De-nox Solutions

FLOWVISION®

QUALITY SYSTEM CERTIFICATION
DNV·GL
ISO 9001
DNV GL BUSINESS ASSURANCE DENMARK A/S

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Flowvision offering

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Flowvision products and markets

- Engineering, manufacture and commissioning of de-nox systems:
  - Selective Non Catalytic Reduction equipment
  - Selective Catalytic Reduction High/Low dust equipment
  - Consulting
  - Service, maintenance and remote optimisation
- Markets:
  - Thermal energy plants:
    - Biomass
    - EfW
    - Conventional coal, oil and natural gas
  - Refineries on shore and offshore
  - Cement plants
- Worldwide

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Flowvision key competences

- Skilled and experienced:
  - Highly qualified employees
  - Experience in delivering systems from order to commissioning
  - Extensive reference list
- Flexible solutions:
  - Systems build to Flowvision standards
  - Systems build to customer specifications and standards
  - Qualified and competitive sub-suppliers
  - Service and consulting
- Design and manufacture according to selected quality standards and certification
  - ISO 9001 certified
  - Other standards e.g. EN 12952-14

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Partnering with Flowvision

- Reliable solutions:
  - Meeting emissions requirements
  - Robust technology
  - Low CAPEX and operational costs
  - Fully automated
- Know-how and efficient processes:
  - Collaborating with costumers to lower the CAPEX and the operational costs
  - Knowledge of standards employed and their impact on de-nox – systems design and selected devices
  - Access to network of sub-suppliers and partners in flue gas cleaning
  - Efficient project execution
- Dedicated to make our customers successful

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Partnering with Flowvision

- Flexible scale of partnership:
  - Consulting
  - From one project to the next
  - Partnering on orders for entire flue gas cleaning systems
  - Outsourced center of competence for de-nox systems
- Preferred terms and conditions:
  - Cash flow neutral
  - Two year warranty from delivery
  - Flowvision standard equipment and/or EN and ISO standards to reduce complexity and costs
  - EXW or DAP

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Selected references

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Selected references

Plant	Client	Reagent
Hooton, UK, WfE, 2xSNCR	Leroux & Lotz	Ammonia solution
Randers, Denmark, biomass boiler 2xSNCR	Verdo	Ammonia solution
Merida, Spain, biomass boiler, 1xSNCR	Fivemasa	Ammonia solution
Veolia, The Netherlands, biomass boiler 1xSNCR	Stork	Urea solution
Nalco, India, Heat recovery boiler 1xSNCR	Thermax	Ammonia solution
Hinnerup, Denmark, straw boiler 1xSNCR	AEA	Ammonia solution
BIOMCN refinery, The Netherlands 2xSCR	Stork	Ammonia solution
Solvay, Torrelavega, Spain 2xSCR	Solvay	Ammonia solution
Kent, UK, biomass boiler, 1xSNCR	BWSC	Ammonia solution
Centrica, UK, 2x gas turbine, 1xSCR	British Gas	Urea solution
Cramlington, UK, biomass boiler, 1xSNCR	BWE	Ammonia solution
Amagerforbrændingen, Denmark, WtE Plant, 2xSCR	B&W Vølund	Ammonia solution

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SNCR - Selective Non-Catalytic Reduction

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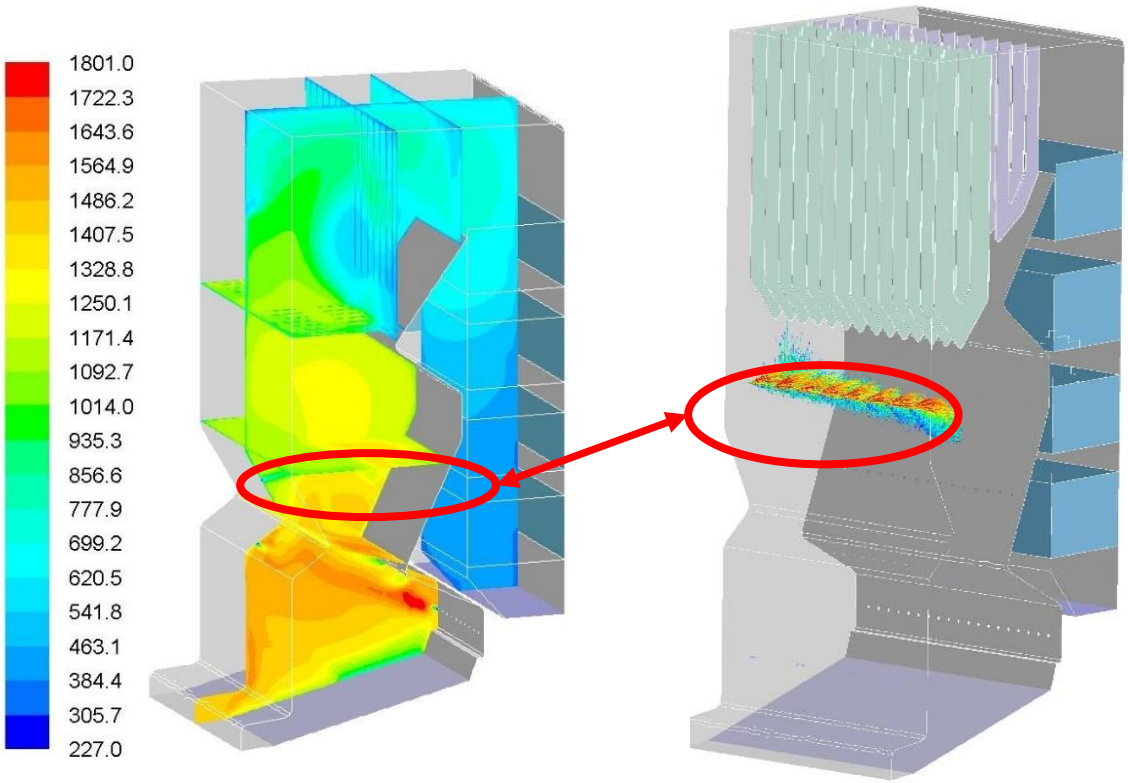
SNCR – optimal temperature range and efficiency

SNCR involves injecting a reagent (ammonia or urea) into the flue gas at a temperature range from 850°C to 1100°C.
The efficiency ranges typically between 30% and 70% emissions reduction.



