compartment areas are among the most critical means of limiting the spread of fires and the amount of firefighting water and firefighting water retention capacity needed should a fire occur.

14. For all measures designed to reduce the risk of fire and subsequent damage from firefighting water, technical specifications should be taken into account and a maintenance and periodic test programme be implemented in order to ensure the continued operability of the corresponding components. This entails, among other things, intelligent drainage systems (e.g., for flammable liquids in open plants) and fire barriers.

15. In order to reduce the risk of fire, plants should be adequately subdivided into fire compartments and fire cells. The size of fire compartments is a key factor in limiting the volume of firefighting water required. Based on past experience, the volume is roughly proportional to the fire's surface area (for calculation examples and equations, see annex II).

4. PLANT-SPECIFIC FIRE PROTECTION

16. Technical measures that seek to limit fires through rapid detection or intervention include:

(a) **Automatic fire detection and alarm systems:** Automatic fire detection systems will shorten the intervention delay time, enabling an intervention before the fire can spread excessively;

(b) **Automatic fire-extinguishing system:** Sprinklers, carbon dioxide extinguishing systems, deluge systems and other automated extinguishing devices extinguish fires or contain them within a smaller area and are effective in minimizing the volume of firefighting water;

(c) **Smoke and heat venting systems:** Smoke and heat venting systems prevent excessive overheating of fire compartments, thus helping to preserve containment and limiting the amount of water required for cooling.

17. **Storage height and density.** Storage height and density (kilograms (kg) of combustible goods per square metre (m^2) of storage area) affect the firefighting water volume in two ways: on the one hand, higher storage density results in a higher thermal load and thus a more intense fire, requiring more firefighting water. On the other hand, effective firefighting becomes increasingly difficult with greater storage height and will generate more firefighting water unless specific protective measures are taken.

18. **Stored liquids.** Owing to their probable release during a major fire, the volume of any liquids stored or contained within production equipment should be added to the retention volume needed for firefighting water.

19. **Flammable substances.** The fire risk and fire spread velocity are dependent on the flammability (flashpoint) of the goods stored; highly flammable liquids generally lead to more-rapidly-spreading and larger fires. Where practicable, containers containing flammable liquids should be designed to minimize the risk of failure in the event of a fire.

20. **Hazardous properties of substances.** Certain properties (e.g. corrosiveness) of hazardous chemicals may limit the choice of materials used in firefighting water retention systems. Likewise, some substances may cause hazardous chemical reactions when released or require the use of extinguishing agents other than water (in which case, a smaller firefighting water retention volume may be required).

21. **Combustible installations, packaging and construction materials.** In addition to goods in storage and production equipment, large amounts of packaging materials (cardboard, plastics, wood, etc.) can contribute to the thermal load. Combustible installations (cables, pipes, ducts, etc.), building materials, furniture and combustible wastes (especially liquid flammable wastes) are another significant and frequently-overlooked factor in fire escalation.

22. Some polymers (e.g. rubber) exhibit exothermic pyrolysis in fire, forming a self-heating mass that is difficult to extinguish and releasing hazardous pyrolysis products in liquid form. Long-time cooling is then necessary, and large volumes of firefighting water are required.

III. DIMENSIONING OF FIREFIGHTING WATER RETENTION FACILITIES

23. Several approaches for calculating the retention volume of firefighting water required exist. While countries may require that this volume be calculated, specific methods are not always prescribed and the retention volumes calculated using the different methods differ significantly. Moreover, most of these methods were developed for "standard fires", which account for up to 90 per cent of all fires; so-called "catastrophic fires", which have an unusual fire development, are not taken into account in the methods.

24. Examination of a number of catastrophic fires involving hazardous activities in the UNECE region shows that the amount of firefighting water used during those accidents was far greater than calculated under most of the known models. This highlights the need for larger retention volumes.

25. The following calculation approaches for firefighting water (see annex II) are among the most validated and are based on scientific and empirical evaluation of actual fire events by independent experts:

- **(a)** **German (Verband der Schadenversicherer e.V. (VdS)) model:** set out in *Planning and Installation of Facilities for Retention of Extinguishing Water: Guidelines for Loss Prevention by the German Insurers,* No. VdS 2557 (see below, *Sources in annex II*);
- **(b)** **Swiss model:** in accordance with *Löschwasser-Rückhaltung – Leitfaden für die Praxis (Firefighting Water Retention: A Practical Guide)* (see reference list).

26. Among the various parameters affecting the volume of firefighting water required to extinguish a fire, the total area of a designated fire compartment seems to have the most important influence. Based on these experience, a stepwise approach to the calculation of firefighting water retention facilities is proposed (for an explanation of the various calculation models, see annex II):

- **(a)** **Step A**: For a quick, rough estimate, direct proportionality of the firefighting water volume required for the largest fire compartment area may be assumed. This can be roughly equated to one square metre (m^2) of fire compartment area resulting in one cubic metre (m^3) of retention volume (e.g. a 5,000 m^2 fire compartment area requires 5,000 m^3 of retention volume);
- **(b)** **Step B**: The retention volume required is up to 10 times smaller if the facility is equipped according to an advanced fire protection concept (e.g. automatic

sprinklers, high expansion foams or extinguishing gases). A 5,000 m^2 fire compartment area would require 500 m^3 of retention volume. In most cases, any liquids present in the fire compartment will spill into the firefighting water, increasing the retention volume. This additional volume should be added;

(c) **Step C**: If specific additional data such as the density and form of stored goods and the thermal load of potentially-affected materials are available, the use of a more advanced methodology, e.g. the German VdS or Swiss model, is preferable, bearing in mind the limitations of these methodologies (see annex II).

27. Steps A and B above can be applied to facilities in all countries, especially where critical data about the hazardous materials is limited or unavailable. This rough estimate will show the order of magnitude of the retention volume required.

28. In developed and industrialized countries, the more advanced calculation methodologies (step C) are recommended for the calculation of firefighting water retention volumes.

29. If the firefighting water retention volume calculated according to steps A to C is too large to be feasible, alternative extinguishing methods, such as sprinklers, should be considered. High-tech firefighting systems, such as ultrafine water drops or carbon dioxide extinguishing systems, may bring additional advantages by diminishing water volume and reducing smoke.

30. The following flow chart (see figure 2 below) provides an overview of the proper dimensioning of the retention capacity required. The most important factors that influence the calculation of this volume are:

(a) The surface area of the fire (normally this would correspond to the largest fire compartment or, in the case of bundled storage, the bunded area) (figure 2, No. 2);

(b) The thermal load of the materials within the fire (including, among other things, combustible construction, building and packaging materials), taking the size and location of the fire into consideration;

(c) The presence (or absence) and efficiency of extinguishing devices, such as sprinklers or deluge systems;

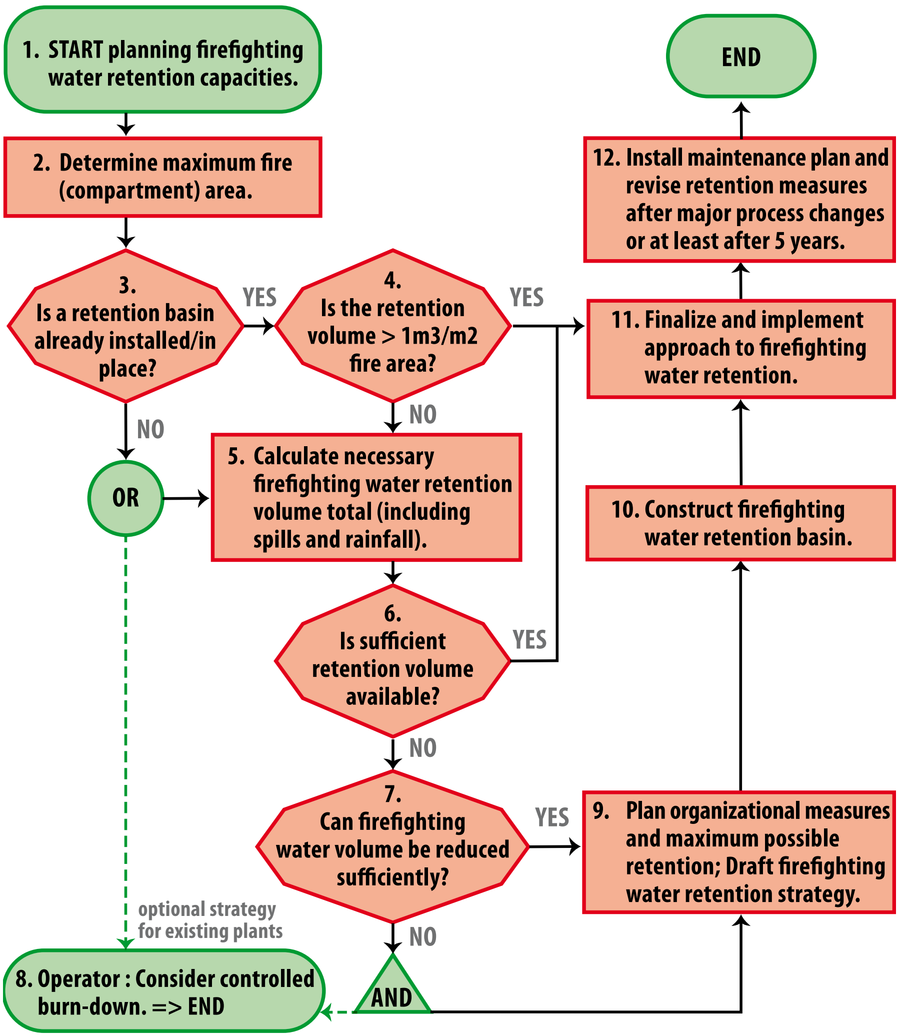
(d) The volume of all chemicals and liquids in production, operation and storage that might be released into the firefighting water;

(e) The maximum rate and duration of water delivery for firefighting purposes;

(f) Potential amount of rainfall during and after the event until the firefighting water can be properly disposed of (this may range from a few days to several weeks; the maximum precipitation rate for the time period in question may be used to determine the additional volume);

(g) Waves and shifting of water (liquid) levels owing to wind.

