Public Disclosure Authorized
Public Disclosure Authorized
Public Disclosure Authorized
Public Disclosure Authorized

BUILDING CODE CHECKLIST FOR FIRE SAFETY

GFDRR
Global Facility for Disaster Reduction and Recovery

Administered by
THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

BUILDING CODE CHECKLIST FOR FIRE SAFETY

GFDRR
Global Facility for Disaster Reduction and Recovery
Administered by THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

Suggested citation: World Bank. Building Code Checklist for Fire Safety (English). Washington, D.C. : World Bank Group.
Credits: The World Bank Group
Cover image: Warsaw, Poland. A fire at the Warsaw Hub construction site. © GrandWarszawski | Dreamstime.com
Back cover image: Krabi, Thailand. Haze caused by forest fires, © Nutkamol Komolvanich | Dreamstime.com

This document is the property of the World Bank.
It is permissible to copy and use any of the material in this report provided that the source is appropriately acknowledged. Further information is available from: © The World Bank 2023

Adaptations—If you create an adaptation of this work, please add the following disclaimer along with the attribution: This is an adaptation of an original work by The World Bank. Views and opinions expressed in the adaptation are the sole responsibility of the author or authors of the adaptation and are not endorsed by The World Bank.

Third-party content—The World Bank does not necessarily own each component of the content contained within the work. The World Bank therefore does not warrant that the use of any thirdparty-owned individual component or part contained in the work will not infringe on the rights of those third parties. The risk of claims resulting from such infringement rests solely with you. If you wish to re-use a component of the work, it is your responsibility to determine whether permission is needed for that re-use and to obtain permission from the copyright owner. Examples of components can include, but are not limited to, tables, figures, or images.

This work is a product of the staff of The World Bank and the Global Facility for Disaster Reduction and Recovery (GFDRR) with external contributions. The findings, analysis and conclusions expressed in this document do not necessarily reflect the views of any individual partner organization of The World Bank, its Board of Directors, or the governments they represent.

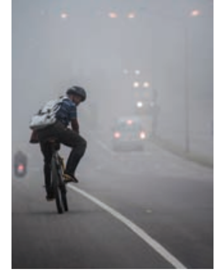
Although the World Bank and GFDRR make reasonable efforts to ensure all the information presented in this document is correct, its accuracy and integrity cannot be guaranteed. Use of any data or information from this document is at the user's own risk and under no circumstances shall the World Bank, GFDRR or any of its partners be liable for any loss, damage, liability or expense incurred or suffered which is claimed to result from reliance on the data contained in this document. The boundaries, colors, denomination, and other information shown in any map in this work do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

RIGHTS AND PERMISSIONS: The material in this work is subject to copyright. Because The World Bank encourages dissemination of its knowledge, this work may be reproduced, in whole or in part, for noncommercial purposes as long as full attribution to this work is given.

Graphic design: Miki Fernández/ULTRA designs, Inc.

Table of Contents

Photo: © matsou



Acknowledgement

This tool was developed by Brian Meacham (Consultant), under the guidance of Keiko Sakoda (Senior Disaster Risk Management Specialist) and Ana Campos Garcia (Lead Disaster Risk Management Specialist). Overall coordination was provided by Kristal Peters (Consultant).

Valuable technical inputs and advice were provided by following global experts: Ai Sekizawa, Antonio Cicione, Colleen Wade, and Kiyoshi Fukui. The team also appreciate peer review comments from Artessa Saldivar-Sali (Senior Infrastructure Specialist, World Bank), Carina Fonseca Ferreira (Disaster Risk Management Specialist), Joaquin Toro Landivar (Lead Disaster Risk Management Specialist), Katherine Coates (Consultant), and Julia Ratcliffe (Consultant).

We thank the World Bank's Global Corporate Solutions Translation and Interpretation Services for editorial assistance, and Miki Fernández for graphic design.

List of Acronyms

AS	Standards Australia
ASTM	American Society for Testing and Materials
BCL	Building Control Regulations
BRCA	Building Regulatory Capacity Assessment
BRR	Building Regulation for Resilience
BSL	Building Standards Law
BSI	British Standards Institution
BWOF	Building Warrant of Fitness
CE	Conformité Européenne
CEN	European Committee for Standardization
CMs	Compliance Documents
CO	Carbon Monoxide
CO2	Carbon Dioxide
CTIF	International Association of Fire and Rescue Services
DRM	Disaster Risk Management
DtS	Deemed-to-Satisfy
ECC	Emergency Command Center

EU	European Union
EVCCP	Emergency Voice Communication Control Panel
FACP	Fire Alarm Control Panel
FACU	Fire Alarm Control Unit
FAS	Fire Alarm System
FRR	Fire Resistance Rating
FSL	Fire Standards Law
HVAC	Heating, Ventilation, Air-Conditioning
IBC	International Building Code
ISO	International Organization for Standardization
ITM	Inspection, testing, and maintenance
LMICs	Low- and Middle-Income Countries
NBC	National Building Code
NCC	National Construction Code
NFPA	National Fire Protection Agency
NZS	Standards New Zealand
THs	Technical Handbooks
UL	Underwriters Laboratories
Urban FRAME	Urban Fire Regulatory Assessment and Mitigation Evaluation Diagnostic
VM	Verification Methods
WHO	World Health Organization

1. Overview

Rapid urbanization and population growth are driving the construction of new buildings, with global building stocks expected to double in the next 15 to 20 years.[1] While such trends will represent significant development advances and offer economic growth opportunities, concern remains regarding the resilience and safety of new and aging building stocks, increased energy and water consumption, and accessibility of the existing and the evolving built environment and infrastructure that support the living environment and lifestyle. Furthermore, this increase in development will result in greater exposure to climate and disaster risks due to the evolving impacts of climate change depending on where development is located and to what level of standards it is constructed. Additional vulnerability can be compounded in unregulated and informal settlements where buildings are constructed with high density on risky sites, using substandard building materials and failing to implement safe design and construction practices. The combination of urbanization and climate change pose significant challenges for countries and cities to form a comprehensive set of regulatory and policy instruments to achieve a more resilient, sustainable, and accessible built environment.

The World Bank's Disaster Risk Management (DRM) engagements support countries to design and implement diversified investments for risk reduction and preparedness. Among various approaches, improving the building regulatory framework and implementation capacity proves to be one of the most cost-effective means of reducing underlying climate and disaster risks,[2] in combination with investments for physical structural improvements/retrofits. In this context, the Global Facility for Disaster Reduction and Recovery (GFDRR)'s global line of work Building Regulation for Resilience (BRR) aims to promote resilient, green, healthy, and inclusive built environments through enhanced regulatory frameworks and implementation capacities.

The BRR offers technical support and advisory services for governments by analyzing the existing regulatory framework and capacity of target countries utilizing the Building Regulatory Capacity Assessment (BRCA) methodology, which identifies key issues and targeted recommendations for countries for priority actions, potentially as part of the DRM investments financed by the World Bank or any other financial sources.

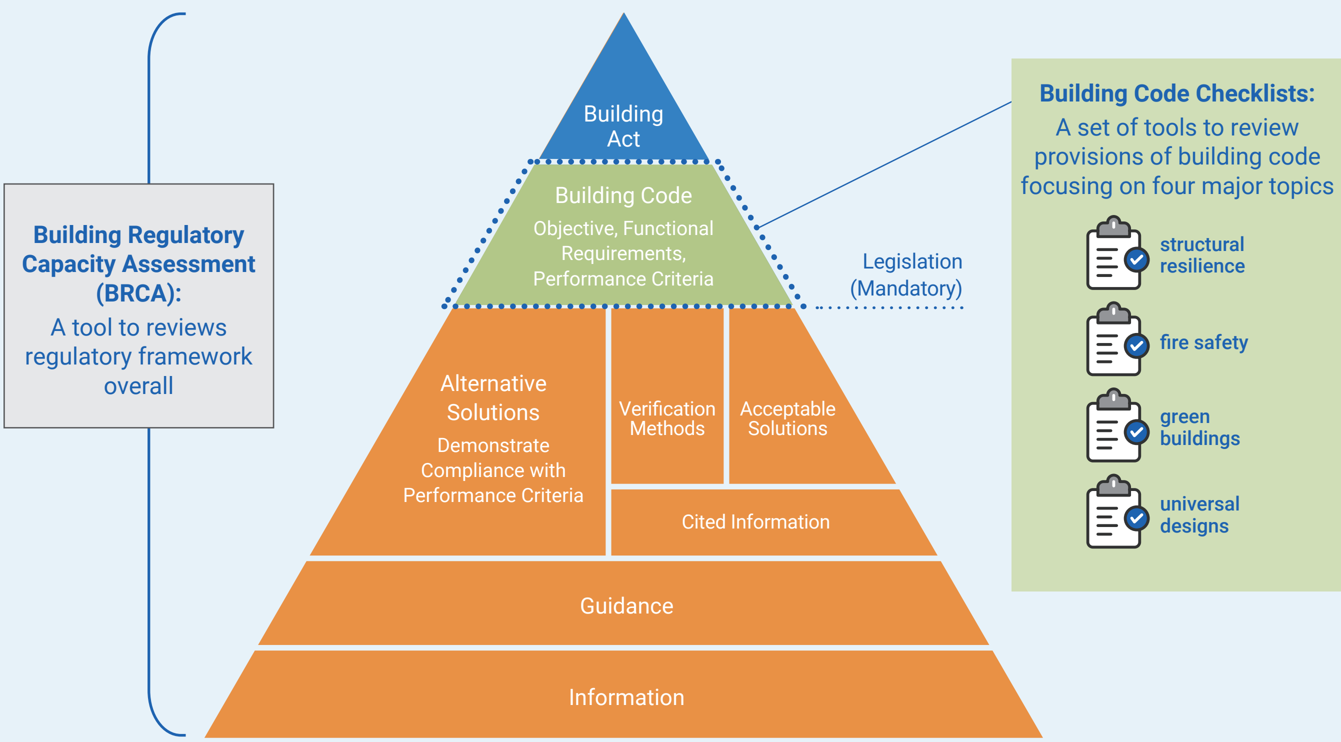
---

1 Global Alliance for Buildings and Construction, 2022 Global Status Report for Buildings and Construction https://globalabc.org/sites/default/files/2023-03/2022%20Global%20Status%20Report%20for%20Buildings%20and%20Construction_1.pdf

2 https://www.gfdrr.org/en/publication/building-regulation-resilience-0

As the BRR expands, demand has grown for technical advice on details of building codes based on global knowledge and practice. Responding to such requests, the BRR has developed a set of checklists that support countries in assessing the comprehensiveness and depth of their building code provisions, focusing on four major elements: structural resilience, fire safety, green buildings, and universal accessibility. This will help countries (or professionals commissioned by governments) to assess their own codes against consolidated checklists referring to global good examples. The methodology has been developed to target subject matter experts in each discipline with basic engineering and architectural background. While each document presents a methodology, users can contact the GFDRR for worksheets for convenient use. This document presents a checklist for **fire safety**.

Figure 1. Objectives of different BRR tools



Source: Figure adapted and modified from the original figure by Building and maintaining New Zealand's homes and buildings.

Photo: © bermuda cat

2. Introduction

The number of people annually who die or are injured by fires in formal and informal structures, or as a result of large outdoor fires, such as wildland fire, reaches into the several tens of thousands. While the data is scarce to understand the global baseline, data collected by the International Association of Fire and Rescue Services (CTIF) indicates 30,860 fire-related deaths occurred in 2018 in the 40 reporting countries alone.[3] Burn injuries from fire reported by the CTIF numbered 51,360 in the 30 reporting alone.[4] These estimates do not include data from Africa, much of Latin America, and other low- and middle-income countries (LMICs).

For instance, research has shown that detailed fire incident data are not available for many African countries as of writing,[5] but where data are available, the situation is troubling. Figure 1 illustrates the number of deaths per year for South Africa reported by fire brigades, which shows an annual increase of approximately 5–10%. However, based on mortuary data, the number of fire-related deaths may be as much as 4 to 5 times higher.[6]

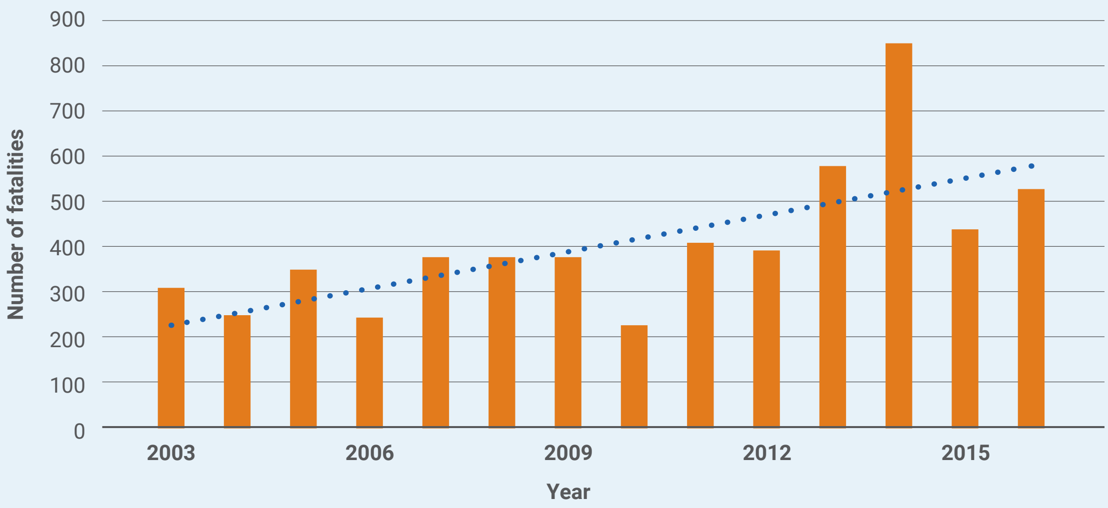
3 World Fire Statistics, Report 25, Table 8, CTIF, 2020 (available at https://www.ctif.org/sites/default/files/2020-06/CTIF_Report25.pdf, last accessed November 22, 2022).

4 World Fire Statistics, Report 25, Table 9, CTIF, 2020 (available at https://www.ctif.org/sites/default/files/2020-06/CTIF_Report25.pdf, last accessed November 22, 2022).

5 Africa: Taking fire safety forwards. Fire and Materials. 2021; 45: 999– 1007. https://doi.org/10.1002/fam.2894. Walls, RS, Cicione, A, Messerschmidt, B, Almand, K

6 Stats SA. *Statistical Release Mortality and Causes of Death in South Africa, 2011: Findings from Death Notification.* Pretoria, South Africa: Pretoria; 2014. doi:Statistical release P0309.3, as cited in Walls, RS, Cicione, A, Messerschmidt, B, Almand, K. Africa: Taking fire safety forwards. Fire and Materials. 2021; 45: 999– 1007. https://doi.org/10.1002/fam.2894.

Figure 2. Number of deaths per year reported by fire brigades in South Africa from 2003 to 2016[5]



In 2018 the World Health Organization (WHO) estimated that 180,000 deaths every year are caused by burns—the vast majority of which occur in LMICs.[7] In addition to those who die, the WHO suggests there are millions more who are left with lifelong disabilities and disfigurements, often with resulting stigma and rejection. While the WHO data include burns from sources other than structure fires, it is clear that the actual number of fire-related deaths and injuries resulting from structure and wildland fires lies between these CTIF and WHO estimates—many tens of thousands of deaths and millions of injuries.

Urban areas in LMICs grow by an estimated 70 million people each year, and low-income countries have seen a 300% increase in built-up areas and a 176% increase in population over the past 40 years.[8] As urban areas grow, so does the fire challenge, both in formal and informal construction.[5] Within the formal construction sector, lack of adequate regulations and compliance capacity from design and construction through to operations of buildings in use, coupled with a growing tendency toward high-rise developments, can result in significant fire losses. This can be seen even in high-income countries, with tragic fires such as the Grenfell Tower fire in London.[9]

Unregulated, informal settlements are particularly at risk of conflagration and frequent distributed fire incidents. This is due to the building materials used, high density of shelters, use of open flame cooking and heating

---

7 https://www.who.int/news-room/fact-sheets/detail/burns (last accessed November 22, 2022).

8 UNDRR (2019). Global Assessment Report on Disaster Risk Reduction. https://gar.undrr.org/sites/default/files/reports/2019-05/full_gar_report.pdf.

9 Homepage | Grenfell Tower Inquiry.

Figure 3. Fire disaster in Imizamo Yethu informal settlement, Cape Town, South Africa 2017

Source: Aletta Harrison, 2017.

devices without safety measures, and narrow roads and paths which limit access for fire apparatus and egress of people. Fires in such settlements can displace thousands of people, even if casualties are low.[10] One example is the informal settlement fire in Imizamo Yethu, Cape Town, which left 10,000 people homeless.[11] Obtaining an accurate picture of the fire problem is quite difficult, and the challenges are significant.

Moreover, the growth of urban areas leads them to encroach upon forests and wildland spaces, thus increasing the risk of interface areas. One example is the Valparaiso fire in 2014 in Chile, which destroyed around 2,900 houses[12] in formal and informal settlements. This trend extends to high-income countries as well, as evidenced from significant wildland and wildland-urban interface fires in Australia, Europe, and North America in recent years.[13]

10 For examples, see lists of informal settlement fires at https://www.iris-fire.com/downloads/media-reports-of-is-fires/ (accessed January 2020) as well as research on fire spread, such as Walls, S.W., Eksteen, R., Kahanji, C. and Cicione, A. (2019). Appraisal of fire safety interventions and strategies for informal settlements in South Africa. *Disaster Prevention and Management.* Vol 28. Iss 3. www.emeraldinsight.com/0965-3562.htm.

11 Kahanji C, Walls RS, Cicione A. (2019) Fire spread analysis for the 2017 Imizamo Yethu informal settlement conflagration in South Africa. *Int J Disaster Risk Reduct.* April 2019. doi:10.1016/j.ijdrr.2019.101146.

12 https://emergenciaydesastres.mineduc.cl/incendio-valparaiso/.

13 For example: Filkov, A.I., Cawson, J., Swan, M.H., Penman, T.D. (2023). Wildland Fire. In: Meacham, B.J., McNamee, M. (eds) Handbook of Fire and the Environment. The Society of Fire Protection Engineers Series. Springer, Cham. https://doi.org/10.1007/978-3-030-94356-1_7; Elhami-Khorasani, N., Ebrahimian, H., Buja, L. et al. Conceptualizing a probabilistic risk and loss assessment framework for wildfires. Nat Hazards 114, 1153–1169 (2022). https://doi.org/10.1007/s11069-022-05472-y; Fernandez-Anez N, Krasovskiy A, Müller M, et al. Current

The trend of increasing number and magnitude of wildland and wildland-urban interface fires is also related to increased temperatures and wind speeds associated with climate change.[14] This combination of urbanization, encroachment on the wildland, and climate change presents significant challenges for resource management, planning and zoning, building and fire regulation, and emergency services.

In addition to the human toll, the global economic impact of fire is staggering as well. In the United States alone, the annual cost of fire is estimated to be between 1–2% of GDP, totaling US$328.5 billion in 2014.[15]

In short, urban fire risk is a global problem—one that can be heightened during periods of rapid urban development. Inadequacies in urban planning, infrastructure and construction practices related to fire prevention and mitigation significantly increase the potential for fire ignition, fire spread, and potential conflagration. Reduction of fire risk requires improved urban planning; infrastructure; building design, construction, and materials; fire suppression capability; more and better data on the impact of structural fires to inform policy; and education and training. These needs and more have been articulated in such documents as the Urban FRAME: Urban Fire Regulatory Assessment and Mitigation Evaluation Diagnostic[16] and the Global Plan for a Decade of Action for Fire Safety.[17]

Proven approaches to fire risk reduction through building and fire regulation include appropriate enabling legislation, well-designed and implemented building and fire regulations, and adequate capacity to undertake building fire safety plan review and construction inspection.

Wildland Fire Patterns and Challenges in Europe: A Synthesis of National Perspectives. Air, Soil and Water Research. 2021;14. doi:10.1177/11786221211028185.

14 For example, see: Urrutia-Jalabert, R., González, M. E., González-Reyes, Á., Lara, A., and Garreaud, R. 2018. Climate variability and forest fires in central and south-central Chile. Ecosphere 9(4):e02171. 10.1002/ecs2.2171; Abram, N.J., Henley, B.J., Sen Gupta, A. et al. Connections of climate change and variability to large and extreme forest fires in southeast Australia. Commun Earth Environ 2, 8 (2021). https://doi.org/10.1038/s43247-020-00065-8.

15 National Fire Protection Association (2017). *Total Cost of Fire in the United States.* https://www.nfpa.org/News-and-Research/Data-research-and-tools/US-Fire-Problem/Total-cost-of-fire-in-the-United-States.

16 https://openknowledge.worldbank.org/handle/10986/34671#:~:text=The%20Urban%20Fire%20Regulatory%20Assessment%20and%20Mitigation%20%28Urban,urban%20fire%20risk%20reduction%20projects%-20and%20investment%20planning.

17 https://wbef.rics.org/globalassets/rics-website/media/decade-of-action-for-fire-safety_november-2021.pdf.

3. Objectives

The Building Code Checklist for Fire Safety aims to assist World Bank teams in the detailed review of the fire safety provisions of building and/or fire regulations.

The purpose of this checklist is to facilitate a robust approach to reviewing fire safety provisions in building and/or fire regulations by providing a discussion of fundamental fire safety components of building and/or fire regulations, a systematic approach to review fire safety provisions in regulations, and examples of how fire safety provisions are addressed within a range of exemplar building regulatory systems. While this checklist can be applied without expertise and experience in fire safety regulations or design, such expertise and experience is extremely valuable to help navigate some of the complexities of codifying fire safety provisions.

A component of a robust contemporary building regulatory system is the inclusion of a comprehensive set of fire safety provisions. The scope of fire safety provisions can be broad, including aspects of fire prevention, structural resilience to fire, active fire detection and signaling systems, automatic and manual fire suppression systems, egress (evacuation) systems, and controls on hazardous materials. How these aspects are addressed can vary widely: they may all be contained in one regulation (for example, the building regulation) or spread across multiple regulations (for example, building regulations, fire service regulations, and urban planning regulations). The regulatory provisions may be highly detailed specifications (that is, prescriptive-based) that are largely self-contained in the building regulation, or they may be function-based, with "high-level" objectives in the building regulation along with reference to standards and guidelines to be followed for detailed design. In some cases, the regulations may reflect a combination of prescriptive- and function-based approaches (see Table 1).

To support countries who have a defined need or interest in fire safety regulatory capacity beyond review of fire provisions in existing building and fire codes, the BRR published the Urban FRAME: Urban Fire Regulatory Assessment and Mitigation Evaluation Diagnostic. The Urban FRAME diagnostic is designed to support government officials and project managers, including World Bank Task Team Leaders, in assessing building fire safety regulatory systems to identify critical gaps and opportunities for building and urban fire risk reduction projects and investment planning.

The Urban FRAME diagnostic focuses on three critical components of the regulatory frameworks for building fire safety: (i) legal and administrative; (ii) development and maintenance; and (iii) local implementation. Because fire safety crosses regulatory regimes—infrastructure and planning, building legislation, and fire legislation—as well as societal capacity-building efforts, the diagnostic includes an assessment of each area. The focus on fire risk reduction in the built environment through regulatory frameworks fits into projects to support national and local capacity building; promote legal and regulatory reforms; alleviate the impacts of poverty; and promote health and human capital. The diagnostic is designed to work with other associated assessments and quantitative analyses, such as the BRR's BRCA and the Emergency Preparedness & Response's Ready2Respond Diagnostic.

Where a more detailed review of fire safety regulatory provisions is warranted, this checklist has been developed to support such needs.

4. Guidance:

How to use the Building Code Checklist for Fire Safety

When reviewing regulations for fire safety components, it is helpful to follow a systematic approach that considers the regulatory provisions in a stepwise manner. The review should take into account the regulatory and market capacity of the jurisdiction under review. Ultimately, for regulatory systems to be most effective, a combination of a robust building regulatory system and adequate regulatory and market capacity is required. The flowchart presented in Figure 4 presents steps to be taken as part of a systematic review.

Figure 4. Steps to be taken in a systematic review of code provisions for fire safety

1

Understand overall regulatory framework

Identify relevant ministries, legislation and regulations with a bearing on building fire safety, including planning/zoning, water infrastructure, electric and gas utilities, building/construction, and fire. This may be available as an outcome of a BCRA or Urban FRAME engagement.

2

Identify fire-related regulations and chapters

Identify which regulations (for example, building, fire, planning, electrical, etc.) contain relevant chapters or sections on the six fundamental fire safety components and subcomponents (see Figure 1) for buildings and where these chapters or sections are located.

- Fire provisions may have their own chapter or section but are sometimes located as part of the mechanical/building services chapter or section.
- Building use/occupancy classifications may be located with fire provisions, with structural provisions, or in their own chapter or section (or all three).
- Fire resistance may be addressed together with fire provisions, structural provisions, or both.
- Egress (escape) provisions may be with located with fire provisions or in a dedicated chapter or section.

3

Undertake a systematic review

Look for provisions that address each of the fundamental fire safety components and subcomponents according to the checklist (see Chapter 5), and assess the adequacy of the regulatory language, including the level of detail provided to assure proper interpretation and execution of the regulatory requirement, and/or to refer to standards or guidelines that provide the necessary level of detail.

1. Provisions may be written in functional language, as prescriptive-based requirements, or using a combination of both.
2. The adequacy of the regulatory language will depend on several factors, including: i) the level of detail provided and the clarity of the stated provisions; ii) the extent to which reference standards are cited; iii) the uniformity of and/or compatibility between the referenced standards; iv) the extent to which non-mandatory guidance is included/cited; and v) the uniformity of and/or the compatibility between the guidance.

4

Assess provisions in a country context

Consider the regulatory and market capacity required to interpret and act upon the regulatory provisions in a manner that can be expected to achieve the fire safety objectives for buildings that are compliant with the regulations.

- Consideration may be given to the market's capacity to work with a regulatory document that is significantly function-based and lacks adequate and consistent reference to accepted standards and guidance—Who will be using regulations? What is their educational background?
- Consideration may be also given to the testing/approval/accreditation systems for materials, products, and systems.

5

Assess interface among fire and other regulations

Review the interface between fire-related and other sections (for example, planning/zoning, structural, mechanical, electrical) as necessary and appropriate.

- Coordination with structural is often required.
- Coordination with mechanical, electrical, plumbing, and urban planning may be needed.

6

Complete checklist and reporting

Summarize findings based on completed checklist. The summary should be presented in a way to highlight identified challenges and opportunities for enhancement.

How and Where Fire Safety Components Are Implemented into Regulation

While robust building and fire regulations incorporate the fire safety components identified above, there is not typically a one-to-one relationship between the defined components and the provisions within the regulations. This is because the structure of building and fire regulations derives from national legislation and regulatory models, meaning that building and fire regulations will be unique to the country for which they are developed, the provisions may be split between different regulations (for example, building and fire), and different terminology may be used.

