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Basics in Process Design

Introduction

Contact

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What is process design?

- What do you think process design is?

What is process design?

- *"Starting from a vaguely defined* ***problem statement*** *such as a customer need or a set of experimental results, chemical engineers can develop an* ***understanding*** *of the important underlying physical science relevant to the problem and use their understanding to* ***create a plan*** *of action and a set of detailed specifications, which, if implemented, will lead to a predicted financial outcome."*

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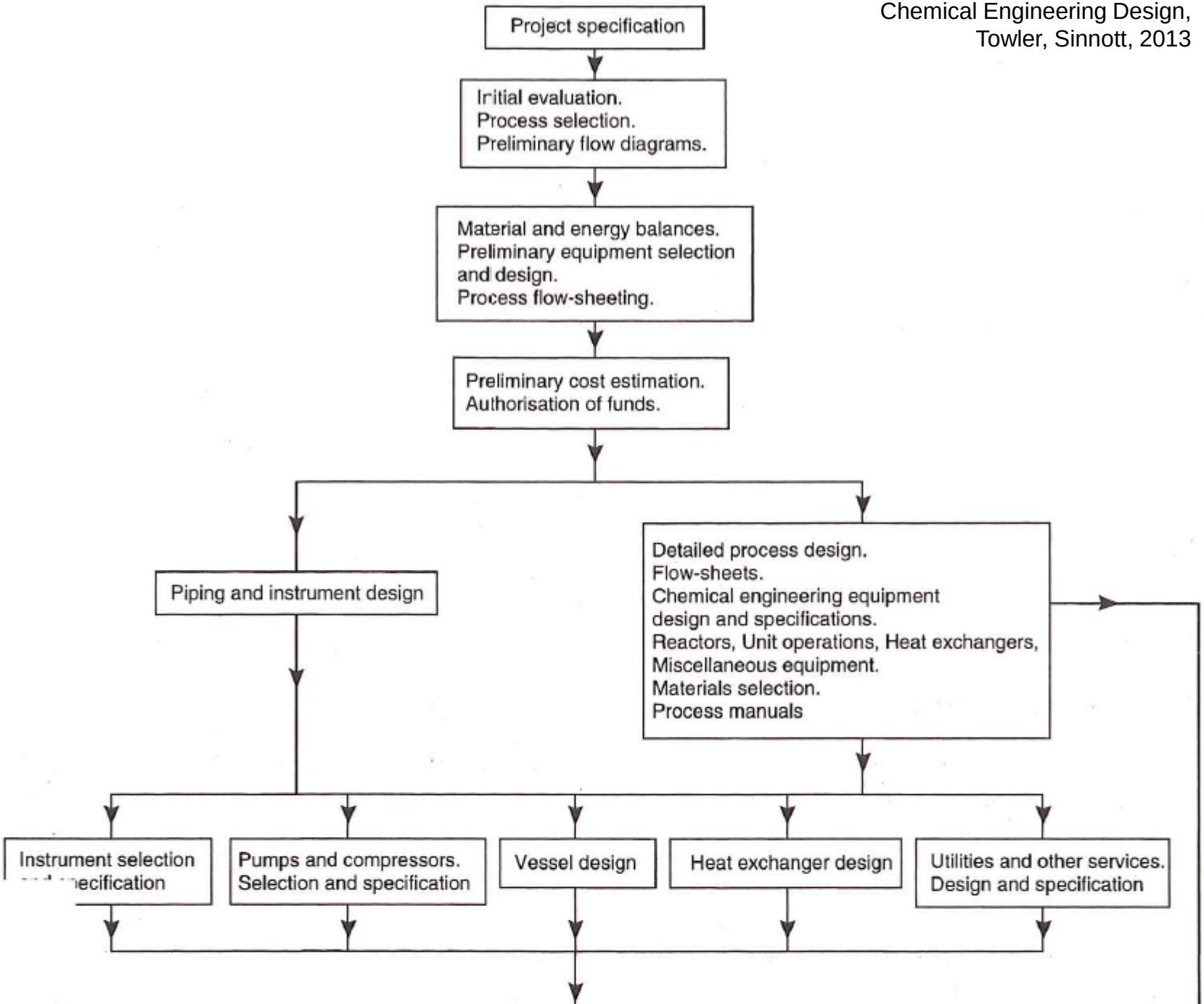
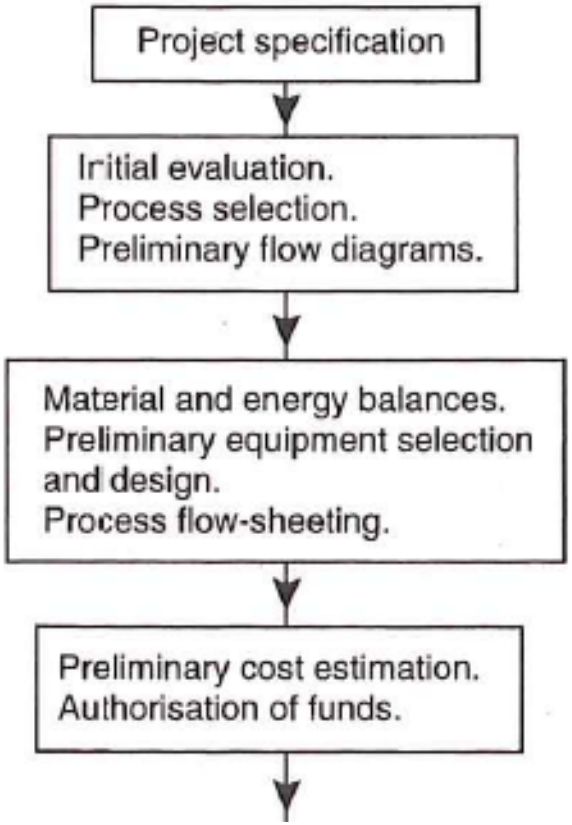
Chemical Engineering Design,
Towler, Sinnott, 2013





