Consequence Modelling for Emergency Response Scenario Plans

RISK 2016: Friday 20th May
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SWISSOTEL SYDNEY
18-20 MAY 2016
RISK2016
RISK ENGINEERING CONFERENCE

Introduction

Emergency Response Scenario Plans are part of the emergency response for facilities with hazardous materials (e.g. flammable, toxic).

This presentation will consider how consequence modelling is the foundation of a good Emergency Response Scenario Plan.

Overview

This presentation will cover:

Emergency Response Scenario Plans

- What is an Emergency Response Scenario Plan?
- Contents of an Emergency Response Scenario Plan.

Example of consequence modelling in Emergency Response Scenario Plans for a full-surface tank fire scenario.

- Determining cooling water requirements
  - Comparison to AS 1940 cooling water requirements
- Determining accessibility of emergency response equipment.

What is an Emergency Response Scenario Plan?

An Emergency Response Scenario Plan:

- Is part of an overall facility Emergency Plan
- Outlines the key emergency details for a representative scenario
- Provides a succinct overview of:
  - Impacts of the event
  - Emergency response requirements – (e.g. firefighting resources).
- Assists emergency preparedness
- Acts as a reference for emergency personnel for:
  - Training
  - Emergency drills
  - During an incident.

What is an Emergency Response Scenario Plan?

Legislation for Major Hazard Facility Emergency Plans

Include...

the emergency planning assumptions, including emergency measures planned for identified incidents and likely areas affected.

the protective resources available to control an incident.

Work Health and Safety Regulations 2011 (Cth) sch 16.

For each major incident hazard and major incident, a description of the measures taken and to be taken to control or limit the consequences of a major incident, including a description of all protective resources available and all emergency response procedures.

Occupational Health and Safety Regulation 2007 (VIC) sch 11.

Contents of an Emergency Response Scenario Plan

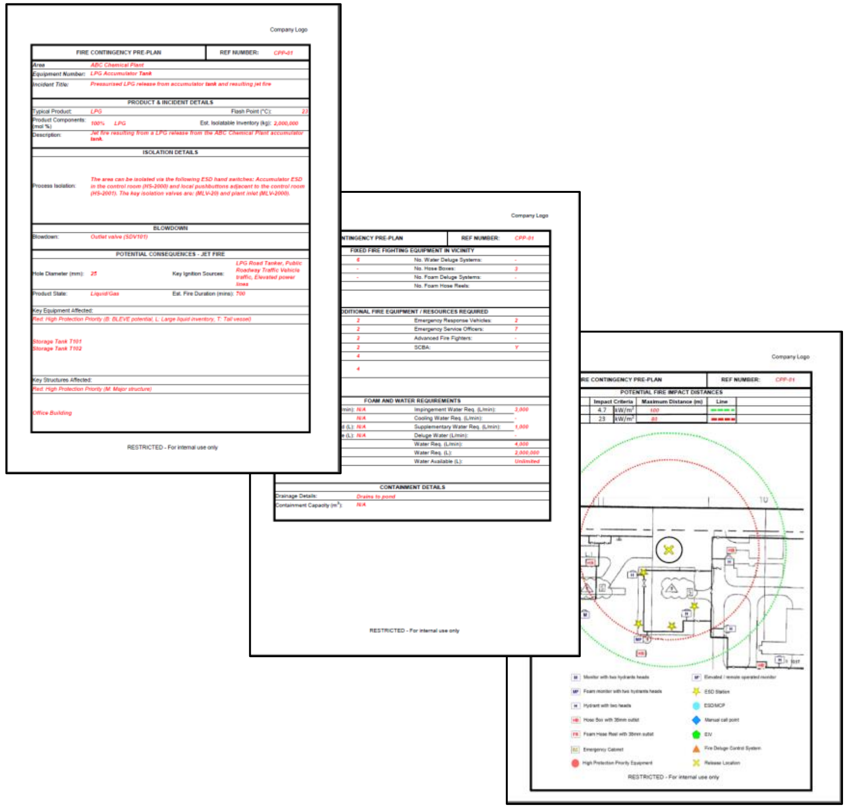
Emergency Response Scenario Plans may be developed for:

- A loss of containment of flammable or combustible material and subsequent ignition.
- A loss of containment of toxic material.

This presentation will examine Emergency Response Scenario Plans for full-surface tank fires.

Contents of an Emergency Response Scenario Plan

An Emergency Response Scenario Plan may contain the following:



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FIRE CONTINGENCY PRE-PLAN	REF NUMBER: CPP-01
Area	ABC Chemical Plant
Equipment Number:	LPG Accumulator Tank
Incident Title:	Pressurised LPG release from accumulator tank and resulting jet fire

PRODUCT & INCIDENT DETAILS

Typical Product:	LPG	Flash Point (°C):	23
Product Components: (mol %)	100% LPG	Est. Isolatable Inventory (kg):	2,000,000
Description:	Jet fire resulting from a LPG release from the ABC Chemical Plant accumulator tank.		

ISOLATION DETAILS

Process Isolation: The area can be isolated via the following ESD hand switches: Accumulator ESD in the control room (HS-2000) and local pushbuttons adjacent to the control room (HS-2001). The key isolation valves are: (MLV-20) and plant inlet (MLV-2000).

BLOWDOWN

Blowdown: Outlet valve (SDV101)

POTENTIAL CONSEQUENCES - JET FIRE

Hole Diameter (mm):	25	Key Ignition Sources:	LPG Road Tanker, Public Roadway Traffic Vehicle traffic, Elevated power lines
Product State:	Liquid/Gas	Est. Fire Duration (mins):	700

Key Equipment Affected:
Red: High Protection Priority (B: BLEVE potential, L: Large liquid inventory, T: Tall vessel)

Storage Tank T101
Storage Tank T102

Key Structures Affected:
Red: High Protection Priority (M: Major structure)

Office Building

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NTINGENCY PRE-PLAN | REF NUMBER: CPP-01

FIXED FIRE FIGHTING EQUIPMENT IN VICINITY

	6	No. Water Deluge Systems:	-
	-	No. Hose Boxes:	3
	-	No. Foam Deluge Systems:	-
		No. Foam Hose Reels:	

DDITIONAL FIRE EQUIPMENT / RESOURCES REQUIRED

	2	Emergency Response Vehicles:	2
	2	Emergency Service Officers:	7
	2	Advanced Fire Fighters:	-
	2	SCBA:	Y
	4		
	4		

FOAM AND WATER REQUIREMENTS

min):	N/A	Impingement Water Req. (L/min):	3,000
	N/A	Cooling Water Req. (L/min):	-
d (L):	N/A	Supplementary Water Req. (L/min):	1,000
e (L):	N/A	Deluge Water (L/min):	-
		Water Req. (L/min):	4,000
		Water Req. (L):	2,000,000
		Water Available (L):	Unlimited

CONTAINMENT DETAILS

Drainage Details:	Drains to pond
Containment Capacity (m^3):	N/A

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RE CONTINGENCY PRE-PLAN | REF NUMBER: CPP-01

POTENTIAL FIRE IMPACT DISTANCES

Impact Criteria		Maximum Distance (m)	Line
4.7	kW/m^2	100	
23	kW/m^2	80	

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- Details of the hazard:
  - Material
  - Inventory
  - Operating conditions
- Consequence description (including potential for escalation)
- Foam and firewater requirements
- Firefighting resources in the vicinity
- Additional resources required
- Isolation / Containment.