Factors for consideration when initiating a review include the government structure (for example, centralized national system, federal system, etc.), the government ministry(ies) or department(s) with responsibility for building and fire legislation and regulations, the legislative structure, and the model used for development of the building and fire regulation (if any). Specific considerations include:

1. Are building and fire regulations under the purview of the same ministry?
2. Do building regulations address all fire safety components for buildings, or are some provisions addressed under fire regulations?
3. Does other legislation/regulation contain requirements relevant to fire safety in buildings, such as electricity infrastructure, water infrastructure, planning and zoning, and hazardous materials regulation, and electrical and mechanical installations in buildings?
4. Is the building regulatory framework (approach) functional/performance-based or prescriptive?
5. If the regulatory framework is functional/performance-based, is there associated “deemed-to-satisfy” (DtS) guidance (also known as “compliance documents” or “approved documents”)?
6. Are the building (and fire) regulations applied uniformly across the country (a national system), by a state or territory (a federal system), or another way?
7. What is (or are) the source of reference standards for materials, system design and installation, etc. (for example, country Bureau of Standards, International Organization for Standardization, etc.)?

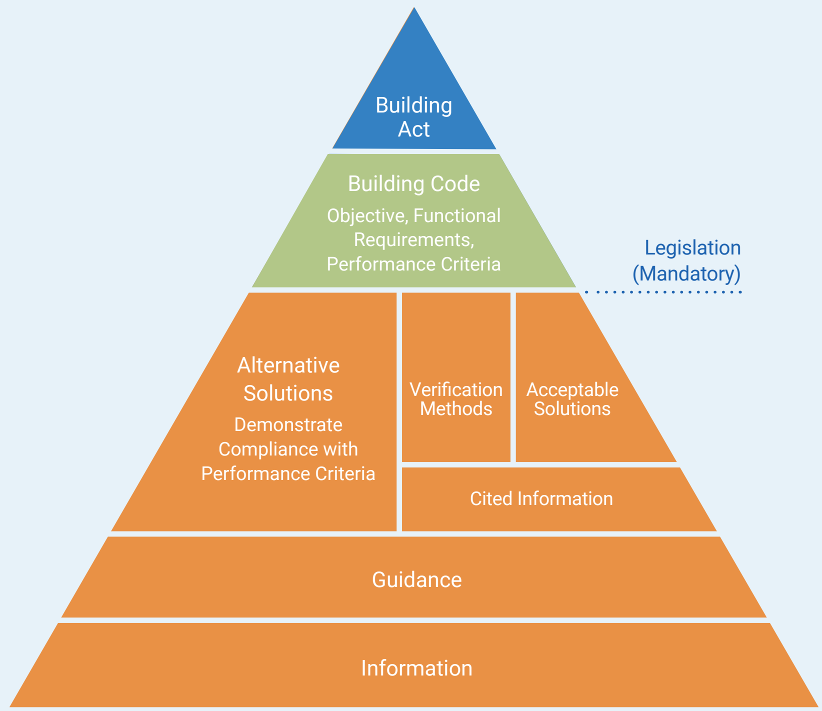
Depending on the answers, a comprehensive review of fire safety components in regulations may require a review of documents associated with several government ministries, agencies, and private-sector entities (in particular, standards). Figure 5 shows a typical structure of building regulatory frameworks. However, to some extent, each regulatory frameworks and building regulation will be structured differently. The structure will largely depend on the legislative structure used in a country, as well as the model used to develop the building regulation (if any). Accordingly, it is difficult to identify precisely where to look in any particular building regulation, fire regulation, or set of building and fire regulations to find references to fire safety provisions.

Structure of Building Regulatory Framework

When starting a review, it is helpful to know that many building and fire regulatory frameworks are variations of one of the following fundamental structures (See Table 1. For simplicity, reference is made to just building acts and building regulations, but a parallel situation may exist for fire service acts and fire regulations):

1. The building act (or equivalent) includes function-based requirements, and the building regulations include primarily prescriptive-based requirements.
2. The building act (or equivalent) includes function-based requirements, and the building regulations include primarily function-based requirements.
   - Detailed requirements for compliance with the function-based requirements of the regulations are in mandatory deemed-to-satisfy (DtS) documents.
   - Detailed requirements for compliance with the function-based requirements of the regulations are in non-mandatory DtS documents.
3. The building act (or equivalent) includes function-based requirements, and the building regulations include a combination of functional, performance-based and prescriptive-based requirements.
4. The building act (or equivalent) includes function-based requirements, and building regulations include primarily prescriptive-based requirements.

Figure 5. Typical structure of building regulatory framework



Source: Figure adapted and modified from the original figure by Building and maintaining New Zealand's homes and buildings.

In regulatory structures that are largely function/performance-based, most find it is essential to have a robust set of reference DtS documents[18] and reference standards to support the proper design of fire safety

[18] As part of many functional and performance-based building regulatory systems, there are non-mandatory, DtS solutions, which if followed are generally considered to meet the requirements of the building regulation. The DtS documents most generally provide a prescriptive pathway to regulatory compliance. One example is the Approved Documents in England and Wales. Approved Document B provides a largely prescriptive approach to complying with the mandatory fire and egress-related function-based requirements of the Building Regulations—England and Wales. In countries which adopt this approach, reference standards are typically cited in the DtS documents (not in the building regulations). For example, Approved Document B in England and Wales cites standards of the British Standards Institution (BSI) and others that address specifics of standard fire tests for flammability, resistance to fire, alarm systems, etc.

systems, as well as the adequate review and approval of these designs. This approach generally requires a robust capacity in the design, enforcement and insurance sectors, since such regulatory structures allow significant flexibility in design. Furthermore, in general, prescriptive building regulations and DtS documents often cite consensus standards from recognized standards development organizations for detailed requitements on material specifications, performance and certification tests, design requirements, installation requirements, etc.

Table 1. Examples of countries' regulatory standards and corresponding deemed-to-satisfy documentation

Country	Regulation	DtS Documents	Standards (Predominant)
Australia	Performance-based	DtS provisions in National Construction Code (NCC)	Standards Australia (AS), International Organization for Standardization (ISO)
Canada	Objective-based	Part B of Regulations	Canadian Standards Association, various US standards, including from the National Fire Protection Association (NFPA), ISO
England	Function-based	Approved Documents	British Standards Institution (BSI), European Committee for Standardization (CEN), ISO, BSI
New Zealand	Performance-based	Compliance Documents	Standards New Zealand (NZS), joint AS/NZS standards, ISO

In many countries that have performance-based regulations, there are also verification methods (VMs), which are largely engineering-based guidance (but not standards). For example, VMs are used in Australia, Japan (within the Building Standards Law), New Zealand, and several Nordic countries.

While it is not practicable to provide extensive examples of how different countries address all fire safety components in their regulations, a few specific examples for resistance to fire/fire spread and for fire suppression are presented in Table 9 and Table 11, respectively. Note that these tables focus on where detailed compliance provisions can be found (including, for example, tables with resistance to fire rating for structural elements, or water supply, pressure and flow requirements for interior hydrants (standpipes)).

Note also that these tables are representative only, since requirements for specific building uses may be found in different code volumes or DtS documents. For example, in Australia, NCC Volume One contains the technical requirements for the design and construction of multi-residential, commercial, industrial, and public assembly buildings and some associated structures. NCC Volume Two contains the technical requirements for the design and construction of smaller scale buildings including houses, small sheds, carports, and some associated structures. In England, Approved Document B – Fire Safety, is presented in two volumes: B1, Dwellings, and B2, Buildings other than dwellings. In the US, one- and two-family dwellings fall under the International Residential Code, and all other buildings fall under the International Building Code (IBC), published by the International

Code Council. In the US, these codes only become promulgated when adopted into law by individual states or jurisdictions. See Appendix A for examples of location of the details relating to resistance to fire and internal hydrant (standpipe) systems compliance in different countries' regulations.

In all regulatory structures, it is essential that the consensus standards be cited as uniformly and consistently as possible to help ensure the following:

1. Potential inconsistencies that may arise from mixing incompatible standards are minimized.
2. Potential inconsistencies that may arise from lack of providing a reference standard for each regulated area (that is, detection, suppression, smoke control, materials testing, etc.) are minimized. Failing to provide standards leaves all decisions to the market, which could result in wide-ranging variation (for example, failing to cite a standard for installation of automatic sprinklers may lead to each design following a different standard, which could create problems for local authorities regarding enforcement and could lead to inconsistency in levels of fire safety in buildings).
3. Reference standards are aligned with all aspects of building regulatory system capacity, including product testing, approval, and market surveillance (for example, it would create challenges if a US fire test standard were cited, but there are no test facilities that can test to that standard and/or materials that comply with the standard are unavailable in the market).

The following chapter provides basic knowledge on six fundamental fire safety components for the built environment. **Users of this tool who are fire safety experts and already familiar with key concepts in fire safety components in building and fire regulations can skip the following section Chapter 5.** Key Fire Safety Components in Building/Fire Regulations and proceed to Chapter 6. Building Code Checklist for Fire Safety.

5. Key Fire Safety Components in Building/Fire Regulations

Building regulations (and sometimes fire regulations or a combination of both) in most countries include provisions/requirements associated with the following six fundamental fire safety components:

1. **Fire Prevention:** regulatory provisions that address the control of potential sources of ignition and readily ignitable materials during building construction and occupancy.
2. **Resistance to Fire/Fire Spread:** regulatory provisions that address the fire performance-based requirements of structural systems, non-structural compartment barriers, and interior and exterior surface materials, openings, building and lot separation, and smoke control.
3. **Occupant Safety, Refuge and Egress:** regulatory provisions that address occupant/occupancy characteristics, safety from falls during escape, protection from fire conditions during escape, escape system components, signage, and emergency lighting.
4. **Fire Suppression:** regulatory provisions that address water supply, manual fire suppression systems and equipment, automatic fire suppression systems and equipment, and fire extinguishers.
5. **Fire Service Access and Facilities:** regulatory provisions that address access for fire apparatus to the building, access of firefighters within the building, and building equipment and facilities to support firefighting operations, including firefighter lifts.
6. **Inspection, Test, Maintenance, Plans & Training:** regulatory provisions that address inspection, test and maintenance (ITM) of fire equipment, fire safety and emergency escape plans and training, fire safety management of the building, and related post-occupancy issues.

While there are many fire safety guidance documents that address the concepts embodied in these components—such as the International Fire Safety Standards Coalition's *International Fire Safety Standards: Common Principles* document;[19] NFPA Standard *550, Guide to the Fire Safety Concepts Tree;*[20] *the International Fire Engineering Guidelines*;[21] and ISO Standard 13387-1:1999, *Fire safety engineering — Part 1: Application of fire performance concepts to design objectives*[22]—none of these align specifically with the structure of building (or fire) regulation, and terminology and definitions differ between documents. As such, while these are useful guidance documents for fire safety analysis and design, they do not provide guidance for review of regulatory provisions.

To provide a specific regulatory review diagnostic that aligns with building (and fire) regulation content, six fundamental fire safety components as listed and defined above are structured here. Note also that the phrasing "building (and fire) regulation" is used here. As mentioned, this is necessary because while many countries include fire safety provisions in building regulations (for example, Australia, England, and New Zealand), in some jurisdictions, regulatory requirements for building fire safety can be found in both building regulations and fire regulations, and sometimes only in fire regulations. For example, in Japan, resistance to fire/fire spread and occupant safety, refuge, and egress are addressed by the Building Standards Law, while prevention, fire suppression and most aspects of fire service access and facilities are found in the Fire Service Law.[23] In Singapore, fire safety regulations are all found in the fire regulations, specifically, the Code of Practice for Fire Precautions in Buildings 2018.[24]

In addition, depending on whether the regulatory system is function-/performance-based or prescriptive-based, detailed provisions might be found in DtS compliance documents rather than in the regulation itself. This is discussed further in a subsequent section. The issue of where fire safety provisions be found is important when reviewing regulations for fire safety, since it means multiple regulations,

---

[19] *International Fire Safety Standards: Common Principles*, Edition 1, International Fire Safety Standards Coalition, 2020, ISBN 978 1 78321 384 9 (online: https://www.rics.org/globalassets/rics-website/media/news/news--opinion/fire-safety/ifss-cp-1st-edition.pdf, last accessed December 6, 2022).

[20] NFPA 550 – Guide to the Fire Safety Concepts Tree, National Fire Protection Association, Quincy, MA, United States, 2022 (free to view online at https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=550, last accessed December 6, 2022).

[21] International Fire engineering Guidelines, Australian Building Codes Board, Canberra, ACT, Australia, 2005 (online: https://www.abcb.gov.au/sites/default/files/resources/2022/Guidelines-international-fire-engineering-2005.pdf, last accessed December 6, 2022).

[22] ISO 13387-1:1999, *Fire safety engineering — Part 1: Application of fire performance concepts to design objectives,* International Organization for Standardization, Geneva, 1999.

[23] See for example discussion in, Sekizawa, A. and Notake, H. (2006). "Performance Requirement for Building Fire Safety from the Viewpoint of Firefighting and Rescue Activity," *Fire Science and Technology,* Vol.25 No.2 (2006) 147-162 (online: https://www.jstage.jst.go.jp/article/fst/25/2/25_2_147/_pdf, last accessed December 6, 2022).

[24] Singapore Civil Defence Force. (2018). Fire Code 2018 Table of Contents. SCDF. https://www.scdf.gov.sg/firecode/table-of-content

which may fall under different government ministries/agencies, may be required for a comprehensive assessment, as may a review of compliance documents. In jurisdictions where the fire safety requirements can be found in multiple regulations, review of just one regulation would be incomplete. The same is true for functional-/performance-based systems where details are found in compliance documents.

There can be further regulatory review complexity due to fire-related items being regulated elsewhere as well, such as regulations for electrical installations, electric utilities, water supply services, planning, environmental, occupational health and safety, and the like.

The specific focus of this diagnostic tool is to support a detailed review of building (and fire) regulations with respect to fire safety provisions in view of the foregoing definitions of the six fundamental fire safety components in building (and fire) regulations.

Robust and comprehensive building (and/or fire) regulations should address each of them. However, the extent to which they are implemented will depend on the fire risk profile, fire safety objectives, and the jurisdiction's building and fire regulatory capacity. The extent of implementation of each of these components may be influenced by any or all of these factors, along with consideration of risk-benefit-cost balancing. In other words, there may be trade-offs associated with various considerations, ranging from area, height, and construction materials used for the majority of buildings to availability and reliability of fire suppression water supply, capacity of the design, enforcement, and fire and emergency services community, and the cost of implementation.

Fire Safety Subcomponents

The six fundamental fire safety components in building (and fire) regulations, along with a more detailed set of subcomponents, are presented in Figure 6.

Figure 6. Fundamental fire safety components and subcomponents in regulations

The dotted blue line shows interdependencies between primary components (that is, egress routes need to be protected). Note that while '2.7 Smoke control / smoke management' is shown here as a subcomponent of 'Resistance to fire / Spread of Fire', the topic may be found as its own section, or with 'Building Services', or sometimes with 'Occupant Safety, Refuge and Egress' in building / fire codes.

The fundamental fire safety components and subcomponents presented in Figure 6 are detailed in the subsequent section as part of the review checklist. The following provides a high-level introduction to the concepts embodied in the structure. Additional discussion on each can be found in Appendix B.

1) Fire Prevention

There are numerous factors that influence the potential for fire ignition in a building and subsequent development of a threatening fire. While many of the factors can be addressed in building and/or fire regulations, some may also be addressed in related legislation and regulation, including those governing utilities (that is, electric, fuel gas, liquid fuels), environmental, occupational health and safety, and consumer safety. Key fire prevention factors that may be addressed in regulations are provided in Appendix B, Table 8.

In which regulation—and where in the regulation provisions—the factors may be found will depend on the regulatory structure of the jurisdiction. However, many building regulations include sections on the following, which should be reviewed:

- Electrical services, electrical equipment, photovoltaic systems, energy storage systems.
- Piped gas services and appliances (for example, heating, cooking).

Building regulations may or may not include fire safety and evacuation training requirements. Likewise, building regulations often address bulk storage (for example, warehouse and storage facilities) and acceptable amounts of flammable and combustible liquids and other materials, but typically do not address "normal" contents and furnishings (for example, chairs, tables, and bedding).

2) Resistance to Fire / Spread of Fire

As used here, resistance to fire/fire spread refers to those features and systems which resist the influences of, or inhibit the spread of, fire and sometimes smoke into, out of, and within a building. This component includes the resistance of a material to ignition, combustion, and failure of materials and systems due to heat or thermal radiation from a fire, as well as resistance against or the protection of an opening in wall, ceiling, or floor against fire spread, hot gases, and smoke. While there is a large range and diversity in the terms used to identify and describe resistance to fire/fire spread components within regulations and more broadly in the literature, they are generally focused on minimizing the potential for a fire external to a building from getting in, for a fire within a building to spread from one space to another in the building, and for a fire to spread from a building to an adjacent property.

Additional details on key resistance to fire/fire spread concepts are provided in Appendix B, Table 9.

3) Occupant Safety, Refuge, and Egress

Detection is the first step in identifying the presence of a fire and triggering subsequent action, such as occupant evacuation. Fire detection, alarm, and communications systems provide the opportunity to detect fire through a wide range of automatic fire detection devices, provide a means for manual fire alarm initiation, provide for a range of alarm signaling capabilities (audible (voice or non-voice) and visual), and provide interfaces with other fire protection systems (such as smoke control/management systems) and other building systems, as appropriate. The types of fire detection, alarm, and communications equipment required in buildings with different occupancy/use classifications vary widely by country and local regulation and based on the other fire safety systems installed.

To facilitate safe escape, the means of escape (sometimes referred to as "means of egress") describe the path of travel that a building occupant encounters, starting with any occupiable point in a building, and ending when they reach a public way outside of the building (for example, a public walkway, street, alley, etc.).

Means of egress is often described in terms of three fundamental components: the **exit access**, which is unprotected or has limited protection and includes the portion of the building between any occupied point and an exit; the **exit**, which provides a protected path of egress from the exit access; and the **exit discharge**, which is outside the building and is the section between the point where occupants leave an exit and the point where they reach a public way.

Depending on building use, the means of escape may include refuge areas and horizontal exits to help protect occupants unable to travel on stairs on their own. The means of escape should be free from safety hazards that might impact escaping occupants and have proper signage and lighting.

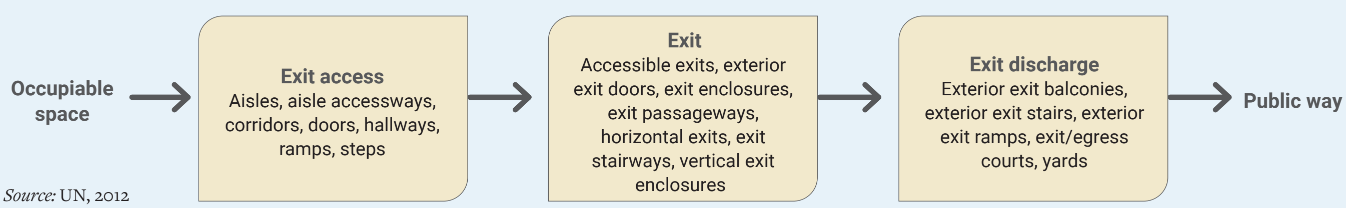
Additional details on key occupant safety, refuge, and egress concepts are provided in Appendix B, Table 10.

4) Fire Suppression

The aim of fire suppression components is to provide means to apply extinguishing agents to a fire. This can range from handheld fire extinguishers to building fire sprinkler systems, hydrant systems, pumps, and related equipment to support manual fire suppression activities by occupants and the fire service.

A primary consideration with either automatic or manual water-based fire suppression is an adequate and reliable water supply. This means not only sufficient volume of water for fire suppression activities, but appropriate flow rates and pressure to deliver the water where required. Water storage and fire pumps may be required to enhance municipal water supplies for such purposes.

Figure 7. Components of Egress (Escape) System



Source: UN, 2012

Additional details on key fire suppression concepts are provided in Appendix B, Table 11.

5) Fire Service Access and Facilities

It can be challenging for the fire service and other emergency responders if building planning and construction fails to adequately address their needs. This includes the ability to get fire apparatus to the building, firefighter wayfinding in the building, a fire command center, firefighter lifts, appropriate exterior and interior hydrant connections, and the like.

Additional details on key fire service access and facilities concepts are provided in Appendix B, Table 12.

6) Inspection, Test and Maintenance (ITM), Plans, and Training

Regulating inspection, test and maintenance (ITM) of fire safety systems and features in buildings is required to assure a proper working state when called upon. Likewise, most buildings should have comprehensive fire and emergency response plans, evacuation plans, and fire safety management plans. The plans should be supported by training, drills, and other exercises which help familiarize occupants and the fire service with procedures that should be followed in case of fire or another emergency.

Additional details on key ITM, planning, and training concepts are provided in Appendix B, Table 13.

6. Building Code Checklist for Fire Safety

The following table is provided as a tool to assist in the review of fire safety provisions in building regulations based on the fire safety components overviewed above. It should be noted that specific guidance for the assessment of regulatory provisions is not possible because (a) all regulatory provisions are contextual to the regulatory and legislative structures and regulatory capacity of a country and (b) there are in many cases more than a single approach to meeting fire safety objectives in a building regulation. Accordingly, in particular the column “where to look in regulation(s)” is neither specific nor comprehensive in terms of where the information may be found. For example, the IBC in the US has more than 12 chapters and numerous detailed provisions for the items listed below alone. By contrast, the building regulations in England and Wales only address the items below in a handful of functional statements, with details found in the non-mandatory Approved Document B – Fire Safety (which in turn has multiple chapters and numerous provisions). While this checklist can be applied without expertise and experience in fire safety regulations or design, such expertise and experience is extremely valuable to help navigate some of the complexities of codifying fire safety provisions. The primary components and major subcomponents are color-coded to align with Figure 6.

Table 2. Checklist for the review of fire performance provisions in building regulations

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
1. FIRE PREVENTION			
1.1 Controls on electrical systems and appliances			
1.1.1 Controls on electrical ignition hazards from electrical distribution systems coming into a building	Some aspects of electricity distribution are typically addressed in regulations other than building regulations (for example, electric utility infrastructure). However, in some countries aspects of electricity utilities, such as connections to buildings, may be addressed in building regulations.	(a) Do the building regulations address electrical utilities to the building? a. If not, what regulations do? i. How do these regulations work with the building regulations? b. If so, what is addressed (for example, cable protection, electrical meter, circuit breakers, etc.)?	Provisions for electric utilities are often found in regulations other than building regulations. However, if contained within building regulations, they may be found in their own section (electrical).
1.1.2 Controls on electrical ignition hazards from electrical distribution systems within a building	Proper and safe installation of electricity distribution in buildings (for example, breakers, proper cabling, outlets, switches, etc.) is critical to help prevent potential ignitions/fires.	(a) Do the building regulations address electricity distribution within a building? a. If not, what regulations do? i. How do these regulations work with the building regulations? b. If so, what is addressed (for example, interior wiring, outlets, switches, etc.)? (b) Are electrical safety components included, such as circuit breakers and ground fault interruption?	Provisions for electrical installations within buildings may be found in external regulations, such as the National Electrical Code in the US. If in building regulations, they may be part of the building services section (mechanical/electrical/plumbing systems).
1.1.3 Controls on electrical ignition hazards from electrical appliances	Most consumer appliances are not controlled by building regulations. However, installations such as fixed lighting and other built-in appliances are included. Also, the energy efficiency components of electrical appliances may be regulated by the building code.	(a) Do the building regulations address electrical wiring and safety for fixed (permanent) appliances (for example, fixed heating systems, cooling systems, HVAC, lighting, elevators)? a. If not, where is this addressed? i. How do these regulations work with the building regulations? b. If so, what is addressed (fixed heating systems, cooling systems, HVAC, lighting, elevators)? c. If so, are safety components included, such as ground fault interruption?	Provisions for electrical installations within buildings may be found in external regulations, such as the National Electrical Code in the US. If in building regulations, they may be part of a dedicated electrical section or part of a building services section (mechanical/electrical/plumbing systems). They may include ground fault interrupters, location/positioning requirements relating to outlets in/near wet areas, and related items.

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
1. FIRE PREVENTION (cont.)			
1.2 Controls on solid, liquid, and gaseous fuels and appliances			
1.2.1 Controls on fuel source distribution connection to buildings (for example, natural gas, propane, and fuel oil)	Some aspects of fuel distribution are typically addressed in regulations other than building regulations (for example, fuel gas utility infrastructure). However, in some countries, aspects of fuel utilities, such as connections to buildings, may be addressed in building regulations.	(a) Do the building regulations address gaseous and liquid fuel connections to buildings? a. If not, where is this addressed? i. How do the other regulations work with the building regulations? b. If so, are safety devices included, such as seismic shut-off valves, spill control, special fire protection, etc.?	Provisions for liquid and gaseous fuel distribution and storage may be in energy utilities regulations. Relevant material may also be found in specific regulations, such as the International Fuel Gas Code in the US. If in building regulations, they may be part of a fire prevention or building services section (mechanical/electrical/plumbing systems).
1.2.2 Controls on fuel sources within buildings (for example, natural gas, propane, and fuel oil)	Proper and safe installations of fuel distribution and storage in buildings is critical (for example, piping, pressure relief valves, shut-off valves, etc.).	(a) Do the building regulations address the safety of solid, liquid, and gaseous fuels for heating, cooking, and related uses in buildings? a. If not, where is this addressed? i. How do the other regulations work with the building regulations? b. If so, are safety devices included, such as seismic shut-off valves, spill control, special fire protection, etc.?	Provisions for liquid and gaseous fuel installations may be part of the building services (mechanical/ electrical/plumbing system) section. They may also be found in specific regulations, such as the International Fuel Gas Code in the US.
1.2.3 Controls on solid, liquid, and gaseous fuels for heating and cooking appliances	Similar to electrical appliances, appliances that use solid, liquid, or gaseous fuels for heating and cooking are a source of potential ignitions and fire. Locations in buildings, separation between appliances/fuel storage and combustible building components may be addressed. Required electrical installations around appliances that use solid, liquid, or gaseous fuels for heating and cooking may be regulated as well.	(a) Do the building regulations address solid, liquid, and gaseous fuels for fixed (permanent) appliances (for example, cooking, fixed heating systems, HVAC, and generators)? a. If not, where is this addressed? i. How do the other regulations work with the building regulations? b. If so, are safety components included, such as pressure relief valves, seismic shut-off valves, liquid spill containment, venting, CO detection, and special fire suppression?	Provisions for solid, liquid, and gaseous fuel installations may be part of the building services (mechanical/electrical/plumbing system) section. They might also be in fire prevention sections. In some cases, they may be found in specific regulations, such as the International Fuel Gas Code in the US. Provisions may include venting, distance to combustibles, requirements for heat or CO2 detection, and related items.