- Block flow diagrams
- Calculate flows from mass and energy balances
- Rough sizing of equipment for
  - storage
  - preprocessing
  - reaction
  - separation,
  - heat exchange
  - transport
- Instrumentation
- Cost estimates

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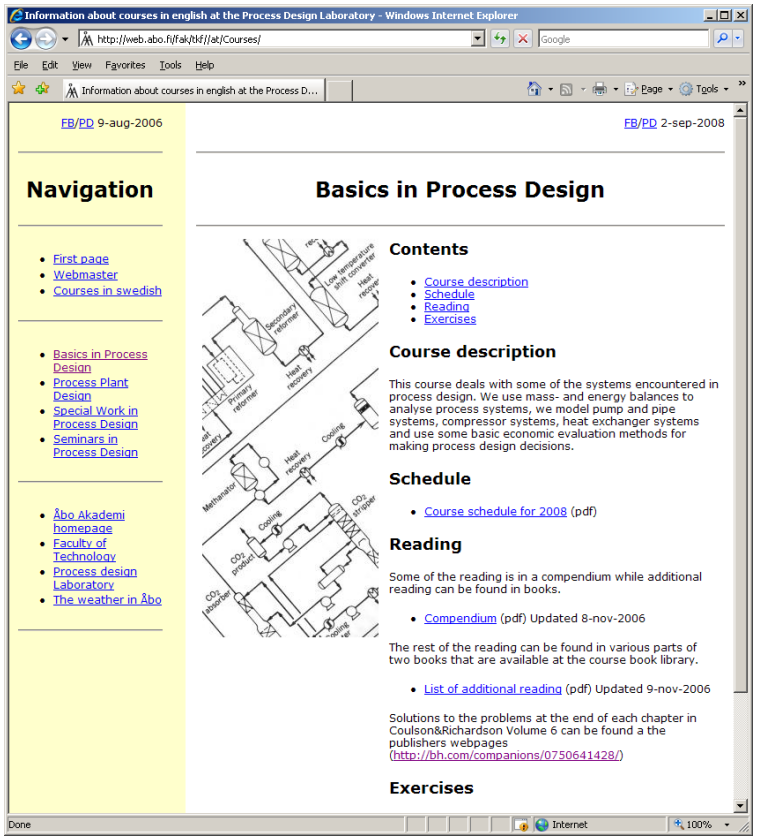
Work

