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Performance based cooling systems

Antea Group

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16 January 2025

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Introduction

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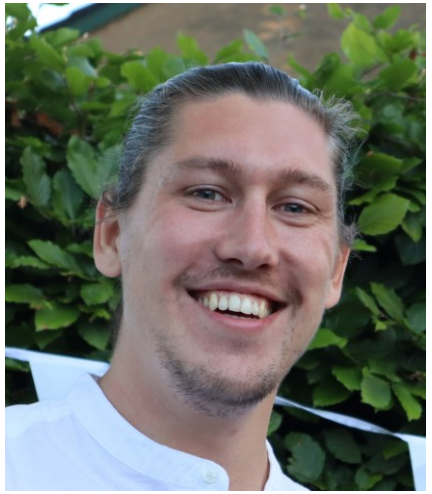

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Who are we?

Antea Group is an international engineering and consultancy firm specialized in full-service solutions in the field of **the environment**, **infrastructure**, **urban design** and **water**. Together we spend each day building a safe, healthy and **future-ready living environment**.

Antea Group aims to be at the forefront of the development and application of sustainable and integral solutions in our living environment. We play a responsible role by using our expertise to ensure a sustainable future.

With pride and with pleasure.

1951

Founded by the **Bosma** brothers, originally under the name **Oranjewoud**, our company grew into what it has become today

2014

Rebranded from **Oranjewoud** to **Antea Group**

2021

70th **anniversary**

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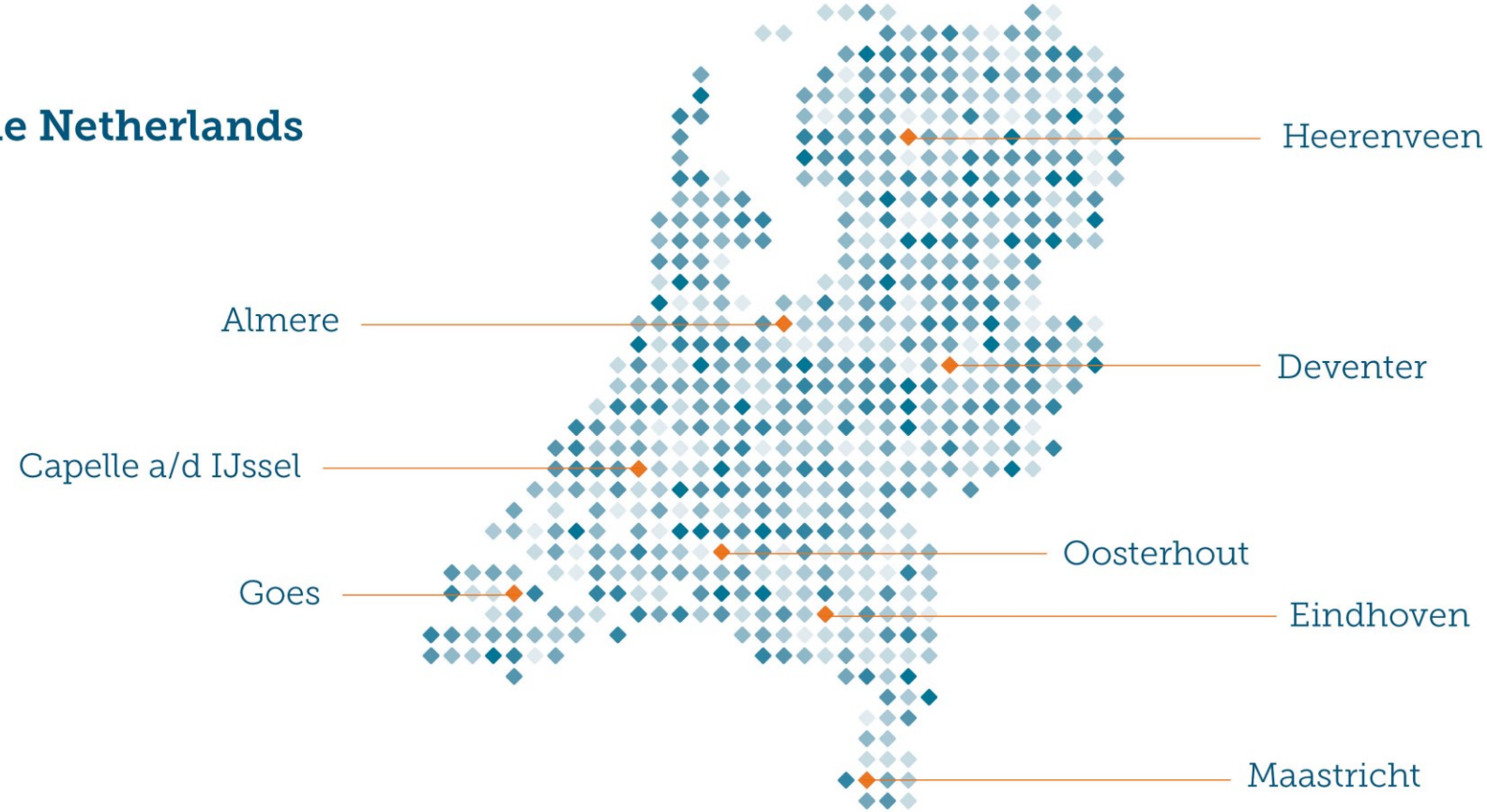
The Netherlands



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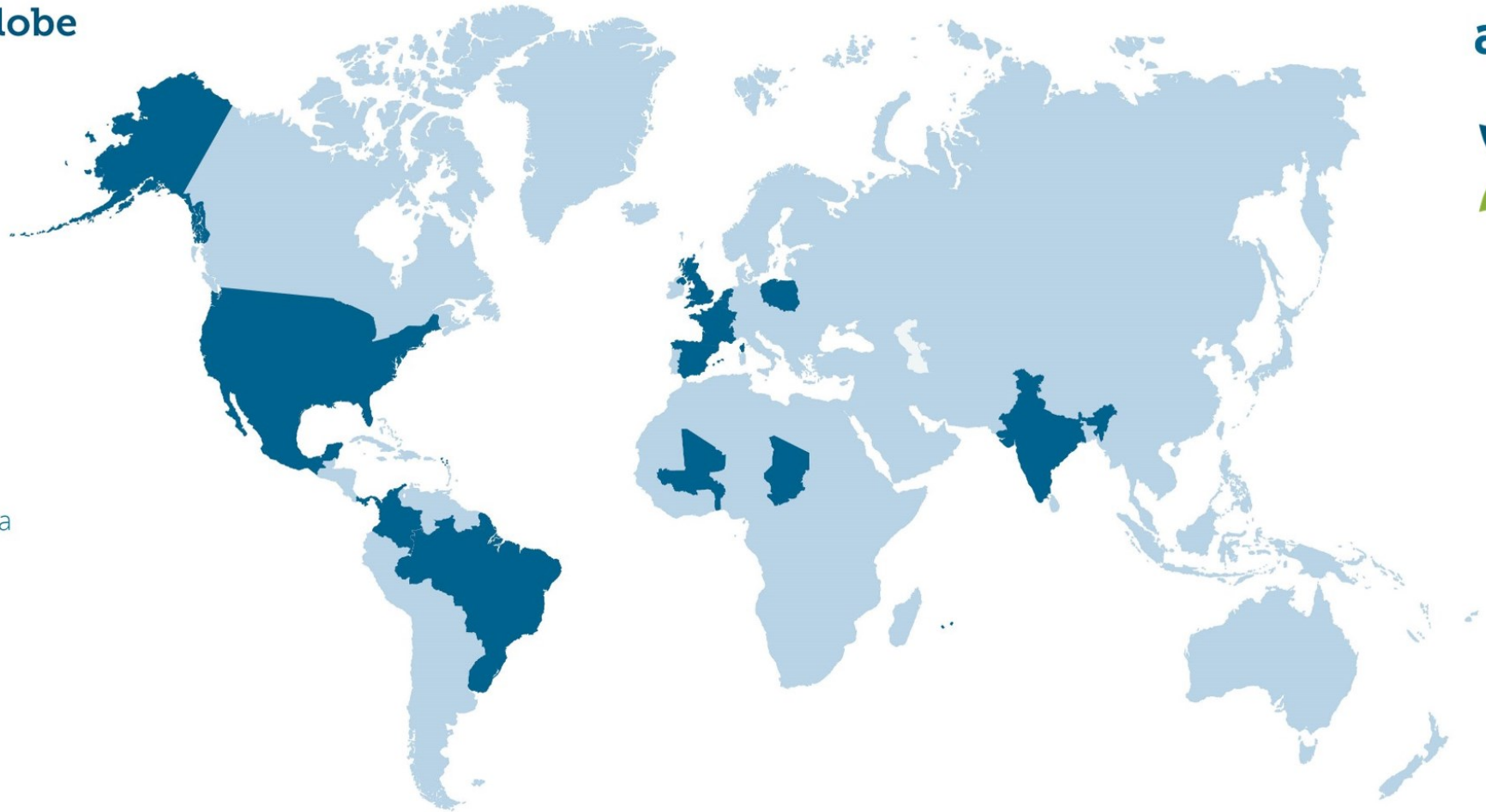
Across the globe