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
1. FIRE PREVENTION (cont.)			
1.3 Hazardous materials			
1.3.1 Controls on hazardous materials storage	Large amounts of combustible, explosive, toxic, or otherwise hazardous materials can present significant fire safety hazards. Strict controls on quantities that can be stored within buildings of various uses are often implemented.	(a) Do the building regulations address storage of hazardous/combustible/ flammable/explosive materials? b. If not, where is this addressed? How do the other regulations work with the building regulations?	If not addressed in building regulations, this may be addressed under fire prevention regulations, hazardous materials regulations within occupational health and safety legislation, chemical safety regulations, or other regulations.
1.3.2 Specific building use/ classification for facilities that use/store large amounts of hazardous materials	In many countries, specific building use/classifications are identified for industries which use and/or store large amounts of hazardous materials. Extra protection is generally provided to safeguard employees and the public.	(a) Do the building regulations have designated building use/ classifications for facilities using and/or storing large amounts of hazardous materials? a. Are there limits on quantities stored? b. Are there special protection requirements for stored materials, for example, higher fire resistance ratings (FRR), smaller compartments, vents, fire suppression, etc.? c. Are there requirements for HAZMAT information (that is, location and type of lockers with information, signage, material safety data sheets, etc.)?	Such controls may be found under specific use/occupancy classes (for example, storage, industrial/ factory, high-hazard facility) as well as fire prevention legislation and/or regulations. As quantities/hazards increase, so too do fire safety requirements (generally).
1.3.3 Limits on hazardous material storage in all other building uses	For building uses that store small amounts of hazardous materials—either for sale (mercantile buildings), cleaning, or other—there is typically a limit on quantities and guidance on storage and protection.	(a) Are there limits on quantities stored? (a) Are there special protection requirements for stored materials (for example, higher FRR, smaller compartments, vents, fire suppression, etc.)? (a) Are there requirements for HAZMAT information (that is, location and type of lockers with information, signage, material safety data sheets, etc.)?	Such controls may be found under use/occupancy classes descriptions, with quantities noted as pertinent to the use. This may also be addressed in fire prevention legislation and/or regulation. As quantities/hazards increase, so too do fire safety requirements (generally).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
1. FIRE PREVENTION (cont.)			
1.4 Controls on smoking/operations with hot surfaces			
1.4.1 Controls on smoking	Smoking materials are a major source of fires, including improperly discarded matches, lighters, and smoking material.	(a) Do the building regulations contain fire prevention measures associated with smoking? a. If not, where are such controls, and how do regulations interact?	May be found in the fire prevention section. May also be in external regulations, such as fire prevention or occupational health and safety.
1.4.2 Controls on operations with hot surfaces	Fire ignition hazards can exist with equipment required for building operation, such as machinery.	(a) Do the building regulations contain fire prevention measures associated with equipment used as part of the operation of the building, manufacturing processes, or other? a. If not, where are such controls located, and how do regulations interact? b. If addressed in the building regulations, are there requirements for separation from combustible materials, fire protection systems, etc.?	May be found in fire prevention section. May also be in external regulations, such as fire prevention or occupational health and safety.
1.5 Controls during construction/renovation			
1.5.1 Controls during construction/ renovation	Fire ignition during construction and renovation is a significant concern. Fire prevention regulations often institute controls while hot work (for example, welding) activities are ongoing, such as fire watches. For new construction and significant renovation/extension/ alteration, additional features, such as temporary fire suppression equipment, may be required.	(a) Do the building regulations address fire prevention during construction and renovation? a. If not, where is this addressed? b. If so, what types of controls are required (for example, special permits, training, fire watch, requirements for manual suppression to be available, etc.)?	Such controls may be found under specific provisions for alterations, renovations, additions, and extensions. These may also be found in reference standards (for example, NFPA 241 Standard for Safeguarding Construction, Alteration, and Demolition Operation). Provisions may also be found in fire prevention legislation and/or regulation.
1.5.2 Controls on hot works	Fire ignition during building works is a significant concern. Fire prevention regulations often institute controls while hot work (for example, welding) activities are ongoing, such as fire watches.	(a) Do the building regulations address fire prevention during construction and renovation? a. If not, where is this addressed? b. If so, what types of controls are placed on hot work, such as welding (for example, special permits, fire watch, etc.)?	Such controls may be found under specific provisions for alterations, renovations, additions, and extensions. These may also be found in reference standards (for example, NFPA 241 Standard for Safeguarding Construction, Alteration, and Demolition Operation). Provisions may also be found in fire prevention legislation and/or regulation.

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
2. RESISTANCE TO FIRE/SPREAD OF FIRE			
2.1 Fire resistance of structural system			
2.1.1 Fire resistance of load-bearing structural system (including load-bearing columns, beams, interior and exterior walls).	The structural system's resistance to fire is critical for a building's structural stability during and after a fire. Stability is necessary to facilitate safe evacuation, fire service activities, and property protection (for example, collapse avoidance). Building materials are typically required by regulations to be tested and rated on their ability to resist temperatures associated with a "standard" fire for a defined period of time without failing to perform their intended function. FRR are listed in minutes or hours and typically determined by standard fire tests. Materials that are combustible (for example, wood) or that may fail under high temperatures (for example, steel) may require protection and be limited as to the size of building in which they can be used. In some cases, analytical approaches may be acceptable. In some jurisdictions, it is permitted to reduce FRR for some members if a full building automatic sprinkler system is installed.	(a) Do the building regulations address structural stability under fire load? (b) Are there specific requirements/ limitations on height and area of building based on construction materials (combustibility/FRR)? (c) Are tables of fire resistance for structural members provided? (d) What members are addressed and what FRR are provided, based on building use (and height and area, as applicable)? (e) What are the bases for FRR? (f) Are the bases for FRR appropriate? (g) Is allowance made for reducing required FRR if a full building automatic fire sprinkler system is installed? (h) Are fire stop/sealant requirements provided for fire-rated assemblies? (i) Are alternate methods for assessing fire response of structure possible, such as Eurocodes for Structures?	The FRR of structural systems may be found in association with building use/occupancy classes or in the fire protection section (which may sometimes be part of the mechanical or building services section). Reference to fire resistance of primary and secondary may also be found under structure, in particular where reference codes such as the Eurocode for Structures are used. Coordination with structural is critical. Reference should be provided to the basis of any FRR stated (for example, materials tested to a recognized fire test standard for the intended use, such as ISO 834, BS 476, EN 1363-1366, AS 1530.4, NFPA 251, ASTM E-119, etc.). In some cases, a "rule of thumb"' or experience-based FRR for building materials, including indigenous materials, may be appropriate (for example, concrete cover on rebar, char depth for timber, thickness of stone, brick, etc.).
2.2 Fire resistance of non-load-bearing structural components			
2.2.1 Fire resistance of walls, ceilings, floors, shafts, and roof	The fire resistance of interior fire-rated compartment barriers is a very important issue for fire safety. The objectives of this measure are to prevent fire spreading in large areas, spaces connecting several floors, such as stairs, shafts, and void spaces, and so forth. Compartmentation is necessary to control fire spread, facilitate safe evacuation, and so forth. See also 2.1 above.	(a) Do the building regulations address the fire resistance of interior (non-load-bearing) walls/partitions? a. If so, in what ways (for example, fire cells/compartments, means of escape (egress), separation of building uses, etc.)? (b) Do shafts need to be built using FRR material? (c) What is the basis for the FRR? (d) Are requirements for fire sealants/ fire stop materials provided? (e) What is the basis of fire stop/sealant performance/rating? (f) Is allowance made for reducing required FRR if a full building automatic fire sprinkler system is installed?	Fire resistance ratings of interior partitions and shafts will be in sections describing those features (for example, shafts with stairs, lifts, piped services, etc.), walls with fire cell separation, components of means of egress, concealed spaces, etc. Reference should be provided to the basis of any FRR stated (for example, materials tested to a recognized fire test standard for the intended use, such as ISO 834, BS 476, EN 1363-1366, NFPA 251, ASTM E-119, etc.).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
2. RESISTANCE TO FIRE/SPREAD OF FIRE (cont.)			
2.2.2 Fire resistance of openings (or closures) in interior fire-rated barriers (for example, door systems, windows, dampers, access panels, ducts, etc.)	See 2.2 above. Also, hot gases will flow through corridors, shafts, and other such spaces, so dampers, self-closing doors, and similar features are needed.	(a) Do the building regulations address the FRR of door systems in fire-rated walls and assemblies? (b) Do the building regulations address the FRR of window openings/ window opening protectives in fire-rated walls and assemblies? (c) Do the building regulations address requirements for fire dampers in mechanical ventilation ductwork passing through walls between FRR floors, ceilings, walls, shafts, and similar? (d) Do the building regulations address the FRR of HVAC system ducts?	See 2.2 above and 2.5 below. Reference should be made to specific component testing, such as fire door systems (for example, NFPA 252, ISO 3008, and EN 1634), windows (for example, NFPA 257 and ISO 5925), dampers, ducts, etc.
2.2.3 Fire resistance of exterior wall systems/façade systems	The fire resistance of exterior wall systems is important to help control for fire external to a building from entering the building. It can also be important to control for exterior wall systems contributing to the fuel load and to fire spread (see also 2.3–2.6 below). Note that for some building uses and sizes, separation distance between buildings/lot lines can be a mitigation measure.	(a) Do the building regulations address the FRR of exterior walls? a. If so, are there requirements for FRR materials/fire (cavity) barriers in exterior wall cavities? b. If so, are there also requirements for the FRR of closures in exterior walls?	These requirements may be found with structural (see 2.1) or in specific sections on exterior wall systems/façade/building envelop. Reference should be provided to the basis of any FRR stated (for example, materials tested to a recognized fire test standard for the intended use, such as ISO 834, BS 476, EN 1363-1366, EN 13501, NFPA 251, etc.).
2.2.4 Fire resistance of roof systems	The fire resistance of roof structures can be important for structural stability and control of fire spread. See also 2.1 above.	(a) Do the building regulations address the FRR of roof assemblies/ systems? (b) Do the building regulations address fire barriers in roof voids between occupancies below the roof?	These may be found in a specific section (under fire) on roofs. See also 2.1 above. Reference should be provided to the basis of any FRR stated (for example, materials tested to a recognized fire test standard for the intended use, such as ISO 834, BS 476, EN 1363-1366, NFPA 251, etc.).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
2. RESISTANCE TO FIRE/SPREAD OF FIRE (cont.)			
2.3 Resistance to flame spread – interior surfaces			
2.3.1 Flame spread limitations on interior wall, ceiling, and floor surfaces	Combustible surface lining materials can facilitate the rapid spread of flames and are therefore typically limited in quantity and/or prohibited in several building use groups, in particular within means of egress (escape pathways). Ignitability, combustibility, and flame spread rating are typically determined by standard fire tests.	(a) Do the building regulations address resistance to flame spread on interior wall, ceiling. and floor surfaces? (b) Are there different ratings based on use/occupancy classification? (c) Are there more restrictive ratings for the means of escape (egress)? (d) What is the basis of the fire spread ratings?	Ignitability/combustibility/surface flame spread provisions may be found in a chapter/section on this topic, or as provisions included under a blanket fire protection section (which may sometimes be part of the mechanical or building services section). Reference should be provided to the basis of any ignitability/combustibility tests (for example, AS 1530.1, EN ISO 1182, and BS 476-4) and to flame spread rating/material restriction (for example, materials tested to a recognized fire test standard for the intended use, such as ASTM E84, BS 476 Part 6 & 7, EN 13501, EN 13823, ISO 5658, ISO 5660, NFPA 286, etc.).
2.3.2 Flame spread limitations in interior cavities/ void spaces (in walls, above ceilings, etc.)	Combustible surface lining materials can facilitate the rapid spread of flame and are therefore typically limited in quantity and/or prohibited in concealed spaces, void spaces, and cavities. These may be within walls, above ceilings, and other such locations.	(a) Do the building regulations address resistance to flame spread of materials used in cavity void spaces of interior walls, ceiling, and floor assemblies? (b) Are there requirements against installation of combustible material in void spaces, such as electrical cables, communication cables, fire alarm system cables, or other services?	See 2.3.1 above. Also, surface flame spread provisions for interior cavities/void spaces may sometimes be found with sections addressing shafts, mechanical spaces, and the like (see also 2.2 above). Reference should be provided to the basis of any flame spread rating/material restriction stated (for example, materials tested to a recognized fire test standard for the intended use: ASTM E84, BS 476, EN 13823, ISO 5658, NFPA 286, etc.).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
2. RESISTANCE TO FIRE/SPREAD OF FIRE (cont.)			
2.4 Resistance to flame spread – exterior surfaces			
2.4.1 Flame spread limitations on exterior wall surfaces/systems	Combustible surface lining materials can facilitate the rapid spread of flame and are therefore typically limited in quantity and/or prohibited in several building use groups, in particular on exterior walls of high-rise buildings.	(a) Do the building regulations address resistance to flame spread of materials used in exterior wall/façade assemblies? (b) Are requirements for resistance to flame spread provided for each component (for example, surface material, insulation, support material, etc.)?	Flame spread limitations on exterior wall surfaces/systems may be located in sections on exterior wall/façade/envelope systems, as part of structural, or within the fire protection section (which may sometimes be part of the mechanical or building services section). Reference should be provided to the basis of any flame spread rating/material restriction stated (for example, materials tested to a recognized fire test standard for the intended use, whether small-scale tests, such as ISO 1182, non-combustibility), reaction to fire test (for example, EN 13501), or large-scale components tests (for example, BS 8414, NFPA 285).
2.4.2 Flame spread limitations in exterior wall cavities/void spaces	Combustible surface lining materials can facilitate the rapid spread of flame and are therefore typically limited in quantity and/or prohibited in concealed spaces, void spaces, and cavities. These may be within exterior wall/façade systems. A particular concern is high-rise buildings.	(a) Do the building regulations address resistance to flame spread of materials used in cavity void spaces of exterior wall/façade assemblies? (b) Are requirements for fire sealants/fire stop materials provided?	See also 2.3.1 and 2.3.2 above.
2.4.3 Flame spread limitations on roof systems/materials	Combustible roof surfaces can facilitate the rapid spread of flame and are therefore typically limited in quantity and/or prohibited.	(a) Do the building regulations address flame spread limitations on roof systems/materials? (b) Do the building regulations prohibit combustible materials as roof coverings?	Fire performance of roof systems and coverings may be found under the fire protection section (which may sometimes be part of the mechanical or building services section), but may also be found under structural or materials sections. Reference should be provided to the basis of any flame spread rating/material restriction stated (for example, materials tested to a recognized fire test standard for the intended use, such as ASTM E108).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
2. RESISTANCE TO FIRE/SPREAD OF FIRE (cont.)			
2.5 Openings in exterior walls			
2.5.1 Protection of openings in exterior walls	Openings in external walls can facilitate the fire spread from within a building to an adjacent building or exterior material or expose a building to fire from an external threat. There may be separation distance requirements in the regulation to address this, and/or requirements for protection of openings (fire resistance, water sprays, etc.)	(a) Do the building regulations address protection of openings in exterior walls to prevent fire spread into or out of the building (such as window protection, window size, door protection, etc.)? (b) Do the building regulations address prevention of ember entry to vents, windows, etc. from exterior fire (for example, trash fire, wildfire, etc.)?	Fire protection of exterior openings may be found in sections on exterior wall/façade/envelope systems, or within the fire protection section (which may sometimes be part of the mechanical or building services section). Planning regulations may also have a bearing, especially in association with building separation (see also 3.3).
2.6 Building/lot separation & exterior fires			
2.6.1 Separation between buildings on same lot	Fire in a building could be large enough to cause the ignition of a nearby building. The threat depends on the building construction, exterior materials, and exterior openings. One way to manage exposure is separation distance between buildings.	(a) Do the building regulations address separation of buildings on the same lot? a. If so, what are the minimum distances before fire protection of external walls and openings in wall is required? Compare with international benchmarks. b. If not, where is this addressed?	Building separation may be found in sections on exterior wall/façade/envelop systems, within the fire protection section, or in planning/zoning regulations. Sometimes, if the buildings have a single owner, minimum separation might only be needed for sleeping occupancies (depends on code objectives). Alternatively, use of fire-rated construction could be an alternative to physical separation.
2.6.2 Separation between buildings on different lots	See 2.6.1 above.	(a) Do the building regulations address separation of buildings on different lots? a. If so, what are the minimum distances before fire protection of external walls and openings in wall is required? Compare with international benchmarks. b. If not, where is this addressed?	See 3.3.1.
2.6.3 Separation between buildings and exterior sources of exposure (for example, trash bins, trees, shrubs, vehicles, etc.)	There is a wide range of sources of potential exterior fires, which if located near the exterior wall of a building could lead to ignition of fire in the building. Exterior sources of potential exposure include trash bins, stored materials, vegetation, vehicles, transformers, etc.	(a) Do the building regulations address separation of exterior fire sources from external wall of buildings? a. If so, what are the minimum distances before fire protection of external walls and openings in wall is required? Compare with international benchmarks. b. If not, where is this addressed?	See 3.1.1.

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
2. RESISTANCE TO FIRE/SPREAD OF FIRE (cont.)			
2.7 Smoke control/management			
2.7.1 Smoke resistance of interior smoke compartment barriers (for example, fire cells, shafts, etc.)	Smoke is a major threat to building occupants in a fire. Due to pressure differentials in a building resulting from interior and exterior temperature differences, smoke can be pushed through cracks and other small openings, which should be fire and smoke sealed. See also 2.2 above.	(a) Do the building regulations include specific requirements for smoke resistive construction? a. If so, what smoke control measures are required (for example, smoke seals)? b. What are the bases for these requirements (for example, standards)? c. Are requirements for fire sealants/fire stop materials provided? d. What is the basis of fire stop/sealant performance/rating?	Resistance to the flow of smoke by passive building components, fire and smoke sealants, dampers, and others may be dispersed throughout the regulations. For example, resistance to smoke spread may be included with fire resistance or egress requirements. Damper requirements may be with mechanical systems. Door closers may have fire resistance requirements.
2.7.2 Smoke resistance of openings in interior smoke barriers (for example, door systems, dampers, ducts, etc.)	See 2.7.1. Also, smoke will flow through corridors, shafts, and other such spaces, so dampers, self-closing doors, and similar features are needed to inhibit smoke flow. See also 2.2 above, as fire and smoke resistance for interior spaces can sometimes be addressed together.	(a) Do the building regulations address resistance to smoke flow between spaces? a. If so, what smoke control measures are required (for example, door closers, smoke dampers within ductwork)? b. What are the bases for these requirements (for example, standards)?	See 2.7.1.
2.7.3 Passive smoke and heat venting components/ systems	Some building uses, such as storage and factory, or atrium spaces in tall buildings may benefit from roof-level vents that exhaust smoke and hot gases, allowing occupants to escape and fire service to conduct suppression operations. Passive vents typically are activated by a fusible link, but in some cases may be activated in conjunction with the operation of the fire alarm.	(a) Do the building regulations address requirements for passive smoke and heat venting systems and/or components? a. If so, for what building uses? b. Are the requirements appropriate in the circumstance? (This may change based on building use and might be benchmarked to international best practice.)	Passive smoke and heat venting requirements may be found in association with specific requirements for select building uses, such as storage/warehouse, factory/industrial, and the like. They may also be found within the fire protection section. Technical details are most often found in reference standards (for example, EN 12101-2, BS ISO 21927-3, NFPA 92, NFPA 204, etc.), handbooks (for example, ASHRAE Handbook of Smoke Control Engineering; SFPE Handbook of Fire Protection Engineering), or guidance documents (for example, CIBSE Guide E).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
2. RESISTANCE TO FIRE/SPREAD OF FIRE (cont.)			
2.7.4 Tenability criteria (smoke layer, temperature, CO, etc.)	Smoke and other products of combustion cause most fire fatalities. Providing pathways clear of smoke for occupants to escape is essential (see 3.3). It can be helpful to have smoke exhaust systems in many buildings; this is a common feature in large buildings and high-rise atria buildings. The design of smoke exhaust systems is often aimed at maintaining tenable environments for people while they evacuate (or fire service while undertaking operations). Tenability criteria may be smoke level above floor, temperature of smoke layer, or concentration of gases/toxicants.	(a) Do the building regulations address tenability requirements that must be maintained by smoke venting/ exhaust systems? a. What are the criteria/ requirements? b. Are the requirements appropriate in the circumstance? (This may change based on building use and might be benchmarked to international best practice.)	Requirements for smoke exhaust systems may be found in the fire protection section of the regulations. However, they might also be found under the mechanical or building services section. Technical details are most often found in reference standards (for example, EN 12101-2, BS ISO 21927-3, NFPA 92, NFPA 204, etc.), handbooks (for example, ASHRAE Handbook of Smoke Control Engineering; SFPE Handbook of Fire Protection Engineering), or guidance documents (for example, CIBSE Guide E).
2.7.5 Design fire requirements	Design of smoke exhaust systems generally requires an assumption about the fire that is expected and mass of smoke that may be produced. Some jurisdictions include design fire specification in their regulations.	(a) Do the building regulations address requirements for design basis fire and/or mass production of smoke for design of smoke and heat venting systems? a. What are the bases of design? b. Are the requirements appropriate in the circumstance? (This may change based on building use and might be benchmarked to international best practice.)	See also 2.7.3 and 2.7.4 above.
2.7.6 Mechanical smoke and heat exhaust – exhaust rates/make-up air	Exhaust rates/volumes will depend on the expected fire and mass of smoke produced. Also, there must be enough fresh air coming in to facilitate proper operation of exhaust fans. Some jurisdictions provide calculation methods to guide these designs.	(a) Do the building regulations address requirements for make-up air and exhaust rates for smoke and heat venting systems? a. What are the bases of design? b. Are the requirements appropriate in the circumstance? (This may change based on building use and might be benchmarked to international best practice.)	See also 2.7.3 and 2.7.4 above.

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
2. RESISTANCE TO FIRE/SPREAD OF FIRE (cont.)			
2.7.7 Pressure differentials	Fires increase temperature, which can result in pressure differentials, which in turn push smoke into cracks and openings. In addition to sealing openings, creating pressure differentials can help impede smoke movement. In some cases, this can include providing barriers between spaces (in this case, pressure differentials may be considered to keep a corridor clear of smoke, for example). Pressure differentials across doors can also make it more difficult for occupants to open the door.	(a) Do the building regulations address requirements for maximum leakage areas/pressure differentials for the design of smoke and heat venting systems? (b) Do the building regulations address requirements for pressure differentials for the design of stairwell pressurization systems? (c) Do the building regulations address requirements for pressure differentials for smoke barrier design? a. What are the bases of design? b. Are the requirements appropriate in the circumstance? (This may change based on building use and might be benchmarked to international best practice.)	See also 2.7.3 and 2.7.4 above.
2.7.8 Stack effect	Stack effect is movement of air into and out of buildings through unsealed openings as a result of differentials between indoor-to-outdoor air density resulting from temperature and moisture differences. From a fire perspective, this can cause smoke to stratify and be pushed onto floors (think of smoke rising from a chimney in cold temperatures) or be pushed higher (less temperature differential to overcome). Either situation can impact evacuation in unconditioned stairs and create other challenges.	(a) Do the building regulations address stack effect considerations in the design of smoke exhaust systems? (b) Do the building regulations address stack effect considerations in the design of smoke control for shafts (for example, lift shafts, stair shafts, etc.)? a. What are the bases of design? b. Are the requirements appropriate in the circumstance? (This may change based on building use and might be benchmarked to international best practice.)	See also 2.7.3 and 2.7.4 above.
2.7.9 Sprinkler interaction	Smoke rises due to the high temperatures produced from a fire. This is why smoke vents and exhaust ports are most often located at ceiling/roof level. Sprinklers cool smoke and fire. In cases where smoke vents/exhaust and sprinklers are used, care must be taken to design appropriately to the interactions.	(a) Do the building regulations address design considerations for smoke and heat venting systems when automatic fire sprinkler systems are also in use? a. What are the bases of design? b. Are the requirements appropriate in the circumstance? (This may change based on building use and might be benchmarked to international best practice.)	See also 2.7.3 and 2.7.4 above.

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
2. RESISTANCE TO FIRE/SPREAD OF FIRE (CONT.)			
2.7.10 Operation (automatic, manual, both – sequence)	In some jurisdictions, the fire service requires full control over smoke exhaust systems, while in others it is possible to have automatic systems with manual override. It can be helpful to define what is permitted and how the system should operate.	(a) Do the building regulations address requirements for operation of the smoke and heat exhaust system? a. Do these address automatic and manual operation? b. Are the requirements appropriate in the circumstance? (This may change based on building use and might be benchmarked to international best practice.)	See also 2.7.3 and 2.7.4 above.
2.7.11 Smoke exhaust controls	The fire service will generally require control over smoke exhaust systems. As such, it can be important to identify the location and controls required for smoke exhaust systems.	(a) Do the building regulations address requirements for the location of smoke and heat exhaust system controls (for fire service or other operator use)?	See also 2.7.3 and 2.7.4 above.
3. OCCUPANT SAFETY, REFUGE, AND EGRESS			
3.1 Fire detection			
3.1.1 Smoke alarms (self-contained smoke detection and alarm function)	Early detection and notification of fire is essential to life safety. Many jurisdictions require self-contained smoke alarms (smoke detection and local sounder) in residential occupancies, which sound in the room/residence of the fire, but not elsewhere in the building (that is, in apartment buildings, alarm sounds only locally in apartment where device is located).	(a) Do the building regulations address requirements for smoke alarms in domestic dwellings? a. If so, does this include all dwellings (for example, detached dwellings, apartments, etc.)? b. If not for all dwellings, which are omitted?	Requirements for smoke detection would typically be found in the fire protection section (which may sometimes be part of the mechanical or building services section). In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical design details may be found in reference standards (for example, BS EN 54 series, NFPA 72, ISO 7240 series, etc.).
3.1.2 System-connected smoke detectors	Early detection and notification of fire is essential to life safety. Many jurisdictions require fire alarm systems (see 3.2), with system-connected smoke detectors, for commercial buildings, public buildings, and others, in particular when there is no fire sprinkler system. In these systems, the detection of smoke should generally sound a general alarm in the building (or portion thereof) and notify the fire service (see also Section 5). Smoke detection is often in corridors, lift lobbies, and other key locations.	(a) Do the building regulations address requirements for system-connected smoke detectors? a. If so, for which building use/occupancy classifications are they required? i. For each required building use, in what locations within the building are they required (for example, all compartments, corridors, lift lobbies, atria, etc.)? b. What are the bases for the requirements (for example, standards)?	Requirements for smoke detection would typically be found in the fire protection section (which may sometimes be part of the mechanical or building services section). Design details may be in reference standards (for example, BS EN 54 series, NFPA 72, ISO 7240, etc.).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
3. OCCUPANT SAFETY, REFUGE, AND EGRESS (CONT.)			
3.1.3 System-connected heat detectors	Early detection and notification of fire is essential to life safety. Heat detectors are used when the environmental conditions are not appropriate for smoke detection or where a later detection of fire is acceptable (heat detectors need a larger, flaming fire to activate them).	(a) Do the building regulations address requirements for system-connected heat detectors? a. If so, in which building use/ occupancy classifications are they required? i. For each required building use, in what locations within the building are they required (for example, attic spaces, mechanical spaces, etc.)? ii. What are the bases for the requirements (for example, standards)?	Requirements for heat detection would typically be found in the fire protection section (which may sometimes be part of the mechanical or building services section). Design details may be in reference standards (for example, BS EN 54 series, NFPA 72, ISO 7240, etc.).
3.1.4 Manual fire alarm buttons	Most every building except 1-2 family dwellings and perhaps some other small residentials will typically be required to have a fire alarm system (FAS). The purpose is to accept inputs from fire and smoke detection devices, manual alarms, sprinkler water flow, and other such devices. Each building that has a FAS should have manual alarm buttons (points) for occupants to manually sound an alarm. These are typically located near exit access.	(a) Do the building regulations address requirements for system-connected manual alarm buttons (boxes, call points)? a. If so, in which building use/ occupancy classifications are they required? i. For each required building use, in what locations within the building are they required (for example, at each exit, at each exit access above grade, etc.)? b. What are the bases for the requirements (for example, standards)?	Requirements for manual alarm buttons would typically be found in the fire protection section (which may sometimes be part of the mechanical or building services section). Design details may be in reference standards (for example, BS EN 54 series, NFPA 72, ISO 7240, etc.).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
3. OCCUPANT SAFETY, REFUGE, AND EGRESS (cont.)			
3.2 Occupant and fire service notification			
3.2.1 FAS/fire alarm control panel (FACP)	Most every building except 1-2 family dwellings and perhaps some other small residentials will typically be required to have a FAS. The purpose is to accept inputs from fire and smoke detection devices, manual alarms, sprinkler water flow, and other such devices. The FACP indicates system status and controls the systems (for example, smoke exhaust). There may be remote fire alarm annunciator panels located at different building entrances to facilitate fire service response. It may also be required that the FACP be connected to the fire service or other monitoring system to report activation of the FAS.	(a) Do the building regulations address requirements for FAS and/or FACP? a. If so, in which building use/ occupancy classifications are they required? b. For each required building use, what alarm initiating (for example, smoke detectors, manual call buttons, sprinkler water flow, etc.) and alarm notification devices (for example, bells, horns) are required to be connected and supervised? (c) Are other devices connected to and/or controlled by the FACP (for example, in-duct smoke detectors and smoke exhaust fans)? (d) Are there requirements for remote alarm annunciators to be located elsewhere in the building? (e) Are there requirements for direct connection to the fire service or other monitored service? (f) What are the bases for the requirements (for example, standards)?	Requirements for FAS/FACP would typically be found in the fire protection section (which may sometimes be part of the mechanical or building services section). Design details may be in reference standards (for example, BS EN 54, NFPA 72, ISO 7240, etc.).
3.2.2 Alarm notification devices (audible)	FASs require installation of alarm notification devices to alert occupants. Audible alarm notification devices may include bells, horns, sounders, speakers, or similar devices. Requirements may include location and sound power level (dBA).	(a) Do the building regulations address audible notification devices for fire and other emergencies? a. If so, in which building use/ occupancy classifications are they required? (b) Are location and sound power level (dBA) requirements provided?	Requirements for audible alarm notification devices would typically be found in the fire protection section (which may sometimes be part of the mechanical or building services section). Design details may be in reference standards (for example, BS EN 54, NFPA 72, ISO 7240, etc.).
3.2.3 Alarm notification devices (visible)	FASs require installation of alarm notification devices to alert occupants. Visible alarm notification devices may include flashing or strobe lights. Requirements may include location and intensity (candela). Visible notification devices are required to meet disability requirements.	(a) Do the building regulations address visual alarm notification devices for fire and other emergencies? a. If so, in which building use/ occupancy classifications are they required? (b) Is intensity level or other requirements provided, in particular for the visually impaired?	Requirements for visible alarm notification devices would typically be found in the fire protection section (which may sometimes be part of the mechanical or building services section). Design details may be in reference standards (for example, BS EN 54, NFPA 72, ISO 7240, etc.).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
3. OCCUPANT SAFETY, REFUGE, AND EGRESS (cont.)			
3.2.4 Emergency voice communication system	In high occupancy buildings, high-rise buildings, and other such complex or high-risk building, many jurisdictions require emergency voice communications to control evacuation. This allows building management or the fire service to direct evacuation appropriate to the event.	(a) Do the building regulations address requirements for emergency voice alarm communications? a. If so, in which building use/ occupancy classifications are they required? (b) Are locations of speakers and intelligibility requirements provided?	Requirements for emergency voice communication systems would typically be found in the fire protection section (which may sometimes be part of the mechanical or building services section). They may also be found with specific special occupancy requirements, such as high-rise buildings. Design details may be in reference standards (for example, BS EN 54, BS 8629, NFPA 72, ISO 7240, etc.).
3.2.5 Emergency voice communication control panel (EVCCP)	Where emergency voice communication systems are required to control evacuation, there needs to be an EVCCP located in a readily accessible and protected space, typically on the ground level, to facilitate building management or the fire service to direct evacuations appropriate to the event.	(a) Do the building regulations address requirements for the control panel and operations for emergency voice communications? (b) Is location of the EVCCP addressed? (c) Is any guidance provided on evacuation sequencing or messaging?	Requirements for EVCCP would typically be found in the fire protection section (which may sometimes be part of the mechanical or building services section). They may also be found with specific special occupancy requirements, such as high-rise buildings. Design details may be in reference standards (for example, BS EN 54, NFPA 72, ISO 7240, etc.).
3.3 Protected means of escape/refuge			
3.3.1 Exit protection (see also Section 2)	Occupants should be protected from fire events during the time required to egress a building. Jurisdictions often require FRR for exits (including corridors, stair shafts, and doors) to provide such protection (see also Section 2).	(a) Do the building regulations address fire protection of exit systems (for example, FRR, flame spread limits, etc.)? a. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	See comments associated with Section 2 above. In addition, fire resistance and flame spread requirements may be in other sections under fire suppression (see section 4), and sometimes under structural. See also Section 2.7 for pressurization (for stair shafts, lift lobbies, etc.).
3.3.2 Refuge areas/ horizontal exits	Occupants should be protected from fire events during the time required to egress a building. For those occupants unable to exit on their own, due to disability, infirmity, or other reasons, areas of refuge inside of the building may be required. Jurisdictions often require FRR for refuge areas to provide such protection. Horizontal exits are often required in hospitals. Communication systems are often also required.	(a) Do the building regulations address requirements for "areas of refuge" for persons with disabilities while awaiting rescue? (In high-rise buildings, these may be associated with exit stair lobbies. For hospitals, there may be horizontal exit requirements.) a. Are the requirements appropriate in the circumstance? This would include space for persons, fire resistance rating of space, use of roll-down fire partitions, etc. (This might be benchmarked to international best practice.)	See comments associated with Section 2 above. In addition, fire resistance and flame spread requirements may be in other sections under fire suppression (see section 4), and sometimes under structural. The communications to areas of refuge may also be found in provisions associated with fire alarm and communications systems (see 3.2 above).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
3. OCCUPANT SAFETY, REFUGE, AND EGRESS (cont.)			
3.3.3 Refuge floors	In very tall buildings, the time required to evacuate by stairs can be quite long and tiring for occupants. To provide safe interruption of egress and time to rest, some jurisdictions require that intervals of refuge floors (no occupancy – just open area, with sprinkler protection and other features) be provided (see also 3.5).	(a) Do the building regulations address the need for refuge floors for very tall buildings? a. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	If required, such provisions would likely be associated with sections on specific building occupancies, in particular high-rise (and more specifically, supertall) buildings.
3.4 Occupant load, travel distance, and exit capacity			
3.4.1 Occupant load limits (by use, room, building, etc.)	The ability to quickly evacuate a room or a building is significantly a function of the number of people and width of exits. As occupant load (and density) increase, the number, location, and capacity of exits need to increase. Establishing occupant load limits by density for different spaces (or other) is an important baseline.	(a) Do the building regulations address occupant load capacity/limits based on building or space use/occupancy classification? (Note that many regulations apply load factors by space, not just building use.) a. Are the requirements appropriate? (This might be benchmarked to international best practice.)	Requirements for egress (evacuation) systems and features may be in the fire protection section, or within a dedicated section (for example, Chapter 10 of the IBC in the US), of the regulations. In some cases, details are in reference documents, such as Approved Document B in England. Dedicated codes on egress requirements are also available (for example, NFPA 101).
3.4.2 Exit capacity	Exit capacity refers to the number of occupants that a given egress component can accommodate. Capacity may be expressed in such terms as mm/person. Total capacity requirements may be mandated, with number of exits determined based on location requirements.	(a) Do the building regulations address exit capacity? a. How are the requirements presented (for example, table, calculation method)? b. Are the requirements appropriate? (This might be benchmarked to international best practice.)	See comments associated with 3.4.1 above.
3.4.3 Exit numbers (including minimum required)	It is generally impractical to assume all occupants can exit via a single path/stair/door. Many jurisdictions require a minimum of two exits from all but very small buildings, and at least two exits from each floor of high-rise buildings, with the total number of exits increasing as occupant load increases.	(a) Do the building regulations address calculation of required number of exits? a. If so, what are the bases (for example, total occupant load, area of building/floor, number of floors, etc.)? (b) Are at least two means of escape required from all building uses? a. Are the requirements appropriate? (This might be benchmarked to international best practice.)	See comments associated with 3.4.1 above.

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
3. OCCUPANT SAFETY, REFUGE, AND EGRESS (cont.)			
3.4.4 Exit locations	It is generally inappropriate to have all occupants enter exits at a single location and discharge to the outside at a single location, in case one exit becomes compromised. Determining the location of exits is a function of travel distance to an exit and remoteness of exit access and discharge.	(a) Do the building regulations address exit location, relative to such factors as travel distance, dead-end corridors, exit remoteness, etc.? a. Are the requirements appropriate? (This might be benchmarked to international best practice.)	See comments associated with 3.4.1 above.
3.4.5 Exit remoteness	Exit remoteness is a measure of distance between exit access points in a building (or floor of a building in high-rises). It is often required that exit access points be located no closer than 1/3-1/2 the diagonal dimension of the floorplate. This is to facilitate having one exit access available in case another is compromised.	(a) Do the building regulations address exit access and exit remoteness? a. If so, what is the basis for the remoteness requirement? b. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	See comments associated with 3.4.1 above.
3.4.6 Exit discharge	Exits should generally discharge to the exterior into a public way or suitably protected courtyard. This pathway to the exterior is the exit discharge. These may include corridors and exit discharge doors.	(a) Do the building regulations address exit discharge requirements, such as "to the exterior of the building," and protection of the discharge area (for example, from vehicles)? a. Are the requirements appropriate?	See comments associated with 3.4.1 above.
3.4.7 Common path of travel	Travel distance to an exit is an important aspect of fire safety, as it relates to time required to reach a safe place. The common path of travel is the distance between the most remote point in a space to the point in the exit access path from which the occupant has two distinct paths to an exit.	(a) Do the building regulations address requirements/limitations on common path of travel and total allowable travel distance? a. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	See comments associated with 3.4.1 above.
3.4.8 Dead-end travel limits	Finding an exit in an emergency can be difficult, and it is important that occupants avoid walking into spaces from which they cannot exit (dead end). Many jurisdictions therefore limit the length of dead-end corridors (for example, to 5 m or 7 m).	(a) Do the building regulations address limits on the length of dead-end corridors in means of escapes? a. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	See comments associated with 3.4.1 above.
3.4.9 Exit width	The width of exit access components (for example, corridors) and exits (for example, stairs) is important. Width of means of escape components should be appropriate to occupant load and exit system components to help ensure flow of persons.	(a) Do the building regulations address width of means of escape components? a. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	See comments associated with 3.4.1 above.

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
3. OCCUPANT SAFETY, REFUGE, AND EGRESS (cont.)			
3.5 Occupant/occupancy characteristics (vulnerabilities)			
3.5.1 Occupancy/ use groups	Different building uses and occupant characteristics present different risks and hazards and therefore require different levels of protection (see also discussion on related issues/coordination issues that follows this table).	(a) Do the building regulations contain a single set of building use/occupancy classifications that apply to all parts of the regulation? a. If not, is there a specific set for fire safety (escape/egress)?	This depends on regulatory structure. In cases where there is more than one set of building use/ occupancy classifications, check that they are not in conflict. This can be particularly important for structure and fire if there are fire-related structural provisions in each section.
3.5.2 Accessible exit components	To the extent practicable, exits should be designed for people of all abilities. Accordingly, components in means of egress, such as doors, should meet accessibility requirements. Note that some jurisdictions do not require all exits to be accessible.	(a) Do the building regulations address the need for all or some exit system components to be accessible?	This may be found with fire provisions, egress provisions, or in an accessibility section.
3.3.3 Refuge areas/ horizontal exits	Occupants should be protected from fire events during the time required to egress a building. For those occupants unable to exit on their own, due to disability, infirmity, or other reasons, areas of refuge inside of the building may be required. Jurisdictions often require FRR for refuge areas to provide such protection. Horizontal exits are often required in hospitals. Communication systems are often also required.	(a) Do the building regulations address requirements for areas of refuge for persons with disabilities while awaiting rescue? (In high-rise buildings, these may be associated with exit stair lobbies. For hospitals, there may be horizontal exit requirements.) a. Are the requirements appropriate in the circumstance? This would include space for persons, fire resistance rating of space, use of roll-down fire partitions, etc. (This might be benchmarked to international best practice.)	See comments associated with 3.3 above. In addition, fire resistance and flame spread requirements may be in other sections under fire suppression (see Section 4 above), and sometimes under structural. The communications to areas of refuge may also be found in provisions associated with fire alarm and communications systems (see 3.2 above).
3.5.4 Occupant self-evacuation lifts	In very tall buildings, the time required to evacuate by stairs can be quite long and tiring for occupants. To address this concern, some jurisdictions allow occupant self-evacuation lifts.	(a) Do the building regulations address requirements for occupant self-evacuation lifts in case of fire or another emergency? a. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	If required, such provisions would likely be associated with sections on specific building occupancies, in particular high-rise (and more specifically, supertall) buildings. Special requirements for the protection of lifts might be found in the mechanical conveyance sections.

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
3. OCCUPANT SAFETY, REFUGE, AND EGRESS (cont.)			
3.6 Safety glazing, protection against falls, etc.			
3.6.1 Safety glazing	Glazing that is used within circulation spaces of a building, in particular means of escape, should provide protection to occupants against breakage, and as appropriate, be fire rated.	(a) Do the building regulations address requirements for use of safety-rated glazing in occupant circulation spaces, exterior windows, etc.? (b) Do the building regulations address requirements for use of fire-rated glazing in means of escape?	Safety glazing may be addressed in a particular safety to occupants section or as part of means of escape. See comments associated with 3.4.1 above.
3.6.2 Handrail (stairs, barriers against falling)	Where means of egress are adjacent to areas of significant height differentials (for example, walkway near a wall that drops off 1m or more), guardrails may be needed. To facilitate the safe egress of occupants via stairs, they should be able to reach a handrail from any point in the stair. Also, handrails should be sized to fit the human hand well.	(a) Do the building regulations address requirements for barriers to prevent falling from height? (In some cases, these may be required if the vertical drop is 1 m or more.) (b) Do the building regulations address requirements for the location and design of handrails in exit stairs (for example, location, quantity, height above riser, cross-sectional dimension of handrail, etc.)? a. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	See comments associated with 3.4.1 above.
3.6.3 Stair geometry (rise, run, landings, etc.)	Uneven stairs (those in which the rise of the step and the distance to the back of the step (run) are non-uniform) can present a tripping hazard. This is true in emergency and non-emergency events alike. As such, many jurisdictions define criteria for rise and run for exit stairs. Similarly, stair landings that are too small can cause flow restrictions, especially as flows from corridors merge into stairs. As such, many jurisdictions define minimum landing dimensions. Likewise, widths of stairs can be problematic if too narrow (restricting flow) or too wide (inability to access a handrail). Such limits may also be defined.	(a) Do the building regulations address stair geometry requirements to meet safe usage needs (for example, are rise and run dimensions given, are minimum widths defined, are minimum landing area and geometry provided, is door intrusion on landings addressed, etc.)? a. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	See comments associated with 3.4.1 above.

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
3. OCCUPANT SAFETY, REFUGE, AND EGRESS (cont.)			
3.6.4 Door swing in exit pathway, exit hardware, locks	The inability for escaping occupants to exit buildings due to door swing or revolving doors has contributed to many large life-loss events. As such, most jurisdictions require exit doors to open in the direction of the path of exit travel. Also, exit doors should be unlocked from the inside, and where they need to be unlocked, should do so automatically on alarm. Pushbar (emergency) hardware should be used where practicable in places of assembly and other large occupant load buildings.	(a) Do the building regulations address requirements for direction of door swing in the means of escape? (b) Do the building regulations address requirements for door closers (see also Section 3)? (c) Do the building regulations address hardware for opening/locking doors which are part of the means of escape? a. If so, are door hardware requirements coordinated with accessibility requirements? b. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	See comments associated with 3.4.1 above. In addition, accessibility sections of the building regulations should be checked.
3.6.5 Door swing exit discharge	For the reasons outlined above, where practicable, exit doors that discharge to public ways should open in the direction of exit travel (that is, out to the street). The exit discharge door should also be protected from parked cars and other obstructions. This may require bollards.	(a) Do the building regulations address requirements on the swing of exit discharge doors to the exterior (which is generally required to be in the direction of escape travel)? (b) Do the building regulations address protection of the exit discharge door swing area (to allow it to open when needed)? a. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	See comments associated with 3.4.1 above. Where planning or other regulation impose competing objectives (for example, narrow sidewalk), this issue may require discussion and coordination.
3.7 Signage, lighting, and emergency power			
3.7.1 Exit signage	Except for places where people live, most are unfamiliar with the location of exits in buildings. This is especially true in buildings where exits are only used in emergencies (or predominantly in emergencies). As such, it is important to have exit signs that are readily identifiable, easy to read/understand, are located to indicate path of travel, and illuminated/photoluminescent to guide people.	(a) Do the building regulations address requirements for exit signage (for example, illumination, size, color, and location)? a. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	See comments associated with 3.4.1 above. In addition, accessibility sections of the building regulations should be checked. Requirements for exit signs may also be found in standards (for example, ISO or others).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
3. OCCUPANT SAFETY, REFUGE, AND Egress (cont.)			
3.7.2 Exit path illumination	Smoke from a fire can make it difficult to see. Also, fire can cause power outages in a building. As such, many jurisdictions require exit path illumination that includes emergency power (batteries) or is photoluminescent to help occupant wayfinding.	(a) Do the building regulations address illumination of escape paths in both normal power and emergency power situations? a. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice and local power reliability.)	See comments associated with 3.4.1 above.
3.7.3 Emergency lighting	Smoke from a fire can make it difficult to see. Also, fire can cause power outages in a building. As such, many jurisdictions require emergency lighting in exit paths that are connected to emergency power (batteries/generators).	(a) Do the building regulations address requirements for emergency lighting in spaces other than the means of escape? (This is important for large areas and others with insufficient or no windows.) a. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	See comments associated with 3.4.1 above.
3.7.4 Wayfinding guidance	In addition to exit signage and pathway illumination, it may be helpful to have message boards or other wayfinding guidance in very large buildings, such as transit terminals, sports arenas, and the like.	(a) Do the building regulations address requirements for wayfinding guidance systems, other than as outlined above? a. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	See comments associated with 3.4.1 above. In addition, accessibility sections of the building regulations should be checked.
4. FIRE SUPPRESSION			
4.1 Extinguishers			
4.1.1 Handheld fire extinguishers	Handheld fire extinguishers can serve as a means for early intervention to suppress a fire. Regulations can identify what type of fire extinguisher is appropriate for which hazards in a building and where they should be located.	(a) Do the building regulations address requirements for handheld fire extinguishers? a. If not, where is this addressed? b. Are the requirements adequate?	Requirements for handheld fire extinguishers may be found in the fire protection section of the regulations. In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Additional details can also be found in standards (for example, NFPA 10).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
4. FIRE SUPPRESSION (cont.)			
4.2 Water supply			
4.2.1 Municipal fire water capacity/ connections (single, dual)	If firefighting water is provided by the local municipality, there will still need to be connections into the building. Connections will also be required from local storage tanks as necessary. It will be critical to understand whether the municipal system can supply the required flows and pressures. For reliability, it may be prudent to have looped connections or feeds from different municipal mains or branch lines.	(a) Do the building regulations address municipal water supply requirements for fire protection systems? a. If not, where is this addressed? b. If so, are requirements adequate?	Requirements for fire water connections may be in the fire protection section of the regulations. In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical details are most often found in reference standards (for example, NFPA 22 and NFPA 24). It may also be important to check water resources regulations, municipal water regulations and the like.
4.2.2 Local water storage capacity and location	See 4.2.1.	(a) Do the building regulations address local water supply (for example, storage tank) requirements? a. If not, where is this addressed? b. If so, are the requirements adequate?	See 4.2.1. Note that NFPA 22 is an example standard on tanks for firefighting water storage.
4.2.3 Fire service connections	For some large, complex buildings, including high-rise, large storage, and large public spaces with interior hydrant (standpipe) systems, there may be a need for connections to firefighting apparatus to provide water.	(a) Do the building regulations address fire service connections for internal hydrant (standpipe) systems, dry sprinkler risers, and/or other fire service water needs? a. If not, where is this addressed? b. If so, are the requirements adequate?	Requirements for fire water connections may be in the fire protection section of the regulations. In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical details are most often found in reference standards (for example, NFPA 22, NFPA 24).
4.2.4 Street hydrant location	While not always a part of building regulations, fire service regulations/ requirements may specify municipal (external) hydrant locations to help coordinate fire apparatus access.	(a) Do the building regulations address requirements for placement of street hydrants (connected to municipal water supply) relative to distance to buildings being protected? a. If not, where is this addressed? b. If so, are the requirements adequate?	This may be found in planning/ zoning regulations and/or municipal water supply regulations. Sometimes information may be provided in fire service regulations.
4.2.5 Fire pump(s)	Depending on the local situation with municipal (or local stored) water supply for firefighting and on the size of the building, fire pumps may be needed to provide the necessary pressure and flow rates for sprinklers and manual suppression.	(a) Do the building regulations address requirements for firefighting water supply pumps? a. If not, where is this addressed? b. Are the requirements adequate?	Requirements for fire pumps may be in the fire protection section of the regulations. In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical details are most often found in reference standards (for example, NFPA 20).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
4. FIRE SUPPRESSION (cont.)			
4.3 Manual suppression			
4.3.1 Exterior fire service hydrants	Fire hydrants are essential for connecting firefighting apparatus to water supplies. There are typically external hydrant systems connected to water mains (see also 4.2.4 above) and internal to the building for firefighter use.	(a) Do the building regulations address requirements for street hydrants (connected to municipal water supply) relative to distance to buildings being protected or other? a. If not, where is this addressed? b. If so, are the requirements adequate?	This may be found in planning/zoning regulations and/or municipal water supply regulations. Sometimes information may be provided in fire service regulations.
4.3.2 Fire service interior hydrants (standpipes)	Interior hydrants (standpipes) are essential for providing firefighting water throughout large and tall buildings. This allows firefighters to connect hoses locally within the building, near the fire, without laying long distances of hose.	(a) Do the building regulations address requirements for location and redundancy of interior hydrants (standpipes) for fire service use? a. If not, where is this addressed?	Requirements for location of fire service hydrants (standpipes) may be found in the building regulations, either in the fire protection section or with specific occupancy requirements (for example, high-rise, storage/warehouse, etc.). In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical details are most often found in reference standards (for example, NFPA 14).
4.3.3 Fire service connections	In some countries, hose reels for fire service use are required. However, other countries have dropped this requirement due to the fire service's preference for bringing their own hoses to connect to interior hydrants. Where provided, regulations can identify where they should be located, hose length, and related parameters.	(a) Do the building regulations address fixed (permanent) hose reels for fire service use? a. If not, where is this addressed (if at all)? b. Are the requirements adequate?	Requirements for firefighter hose reels may be found in the fire protection section of the regulations. In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical details are most often found in reference standards.
4.3.4 Manual fire suppression water capacity (flow and pressure)	It is necessary to understand water capacity, flow, and pressure needs for the interior fire service hydrant (standpipe), along with sprinkler systems requirements, to design overall firefighting water supply systems for the building.	Do the building regulations address requirements for capacity (flow rate) and pressure of interior hydrants (standpipes) for fire service use? If not, where is this addressed? Are the requirements adequate?	Requirements for minimum water supply may be in the fire protection section of the regulations. They may be combined to include sprinklers and interior hydrants (standpipes) and defined in terms of flow, pressure, and duration (for example, 30 min or 60 min capacity). In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical details are most often found in reference standards (for example, NFPA 13,14, 24).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
4. FIRE SUPPRESSION (cont.)			
4.3.5 Occupant-use hose reels	In some countries, occupant-use hose reels are used for early intervention to suppress a fire. However, other countries have dropped this due to potential risk to user (if not successful in controlling fire). Where provided, regulations can identify where they should be located, hose length, and related parameters.	(a) Do the building regulations address requirements for fixed (permanent) occupant-use hose reels for firefighting? a. If not, where is this addressed (if at all)? b. Are the requirements adequate?	Requirements for occupant hose reels may be found in the fire protection section of the regulations. In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical details are most often found in reference standards.
4.4 Automatic suppression			
4.4.1 Automatic sprinkler system	Automatic fire sprinklers are among the most effective way to control fires when small and to keep them small, limiting impacts to life and property. Most jurisdictions require a full building automatic fire sprinkler system to be installed in all high occupancy buildings, high-rise buildings (residential, commercial, institutional), hospitals, and other such complex or high-risk buildings. Some jurisdictions require sprinklers for storage, industrial, and most other occupancies as well. Some jurisdictions require all buildings except 1-2 family dwellings to be sprinklered.	(a) Do the building regulations require installation of automatic fire sprinkler systems? a. If so, in which building use/ occupancy classifications are they required? (b) Are there any boundary conditions that define when an automatic fire sprinkler system is required, such as height of building, occupant load, nature of the materials stored in the building, etc.?	A requirement for a building to have automatic fire sprinkler systems would most typically be found in the fire protection section (which may sometimes be part of the mechanical or building services section). However, they may also be found with specific special occupancy requirements, such as high-rise buildings, high-hazard buildings, and the like. In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical design details are most often found in reference standards (for example, BS EN 14972, BS 9251, ISO 6182, NFPA 13).
4.4.2 Sprinkler design density/ hazard classifications	Design of automatic fire sprinklers depends on the expected fire loads. Different regulatory approaches are used, such as light hazard or ordinary hazard, to define design parameters. The building regulation may define different categories for different building uses (for example, office may be light hazard).	(a) Do the building regulations address sprinkler design density/hazard classification requirements? a. If not, where are these addressed? b. Are the requirements adequate?	Requirements for sprinkler hazard classification may be in the building regulations, either in the fire protection section or with specific occupancy requirements. Design details are most often found in reference standards (for example, BS EN 14972, BS 9251, ISO 6182, NFPA 13).
4.4.3 Sprinkler design area	Sprinkler systems are typically designed by considering hydraulically remote design areas in which a specified number of sprinklers may be activated. This is necessary to understand water capacity, flow, and pressure needs.	(a) Do the building regulations address sprinkler design area requirements (for example, hydraulically remote location, number of heads operating, floor area, etc.)? a. If not, where are these addressed? b. Are the requirements adequate?	Requirements for minimum water supply may be in the fire protection section of the regulations. They may be combined to include sprinklers and interior hydrants (standpipes), and defined in terms of flow, pressure, and duration (for example, 30 min or 60 min capacity). In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical details are most often found in reference standards (for example, BS EN 14972, BS 9251, ISO 6182, NFPA 13).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
4. FIRE SUPPRESSION (cont.)			
4.4.4 Sprinkler water capacity, flow, and pressure	It is necessary to understand water capacity, flow, and pressure needs for sprinkler systems, along with interior fire service hydrant (standpipe) requirements, to design firefighting water supply systems for the building.	(a) Do the building regulations address water capacity, flow, and pressure requirements for sprinkler systems? a. If not, where are these addressed? b. Are the requirements adequate?	Requirements for minimum water supply may be in the fire protection section of the regulations. They may be combined to include sprinklers and interior hydrants (standpipes), and defined in terms of flow, pressure, and duration (for example, 30 min or 60 min capacity). In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical details are most often found in reference standards (for example, BS EN 14972, BS 9251, ISO 6182, NFPA 13).
4.4.5 Water flow alarm (local)	Sprinkler heads are a form of heat detection, so when the sprinkler activates, it should sound a local water flow alarm—typically located on the outside of a building—to signal to people that water is flowing.	(a) Do the building regulations address requirements for water flow alarms connected to sprinkler systems? a. If not, where are these addressed?	Requirements for installing a local water flow alarm may be in the fire protection section of the regulations. In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical details are most often found in reference standards (for example, BS EN 14972, BS 9251, ISO 6182, NFPA 13).
4.4.6 Water flow (connection to FACP)	Sprinkler heads are a form of heat detection, so when the sprinkler activates, it should sound an interior alarm via the FACP, to signal to occupants that there is a fire. This is important because smoke detectors and other such devices may not be installed in sprinklered buildings, so flow alarms are the primary alarm initiating devices.	(a) Do the building regulations address connection of the sprinkler system to the building FACP? a. If not, where are these addressed?	Requirements for installing water flow switches for the FACP may be in the fire protection section of the regulations. In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical details are most often found in reference standards (for example, BS EN 14972, BS 9251, ISO 6182, NFPA 13).
4.4.7 Sprinkler supervision	Supervision of fire sprinkler systems is important to monitor positions of valves.	(a) Do the building regulations address connection of the sprinkler system to the building FACP? a. If not, where are these addressed?	Requirements for supervision may be in the fire protection section of the regulations. In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical details are most often found in reference standards (for example, BS EN 14972, BS 9251, ISO 6182, NFPA 13).
4.4.8 Special extinguishing systems	Some spaces in certain buildings may require suppression systems that do not use water (for example, chemical systems for commercial stove/oven exhaust systems, inert gas in computer space).	(a) Do the building regulations address requirements for special suppression systems, such as chemical systems, inert gases, and the like? a. If so, in which building use/occupancy classifications, or within which specific rooms or for specific uses in a building, are they required (for example, kitchen range exhaust hood)? b. If not, where is this addressed?	Requirements for areas which require special extinguishing systems may be found in the fire protection section of the regulations or under specific use/occupancy groups. In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical details are most often found in reference standards.

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
4. FIRE SUPPRESSION (cont.)			
4.4.9 Automatic extinguishing system supervision	Any installed special extinguishing system should be supervised by the building FACP to indicate alarms and notify responsible persons if there is a problem with the system.	(a) Do the building regulations address connection of special extinguishing systems to the building FACP? a. If not, where are these addressed?	Requirements for supervision of special extinguishing systems may be found in the fire protection section of the regulations. In some cases, requirements will be found under fire service legislation, such as in a fire regulation. Technical details are most often found in reference standards.
5. FIRE SERVICE ACCESS AND FACILITIES			
5.1 Access for fire apparatus and equipment	Access for fire apparatus is critical, yet usually not included in building regulations. Rather, attributes such as roadway width, turning radius, and access to buildings is often found in planning regulations. This needs to be coordinated. Access should not be over underground parking.	(a) Do the building regulations address fire service access for apparatus (that is, roadway width, turning radius, prohibition over underground parking, etc.)? a. If not, where is this addressed?	Fire service access for apparatus may be found in planning regulations, transportation regulations, or other. It may be dependent on fire service resources and the types of apparatus deployed in the local municipality.
5.2 Access to stairs, hydrants, and hose reels	The fire service should have clear access within buildings, especially to locations of FACPs and emergency command centers (ECCs). It should also be easy for them to readily identify stairways and firefighter lifts for operational and occupant evacuation needs.	(a) Do the building regulations address requirements for fire service access and wayfinding in buildings, especially to stairs, ECCs, fire pump room, and other critical spaces? a. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	See comments associated with Sections 3 and 4 above.
5.3 Firefighter lifts	All high-rise buildings present challenges for the fire service, from bringing equipment to upper floors, to evacuating impaired or disabled persons. As such, many jurisdictions require either dedicated firefighter lifts or controls that allow firefighters to take control of lifts in emergencies.	(a) Do the building regulations address requirements for fire service lifts? a. Are the requirements appropriate in the circumstance? (This might be benchmarked to international best practice.)	Firefighter lifts may be addressed in the fire protection section. Special requirements for the protection of firefighter lifts might also be found in the mechanical conveyance sections.
5.4 Firefighter communications and command center	In high occupancy buildings, high-rise buildings, and other such complex or high-risk building, many jurisdictions require a dedicated ECC (fire command center) for use by the fire service to direct evacuation communication, control lifts, control smoke exhaust, and similar functions. Such ECCs are typically protected by fire-rated construction. The ECC would house the FACP/ EVCCP and other similar controls.	(a) Do the building regulations address requirements for an ECC for use by the fire service or other emergency response and management personnel during emergencies? (b) Is the location of the ECC addressed? (c) Is ready access to the ECC addressed? (d) Is protection of the ECC addressed?	Requirements for ECC would typically be found in the fire protection section (which may sometimes be part of the mechanical or building services section). However, they may also be found with specific special occupancy requirements, such as high-rise buildings. Provisions may also be located in the structural section, if controls for other events is also anticipated (for example, earthquake, flood, cyclone).

Table 2. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
6. ITM, PLANS, AND TRAINING			
6.1 ITM for fire protection systems	To help ensure that fire safety systems and features are available and working properly when needed, a robust set of ITM provisions should be considered. In some cases, these may be associated with reference equipment standards (for example, fire detection and fire suppression).	(a) Do the building regulations include requirements for scheduled ITM? a. If not, where is this addressed? b. If so, do the building regulations also include other audits/reports, such as a BWOF report in which the owner certifies systems are maintained in working order?	This may be a unique section in the building regulations or associated with reference standards for each type of fire safety equipment.
6.2 Evacuation planning and training	While it is important to have robust means of escape, it is also important to have evacuation plans, training, drills, and the like to help occupants understand their role in an emergency in getting themselves to a place of safety.	(a) Do the building regulations include requirements for evacuation planning and training? a. If not, where is this addressed?	These requirements may be associated with means of escape, as a separate section, or in separate regulations (for example, building evacuation legislation and regulation).
6.3 Fire safety management plans	In addition to robust ITM plans and evacuation plans, buildings should have broader fire safety/risk management plans to help ensure systems are maintained, people are trained, combustibles are not stored in means of escape, combustibles are not stored near building façade, and similar good practices.	(a) Do the building regulations include requirements for fire safety management plans? a. If not, where is this addressed?	These requirements may be associated with fire prevention, as a separate section, or in separate regulations (for example, occupational health and safety).
6.4 Temporary use requirements/ permits	It is sometimes the case that temporary buildings / structures are erected for special events. Such buildings / structures should have a permit and inspection process, appropriate to the structure, and a limited time that the temporary structure is to be allowed.	(a) Does the building code address permitting of temporary structures and/or uses? a. If not, is this addressed in another document / regulation, such as zoning? (b) If temporary structures/uses are permitted, is there a specific permitting process for temporary uses? a. Does the permit process include inspection of structural integrity and fire / evacuation safety? b. Does the permit place limits around the definition of 'temporary' in terms of time that the structure can exist / use is permitted (e.g., single event, one day, one week, one month)? (c) Is there a process for addressing temporary structures / uses that exceed permitted time (e.g., demolition, conversion to permanent, ...)?	Requirements for temporary structures / uses would typically be found in the Administrative section of the building / fire code. In some cases, separate legislation / regulations may be in place.

While the above list is extensive it is not necessarily exhaustive. Also, as noted previously, not all principles/features/systems may be required/appropriate in the country of focus. In addition some of the details associated with the fire safety principles/features/systems may be located in mandatory or non-mandatory guidance and/or referenced standards.

Lastly, there are several related issues, which may not fit simply as a fire safety component (such as building use/occupancy groups), are coordination issues, or are found in related legislation (for example, utilities). Table 3 contains various items of concern such as those overviewed.

Table 3. Related review items

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
A1. USE/OCCUPANCY CLASSES			
A1.1 While not a fire safety principle/strategy, for building regulation, this sets benchmark criteria for specific fire safety requirements (based on population of building, size of building, primary activity of building, etc.)	In general, building use/classification depends on the climate, geography, cultural background, etc. of a country. An important point is that building-use classes in the building regulations should reflect the building uses of the country in question. Specific to fire safety, different building uses and occupant characteristics present different risks and hazards and therefore require different levels of protection. This should be considered.	(a) Do the building regulations contain a single set of building use/occupancy classifications that apply to all parts of the regulation? a. If not, is there a specific set for fire (and life safety)? (b) Are there any other use/occupancy classifications (for example, for structural)? (c) If more than one set of use/occupancy classifications exist, is there any conflict between them?	This depends on regulatory structure. They may be found as their own section, in a section on structural, fire or both, or within an annex. In cases where there are more than one set of building use/occupancy classifications, check that they are not in conflict. This can be particularly important for structure and fire if there are fire-related structural provisions in each section.
A1.2 Special provisions for mixed-use occupancy buildings	When a building contains multiple uses (for example, high-rise residential on top of commercial or retail space), care should be taken to identify what provisions apply to the building and/or its parts (for example, most restrictive for the use applies or mix based on uses).	(a) Do the building regulations contain special provisions for mixed-use occupancies? a. If so, does the entire building need to comply with the most restrictive use? b. What triggers the "dominant" use?	This would typically be found wherever the overall discussion of building use/occupancy classes is found. This may be in a regulation (for example, the IBC in the US) or in a reference document (for example, Approved Document B in England).
A1.3 Special provisions for high-rise buildings	High-rise buildings are characterized by long times for occupant evacuation and fire service response. They may also have large populations. The consequences of a fire are generally higher (in particular structural failure). These factors often warrant additional requirements (for example, higher fire resistance requirements, automatic sprinklers, voice communications) over low-rise buildings of the same use.	(a) How is "high-rise" defined? (b) Do the building regulations contain special provisions for high-rise buildings? (c) If not, has consideration been given to special needs associated with fire stability, egress, and firefighting in tall buildings, and if so, where are provisions for this?	This would typically be found wherever the overall discussion of building use/occupancy classes is found.

Table 3. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
A1. USE/OCCUPANCY CLASSES (cont.)			
A1.4 Special provisions for atria	Depending on area, height, and openness to floors above grade, this may impact fire and smoke control, suppression system, and egress. As such, additional requirements or guidance may be warranted.	(a) Are buildings with atria allowed? a. If so, do the building regulations contain special provision for atria? b. If not, how is fire detection, smoke control, suppression and egress addressed for atria spaces?	This would typically be found wherever the overall discussion of building use/occupancy classes is found.
A1.5 Underground structures	Underground structures, especially with large numbers of people (for example, malls), also require special provisions because they are characterized by high density of occupants, limited (upward) evacuation, smoke exhaust challenges, and darkness if electrical outage occurs.	(a) Are underground buildings/structures addressed by the building regulation? a. If so, do the building regulations contain special provisions for the unique features of underground spaces? b. If not, how is fire detection, smoke control, suppression, and egress addressed for atria spaces?	This would typically be found wherever the overall discussion of building use/occupancy classes is found.
A2. COORDINATION ISSUES			
A2.1 Fire stability of structure with structural provisions	As noted in Section 3.3.1 above, fire resistance of structural systems may be found in association with building use/occupancy classes or under fire protection (which may be part of the mechanical or building services), but may also be found under structure, in particular where reference codes such as the Eurocode for Structures are used. Coordination with structural is critical.	(a) Do the building regulations address fire stability of structure in more than one location (section/chapter)? a. If so, do the separate requirements work appropriately together? (b) Is there a priority as to when one set of provisions has precedence over the other?	The building regulations need to work as a cohesive, coordinated system. In some cases, requirements for fire protection systems may be under mechanical, and in some cases may also be addressed under structural requirements, especially as associated with specific hazard design (for example, earthquake).
A2.2 Alternate methods of design	Many building regulations allow for the use of alternate design methods (engineered design/performance-based design). It is important to check that this is coordinated across areas.	(a) Do the building regulations allow for use of alternate methods/engineered design? a. If so, what are requirements for designers? i. When can alternate (engineered) methods be used? ii. Are specific methods for alternate (engineered) design cited? (b) If more than one approach is listed/possible, which has precedence?	The building regulation may have a single administrative clause that permits alternate (engineered) designs in all areas or may allow only for specific areas (for example, structural). Where engineered design impacts more than one area (for example, application of Eurocodes for Structure, which includes an approach to fire engineering), it needs to be clear which provisions have precedence/priority.

Table 3. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
A2. COORDINATION ISSUES (cont.)			
A2.3 Seismic bracing of fire protection systems	In seismic zones, it can be important to have seismic bracing of non-structural systems and components, including fire protection systems. Coordination with structural design is important to understand if and when seismic bracing is needed for fire protection systems, and if so, how best to address it in the building regulation.	(a) Do the building regulations address seismic bracing of fire protection systems, particularly firefighting water supply, interior hydrants, and sprinklers? a. If so, where is this addressed? i. Are the requirements appropriate in the circumstance? (This may change based on building use and might be benchmarked to international best practice.)	The building regulations need to work as a cohesive, coordinated system. In some cases, requirements for fire protection systems may also be addressed under structural requirements, especially as associated with specific hazard design (for example, earthquake).
A2.4 Coordination with mechanical, electrical, and plumbing provisions on smoke and electrical	As noted in 4.4.1 above, requirements for smoke exhaust systems may be found in the fire protection section of the regulations. However, they might also be found under the mechanical or building services section. Also, sprinklers and manual fire protection systems may be designed by mechanical or plumbing engineers. Coordination with mechanical engineers for these systems is very important when reviewing regulations.	(a) Are there any conflicts between fire provisions and mechanical, electrical, or plumbing provisions within the building regulations? (b) Are there any conflicts between fire provisions and energy efficiency provisions within the building regulations (for example, as associated with items such as photovoltaic systems, energy storage systems, and thermal insulation)?	The building regulations need to work as a cohesive, coordinated system. In some cases, requirements for fire protection systems may be under and/ or required to coordinate with mechanical, and may also have relevance to energy efficiency, and other clauses.
A2.5 Coordination with vertical transport on elevator recall and/or firefighter lifts /and/or occupant self-evacuation lifts	In cases where firefighter lifts and/ or occupant self-evacuation lifts are used, coordination with vertical transportation requirements is important.	(a) Are there any conflicts between fire provisions and vertical transport provisions within the building regulations?	The building regulations need to work as a cohesive, coordinated system. In some cases, requirements for fire protection systems may require coordination with vertical transport.
A2.6 Coordination with accessibility on accessible components in egress system	As noted in 4.3 above, most egress systems will have at least some accessible features. Coordination with accessibility requirements in the regulations is important.	(a) Are there any conflicts between fire provisions and accessibility provisions within the building regulations?	The building regulations need to work as a cohesive, coordinated system. In some cases, requirements for fire protection systems may require coordination with accessibility.
A2.7 Coordination with façade/external wall/ envelope on insulation, fire spread, etc.	External wall/façade systems can be very complex, and sometimes use materials such as insulation, which may be combustible. Fire performance of materials in façade and insulation systems should be coordinated with energy performance/mechanical.	(a) Are there any conflicts between fire provisions and façade provisions within the building regulations?	The building regulations need to work as a cohesive, coordinated system. In some cases, requirements for fire protection systems may require coordination with façades.

Table 3. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
A2. COORDINATION ISSUES (cont.)			
A2.8 Consistent use throughout all sections	There are many standards organizations worldwide. Most countries have their own. There are also International Standards (ISO) and regional standards (for example, CEN in Europe). To the extent practicable, standards that address a particular topic should come from the same organization to assure compatibility. Care should be taken to avoid use of incompatible standards in the building regulations. For example, sprinkler requirements from NFPA in the US might not be compatible with manual fire suppression design guidance from BSI or other. Also, consistent approach to citing standards should be adopted. Either provide references in all building regulation sections, or in an annex, but not a mix of both.	(a) Do the building regulations uniformly cite consensus standards from the same organization (for example, BSI, CEN, and NFPA) within each section (for example, structure, fire, mechanical, etc.)? a. If not, do the building regulations uniformly cite comparable consensus standards within each section (for example, structure, fire, mechanical, etc.)? (b) What checks have been carried out to assure compatibility between cited standards?	Standards that are cited in the building regulations may be found within each specific section (for example, structural, mechanical) or may be consolidated into a schedule or annex to the regulations.
A2.9 Consistent and uniform reference to same source(s)	A consistent approach to citing standards should be adopted for use throughout all code sections. As used here, consistency refers to how the reference is stated, for example, NFPA 13 or NFPA 13 Design of Sprinkler Systems, or other. It is recommended that titles be included so that the reader better understands the content.	(a) Do the building regulations use the same approach to citing standards consistently throughout (for example, cited in specific chapter as BS XXXX:2020; or EN 1990:2002/A1:2005; or NFPA 13, Design of Sprinkler Systems, NFPA, Quincy, MA, United States)? a. If not, suggest that all be made consistent. (b) Do the building regulations reference specific dated versions of a standard or reference the current version of a standard?	Standards that are cited in the building regulations may be found within each specific section (for example, structural, mechanical) or may be consolidated into a schedule or annex to the regulations. There may be good reasons to reference an older version of a standard in some instances.
A3. TESTING/CERTIFICATION			
A3.1 Required product/system marking (for example, CE, UL, etc.)	Building regulations should state requirements for listing or certification of fire protection systems and materials.	(a) Do the building regulations require building products to be tested and approved, and marked with appropriate indication (for example, CE mark, UL label, etc.)? a. If not, how is product quality and conformity assessed?	If not addressed in the building regulations, there may be other legislation or treaties that require appropriate product performance certification (for example, the Construction Product Directive and Regulations in the EU).

Table 3. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
A3. TESTING/CERTIFICATION (cont..)			
A3.2 Accredited test facilities	A check should be made as to the presence of accredited laboratories to conduct cited approval/certification requirements.	(a) Do the building regulations address the need for accredited laboratory facilities to be used in conducting product tests and issuing performance and/or conformity certifications? a. If not, how is product quality and conformity assessed?	If not addressed in the building regulations, there may be other legislation or treaties that require appropriate product performance certification (for example, the Construction Product Directive and Regulations in the EU).
A3.3 Market surveillance	Should be checked if exists.	(a) Do the building regulations address the need for market surveillance of construction products? a. If not, how is product quality and conformity maintained?	If not addressed in the building regulations, there may be other legislation or treaties that require appropriate product performance certification (for example, the Construction Product Directive and Regulations in the EU).
A4. OTHER LEGISLATION/REGULATIONS			
A4.1 Electricity infrastructure/distribution system/building power supply requirements (primary)	Electricity is one of the most common sources of fire ignition. Inadequate electricity infrastructure leading to buildings can create ignition hazards. This can be a particular concern in informal settlements and construction. Also, unreliable electricity can significantly impact safety systems. Understanding and coordinating with electricity infrastructure is critical.	(a) Do the building regulations address electric utility requirements for the building, for example, reliability, distribution, and the like? a. If not, where is this addressed?	Electric utility system requirements may be found in power/utilities regulations or other.
A4.2 Emergency power supply requirements	Following from 6.2 above, emergency power requirements for fire safety systems need to be coordinated with overall building emergency power needs.	(a) Do the building regulations address emergency power requirements? a. If not, where is this addressed?	Electric utility system requirements may be found in power/utilities regulations or other.
A4.3 Piped fuel (gaseous/ liquid) utilities.	Piped fuel is a common source of fire ignition. Inadequate infrastructure leading to buildings can create ignition hazards and provide additional fuel if ignited. This can be a particular concern in informal settlements and construction. Understanding and coordinating with piped fuel infrastructure is critical.	(a) Do the building regulations address piped fuel (gaseous and liquid) services to the building? a. If not, where is this addressed?	Piped fuel system requirements may be found in power/utilities regulations or other.

Table 3. (cont.)

Topic	Relevance	Diagnostic Question	Where to Look in Regulation(s)
A4. OTHER LEGISLATION/REGULATIONS (cont.)			
A4.4 Municipal water system requirements	As noted in 4.2.16 above, if firefighting water is provided by the local municipality, there will still need to be connections into the building. Connections will also be required from local storage tanks as necessary. It will be critical to understand whether the municipal system can supply the required flows and pressures. For reliability, it may be prudent to have looped connections or feeds from different municipal mains or branch lines.	(a) Do the building regulations address connections to municipal water supply for firefighting water? If not, where is this addressed?	Municipal water supply requirements may be found in water resources/utilities regulations or other.
A4.5 High-hazard zoning provisions	Planning and zoning regulation typically defines where hazardous facilities/industrial operations can be located. These may have specific fire protection needs. Also, if residential or other commercial buildings are permitted in these areas, fire exposure requirements should take account of this.	(a) Do the building regulations address permissible location of high-hazard facilities relative to residential and other building uses? a. If not, where is this addressed?	Planning and zoning requirements may be found in planning/zoning regulations or other.
A4.6 Land management/ wildfire exposure requirements	In many countries, urban environments are merging with the wildland, and with climate change increasing temperatures and extending droughts, fires at the wildland-urban interface are increasing. Some jurisdictions have created special codes or standards to address particular needs in the wildland-urban interface. These, and fire suppression, need to be coordinated.	(a) Do the building regulations address specifically protection against wildfire threats, including such features as screening to prevent ember penetration, noncombustible fencing and decking, noncombustible roof materials, etc.? a. If not, where is this addressed?	Wildfire land management requirements may be found in land/resource management regulations or other. In some jurisdictions, specific codes or standards for buildings located in the wildland-urban interface exist (for example, the International Code Council Wildland-Urban Interface Code).

Appendix A – Location of Fire Provisions in Building Regulatory Systems

As discussed in Regulatory Structures, there is a variety of approaches to building regulatory system structures. While most building regulatory systems address all of the fire safety principles/strategies/systems overviewed in this checklist, the overall functional description of each, the detailed requirements, and the design and testing specifications may all exist in different documents.

It is not practical to try and describe every type of regulatory structure in detail (see overview of main types in Chapter 3 and 4). For each type, there can be significant differences in where required information is to be found, and the level of detail of the information (requirements) provided. In regulatory structures that are largely functional/performance-based, most find it is essential to have a robust set of reference Deemed-to-satisfy (DtS) documents and standards to support the proper design of fire safety systems and the adequate review and approval of these designs. Many of these countries also have Verification Methods (VMs), which are largely engineering-based guidance (but not standards).

Note that while for most countries there is generally a consistent approach across all provisions within a building regulation with respect to functional or prescriptive and level of detail, although in some countries some provisions are more specification-based than others. This can occur when differences in capacity are viewed as existing across regulated areas. For example, some European countries defer all details of structural design to the Eurocodes for Structure, as structural engineering is viewed as a rather mature discipline. At the same time, some of the same European countries include detailed requirements (specifications) for fire, since fire engineering is viewed as immature in the country.

Similarly, some European countries allow for "self-certification" of designs, either based on the extent to which a discipline has a well-organized professional body that charters/certifies its members (for example, self-certification of structural designs by a chartered member of the Institution of Structural Engineers (UK)) or based on the use of pre-approved solutions (for example, the Robust Details for acoustics Home Page (robustdetails.com).

There are also approaches that utilize the private sector to complete assessments/tests of buildings for compliance purposes. A common example of this is "energy performance" testing, which may involve door fan (blower) tests and thermal imaging to assess leakage areas, thermal bridging, and related building energy performance issues. In the US, there are requirements for building fire safety system commissioning for many buildings, which is undertaken by private-sector firms.

Given the variability in regulatory typologies, the following overview is necessarily presented at a high level and does not include extensive treatment of the cited regulatory systems.

Table 4. Examples of various regulatory systems

Country	Regulatory Approach/ Level of Detail	Use of DtS Provision and Level of Detail	Use of VMs	Location of Reference Standards
Australia	Performance-based/performance requirements not highly detailed.	Non-mandatory DtS provisions are included in the NCC. These are mostly rather detailed specifications.	VMs exist, including for fire. In addition, for performance, International Fire Engineering Guidelines are used.	Cited in NCC, DtS option and in VMs.
Canada	Objective-based/ objectives not highly detailed.	Mandatory DtS provisions included as Part B of National Building Code (NBC).	No specific VM for fire.	Cited in NBC, Part B, DtS provisions.
England	Function-based/not highly detailed.	DtS provisions in non-mandatory Approved Documents.	No specific VM for fire. BS 9999 and BS 7974 can be used.	Cited in Approved Document B for fire.
Germany	Function-based/not highly detailed at Federal Model Code level.	Mandatory detailed provisions included in Technical Requirements for Buildings.	No specific VMs. Rather, requires "proof engineer" to validate any engineered designs.	Cited in Technical Requirements for Buildings.
Japan	Performance-based/ some specific requirements.	Performance and specifications included in Building Standards Law (BSL) and Fire Standards Law (FSL).	DtS equations for fire verification included in BSL for evacuation, smoke exhaust, and fire resistance. Active systems in FSL.	Cited in BSL & FSL.
New Zealand	Performance-based/performance requirements not highly detailed.	Non-mandatory DtS provisions are included in non-mandatory Compliance Documents (CMs).	VMs exist, including for fire. In addition, for performance, International Fire Engineering Guidelines are used.	Cited in Compliance Documents and VMs.
Scotland	Function-based/not highly detailed.	DtS provisions in non-mandatory Technical Handbooks (THs).	No specific VM for fire. BS 9999 and BS 7974 can be used.	Cited in Technical Handbook: Fire.

Table 4. (cont.)

Country	Regulatory Approach/ Level of Detail	Use of DtS Provision and Level of Detail	Use of VMs	Location of Reference Standards
Singapore	Performance-based regulation/specific requirements in compliance documents.	Performance included in Building Control Regulations (BCR) and Fire Safety Regulation (FSL). DtS in Code of Practice for Fire Precautions in Buildings.	No specific VM for fire. There is as specific Fire Safety Engineering Guideline that must be followed for performance designs. BS 9999 and BS 7974 may be used.	Cited in Code of Practice for Fire Precautions in Buildings.
South Africa		SAN10400 T which is DtS.	Rational designs must be undertaken by a competent person (fire engineering) (see annex C) in accordance with the requirements of BS 7974, in order to achieve the same level of fire safety implied in 4.2 to 4.59 (inclusive) of this part of SANS 10400.	
US	Largely prescriptive-based with some performance language.	Mandatory compliance with prescriptions, unless alternate methods or materials are approved by the Authority Having Jurisdiction.	No specific VM for fire.	Cited by the Building Code. (Note: model Building Code developed in private sector and adopted into legislation at state or local level.)

Table 5. Exemplar location of resistance to fire compliance details in different countries' regulations

Country	Building Regulation/Code	Fire Regulation/ Code	DtS Document	Exemplar Referenced Consensus Standards
US	International Building Code, Chapter 6, Types of Construction, Table 601 and Chapter 7, Fire and Smoke Protection Features, Section 703.			ASTM E119, Standard Test Methods for Fire Tests of Building Construction and Materials, or UL 263, Fire Tests of Building Construction and Materials.
Australia			National Construction Code, Specification C1.1 Fire-resisting construction.	AS 1530.4:2014 Methods for Fire Tests on Building Materials, Components and Structures - Fire-resistance tests for Elements of Construction.
England			Approved Document B2, Section 7: Loadbearing elements of structures, and Appendix B, Table B3.	BS EN 13501-2:2016 Fire classification of construction products and building elements.
New Zealand			C/AS2 Acceptable Solution for Buildings other than Risk Group SH, Section 2.3 Fire resistance ratings.	a) AS 1530 Methods for fire tests on building materials and structures–Part 4: Fire resistance tests of elements of building construction, or b) NZS/BS 476 Fire tests on building materials and structures – Parts 21 and 22.
Singapore		Singapore Fire Code, Clause 3.3, Fire Resistance of Elements of Construction, Table 3.3A.		BS 476: Part 20 to 23, which specify tests for stability, integrity, and insulation.

Table 6. Exemplar location of internal hydrant (standpipe) systems compliance details in different countries' regulations

Country	Building Regulation/Code	Fire Regulation/Code	DtS Document	Referenced Consensus Standards
US	International Building Code, Chapter 9, Fire Protection and Life Safety Systems, Section 905, Standpipe Systems (same text as in IFC)	International Fire Code, Part III – Building and Equipment Design Features, Section 905, Standpipe Systems (same text as in IBC)		NFPA 14, Standard for the Installation of Standpipe and Hose Systems
Australia			National Construction Code, Part E1 Firefighting equipment (DtS), Provision E1.3, Fire hydrants	AS 2419.1, F Fire hydrant installations: Part 1 - System design, installation and commissioning
England			Approved Document B2, Section 16: Fire mains and hydrants	BS 9990, Non-automatic fire-fighting systems in buildings – Code of practice
New Zealand			C/AS2 Acceptable Solution for Buildings other than Risk Group SH, Section 2.2, Fire safety systems, Table 2.2	NZS 4510, Fire hydrant systems
Singapore		Singapore Fire Code, Clause 6.2, Rising Main and Hose Reel Systems		SS 575-A1, Code of practice for fire hydrant, rising mains and hose reel system

Note that in the case of interior hydrants (standpipes, rising mains) there is a close relationship to the referenced standards for design and installation requirements. This means that the combination of provisions in the regulations and in the standards is needed to obtain a complete picture of the performance, design, and installation requirements. This differs from the resistance to fire provisions in regulations, where the referenced standards address how the tests are to be conducted, but the performance-based requirements are contained in the regulation.

Appendix B – Primer on Building Fire Safety Concepts

As presented in the body of this report, there are six fundamental fire safety components in building (and fire) regulations, along with a more detailed set of subcomponents. This annex has been prepared to provide additional detail and context to the general summaries provided.

Fire Safety Subcomponents

The six fundamental fire safety components in building (and fire) regulations, along with a more detailed set of subcomponents, are presented in Figure 1. The dotted blue line shows interdependencies between primary components (that is, egress routes need to be protected).

Figure 8. Fundamental fire safety components and subcomponents in regulations

The dotted blue line shows interdependencies between primary components (that is, egress routes need to be protected). Note that while '2.7 Smoke control / smoke management' is shown here as a subcomponent of 'Resistance to fire / Spread of Fire', the topic may be found as its own section, or with 'Building Services', or sometimes with 'Occupant Safety, Refuge and Egress' in building / fire codes.

The fundamental fire safety components and subcomponents presented in Figure 8 are detailed in the subsequent section as part of the review diagnostic. The following provides a high-level introduction to the concepts embodied in structure.[25]

B.1 Fire Prevention

There are numerous factors that influence the potential for fire ignition in a building and subsequent development of a threatening fire. While many of the factors can be addressed in building and/or fire regulations, some may also be addressed in related legislation and regulation, including those governing utilities (that is, electricity, fuel gas, and liquid fuels), environmental, occupational health and safety, and consumer safety. There are also fire prevention factors and approaches that can help to manage buildings in use. An exemplar set of factors to support prevention of ignition and fire, which can be addressed in regulation, is provided below.

Table 7. Fire Ignition Factors That May Be Regulated

1. Sources of potential ignition	a. Electrical services and connected appliances/devices (including lighting)
	b. Piped gas services and connected open flame appliances/devices (for example, stove, heater)
	c. Smoking material/means to light smoking material (for example, matches, lighter)
	d. Open flame lighting (for example, torches)
	e. Maintenance/construction equipment (for example, welders, electrical tools)
	f. Internal exposure from a fire
	g. External exposure from a fire due to accidental or natural causes
2. Types of potential fuels	a. Combustible construction materials (for example, timber)
	b. Combustible interior and exterior surface finishes
	c. Combustible building contents and furnishings
	d. Combustible stored materials and products
	e. Accumulated combustible trash/waste material
	f. Combustible or flammable gases or liquids
3. Potential causes of ignition-fuel interactions	a. Design, construction, or installation deficiency (for example, electrical installation, no fire stopping)
	b. Mechanical or electrical system/component/equipment failure
	c. Unsafe use by occupant of ignition source and/or fuel (for example, cooking with open flame)
	d. Error in operating equipment (for example, industrial process)
	e. Arson
	f. Natural causes (for example, lightning strike, wildland fire)
	g. Accidental exposure (for example, exterior vehicle fire)
4. Operational practices that impact prevention of ignitions	a. Inadequate ITM equipment and systems
	b. Inadequate fire safety/fire risk management planning, testing, and implementation
	c. Inadequate fire and evacuation training and education of building occupants and operators
	d. Inadequate policies and procedures (for example, no smoking)
	e. Inadequate environmental and occupational health and safety policies related to fire
	f. Inadequate environmental and occupational health and safety training of staff

[25] Some of the text and figures are excerpted and adapted from the *Performance-Based Guidelines for the Design and Construction of UNDG Common Premises Office Buildings*, United Nations Development Group, ©2012 United Nations. Used with the permission of the United Nations.

In which regulation—and where in the regulation provisions—the factors may be found will depend on the regulatory structure of the jurisdiction. However, many building regulations include sections on the following, which should be reviewed:

- Electrical services, electrical equipment, photovoltaic systems, energy storage systems.
- Piped gas services and appliances (for example, heating, cooking).

Building regulations may or may not include fire safety and evacuation training requirements. Likewise, building regulations often address bulk storage (for example, warehouse and storage facilities) and acceptable amounts of flammable and combustible liquids and other materials, but typically do not address "normal" contents and furnishings (for example, chairs, tables, and bedding).

Table 8 summarizes key fire prevention factors as addressed in the review diagnostic.

Table 8. Key fire prevention factors

Driving Feature	Impacts on Fire and Life Safety	Regulatory Considerations
1.1 Controls on electrical systems & appliances	In formal construction, electrical sources are a significant source of fire ignitions globally. This can result from the electrical infrastructure and/or connected appliances. This is also a major factor in informal construction, especially where power is drawn from inadequate and often illegal electric utility connections.	Proper installation of electrical infrastructure outside, leading to, and within buildings. Internal to buildings: proper circuit breakers, surge interruption, protection of wiring (that is, in rated jacket material, conduit, etc.) and related issues to minimize potential for ignition via electrical systems and/or connected appliances.
1.2 Controls on solid, liquid, and gaseous fuels and appliances	The presence of solid, liquid, and gaseous fuels for heating and cooking purposes is a source of potential fire ignitions. This can result from inadequately connected appliances, improper use of appliances, problems with piping and/or storage, and problems with interaction with electrical systems and appliances.	Proper installation of solid, liquid, or gaseous fuel infrastructure, outside, leading to, and within buildings. Internal to buildings: proper piping, storage, connections to appliances, separation distances, venting, and related issues to minimize potential for ignition and/or subsequent contribution to the fuel load.
1.3 Controls on hazardous material storage	Stored materials with high ignition potential and/or significant burning characteristics can present significant fire hazards. In large quantities these can overwhelm building fire safety systems. The amounts should be limited and storage requirements specified.	Limitations on amount of flammable, combustible, and explosive materials; requirements for storage containers and/or compartments; fire protection systems (for example, suppression systems, venting systems, or other).
1.4 Controls on smoking/ operations with hot surfaces	Smoking materials are a major source of fire ignitions, as is operational equipment with exposed hot surfaces, which can ignite nearby materials.	Prohibition of smoking within buildings and within defined distances; requirements for smoking material disposal; requirements for separation of hot surfaces from required equipment to combustible materials.
1.5 Controls during construction/renovation	A significant source of fires in buildings under construction and undergoing renovation is hot works, such as welding. In addition, buildings under construction and renovation may not have complete fire safety systems in place and may have hazards such as paint thinner and others, which could have self-ignition and flammable gas concerns.	Requirements for hot works permits; painting permits; hazardous waste disposal; fire watches; temporary suppression systems; and related items.

B.2 Resistance to Fire/Spread of Fire

As used here, resistance to fire/spread of fire refers to those features and systems that resist the influences or inhibit the spread of fire and sometimes smoke into, out of, and within a building. This component includes:

i) the resistance of a material to ignition and combustion and failure of materials and systems due to heat or thermal radiation from a fire and

ii) the resistance or protection of an opening in wall, ceiling, or floor against fire spread, hot gases, and smoke through the opening.

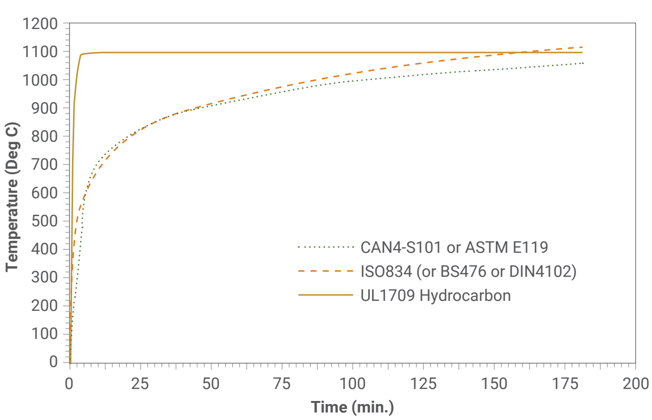
While there is a large range and diversity in the terms used to identify and describe resistance to fire/fire spread components within regulations and more broadly in the literature, they are generally focused on minimizing the potential for a fire external to a building from getting in, for a fire within a building from spreading from one space to another in the building, and for a fire spreading from a building to an adjacent property.

Fire Resistance

Many building materials are required by regulation to be tested and rated on their ability to resist the increased temperatures associated with a fire for a defined period of time without failing to perform their intended function. To facilitate a common mode of reference for establishing fire resistance, standard test methods exist which essentially result in the application of a specific time-temperature relationship to a building element, product, system, or assembly in a specially designed test furnace. A fire resistance rating is determined based on the time at which the material “fails” under the criteria established within the test method. This is illustrated below.

Two exemplar test standards for fire resistance are ISO Standard 834 and the American Society of Testing and Materials (ASTM) Standard E119. Ratings are typically provided in terms of minutes or hours, depending on the standard used (for example, 15-minute, 30-minute, 60-minute, 90-minute, and so on, or 1-hour, 2-hour, 3-hour, and so on). The determination of what fire resistance rating is required for different building elements,

Figure 9. Time-temperature curve



Source: File:Din iso astm ul curves.JPG - Wikimedia Commons

Figure 10. Large-scale fire test furnace

Source: Brian Meacham

products, systems, or assemblies is typically defined in building regulations (codes) or associated compliance documents.[26]

In general, the fire resistance rating that is required by a building regulation for a building element, product, system, or assembly increases based on the relative importance of that building feature to a building's overall fire performance. As such, primary structural systems (for example, columns and beams) and fire separation walls and shaft walls will have higher fire resistance requirements than non-structural partitions and other walls not forming part of the egress system. This concept generally holds true whether fire protection requirements are established based on regulatory provisions or engineering analysis (that is, more important elements are required to resist temperatures longer than less important elements).

Within building regulations, FRR are generally required for load-bearing elements, such as columns, beams, trusses and joists, floor and ceiling assemblies, fire walls used to separate buildings or major building uses, and certain types/classes of interior partitions, which are intended to restrict fire spread within or between floors (variously defined as fire compartments, fire cells, and similar) and into the exit system.

Surface Flame Spread

A significant concern in buildings is flame spread along/just above the surface of a material. This is particularly the case for ceiling and wall linings, but also floor covering on the interior of a building and the external wall/façade surface and roof on the exterior of a building. Combustible surface lining materials can facilitate the rapid spread of flame and are therefore typically limited in quantity and/or prohibited in several building use groups, in particular within means of egress (escape pathways) on the interior and on exterior walls of high-rise buildings.

Figure 11. Photos of vertical flame spread test for two wall lining materials

Source: Brian Meacham

[26] In countries which have performance-based building regulations (codes), details such as fire resistance ratings are often not defined within the regulation. However, as a companion to the regulation, there is typically a compliance document (approved document, DtS solution, etc.) of some sort that provides one or more means of complying with the regulation, and such compliance documents often provide guidance on fire resistance requirements for various building elements.

There is a wide range of approaches and test standards for surface flame spread. Most are "index" type test standards, which report comparative outcomes based on a defined scale or index (for example, materials reported as Class A, Class B, or Class C as per associated flame spread index determined by testing).

For interior ceiling and wall finishes, ASTM E84 (or equivalent) is most often used in the US. ASTM E84 tests materials in the ceiling configuration. In Europe, the Single Burning Item test, EN 13823:2020, is the fundamental standard. This 'reaction to fire' test is used to assess the fire performance of most construction products (excluding floorings), measuring flame spread, smoke production, heat release rate and burning droplet production. The Single Burning Item test evaluates materials in a corner configuration (materials on walls and ceiling). There is also a room corner test in the US (NFPA 286) and internationally (ISO 9705). A wide range of tests exist for exterior wall assemblies as well (for example, NFPA 285, BS 8414, DIN 4102-20, and AS 5113).

It should be noted that not all standard test methods deliver the same information. As such, it is important to understand what outcomes are reported, and whether those outcomes are compatible with the building regulations and other reference standards.

Compartment Fire Spread

Fire spread within a compartment is a complex phenomenon. For the purpose of this checklist, the dominant mechanisms for fire spread (and increased localized and compartment temperatures) can be considered ignition of materials due to direct flame impingement and to thermal radiation.

Flame impingement can be important in such situations as igniting combustible items stored above the fire source (for example, flame from burning items on a low shelf of a storage rack impinges upon and ignites combustible materials above), flame extension horizontally along a ceiling igniting other combustibles, or flame extension outside of a compartment and igniting materials in an adjacent space (for example, from one space to another within a building through an open doorway).

Figure 12. Flame impingement on ceiling

Source: US NIST

Thermal radiation can result in the ignition of nearby materials in the following ways:

- The initiation fire (first materials burning) in a compartment creates a sufficiently high radiant heat flux to ignite a nearby item (or items).
- The initiation fire in a compartment is sufficiently large, and the compartment is sufficiently small, such that the fire creates a sufficiently hot upper gas layer that radiates thermal energy downward to other materials in the compartment, causing them to ignite (when all secondary items in the compartment ignite at about the same time, the phenomenon is known as flashover, and the resulting condition is referred to as full room involvement).
- Hot gases escaping the compartment extend into an adjacent space, ignite, and result in flame extension or an extended hot upper gas layer, which ignites additional materials as per the above mechanisms.

The sequence of fire growing from the initiation fire to flashover through the creation of a hot upper gas layer and subsequent ignition of other materials in a compartment is illustrated below.

Figure 13. Initial item burning

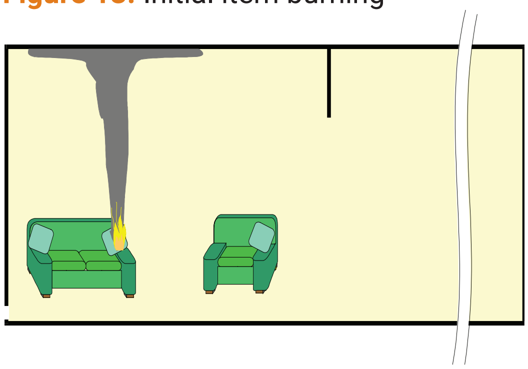


Figure 14. Hot gas layer forms

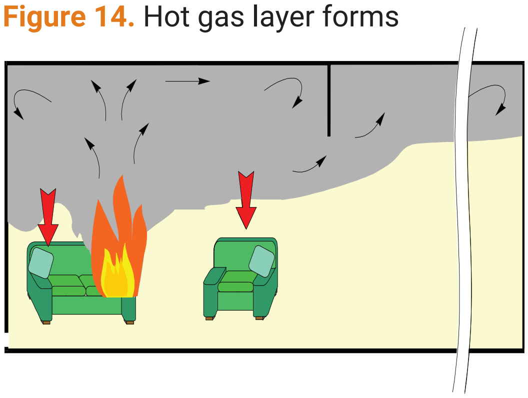
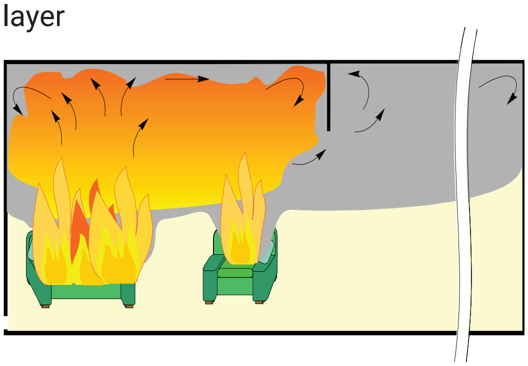


Figure 15. Radiant ignition from upper layer



Source: UN, 2012

The above illustrations can also be used to imagine item-to-item radiant ignition. Here, assume there is no ceiling or that the ceiling is very high. In this case, the initiation fire would still likely grow to engulf the entire sofa (last illustration), at which point the energy output would likely be high enough to ignite the nearby chair. This concept also applies to radiant ignition via windows or other exterior openings (inside-to-outside and vice versa).

Given that fire spread results primarily from flame impingement or thermal radiation (from a burning item or a hot gas layer), the control of fire spread through passive features is aimed at keeping the fire and resulting hot gases contained to the compartment (room, space) of fire origin. This is accomplished by having compartment barriers that resist ignition and failure under high temperatures, by using fire sealant and fire stop materials around compartment boundaries (especially fire-rated compartment boundaries), and by protecting openings in compartment barriers, vertical shafts, ventilation ductwork, plenums, and similar spaces so as to prohibit or limit flame extension or the spread of hot gases (using measures such as heat-activated dampers, door closers, and shutters).

Smoke Spread

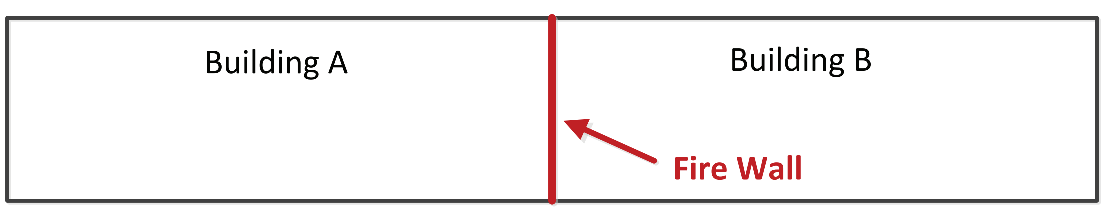
Much like controlling the fire spread by containment to the compartment of origin, the aim of passive means of smoke control are to limit the ability of smoke to pass from one compartment to another by protecting openings in compartment barriers, vertical shafts, ventilation ductwork, plenums, and similar spaces. While passive smoke control measures are similar to controls for the spread of hot gases (for example, sealants and opening protectives), the difference is that smoke can be toxic at low temperatures, so passive smoke control measures should consider low energy fires (smoldering, sprinkler controlled) as well as larger fires. Of particular concern is the spread of smoke into the exit system and vertically throughout the building. While the use of some opening protective devices may be temperature-actuated (for example, fire doors, dampers, and shutters), others may be actuated by smoke detectors (for example, smoke dampers and door closers).

Compartment barriers

While the concept of using compartment barriers (compartmentation) for the control of fire and smoke spread is easy to understand, the descriptions and definitions of the various levels of compartmentation are numerous, and it can sometimes be difficult to understand why the differences exist. This is further complicated by the use of different terms for the same function in different countries (for example, a fire area in the US is essentially the same as a fire cell in New Zealand or a compartment in England, but the FRR of compartment barriers, the allowable floor areas, and protection of openings all differ by country). The following represents a sample of barrier terminology. The definitions and discussion are not meant to be comprehensive, but to provide an overview of the concepts.

- **Fire walls** are building elements used to divide a single building into two or more buildings. Starting at the foundation and continuing vertically to or through the roof, a fire wall is intended to fully restrict the fire spread from one side of the wall to the other (as illustrated in the plan view below). Fire walls are higher level fire-resistance-rated building elements than both fire barriers and fire partitions. Because the concept of fire walls is to create smaller buildings within one larger structure, it is critical that a fire wall be capable of maintaining structural stability under fire conditions. If construction on either side of a fire wall should collapse, such a failure should not cause the fire wall to collapse for the prescribed fire-resistant time period of the wall.

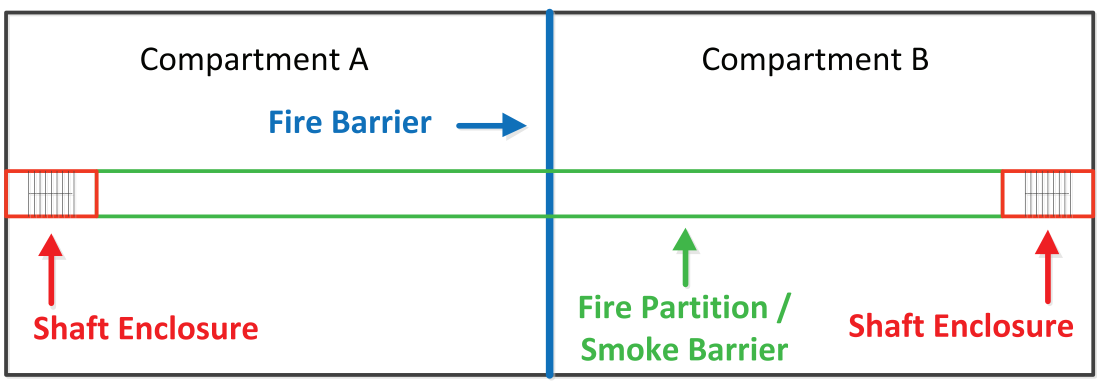
Figure 16. Illustration of fire wall



Source: UN, 2012

- **Fire barriers** are fire-resistance-rated building elements that create a barrier restricting fire spread to and from one portion of a building to another. All openings within a fire barrier should be protected with a fire-protective assembly. Fire barriers are often used to create smaller fire areas containing same uses of the building or to provide egress through a protected exit system. A common use of fire barriers is to totally isolate one portion of a floor level from another (fire compartment or fire area). This is illustrated in the floor plan below, where the fire barrier is used to separate a floor. This arrangement also serves to provide a horizontal exit, such that each compartment has two exits: stair and horizontal exit.

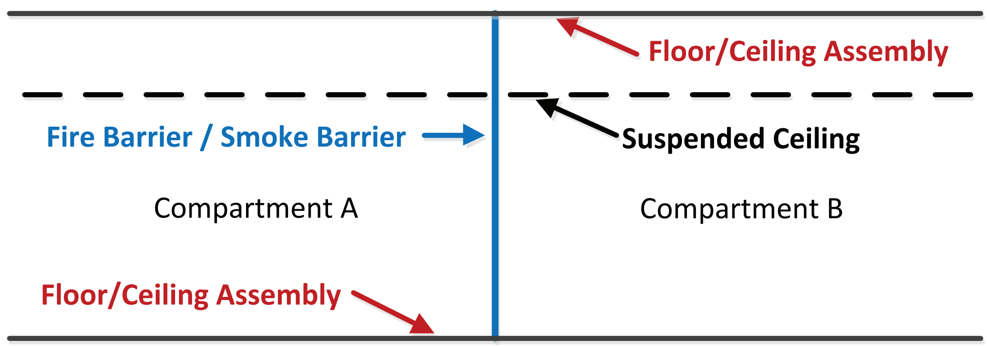
Figure 17. Illustration of fire barrier and shaft enclosures



Source: UN, 2012

- **Shaft enclosures** are intended to restrict the fire spread, hot gases, and smoke vertically within a building. Shaft enclosures are typically required to have an FRR equivalent to the floors/ceilings through which the shaft penetrates. Exit stairways, elevator shafts, pipe chases, and rubbish chutes are examples where shaft enclosure requirements would apply. The above shows a shaft enclosure around the exit stairways.
- A **fire partition** is a wall or similar vertical building element that is utilized to provide fire-resistive protection under specific conditions, such as corridor walls (see above). A fire partition is considered a lower type of fire-resistance-rated assembly than a fire barrier; accordingly, it is not permitted as an enclosure element for defining a fire area.
- **Smoke barriers** are intended to prevent the spread of smoke from one floor or area of a floor to another. Smoke barriers should form an effective membrane continuous from outside wall to outside wall, and from the top of the foundation or floor/ceiling assembly below to the underside of the floor or roof sheathing, deck, or slab above, including continuity through concealed spaces, such as those found above suspended ceilings, and interstitial structural and mechanical spaces. This is illustrated in the elevation view below, where the smoke barrier (blue) is continuous from floor deck to the underside of the ceiling deck,

Figure 18. Illustration of fire/smoke barrier



Source: UN, 2012

even through the interstitial space above the suspended ceiling (dashed line).[27] Smoke barriers typically have a 1 hour fire-resistance rating. In the above diagram, the corridor wall (fire partition) could also serve as a smoke barrier, if properly installed and protected.

- A **smoke partition** is intended to restrict the spread of smoke from one area to another, but is not required to restrict the spread of flame and heat, and therefore has no FRR requirement.

Penetrations and openings in the above barriers, shafts, and partitions (including doors, ducts and plenums) are typically required to be sealed or protected, respectively, by materials, systems, or components that match the barrier performance (in terms of FRR, restriction of smoke passage, etc.). Concealed spaces, if breached by fire, can provide a route for fire spread, hot gases, and smoke. Care should therefore be taken to provide barriers against fire spread, hot gases, and smoke, and to restrict the use of combustible materials (other than allowable combustible building elements) in concealed spaces.