- 9 weeks of lectures
- One lecture per week
- Weekly reading assignment
- Weekly exercise assignments with compulsory reports (and corrections)
- Exam (open book)

Course material

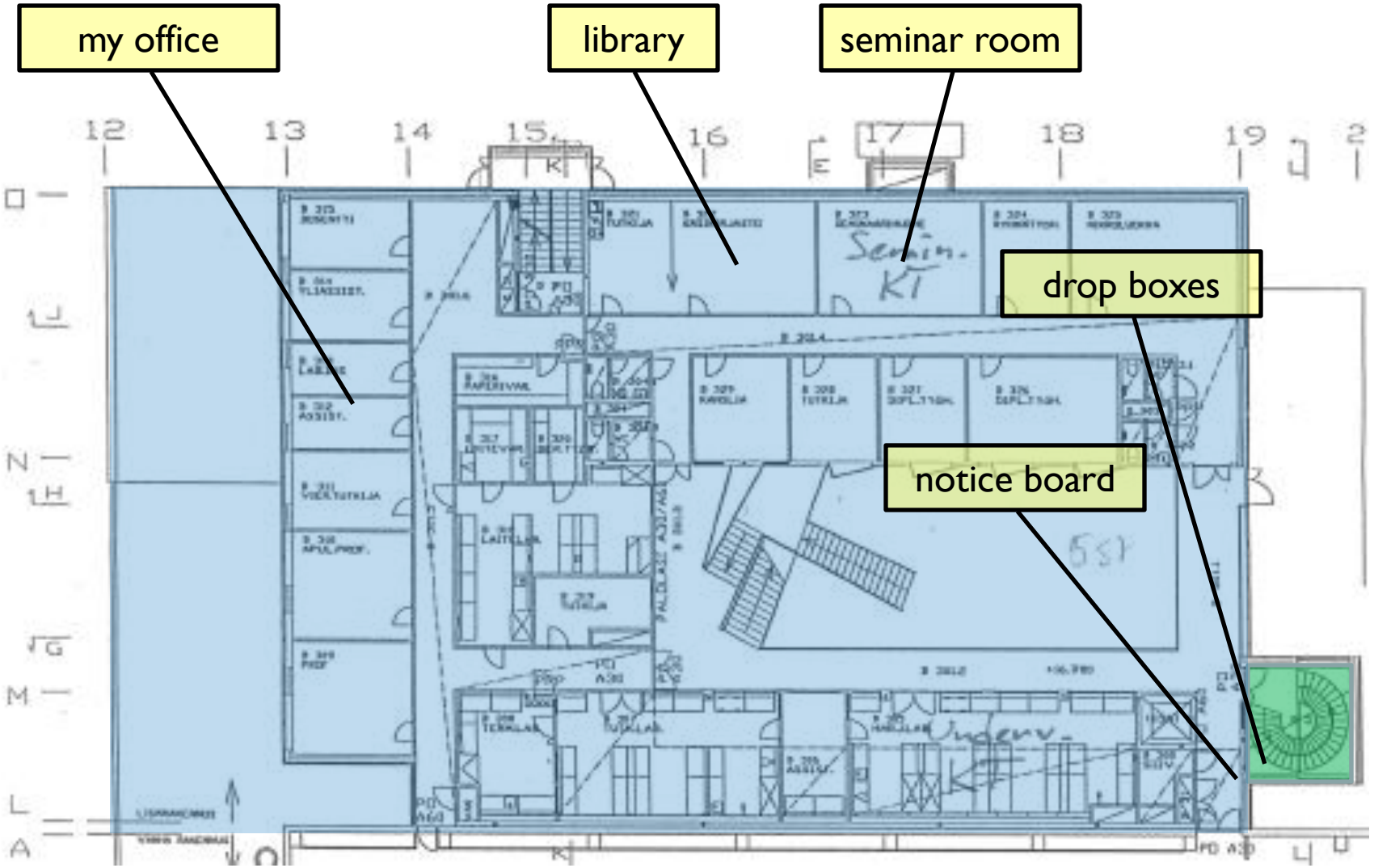
- Course info
  - Schedule
  - Compendium
  - Exercise assignments
  - Additional reading