Contents of an Emergency Response Scenario Plan

Details of the Hazard

Plant area and equipment

EMERGENCY RESPONSE SCENARIO PLAN		REF NUMBER:	*ERSP-01*
Area	***Tank Farm A***		
Equipment Number:	***Crude Oil Storage Tank, T1***		
Incident Title:	***Full surface fire from tank T1***		
PRODUCT & INCIDENT DETAILS			
Typical Product:	***Crude Oil***	Flash Point (˚ C):	***-32***
Product Components: (mol %)	***N/A***	Est. Isolatable Inventory (kg):	***14,000,000***
Description:			

Inventory

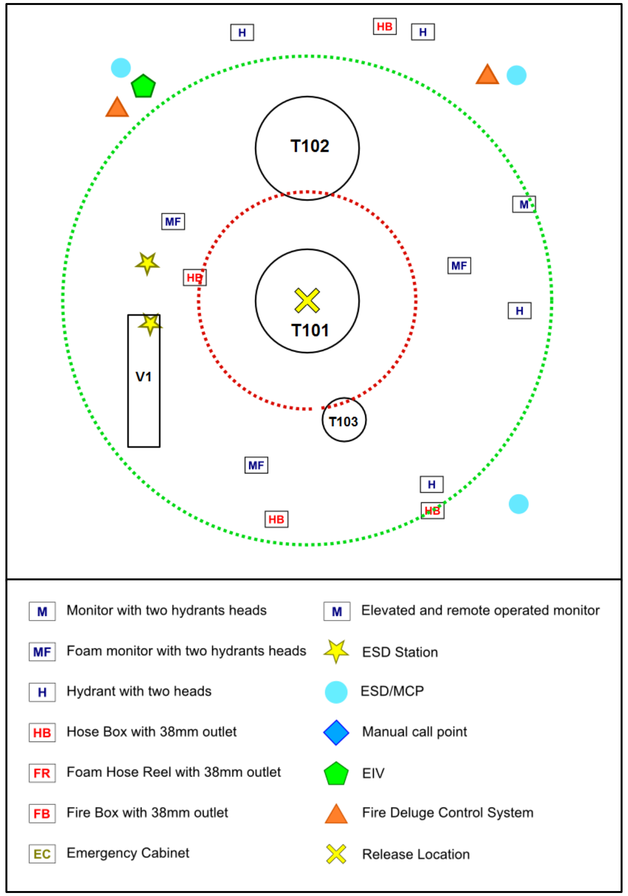
Material and properties

Contents of an Emergency Response Scenario Plan

Consequence Description

Fire scenario description

POTENTIAL CONSEQUENCES - TANK-TOP FIRE			
Tank Diameter (m):	***45***	Key Ignition Sources:	**-**
Product State:	***Liquid***	Est. Fire Duration (mins):	***900***
Key Equipment Affected:			
Red: High Protection Priority (B: BLEVE potential, L: Large liquid inventory, T: Tall vessel)			
Storage Tank T102			
Key Structures Affected:			
Red: High Protection Priority (M: Major structure)			
Load-in Bay infrastructure ***Driver's tea room***			



Potential for escalation

Contents of an Emergency Response Scenario Plan

Firefighting Requirements

Firewater requirements

Foam requirements

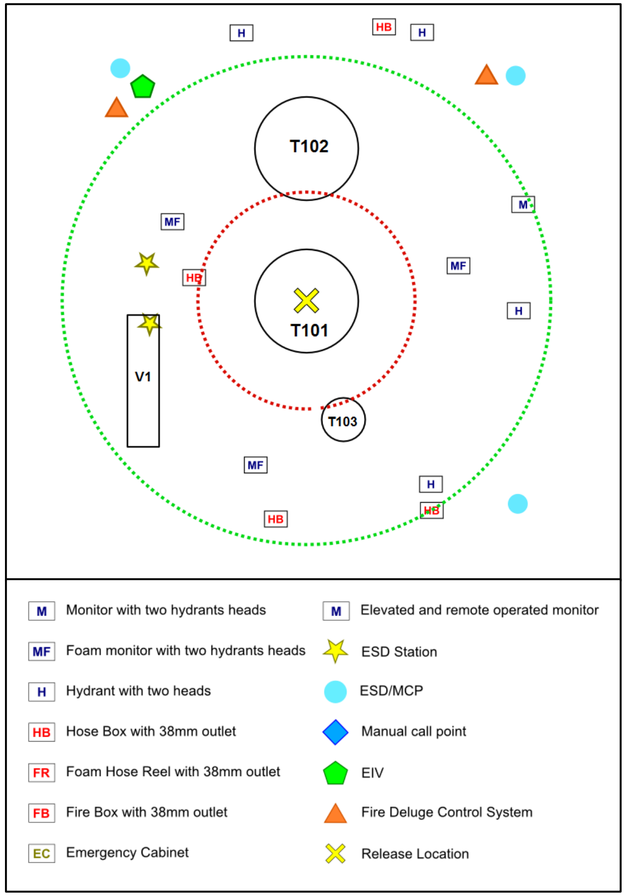
FOAM AND WATER REQUIREMENTS			
Fixed Foam Solution Required (L/min):	***5,000***	Water Req. for Foam (L/min):	***5,000***
Foam Type:	***AFFF***	Cooling Water Req. (L/min):	***2,000***
Foam Concentrate Required (L):	***9,000***	Deluge Water Req. (L/min):	***10,000***
Foam Concentrate Available (L):	***3,000***	Supplementary Water Req. (L/min):	***1,200***
		Water Req. (L/min):	***18,200***
		Water Volume Req. (L):	***1,001,000***
		Water Volume Available (L):	***Unlimited***
Other:	***In the event of a fire, additional foam will need to be supplied to the area (e.g. foam trailers)***		

Contents of an Emergency Response Scenario Plan

Firefighting Resources

Firefighting resources in the vicinity

FIXED FIRE FIGHTING EQUIPMENT IN VICINITY			
No. Fire Hydrants:	*2*	No. Water Deluge Systems:	*2*
No. Fire Monitors:	*-*	No. Hose Boxes:	*4*
No. Foam/Water Monitors:	*1*	No. Foam Deluge Systems:	*2*
Detail:			
FIRE EQUIPMENT / RESOURCES REQUIRED			
Portable Monitors:	*2*	Emergency Response Vehicles:	*2*
Foam Cannons:	*2*	Emergency Service Officers:	*-*
64 mm x 30 m Hoses:	*2*	Advanced Fire Fighters:	*2*
Supplementary Hoses:	*3*	SCBA:	*Y*
38 mm x 30 m Hoses:	*2*		
38 mm Branches:	*2*		
Other:			



Additional resources required

Contents of an Emergency Response Scenario Plan

Isolation and Containment

Available isolation and emergency depressuring.

