Model code of safe practice

Part 19

Fire precautions at petroleum refineries and bulk storage installations

3rd edition
EI MODEL CODE OF SAFE PRACTICE PART 19: FIRE PRECAUTIONS AT PETROLEUM REFINERIES AND BULK STORAGE INSTALLATIONS

3RD EDITION

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EI MODEL CODE OF SAFE PRACTICE PART 19: FIRE PRECAUTIONS AT PETROLEUM REFINERIES AND BULK STORAGE INSTALLATIONS

FOREWORD

EI Fire precautions at petroleum refineries and bulk storage installations (EI 19) provides guidance on selecting, implementing and monitoring the continuing performance of installation-specific justified risk reduction measures – from prevention through detection, protection systems to mitigation measures – to reduce the risk from design event fires at installations that process and store crude oil, petroleum, intermediates and refined products.

In line with recent legislation in the UK, Europe and elsewhere in the world, EI 19 does not set out prescriptive practices for adoption. Instead, it provides good practice guidance on options that may be appropriate to implement in order to satisfy pertinent risk drivers such as legislation, safety, environmental protection, asset protection, reputation and business continuity. The publication is based upon a framework of risk-based fire and explosion hazard management (FEHM) to achieve this, although it recognises that other approaches can be used. NB: Although the term ‘explosion’ is used within this definition it should also be realised that not every substance or hazardous circumstance will give rise to potential explosion conditions or create an explosion but for the purposes of this publication the term will be used throughout for consistency.

The guidance in this publication should assist process safety engineers, safety advisors, designers, emergency planners or others with responsibility for fire and explosion hazard management to meet the pertinent requirements of the European Seveso II Directive, whether installations are classified lower or upper tier.

This publication is based primarily on the UK and European legislative framework, publications and good practice. However, its guidance is internationally applicable provided it is read, interpreted and applied in conjunction with relevant national and local requirements. It can be used as a basis for establishing a consistent fire and explosion hazard management policy for companies with multi-installation operations within a country or across several countries.

The third edition of EI 19 was commissioned by the Energy Institute’s Process Safety Committee, contracted to Resource Protection International and directed by a Steering Group. It supersedes the second edition, published in 2007. Whilst amendments have been made throughout, major changes have been made to:

- Define key principles.
- Enhance guidance on consideration of environmental impacts of fire-fighting and the need for environmental risk assessment; in particular, containment system capacity and firewater management.
- Provide guidance on fire response for ethanol and related polar substance handling/storage; in particular, pertinent foam types.
- Enhance guidance on fire and explosion scenarios, consequences and modelling.
- Provide guidance on control measures for vent fires.
- Include guidance on potential scenarios, the role of congestion, incident consequences and examples of substances with a propensity to form large flammable vapour clouds.
- Clarify basis for determining whether scenarios are credible by referencing their likelihood to risk tolerability criteria.
- Enhance guidance on storage tank layout, secondary and tertiary containment systems requirements.
- Enhance guidance on detection systems.
- Define need for a policy on passive fire protection (PFP).
- Provide guidance on PFP maintenance.
- Update guidance on halon substitute gaseous extinguishing media.
Provide guidance on fire water systems.
Enhance guidance on foam systems for storage tanks.
Enhance guidance on option of controlled burn (CB).
Provide guidance on rapid intervention vehicles (RIVs) and mobile incident response units (MIRUs), and typical fire equipment on board.
Provide guidance on vulnerability and siting of critical equipment and resources.
Enhance guidance on control of incidents by defining command structure.
Enhance guidance on scenario-specific ERPs.
Enhance guidance on dynamic risk assessment (DRA).
Enhance guidance on typical FEHM (detection and protection) measures at various other installation areas.
Provide guidance on typical FEHM (detection and protection) measures for road and rail tanker loading racks/gantries.
Enhance guidance on water supply requirements.
Revise minimum foam solution application rates and consider foam application to prevent boilover.
Define requirements for emergency responder (ER) competence.

The 2nd edition of this publication was being finalised at the time of the Buncefield bulk storage installation major accident in December 2005 and since then there have been changes in the regulatory approach to fire precautions at such installations, encompassing fire prevention measures, incident detection techniques, fire protection, fire-fighting and response and emergency planning requirements. Some of these relate to process considerations, which are not specifically covered in detail in this 3rd edition of this publication but may be relevant for overall FEHM – wherever possible these are addressed. In addition to changes in the regulatory approach there have been new developments in hardware, understanding of potential to cause vapour cloud explosions (VCEs), changes in thinking in issues such as human and organisational factors, and new approaches to fire response. It is not within the scope of this publication to describe all of these and as such, users may wish to consult the relevant Buncefield investigation reports for more detail. However, where appropriate, and where they enhance the overall guidance in this publication, such measures are given credit. It should also be noted that whilst a great deal of focus has been placed on this particular incident in recent years, the circumstances that led up to it, and the recommended prevention and mitigation measures, this publication is also relevant to other types of fire incident types and scenarios. Consequently, some of the guidance contained herein may not always be relevant to the particular type of incident mentioned.

