Draft UNECE Safety Guidelines and Good Practices for Fire-water Retention

(draft as of 14 November 2017)

Summary

These safety guidelines and good practices for fire-water retention were developed based on the needs identified by Parties to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention), and to the Convention on the Transboundary Effects of Industrial Accidents (Industrial Accidents Conventions) at a seminar on the occasion of the 25th anniversary of the so-called "Sandoz accident" (Bonn, Germany, 8–9 November 2011).[1] In 1986, as a result of a fire at an agrochemical warehouse at the Sandoz pharmaceutical company site near Basel, Switzerland, 30 tonnes of toxic chemicals were released into the Rhine River due to the lack of fire-water retention. This caused vast transboundary water pollution, threatened drinking water supplies and devastated fish stocks in Switzerland, France and Germany, reaching even 700 kilometres downstream to the Netherlands.

Following this and other accidents, in 2016, the Bureaux to the Industrial Accidents and Water Conventions endorsed a proposal to develop safety guidelines and good practices for fire-water retention by the UNECE Joint Ad Hoc Expert Group on Water and Industrial Accidents (JEG). The objective of the safety guidelines is to enhance existing practices with regard to fire-water retention and to promote harmonized safety standards in the UNECE region. Under JEG's leadership, a small group of international experts on fire-water retention was tasked with the elaboration of these safety guidelines in the biennium 2017–2018. The draft safety guidelines and good practices for fire-water retention are contained in this document.

Part A provides an introduction to the issue of fire-water retention, its transboundary dimension and basic safety principles that should be respected. It also defines the terminology used and outlines the scope of the document. Parts A and B of the document contain specific safety guidelines for fire-water retention. Good practices for fire-water retention and further safety recommendations can be found in Part C. The annexes contain additional information, such as information about past major fire-accidents, including related costs (annex I), and different calculation models for fire-fighting water (annex II). References used for the preparation of this document and those intended for further reading, are included in Part D.

In the period during which the guidelines were elaborated, the JEG 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 supported actively the development of the safety guidelines: Mr. Claes-Hakan Carlsson (Sweden), Mr. Pavel Dobes (Czechia), Mr. Jesper Hansen (Switzerland), Mr. Lukasz Kuziora (Poland), Ms. Leighanne Moir (United Kingdom), Mr. Bert van Munster (Netherlands), Ms. Cornelia Sedello (Germany), Ms. Maarit Talvitie (Finland), Ms. Tuuli Tulonen (Finland) and Mr. Wolfram Willand (Germany).

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

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BACKGROUND AND ACKNOWLEDGEMENTS

On the occasion of the 25th anniversary of the Sandoz accident a UNECE seminar was held in Bonn, Germany, on 8–9 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 of 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). The objectives of the seminar were mainly the following:

(a) Reflect on the work carried out and progress achieved in the area of prevention of accidental water pollution in the UNECE region; and

(b) Examine existing deficits in 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 important challenges regarding fire protection and containment of fire-fighting water in order to prevent the contamination of transboundary rivers, in particular at processing plants. Most countries lack specific legislation and regulations regarding fire-water retention and size requirements for retention basins remain inadequate. Several fire accidents or near-misses in recent years supported these findings. It was therefore recommended to address the issue jointly through the development of related guidance. To this end, the Bureaux to the Water and the Industrial Accidents Conventions endorsed a proposal to develop safety guidelines and good practices for fire-fighting water retention by the Joint Ad Hoc Expert Group on Water and Industrial accidents (JEG).

As a first step, a questionnaire was sent to all Focal Points of the Industrial Accidents and Water Conventions to identify needs as well as available expertise in this area. Under JEG's leadership, a small group of international experts on fire-water retention was then established and tasked with the elaboration of safety guidelines and good practices for fire-water retention in the biennium 2017–2018. The present document contains these draft safety guidelines and good practices for fire-water retention, developed by the JEG in cooperation with the expert group on fire-water retention and supported by the UNECE secretariat. In the period during which the guidance was elaborated, the JEG 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 supported actively 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), Mr. Bert van Munster (Netherlands), Ms. Cornelia Sedello (Germany), Ms. Maarit Talvitie (Finland), Ms. Tuuli Tulonen (Finland) and

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

Mr. Wolfram Willand (Germany). The work was supported by Ms. Claudia Kamke from the UNECE secretariat.

This document contains the UNECE Safety Guidelines and Good Practices for Fire-Water Retention, elaborated by the experts during three meetings in 2017.[3] A previous version of the draft Safety Guidelines was also discussed at an international seminar on fire-water retention (Slubice, Poland, 5 September 2017)[4] and subsequently revised, based on the feedback received at the seminar. It is envisaged that the final draft Safety Guidelines and Good Practices for Fire-water Retention be presented for endorsement to the 8th session of the meeting of the Parties of the Water Convention (Astana, 10-12 October 2018) and to the 10th meeting of the Conference of the Parties of the Industrial Accidents Convention (Geneva, 4-6 December 2018).

[3] The minutes of these meeting are available from http://www.unece.org/index.php?id=44842, http://www.unece.org/index.php?id=45437 and http://www.unece.org/index.php?id=45435.

[4] For more information, see here: http://www.unece.org/index.php?id=45431.

PART A – INTRODUCTION TO THE RELEVANCE OF FIRE-WATER RETENTION AND ITS TRANSBOUNDARY DIMENSION

1. Fire-water retention is not only an issue of national concern. It is just as relevant in a transboundary context as contaminated fire-water released into transboundary rivers could also affect other countries, even if located far away from the accident. The Sandoz accident in 1986 was a tragic reminder of this fact when, as a result of a fire in an agrochemical warehouse at the Sandoz pharmaceutical company site near Basel, Switzerland, due to the lack of fire-water retention 30 tonnes of toxic chemicals were released into the Rhine River. This caused vast transboundary water pollution, threatened drinking water supplies and devastated fish stocks in Switzerland, France and Germany, reaching even 700 Km downstream to the Netherlands.

2. Two UNECE treaties — the Industrial Accidents and Water Conventions[5] — 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[6] and obligations to prevent accidental pollution,[7] to inform potentially affected countries if such has happened[8] and to ensure joint contingency planning.[9] Issues related to the prevention of accidental water pollution are therefore addressed in close cooperation with the Water Convention through the Joint Ad Hoc Expert Group on Water and Industrial accidents (JEG).

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[5] 1992 Convention on the Transboundary Effects of Industrial Accidents and 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes.

[6] The polluter pays principle contained in the Industrial Accidents Convention (Preamble, preambular para. 9) and Water Convention (art. 2, para. 5b) is a general principle of international environmental law that aims to ensure that the final costs of pollution, control and reduction are born by the polluter.

[7] According to the Water Convention (art. 3, para.1, subpara. 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.

[8] The Water Convention obliges Parties to inform each other about any critical situation that may have 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.

[9] 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 and 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).

3. Even more than 30 years after Sandoz, many countries still face a number of important challenges with regard to fire-water retention. An exchange of the legislative situation in those countries represented in the JEG and Expert Group on Fire-water Retention revealed that countries often lack specific laws and regulations on fire-water retention. And even if a country had some basic regulations in place, they are often rather general and incomplete, e.g. only covering storage facilities but not production and processing plants.

4. In recent years, a number of fire accidents that led to a huge production of fire-fighting water have occurred, not necessarily at storage plants but, more prominently, at processing and production plants of industrial facilities. Examples of some major accidents and near-misses regarding fire-water retention issues in UNECE countries, including their financial costs and a short description of what happened, can be found attached (see annex I). The potential damages of such accidents can be severe and the costs high, not only within a country but also across borders. This leads in practice often to companies' bankruptcy and governments need to take over the remaining costs for the accident and aftercare management, causing a huge financial burden over many years.

5. In order to avoid this financial burden arising from the negative effects of such accident 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 they happen, requires high quality work and coordination by all relevant stakeholders at the national and cross-border levels. Only if we all work together, we can make this possible.

6. <u>Operators</u> should thus be encouraged to take measures to prevent any damage they will be held liable for. <u>Governments</u> and <u>competent authorities</u> should put in place stringent regulatory frameworks to ensure that operators implement the necessary safety measures to prevent such accidents from happening. <u>Joint Bodies</u> play a crucial role in transboundary cooperation basins for pollution reduction, preventing accidental water pollution and ensuring the sustainable and equitable use of waters, providing an important platform for transboundary cooperation and the implementation of harmonized safety standards to prevent accidental pollution.