ISOLATION							
Process Isolation:	***Key isolation valves are: Crude Oil Tank inlet (V02) and outlet (V01)***						
BLOWDOWN							
Blowdown:	***No liquid blowdown***						

Containment of contaminated firewater

CONTAINMENT DETAILS							
Drainage Details:		***Drains to slops tank***					
Containment Capacity (m^3):		***25,000***					

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Consequence Modelling in Emergency Response Scenario Plans

Consequence modelling is used to determine the potential impacts of:

- Fires and explosions
- Toxic gas clouds.

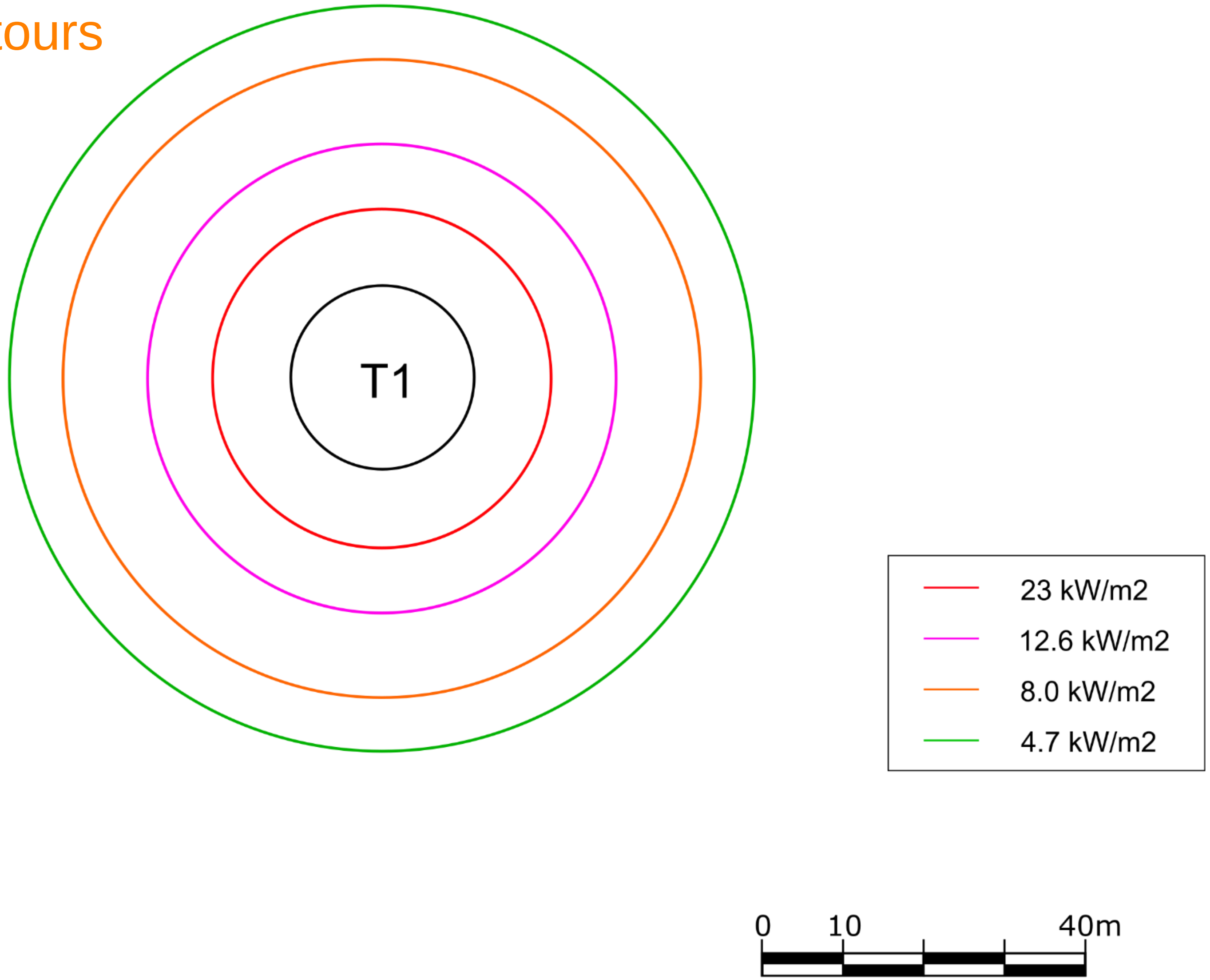
In Emergency Response Scenario Plans for full-surface tank fire scenarios, consequence modelling can be used to determine:

- Cooling water requirements to protect against escalation
- Accessibility of emergency response equipment.

Consequence Modelling in Emergency Response Scenario Plans

Heat Flux Contours

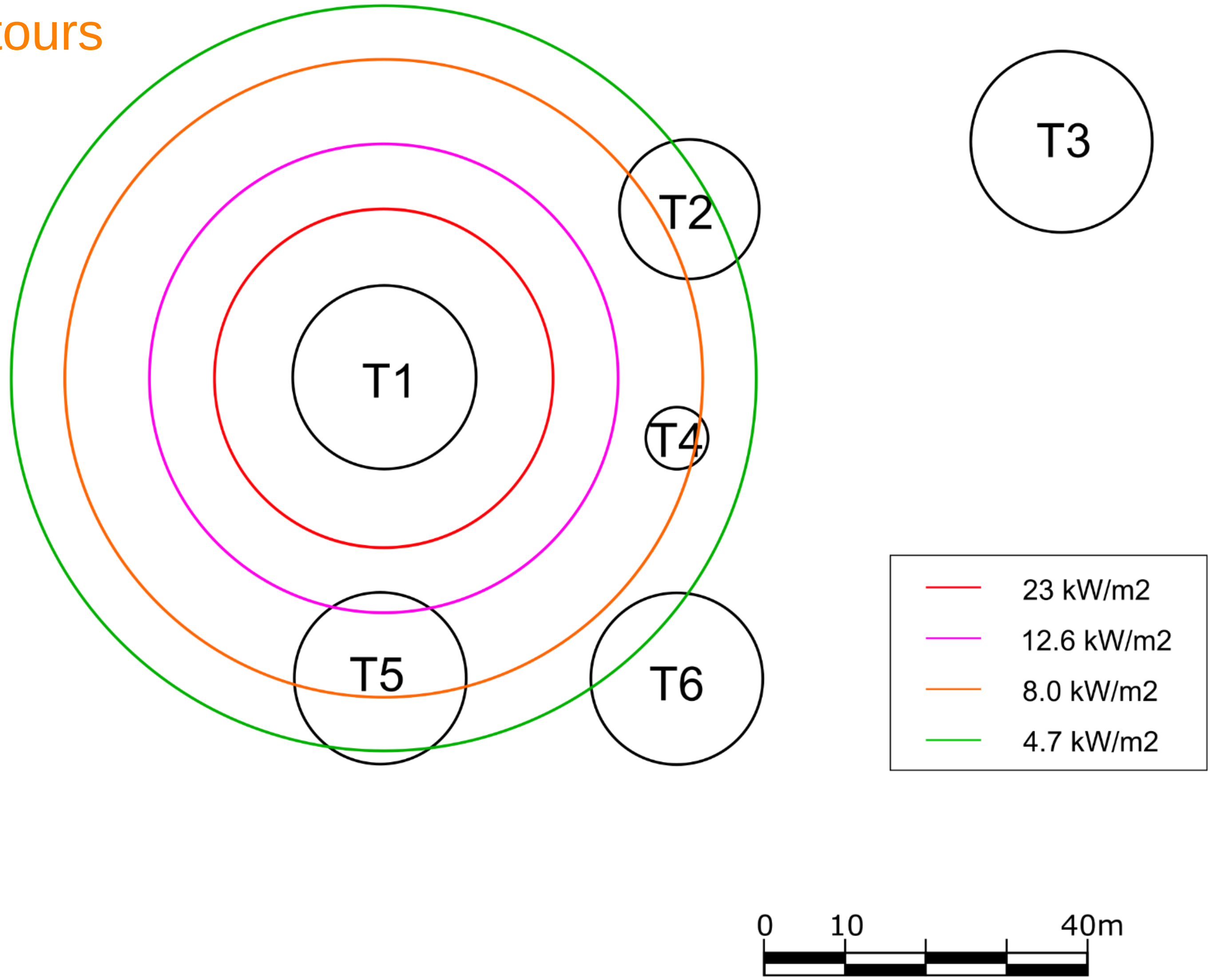
Tank Height



Consequence Modelling in Emergency Response Scenario Plans

Heat Flux Contours

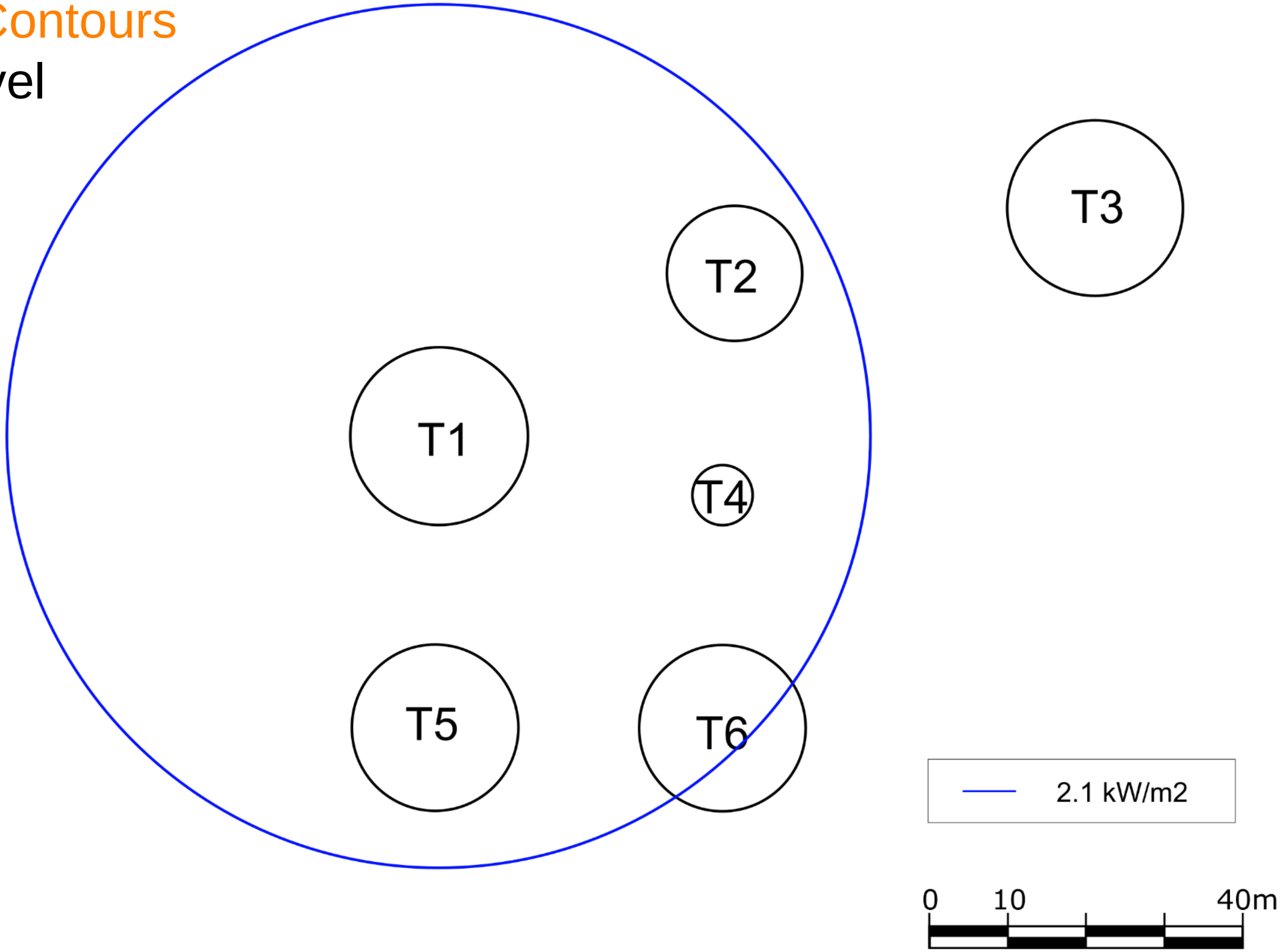
Tank Height



Consequence Modelling in Emergency Response Scenario Plans

Heat Flux Contours

Ground Level



Cooling Water Requirements

A fire has the potential escalate due to:

- Flame impingement on equipment containing hazardous materials
- High radiant heat impacting equipment containing hazardous materials
- Damage to major structures or equipment.

Where these items are considered critical, cooling water may be applied by monitor or fixed spray system to protect the equipment.

Cooling Water Requirements

For a large atmospheric storage tank, full-surface tank fires have potential for:

- Large fire events with wide effect zones
- Fires that continue for a lengthy duration
- Escalation to tanks with similarly large inventories of flammable and combustible materials.

To prevent escalation of a full-surface tank fire, cooling water may be required to protect adjacent tanks exposed to the heat from the fire.