FIGURE 2 FLOW CHART FOR THE DIMENSIONING OF FIREFIGHTING WATER RETENTION FACILITIES



31. Generally speaking, the retention volume can be drastically reduced by implementing efficient measures (figure 2, No. 7) to prevent fires from spreading, by using automated fire detection in combination with automatic extinguishing systems, and by applying efficient firefighting techniques. If this is not done, the firefighting water volume may be extremely large. The approximate volume, based on past experience, is up to 1 m^3 per 1 m^2 of fire surface area (not accounting for rainfall or the volume of released chemicals).

32. If a retention volume of more than 1 m^3 per 1 m^2 of the maximum potential fire (compartment) surface area is already available and effectively usable, this may be considered adequate and further dimensioning considerations may be omitted (figure 2, No. 4) unless the hazards noted above indicate that a greater volume of firefighting water will be required. It is nonetheless recommended that as many measures as practicable be employed in order to reduce the actual volume of firefighting water (figure 2, No. 7) since the construction of large retention volumes is very expensive and any contaminated water will have to be disposed of eventually, usually at high cost.

33. Lastly, if an adequate retention volume cannot be achieved (on site), the maximum attainable volume should nonetheless be installed and complemented with additional organizational measures (e.g. specific instructions and training for firefighting brigades, special firefighting techniques, extinguishing agents other than water, special contingency planning, planning for external retention volumes and disposal of firefighting water during the fire) (figure 2, No. 9). In certain cases where human health and safety are not at risk, a controlled burn-down of parts of the facility, using only a minimum of water to cool adjacent buildings or structures and prevent the fire from spreading, should also be considered (figure 2, No. 8). This option may prevent damage to groundwater and surface waters, but the operator must always consult the competent authorities and external firefighting brigades and the decision-makers must not expose people to additional hazards.

IV. PLANNING AND DESIGN OF RETENTION SYSTEMS

34. In protecting people and the environment from contaminated firefighting water, the design of the retention system is one of the most important issues. The following chapter refers to the German VdS model and provides a short overview of the points to be considered by planners, operators and the competent authorities.[23]

[23] For additional guidance, see *Ian Walton (2014), Containment Systems for the Prevention of Pollution: Secondary, tertiary and other measures for industrial and commercial premises.* Construction Industry Research and Information Association (CIRIA) Report No. C736. London. Available at https://cdn.shopify.com/s/files/1/0523/8705/files/CIRIA_report_C736_Containment_systems_for_the_prevention_of_pollution.compressed.pdf See also the reference documents prepared within the framework of the European Union Industrial Emissions Directive (Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control), 2010 O.J. (L 334), pp. 17–119), available at http://eippcb.jrc.ec.europa.eu/reference/

35. It is important that retention systems are adjusted to conditions of the location of the production site. The retention system should also be designed as a logically coherent, integral system that includes fire protection and reduction measures, firefighting water collection, storage and disposal in light of the on-site conditions.

36. In order to avoid damage caused by contaminated firefighting water, appropriate technical equipment is required.

37. There are several possible types of systems for the retention of contaminated firefighting water. They may be installed permanently (e.g. preinstalled water barriers or permanent retention basins, with pumping installations where necessary) or provided as mobile facilities (e.g. firefighting water barriers, drain-sealing pads and devices or mobile storage tanks).

38. Owing to safety and reliability considerations, permanently installed retention systems should be preferred wherever possible.

39. Permanently installed retention systems may be automatically (passive or self-activating) or manually triggered systems. Automatically triggered systems have two different independent triggering lines in order to ensure functionality and avoid accidental activation. Manually activated systems are generally less reliable in stressful situations.

40. Where mobile facilities are used, care must be taken to ensure that they can be installed rapidly and can be managed with minimal effort, i.e., their set up should be possible with two people maximum.

1. GENERAL REQUIREMENTS

41. With regard to stability, watertightness and durability, facilities used as retention devices (e.g. retention ponds and contingency basins) should be impermeable and resistant to contaminated firefighting water. Retention facility components that might be exposed to a fire should be resistant to high temperatures and to physical and chemical impact.

42. In addition to stability and durability, the functional safety of retention systems should be considered. When using self-acting retention systems, it is important to ensure that the shutdown position can be guaranteed at any time. Therefore, two independent power supply systems should be provided.

43. When using manual systems, a sufficient permanent on-site workforce should be available so that the retention devices can be activated as soon as possible.

44. If firefighting water will be held in underground systems or cellar basins, it is important to ensure that no flammable or explosive vapours are present.

45. Any indoor connections to the retention facility, including doors and inspection shafts, must be fire-resistant.

2. INSTALLATION OF RETENTION SYSTEMS

46. Generally speaking, retention devices should be arranged in such a way that they cannot be damaged by daily operations and are accessible for maintenance at any time.

47. Water barriers should be installed inside buildings (in gateways or floors) and other facilities so that firefighters can enter the building or facility during the extinguishing procedure. If these water barriers need to be installed manually, they should be stored near the corresponding gateway or floor and be easily accessible and protected against damage. If no permanent on-site work force can be guaranteed, the water barriers should be installed in advance.

48. If the sewer is used as a part of a retention system, it must be stable, resistant to contaminated firefighting water and watertight. Furthermore, the sewer should be closed up in an emergency without causing backflow into connected systems. Where the sewer is also used for draining wastewater or cooling water, this fact should be taken into account during the planning and dimensioning of the potential retention volume. If the firefighting water may be mixed with flammable liquids, draining through the sewer is allowed only where the build-up of an explosive atmosphere can be excluded.

49. Inspection shafts should be installed in the sewer for controlled sampling by the operator.

50. For open retention basins or other systems that are exposed to rainfall, a system for controlling accumulated liquid volume during ordinary operations is required in order to avoid overflow and ensure that sufficient available retention capacity is maintained.

51. Where pumps are used for the transport of contaminated firefighting water to a retention basin, they should be designed to deliver the required output even under extreme conditions and should be permanently installed. Where this is impossible, the operator should ensure that well-trained workers are available to install mobile devices at any time. Pumps may be triggered automatically or manually, depending on the existing emergency concept. Furthermore, a reliable power supply must be ensured even in the event of a fire and transfer drains and pipes must be of a size that can handle the anticipated volume of liquid.

52. When installing permanent or temporary retention basins, the existing legislation on construction, water protection and hazardous goods should be consulted. The basins should be equipped with ventilation and air extraction devices designed for maximum input and output flows inside the basin.

53. In principle, retention devices should be located outside the production and storage units. Where flammable substances are present, their rapid and safe removal is important so that they do not cause further expansion of the fire.

54. Furthermore, the secondary containment of the chemical may be used as a retention device. However, the containment should be dimensioned so that, in addition to the leakage volume of the hazardous substances, the volume of firefighting water (including cooling water, rainwater and any foam blanket) can be retained (i.e., additional freeboard space should be envisaged). Catchment areas and retention devices for the retention of contaminated firefighting water should be arranged and equipped so as to detect overfilling immediately in order to prevent the liquid from overflowing into adjacent fire compartment areas. Additionally, they should be accessible at any time in the event that further action (e.g. the removal of liquids) is required to prevent overfilling.

55. For the retention of firefighting water containing flammable liquids, the guidelines for explosion prevention should be respected.

56. Retention basins and barriers used for firefighting water retention must be stable, watertight and mechanically, thermally and chemically resistant.

3. RETENTION DEVICES

57. Retention devices should have overfill detection systems or alarms and may include, for example, firefighting water bulkheads or other mechanical-shut-off barriers that only lead to a retention basin when activated during a fire. A retention basin is normally a basin that is permanently available.

58. The shut-off devices should be accessible at any time and should be easily operable. In some cases, such as the containment of flammable liquids, an automatic or remotely-operated system may be necessary since local operation might be too dangerous. Automatically-operated safety devices such as pumps and gate valves should have an independent power supply. Because these safety devices can fail, precautions (e.g. redundancy, duplication, fail-safe installations and/or mobile equipment) must be taken.

