

# **AUTOMATIC SYSTEM FOR AMMONIA NEUTRALIZATION IN SCENARIO OF LARGE RELEASE IN STORAGE TANKS**

*Hormando Leocadio, Ph.D. – Usiminas – Research & Development Center*

*Tiago Neves de Almeida – Usiminas – Reduction Division*

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# AMMONIA

An Essential element in fertilizer



- ✓ Anhydrous Ammonia ( $\text{NH}_3$ ) for **fertilizer** manufacturing and industrial **refrigeration**;
- ✓ Cryogenic **liquid** (13bar@35°C) **gas** at atmospheric pressure (-33°C).
- ✓ **Gas** 0.7kg/m<sup>3</sup>@atm; **Liquid** 639kg/m<sup>3</sup>@4bar
- ✓ Dissolves quickly in water resulting in ammonium hydroxide ( $\text{NH}_4\text{OH}$ ).



## Risk & Storage

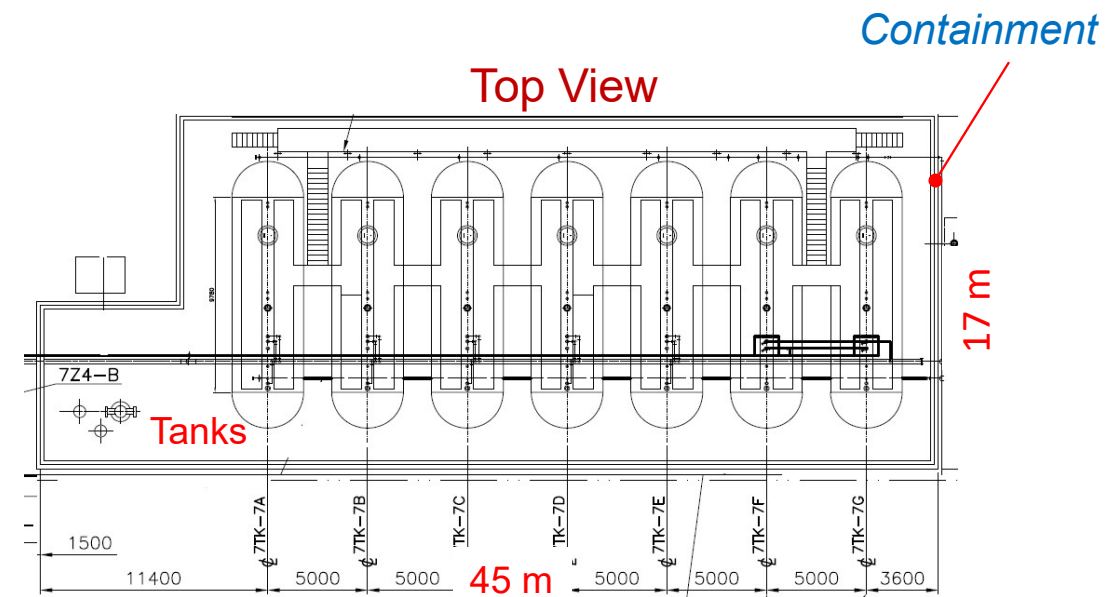
- ✓ Pressurized storage in liquid form (15 bar).
- ✓ Transport: ships, trains and tank trucks.
- ✓ Toxic and flammable: Human exposure limit 20ppm(0.0002%); Eye irritation 70 ppm; **Dangerous to life** 300 ppm (0.03%).
- ✓ Vaporizes at atmospheric pressure forming floating cloud 14,000 ppm (1.4%).

Ammonia cloud of 2.5 km, after pipeline rupture  
Kansas, USA



# Usiminas – Ammonia Storage Tanks

- ✓  $\text{NH}_3$  generated from coke manufacturing process;
- ✓ Stored liquefied (15 bar) in **7 tanks** of **123 m<sup>3</sup> each**
- ✓ Safety: 100% suitable to **NR13** with two PSV's.