Smoke control (management) systems

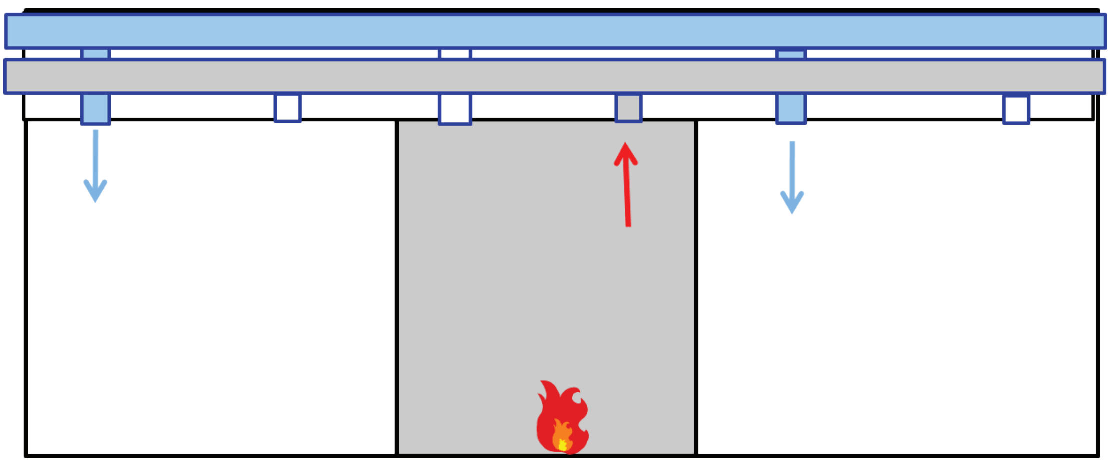
Smoke control systems, or smoke management systems as they are also known, serve two primary functions: restricting the passage of smoke from one area to another, and venting or exhausting smoke from a building or portion of a building to the outside. Systems designed to restrict the passage of smoke from one area to another may use dampers in ductwork and return air plenums and may use fans to provide pressure differentials (to keep smoke contained to a specific area). They are often coupled with either independent smoke detection devices (such as in-duct smoke detectors) to close dampers or may receive input from a fire alarm control unit (FACU) or building management system. Such systems may require the use of self-closing doors or employ automatic door release/closure devices, where doors are

[27] Note that fire barriers need to be continuous from deck-to-deck in the same manner.

electromechanically held open during normal use, but release (close) upon activation of a local smoke detector or the FAS. Smoke control systems need to be closely coordinated with passive fire protection systems.

Smoke control systems can be complex, with requirements varying by country, by region, and by standard. The concept of using positive and negative pressure to contain or restrict the passage of smoke can be targeted at whatever level is desired (for example, floor of a building, compartment within a floor, exit stair enclosures, stair or elevator vestibule (lobby), etc.) and may be required in some instances, such as within high-rise buildings.

Figure 19. Illustration of exhaust of smoke from fire compartment with positive pressure in adjacent compartments

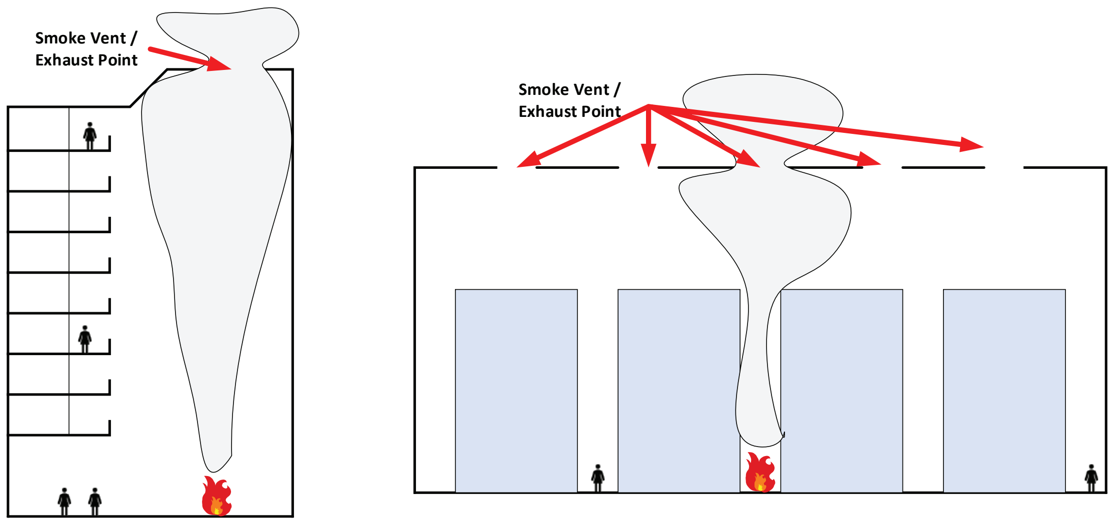


Source: Brian Meacham

Smoke control or management systems used specifically to exhaust smoke from a particular space, such as an atrium in a high-rise building or a large warehouse, may employ natural ventilation (that is, smoke or heat actuated vents) or mechanical exhaust. In either case, the aim is to provide sufficient venting or exhaust capacity to remove the required amount of smoke for the target time. Such systems are often used to maintain the smoke layer above a certain point from the highest occupied floor level during occupant evacuation.

Key aspects for smoke exhaust system design include the design fire size (which dictates how much smoke will be produced), the level at which the smoke layer needs to be maintained and for how long, availability of make-up air, and location and size of vents or exhaust ducts and fans. Reliable primary and backup power is required.

Figure 20. Illustration of smoke vent/exhaust in atrium and warehouse



Source: Brian Meacham

Exterior Fire Spread

With respect to exterior walls and roof assemblies, flame impingement and thermal radiation can be important in situations such as flame extension into or out of an opening. Depending on building geometry, flames extending out of an opening could come in contact with a surface, which if combustible could result in ignition, or could otherwise cause damage depending on the material (for example, flame impingement could cause breakage of glass in window opening or façade). Similar responses can result from thermal radiation emanating from the flame as well (ignition of materials and breakage of glass). This is a common form of building-to-building fire spread.

Figure 21. Impact of fire spread between informal structures

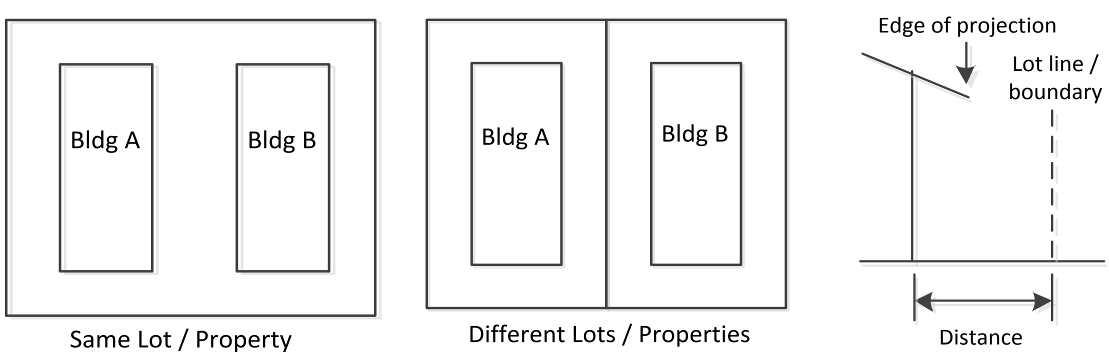
Source: ©Justin Sullivan, 2018

The reverse situation is also of concern, where direct flame impingement or thermal radiation from exterior fire threats, such as from adjacent buildings, exterior combustibles (for example, trash or stored combustible materials), or wildland fires, could result in ignition of the exterior or interior of the building of concern. In addition, in areas prone to wildland fires, additional threats exist in terms of burning brands which may come to rest on combustible surfaces, in some cases being driven by winds through screening and other protective measures.

To address these concerns there are two primary strategies: provide adequate separation distance between the building of concern and other buildings, property, and vegetation; or protect the exterior wall and roof assemblies through the choice of materials, limitation in openings, and/or protection of openings. A few key concepts are illustrated below.

The first two diagrams show that typically, some level of separation distance is required between buildings on the same lot (property) or adjacent lots, particularly when the exterior walls and roof assemblies are combustible or have unprotected openings. This not only helps to reduce the likelihood of building-to-building ignition but also allows access for fire service apparatus. In some cases, the distance will be impacted by building shapes or features, such as projection (as in a roof overhang). In such cases, distances may need to be increased, since the overhang could trap hot gases and result in a more intense (hotter) fire. The required distances may be set by regulation or calculation.

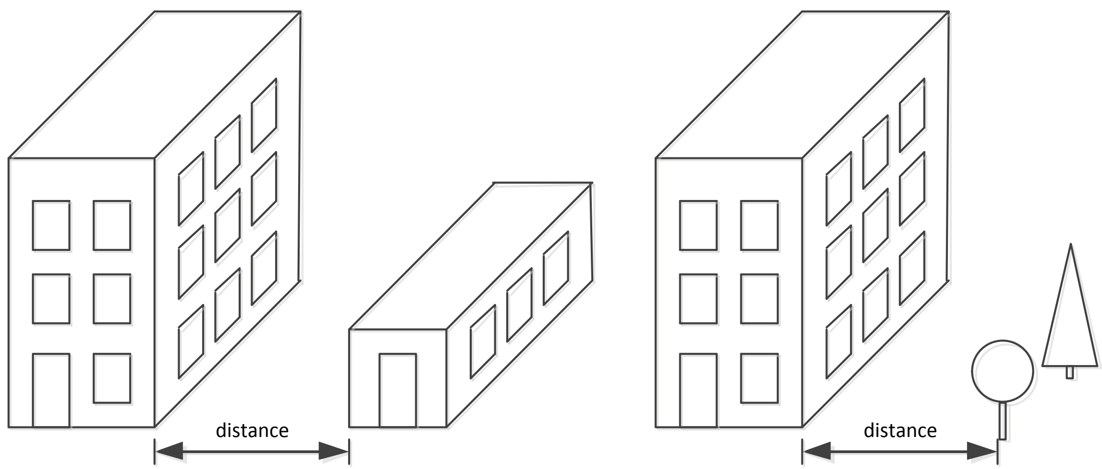
Figure 22. Illustration of building and lot separation



Source: UN, 2012

The following diagrams illustrate issues associated with unprotected openings (windows, in this case), which play a role in distances from other properties and from vegetation (in areas prone to wildland fires). There may also be concerns with the height of adjacent buildings, especially with respect to roof construction, but also from general fire exposure. With respect to roof construction, the lower building in the diagram below would be exposed to radiant energy from a fire in the taller building, which would impact the fire resistance requirements for the roof of the lower building and/or the protection of openings in the exposed sides of each building.

Figure 23. Illustration of separation based on unprotected openings



Source: UN, 2012

Given the wide range of construction materials, exterior wall (cladding) materials, and roof materials, there are numerous ways to address the above concerns, ranging from well-defined regulatory requirements for separation and protection based on combinations of materials, construction and distance, to engineering analysis of thermal radiation exposure.

Wildland Fires

Wildland fire is a growing threat in many parts of the world. As urban environments expand into the natural environment, and with climate change increasing temperatures, extending droughts, and increasing wind speeds, the potential for fires in the wildland-urban interface are growing. This has prompted many governments to include consideration of wildland fire prevention and mitigation into planning and building regulations.

In addition to the external building fire protection approaches outlined above, additional protection for buildings includes the use of metal screening to prevent embers from impacting windows or penetrating openings, such as roof vents.

Also, the concept of creating "defensible spaces" around buildings is included in some regulations. Defensible space is the buffer space created between a building and the grass, trees, shrubs, or any wildland area that surrounds it. This space can be helpful to slow or stop the spread of wildfire and can help protect a building from igniting from embers, direct flame contact, or radiant heat.

Table 9 summarizes key resistance to fire/fire spread concepts.

Table 9. Key resistance to fire/spread of fire concepts

Driving Feature	Impacts on Fire and Life Safety	Regulatory Considerations
2.1 Fire resistance of structural system	Structural stability in case of fire.	Fire resistance of structural frame, interior and exterior walls, doors, ceilings, floors, and roofs. Acceptable materials, test standards, overall height and area consideration, size of compartments, other fire protection systems.
2.2 Resistance of interior walls, ceilings, floors, and shafts	Control/limit fire spread between compartments.	Fire resistance of interior walls, exterior walls, doors, windows, and opening protection. Barrier construction, opening protection (for example, doors), area of exterior windows, building spacing (to building or property line), test standards.
2.3 Resistance to flame spread – interior surfaces	Control/limit fire spread on surfaces and contribution to fire size and smoke production.	Combustible interior finish materials can significantly contribute to fuel load, fire spread, and smoke spread. Materials with higher resistance to spread of flame/smoke help to reduce risks.
2.4 Resistance to flame spread – exterior surfaces	Control/limit fire spread on surfaces and contribution to fire size and smoke production.	Requirements for exterior wall (cladding, façade) material and construction; materials, design and construction of roof assembly; planning and resource restrictions; area and height of building; exterior vegetation.
2.5 Protection of openings in exterior	Control fire spread from interior to outside, or exterior to interior.	Area, location, and protection of openings (windows, vents, etc.), distance from other buildings, storage, lot lines.
2.6 Building/lot separation & exterior fires	Control fire spread from one building/ property to another.	Distance from other buildings, storage, lot lines.
2.7 Smoke control/ management	Control/limit smoke spread between compartments, via ducts, cavities, etc., and provide for smoke exhaust where needed.	Resistance to smoke flow via interior walls, doors, ducts, plenums. Requires contiguous barriers, usually requires mechanical dampers, and may also need active systems. Smoke exhaust may require operable windows or vents, or require mechanical smoke exhaust systems.

B.3 Occupant Safety, Refuge and Egress

Detection is the first step in identifying the presence of a fire and triggering subsequent action, such as occupant evacuation. Fire detection, alarm, and communications systems provide the opportunity to detect fire through a wide range of automatic fire detection devices, provide a means for manual fire alarm initiation, provide for a range of alarm signaling capabilities (audible (voice or non-voice) and visual), and provide interfaces with other fire protection systems (such as smoke control/management systems) and other building systems, as appropriate. The types of fire detection, alarm, and communications equipment required in buildings with different occupancy/use classifications vary widely by country and local regulation and based on the other fire safety systems installed.

Fire Detection, Alarm and Communication Systems

Automatic fire detection devices include smoke, heat, gas (for example, CO), and flame detectors, as well as water flow switches within sprinkler systems, and occasionally other safety-related initiation devices. The extent to which smoke, heat, and gas detectors are required varies based on building use, height, the presence of sprinklers and other fire protection systems, and the country where the building is located (for example, if sprinklers are installed, area smoke detection typically is not required; in high-rise buildings, smoke detectors are usually found in lift lobbies to initiation elevator recall; etc.).

Manual fire alarm stations (boxes, points, buttons) are used to manually activate the FAS. They are typically located near exit doors which discharge directly to the outside, as well as at the entry point to an exit enclosure (for example, exit stairway) in multi-story buildings and within pre-determined travel distances within buildings with long travel distances to an exit.

Figure 24. Smoke detector

Source: UN, 2012

Figure 25. Manual fire alarm station

Source: UN, 2012

Figure 26. Horn/strobe unit

Source: Brian Meacham

Fire detection and alarm systems are typically controlled by an FACU (panel, system). The FACU receives input from automatic fire detection and manual alarm devices, initiates alarm signals to occupants within the building, and in some cases, notifies the local fire service, and when needed, activates other fire protection systems, such as door releases, smoke exhaust fans and dampers, and so forth. FACUs and alarm signaling systems (see below) require reliable primary and backup power.

The fire alarm (or occupant notification) component typically consists of audible and visual signals. Audible signals may be provided by bells, horns, buzzers, or similar non-voice devices, or by audio speakers. In some situations, such as high-rise buildings, pre-recorded and live voice systems are required. Visual signals are typically provided by strobe lights or other approved visual alarm indicators. High-rise buildings may also require two-way communication systems for use by firefighters, typically located within or near stairways and elevator lobbies.

Means of Egress

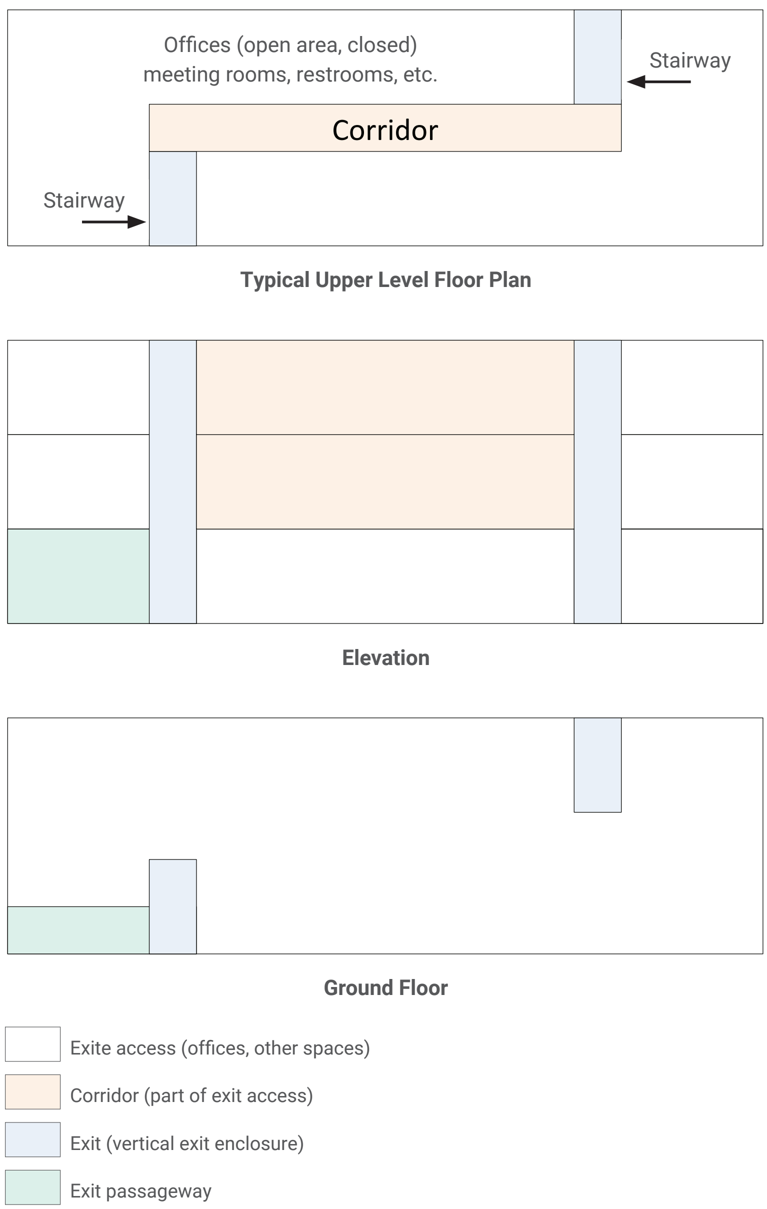
The means of egress (sometimes referred to as 'means of escape') describes the path of travel that a building occupant encounters, starting with any occupiable point in a building, and ending when they reach a public way outside of the building (for example, public walkway, street, alley, etc.).

Means of egress is often described in terms of three fundamental components: the **exit access**, which is unprotected or has limited protection and includes the portion of the building between any occupied point and an exit; the **exit**, which provides a protected path of egress from the exit access; and the **exit discharge**, which is outside the building and is the section between the point where occupants leave an exit and the point where they reach a public way.

The means of egress components can be visualized with the help of the figures below, which is a generalized representation of a three-story office building. The top illustration reflects a typical floor, highlighting the corridor (pink), which is part of the exit access system (path to get to an exit) and two exits, which are on the upper floors of the building, are protected stairways (blue). The middle illustration is an elevation, or side view, showing the corridors (exit access) on floors 1 and 2 (pink), the exits, shown in this view as vertical stairway enclosures (blue), and an exit passageway (green) on the ground floor, which is a protected path to the outside. The bottom illustration shows how an exit stairway may discharge directly to the outside (top right) or connect to an exit passageway (green, lower left), which in turn discharges to the outside. In these diagrams, the blue and the green reflect the protected components that make up the exit, and white and pink are unprotected spaces occupants must walk through to reach a protected exit.

Typically, the exit access component makes up most of the means of egress in a building, as it essentially covers all of the occupied portions of the building aside from the exit (white and pink spaces). Depending on the building use or occupancy classification, many parts of an exit access have no particular requirements for protection (for example, from smoke or flame), except where separation is required due to limits on compartment size or for separation from other uses in the buildings that may be more hazardous (for example, kitchen).

Figure 28. Illustration of components of egress (escape) system



Source: UN, 2012

Some exit access components, such as corridors (pink), may have smoke- or fire-protective features to help maintain safe environments while occupants exit the space. Components that make up the exits are typically protected by fire-resistance-rated construction and other safety features, as the intent is to provide a protected environment from the time occupants enter the exit until they are discharged outside of the building.

A means of egress often includes both vertical (for example, protected stairway) and horizontal components. To aid safe egress in an emergency, means of egress should be designed, constructed, and maintained to be obvious, continuous, direct, unobstructed, and undiminished. Features such as unobstructed and illuminated exit signage, emergency lighting, and photoluminescent markings help make the means of egress obvious. Accessibility is also a consideration.

Direct and continuous means of egress is often achieved through such features as corridors connecting to vertical exit enclosures housing stairways, the use of horizontal exit enclosures if occupants need to change from one stairwell to another on a transfer floor (as may be the case in high-rise buildings), and the use of exit passageways to reach the exterior of the building on the ground level. In some very tall buildings, lifts may sometimes be used. However, lifts are often recalled to the primary level of exit discharge upon activation of the fire alarm for fire service use.

Unobstructed means of egress are a function of design (for example, providing minimum functional corridor widths and heights, door openings, stairway widths, and headroom;

minimizing wall-mounted fixtures within the path or travel, etc.) and operational procedures (for example, keeping furniture and storage out of corridors, stairways landings, exit passageways, etc.). Undiminished means of egress are those that maintain their required capacities throughout (for example, widths and capacities for the occupant load anticipated).

Building Use/Occupancy Classification

A building's use or occupancy classification is important as it is typically used to convey to designers, users, and emergency responders a sense of key attributes, such as activities (for example, residential, retail, medical, office space, etc., as well as time of day and day of week the building is occupied), associated occupant characteristics (for example, awake or asleep, restrained, medicated, or otherwise incapable of self-evacuation, familiarity with the building layout, etc.), and hazards that may be present (for example, combustible or flammable liquid storage, natural gas, propane or other flammable gases for heating or cooking, hazardous operations, etc.). For example, considering the aforementioned factors, if a building primarily houses offices, the egress requirements would be different than if a building housed a large assembly space (for example, movie theater), medical facilities, or residential units.

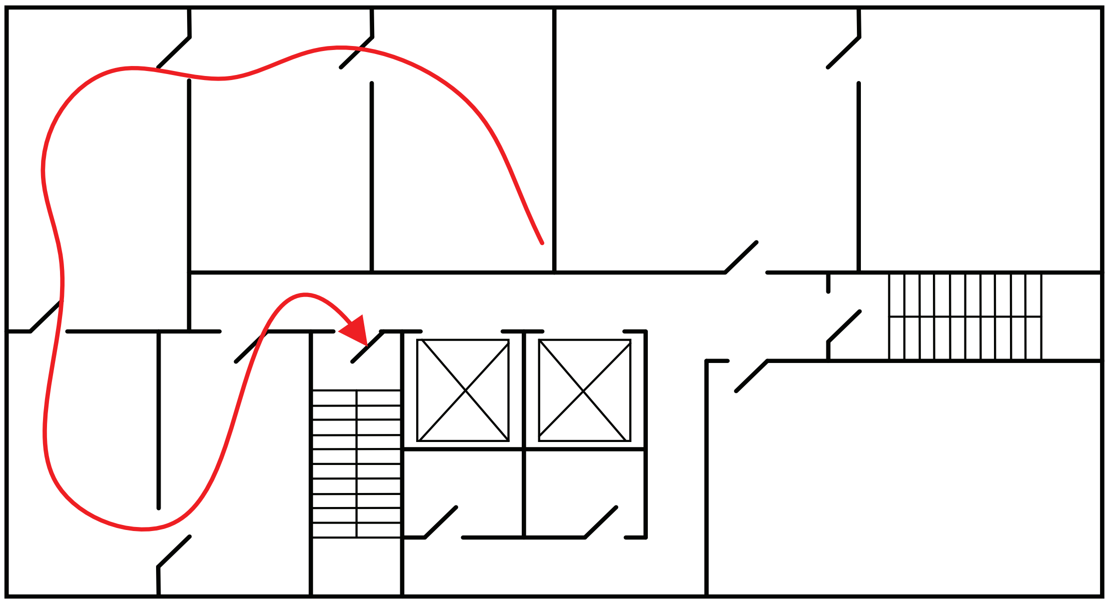
Travel Distance, Number, Arrangement and Capacity

The number, arrangement, and capacity of exits required for portions of a building and for the entire building (all spaces) are largely a function of the use/occupancy classification of the building, travel distance to an exit, the occupant load, and the expected characteristics of the occupants (for example, age, ability, etc.). Protection of the exits is dependent upon the above factors, as well as on the size of the building (height and area) and fire safety systems installed.

In egress system design, travel distance and exit separation are important because of the time required for occupants to reach an exit and the potential hazards occupants may face along the way. Occupant load is important due to factors such as occupant density and the related reduction in movement speed; occupant density and flow through corridors, down or up stairs, and through doorways; and the number of persons at risk during an event (for example, fire, earthquake, deliberate event, etc.).