59. Generally speaking, there are two different types of retention devices:

(a) Central retention devices for multiple facilities at the same site (e.g. discharging through rainwater and cooling-water sewers into a central retention or contingency basin). These devices are not located on the operator’s property and are managed by someone else (e.g. a water treatment plant);

(b) Local retention devices directly connected to a facility (e.g. retention basins). These devices are located on the property of the operator, who is also responsible for maintaining them.

60. Local retention devices should be constructed in such a way that:

(a) Secure retention – impermeability and durability – are ensured;

(b) Additional retention volume for potential leakage is provided.

61. Where no local retention device can be provided, a central retention device (e.g. the contingency basin of a wastewater treatment plant or industrial area) may be selected. In this case, the secure discharge of firefighting water and the impermeability and the durability of all construction materials (including the sewer systems) must be ensured.

4. PLANNING AND MAINTENANCE OF FIREFIGHTING WATER RETENTION SYSTEMS

62. **Sewerage system**. Especially in existing facilities, the plant's internal sewerage system may be part of the approach to firefighting water retention. If flammable liquids can be released into the firefighting water or explosive vapours can develop, sewerage systems and underground parts of buildings must not be used for retention unless complete explosion protection can be guaranteed. If the sewerage system is to be integrated into the firefighting water retention strategy, the system must:

(a) Be watertight and able to resist any chemical attack from firefighting water;

(b) Not discharge storm water overflow into a surface water body directly (storm water sewerage) or indirectly (wastewater sewerage) in the event of heavy rain.

63. **Watertightness of storage basins.** Local retention of firefighting water in the affected building is generally preferred. Periodic checking of the condition and functioning of stationary and temporary shut-off devices and immediate repair of any defects found should be ensured.

64. The penetration of rainwater drainage pipes, pipelines (or other pipes, e.g. for wastewater) or cables into the floors or walls of facilities used for the retention of firefighting water or affected fire compartments should be avoided; otherwise, the openings should be structurally waterproofed or situated above the maximum flooding level. Where this is impossible, the pipes must be constructed of fireproof materials or covered by a suitable protective coating.

65. The internal wastewater treatment facility of an affected company will normally be unable to treat contaminated firefighting water, which has a far more complex composition and higher contamination load than the normal wastewater of the plant or operation and is likely to produce a higher volume than is normally handled. The wastewater treatment unit might also be compromised or rendered non-functional owing to the fire and the impact of contaminants and foams.

66. In many industrial processes, connecting plastic pipes or other infrastructure may be damaged by fire. It should be assumed that all production chemicals, cooling water, rinsing water and wastewater located in the area affected by fire will leak simultaneously.

67. **Maintenance and quality assurance**. Where firefighting water retention measures have been installed and a retention concept is in place, it is essential to ensure the continued functioning of this system. To that end, an inspection and maintenance plan (figure 2, No. 12) covering at least the following issues should be implemented:

(a) Constructional integrity of the retention volume(s);

(b) Constructional integrity of fire compartments;

(c) Integrity and functioning of all firefighting water conduits;

(d) Functional testing and maintenance of barriers, pumps, slide valves and other technical devices required in order for the firefighting water retention to be effective;

(e) Testing and maintenance of fire detection and extinguishing systems;

(f) Testing and maintenance of explosion protection equipment and installations;

(g) Testing and maintenance of ventilation systems and smoke and heat vents;

(h) Compliance with storage regulations for hazardous substances and combustible goods;

(i) Knowledge of and compliance with the relevant operation procedures, safety instructions and contingency plans;

(j) Periodic cleaning to remove silt and debris, especially from any transfer pipes and drains.

68. **Weather (wind and rain)**. A significant additional retention volume will be required in the event of heavy rain during a fire event, and in the period after the fire until the firefighting water can be disposed of; this may range from a few days to several weeks. Obviously, these external factors cannot be accurately foreseen, but the prevailing conditions in the geographic area should be taken into account in the fire protection concept. The calculations are normally based on the maximum local 10-year rainfall intensity but, owing to climate change, previous flooding in the geographic area should also be considered.

V. FIREFIGHTING WATER DISPOSAL

69. Because firefighting water must always be considered contaminated, special considerations must be taken into account when disposing of it. A proper assessment of the firefighting water, accompanied in most cases by a qualified laboratory analysis of the degree of the contamination, should be conducted prior to its disposal.

70. While most wastewater treatment plants (on- or off-site) should be able to treat cooling water without additional measures, the degree of contamination should be assessed prior to treatment.

71. For any other type of firefighting water, it is necessary to determine whether the level of contamination is sufficiently low to permit disposal through a wastewater treatment plant. This determination must be made in consultation with the competent water authority and the wastewater treatment plant operator. Where the firefighting water contains toxic or corrosive chemicals (including extinguishing foams, e.g. with fluorinated carbon chains), or toxic combustion products, pre-treatment – either on site or at a specialized treatment facility – is likely to be required. Very heavily contaminated water may need to be disposed of through a dedicated chemical waste disposal facility.

72. The logistics for the proper transport of firefighting water to the disposal unit(s) should be part of the safety management system and include compliance with any applicable waste legislation.

ANNEX I

EXAMPLES OF MAJOR FIRE ACCIDENTS IN THE UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE REGION[24]

[24] This list is not exhaustive. Further case studies and lessons learned can be found in various sources.

1. The table below presents an overview of fire accidents in the UNECE region and their key parameters.[25] Following the table are more detailed descriptions of the accidents.

OVERVIEW OF SOME FIRE ACCIDENTS FROM THE UNECE REGION AND THEIR KEY CHARACTERISTICS

No.	Year, company, place, country (transboundary or national)	Fire-compartment area	Volume of firefighting water used	Total costs of the accident
1.	1986, Sandoz, Schweizerhalle, Switzerland (transboundary effects)	4,500 m^2 (burning)	20,000 m^3	SwF 141 million (of which 60 million for soil remediation, 42 million for compensation payments, 15 million for building loss and 24 million other costs).[a]
2.	2005, Schweizer AG, Schramberg, Germany (potential, but no eventual transboundary effects)	2,775 m^2 (burning)	3,500 m^3	€1 million (costs for the disposal of firefighting water only)
3.	2006, Brenntag Química, Caldas de Reis, Spain (no transboundary effects)	14,734 m^2 (burning)	3,000–3,500 m^3 (estimate)	Inside the establishment: €3.4 million in damages in the establishment; €1.6 million for response, clean up and remediation inside the establishment; total cost for the operator: €5 million. Outside the establishment (social costs, including response, clean up and remediation outside the establishment): €8 million.
4.	2009, Abloy Company, Joensuu, Finland (no transboundary effects)	180 m^2	2,200 m^3	The damage was roughly estimated to cost "millions of euros"

[25] These examples are catastrophic accidents representing worst case incidents. The amount of firefighting water retention volumes needed are far beyond the ones resulting from the calculation models presented in Annex II of these safety guidelines.

No.	Year, company, place, country (transboundary or national)	Fire-compartment area	Volume of firefighting water used	Total costs of the accident
5.	2011, Chemie-Pack storage facility, Moerdijk area, the Netherlands (no transboundary effects)	6,500 m^2	38,000 m^3	€13 million
6.	2011, Remiva ltd., Chropyně, Czechia (no transboundary effects)	150 m^2 (later expanded up to 5,000 m^2)	6,350 m^3 of firefighting water; 38 m^3 of heavy fire foam (26 tons)	€10 million

[a] See Schweizer Radio und Fernsehen (SRF) (Swiss Radio and Television), "Schweizerhalle-Brand vor 30 Jahren – eine Nacht des Schreckens", 30 October 2016 (in German). Available at https://www.srf.ch/news/schweiz/schweizerhalle-brand-vor-30-jahren-eine-nacht-des-schreckens

1. SWITZERLAND – FIRE AT THE SANDOZ WAREHOUSE IN SCHWEIZERHALLE IN 1986

2. Shortly after midnight on 1 November 1986, a major fire broke out in a chemical warehouse near Basel at the Schweizerhalle site of the Swiss chemical company Sandoz. In the building was a mixed storage of 1,350 tons of chemicals, among them several pesticides, herbicides and mercury compounds, as well as highly flammable solvents. It took 160 firefighters almost seven hours to manage the large fire, even with the deployment of a special firefighting boat on the nearby Rhine River.

3. Approximately 20,000 m^3 of water was used for extinguishing and cooling the fire. Since the site had, at that time, no facilities for the retention of firefighting water, all of this firefighting water, together with 40–50 tons of highly environmentally toxic substances, was discharged into the Rhine through the rainwater drainage.

4. As a result, the entire population of eel, along with other fish species, was killed up to a distance of 400 kilometres downstream. Damage to other aquatic organisms could be seen as far as the Netherlands. Finally, the extraction of drinking water was suspended on the entire river from Schweizerhalle to Rotterdam until contamination levels had returned to normal values.