7. These safety guidelines and good practices are intended to support governments, competent authorities and operators to apply measures and improve existing practices to prevent accidental pollution of soil and water, including such pollution causing 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 the Sustainable Development Goal 6 on ensuring the availability and

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

A.1. DEFINITIONS AND TERMINOLOGY

8. 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 Accident Convention or the Water Convention;

(b) "Effects" 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) "Fire-fighting water" means water that is used to extinguish a fire, including sprinkler and non-sprinkler water;

(d) "Hazardous activity" 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" 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, or
   (ii) During transportation as it is covered by paragraph 2 (d) of article 2 of the Industrial Accidents Convention;

(f) "Joint Body" means any bilateral or multilateral commission or other appropriate institutional arrangements for cooperation between the Riparian countries;

(f) "Operator" 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;

(g) "Riparian countries" mean countries bordering the same transboundary waters;

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

(i) "Transboundary waters" means any surface waters or groundwater 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.

A.2. SCOPE

9. The focus of the safety guidelines and good practices for fire-water retention is on the prevention of accidents that affect people and the environment and, in particular, on the prevention of fires which may provoke water and soil pollution.

10. These safety guidelines and good practices apply to all hazardous activities, including manufacture, production, storage and other activities according to Annex I of the UNECE Convention on the Transboundary Effects of Industrial Accidents (Industrial Accidents Convention).[10] In accordance with its article 5, the scope of the application of the Industrial Accidents Convention can be expanded.

11. Fire-fighting water can cause considerable damages if it enters surface water, infiltrates the ground, or contaminates groundwater. Substances or objects that are not toxic itself, like ammonium fertilizers, PVC, automobile tyres or elementary sulphur, can produce large amounts of toxic fire gases, and cause highly contaminated fire-fighting water (even burned packaging material is contaminating fire-fighting waters as a water-endangering solvent). Therefore, as adverse effects on the properties of water bodies cannot be excluded, fire-fighting water should be prevented from entering surface and groundwater as it must be considered potentially hazardous to the environment irrespective of the substances involved in the fire.

12. These safety guidelines and good practices for fire-water retention are derived from operational industry and fire fighters' experience. This includes learning from history and the details of past major accidents and the remedial and prevention measures, designed to prevent recurrence or eventually to minimize consequences.

13. These safety guidelines are developed to minimize the risk of fire and to safely retain fire-fighting water. Cooling water that is unlikely to be contaminated and can be segregated may be treated differently, provided that it is used to prevent domino effects for neighbouring equipment, the plant or installations.

14. 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.

15. These safety guidelines constitute a minimum set of good practices and recommendations to ensure a basic safety level. They aim at facilitating a harmonised level of major accident prevention, including fire-fighting water retention, and an acceptable level of risk within and beyond the UNECE region. These guidelines are

[10] The full test of the Convention, including Annex I, is available from http://www.unece.org/env/teia/about.html.

intended to support existing requirements and recommend enhancement of practices, wherever appropriate.

A.3. BASIC SAFETY PRINCIPLES

16. Operators of hazardous facilities 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 fire-fighting waters.

17. Technical and organisational measures in the case of an accident should be ensured. Therefore, emergency plans should be established by operators (internal emergency plans) and by authorities (external emergency plans). These plans should be compatible with one another and regularly tested and updated. They should also include measures necessary for fire prevention and fire-water retention, to limit their potential consequences for human health and the environment.

18. The accidental release of fire-fighting water can pose a potential risk to neighbouring countries in case of transboundary waters. In case of an accident, Governments concerned should inform each other of measures taken or planned to be taken to retain and/or dispose of the fire-fighting water.

19. Experience from the past shows a high risk of ground- and surface-water contamination through the use of fire-fighting foams containing mixtures of Per- and Polyfluorinated Carbons (PFC) or other persistent compounds with fire-fighting water. If there is a need to use such extinguishing agents, the potential environmental consequences must be carefully considered for each installation.

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

21. Two independent power sources are required to provide for the power supply of automatically triggered fire-fighting water delivery systems, e.g. pumped deluge systems. If using self-acting systems, (e.g. systems that are operated pneumatically, hydraulically, or by gravitational force) a second independent power supply is not required.

22. A reliable high-integrity fire detection system should be installed to ensure the earliest possible detection of a fire. Account must 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.

23. An assessment of the required fire-fighting water quantity and the supply of the respective fire-fighting water must be undertaken.

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

25. For the retention of fire-fighting water, preference should be given to 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 fire-fighting water should be preferred over a local retention of fire-fighting water (e.g. in the building itself or at the point where the fire starts), to avoid hindrance to firefighters.

26. Components of facilities for retention of fire-fighting water that could be exposed to a fire, shall be designed in such a way as to be resistant to the temperatures and heat radiation to be expected. Moreover, they shall prove sufficient durability and resistance to other physical and chemical attacks during fire. Installations that penetrate a fire-water retention basin and that are not able to withstand a major fire (e.g. plastic tubes) must be avoided.

27. If fire-fighting water can mix with flammable liquids or if ignitable gas can be emitted, the requirements for 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 fire-fighting water.

PART B – RECOMMENDATIONS FOR FIRE-WATER RETENTION

28. These safety guidelines and good practices for fire-fighting 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 fire-fighting waters.

29. The safety guidelines are designed to prevent fire incidents at hazardous facilities 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.

30. 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[11]. Non-Parties are also encouraged to take the necessary actions.

31. 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.

B.1. RECOMMENDATIONS TO GOVERNMENTS

32. Governments should provide leadership and create suitable administrative frameworks to establish the need for fire-fighting water retention in case of emergencies at all hazardous activities.

33. Governments should adopt policies for the safety of hazardous activities, including concepts for fire protection and retention of fire-fighting waters. They should raise awareness and share experience and good practices through educational/training programmes and other means.

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

35. Governments should encourage operators to provide details of the fire protection measures as part of the application for a hazardous activities operating permit. This should be complemented by a financial security or any other liability, based on arrangements to be decided by countries, in order to ensure that all obligations arising

[11] The General Duty Clause aims to establish the principle, as a matter of law in most countries, that operators of hazardous installations have the responsibility for the safe operation of their installations. Further information about the General Duty Clause could be found in the UNEP Flexible Framework Guidance available at: http://www.unep.org/resourceefficiency/Portals/24147/Safer%20Production%20%28Web%20uploads%29/UN_Flexible_Framework_WEB_FINAL.pdf.

under any permit issued, including closure and post-closure requirements, as well as any other obligations, can be met. The requirements include insurance to allow proper settlement of any costs associated with an accident.

36. Governments should aim to 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[12] could be used as a reference.

37. 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 external emergency plans.

38. In accordance with art. 17 of the UNECE Industrial Accidents Convention, one or more competent authorities should be designated. Governments should aim at designating such 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.

39. 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, cease of operations in cases of unsatisfactory safety performance and environmental protection

40. 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 learnt. Descriptions of lessons learned should be freely available to all stakeholders.

41. Governments should create Joint Bodies for jointly managing their transboundary watercourses where they do not exist yet (in accordance with art. 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 in transboundary river catchments, including those with fire-fighting water emissions.

42. Governments should work through the Joint Bodies to raise awareness about the risks of accidental water-pollution posed by fire-fighting water emissions, including the potential transboundary consequences, and to support the implementation of harmonized safety

[12] The Protocol on Civil Liability and Compensation for Damage Caused by the Transboundary Effects of Industrial Accidents on Transboundary Waters is a joint Protocol from the UNECE Industrial Accidents and Water Conventions. It was adopted and signed by 22 countries at the Ministerial Conference "Environment for Europe" in Kyiv, Ukraine, on 21 May 2003 (2 more countries signed the Protocol later in 2003). The Protocol is not in force.

standards and approaches between riparian countries to prevent accidental pollution through fire-fighting emissions.

43. Governments should inform their downstream neighbouring countries without delay in case of an accident which could cause transboundary pollution, including through fire-fighting water emissions, using their bi- or multilateral agreements, if any, and early warning systems according to their national regulations.[13]

B.2. RECOMMENDATIONS TO COMPETENT AUTHORITIES

44. Competent authorities should ensure within their organisation that they have expertise related to:

- Accident prevention (i.e. fire protection), emergency preparedness and response;
- Inspection and audit;
- Permitting requirements for operation of the hazardous activities (fire compartment areas).

45. Competent authorities should carefully consider the fire risk and the fire-fighting water management when issuing a licence for operating a hazardous activity. The licensing authority should thoroughly examine the capability of the operator to ensure continuous safe and effective operations under all foreseeable conditions (fire compartment areas, fire-fighting water retention).

46. Competent authorities should require the operator to draw up a report on major hazards and potential accident scenarios, including fires and retention capabilities for fire-fighting waters. The report should be thoroughly assessed by the competent authority before acceptance. Acceptance by the competent authority of the report on major hazards does not imply any transfer of responsibility for control of major hazards from the operator or the owner to the competent authority.

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

48. 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.

49. 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.

[13] The Parties to the Industrial Accidents Convention, in accordance with article 10, shall provide for the establishment and operation of compatible and efficient accident notification systems at appropriate levels to inform neighbouring countries. This can be assured 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.

50. The inspection regime of hazardous activities as defined by the competent authorities should reflect the following:

- Hazard Potential;
- Proximity to sensitive environments or communities;
- Fire Protection Strategy, including the respective equipment
- Previous inspection record and performance of the operator
- Historical accident and incident record at the facility.

51. Competent authorities should ensure that operators:

- Draw up internal emergency plans, including the fire-brigade intervention plan and put them into effect without delay when an accident occurs; and
- Supply them with the necessary information to enable competent authorities to draw up external emergency plans.

52. Competent authorities should ensure that the operator provides training to the on-site personnel on how the fire-fighting systems that have to be activated manually work and how they should be used. Training on this issue should be undertaken on a regular basis and at least yearly.

53. Competent authorities may require the operator to provide any additional information necessary to enable them to fully assess potential accidents.

54. Competent authorities are responsible for establishing permit conditions based on international accepted safety standards and sound fire protections systems.

55. The competent authorities should approve remediation plans for fire- and explosion scenarios at hazardous industries.

56. The competent authorities should control the installations for the retention of fire-fighting water.

B.3. RECOMMENDATIONS TO OPERATORS

57. 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 fire-fighting waters.

58. Safety measures cover the fields of prevention, support during the fire event and monitoring after fire. In case of damage or an accident, it is the operator's responsibility to determine the situation and to initiate emergency measures and countermeasures as required.

59. All parts of a facility for retention of fire-fighting water and its triggering devices (e.g. automatically shutting valves) should be installed so that they will not be damaged by operational activities. Installation is to be carried out so that accessibility for

maintenance purposes and in the case of danger / fire is ensured at any time. This may include the need for remotely actuated systems.

60. Should parts of the sewerage system or other pipelines be used for discharging of fire-fighting water into collecting facilities, the impermeability of the corresponding section of the sewer / pipeline should be proven and ensured through long-term control and maintenance by the operator.

61. If the section for the sewerage system used to drain fire-fighting water into a retention facility also serves the drainage of operational wastewater, this shall be taken into account for the design and dimensioning of connected volumes of retention. The inlet into the pipeline or the sewer has to be designed so that burnt material or other coarse debris cannot block the inlet pipe nor enter into the pipe. Immersion tubes or inlet structures with coarse screens can be installed to this end.

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

63. The locations of installation and triggering devices for the fire-fighting water retention facilities are to be marked in the ground plans for use by the operator's fire brigade.

64. Fire-fighting 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. The inspections shall be carried out as laid down in the maintenance instructions by the manufacturer and/or the installer. The operator is responsible for the observance of the inspection and maintenance intervals.

65. Fire-fighting equipment for open-air located facilities should be constructed so as to ensure its operability under the most severe expectable meteorological conditions (extreme temperatures, strong wind etc.).

66. The personnel should be instructed and trained on how the fire-fighting water retention systems that are activated manually work and how they should be used. Instruction and training shall be repeated regularly, and at least yearly.

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

68. Connections, seals, and other wear parts are to be exchanged / 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.

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

- visual inspection of the retention basins
- control of the gate valves in terms of impermeability at least once a year
- control of the operational reliability of gate valves, pumps, alarm and additional devices

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

70. Operators should work out a Fire-fighting Water Retention Concept and a general on-site emergency plan taking i.e. note to the disposal of fire-fighting water. These plans should be agreed with the competent authority.

PART C – TECHNICAL AND ORGANISATIONAL MEASURES

C.1 FIRE-PROTECTION CONCEPT

71. Operators should elaborate and implement a sound fire protection concept that has to be adjusted to technical and organizational needs and new developments. The personnel should be trained regularly according to the concept.

72. The fire-protection concept can be divided into general and individual measures, as well as structural and plant-specific fire-protection measures. Together these measures make the occurrence of a fire a low probability. The measures will also allow to detect fire outbreaks earlier so that the minimum quantity of fire-fighting water is needed.

73. The fire-protection concept should include a fire-water retention concept and integrate or include references to the following organisational plans:

- waste and storm water sewage plan, including intervention points and discharge points into surface waters or public sewer systems
- internal emergency plan, including alarm and evacuation organization
- fire brigade response plan, including emergency contacts, access routes, floor plans and chemical inventories

74. The fire-water retention concept is the documentation of the layout, dimensioning and functioning of all measures implemented by the operator in order to succeed with the retention of the used fire-fighting water.

C 1.1 GENERAL MEASURES

75. The use of non-combustible building materials reduces the fire load and the fire spread in the building and, consequently, the quantity of fire-fighting water required to extinguish the fire. Therefore, 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.

76. If an adequate infrastructure of defensive fire protection system exists (intervention time, class of fire brigade, local knowledge), the installation of a fire detection and fire alarm system and the resulting early detection of a fire can restrict the extent of fire, and the fire spread, and, thus, the required quantity of fire-fighting water.

77. Fire-fighting strategies and run-off management may consider possible methods of reducing the amount of firewater run-off generated, for example by the use of sprays rather than jets, controlled burn and the possible re-cycling of fire-fighting water, where safe and practicable to do so.

78. By means of automatic (water) extinguishing systems (sprinklers and deluge systems) the fire can be extinguished or its spread can be stopped at the earliest stage of development (and possibly even without additional fire-fighting water being used by the fire brigade).

The quantity of fire-fighting water required by the fire brigade can then be up to factor 10 less than when compared to a developed fire without an extinguishing system.

C 1.2 INDIVIDUAL MEASURES

79. The individual fire protection measures consist of:

- constructional measures
- facilities for detection and notification of fires
- mobile and stationary fire-fighting equipment
- provision of suitable fire-fighting agents in adequate quantities
- administrative measures such as regulations for storage facility, fire prevention plans, training of personnel
- a well-trained and equipped fire brigade that is familiar with the special aspects, e.g. a fire in a pesticide storage, and
- facilities and measures for the containment of contaminated fire-fighting water.

C.1.3. STRUCTURAL FIRE PROTECTION

80. Constructional measures aim to contain fires within a limited area of the facility.

81. Fire-compartment areas are among the most critical issues to limit the spread of potential fires and subsequently limiting the needed fire-fighting water and the fire-fighting water retention capacity.

82. To reduce the risk of fire, plants have to be adequately subdivided into fire compartments and fire cells. For all the items used, i.e. as fire barriers, technical specification have to be taken into account and a maintenance and periodic test programme that ensures the continued operability of the corresponding components.

83. The size of fire compartments is a key limiting factor for the volume of fire-fighting water needed. The volume is somewhat directly proportional to the fire surface area. Calculation examples and numerical relations are given in Annex 2.

C.1.4. PLANT-SPECIFIC FIRE PROTECTION

84. Technical measures aim to limit fires by providing rapid detection or intervention.

- *Automatic fire detection and alarm:* Automatic fire detection systems will shorten the intervention delay time, enabling an intervention before the fire can spread excessively.
- *Automatic fire-extinguishing system (e.g. sprinkler):* Sprinklers, deluge systems and other automated extinguishing devices will extinguish fires or contain them within a smaller area. This very effectively minimizes the volume of fire-fighting water.
- *Smoke and heat venting system:* Smoke and heat venting systems prevent excessive overheating of fire compartments, thus helping to keep containments intact and limiting the amount of water needed for cooling.

85. Storage height and density: Storage height and density (kg combustible goods per m^2 storage area) affect the fire-fighting water volume in two ways. A higher storage density obviously causes a higher thermal load and thus a more intense fire, requiring more fire-fighting water. On the other hand, effective firefighting becomes increasingly difficult with greater storage heights. This also means more fire-fighting water, unless specific protective measures are taken.

86. Stored liquids: Due to their probable release during a major fire, the volume of any liquids stored or contained within production equipment must be added to the retention volume needed for fire-fighting water.

87. Flammable substances: The fire risk and the fire spread velocity are dependent on the flammability (flash point) of the stored goods. Highly flammable liquids generally lead to more rapidly spreading and larger fires.

88. Hazardous properties of substances: Certain properties (e.g. corrosiveness) of hazardous chemicals may limit the choice of materials used for the fire-fighting water retention systems. Likewise, some substances may cause dangerous chemical reactions, when released or may demand the use of other extinguishing agents than water (in which case, there may be a need for a smaller volume of fire-fighting water retention).

89. Combustible installations, packaging and construction materials: Not only the goods in storage and production equipment contribute to the thermal load, often, large amounts of packaging materials (cardboard, plastics, wood etc.) are present. A significant contribution, frequently overlooked, may come from combustible installations (cables, pipes, ducts etc.), building materials or furniture.