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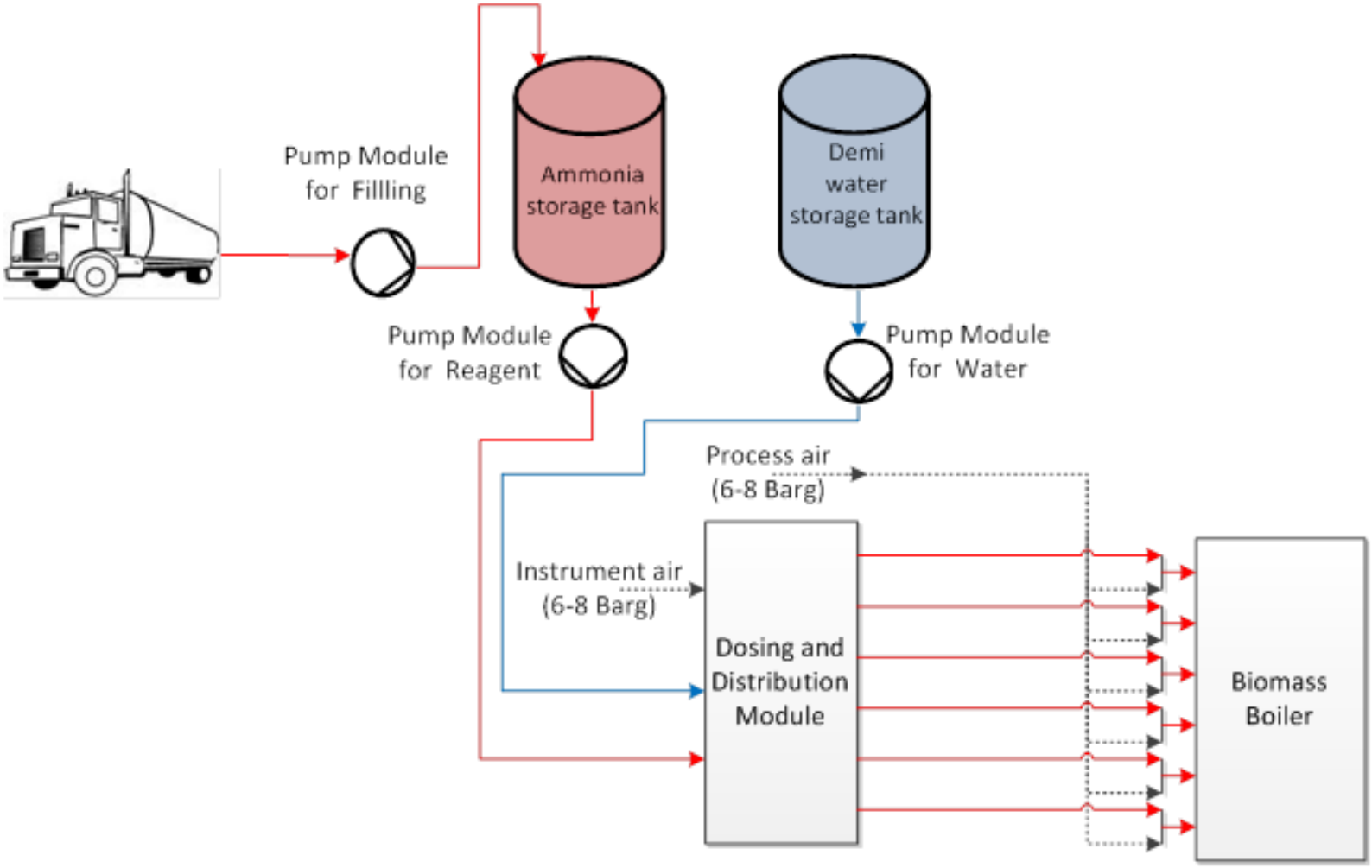
Typical Scope of Supply



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Pump Module for Filling (PMF)

Installation example of a Pump Module for Filling (PMF) with flexible hoses one for filling and one for vapour return.

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Reagent Storage Tanks

Example of vertical double walled stainless steel tanks placed in a concrete catch basin.

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Pump Module for Reagent or Water (PMR - PMW)

The module shown is equipped with dual pumps in redundant configuration.

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Dosing and Distribution Module (DDM)

DDM for measuring and control of the necessary flow during the actual operating conditions assembled in cabinet.

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SNCR Advanced Twin Fluid Lances (ATF)

FlowVision offers its extensive injection knowhow regarding lances design and spray patterns.

The Advanced Twin Fluid (ATF) technology provides the following advantages:

- Low air consumption.
- High fluid penetration capability (High impulse injectors)
- 22mm, 16mm & 10mm outer diameters.
- Optimized spray coverage of a cross sectional area generating any desirable spray pattern matching the application.

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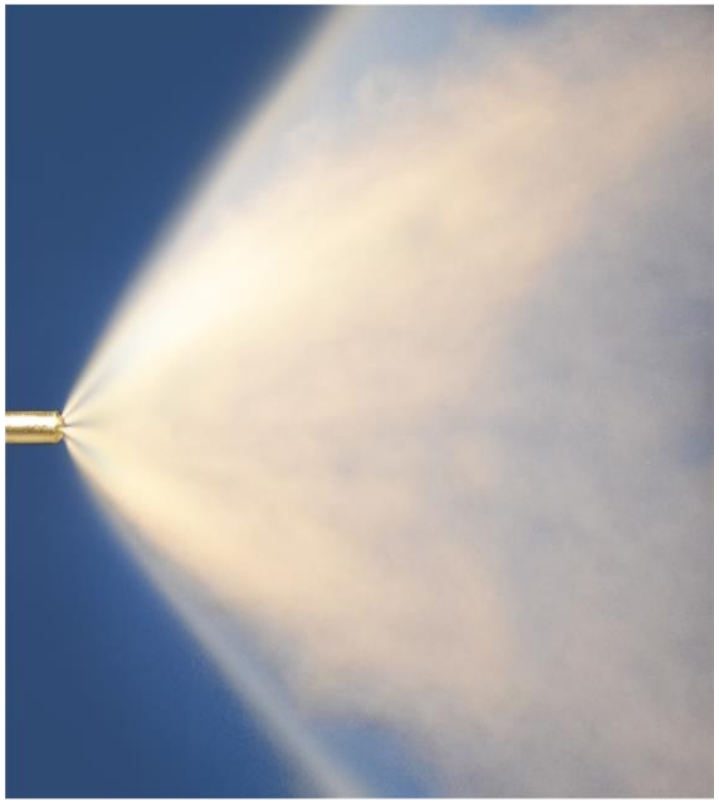
SNCR Injection Technology:

FlowVision can adjust the spray pattern for each application and thereby secure best possible coverage.



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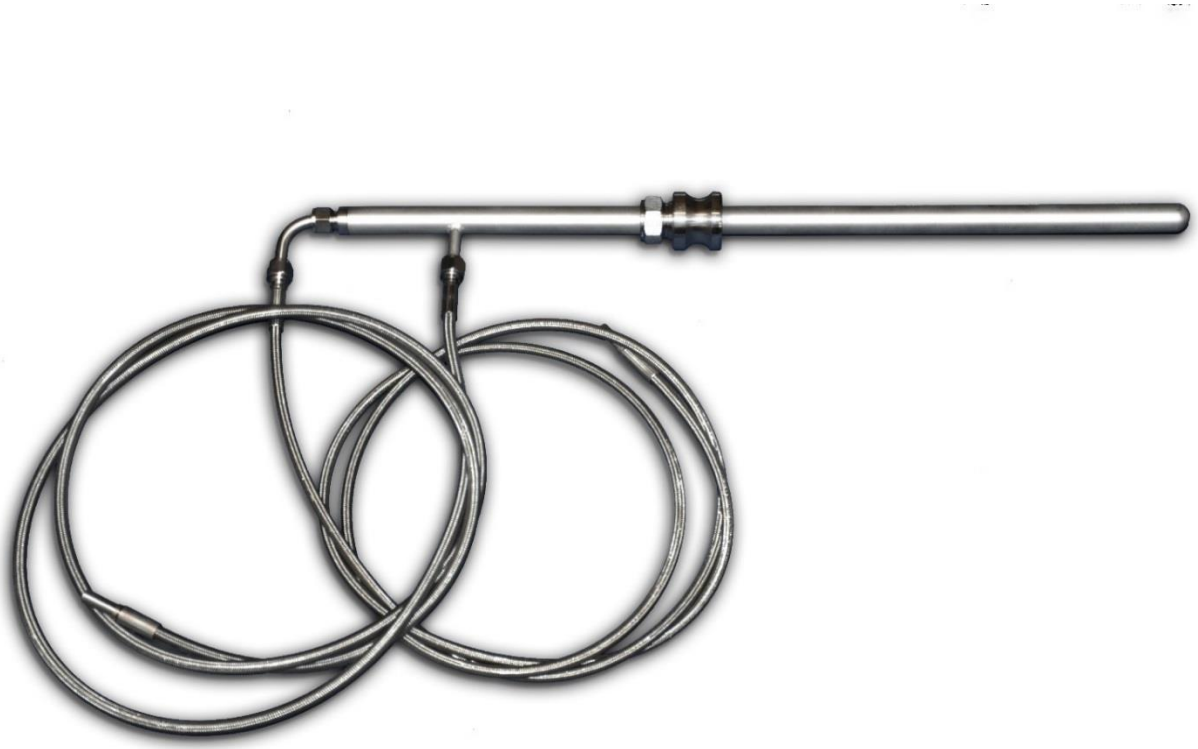
SNCR Advanced Twin Fluid Lances (ATF)



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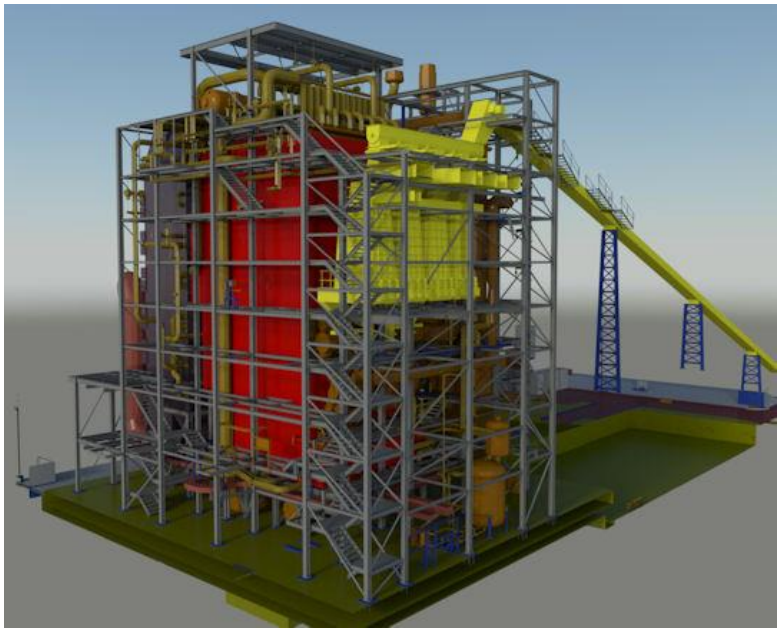
50 MW biomass Boiler SNCR example

2 SNCR systems for Cramlington & Kent, UK - CHP Biomass Boilers



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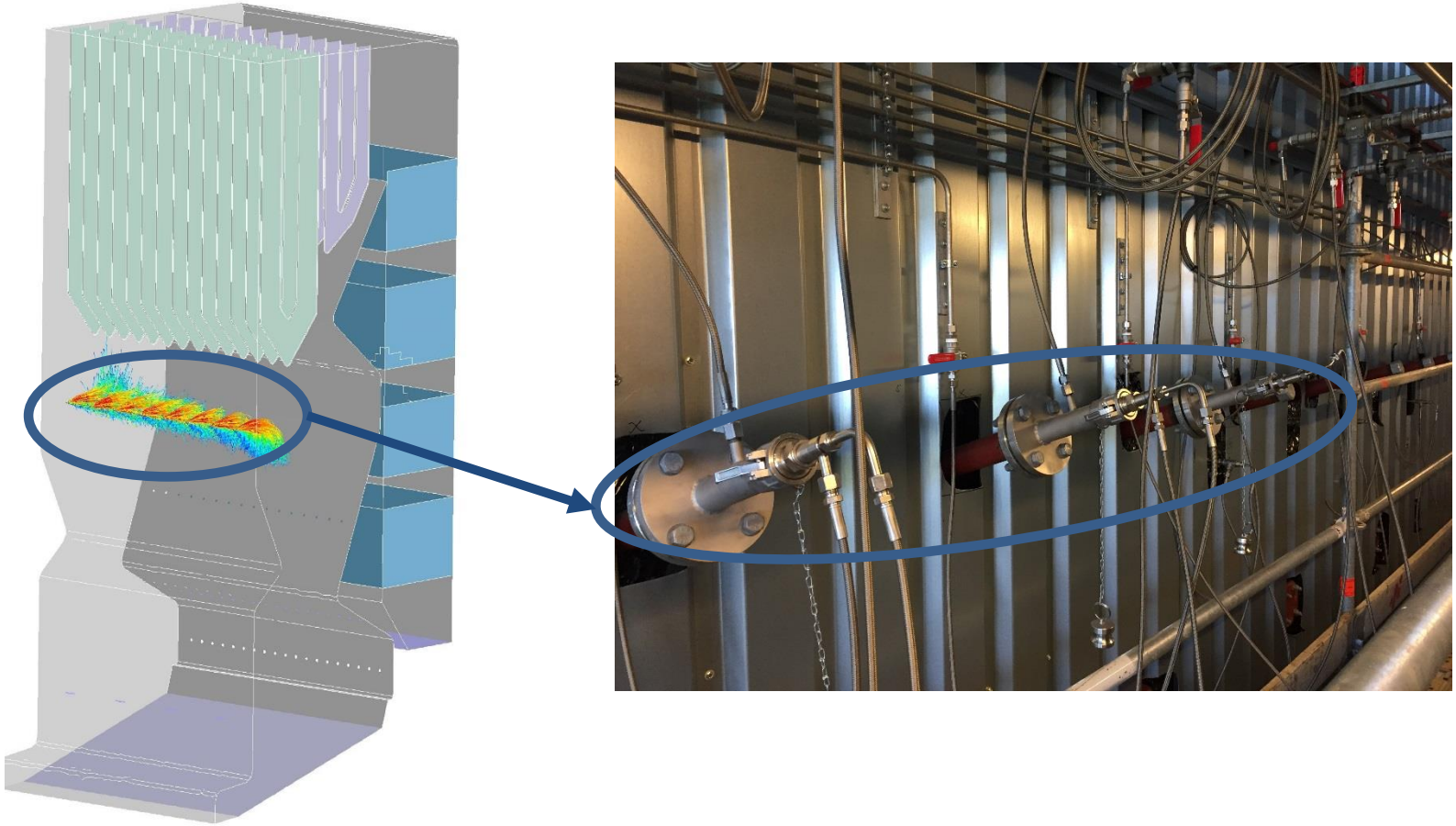
50 MW biomass Boiler SNCR example

CFD is used for optimum lances location and configuration.



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50 MW biomass Boiler SNCR example

Flue Gas Flowrate:	116,280 Nm^3/hr
Inlet NOx:	360 mg/Nm^3 @ 6% O_2 dry
NOx Downstream SNCR:	<250 mg/Nm^3 @ 6% O_2 dry
NH3 Slip:	8mg/Nm^3 @ 6% O_2 dry
Reagent:	Ammonia solution

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SCR - Selective Catalytic Reduction

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SCR – optimal temperature range and efficiency

SCR involves injecting either an ammonia or urea reducing agent into the flue gas where a temperature of between 200◦C - 550◦C exists.

The major difference with SCR is that a catalyst is used, which accelerates the chemical reaction and allows it to occur at lower temperatures.

SCR technology is capable of achieving >95% NOx reduction.

