Part II
Design and Analysis of Protective Systems – General Loss Prevention Engineering

Handbook of Loss Prevention Engineering, First Edition. Edited by J. M. Haight.

6
General Loss Prevention Engineering Programs – Including Fire Loss Control

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6.1
Background

Loss prevention and fire control programs have for many years applied a very high standard of protection for mitigating exposures to risk of their client's facilities. Loss prevention is not the same as safety and differs from the traditional safety approach. First, there is more concern with those accidents that arise out of the technology and more emphasis on foreseeing hazards and taking action before accidents occur: second, there is more emphasis on a systematic rather that a trial-and-error approach, particularly systematic methods of identifying hazards and estimating the probability that they will occur and their consequences. and third, there is concern with accidents that cause damage to plant and loss of profit but do not injure anyone, in addition to those that do cause injury.

Loss prevention can be applied in any industry, especially highly technical ones, but the term and the approach have been particularly widely used in the oil and chemical industries, which are exposed to the major hazards of fires, explosions, and toxic releases (Kletz, 1990).

The approach to loss prevention includes standards sometimes referred to as HPR (highly protected risk) standards, although this is an insurance term and not completely accurate. Insurance is only one part of the consideration set of any loss prevention approach to asset conservation.

The term ''highly protected risk'' means different things to different insurance companies, but in general means that a risk meets all of the characteristics deemed necessary to protect a facility. This often includes protection that exceeds the requirements of building and fire codes and standards. A management commitment to loss prevention is the primary requirement to qualify as an HPR (Frank, 2008).

First and foremost, the human element should be considered. We must not place employees or others at personal risk by under protecting our facilities. The only way that we can properly address this risk is through a full evaluation and analysis up front. This means a thorough review with the company's risk management and

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loss control organization to arrive at the asset protection solution that is best for the company, in both the short and longer term.

6.2 Introduction

The goals and objectives of a comprehensive loss prevention program should begin at the early stages of any project and not be limited to a building or plant after it has been commissioned and operating. If safety and property loss control (PLC) professionals are to give their employees better value for money and achieve a higher standard of risk mitigation, they must equip themselves to contribute to the early stages of design and make sure they are involved (Kletz, 1990)

6.3 Elements of a Fire Loss Control Program

6.3.1 Policy Statement

A program involving risk identification, evaluation, and control of fire hazards is known as a *fire loss control program*. Business owners and facility management often apply the four standard approaches to treating risk: risk avoidance, risk mitigation, risk transfer, and risk acceptance.

Property risk can involve loss of assets, business interruption and reputation, or negative branding. This can result in significant financial losses. For any program involving the welfare of a corporation and its employees to be effective, the total support and the sustained interest of top management are essential. In addition to top management support, the policy of controlling losses must be communicated to lower levels of management and to all employees.

This can be accomplished during the formation of the loss control program by a written policy statement from the Chief Executive Officer (CEO). Their support of the program, including outlining the procedures, objectives, responsibilities, and accountabilities, will demonstrate further their desire that all employees of the organization support those responsible for the formation and implementation of the loss control organization and function.

The objectives of the fire loss control program should be fully stated, with emphasis on the protection of the employees against injury and the conservation of corporate assets.

6.3.2 Roles and Responsibilities

A PLC program is established through a combined effort consisting of employees, consultants, underwriters, design agents, service vendors, and construction contractors. In the author's experience, the respective roles should include, but are not limited to:

1) Employees
   a. Design, implement, and maintain all aspects of the PLC program utilizing all available resources.
   b. Perform human element functions and selective maintenance program functions.
   c. Are the greatest asset of any company.
2) Consultants
   a. Provide program vision and leadership.
   b. Provide oversight management and coordination.
   c. Identify, develop, and drive corporate initiatives.
   d. Visit facility sites (normally every six months):
      i. hazard recognition and risk assessment
      ii. audit programs
      iii. coordinate program initiatives.
   e. Support project activity:
      i. establish protection criteria
      ii. define regulatory impact
      iii. review design specifications and drawings
      iv. monitor insurance PLC support.
3) Design agents

   Provide design drawings and specifications to meet client's standard, considering local codes.
   a. Structural integrity:

      To assure adequate structural integrity, buildings must be designed for snow loads and windstorms common to the area.

      Metal deck roof systems require full mechanical fastening to provide wind uplift resistance.

      Special design is needed in areas having unique physical and climatic conditions such as earthquakes and hurricanes.
   b. Fire walls and partitions:

      Fire walls and partitions philosophically are to be avoided unless required based on building regulations and hazard control considerations. A typical manufacturing layout including staging areas should not require barriers. Possible needs would include separating high hazards involving flammable liquids or gases, protecting egress corridors (building code), complying with area limitation restrictions (building code), and providing separation from adjoining warehouse occupancy.

      Owing to highly combustible fuel loads particularly in warehouse occupancies, a fire barrier is normally required to reduce this exposure to adjacent manufacturing operations.
   c. Hazards isolation:

      Highly flammable and explosive hazards require isolation typically utilizing passive fire systems such as fire barriers. Hazardous operations require strategic placement to minimize exposure and to facilitate provision of explosion relief to the outdoors.

d. Emergency egress/exit system:
   Historically, exit systems have been designed to facilitate evacuating a building due to fire. There are additional reasons why building evacuations will occur, such as a bomb threat.
   Design parameters for egress are extensive, complex, and detailed. Moreover, fundamental principles supporting these design features are not fully understood by most design practitioners.
   In simple terms, components of an emergency egress system include the following:
   i. Doors with adequate capacity for a determined number of people to leave the building spacing between doors to satisfy limits for travel distance.
   ii. Locating doors remote from one another to provide a choice of direction for exiting.
   iii. Exit access aisles arranged to circulate (meaning no dead-end traps). Examples of the way to an exit being obvious are entry into small rooms where the entry is the exit, and clearly marked aisles which provide a choice of direction eventually leading to an exit door.
   iv. A layout of an exit system must be coordinated with obstructions such as partitions and the location of machinery, equipment, and furnishings. This principle is important and often overlooked. For example, a building shell could be designed with a simple exit system to an open space. After filling the space, exit arrangements may not be adequate.
   v. Any change to existing partitions and floor space should include an egress evaluation. When the egress system is affected, egress components would require rearrangement to maintain required egress within the parameters of applicable design standards. The Life Safety Code (NFPA 101) provides the necessary information to address these types of issues for each respective occupancy type.

