Paper 5d:

4000 mtpd Ammonia plant based on proven technology

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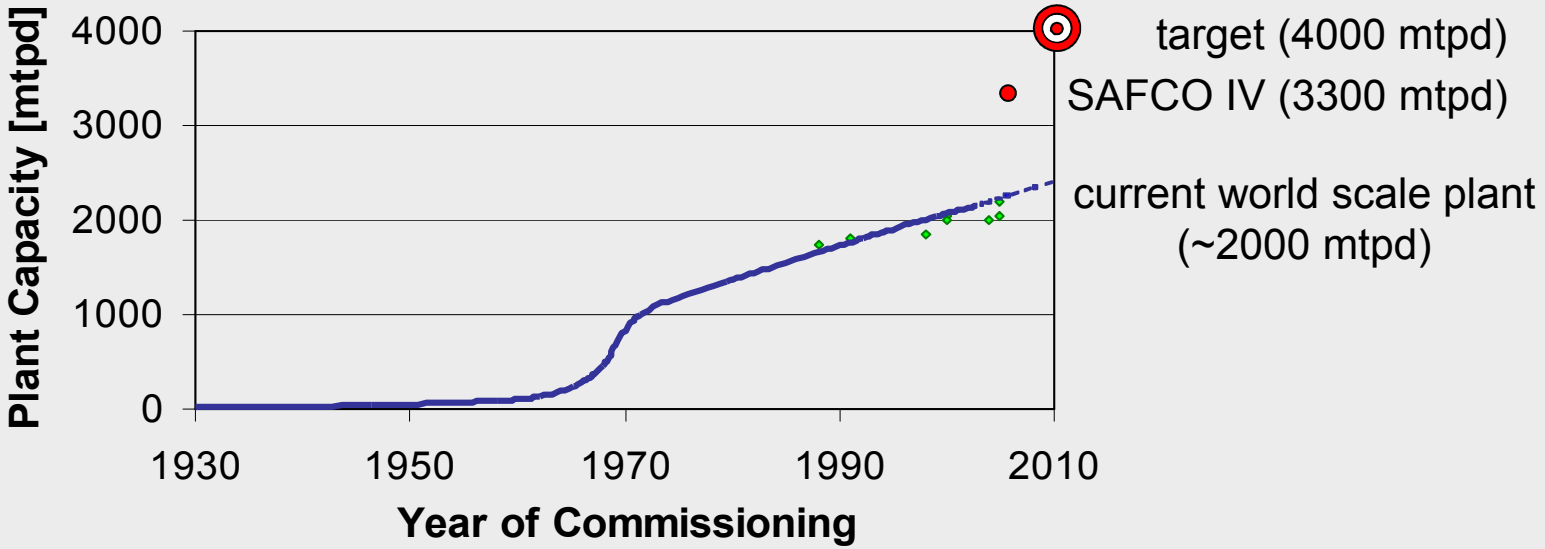
Overview

- Optimizing Plant Economics
- Plant Concept for 4000 mtpd Ammonia
  - Static Equipment
  - Rotating Equipment
  - Piping
  - Arrangement
  - Cost
- Conclusion

