Nozzle positioning study to determine the optimal arrangement of water deluge systems in crowded petrochemical units

Deluge systems

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Background

Julia Di Domenico Pinto

▸ Chemical Engineer

 – Graduated in UFRJ (Brazil)

 – Master in Chemical Engineering: Quantitative Risk Analysis

 – Post graduation in Occupational HSE

 – Professional Doctorate in Process and Product Design

▸ HSE engineer for 7 years.

▸ Process engineer for around 1,5 years.

Julia Di Domenico Pinto

▶ HSE designs for Offshore and Onshore facilities.

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Table of Content

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Introduction

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Introduction

- ▶ Chemical/Petrochemical and the Oil & Gas industry handle large quantity of hazardous substances
  - Prone to Fire & Explosion
- ▶ Main consequences:
  - Structures, human life and environment
  - Domino effect

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Introduction

▶ **Deluge System**

  – Designed to provide

    ▪ Fire control

    ▪ Extinguishment

    ▪ Avoid fire escalation

▶ **Act when a fire is detected/visualized**

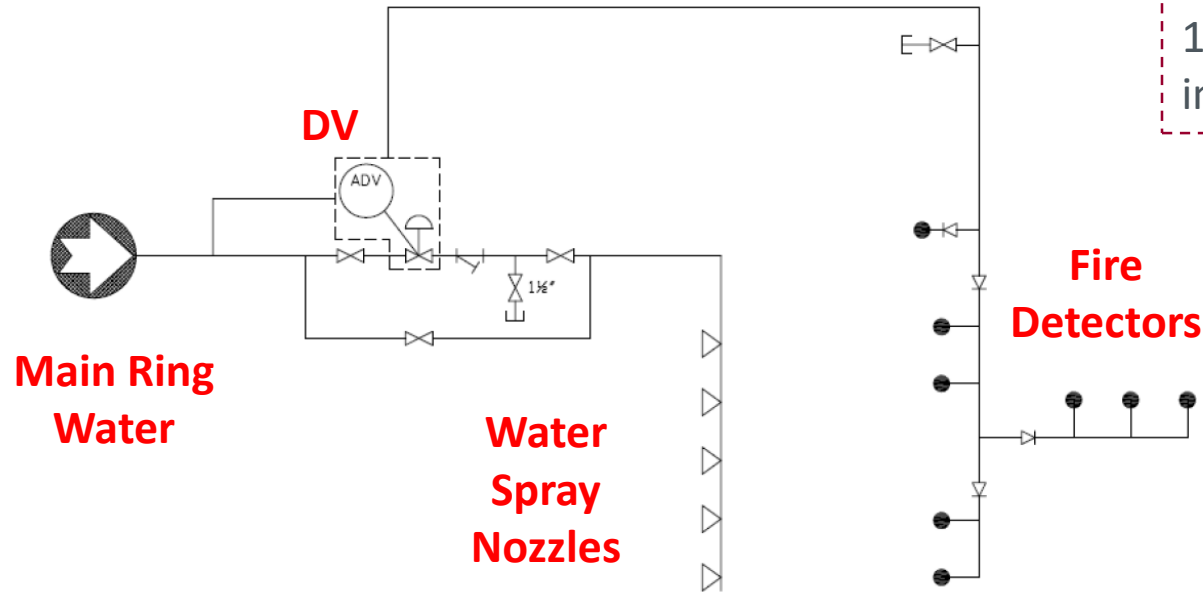 – Release water by means of special types of **nozzles**