4) Service vendors
   a. Provide support to fire system maintenance program.
   b. Provide education and training for emergency organization.
5) Construction contractors
   a. Construct and install fire safety systems to design drawings and specifications.

6.4
Fire Prevention Controls

6.4.1
Design Considerations – Selection of Materials for Construction

Standards for loss control should be integrated into the design and construction of the building, including any capital projects involving expansion or renovation. It is always more expensive to retro-fit asset protection features than to provide them initially. When building a new factory or undertaking a major expansion, business

security needs, coupled with insurance considerations and building fire codes and regulations, should lead to the application of the highest level of protection.

Mitigating risk associated with fire at the design phase should include standards that require evaluation and selection of building materials based on their resistance to fire and other properties such as smoke production and flame spread. The best means of preventing a fire is to avoid the existence of a hazard. Examples that invoke risk mitigation during the design stage of a project include avoiding equipment utilizing combustible hydraulic fluids or using steam-fired ovens and dryers versus gas-fired, therefore eliminating the risk of open flame heating.

The fire risk is greatly reduced when construction materials are non-combustible. With a non-combustible building, fuel continuity is lacking; therefore, a fire situation is restricted to the size of a given pile of combustible contents. A risk-based design approach should be considered, especially when choosing between combustible and non-combustible construction. For example, a non-combustible material will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. An example is a mineral wool-insulated, metal-clad panel. A limited-combustible material has a potential heat value not exceeding 8141 kJ kg^{-1} (3500 Btu lb^{-1}) and meets a prescribed flame spread index. The following examples reveal appropriate material selection when applying these design approaches::

- The interior finish of walls and ceilings may cause rapid fire growth and spread. Finishing materials with favorable fire characteristics should be selected.
- The roof covering material/system should be resistant to ignition and fire spread.

One should design fires whenever possible to be small and slow growing, as shown in the red zone Figure 6.1. These fires are easier to control and allow more

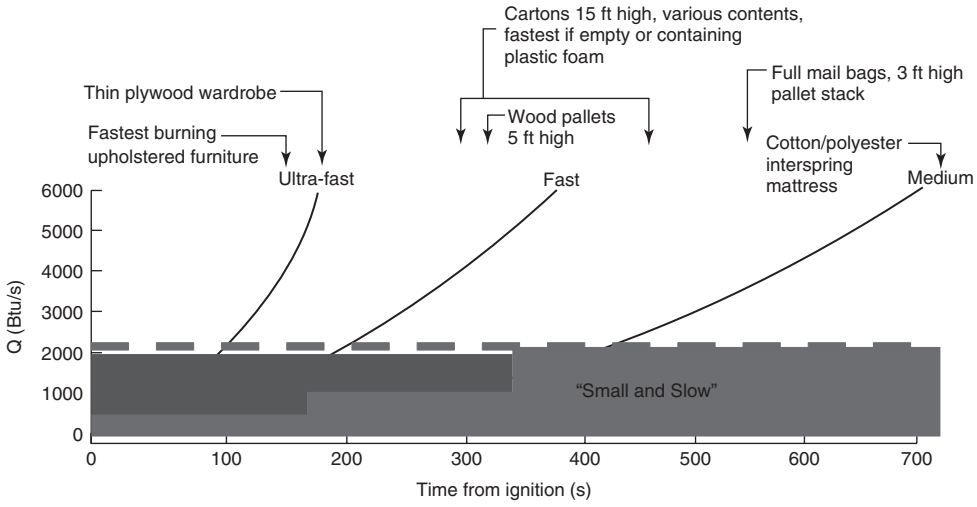


Figure 6.1 Fire severity classes.

time for responders. Special fire protection systems are applied for medium, fast, and ultra-fast fires quickly and return them into the red zone.

Material selection should consider fire growth, designing fires that will be small and slow growing, resulting in a low heat release rate. Fires of this size are much easier to protect against and allow more time for fire response. Special sprinkler protection would be applied to protect against medium, fast, and ultra-fast fires.

Plastic materials should be avoided whenever possible. All plastic materials are combustible and produce large amounts of smoke. The combustibility of plastic materials is a complex subject and often requires detailed discussion with consultants and insurance PLC engineers. Plastic materials have a heat value that is three times greater and their combustibility may be 10 times greater compared with natural combustible materials. Some plastics are highly combustible and dangerous whereas others are relatively fire safe when protected with an adequate sprinkler system.

When burning or exposed to a heat source, plastic materials exhibit peculiar fire behavior even when advertised as having favorable fire characteristics. Products of combustion include corrosive gases, toxic smoke, and unburned flammable gases. Plastics burn fuel rich, so in effect they produce a gas- or air-borne fuel that spreads beyond the origin of the fire, autoignites at high temperatures, and causes a fire to spread even when there is no continuity of fuel from other combustible materials.

Projects requiring the use of plastic materials should be controlled by specific plant guidance and procedures highlighting the precautions for use. Examples of restricted use include process piping, metal sandwich wall and ceiling panels, insulation in roof construction, suspended ceiling systems and acoustics, insulation for plant and equipment, filters in air handling systems, cooling tunnels, conveyor belts, and temporary coverings.

In the early 1970s, plastics manufacturers introduced two types of rigid foam polymers – polystyrene and polyurethane – to US builders to improve insulation values in wall and ceiling assemblies. Because of their excellent thermal insulating properties, these foam plastics have wide acceptance in building construction. Today, foam plastics such as expanded polystyrene (EPS) or extruded polystyrene (XPS), polyurethane, and polyisocyanurate remain popular choices for building insulation. Foam plastics are hydrocarbon-based materials derived from organic petrochemical compounds. They all burn with varying degrees of flammability, and produce great quantities of toxic and corrosive smoke. When these products were first introduced, manufacturers, builders, and approval authorities failed to recognize their severe flammable properties. Plastics manufacturers relied on invalidated, nationally recognized fire test methods to rank the flammability of these materials. Using invalidated fire test methods and models resulted in some foam plastics being misapplied. In some applications, the use of foam plastics presents an unacceptable fire risk, which can threaten the fire security within a building.

For example, XPS foam (Figure 6.2) is a thermoplastic. Thermoplastic resins can be repeatedly softened and hardened by heating and cooling without a chemical reaction taking place. When exposed to flame, thermoplastics melt and form

Figure 6.2 Interior "sandwich panel" – polystyrene (XPS).

a liquid pool beneath the flame. The liquid pool burns similarly to a highly flammable liquid.

