Fire and protection in chemical manufacturing site

CFPA-E Guideline No 18:2013 F

CFPA EUROPE

FOREWORD

The European fire protection associations have decided to 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 those responsible for safety in companies and organisations. 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 companies and organisations to increase the levels of fire safety.

The proposals within this guideline have been produced by the Swissi AG and the author is Hans-Heinrich Wolfensberger from Switzerland.

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 must apply.

Copenhagen, 7 Mars 2013
CFPA Europe

Jesper Ditlev
Chairman

Helsinki, 7 Mars 2013
Guidelines Commission

Matti Orrainen
Chairman

CFPAEUROPE®

European Guideline

Contents

Key words: Flammable liquids, Risk assessment, Fire loss category, Fire protection

European Guideline

1 Introduction

Explosions and fires in production buildings of speciality chemicals manufacturers have in the past years lead to substantial property damage and subsequent business interruption. Whenever a fire or explosion takes place in areas with large quantities of highly flammable liquids common preventive and mitigating measures might not be sufficient to avoid substantial property and business loss or serious environmental impact. The main measure in such buildings, the avoidance of ignition sources, has been shown, by itself, not to be sufficient.

2 Scope

OECD has published "Guiding Principles for Chemical Accident Prevention, Preparedness and Response". The focus of these guiding principles is a general description of chemical accident prevention.
This Guideline applies to chemical manufacturing buildings (plants) and defines preventive and emergency measures which help limit damage once a fire or explosion has occurred. It applies to synthesis areas as well as to physical operations (formulation, standardization) in manufacturing and pilot plants and should, where reasonable, also be applied for any infrastructure activities where chemicals are handled (e.g. waste treatment and disposal units).
To support the evaluation of the fire risk a methodology is explained. This methodology is based on the quantities of highly flammable liquids present and on the processes operating.
It does not apply to warehouses, tank farms and laboratories.

3 Riskassessment

The most critical issue at hand is the fire load consisting of volatile organic solvents with low flash points. When highly flammable liquids ignite after an explosion or after a spill the fire spread is very fast and uncontrolled. Electrical installations, instruments and cables, and thermoplastic ventilation ducts will be rapidly destroyed by the fire. The time taken for a 1000 l container (tank, receiver, vessel) to rupture, when it is heated by a fire (radiant heat flux about 50 kW/m2), is between 5 – 15 minutes, depending on such factors as the boiling point and heat capacity. Additionally, if structural steel does not have adequate heat protection, its static load bearing integrity will diminish within a few minutes.
In case of rapid and uncontrolled fire spread even a professionally trained plant fire brigade may not able to save the building, the load bearing structure and valuable equipment. In many cases the time from fire detection to intervention - even with optimal response time (≤15 minutes typically) - would be too long to efficiently fight the fire.

[1] OECD Environment, Health and Safety Publications, Series on Chemical Accidents, No 10, 2nd Edition, 2003
[2] In the immediate vicinity the following can occur:
12.5 KW/m^2 First-degree burn after 10 seconds
25 KW/m^2 Wood spontaneously ignites
75 KW/m^2 PVC spontaneously ignites.