Reference:
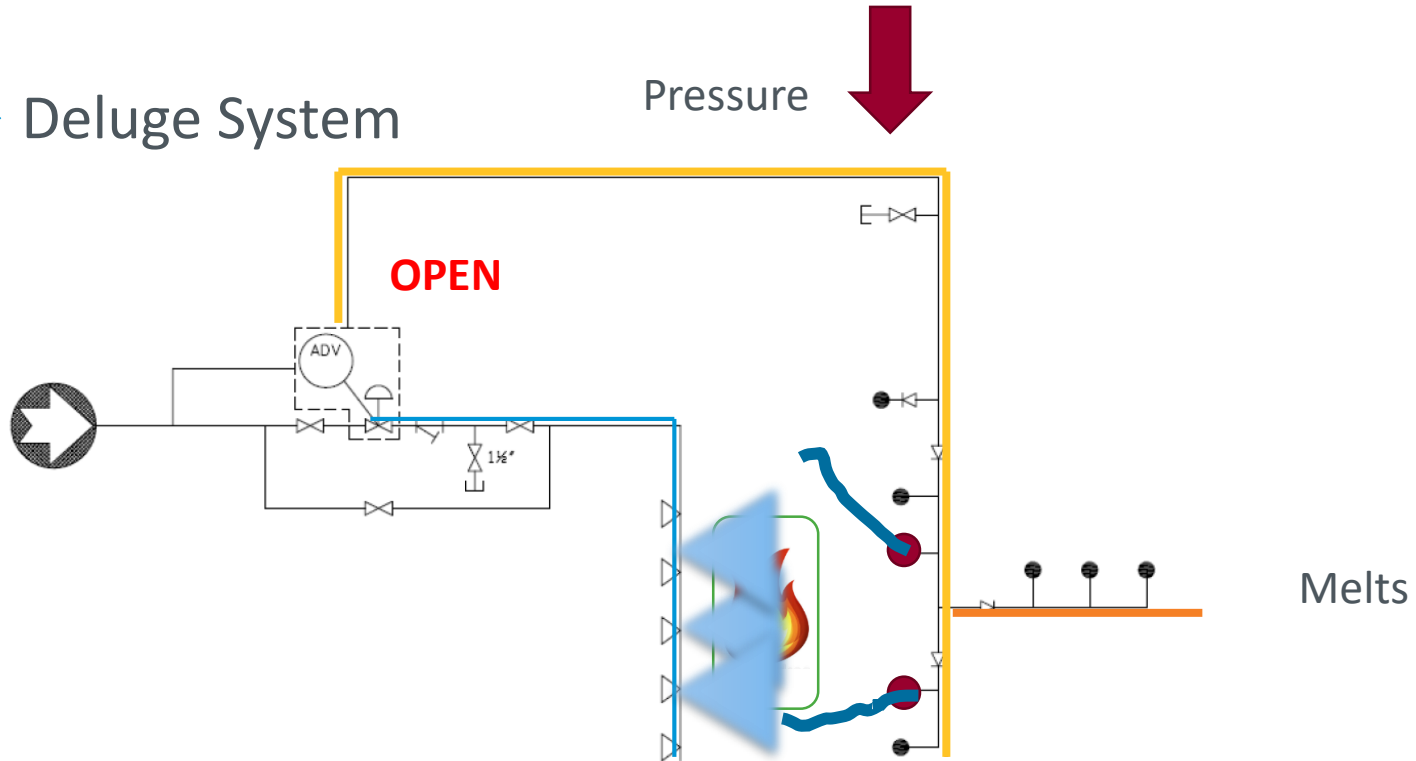Intellisys Fire Security Systems LLP. HVWS / MVWS System.

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Introduction

▸ Automatic Deluge System

DV

Main Ring Water

Water Spray Nozzles

Fire Detectors

1. The deluge valve shall be installed in a safe location

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Introduction

▶ Deluge System

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Nozzle Positioning Study

Nozzle Positioning Study

▶ Pipes arranged in rings

▶ This is the ~~standard~~ procedure wh~~...~~
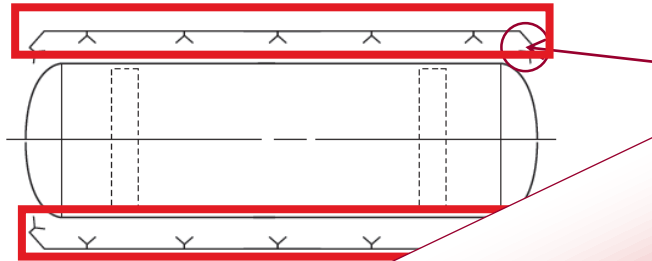
Nozzles

▶ Whole ~~...~~

~~W~~hat if there is not enough space to design the rings ?

Revamp / Offshore

Nozzle Positioning Study

Nozzle Positioning Study

▶ 3D analysis is done around the equipment considering:

- geometry and dimensions of the equipment;

- all the obstacles in the surroundings ;

- different types of spray nozzles;

- different piping configurations.
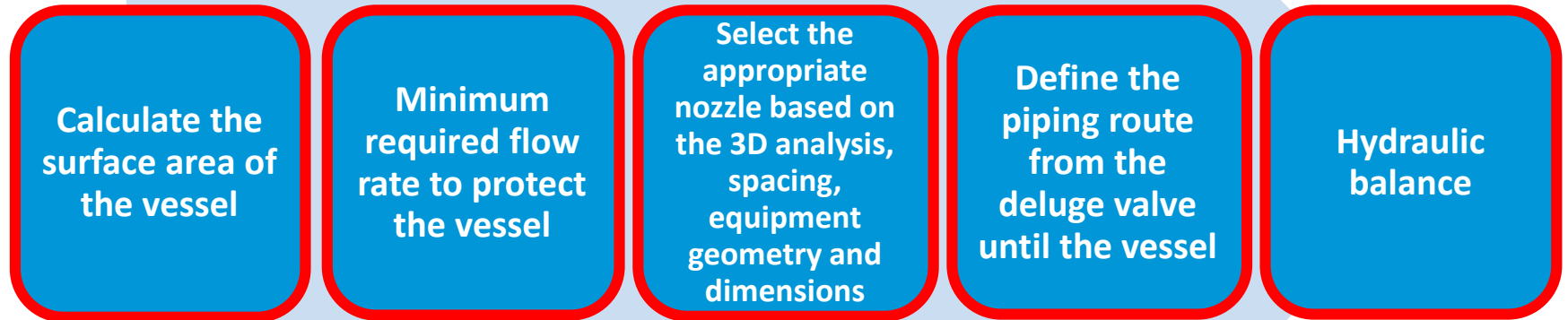

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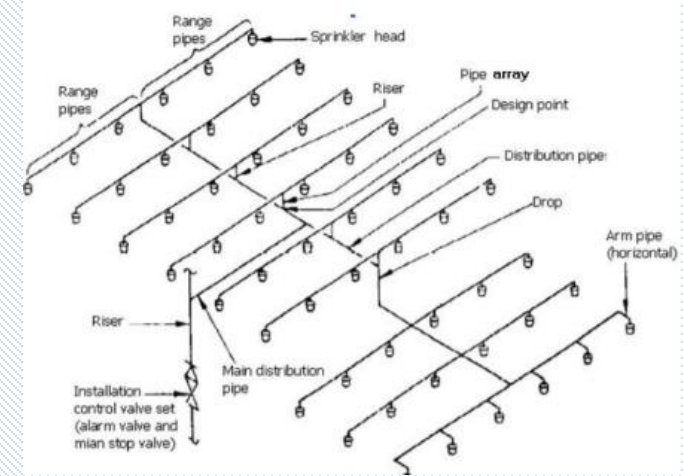
Study case

Study Case

▶ REVAMP (change in service)

– Pressured vessel V-001

– Flammable

– Extreme P and T operating conditions

– Located in a very crowded area

TYPICAL Ring design

Equipment	V-001
Service	C1-C5
Operating Temperature (ºC)	50
Pressure (barg)	155
Mixture Flash Point (ºC)	-60
Length (m)	17
Diameter (m)	5.8

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Methodology

Calculate the surface area of the vessel → Minimum required flow rate to protect the vessel → Select the appropriate nozzle based on the 3D analysis, spacing, equipment geometry and dimensions → Define the piping route from the deluge valve until the vessel → Hydraulic balance

