International Standard

ISO 6021

Firebrand generator

First edition
2024-03

Reference number
ISO 6021:2024(en)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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*.

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

Large outdoor fires present a risk to the built environment. Wildfires that spread into communities, known as wildland-urban interface (WUI) fires, have destroyed communities throughout the world and are a growing problem in fire safety science. Another example of large outdoor fires are large urban fires, including those that can occur after earthquakes. Over the past several decades, fire safety science research has invested a great deal of effort into understanding fire dynamics within buildings. However, research into large outdoor fires, and how to potentially mitigate the loss of structures in such fires, lags behind other areas of fire safety science research. Once a wildland fire reaches a community and ignites structures, structure-structure fire spread can occur under similar mechanisms as in urban fire spread. Firebrand showers are a main driver of fire spread in large outdoor fires but there is no accepted internationally harmonized device for generating firebrand showers. The purpose of this document is to provide a solution for such harmonization. The firebrand generator described in this document is a stand-alone device.

Firebrand generator

1 Scope

This document specifies rules and requirements concerning the construction and operation of a firebrand generator. This document is applicable to all firebrand generators.

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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13943 and the following apply.

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

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

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

3.1
firebrand
airborne object capable of acting as an ignition source and carried for some distance in an airstream

Note 1 to entry: For further information, see Reference [18].

3.2
forest fire
unwanted fire burning forests and wildlands

Note 1 to entry: This term is used primarily, but not exclusively, in Europe.

Note 2 to entry: This term is defined in France as a fire that has reached forests, heaths, underbrush vegetation or scrub with an area of at least 1 hectare, regardless of the area travelled.

[SOURCE: References [20] and [21], modified — original texts have been restructured to fit ISO format.]

3.3
informal settlement
unplanned settlement and area where housing is not in compliance with current planning and building regulations (unauthorized housing)[SOURCE: UN Glossary of Environment Statistics][19]

3.4
spot fire
fire caused by flying firebrands at a distance from the original fire

[SOURCE: ISO/TR 24188:2022, 3.1.9]

3.5
urban fire
fire which occurs in an urbanized area

[SOURCE: ISO/TR 24188:2022, 3.1.11]

3.6
wildland fire
fire occurring in peat, forests, scrublands, grasslands or rangelands, either of natural origin or caused by human intervention

Note 1 to entry: This term is used primarily, but not exclusively, in North America.

[SOURCE: ISO/TS 19677:2019, 3.3, modified — reference to "peat" added and Note 1 to entry added]

3.7
wildland-urban interface
WUI
area where structures and other human development adjoin or overlap with wildland

[SOURCE: ISO/TS 19677:2019, 3.4]

3.8
wildland-urban interface fire
WUI fire
wildland fire that has spread into the wildland-urban interface (WUI)

Note 1 to entry: It is also possible for fires to start in the willdland-urban interface (WUI) and spread into the wildland.

[SOURCE: ISO/TR 24188:2022]

4 Importance of firebrand showers on ignition processes

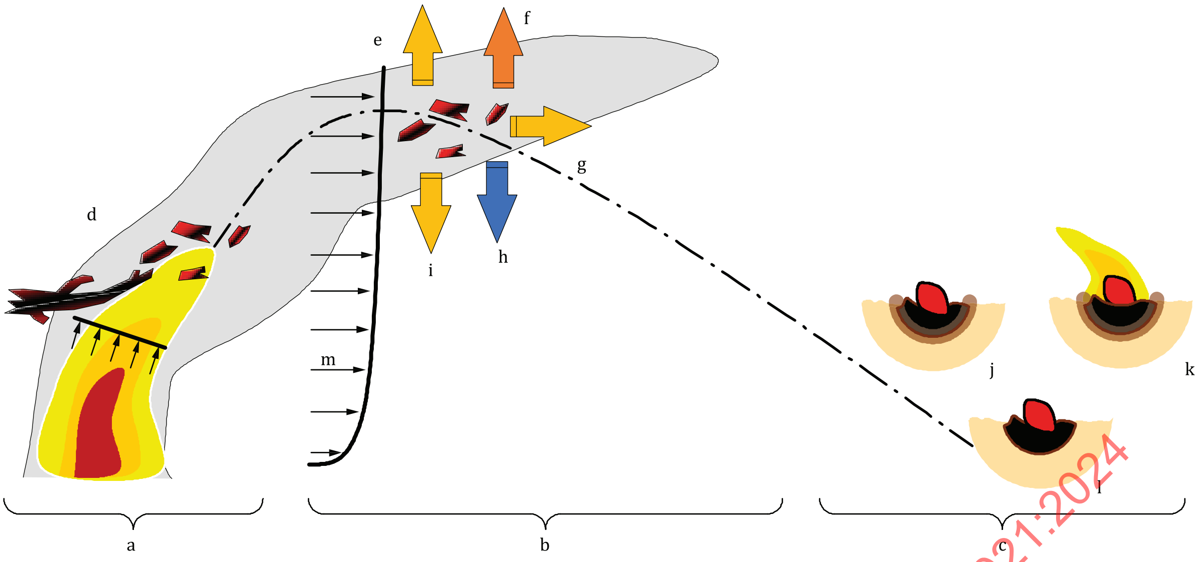
Large outdoor fires involve the interaction of topography, weather, vegetation and structures. Large outdoor fires differ from enclosure fires in several ways; most notably the fire spread processes are not limited to well-defined boundaries, as is the case in traditional building or enclosure fires.[1],[2],[3] Ignition can occur in three ways.[4]

1) Direct flame contact.

2) Thermal radiation: the probability of ignition depends on the distance and on the time of exposure. This can occur at distances of tenths of metres (dm).

3) Firebrands: the probability of ignition depends on the accumulation. This can occur at long distances (several hundred metres).

Firebrand processes have been extensively reviewed.[1],[2],[3],[4] Physical aspects of the firebrand processes are shown in Figure 1.



a Firebrand generation.
b Firebrand transport and thermochemical changes.
c Ignition of target fuel.
d Firebrand broken off by wind and/or fire-generated plume.
e Lofting by buoyant fire plume.
f Heating from flame or smoldering/glowing reactions.
g Drag force from relative motion with wind.
h Convective and radiative cooling.
i Gravity.
j Smoldering ignition.
k Flaming ignition.
l No ignition.
m Wind.

Figure 1 — Firebrand processes in large outdoor fires

5 Experimentally simulated firebrand showers

5.1 General

A major challenge in understanding firebrand transport and ignition is related to showers of firebrands that are generated in actual large outdoor fires. While studying the fundamental ignition processes of individual firebrands is important, these studies are not able to quantify the vulnerabilities of structures to ignition from firebrand showers or to elucidate the physics of firebrand transport. To accomplish this measurement, methods are required that are capable of replicating firebrand showers that occur in actual large outdoor fire events. In particular, well-controlled firebrand showers that can be produced in the laboratory are needed which can then be directed at various construction products as well as various vegetation types.

Alternative methods of firebrand generation are discussed in Annex A.