Cooling Water Requirements

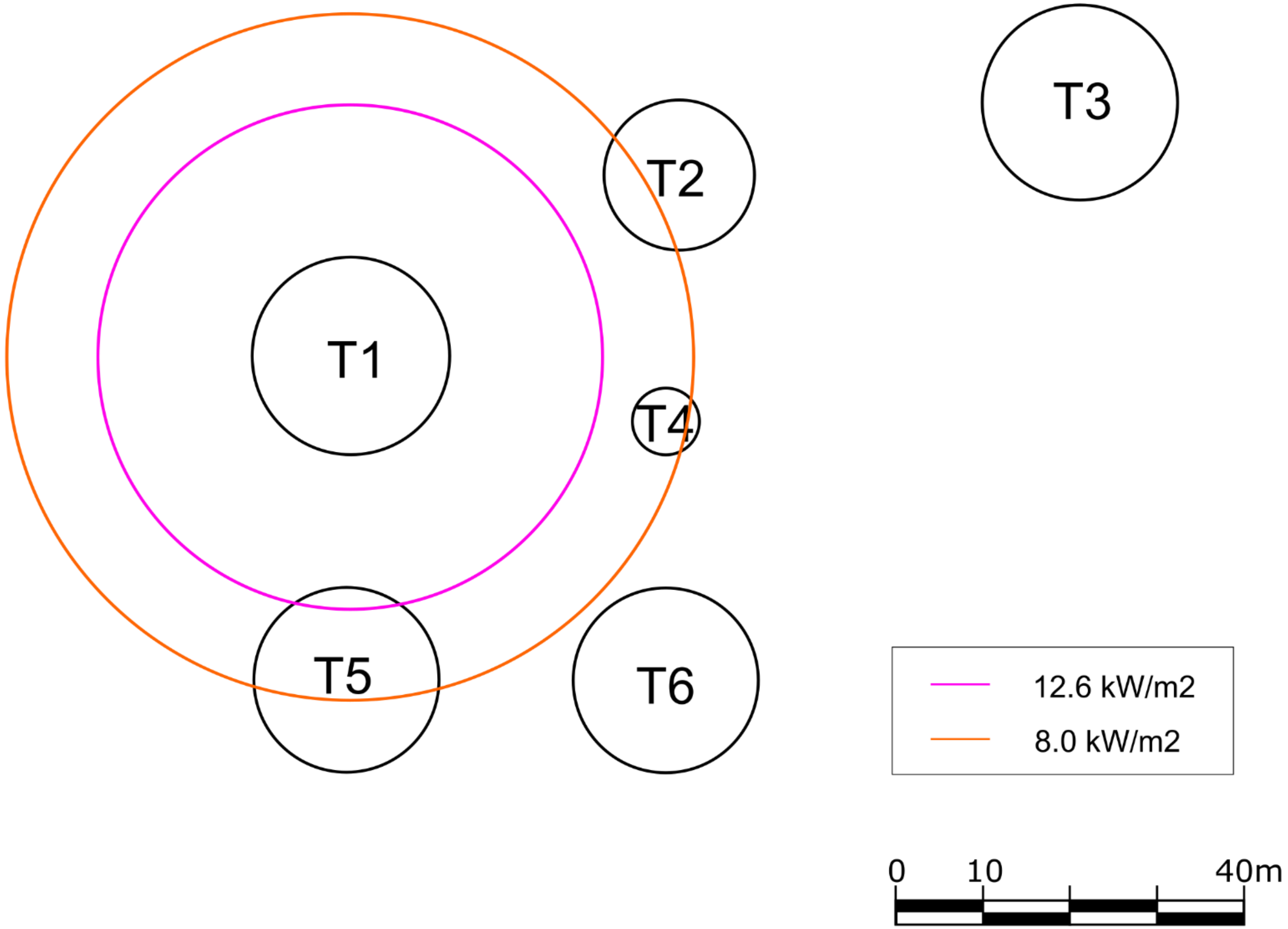
R4Risk Performance-based Methodology

- The maximum heat flux received by exposed tanks from the fire is determined from consequence modelling.
- The cooling water application rate is determined based on the amount of water required to absorb the thermal radiation received from the fire.

