TECHNOLOGY CENTRE MONGSTAD

The Third MEA Campaign at the CO_2 Technology Centre Mongstad

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CO_2 Technology Centre Mongstad (TCM DA)

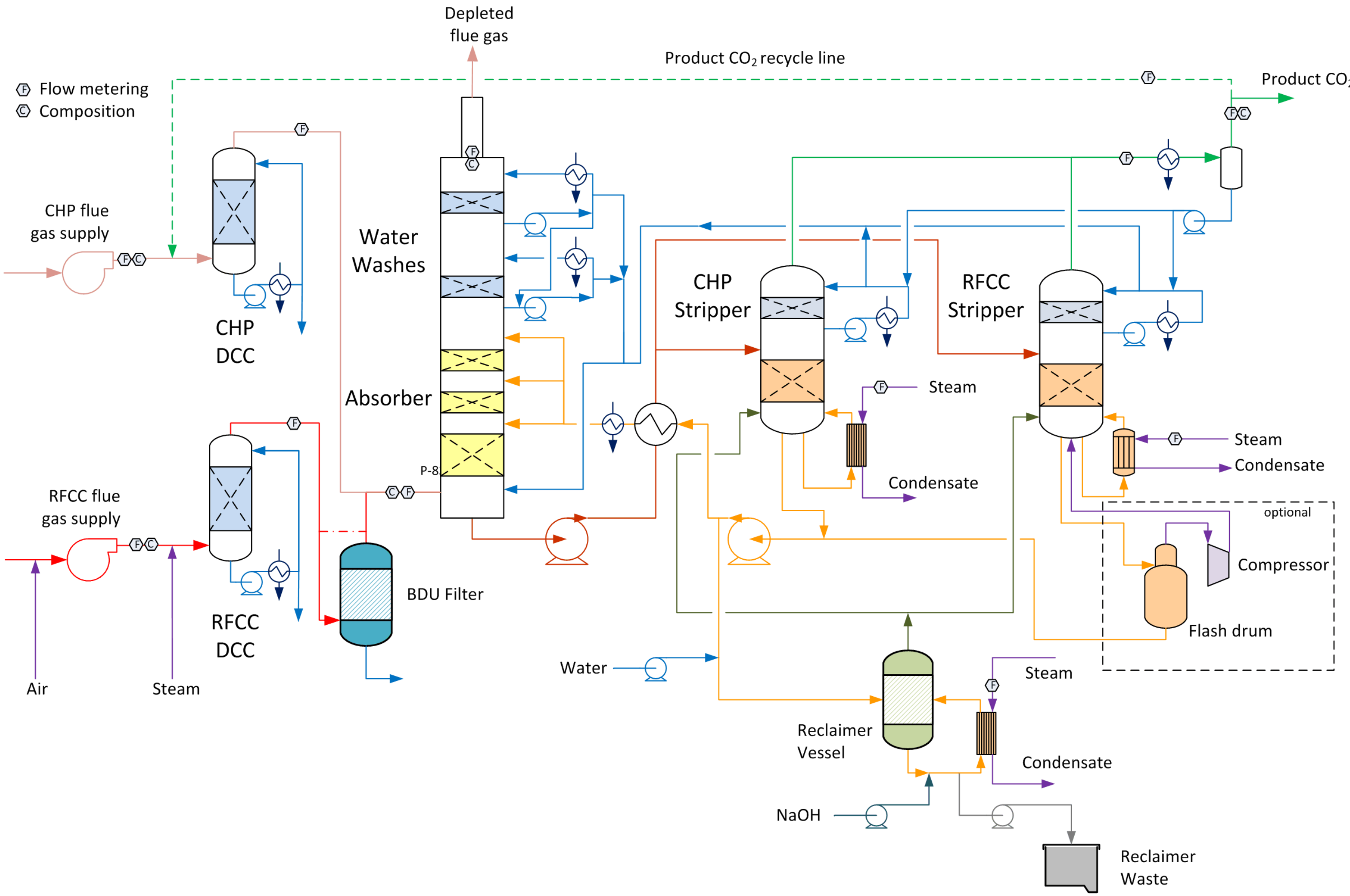
Located at the Mongstad industrial site:

Generic amine amine plant designed and constructed by Aker Solutions and Kværner.