## Usiminas – Ammonia Storage Tanks

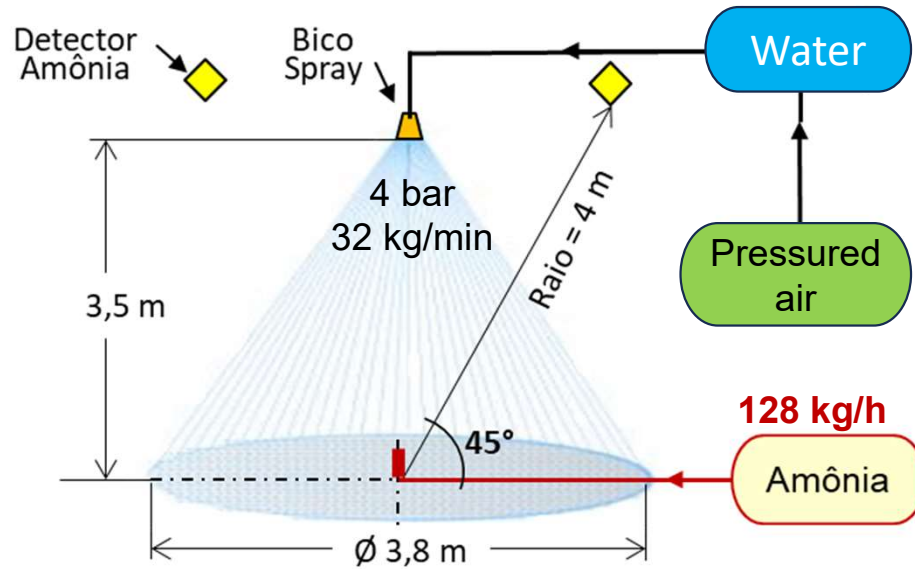
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## The Challenge

- ✓ **93% Risk** ranking of 249 accidental scenarios.
- ✓ **Worst** leakage scenario: 7,668 kg/h - 12 m<sup>3</sup>/h;
- ✓ Develop & Build automatic **mitigation system**
  - **Neutralize 100%** ammonia leakage
  - **Response time ≤ 5 s** : Avoid Cloud Formation



# Experimental Apparatus



Nozzle A - 100 µm water droplets  
 Nozzle B - 200 µm water droplets - **OK**

Detector 1			Detector 2		
No spray (ppm)	With spray (ppm)	Efficiency (%)	No spray (ppm)	With spray (ppm)	Efficiency (%)
356	31	91	240	11	95
325	26	92	301	27	91
320	16	95	310	25	92