Introduction

Optimizing Plant Economics

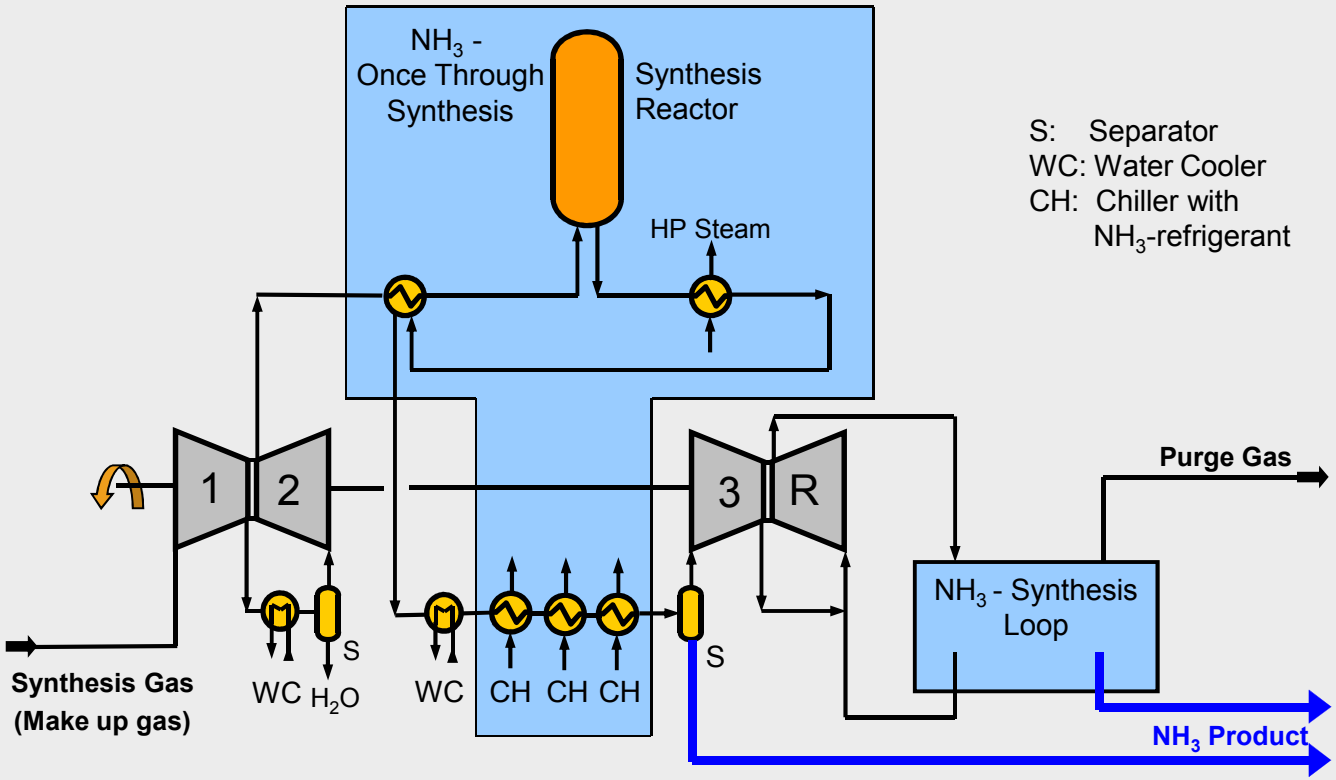
- improvement of energy efficiency
  → to a large extent done up to about 10 years ago
- plant relocation towards low-cost natural gas sites
  → in progress - almost no new plants at high cost sites
- capacity scale up aiming at "economy of scale"
  → persistent trend, expected to dominate the future



4000 mtpd Ammonia Plant Concept

Overview

- checked capacity: 4250 mtpd
- based on SAFCO IV concept (Uhde Dual Pressure Process)



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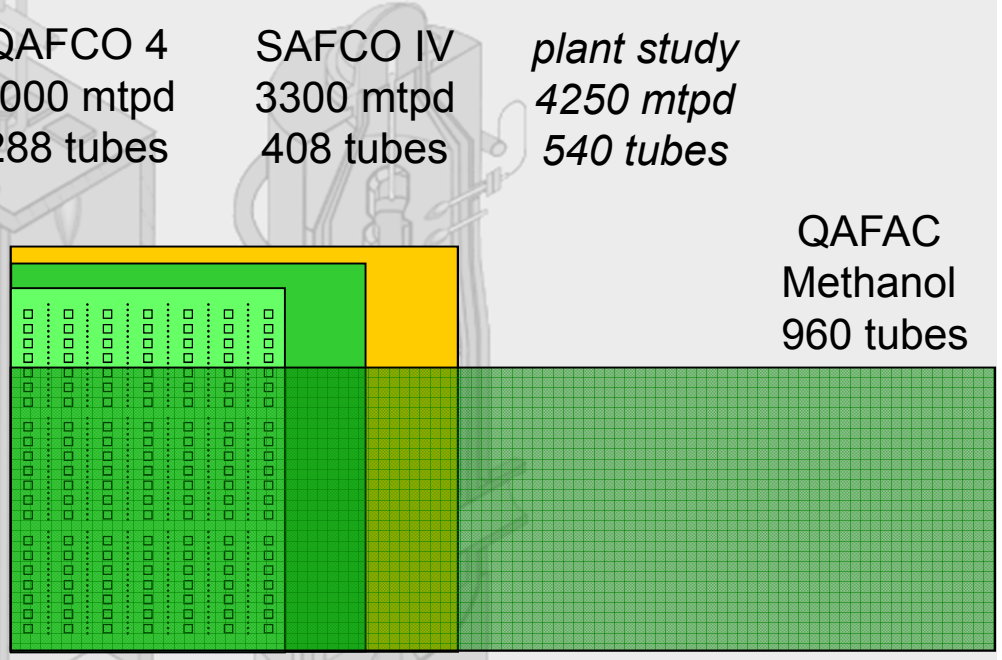
Static Equipment

Reforming Section (1)

- **Primary Reformer**
  - modular design
  - tube & burner groups remain unchanged