Oil refinery (flue gas with ~13% CO_2) and gas fired power plant (flue gas with ~3.5% CO_2) available.

TCM Owners: Gassnova (Norwegian state), Statoil, Shell, Total:

New participant agreement with operations for 3 more years (Aug 2017 – Aug 2020).


Depleted flue gas
Product CO_2 recycle line
Flow metering
Composition
Product CO_2
CHP flue gas supply
Water Washes
CHP DCC
CHP Stripper
RFCC Stripper
Absorber
Steam
P-8
Condensate
Steam
Condensate
RFCC flue gas supply
optional
Compressor
RFCC DCC
BDU Filter
Flash drum
Water
Steam
Air
Steam
Reclaimer Vessel
Condensate
NaOH
Reclaimer Waste

MEA-3 Approach and Targets

Approach:

1. follow (as much as possible) industrial approaches

2. existing guidelines for running CO_2 absorption amine plants

Targets:

MEA-3 aims to produce data and information that are relevant to realization of the full-scale CO_2 capture plants.

Business Significance of MEA Baselines: How They will be Used by Vendors?

- Measure
- Compare
- Diagnose
- Improve
- Optimize

Research Significance of MEA Baselines: How does it accelerate CCS?

- Development of plant control schemes
- CO_2 product composition for CO_2 storage and EOR
- Workplace monitoring
- Corrosion monitoring
- Emission monitoring & control techniques
- Flue gas composition and impurities
- Flue gas pretreatment
- Column flow distributions and mass transfer
- Detailed degradation mechanisms & inhibition
- Impact of dynamic operations

MEA Campaigns 2013-2017

MEA-1 Highlights

- Dec 2013 – Feb 2014
- Aker Solutions campaign

- Plant commissioning (in practice)
- CHP baseline established at capacity of 47.000 Sm3/hr and 4.1 GJ/t CO2
- Emission profiles and degradation mechanisms established

MEA-2 Highlights

- Jun 2015 – Oct 2015
- TCM campaign

- Commissioning of the instrumentation project
- CO_2 mass balance closure
- CHP baseline revisited and re-established at the full capacity of the amine plant and 3.6 GJ/t CO2

MEA-3 Major Goals

- Jun 2017 – ongoing
- TCM campaign

- **WP A:** Reduction in CO_2 avoided cost by parameter investigations
- **WP B:** Reduction in technology gaps
- **WP C1:** Reduced energy and operational costs by model predictive control (Climit Demo: DOCPCC)
- **WP C2:** Process parameters impact on aerosol emissions and RFCC baseline (Climit Demo: AeroSolve)
- **WP D:** Reduced energy penalty and flexible operation (Academic collaboration)

MEA-3

WP B: Technology Gap Closure (ongoing)

WP C1: DOCPCC Climit Demo (operations completed)

WP C2: Aerosolve Climit Demo (ongoing)

WP D: Academic collaborations (operations completed)

WP A: Reducing the Cost of Carbon Capture (not started)

Started **June 12**, MEA-3 will be operated at minimum length until **October 31**

Priority of MEA3:

WP C1: DOCPCC

WP C2: Aerosolve

Collaboration Partners:

Statoil (Industry)
Shell (Industry)
Sasol (Industry)
Total (Industry)
Gassnova (Public)
US DOE NETL (Public)
SINTEF (Research)
TNO (Research)
NTNU (Academia)
Imperial College (Academia)
DTU (Academia)
University of Oslo (Academia)
Cybernetica (Industry)
The ROAD project
Engie (Industry)
Uniper (Industry)

Preliminary highlight results

WP B Technology Gap Closure:

Amine degradation is a major disadvantage of MEA as an absorbent for CO_2 removal

Injection of $KHSO_3$ oxygen inhibitor for reduced MEA degradation → lower MEA degradation during operations with high O_2 flue gas (gas turbine)

WP C2 Aerosolve Climit Demo:

Aerosols has caused inherent and unacceptable amine emissions during previous carbon capture work, at TCM and elsewhere.