15 kg Water → 1 kg NH<sub>3</sub>

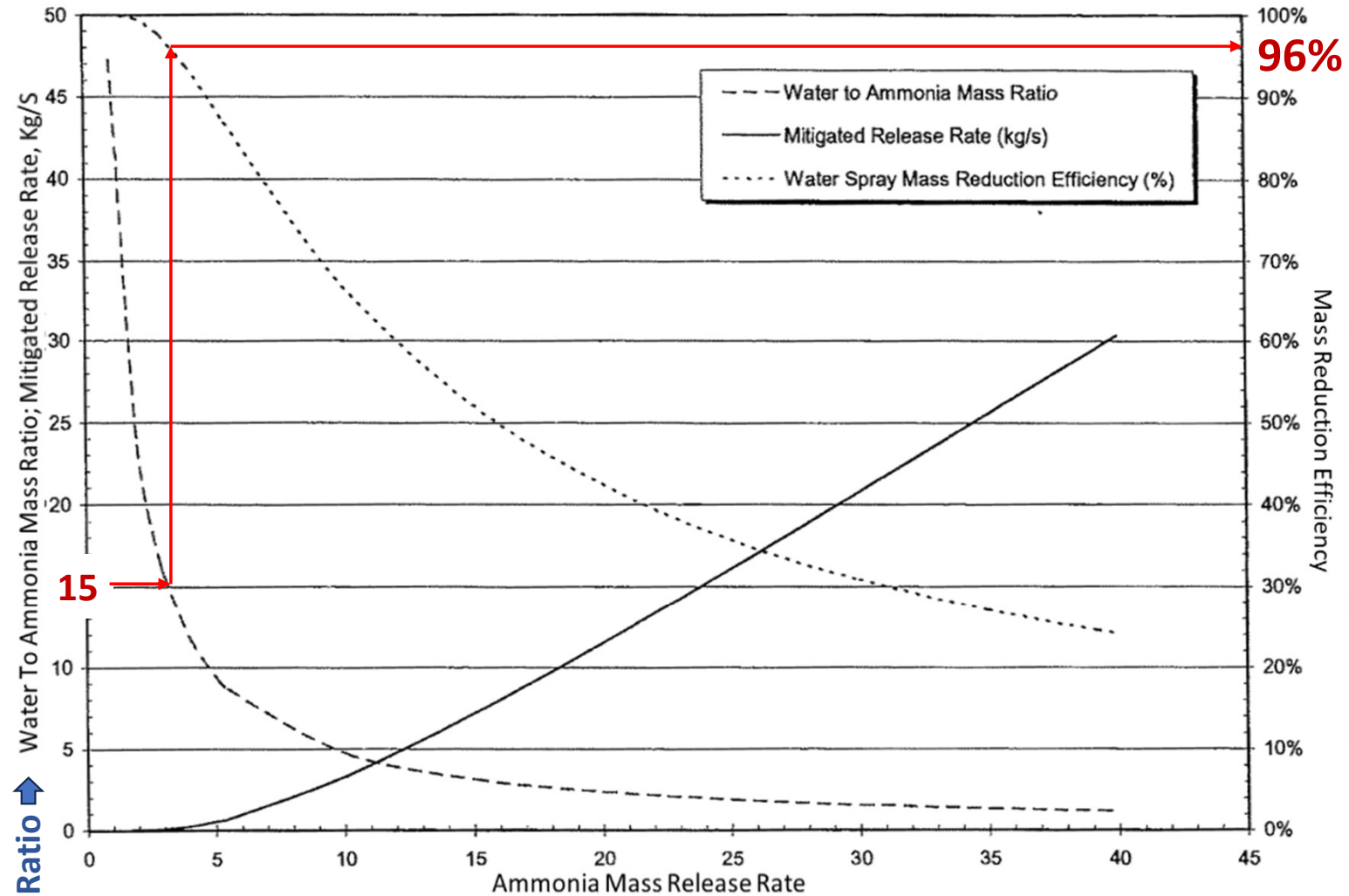
$$R = Ratio = \frac{Water}{Ammonia} = 15$$

Average Efficiency = 93%

## Mitigation Efficiency

**Chevron Refinery  
United States**

Designed spray  
neutralization system  
for ammonia leakage -  
storage tanks.