    ⇨ easy scale-up
  - cold outlet manifold ok

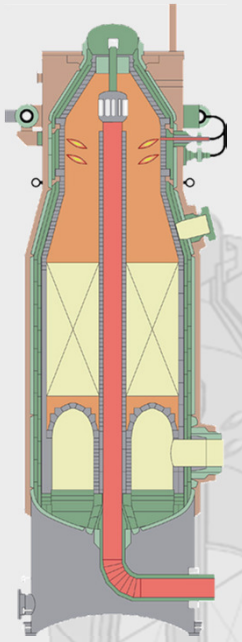


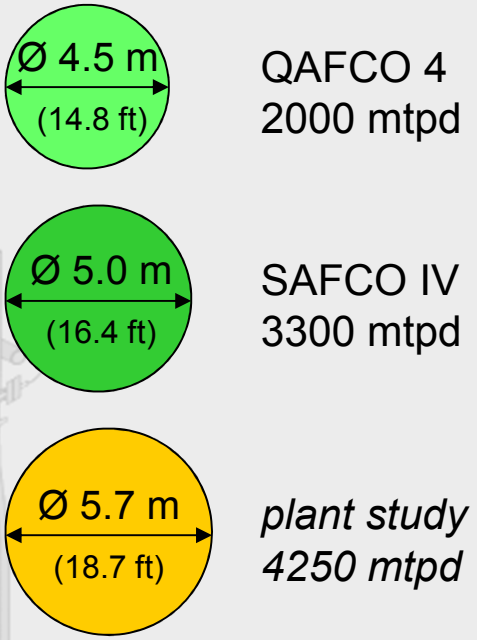
- **Convection Bank**
  - API / ASME compliant design
  - well proven in refinery service

Static Equipment

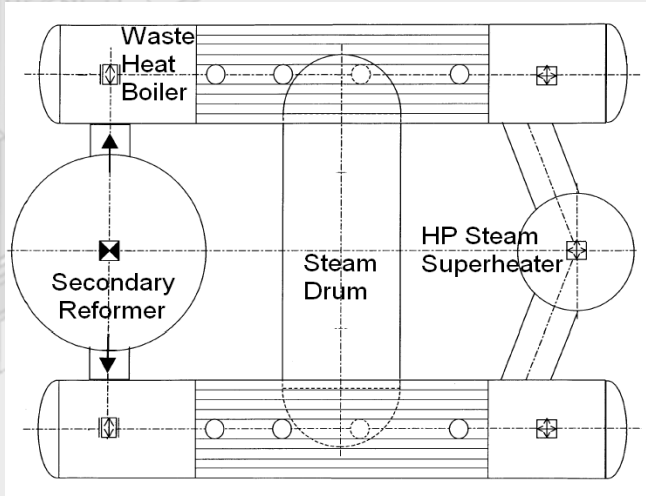
Reforming Section (2)

- **Secondary Reformer**
  - similar to much larger ATRs (diameters of up to 8 m, i.e. 26.2 ft)
  - small span of refractory arch





- **Reformed Gas Waste Heat Boiler**
  - limited at 3800 mtpd
  - dual flow design with references for single boilers