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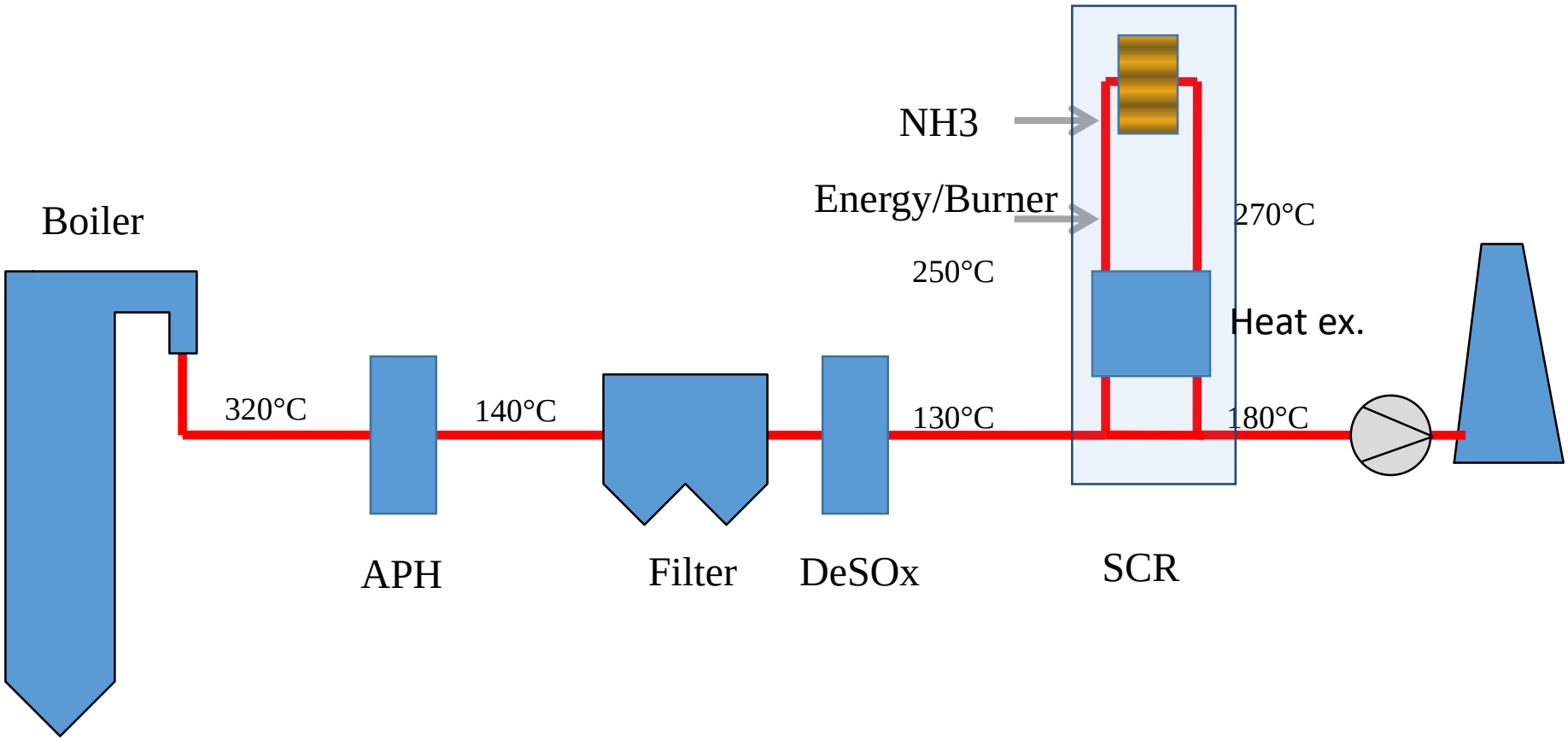
SCR – Low Dust Commonly used in Biomass applications



Low Dust SCR - Connected after dedusting, generally after DeSOx.
Advantage: No dust, smaller catalyst volume, longer catalyst lifetime

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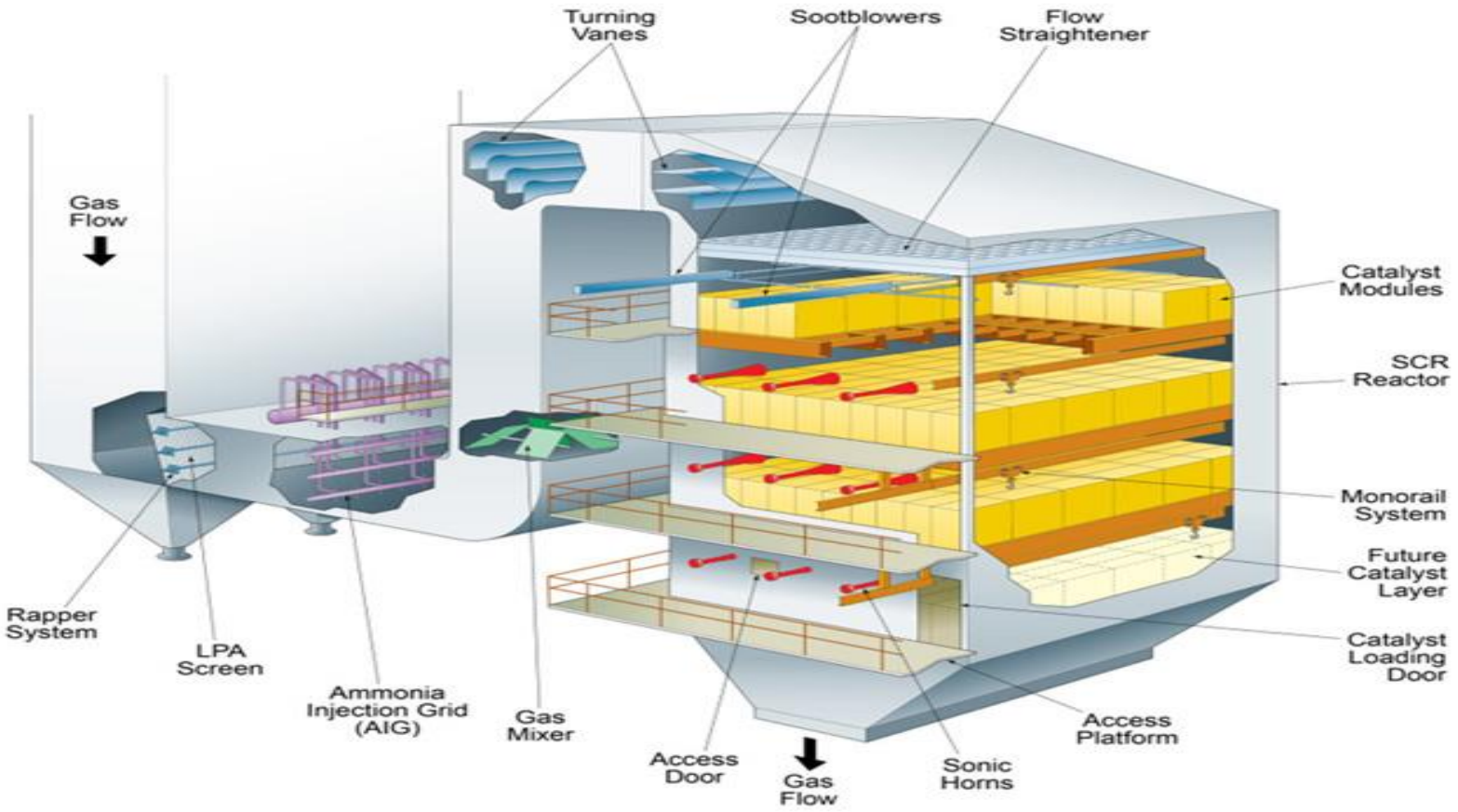
SCR – overview