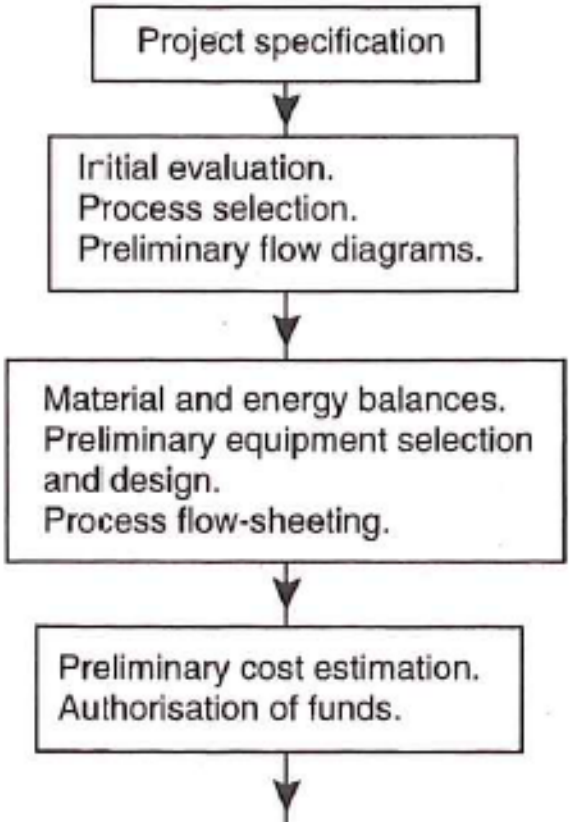
    ebrary



http://web.abo.fi/tkf/at/Courses

Axelia II 3rd floor – Process Design and Systems Engineering





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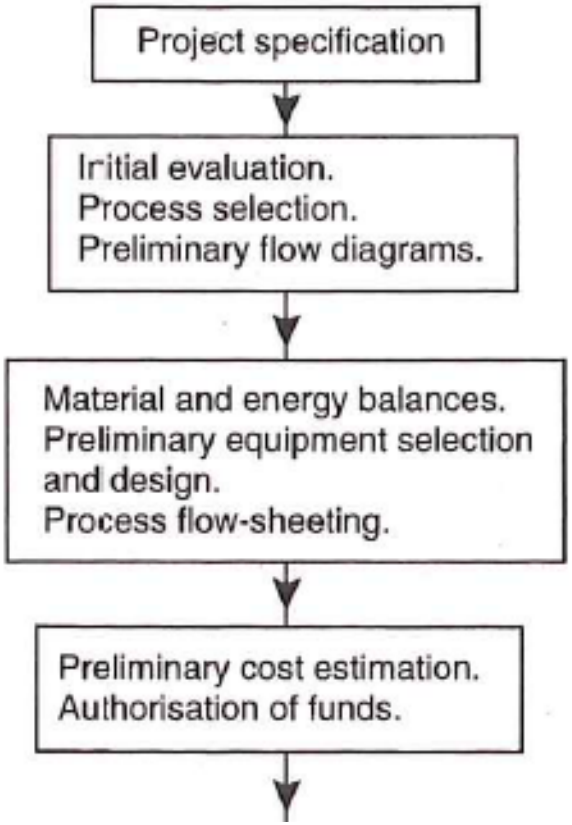
Specification