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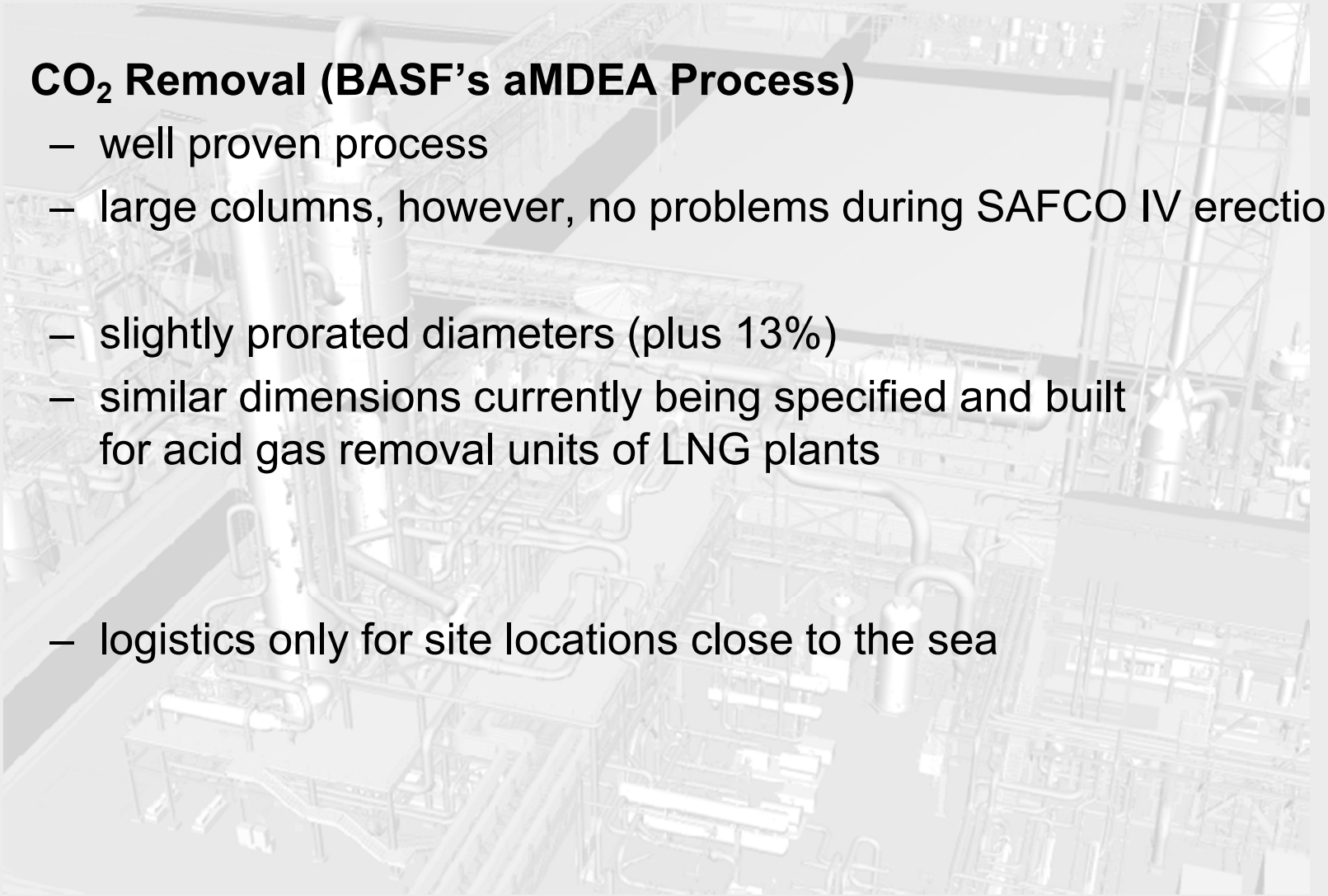
Static Equipment

Gas Conditioning



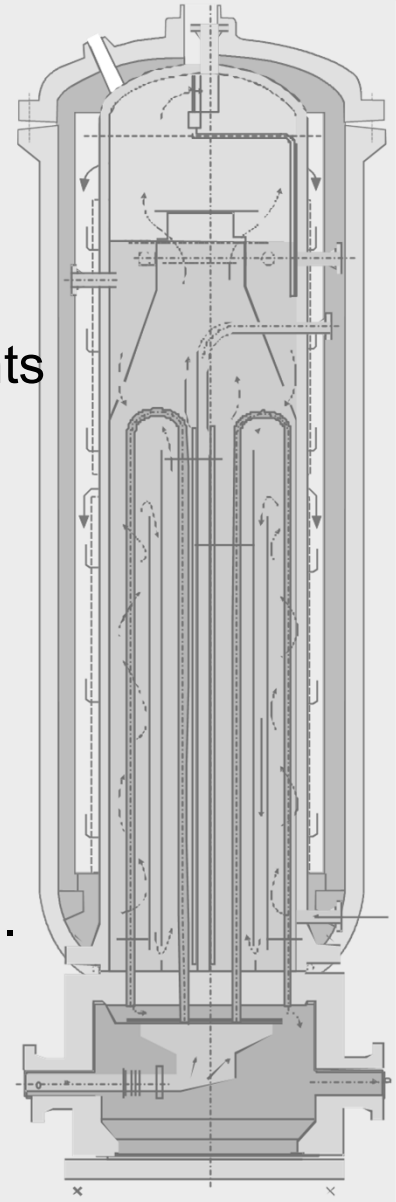
- **CO_2 Removal (BASF's aMDEA Process)**
  - well proven process
  - large columns, however, no problems during SAFCO IV erection
  - slightly prorated diameters (plus 13%)
  - similar dimensions currently being specified and built for acid gas removal units of LNG plants
  - logistics only for site locations close to the sea

Static Equipment

Ammonia Synthesis

- **Ammonia Converters**
  - Once Through Converter with references for operating conditions and dimensions in AMV plants e.g.: Terra Courtright (former CIL), Zhong Yuan Chem. Fert. Puyang
  - only slight prorating for loop converters
  - no significant technological risk

