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Environmental damage limitation from fire-fighting water run-off

Limitation des dommages environnementaux dus au ruissellement des eaux de lutte contre l'incendie

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 26368 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 3, *Fire threat to people and environment*.

Introduction

Fires involving commercial storage facilities and industrial plants are generally controlled by applying large volumes of water. These facilities routinely store or use large quantities of materials and manufactured products, often flammable and combustible. These substances, whether combusted or not, can be transported by uncontrolled water run-off in the event of a fire and could give rise to severe environmental pollution problems.

The latest Organisation for Economic Co-operation and Development (OECD) report in the series *Environmental Outlook for the Chemicals Industry*[1], notes that, in the European Union, chemical accidents that cause ecological harm often involve water pollution; this pollution is frequently the result of fire-water run-off.

The seriousness of these threats depends on various factors, including the nature and quantity of the materials involved, the emergency planning measures in place, and the location of the fire relative to susceptible populations and environments. Contamination far beyond the locality of the fire can result from fire scenarios that generate large quantities of harmful combustion products and fire suppression that involves large quantities of water. The environmental hazard can be worsened by interactions between the product that is burning, the combustion products produced and the extinguishing agent.

This Technical Report provides a summary of current approaches to controlling and reducing adverse environmental impacts caused by fire-water run-off. The intended audience for this Technical Report includes, but is not necessarily limited to:

— Fire-fighters and investigators.

— Building owners and managers.

— Storage facility operators.

— Materials and product manufacturers.

— Insurance providers.

— Environmental regulatory authorities.

— Civil defence organizations.

— Public health authorities.

— Industrial safety authorities.

Environmental damage limitation from fire-fighting water run-off

1 Scope

This Technical Report provides information for the development of specifications and procedures aimed at limiting adverse environmental impacts caused by fire-water run-off (see References [2] to [7]). The information is applicable to commercial facilities, such as warehouses, chemical storage facilities, refineries, process plants which handle and/or store products with a potential pollution potency, and vehicles for the transport of such substances. It is only applicable to land-based operations (i.e. not oil tankers or off-shore oil drilling platforms), and to wildland fires.

As such, this Technical Report provides a summary of current potential approaches for controlling and eliminating adverse environmental impacts caused by fire-fighting water run-off. It offers relevant information for the design and sizing of water basins to limit the dispersion of contaminated water into the environment at large (see References [8] to [12]). This Technical Report is divided into three main parts: a description of the hazards of fire run-off, environmental damage limitation and details concerning the possible design of water basins.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13943, *Fire safety — Vocabulary*

ISO 14001, *Environmental management systems — Requirements with guidance for use*

ISO 14050, *Environmental management — Vocabulary*

ISO 26367-1, *Guidelines for assessing the adverse environmental impact of fire effluents — Part 1: General*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13943, ISO 14001, ISO 14050, ISO 26367-1 and the following apply.

3.1
fire effluent
totality of gases and aerosols, including suspended particles, created by combustion or pyrolysis in a fire

NOTE For the purpose of this Technical Report, fire effluent also includes run-off water generated during fire-fighting activities.

3.2
fire-water run-off
aqueous fire effluent containing dissolved and waterborne materials

NOTE Materials that may be present include substances affected by the fire, combustion products, and substances used to fight the fire.

3.3
biochemical oxygen demand
BOD
indirect measure of the concentration of biologically degradable material present in water

NOTE This definition is based on OECD documents (References [13] and [14]).

3.4
chemical oxygen demand
COD
measure of the oxygen required to fully oxidize all compounds, both organic and inorganic, in water

NOTE This definition is based on OECD documents (References [13] and [14]).

3.5
contaminated fire water
water that has become contaminated with process materials used at a facility and the products resulting from combustion or products used as part of the extinguishing process

4 Emission to the aquatic environment

4.1 Contamination pathways

4.1.1 General

The major threat to the aquatic environment posed by fires arises from the direct run-off of contaminated fire-fighting water into rivers, streams, lakes, ground waters and sewage treatment works.