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Loading of catalyst

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SCR - Injection Systems

Injection of ammonia into the flue gas:

External evaporation:
Evaporation the reagent outside the flue gas ducting applying an AFCU, Ammonia Flow Control Unit and AIG, Ammonia Injection Grid upstream the catalyst.

Direct injection (Lower CAPEX, small footprint):
Direct injection and evaporation of reagent into the flue gas duct using the flow and heat for distribution and mixing.

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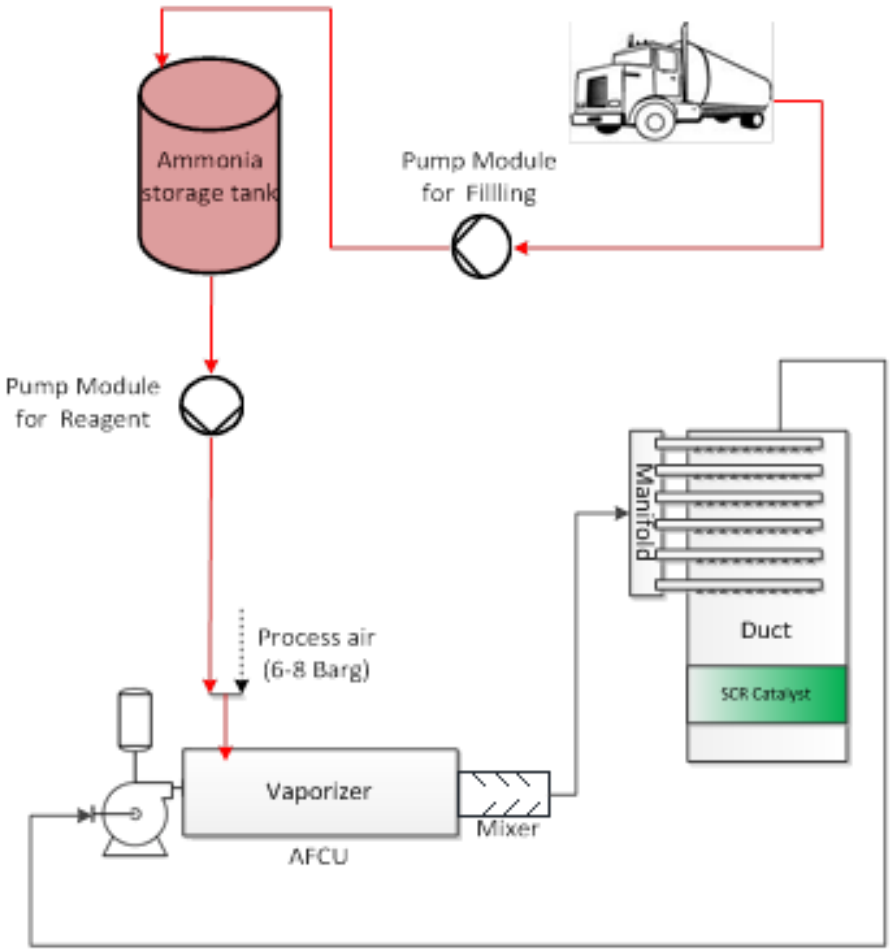
SCR - Injection Systems External evaporation using AFCU



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SCR - Injection Systems External evaporation using AFCU:

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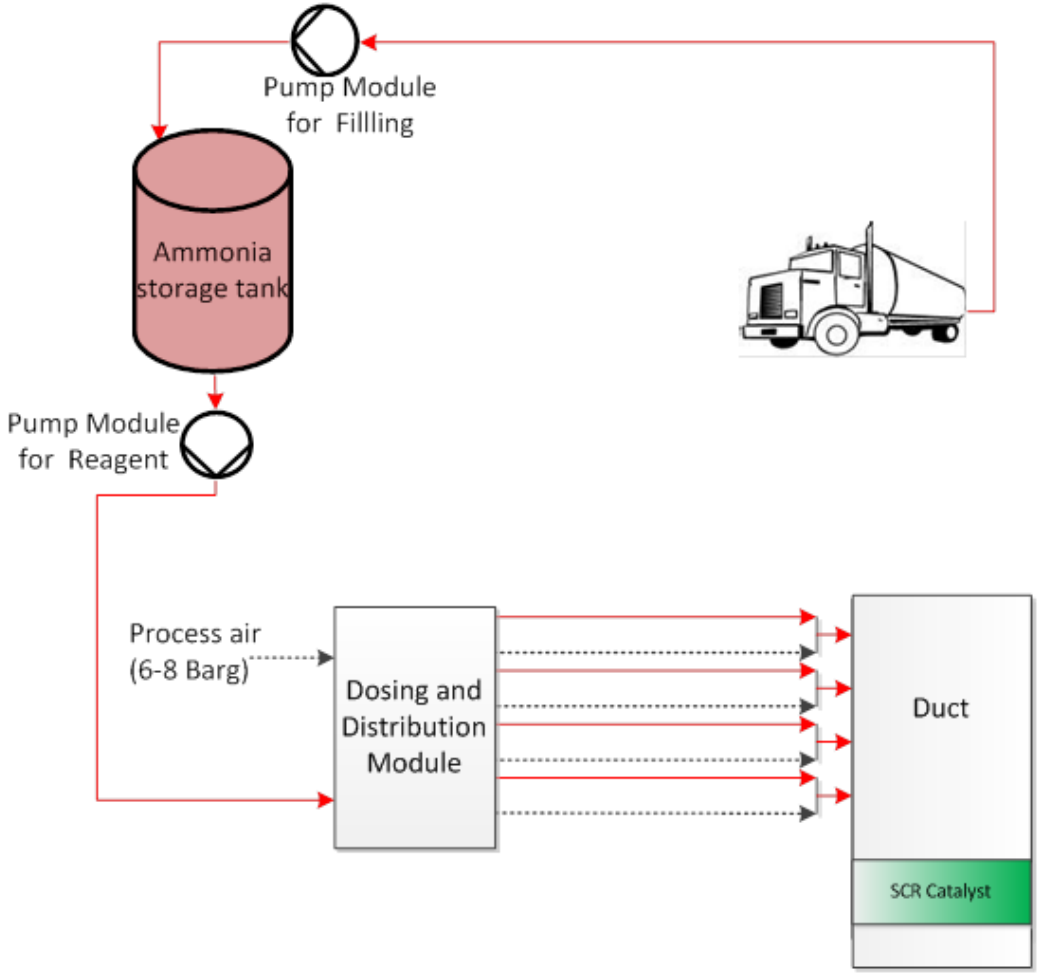
SCR - Injection Systems Direct injection



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SCR - Injection Systems Direct injection example

Babcock & Wilcox Vølund – Amager Bakke, Denmark
2 x 840 tpd WTE
SCR Systems for Waste to Energy Boilers
> 96% NOx Reduction
< 2 mg/Nm3 @ 11% O2 NH3 slip

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SCR - Injection Systems direct injection

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Process Control

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Feedback control system

The volume of reagent injected is governed by a feedback control system relating to the NOx-emissions measurements in the stack / flue gas outlet to the external environment.

The feedback control system increases reagent volume if the emissions are above the set-point and decreases the reagent volume if the emissions are below the set-point.

The feedback control system is run by a PID controller e.g. to avoid overshooting the logic has settings for the size of the increments/changes and the time delay between increments.

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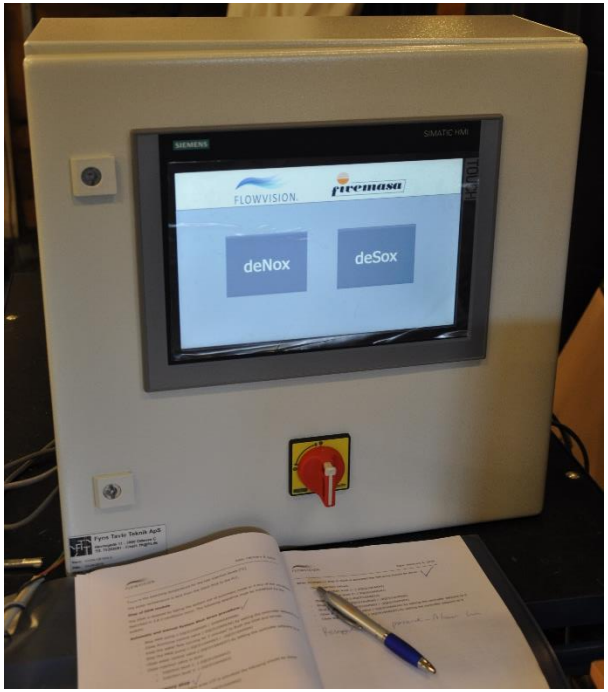
PLC



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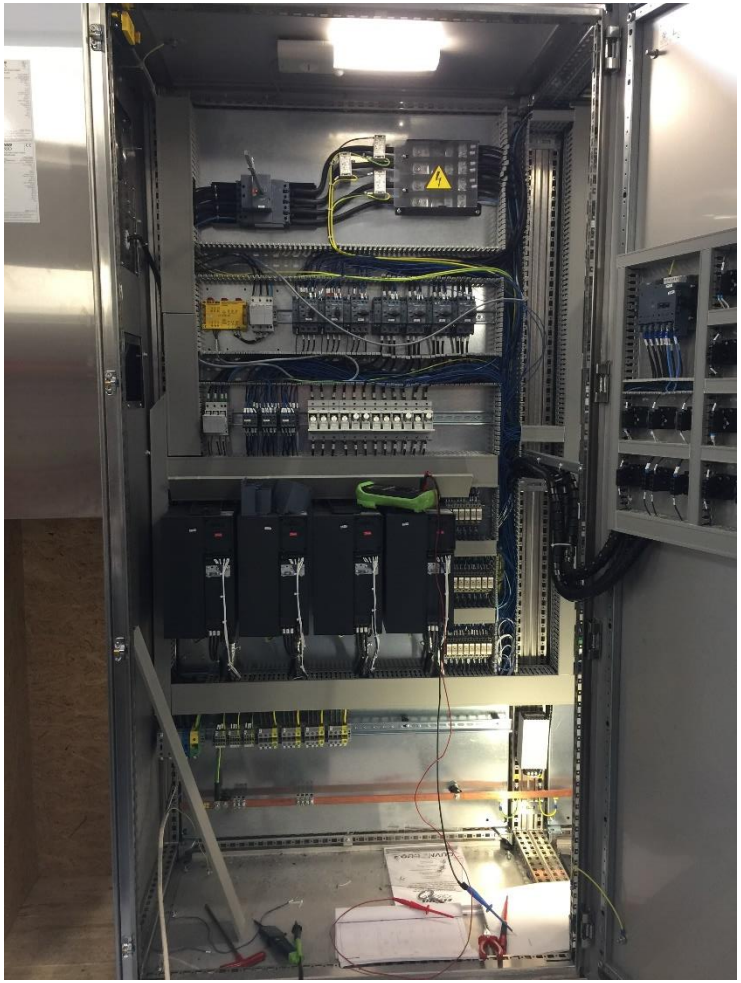
Control cabinet