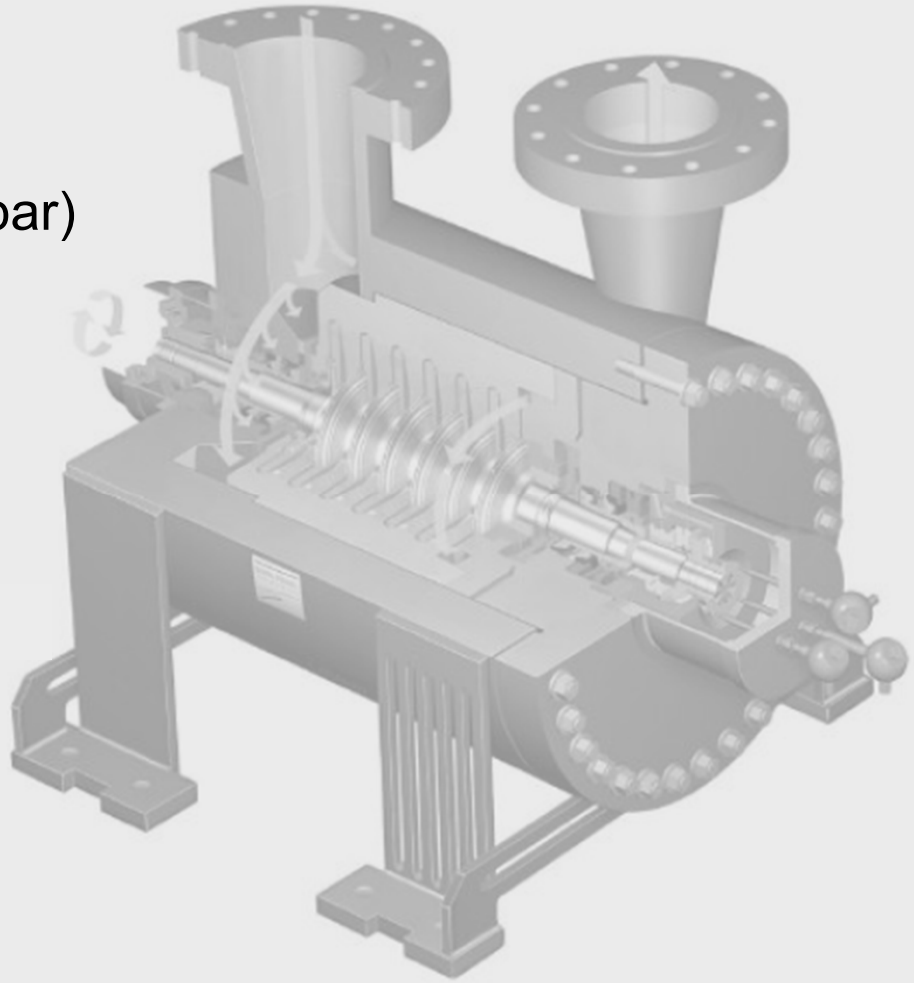
- **Synthesis Gas Waste Heat Boilers**
  - nitriding and embrittlement of the tube sheet may in principle become an issue at large capacities ...
  - however, conventional design for 4250 mtpd is fully feasible



Rotating Equipment

Natural Gas Compressor Train

- design depends on feed gas conditions
- typical (feed gas pressure: 20 bar)
  - barrel type compressor
  - 6 impellers
  - 5.4 MW @ 10500 rpm
- references exist e.g. in pipeline service
- feasible concept



Rotating Equipment

Process Air Compressor Train

- compressor dimensions considerable,
  however, relatively small train when compared to process concepts using autothermal reforming or excess air

- *option 1: constant number of casings*
  2-casing train without reference for flow and casing size respectively, however still feasible
  - horizontally split compressor — SAFCO IV:
  - 2/2 // 3/3 impellers — 2/2 // 2/4 impellers
  - 31 MW @ 4500 // 9000 rpm — 25 MW @ 5135 // 8657 rpm

- *option 2: constant casing size*
  3-casing train with references for each casing
  - 33 MW @ 4600 // 7300 rpm

- feasible concepts available

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Rotating Equipment

Synthesis Gas Compressor Train

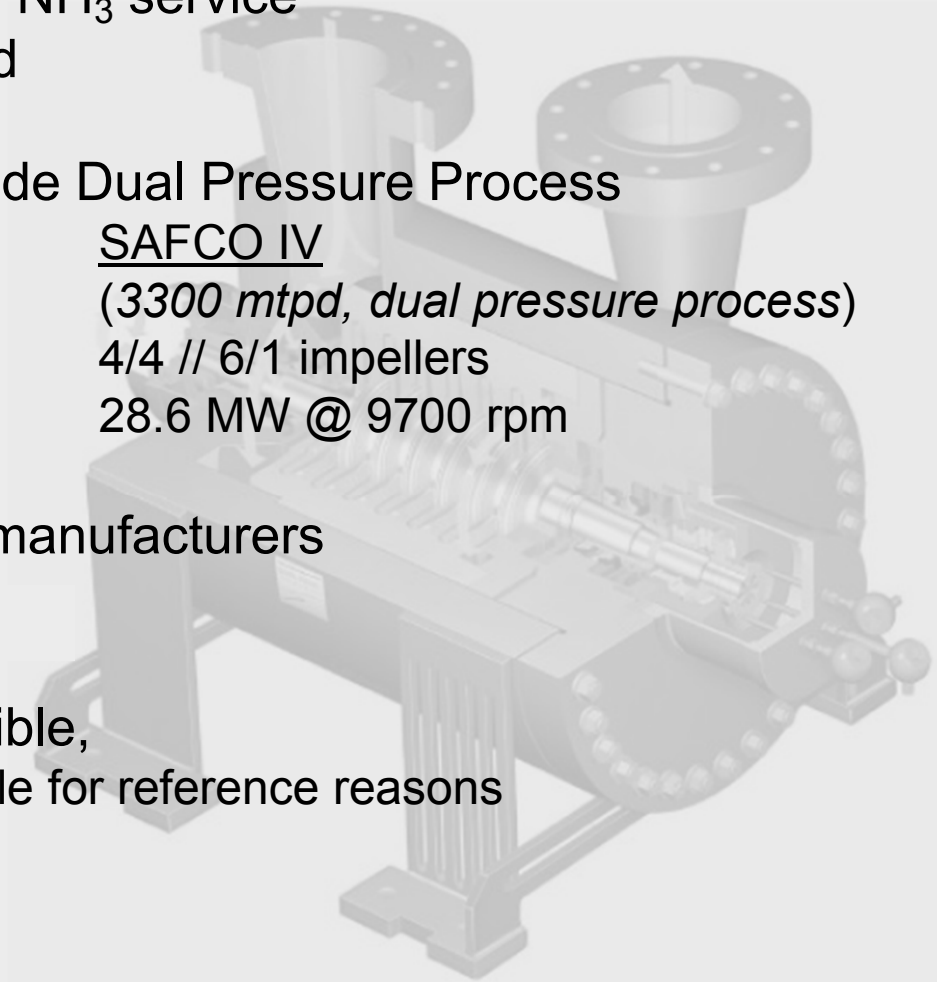
- operating conditions unique to NH_3 service
  => no references at 4250 mtpd

- relatively small duty due to Uhde Dual Pressure Process

QAFCO 4	SAFCO IV
(*2000 mtpd, conv. process*)	(*3300 mtpd, dual pressure process*)
5/4 // 8/1 impellers	4/4 // 6/1 impellers
27.3 MW @ 9535 rpm	28.6 MW @ 9700 rpm

- feasible concepts of different manufacturers
  4/4 // 7/1 impellers
  38 MW @ 9000 rpm
- single flow steam turbine feasible,
  dual flow design may be preferable for reference reasons

