How does the Israeli regulator fails in assessing the impact of major ammonia incidents

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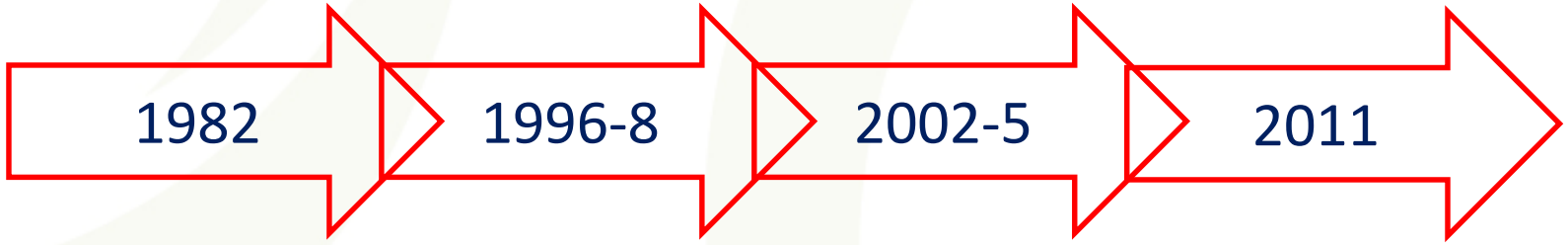
- Historical overview
- Quantitative vs qualitative risk assessments
- Risk management responsibility
- Mechanical integrity of ammonia-based cooling system
- Separation distances
- The unavoidable conflict

Historical overview



First use of non-Gaussian model for ammonia

QRA for the Haifa Bay: including the ammonia tank, Haifa Chem. & Deshanim

Dangerous facilities are requested to prepare the 'plant-case'

Risk management program: based on CalArp

Specific requests from ammonia-based cooling facilities

MOEP: determination of valid separation distances

MOEP: guideline for management of earthquakes, and other external causes

Historical overview

- In the early eighties Dr. Ilan Seter has compared two optional storage methods of bulk ammonia: liquefied vs. refrigerated. It was probably the first time that non-Gaussian (i.e. non Pasquill-Gifford-Turner PGT) models were used to solve industrial issues in Israel

- By that time, the Israeli Civil Defense Forces were the only authority that attempted to request certain safeguards (concrete shields and bunkers) to protect the public. They used a simplified version of the PGT model. The endpoint was LD_{50}/LC_{50}

Quantitative (probabilistic) vs consequence risk assessments

In 1998 TNO performed a probabilistic risk assessment to Haifa Bay

- **Individual risk** has been drawn to the threshold level of 10^{-5} and 10^{-6} annual fatalities
- The Dutch F/N curve has been used to account for the **societal risk**

- Following the report, all significant risk were handled by adding safety measures …

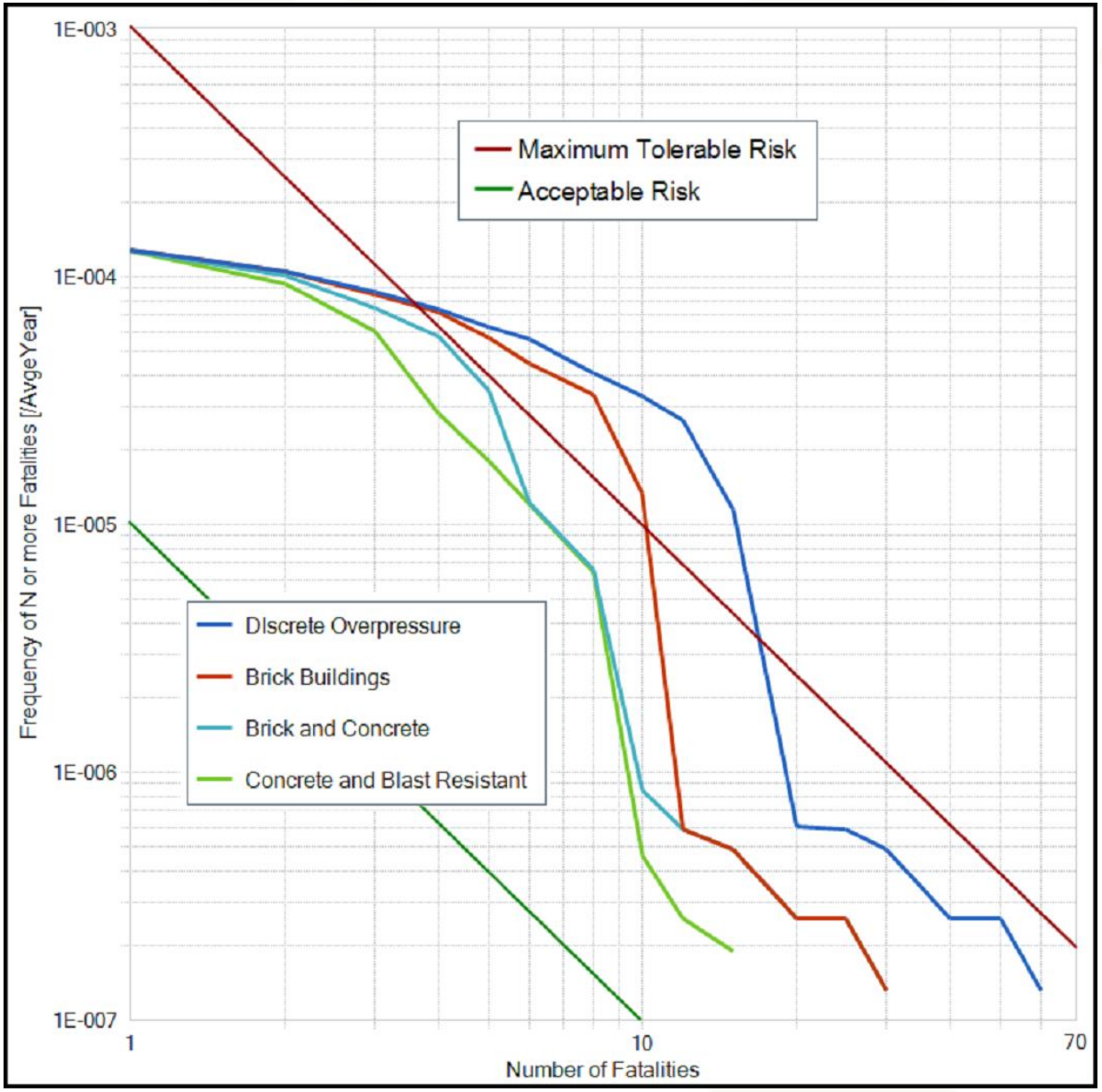
but,

Probability vs consequence risk assessments (cont.)

- Any change, no matter how minor it was, requested re-evaluation of the IR and the associates societal risk
- It is not just that it was extremely expensive

- actually only few could understand what IR means, and less than few, what the societal-risk curve means

so it goes…



Taken from, **Victor Borges**,
https://blogs.dnvgl.com/software/wp-content/uploads/2016/01/FN-Curve.png

Probability vs consequence risk assessments (cont.)

It was then **abandoned** …

The risk survey, the F/N curves and the quantitative-risk-assessment as an acceptable methodology

And so it goes

Risk management responsibilities

In the previous decade the MOEP has adopted the American risk management program (RMP) in its Californian version (aka CalArp).

The benefits:

- Relevant to regulated substances only (ammonia is one of them)
- Relevant to regulated processes
- Determines three levels of risk-management-programs based on the risk of the substance in the process

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Risk management responsibilities (cont)

The problem(s):

- Risk management is to be under the responsibility of the facility…
- The regulator does not have the capabilities (manpower, skills) to assess the completed RMP that has been made by the facility
- An RMP must be backed-up with designated codes to guarantee the mechanical integrity of the process. The Israeli legislation is far from being adequate

and so it goes

The mechanical integrity case: when the market is too small

One of the best ways to managing the risks is to provide a suitable and designated ‘code’ to maintain the mechanical integrity of the hazardous process. The MOEP has done it for industrial cooling systems based on ammonia as the primary coolant, yet:

- In a small market like the Israeli market, the code has been prepared by the largest engineering company, that designed many ammonia cooling systems.
- Ammonia facilities were inspected by the same engineering company.

no ‘Chinese wall’ could block the conflict of interests…

Separation distances (SD)

In 2011 the MOEP has published a guideline of planning criteria related to major incidents involved with hazardous substances

The five drawbacks of the SD guideline relevant to ammonia are:

- The substance
- The software used
- The reference scenario
- The impact assessment
- The protection layers

Apparently, the SD guideline is not related to the risks of ammonia

Separation distances: The substance

- A buoyant gas. The density of ammonia is 0.59 (air=1)

At different temperatures of air and ammonia the density is given by: $0.59\frac{T_{air}}{T_{ammonia}}$ If ammonia released at its boiling point, then the density of ammonia is ~0.74 (air @25^{O}C)

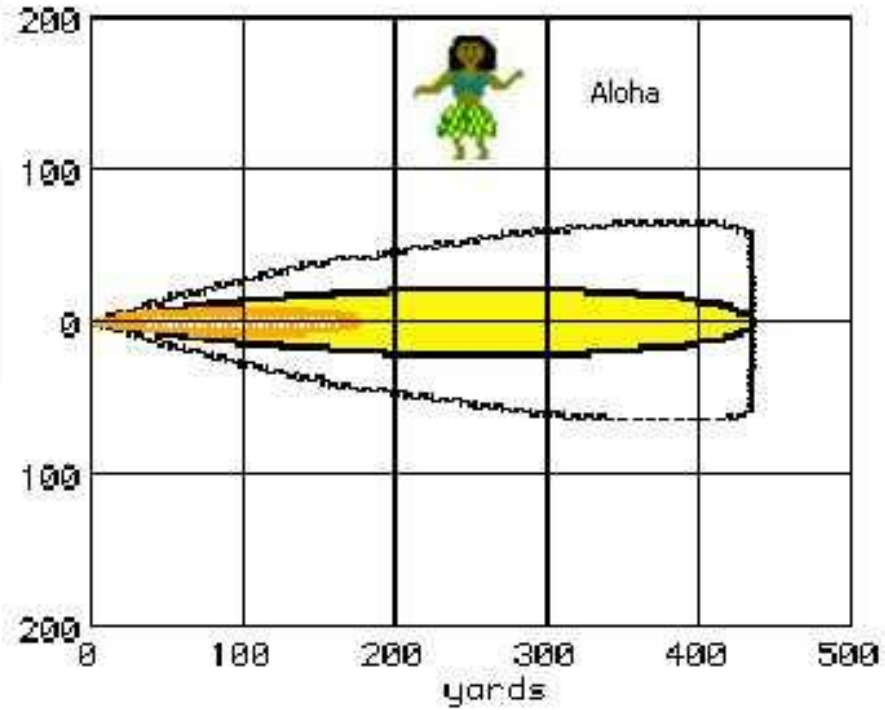
- Ammonia is stored mostly at ambient temperature under pressure. Hence, on tank rupture it flashes (the same applies to the widely used substances: chlorine, LPG and LNG)
- Ammonia vapors form aqueous ammonium hydroxide in contact with water. This is an equilibrium process.
- As a function of the humidity, it may also forms droplets of ammonium hydroxide. Again this is an equilibrium process

Not easy, and some may say even complex, to model.
So it goes…

Separation distances: The Software in use

The Pro's of ALOHA

- Easy to use
- Quick response
- Public domain
- Free of charge
- The best package for first responders*



*In Israel, the first responders are the fire-brigades

Separation distances: The Software (cont.)

And the Con's of ALOHA

- Cannot model lighter than air gases
- Does not do flash simulations
- Cannot model boiling of super cooled liquids
- Cannot take into account the H_2O/NH_3 equilibrium
- The worst package for ammonia risk-assessments

So it goes like that: inapplicable model yields inapplicable results

Separation distances: The reference scenario

The SD guideline uses a predetermined list of scenarios for calculating the separation distances. In most cases the scenarios chosen are the ‘most probable’ rather than the ‘worst-case’ scenarios. However:

- This principle by itself is a trigger of endless conflicts: when it comes to planning the ‘worst-case’ scenario is always ‘on the table’!

Planning committee typical arguments: but what if…, better safe than sorry…, if there is a doubt then no doubt… so it goes

Separation distances: The reference scenario (cont.)

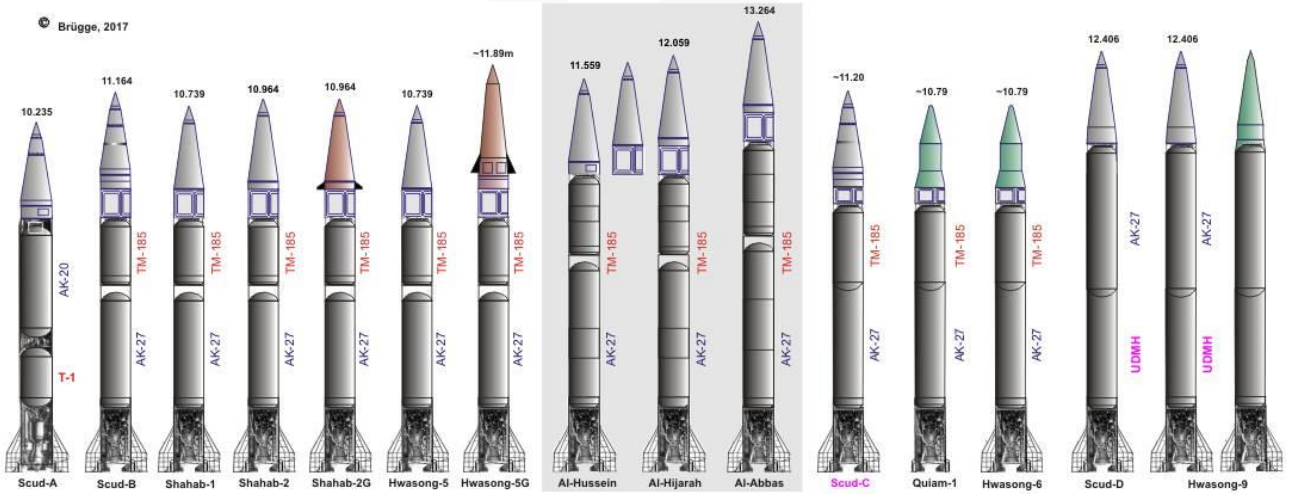
- The civil defense forces look at the worst-case scenario
- When considering earthquakes the worst-case scenario is used, but with endpoints relevant for SD
- For the public and media, the only relevant scenario is hostile attack (by missiles, bombs etc.). In public opinion these scenarios are always catastrophic.
- All of the above refers to stationary sources, transportation is an unresolved and untreated issue

Failure to develop an appropriate methodology to incorporate all aspects into one consistent guideline turns the planning challenge into an impossible mission, so it goes

The best way to take hostile attacks into account is by doing a comparative risk assessment.

For example:

*If a missile carrying 500kg of TNT hits a tank containing hazardous substances, what would be the **number of casualties** in comparison to the same missile hitting other civilian and non-industrial target*



Separation distances: The impact

The SD guideline uses PAC-3 as the endpoint for setting the acceptable separation for existing facilities and PAC-2 for new facilities. For ammonia, PAC-2 and PAC-3 are identical to AEGL-2 (160 ppm 1hr exposure) and AEGL-3 (1,100 ppm 1hr exposure), respectively.

AEGL-2 is the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape.

AEGL-3 is the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death.

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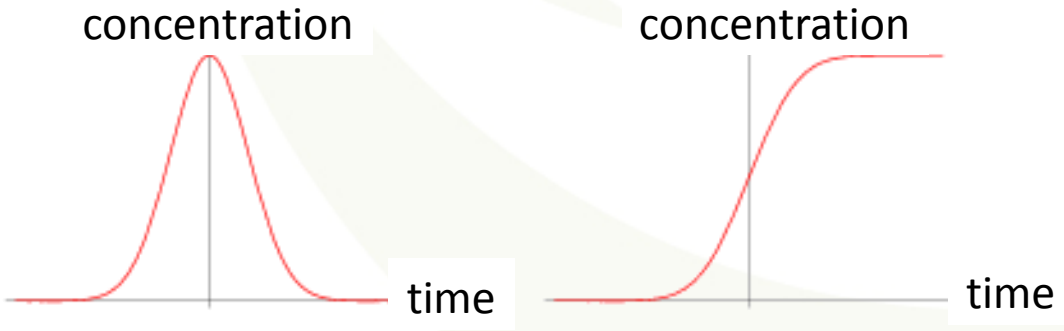
Separation distances: The impact (cont)

These criteria does not match instantaneous releases (less than 1hr exposure) such as:

- Tank rupture
- Spill over water or into water
- Short term operational faults (loading/unloading incidents)
- and more…



Separation distances: The protection layers

Unfortunately, the SD guidelines allows only passive protection layers when calculating the SD. Active protection layers could be used for existing plant , and if used, most probably the ‘worst case’ scenario would become the reference scenario.

