Infrastructure Factsheet

Description of the infrastructure	
Name(s) of the infrastructure(s)*:	**TA4.5: SINTEF SOLVENT DEGRADATION RIG (SDR)**
Location (town, country):	Trondheim, Norway
Website:	www.sintef.no
Legal name of organisation operating the infrastructure:	SINTEF AS
Location of organisation (town, country):	Trondheim, Norway
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**Infrastructure (s): means a facility, a resource (or a coherent set of them) together with the related services that are used by the scientific community to conduct research.*
***Installation: is a part of an infrastructure that could be used independently from the rest.*

Description of the facilities

Brief general description of the infrastructure to which access is offered highlighting its state-of-the-art equipment and services offered to users that make it rare or unique in Europe. Outline the areas of research normally supported by the infrastructure, as well as any possible new areas opening to users. If the infrastructure is composed of several installations**, are these described here including their specific features. If parts of the infrastructure are still under construction, the description includes the starting date of construction and indicative date when access can realistically be made available.

TA4.5: SINTEF SOLVENT DEGRADATION RIG (SDR)

Purpose and brief technical description, including figures as appropriate

The SDR rig is a laboratory test rig built to study the degradation of amine solvents over time under simulated CO_2 capture conditions. Execution of a process protocol should give a qualitative picture of what degradation products are formed for a given solvent system. The experimental results would provide input on what degradation products to look for in emissions from a plant running on the specified solvent. These experiments should also give a relatively good picture of the risks presented by the different solvents.

Process protocols that can be run in the SDR rig consist of Standard, High Oxygen, High NO_x and High Temperature Protocols. Each protocol has different process condition as well as different gas composition resulting in different degradation products. In this rig, both oxidative and thermal degradations occur simultaneously. The rig operates 24 hours for 14 weeks (4 process protocols).

Standard Protocol. The objective of this protocol is to measure degradation products of a specified solvent under normal operating condition for 5 weeks. The absorber and desorber operate at 40 and 120°C with the flue gas flowrate of 1 NL/min. The simulated flue gas used in this protocol consists of 85% N_2, 12% O_2 and a CO_2 concentration of 3% (giving a resulting rich realistic CO_2-loading in the absorber section. The solvent CO_2-loading can be controlled in both the absorber and desorber section of the test rig.. Typically trace concentrations of NO_x is also added, in order to study the formation of potential nitrosamines in the process. The liquid and gas samplings will be conducted at the end of the protocol (week 5). However, additional sampling may also be taken in week 3.

High Oxygen Protocol. This protocol studies the effect of high O_2 content in the flue gas on the degradation products gas from a specified solvent. The rig operating conditions are similar to those of the standard protocol (Tabs = 40°C, Tdes = 120°C, gas flowrate = 1 NL/min) with higher O_2 concentration (18%). The protocol

operates for 3 weeks after the standard protocol ends. Sampling will be conducted at the end of the protocol (week 3).

High NO_x Protocol. Effect of high NO_x (50 ppm) on the degradation products is studied in this protocol for 3 weeks. The rig operating conditions are similar to those of the standard protocol. The protocol operates after the high O_2 protocol ends. Sampling will be conducted at the end of the protocol (week 3).

High Stripper Temperature Protocol. Thermal degradation is studied in this protocol. Stripper temperature is set to 140°C. The protocol operates after the high NO_x protocol ends. Sampling will be conducted at the end of the protocol (week 3).

Analysis. Some degradation products can be analyzed with LC-MS-MS-QQQ with an instrumental detection limit of about 5 µg/L. Typical degradation products of MEA consist of OZD, HEF, HEGly, HEPO etc. NDELA and NHEGly are two of the nitrosamines produced during the campaign.

State of the Art, uniqueness (if applicable), and any specific advantages (e.g. technical, economic etc)
The major part of the infrastructure contains various experimental techniques used to evaluate the performance of sorbents. All techniques offered are modern and the results obtained are expected to be of high scientific quality. The experiments can be conducted under realistic conditions at high temperatures, pressures, and under high partial pressures of steam. Also tests in a sulphur environment can be carried out. The equipment is monitored by skilled technicians/scientists. The choice of the right experiment/experimental conditions for a specific test can also be established through discussion with our experts.

The pilot is very well suited for testing new promising solvents before they are tested on larger units. Estimates of energy requirements, column heights, and operational aspects of the solvent will be revealed by the pilot plant as well as data for process modeling. The lab pilot is recently rebuilt with new and more efficient packing. The total liquid holdup is small (thus it is possible to test more expensive solvent systems without high costs). The burner gives a constant and reliable source of gas and the plant is very well instrumented and controlled such that steady state conditions in the column are easily obtained.

The whole plant is controlled by a process control system from Siemens (PCS 7). Around 120 temperatures and 75 other tags (pressures, analysers etc.) are handled by the system. Data treatment systems have been made such that the results are easily processed and presented. Experienced and skilled technicians/scientists give the necessary support to get the best out of the campaign program.