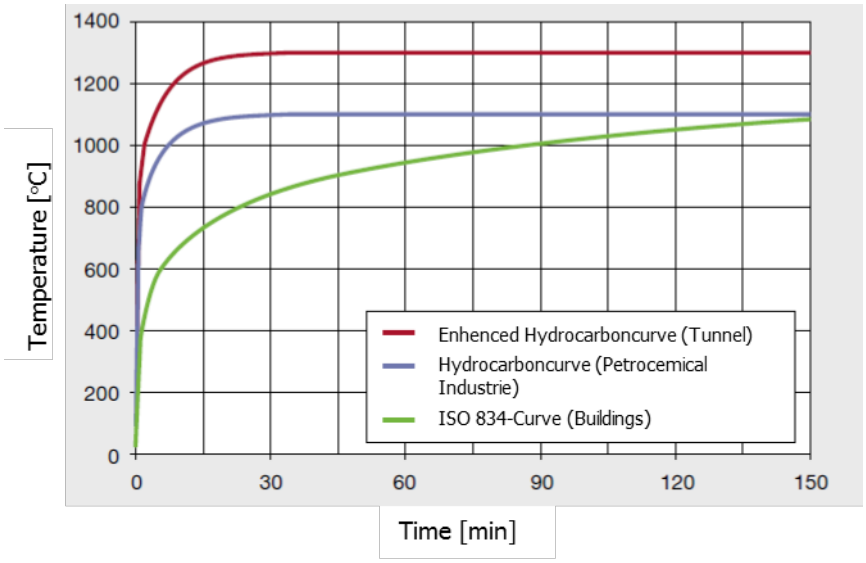

Fig 1: Standard fire time/temperature curves from standardized fire progresses

For a rough assessment of a risk one needs the "Largest Individual Quantity" (LIQ) and the "Total Volume" (TV) of solvents with a boiling point up to 150 °C that are potentially present in a manufacturing building or fire compartment. To correctly assesses the fire risk and determine the safety measures, a good understanding and knowledge of the development and the impact of pool fires are needed.

3.1 Determination of "Fire loss category"

	Largest Individual Quantity[1], LIQ [t], Total Quantity, TQ, [t]							
	<0,5 LIQ	<1 TQ	<1 LIQ	1 - 10 TQ	<5 LIQ	10 - 30 TQ	<10 LIQ	>30 TQ
Stored in tank, receiver, bulk containers, drums								
The above and processed in reactors								
The above and distilling, condensing								
The above and/or processing under pressure (above b.p.)								

[1] This could be one drum, one tank, one container, one "Swiss container" (4 m^3 tank on wheels), one day tank, one reaction vessel, etc.

Category 1	Basic fire risk, basic fire protection measures adequate
Category 2	Elevated fire risk, will need additional fire protection measures
Category 3	High fire risk, additional fire protection measures mandatory

Any additional impact on the scale of a fire/explosion risk, such as critical exothermic reactions, work at elevated temperatures, the use of oxidizing materials or peroxides, or the processing of large amounts of highly ignition sensitive powders must also lead to the assessment being of an elevated fire risk.

4 Control measures

4.1 Category 1, Basic fire risk

4.1.1 Constructional fire protection

For Building Construction the national and local building codes must be followed. In addition the following items have to be considered:

- The load bearing should preferably be of concrete.
- The use of non-combustible construction materials including insulation in roofs and walls is mandatory.
- For insulated steel roofs, non-combustible insulation, in combination with suitable mechanical fastenings and low fire-load vapour barriers, should be used to provide adequate fire protection.
- Fire compartments should not exceed a size of about 3'000 m2. Dangerous processes
- (e.g. high pressure or high temperature processes) should be undertaken in separate fire compartments.
- Floors of multi-storey buildings or open structures should preferably be of concrete. Even if no fire resistant horizontal subdivision is achieved due to unprotected openings for vessels etc., such a concrete floor will reduce the speed of a fire spreading, compared with steel grate floors.
- Drainage/Spill control systems are needed and should be designed to avoid simultaneously flow of flammable liquids and fire fighting water into nearby critical areas to avoid domino effects. Sloped surfaces (minimum 1%), trenches, drains and bunds are typical technical solutions to keep a pool size as small as possible.
- All production buildings containing significant amounts of flammable and / or explosive materials need lightning protection.

4.1.2 Fire water supply

Based on the high risk, a high fire water capacity is essential. Statistic evaluations have shown that without fixed extinguishing systems, volumes of 8'000 l/min up to 12'000 l/min were used for limiting the impact and extinguishing a fire.
The water supply should provide fire fighting water for a minimum of 2 hours and preferably 3 to 4 hours. The water supply must be available all times and be protected from frost.
The pressure in the system must be maintained at a sufficient level to meet the highest site fire water demand.
An adequate number of hydrants (preferably above ground) need to be provided at 50 to 75 m intervals.