Previous installation of a Brownian diffusion filter has now allowed for CO_2 removal from refinery flue gas

MEA degradation inhibitor

- Injection of $KHSO_3$ (potassium bisulfite)
- $SO_3^{2-} + \frac{1}{2} O_2 \rightarrow SO_4^{2-}$

	NH_3 emissions	Heat stable salt (excl. SO_4^{2-}) and degradation products
Without inhibitor	~ 20 ppm	~ 1 (normalized)
With inhibitor	~ 2 – 3 ppm	~ 1/10 (relative to normalized)

- Degradation from 1.5 kg MEA/ton CO_2 to about *X* kg MEA/ton CO_2 (to be assessed)
- Injection philosophy;
  - SO_3^{2-} solvent bulk concentration about 500 – 1000 ppm, reaction with O_2 in the film.
  - Use of NH_3 emissions for estimating SO_3^{2-} dosage rates during operations (equivalent to oxygen absorption)
  - Potassium ions used as indicator for total amounts of inhibitor injected
  - Use of reclaimer to remove K_2SO_4 with caustic injection when approaching solubility limits

Aerosolve Climit Demo

- Refinery flue gas (RFCC) contains high amounts of sulfuric acid mist
  - Up to about 10 ppm SO_3 equivalent and some catalyst fines
- Previous operations demonstrated unacceptable amine emissions of about 500 – 1000 ppm
  - Emission permit breaches, neighbor complaints, high loss of amines

- Much resources used to investigate the RFCC flue gas
  - ELPI+ and iso-kinetic measurements
  - 16 – 25 million particles per cm^3, primarily aqueous sulfuric acid mist particles
  - Conducted further investigations;
    - Use of 1000 Sm3 / hr pilot Brownian Diffusion (BDU) filter
    - Mixing of RFCC flue gas into gas turbine (CHP) flue gas for determining relation between particle amounts and emissions

- Investment decisions for a full scale BDU filter installation taken by TCM owners
  - Stable pressure drop of about 25 mbar across filter, no indications of clogging
  - 0.5 millions particles / cm^3 downstream filter
  - Design 35.000 Sm^3/hr, total installation costs about 10 MNOK (1.2 MUSD)

Aerosolve Climit Demo

Thank you for your attention!!!

