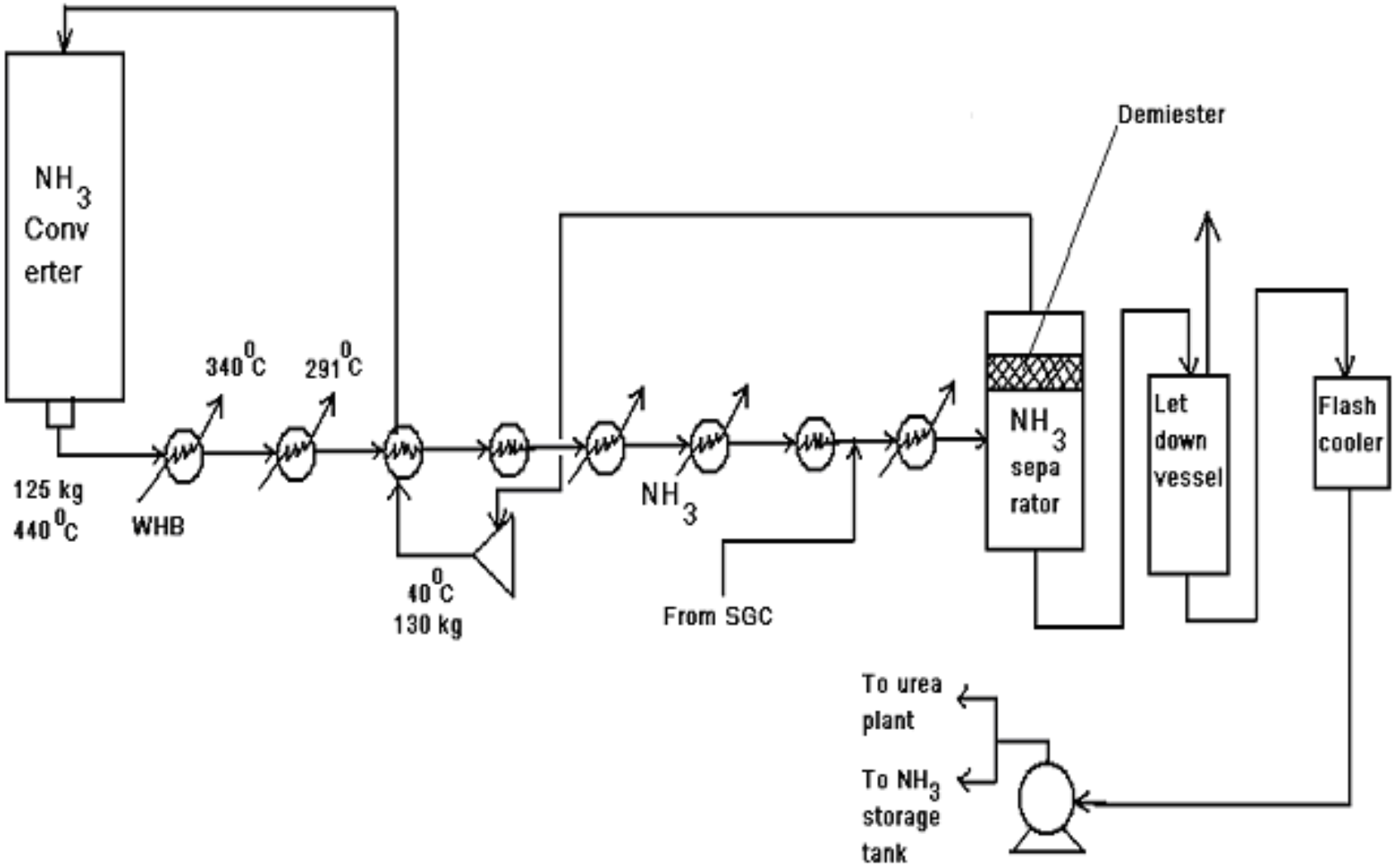
H_2 Recovery Section

KAFCO's H_2 Recovery Section



Storage and Shipping

Three methods exist for storing liquid ammonia

1) Pressure storage at ambient temperature in spherical or cylindrical pressure vessels having capacities up to about 1500 t (UFFL)

2) Atmospheric storage at – 33°C in insulated cylindrical tanks for amounts to about 50 000 t per vessel (ZFCL, KAFCO)

3) Reduced pressure storage at about 0°C in insulated, usually spherical pressure vessels for quantities up to about 2500 t per sphere

- The determining factors for the type of storage - apart from the required size - are temperature and the quantity of ammonia flowing into and out of storage.