4.1.3 Fire extinguishers and wall hydrants (small hose stations)

Dry Risers (Standpipe Systems according to EN 14461 ff)
In multi-storey buildings dry risers (standpipe systems) are needed in fire protected staircases. They are also needed in multi-storey open plants. The dry riser pipe should have a diameter DN 80 und the water flow designed to provide 300 l/min.
Open plants should have fixed monitors for fire protection around the installation.

Wall Hydrants (Small Hose Stations Type F, according EN 671-1)
Wall hydrants are needed. Wall hydrants have to be located so that all areas can be reached.
Small hoses should have minimum 25 mm diameter (1 inch) and not be longer than 30 m.
They have solid rubber pressure hoses and a multipurpose branch-pipe.
Preferably, wall hydrants should be prepared for dual use (water / foam combination). An inline foam inductor, a foam nozzle and a foam compound container should be installed.
The water flow should be requested for a minimum of 2 hours or a time identified by risk analysis.

Fire Extinguishers
For first response fire fighting, an adequate number of suitable portable or wheeled fire extinguishers must be available in all areas. The maximum travel distance should be about 20 m to the nearest fire extinguisher.

4.1.4 Special extinguishing agents

Foam
Enough foaming agent e.g. AFFF or equivalent, must be stored on site or at the fire brigade. The stored quantity depends on the maximum expected fire water supply. For polar solvents apply alcohol resistant foaming agents.
Foam supplies need to be checked regularly in accordance with the manufacturer's instructions and these checks must be recorded.

4.1.5 Smoke and heat venting

Smoke and heat venting must be installed. The remote opening of these vents should be automated or be operable manually from a safe area (e.g. stairway or near exits) and should be independent of general electric power.

4.1.6 Manual alarms

Manual fire alarm points (push-button alarm boxes) must be strategically located throughout the site and production units and should not be obstructed. They should be clearly marked. At least one call point must be present in every building on every floor. Call points should preferably be located close to escape routes. It is recommended that travel distance to an alarm point is kept below 60m.
A reliable internal alarm is necessary. In high noise areas audible alarms may need to be supplemented with visible alarms (lights or beacons). The alarm system must have continuously monitored circuits and equipment to ensure reliable operation. A back-up power supply is mandatory

4.1.7 Preventive maintenance

All of the installations, apparatus, and equipment used for fire prevention and fighting have to be included in a "Preventive Maintenance Program".

4.1.8 Explosion protection

In areas where flammable liquids, gases, or combustible powders are handled or where flammable liquids and/or gases are stored, Ex-zones must be defined.
Explosion protection measurements should be taken in compliance with the ATEX explosion protection rules. In ex-zones, only certified components and equipment must be used.

4.1.9 Organization of fire safety

Fire protection responsibility

Fire protection officers must be appointed, who report directly to the site management. Suitable education and practical training should be provided for the nominated persons.
Responsibilities include coordination and implementation of the fire protection measures according to the site organization, in particular:

- Fire safety on-site
- Control and maintenance of all fire protection devices
- Supervision of repair work to fire and safety systems and securing of restarting
- Development of the emergency plan
- Staff training and education
- Updating of fire protection documentation.

The fire safety delegates should be involved in the development of fire safety concepts.

Internal inspection
An internal inspection system should be implemented, that ensures the periodical checks of installations and organizational measures, which are relevant for fire protection.
All inspections should be documented. Findings and deviations should be reviewed, prioritized and corrected as fast as possible. Follow-up plans should be established with clear target dates and responsibilities, and the status of follow-up actions should be regularly checked.

Hot work
Hot work such as welding and cutting should be carried out only by suitably qualified persons who are appropriately instructed. All sites conducting hot work outside the workshop should have a written hot work procedure that requires a written permit issued by an authorized individual and copy posted in the area where the work is carried out (see Guideline 12: Fire Safety Basics for Hot Work Operatives)

Fire safety training
All employees must periodically be trained in fire safety or minimally emergency response procedures. The training should cover at least the following points:
- Fire prevention measures
- Actions in case of a fire
- How to trigger a fire alarm and to whom
- First rescue activities
- Location, operation and application of hand-held extinguishers
- Evacuation drill periodicity and procedures
- Fire risks on the site.