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90 offices

As member of the Inogen Alliance network we provide global coverage

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PGS 29 and NFPA

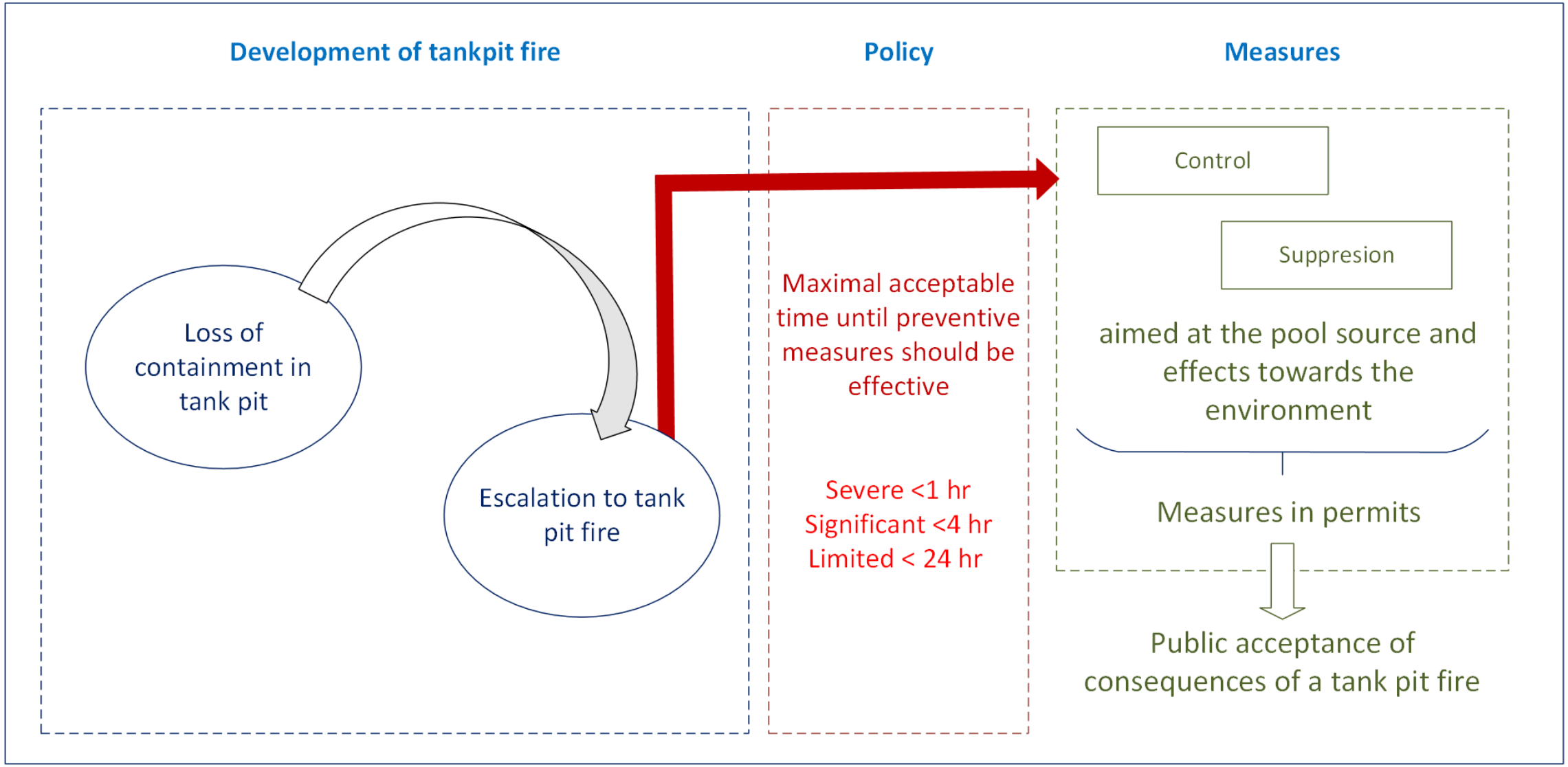
- Dutch guideline PGS 29
  - Vertical cylindrical storage tanks of flammable liquids
  - Best practice
  - Gives an overview of possible measures on a risk-based principle
  - Referencing: NEN, EEMUA, ISO, API, ASTM, NFPA

- In the past a tankpit fire was considered not ‘credible’
  - Meaning this was a scenario for which the operator did not have to take measures

PGS 29 and NFPA

- Developments in the last few years
  - Investments in stationary fire fighting measures
  - Investments in cooling systems
  - Investments in company fire brigades
- Especially for the existing infrastructures these investments have impact
- But in general
  - In the design codes (NFPA, API, ASTM etc.) of oil storage tanks and tank pits this scenario was addressed

PGS 29 – tank pit fire



Special cases

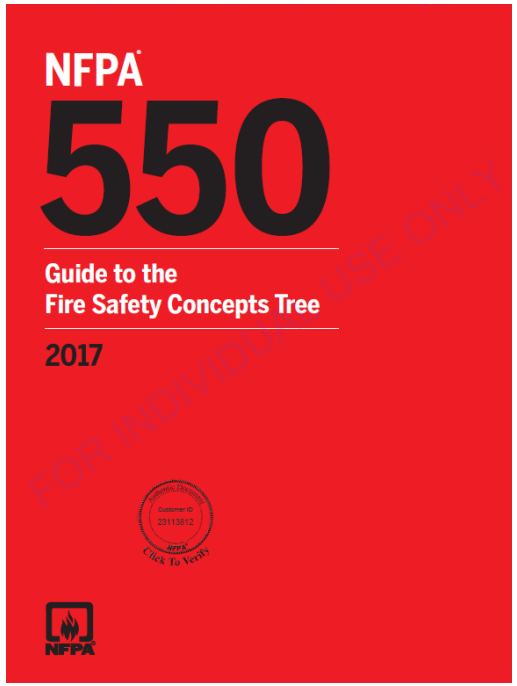
- The storage of monomers
  - Thermally instable or the risk of exothermic reactions
  - Necessity to prevent escalation