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KEY TECHNICAL CHANGES

This section sets out in a generalised form, the key technical changes between the 2nd and 3rd editions of EI 19 (EI Fire precautions at petroleum refineries and bulk storage installations).

The key technical changes are to:

- Define key principles.
- Enhance guidance on consideration of environmental impacts of fire-fighting and the need for environmental risk assessment. Section 1.7.3.
- Provide guidance on the required capacity (e.g. via secondary and tertiary containment) to hold safely the anticipated or foreseeable volume of hazardous liquids, including firewater. Section 1.7.3.
- Enhance guidance on firewater management, including the option of recirculation. Sections 1.7.3, 2.5.5, 4.8.3, 4.8.6, 6.5.2, 7.2.6, 8.7, and Annexes D.6 and D.11.
- Provide guidance on fire response for ethanol and related polar substance handling/storage; in particular, pertinent foam types. Sections 2.2 and 6.4.3.
- Refer to special hazards in storage and handling of petroleum additives, such as diesel cetane improvers. Section 2.2.
- Enhance guidance on fire and explosion scenarios, consequences and modelling with reference to incident experience (e.g. from large atmospheric storage tank fires (LASTFIRE) project); e.g. VCEs, bund fires, boilover. Sections 2.5.4, 2.5.5 and 2.5.8.
- Provide guidance on control measures for vent fires. Section 2.5.5.1.
- Include guidance on potential scenarios, their likelihood in areas with a lack of congestion, incident consequences and examples of substances with a propensity to form large flammable vapour clouds. Section 2.5.8 and annex B.5.
- Clarify conditions under which flash fires might occur. Section 2.5.9.
- Revise guidance on overpressure consequences. Section 2.6.3.
- Enhance guidance on fire and explosion modelling. Section 2.7.1.
- Clarify basis for determining whether scenarios are credible by referencing their likelihood to risk tolerability criteria. Section 3.2.3.
- Consider merits of using cost benefit analysis (CBA) in design/credible scenario selection. Section 3.2.3.
- Clarify general principles in controlling flammable substances. Section 4.2.1.
- Provide guidance on isolation of sources of ignition. Section 4.4.1.
- Clarify circumstances when it might be appropriate to use a smaller than usual separation distance between tanks and other items of plant when designing a facility. Section 4.8.1.
- Enhance guidance on storage tank layout/secondary containment. Section 4.8.3.
- Clarify intent of bund volume compared to storage tank operating capacity. Section 4.8.3.
- Provide guidance on benefits/disbenefits of using double or full containment-type tanks in reducing the consequences of a loss of containment. Section 4.8.3.
- Provide guidance on tertiary containment systems, and their capacity rating. Section 4.8.6.
- Refer to need to consider facility topography and the potential path of vapour and liquid releases when locating fire protection and other safety critical equipment. Section 4.8.7.
- Provide guidance on location of flanges/pipework, and the vulnerability of long bolt flanges. Section 4.8.8.
- Enhance guidance on detection systems (e.g. flammable gas, toxic gas, liquid and fire
detection, gas imaging and their application) to assist implementation by capturing
the experience gained and equipment developments. Section 5.
- Refer to safety integrity of detection control systems. Section 5.3.
- Define need for a policy on PFP. Section 6.2.2.
- Provide guidance on maintenance of PFP. Section 6.2.3.
- Provide guidance on water quality and type for use as firewater. Section 6.4.2.
- Update guidance on gaseous extinguishing media that have reduced impacts to air
compared to halons. Section 6.4.5.
- Provide guidance on fire water systems and winterisation. Section 6.5.2.
- Enhance guidance on foam systems for storage tanks. Section 6.5.7.
- Provide guidance on the need for assurance of ongoing integrity of enclosures where
gaseous extinguishing systems are used. Section 6.5.9.
- Provide guidance on the appropriateness of using foam to blanket vapours from LNG
etc. Section 7.2.1.4.
- Clarify guidance on when to evacuate areas during emergency response to potential
BLEVE situations. Section 7.2.5.
- Provide guidance on availability of operations/maintenance personnel to serve as
auxiliary ERs when installation-wide events occur. Section 7.3.3.2.
- Enhance guidance on option of CB, including its development as a design philosophy
and operational strategy. Section 7.2.6.
- Provide guidance on RIVs and MiRUs, and typical fire equipment on board. Section 7.6.1.
- Provide guidance on vulnerability and siting of critical equipment and resources.
Section 7.6.4.
- Enhance guidance on control of incidents by defining command structure. Section 8.5.
- Enhance guidance on scenario-specific ERPs. Section 8.7.
- Enhance guidance on DRA. Section 8.9.2.
- Enhance guidance on typical FEHM (detection and protection) measures for storage
tanks, process areas, LNG installations, marine beths and jetties, etc. Annex C.
- Provide guidance on typical FEHM (detection and protection) measures for road and
- Clarify applicability of insulation in providing fire protection. Annex D.2(ii).
- Provide guidance on cooling atmospheric tanks impinged by flame. Annex D.5(iii).
- Clarify context of scenario for foam/cooling water example. Annex D.6, Box D.1
- Revise minimum foam solution application rates and consider foam application to
- Define requirements for ER competence. Annex E.1.
- Update listing of references and bibliography (e.g. codes of practice, design standards,
specifications, guidance, etc.). Annex I.
ACKNOWLEDGEMENTS