Cooling Water Requirements

Heat Flux Contours

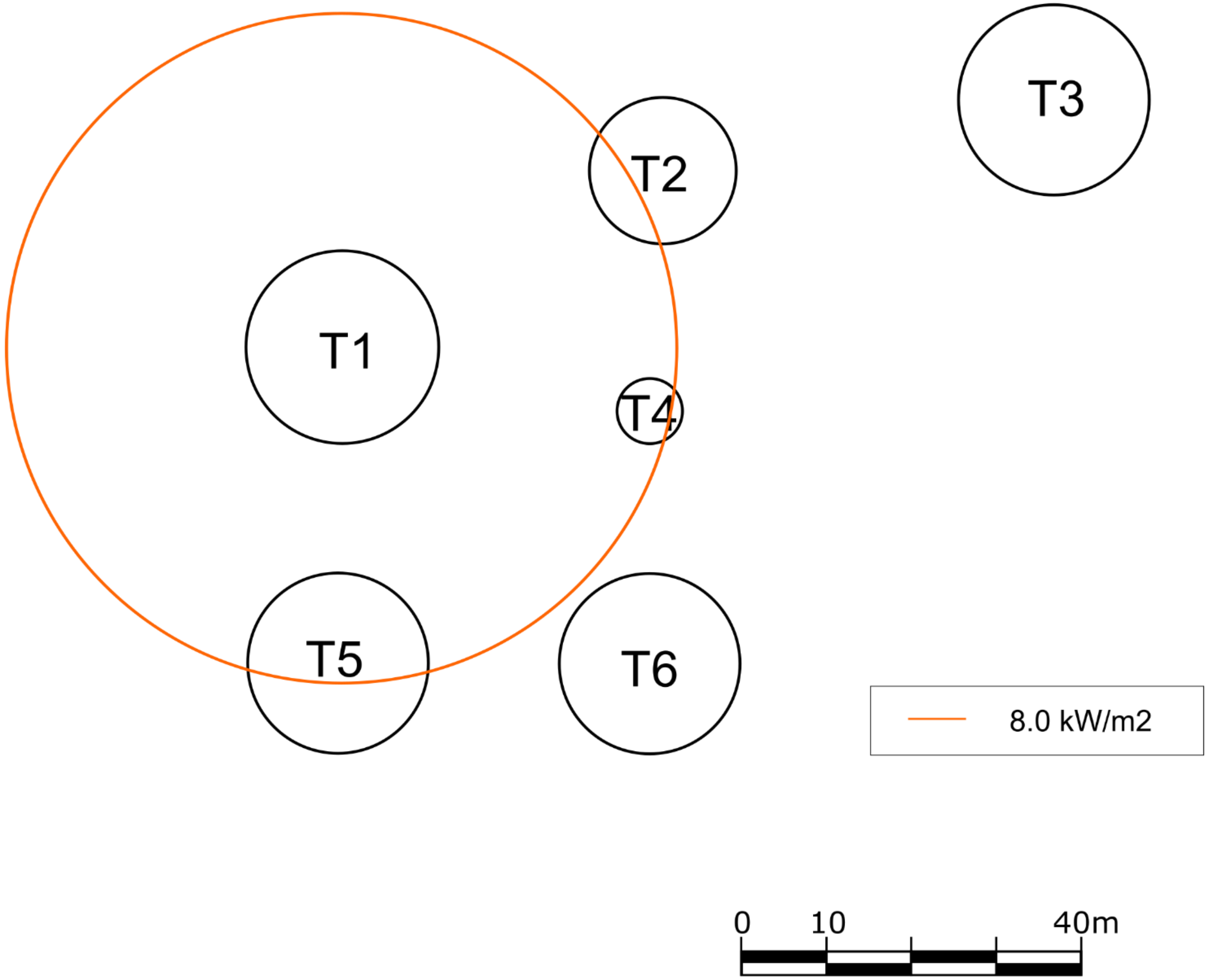
Tank Height



Cooling Water Requirements

Heat Flux Contours

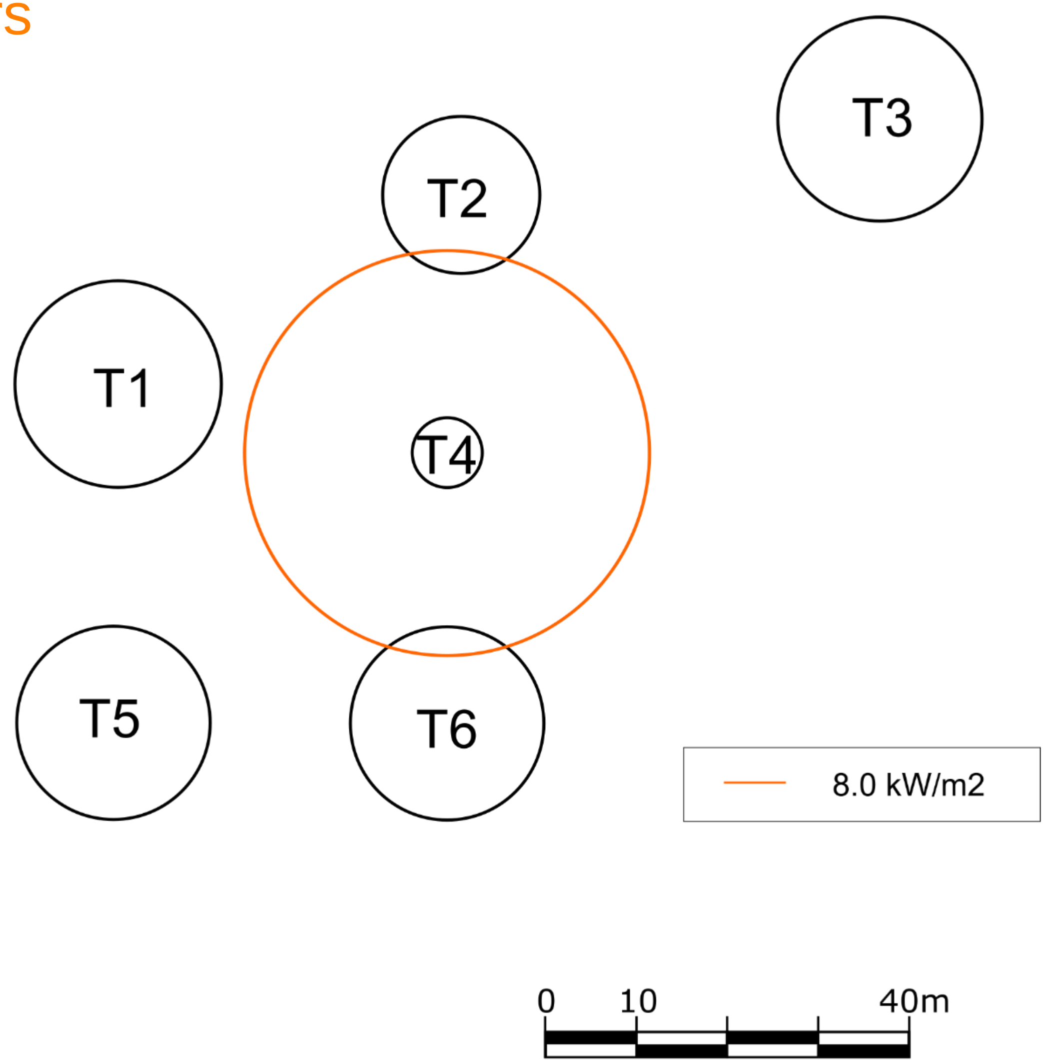
Tank Height



Cooling Water Requirements

Heat Flux Contours

Tank Height



Cooling Water Requirements

Flame Impingement

Furthermore, consequence modelling can be used to assess the potential for the flame of a full-surface tank fire to impinge on a neighbouring tank.

With flame impingement the heat received from the flame is greater than the expected radiant heat. Therefore greater protection is required.

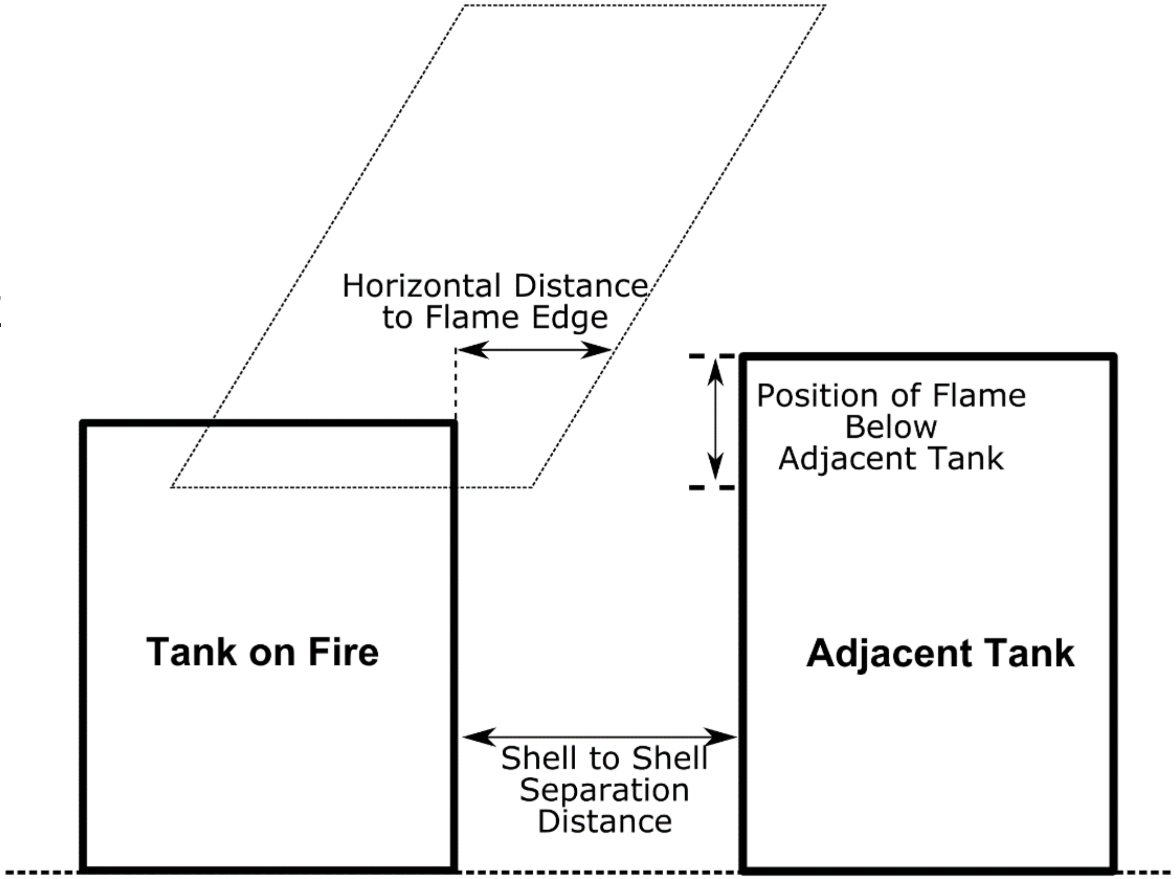
Flame impingement could be considered when:

- Tanks are in close proximity
- The neighbouring tank extends above the tank on fire (due to site topography or tank height).

