Ammonia handling at DTU Energy

Riccardo Caldogno, Anke Hagen, Xiufu Sun

List of contents

- Challenges related to ammonia gas line
- Ammonia supply line
- Failing parts
- Safety measures

Challenges: NH_3 bottles cooling down

1690 W SOC stack

↓ A lot of hydrogen needed

High fuel consumption:
up to 15.5 Nl/min of NH_3 (17 kg/day)

↓

A lot of NH_3 (gas) is taken from the bottle

↓

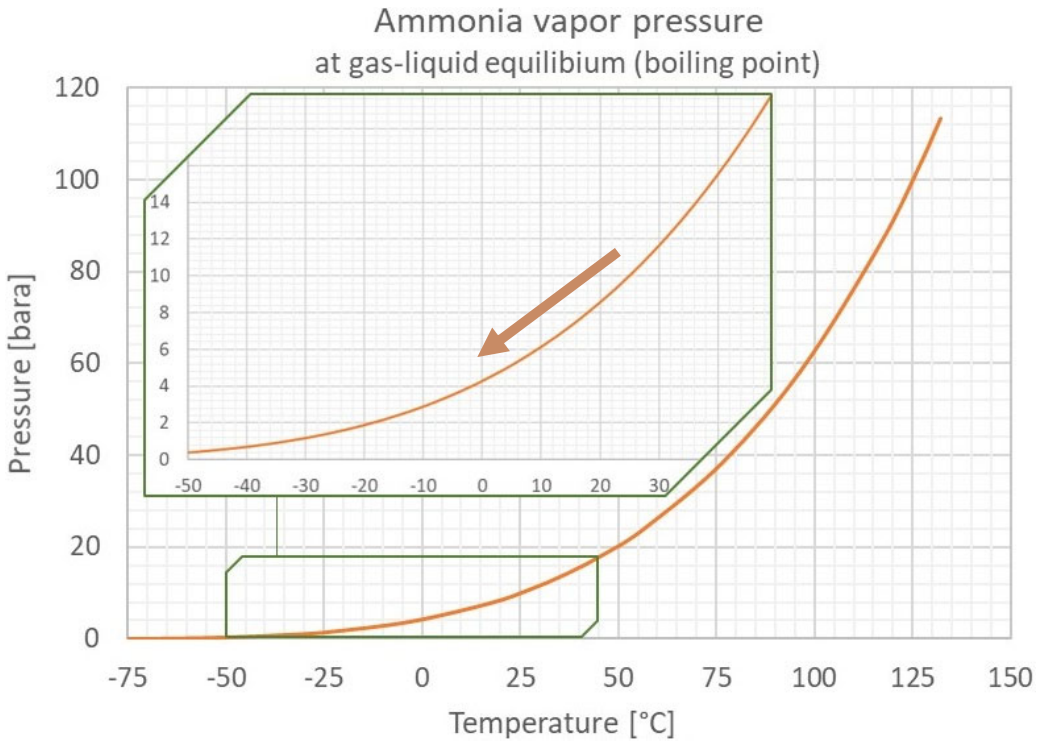
A lot of liquid NH_3 in the bottle switches to gaseous phase (endothermic process)

↓

The NH_3 in the bottle cools down ← Cold weather

↓ Gas-liquid equilibrium

The NH_3 pressure in the bottle drops → The ammonia supply stops if p < 3 bar (min pressure for the MFC to work)