90. Some polymers exhibit exothermic pyrolysis in fire (e.g. rubber) and form a self-heating mass difficult to extinguish and releasing dangerous pyrolysis products in liquid form. Long-time cooling is then necessary, leading to extensive volumes of fire-fighting water.

C.2. FIRE-FIGHTING WATER RETENTION DIMENSIONING

91. Several methodological approaches for calculating the needed retention volume of fire-fighting water exist. However, the methods are not mandatory within the countries and differ significantly in the resulting retention volumes. Also the methods developed mainly take into account “standard fires” which comprise up to 90 % of fires experienced. The so called catastrophes which have an unusual fire development are not taken into account in the methods.

92. Considering a number of catastrophic fires at facilities of the UNECE Industrial Accidents Convention, the amount of fire-fighting water used during those accidents was much higher than calculated in most of the known models (see annex I), highlighting the need for larger fire-fighting water retention volumes.

93. The following calculation approaches for fire-fighting water are among the most validated and are based on scientific and empirical evaluation of actual fire events by independent experts:

- German Guidelines for Loss Prevention by the German Insurers (Planning and Installation of Facilities for Retention of Extinguishing water) (VdS 2557, 2013)
- Swiss Fire-fighting water Retention Guideline (2015)

94. Amongst the various parameters affecting the volume of needed fire-fighting water to extinguish a fire, the total area of a designated fire compartment, seems to have the most important influence (see chapter C.1.3. and annex II).

95. Based on these experiences a stepwise approach for the calculation of fire-fighting water retention facilities is proposed (see also annex II).

A. For a fast and rough estimation, a direct proportionality of the fire-fighting water volume needed to the largest fire-compartment area can be assumed. This can be roughly equated to one square meter fire compartment area resulting in one cubic meter of retention volume (i.e. 5000 m^2 fire compartment area needs 5000 m^3 of retention volume).

B. Up to 10-fold smaller retention volumes are needed, if the facility is equipped according to an advanced fire protection concept (i.e. automatic sprinkler). Accordingly, 5000 m^2 fire compartment area would require 500 m^3 of retention volume. In most cases all kinds of liquids that are present in the fire compartment, will spill into the firefighting water and enlarge the requested retention volume. These volumes should be added.

C. If there are specific additional data available, such as the density of stored goods and the thermal load of potentially affected materials, a more advanced methodology may preferably be used, e.g. the German VdS or Swiss fire-fighting water retention guideline, bearing in mind the restrictions of these methodologies (annex II).

96. Steps A and B above can be applied to facilities in all countries, especially when critical data about the hazardous materials is limited or not available. This rough estimation will show the order of magnitude of the needed retention volume.

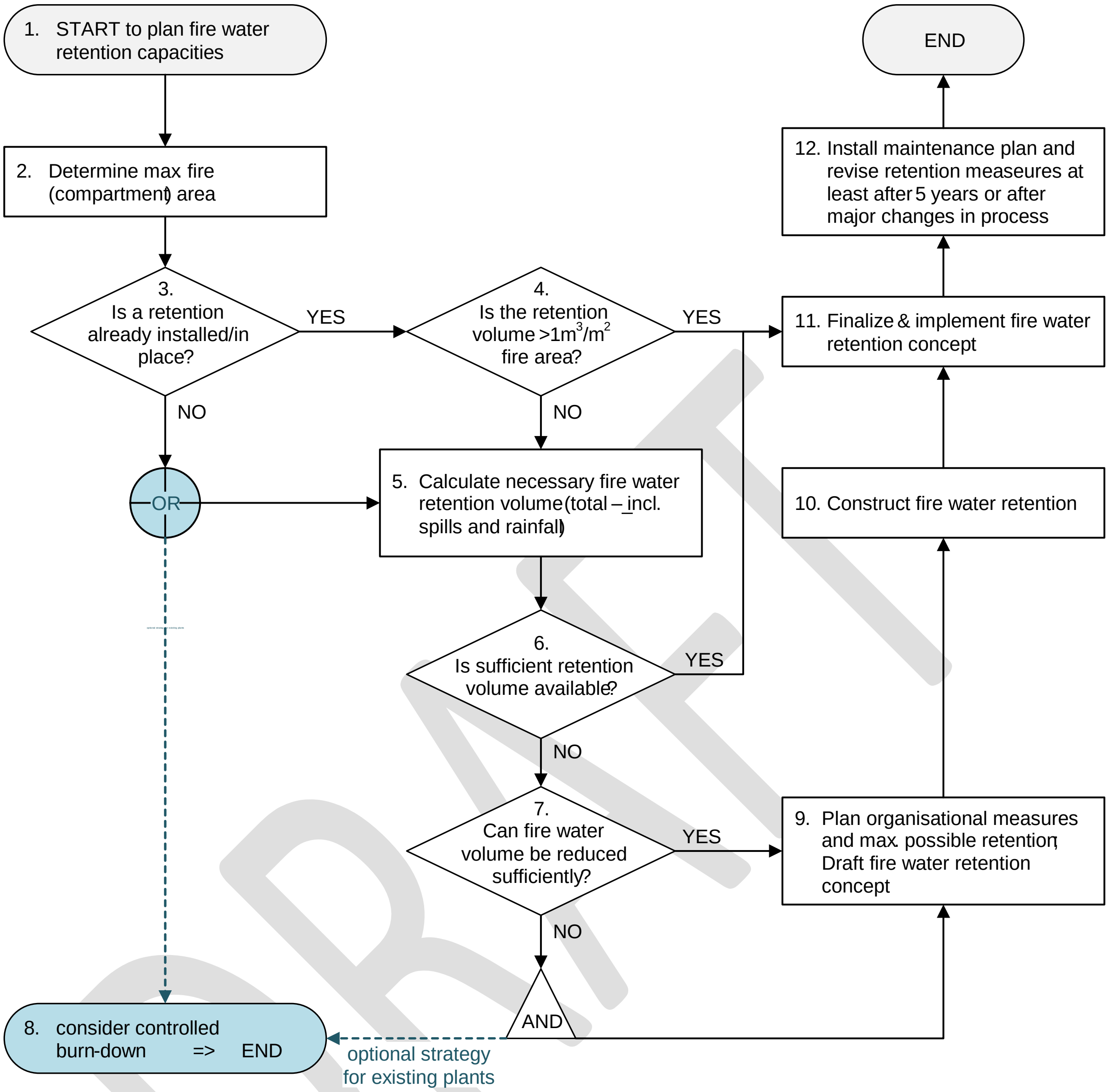
97. In developed and industrialized countries, the more advanced methodologies according to step C are recommended for the calculation of fire-fighting water retention volumes.

98. If the fire-fighting water retention volume calculated according to steps A to C is too large for realization, alternative extinguishing methods should be considered, such as sprinklers.

99. The below flowchart (see Fig. 1.) provides an overview of the proper dimensioning of the retention capacity needed. Various factors influence the calculation of this volume, most importantly the following:

- The surface area of the fire (normally this would correspond to the largest fire compartment – or in case of bundled storages the bund area) [fig. 1 № 2]
- The thermal load of the materials within the fire (including combustible construction materials and building materials, packaging materials etc.), respecting the size of fire as pool fire size and location.
- the presence (or absence) and efficiency of extinguishing devices, such as sprinklers/deluge systems
- the volume of all chemicals and liquids in production, operation and storage that can be released into the fire-fighting water
- the maximum water delivery rate for fire-fighting purposes
- the possible amount of rainfall during and after the event, until the fire-fighting water can be properly disposed of (this may be anything from a few days up to several weeks; the maximum precipitation rate for the appropriate time may be used to determine the additional volume)
- waves and shift of water (liquids) levels due to wind.

Fig. 1 Flow chart for fire-fighting water retention dimensioning.



100. Generally, the retention volume can be drastically reduced by implementing efficient measures [fig. 1 № 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 fire-fighting water volume can be extremely large. A realistic estimate based on experience results in a volume of up to 1 m^3 per 1 m^2 of fire surface area (not accounting for rainfall or the volume of released chemicals).

101. If a retention volume of more than 1 m^3 per 1 m^2 of the maximum possible fire (compartment) surface area is already available and effectively usable, this may be considered as adequate, and further dimensioning considerations may be omitted [fig. 1 № 4] unless the hazards noted above indicate a greater volume of fire-fighting water will be required in that circumstance. It is nonetheless recommended to employ as many measures as practicable to reduce the actual volume of fire-fighting water [fig. 1 № 7],

since any excess of contaminated water will have to be disposed of eventually – usually at high cost.