The 3rd edition of EI Fire precautions at petroleum refineries and bulk storage installations (EI 19) was commissioned by the Energy Institute’s Process Safety Committee. The project was contracted to Resource Protection International, whose contributors were Paul Watkins, Dr Niall Ramsden and Mark Plastow. The project was directed by a Steering Group that comprised:

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The Institute wishes to record its appreciation of the work carried out by them in providing technical direction to the project.

Significant comments on the draft of this publication were received during its technical reviews from:

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Dr Mike Nicholas Environment Agency
Ken Palmer Consultant
Roger Roue The Society of International Gas Tanker and Terminal Operators (SITGTO)
Stuart Warburton Essar Oil UK Ltd. Stanlow Refinery
Kevin Westwood BP

Such comments have been considered and, where appropriate, incorporated. The Institute wishes to record its appreciation of the work carried out by them and others who participated during the technical review.

Project co-ordination and technical editing was carried out by Dr Mark Scanlon (Energy Institute).
KEY PRINCIPLES

The 3rd edition of EI 19 outlines some key principles, which, historically, have been addressed but by virtue of increased knowledge, incident experience and technological developments, they are considered paramount to ensure that appropriate, justified and relevant fire precautions and other aspects of fire hazard and explosion management (FEHM) are promoted. They should be considered as guiding principles that should form part of an installation’s FEHM policy.

1. **FEHM – EI 19** sets out a methodology by which installation operators can assess fire and explosion scenarios, compare various risk reduction measures, and define an installation-specific FEHM policy, and offers guidance on implementation.

2. **Fire prevention** – Emphasis is placed on prevention of fires in the first instance, as well as the circumstances in which events can lead to fires or explosions, such as prevention of loss of containment and sources of ignition.

3. **Incident detection** – Ensuring that if a loss of containment or fire event occurs, that they are rapidly detected to enable effective incident response (including process measures such as isolation) to occur.

4. **Fire protection** – Guidance is given on PFP and active fire protection (AFP) measures that may be implemented as mitigation measures in the event of a fire event. Emphasis is placed on ensuring that relevant and effective fire protection is selected and that a system of fire systems integrity assurance (FSIA) is adopted.

5. **Maintaining FEHM policy** – EI 19 covers many aspects of incident response, recognising at all times that the focus should be on incident prevention. However, where response measures need to be addressed, guidance is given on options, strategies and preplanning measures with particular emphasis on:
   - emergency response planning;
   - training and competencies;
   - life safety and environmental protection;
   - management of fire-water runoff, and
   - FSIA.
OVERVIEW

Section 1 clarifies the scope and exclusions, and describes how the publication should be applied internationally. It introduces the concept of risk-based FEHM, which is the framework upon which the publication is based. It also notes the legislative trend towards a risk-based approach and sets out a portfolio of other risk drivers.

Section 2 outlines the fire-related hazards of petroleum and its products (including their IP classification) and common fire and explosion scenarios that should be considered as part of a risk-based FEHM approach. It addresses such scenarios as pool fires, jet fires, boiling liquid expanding vapour explosions (BLEVEs), and VCEs.

Section 3 expands on the key steps in the FEHM process: fire scenario analysis – typical scenarios are outlined for various facilities/areas; review risk reduction options – a listing of options is provided; define FEHM policy between the limiting cases of burndown and total protection; and implement FEHM policy, by referring to a range of measures from FSIA through to staff personnel competency development and emergency response planning.

Section 4 describes several means of hazard avoidance that aim to prevent unplanned releases and avoid their ignition. Fire prevention measures described include: control of flammable substances; control of sources of ignition; maintenance; installation layout; and operations.