2. GERMANY – FIRE AT SCHWEIZER AG FACTORY IN SCHRAMBERG IN 2005

5. A fire at Schweizer AG, a producer of printed circuit boards, occurred in Schramberg on 5 June 2005, with a fire area of approximately 6,500 m^2. The whole factory area was about 34,000 m^2. The fire broke out in the wastewater treatment area and spread into the electroplating production and parts of the chemical storage. All the chemicals in production were released into the firefighting water — a total of approximately 400 tons of chemicals. About 1,000 m^3 of highly contaminated firefighting water, containing heavy metals, acids, solvents and traces of cyanide, could be retained in basins and improvised barriers on site. The firefighting water contained such aggressive substances that it etched through steel tanks within 72 hours. Another 1,000 m^3 of firefighting water was retained in an overflow basin for rainwater in Schramberg. Because of heavy rain forecasted, the firefighting water had to be transported quickly by means of special trucks to several chemical waste disposal facilities all over Germany. Parts of the firefighting water were released into the sewage treatment facility of Schramberg. Although it was provisionally chemically treated, the whole biology of the treatment facility was destroyed. The costs associated with the disposal of the firefighting water were €1 million.

3. SPAIN – FIRE AT THE BRENNTAG COMPANY IN CALDAS DE REIS IN 2006

6. On 1 September 2006 a fire destroyed most of the storage facility of the company Brenntag Química, S.A., in Caldas de Reis, Pontevedra. The fire was reported to the emergency services at 2.04 p.m and was extinguished early the next day 12.14 a.m. on 2 September 2006.

7. During the unloading operation from the tank truck of 24,000 litres to containers with a capacity of 1,000 litres, a fire broke out. A deflagration of flammable gases followed. No one was injured in the accident, but the fire destroyed large parts of the storage facility. Owing to the high temperatures produced by the blaze, the chemicals stored at the site were largely incinerated. However, residue from the chemicals, mainly toluene and styrene, reached the nearby Umia River with the firefighting water. The river was partly contaminated with chemicals, primarily toluene. The extraction of drinking water was temporarily suspended. The suspension affected a population of 110,000 people.

8. The company's activity at the site was the storage and distribution of chemicals. The storage facility was a Seveso establishment to which articles 9, 11 and 13 of Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances[26] (Seveso II Directive) were not applied. If the facility was active today, it would be classified as a lower-tier establishment, according to 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[27] (Seveso III Directive).

9. A combination of a static electricity discharge originating in the tank truck and existing high temperature conditions were considered the most probable cause of the accident. The fire area, which was contained within the boundaries of the facility, reached 14,734 m^2.

26 1997 O.J. (L 10), pp. 13–33.

27 2012 O.J. (L 197), pp. 1–37.

10. The estimated amount of water used was 3,000–3,500 m^3, based on the number of crews of different fire brigades included among the respondents, the equipment used and the duration of the emergency. Part of the firefighting water was contained and later recovered for treatment but most of it reached the nearby Umia River through the surface water drains of the facility, causing contamination owing to its content of chemicals, mainly toluene and styrene. Immediate measures were taken by the regional and local authorities to prevent the chemicals from spreading further. To contain and remediate the contamination, 5 kilometres downstream from the site of the accident a dam was built with sandbags. Next to the dam a series of retention dikes were built to channel the contaminated water to eight ponds for a decontamination process in three phases using active carbon (40 tons), oxygen and sand filters. Following treatment and subsequent inspection to verify acceptable water quality, the water was fed back into the river, starting two weeks after the accident. By one month after the accident the river had mostly recovered.

11. Environmental degradation included damage to protected and non-protected wildlife, including mortality, damage to freshwater habitats and water resources for residential and recreational uses, and damage to a protected area, a Natura 2000 site, located downstream of the site where the accident happened.

12. The list of chemicals involved is a long one, including toxic or highly toxic substances such as hydrogen fluoride, benzene, formaldehyde, flammable or highly flammable substances such as xylene, toluene and styrene and other substances. As mentioned above, toluene and styrene were the main drivers of the contamination when they were washed into the river by the firefighting water.

4. FINLAND – FIRE AT THE ABLOY COMPANY IN JOENSUU IN 2009

13. A fire at a company called Abloy took place in 2009. Abloy is an upper-tier Seveso facility,[28] mainly because of its electroplating department, which is also where the fire occurred. The fire most probably started when the bus bars of the process power supply system overheated. The overheating was probably due to loose coupling in the bus-bar system.

14. The part of the establishment where electroplating was located was completely destroyed in the fire. The surface area of the electroplating department was 180 m^2 with a height of 6 meters. This was all one fire compartment but it was a separate compartment from other departments. In total, the factory area was around 21,000 m^2. Most pipes, basins, etc., were polypropylene, and some were PVC. All the plastic basins melted. Those that were of steel had plastic plugs, so their content was also released.

[28] An upper tier facility, in accordance with annex I to the Seveso III Directive.

15. The amount of water used was around 2,200 m^3. Not all of this was used to fight the fire, some was also needed to keep the hoses from freezing (in winter). Approximately 600 m^3 of a mixture of water and liquid chemicals was recovered from inside the factory and 65 m^3 from a nearby ditch. Some contaminated water also ended up at the municipal wastewater treatment facility (via the company's own wastewater treatment facility).

16. At the time of the fire, the electroplating department contained around 108 m^3 of various hazardous chemicals (e.g., chromium and nickel compounds, various acids and alkali as well as cyanides) and around 86 m^3 of rinsing water. The chemicals mixed with the firefighting water. The environmental damages were measured after the fire from the snow, soil, groundwater, rainwater sewerage system, nearby watercourses and the municipal wastewater treatment plant's outbound water and slurry. The most significant environmental damage was caused by the process chemicals, especially heavy metals and cyanide, and occurred within or near the factory site. The pH value measured from the firefighting water (outside the building) was 1–2.

5. NETHERLANDS – FIRE AT THE CHEMIE-PACK STORAGE FACILITY IN MOERDIJK IN 2011

17. The fire at a company called Chemie-Pack, located in Moerdijk, the Netherlands, took place on 5 January 2011. The company's business activities consisted of mixing, distributing and packaging chemical powders and liquids. They did not actually produce any chemicals.

18. The fire started outside in the yard, while resin was being pumped from one immediate bulk container tank into another. Owing to the cold weather conditions, the pump's exhaust silencer began to freeze up. However, when the resin stopped flowing, it was decided to heat the middle of the pump with the gas burner. The use of open fire was against the provisions of the permit. This was a big risk because of the direct proximity of xylene, used to clean the pump and collected in a tray under the pump, which resulted in xylene catching fire. The attempt to extinguish the fire manually failed owing to the continuous flow of the burning resin. The company's emergency response team could not extinguish the fire when it began. Chemie-Pack's technical and organizational risk management processes did not live up to the levels of the risk of the company. The necessary organization and means allowing for an effective intervention were simply not present.

19. The fire at the Chemie-Pack storage facility occupied an area of approximately 6,500 m^2. The company had five large sheds in each of which hundreds of tons of hazardous materials were stored. In the outdoor area, there were another several hundred plastic containers, each filled with 1,000 litres of flammable liquid. In addition, a container with 16,000 litres of acetone (80 barrels of 200 litres each) and a tanker filled with 33,000 litres of a very flammable substance were located on-site.

20. The amount of firefighting water amounted to approximately 14 million litres. For the foam blanket 18,850 litres of foam shaping means were necessary. The large amount of firefighting water was stored in the sewers and embedded ditches. The contaminated firefighting water (38,000 m^3) was later transported by trucks to a waste disposal plant.

21. The effects of the fire were limited to the substantial material and environmental damage at the port and industrial area of Moerdijk. The materials list of Chemie-Pack included 52 pages, mentioning hundreds of flammable, corrosive, toxic and environmentally harmful substances. The soil on which the company Chemie-Pack and two adjacent companies were built had to be cleaned up. There were no threats to food safety or (drinking) water quality.

22. The total cost of this fire disaster is estimated at €71 million.[29]

6. CZECHIA – FIRE AT THE REMIVA FACILITY IN CHROPYNĚ IN 2011

23. A fire at the Remiva company took place in Chropyně, Czechia (Moravia), in 2011. The Remiva facility is used to store and recycle many kinds of plastic waste (polyethylene, polystyrene, polypropylene, polyurethane, polyamide, polytetrafluoroethylene, polycarbonate; and acrylate) on its grounds. As such, the facility was not treated as a Seveso plant. Nevertheless, the entire facility was divided into several fire compartments, equipped with electric fire signalization. The storing height was limited to 1.5–2.5 meters, and construction fire safety plans had been drawn up. Approximately 1,500 tons of plastic waste were stored right before the fire started on 8 April 2011 at 1.03 a.m.

24. The exact cause of the fire, generating losses initially estimated up to €10 million, was not specified. The company had violated most of the safety and fire recommendations for material storage. For example, the width of walkways between the bags for waste storage and the recommended height and location of material storage were not in accordance with the fire code. These and other violations facilitated the rapid spreading of the fire.