- Production of 150000 ton/year ammonia (NH_3)
- 8000 h/year operation

- Is this specification reasonable?
  - www.indexmundi.com
  - www.kbr.com



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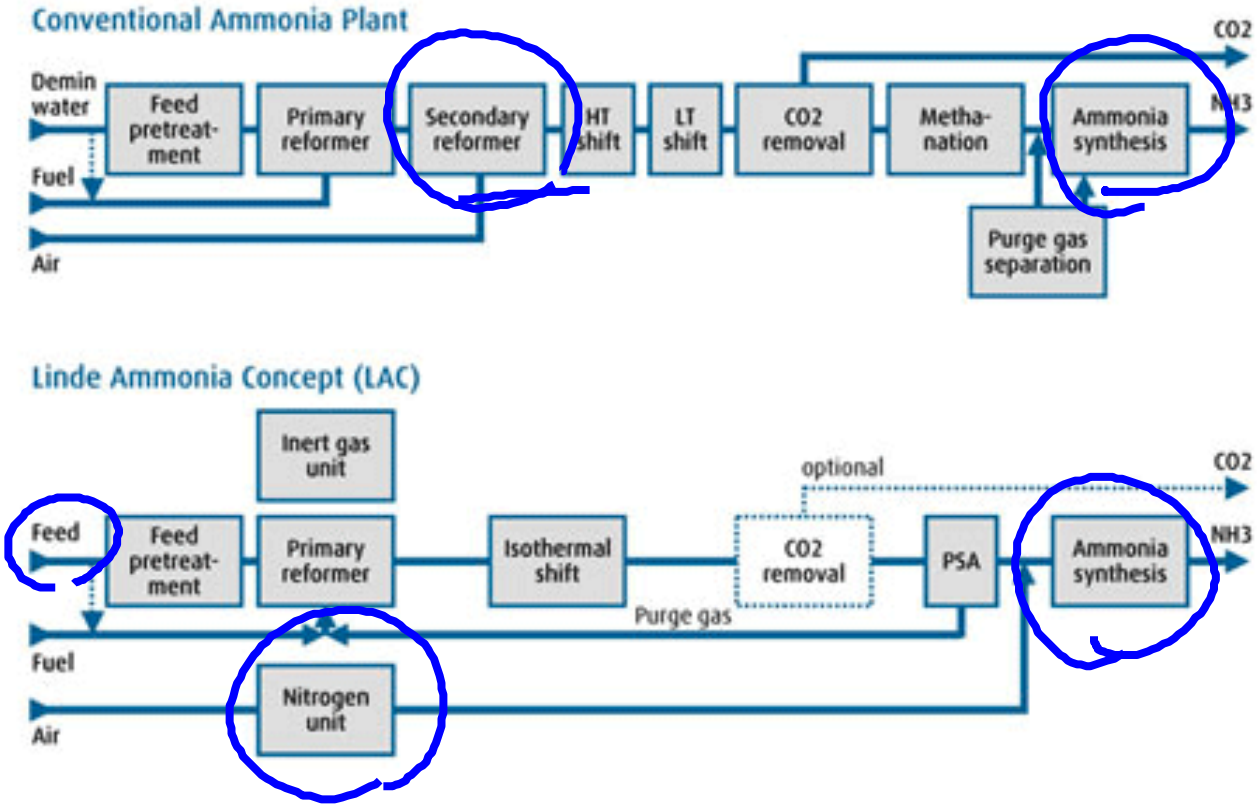
Process comparison of a conventional ammonia plant and Linde Ammonia Concept (LAC)



Source: Linde Engineering (http://www.linde-engineering.com/)

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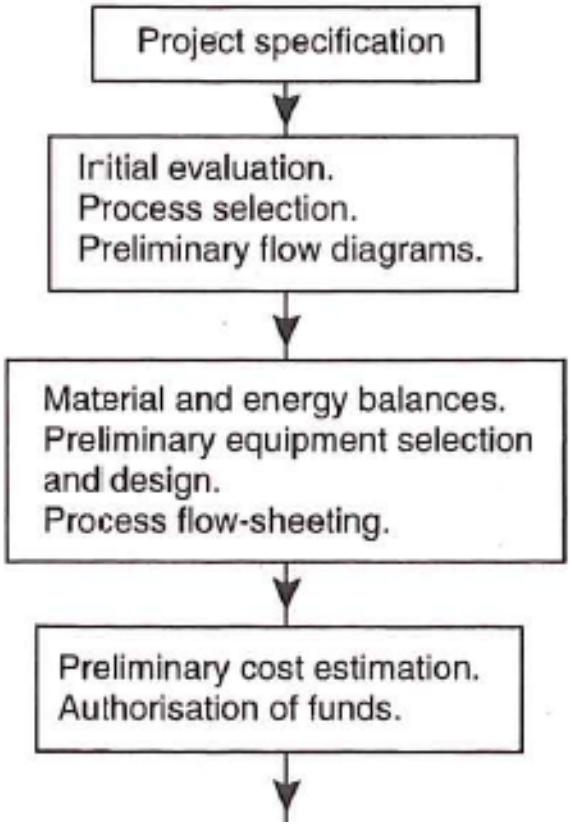
Process selection

- Haber-Bosch
  - Hydrogen from steam reforming of natural gas/petroleum gas/naptha
  - Nitrogen from air distillation
  - Ammonia synthesis in catalytic high pressure/temperature reactor
  - Separation by condensation of ammonia from gases
  - Recycle of unreacted gases



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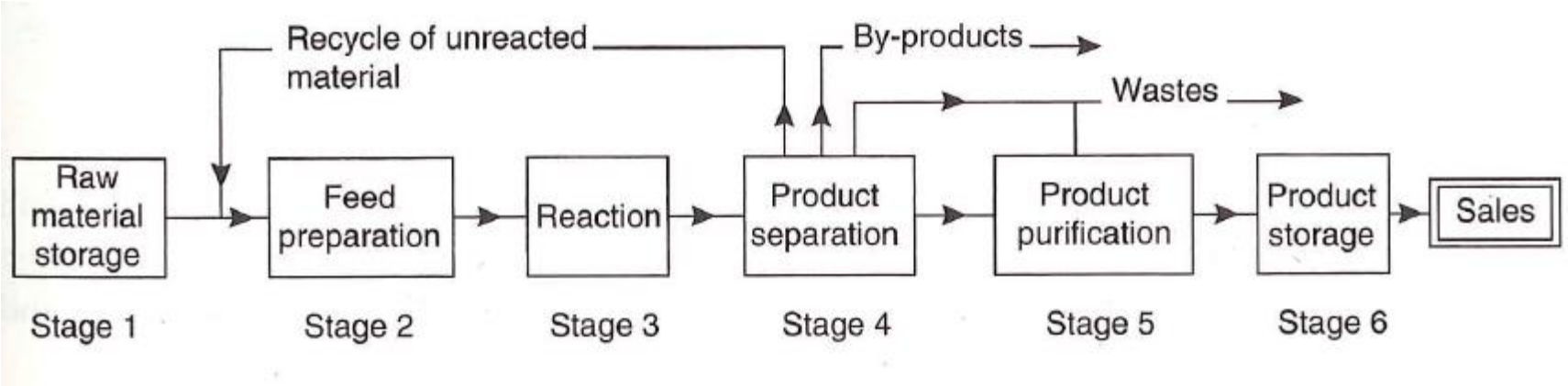
Block flow diagram