- feasible concepts available



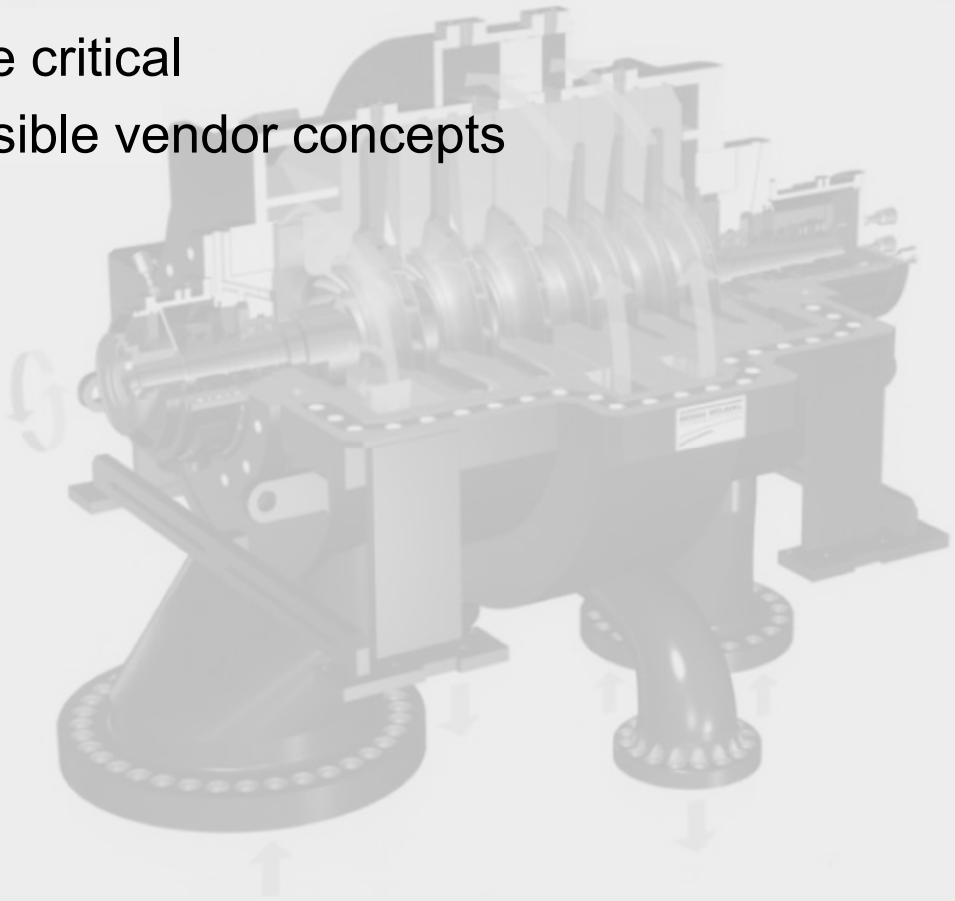
Rotating Equipment

Refrigeration Compressor Train

- ammonia refrigeration is customary technology

- scale-up is not expected to be critical
- expectation confirmed by feasible vendor concepts

- feasible concepts available



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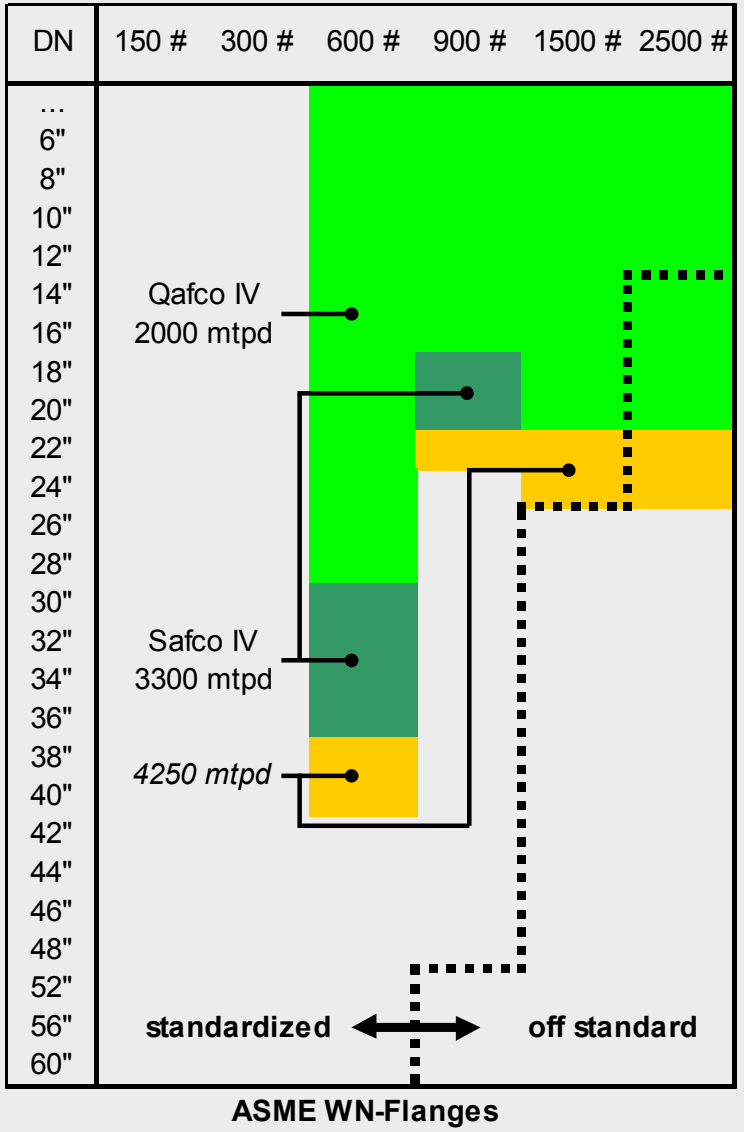
Piping

- 600# and 900# (typical front-end)
  - backed by ASME code
  - reasonable scale up
- 1500# (typical once through synth.)
  - backed by ASME code
- 2500# (typical synthesis loop)
  - already off standard at 2000 mtpd and below
  - size reduction due to Dual Pressure Process
  - fully feasible