Table: Characteristic features of ammonia storage tanks (Max Appl)

Type	Typical pressure, bar	Design temperature, °C	t ammonia per t steel	Capacity, t ammonia	Refrigeration compressor
Pressure storage	16 – 18	ambient	2.8	< 270*	none
Semi-refrigerated storage	3 – 5	ca. 0	10	450 – 2700	single stage
Low-temperature storage	1.1 – 1.2	– 33	41 – 45	4500 – 45 000	two-stage

Pressure Storage

This system is especially suitable for:

✓Storing small quantities of ammonia

✓ Balancing production variations with downstream units processing pressurized ammonia

✓Loading and unloading trucks, tank cars, and marine vessels carrying pressurized

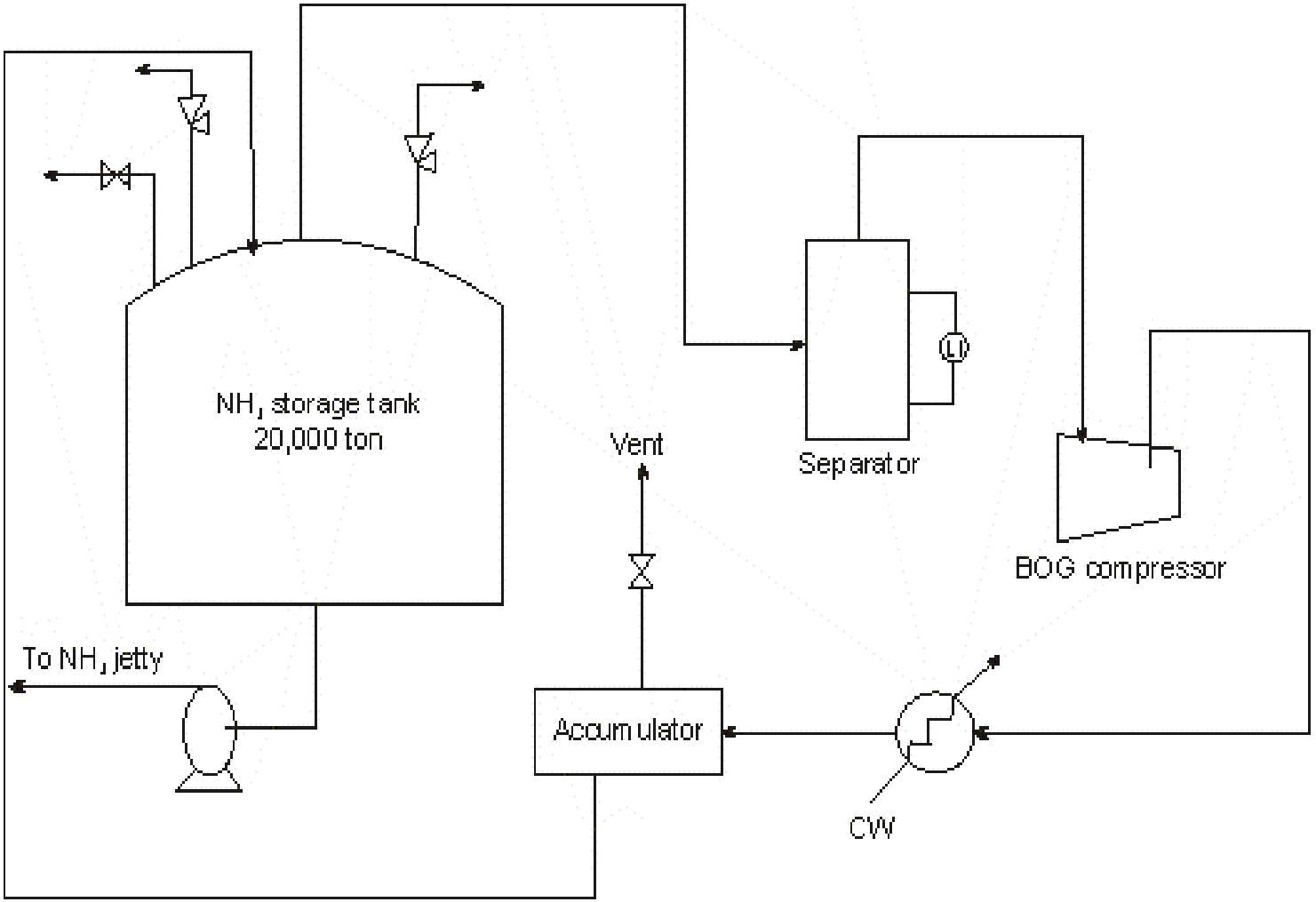
✓Entrance to or exit from pipeline systems