Calculations

▸ Calculate the surface area of the vessel

$$S = \pi D L + 2\pi \left(\frac{D}{2}\right)^2 \qquad \Longrightarrow \qquad S = 362{,}6 \text{ m}^2$$
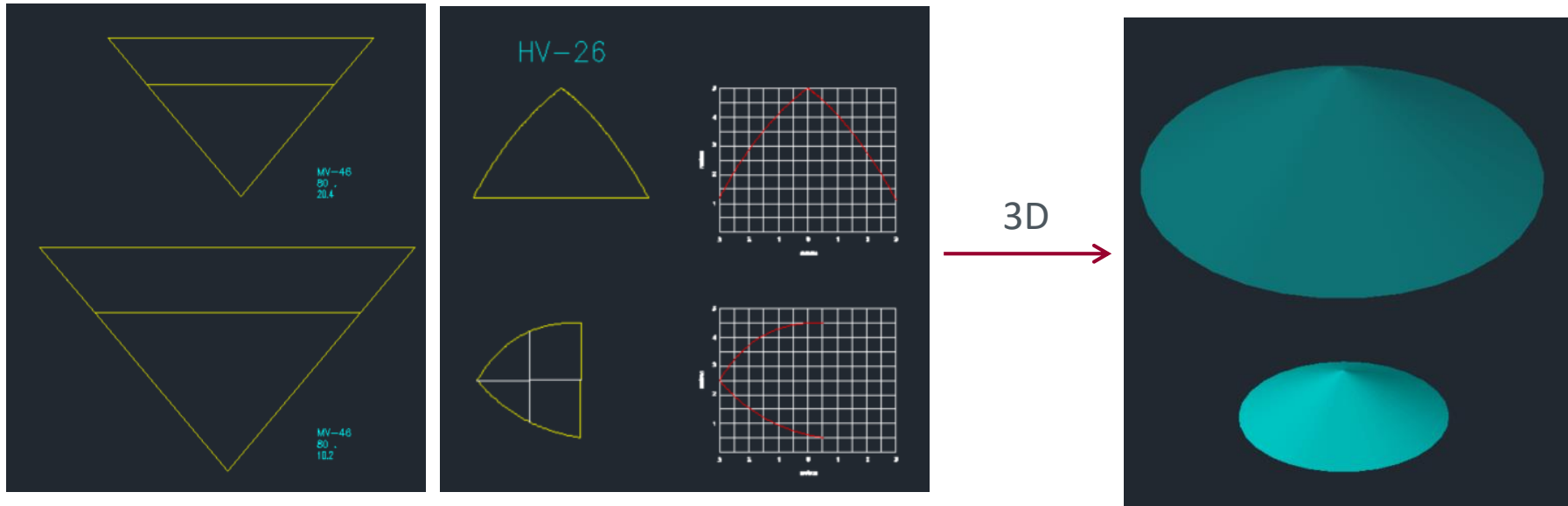
▸ Minimum required flow rate to protect the vessel

✦ From NFPA 15, min rate = 10,2 (L/min)/m^2

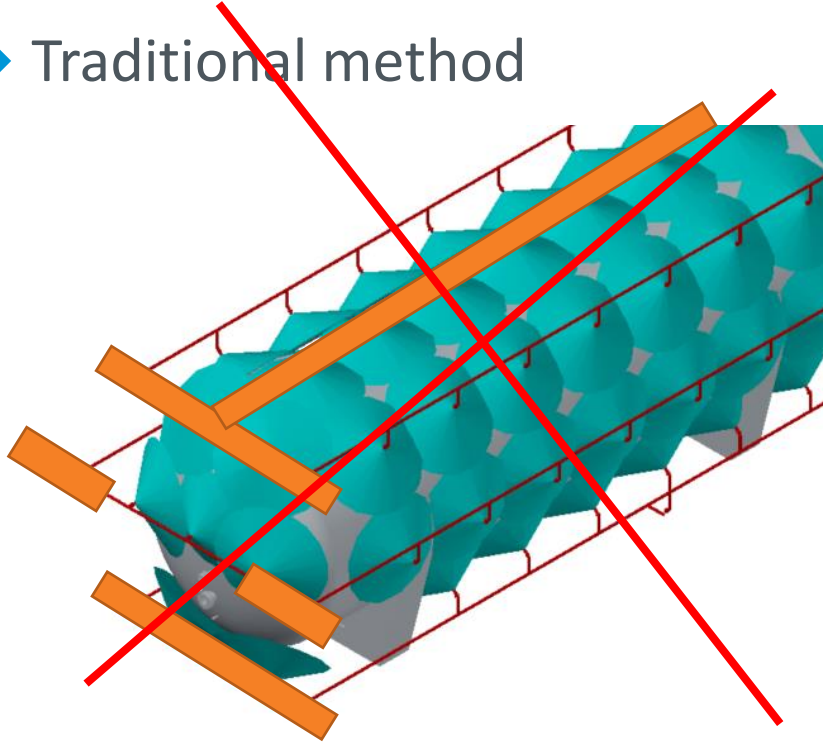$$Q_{min} = 362{,}6 \times 10{,}2 = 3698{,}6 \; L/\min = 222 \frac{m3}{h}$$

Calculations - 3D Study

▶ Select the appropriate nozzle based on the 3D analysis, spacing, equipment geometry and dimensions

3D

Calculations - 3D Study

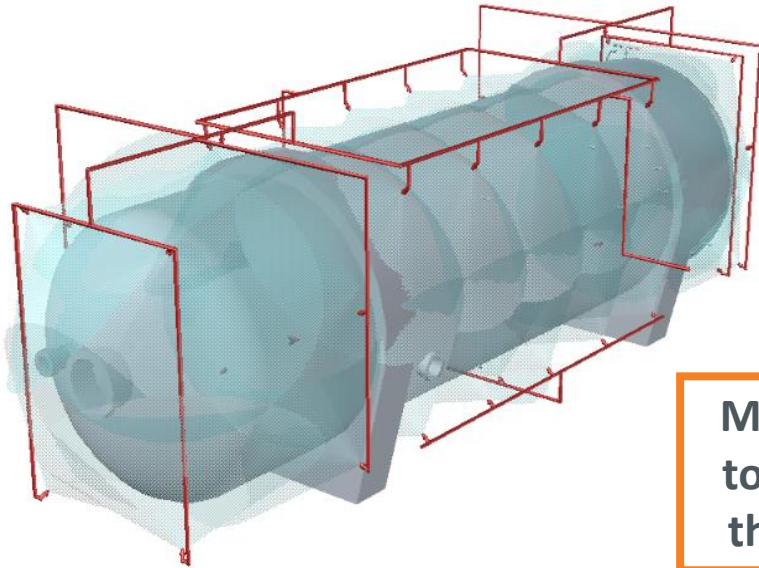▶ Traditional method

- MV-10
  - Too small
- 3 rings
  - Too many

MAJOR ISSUES
- Site obstacles
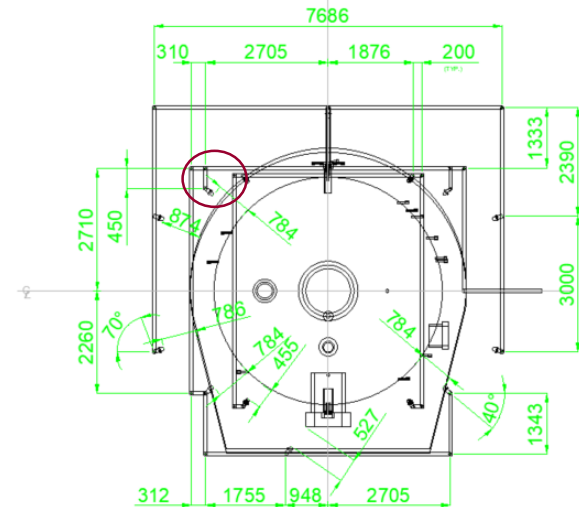- Cones are not overlapping
- Too many nozzles
- Empty spots

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Calculations - 3D Study

▶ **Alternative after 3D analysis**

— New piping configuration
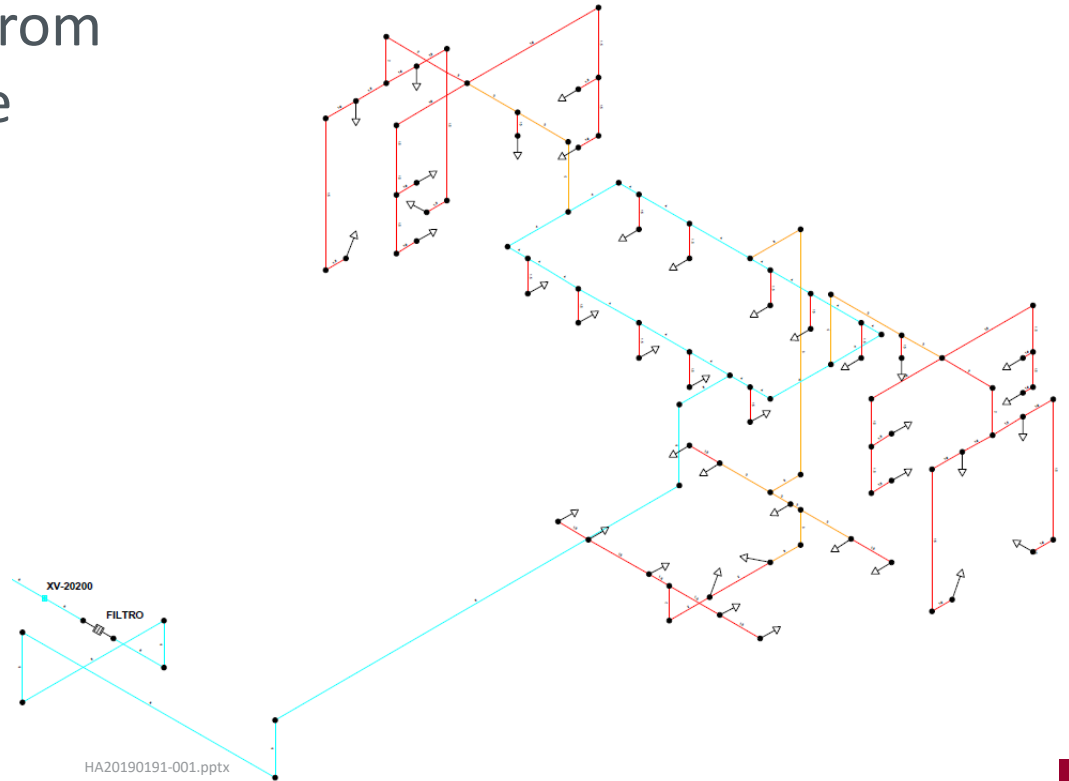— Nozzle angle towards the equipment is important