Cooling Water Requirements

Flame Impingement

Flame properties from modelling are used to assess flame impingement



Cooling Water Requirements

AS1940 Methodology

An alternate methodology to determine cooling water requirements is provided in Australian Standard AS 1940 - *The storage and handling of flammable and combustible liquids*

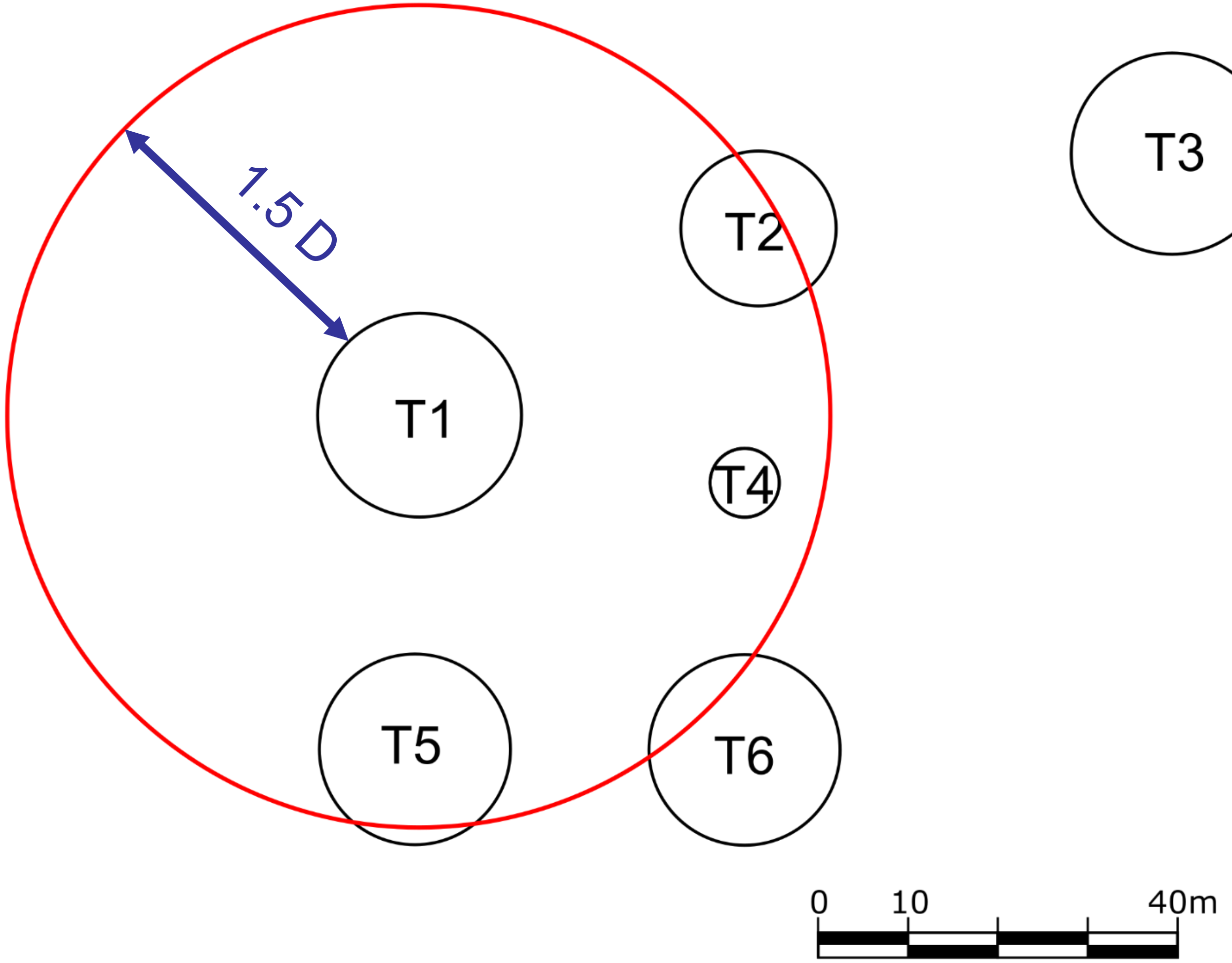
AS 1940 prescribes the following:

- Cooling water is required for all exposed tanks within a shell-to-shell separation distance of 1.5 times the tank on fire's diameter.

- The cooling water application rate is determined from the ratio of the shell-to-shell separation distance to the diameter of the tank on fire.

Cooling Water Requirements

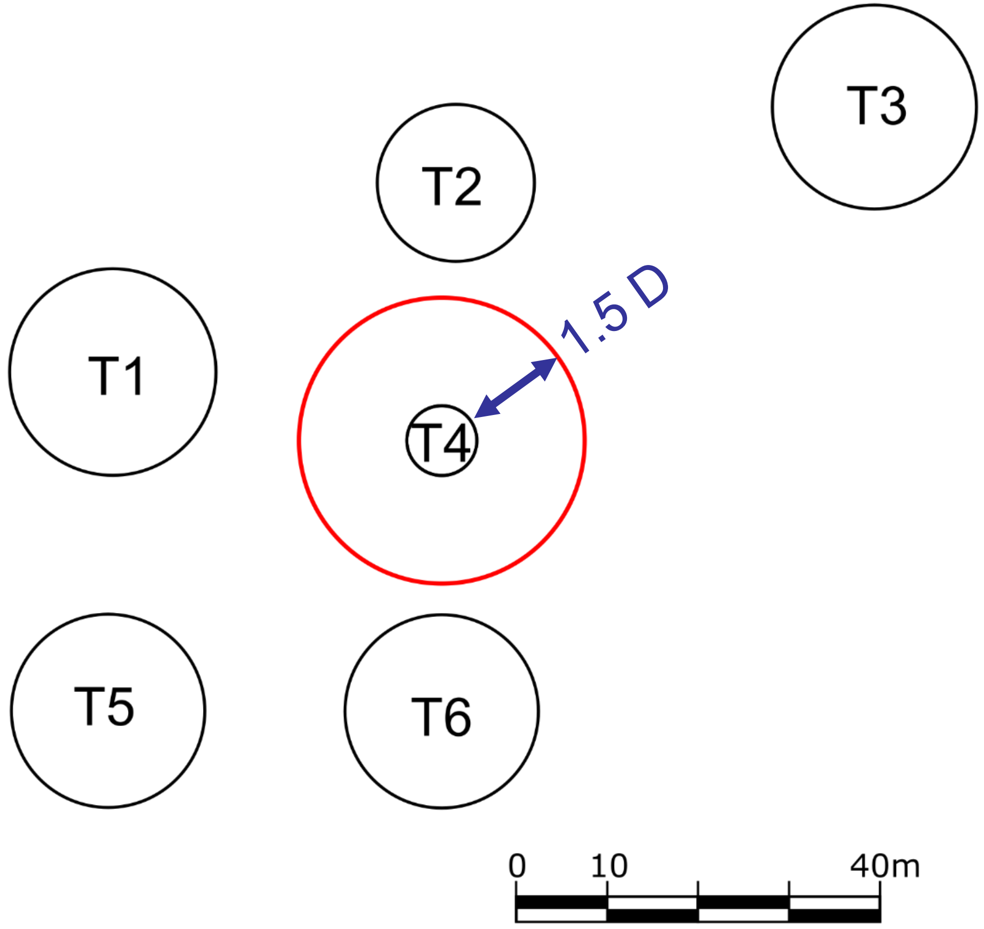
AS1940 Methodology



Tanks requiring cooling water (1.5D separation distance)

Cooling Water Requirements

AS1940 Methodology



Cooling Water Requirements

Consequence modelling has the potential to reveal situations where an AS1940 approach underestimates the requirements.

Consequence modelling considers the particulars of the facility and equipment including:

- Material properties (e.g. burn rate, flame properties).
- Typical site weather conditions
- Site layout
- Site topography
- Differences in vessel height.

Accessibility of Emergency Response Equipment

Once the cooling water requirements have been decided, an assessment will determine:

- Availability and accessibility of emergency response resources
  - Firewater supplies
  - Firefighting equipment
- Requirement for additional resources.

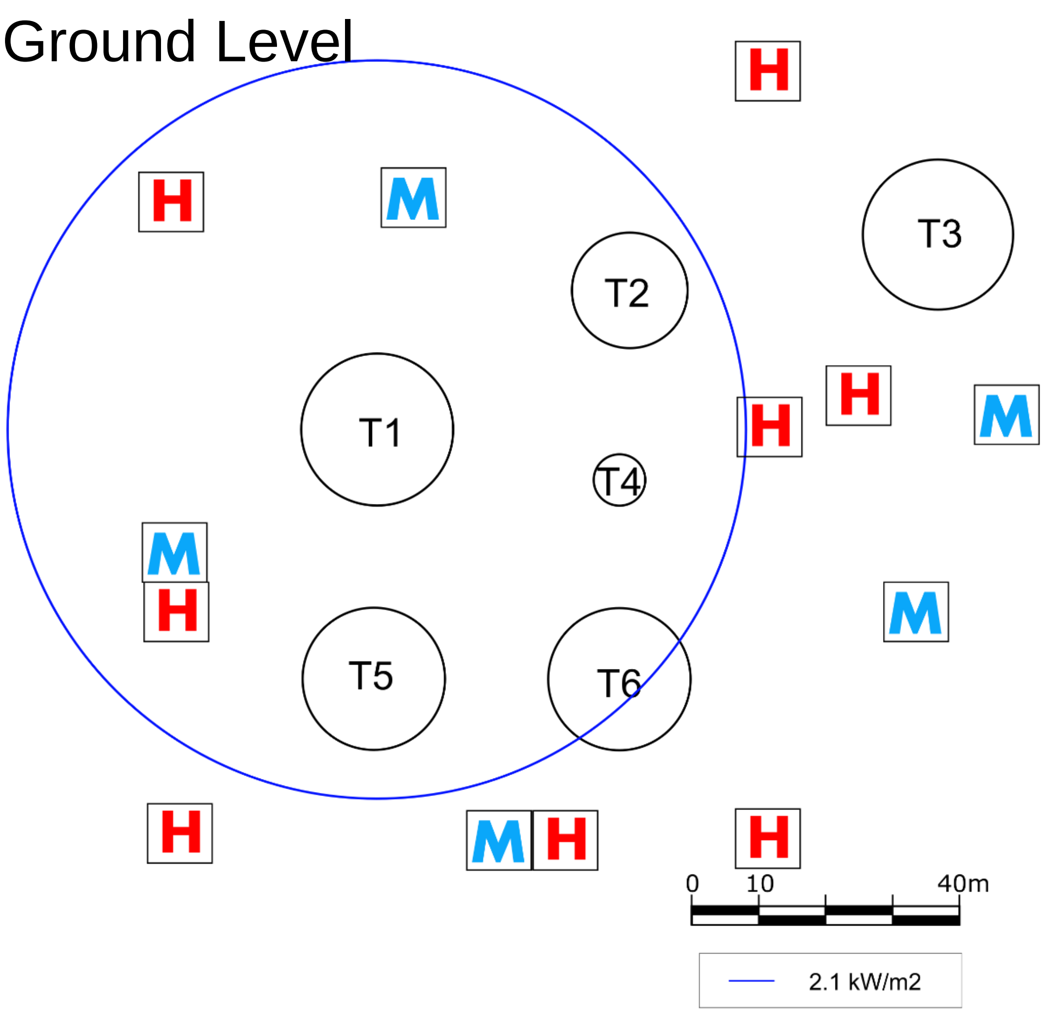
This is achieved by assessing the radiant heat received at the following equipment:

- Activation panels
- Manually activated valves for the firewater system
- Foam and firewater monitors
- Fire hydrants and hose reel boxes.

Accessibility of Emergency Response Equipment

Heat Flux Contours

Ground Level



Heat Radiation	Effect
4.7 kW/m²	Will cause pain in 15-20 seconds and injury after 30 seconds exposure (at least second degree burns)
2.1 kW/m²	Minimum to cause pain after 1 minute

Hazardous Industry Planning Advisory Paper No 2, "Fire Safety Study", NSW Government Planning, January 2011.

Accessibility of Emergency Response Equipment

If cooling water cannot be supplied using the fixed equipment, additional resources may be required.

Wind direction should be considered when assessing accessibility of firefighting equipment as this may vary:

- Equipment requiring cooling
- Available firefighting equipment.

The representative scenario will consider if there is adequate protection for all wind directions.

Summary

Emergency response scenario plans assist in emergency preparedness and provide a reference for emergency personnel.

Consequence modelling is the foundation of a good Emergency Response Scenario Plan as it considers the specific incident event and conditions including:

- Materials
- Specific equipment involved and site layout
- Site conditions and weather.

For fire scenarios, consequence modelling should be used to:

- Assess the potential impacts for equipment in the vicinity
- Determine the requirements for cooling water
- Assess the accessibility of emergency response equipment.

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Thank you

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