

Flash Fire Risk Assessment for the Upstream Oil and Gas Industry

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Contents

	Page
1 Scope	1
1.1 General	1
1.2 Conditions of Applicability	1
2 Terms, Definitions, Acronyms, and Abbreviations	1
2.1 Terms and Definitions	1
2.2 Acronyms and Abbreviations	2
3 Flash Fire	3
3.1 General	3
3.2 Risk of Injury due to Flash Fire	3
3.3 Class I Division 1 and Division 2 Locations; Flammable Vapor Illustrations	3
4 Hazard Evaluation	4
4.1 General	4
4.2 Hazard Identification	4
4.3 Simultaneous Operations (SimOps)	4
4.4 Loss of Containment	4
5 Risk Assessment Methods	5
5.1 General	5
5.2 Example Risk Assessment Technique	5
5.3 Flash Fire Risk Assessment Worksheets and Coversheet	6
5.4 Illustrated Risk Assessment for Oil and Gas Operations	6
6 Mitigation	6
6.1 Layers of Protection	6
6.2 Hierarchy of Controls	6
6.3 FRC Selection Based on Risk Assessment	7
7 General FRC Guidelines	8
Annex A (informative) Examples of API 500 Illustrations	10
Annex B (informative) Bowtie Model	14
Annex C (informative) Flash Fire Risk Assessment Coversheet	16
Annex D (informative) Flash Fire Risk Assessment Worksheet	19
Annex E (informative) Example Flash Fire Risk Assessment Coversheets and Worksheets	21
Annex F (informative) FRC Use Decision Tree	29
Bibliography	30
Figures	
1 Risk of Flash Fire	3
2 Hierarchy of Controls Illustration	7
A.1 Hydrocarbon Pressure Vessel or Protected Fired Vessel in a Nonenclosed Adequately Ventilated Area	10
A.2 Ball or Pig Launching or Receiving Installation in a Nonenclosed Adequately Ventilated Area	11

Contents

Page

A.3 Flammable Gas-blanketed and Produced Water-handling Equipment in a Nonenclosed Adequately Vented Area	11
A.4 Compressor or Pump in an Adequately Ventilated Nonenclosed Area	12
A.5 Drilling Rig Derrick Fully Enclosed (Open Top)	12
A.6 Drilling Rig Open Substructure and Semi-enclosed Derrick	13
B.1 Example FRC Bowtie Worksheet	14
B.2 Flash Fire Bowtie Example	15
C.1 Flash Fire Risk Assessment Coversheet	18
D.1 Flash Fire Risk Assessment Worksheet	20
E.1 Example Drilling Flash Fire Risk Assessment Coversheet	22
E.2 Example Drilling Flash Fire Risk Assessment Worksheet	23
E.3 Example Gas Processing/Midstream Flash Fire Risk Assessment Coversheet	24
E.4 Example Gas Processing/Midstream Flash Fire Risk Assessment Worksheet	25
E.5 Example Completions Flash Fire Risk Assessment Worksheet	26
E.6 Example Production Operations Flash Fire Risk Assessment Worksheet	27
E.7 Example Drilling Flash Fire Risk Assessment Worksheet with Special Conditions	28
F.1 FRC Use Decision Tree Flow Chart	29

Table

B.1 Flash Fire Engineering and Administrative Controls	15
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Flash Fire Risk Assessment for the Upstream Oil and Gas Industry

1 Scope

1.1 General

This recommended practice (RP) provides guidance for the upstream oil and gas industry on hazard identification and risk assessment exercises to assess and mitigate the risk of human injury caused by exposure to a flash fire.

The scope of this document is limited to personnel exposed to the risk of hydrocarbon based flash fires in the upstream Exploration and Production sector of the oil and gas industry. In general, this group includes oil and gas production, drilling, well bore (well servicing) operations, and gas processing prior to interstate pipeline transportation.

1.2 Conditions of Applicability

This RP focuses on flash fires that result from the unexpected ignition of hydrocarbon vapors. Emergency preparedness (e.g. firefighting, hazmat response) for exposure to fire event greater than a flash fire is excluded from this RP and is addressed by NFPA and other standards organizations.

Arc flash, as discussed in NFPA 70E and its other related standards, are outside the scope of this document.

Maintenance, care, and limitation of various fire resistant clothing (FRC) materials are outside the scope of this document. These items are addressed by the manufacturer and clothing-related standards.

2 Terms, Definitions, Acronyms, and Abbreviations

2.1 Terms and Definitions

For the purposes of this document, the following definitions apply.

2.1.1

Class I, Division 1 location

A location in which ignitable concentrations of flammable gases or vapors are expected to exist under normal operating conditions or in which faulty operation of equipment or processes might simultaneously release flammable gases or vapors and also cause failure of electrical equipment.

2.1.2

Class I, Division 2 location

A location in which flammable gases or vapors may be present but normally are confined within closed systems; are prevented from accumulating by adequate ventilation; or the location is adjacent to a Division 1 location from which ignitable concentrations might occasionally be communicated.

2.1.3

Class I location

A location in which flammable gases or vapors are, or may be, present in the air in quantities sufficient to produce explosive or ignitable mixtures.

2.1.4

fire

A rapid oxidation process, which is a chemical reaction resulting in the evolution of light and heat in varying intensities.

2.1.5**fire resistant clothing****FRC**

Apparel designed by the manufacturer to not increase the extent of injury experienced by the wearer when exposed to a hydrocarbon flash fire.

NOTE The acronym has been defined in the following ways by various industry and regulatory organizations (e.g. NFPA, CEN, CAN/CGSB, ISO, ASTM, etc.) as flame resistant clothing, fire retardant clothing, fire resistive clothing, and flame retardant clothing.

2.1.6**flash fire**

A fire that spreads rapidly by means of a brief flame front through a diffuse fuel, such as gas or the vapors of an ignitable liquid, without the production of damaging pressure.

2.1.7**Greenfield site**

A well site where neither oil nor gas has been brought to the surface from the formation. A production or processing facility where hydrocarbons have never been delivered via pipeline, flow line, tank truck, or processing equipment.

NOTE Water disposal sites are not Greenfield sites.

2.1.8**loss of containment**

The unplanned or uncontrolled release of flammable hydrocarbon materials to the work environment.

2.1.9**lower explosive limit****LEL**

The minimum concentration of flammable gas or vapor that supports self-propagating flame when mixed with air (oxygen) and ignited.

2.1.10**personal protective equipment****PPE**

Clothing and equipment designed to protect personnel from workplace injuries or illnesses resulting from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards.

2.1.11**simultaneous operations****SimOps**

When two or more activities or process operations are being performed concurrently in close proximity.

2.2 Acronyms and Abbreviations

CEN	European Committee for Standardization (based on French title: Comité Européen de Normalisation)
FRC	fire resistant clothing
LEL	lower explosive limit
PPE	personal protective equipment
SimOps	simultaneous operations

3 Flash Fire

3.1 General

Fires will occur when sources of ignition meet flammable vapor and air (oxygen) mixtures in the proper proportions within the flammable range.

3.2 Risk of Injury due to Flash Fire

Figure 1 shows the three elements required for a person to be at risk of exposure to a flash fire. To produce a flash fire, a hydrocarbon fuel vapor source must exist at or above the lower explosive limit (LEL) and it must be in proximity to an ignition source. A flash fire can exist without risk to a person, and a person must be in proximity to be at risk of injury.

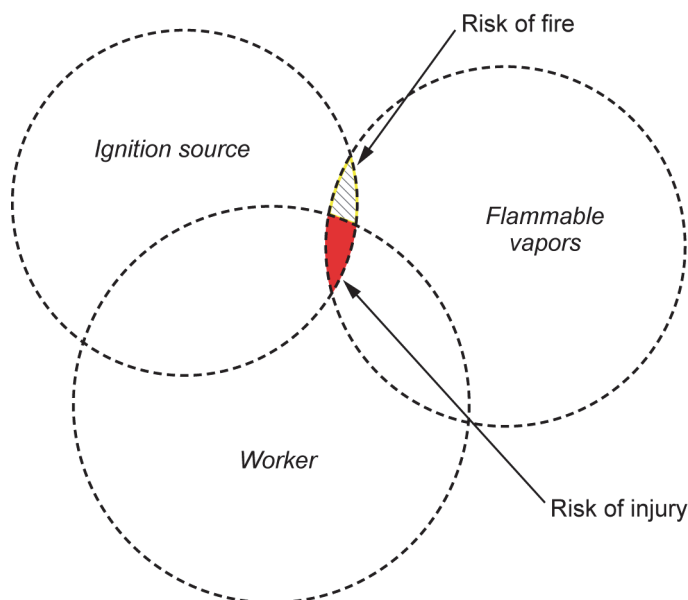


Figure 1—Risk of Flash Fire

The risk of injury to the person can be prevented in one of three ways:

- prevent the fire by controlling the fuel source,
- prevent the fire by controlling the ignition source,
- prevent the person from being in proximity to the potential hazard.

FRC, when worn as designed, may lessen harm to a person exposed to a flash fire. The burn injuries to persons wearing clothing that ignites or melts are greater than the injuries received if clothing does not ignite.

It should NOT be assumed that the use of FRC will fully protect the exposed person from injury.

3.3 Class I Division 1 and Division 2 Locations; Flammable Vapor Illustrations

A knowledge of Class I locations can aid in the identification of areas with the potential for flammable mixtures and as such a potential need for controls. API 500 provides guidance and numerous illustrations for the determination of Class I locations in petroleum facilities. Examples of API 500 illustrations can be found in Annex A.

Conditions within a classified area may change, resulting in a change to the risk of flash fire. If hydrocarbons have not been introduced or have been removed, additional controls may not be needed. For example, if working on a purged and inert system or drilling through a zone that does not produce hydrocarbon vapors at the surface, no risk of flash fire would be expected.

4 Hazard Evaluation

4.1 General

Where potential flash fire hazards exist, employers shall conduct a risk assessment and utilize controls to mitigate the risk of flash fire injury. See Section 6 ("Mitigation") and Section 7 ("General FRC Guidelines").

4.2 Hazard Identification

This RP recognizes that hazard identification is done prior to risk assessment. The hazard assessment process should include an identification of fuel sources, ignition sources, and job tasks.

Risk assessments may take many forms, such as those included in Section 5 and the annexes. These tools are provided as a resource, blending hazard identification steps with risk assessment and mitigation. These worksheets are not intended to replace existing safe work practices that have been implemented. Employers may rely on established methods to identify the risk of flash fire such as job hazard analysis, job safety analysis, or other risk assessment techniques.

4.3 Simultaneous Operations (SimOps)

SimOps is a regular occurrence in the upstream Exploration and Production sector of the oil and gas industry and should be a consideration when determining the potential risk for flash fire. When SimOps occur, the operation with the highest flash fire risk level of all affected operations shall determine if FRC is utilized for the entire SimOps activity.

4.4 Loss of Containment

The employer shall evaluate the risk of loss of containment. If personnel are performing a task that increases the probability of release of flammable materials, the employer shall take steps to mitigate the risk.

As part of this risk assessment the employer shall consider the following questions.

- a) Is the worker doing a task that increases the risk of loss of containment?
- b) Will the product released produce a flammable vapor?
- c) What controls are currently in place to minimize the risk of the flammable vapors to the air?
- d) What controls can be put in place to minimize the risk of a release?

The concept of performing a flash fire risk assessment that evaluates the inherent risk of materials while considering the risk of loss of containment is consistent with established industry standards. Flammable gases (NFPA Hazard Level 4 as defined in NFPA 704) are usually vapors and are ignitable at normal temperatures if a process is open under normal atmospheric conditions. Flammable liquids (NFPA Hazard Level 3) are usually ignitable at normal temperatures if a process is open. Less hazardous (NFPA Hazard Rating 2 or 1) materials produce flammable vapors if heated above their flash point. If containment failure occurs with flammable gases, liquids or heated combustible liquids the worker is exposed to the risk of flash fire.

5 Risk Assessment Methods

5.1 General

Many methodologies are available to assess the risks associated with activities that pose a flash fire hazard. Using the appropriate methodology will promote a better understanding of the risk and the necessary mitigation measures. The employer is responsible for determining which assessment methodology best suits their needs.