Make sure to overlap the cones

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Calculations

▸ Define the piping route from the deluge valve until the vessel

▸ Hydraulic balance

XV-20200

FILTRO

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Results

▸ **Minimum requirements:**

Min P 1,4 barg (NFPA 15)

Min. flow	222 m³/h

Min. pressure drop

Nozzle positioning study	
Hydraulics	260 m³/h
No. nozzles	40
Type	MV-46, 110°
DV Pressure	5,9 bar

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Examples

Examples of nozzle positioning study
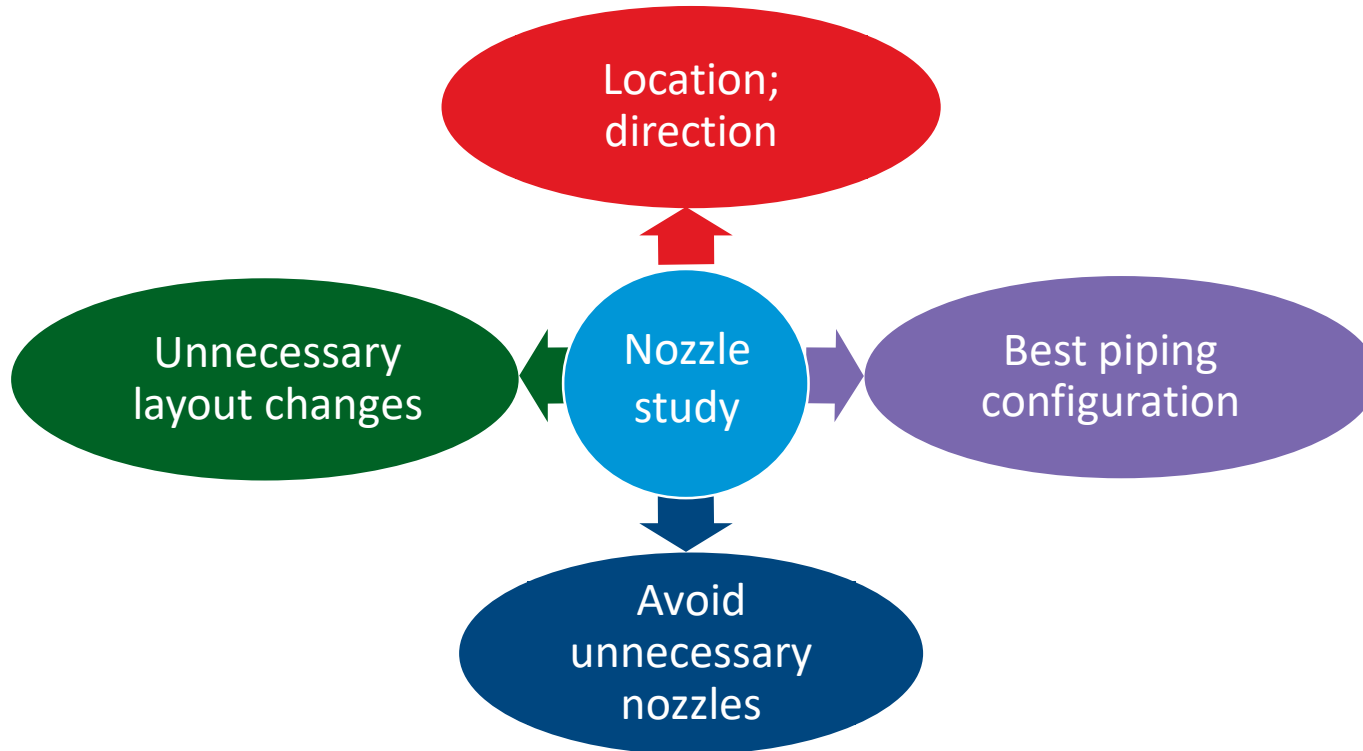
▶ Loading/Unloading
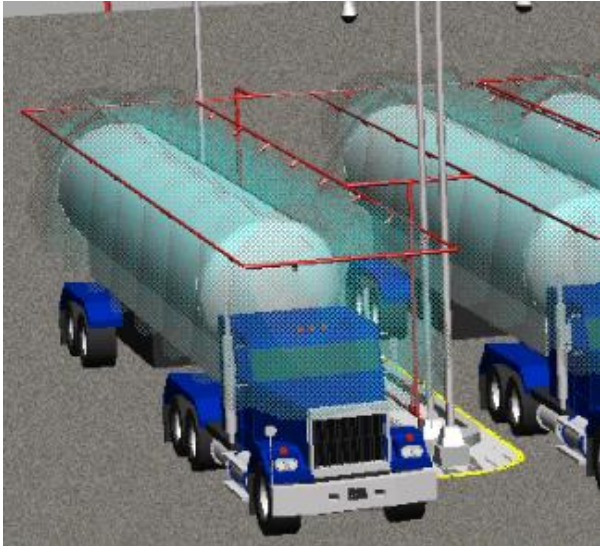
▶ Compressor house

