Consultant (George Van Bommel) Report

Opinion on additional alternative HCL filling road-tanker-truck

Remarks & Comments on proposed alternative

The independent consultant of BioTorTech BV (BTT) has attended the ammonia alternatives scenario meeting (16th august 2017) in the town hall of Haifa. In great detail, dr. Eli Stern gave the scientific and theoretic explanations to the risk questions of the stakeholders in the Hebrew language.

Introduction:

The basis of this short report is the emerged situation that the 12,000 metric ton (mt) Ammonia Storage tank in the Haifa port, is decommissioned and stopped operations, because of the terrorism attack threat either on the large storage tank and/or on the NH3 (ammonia) tanker ship during the unloading operations. A 1km long onshore atmospheric 8" pipeline filled the NH3 storage tank every three weeks by a visiting NH3 tanker ship, with a parcel size of 8,000 to 12,000 ton of NH3. The typical port mooring duration of the NH3 tanker ship was about 24 hours. This was the so-called "Business As Usual" BAU case reference, to compare the risks.

This NH3 storage tank was the raw material buffer for the Dshanim ICL fertilizer plant and the Haifa Chemicals Ltd. Plant in Haifa, which were directly connected to this feedstock of NH3, through an underground 5 km pressurized pipeline of 6" in diameter.

The fertilizer plants "internal" on-site storage capacity Dshanim ICL is 450 ton NH3 and HCL North is only 90 ton (2 cigar type 45 ton storage tanks), meanwhile the HCL North road tank terminal location filled also 5 road tank trucks (of 25 ton NH3 capacity each) daily, and drive to Haifa Chemical South plant in Mishor Rotem, some 250 km south of Haifa, to fill-up the onsite plant buffer of 450 ton.

Total hourly consumption of the 3 plant sites combined, averages out to about 12.0 - 14.0 tph (ton per hour). Respectively: Dshanim 36,000 tpy (ton per year), Haifa Chem. North 42,000 tpy, Haifa Chem. South 42,000 tpy which adds up to a typical total of 100,000 -120,000 tpy (including other NH3 users).

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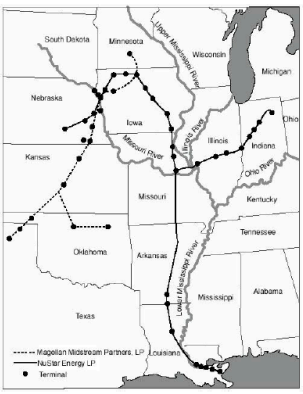
Best Practices in NH3 Storage and Transport

Best Practices concerning off-loading NH3 ships, always have an intermediate large NH3 Buffer-Storage tank in or near the port area to facilitate fast unloading (reducing port mooring time port costs for the ship) through one or more marine (un)loading-arms, with typical capacities varying from small parcel ships of 100 tph to larger fully refrigerated vessel, who unload at a rate of 500 ton per hour of NH3.

From such Buffer or Storage tank, the Ammonia is distributed either through a pressurized pipeline to the consumers or Fertilizer Plants or through river tank barge, road tank truck, or rail tank car. More that 1,800,000 ton/y NH3 is transferred in USA over 4800 km NH3 pipelines, FSU Togliatti to Ukraine Odessa 2470 km NH3 pipeline, Antwerp BASF to harbor 10 km, and many more..



The pipelines are 8-10 inch diameter, constructed of plain carbon steel, with a total length of approximately 3000 miles.

Presented additional option:

This additional option of HCL by **filling of road-tank-truck directly from the small parcel size 1.200 mt NH3 ship** (assuming only full refrigerated -33C and atmospheric tank) **in the port area** was also introduced as alternative, and an additional information (corresponding PFD Haifa Chemicals Ltd. dwg 166-00-XX) was received by BTT on Monday 21 August 17 (see last page).

The HCL mass and material balance on this NH3 trucks loading terminal PFD show an intended load out & filling flow of about **30 (summer)** up to 39 **ton per hour** (in winter). The indicated values in the stream numbers, engineering values for the NH3 flows, densities, pressures, line velocities, temperature are checked by the consultant and are found correct. However, typical unloading liquid velocities for piping are **very low, only 0.4 – 0.7 m/s per HCL** PDF, however **much higher design values are applied of 3.0 m/s for liquids** and 30 m/s for gases & steam are commonly applied in process engineering fields.

The intended directly pumping conditions, **rely heavily on the pumping capacity and type of parcel ship**, which can deviate unfortunately. In theory, these can be a 100 different ship pumps, capacities and pressures.

A typical tank truck **in USA** is about 11500 gal, or 43.5 m3 or 33.5 ton (@ max 300 psi = 20 Bar pressure), assumed the Israel Haifa case they **apply relatively small 25-ton "dedicated" NH3 road tank trucks** in Israel.

It seems, that the Haifa group did not pay much attention to the following issues:

- Total hourly consumption of the 3 plant sites combined averages about 12.0 - 14.0 tph (ton per hour). Dshanim 36,000 tpy + Haifa North 42,000 tpy+ Haifa South 42,000 tpy ± a total of 100,000 -120,000 tpy (including other NH3 users), resulting in some **100 port visits per year of a 1200 ton ship**.
- The one ship unloading of 1200 mt takes in summer (worst case) approximately:
    - Mooring, Connecting & disconnecting ship = 4 hrs
    - Cooling & heating systems startup = 4 hrs
    - Actual pumping-filling at max rate of 30 tph = 40 hrs

      + **48 hrs/ship**
- Simple calculation (4800/8760 hrs per year), indicates that **55% of the time in a year**, a small NH3 ship is moored in the Haifa port unloading.
- The internal Haifa plant consumptions are **in 48 hrs** (unloading ship presence) at the lowest consumption rate of 12 tph, corresponding with some **576 ton NH3**, thus the road tanker truck must find (1200 – 576) = **624 ton NH3 storage buffer,** present "on-site" buffer storage-stock is 450 ton at Dshanim and Haifa Chemical North of 90 ton, **thus 540 ton only in Haifa region available, so Haifa Chemical South's buffer of 450 ton MUST be used** and incorporated in such a alternative.

- Amount of 25 ton road tanker truck's to be filled, is about 1200/25 **is 48 trucks** to empty the ship in 48 hrs**, so every hour one truck load (in 200 days per year) available.**

  The consultant envisages **supplying 600 ton per day** theoretically (during 48 hrs unloading) and assuming ALL 3 plants are in operation, 365 days per year):

- 7.2 loads of 25 ton to Dshanim, = 180 ton/day
- 8.4 loads of 25 ton to Haifa Chemical North = 210 ton/day
- 8.4 loads of 25 ton to Haifa Chemical South = 210 ton/day

The practical, efficient delivery only goes in **full road tank truck**s thus during the full 48 unloading hours (= 1200 mt), therefore:

- First 24 hr day 7 loads, next 24 hr 7 loads to Dshanim = 350 ton/48 hrs
- First 24 hr day 8 loads, next 24 hr 9 loads to Haifa North = 425 ton/48 hrs
- First 24 hr day 9 loads, next 24 hr 8 loads to Haifa South = 425 ton/48 hrs

- The limited **90 ton storage cigars at Haifa Chemicals North is the bottleneck**!, for smooth operation. Internal consumption in 48 hrs is 230 ton, missing the required buffer of 425-230 = **195 ton to less buffer capacity on HCN site** while waiting till next parcel ship and next internal road tank trucks arrive. *(BTT advised to create for this alternative also an excel logistical model, so visualize the implications and bottlenecks).*

- **Theoretically all these operations are possible,** but this needs a high amount of logistical planning of 100 parcels ships (or every 3.5 days a new, different NH3 ship arriving) and some 4800 road tanker truck movements, with some **38,400 yearly flange-hose hook-ups at load out, thus practically a nightmare for continuous plant operations & maintenance.**
- The consultant STRONGLY advises to **have at least 2 (two) parallel NH3 load out bays to fill the road tank trucks** in Haifa port, with enough visual & oral communications means, because the parcel ship pumps are 1 km away from the actual direct loadout or discharge point.
- For Haifa Chemicals South, this road tanker truck unloading is already common practice, but for Dshanim and especially Haifa Chemical North (consuming approx. 2/3 of all NH3 imports) will be a **great operational & logistical challenge to safely and risk reducing transporting**, to get the NH3 undisturbed in an almost continuous base to the plant gates.
- Having "**no-buffer" at the Haifa port shore, means, "no-room" for logistical flexibility, "no-time" for human or mechanical error,** "more NH3 and longer handling, compared to piping". IOW: Uncoupling of Input & Output streams in continuous production & control processes is paramount or key for every operations manager, meaning buffer input of raw materials (NH3) and storage of end products.
- Every hick-up in transport or unloading will result directly in a plant operations disturbance or Shut-Down, meaning frequent restarts of the processes at the plants, meaning increased safety and operational hassle.
- Personally, I see these **"moving" trucks as easy targets and hard to protect**. Recent European terrorist incidents-attacks, show the **use of trucks as weapons**, especially dangerous with the hazardous NH3 as tank content.

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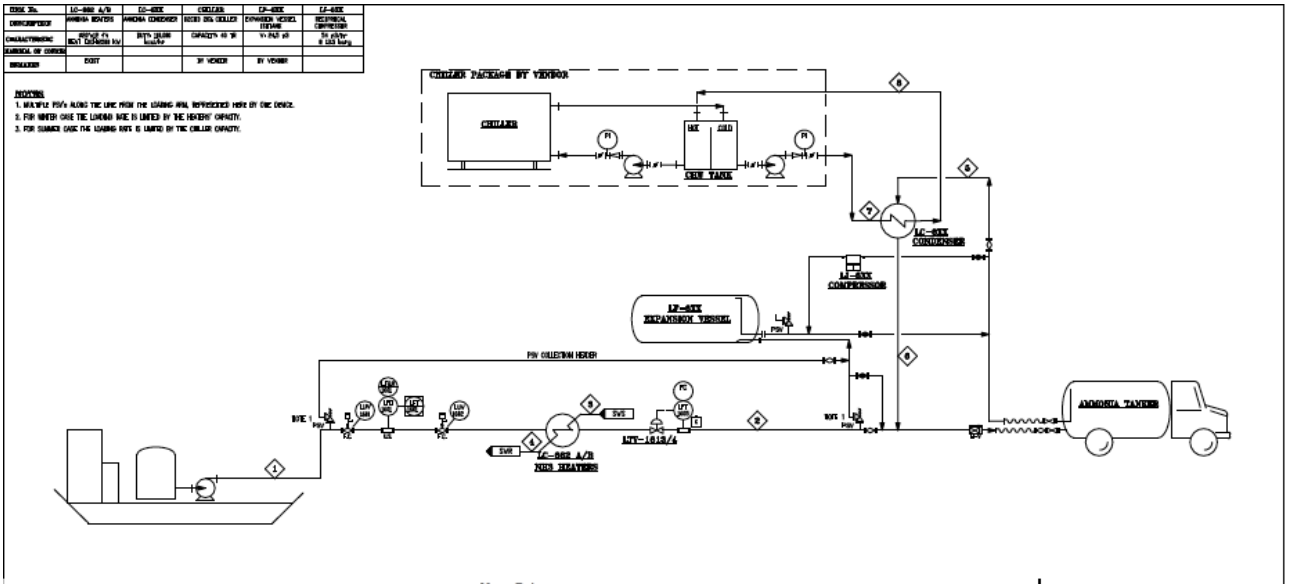
Snapshot of the HCL drawing with mass & material balance for a Road-tanker-truck terminal in Haifa port.



Mass Balance

Stream NO.		1	2	3	4	5	6	7	8
Stream Description		Ship Pump Discharge	Heater Outlet	Sea Water Supply	Sea Water Return	Truck Vapor Outlet	Condenser Outlet	Chilled Brine Supply	Chilled Brine Return
Fluid		Anhydrous Ammonia	Anhydrous Ammonia	Sea Water	Sea Water	Ammonia Vapor	Anhydrous Ammonia	Ethylene Glycol 10%	Ethylene Glycol 10%
Pipe Diameter	inch	8	6	8	8	3	3	3	3
Summer Case									
Velocity	m/s	0.4	0.7	3.4	3.4	3.0	0.04	1.4	1.4
Pressure	barg	11.0	9.5	4	0	9.5	9.5	4	0
Temperature	°C	-33	15	28	24	27	27	10	15
Density	kg/m3	682	617	1,028	1,024	8.16	601	1,000	1,000
Flow	Am3/h	44	49	400	402	49	0.7	22	22
	kg/h	30,000	30,000	411,200	411,200	397	397	22,300	22,300
Winter Case									
Velocity	m/s	0.5	0.9	3.4	3.4	3.8	0.02	1.4	1.4
Pressure	barg	11.0	9.5	4	0	4.2	4.2	4	0
Temperature	°C	-33	5	17	13	5	5	0	3.4
Density	kg/m3	682	632	1,028	1,024	4.11	632	1,000	1,000
Flow	Am3/h	57	62	400	402	62	0.4	22	22
	kg/h	39,000	39,000	411,200	411,200	254	254	22,300	22,300

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TERMINAL
AMMONIA TRUCKS LOADING IN THE TERMINAL
PROCESS FLOW DIAGRAM