Polyisocyanurate and specially formulated polyurethane foams are considered thermoset plastics. When heated, thermosetting plastic resins undergo a chemical reaction and cannot be softened by further heating without causing a chemical change that alters the material. When most thermosetting materials are exposed to a flame, they char rather than melt. The charring effectively helps protect the remaining thermosetting foam from igniting, and limits flame propagation. Non-combustible building materials and insulation should always be considered first. Foam plastic materials should not be permitted.

Although large-scale fire tests indicate that approved foam insulated panels do not contribute to fire spread, one should not get a false sense of comfort. These panels will contribute large amounts of potentially harmful smoke when exposed to a large fire. As a result, a growing number of fire departments will no longer fight fires in buildings with any plastics used in construction. Their approach is strictly defensive of surrounding exposures, with little or no internal attack of the fire. Owing to the poisonous smoke given off by these materials, many fire departments see no distinction between polyurethane and polystyrene.

Clearly, the design input when considering building materials can pose a significant risk to property and emergency responders. A comprehensive risk management strategy starts at the design phase and should reflect a forward looking approach to risk mitigation. The recently issued ASSE standard ANSI/ASSE Z590.3 *Prevention Through Design* (ASSE, 2011) underscores this concept and identifies several methodologies intended to achieve the same objective.

6.4.2 Fire Prevention Controls

To benefit from design objectives, maintaining the facility must also be accomplished. Numerous threats can cause property loss: fire, windstorm, flood, earthquake, and others. Insurance statistics reveal that fire is by far the greatest threat to commercial and industrial property. Historically, fire represents over 75% of the total dollar loss sustained by these types of properties in the average year (Karter, 2005).

A full complement of "human element" programs must be established, including preventing losses and controlling losses when an incident occurs. These actions are often referred to as the "human element" aspect of risk control, also referred to as administrative controls and subsequent actions. Activities include managing a hazard prevention program, maintaining facility systems to prevent ignition sources and for fire systems to be ready to respond, and providing a plant emergency organization (PEO) for incident response. Human element programs include written procedures, checklists, scheduled tasks, and record keeping. Key elements for consideration include the following:

1) Education and awareness are essential ingredients to an effective fire prevention program. By providing a proper attitude, establishing awareness, and understanding the opportunity for incidents to occur, plant employees will be better prepared and motivated to maintain a safe working environment.
2) Hazardous operations require specific attention given to establishing procedures and practicing safe operations, especially for explosion hazards.
3) Fuel and ignition prevention includes dealing specifically and directly with flammable and combustible materials and ignition opportunities. This requires managing and controlling materials which could burn or explode and sources of ignition which could serve to ignite or explode these materials.

Hazardous materials and processes may require permits from local regulatory authorities. The permit system should serve as a means for managing hazardous situations with or without local authority involvement. Sources of ignition could be electrical, mechanical, and chemical in nature. Open flames such as cutting and welding with an acetylene torch and hot surfaces serve as frequent causes of fires.

6.4.3
Preventing Losses – Safe Hot Work Practices

The purpose of establishing a procedure or guideline is to ensure that all dangers associated with hot work are identified and the appropriate control measures are in place to alleviate the risk of fire, explosion, and/or personal injury. It is essential that the contents of procedures or guidelines are communicated to and understood by the employees and contractors through awareness programs and periodic refresher training sessions. Given the centrality of people in risk management, it is clear that the best way to prepare to handle risk is to create an environment where people will not cause problems through their actions and inactions and where they are capable of solving problems effectively when they arise. The prevention of people-induced problems can be particularly achieved by making sure they are qualified to do what they are assigned to do.

Many serious fires and explosions occur during maintenance and construction activities as a result of hot work conducted on buildings, plant/machinery, or within tanks, silos, and similar confined areas. The majority of incidents result from carelessness or inadequate precautions and supervision. Hot work includes

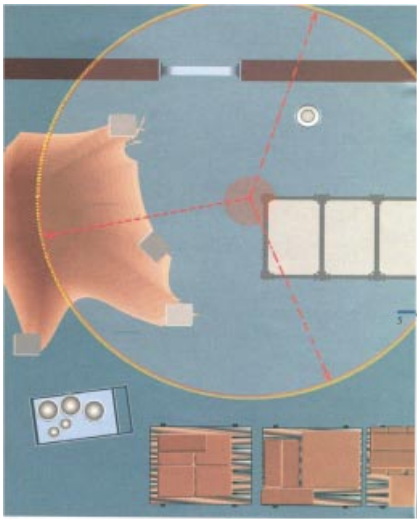


Figure 6.3 Aerial view (hot work).

operations requiring the use of open flames and the local application of heat- and spark-producing equipment. Examples of hot work include the following:

- gas/electric welding and cutting apparatus
- blow lamps/blow torches, soldering and open flame equipment
- bitumen/tar boilers, quartz halogen lamps, and other equipment
- producing a surface temperature exceeding 392 °F (200 °C)
- grinding and cutting discs.

These activities can ignite adjacent or unseen material through heat conduction, sparks, or hot metal. Sparks or hot metal can travel an appreciable distance while still retaining the capability of igniting combustible materials or flammable vapor, thus putting areas both within and outside the designated work area at risk. The sparks and hot particles can travel as far as 30–50 ft (~10–15 m) and are capable of igniting flammable and combustible materials within such a range.

For this reason, all combustible materials should be removed or covered with approved fire blankets. Openings in floors and walls should be protected with metal plates and other non-combustible material (Figure 6.3).

Any hot work carried out on ladders, platforms, and machinery, and in tanks, vessels, and pits may require additional permits and/or other procedures. The person responsible for issuing the permit should consider all factors, including working at heights, confined space entry, lockout/tag out, and so on.

Employees responsible for issuing a hot work permit should be trained in hazard recognition. Too often, permits are issued when hazards exist and go unrecognized.

The work site should be inspected for hazard identification and required conditions and precautions should be fully communicated. The permit should clearly

and specifically identify the area to which it applies. A single permit should not apply to a large area, otherwise a hazard control may be defeated.

The duration of a permit should be dependent on the hazardous nature of the work area, and in all circumstances should be for a minimum period of time, because conditions change with time, especially during construction activity. As conditions change, hazards may be introduced. When work is planned by either employee or contractor, the permit system should be strictly followed.

Prior to issuing a hot work permit, the authorized employee should consider the potential incompatibility with any other permits in the area, that is, sprinkler impairment, confined space entry, and so on.