- The facility is very flexible with easy access to all parts of the plant. Most modifications of the plant may be done inexpensively and additional instrumentation can be added for special purposes.
- The SDR rig is designed to study degradation products formed for a given solvent system under certain process conditions. The experimental results would provide input on what degradation products to look for in emissions from a plant running on the specified solvent. The laboratory has a close co-operation with analytical laboratories (SINTEF Biotechnology), which makes it possible to analyze liquid samples for degradation products and amines.

Scientific environment (related and potentially available scientific and technical services at RI's location e.g. analysis, material preparation etc.)

We offer the abovementioned experiments to be carried out in one infrastructure. Skilled scientists and technicians are available to assist visiting researchers. Also, a desk with internet access will be available during the stay. We have, in our laboratory several degradation equipment's and we cooperate with other laboratories at SINTEF that offer environmental evaluation of the solvent (biodegradation and ecotoxicity, see publication list below).,We offer access to the lab pilot plant for performing solvent test campaigns with technicians and researchers from SINTEF and NTNU. They have used the pilot since 1998 and will give valuable experience and help in operation and interpretation of the results.

The SDR rig has been used to measure degradation products from specified solvents in CCM Amine 4 Process Protocol and Testing of Solvent in SDR rig. The analysis facility is very good including advanced analysis of degradation products because of a very well equipped analytical laboratory at the site (SINTEF Biolab).

CCS PROJECTS:

EU-funded CCS projects:

The infrastructure has been central in the accomplishment of several national and international projects, and 6th and 7th FP projects such as CASTOR, DECARBit, CAESAR, CESAR, CACHET, CACHET II, Democlock, iCap, Octavius, Ulcos, HETMOC, ELECTRA, CARENA, MATESA, ASCENT, HiPerCap.

Other CCS projects:

BIGCCS, Solvit, CCM Technology Qualification Programme - Amine 4

Main/major non-CCS projects:

Patents:

Selected publications:

- Aslak Einbu, Eirik DaSilva, Geir Haugen, Andreas Grimstvedt, Kristin Giske Lauritsen, Kolbjørn Zahlsen an Terje Vassbotn. "A new test rig for studies of degradation of CO_2 absorption solvents at process conditions; comparison of test rig results and pilot plant data for degradation of MEA". Energy Procedia 37 (2013) 117-726.
- E. F. da Silva, H. Kolderup, E. Goetheer, K. W. Hjarbo, A. Huizinga, P. Khakharia, I. Tuinman, T. Mejdell, K Zahlsen, K. Vernstad, A. Hyldbakk, T. Holten, H. M. Kvamsdal, P. van Os and A. Einbu. "Emission studies from a CO_2 capture pilot plant." Energy Procedia 37 (2013) 778-783
- E. F. da Silva, H. Lepaumier, A. Grimstvedt, S. J. Vevelstad, A. Einbu, K. Vernstad, H. F. Svendsen and K. Zahlsen. "Understanding 2-Ethanolamine Degradation in Postcombustion CO_2 Capture." Industrial & Engineering Chemistry Research 51 (2012) 13329-13338.
- H. Lepaumier, E. F. da Silva, A. Einbu, A. Grimstvedt, J. N. Knudsen, K. Zahlsen and H. F. Svendsen. "Comparison of MEA degradation in pilot-scale with lab-scale experiments." Energy Procedia 4 (2011) 1652 1659.
- D. D. D. Pinto, T. W. Brodtkorb, S. J. Vevelstad, H. Knuutila and H. F. Svendsen. "Modeling of Oxidative MEA Degradation." Energy Procedia 63 (2014) 940-950
- S. J. Vevelstad, A. Grimstvedt, J. Elnan, E. F. da Silva and H. F. Svendsen. "Oxidative degradation of 2-ethanolamine: The effect of oxygen concentration and temperature on product formation." International Jourr of Greenhouse Gas Control 18 (2013) 88-100
- S. J. Vevelstad, A. Grimstvedt, H. Knuutila, E. F. da Silva and H. F. Svendsen. "Influence of experimental se on amine degradation." International Journal of Greenhouse Gas Control 28 (2014) 156-167
- S. J. Vevelstad, M. T. Johansen, H. Knuutila and H. F. Svendsen. "Oxygen and Temperature Effect on Formation of Degradation Compounds from MEA." Energy Procedia 63 (2014) 957-975.
- O. G. Brakstad, A. Booth, I. Eide-Haugmo, J. A. Skjaeran, K. R. Sorheim, K. Bonaunet, S.-H. Vang and E. Falck da Silva. " Seawater biodegradation of alkanolamines used for CO2-capture from natural gas." Int. J. Greenhouse Gas Control 10 (2012) 271-277
- L. Sørensen, E. F. d. Silva, O. G. Brakstad, K. Zahlsen and A. Booth. " Preliminary Studies into the Environmental Fate of Nitrosamine and Nitramine Compounds in Aquatic Systems." Energy Procedia 37 (20 683-690.

FACILITY AVAILABILITY:

Unit of access:

Day

Availability per year:

Min 30 days

Expected duration of single experiment:

30 days

OPERATIONAL OR OTHER CONSTRAINTS:

Specific risks:

Legal issues: