European Guideline

CFPA-E No 29:2013 F

Protection of Paintings: Transport, Exhibition and Storage

CFPA EUROPE

FOREWORD

The European fire protection associations produce common guidelines in order to achieve similar interpretation in European countries and to give examples of acceptable solutions, concepts and models. The Confederation of Fire Protection Associations in Europe (CFPA E) has the aim to facilitate and support fire protection work in European countries.

The market imposes new demands for quality and safety. Today, fire protection forms an integral part of a modern strategy for survival and competitiveness.

This guideline is primarily intended for Museum Curators or Fire Safety Managers, but it is also addressed to the rescue services, consultants, safety companies etc. so that, in course of their work, they may be able to help to increase the levels of fire safety in museums.

The proposals within this guideline have been produced by the Spanish Fire Protection Association (CEPREVEN), with the technical support of PROTECTURI (Safety Historical Heritage Association from Spain). The Annex 3 to this Guideline contains, for further information, the requirements for Fire Protection extracted from the CFPA Guideline "*Security Guidelines for Museums and Showrooms",* produced by the VdS.

This Guideline has been compiled by Guidelines Commission and adopted by all fire protection associations in the Confederation of Fire Protection Associations Europe.

These guidelines reflect best practice developed by the countries of CFPA Europe. Where the guidelines and national requirement conflict, national requirements shall apply.

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Keywords: Work of art, Painting, Museum, Transport, Salvage, Fire extinguishing systems, Emergency Plan.

1 Scope

The purpose of this paper is to describe fire safety measures, applied specifically to the protection of paintings during transport, exhibition and storage.

The automatic fire protection systems that are presented here are primarily intended to protect the storage of works of art. Its application in the field of exhibition halls should be considered with all its limitations.

The museum curator, or the person responsible for the collection, must decide on the most suitable system or installation, taking into account the information given and the specific characteristics of the site, organization, and works of art.

Some advice is also given on organisation in the event of an emergency, recovery of the works of art after a fire, and prevention of damages during transport

2 Introduction

2.1 General Concept

The imposition of changes in fire suppression systems, resulting from recommendations of international meetings regarding the possibility greenhouse gases emissions has presented difficult issues for museums and other institutions responsible for the protection of the artistic and cultural heritage.

Those agreements included a calendar with deadlines for the replacement of the current systems with an alternative that may meet the new recommendations. The resultant uncertainty is caused, partly, by the lack of information from the competent institutions, since the only documentation available on the subject is provided by the companies of the fire fighting sector. That information is, in many cases, really valuable, but in some others it is clear that it has not been compared and contrasted enough for its application.

The absence of experience in the use of different fire extinguishing systems proposed for those spaces which house cultural or artistic heritage objects has increased the confusion of the people in charge of the protection of cultural and artistic heritage.

It must be stated that any work of art is unique and never-to-be-repeated, presenting a very special as witness of our past, documenting the evolutive process and the work of human kind through history. But it is also, and on top of all, a mix of fragile materials that survive within an unstable balance with the environment surrounding them.

Thus, the efforts of museums have been recently directed to preventive conservation, meaning the study of the effects of the environment on those objects, in order to be able to prevent if possible

the damaging effects responsible for degradation reactions. Within these preventive conservation measures, all existing factors (such as environmental or pollutant) and other possible factors are taken into consideration. Within the latter, fire, being the most devastating hazard, is maybe one of the most important factor. Consequently, the systems destined to extinguish and control a fire have to be taken into consideration as well, since in certain cases those systems might also become in the long term agents as hazardous as a fire itself.

Therefore, it is extremely important that the knowledge about the particularities of the features that spaces of protection of the artistic and cultural heritage should meet, and the knowledge about safety from the point of view of preservation, in order to be able to implement systems from that perspective.

Given the importance and uniqueness of the protected objects, we must consider that, in order to obtain high levels of safety, a worst-case scenario policy should be applied. If those scenarios are manageable, all other possibilities are automatically covered.

2.2 Works of art preservation conditions

Conditions for preserving works of art in daily situations are common knowledge and therefore outside the scope of this study. The needs that will be evaluated will be temperatuer and humidity in emergency situations, with the aim of keeping the integrity of the works of art intact

The factors to be taken into account are:

2.2.1 Temperature

The Works of art have to be maintained at a stable temperature continuously. In general, it can be considered that in no case temperature should surpass 80ºC, since above this temperature the materials that conform the pictorial layer soften, become unstable and begin to be disturbed. From 140ºC upwards, the damage is irreversible and the work of art can be considered destroyed. In particualr acses the museum´s curator may specify more accurate and acceptable temperature levels, specific to the nature and composition of the works of art to be protected.

Given that it has been proved that in a confined fire the temperature may reach 600ºC within approximately 10 minutes, the systems, procedures and actions should be designed specifically for each space with the preservation of the works of art in mind.

2.2.2 Humidity

In general, humidity in the spaces in which works of art are held is kept around 50-55%. The admissible variation in the humidity can vary as a function of the characteristics and composition of the paintings, and should be established by the museum´s curator. This should be considered when studying the effect of water as fire extinguishing agent. It should also be taken into account

that certain fire extinguishing systems produce a variation of 8% in the humidity levels at their start.

Therefore, it is necessary to consider the variation in humidity as one of the most detrimental effects for works of art, since it produces a dimensional variation in supports such as linen cloths, wood and frames that in addition to being very fast, cause the expansion and contraction of the pictorial layers and as a result cracking of their surfaces, provoking possible loss of parts of them and the embrittlement of all the layer.

2.2.3 Light

The effects of light on works of art are really important, and although it might seem not appropriate for this study, they should be taken into account for the reasons described here.

Even visible light can break down the paintings, but there are two types of light that are specially harmful for works of art: ultraviolet light and infrared light. The first produces color loss in the pictorial layer, which implies the progressive loss of color and therefore the loss of all polychromy. The latter is considered to be less detrimental, but this assumption is debatable, since its effects are less evident on plain sight but are equally important. The effects provoked by infrared light are the mobilization of water particles in the pictorial layer, producing heat at a molecular level and therefore an embrittlement of the layer that can go easily undetected.

The inclusion of the topic in this study is justified, for there are fire extinguishing systems that use infrared lights (infrared barriers) for large spaces as active detectors: they send a beam of infrared light between the emitter and receiver, being the work of art the receiver. This beam, active 24 hours a day during the whole year, could provoke the damage described. There are also cameras with night vision (with infrared lights) that might cause the same harm to the works of art.

Thus, all these systems are not viable for museums, except for if they are installed in a way that the beams of light avoid works of art or are in spaces where works are not lodged.

3 Safety organisation in museums

Before approaching the following subjects, it must be assumed that the collaboration of all security personnel of the museums must be granted, understanding that the objective is the preservation of irreplaceable cultural and artistic heritage. Whereas other institutions can have third party insurances, there is no insurance that could replace the historic value of some works of art.

In any case, no emergency intervention squads can be formed without undergoing initial training and annual revision courses on any possible updates in procedures, norms and concepts.

3.1 Daily Methodology

The maintenance of the fire extinguishing and detection systems shall be undertaken by qualified companies, with expertise in the application of national legislation and standards. Nevertheless, the presence of safety personnel in each building to carry out patrols is a guarantee for the maintenance of those systems.

An applied methodology shall be established for each building, taking into account the placement of the facilities, their complexity, their automatization and its integration within the control center, so during the patrols, and especially during closing hours and the hours with less personnel present in the building, the exact points to detect any anomaly as soon as possible and minimizing any harm are established and set accordingly. Should no control center exist, transmission to an ARC (Alarm Receiving Center) is highly recommended so that they can bemonitored 24 hours a day, seven days a week.

Each building is different, each collection is unique and the way of working and control needed in each space varies. The person responsible for building security will need to establish which checks are to be performed during patrols along with the approval from the maintenance manager. The maintenance manager may, in turn, give advice on any points of weakness, points which are difficult to access and how frequently they should be checked.

An important point to be taken into account on prevention is the verification of daily maintenance as risk-free and controlled in order to avoid accidents.

It is very important to avoid hot works as far as possible. In case a hot work must be developed, follow the safety recommendations as stated in CFPA E Guideline No 12:2012-F. An example of a hot work permit sheet is shown in Annex 1.

3.2 Transportation of works of art

Nowadays, the transportation of works of art is done in fairly good conditions, but following procedures that have not been adapted to the latest technological developments, so could be improved to increase the safety of the artifacts.

Regarding the main subject of this report: the protection of works of art against fire, two subsections can be identified: passive protection and active protection, the latter being the detection and extinguishing of fires.

Firstly, the worst-case scenario should be drafted, as stated in the introduction. In this case, it would be a traffic accident in which the truck transporting the works of art is overturned, the box or truck body is broken and a fire is caused by leaking fuel, the event happening remote from a fire station. Starting from this scenario, the current and the appropriate measures will be addressed.

3.2.1 Active Protection

Given the scenario described, fire detection protection cannot really be useful except in the specific case of a fire starting for any of the multiple causes that can happen within the vehicle (overheated brakes, short circuit, sparks...) that involve smoke going inside the truck body or box, undetected by the driver or drivers.

Considering fire extinguishing, active protection would be inoperative if gaseous fire suppression agents are used, since the safe opening in the truck body or box would prevent the gasses from reaching the needed density and tightness levels for it to be efficient. Therefore, a powder-based extinguisher agent is the more appropriate solution for this cases, since it is a solid material that does not require the enclosure that other solutions do.

Moreover, it must be considered that due to the impact, the packaging may be damaged and the works exposed, so water should be avoided. Even if the packaging is not damaged, given the current quality of packaging systems, the waterproofness may be low or non-existent.

In the same way that storage spaces in museums should have certain specific conditions in order to ensure the protection of the works of art, if the means of transports are considered as 'mobile storage rooms', the same rules for the museum's spaces can be applied to them, plus the risks that come from the fact that they are vehicles, therefore moving.

Then, trucks should be provided with:

- At least two fire detection units, located in the ceiling of the box/body covering both the front and the back of the space.

- Fixed fire extinguishing systems. The current systems (one automatic extinguisher located at the back) are not enough, for the range of action is limited. Therefore, a fire extinguishing system with two nozzles in trucks with a length less than twelve meters, or three in longer trucks, should be installed to ensure the coverage of the protection.

The extinguisher powder shall be specifically designed to avoid any harm to the works of art, and should be certified by a specialised laboratory.

3.2.2 Packaging

Conventional wooden packaging currently used for storage and transportation of works of art are nothing but mere containers, not offering efficient protection to the contents against the changes in climatic conditions nor, of course, the effects of fire.

Furthermore, being wooden containers, they are possible vessels for the transmission of insect plagues, so they shall meet the requirements stated on the IPSM-15 (March 1st 2005).

It is also important to be aware of the difference between the concepts of 'fireproofing', and 'thermal insulation':

- Fireproofing consists in exposing a certain material to one or several non-combustible materials, either for making that certain material fireproof or for retarding its combustion point. Flame retardants should be used with caution when it comes to cultural and historical material.

- Thermal insulation is the ability of avoiding the heat transmission to the side which is not exposed to the source of heat.

The aforementioned wooden boxes, if considered fireproofed, are not thermal insulated, so when exposed to a prolongued source of heat the inside of the box can become hot, harming the works of art. For temperatures over 80ºC, the works of art would be harmed, and for temperatures over 140ºC the harm would be important and irreversible, leaving the works nearly destroyed. Having said this, and given that those temperatures would be reached easily in case of fire, it is highly important the use of thermal insulated packaging.

Also, the thermal insulation is vital if the storage space does not offer the appropriate climatic conditions, since the current packaging system would not guarantee the endurance of the isolation for longer than one hour, as demonstrated by studies carried out by well-known institutions.

Another important feature is the water tightness. The packaging should be resistant to water not only when water is sprinkled over them, but also when completely submerged on it.

Therefore, the ideal conditions for the packaging should be:

- Fireproofed: the packaging should retain its structural integrity when subjected to high temperatures for a certain period of time.

- Thermal insulated: the temperature inside the packaging should not overpass a certain value when subjected to high temperatures for a period of time.

- Water tightness: when sprayed with water for a certain period of time, the humidity inside the packaging should not vary.

- Climatic stability: the inside of the packaging should register no variations when exposed to external climatic conditions for a period of 12 hours.

3.3 Organisation for the recovery of works of art

Safeguarding measures at museums are, if possible, more important than in any other type of facility, given the importance of the works to be protected. It is then necessary to undertake some predetermined measures in the case that the emergency shall occur, with the aim of minimising the damage.

Basic measures that should be taken would be:

- The stocktaking of the contents and essential structural aspects for each floor, using basic priority codes stating the order in case of relocation. These codes will classify the works of art in three categories, leaving less-important and large (thus difficult to move) objects aside.

- All contents shall be photographed and registered on each floor's map. A copy of that map should be stored for reference after the emergency. One laminated copy shall be assigned to each work area, stating the order and priority for relocation, with indications for the disassembling and handling of the goods.

- Any keys or tools needed to access the area shall be stored along with the map, and shall be easy to reach (anyway, to prevent malicious acts, a procedure to ensure the keys can be taken only by responsible people should be implemented). The magnitude of the task must be properly assessed in direct relation with the number of people and the tools available.

3.3.1 Priority Categories

The key task in the development of fire prevention plans is one of the most difficult ones. Experience proves that the person in charge of the development of the plan can easily get into conflict with the people in charge of preservation, as they are the ones responsible for identifying and establishing the content relocation priority, basing their decisions in the importance of the work and in the ease of its handling.

A proposal for a classification system could be:

1: A Priority: International heritage objects. This group includes a minimum number of works that should be relocated first for its historical meaning or artistic value.

2: B Priority: National heritage objects. This group includes works that are important for explaining the history of certain buildings or its inhabitants. It is also small.

3: C Priority: Works that are difficult/impossible to replace.

4: Unclassified: Works that are relatively unimportant or difficult to relocate given its size or weight.

The following graph shows a possible classification:

Inventory nr	Name	Condition	Property/ Rented	Priority	location	NEW location
123/tre-34	Farmer	Good	P	A	34.6	Storage A
987-KLO/pQ4	Landscape	average	R	B	23.9	Storage B

3.3.2 Organization of the recovery for each room

The following task is preparing a priority card for each room, area or space. This card will state any A Priority works in the room, each with its correspondent picture. This way, the works are easily spotted even in emergency situations. The card should also state any information regarding specific measures to be taken when relocating the works. Previously, any intervention groups should have been trained in disassembling and handling their assigned works.

The card will point any possible evacuation routes, where the security material needed for that evacuation is located and the destination for the works during the emergency.

All works that are not relocated shall be protected in-situ. Plastic bags, polycarbonate or NOMEX layers might be useful and will resist, to a point, the effects of fire, smoke, water and mechanical damage.

3.3.3 Evacuation of works of art

Firstly, suitable areas shall be located for temporary placement of the works while they are being catalogued and packed, before moving them to a safe storage area previously decided.

For new or restored buildings that include sectorisation of its areas, it is highly effective (considering the understaffing at night) to establish a collection recovery plan that is simple, easy to remember and to execute. This plan should include the relocation of the works through the most direct route, performing a horizontal relocation to a temporary room in another sector, which will become a temporary storage area. The sectorisation will avoid the spread of smoke and flames.

3.4 Deposits or temporary storage areas for works of art

Once the works of art that were more at risk are disassembled and taken to the temporary storage areas, the relocation to the storage areas with enough preventive measures or to the meeting points outside the building(s) can begin.

It would be positive to establish a collaboration agreement with any artistic or cultural institutions nearby, so when facing an emergency, those institutions may act as storage spaces for the works of art from the damaged building. This is highly convenient, for the distance between institutions can be relatively short in many cases, and the receiving institution will surely have the proper climatic and security systems to preserve the works of art. Those institutions might even have the appropriate workshops to proceed to the restoration of possible damages to the works of art.

3.5 Coordination with external forces

The Security Department or the Security Manager shall have an updated and easily accessible list with the numbers and addresses of all the key services. This list should contain the contact information for the fire brigade, and also for those experts who might be useful to restore the basic services in case of an emergency, such as:

- Builders, plumbers, carpenters, electricians ...
- Heritage recovery experts
- Smoke removal professionals
- Movers specialised in fragile items
- Phone numbers for basic suppliers (electricity, gas, water)
- Insurance companies
- Contractor pumps and generators
- Emergency services (police, hospitals, paramedics and fire brigade)

Coordination with the local fire brigade is is highly important and is essential for the effectiveness of any fire prevention plan for historic buildings. Communication with the emergency services prior to the emergency is also necessary, to ensure the integration of the plan with the possible actions of those services.

The fire brigade should be invited regularly into the building to familiarise them with the layout and structure, as well as participating in the fire drills. They will get to know where the water pumps are, how many buildings there are, how they are set out and other important aspects that will maximize their efficiency in case of emergency while at the same time minimise the damage. All relevant information should be included in the emergency plan.

Information about extracurricular activities, exhibitions or special events should be communicated to these forces. Temporary changes in the layout, structural changes or any other important information that might be useful in case of an emergency should also be reported.

4 Fire Safety

The need for fire extinguishing and protection systems is justified by the difficulty in keeping efficient watch of all the areas of a building, so in case of emergency (fire, intrusion or any other incident) it can be detected and solved quick and accurately with all the needed means.

The use of new technologies allows a thorough study of those needs and a wider and better control of the spaces that need protection.

Personnel shall be trained according to the requirements to operate efficiently the control centers.

Architecture shall be modular, with open communication protocols and full system integration.

The equipment shall be tested under the worst-case scenario conditions to guarantee the best operation.

4.1 Automatic fire detection systems

The automatic fire detection system surveys constantly the spaces within the building or facility, and, periodically, those spaces in which the risk is higher due to the activity taking place on them. There are certain productive processes that, for example, involve high temperatures, open flames and other hazards, needing specialized detection systems to ensure the risks are controlled and kept within the safety margins.

All the information of alarm resulting from detectors shall be centralized to indicate precisely the location of the fire.

Types of detectors:

- Optical Detectors: detect the obscuration of the light provoked by the solid particles in the smoke.

- Heat Detectors: detect the increase of the temperature above a certain level as well as they detect the increase of temperature in a certain period.

- Flame detectors: these detectors are able to identify the frequency and wavelength of flames differentiating them from other light sources.

- Aspiration detection: this is the most effective of all measures, since it takes air samples and analyzes them in analysis chambers with laser technology. They can detect imperceptible changes even before they can be noticed by their smell. It can detect a potential risk when the dielectrics are at their initial heating stage. The cost is high, so its implementing is done in specific areas of the building that show a potentially high risk of fire, or where other detection systems are not suitable.

4.1.1 About fire extinguishing systems

There are currently fixed systems for storage rooms and closed spaces that are being used for works of art storage at museums.

It must be taken into account that the needs for preservation of works of art are really specific, and the agents appropriate to extinguish a fire in any other storage space might not be suitable to get in contact with works of art.

Thus, and given the disadvantages of some extinguishing agents on their application not only from the point of view of the preservation of works of art, but also from their operational features, it would be advisable to briefly consider each of the agents.

The main properties and secondary effects related to the use of different extinguishing agents are described in the Annex 2.

4.1.2 Choosing the fire extinguishing system for museums

It is clear that, from the point of view of safety, the main worry is to extinguish the fire. But if, taking the advantage of having a fire extinguishing system installed, it can be adjusted so it protects the works of art against any secondary effects of fire as well, a whole new issue, not covered until now, would be solved.

The conditions for the fixed systems for the storage of works of art are established, based on these considerations, by the responsible for Security and Restoration, and the Management of the museum, following these premises:

- No system can be installed without an authorization from Conservation-Restoration.

- The relationship between protection and the effects of it on the works of art should be evaluated and accepted if no other solution is available.

- Systems should not produce any instant harm to the works.

- The possibility of damage to the works of art should be evaluated in specialised laboratories to decide if they are acceptable, to establish the period before damage is irreversible, the restoration process and the final consequences.

Once these premises have been established, the desired conditionants for this kind of systems are defined:

- Appropriate extinguishing according to the combustible material.
- Temperature control.
- Humidity control.
- Fireproof effect (physical separation layer between the fire and the protected artworks).
- Personnel protection in case of the works' relocation.

- No need for SCBA's (Self-Contained Breathing Apparatus) to enter the space.
- Duration of the all the above for a prolonged time.

As said before in this document, it is difficult that a single fire extinguishing system can fulfil completely these conditions. For that reason, it is important that whatever the selected system is, it should be tested previously to installation in conditions similar to the real ones, to know certainly the grade of achievement of the conditions stated above this paragraph.

The operation of any fire extinguishing systems shall be automatic.

5 Emergency action plans

5.1 Evacuation and emergency plan

The emergency plan for a museum is the key for the safety of the whole museum. The objective of this plan is to protect human lives in case of emergency of any kind which could be a threat for human beings.

The emergency plan of a museum shall include, written and with attached maps, all the actions of the personnel of the museum in case of any emergency at any given moment within the 24 hours of a day, every day of the year. For this purpose, the plan will appoint and have a list of the people responsible for First Intervention (fire extinguishing equipment), Emergency Evacuation Alarm and First Aid, along with the Emergency Chief and any deputy chiefs in case of absence of any of the appointed chiefs.

The emergency plan should be supervised and approved by the Fire Prevention Service of the correspondent city council or, failing that, the assigned civil defense organization in the area of the museum.

When drawing up the plan, it is important to take into the account the timing, meaning making a list of the existing personnel at each moment during the day and night, and for every season, since there is not the same amount of people in the facilities during the day or during night hours, nor during holidays… A good solution to avoid problems regarding this is to hire an external security company that can guarantee the presence of its personnel during all hours and avoids the problem of many museums have of having to close spaces due to the lack of personnel, which affects the public opinion of the institution and it complicates the organization of emergency plans.

The emergency plan shall be constantly updated, so there must be a person responsible for doing so within the staff of the museum. All members of the teams included in the plan shall undertake annual training on their responsibilities.

At least one yearly fire drill should be made. Any difficulties and problems in that drill will be evaluated to assess any possible problems and provide solutions and improvements.

A copy of the plan shall be stored in the entrance of the building, in a fireproof locker, with a complete set of maps of the facilities for the exclusive use of the fire brigade. Another copy should be stored at the nearest fire station.

The emergency plan should be in concordance with the CFPA Guideline No.25:2010 F, considering the local requirements and legislation.

5.2 Damage control plan

The damage control plan is supplementary and parallel in its action to the emergency plan, although the former focuses in the evacuation and relocation of goods, and the latter in the safeguard of human lives involved in the emergency.

The objectives of this plan are:

- To minimise the impact of the emergency restricting the propagation of smoke and heat.
- To reduce the loss of the institution's goods relocating the important works to a safe place.
- To rescue important documents.
- To minimise the impact of the fire extinguishing process, reducing the collateral damage caused by water.
- To protect the damaged buildings (against weather inclemencies and intrusions to prevent more damage or losses).
- To promote awareness of the existent risks among the management and personnel of the institution.

The skillful use of limited resources can have a considerable impact in the amount and cost of the damage, and can also ensure that an organisation can recover faster from the effects and damages of a fire. In modern commercial practice, the existence of a damage control plan is an essential feature of the recurrent planning of business.

The application of a logical plan allows the best allocation of the available resources; for example, the initial use of key tools is undertaken by those familiarised with them and trained in secure techniques, whereas other resources are destined to less delicate activities (evacuation of the building or buildings among others).

It is not the incident what matters, but the process for the building to be secured against more damage or the way in which its content is relocated safely.

The damage control plan established will need to be integrated with other plans of the institution, such as plans to manage emergencies or crisis, plans for evacuations or plans for the interruption of the activity.

The establishment of a damage control plan needs the establishment of a plan about the best allocation for the available resources, and more specifically, personnel. The seriousness of the emergency will be different when the building is empty or when the fire starts during night hours. The tasks to be carried out in a damage control plan will be:

- Calling the fire brigade.
- Evacuation of the non-essential personnel.
- Control and evacuation of visitors.
- First actions against the fire.
- Provide technical assistance to the fire brigade upon their arrival.
- Take the needed measures to prevent the fire from expanding (cut the electricity, close doors and windows, act upon the airing system, etc)
- Relocation and storaging of important works from exhibitions.
- Limit the impact of the extinguishing agents (mainly water)
- Dissipate the smoke.
- Recover articles and works after the fire is extinguished.
- Secure the place

The plan itself and any documents regarding it will be classified as confidential and strictly controlled. Copies of these documents shall be numbered, and non-authorized copies are strictly forbidden.

5.2.1 Organisation of a damage control plan

One of the greatest benefits from this kind of plan are the improvements in the risk reduction that can be obtained with an insignificant cost. The actions to be considered within the plan will be:

- Determine the needed equipment according to the size of the museum.
- Recruitment and training of teams formed by four operators plus one team manager.
- Complete the identification and inventory process to establish priority for relocation.
- Establish a detailed damage control plan and reserve lists.
- Purchase tracking and communication systems to be in contact with all the members of the teams at the same time.
- Purchase of needed equipment and supplies to carry out the damage control plan.
- Establish spaces for temporary storage of relocated works.
- Training and practice of the teams
- Appointment of support staff to aid in the relocation of works.
- Fire drill/ emergency practices involving all the staff and the fire brigade.

5.2.2 Damage control teams training

One of the most typical mistakes when establishing emergency plans is preparing detailed plans and not giving them the importance they deserve thinking everything is under control. This is really dangerous.

Training for all personnel involved with a role in the plan is essential. This training shall begin with sessions about the contents and aims of the plan until every person involved understand completely all the details. Then they have to perform limited practical sessions with individuals and groups.

These sessions will be aimed at training the teams in the use of the different fire extinguishing systems within reach, as well as the specific considerations for the relocation and handling of works of art in a safe way that ensures the possibility of treatment and restoration afterwards.

Training should be annual. Once all the team is trained, a complete fire drill should be performed at least once a year, being recommended to involve the external emergency services if possible.

5.2.3 Resources and equipment needed for damage control plans

A study prior to the plan will established which are the needs and the needed amounts for the required resources that should be placed at least at two points in the main floor or exhibition space of each protected building, and that should include at least the following: (this list is orientative, may vary depending on each building's needs)

- One trolley/cart that can be handled by a single person.
- Two light four-meter ladders
- An organized toolbox, including cutter, pliers and small crowbars.
- To big flashlights with extra batteries.
- Four plastic buckets, trowels, mops and sponges.
- Ten folding plastic boxes.
- One bubble wrap roll
- One wrapping paper roll
- Fifty big plastic bags
- Fifty medium plastic bags
- Slings for frames or other furniture
- Protective blankets for thin surfaces
- Carts for heavy items
- Adhesive tape, labels, strings, markers and scissors.
- Protective clothes (paper masks, rubber gloves and shoe protectors).

In those zones where the support personnel will help recovering, relocating and packaging, there should be:

- Ten paper towel rolls
- Two water hand sprinklers
- Five two-liter distilled water bottles
- Frame preservation equipment

- First aid kits
- Two eye wash bottles
- Two hundred big plastic bags with a zipper
- One acid-free silk paper roll.
- One box with desk supplies (pens, pencils, chalk, clips, labels ...)
- Fifty plastic aprons
- Two water/dry vacuum cleaners.
- Six big electric fans
- One big toolbox with the appropriate supplies.
- Eight slings for frames and other furniture
- Fifty meters of 50-mm string
- Two extensible seven-meter ladders
- Additional slings
- Additional carts for heavy items
- Additional protective blankets and sheets
- Four 20x10m canvas

Each one of the experts in preservation shall specify the contents of each of the emergency boxes and its location, and this must be kept safely in the designated place.

The need for two-way radios should be considered. At least one of the radios must be available for the fire brigade chief.

If there are specific security tools in place for the protection of frames or other objects, the keys to those tools must be included in the toolboxes. At the same time, if the relocation plans for large objects need scaffolds or ladders, those should be placed nearby.

5.2.4 Protection for the members of the damage control teams

It is essential that all personnel of the teams are insured for all the activities of the team. This includes the specific training and personal protective equipment.

All personnel working inside the building in an emergency shall be provided with the proper clothing and personal protective equipment. This should include:

- Helmet with band and flashlight.
- Fireproof overall
- Safety boots with antipunching soles and steel toe caps.
- Leather cut and fireproof safety gloves
- Supervision personnel should wear a colored vest or other kind of marked clothing.

5.2.5 Security during the action of the damage control plan

All personnel required to intervene in an emergency shall be provided with a document that identifies him/her as a member of the organization of the damage control plan and that he/she needs free access to all zones during emergencies.

Management must foresee that regular security measures can be overpowered and ineffective in case of any emergency. It is therefore essential that the participation of the security forces is included, to secure not only the building, but the works and goods that have been recovered or are being relocated from the damaged buildings.

5.3 Procedures after the fire extinction

Access to the building or facility might be restricted due to safety or structural reasons, or for the investigation of the causes of the fire. In fact, the integrity of the building or its remains must be studied first by the experts to determine the stabilisation processes that need to be carried out before any other access is allowed. It may be necessary to contact the local authorities, who probably will want to demolish part or the entire damaged building, and ask them to consult the historic heritage experts before taking a definite determination which might be irreversible. In these cases, advice from the expert can be of great help. It must not be forgotten that the legislation on damaged structures suggest alternatives to demolition when suitable.

Warning signals and barriers shall be set on the zone. Valuable goods or its remains are to be looked for amidst the debris. If found, they would be labeled and registered with their current state. A damaged ceiling will be covered by a canvas to minimize the effect of weather.
The temporary recovery works will be organised by a qualified expert (architect) to ensure the proper stability of the structure.

Where possible, residual water will be removed using mops, water vacuum cleaners and sponges.

Aside of the strength of pressurised water, which damages fragile materials, it must be taken into consideration that water also dissolves soluble materials and can literally disintegrate them.

Once the fire is extinguished within masonry structures, they will have absorbed huge amounts of liquid and several detrimental processes can take place. During winter, frost may cause the crystallization of the liquids inside the softened masonry, causing it to crack open and peel. The drying process may bring mineral salts to the surface of the piece, where they crystallize and provoke the peeling of the surface. Mold and fungi will also appear in the wooden and other organic material surfaces causing putrefaction. Hence, the protection, insulation, ventilation and draining are essential particularly around the winter season.

Professional advice from restoration experts ought to be taken about the recovery of damaged articles. This needs to take place with no delay, since the decomposition products from the combustion can be highly acid, therefore highly corrosive.

Used fire extinguishers need to be replaced, and hoses need to be cleaned and rolled back.

The place shall be secured against robbery; broken windows must be covered and broken doors replaced. The need for strengthening temporarily the safety of the facilities should be an option to consider.

6 Guidelines

Fire

Guideline No 1:2002 F - Internal fire protection control
Guideline No 2:2013 F - Panic & emergency exit devices
Guideline No 3:2011 F - Certification of thermographers
Guideline No 4:2010 F - Introduction to qualitative fire risk assessment
Guideline No 5:2003 F - Guidance signs, emergency lighting and general lighting
Guideline No 6:2011 F - Fire safety in care homes for the elderly
Guideline No 7:2011 F - Safety distance between waste containers and buildings
Guideline No 8:2004 F - Preventing arson – information to young people
Guideline No 9:2012 F - Fire safety in restaurants
Guideline No 10:2008 F - Smoke alarms in the home
Guideline No 11:2005 F - Recommended numbers of fire protection trained staff
Guideline No 12:2012 F - Fire safety basics for hot work operatives
Guideline No 13:2006 F - Fire protection documentation
Guideline No 14:2007 F - Fire protection in information technology facilities
Guideline No 15:2012 F - Fire safety in guest harbours and marinas
Guideline No 16:2008 F - Fire protection in offices
Guideline No 17:2008 F - Fire safety in farm buildings
Guideline No 18:2013 F - Fire protection on chemical manufacturing sites
Guideline No 19:2009 F - Fire safety engineering concerning evacuation from buildings
Guideline No 20:2012 F - Fire safety in camping sites
Guideline No 21:2012 F - Fire prevention on construction sites
Guideline No 22:2012 F - Wind turbines – Fire protection guideline
Guideline No 23:2010 F - Securing the operational readiness of fire control system
Guideline No 24:2010 F - Fire safe homes
Guideline No 25:2010 F - Emergency plan
Guideline No 26:2010 F - Fire protection of temporary buildings on construction sites
Guideline No 27:2011 F - Fire safety in apartment buildings
Guideline No 28:2012 F - Fire safety in laboratories
Guideline No 29:2013 F - Protection of paintings: transport, exhibition and storage
Guideline No 30:2013 F - Managing Fire Protection of Historic Buildings
Guideline No 31:2013 F - Protection against self-ignition and explosions in handling and storage of silage and fodder in farms

Natural hazards

Guideline No 1:2012 N - Protection against flood
Guideline No 2:2013 N - Business Resilience – An introduction to protecting your business
Guideline No 3:2013 N - Protection of buildings against wind damage
Guideline No 4:2013 N - Lightning protection

Security

Guideline No 1:2010 S - Arson document
Guideline No 2:2010 S - Protection of empty buildings
Guideline No 3:2010 S - Security system for empty buildings
Guideline No 4:2010 S - Guidance on key holder selections and duties


European
Guideline

ANNEX 1

HOT WORK PERMIT

European Guideline

CUT AND WELD WORK PERMIT

Date _____
Floor _____ Section_____
Department _____ Company _____
Work description)_____
Adopted security measures ____ _____

The section in which the work is to take place has been inspected and all needed security measures have been adopted.
Permit valid until _____

Signature:

Start time _____ End time _____

IMPORTANT

Before authorizing any cut and weld work, the person responsible for fire extinguishing systems will inspect the work area and confirm that the measures to prevent fires have been taken:

PREVENTION

Sprinklers check: YES:___ NO:___
Cut and Weld equiment check: YES:___ NO:___
Presence of fire extinguishers in the work area: YES:___ NO:___

WITHIN 10 METRES

Floor free of combustible materials: YES:___ NO:___
Combustible floors protected with wet sand or metallic sheets; YES:___ NO:___
No uncontrolled combustible material nor flammable liquids present: _____
Combustible or flammable materials protected with covers or metallic sheets: YES:___ NO:___
Openings/holes in floors or walls covered:
YES:___ NO:___

WALL OR CEILING WORKS

Non-combustible structure: _____
Combustible materials removed: _____

CLOSED SPACE WORKS

(Tanks, containers, conducts, vents, filters…)
Combustible removed from equipments: _____
Flammable vapors removed: _____

FINAL CHECK

Will take place two hours after the work has been finished: _____

Signed:
Supervisor

ANNEX 2

ADVANTAGES AND DISADVANTAGES RELATED TO THE USE OF FIRE EXTINGUISHING SYSTEMS

Halocarbon agents

H.C.F.C.: Hydrochlorofluorocarbons, also known as NAF-S-III, Halotron and Haloclean. These gases are completely banned in Europe.

H.F.C.: Hidrofluorocarbons, the most spread being HFC 227-ea and HFC-23.

These concepts must be reviewed beforehand:

- O.D.P. - Ozone Depletion Potential: it measures the contribution of the gas to the destruction of Ozone layer in the atmosphere, in comparison with Trichlorofluoromethane which ODP =1.
- G.W.P. - Global Warming Potential: it measures the contribution of a certain gas to greenhouse effect, in comparison with CO_2 which ODP=1.
- A.L.T. - Atmospheric Life Time: it measures the life time of a certain gas in the atmosphere.
- LOAEL, Lowest Observed Adverse Effect Level: The lowest concentration of gas at which an adverse toxic or phisiologic effect has been observed.

HFC 227-ea has zero ODP, GWP index of 6300 and an ALT of 36.5 years. Cardiotoxic LOAEL is 10,5% of concentration (from this % onwards it is considered dangerous). Many limitations regarding human action: during its discharge it is necessary to wear protection.

HFC-23 has zero ODP, GWP index of 11700 and an ALT of 264 years. Cardiotoxic LOAEL of 50% of concentration.

Both gases have a high GWP index, and they have been banned or its use has been restricted in some European countries.

Decomposition products: if the discharge of the gases is done in presence of fire, it may result in the creation of highly toxic and corrosive vapors, mainly Hydrofluoric Acid (HF). Depending on the type/source of the fire, levels of 6000 ppm of HF were registered. A quick discharge in addition to a early smoke detection system can contribute to minimize this undesirable effect.

A disadvantage to be taken into account, is that, when activated, they increase the pressure of the space so fast that they could damage the partitions of a non-prepared space, as well as any windows or doors. The same effects could affect pictures and frames, breaking the protective glass or causing an important movement within the linens. To avoid such overpressure and its effects, dampers can be installed in the protected room.

Inert Gases

The two principal gases are Inergen and Argonite. Being inert gases, they are present in the atmosphere and therefore do not produce any harm to the ozone layer or contribute to global warming.

One disadvantage of these gases is that they require a large quantity of bottles to suffocate fires. This need for the storage volume must be considered. They are high pressure installations, and this also has to be taken into account regarding the quality of the system components.

Inert Gases can also produce an overpressure in the room protected after discharge. This overpressure effect is worse for Inert Gases than for Halocarbon Gases, since the storage pressure is usually higher, but it can be minimized by the installation of dampers in the room to be protected.

Regarding the effects on people, given the decrease in oxygen concentration, and that in order to maintain the salubriousness of the substance it contains 8% of CO2 (Inergen), it could cause hyperventilation upon inhalation. Added to the possible anxiety or stress in case of emergency, this could be potentially harmful for people's health.

And as for the works of art, these gases produce a quick decrease of 7% of ambient humidity; therefore, it could produce tautness in the linens because of its expansion and contraction.

Fire could be reactivated if the concentration of gas is reduced due to leaks or air currents caused by the relocation of works of art.

When discharged, an instant condensation of the ambient humidity in the shape of water drops, that scatter around the room, producing a fog-effect that could affect to the works of art, since if they were exposed to the rapid decrease of the temperature plus the water present in the room's atmosphere, the surface of the linen could become crystallized and damage it irreparably.

No decomposition products were detected.

Carbon Dioxide

The efficiency of carbon dioxide (CO_2) is based on its suffocation effect, and not in the cooling.

When CO2, on its liquid form, is discharged at atmospheric pressure, a part of it becomes vapor, and the rest is cooled down by evaporation becoming dry ice at a temperature of 79ºC below zero.

Regarding the preservation of works of art, it would produce a sudden decrease on the ambient temperature and a possible projection of dry ice at the temperatures mentioned earlier.

It requires large volumes for gas storage, and they are high-pressure storage facilities.

The most important disadvantage would be its effect on health. Even when CO_2 is not toxic, it displaces oxygen and could produce asphyxiation. Being colorless and odorless, it would be relatively easy to step inside a suffocating atmosphere area and lose consciousness or even die. Hence, the use of this gas is not recommended if there is human presence in the facility.

Decomposition products: no toxic or corrosive products were detected. However, it produces a fog that hinders vision. So, adding this to the thermal shock, it is not recommendable to discharge the gas directly over delicate objects.

Water-based fire extinguishing systems

With a discharge of this kind of systems, the variation in ambient humidity is critical and the potential damage to the works of art is really high. Here are some considerations about some of the effects and damage that those works of art could have to endure:

- It causes a quick cooling of materials and vitrification in some cases.
- As dew, it could cause condensation and fixing of water particles in the surfaces.
- Cathodic corrosion.
- Swelling of the cellulose of woods and linens, with dimensional variation (polychromy, being rigid because of the polymerization, cannot resist these variations and breaks)
- Possible biological formations due to the humectation of microscopic dust and fiber substrates.
- Could act as solvent for techniques such as watercolors or inks.
- Causes the deposit of the smoke in the surface of paper, obscuring it preventing the reading of previously printed notes.

The unstable nature of paper, based on hydrogen bridges that are formed from the loss of water of the pulp, makes it sensitive to a reversal process of rehydration, which could cause weakening and disintegration.

In the case of collages, provokes the swelling of the old gluing and the separation of the parts.
On archeological materials, the problem lays on the permanence of water particles in contact with metallic objects (corrosion).

Regarding fabric, the risk involves the retention of humidity in fibers and dust substrates, with the risk of starting to rot plus the aforementioned biological inconveniences.

Material	Relative humidity value recommended for its stability (%)
Fabric	45-55
Wood	50-55, requires maximum stability
Paint over wood	50-55, requires maximum stability
Paint over metal	40
Finishings	50-55, requires maximum stability
Glue of animal origin	50-55

Table 1: Relative humidity values for the preservation and stability of different materials.

It is clear that all water systems, in any of their forms (sprinkled, nebulized ...) and either in fixed or portable systems are not viable when it comes to the prevention and protection of works of art, if a more suitable alternative exists.

Dry-Chemical based fixed fire extinguishing systems

Once the features of the most common powders are analyzed, it can be noticed that the composition and granulometry varies greatly from one to another. In some cases, marble powder, which makes the powder highly abrasive, or agricultural phosphate, equally harmful for works of art, is used.

Therefore, and regarding the needs for conservation of the works of art, it is necessary that the powder has certain physical features, with the need of the extinguishing agent to meet the following requirements:

1. It cannot be harmful for people, meaning, it cannot be toxic
2. It has to have a granulometry level high enough to allow its cleaning through aspiration or a similar process.
3. It cannot produce an increase neither in temperature nor humidity.
4. It must create a protective layer that covers both the space and the works of art from the humidity that may result from fire extinguishing processes.
5. It must not produce any undesirable decomposition products, nor those products be fixed to any of the works.
6. If possible, it must offer some protection against the increase of the temperature.
7. It must be compatible with the existing fire detection systems.

It must also be considered that a fixed extinguishing system using dry-chemical agents is not a high-pressure system, so the installation and maintenance of the system is greatly simplified. The

powder is stored in recipients that are similar to conventional extinguishers, but with the required size regarding the space to cover.

However, each user should value, depending on their needs, risk factors and location, the convenience of one type or another of automatic extinguishing systems.

To minimize the damage to the artworks, the selection of a dry-chemical fire extinguishing system should be taken having into account that:

- The system is designed for its implementation in closed spaces such as storage rooms and other rooms with potential risk.
- Not all types of powder in the market are valid. They should join the special conditions as stated in the beginning of this section.
- Minimum requirements in the storage of works of art have to be met in order to minimize the projection of the agent on them, and these requirements have to be easy to meet.
- A procedure for the posterior cleaning has to be established in case of the discharge of the system.
- The possibility of an accidental discharge has to be eliminated, possible nowadays with the developments in the systems and the maintenance according to the specifications.

Inerting

Inerting is not really a fire protection system but a fire prevention system. As it is commonly known, the persistance of a fire requires the presence of oxygen. Normal concentration of oxygen in the air is around 21%. If the % of oxygen in the air is reduced under 13%, a fire can not subsist. Anyway, the maximum concentration admissible of oxygen to avoid the peristance of a fire should be obtained by performing a specific test, considering the characteristics of the materials and configuration involved.

Basically the inerting system permits to reduce oxygen concentration in a room by injecting nitrogen (which has been extracted from the air). The room protected is equipped with oxygen concentration detectors. When the maximum admissible concentration of oxygen is reached, nitrogen is injected to decrease it.

The efficiency of the system depends on the integrity of the walls. Any leakage in the room, temporal or permanent, must be taken into consideration to design the maximum capacity of the nitrogen generator. The higher the leakage is, the more nitrogen must be injected.

Inerting does not altere humidity or temperature conditions in the room, so it makes this system appropiate for the protection of storage of artworks. In many of the existing storage museums there is an almost permanent transit of pictures in and out of the room. In those cases the quantity of nitrogen to be injected can be very high, and it must be studied if the inerting system is cost-effective.

Sometimes storage rooms can also be used to examine, study, or classify the works of art. Although the maximum required oxygen concentration in the room provides a breathable atmosphere, it is not advisable for a person to stay inside for very prolongued periods, since oxygen depletion can cause some health problems like headaches, vomiting, and the increase of cardiac arhythma.

ANNEX 3

CONSIDERATIONS FOR FIRE PROTECTION FROM THE CFPA SECURITY GUIDELINE FOR MUSEUMS AND SHOWROOMS

The risk of fire (fire, heat, smoke and fire gases, extinguishing water etc.) in museums and other facilities that exhibit objects of art and cultural heritage poses a serious threat to these organizations. Although a fire and loss of profits insurance policy may compensate for the material damage caused by a fire, the personal injuries and damage resulting from partial or total loss of irreplaceable artefacts, collectors´ items and exhibits are much more serious.

The damage that such a negative incident can do to a museum´s image must not be underestimated either. Preventive fire protection measures are able to mitigate the fire risk in museums and showrooms effectively. Intelligent investments in structural and technical features in combination with organisational measures ensure safe operation of museums and showrooms.

This not only applies to new buildings; suitable measures are capable of realising improvements in old buildings. Pursuant to the relevant legal standards of the Federal States (regional building codes, industrial health and safety laws), the operator is obliged to determine and implement the necessary precautions.

1 Holistic fire protection concept

Effective fire protection can only be achieved by a fire protection concept tailored to the respective museum. This brings all individual protection measures into line. A fire protection concept includes measures of preventive fire protection (with individual structural, system-related and operational/organisational elements) as well as fire defence that consist of rescue and fire-fighting operations. All these necessary components interact with each other. A fire protection concept is required to meet the principal fire protection goals. Structural systems need to be designed in such a way that they prevent development of a fire and spread of fire and smoke and make it possible to rescue people and effectively fight the fire in case of an emergency. Consequently, the fire protection concept specifies the general and user-specific measures.

Should it not be possible to comply with the necessary measures of the concept, then the alternative strategy must be designed to compensate for this. Operators of old buildings should therefore check regularly whether any upgrades are required.

Fire defence is not intended, nor is it suitable, to compensate for deficiencies in preventive fire protection. Measures envisaged in preventive fire protection plans must take into account the capacity and resources of the local fire brigade, e.g. alarm transmission paths, equipment, response time.

Structural fire protection forms the basis of fire protection, which includes determination of fire compartment sizes, required fire resistance classes of supporting and non-supporting structures, as

well as specifications on the burning behaviour of building materials (Material classes in line with EN 13501, Part 1). System-related fire protection measures complement structural fire protection. They include e.g. configuration of smoke and heat removal systems, automatic fire detection and alarm systems, fire extinguishing systems, alarm systems and other fire suppression measures such as risers, wall hydrants, manual fire extinguishers etc. Streamlined operational-organisational measures are a vital prerequisite for smooth interaction of structural and technical fire protection measures in case of an emergency. However, they are never able to compensate for "softer" requirements that apply to structural and technical fire protection measures. Organisational measures include, e.g., developing and updating fire safety regulations, alarm and contingency, regular fire protection drills for employees or the development of plans for the fire brigade.

Moreover, the measures specified in the alarm and contingency plans are designed to help minimise the actual scope of the damage in case of a fire and contain possible fire loss.

Organisational and management of fire protection is of a paramount importance. A fire protection commissioner is usually entrusted with this responsibility. This organisation of the procedures to be followed in case of an alarm need to be regularly reviewed by drills conducted at least once a year.

Important note: A fire prevention inspection by the local fire protection commission does not replace inspection of fire protection equipment and organisational measures, and ensuring their permanent readiness for operation, which is the responsibility of every fire protection organisation.

2 Structural fire protection measures

All structural measures are subject to the building codes, special building regulations and the relevant technical building regulations introduced by the Federal States. The individual experts responsible for fire protection should be involved and consulted as early as possible in developing all building activities.

This ensures that principal fire protection requirements are considered. The consultants and engineers of the fire insurer provide valuable input as well. Fire protection should also be considered in structural measures not subject to building permits as well as refurbishment and construction measures.

2.1 Fire and smoke compartments

Museums and buildings with exhibitions must be divided into fire and smoke compartments relative to their size. The building codes and special building regulations of the respective country need to be complied with.

Rooms with a particular concentration of assets (e.g. storage) should generally be divided into separate fire compartments – even if they do not comply with construction requirements. If necessary, larger storage should be divided into several fire compartments in order to avoid the

total loss of the storage. When the building is divided into fire compartments, it is necessary to make sure that they have a smoke-proof closure.

Note: There are burglar-resistant doors that provide protection against burglary and theft as well as protection against smoke and fire.

2.2 Evacuation routes

The length of evacuation routes depends on the type and occupancy of the building. All components of the evacuation routes as well insulation materials, walls and ceiling covering must consist of incombustible material (EN 13501 Part 1, class A). Corridors that are generally accessible and connecting bridges in buildings of low height need to be isolated at least by fire retardant components (F90 AB). Other buildings are subject to stricter requirements (structural walls to fire-break standard).

To achieve ”Safe setting” of intruder alarm systems, the installation of electrical locking systems to doors of evacuation routes may have to be considered. However, it is vital that the building code, special building regulations and fire regulations of the respective country need to be complied with.

2.3 Opening in fire break walls

Openings for air conditioning systems, doors and fire sealing of openings for cables (etc) must be achieved by systems approved by the planning authorities.

Changes to approved fire-resistant closures are subject to separate regulations. Otherwise, doors could lose their approval.

The provisions that apply to changes to fire-resistant closures must also be complied with when installing an intruder alarm system; this also applies to restructuring or extensions.

2.4 Especial rooms and areas

Rooms or sectors (e.g. workshops) that pose a particular fire hazard (e.g. storage of flammable liquids) or with higher risk of damage to assets (e.g. storage) need to be isolated from other sectors by fire-resistant and smoke-proof partitions. Rooms and buildings are regarded as isolated by fire-resistant partitions in the sense of these Guideline if they are protected by fire-proof ceilings and walls as well as fire-resistant doors and closures. Moreover, storage should not be established in attics if there is a significant hazard due to the structural fire load represented by wooden roof trusses, often in combination with flammable insulation material and flammable roof cladding (e.g. trapezoidal corrugated sheets for flat roofs). The latter creates a formidable difficulties for fire fighters.

2.5 Insulating materials

If possible, insulating material should be non-flammable and meet class EN 13501 Part 1, class A, for building material.

2.6 Completion of the interior/furniture

Non-flammable materials should be used for completing interior decoration. If that is not possible, flame-retardant material that does not drip must be used. If possible the use of halogenated plastic should be minimised. Fire loads and potential ignition sources should be avoided.

2.7 Fire protection for special systems

Electrical Distributors

If possible, electrical distributors should be installed outside exhibition areas and storage rooms. Electrical distribution units in exhibition areas and storage rooms must be isolated by fire-resistant and smoke-proof partition walls. Residual current protective devices need to be installed in all electrical distribution equipment. Local regulations shall be considered. Isolation of the power supply to these rooms upon leaving them also makes sense.

Electrical systems

Electrical systems and equipment need to be installed and operated in line with approved technical regulations in each country. Moreover, the relevant accident prevention regulations also need to be considered when installing, modifying and maintaining electrical systems and equipment. Residual current protective devices have to be installed in electrical systems. The rated differential current on the protective device must not exceed 300 mA, and 30 mA for additional personal protection.

Lights must be selected and installed according to the relevant local standards. They must be installed in a way that they do not cause any fire.

Ventilation systems

The respective relevant model guideline on fire protection requirements for ventilation systems needs to be consulted. Ventilation pipes need to have a smooth interior surface and consist of non-flammable materials including their insulation and cladding. In order to prevent fire spread to other fire compartments, blocks or floors of buildings, they must feature a fire-proof design or be protected by fire-resistant dampers activated by smoke detectors approved by building permits.

To prevent spread of smoke, additional measures might be required such as monitoring by smoke detectors or possibly deactivation of the ventilation system by a fire detection and alarm system.

Elevator systems

Elevator systems must be designed in line with the requirements resulting from building laws and industrial safety regulations. Moreover, they should be equipped with a state-of-the-art fire control that initiates automatic evacuation rides in all elevator cars (rerouting elevator cars to access or alternative levels).

Room for electronic systems

Rooms that house systems for information technology (IT systems) and surveilance equipment require a fire-resistant isolation from other areas.

3 Fire Protection trough suppression and security systems and equipment

3.1 Fire detection and alarm system

Museums and showrooms should be equipped with a fire detection and alarm system (FDAS) with a supression range that covers the whole building. The purpose of a fire detection and alarm system is to detect a fire early, localise it and notify the control room responsible. This function is performed by automatic detectors , among others, supplemented by non-automatic fire detectors (manual alarms).

Information on the installation and operation of fire detection system can be found in the *EN54 Parts 1 to 25: Fire detection and fire alarm systems.*

3.2 Internal alarm systems

Following consultation of the fire brigade in charge of the fire protection authority, suitable personnel alarm systems, preferably electro-acoustic emergency warning systems, must be installed.

Transmission of voice announcements, suitable for the respective situation by such warning systems, ensures that organisations designated for this purpose, and individuals affected, are informed and receive specific instructions on what to do.

3.3 Smoke removal

The staircase must feature a smoke removal system and/or ingress of smoke must be prevented (smoke exhaust ventilation systems, smoke repression systems, air locks). Actuators of smoke exhaust ventilation systems must be designed and mounted in such a way that they can be operated safely.

When designing a new museum, the installation of smoke and heat exhaust ventilation systems (SHEVs) should be taken into account during the planning. The general term SHEV means natural smoke exhaust ventilation systems (NSHEVs) as much as motor-operated smoke exhaust systems

(SEs). Their purpose is to prevent personal injuries and damage to works of art and collectors´ items caused by aggressive and toxic smoke gases and heat exposure.

Note: For more information, refer to *Guidelines for natural smoke and heat exhaust ventilation systems (NSHEVs),* CEA 4020.

The installation and operation of a smoke and heat exhaust ventilation system must be synchronised with other technical systems (e.g. extinguishing system, air conditioning system) and the fire protection commissioner must be consulted. For instance SHEVs must not open automatically in rooms protected by a gas extinguishing system.

Smoke exhaust ventilation systems should have the following features:

- The smoke exhaust ventilation system must be planned and designed for every individual application.
- Smoke removal pipes and dampers that penetrate ceilings or walls of defined fire resistance classes need to be of the same fire resistance class.
- Only non-flammable materials must be used for smoke removal pipes.
- The smoke exhaust ventilation system should be designated in such a way that they are protected from any external impacts.
- Smoke exhaust ventilation systems should improve asset protection as well as rescue possibilities for people (e.g. facilitated access for rescue forces and evacuation through staircases that can be accessed safely).

It should also be possible to remove smoke from exhibition areas and storage. The smoke exhaust ventilation system should be dimensioned in such a way that the low-fuming layer is above the exhibition level of the artefacts. Required openings for gas streaming out should not be in the outer facade since aspects of burglary/theft/vandalism protection also need to be considered.

3.4 Supply of extinguishing water

In coordination with the relevant authority, a sufficient and effective supply of extinguishing water must be ensured to achieve fast fire suppression. The nearest water hydrant should not be more than 150m away from the building or its entrance.

3.5 Fire extinguishing systems and equipment

Suitable fire extinguishers and, if necessary, a sufficient number of wall hydrants must be installed in clearly visible locations within the corridors. Water and foam extinguishers are generally recommended for administration areas, while water, foam, powder, grease fire and/or CO_2 extinguishers may be suitable for other areas, depending on the type of exhibits and occupancy. The incorrect extinguishing agent may not only have a negative direct suppression effect but also damage the objects affected by the fire, which needs to be taken into account. The right choice of extinguishing agent should also be made through consultation with the fire brigade restorers.

3.6 Automatic fire extinguishing systems

In general, automatic fire extinguishing systems, if possible, with residue-free, non-corrosive extinguishing agents without expanding effect are the only option suitable for museums. This is provided by many gaseous extinguishing agents. As people need to leave the premises before gaseous extinguishing agents can be applied (depending on the gas used), gas extinguishing systems are generally not suitable for all the areas with public access.

As water extinguishing systems (e.g. water mist extinguishing systems, pre-action sprinkler systems with pipes not holding water, permanently activated by a fire detection and alarm system) can be activated selectively and deliver fast and localised suppression with water volumes adequate for the relevant risk, they may also contribute to reducing the scope of the damage.

In view of the protection goals, the type of extinguishing system to be installed can be determined as early as the planning stage in close consultation between a competent planning office or an approved installer, the relevant museum representatives and the insurer.

More information related to planning and installation of fire extinguishing systems can be found in the relevant EN standards.

Permanent oxygen reduction in rooms not frequented by the public may reduce the risk of fire development as an alternative to fire suppression. This option is particularly suitable for storage or showcases (small volumes). Where there are plans for a reduction system, it must be included in the holistic fire protection concept. Special emphasis must be placed on the public health protection of visitors and employees.

4 Organisational fire protection measures

Organisational fire protection measures must always be kept up to date and coordinated with the relevant fire protection organisation and, if required, the insurer. Aside from designating a fire safety commissioner and regular fire safety training of staff, organisational fire protection also includes the development and regular update of:

- Fire safety regulations.
- Alarm plan.
- Escape and rescue plan.
- Contingency plan.
- Fire protection plan.
- Fire brigade plan.
- Planning and monitoring of required maintenance.

Moreover, other fundamental factors such as housekeeping, no smoking policy, flammable repair and maintenance jobs can etc also need to be taken into account.

4.1 Fire Protection Commissioner

In general, the museum´s management is responsible for fire protection. It may transfer the responsability for organisation and management of fire protection to a person (fire protection commissioner) whom it sees fit. The fire protection commissioner reports directly to the management and is responsible for fire protection within the duties entrusted to him. The fire safety officer must have the personal and technical qualifications to carry out fire protection. To this end, he needs to be duly authorised.

The safety commissioner who is always responsible for fire protection pursuant to the health and safety regulations, may also be designated as fire protection commissioner. The fire protection commissioner must be able to identify and judge risks, and he needs to see if that they be removed and damage is minimised. He has the following responsabilities:

- Formulating fire safety regulations, alarm, contingency and fire protection plans.
- Conducting fire safety training for staff and documenting it.
- Organising and supervising fire safety inspections.
- Instructing and supervising removal of fire safety deficiencies.
- Defining substitute meaures in case fire safety systems and equipment fail or are shut down.
- Consulting on matters of fire protection, e.g. for planning of new buildings or refusbishments.
- Responsible for keeping constant contact with the fire brigade, authorities, insurers and joint drills and inspection rounds.

Keeping a fire safety track record that documents the most important activities is generally recommended. It should in particular define which inspections and tests need to be conducted and how/when they were conducted. Any deficiencies and how they were removed should also be recorded. Inspections should be conducted by way of a checklist. Moreover, fires and their causes, even if immediately suppressed, should be documented in the track record to identify potential weaknesses.

4.2 Fire safety regulations

Due to their importance, fire safety regulations need to be put into force by the management and communicated to all employees. The fire safety regulations need to be constantly kept up to date, taking in particular into account changes in procedures and structural systems. They must contain the most important measures of fire protection at work and specify how to bahave during and after a fire. They should be formulated in accordance with the relevant fire protection organisation. The following structure is generally recommended:

- Reduce fire loads to the minimum.
- Define how to behave in case of a fire and train employees.
- Define regulations for assembly and installation jobs.

- In principle, so called ”hot works” should not be permitted, except with a special permit and after taking appropiate precautions for fire protection.
- Instruct contractors and supervise their work.
- Constantly ensure and monitor good housekeeping.
- Avoid ignition sources.
- No smoking policy – if necessary, install separate smoking zone isolated by special fire safety measures.