102. Finally, if an adequate retention volume cannot be achieved (on-site), the maximum attainable volume should nonetheless be installed and complemented with additional organisational measures (e.g. specific instructions and training for fire-fighting brigades, special fire-fighting techniques, other extinguishing agents than water, special contingency planning, planning for external retention volumes and for disposal of fire-fighting water during the fire) [fig. 1 № 9]. Also to be considered, in certain cases where human health and safety is not at risk, is to allow for a controlled burn-down [fig. 1 № 8] of parts of the facility – using only a minimum of water to cool adjacent buildings/structures and prevent the fire from spreading. This can be an option to prevent damage to ground and surface waters, but it must always be agreed upon with the competent authorities and the external fire-fighting brigades and must not expose people to additional hazards.

103. Hi-tech fire-fighting systems such as ultrafine water drops may bring additional advantages by diminishing the fire-fighting water volume.

C.3. PLANNING AND DESIGN OF RETENTION SYSTEMS

104. In protecting people and the environment from contaminated fire-fighting water, the design of the retention system is one of the most important topics. The following chapter refers to the Guidelines for Loss Prevention by the German Insurers: Planning and Installation of Facilities for Retention of Extinguishing Water (VdS 2557: 2013), and will give a short overview of the issues to which planners, operators and competent authorities should pay attention.

105. It is important that retention systems are adjusted to conditions of the location of the production site. The retention system must also be designed as a logically coherent, integral system, considering fire protection and reduction measures, fire-fighting water collection, storage and disposal.

106. To avoid damages caused by contaminated fire-fighting water, the implementation of appropriate technical equipment is required.

107. There are several possible types of systems for the retention of contaminated fire-fighting water. The systems can be installed permanently (i.e. pre-installed water barriers or permanent retention basins, if necessary with pumping installations) or be provided as mobile facilities (i.e. fire-fighting water barriers, hoods and sealing pads, mobile storage tanks).

108. Due to safety and reliability aspects, permanently installed retention systems should be preferred, if possible.

109. The permanently installed retention systems can be subdivided into passive, self-activating and manually triggered systems. The automatically triggered systems need to

have two different independent triggering lines to ensure functionality and to avoid activation by accident. Manually activated systems are generally less reliable in stressful situations.

110. When using mobile facilities, it has to be guaranteed, that they can be installed rapidly and can be managed with minimum effort (i.e. set up has to be possible with two people maximum).

C.3.1. GENERAL REQUIREMENTS

111. Regarding stability, tightness and durability, facilities that are used as retention devices (i.e. retention ponds, contingency basins etc.) have to be resistant to any contaminated fire-fighting water and the necessary impermeability has to be assured (i.e. less than 50ml per hour and per meter barrier leakage rate). Retention facility components that can be exposed to the fire must be resistant to high temperatures and other physical and chemical impacts.

112. Besides stability and durability, the functional safety of retention systems should be considered. When using self-acting retention systems, it has to be ensured that the shut-down position can be guaranteed at any time. Therefore, two independent power supply systems should be provided.

113. When using manual systems, a sufficient permanent onsite work force has to be held available, so that the retention devices can be activated as soon as possible.

114. If fire-fighting water will be held in underground systems or cellar basins, it must be ensured that no flammable or explosive vapours are present.

115. All connections to the retention facility, if indoors, must be fire-resistant, including e.g. doors and inspection shafts.

C 3.2. INSTALLATION OF RETENTION SYSTEMS

116. Generally, 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.

117. 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 the water barriers need to be installed manually, they should be stored near the corresponding gateway or floor and be easily accessible. They also have to be protected against damage. If no permanent onsite work force can be guaranteed, the water barriers have to be installed in advance.

118. If the sewer is used as a part of a retention system, it has to be ensured that the sewer is stable, resistant to the contaminated fire-fighting water and tight. Furthermore, the sewer has to be closed-up in an emergency without causing backflow into connected systems. When the sewer is also used for draining waste- or cooling-water, this fact has

to be taken into account during planning and dimensioning of the possible retention volume. If the fire-fighting water can be mixed with flammable liquids, draining through the sewer is allowed only if the build-up of an explosive atmosphere can be excluded.

119. Furthermore, inspection shafts should be installed at the sewer for controlled sampling by the operator

120. In case of open retention basins or other systems, which are exposed to rainfall, there must be a system to control this during ordinary operations to avoid overflow.

121. When pumps are used for the transport of contaminated fire-fighting water to a retention basin, they have to be designed to deliver the required output even under extreme conditions. Pumps need to be installed permanently. If this cannot be provided for, the operator has to ensure that well trained workers can install mobile devices at any time. Pumps can be triggered automatically or manually dependent on the existing emergency concept. Furthermore, a reliable power supply is to be guaranteed even in the case of a fire.

122. When installing permanent or temporary retention basins, the existing legislation in terms of building, water protection and dangerous goods should be considered. The basins should be equipped with ventilation and air extracting devices, which are designed for maximum in- and output flows inside the basin.

123. In principle, retention devices should be located outside of production and storage units. Especially when flammable substances are used, a fast and safe removal of these substances during a fire is very important, so that they do not cause a further expansion of the fire.

124. Furthermore, the secondary containment of the chemical could be used as retention device. However, it has to be dimensioned so that in addition to the leakage volume of the hazardous substances, the volume of the fire-fighting water can be held (i.e. mostly an additional volume of 30 cm in height should be considered). Catchment areas and retention devices for the retention of contaminated fire-fighting water have to be arranged and equipped to detect overfilling in time, in order to prevent the overflow of the spilling liquid to adjacent fire-compartment areas. Additionally, they have to be accessible at any time so that further actions can be initiated, if necessary.

125. For the retention of fire-fighting water containing flammable liquids, the guidelines for explosion prevention have to be respected.

126. The retention basins have to be stable, tight and mechanically, thermally and chemically resistant.

C.3.3. RETENTION DEVICES[14]

127. Retention devices should have overfill detection/alarms.

128. The shut-off devices have to be accessible at any time and they need to be easily operable. Automatically operating safety devices (e.g. pumps, gate valve) have to have an independent power supply. In case of a failure of these safety devices precautions need to be taken (e.g. redundancy/duplication, fail-safe installations, mobile equipment).

129. Generally it should be distinguished between two different types of retention devices:

- Central retention devices for a number of facilities on a site (e.g. discharging through rain- and cooling-water sewers into a central retention/contingency basin). Central retention devices are not located on the property of the operator and their running is the responsibility of someone else than the operator, for example a water treatment plant; and
- Local retention devices directly connected to a facility (e.g. retention basins). Local retention devices are located on the property of the operator who is also in charge of the necessary maintenance.

130. Local retention devices should be constructed in a way that

- a secure retention is ensured – Impermeability and durability need to be assured
- additional retention volume for possible leakage is provided.

131. If no local retention device can be provided/realised, a central retention device (e.g. contingency basin of a wastewater treatment plant or of an industrial area) can be chosen. In this case, it needs to be guaranteed, that a secure discharge of the fire-fighting water is possible and the impermeability and durability of all construction materials (including the sewer systems) is assured.

C.3.5. REQUIREMENTS FOR FIRE-FIGHTING WATER BARRIERS

132. Barriers for the retention of contaminated firefighting water as a part of the retention device need to be impermeable (less than 50ml per hour and meter barrier leakage rate) and resistant to mechanical, thermal and chemical exposure.

133. The operational readiness of the retention barriers should be guaranteed within 60 seconds after the alarm is set.

C.3.6. PLANNING AND MAINTENANCE OF FIRE-FIGHTING WATER RETENTION SYSTEMS

134. Sewerage system: Especially in existing facilities, the internal sewerage system of the plant can be part of the fire-fighting water retention concept. If flammable liquids can be

[14] Retention devices can be, for example, firefighting water bulkheads or other mechanically shut-off-barriers which only lead to a retention basin when being activated in the event of a fire. A retention basin normally is a basin that is permanently available.

released into the fire-fighting water or explosive vapours can evolve, 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 fire-fighting water retention concept, it must be safeguarded that the system:

- is proved to be leak-tight and can resist any chemical attack from the fire-fighting water
- does not discharge into a surface water body directly (storm water sewerage) or indirectly (waste water sewerage) via a storm water overflow in case of heavy rain

135. Tightness of storage basins: A local retention of fire-fighting water in the affected building itself is generally preferred. Periodic checking of the condition and functioning of stationary and temporary shut-off devices and immediate repair of detected defects should be ensured. If rainwater pipes for roof drainage, pipelines or other pipes (e.g. for waste water) or cables penetrate floors or walls of facilities used for the retention of fire-fighting water or affected fire compartments, the openings have to be structurally waterproofed or situated above the maximum flooding level or should be avoided. If this is not possible, the pipes must be constructed of fireproof materials or be covered by suitable protective coatings.