Conclusions

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Conclusion

Location; direction

Unnecessary layout changes

Nozzle study

Best piping configuration

Avoid unnecessary nozzles

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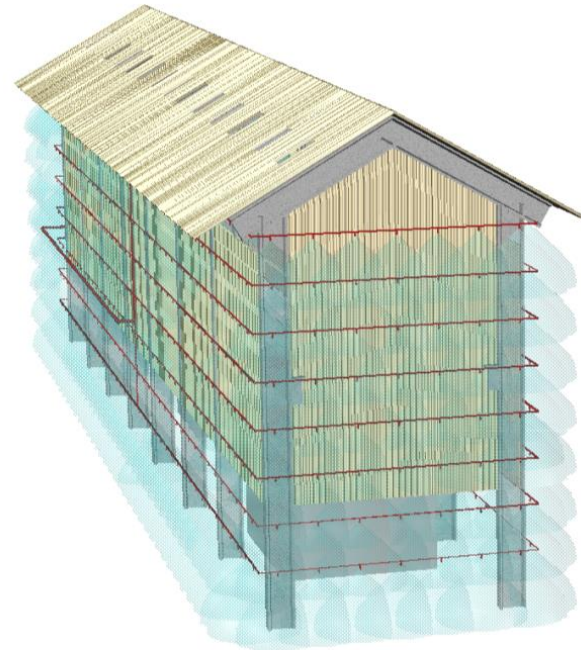
References

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▸ Kidde Fire Systems. Spray Nozzles of medium velocity (MV). Available in: < https://kidde-fenwal.com/Public/Kidde>. Accessed in 15 jan. 2019.

▸ NFPA 15. Standard for Water Spray Fixed Systems for Fire Protection, 2017

▸ NFPA 30. Flammable and Combustible Liquids Code, 2018

▸ SNP. The Spray Nozzle People. Available in: <http://www.spray-nozzle.co.uk/spray-nozzles>. Accessed in 20 jan. 2019.

▸ Viking Deluge System. Technical Manual for Operation Maintenance, and Troubleshooting. June, 2009.

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Questions?

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Back-up

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Introduction

▶ Fire detection system

  – allow for early response

▶ Various types

  – smoke, heat, ultraviolet (UV) or infrared (IR) detection

▶ Activated

  – Hydraulic, pneumatic, electric, manual release system or any combination

▶ Water spray nozzles

  – break apart a fluid flow into a spray pattern

  – can handle low, medium or high velocity

**Veejet
Medium Velocity**