25. The fire hit an area of 12,250 m^2, divided into the two large fire compartments. The amount of water used was around 6,350 m^3, in addition to a limited amount of 38 m^3 of heavy foams. It seems that no specific firefighting water retention measures were in place, and the on-site sewerage system was outdated. The whole area was watched and controlled by units of the professional fire brigade, which fought this difficult fire until 19 April 2017. In total, 73 fire brigade units and 567 firefighters participated in extinguishing the fire. Fortunately for the population of Chropyně, the wind, carrying toxic fumes from the fire, blew towards an area of Chropyně with a low population

[29] For more information about the accident, see Dutch Safety Board report, "Fire in chemical firm, Moerdijk, 5 January 2011", The Hague, February 2012. Available (in English) at https://www.onderzoeksraad.nl/en/page/1571/fire-in-chemical-firm-moerdijk-5-january-2011

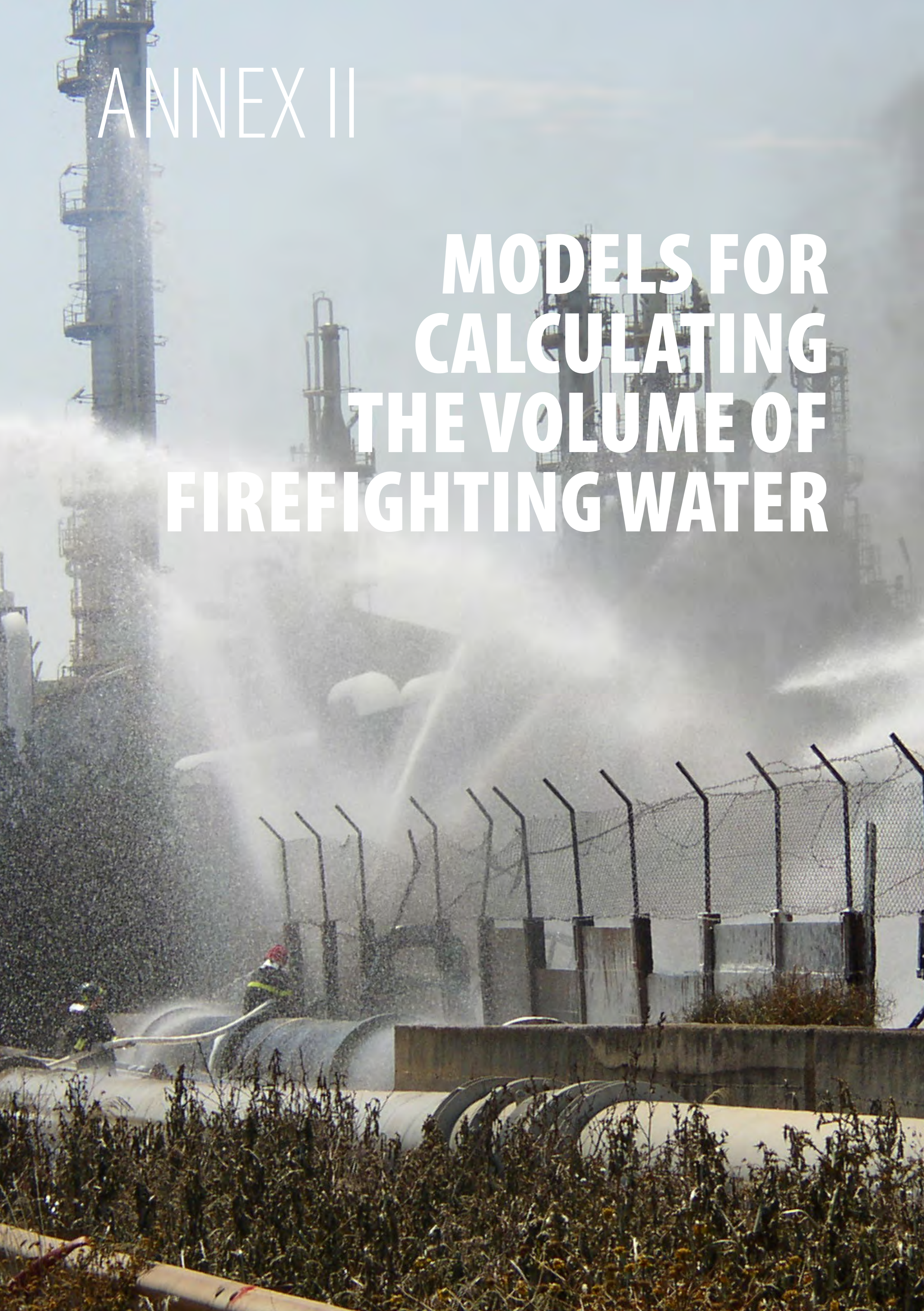
density. A huge cloud of black smoke and soot were visible from the surrounding towns and villages. Potential air pollution (mostly aromatic hydrocarbons) was monitored by the fire brigade in the close neighbourhood of the facility.

26. Initially, a second-level alert of the chemical accident was declared by the county fire brigade operation centre, which was later upgraded to a third-level alert due to strong winds (15 metres per second). At 2 a.m., the chemical alert for the whole town of Chropyně was declared, because the emergence of toxic gaseous fumes was expected from the fire, containing phosgene, carbon monoxide, aromatic hydrocarbons and solid particles. Several streets of the town in the close neighbourhood of the facility were evacuated during the first day of the fire.

27. Firefighting water and heavy foams used during the fire leaked into the local sewerage system and flowed — under the supervision of fire brigade and the management of the local water cleaning station — towards the water cleaning station and further to the River Moravia. The operation commander (i.e., the chief of the fire brigade), after communication with the management of the local water cleaning station, banned the further use of heavy foams within this fire intervention. This early decision mitigated the potential occurrence of more significant environmental damages. There is no specific data available about how much of the firefighting water in this case was recovered and/or cleaned. The production in the rest of the facility, saved from the fire, was renewed within a few weeks of the fire.

ANNEX II

MODELS FOR CALCULATING THE VOLUME OF FIREFIGHTING WATER



1. This annex presents several accepted models for calculating the volume of firefighting water required in the event of a fire, as well as a new calculation model proposed by the United Nation Economic Commission for Europe (UNECE) Joint Expert Group on Water and Industrial Accidents.

2. Each model represents a different approach and comes from widely-available sources. The characteristics of each model are briefly described. The models are presented in sequence according to their complexity, beginning with the easiest one.

3. Where there are several fire compartments within a facility, the calculation should be based on the one with the highest thermal load. If only the area of the fire compartments is known, the largest one should be considered relevant. The letter "R" in equations means the calculated volume of contaminated firefighting water that must be retained.[30] At the end of the annex, several simple comparisons of the models' results are provided. The graphs (see figures 3 and 4) show the differences in the results achieved using the various models. The comparison should be considered only for purposes of demonstration, bearing in mind that the input data is different for each model.

1. THE SANDOZ AND CIBA MODEL

4. The Sandoz and Ciba model estimates that 3 m^3 to 5 m^3 of firefighting water needs to be delivered per ton of stored material, depending on the quantity of the flammable materials, hazard categories of stored products and expected fire duration. While this methodology is very simple and requires little input data, it is based on only a few case studies and thus could not be extended to every potential scenario. In the charts located at the end of this annex, the model is converted to fireload as a non-liquid material with an estimated burning energy of 18 megajoules (MJ) per kilogram (MJ/kg) (e.g. cellulose).

R [from 3 m^3 to 5 m^3] = 1 ton of stored material

Sources

International Organization for Standardization (2012). Environmental damage limitation from fire-fighting water run-off. ISO/TR 26368:2012. Available at www.iso.org/standard/43530.html

Walton, Ian (2014). Containment Systems for the Prevention of Pollution: Secondary, tertiary and other measures for industrial and commercial premises. Construction Industry Research and Information Association (CIRIA) Report No. C736. London. Available at https://cdn.shopify.com/s/files/1/0523/8705/files/CIRIA_report_C736_Containment_systems_for_the_prevention_of_pollution.compressed.pdf

30 In accordance with the obligations (under the Water and Industrial Accidents Conventions) to prevent accidental water pollution and its transboundary effects, contaminated firefighting water must be retained.

2. THE BUNCEFIELD MODEL

5. While the Sandoz and Ciba model is derived from a relatively small number of incidents involving the production and storage of particularly hazardous materials, the Buncefield model was developed as a result of an incident involving simpler but larger-scale fuel storage premises. The best estimate for firefighting water demand is represented by equation below.

R [from 1 m^3 to 3 m^3] = 1 ton of stored material

6. In the graphs at the end of this annex, the mass is converted to an equivalent fire load using an estimated energy of combustion of 47 MJ/kg (corresponding to an average value for petrol).