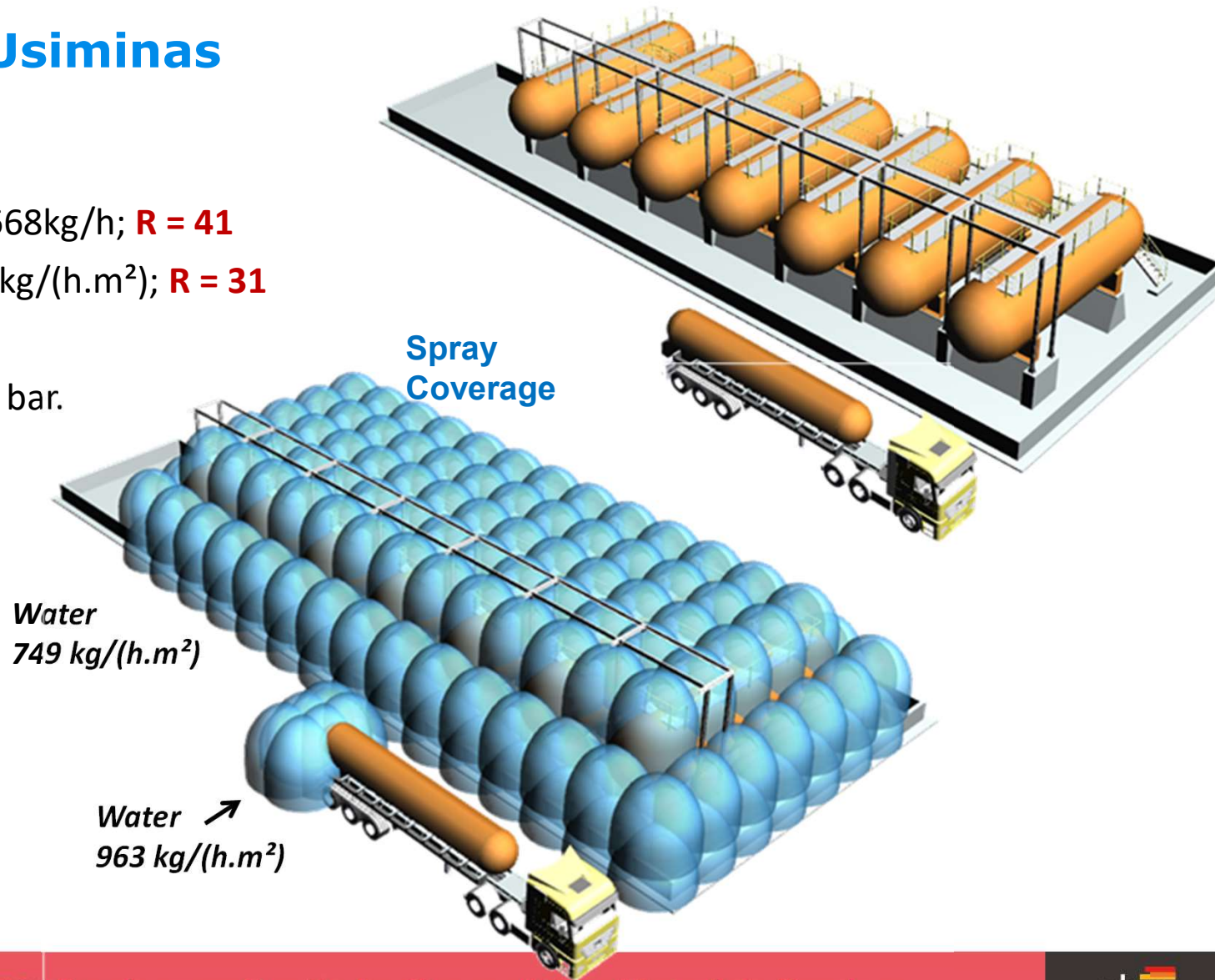
# Mitigation System at Usiminas

## ✓ Mitigation Efficiency 100%

- Worst Leakage of Ammonia = 7,668kg/h; **R = 41**
- Containment: NH<sub>3</sub> vaporation 24kg/(h.m<sup>2</sup>); **R = 31**

## ✓ Response time ≤ 5 sec

- ✓ System Water Flow = 379 m<sup>3</sup>/h @ 8 bar.
- ✓ 154 spray nozzles covering 476 m<sup>2</sup>







Thank you for your attention

*Hormando Leocadio*

[hormando.leocadio@usiminas.com](mailto:hormando.leocadio@usiminas.com)

*(31)98643-3087*

## Avaliação do risco social

Contribuição dos cenários para o Risco Social

<i>RISK RANKING</i>				
Hipótese	Área	Local	Produto	<i>Risk Ranking</i>
22	Carboquímicos	Rompimento da linha de carregamento	Amônia Anidra	56.15%
24	Carboquímicos	Ruptura catastrófica tanques de armazenamento	Amônia Anidra	37.67%
<b>SUBTOTAL</b>				<b>93,82%</b>
<b>Outras 247 Hipóteses Acidentais</b>				<b>6,18%</b>
<b>TOTAL</b>				<b>100%</b>