136. The internal waste water treatment facility of an affected company will normally not be able to treat the contaminated fire-fighting water. This is due to the fact that the fire-fighting water has a much more complex composition and higher contamination load than the normal waste water of that plant/operation, and the volumes are likely to be higher than normally handled. The waste water treatment unit might also be compromised or out of function due to the fire.

137. In the case of electroplating and printed circuit board plants, it must be assumed that all production chemicals, cooling-, rinsing- and waste water, located in the area affected by fire, will leak simultaneously, since different parts of the production line are connected by plastic pipes, which cannot withstand a fire. Similar considerations should be applied to other production processes.

138. Maintenance and quality assurance: When fire-fighting water retention measures have been installed and a retention concept is in place, it is essential to secure the continued functioning of this system. To this effect, a maintenance plan [fig. 1 № 19] should be implemented, covering at a minimum the following aspects:

- the constructional integrity of the retention volume(s),
- the constructional integrity of fire compartments,
- the integrity and functioning of all fire-fighting water conduits,
- the functional testing and maintenance of barriers, slide valves and other technical devices needed for the fire-fighting water retention to be effective,
- the testing and maintenance of fire-detection and extinguishing systems,
- the testing and maintenance of explosion protection equipment and installations,
- the testing and maintenance of ventilation systems and smoke and heat vents,
- the compliance with storage concepts for hazardous substances and combustible goods,

- the knowledge of and compliance with fire-relevant operation procedures, safety instructions and emergency plans, etc.

139. Weather (wind, rain): A significant additional retention volume will be needed in case of heavy rain during a fire event, and in the period after the fire until the fire-fighting water can be disposed of. This can last from a few days up to some weeks. These external factors can obviously not be accurately foreseen, but the prevailing conditions in the geographic area should nevertheless be taken into account in the fire protection concept. Normally the calculations are based on the local maximum 10-year rainfall intensity, but due to the climate change, an experience with flash-floods in the geographic area should be considered as well.

C. 4. FIRE-FIGHTING WATER DISPOSAL

140. Fire-fighting water must always be considered as contaminated with water endangering substances. Special considerations have to be taken when disposing of it. A proper assessment – in most cases accompanied by a qualified laboratory analysis – of the degree of contamination must be undertaken prior to disposal.

141. Water used solely for the cooling of buildings and/or installations not directly involved in the fire can, in most cases, be considered as not or only weakly contaminated. Most public waste water treatment plants should be able to treat this without additional measures. However, this should also be subject to an assessment of the degree of contamination. It should also be verified that the public waste water treatment plant is actually capable of treating that water, especially if chemicals hazardous to the aquatic environment according to annex I to the Industrial Accidents Convention, are present in the facility.

142. For any other type of fire-fighting water, it must be evaluated whether the contamination is sufficiently low that a disposal in a wastewater treatment plant is possible. This must always be in consultation with the competent water authority and the wastewater treatment plant operator. When the fire-fighting water contains toxic or corrosive chemicals (including extinguishing foams e.g. with fluorinated carbon chains), or toxic combustion products, a pre-treatment – either on-site or at a specialised treatment facility is likely to be needed. Very heavily contaminated water may have to be disposed of at a dedicated chemicals waste disposal facility.

143. Proper transport logistics of fire-fighting water’s transport to disposal unit(s) should be the part of emergency plans.

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ANNEX I – EXAMPLES OF MAJOR FIRE ACCIDENTS IN THE UNECE REGION

Overview of some fire accidents from the UNECE region and their key characteristics

In the table below you can find an overview of fire accidents in the UNECE region and their key parameters*. A more detailed description of the accidents is provided below.

No.	Year	Country	Company / Place	Fire-compartment area	Volume of fire-water used	Total costs of the accident
1.	1986	Switzerland	Sandoz / Schweizerhalle (transboundary effects)	4,500 m^2 (burning)	20,000 m^3	141 mio CHF (of which 60 mio. for soil remediation, 42 mio. for compensation payments, 15 mio. for building loss and 24 mio. other costs).
2.	2005	Germany	Schweizer AG /Schramberg	2,775 m^2 (burning)	3,500 m^3	1 mio. EUR (only disposal of fire-fighting waters)
3.	2009	Finland	Abloy Company / Joensuu	180 m^2	2,200 m^3	"millions of Euros"
4.	2011	Netherlands	Chemie-Park storage facility / Moerdijk area	6,500 m^2	38,000 m^3	13 mio. EUR
5.	2011	Czechia	Remiva ltd. / Chropyně	150 m2 (later expanded up to 5000 m2)	6 350 m3 of fire water; 38 m3 of heavy fire foam (26 tons)	10 mio. EUR

*These examples are catastrophic accidents representing worst case incidents. The amount of the needed fire-water retention volumes are far beyond the ones resulting of the calculation models presented in Annex II.

1. Switzerland – Fire at Sandoz warehouse, Schweizerhalle, 1986

Shortly after midnight on November 1^{st} 1986, a major fire broke out in a chemicals warehouse near Basel at the Schweizerhalle site of the Swiss chemicals company Sandoz. In the building was a mixed storage of 1350 tonnes of chemicals, amongst them several pesticides, herbicides and mercury compounds, as well as highly flammable solvents. It took 160 firefighters almost 7 hours to manage the heavy fire, even using a special fire-fighting boat from the nearby river Rhine.

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

As a result, the entire population of eel, along with other fish species, was killed up to a distance of 400 km downstream. The damage to other aquatic organisms could be seen as far away 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 in Schramberg on 5 June 2005

A fire at Schweizer AG, a producer of printed circuit boards, occurred in Schramberg with a fire area of approximately 6,500 m^2. The whole factory area was about 34000 m^2. The fire broke out in the waste water treatment area and spread into the electroplating production and parts of the chemical storage. All chemicals in production were released into the fire-fighting water, i.e. in total 400 tons of chemicals were mixed with the fire-fighting water. About 1,000 m^3 of highly contaminated fire-fighting water, containing heavy metals, acids, solvents and traces of cyanide, could be retained in basins and improvised barriers on site. The fire-fighting water was partly so aggressive, that it etched through steel tanks within 72 hours. Another 1000 m^3 of fire-fighting water was retained in an overflow basin for rainwater in Schramberg. Because of heavy rain announced by the weather forecast, the fire-fighting water had to be transported just in time with special trucks to several chemicals waste disposal facilities all over Germany. Parts of the fire-fighting water were released to the sewage treatment plant of Schramberg. Although it was provisionally chemically treated, the whole biology of the treatment plant was killed. The costs of disposal of the fire-fighting water were 1 million Euro.

3. Finland – Fire at Abloy company in Joensuu in 2009

A fire at a company called Abloy took place in 2009. Abloy is an upper-tier Seveso plant[15], 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.

The part of the establishment where electroplating was located was completely destroyed in the fire. The surface area of the burning department was 180 m^2 with the height of 6 m. This was all one fire compartment but it was a separate compartment from other departments; the whole factory area was around 21 000 m2. Most pipes, basins etc. were polypropylene,

[15] An upper tier installation in accordance with annex I to the Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC Text with EEA relevance (European Union Seveso III Directive).

some also PVC. All the plastic basins melted. Those that were of steel had plastic plugs, so their content was also released.

The amount of water used was around 2200 m^3. Not all of this was used to fight the fire, some was also needed to keep the hoses from freezing (winter). 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 waste water treatment plant (via the factory's own waste water treatment plant).

At the time of the fire, the electroplating department contained around 108 m3 of various hazardous chemicals (e.g. chromium and nickel compounds, various acids and alkali as well as cyanides) and around 86 m3 of rinsing water. The chemicals mixed with the fire-water. The environmental damages were measured after the fire from the snow, soil, ground water, rainwater sewage system, nearby watercourses and the municipal waste water treatment plant's outbound water and slurry. The most significant environmental damages were caused by the process chemicals, especially heavy metals and cyanide, and were located within or near the factory site. The pH value measured from the fire-fighting water (outside the building) was 1-2.[16]

4. Netherlands – Fire at Chemie-Park storage facility, Moerdijk area, 5 January 2011

The fire at a company called Chemie- Pack, located in Moerdijk, 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.

The fire started outside on the yard, while resin was being pumped from one immediate Bulk Container (IBC) tank into another one. Due 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 due to 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 due 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 organisational risk management processes did not live up to the levels of the risk of the company. The necessary organisation and means allowing for an effective intervention were simply not present.

The Moerdijk Pack was a fire with an area of approximately 6,500 m^2. The company had 5 large sheds. In each of them hundreds of tons of hazardous materials were stored. In the outdoor area, there were another several hundred plastic containers, each of which was filled with 1,000 litres of flammable liquid. In addition, a container with 16,000 litres of acetone (80

[16] More information about the accident may be found (in Finnish only) at http://tukes.fi/Tiedostot/kemikaalit_kaasu/Abloy_Onnettomuustutkintaraportti.pdf

barrels of 200 litres each) and a tanker filled with 33,000 litres of a very flammable substance were located on-site.

