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Guidelines for assessing the adverse impact of wildland fires on the environment and to people through environmental exposure

Lignes directrices pour l'évaluation de l'impact négatif des feux d'espaces naturels sur l'environnement et les personnes par exposition environnementale

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document gives guidance and provides a methodology for assessing the adverse environmental impact of wildland fires and wildland firefighting operations. The serious consequences of the adverse impact of fire effluent from forest, shrubland and grassland fires to the environment and to people, through environmental exposure, have confirmed that it is an important issue that urgently needs to be dealt with internationally and systematically. This document provides a framework for a common treatment of the environmental impact of wildland fires.

General awareness of the fact that large wildland fires present serious and persistent adverse effects on the environment has been accentuated by a number of high impact incidents over the past half century. In Annex A, some recent wildland fire incidents are listed and their environmental impact is described.

This document has been prepared in accordance with ISO Guide 64[1].

Guidelines for assessing the adverse impact of wildland fires on the environment and to people through environmental exposure

1 Scope

This document addresses the impact of wildland fires and firefighting activities on the environment (air, water, soil, wildlife and vegetation). It further addresses the impact of wildland fire effluents on exposed human population, including firefighters, as well as food production, land, sea and air traffic, and the built environment. It also describes the environmental impacts of firefighting activities.

This document also provides requirements and recommendations to quantify such impacts of wildland fires and to establish post-fire mitigation measures.

The wildland fires covered include both natural wildland fires and man-initiated fires, including prescribed burning and agricultural fires, but not peat fires nor coal seam fires.

This document is intended to serve as a tool for the development of standard protocols for:

— the assessment of local and remote adverse environmental impacts of wildland fires;

— the assessment of the effects of smoke and gas exposure on firefighters and exposed human populations.

It provides guidance for incident commanders and other responsible or affected parties when decisions regarding firefighting strategies, tactics, and restoration are made. It is intended principally for use by firefighters and investigators, insurance providers, environmental regulatory authorities, civil defence organisations, public health authorities and land owners.

This document does not include specific instruction on compiling and reporting the information needed to assess environmental damage caused by a fire incident, nor does it include specific sampling methodologies and analysis requirements. These topics are the focus of documents in the ISO 26367 series. This document does not address either fire damage to the built environment, direct acute toxicity issues, which are covered by other ISO standards, nor does it address economic impact, although the impact of climate change is discussed in Annex D.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 14050, *Environmental management — Vocabulary*

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

ISO 26367-2, *Guidelines for assessing the adverse environmental impact of fire effluents — Part 2: Methodology for compiling data on environmentally significant emissions from fires*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13943, ISO 14050, ISO 26367-1 and ISO 26367-2 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
fuel
<wildland fires> biomass of a defined maximum cross-section

Note 1 to entry: It is expressed in tonnes per hectare ($t.ha^{-1}$).

[SOURCE: AFAC Bushfire Glossary[2]]

3.2
wildland
land that either has never suffered human intervention or has been allowed to return to its natural state, or that is managed for forestry or ecological purposes

3.3
wildland fire
fire occurring in forests, scrublands, grasslands or rangelands, either of natural origin or caused by human intervention[SOURCE: NFPA 1144[3]]

3.4
wildland urban interface
WUI
area where structures and other human development adjoin or overlap with wildland

[SOURCE: AFAC Bushfire Glossary]

4 Wildland fire variables

The following variables shall be considered when evaluating the environmental impact of wildland fires. They all have an impact on combustion efficiency and environmental impact[4]. Depending on the particular fire conditions, there can be other variables that are also important to consider.

— Fire size: influences the quantities of airborne pollutants that are produced.

— Fire duration: influences the quantities of airborne pollutants that are produced and the impact they have on soils.

— Fuels: fuel type and form, moisture content and fuel density affect the fire intensity and rate of spread. In a particular wildland fire, either the predominant fuel is grass, scrub or trees, or the fire can progress from an area with one predominant form of fuel to an area with a different predominant form of fuel.

— Topography: upslope conditions result in a fire that produces different emissions from those produced by a fire occurring under no slope or downslope conditions; the former case results in more efficient combustion. Slopes are also more prone to erosion following a fire[5]. Post-fire turbidity levels in watercourses are affected by the steepness of the burned slopes[6].

— Weather preceding a fire: includes precipitation (rain, snow, sleet, hail), air temperature and humidity. For example, high temperatures, no rainfall and low humidity result in a fire that produces different emissions from those produced by a fire occurring after a period of low temperatures, rainfall and high humidity; the former case results in more efficient combustion[7]. Prolonged drying is not necessary. Surface fuels can dry out sufficiently to support a fire in one week without rain[8].