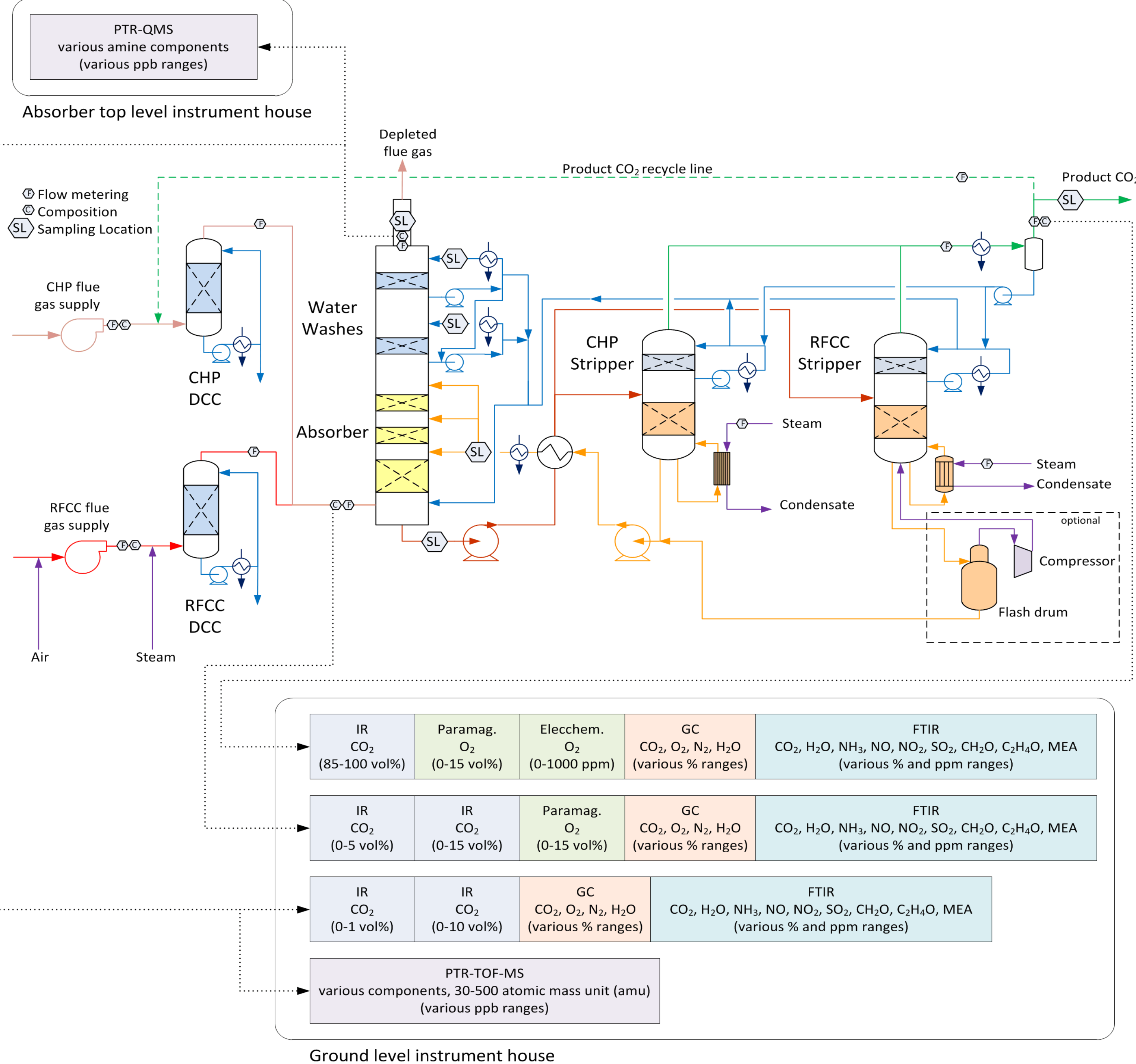
Acknowledgments to TCM DA owners

GASSNOVA

Statoil

sasol
reaching new frontiers

TOTAL



PTR-QMS
various amine components
(various ppb ranges)
Absorber top level instrument house
Depleted
flue gas
Product CO₂ recycle line
Product CO₂
Flow metering
Composition
SL Sampling Location
SL
CHP flue
gas supply
CHP
DCC
Water
Washes
Absorber
CHP
Stripper
RFCC
Stripper
Steam
Condensate
Steam
Condensate
optional
Compressor
Flash drum
RFCC flue
gas supply
RFCC
DCC
Air
Steam
IR
CO₂
(85-100 vol%)
Paramag.
O₂
(0-15 vol%)
Elecchem.
O₂
(0-1000 ppm)
GC
CO₂, O₂, N₂, H₂O
(various % ranges)
FTIR
CO₂, H₂O, NH₃, NO, NO₂, SO₂, CH₂O, C₂H₄O, MEA
(various % and ppm ranges)
IR
CO₂
(0-5 vol%)
IR
CO₂
(0-15 vol%)
Paramag.
O₂
(0-15 vol%)
GC
CO₂, O₂, N₂, H₂O
(various % ranges)
FTIR
CO₂, H₂O, NH₃, NO, NO₂, SO₂, CH₂O, C₂H₄O, MEA
(various % and ppm ranges)
IR
CO₂
(0-1 vol%)
IR
CO₂
(0-10 vol%)
GC
CO₂, O₂, N₂, H₂O
(various % ranges)
FTIR
CO₂, H₂O, NH₃, NO, NO₂, SO₂, CH₂O, C₂H₄O, MEA
(various % and ppm ranges)
PTR-TOF-MS
various components, 30-500 atomic mass unit (amu)
(various ppb ranges)
Ground level instrument house