The National Fire Protection Association (NFPA) indicates that leading ignition sources controlled by contractors is hot work and occurs 74% of the time. In fact, one in 20 fire losses are sparked by improperly managed hot work and the average gross cost of hot work fire losses is US$1.4 million (Karter, 2005.)

A permit should clearly indicate:

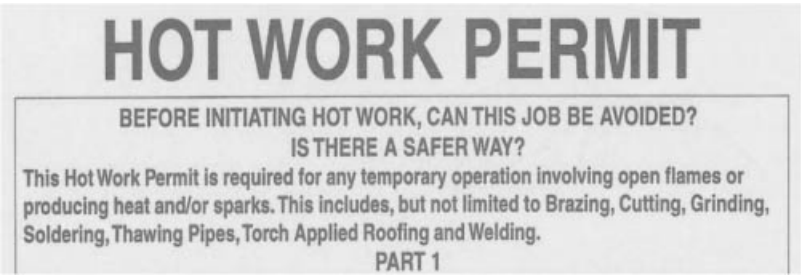
- The employee responsible for the hot work and the employee and/or contractor carrying out the work.
- The area where the activity is to be carried out, the equipment and/or the structure to be worked upon, and the type of work being carried out.
- Date of issue and time of expiration.
- Pre-inspection sign-off by the issuing associate of the conditions under which the permit is issued and commencement time and acceptance sign-off by the employee and/or contractor conducting the work.
- The area manager/supervisor has been notified.
- The employee or contractor's name assigned to the fire watch detail, fire watch duration, and fire watch signature place holder or check box to verify that the fire watch was completed as the permit required.
- Completion and sign-off of the required checks on cessation of the hot work by the employee and/or contractor carrying out the work.
- Final acceptance sign-off by the issuing employee.

The tendency to assume that the person performing the welding understands the hazards can lead to fatal consequences, as evidenced by the following event.

During electric welding, the return lead (sometimes incorrectly called the earth lead) has to be attached to the object being welded. Failure to attach it correctly as close as possible to the weld, and certainly no more than 2 m away, has resulted in several accidents. For example, a welder was welding a bracket on to the outside of a tank containing caustic soda solution. He attached the return lead to a valve which was fixed to the tank. There was a high resistance between the valve and the tank so the return current traveled through the liquid and electrolyzed it. This produced hydrogen, which exploded, killing one man and blinding another (Kletz, 1990).

In order to help avoid similar incidents, the following best practices should be considered for implementation into your hot work program.

1) **Procedure/planning** – Require that all permits include a statement, ''Before Initiating Hot Work, Can This Job Be Avoided? Is There A Safer Way?''



HOT WORK PERMIT

BEFORE INITIATING HOT WORK, CAN THIS JOB BE AVOIDED?
IS THERE A SAFER WAY?

This Hot Work Permit is required for any temporary operation involving open flames or producing heat and/or sparks. This includes, but not limited to Brazing, Cutting, Grinding, Soldering, Thawing Pipes, Torch Applied Roofing and Welding.

PART 1

2) **Graded approach** – Consider implementing a graded approach for hot work jobs based on the perceived risk using categories of normal and high hazard. For example, fire-watch duration would be 30 min for normal and 1 h for high hazard.
Example: Normal hazard areas contain moderate amounts of combustible materials, such as in-process storage of raw, work-in-progress and packaging materials.
Example: High hazard areas contain high concentrations of combustibles, fast-burning combustibles, fixed combustibles or difficult to shield combustibles. Examples include combustible construction, confined/concealed spaces, and external plant areas not protected by sprinklers. Hot work that is elevated above the floor is always designated high hazard.
3) **Fire monitoring** – Implement a fire monitoring process that would be required to identify any latent heat sources within the area. Institute a single check to be required 1 h after completion of the hot work for normal hazard. Institute an hourly check after completion of hot work for high hazard jobs.

Fire monitoring - see condition 9

☐ Normal hazard area - single check required 1 hour after completion of fire watch.
☐ High hazard area - hourly check required for 2 hours after fire watch completion.

Fire monitor name:	* 1 hour	* 2 hour

* as appropriate

Pre-inspection by responsible associate		Accepted by associate/contractor	
Name:	Initial:	Name:	Initial:
Time issued:		Company:	

At completion of hot work, associate / contractor must

Have cleaned up debris and removed all materials	Initial when done	
Have carried out a fire watch as specified above	Initial when done	
If applicable, fire & smoke detection system has been reactivated	Initial when done	
If applicable, FM global notified that sprinkler impairment has ceased	Initial when done	

Inspection completed by associate/contractor	Completion accepted by responsible associate
Name:	Name:
Time completed:	Time inspected:

4) **Job status board** – Implement a status board in a visible area of the facility showing all of the active hot work permits. Pictures of authorized employees should also be posted next to this job status board. Consider using two or three authorized employees per work shift.

6.4.4 Identifying Electrical Hazards

Electrical hazards frequently rank in the top three causes of fires. A preventive maintenance program aimed at identifying sources of ignition should be an integral part of every facility's maintenance program. The objective is to reduce the risk of a major fire while maximizing the availability of the equipment.

Thermography is a type of infrared imaging. Infrared radiation is emitted by all objects based on their temperatures. Thermography makes it possible to "see" without visible illumination. The amount of radiation emitted by an object increases with temperature. When viewed by a thermographic camera, warm objects stand out well against cooler backgrounds (Figures 6.4 and 6.5). An infrared thermography survey can be utilized for many applications, including the following:

1) Firefighters use it to see through smoke, locate people, and localize the base of a fire.
2) Electrical maintenance technicians locate overheating joints and parts, a telltale sign of failure.
3) Building construction technicians can see heat leaks to improve the efficiencies of cooling or heating.

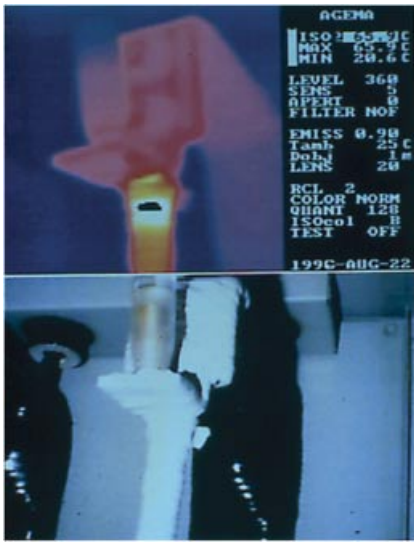


Figure 6.4 Thermograph survey (electrical connection).

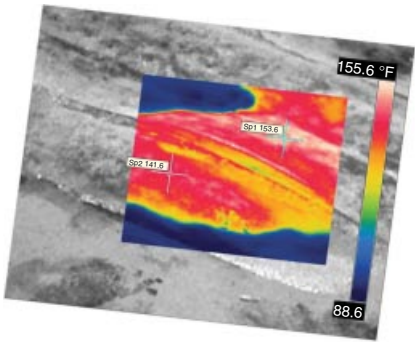


Figure 6.5 Thermal survey of roof blister.

The untimely shutdown of electrical distribution equipment and primary mechanical systems often results in lost production, higher operating costs, dissatisfied customers, and lost profits.

Implementing a sound infrared thermographic imaging program is potentially the single most important preventive measure. Conservative estimates indicate that an average saving of $14 is derived from each $1 invested in such a program.

The following best practices should be considered:

1) Conduct an infrared thermographic survey annually.
2) Survey equipment that has recently been started up (baseline survey and equipment has been installed properly).
3) Survey equipment that is scheduled to be shut down (outage). Identified problems can be repaired.
4) All facilities should consider purchasing their own thermal imaging device (spot radiometer/infrared camera).

6.4.5 Controlling Losses

Controlling an incident and subsequently the extent of loss is important and difficult. A detailed but simple plan should be prepared for incident response, command, and control.

Having an effective plan requires forethought, time, and experience. This plan will include the following:

1) System readiness
   Fire protection systems are designed to be highly reliable. Because these systems remain idle day-to-day, a high level of inspection, testing, and maintenance is required.
   a. Impairment procedure:
      i. Whenever any fire protection system is taken out of service or made inoperable due to an electrical or mechanical fault, an impairment

procedure must be followed. This procedure should be established and strictly adhered to. Although the procedure applies to all fire protection systems, its use would be most familiar to employees when closing a sprinkler valve.

b. Fire pumps:
   i. Fire pump systems are complex systems which contain many electrical and mechanical components. Engines, motors, controllers, pumps, and their accessories require detailed attention. These systems are not used on as regular a basis as manufacturing machinery and utility equipment. This creates a tendency to forget about fire pumps and other equipment until a fire occurs; therefore, an extraordinary effort is necessary to assure that this equipment is ready and able to perform. A weekly run test and system check should be performed following standard procedures and applicable standards/codes. Preventive maintenance procedures and surveillances should be detailed and complete.
   ii. A water supply dependent on a single motor-driven fire pump is defined as a single point of failure. If this motor-driven pump does not start automatically and operate continuously throughout the duration of a fire incident, sprinkler protection will be defeated. A single-pump water supply is often not acceptable for a designated HPR property.

2) Alarm, response, and action
Detailed procedures and instructions should be in writing to determine who does what and when:
   a. Notification – Arrangements should be made to notify members of the plant fire brigade to achieve a quick response. Established procedures should initiate a call for immediate notification of the public fire department/brigade. If the plant chooses, it may entrust the decision whether to call the public fire department to the Plant Brigade Commander on site. This decision should be based on size, complexity and certainty of knowledge of the incident, and adequacy of the available plant team and equipment.
   b. Detailed evacuation procedures should establish how evacuations will be accomplished, including alarm systems, assembly points, and methods of accounting for all persons on-site. Where practical, fire wardens should be designated to assist evacuees and to ''sweep'' all areas to verify that the building/area has been vacated by all people.

6.4.6
Fire Impairment Management

When any fire protection system or piece of equipment has been taken out of service, either entirely or in part, then that fire protection system or equipment is considered to be impaired. Impairments to fire protection equipment leave a facility vulnerable to large property losses and, therefore, steps should be taken to manage them properly.

There are basically two kinds of impairments: those that are planned and those that are unplanned. An example of a planned impairment is a sprinkler system that is briefly taken out of service to tie-in some new sprinklers protecting a new office area extension within the plant. An example of an unplanned impairment is an underground fire main which has to be shut down for repairs following a sudden pipe joint failure, leaving numerous sprinkler systems out of service until repairs are completed. The facility should develop and implement procedures for the proper management of both planned and unplanned impairments.

6.4.6.1 **Planned Impairments**

Whenever it is necessary to remove an automatic fire protection system temporarily from service, the process should be managed carefully. During any impairment, the fire risk increases significantly. A well-managed impairment process will help ensure that a major fire loss does not occur.

The steps listed below should be followed to manage any planned impairment properly:

- Notify your insurance underwriter well in advance of the date and time of the planned impairment. Generally, 48 h advance notification should be given; however, as much notice should be given as possible, which at times may be more or less than this. Notification may be accomplished by telephone, facsimile, or email.
- Notify the PEO about the impairment so that it can make adjustments in the emergency response plan in the event of a fire in an area affected by the impairment.
- The impairment should be scheduled for a day and time when the facility is least exposed to a loss. This is normally when production operations are shut down. All hazardous operations should also be shut down.
- Sources of ignition should be eliminated in the area covered by the impaired system. Hot work operations should not be allowed in the area during the impairment.
- Arrange for temporary protection, such as portable fire extinguishers and charged fire hose lines, to be available for immediate use in the impaired area.
- Consider providing temporary water supply connections, where feasible, to maintain interior sprinkler systems in service during impairments of exterior fire service mains and lead-ins. For example, fire hose connections to a system's main drain can supply enough water to a sprinkler system to support effectively the operation of numerous automatic sprinklers.
- Arrangements should be made so that the length of impairment will be kept to an absolute minimum. For example, an addition to an existing sprinkler system can be entirely completed except for the connection of the feed line to the existing system. The existing system can then be impaired for a very short period of time while the feed line is connected to the system.
- The impairment permit system should be used to help ensure that all impairments are authorized, proper precautions are taken, and impaired systems are restored to service without undue delay.

PLANNED IMPAIRMENT

System to be Shutdown (Please indicate by placing an ' x ' in the box)

- ☐ Automatic Sprinkler System
- ☐ Alarm System
- ☐ Firewater Storage Tank
- ☐ Fire Pump (s)
- ☐ Fire Main
- ☐ Other (e.g. CO2, Halon etc)

Comments :

Reason for Shutdown :

Area Affected :

Start Time / Date : Date :

Estimated Duration : Days Hours

Precautions being followed : (Please indicate by placing an ' x ' in the box)

- ☐ Use shut off tag
- ☐ Notify department heads
- ☐ Cease all hazardous operations
- ☐ Hose / extinguishers available
- ☐ Ban welding / cutting / hotwork
- ☐ No Smoking
- ☐ Other (Please Specify)
- ☐ Notify Fire Department
- ☐ Notify Alarm Company
- ☐ Work to be continuous
- ☐ Additional watchman surveillance
- ☐ Emergency connection planned
- ☐ Continuous Fire Watch

Change to Impairment Conditions :

Time Restored : Name : ☐ AM

Date : ☐ PM

INSTRUCTIONS :

1 Fill out Section 1 prior to shutdown (48 hours before where possible) and e-mail to address above.

2 Fill out Section 2 and resend e-mail if there are any changes to the impairment.

3 Fill out Section 3 when the impairment is restored and e-mail to address above.

Figure 6.6 Fire impairment tag.

- When the valve is reopened, the impairment shutoff tag (Figure 6.6) should be taken off the valve and retained with the other impairment records. This provides a positive check at the management level that the valve was closed and then reopened.

The NFPA indicates that between 2006 and 2010, the total estimated gross cost of fire pump impairment-related losses was $102 million. The types of fire pump failures cited include the following (Karter, 2005):

40% – manual pump not started or delayed start
30% – automatic pump impairment before loss
13% – electric power failure
13% – water supply impairment
4% – pump failure during fire.

6.4.6.2 Unplanned Impairments

The precautions that should be taken during an unplanned impairment are basically the same as those that should be taken during a planned impairment. One main difference is the lack of preparation time during which to notify the insurance underwriter, and to take steps to minimize the exposure within the facility.

It is therefore important that unplanned impairments be treated as emergency situations and that all efforts are taken to restore the impaired protection to service as quickly as possible.

If the unplanned impairment must exist during a period of time when operations are not being carried on within the facility, and at the same time electronic fire surveillance of the facility is impaired, then a fire watch should be established within the facility in those areas affected by the impairment.

6.4.6.3 Restoration of Impaired Systems

Impaired fire protection systems should be fully restored to automatic operation as soon as possible following completion of the work that required the impairment. A notification tag can help identify the problem to occupants in the area, so they know what they can expect and when to expect the system to be back online.

When restoring a sprinkler system to service, lock the sprinkler system control valve in the fully open position and perform a main drain flow test. The drain test will help ensure that no serious obstructions exist in the supply to the system. This restoration step is often overlooked on many impairment permit forms.

6.4.7 Plant Emergency Organization (PEO)

The first organized fire protection unit was established when Augustus became ruler of Rome in 24 BC. Augustus had the foresight to create a watch guard service to look for fires and prevent them from starting. The fear of a fire's capacity to cause death and destruction was just as prevalent then as it is today (Cassidy, 1992).

Emergencies strike without warning. An explosion and severe fire sweeps through an office. An earthquake shakes hundreds of computers from high storage. A sudden power outage shuts down critical equipment or processing lines. A flood submerges perishable products with contaminated floodwater. When an emergency hits, your response in the next minute could mean the difference between business property survival and disastrous loss. And survival depends upon your own readiness.

No matter what your business involves – an office building, a healthcare facility, a manufacturing plant, a shopping mall, a college campus, or a warehouse – you need an emergency response plan, one that assures that your organization will survive the worst possible emergency.

By averting or minimizing devastating property losses, emergency response plans protect jobs and business profits. Unfortunately, many companies put their facilities at risk by neglecting a thorough emergency response program.

Each facility should organize and maintain an adequately staffed and trained PEO. For a manufacturing environment, the PEO should include a team on every shift that is able to extinguish a fire, either an incipient fire or structural fire, as determined by the individual needs of the site. Top site management support is essential for a successful PEO plan.

Next, evaluate the impact of the hazards on your property, the general public, the environment, or your ability to resume business after an emergency. Examples of events include fire, floods, hail storms, winter freeze-ups, roof collapse, windstorms, and earthquakes.

How could each of these affect your day-to-day business operations? Consult with organizations outside the company, such as municipal emergency planners or loss control consultants, to help you identify natural hazards common to your area.

6.4.7.1 **Firefighting Team Selection**

The facility should determine the type of firefighting team that is most appropriate for the site based upon numerous factors, including the size of the site, proximity to the site of the nearest public fire department, severity of various fire hazards, and availability of qualified employees on all shifts.

It is appropriate for some facilities to establish a firefighting team whose objective is to fight only small, incipient-stage fires that involve only a small quantity of building contents. Other facilities may need to establish a team that can fight large fires that could involve the building structure in addition to a large quantity of building contents.

Incipient-stage firefighting teams typically respond to a fire directly from their workstations, and normally do not wear firefighting gear or self-contained breathing apparatus. They fight fires until they are required to take evasive action from the heat, smoke, and flames for self-preservation. Incipient-stage teams use portable fire extinguishers and small hose lines ranging in size from $^{3}/_{4}$ in (19 mm) to $1\,^{1}/_{2}$ in (38 mm) in diameter.

Structural firefighting teams typically fight interior fires and are trained in the use of all types of manual fire suppression equipment that is available on the site. They wear a full complement of firefighting gear and self-contained breathing apparatus. The type of brigade utilized depends on a number of factors, including size of the site, severity of the hazards, protection of the buildings, proximity of the local fire department and availability of qualified personnel. The criteria for both types of fire brigades can be found in several nationally recognized codes and regulations, including OSHA (Occupational Safety and Health Administration), NFPA (National Fire Protection Association), and IFSTA (International Fire Service Training Association).

The safety of all PEO members is a primary objective and should be assured through appropriate training, sufficient and well-maintained equipment, effective hazard management, coordination and pre-planning with the public fire department and other emergency responders, and an effective system of communication among all PEO members during the emergency. All procedures should be in compliance with any related laws, rules, or regulations.

A structure for the PEO should be developed based on the type of firefighting team (incipient or structural) and the specific needs of the facility. Team positions and position descriptions should be established for each shift. Assignments should be made for each position on each shift using employees who have the proper qualifications for the position.

6.4.7.2 **Salvage and Restoration**

Immediately following a fire incident, action should be taken to salvage stock and equipment and to restore fire protection systems to full service. Effective salvage and restoration can significantly reduce damage to physical assets and loss of revenue.

Smoke from a fire contains corrosive chemicals that can cause severe damage to metal and glass materials. The soot and odor from smoke can contaminate raw materials and finished products. The amount of damage is directly related to the time of exposure. Smoke should, therefore, be immediately purged from building areas. Equipment should be dried and cleaned of all contaminants as soon as possible. Raw materials and finished goods should be examined and inventoried, but only in a clean and dry environment.

Experience has shown that the packaging of finished goods can be an effective barrier against smoke contamination provided that the smoke is removed from the environment as soon as possible. An alternative is to remove the product from the fire area to a clean environment as soon as possible.

It is also possible to salvage and restore sensitive computer electronics that have become contaminated by smoke from a fire. Effective restoration, however, requires the involvement of specialized contractors who have proper training, experience, equipment, and cleaning solutions. Also, this restoration work must be initiated immediately. High-value computer facilities should consider establishing a contract with a qualified restoration contractor in advance of any fire.

An effective salvage and restoration process requires planning and training. The PEO team can be utilized for this purpose and augmented as needed. Outside contractors may need to be included on the salvage team and in the planning process so that they will respond quickly when needed.

Fire protection systems should be repaired as needed and fully restored to automatic service as soon as possible to protect the plant from a rekindling fire or another unrelated fire event.

6.4.7.3 **Training**

PEO team members should receive training as appropriate for each position so that they can accomplish their duties safely and effectively. Training should include a combination of both classroom instruction and practice drills. Both are required and necessary.

Fire brigade personnel should be:

- physically fit and able to perform under stressful situations
- familiar with other personnel and equipment and have a working knowledge of the organization's fire safety plan

- comprehend and implement written and verbal instructions and apply them to crisis situations (sometimes knowledge of a second language is required).
- able to communicate effectively during a crisis (Cassidy, 1992).

A written test should be administered to each participant to verify and document that a minimum acceptable level of learning and understanding has been accomplished.

Training should also be in compliance with any laws, rules, and regulations in terms of both content and frequency.

The public fire department should be utilized in the process of training PEO team members if they have the proper equipment and are willing to provide this training. They often can be very helpful in training employees in the proper use of fire hoses and portable fire extinguishers.

6.4.7.4 **Written PEO Plan**

The plan should be developed for hazards with a high frequency of occurrence or whose severity of impact may be significant. This includes natural hazards such as flooding, earthquake, hurricane, tornado, and severe weather.

A written PEO plan should cover the following:

- Define the PEO member positions such as PEO Manager, Fire Chief, firefighters, hose operators, fire extinguisher operators, fire pump operator, utilities operator (gas, electricity, and other), fire department coordinator, evacuation monitors, communications coordinator, and so on.
- Overall objectives of the PEO relative to firefighting (incipient, structural), evacuation, hazardous materials coordination, medical coordination, salvage, and restoration.
- Minimum qualifications of members.
- Training and continuing education requirements for members including both classroom instruction and drill exercises.

The following best practices should be considered for your PEO:

- Protected building zone drawings:
  - Locate sprinkler zone drawings at each sprinkler riser to assist the PEO team during their response and help identify the areas of protection for each sprinkler riser.
- Facility drills:
  - Conduct performance evaluations during post-drill critiques to ensure that continuous improvement initiatives are being implemented.
  - Consider establishing a drill on a semi-annual basis. Mature drill programs should consist of unannounced drills.
  - Consider utilizing desk-top training for drill scenarios that cannot be exercised due to complexity or resources.
  - Consider rotating PEO assignments on an annual basis to strengthen the team and broaden the depth of each member's knowledge.
  - Consider inviting the fire department for site tours on an annual basis to ensure their familiarity with the building layout and hazards.

In summary, is your business ready to survive the worst possible emergency? Today's businesses operate in a world of just-in-time manufacturing, computer-controlled processes, and a high dependence on telecommunications and data processing functions. The quest for high efficiency and maximum profitability has eliminated duplication and redundancy which provided a measure of resiliency when something went wrong. Business continuity and information technology disaster recovery planning have become essential to maintain critical business functions during interruptions or disruptions (Schmidt, 2008).

Controlling a loss by preventing or minimizing damage is the major goal of an emergency response plan. Doing it right depends upon taking one's assumptions seriously: an emergency will occur at some point in the history of your company. Never assume it happens to someone else.

Appendix A. Loss Prevention Survey

PREP Survey Overview

The PREP Survey is a tool to assist in the measurement and improvement of the level of risk at a facility due to fire. The structure of the survey is designed to teach facility management about successful risk control and motivate them to take responsibility for achieving acceptable levels of risk.

In summary, the PREP Survey does the following:

1) Determines the current level of risk at a facility.
2) Helps the manager identify strengths and weaknesses in the Property Conservation Program (PCP).
3) Assists the manager in making improvements in a time-efficient manner using cost-effective solutions, enhancing the overall property risk control process.

Administration – Activity Ratings

Required activity	Inadequate (I)	Fair (F)	Good (G)	Excellent (E)	Your rating
Property Conservation Program (PCP) Policy Statement and Programs	No written policy or program which includes: Assigned responsibilities Loss prevention Loss control Life safety	Policy and program not written but communicated verbally to employees. Program partially written. Program not up-to-date	Policy and program written and distributed to all managers. Program updated annually which includes personnel changes, process changes, etc.	In addition to "Good," program is regularly communicated to all employees. Property loss control (PLC) recommendations are substantially completed and PLC. budget and objectives are established annually	—

(*continued*)

Required activity	Inadequate (I)	Fair (F)	Good (G)	Excellent (E)	Your rating
PCP Manager assigned	No recognized PCP Manager or responsibilities insufficiently defined	PCP Manager appointed but no formal training	PCP Manager provided with formal training or has experience	In addition to "Good," PCP Manager given adequate time and authority to implement PCP and enforce property loss control rules	—
Direct top management involvement	Management supports PCP program but has little involvement	Management is involved in PCP program but inconsistently. No formal review. PCP is low priority	Management is involved in PCP program. Periodically reviews status. At least annual walk-around loss control inspection. PCP is medium priority	In addition to "Good," senior management meets with PCP Manager periodically to review PCP program and participates in quarterly walk-around loss control inspection. PCP program is high priority	—
Employee communication and training	Employees verbally made aware of fire hazards or emergency plans. No formal, written system	Employees receive written information on fire hazards and evacuation procedures at time of hire. Includes smoking, welding, and housekeeping rules	In addition to "Fair," emergency team organized and trained. Employees practice emergency action annually. Annual update meeting	In addition to "Good," employee meeting held at least quarterly on PCP program and in between if changes warrant	—
Property incident reporting, internal, and external	Incidents of fire, etc., not reported; procedures inadequate. Employees do not report all small fires	All employees understand requirement to report ALL fires, no matter how small. External report not always made	In addition to "Fair," incidence of fire, explosion, windstorm reported to Corporate Risk Management	In addition to "Good," investigation reports of losses sent to Corporate Risk Management	—
Investigation of fire, explosion, or windstorm incident	No written incident investigation made	Manager requires investigation of only major occurrences	In addition to "Fair," investigation is made of every incident within 24 h	In addition to "Good," log maintained to help identify recurring causes	—

Loss Prevention (Ignition and Fuel Management)

Activity Ratings

Required activity	Inadequate (I)	Fair (F)	Good (G)	Excellent (E)	Your rating
Hazard Inspection Program	Procedures for program not written but verbally implemented. Includes housekeeping, welding, smoking, flammables, etc.	Hazard inspections conducted but not on a regular schedule. No form used. Form used, but incomplete	Hazard inspections conducted on a regular schedule using a standard form which is complete. Frequency at least monthly	In addition to "Good," standard form is reviewed by management and copy is kept on file	—
No smoking policy	Smoking rules not formally established. Left up to employees	Smoking rules established and partially implemented but not strictly enforced	Smoking policy in writing and posted where required. Policy is effectively enforced	In addition to "Good," areas are periodically re-evaluated to determine need for policy. Approved smoking areas are provided	—
Hot work permit procedures	Procedure not implemented.	Written procedure but not enforced	Written procedure enforced. Outside contractors are included in adherence to procedures	In addition to "Good," complete adherence to the Hot work tag program	—
House-keeping practices	Condition of premises appears disorderly, storage poorly arranged, fire extinguishers and aisle ways blocked, unnecessary refuse about	Housekeeping appears adequate and requirements are verbally enforced by occasional inspection	Housekeeping requirements are obviously enforced and checks are regularly conducted	In addition to "Good," procedures are updated annually, the operation has a management process in place to deal with storage safely	—
Safe handling of flammable materials	Partial procedures developed for flammable materials. No Material Safety Data Sheets (MSDSs) available.	Written procedures available but employees not trained to handle hazards involving these materials	Written procedures and MSDSs available and employees are trained in proper procedures	In addition to "Good," procedures are updated annually, including additional instruction on new materials introduced into the plant	—

Required activity	Inadequate (I)	Fair (F)	Good (G)	Excellent (E)	Your rating
Preventive maintenance	No preventive maintenance program. Equipment usually repaired when it breaks down	Preventive maintenance program established but only partially effective. Preventive maintenance schedule only for major equipment	Preventive maintenance program in writing, schedule includes most equipment and followed faithfully. Records maintained	In addition to "Good," preventive maintenance personnel knowledgeable of potential ignition sources requiring preventive maintenance. Infrared scans done annually	—

Loss Control (Suppression and Fuel Loading)

Activity Ratings

Required activity	Inadequate (I)	Fair (F)	Good (G)	Excellent (E)	Your rating
Emergency response procedures for emergency team	Procedures exist but not implemented. Depend solely on local fire department	Written emergency response procedures developed by local management for fire and windstorms. Procedures provided to ALL supervision with occasional training	In addition to "Fair," emergency team receives regular training in specific duties and has practiced these skills	In addition to "Good," all employees are instructed to use fire extinguisher and to follow specific shutdown procedures. Continuous training provided and drills are held annually	—
Coordination with public fire department	Fire department makes annual inspection of premises but local emergency team procedures not coordinated with fire department	Fire department invited to visit premises for inspection. Verbal arrangement with fire department on interface with private emergency team	In addition to "Fair," written procedures establish interface between public fire department and private emergency team	In addition to "Good," public fire department involved in training emergency team and has reviewed emergency response procedures	—

Required activity	Inadequate (I)	Fair (F)	Good (G)	Excellent (E)	Your rating
Inspection of protection equipment	Procedures for protection equipment inspection not written but verbally understood. Inspection includes sprinklers, valves, gauges, extinguishers, hoses, etc.	Protection equipment inspections conducted but not on a regular schedule. No form used. Form used but not complete. Frequency regular, at least monthly	Protection equipment inspections conducted on a regular schedule using a standard form which is complete. Frequency is weekly	In addition to "Good," standard form is reviewed by management and kept on file	—
Fire protection impairment procedures	Impairments to fire protection equipment not reported or only to local fire department	Verbal understanding to call PLC engineer procedures incomplete	In addition to "Fair," watchman services used during idle periods. Impairment procedures written in PCP program	In addition to "Good," management plans impairments in advance at times when premises least exposed. Impairment tag program is completely adhered to	—
Combustible loading and arrangement of storage and inventory	Combustible loading appears to exceed sprinkler capacity or could hinder early extinguishment	Combustible loading and storage arrangement usually acceptable but becomes out of control during peak periods. Some areas are inadequate but premises overall acceptable	In addition to "Fair," management makes serious effort to minimize loading at all times. Written instructions or signs posted help ensure compliance	In addition to "Good," combustible loading is minimized to the extent possible through prudent purchasing of incoming materials and preplanning for large production runs	—

Life Safety (Employee Evacuation)

Activity Ratings

Required activity	Inadequate (I)	Fair (F)	Good (G)	Excellent (E)	Your rating
Emergency evacuation procedures	Employee evacuation procedures verbally understood	Written procedures developed and provided to supervision and all employees. Evacuation routes are posted	In addition to "Fair," procedures are up-to-date and evacuation is practiced at least annually	In addition to "Good," new employees receive instruction at time of hire on what to do during an evacuation	—

Required activity	Inadequate (I)	Fair (F)	Good (G)	Excellent (E)	Your rating
Maintaining aisle ways and emergency exits	Emergency aisle ways and exits not always clear and in good repair	Emergency aisle ways and exits included on hazard inspection and are checked monthly. Emergency lighting installed where required	In addition to "Fair," aisle ways and exits are well maintained and signs readily identify exit route. Emergency lighting is regularly checked	In addition to "Good," emergency aisle ways are clearly marked off	—
Employee emergency communication	Emergency notification system installed but does not cover entire facility or communication method inadequate to insure complete understanding by all employees	Emergency notification system consists of distinctive alarm sounding device or vocal (public address) system which can be effectively heard above all other sounds in all areas	In addition to "Fair," notification system is properly maintained and tested monthly	In addition to "Good," employees are knowledgeable and trained in the emergency notification system and specific evacuation procedures. Annual drill conducted	—

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