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CFD calculations and physical flow modeling

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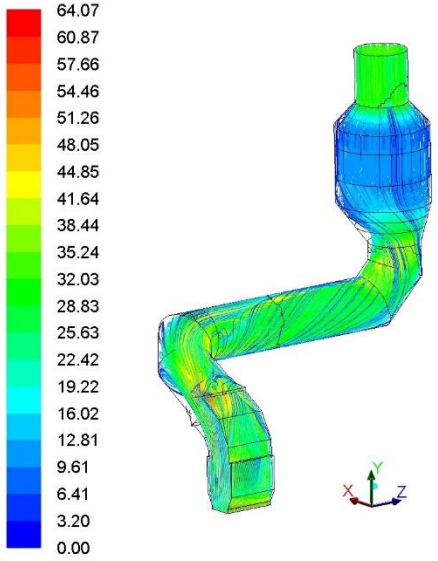
CFD for multiple applications

Flowvision provides flow simulation and engineering services for multiple applications, including CFD design tools to optimize the design of de-nox system.

- Simulations of the flow, droplet distribution and vaporization status.
- Design the flow, pressure and temperature distributions.
- Simulation of combustion process inside a furnace.
- Design criteria to ensure:
  - Sufficiently uniform flow distribution at catalyst inlet
  - Proper ammonia/urea mixing at catalyst inlet
  - Maximum temperature distribution at catalyst inlet
  - Low pressure drop through the system



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Physical Flow Modeling

Flowvision constructs cold flow three dimensional physical models of ducting systems in various scales

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Advantages of Physical Flow Modeling

- A physical flow model enables to test and validate many parameters, including;
  - System arrangement
  - Applicability of flow conditioning devices
  - Reduction of dust precipitation
  - Confirm the installation location of reagent injection and mixing devices in de-nox reactors
  - Measuring the system pressure drop

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Remote optimization and support

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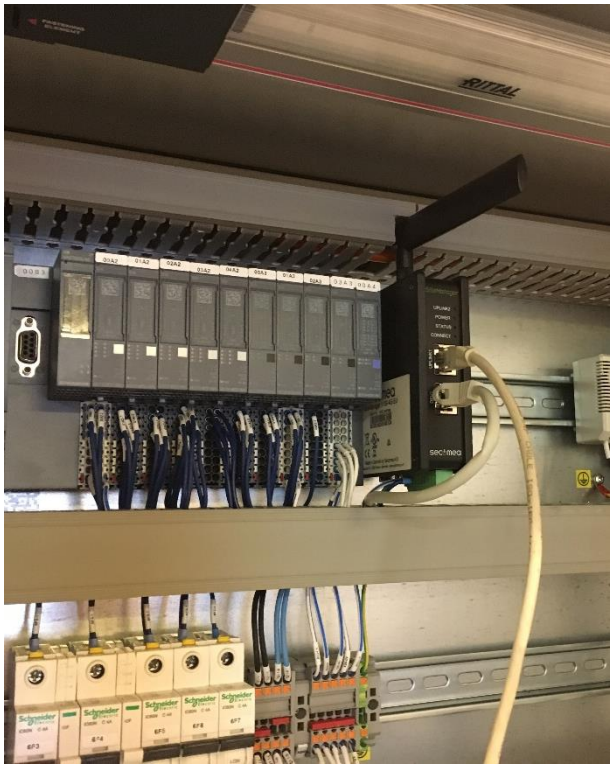
Remote optimization and support

Flowvision provide remote surveillance and support to de-nox systems (Secomea):

- Overseeing consumption, emission values and performance trends ensuring optimal performance and low cost
- Trouble shooting
- Recommendation for maintenance
- Upgrades, modifications or changes in the PLC software and HDMI



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A typical project with Flowvision

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A typical project with Flowvision (1)

- Collaboration with customer for preparation of de-nox system design and submission of order:
  - Discussion of scope and design
  - Preliminary CFD calculations or other calculations on efficiency for decreasing emissions
  - Agreement on standards and devices used
  - Agreement on deliverables
  - Commitments to guarantees
  - Transport arrangements
  - Terms and conditions
  - Order signed

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A typical project with Flowvision (2)

- Engineering and manufacture:
  - Final CFD calculations or other calculations on efficiency for decreasing emissions
  - Flowvision engineering documents send to customer
  - Flowvision orders to sub-suppliers
  - Quality assurance for ammonia/urea tanks and other large items produced at sub-supliers
  - Pump skids and dosing and distribution modules received at Flowvision for coding of automisation and FAT
  - Delivery to site of tanks, other large items, pump skids and dosing and distribution modules incl. automisation

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A typical project with Flowvision (3)

- Installation and commissioning:
  - All connecting piping and connection of power and signals by partner
  - Cold and hot commissioning by Flowvision including optimization of the feedback control system
  - Documentation by Flowvision
  - Remote support and optimization by Flowvision
  - All claims on de-nox system performance towards Flowvision according to warranty
  - Flowvison delivery of spare parts and service on demand

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