Section 5 describes the use of fire and flammable gas detection to give early warning of a fire event in critical installations or where there is a high emphasis on life safety. Their use should enable immediate investigation and/or fire response. The section describes the various types, their application to various installations/areas and design issues.

Section 6 describes PFP and AFP measures, which are intended to reduce the consequences of fire. Options, applications and design issues are reviewed for PFP materials in limiting temperature rise and preventing excessive heat absorption. The capabilities of AFP media are reviewed for controlling a fire, extinguishing a fire, or preventing ignition during an emergency in typical installations/areas. In addition, media application is reviewed, whether using fixed or semi-fixed systems and portable/mobile fire response equipment.

Section 7 provides incident response strategies for various fire and explosion scenarios to maintain FEHM policy; it includes options for mobile and portable fire response, including the specification, use and maintenance of fire-fighting equipment ranging from fire monitors to ER personal protective equipment (PPE). The guidance on incident response strategies reflects experience and good practice in fire response; it can be used as a basis for developing installation-specific fire response strategies accompanied by ERPs.

Section 8 sets out the requirements for maintaining an effective FEHM policy, in particular through emergency planning from high-level incident preplans through to scenario-specific ERPs. In addition, it covers personnel competency development, emergency response plan testing and FSIA for fire and flammable gas detection and fire protection systems.

Annex A reviews the requirements of pertinent UK and European legislation, such as the UK Control of Major Accident Hazards (COMAH) Regulations and Seveso II Directive, respectively.

Annex B provides the IP classification and physical properties of petroleum and its products, which should be used when assessing their fire-related hazards.

Annex C provides typical applications of the most common fire and flammable gas detection and fire protection risk reduction measures for various installations/areas.

Annex D provides guidance on typical fire-fighting media application rates for various equipment types and fire scenarios, focusing mainly on applying water and foam to large petroleum fires for extinguishment and/or cooling. In addition, some guidance is provided on incident experience and recent good practice.
Annex E provides an example ER competency profile based on four units: operations; maintenance; procedures; and skills.

Annex F details the European basis of classifying fires and reviews other classification systems.

Annex G provides an example installation-specific ERP and an example scenario worksheet. In addition, some benchmark radiant heat levels and their effects are provided.

Annex H provides a glossary of terms and abbreviations.

Annex I provides details of publications referenced and a bibliography of additional ones (e.g. codes of practice, design standards, specifications, guidance, etc.). It also provides a listing of contact details for pertinent organisations.
1 INTRODUCTION

1.1 INTRODUCTION

This section clarifies the scope and exclusions, and describes how the publication should be applied internationally. It introduces the concept of risk-based fire and explosion hazard management (FEHM), which is the framework upon which the publication is based. It also notes the legislative trend towards a risk-based approach and sets out a portfolio of other risk drivers.

Generally, the petroleum industry is successful in minimising fire incidents and containing their effects. This should not lead to complacency, however, and this publication aims to help maintain and, indeed, improve FEHM.

1.2 SCOPE

EI 19 provides guidance on selecting, implementing and monitoring the continuing performance of installation-specific justified risk reduction measures – from prevention through detection, protection systems to mitigation measures – to reduce the risk from design event fires at installations that process and store petroleum (e.g. crude oil), intermediates (e.g. naphtha) and its products (e.g. gas oil). The publication provides a framework of good practice which should assist attainment of legal compliance, in particular with the pertinent requirements of European Seveso II Directive, and satisfying other risk drivers.

Its scope includes petroleum refineries and bulk storage installations (e.g. terminals, depots and larger customer storage installations). In addition, it can be applied to bitumen refineries and bulk storage installations, blending and storage at lubricants installations, and similar petroleum industry installations. Installations excluded from scope are:

- filling stations;
- smaller customer storage installations;
- natural gas storage installations (at ambient conditions), and
- processing and storage on offshore installations.

Whilst the publication is built upon the principles of FEHM, the focus is on fire aspects, whereas, explosion hazards, prevention and protection are specialised topics and are outwith the scope.

1.3 APPLICATION

In line with recent legislation in the UK, Europe and internationally, this publication does not set out prescriptive practices for adoption. Instead, it provides good practice guidance on options that may be appropriate for users to implement in order to satisfy pertinent risk drivers; in particular, legislation, safety (e.g. to personnel and society), environmental protection, asset protection, reputation and business interruption.

Reducing the likelihood or consequences of fires may assist in risk reduction for any risk driver; yet, when a measure is considered for risk reduction, it should be justified using cost benefit analysis (CBA) and for safety and environmental risk drivers in the UK using as low as reasonably practicable (ALARP) principles. The reasons why any particular fire risk reduction measure is provided should therefore be understood, appropriate performance