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

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.

The total cost of this fire disaster are estimated at an amount of 71 million Euros.[17]

5. Czechia – Fire of plastic waste in the Remiva ltd., Chropyně, 2011

A fire at the company Remiva took place in Chropyně town in 2011. The Remiva facility deals with storing and further recycling of many kinds of plastic waste (polyethylene, polystyrene, polypropylene, polyuretane, polyamide, polytetrafluorethylene, polycarbonate, acrylate) on its grounds in the town of Chropyně in Czechia (Moravia). 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 signalisation, storing height was limited to 1.5-2.5 m and construction fire safety plans were drawn up. Approximately 1 500 tons of plastic waste were stored right before the fire started on 8 April 2011 at 01:03 a.m.

The exact cause of the fire, the losses of which were preliminary estimated to up to 10 million Euro, 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.

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. No specific fire-fighting water retention measures were probably put in place (only old sewerage system). The whole area was watched and controlled by units of the professional fire brigade, which had been fighting this difficult fire until 19 April 2017. In total, 73 fire brigade units and 567 firefighters participated in extinguishing the fire. The population of the town Chropyně was quite lucky because the wind, carrying away a lot of toxic fumes from the fire, blew towards the area with a low population density. A huge cloud of black smoke and soot was visible from the surrounding towns and villages. Potential air pollution (mostly

[17] More information about the accident may be found (in English) at https://www.onderzoeksraad.nl/en/onderzoek/1805/fire-in-chemical-firm-moerdijk-5-january-2011.

aromatic hydrocarbons) was monitored by the fire brigade in the close neighbourhood of the facility.

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 wind (15 m/s). At 2 a.m. the chemical alert for the whole town Chropyně was declared, because the emergence of the toxic gaseous fumes was expected from the fire, containing phosgene, carbon monoxide, aromatic hydrocarbons and solid particles. Several streets of the town Chropyně in the close neighbourhood were evacuated during the first day of the fire.

Fire-fighting 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 chieftain of the fire brigade) banned, after the communication with the management of the local water cleaning station, the further use of heavy foams within this fire intervention. This early decision mitigated the potential occurrence of bigger environmental damages. There is no specific data available about how much of the fire-fighting 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.[18]

[18] More information about the accident may be found (in Czech only) at http://www.hzscr.cz/clanek/casopis-112-rocnik-x-cislo-8-2011.aspx .

ANNEX II – DIFFERENT MODELS FOR CALCULATING THE VOLUME OF FIRE-FIGHTING WATERS

This annex presents different calculations models of fire-fighting waters. It is intended to present alternative, accepted models to calculate fire-fighting waters. In addition, this annex includes also a new calculation model proposed by the UNECE Expert Group on Fire-water Retention.

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

If there are several fire compartments within a facility, the one with the highest thermal load is decisive. If input data is just the surface of fire compartment, then the surface of the largest fire compartment has to be chosen. The letter "R" in equations always means calculated volume of contaminated fire-fighting water that has to be retained. At the end of annex II several simple comparisons of the models' results are presented. Graphs show the differences between the results of all models. The comparison should only be considered demonstratively keeping in mind a different input data for each model.

1. Sandoz and Ciba method (S&C)

This method anticipates 3 m^3 to 5 m^3 of needed fire-fighting water delivery per ton of stored material depending on the quantity of the flammable materials, hazard categories of stored products and expected fire duration. It is a very simple method to apply that requires little input data. It is based on only a few case studies so the method could not be extended to every potential scenario. In the end of this annex, in the charts, the method is converted to fire load as a non-liquid material with the burning energy estimated to be 18 MJ/kg (like cellulose).

$$R \text{ [from } 3\ m^3 \text{ to } 5\ m^3] = 1 \text{ ton of stored material}$$

(Source: ISO/TR 26368:2012 - Environmental damage limitation from fire-fighting water run-off / found in CIRIA report C736 - Containment systems for the prevention of pollution)

2. Dimensioning according to thermal load

Another very easy and simple method is based on the thermal load and the water warmth-binding capacity. This method anticipates determining the total fire load as a sum of the mobile thermal loads Q_m (i.e. products, storage materials, equipment etc.) and the immobile thermal loads, Q_{im} (i.e. thermal load of buildings, insulation, damping and cladding).

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

To define the required volume of fire water that has to be retained, the calculated total thermal load has to be divided by water warmth-binding capacity - 2,6 GJ/m^3. According to scientific investigations, only half of the fire-fighting water is reaching the burnt material due to evaporation. Therefore, the double volume of the required calculated volume of fire-water is needed. The equation of the model is presented below.

$$R\ [m^3] = Q_{total} \text{ [GJ]} / 2{,}6\ [GJ/m^3]\ V = Q_{total} \text{ [GJ]} / 2{,}6\ [GJ/m^3]$$

In the charts at the end of this annex, the input data of this method is simplified in such a way that only thermal load of stored materials has been taken into consideration

3. Province of Hessen

This method has been developed by the German province (Land) of Hessen in 2011 (Hessenweit abgestimmte Empfehlung, 2011) for industrial sites based on empirical data or assessment of the fire load. The dimensioning of fire water retention basins can be calculated for this case according to following equations:

$$R\ (m^3) = \text{fire area}\ (m^2) * 0{,}135 \text{ - for fire area up to } 600\ m^2$$

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

$$R\ (m^3) = \text{fire area}\ (m^2) * 0{,}18$$

(Source: "Rules for the Calculation of Fire Water Retention Facilities with the Storage of Materials Hazardous to Water" - developed from the project group 'Fire Protection in Industry Buildings' from the expert commission 'Construction Supervision' at ARGEBAU: https://umwelt.hessen.de/sites/default/files/HMUELV/handlungsempfehlung_loeschmittel_im_brandfall.pdf).

4. Office for Waste, Water, Energy and Air of the canton of Zurich (AWEL)

This model is proposed by Office for Waste, Water, Energy and Air of the canton of Zurich (AWEL). The volume of firewater depends on the concept of fire protection and storage, the risk of fire of the stored materials and the size of the fire compartment. The basis of the calculation is taken from empirical data and looks as follows:

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

Where:
Theoretical volume – from a chart, based on empirical data
Storage factor – depends on mass per square meter (0,5; 0,8; 1,0; 1,2)
(Source: "Löschwasser-Rückhaltung Leitfaden für die Praxis". Amt für Abfall, Wasser, Energie und Luft Betrieblicher Umweltschutz und Störfallvorsorge, canton Zurich: http://www.praever.ch/de/bs/vs/WeiterePublikationen/Seiten/Leitfaden%20Lo%CC%88schwasserr%C3%BCkhaltung_rev2016_web.pdf).

5. German insurance industry (VdS)

The most advanced and complicated method of those presented is the VdS Formula, provided by the German insurance industry and published in guideline 'VdS 2257'. This method is based on the type and quantity of combustible materials, the presence of the fire detection systems, the size of the biggest fire compartment, the type of fire brigade and the fire protection technical infrastructure. The equation is the following:

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

where:
A – object surface or biggest fire compartment [m^2]
SWL – is the specific water input [m^3/m^2]

BAF – fire section area factor [dimensionless]
BBF – fire load factor [dimensionless]
M – volume of all stored materials [m^3]
BSF – fire protection factor [dimensionless]
The coefficients of the equation are dependent on the other tabulated values. Due to the complexity of the method and the number of dependent tables, they are not indicated in this annex.

An automatic calculation sheet to calculate the volume for contaminated extinguishing water has been developed and can be downloaded free of charge from https://shop.vds.de/en/download/4985801dafb52f4d08e8aa83b5bc0e90.

(Source: "VdS 2557: 2013-03 (01) Planning and Installation of Facilities for Retention of Extinguishing Water". Guidelines for Loss Prevention by the German Insurers)

6. Model of the Expert Group on Fire-water Retention (JEG Model)

The method proposed by JEG is easy to use and secure. The method anticipates 1 m^3 of the retention basin per square meter of the protected object surface or its biggest fire compartment (1). The calculated volume can be reduced to 10% of the initial by providing always operational factory fire service (2).