Sources

Dickinson, Chris (2018). "Developments in thinking about emergency liquid containment systems in the process and allied industries" in *Hazards 28: Cost Effective Safety", IChemE Symposium Series No. 163 (Rugby, Institution of Chemical Engineers)*. Available at https://www.icheme.org/media/11899/hazards-28-paper-12-developments-in-thinking-about-emergency-liquid-containment-systems-in-the-process-and-allied-industries.pdf

Energy Institute (2012). Model Code of Safe Practice Part 19: Fire precautions at petroleum refineries and bulk storage installations, 3rd ed. London. Available at https://publishing.energyinst.org/__data/assets/file/0013/51403/Pages-from-MCSP-Pt.-19.pdf

3. THE IMPERIAL CHEMICAL INDUSTRIES (ICI) MODEL

7. The Imperial Chemical Industries (ICI) model was developed by ICI for internal use in assessing the flow rate and duration of fires at chemical plants. Unlike the other methods mentioned in this annex, it is based on a fire in an entire chemical plant rather than a discrete area of a fire compartment. It estimates the different volumes of firefighting water for three potential hazard ratings of an industrial facility, as seen from the following table:

FIREFIGHTING WATER DEMAND BASED ON THE HAZARD SEVERITY RATING OF AN INDUSTRIAL FACILITY

Hazard rating of the industrial facility	Four hours of firefighting water demand in m^3
High severity	1,620–3,240
Medium severity	1,080–1,620
Low severity	540–1,080

"High severity" includes plants with:

- Over 500 tons of flammable liquid above its flashpoint;
- Over 50 tons of flammable gas above its boiling point and over 50 bars;
- Over 100 tons combustible solids with ready flame propagation;
- Other factors that increase severity.

"Medium severity" covers plants that fall between the high and low severity ratings.

"Low severity" includes plants with:

- Less than 5 tons of flammable liquid above or below its flashpoint;
- Less than 100 kg of flammable gas under 1 bar or flash liquid;
- Less than 5 tons of readily combustible solids;
- Other factors that decrease severity.

Sources

Walton, Ian (2014). Containment Systems for the Prevention of Pollution: Secondary, tertiary and other measures for industrial and commercial premises. Construction Industry Research and Information Association (CIRIA) Report No. C736. London. Available at https://cdn.shopify.com/s/files/1/0523/8705/files/CIRIA_report_C736_Containment_systems_for_the_prevention_of_pollution.compressed.pdf

Beale, Christoper J. (1998). "A. methodology for assessing and minimising the risks associated with firewater run-off on older manufacturing plants" in *Hazards XIV: Cost Effective Safety*", IChemE Symposium Series No. 144. (Rugby, Institution of Chemical Engineers). Available at https://www.icheme.org/media/10636/xiv-paper-14.pdf

4. THE THERMAL LOAD MODEL

8. Another easy and simple method is based on thermal load and specific heat-binding capacity (the total amount of energy needed to heat 1 m² of water from 20° C to 100° C and subsequently evaporate it). The "dimensioning according to thermal load" method calculates the total fire load as the sum of the mobile thermal loads Q_m (e.g. products, storage materials, equipment and similar) and the immobile thermal loads, Q_{im} (e.g. the thermal load of buildings, insulation, damping and cladding).

$$Q_{total}\ [GJ] = Q_m\ [GJ] + Q_{im}\ [GJ]$$

9. In order to calculate the required volume of firefighting water that must be retained, the calculated total thermal load has to be divided by the specific heat-binding capacity: 2.6 GJ/m³. Research has shown that as a result of evaporation, only half of the firefighting water reaches the burned material; thus, twice the volume of the firefighting water calculated is required.

$$R\ [m^3] = Q_{total}\ [GJ] / 2.6\ [GJ/m^3]\ V = Q_{total}\ [GJ] / 2.6\ [GJ/m^3]$$

10. It is clear from the context of the method and the assumptions made in the method that it applies only to fires that are limited to buildings, and primarily to fully-developed fires being fought by water sprays. The bypassing of a fire by applied water jets would be far more variable than the 50 per cent assumed for this model.

11. In the charts at the end of this annex, the input data for this method is simplified; only the thermal load of the stored materials has been taken into consideration.

Source

Germany, Hessian Ministry for the Environment, Climate Protection, Agriculture and Consumer Protection (2011). *Handlungsempfehlung: Vollzug des Gebotes zur Rückhaltung verunreinigter Löschmittel im Brandfall – Hessenweit abgestimmte Empfehlung (Policy recommendation: Compliance with the instructions to retain contaminated extinguishing agents in the event of a fire – Recommendation of the German Federal State of Hessen).* Available at https://umwelt.hessen.de/umwelt-natur/wasser/gewaesserschutz/rueckhalt-von-verunreinigtem-loeschwasser

5. THE GERMAN FEDERAL STATE OF HESSEN MODEL

12. The method developed for industrial sites by the German Federal State of Hessen in 2011 for industrial sites is based on empirical data or assessment of the fire load. The dimensioning of firefighting water retention basins can be calculated as follows:

For fire areas under 100 m², an extinguishing agent rate of 10 litres per minute per square metre (L min/m²)

For fire areas measuring 100–200 m^2, an extinguishing agent rate of 3 L min/m^2

For fire areas measuring 201–600 m^2, 200 m^2 < Fire Area < 600 m^2 R (m^3) = fire area (m^2) * 0.135

For objects or fire compartments larger than 600 m^2, the equation changes as follows:

$$R\ (m^3) = \text{fire area}\ (m^2) * 0.18.$$

13. These equations are based on sound empirical data from 312 fires, taking into account the realities of firefighting operations rather than theoretical predictions by experienced assessors. However, since neither the source data nor a statistical analysis of it has been published, it is impossible to assess its accuracy or to determine the design margins required.

Source

Argebau, *Rules for the Calculation of Fire Water Retention Facilities with the Storage of Materials Hazardous to Water, 1992*. Available at https://www.is-argebau.de/suchen.aspx?id=1623&o=1623&s=L%C3%B6R%C3%BCRL

Germany, Hessian Ministry for the Environment, Climate Protection, Agriculture and Consumer Protection (2011). *Handlungsempfehlung: Vollzug des Gebotes zur Rückhaltung verunreinigter Löschmittel im Brandfall – Hessenweit abgestimmte Empfehlung (Policy recommendation: Compliance with the instructions to retain contaminated extinguishing agents in the event of a fire – Recommendation of the German Federal State of Hessen)*. Available at https://umwelt.hessen.de/umwelt-natur/wasser/gewaesserschutz/rueckhalt-von-verunreinigtem-loeschwasser

6. THE SWISS MODEL

14. The Swiss model is used by the local authorities of 23 of the 26 Swiss cantons and by the Principality of Liechtenstein. The volume of firefighting water required is calculated based on the fire protection arrangements provided, the storage system, the fire risk of the stored materials, and the size of the fire compartment using empirical data taken from European Insurance Industry and other sources. The theoretical volume is taken from a table based on empirical data and the storage factor is based on mass per square metre (0.5; 0.8; 1.0; 1.2).

$$R\ [m^3] = \text{theoretical volume}\ [m^3] \times \text{storage factor}$$

Source

Konferenz der Vorsteher der Umweltschutzämter der Schweiz (Conference of Chiefs of Environmental Protection Services) (2015). *Löschwasser-Rückhaltung – Leitfaden für*

die Praxis (Firefighting Water Retention: A Practical Guide), 1st ed. Zurich. Available in French, German and Italian at www.kvu.ch/de/arbeitsgruppen?id=190.

7. THE VERBAND DER SCHADENVERSICHERER E.V. (ASSOCIATION OF NON-LIFE INSURERS) (VDS) MODEL

15. A very advanced and complex model is the Verband der Schadenversicherer e.V. (Association of Non-Life Insurers) (VdS) formula, developed by the German insurance industry and published as Guideline VdS 2257. It takes many influencing factors into account and is based on an extensive evaluation of empirical data, scientific studies and industrial experience. This method takes into consideration the type and quantity of combustible materials, the presence of fire detection systems, the size of the largest fire compartment, the type of fire brigade and the fire protection technical infrastructure.

$$R = \{(A \times SWL \times BAF \times BBF) + M\} / BSF$$

Key:

A = object surface or largest fire compartment [m²]

SWL = specific water input [m³/m²]

BAF = fire section area factor [dimensionless]

BBF = fire load factor [dimensionless]

M = volume of all stored materials [m³]

BSF = fire protection factor [dimensionless].

16. The coefficients of the equation are dependent on the other tabulated values. Owing to the complexity of the method and the number of dependent tables, they are not included in this annex.