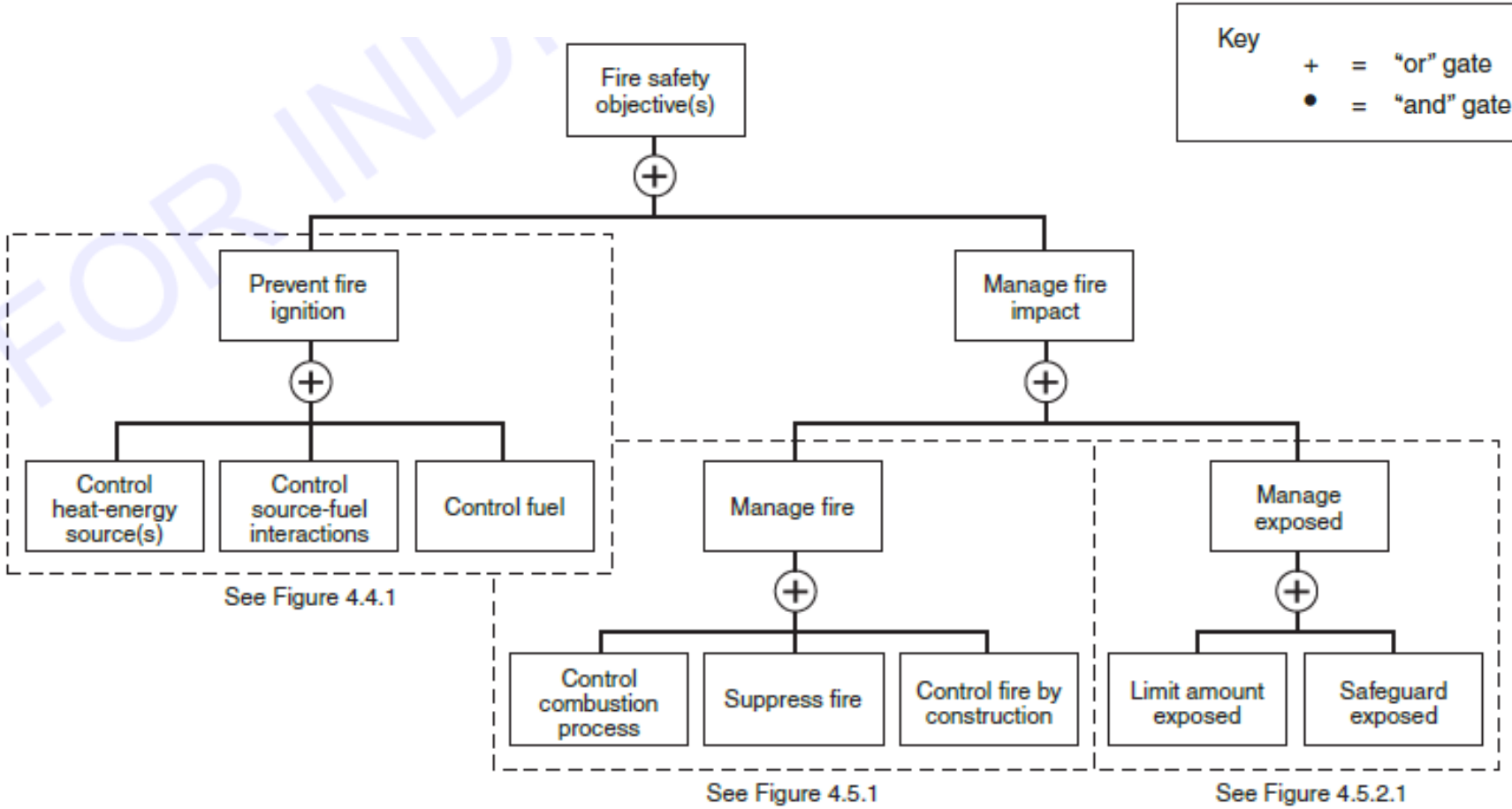
- Small tank pits, close together
  - Necessity to cool nearby tanks
  - Existing cooling equipment but inadequate

NFPA 550

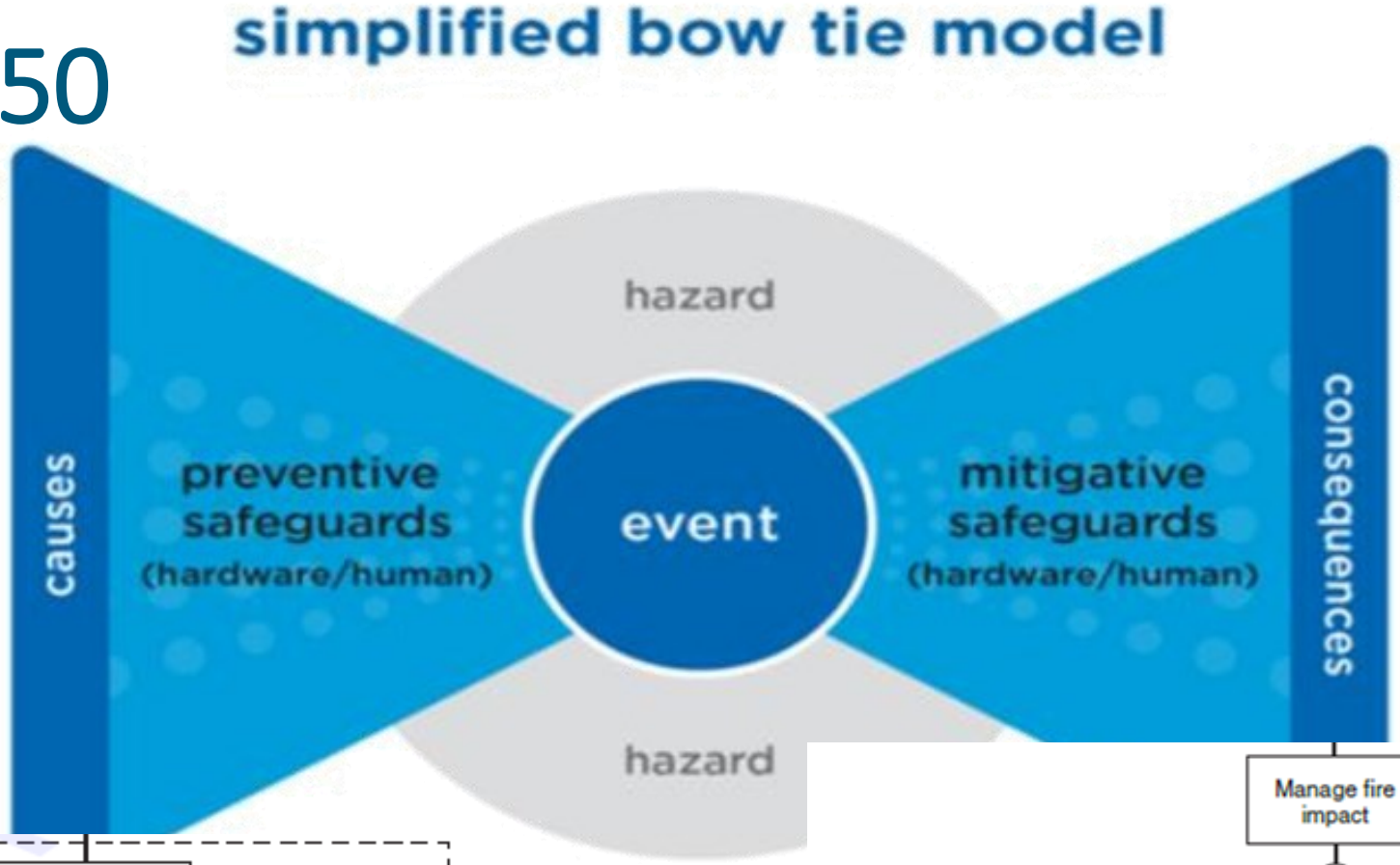
- Defining fire safety objective
  - Prevent fire