5.2 Description of an ISO Standard Firebrand Generator

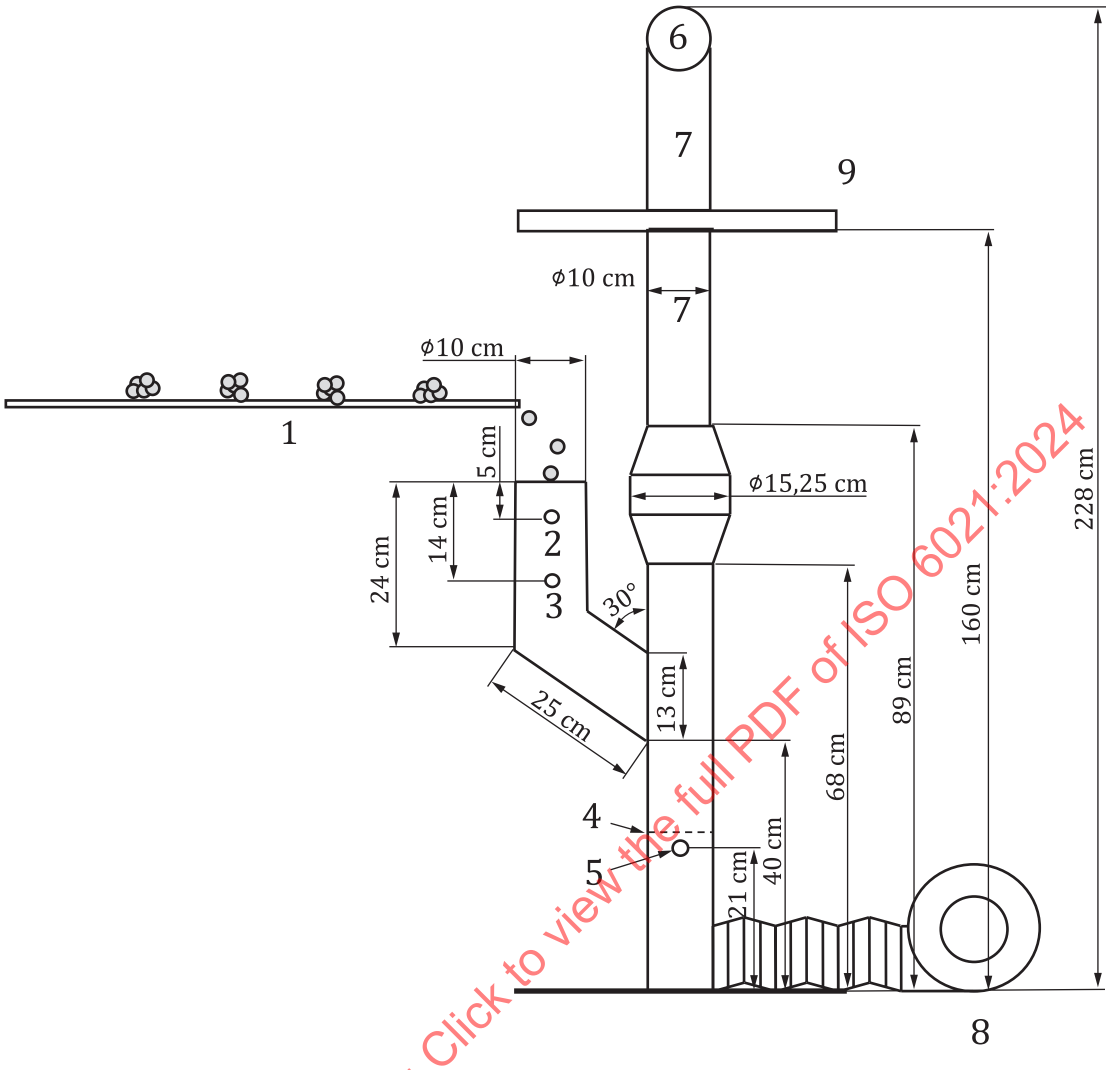
5.2.1 General

To address the problem of showers of firebrands generated in large outdoor fires, the Firebrand Generator developed by Manzello and co-workers was constructed to generate controlled, repeatable firebrand showers commensurate to those measured from actual large outdoor fires and then modified to produce firebrand showers for a continuous duration. Both full-scale and reduced-scale versions of this experimental technology have been developed which can produce a continuous flow of firebrand showers. For the purposes of this document, the reduced-scale device is described. Here, the device is described as a stand-alone apparatus. However, it can easily be coupled to other standard test methods, such as roofing assemblies, decking assemblies, wall assemblies, or to investigate ignition of mulch and ornamental vegetation.

5.2.2 Principles of operation of the ISO Standard Firebrand Generator

The ISO Standard Firebrand Generator consists of two parts; the main body and continuous feeding component (see Figure 2). The feeding component is connected to the main body (stainless steel) and has two gates (stainless steel) to prevent fire spread. Each gate is opened and closed alternatively. A handheld propane burner is used as the ignition source. A conveyor is used to feed wood pieces continuously into the device. As an example, Japanese Cypress wood chips have been used to produce firebrands. These same-size wood pieces have been shown to be within the projected area/mass of burning structures. Figure 3 displays a direct comparison of firebrands produced using the firebrand generator and those measured from burning structures. The description below provides details for this wood type, but any wood type shall be used. As another example, Douglas-fir wood pieces have been used to produce firebrand showers commensurate to vegetative firebrands. It is important to note that a distribution of firebrands is produced by the firebrand generator even though the input conditions are of a single size. Currently, there are no known data for firebrand projected area/mass from informal settlement fires but once available, the firebrand generator input conditions may be adjusted to attempt to reproduce such fires.

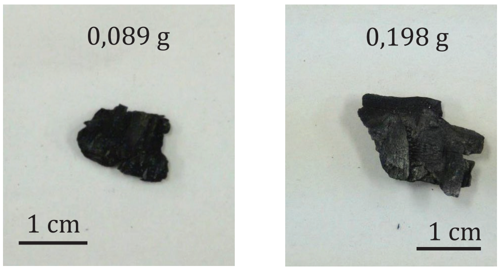
Dimensions in centimetres



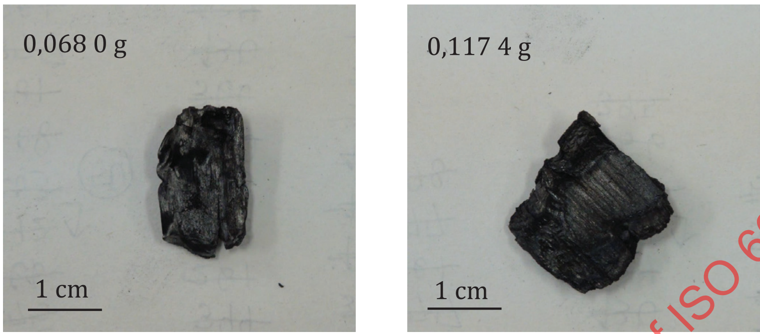
1 conveyer belt system
2 gate 1
3 gate 2
4 mesh for firebrands
5 propane burner
6 firebrand shower exit
7 main body
8 blower
9 support system (optional)