17. An automatic calculation sheet for calculating the volume of contaminated extinguishing water can be downloaded free of charge.[31]

Sources

Verband der Schadenversicherer e.V. (Association of Non-Life Insurers) (VdS) (2013). *Planning and Installation of Facilities for Retention of Extinguishing Water: Guidelines for Loss Prevention by the German Insurers,* VdS No. 2557 (Cologne, VdS Loss prevention GmbH. Available at https://vds.de/fileadmin/vds_publikationen/vds_2557en_web.pdf

[31] https://shop.vds.de/en/download/4985801dafb52f4d08e8aa83b5bc0e90 See also the calculation sheet contained in annex to VdS 2557 (2013), *Planning and Installation of Facilities for Retention of Extinguishing Water: Guidelines for Loss Prevention by the German Insurers* (under Sources). Available at https://shop.vds.de/de/download/98fb-1f3694e9fe758d5c1585129439b7/

8. THE JOINT EXPERT GROUP ON WATER AND INDUSTRIAL ACCIDENTS MODEL

18. This method, proposed by the Joint Expert Group on Water and Industrial Accidents (JEG model), is easy to use and safe. The JEG model estimates 1 m^3 of the retention basin per square metre of the protected object surface or its biggest fire compartment (1):

$$R\,[m^3] = A_f\,[m^2]\ (1)$$

A_f – largest fire compartment surface area [m^2]

19. The calculated volume can be reduced to 10 per cent by providing a constantly operating factory fire service (advanced JEG model) (2):

$$R\,[m^3] = 0{,}1 * A_f\,[m^2] \text{ – if a constantly operating factory fire service is provided (2)}$$

A_f – largest fire compartment surface area [m^2]

20. The model outcome shown in the graphs at the end of this annex represents the advanced JEG model. The volume of all liquids in the fire compartment areas should be combined. A comparison of the advanced JEG model with the other models shows that with lower fire densities, this model provides results within the mid-range of the other models. In the event of higher fire densities, the model achieves comparatively lower values.

9. COMPARISON

21. Bearing in mind the differences between and the complexity of these models, the comparisons were made with some simplifications. Every model is represented on the graphs by one line. The graphs represent the smallest achievable volumes, e.g. owing to the use of the maximum fire protection (the German VdS model and the Advanced JEG and Swiss model) and/or the presence of the relatively less hazardous materials or lowest risk (the Swiss, Sandoz and Ciba, Buncefield and ICI models). The ICI model is represented by a straight line because it is not dependent on the surface of the fire zone. The Swiss model is limited to an area of 4,500 m^2 because Swiss fire protection regulations do not normally allow for larger fire compartments. As an exception, larger areas must be evaluated within an individual fire risk analysis.

22. Selected input data:

- **(a)** Fire loads expressed in [MJ/m^2]: 500 and 1,296 as an upper reliable boundary for the German VdS model;
- **(b)** Fire compartment area: from 500 m^2 up to 20,000 m^2 — enlarging by 500.

The results are expressed in m^3.

FIGURE 3 COMPARISON OF METHODOLOGIES FOR DETERMINING FIREFIGHTING WATER VOLUME WITH A FIRE LOAD OF 500 MJ/M²

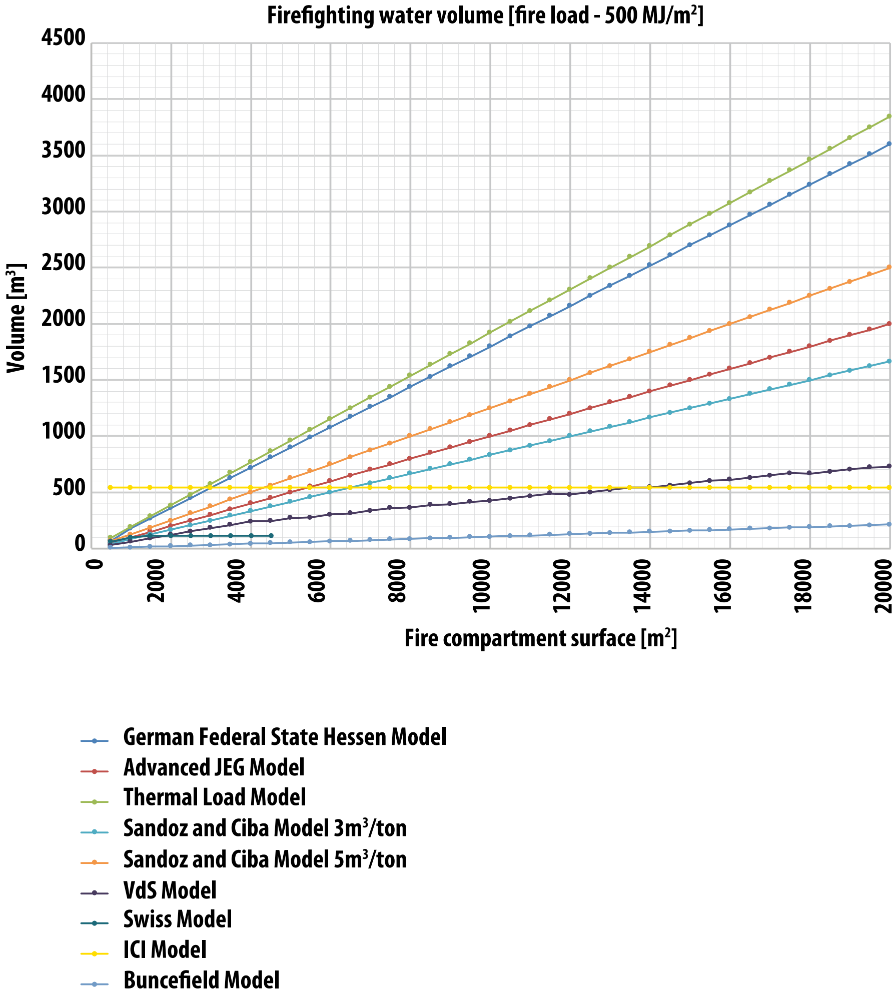
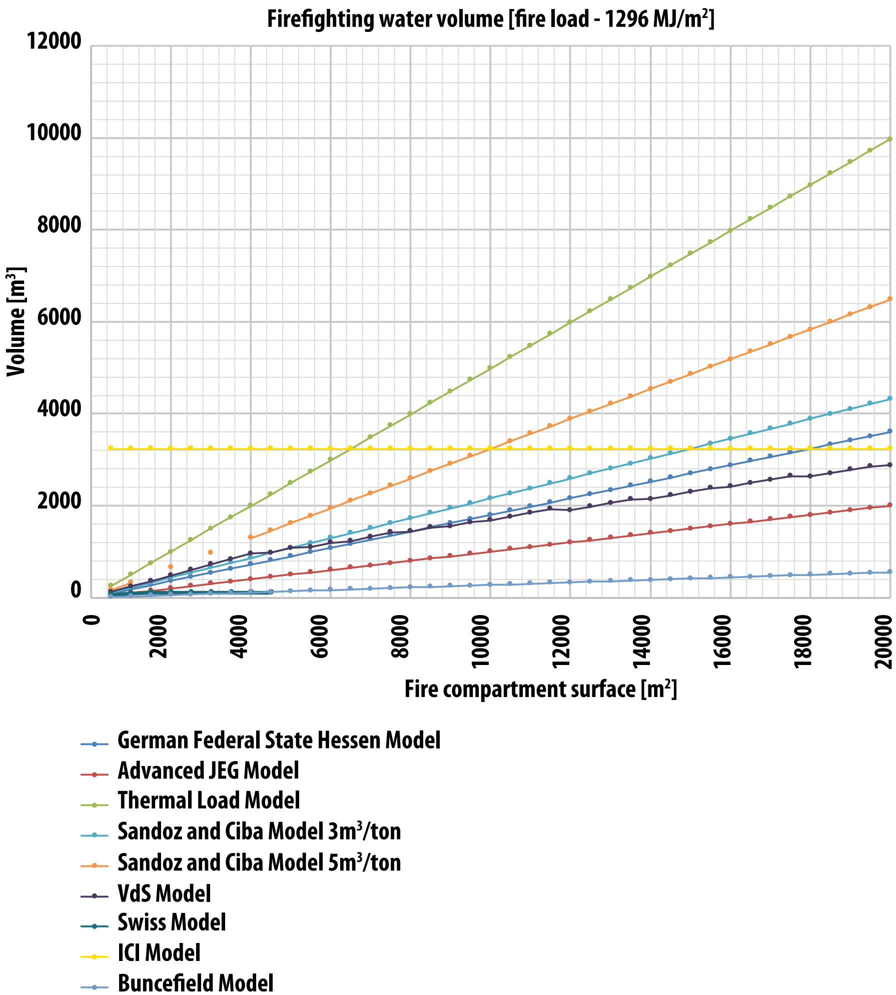


FIGURE 4 COMPARISON OF METHODOLOGIES FOR DETERMINING FIREFIGHTING WATER VOLUME WITH A FIRE LOAD OF 1,296 MJ/M²



REFERENCES

Ale, B. J. M., M. H. A. Kluin and I. M. Koopmans (2017).
Safety in the Dutch chemical industry 40 years after Seveso.
Journal of Loss Prevention in the Process Industries, vol. 49, part A (September), pp. 61-69.