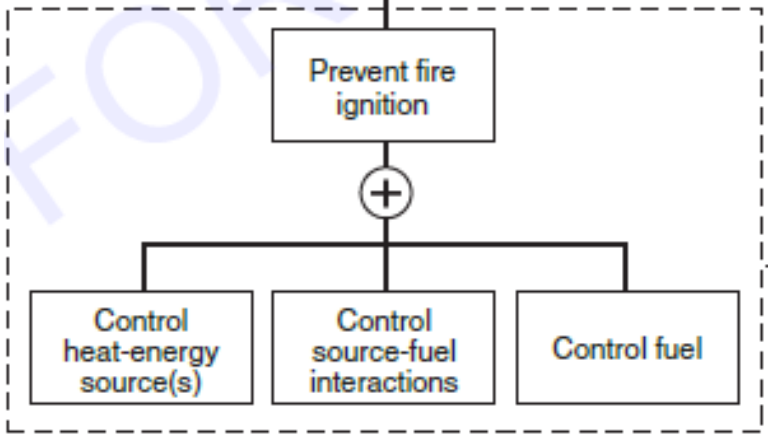
    or
  - Manage impact

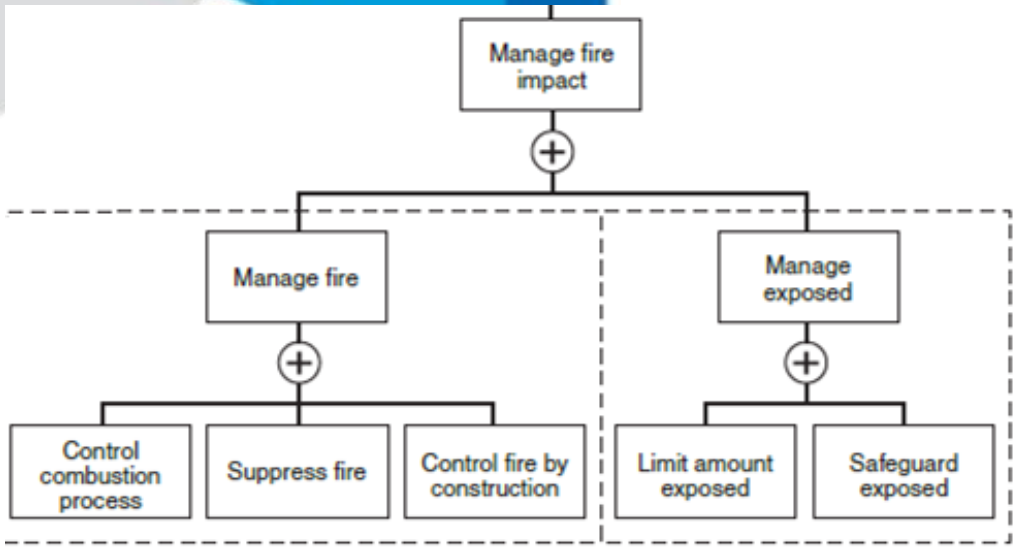




NFPA 550


simplified bow tie model
causes
preventive safeguards (hardware/human)
hazard
event
hazard
mitigative safeguards (hardware/human)
consequences


Prevent fire ignition
Control heat-energy source(s)
Control source-fuel interactions
Control fuel


Manage fire impact
Manage fire
Manage exposed
Control combustion process
Suppress fire
Control fire by construction
Limit amount exposed
Safeguard exposed

Consequence scenarios

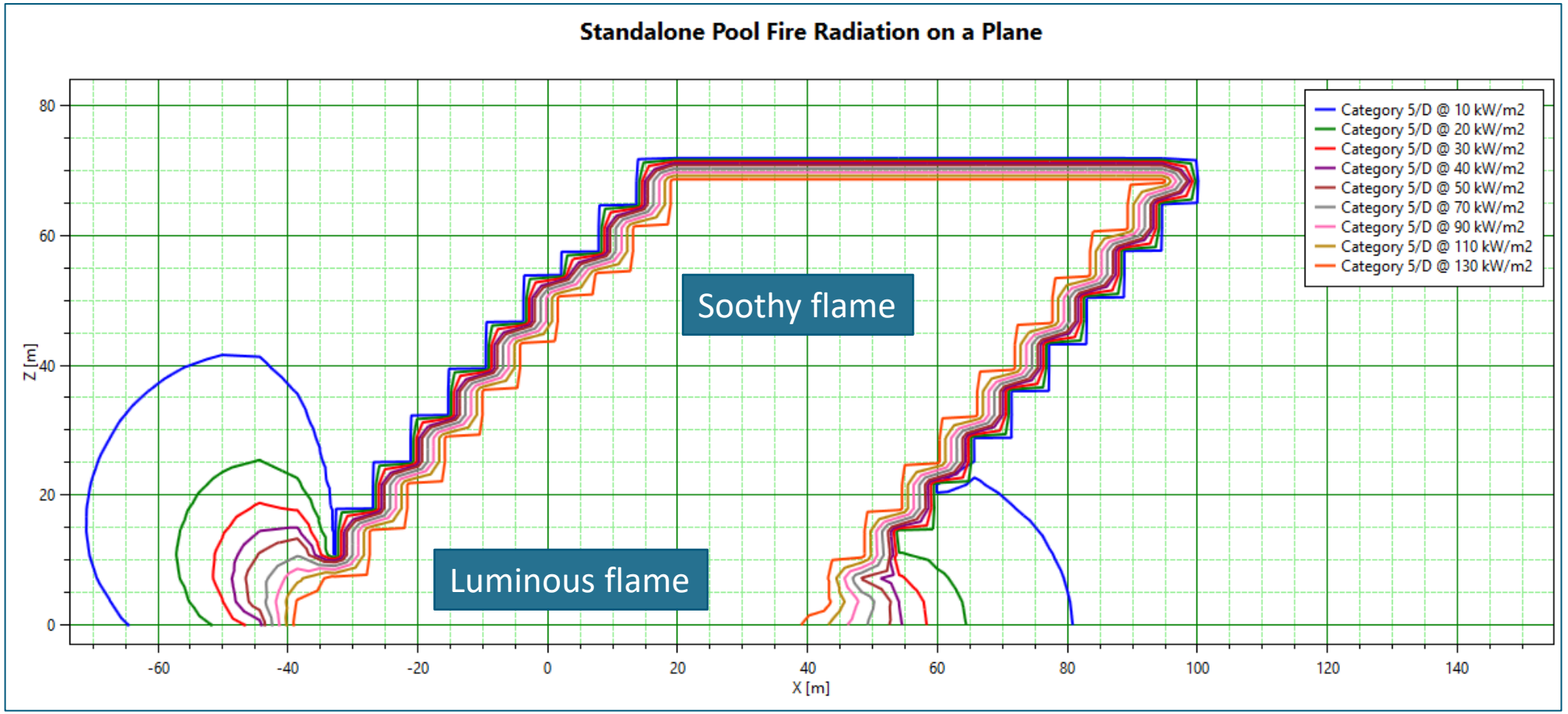
Determine the possible escalation scenarios, for instance:

- Explosion due to tank temperature reaching the auto ignition temperature of the content
- Tank integrity failure due to continuous exposure to radiation > 10 kW/m^2 for extended period (> 1 hr)
- Run-away due to tank content reaching polymerisation temperature

General approach

- Determine maximum temperature for each scenario
  - Auto ignition temperature
  - 10 kW/m^2 heat radiation temperature
  - Content polymerisation temperature
- Determine tank and content specifications:
  - Tank: Wall thickness, material etc
  - Content: Heat capacity, conductivity, density etc
- Calculate the heat radiation on the tank
- Determine the cooling system activation time
- Calculate the required amount of cooling water for each scenario at multiple tank fill levels (20, 50, 90%)
- Highest amount of cooling water = cooling system requirement

Calculate heat radiation with Phast



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Calculate heat radiation using hydrocarbon curve

Hydrocarbon curve equation:
$T = 20 + 1080 * (1 - 0{,}325*e^{-0{,}167*t} - 0{,}675*e^{-2{,}5*t})$ [°C]

Radiation equation:
$Q = \varepsilon*\sigma*A*T^4$

Q = Heat radiation [kW/m^2]

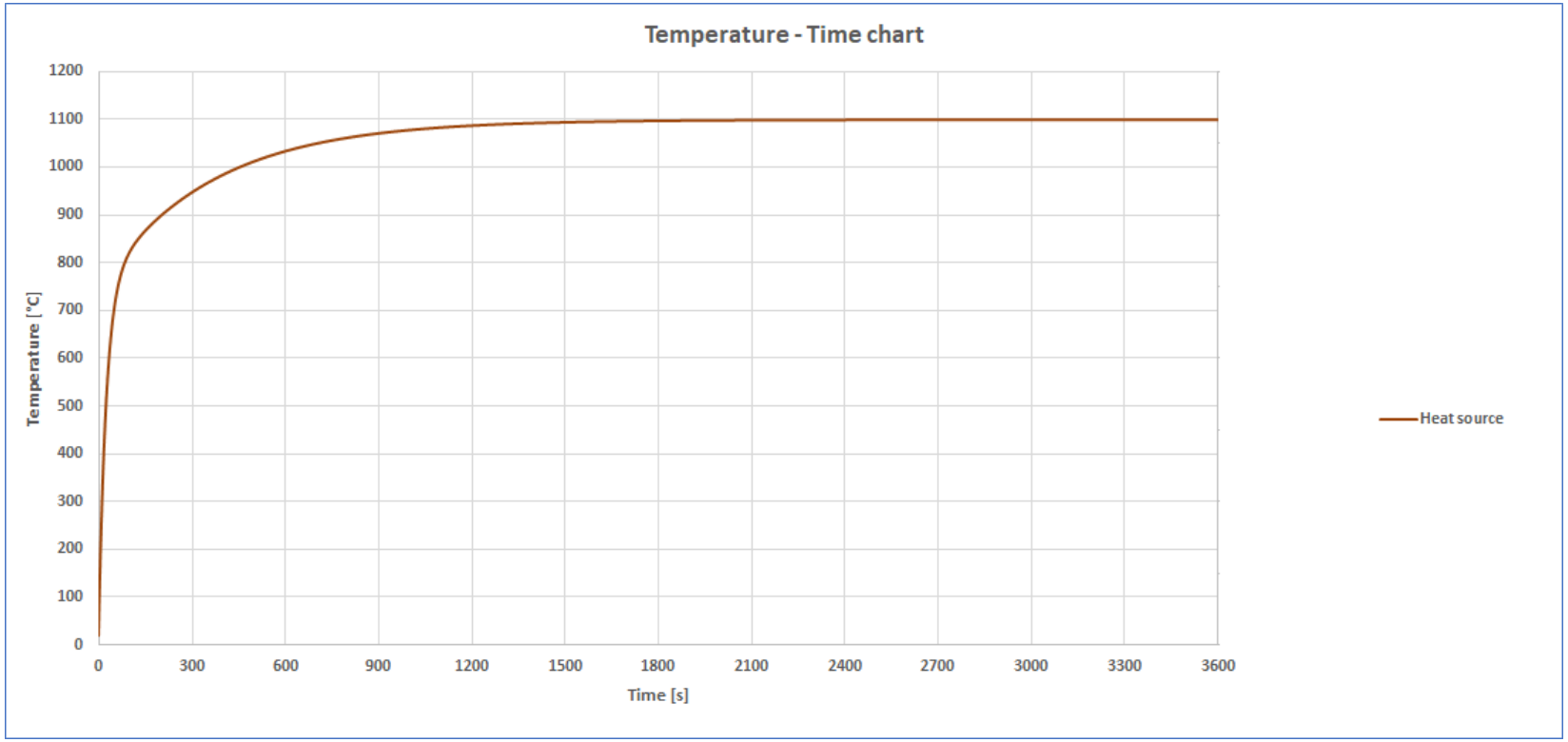
ε = Emission factor (0,75) [-]

σ = Stefan-Boltzmann coëfficient [-]

A = Surface [m^2]

T = Temperature [K]

For a hydrocarbon fire:
T = 1.100 °C
Q = 151 kW/m^2



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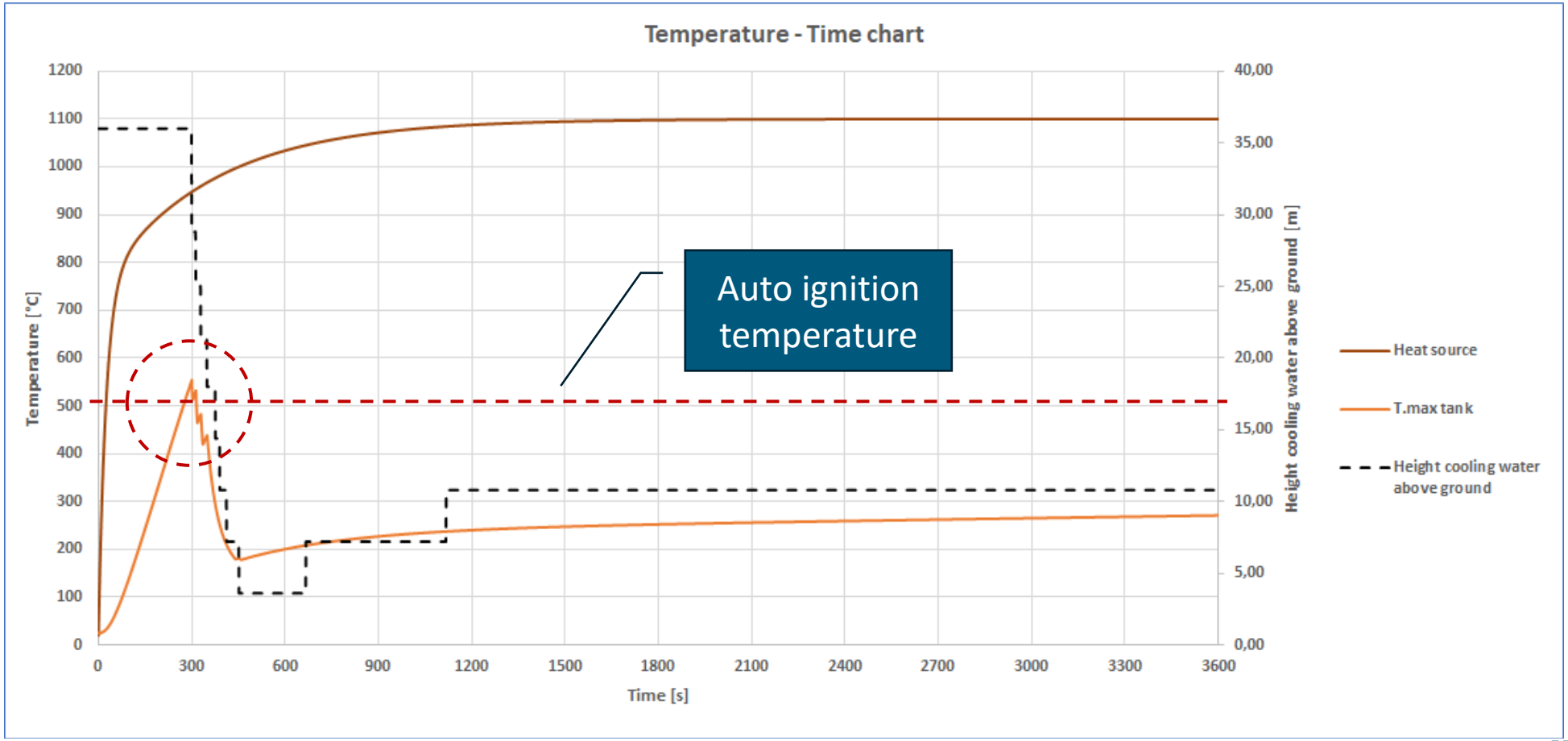
Case study 1

- Tank in tankpit fire
- Objectives:
  - Keep tank temperature below auto ignition temperature
  - Keep tank content temperature below polymerisation temperature
- Critical system parameters:
  - Amount of cooling water
  - Activation time of the cooling system

Activation time (300 s)



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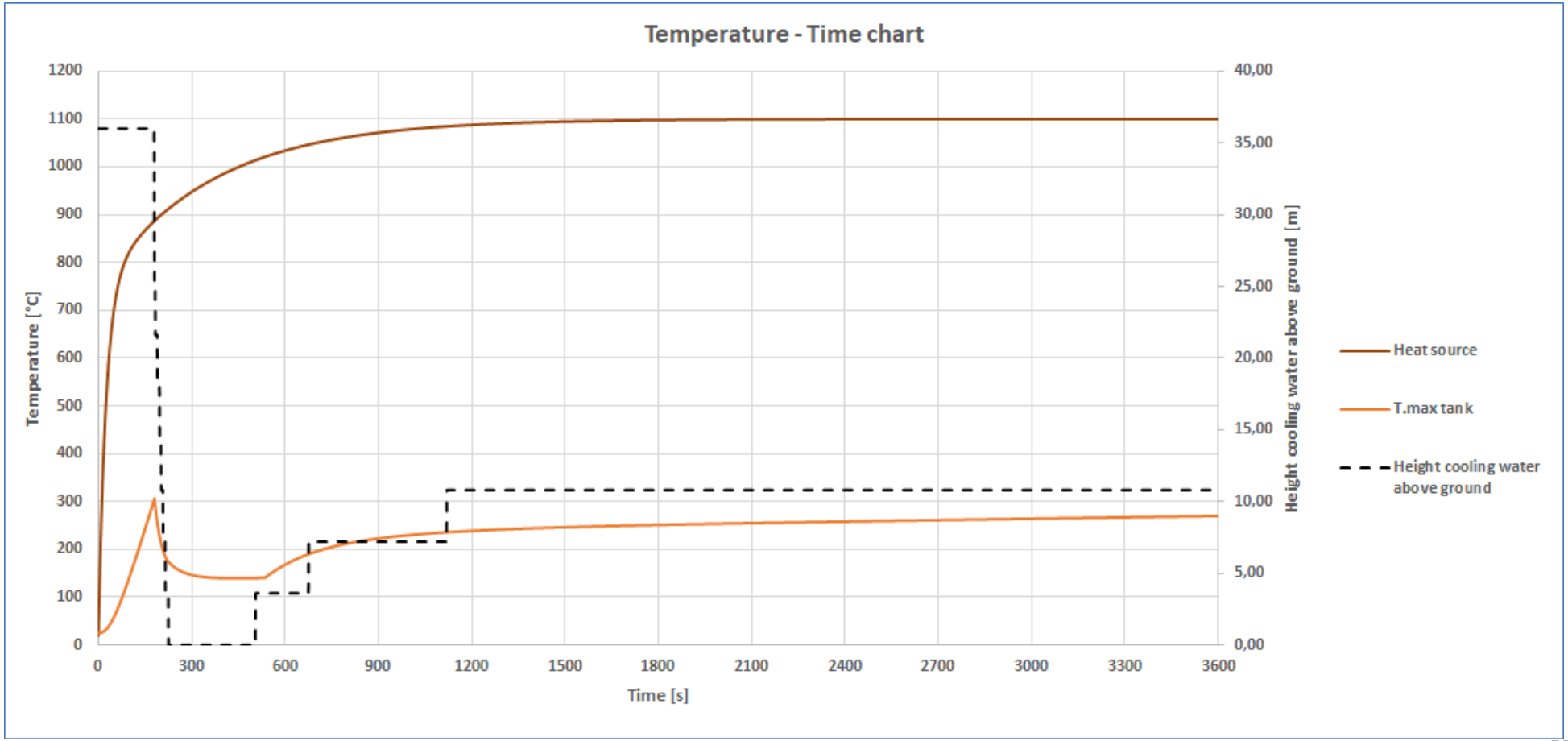
Activation time (180 s)



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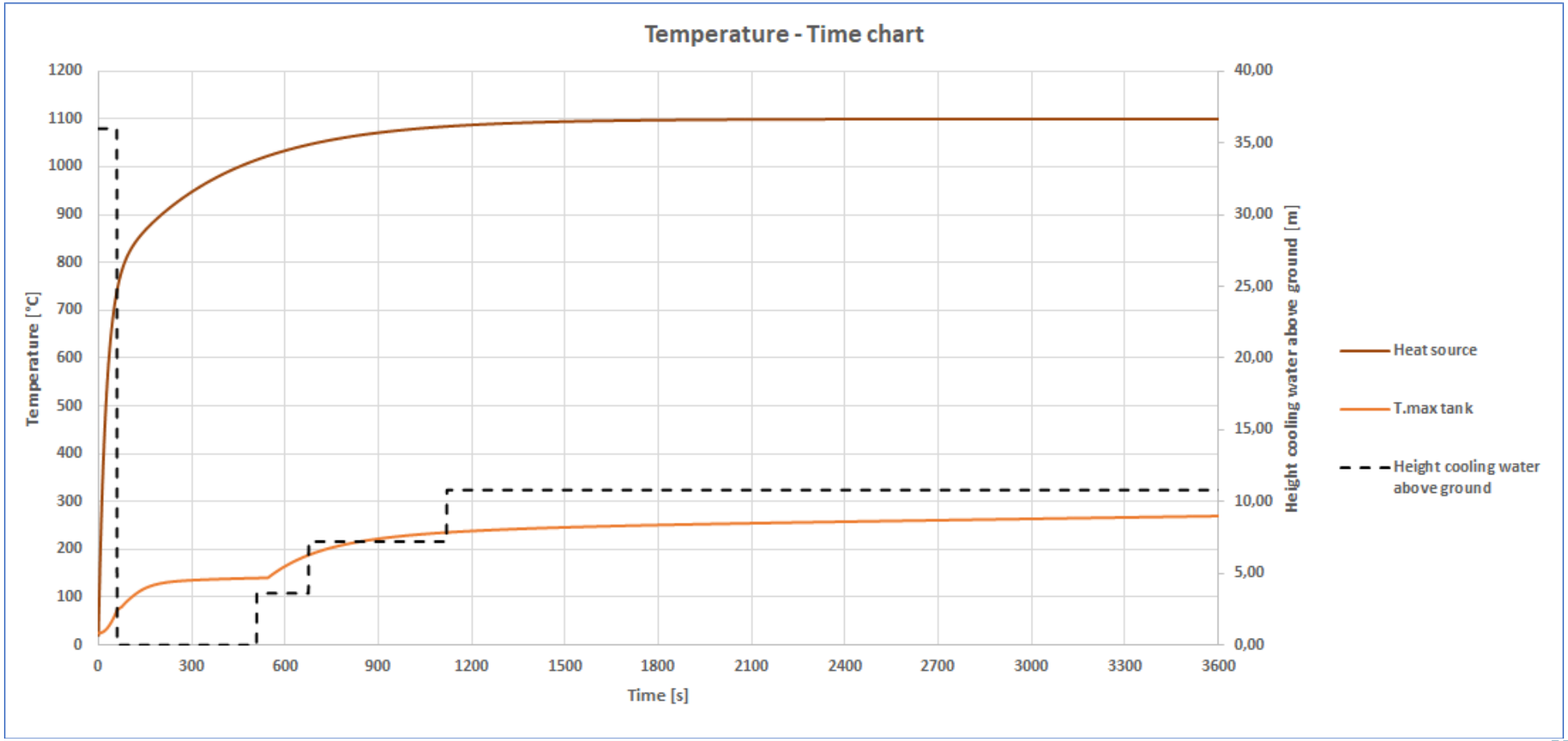
Activation time (60 s)