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

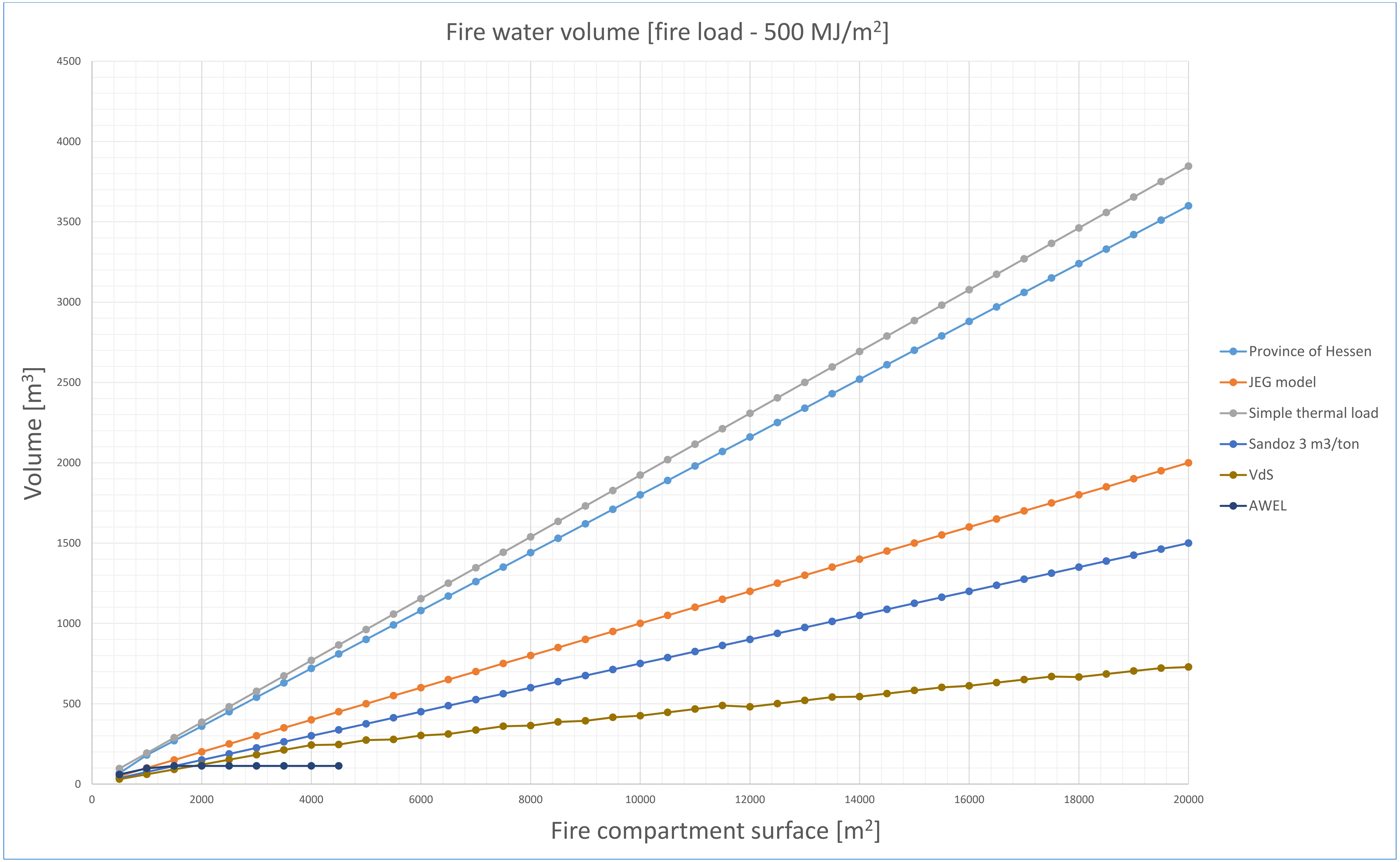
$R\ [m^3] = 0{,}1 * A_f\ [m^2]$ – if always operationally factory fire service provided (2)
A_f – biggest fire compartment surface [m^2]
The model outcome shown at the end of the annex is reduced to 10%. By comparing the JEG model to the other models, it is concluded that within lower fire densities, the model results in the middle of the others. In case of higher fire densities the model achieves comparatively lower values.

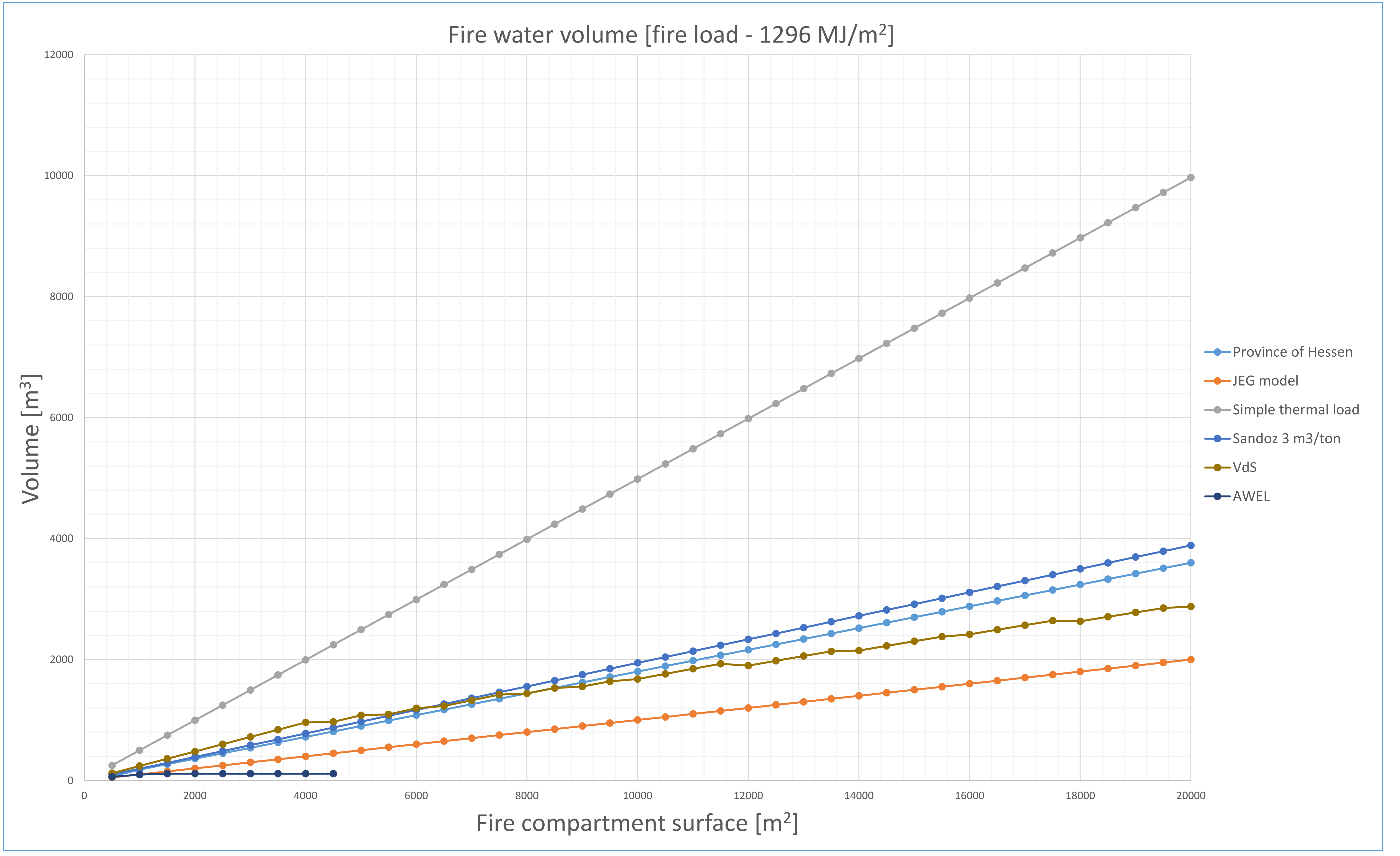
7. Comparison

Bearing in mind the differences in all models and their complexity, the comparison was made with some simplifications. Every model is represented in the graph by one line. The graphs represent the smallest achievable volumes, e.g. due to the use of the maximum fire protection (VdS, JEG, AWEL) and/or the presence of the relatively less hazardous materials (AWEL, S&C). The AWEL model was limited to an area of 4500 square meters due to model limitations.

Chosen input data:
a) fire loads expressed in [MJ/m^2]: 500 and 1296 as a upper reliable boundary for 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.


Fire water volume [fire load - 500 MJ/m2]
Volume [m3]
Fire compartment surface [m2]
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
Province of Hessen
JEG model
Simple thermal load
Sandoz 3 m3/ton
VdS
AWEL



Fire water volume [fire load - 1296 MJ/m2]
Volume [m3]
12000
10000
8000
6000
4000
2000
0
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
Fire compartment surface [m2]
Province of Hessen
JEG model
Simple thermal load
Sandoz 3 m3/ton
VdS
AWEL