- Ancillary equipment, Coating, Wall thickness (<30 mm), SSC

Low temperature Storage

- 20 days equivalent storage in modern plant requires large volume.
- For large storage volume, capital investment is significantly small for atmospheric storage than high pressure system.
- At – 33^{o}C, single or double walled tank with insulation at the pressure of 1.1-1.5 bar, cylindrical flat bottom and doomed roof is the existing trend.
- Two refrigeration system (1 stand by powered by diesel engine) usually with two stage reciprocating compressor is provided.
- Incoming ammonia at ambient temperature is flashed to reduce temperature up to – 33^{o}C. The flashed vapor is send to the compressor

NH_3 Storage at Atmospheric Pressure



KAFCO's Ammonia Storage System

Transportation

Transportation in Small Containers

The most common containers are:

- Cylindrical steel bottles and pressurized flasks for about 20 - 200 kg anhydrous ammonia to meet the requirements of laboratories, small refrigeration systems
- Polyethylene canisters, metal casks, and the like for 25 % aqueous ammonia.

Transportation by Truck and Railcars

- Normally, shipping liquid ammonia by truck is used only where other means of transport are not available, e.g., in the agricultural practice of direct fertilization.
- Rail cars capacities normally up to 100 m^3; Jumbo rail cars 150 m^3

Transportation in Ocean Going Vessels

- A total of 10×10^6 t of anhydrous ammonia was transported by ocean-going vessels (IFA statistics).
- Most river barges have loading capacities of 400 to 2500 t and mostly have refrigerated load, but a few are pressure vessels.

Transport by Pipelines

- Transport of large volumes of ammonia by pipeline over great distances is far more economical than by river barge or rail.
- In the USA the MidAmerica Pipeline System (MAPCO) extends from northern Texas, across Oklahoma, Kansas, Nebraska and Iowa and ends in Minnesota, all intensive agricultural areas. The total length is 1754 km has a peak delivery capacity of 8000 t/d. The Gulf Central Pipeline is with 3057 km the longest system and connects the major producers along the Texas and Louisiana Gulf coast with terminals in Arkansas, Iowa, Illinois, Indiana, Nebraska, and Missouri MidAmerica Pipeline.

Environmental, Safety and Health Aspects

- Measured by its overall environmental impact - air, water and soil pollution, materials and energy consumption - ammonia production is a rather clean technology with high-efficiency process design and no severe cross-media dilemmas.
- NOx Source: Fired PRF, fired heaters, auxiliary boilers (0.16 % of total anthropogenic emission by ammonia plant)
- SOx source: From fuel oil,other air pollution source H_2S, CO,dust
- Water Pollution: … …. …. …. …. … Methanol, amines etc.
- Noise: depressurizing of large gas quantities for control or venting, steam blowing, burner noise, resonance vibrations in the flue gas ducts, and noise from compressors, blowers, and pumps.
- Measures for noise reduction include installing low-noise let-down valves, use of silencers, sound-reducing enclosures for compressors or housing them in closed buildings.

Safety Features

Three potential hazard:

- Fire/explosion hazard from the hydrocarbon feed system
- Fire/ explosion hazard due to leaks in the synthesis gas generation and purification, compression, or synthesis section (75 % hydrogen)
- Toxic hazard from release of liquid ammonia from the synthesis loop.

❑ HAZOP-Studies and risk analysis procedures (ICI) to ensure safety from design phase.

❑ Storage safety: Ammonia is toxic and even a short exposure to concentrations of 2500 ppm may be fatal.

Health Aspects and Toxicity of Ammonia

Human Exposure:

- Short term exposure limit: 100 ppm (10 min)
- The time-weighted average Threshhold Limit Value (TLV) : 25 ppm

[50 - 72 ppm] – does not disturb respiration significantly

[100 ppm] – Irritates the nose and throat and causes a burning sensation in the eyes and tachypnoe

[1700 ppm] – coughing with labored breathing, sometimes with momentary inability to breath

[5000 ppm] – Higher causes death by respiratory arrest