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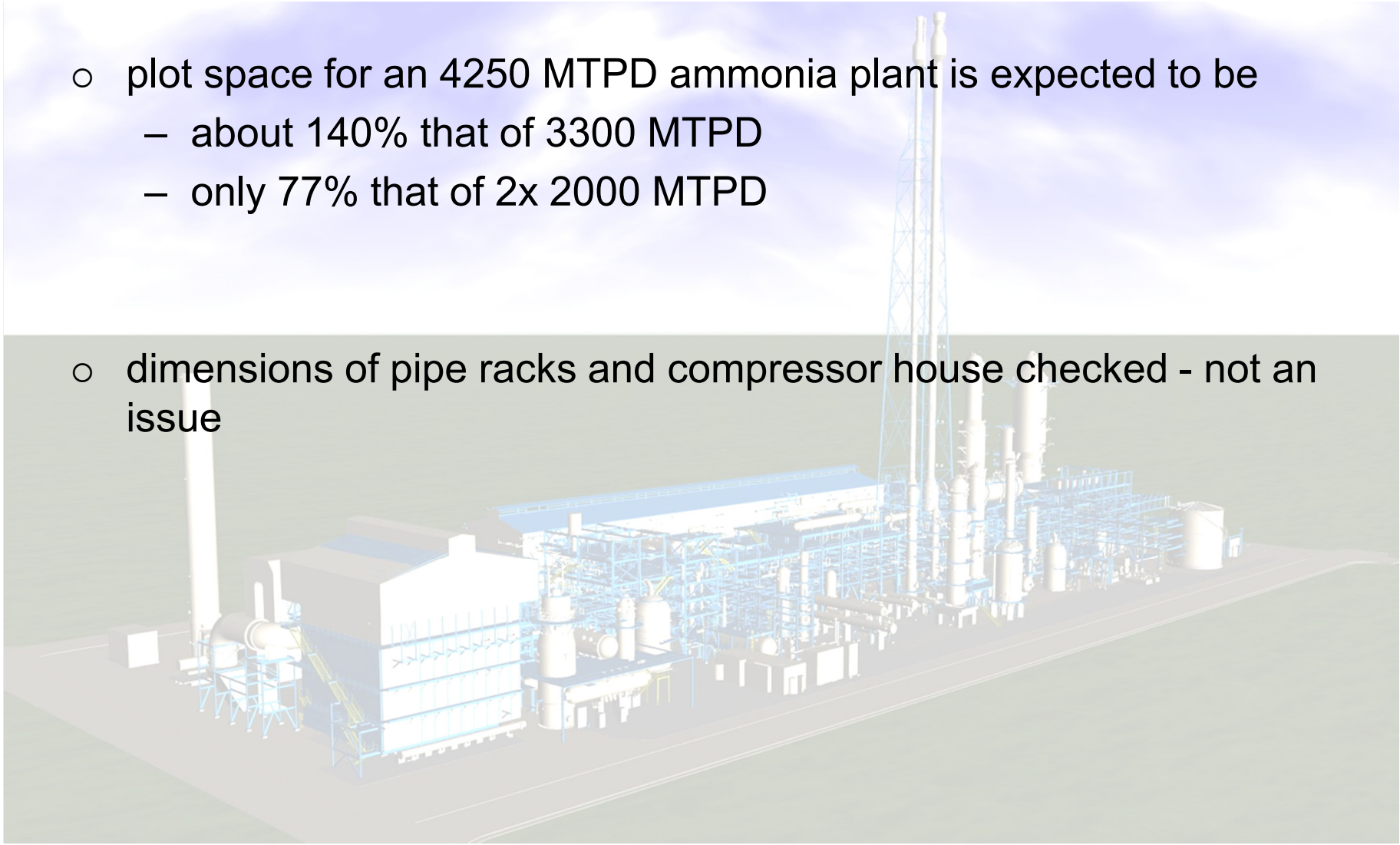
Plant Arrangement

- plot space for an 4250 MTPD ammonia plant is expected to be
  - about 140% that of 3300 MTPD
  - only 77% that of 2x 2000 MTPD

- dimensions of pipe racks and compressor house checked - not an issue



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Cost

- capital expenditure
  - specific cost (cost per mtpd installed) of a 4000 mtpd plant is expected to be only **86%** of a 2000 mtpd plant
  - further cost reduction on owners side (for example due to reduced plot space requirements)
- operating expenditure
  - Dual Pressure Process cuts gas cost by 4% due to lower energy consumption
  - further savings (e.g. personnel cost)
- significant savings to be expected

Conclusion

- clear market demand for ammonia plants with very large capacities
- first next generation plant already under construction by Uhde
- Uhde's Dual Pressure Plant concept is fully viable for a capacity of 4250 mtpd (and shows potential for even larger capacities)
- 4250 mtpd plant represents only moderate upscale of the 3300 mtpd reference plant
- concept with best possible reference situation for a next generation ammonia plant
  ⇒ safe and reliable operation
  ⇒ safe investment
- "economy of scale" pays off
- **4250 mtpd ammonia plants are offered by Uhde on a lump-sum turn-key basis**