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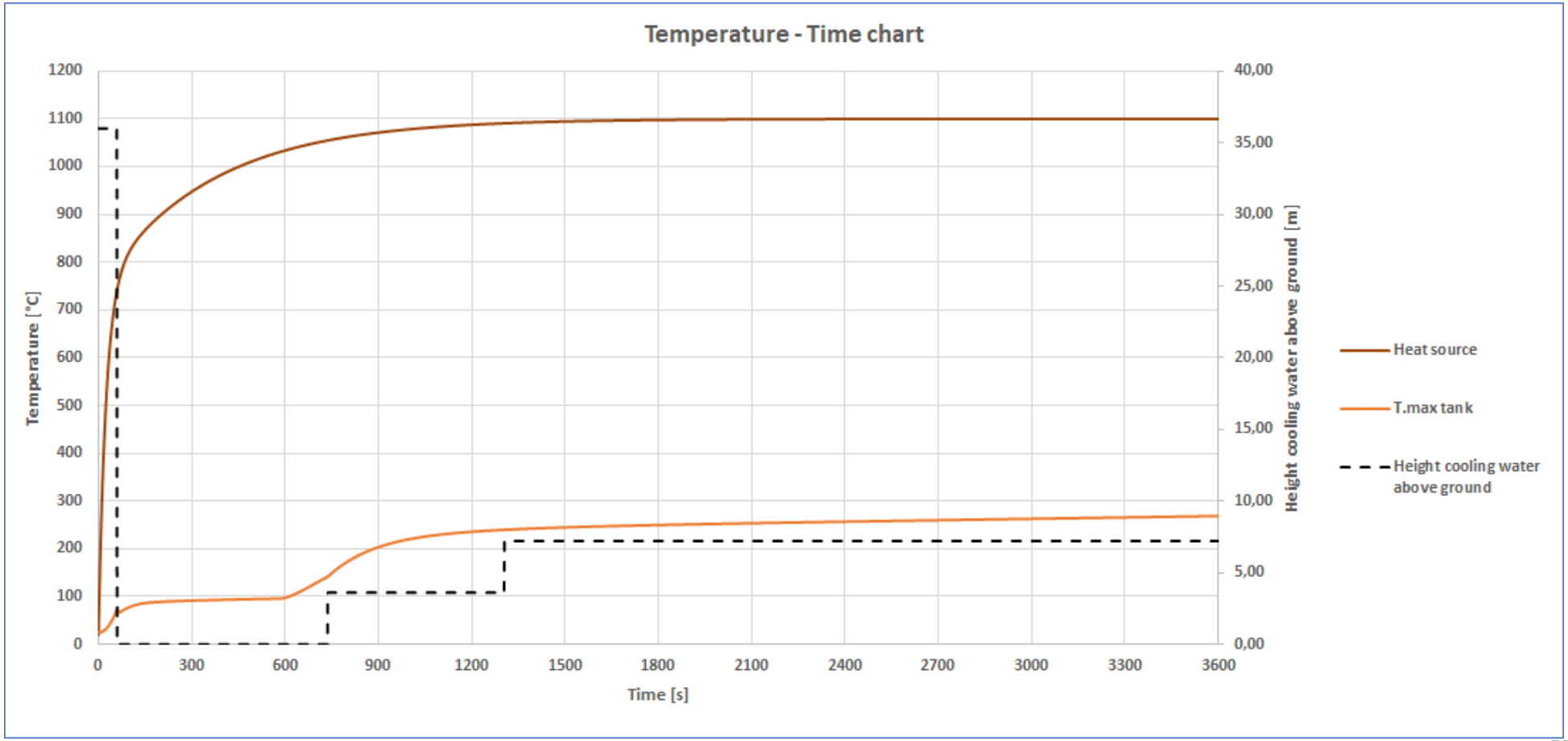
Tank fill level (90%)



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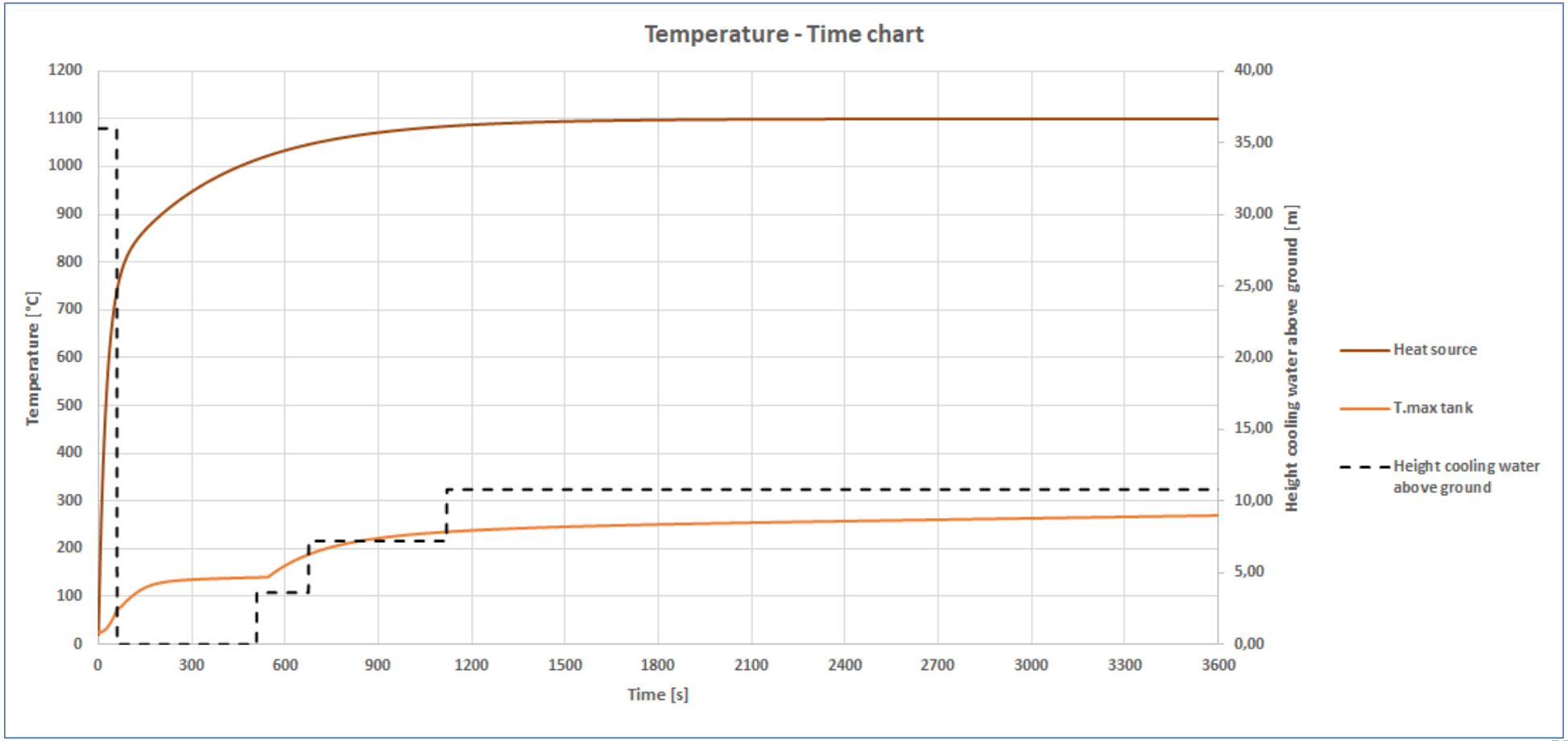
Tank fill level (50%)