Consideration should be given to various factors during a risk assessment including, but not limited to, the following:

- a) proximity of the workers to the flash fire hazard;
- b) potential for the task creating loss of containment (e.g. line breaking);
- c) current operations (drilling, completions, production, construction, gas processing, etc.);
- d) engineering controls to reduce the likelihood or consequences of flammable releases;
- e) flash fire accident history;
- f) means and duration of egress from the potential flash fire exposure zone;
- g) multiple fuel sources;
- h) chemical exposure;
- i) SimOps.

Other conditions might reduce the risk of flash fire. For example, process piping that contains heavy oil may be in good condition and operating well within safe operating pressures. Proper design and maintenance of the system is considered effective engineering control.

5.2 Example Risk Assessment Technique

The Bowtie Model is an assessment technique that uses a visual representation to illustrate the risk factors. The exposure to a flash fire (which is the critical event of concern) is placed centrally between the threats on the left (i.e. the factors that can result in a flash fire) and the consequences on the right (the potential adverse results if the flash fire were to occur). Potential consequences would range from “no consequences” to “fatal result.” Prevention measures are the “defense barriers” expected to prevent a threat (on the left side) leading to a flash fire. Mitigation measures (on the right side) are the “defense barriers” that prevent damage and/or reduce its severity. The effectiveness of each “defense barrier” may be reduced by degrading factors (e.g. lack of training).

Following completion of the bowtie model(s), an assessment of the adequacy of the identified “defense barriers” should be completed. Each operation/activity for which a bowtie was created should be assessed. For each operation/activity, the threats and consequences are given a preliminary risk evaluation (low, medium, or high). For each threat/consequence, the defense barriers are listed and the resultant risk levels are determined.

Annex B shows an example of a blank bowtie as well as an example of how to complete the bowtie for a flash fire risk assessment.

5.3 Flash Fire Risk Assessment Worksheets and Coversheet

Annex C provides a 1-page overview/checklist for conducting a risk assessment. This document would be an appropriate format to use as a cover page for a series of assessments.

The employer can use Annex D or other techniques to illustrate the adequacy of the “defense barriers.”

5.4 Illustrated Risk Assessment for Oil and Gas Operations

As examples, the Flash Fire Risk Assessment Coversheet and Worksheets have been filled out in Annex E to show scenarios that can be encountered.

6 Mitigation

6.1 Layers of Protection

Safe operations are the result of layers of protection or safeguards. These layers of protection are put in place to prevent an incident from occurring or mitigate the consequences of an event. Protective layers shall be maintained to ensure effectiveness. Stronger and more numerous independent protection layers will lessen the likelihood that an event will occur or result in harm.

Flash fire injuries result from a failure of several protection layers. Flammable vapor must be present at concentrations at or above the LEL, which results from the failure of safeguards designed to ensure containment within equipment and piping, and there must also be an ignition source. Safe work practices, LEL monitoring, electrical area classification, etc. are layers of protection intended to prevent ignition sources while flammable vapor is present.

Personnel would need to be present at the location of the fire for an injury to occur. Site control and proximity exclusion prevent exposure. In the event other protective measures fail, garment selection and PPE offers a final layer of protection intended to lessen injury severity.

6.2 Hierarchy of Controls

The selection of controls for mitigating hazards identified during a risk assessment should be based upon the hierarchy of controls. The traditional hierarchy of controls is illustrated in Figure 2.

The hierarchy of controls illustrates that methods at the top of the list are potentially more effective and protective than those at the bottom. Proper utilization of the hierarchy of controls can lead to the implementation of safer systems where the risk of illness or injury has been substantially reduced.

Elimination and substitution, while most effective at reducing hazards, also tend to be the most difficult to implement in an existing process. If the process is still at the design or development stage, elimination and substitution of hazards may be inexpensive and simple to implement. This is the theory behind the safety-through-design protocols. For an existing process, major changes in equipment and procedures may be required to eliminate or substitute for a hazard.

Engineering controls are used to remove a hazard or place a barrier between the worker and the hazard. Engineering controls can be effective in protecting workers and should be independent of worker. The initial cost of engineering controls can be higher than the cost of administrative controls or personal protective equipment (PPE); but over the longer term, operating costs are frequently lower and, in some instances, can provide a cost savings in other areas of the process. Equipment and engineering controls associated with protecting against flash fires shall be designed, installed, inspected, tested, and maintained before being considered adequate control.