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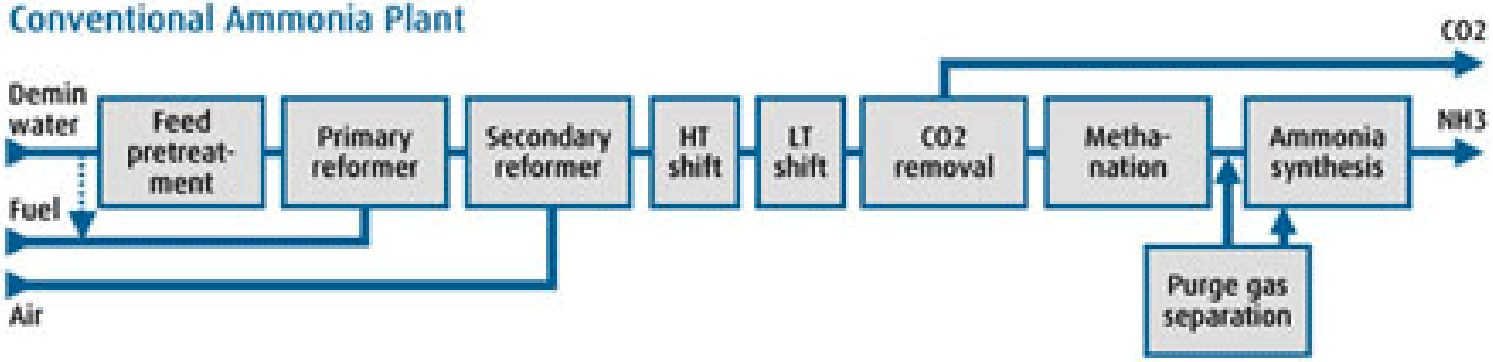
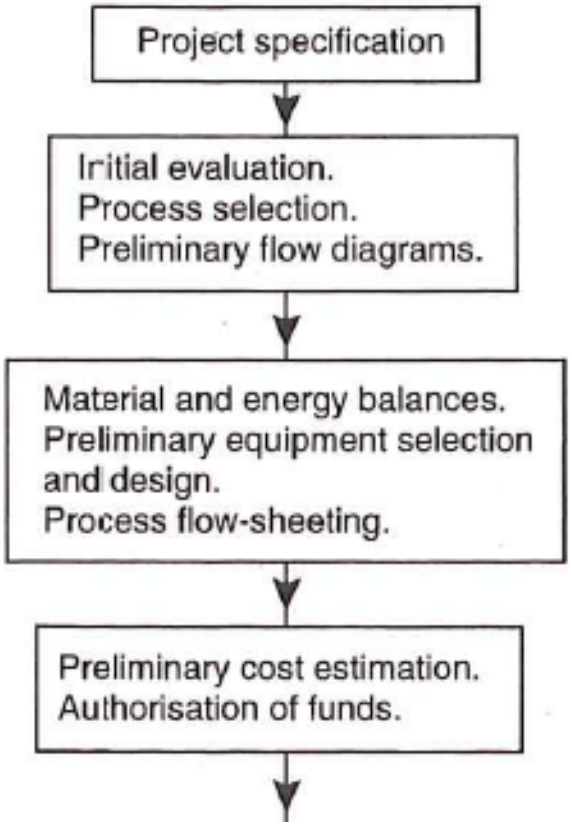
Conventional Ammonia Plant





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Reactors

- Kinetics is used for calculating average residence time τ in reactor (CSTR, plug flow, catalyst filled...)
- Volume flow through reactor, $\dot{V}$, from mass balances
- Reactor volume

$$V = \dot{V} \cdot \tau$$

- Length/diameter depending on reactor type

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Separation

- Screening, filtering, centrifuging
- Distillation
- Decanting
- Sizing according to type of separation based on mass/volume flow, concetration, particle size...

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Storage

- Volume flows from mass balances
- Delivery by truck, train, pipeline, ship demands intermediate storage
- Buffer storage for short periods of time
- Silos for solids, tanks for liquids and gases...
- Storage volume

$$V = \dot{V} \cdot \tau$$

- Dimensions depend on storage type

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Preprocessing

- Screening, grinding
- Melting, gasifying, freezing
- Mixing

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Transport

- Belt conveyors, screws, pneumatic conveyors etc for solids
- Pipes and pumps for liquids and slurries
- Ducts and fans for low pressure gases
- Pipes and compressors for high pressure gases
- Sized according to type of transport and mass flow

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Heat exchange

- Plate heat exchangers, shell and tube heat exhangers, regenerative heat exchangers

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Instrumentation

- Temperature
- Pressure
- Flow
- Level
- Concentration
- ...
- For control, indication, quality, permit, safety, production

http://v2.centralstory.com/about/squiggle/