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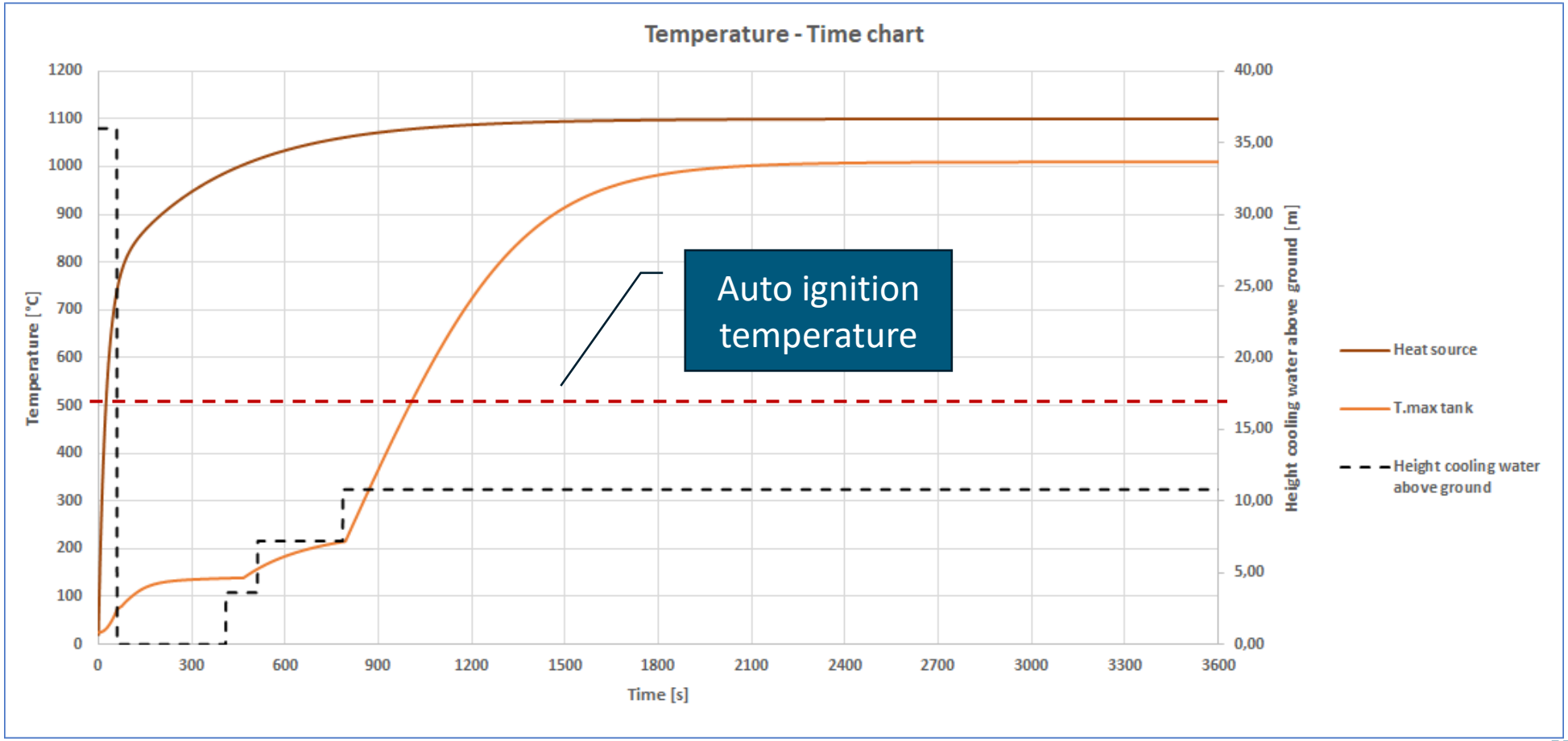
Tank fill level (20%)



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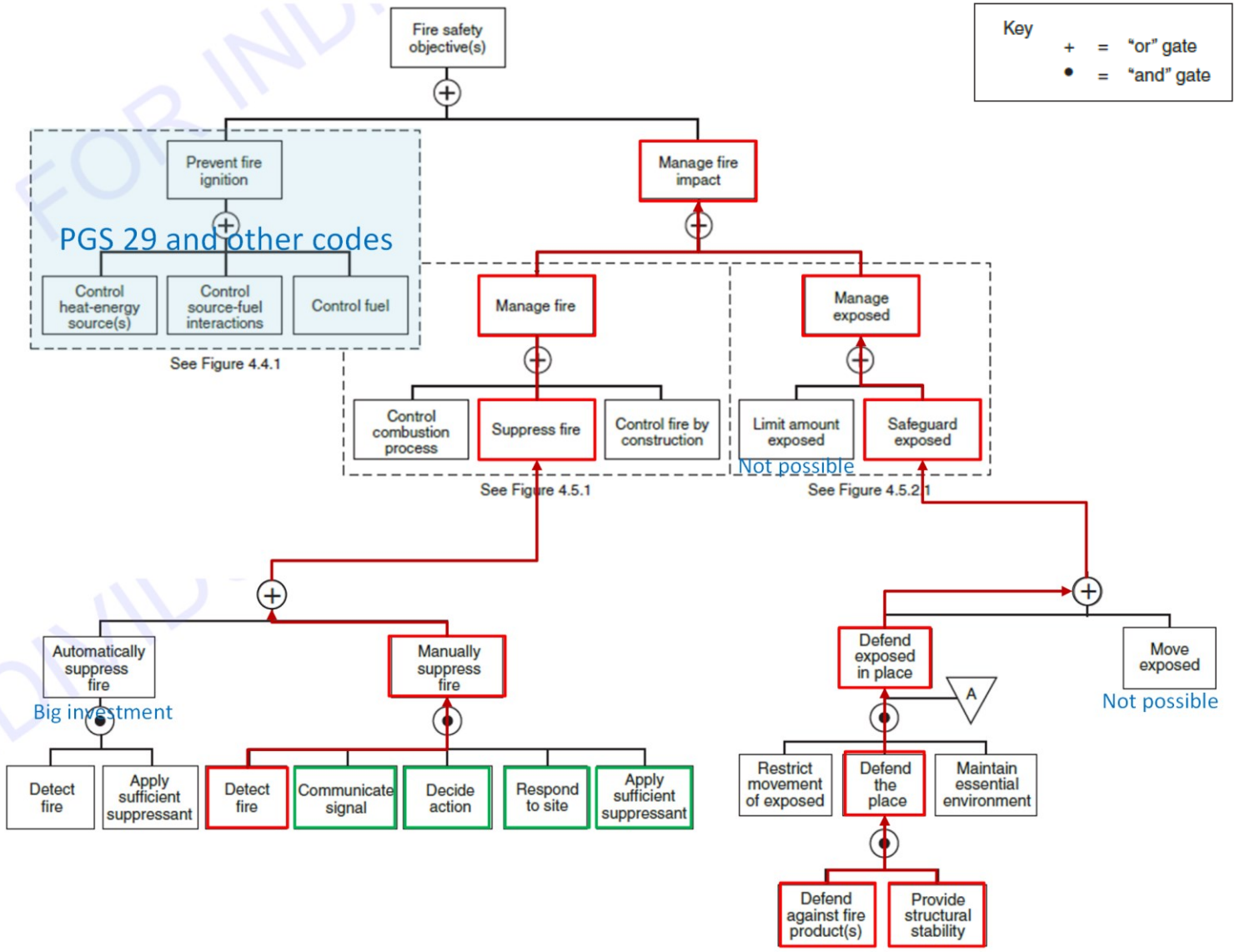
Case study 1

- Objectives were aimed at managing the temperature of the tank

- How:
  - Rapid detection
  - Cooling < 60 sec
  - Manual fire repression < 60 min



Case study 1

- Results:
  - Existing cooling system keeps tank and content below the maximum temperature
    - Automatic control valves – cooling water system tanks
  - Fire department has enough time to manually supress the fire
    - Investing in fast detection system, with redundancy
  - No fixed fire fighting system required
  - Cost and material savings: Pumps, pipes, valves etc.

Other case studies

- Tank exposed to heat radiation from nearby tank fire
  - Objectives:
    - Keep tank temperature below auto ignition temperature
    - Keep heat radiation on tank < 10 kW/m^2
    - Determine if capacity of existing cooling water (max 17 l/min/m) is sufficient
- Dry-spot analysis
  - Objective:
    - Evaluate acceptable dry-spot size
- Inhibitor consumption during and after tank pit fire
  - Objective:
    - Maintain safe inhibitor level

Recap and benefits

- Performance based cooling can be a requirement according to PGS 29
- Performance based cooling can result in less cooling water needed than the standard 2 l/min/m^2
  - Existing systems: sometimes 17 l/min/m (requirement from older PGS 29 versions) can be sufficient. -> no need to invest in new cooling system
  - New systems: smaller pumps, pipes, valves etc.

Key take-away's

- Methodology:
  - Theoretical models are readily available
  - Be thorough with determining objectives
  - Show your work/be transparent
  - Show where you are conservative/worst case principles
- Fire safety:
  - Invest in rapid fire detection systems
  - Activate the cooling system as soon as possible

"A fire can be extinguished with a glass of water if you catch it early enough"

Thank you

Questions

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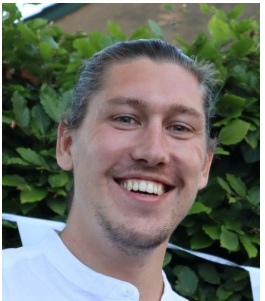

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