The polluting effects of fire-fighting water run-off, related to both surface water and ground water, are due to one or more of the following:

— direct toxicity or ecotoxicity (i.e. LD_{50} determination on Daphnias);

— an increase or decrease in the biochemical oxygen demand (BOD);

— an increase or decrease in the chemical oxygen demand (COD);

— physical effects such as suspended solids polluting river beds or the gills of fish;

— sanitary quality of public bathing water;

— an increase or decrease in pH;

— metals released in the environment.

4.1.2 Impact modes

The impact that any discharge of fire run-off has on the aquatic environment is determined by a wide variety of factors:

a) The volume of run-off produced, the time of travel from the site of the fire to the receptor, the dilution afforded in the receiving water body, and the temperature and chemistry of the receiving water body.

b) The sensitivity and the distance (time of travel from the site) of the primary and secondary receptors, such as public drinking-water abstraction points, fisheries and all potential aquatic and non-aquatic ecosystems.

c) The chemical composition of the run-off as determined by the source of the fire, e.g. in the case of fires at sites storing chemicals, a complex mix will be involved including:

   — the stored chemicals and their thermal decomposition products washed off the site by the run-off,

   — the solid and condensed decomposition products of combustion of the building and of substances stored on site, and

   — additives to the water used in fire suppression, such as fire-fighting foam.

NOTE 1 Contamination could be a consequence of interactions between the pollutants and their targets. For example, pollutants can be concentrated at different steps in a food chain and their impact can occur far from the primary affected targets.

NOTE 2 References [15] to [20] give information on the toxicity of chemical fire suppressants.

Contamination can be in the form of pollutants floating on water, pollutants miscible in water, and pollutants mixing with sediment.

4.1.3 Acute effects

The acute effects of a discharge of run-off to surface water usually appear immediately. The impacts, although often short term, can be very serious and can include the contamination of public drinking water supplies during or immediately following the fire. The effects are usually greatest within the immediate vicinity of the site, where the levels of pollutants will be at their highest. Acute effects can be followed by long-term disruption in the ecosystem that can occur up to several years after the contamination event (see A.4).

NOTE Acute effects can also peak at some distance from the fire. For example, an oxygen sag can form downstream of the discharge point when more toxic breakdown products can be formed, such as ammonia forming from the breakdown of protein-based foams. Furthermore, sensitive receptors can be located well downstream of the discharge point.

4.1.4 Long-term effects

Long-term environmental impacts from exposures to large fires (i.e. the impacts occurring after the fire, over a period of years) will be experienced largely within the local environment, within the fire deposition zone and along impacted streams and watercourses and ground waters as defined in ISO 26367-1. Information concerning such incidents can be found, for example, in the Major Accident Reporting System (MARS) described in the Note below.

NOTE The Major Accident Reporting System (MARS) is a distributed information network consisting of 15 local databases on an MS-Windows platform in each Member State of the European Union and a central UNIX-based analysis system at the European Commission's Joint Research Centre in Ispra (MAHB, Major Accident Hazards Bureau) that allows complex text retrieval and pattern analysis. MARS is used by both EU and OECD member countries to report industrial accidents in the MARS standard format and to exchange accident information (see Annex A).

Long-term impacts can also arise from direct ingestion by flora and fauna of toxic/carcinogenic/ecotoxic organic compounds within watercourses contaminated by fire-water run-off. Pollution of ground water can also lead to the long-term (decades) or permanent closure of public and commercial water supplies that are drawn from ground water or taken from surface waters that are fed by contaminated ground waters.

The nature and place of any intervention that occurs has a major effect on the environmental impact of that intervention. Some information is given below concerning what is appropriate to monitor in order to determine the environmental impact of a particular intervention and whether a controlled burn (i.e. allowing a fire to burn out under the control of the fire authorities) is not sometimes a viable alternative to traditional extinguishment. If extinguishing media have been collected, samples should be taken for analysis. Further, samples should also be taken from ground water and surrounding watercourses or lakes.

The exact species that should be monitored in samples taken on site should be determined based on the products stored on site and their likely breakdown products as well as on the fire-fighting agent(s) used. Examples of relevant analyses include: PAH, dioxins, metals, pH, BOD, COD and suspended solids (SS). In some cases, toxicity tests and biological monitoring may also be useful.