The term ‘passive protection’ has been introduced in the American RMP as one of the conditions for classifying a regulated process to class-1 process. In other words it was used as a condition for exempting a hazardous process from a list of technical provisions and risk-management requirements

Separation distances: The protection layers (cont)

- When loading and unloading ammonia (a manned operation), the plant operator cannot be regarded as a safeguard
- Use of detectors in conjunction with shutoff valve (all automatic) is not taken into account as a safeguard
- Use of detectors to monitor the incident and actuate reduction measures such as water sprinklers, is not considered as a safeguard
- so it goes

All of these flaws cause endless debates. The ammonia conflicts are resolved by either eliminating the ammonia, or by using completely unreasonable and gigantic protection measures

To overcome the high tendency of ammonia to cause major planning conflicts, the Israeli regulator should revise its attitude to risk assessment and risk management and develop a new methodology which is: consistent, widely acceptable, robust, and **risk-oriented**

Thank you

Hazmat,
risk engineering team

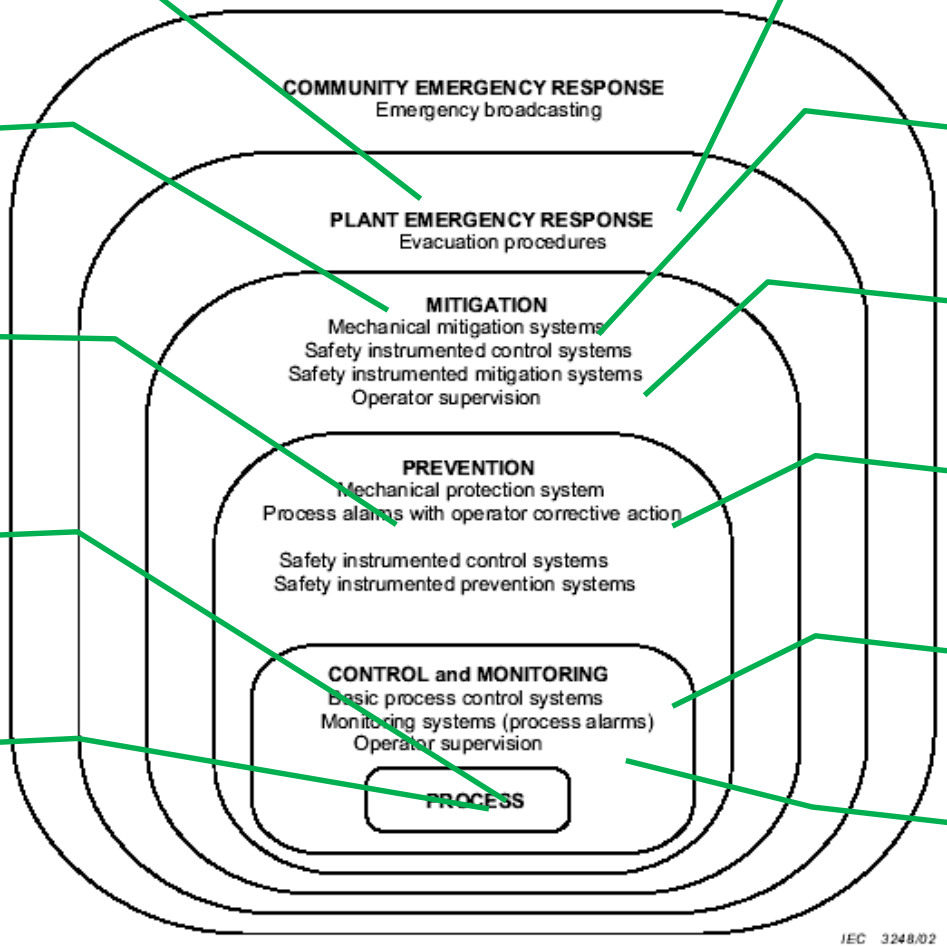
Egress modelling

SIL Studies

Design of safeguards

HAZID

Design for safety



Design of safeguards

Design of safeguards

CFD, QRA, Consequences risk assessment

HAZOP, SIL

HAZOP, FMECA, WHAT-IF

Design of safeguards

All about us in two words: ***protection layers***