Figure 2 — ISO Standard Firebrand Generator

The blower speed at the exit shall be adjusted to produce either glowing or flaming firebrand showers. In the case of Japanese Cypress wood chips, when the blower was set to provide an average velocity below 4,0 m/s (measured at the exit of the firebrand generator when no wood chips were loaded), insufficient air was supplied for combustion and this resulted in a great deal of smoke being generated in addition to firebrands. Above 4,0 m/s, smoke production was mitigated but many firebrands produced were in a state of flaming combustion as opposed to glowing combustion. Glowing firebrands were desired in order to achieve a direct comparison with the full-scale experimental results. A longer main body (key element 7) may be adapted so that the firebrand generator can be installed in a wind faclity. The efficacy of a firebrand generator in developing continuous firebrand showers has been shown for shorter main body lengths. The main body length may be tailored to the needs of the user.



a) Firebrands generated from wooden structures



b) Firebrands generated from the ISO Standard Firebrand Generator

Figure 3 — Typical firebrands

6 Operation requirements and guidance

A conveyor is needed to feed wood pieces continuously into the device. The conveyor belt should be operated at 1,0 cm/s, and wood pieces should be placed on the conveyor belt at 12,5 cm intervals. The wood feed rate should be fixed at 80 g/min, near the upper limit of reduced-scale firebrand generator.

Japanese Cypress wood chips (as an example), as shown in Figure 4, may be used to produce firebrands.[5] The overall dimensions of the wood chips (fuel) used for firebrand generation before combustion are (28 ± 8) mm (length), (18 ± 6) mm (width), and (3 ± 1,0) mm (thickness) (average ± standard deviation), respectively. The wood pieces are supported using a stainless-steel mesh screen (0,35 cm spacing).

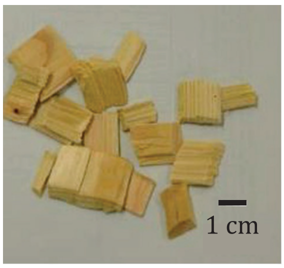


Figure 4 — Example of wood chips used to generate firebrands

The firebrand generator should be driven by a 0,4 kW blower. The blower is connected to the firebrand generator using flexible hose. In the case of Japanese Cypress wood chips, the maximum possible air mass flow rate obtained from the blower was 38,5 g/s for a velocity of 4 m/s.

The handheld propane burner was connected to a 0,635 cm diameter copper tube with a propane regulator. This configuration allowed for a 1,3 cm flame length from the burner. The propane mass flow rate was measured as 0,1 g/s. The burner was kept on continuously.

7 Reproducibility

Both the full-scale and reduced- scale firebrand generators have been reproduced by other organizations. In the case of the full-scale firebrand generator, the Insurance Institute for Business and Home Safety (IBHS) in the USA has used the concept in their full-scale testing laboratory. The ISO Firebrand Generator has been reproduced by the Association for the Development of Industrial Aerodynamics (ADAI),part of the University of Coimbra, in Portugal (see Figure 5).[6]

NOTE In this iteration, no external wind is applied and the device is being used as a stand-alone option.

Figure 5 — ISO Firebrand Generator reproduced by the Association for the Development of Industrial Aerodynamics (ADAI), University of Coimbra.[6]

Depending on the selected wood feed rate into the device, the number and mass flux of firebrands generated shall be determined.

Annex A
(informative)

Alternative methods of firebrand generation

A.1 Review of methods for generating firebrands in fire tests

A.1.1 Wooden cribs

Wooden cribs have been used to simulate firebrands in test methods. While these have been used in legacy roofing and decking test methods to simulate a firebrand in contact with a roof or deck, it is now well-known that a firebrand generator can be used to simulate firebrand showers seen in actual large outdoor fires.[7],[8],[9],[10]. It has also been shown that large wood cribs could not ignite various mulches,[11] but firebrand showers produced using the firebrand generator could easily achieve ignition in the same mulch types.

Joint Japan/USA research has conducted post-fire investigations of Japanese urban fires and used the firebrand generator technology described here to re-create firebrand sizes and masses from actual Japanese urban fires.[12],[13],[14]. Firebrand showers created using the firebrand generator were used to determine the vulnerability of Japanese roof tiles to firebrand attack and to compare them to various tile roofing types used in Australia and the USA.

Wooden cribs have been used by Japanese researchers to study firebrands attacking mock-up roof specimens, where the different types of roof-tiles and eaves were tested.[15],[16] The major limitation of using wood cribs to generate firebrands is that the size, mass and duration of the firebrand attack is very hard to control. These parameters are simple to adjust using the firebrand generator.

Joint Japan/USA research has also shown than the firebrand generator can easily be coupled to radiant panels to provide combined firebrand showers in the presence of well-controlled radiant heat fluxes to test specimens.[17]