Argebau,
Rules for the Calculation of Fire Water Retention Facilities with the Storage of Materials Hazardous to Water, 1992.
Available at https://www.is-argebau.de/suchen.aspx?id=1623&o=1623&s=L%C3%B6R%C3%BCRL

Chemical Business Association (CBA), Solvent Industries Association (SIA) and Health and Safety Executive (HSE) (2008).
Guidance for the storage of liquids in intermediate bulk containers.
Available at http://www.chemical.org.uk/wp-content/uploads/2018/02/IBC_GUIDANCE_ISSUE_1_March_2008_FINAL.pdf

Confederation of Fire Protection Associations (CFPA) Europe (2013).
Fire and protection in chemical manufacturing site. CFPA E Guideline No 18:2013 Copenhagen and Helsinki: CFPA Europe.
Available at http://cfpa-e.eu/wp-content/uploads/files/guidelines/CFPA_E_Guideline_No_18_2013_F.pdf

Energy Institute (2013).
Guidance on Risk Assessment and Conceptual Design of Tertiary Containment Systems for Bulk Storage of Petroleum, Petroleum Products and Other Fuels. London.
Available at https://publishing.energyinst.org/__data/assets/file/0010/66682/Pages-from-WEB-VERSION-Guidance-on-risk-assessment-and-conceptual-design-of-tertiary-containment-systems...03.10.13.pdf

European Commission.
Major Accident Reporting System online (eMars database),
Available at https://minerva.jrc.ec.europa.eu/en/emars/content

Fowles, Jeff, Marie Person and Dominique Noiton (2001).
The Ecotoxicity of Fire-Water Runoff: Part I – Review of the Literature. New Zealand Fire Service Research Report No. 17. New Zealand: New Zealand Fire Service Commission.
Available at https://fireandemergency.nz/assets/Documents/Research-and-reports/Report-17-The-Ecotoxicity-of-Fire-Water-Runoff-Part-I-Review-of-the-Literature.pdf

Fowles, Jefferson (2001).
The Ecotoxicity of Fire-water Runoff: Part III – Proposed Framework for Risk Management. New Zealand Fire Service Research Report No. 19. New Zealand: New Zealand Fire Service Commission, July 2001.
Available at https://fireandemergency.nz/assets/Documents/Research-and-reports/Report-19-The-Ecotoxicity-of-Fire-Water-Runoff-Part-III-Proposed-framework-for-Risk-Management.pdf

France, Bureau for Analysis of Industrial Risks and Pollutions.
Analysis, Research and Information on Accidents (ARIA) database.
Available at www.aria.developpement-durable.gouv.fr/the-barpi/the-aria-database/?lang=en

Germany, Hessian Ministry for the Environment, Climate Protection, Agriculture and Consumer Protection (2011).
Handlungsempfehlung: Vollzug des Gebotes zur Rückhaltung verunreinigter Löschmittel im Brandfall – Hessenweit abgestimmte Empfehlung (Policy recommendation: Compliance with the instructions to retain contaminated extinguishing agents in the event of a fire – Recommendation of the German Federal State of Hessen).
Available at https://umwelt.hessen.de/sites/default/files/HMUELV/handlungsempfehlung_loeschmittel_im_brandfall.pdf

Germany, Rhineland-Palatinate, Ministry of the Environment, Energy, Food and Forests (2019).
Leitfaden Brandschadensfälle : Vorsorge – Bewältigung – Nachsorge (Guidance document for Fires: Before – During – After). Mainz.
Available at https://mueef.rlp.de/fileadmin/mulewf/Publikationen/Leitfaden_Brandschaden2019_Internet.pdf

Institution of Chemical Engineers (IChemE) (2012).
Loss Prevention Bulletin: Environment Agency (special issue).
Available at https://www.icheme.org/knowledge/loss-prevention-bulletin/free-downloads/issues/issues/

Internationale Kommission zum Schutz der Elbe – Mezinárodní komise pro ochranu Labe (IKSE-MKOL) [International Commission for the Protection of the Elbe River].
Empfehlungen zur Problematik der Löschwasserrückhaltung: Aktualisierung [Recommendations for the issue of fire-water retention: Update] (2014) in Empfehlungen der IKSE für den Bereich der Störfallvorsorge, Anlagensicherheit und Störfallabwehr [IKSE Recommendations for Fires: Before, During and After].
Available at https://www.ikse-mkol.org/themen/unfallbedingte-gewaesserbelastungen/empfehlungen/

Ireland, Environmental Protection Agency (1995).
EPA Guidance on Retention Requirements for Firewater Run-off. Wexford.
Available at http://www.epa.ie/pubs/advice/licensee/guidancenotefirewaterretention/

Kärrman, Anna, and others (2016).
Study of environmental and human health impacts of firefighting agents: a technical report. Örebro: Örebro University.
Available at https://oru.diva-portal.org/smash/get/diva2:1068268/FULLTEXT01.pdf

Noiton, Dominique, Jefferson Fowles and Helen Davies (2001).
The Ecotoxicity of Fire-Water Runoff: Part II – Analytical Results. New Zealand Fire Service Commission Research Report No. 18. New Zealand: New Zealand Fire Service Commission.
Available at www.researchgate.net/publication/272508692_Fire_Research_The_Ecotoxicity_of_Fire-Water_Runoff_Part_II_Analytical_Results_ESR

Scholz, Miklas (2014).
Firewater Storage, Treatment, Recycling and Management: New Perspectives Based on Experiences from the United Kingdom. Water, vol. 6, No. 2 (June), pp. 367–380.
Available at www.mdpi.com/2073-4441/6/2/367

Swords, Pat (2014).
Fire water retention – latest guidance for appropriate design. IChemE Symposium Series No. 159. Rugby: Institution of Chemical Engineers.
Available at https://www.icheme.org/media/8931/xxiv-paper-37.pdf

Winkelmann-Oei, Gerhard, and Jörg Platkowski (2015).
Checklists for surveying and assessing industrial plant handling materials and substances, which are hazardous to water: No. 8 Fire Prevention Strategy. Updated 09/2014, Document No. 16/2015. Dessau-Roßlau, Federal Environment Agency.
Available at www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/check08_fireprevention_en_2014.pdf

United Kingdom, Competent Authority for the Control of Major Accident Hazards (COMAH) (2011).
Buncefield: Why did it happen? The underlying causes of the explosion and fire at the Buncefield oil storage depot, Hemel Hempstead, Hertfordshire on 11 December 2005.
Available at www.hse.gov.uk/comah/investigation-reports.htm

United Kingdom, Health and Safety Executive, Waste Industry Safety and Health Forum (WISH) (2017).
Reducing Fire Risk At Waste Management Sites. *Waste* 28, No. 2 (April).
Available at https://wishforum.org.uk/?page_id=33

United Nations, Economic Commission for Europe (2013).
Convention on the Protection and Use of Transboundary Watercourses and International Lakes. ECE/MP.WAT/41.
Available at https://www.unece.org/index.php?id=35072

United Nations, Economic Commission for Europe (2015).
Safety Guidelines and Good Industry Practices for Oil Terminals. ECE/CP.TEIA/28.
Available at www.unece.org/index.php?id=41066

United Nations, Economic Commission for Europe (2017).
Convention on the Transboundary Effects of Industrial Accidents. Sales No. T.17.II.E.7.
Available at http://www.unece.org/index.php?id=45611&L=0

United States of America, U.S. Chemical Safety and Hazard Investigation Board (2015).
Final Investigation Report: Caribbean Petroleum Tank Terminal Explosion and Multiple Tank Fires. Report No. 2010.02.I.PR.
Available at www.csb.gov/caribbean-petroleum-refining-tank-explosion-and-fire

Safety guidelines and good practices for the management and retention of firefighting water

The safety guidelines and good practices have been developed by the Joint Expert Group on Water and Industrial Accidents, in cooperation with an Expert Group on Fire-water Retention and the United Nations Economic Commission for Europe (UNECE) secretariat, to enhance existing practices regarding firefighting water retention and promote harmonized safety standards. By using these guidelines, governments, competent authorities and operators can more effectively minimize the risk of fire and safely retain firefighting water.

The mission of the Joint Expert Group is to assist countries in devising and implementing measures aimed at strengthening the prevention of and preparedness for accidental water pollution, especially in a transboundary context. It is supported and serviced by the UNECE Convention on the Transboundary Effects of Industrial Accidents (Industrial Accidents Convention) and the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) — which together provide a legal framework for addressing the risk of transboundary water pollution arising from industrial accidents.

The Meeting of the Parties to the Water Convention at its eighth session (Astana, 10–12 October 2018) and the Conference of the Parties to the Industrial Accidents Convention at its tenth meeting (Geneva, 4–6 December 2018) took note of the guidelines and recommended their use and implementation by countries in order to prevent accidental pollution of soil and water, including pollution that could cause transboundary effects.

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Palais des Nations
CH - 1211 Geneva 10, Switzerland
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E-mail: unece_info@un.org
Website: http://www.unece.org

ISBN: 978-92-1-117209-6

Layout and Printing at United Nations, Geneva – 1914406 **(E)** – October 2019 – 964 – **ECE/CP.TEIA/40 - ECE/MP.WAT/58**