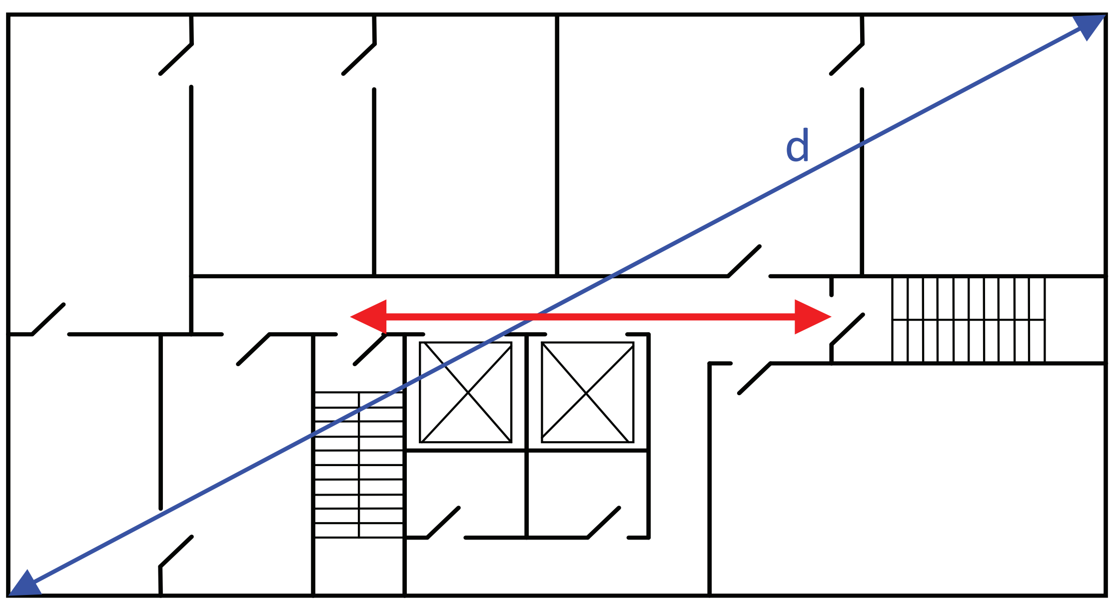
Factors that influence allowable travel distance include location and number of exits (per building, per floor in a building), fire resistance of exit access components, and presence of an automatic sprinkler system (travel distances are typically allowed to be longer in sprinklered buildings). Travel distance is generally measured from the most remote point, along travelable paths (for example, around obstructions, through doorways) to the point of entering an exit (for example, door to protected stairwell, door to the exterior), as shown in the red curved line below. Requirements for exit separation (remoteness) should consider the overall dimensions of the floorplate, travel distance, and number of exits. Generally, it is recommended that exits be separated by at least 1/2 the diagonal dimension of the floor plate (1/3 if building is sprinklered). Co-locating two exits in the same shaft of a high-rise building, for example, should be avoided when possible, so as to minimize dead-end corridors and facilitate egress options in case of a fire event that might block access to one of the exits.

Figure 29. Illustration of travel distance to exit



Source: UN, 2012

Figure 30. Illustration of exit separation



Source: UN, 2012

Occupant Characteristics

Occupant characteristics reflect those attributes of the expected occupants which may be important to response, decision-making, and susceptibility to hazard events. Regulatory provisions for egress systems should take into account such factors as occupant familiarity with the building and exits, occupant roles and responsibilities—particularly where delays may be associated with waiting for a responsible person to indicate the need to evacuate the building—and the presence and number of sensitive or vulnerable populations.

Height and Construction

Building height is important with respect to availability of exits, travel distance, travel time, and the ability for emergency personnel to undertake operations. In high-rise buildings, there are typically only a few exits (two to four vertical exit enclosures housing stairways), significant queue times could be expected, and walking speeds are slower on stairs than on horizontal surfaces. In addition, firefighting and rescue apparatus cannot reach above the fifth floor above street level of most buildings, meaning there may be counter flow on stairs as firefighters are going up as occupants are going down, which can further slow egress, and at least one stairway may be taken out of use by firefighters who are staging an attack, thereby reducing the overall number of available exits and exit capacity.

Building construction is important with respect to response of the building to the hazard of concern. With respect to egress design, building construction often focuses on combustibility of the framing material and associated resistance to fire, particularly when no suppression systems are installed. More combustible materials, such as light frame timber, are typically limited in height and area since less fire protection may be afforded to occupants, whereas concrete structures in some cases have no height or area limitation, as they are typically expected to withstand a fire for a period of time to allow evacuation and firefighting operations. However, construction is also important for egress for hazards such as earthquake and deliberate events, where damage to the structure and non-structural systems could result in damage to means of egress.

Occupant Self-Evacuation Lifts

For supertall buildings, because of the vertical distance and time required to evacuate a building solely via stairways, some countries permit the use of occupant self-evacuation lifts. Occupant self-evacuation lifts typically have additional protection so that they can be used during emergencies. This may include higher fire resistance of the elevator shaft walls, smoke-protected lift lobbies, protection against water entry and impacts to the lift cab, shaft and equipment, messaging, and means of communication for occupants who are waiting for the lifts.

Signage, Pathway Marking, and Communications

To help facilitate safe egress during emergencies, exit signage, pathway marking and illumination, and fire safety and communications systems play significant roles. This starts with detecting fires, notifying and communicating with occupants, providing clear indication of exit pathways, notifying emergency responders, providing smoke control or management for tenability, suppressing or controlling fires, preventing the passage of smoke or fire from one compartment to another, and providing for emergency responder communications.

Table 10 summarizes key occupant safety, refuge, and egress concepts.

Table 10. Key occupant safety, refuge, and egress concepts

Driving Feature	Impacts on Fire and Life Safety	Regulatory Considerations
3.1 Fire detection	Facilitates early detection of fire conditions (smoke, heat, flame) to facilitate occupant evacuation and fire service response.	Early detection of a fire requires some form(s) of smoke, heat, CO and/or flame detection. Residential may have self-contained smoke alarms. Other uses may have system-connected devices.
3.2 Occupant and fire service notification		Should be some form of FAS in all buildings to notify occupants and facilitate fire service response. All fire alarm and communication systems and components need to be maintained, inspected, and tested to assure proper operation.
3.3 Protected means of escape/refuge	Ability to safely reach an exit in the case of a fire; time required to reach an exit/refuge area; and ability to safely reach an exit if one is compromised by fire.	Protection of exit access, exit enclosures, exit passageways, horizontal exits, exit stairways, vertical exit enclosures, occupant load, building size and layout, building type/construction, and other safety systems.
3.4 Occupant load, travel distance, exit capacity	Speed of movement, flow through openings, ability to self-evacuate, exit protection, easily opening and unlocked doors.	Number of exits, exit capacity, protection of exit access and exit enclosures, exit discharge. Total travel distance should be such that safe egress is facilitated. Adequate separation in case one exit is compromised.
3.5 Occupant/occupancy characteristics (vulnerabilities)	Ability for persons of all abilities to safely evacuate a building in case of fire or another event.	To account for a range of abilities, it may be necessary to provide specific design parameters for stairs, ramps, doors, hardware, areas of refuge, lifts, and suitable audible, visual, and tactile means of communication.
3.6 Safety glazing, protection against falls, etc.	Occupants need to be protected from glass breakage in exits, expect regular walking surfaces and uniform stair configurations, and be protected from falls from height.	Safety of glazing in exit pathways, barriers for protection from falls on elevated walkways, atria, etc., smooth and uniform floor surfaces, stair dimensions, handrails in stairways, etc.
3.7 Signage, lighting, emergency power	Occupants need to be able to easily identify and locate exits and have adequate lighting. Critical lighting, alarm, and communications systems should have appropriate emergency power.	Aisles, aisle accessways, corridors, doors, hallways, stairs, steps, ramps, surfaces, and exit passages should be sized to maintain unobstructed and unrestricted flow; signage, illumination, and pathway marking should be readily identifiable and understood.

B.4 Fire Suppression

The aim of fire suppression components is to provide means to apply extinguishing agents to a fire. This can range from handheld fire extinguishers, building fire sprinkler systems, hydrant systems, pumps, and related equipment to support manual fire suppression activities by occupants and the fire service.

A primary consideration with water-based fire suppression, either automatic or manual, is an adequate and reliable water supply. This means not only sufficient volume of water for fire suppression activities, but appropriate flow rates and pressure to deliver the water where required. Water storage and fire pumps may be required to enhance municipal water supplies for such purposes.

Fire Suppression Water Supplies

The efficacy of any fixed water-based automatic or manual suppression system in a building is strongly related to the appropriateness and reliability of the water supply. There are three primary sources: piped supply (mains), on-site storage (tanks or perhaps ponds), and fire service connections (to standpipe or sprinkler system).

When assessing building fire suppression system needs, the type of system, source of water, and reliability of the system should be considered, especially where water supply infrastructure may be unreliable or water resources are limited. Fire suppression water flow rates, pressures, and minimum supply (quantity or time) requirements will be established by relevant design and installation standards for suppression systems and water supplies.

Piped (mains) systems typically rely on a local or regional water authority (government or privately owned and/or operated) to provide a connection from the nearest water main(s) into the building. To minimize the potential for loss of water supply due to a problem with the water authority system, it is generally recommended to have two separate lines into a building, particularly for high-rise or large area buildings. Inside of the building, a suite of check valves, backflow prevention valves, and other controls are used to isolate the fire suppression water from potable supplies. Where increased pressure is needed to support the hydraulic demands of sprinkler or standpipe systems, fire pumps may be used (see below).

In locations where there is no water authority piped mains system, the water supply infrastructure is unreliable, a supplemental water supply may be needed within the building, or water shortages can be expected due to climatic conditions (for example, drought), on-site storage is an option. In high-rise buildings, this may involve tanks within the building (basement, upper floors or roof). For water mist systems, there may be numerous tanks distributed in areas protected by the system. In some cases, the use of a dedicated fire suppression water pond or other outside source may be considered, but only if suitable controls are placed on screening of debris and the water supply (source) can be considered suitably reliable (for example, it would be inappropriate to rely on a source that cannot be expected to meet demands).

In locations where the water authority main supply lacks the pressure or flow rate to meet the design requirements for sprinklers and/or standpipe systems, a fire pump may be needed. Fire pumps come in a variety of sizes based on system design parameters, but are often located near the incoming mains (or on-site storage, if at a low level) and supply directly into the sprinkler and/or standpipe systems. Fire pumps are typically powered by diesel or electric motors, with a suitable emergency backup power source. Fire pumps should be sized to meet fire suppression needs for a period of time commensurate with the automatic and manual fire suppression systems design parameters (that is, most installation standards required flow and pressure criteria to be met for some minimum period of time).

Figure 31. Exemplar fire pump

Source: UN, 2012

Figure 32. Exterior connection to sprinkler system

Source: UN, 2012

In some buildings, particularly high-rise buildings, there will typically be fire service (fire department) connections outside of the building, which allow connection from the responding fire apparatus into the building's sprinkler and/or standpipe systems. These connections may be built into the exterior wall, come up through the ground (sidewalk or other surface), or have some other suitable arrangement. Threads of these external fire service connections should match local fire service hose connections.

Manual Fire Suppression Systems

Portable fire extinguishers discharge small amounts of water, gaseous, or chemical fire extinguishing agents when activated. Portable fire extinguishers are rated based on the suitability of the extinguishing agent for the expected hazard (for example, paper, liquid fuel, and electrical source).

Manual fire suppression systems include all systems which require human intervention and action, whether trained fire service, trained fire brigade, or trained building occupant. These systems include internal standpipe (hydrant) systems, interior hose systems, and portable fire extinguishers.

Standpipe (hydrant) systems consist of interior risers and branch lines aimed at distributing the fire suppression water supply to various points in a building, primarily for the use of the responding fire service, for connection of hoses to facilitate manual fire suppression operations. Such systems are generally seen in high-rise or large floor-plate buildings, where it is more challenging to effect fire suppression operations from outside of the building. Outlets will typically be a combination of on/off valve and fire service connection, which should be matched to the threads on hoses used by the local fire service. In tall buildings, such systems will include pressure reducing valves to regulate pressure to appropriate levels at each floor.

Although discouraged in several countries for reasons of user safety, some countries allow for interior hose systems for use by either responding firefighters or trained building occupants. Such systems are often characterized by small diameter, rigid hoses (like a garden hose) on hose reels (often called hose reel systems). These systems allow the user to turn on the water immediately and move toward the fire with a charged line. In some cases, interior hose systems have folded or rolled flat flexible hose, which needs to be first extended before the water supply is turned on.

Automatic Fire Suppression Systems

Automatic fire suppression systems encompass any system intended to suppress or extinguish a fire without the need for manual intervention. The most common automatic fire suppression system is the automatic fire sprinkler system. There are other water-based systems as well, including fine water mist, deluge, and foam systems, which are variations on a theme (water, pipes, and nozzles). There are also gaseous and chemical fire extinguishing systems, which are typically used for special applications, such as in electrical equipment rooms, kitchen range hoods, and similar. For the purpose of this checklist, the focus will largely be on automatic sprinkler systems.

Figure 32. Exterior connection to sprinkler system

Source: UN, 2012

Figure 33. Interior hydrant/standpipe valve and hose connection

Source: UN, 2012

In concept, automatic sprinkler systems are simple, comprised of a water supply, distribution network (risers and branch lines), control valves, and sprinkler heads (water discharge). The intent is to deliver water to the general location of where a fire is burning to control the fire spread in order to facilitate evacuation and limit damage to property while the fire service responds. If detected early enough, and if sufficient water is delivered to the fire, only a small amount of water is needed to control a fire. In cases where the initial fire is small, and the fuel load limited, the sprinkler system may suppress (extinguish) the fire. Each sprinkler head operates individually (that is, they do not all activate at the same time). Sprinkler systems can be "wet" (water is always in the system) or "dry" (water is introduced only when a sprinkler head or other detection device actuates). Wet systems are most common. Dry systems may be used in such cases as when sub-freezing temperatures are a concern (for example, unconditioned storage building, loading dock, attic spaces, etc.). Water flow and pressure requirements will be established in relevant design and installation standards.

A sprinkler head is activated when the heat from a fire melts a fusible link, which in turn releases a cap (cover) whose function is to contain the water in the system, allowing the water to discharge onto the fire. The shape of the deflector drives the resulting pattern of water spray. Typical sprinkler activation temperatures are in the range of 57–80 ^{0}C, although much higher activation temperature heads are also available for use where the ambient room temperatures are high. Temperature ratings, response time indices, flow, and pressure specifications are generally based on the hazard classification for a building or space in a building. Different sprinkler head designs are available for mounting in an upright, downward (pendant), or sideways (side wall) orientation.

Figure 35. Exemplar sprinkler head

Source: UN, 2012

Figure 36. Fire sprinkler roof (ceiling) mount side view

Source: Brandon Leon

Figure 37. Side wall sprinkler

Source: Angelsharum

As noted above, there are some situations for which automatic suppression system options other than sprinklers may be viable, appropriate, or even necessary. For the purpose of this checklist, such systems are referred to as alternative automatic fire extinguishing systems. Water-based systems include fine water mist, deluge, and foam systems. Fire water mist systems are typically high-pressure systems which use less water than sprinklers. Such systems may be viable in small volume spaces with limited water supply. Deluge systems apply a large amount of water to all heads simultaneously. Although a variation on a sprinkler system, the heads do not have fusible links, so water flows from all heads when the system is actuated. Such systems are used for water curtains and similar applications. Foam systems employ additives to either provide a layer of material on the surface of the resulting water pool to help smother a fire (used for fuel storage tanks, for example) or to result in large volumes of lightweight foam (like a thick layer of soap bubbles) to engulf and surround materials to be protected.

Gaseous systems deliver either inert gas or gaseous compounds to reduce the oxygen to support combustion, interrupt the chemical reaction supporting combustion, or transfer heat away from the reacting materials. These systems can be total flooding or applied locally (for example, CO_2 fire extinguisher). Chemical fire extinguishing systems deliver chemical compounds, typically in dry powder form, to smother a fire or to interrupt the chemical reaction supporting combustion. Typical applications include handheld fire extinguishers and kitchen exhaust hood extinguishing systems. Table 11 summarizes key fire suppression concepts.

Table 11. Key fire suppression concepts

Driving Feature	Impacts on Fire and Life Safety	Regulatory Considerations
4.1 Extinguishers	Provides occupants and internal fire brigades an opportunity for early suppression.	Size, type (extinguishing agent), and location of handheld fire extinguishers.
4.2 Water supply	Facilitates life safety and property protection. Required for automatic and manual fire suppression.	Fire suppression water supplies need to be able to reliably provide the necessary volume, flow rate, and pressure needed for the required amount of time (based on standards or design). The water supply system and components (for example, tanks, valves, and pumps) need to be maintained, inspected, and tested to assure proper operation. Reliable primary and backup power is needed for pumps.
4.3 Manual suppression	Facilitates life safety and property protection. Choice of standpipe systems and/or portable fire extinguishers. Should carefully consider the user.	Required for all high-rise, large area, and high occupant load buildings. Manual fire suppression systems and components need to be maintained, inspected, and tested to assure proper operation. Water-based systems require a reliable water supply. Portable fire extinguishers need to be matched to the hazard.
4.4 Automatic suppression	Facilitates life safety and property protection. Reduces fire damage. Helps when fire service support/response is limited.	Sprinklers beneficial in all high-rise, large area, and high occupant load buildings. Requires coherent set of design standards. All automatic fire suppression systems and components need to be maintained, inspected, and tested to assure proper operation. Water-based systems require a reliable water supply. Alternate fire extinguishing systems need to be matched to the hazard.

B.5 Fire Service Access & Facilities

It can be challenging for the fire service and other emergency responders if building planning and construction fails to adequately address their needs. This includes the ability to get fire apparatus to the building, firefighter wayfinding in the building, a fire command center, firefighter lifts, appropriate exterior and interior hydrant connections, and the like.

Fire Service Access

Access for fire apparatus is critical, yet usually not included in building regulations. Rather, attributes such as roadway width, turning radius, and access to buildings is often in planning regulations. This needs to be coordinated. Access should not be over underground parking. In addition, the fire service should have clear access within buildings, especially to FACP and ECC locations. It should also be easy for them to readily identify stairways and firefighter lifts for operational and occupant evacuation needs.

Fire Service Lifts

For high-rise buildings, many countries require either (a) dedicated fire service lifts or (b) the ability for lifts to be commandeered by the fire service in case of fire. Lifts for use by the fire service typically have additional protection so that they can be used during emergencies. This may include higher fire resistance of the elevator shaft walls, smoke-protected lift lobbies, and protection against water entry and impacts to the lift cab, shaft, and equipment. They are also typically sized to allow for transport of a stretcher or other means of moving incapacitated persons. The fire service may use the lifts for staging equipment (typically to the floor below the fire) or for assisting in the evacuation of persons who cannot self-evacuate.

Fire Command Center

In high-rise buildings, it is common to have a fire command center, which is a secure and protected space within a building near a main entrance on the level of building access for use by fire service command when responding to a fire or other emergency event. The fire command center typically houses either the FACU or a remote-control station for such, any fan control for smoke management systems, microphone and controls for voice alarm signaling, elevator controls, and other building management or security systems, displays or controls as deemed necessary to understand the situation and communicate with occupants and firefighters as necessary. Fire command centers often contain building layouts and other critical information to help facilitate firefighting and emergency response activities. Table 12 summarizes key fire service access and facilities concepts.

B.6 ITM, Plans and Training

Fire safety systems and features in buildings require regulating inspection, test, and maintenance (ITM) to assure a proper working state when called upon. Likewise, most buildings should have comprehensive fire and emergency response plans, evacuation plans, and fire safety management plans. The plans should be supported by training, drills, and other exercises which help familiarize occupants and the fire service with procedures that should be followed in case of fire or another emergency.

Table 12. Key fire service access and facilities concepts

Driving Feature	Impacts on Fire and Life Safety	Regulatory Considerations
5.1 Access for fire apparatus & equipment	To facilitate proper response, there needs to be adequate roadway access and access to the building for firefighting apparatus. There is also a need for access to hydrants or other water supplies.	Roadway width, turning radius within dead-end streets/ parking areas, sidewalk width, building separation, underground structures, location of electricity lines or other utilities, key boxes for locked doors, etc.
5.2 Access to stairs, hydrants, hose reels	To facilitate adequate movement and operational activities, there needs to be clearly marked doors for fire command, fire pumps, interior hydrants, designated access stairs, and so forth.	Appropriately sized stairways (for example, widths and landings) to facilitate two-way flows and staging operations, properly located interior hydrant connections, proper marking of floors, stairs, and the like.
5.3 Firefighter lifts	For high-rise buildings, (a) dedicated fire service lifts or (b) the ability for lifts to be commandeered by the fire service in case of fire is essential for firefighter access to upper levels. Lifts for use by the fire service typically have additional protection so that they can be used during emergencies. The fire service may use the lifts for staging equipment (typically to the floor below the fire) or for assisting in the evacuation of persons who cannot self-evacuate.	Adequate fire resistance of the elevator shaft walls, smoke-protected lift lobbies, and protection against water entry and impacts to the lift cab, shaft, and equipment. Sized to allow for transport of a stretcher or other means of moving incapacitated persons.
5.4 Firefighter communications & command center	Provides a base for on-site emergency command operations. Houses fire alarm and emergency communications controls. Needs to be accessible and protected.	Requirements for location, fire resistance, size to accommodate fire and communications control equipment and emergency operations, appropriate signage, backup lighting, and power.

Table 13. Key ITM, plans, and training concepts

Driving Feature	Impacts on Fire and Life Safety	Regulatory Considerations
6.1 ITM for fire protection systems	A common major contributor to large fire losses is the failure of installed fire protection systems and features to work as intended when needed. Testing of systems at the time of construction (commissioning) and routine ITM helps assure systems are in operational condition.	Building and fire regulations may call for commissioning tests and regular ITM. Often, reference standards for specific systems (for example, fire alarm, fire sprinkler, and smoke exhaust) will include recommended ITM timing. Some regulations, such as the Building Regulation in New Zealand, require Building Warrant of Fitness (BWOF) certifications and audits for safety critical systems.
6.2 Evacuation planning and training	Fire safety systems are just one part of the safety equation. For the systems to be effective, occupants need to know what to do in a fire emergency. Appropriate planning and training are needed to facilitate this.	Building and fire regulations may include simply a requirement that evacuation and planning be undertaken by the responsible person. However, in some cases guidance can be provided as annex material to help the process.
6.3 Fire safety management plans	Similar to evacuation planning and training, fire safety management plans are helpful for managing transient fuel loads (for example, trash), checking systems in accordance with ITM requirements, reflecting coordination with the fire service, and the like.	Building and fire regulations may include simply a requirement that fire safety management plans be developed and maintained by the responsible person. However, in some cases guidance can be provided as annex material to help the process.
6.4 Temporary use requirements/ permits	Clear guidance on when permits are required is essential.	Regulations should address conditions requiring permits and inspection.

B.7 Other Items Impacting Fire & Life Safety Systems and Features

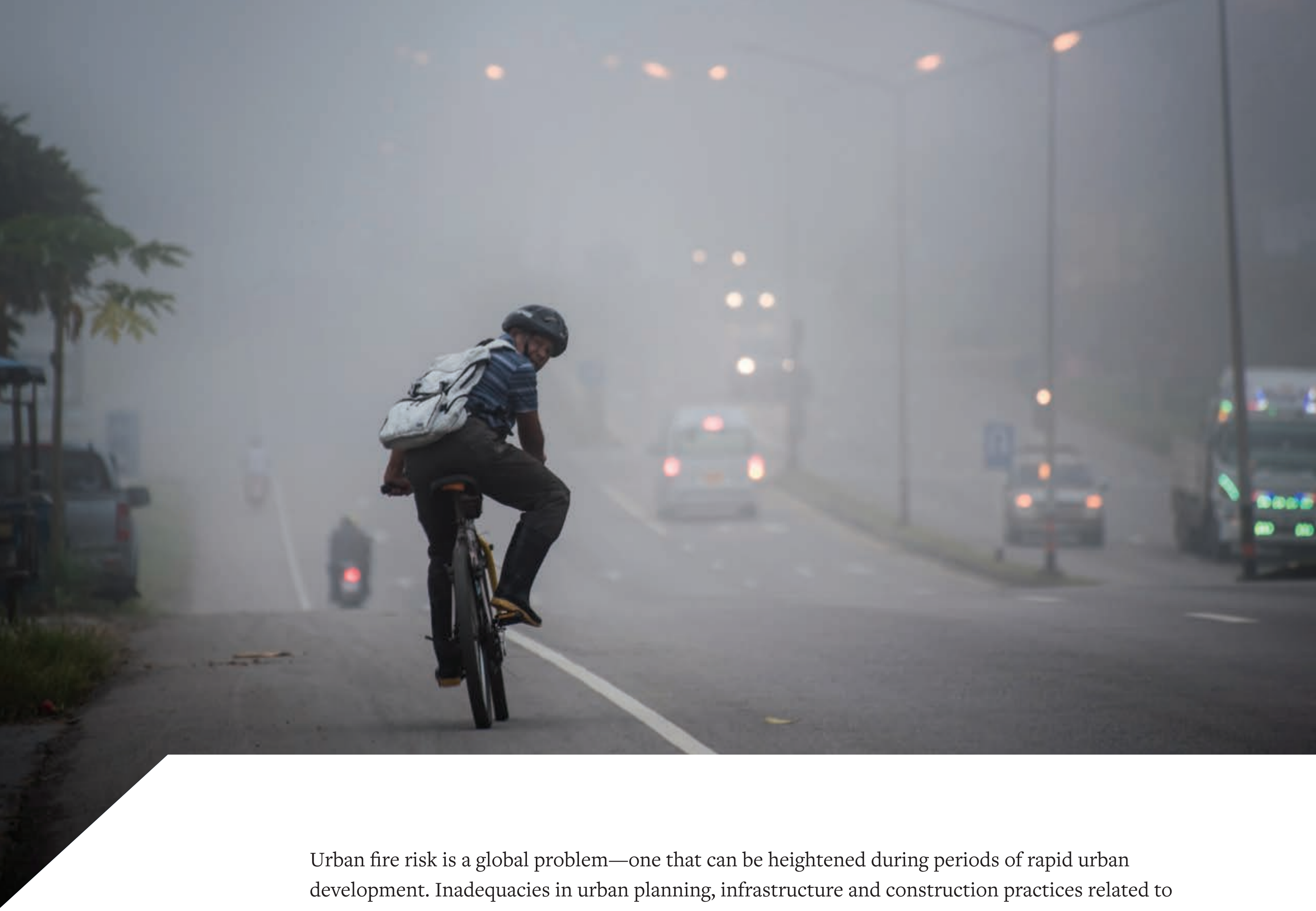
In addition to the fire safety systems and features overviewed above, there are other considerations in building regulations that should be checked, and there are some specific features that may be appropriate, especially for tall buildings.

Electrical Power Service

Many of the active fire safety systems in a building—from fire detection and alarm systems to smoke and heat exhaust systems—required electrical power. It is important that regulatory provisions be in place for reliable primary power and for emergency backup power if primary power is unavailable. Requirements for emergency backup power should be identified for each fire safety system that is expected to be operable in case of fire. In addition, emergency backup power requirements for fire service lifts and other building systems may be needed as well.

Controls on Hazardous Materials

Controls on hazardous materials that can be stored in buildings of different occupancy or use classification may be in building regulations, fire regulations, occupational health and safety regulations, or some combination. Generally, the regulatory structure should contain a combination of limits on materials stored and associated compartment size limitations, fire resistance requirements, fire suppression requirements, and informational requirements for first responders. If a building regulation has a focus on control of hazardous materials, reference to relevant standards and guidelines is recommended.



Urban fire risk is a global problem—one that can be heightened during periods of rapid urban development. Inadequacies in urban planning, infrastructure and construction practices related to fire prevention and mitigation significantly increase the potential for fire ignition, fire spread, and potential conflagration. This checklist aims to facilitate a robust approach to reviewing fire safety provisions in building and/or fire regulations by providing a discussion of fundamental fire safety components of building and/or fire regulations, a systematic approach to review fire safety provisions in regulations.

GFDRR
Global Facility for Disaster Reduction and Recovery

Administered by
THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP