

Guide on Historic Buildings and Fire in War-affected Countries

By request of the Maidan Museum and The Heritage Emergency Response Initiative

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Introduction

This short introductory guide is about historic buildings in danger from fire in a war zone before the fire brigade arrives. It includes historic or valuable structures such as wooden churches. The guide can also be applied to buildings housing heritage collections. This guide is **NOT** on (evacuation of) heritage collections housed in the buildings.

In this guide we use a Risk-Informed Approach (*Image 1*) derived from the Disaster Cycle and ordered our chapters accordingly: *Prevention and Mitigation*, *Response* and *Recovery and Salvage* of historic buildings, including wooden buildings and building-integrated art works, under threat of fire in a war. They are written for non-fire experts and all the recommended response measures are meant to be implemented before the fire brigade reaches the fire. Therefore there is a focus on substitutes for professional materials and equipment, including suggestions for materials that can be sent to Ukraine.

For more details on *Prevention and Mitigation*, *Response* and *Recovery and Salvage* of Historic Buildings and Fire in War-affected Countries we refer to the ICCROM publications ‘First Aid to Cultural Heritage in Times of Crisis – Handbook and Toolkit’ and ‘Protecting Cultural Heritage in Times of Conflict’ (see *Literature*). These publications touch on more relevant subjects needed for the first aid of heritage assets outside the danger of fire.

The guide is a joint effort by Heritage for Peace (René Teijgeler), Norwegian Institute for Cultural Heritage Research (Nina Kjølseth Jernæs), Blue Shield International, ICON, Fundacion Fuego and individual fire experts.

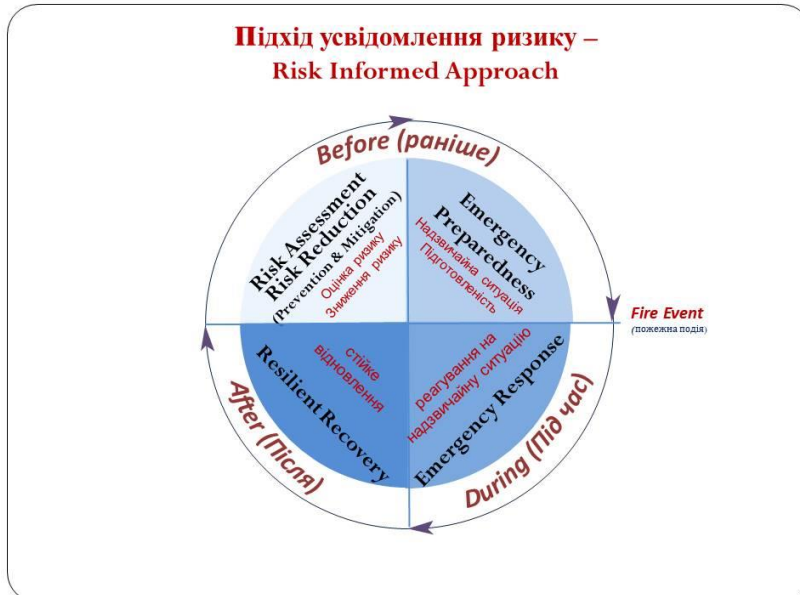


Image 1: Risk Informed Approach (© Chris Marrion)

Chapter 1: Fire Prevention and Mitigation

Protecting a building from a Possible Fire

A fire needs three elements to start: heat, fuel and oxygen as illustrated in the Triangle of Fire (*Image 2*). For a fire to occur these three elements must be present and combined in the right proportions. If any of the three elements are removed, the fire is extinguished. Subsequently, fire prevention, fire mitigation, and fire response are directed towards removing, stopping or mitigating one of these elements.

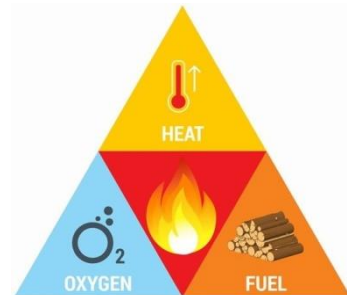


Image 2: Triangle of Fire
(Source: nowscience.co.uk)

A risk management plan for heritage institutions in general has the advantages of raising hazard awareness, assigning roles and responsibilities – who is doing what during a hazard, clear communication lines, a set response plan and finally a clear recovery plan. One part of a risk management plan is a risk-informed Fire Plan or Fire Strategy.

FIRE STRATEGY

Design a risk-informed **FIRE STRATEGY** consisting of

- Risk Assessment
- Risk Reduction measures
 - Preventive measure
 - Mitigation measures

RISK ASSESSMENT

Understanding the fire hazard within your building and around it

- What could be the causes of fire
- What are the weakest points once a fire breaks out
- See for details Michal, Stefanski and José Luiz Pedersoli Jr., 2016 (*see Literature*)

FIRE PREVENTIVE MEASURES

Fire prevention plan

- Document interior and exterior
 - Photographs, videos, written reports
 - Overview and details of specific original features
- Contact the fire brigade in advance
 - To ask advice and share information
 - To ensure access for the fire brigade and fire engine to the building
- Develop an evacuation plan
 - Escape routes for staff and visitors
 - Easiest and fastest route to safeguard collections
- Conduct fire drills
 - To address protocols and obstacles. Individuals may not follow appropriate action if they have never experienced that action
 - Include fire extinguisher training
- Lockdown
 - Remember the importance of the building for the community (churches, libraries, museums)
 - Guard 24/7 to prevent looting, theft and vandalism

- Limit ignition sources (inside and outside)
Anything that can cause a fire should be checked and if possible removed
 - Bad electrical wiring, open flames, heaters, cookers, coffee makers, hot renovations works, candles, human clutter
 - Camp-fires, fire-wood, outside cookers, renovation works
- Limit combustible materials (inside and outside)
Anything that can be fuel for a fire should be stored in a safe place or removed
 - Storage materials, textiles, flammable liquids and adhesives, wood, paper, plastic, litter, and powdered materials or dust. To reduce the heat thus self-termination of the fire, do not stack materials high or in the corner of the room
 - Bushes, shrubs, trees, undergrowth, building construction, storage materials, and human clutter. Clear at least a 10-meter perimeter of the building from outside combustible materials

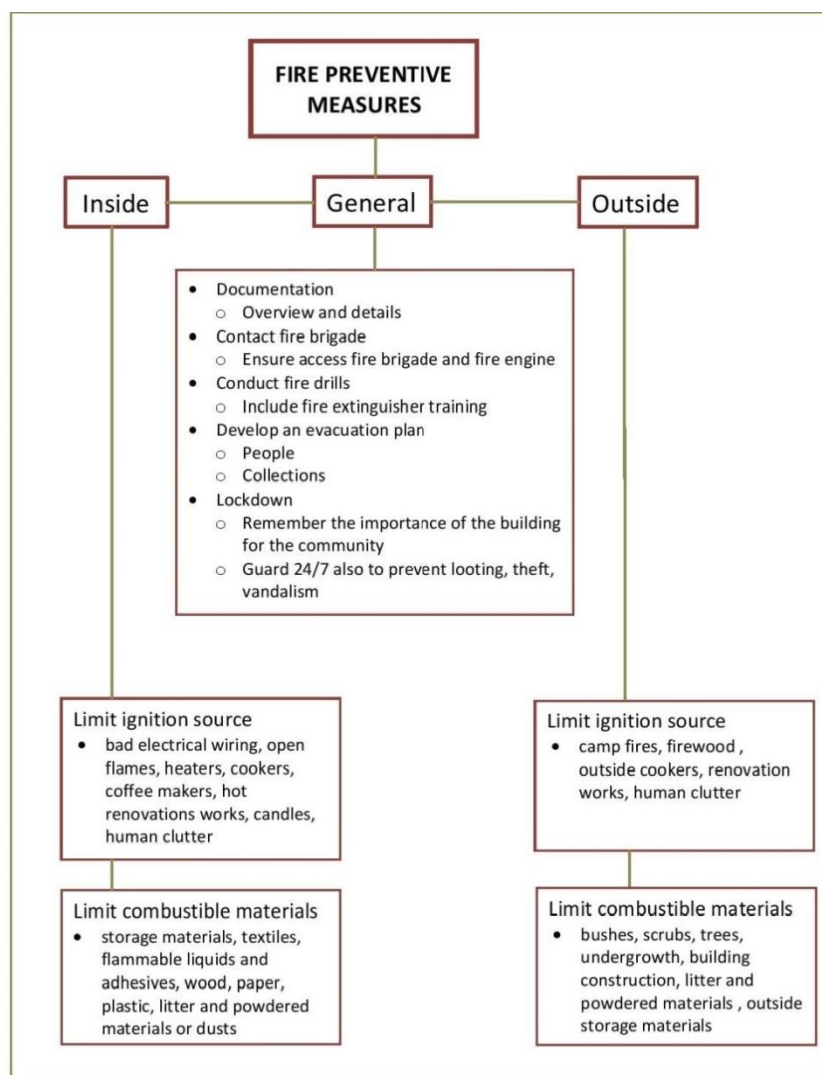


Image 3: Fire Preventive Measures (© René Teiggeler)

FIRE MITIGATION MEASURES

Fire mitigation plan

- Notification
 - Early warning for an outbreak of fire
 - Fire alarms
 - Fire and smoke detection systems
 - Guards 24/7
- Fire suppression systems (sprinkler installations)
- Fire hose reel. It has its own water pipe system
 - Needs regular maintenance
 - For outside use a fire hose cover
- Fire extinguishers
 - Should be present in the most important spaces
 - Travel distance to a portable fire extinguisher should not exceed 20 meters
 - See more on fire extinguishers in the chapter Response
- Prioritize the most valuable adjacent buildings that are at risk of catching fire according to their heritage value
 - If buildings are connected (attached, semi-detached, or closely placed), one might consider SACRIFICING other buildings
 - Use machines to demolish buildings that can be sacrificed
- Prevent fires from spreading – exterior and interior
 - Compartmentation and fire separation with fire protective shields or covers
 - Between rooms
 - Between adjacent or semi-detached buildings
 - Large attics that can cover several buildings
 - Keep doors closed and board-up exterior windows



Image 4: Fire Hose Reel
(Source: Firechief.net.au)



Image 5: Use of textile fire covers to cover roofs in the past in Norway appr. 19th century
(Source: Riksantikvarens Archive, Norway)

- In case **Water supply is available**
 - For **Exterior Use** make use of **Textile Fire Covers** to cover buildings before a possible fire.
 - Use wool or linen covers, only when made wet, possibly finished with a fire/flame retardant chemical.
 - If possible provide the wet wool or linen covers with pockets. This way the water will collect in the pockets and thus can withstand high temperatures for some time
 - A good alternative to wet linen and woollen covers are the affordable and practical glass fibre blanket fabric - however, this will still not provide full protection.
- In case **No Water Supply is available:**
 - Professional fire protective shields are more effective than wet woollen or linen covers. For **Interior and Exterior Use**
 - Though fire protective shields can be used for protecting the interior and immovable artefacts inside the building the rule is that if the building becomes fully ignited, the covered objects within the building are also lost. Therefore, **the protection of the building itself is priority number one.**
 - Use professional **Fire Protective Shields** to cover the building, parts of the building (the wall or wooden roof if there is high risk for sparks or flash-over), interiors, or big artefacts. They can be hung up with nails through grommets/eyelets
 - Formats: Big sizes and shields on rolls for covering a whole wall or building are commercially available, 4 x 4 metres or larger for covering valuable inventory items and with grommets for easy fastening. Tailor-made sizes are possible by different manufacturers and suppliers. However, the seams can be a weakness if not made to be fireproof in case you sew two or more pieces together yourself.
 - To prevent the fire from spreading large fire protective shields can also be used to hang up with ropes between unattached buildings or to (partly) cover a roof or wall as a form of compartmentation or partition.

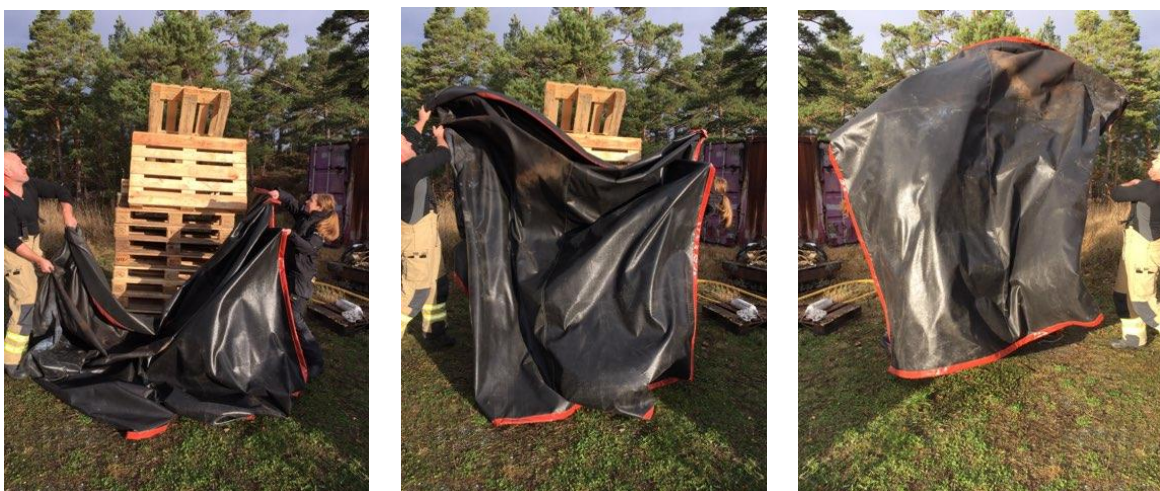


Image 6: Test how to cover a large inventory object (mock up) with a fire protective shield for two persons (Source: Norwegian Institute for Cultural Heritage Research)

- Fire protective shields can be used for inside protection of
 - Interiors, integrated art, and big artefacts like wall paintings, murals, decorative wooden pulpits, wooden sculptures, altar pieces or iconostasis
 - If possible, the cover should reach the floor but it depends on the size of the artefact.
 - At least two people are needed to cover large items
 - Be aware of the fact that large fire protective shields might have an inside and an outside!
- Though the fire protective shields can stand high temperatures, to slow down the temperature reaching the surface even more it can be combined with rock wool that does not touch the object or similar material to create a sandwich – multi-layered shield but only if you have time to do so
 - One Spanish manufacturer, Subic, provides multilayer fire protective shields: Tejiprotect but again only if time allows. Not tested for use on heritage material, *see Literature*
- In tests performed in Norway in 2021 **three out of the seven commercially available products of fire protective shields** were found suitable for indoor covering of heritage objects as well as outdoor use. The tested materials will stand heat up to approximately 1000° C and withstand water, also *see Literature*:
 - Dale Intertec: Silicone coated hybrid fabric containing E-glass: E-glass filament + vulcanised silicone coating on both sides. 150 cm/width
 - Vitrea: Svetsduk EGF550 S2-60: E-glass with silicone coating. 50 cm/width
 - Hiltex: Preox Para Aramid fabric: Preox and Para-Aramid textile twill with aluminium transfer foil on one side. 150 cm/width
- For more information see *Needed Equipment* and *Literature*

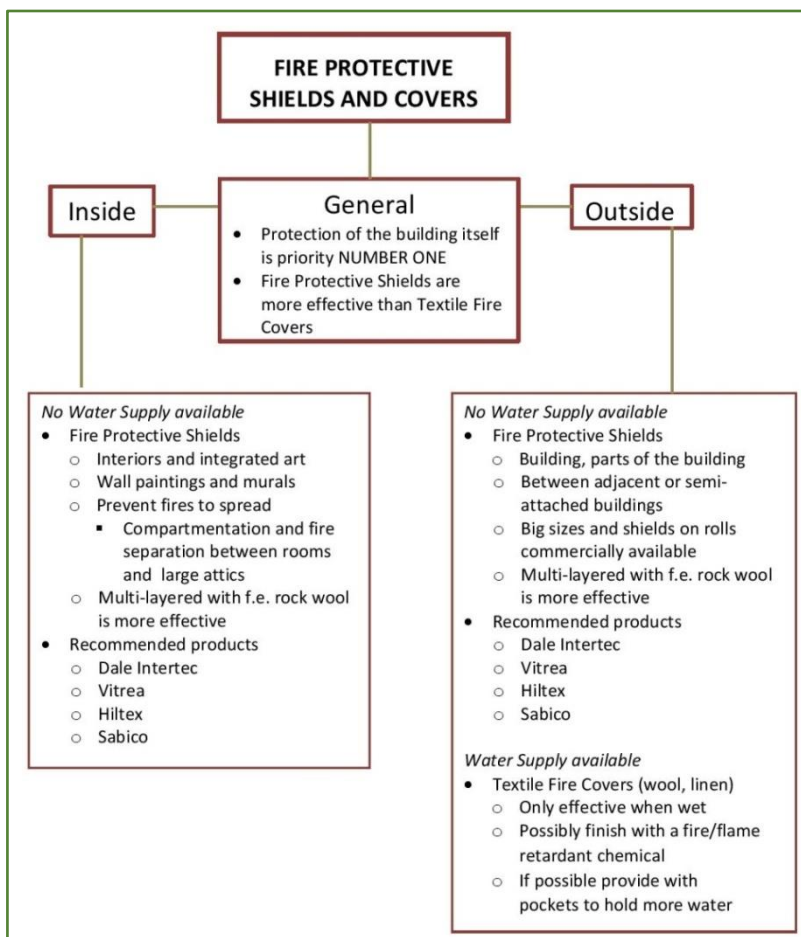


Image 7: Fire Protective Shields and Covers (© René Teiggeler)

- There are several ***Fire Retardant Coatings for Wood*** available both for the interior and the exterior of the building.
 - ***DO NOT APPLY*** a fire/flame retardant chemical on historical wood or objects
 - These products are developed for new fresh wood-based constructions
 - There are no effective fire retardants for timber, only surface spread of flame treatments. They can weaken structural timber over time
 - Preparation for the application of fire retardants will destroy historical traces and carpenters' marks.
 - In the long-term most retardants used outdoors are affected by moisture and it can also weaken the structural timber
 - Research shows that
 - Ammonia containing retardants can degrade the surface of wood and cause defibring of historical roof beams
 - Phosphorous containing retardants are prone to efflorescence in high moisture conditions and can reduce wood strength
 - Silicon based retardants have a negative impact on the strength of the timber
 - Modern retardants not containing any chemicals can change the texture and colour of the historical material, turn it slightly opaque and hide decorative features

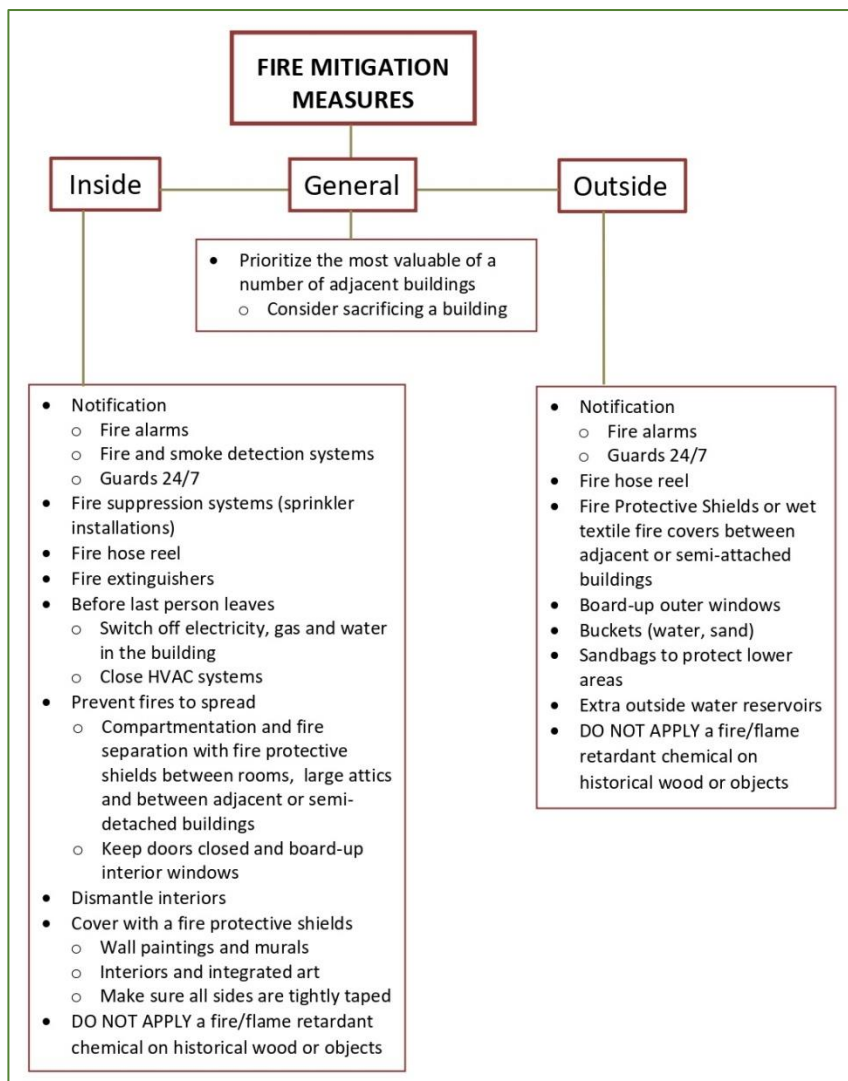


Image 8: Fire Mitigation Measures (© René Teijgeler)

Chapter 2: Response

Protecting a building from an Ongoing Fire

- **Prioritize** the most valuable parts of the building, both inside and outside that run the highest risk of getting damaged.
- In case **Water Supply is available**
 - Use a Fire-hose reel if available. They are more effective than fire extinguishers in the first minutes of a fire it has its own water pipe system (*see Image 4*)
 - Needs regular maintenance
 - For outside use a fire hose cover
 - Create water barriers between the fire and the valuable heritage building
- **Fire Protective Covers and Shields**
 - If time and circumstances allow (*see Image 5 and Image 6*)
 - Cover the building's weakest points from a blaze with a Fire Protective Shield according to the situation
 - Cover interiors, big artefacts, wall painting, and murals with Fire Protective Shields
 - If woollen or linen covers are used for the exterior: Wet them with a fire hose
- In case the **Building has caught fire**:
 - Panelled wooden building
 - Disassemble parts of the wooden building for example the wooden roof, to stop the fire from spreading according to the situation (*see Image 9*)
 - Cause overpressure in the building for example with the use of fans attached to an engine or diesel aggregate. It can help distancing the smoke and fire.
 - Use portable fire extinguishers
- **Portable Fire extinguishers**
General
 - Fire extinguishers are mainly used inside the building but also sometimes outside (*see Image 10*)
 - Most fire extinguishers will have a **negative impact** on heritage surfaces. The impact depends on the heritage material and the type of extinguisher
 - This means that which type of fire extinguishers to use for what classification of fires (Class A, B, C, D, E, F) under normal circumstances are in several cases **NOT VALID** for heritage buildings and artefacts
 - All fire extinguishers have a colour code that identifies their content. You can find the colour code on the band around the canister. But again in several cases the type of extinguishers in combination with fire classifications are **NOT VALID** for heritage buildings and artefacts
 - When NOTHING ELSE is available to mitigate or stop the fire **Use a portable fire extinguisher** on heritage objects rather than refraining from it, independent of the type of the product. The secondary damages are acceptable if the fire can be extinguished
 - In general fire extinguishers for our purposes should contain as **few chemicals** as possible
 - When using a fire extinguisher keep the door behind you OPEN so you can escape any time and keep your body low to avoid breathing in the smoke.

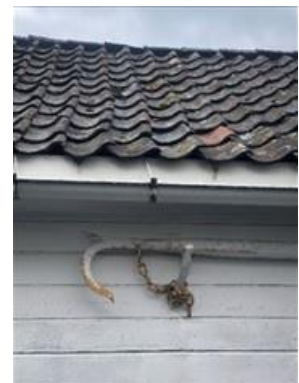


Image 9: Tool for disassembling parts of a wooden panel or structure (Source: Norwegian Institute for Cultural Heritage Research)

Specific

- **Water Mist (H₂O) fire extinguishers** (plain tap water, not ‘water plus’ that contains additives) are recommended for wood, paper, textiles, porcelain, paintings, and painted surfaces. Paintings on canvas might suffer light damage.
 - Colour code (transparent)
 - The water mist extinguishers work quicker but you need to be closer to the fire than using other extinguishers. They form a dense mist that covers the fire from oxygen.
 - Also for iconostases. Water mist affects the gesso of the iconostasis but it is the best option though some damage might occur. Compared to the damage of the use of other fire extinguishers this damage is minimal
 - Paintings on canvas might suffer light damage
- **Plain Water Jet or Spray (H₂O) Extinguisher** are the second best option for the uses mentioned for the water mist extinguishers: wood, cloth, paper, textiles, paintings and painted surfaces. They can be refilled with tap water and pressurised with air from a bicycle pump.
 - Colour code (transparent)
- **Carbon dioxide (CO₂) extinguishers** are used for flammable fluids, liquefiable solids and electrical equipment
 - Colour code
 - **Not efficient for Exterior use**
 - If nothing else **Interior use**
 - CO₂ gas reduces or displaces the normal oxygen concentration in breathing air. Breathing of oxygen-depleted air can lead to death by asphyxiation (suffocation) so **NOT FOR USE** in confined spaces except for electrical fires
 - CO₂ extinguishers are the only ones to use for fires in server rooms, PC or laptops. If used in this case wear at least a gas mask
 - The non-insulated horn of the CO₂ extinguisher can cause frost burn if touched when in use - be careful!
 - CO₂ extinguishers could be used on glazed paintings (any type of paint), as the damage would be more controlled. They are also popular in archives as they leave nothing after spraying
 - CO₂ extinguishers will **Damage** wood and textile surfaces, and could cause more damage to paintings than the water mist extinguishers
 - Make sure that with PC’s and laptops you direct the horn towards the vent holes.
 - Water or powder-based extinguishers are **NOT RECOMMENDED** due to electrocution risk and equipment damage.
- **Foam fire extinguishers** are used for solids, liquids such as oil, paint, petrol, solvents.
 - Colour Code
 - Foam fire extinguishers may cause **Damage to historic fabric, fixtures and artefacts** and, therefore, they are **Not an appropriate solution** for heritage buildings



Image 10: How to use a fire extinguisher (Source: SafetyBanners.org)

- **Dry Powder fire extinguishers** are used for organic solids, liquids such as oil, paint, petrol, solvents, burning metals
 - Colour Code
 - Dry powder systems are **Not suited for heritage buildings**. This is due to a very serious risk of significant **damage to historic fabric, fixtures, and artefacts** caused by the composition of the powder used, particularly when damp or combined with water. They can also cause **corrosion** on iron and metal objects. There are also serious health risks and low visibility
 - Dry powder extinguishers release a toxic substance (inorganic salts and additives) that is easily inhaled if used in an enclosed space without adequate respiratory protection thus use a gas mask
 - Dry chemical powder fire extinguishing equipment also comes in the form of Fire Balls filled with dry powder. As for the regular Dry Powder Fire extinguishers the advice remains to **NOT USE** them for heritage buildings and artefacts.

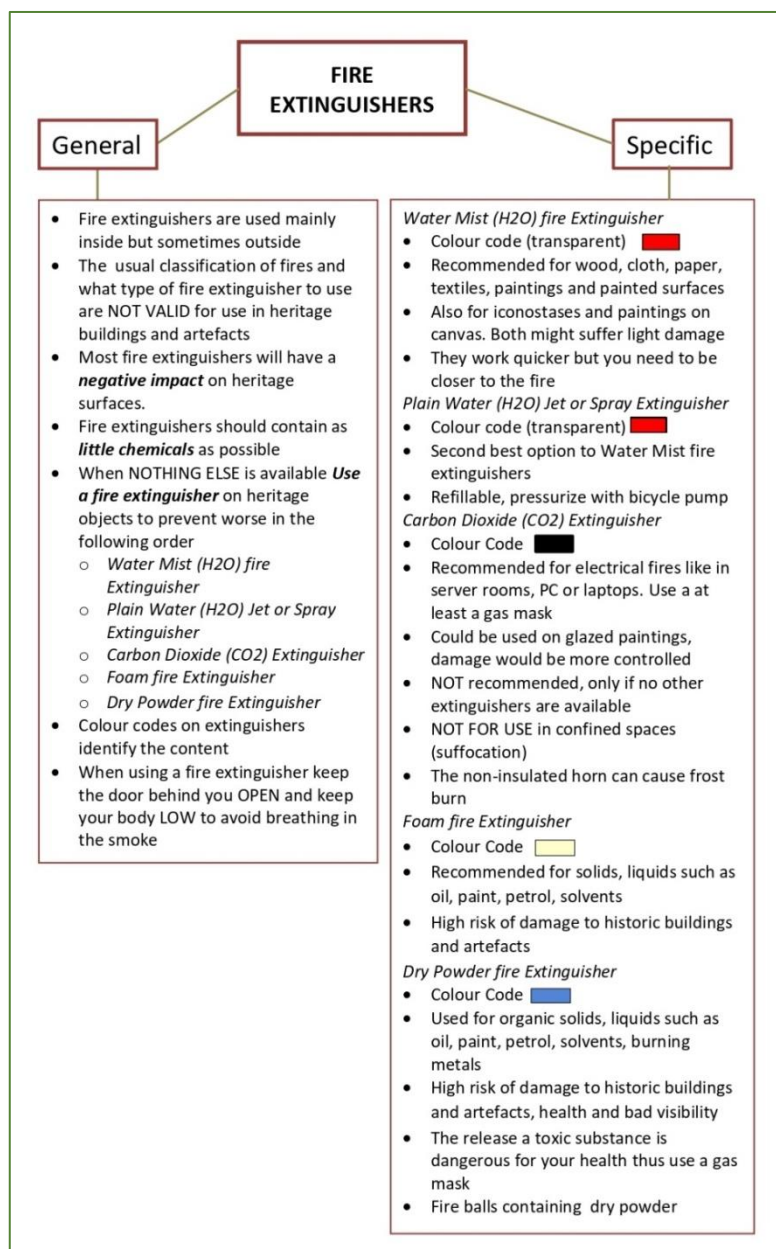


Image 11: Fire Extinguishers (© René Teijgeler)

- If **Water Supply** is an issue:
 - Buckets filled with sand or empty ones to carry water from a distance can be employed if nothing else. Buckets of sand have been very effective historically at putting out small fires/sparks during war
 - Create water reservoirs or water tanks near the building using for example bowsers. Bowsers come in all sizes, from small cylinders on wheels, to lorries. But also portable and self-supporting water tanks (*see Image13 and 14*)
 - In Norway water mini-stations have been used in areas without water supply close to wooden heritage objects. These are standard containers with a water reservoir of 6 or 10 cubic meters and a fifty-meter fire hose (*see Image 12*)



Image 12. Mini fire-station, including water supply in Norway (Source: Norwegian Institute for Cultural Heritage Research)



Image 13: 1000 litre Fire unit trailer (Source: <https://www.gumtree.com.au>)



Image 14. Self-supporting water tank (Source: Eldred Environmental)

Chapter 3: Recovery and Salvage

After a fire

- Ask yourself the question: *Is it safe to enter the building?*
 - If present listen to the advice of the fire fighters
- Watch out for **Mines, booby traps, and other explosive devices** that might have been placed around or even inside the building. If you suspect any explosive devices to be present call for help from the military. Do not touch!
- Do not touch **Unexploded Devices**. Wait for military experts to defuse and clear these devices. Do not touch!



Image 15: Symbols of danger of explosions, entry forbidden, watch out for falling rubble, do not smoke (No Source)

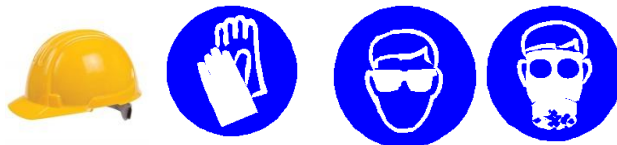


Image 16: Symbols of protective clothing (No Source)

- Only enter the building with **Protective clothing, safety goggles, and a hard hat**
- If the building has limited damage, make sure the inside of the building gets **Sufficient air circulation** to avoid mould and minimize the odour of fire and smoke especially if water has been used to extinguish the fire.
- Close all doors and windows to prevent them from sagging.
- Place **Fences** around the damaged building and put up warning signs like ‘No Entry,’ ‘Watch out Falling Rubble’ or ‘Danger of Explosion’
- **Document** the damaged building (photographs, videos, written reports) before taking measures. This can be vital for recording evidence of possible war crimes, and for restoration of the building
- **Prioritize** the stabilization of the weakest parts in the construction after a fire
 - Shore up the weakest parts or raise scaffolds to prevent walls tumbling down. See *Literature*
- **Prioritize** the recovery or salvage of the most valuable damaged parts or those with the highest risk of being damaged further
- **Document** the recovery or salvage measures you have taken (photographs, videos, written reports)
- **Remains**, depending on the kind of the rubble
 - If the remains have fallen in a sequence, like a tower, leave them as they are as they have fallen in a certain order. Cover them with sand so nobody else can disturb the order
 - If the remains did not fall down in a certain order collect them from the building in one place and store them inside or outside the building but avoid airtight covering. Protect them from the weather, insect damage and looters. This is useful for later restoration of the building. This includes stone details, glass, bricks, wooden parts with profiles, marks or traces etc.

Mark, describe and photograph the individual pieces where they were found. If remains are wet dry those in a natural way for example by enough air circulation.

- **Handling Soot and Smoke affected surfaces**

- Always use Protective clothing handling soot covered and burnt objects
- Prioritize. Highest priority - structurally damaged, compromised, or porous surfaces with heaviest soot layers
- Avoid touching affected surfaces!

- **Soot affected surfaces**

Soot is a black oily and solid residue of a fire with high carbon content. Fire residues are acidic, abrasive and they contain substances that are harmful for both people and objects Thus extreme sensitivity is needed when handling soot covered and burnt objects.

- Soot becomes increasingly bonded to the surfaces and is much more difficult to remove over time and this can lead to secondary damage
- High oxygen fires can result in dry residue which makes it easier to remove
- Smothering or low oxygen fires result in wet residues and these are more difficult to remove

- **Initial Soot Removal Steps**

- Air dry if the objects are damp or wet
- VACUUM CLEAN without touching the object for example vacuuming through a screen. A puffer might also help like the ones used for camera lens cleaning (*see Image 17*)

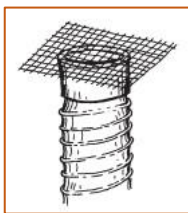


Image 17: A protective screen over the vacuum cleaner hose (Source: Adapted from Mechanical Surface Cleaning of Textiles – Canadian Conservation Institute (CCI) Notes 13/16)

- DO NOT tightly wrap or stack soot-affected objects
- AVOID cross-contamination or re-contamination
- DO NOT ATTEMPT FURTHER CLEANING TREATMENTS especially not with water or sponges, wait for a conservator!
- Store cleaned objects in a clean dry place

- **Initial Smoke reduction of affected objects**

Smoke is basically fuel that didn't burn, made visible by the presence of small particles of carbon and other material. Complete combustion gives off light, heat, the gas carbon dioxide, and water vapour. Smoke includes small droplets of wood tars (if originating from a wood fire), gases, soot, and ash. Smoke is not only dangerous to people, but also to collections. The acidic nature of the smoke film causes discoloration, corrosion, and overall damage.

- Store objects in a separate large room with mechanical ventilation or some kind of air circulation. This will dispel most lingering odours over time
- Seal the object in a plastic bag or greaseproof paper, then placing in a refrigerator until the odour disappears.
- Sealing the object in a bag with one of the following odour-absorbing materials
 - Carbon
 - Baking soda
 - Unscented clay cat litter
 - Zeolites (commercial adsorbents in powder form)

Ensure the object does not come into direct contact with the substance, as this may cause damage

- Commercial companies often offer smoke treatment by replacing smoke odour by another nice smelling odour similar to Air Fresheners For Bathroom Smells. However, that is no final solution as the smoke odour is not absorbed but suppressed.
- **DO NOT ATTEMPT FURTHER CLEANING TREATMENTS** especially not with water or sponges, wait for a conservator!

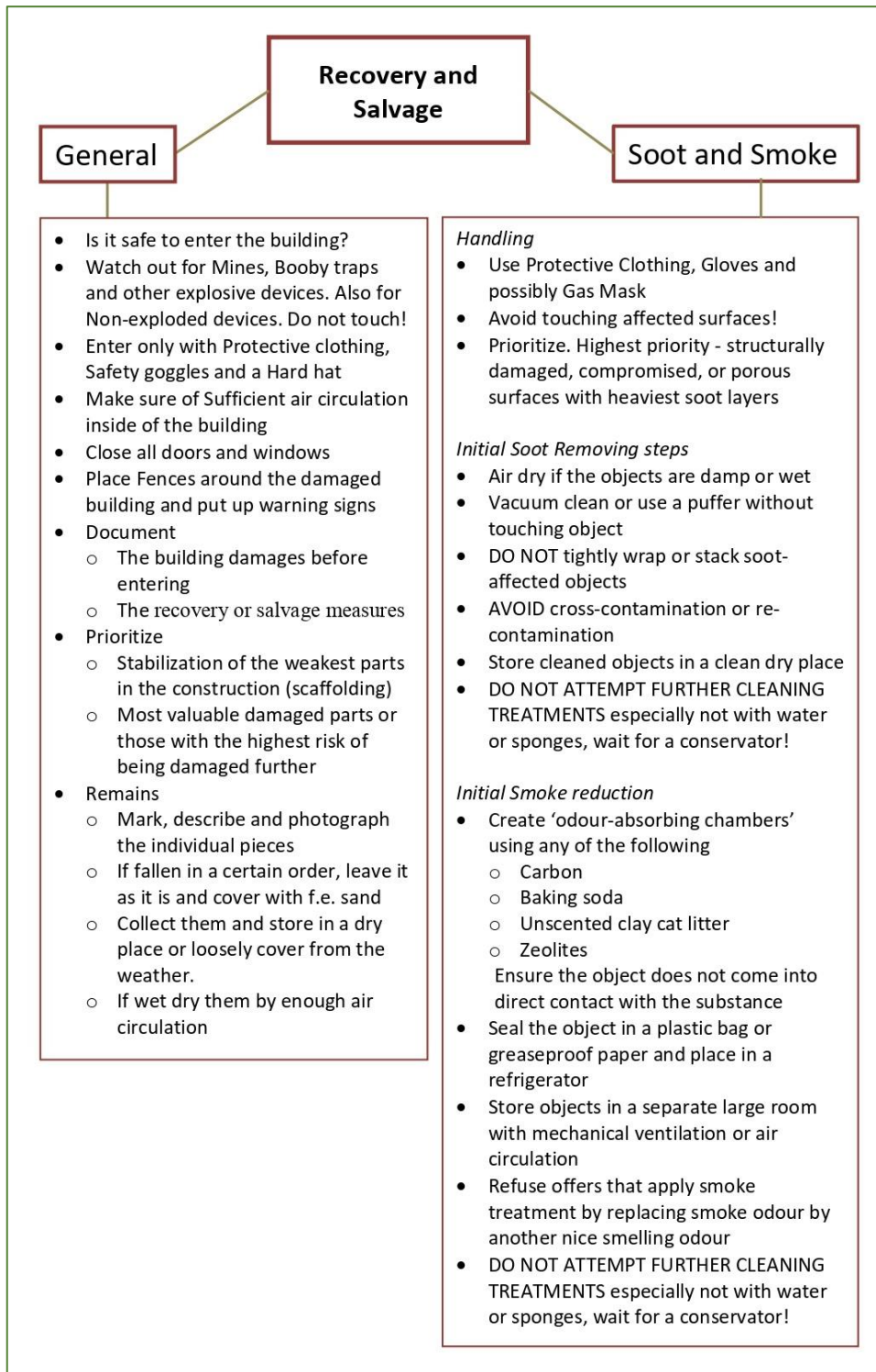


Image 18: Recovery and Salvage (© René Teijgeler)

Needed Equipment

- Documentation equipment
- Sandbags in large quantity
- Empty buckets and buckets filled with sand
- Wet woollen or linen fire textile covers
- Fire protective shields
- Dense material, plywood or similar
- Diesel aggregate or other types of aggregates
- Fire hose reel
- Different portable Fire extinguishers, dependant on use
 - Water mist fire extinguishers
 - Plain water jet or spray extinguishers
 - Carbon dioxide (CO₂) extinguishers
- Tool for disassembling parts of a wooden panel or structure
- Water reservoirs, water tanks or water mini-station
- Protective clothing, safety goggles and a hard hat
- Fences and warning signs
- Scaffolding tools and equipment
- Vacuum cleaner with HEPA filter
- Plastic bags and greaseproof paper
- Odour absorbing materials

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