SOLUTION → heating blankets to keep the NH_3 bottle warm enough

Challenges: condensation

The heating blankets could get too warm

↓

The NH_3 T and p in the bottles become too high

↓

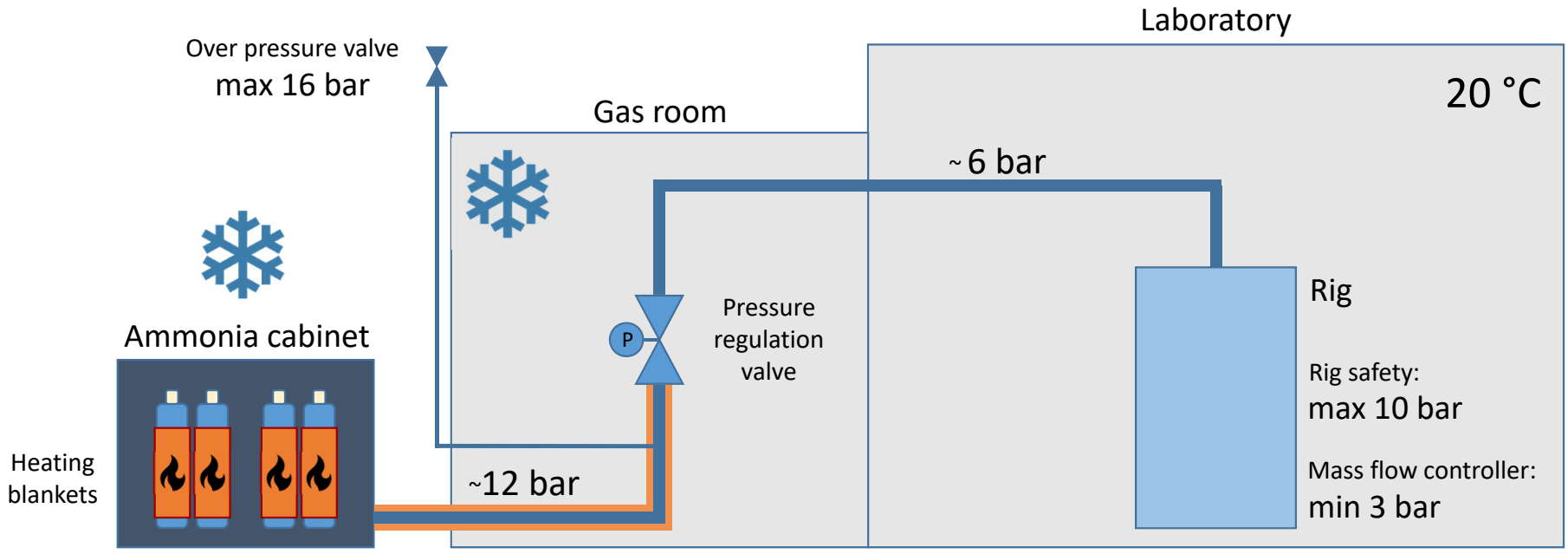
1_ the rig safety alarm triggers if p > 10 bar (max pressure allowed for the ammonia in the rig)

2_ NH_3 can condensate in the pipes of the lab if they are at a T lower than the one of the bottles → Risky for the MFC

3_ the NH_3 flowing through the MFC expands a lot (~ 9 bar → ~ 1 bar), cooling down significantly (when it happened to us, the NH_3 pipe was covered with frost) and condensing → Too cold gas (or even liquid) to the stack

SOLUTION → pressure regulation valve, to keep the pressure (and temperature) inside the pipes at acceptable values

NH_3 supply line



NH_3 supply line

ure valve
6 bar

Ammonia cabinet

P

~12 bar

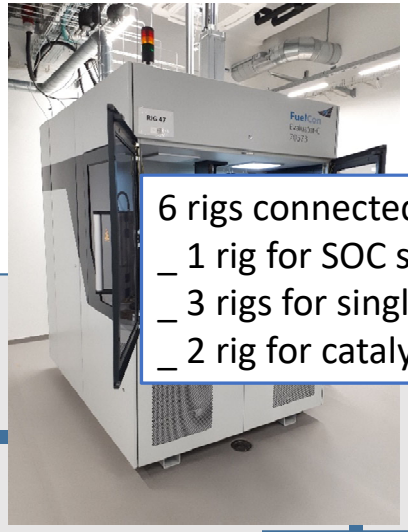
Rig

Rig safety:
max 10 bar

Mass flow controller:
min 3 bar

NH_3 supply line

ure valve
6 bar



6 rigs connected to NH_3 line:
_ 1 rig for SOC stack testing
_ 3 rigs for single-SOC testing
_ 2 rig for catalysts testing

Ammonia cabinet

P

~12 bar

Rig

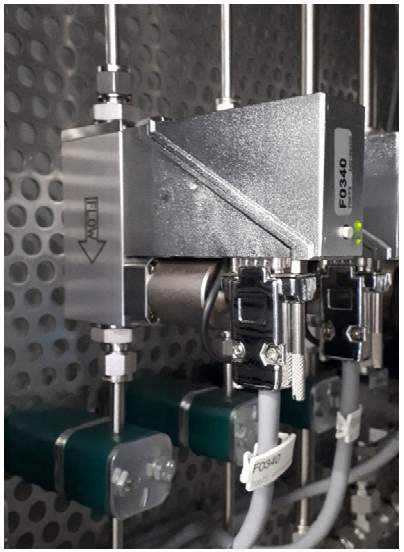
Rig safety:
max 10 bar

Mass flow controller:
min 3 bar

Failing parts

Broken magnetic valve

Mass flow controller



Ammonia is quite aggressive against some materials, so it is important to install valves and mass flow controllers made of materials suitable for such gas

Safety measures

_ protections to use while working with the ammonia gas line

Mask and air bottle

Protective apron

_ ammonia sensors placed on the lab ceiling and inside the rigs to detect leakages

_ over pressure valve, to discharge ammonia to the atmosphere if the pressure is dangerously high

_ door safety alarms in the rig: if NH_3 is used and the door of the rig opens, the flow of NH_3 is stopped automatically

Summary

- powerful and well-functioning ammonia infrastructure that allows a stable supply for testing of cells, stacks and catalysts, even with high flow rates
- reliable instruments (valves and MFC) that allow long-term testing
- strict safety measures for a secure work environment