Safety instructions
All Third Party Personnel (TPP), visitors and contractors of the site should be informed about fire prevention and correct behaviour, in case of an emergency (e.g. fire alarm, accidents, evacuation procedures, etc.) when entering the site.

Documentation
For each building, fire protection documentation should be compiled, regularly updated and readily available in case of emergency at a pre-defined places and/or in copy sent to the external fire brigade. The documentation should contain at least the following information:
- A description of the type of construction and load bearing structure
- A description of technical fire protection systems
- Supply of energy and water
- Supply of fuel and shutoffs
- Emergency plans, fire prevention plans, checklists
- Inventory of chemicals, gases, compressed gas cylinders, radiation sources etc.
- Organization, responsibilities, responsible persons.

Fire brigade
On each site, intervention by a public or on-site fire brigade should be ensured. The first intervention time should not exceed 15 minutes unless other protective methods have been adopted.

Equipment, staffing and training of the fire brigade should be appropriate for the fire risk and should comply with the relevant local laws, regulations, guidelines, and standards.
Accurate emergency plans, fire protection plans, and water supply plans must be available.

4.2 Category2, Elevated fire risk

The measures described below are in addition to the basic fire measures.

4.2.1 General fire protection

Consideration should be given to:

- Smaller fire compartments
- Reduction of the fire load per fire compartment

4.2.2 Gas detection

Spot type detectors should be installed in areas where there are potential leak sources like pumps, compressors, tank car and tank truck facilities, control rooms and air inlets in the vicinity of potential large flammable gas releases, ditches, trenches, sumps and other low points where heavy flammable vapours could accumulate. A whole plant or area can be protected by an array of correctly placed detectors. Gas detection systems should be used for emergency functions like shutdown of processes, activation of emergency ventilation etc.
The gas detectors should be located in accordance with the manufactures instructions. Regular, recorded calibration and maintenance is important to keep the system functional.

4.2.3 Fire detection

Fires usually begin small; therefore it is very important to detect a fire as quickly as possible so that immediate action can be taken. When a fire does occur, the actions taken in the first minutes are the most important to avoid a large fire with consequent injury to personnel and damage to equipment. In areas with low manning levels (automated plant) automatic detection and alarm systems are mandatory.
Fire detectors shall also be strategically placed in ventilation ducts or other parts of installations in order to detect fires starting inside processing equipment
Alarms have to be monitored in a permanently manned central station (e.g. Guard house, Fire Brigade) to ensure prompt and adequate response to all emergencies.

4.2.4 Semi-automatic extinguishing systems

A special consideration is the installation of a semi-automatic extinguishing system, where open nozzles, pipes etc. are installed as well as a fire detection system with an alarm transmission to the fire brigade. In contrast to automatic extinguishing systems, the fire brigade manually operates the system. Such systems however, require rapid intervention by the fire brigade (<5 minutes), an

excellent water supply and a pump vehicle with adequately sized pumps. Foam (AFFF) can be injected in these systems. A precedent condition is a well exercised site fire brigade.

4.3 Category 3, High fire risk

The measures described below are in addition to the basic measures.
A case-by-case evaluation must determine which measures (reduction of the fire compartment area, gas detection, fire detection, constructional explosion protection etc.) are chosen in addition to the other measures in order to reduce the risk to an acceptable level.

4.3.1 General fire protection

Consideration should be given to:

- Smaller fire compartments
- Reduction of the fire load per fire compartment
- Elimination of daily service tanks on direct supply form tank farms.

4.3.2 Automatic extinguishing systems

Buildings should be protected with automatic extinguishing systems e.g. sprinkler or deluge systems. If an automatic extinguishing system is installed, larger fire compartments (see 5.1.1) can be accepted.
The water and hose stream demand resulting from the requirements of the appropriate sprinkler rules must be addressed.

4.3.3 Fire brigade

The introduction of a professional fire brigade is recommended.

5 Europeans 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

Natural hazards

Guideline No 1:2012 N - Protection against flood
Guideline No 2:2013 N - Business Resilience – An introduction to protecting your business

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