— Weather during a fire: includes wind speed, air temperature and humidity. For example, high winds, high temperatures and low humidity result in a fire that produces different emissions from those produced by a fire occurring when there is little or no wind, low temperatures and high humidity; the former case results in more efficient combustion.

— Weather following a fire: includes precipitation (rain, snow, sleet, hail), and humidity. Rainfall immediately after a fire can lead to soil loss and contamination of water supplies. Humidity has an influence on the nature and persistence of aerosols and particulates in smoke plumes.

5 Environmental impact of wildland fires

5.1 General

This Clause describes the nature of environmental impacts of wildland fires on the following:

— air (see 5.2),

— water (see 5.3),

— soil (see 5.4),

— wildlife (see 5.5),

— vegetation (see 5.6),

— exposed human populations (see 5.7), including firefighters (see 5.8),

— food production (see 5.9),

— land, sea and air traffic (see 5.10), and

— the built environment (see 5.11).

The effect of recurrence is considered. Individual fires have some effects, but recurrent fires are particularly responsible for adverse impact on vegetation and soil[9].

Firefighting activities can also have a significant environmental impact[10]. This is presented in Clause 6.

For each case, quantification techniques and post-fire mitigation measures are specified. Post-fire mitigation includes both short-term and long-term measures.

Overall, factors that shall be considered in assessing the total impact of wildland fires include ecological, social and health-related.

NOTE The economic impact is not addressed in this document but a methodology for assessing socio-economic impact of wildland fires is available[11].

5.2 Fire testing and data collection

As relevant quantitative data on environmentally hazardous components of fire effluent cannot routinely be obtained from actual wildland fires, appropriate data have also to be obtained from prescribed burns, real-scale fire tests and simulations involving physical fire models.

Real-scale wildland fire tests have many limitations. As well as problems regarding repeatability due to variations in weather conditions, slope and vegetation heterogeneity, real-scale fires are often conducted out of the fire season when conditions are vastly different to those occurring during actual fires.

Although real-scale fire tests provide important information concerning the fire dynamics, some measurements can be conducted at laboratory scale. Both real-scale fire tests and laboratory experiments are complementary and necessary.

While real-scale fire tests provide important information concerning airborne emissions, some measurements, such as emission factors (for carbon monoxide (CO) and carbon dioxide (CO_2) for instance), can be conducted at laboratory scale[12]; however, caution is necessary. Laboratory data can overestimate the quantity of emissions of some species[13].

5.3 Impact of wildland fire on air

5.3.1 Nature of impact

Airborne emissions from wildland fires comprise particulates, aerosols and gases. Wildland fires are a significant source of airborne particulate matter on a global scale[14]. Concerns include acute health effects near the fires[4], climate effects and regional visibility[15]. Human health effects are addressed in 5.8.

The production of aerosols plays an important role in the regional radiative balance and can produce regional cooling[16]. Forest fires, when compared to all fires, are a significant source of polyaromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs)[17].

Prescribed burns can also have a significant impact on air quality, due to the production of airborne particulates, such as fine particles ($PM_{2.5}$)[18]. Prescribed burning can produce smaller smoke plumes than wildland fires[19].

Agricultural fires can cause long-term air quality issues[20].

As well as the primary combustion products, secondary combustion products can result from photochemical reactions in the smoke plume[21].

A list of major airborne combustion products is given in Annex B.

5.3.2 Quantification of impact

An estimate of the total quantities of pollutants produced in a wildland fire shall be modelled. The USDA First Order Fire Effects Model (FOFEM)[22], or a similar model, can be used.

During prescribed burns, land-based measuring stations should be used to record both gases and particulates[23].

Aircraft should be used to carry out comprehensive analyses of smoke plumes[25].

In areas remote from a wildland fire, the impact on air quality should be measured by a three-hour Pollutant Standards Index (PSI), such as the one developed by the U.S. Environmental Protection Agency[25], or similar model.

NOTE In the PSI system, a measure of air-quality readings within the 51 to 100 range indicate “moderate” air quality, while the range of 101 to 200 points to “unhealthy” conditions. Measurements between 201 and 300 represent “very unhealthy” conditions, while readings above 300 indicate a “hazardous” situation.

5.3.3 Mitigation of impact

It is difficult to control the impact of wildland fires of uncontrolled origin. The wildland fire variables described in Clause 4 are important factors. However, where wildland fires are the result of agricultural practices or prescribed burning, attention shall be paid to weather and climate factors. In particular, wind conditions shall be considered.

5.4 Impact of wildland fire on water

5.4.1 Nature of impact

Water bodies that can be affected include streams, rivers, lakes, water storages, aquifers and coastal waters. Contaminants can come from water run-off from firefighting activities or rain following fires.

Contamination can be caused by combustion products of vegetation, combustion products of manufactured items or structures, soils loosened by vegetation loss, and firefighting activities. Contamination resulting from firefighting activities is addressed in Clause 6.

Pollutants can be solid or liquid. Solids can be soluble or insoluble in water. Soluble materials can be toxic to riverine wildlife; insoluble materials can cause discolouration and cloudiness which can interfere with the ecology of a waterway[26].

Run-off can be contaminated by combustion products of manufactured products. Examples include preservatives used in timber construction, such as copper chrome arsenate (CCA).

Vegetation removal can lead to erosion and soil loss by wind and by rain for an extended period after the fire. If these sediments run-off into a nearby watercourse, pollution can result. Water temperatures in watercourses can increase due to both radiation and run-off[6].

Run-off from fires in coastal areas can have a negative impact on the ecology and biota of coastal regions and coral reefs.

5.4.2 Quantification of impact

Existing water monitoring stations shall be used to provide data on the impact of wildland fires on water quality[27].

5.4.3 Mitigation of impact

Guidelines for mitigating the impact of activities resulting from wildland fires shall be provided. Measures recommended include wedging straw or hay bales across run-off routes[28].

In some cases, such as in 5.4.3.1 and 5.4.3.2, special guidelines shall be implemented.

5.4.3.1 Firefighting chemicals and firefighting water

Both land and aerial application shall be considered.

For land application, the following guidelines, based on USDA guidelines[29], shall be implemented to minimize the likelihood of firefighting chemicals entering a stream or other body of water.

— During training or briefings, inform field personnel of the potential danger of fire chemicals, especially foam concentrates, in streams or lakes.

— Locate mixing and loading points where contamination of natural water, especially with foam concentrate, is minimal.

— Maintain all equipment and use check valves where appropriate to prevent release of foam concentrate into any body of water.

— Exercise particular caution when using any fire chemical in watersheds where water abstraction, fisheries, fish hatcheries or other sensitive habitats are located.

— Locate dip operations to avoid run-off of contaminated water back into the stream.

— Dip from a tank rather than directly from a body of water, to avoid releasing any foam into these especially sensitive areas.

— Use a pump system equipped with check valves to prevent flow of any contaminated water back into the source body of water.

— Avoid direct drops of retardant or foam into rivers, streams, lakes, or along shores. Use alternative methods of fire line building in sensitive areas.

— Notify proper authorities promptly if any fire chemical is used in an area where there is likelihood of negative impacts.

The aerial application of retardant or foam within 100 m of waterways shall be avoided[30]. Where such an application occurs, the adverse effects on threatened and endangered species shall be assessed immediately[31].

5.4.3.2 Post-fire salvage harvesting operations

The following guidelines, as recommended by the Australian CRC for Forestry[32] to mitigate impacts on run-off, erosion and water quality, shall be implemented:

— Remove logs up-slope when cable harvesting if permitted by the road network.

— Do not disturb riparian buffers.

— Place logs and harvest slash in the run-off convergence zones (areas where run-off accumulates from multiple up-slope directions) of harvested sub-catchments.

— Retain and distribute harvest slash across hill slopes.

— Apply additional erosion control measures (e.g. mulch) to harvested hill slopes.

5.5 Impact of wildland fire on soil

5.5.1 Nature of impact

Adverse impacts include breakdown of surface structure, deposition of ash and impact on soil microbial communities[33]. There are also non-adverse effects such as recycling of nutrients[34]. Nutrient losses can be enhanced by soil leaching and erosion[35]. A major short-term impact is an increase in pH[35].

Pollutants can be solid or liquid. Solids can be soluble or insoluble in water.

The application of firefighting chemicals can impact on soil microbial communities[36].

Vegetation removal can lead to erosion and soil loss by wind and by rain.

5.5.2 Quantification of impact

Spatial analysis modelling shall be used to maximise the benefits of erosion control activities[5].

Soils shall be sampled prior to and following prescribed burning in order to study changes in soil nutrients[34].

5.5.3 Mitigation of impact

Guidelines on reducing soil erosion shall be provided.

NOTE Techniques for the prevention of erosion and soil loss are dependent on the local ecology and climate.

In the short term mulching and planting of seeds shall be used to encourage the regrowth of grasses[35]. Long term mitigation should include reforestation where appropriate.