In cases where action is required to prevent the fire from spreading, for example by applying cooling water to the area around storage tanks, care should be taken to ensure this water does not become polluted.

4.2 Control of fire-fighting water run-off to surface water and ground water

Fire-fighting water containment should be considered for industrial sites over and above the requirements for ordinary bundings and secondary containment systems. A containment system may be needed to protect both surface and waste-water drainage systems. Lagoons may be constructed whose retention capacity is adequate for the area concerned. Specific places, such as car parks, should be identified as potential capture areas as these are easily modified to provide retention capacity for run-off water.

4.3 Permanent or portable tanks are another option for fire-water retention

Permanent or portable tanks should be constructed of a material resistant to the substances intended to be retained and tanks should be vented to avoid pressure build-up. Shut-off valves or penstocks that can isolate parts of the site in an emergency are another alternative to prevent contaminated water from reaching a drain or surface water. In this case, the contaminated water is held within the drainage system and removed as soon as practicable (and with the approval of the environment gency and/or sewerage provider). Further information on the types of system that can be used can be found in References [10], [21] and [33].

5 Environmental damage limitation

5.1 Initial risk assessment

Identification of pollution sources, assessment of the risk and development of protection strategies should be defined and developed prior to a major incident. The protection strategies identified should take into account possible atmospheric pollution, domino effects, water run-off displacement, which samples should be taken and which analyses should be conducted.

5.2 Risk reduction strategies

If the risk screening assessment shows a high or medium risk of pollution from fire-fighting, site operators, in liaison with fire and rescue services, environmental regulators and other stakeholders, should consider ways to reduce this risk to an acceptable level or mitigate the impact of the risk.

There are four main ways to reduce risk, which can be implemented at any given site:

a) Prevention

This measure should be given the highest priority, i.e. the prevention of the fire in the first place, e.g. by segregating or controlling sources of ignition.

b) Automatic detection and fire protection

This measure ensures that if a fire does start, it is detected and fire-fighting is instigated as quickly as possible. The fitting of automatic detection and protection systems such as automatic sprinkler systems is one traditional methodology although numerous others exist. Site operators should seek advice on such systems from fire experts, such as the Fire and Rescue Service and their insurers.

c) Containment

This measure mitigates the impact of a fire through the installation of facilities for containing fire-water run-off such as storage lagoons or chambers, shut-off valves and isolation tanks or areas.

d) Alternative strategies

This measure reduces the impact of a fire by planning suitable fire-fighting strategies with the Fire and Rescue Service, such as:

— reducing the amount of fire water generated, such as by using sprays rather than jets;

— recycling fire water where this is not hazardous.

5.3 Fire-fighting tactics

5.3.1 Relation between fire-fighting tactics and water usage

Fire-fighting tactics have a strong impact on the nature and volume of fire-water run-off. There are two main strategies for fire-fighting tactics in industrial fires within the scope of this Technical Report. The choice between the two different tactics depends mainly on the nature of the fuel involved. The main steps in both tactics are listed below:

a) **Limitation of the propagation of the fire**. Fire-fighting is related to the limitation of the fire propagation to a given limit determined generally by fire-fighters as part of the strategic planning for an industrial site. The goal of this first step is to avoid propagation to surroundings, e.g. other buildings. At this step, the extinguishment medium is typically water.

b) **Fire control**. In this case, propagation is limited and the progress of the fire towards extinguishment has started. This part of the operation can begin within a few minutes to hours after starting the fire-fighting. Depending on the nature of the fuel, tactics will differ in this step, e.g.:

    1) *Hydrocarbon fires (refineries and oil depots, gas stations, rail and road tanks), chemical industries and some warehouses*: In this case, foam is required in order to proceed to extinction. Tactics involving foam need significant hydraulic systems and lead time before applying the extinguishing medium. During this delay, fire is limited ("controlled") by water.

    2) *All other fires*: In this case, water is used in variable quantities to bring the fire to extinguishment, depending on the specific fire to be controlled.

c) **Fire extinguishment**. This is the final step, which is also coupled with a survey of the damage and plan for the next steps (i.e. fire survey).

In step 5.3.1 b), when foam is used, extinguishment will usually be quick (a few minutes) once the foam application has begun. If not, there is a risk that the fire will reignite and the procedure must be restarted. Tactics using foam are typically considered to require at least double the time of other tactics. This generates a much greater volume of water, and the presence of foam and emulsifier agents leads to a more complex composition of the water to be managed both in terms of quantity and toxicity.

5.3.2 Controlled burn

In some very specific cases, the fire-fighting tactics can specifically involve a decision to "not attack the fire actively"[22][23] in the fire-fighting operations once the risk of escalation has been minimized and there are no further risks to humans. This is often called a "controlled burn" tactic. This is generally chosen for one of three main reasons, i.e. when fire-fighters do not know how to extinguish the fire, when the risks associated with active fire-fighting are too great for the fire-fighters, and upon directive from the relevant jurisdiction authority. The choice to use this approach may minimize adverse environmental impacts caused by polluted fire-water run-off by restricting the use of fire-fighting media such as water or foam. Under some circumstances, these tactics may also reduce air pollution as a consequence of more efficient combustion and dispersion of gaseous pollutants formed in the fire. This tactic may be used as the sole fire-fighting strategy or as part of a strategy when water/foam are also used during different stages of the fire. The choice of this tactic, however, involves complex decision making by the fire management team. In this contex, it is important to consider:

— What effect fighting the fire with water or foam may have in terms of potentially contaminating water resources, fisheries, aquatic fauna and flora.

— Whether there is a realistic possibility of managing a controlled burn, without attempting extinguishment, taking into account the accompanying risks of short-term air pollution and longer-term pollution of land and water in the event that the smoke plume comes to ground level, and the risk of fire spread to adjacent structures.

— Whether it is possible to minimize adverse health effects on humans (as this takes priority over environmental concerns).

5.4 Factors in assessing the volume of water run-off

5.4.1 Process facilities

To assess the volume of contaminated fire water that may be generated in the process areas, the following points should be considered:

a) The construction of the main sprinkler distribution pipes (150 mm or above) and level of explosion proofing according to ISO 6182-1[61]. Rules to design sprinkler explosion resistance can be assessed by existing engineering guidance[24][25].

b) The Assumed Maximum Area of Operation (AMAO) on which the sprinkler design is based compared to the actual floor area.

c) The presence of compartmentalization and the level of fire resistance supporting such compartmentalization (e.g. fire doors, etc.).

d) The presence of explosion-relieving areas and walls in the building design.

e) The volume of process water/product present in the process equipment that may combine with and contaminate the fire water.

f) The volume needed for rain/standing water in the process.

5.4.2 Tank farm zones

To assess the volume of contaminated fire water that may be generated in the tank farms, the following points should be considered:

a) The design and duration of the deluge system.

b) The number of tanks, their size, construction or separation distances[26].

c) The presence of radiation walls.

d) The size and make of bunds.

e) The type and quantity of product at risk.

f) The location of the tank farm and its proximity to other property.

g) The volume needed for rain/standing water in the process.

Potentially environmentally damaging materials should always be stored in adequately bunded areas. Bunds are normally arranged to hold the total of the tank volume, plus 10 %, this being the volume of the initial fire-fighting or fire protection water or foam. However, much more than this volume would be required to fight a fire. Therefore, bunds cannot normally be relied on as fire-water retention. They should only realistically be used to provide temporary containment to gain time.

5.4.3 Warehouse zones

To assess the volume of contaminated fire water that may be generated in warehouses[27][28][29], the following points should be considered:

a) The sprinkler design density and duration at the roof level, and whether in-rack protection is included.

b) The nature of the materials stored.

c) The warehouse design.

NOTE The emergency plan may consider fire-fighting strategies and possible ways to reduce the amount of fire-water run-off generated. For example, this could be by the use of sprays rather than jets, allowing controlled burning and possibly recycling of fire-fighting water where it is safe to do so.

