



## Ammonia concentration measurements

Authors: Tuula Kajolinna

Confidentiality: Confidential

Report's title <b>Ammonia concentration measurements</b>		
Customer, contact person, address Wärtsilä Finland Oy, Anu Solla P.O. Box 414, CH-8401 Winterthur, Switzerland	Order reference PO4501704770	
Project name Cleen Oy MMEA WP4.2.2 - Sampling and process emission studies	Project number/Short name 71091	
Author(s) Tuula Kajolinna	Pages 7/0	
Keywords	Report identification code VTT-R-04802-11	
Summary		
Confidentiality   Confidential		
Espoo 8.7.2011		
Written by	Reviewed by	Accepted by
Tuula Kajolinna, Research Scientist	Tuula Pellikka, Team Leader	Jukka Lehtomäki, Technology Manager
VTT's contact address P.O.Box 1000, FI-02044 VTT, firstname.surname@vtt.fi, www.vtt.fi		
Distribution (customer and VTT) Customer, 1 piece, Anu Solla VTT, 1 piece		
<i>The use of the name of the VTT Technical Research Centre of Finland (VTT) in advertising or publication in part of this report is only permissible with written authorisation from the VTT Technical Research Centre of Finland.</i>		

## Contents

1	Introduction.....	3
2	Description.....	3
2.1	Sampling locations.....	3
2.2	Measurement arrangements.....	4
3	Methods.....	5
4	Results .....	5

## 1 Introduction

This project is part of research project “Cleen Oy MMEA WP4.2.2 - Sampling and process emission studies - Online monitoring of nitrous compounds (amines, ammonia) - special emphasis on sampling”. The objective in the project was to measure concentrations of ammonia before and after Metallic Selective Catalyst Reducer (SCR) in the test set-up of Wärtsilä Finland Oy located in Vaasa, Finland.

Two measurement campaigns were arranged; from May 31<sup>st</sup> to Jun 3<sup>rd</sup> and Jun 8<sup>th</sup> 2011. Measurement experts from VTT were Senior Research Technician Hannu Vesala, Research Engineer Harri Mustikkamäki and Research Scientist Tuula Kajolinna.

## 2 Description

Measurements were made from engine of Wärtsilä Finland with maximum output power of 1200 kW. Used fuel was LSG180 (HFO).

### 2.1 Sampling locations

Ammonia concentrations before SCR were measured from different locations and distances after urea injections (A1, A2 and AS). After SCR, ammonia concentrations were measured only from one measurement point, A3 ) on A3. Ammonia concentration sampling locations and urea injection locations are shown in Figure 1.

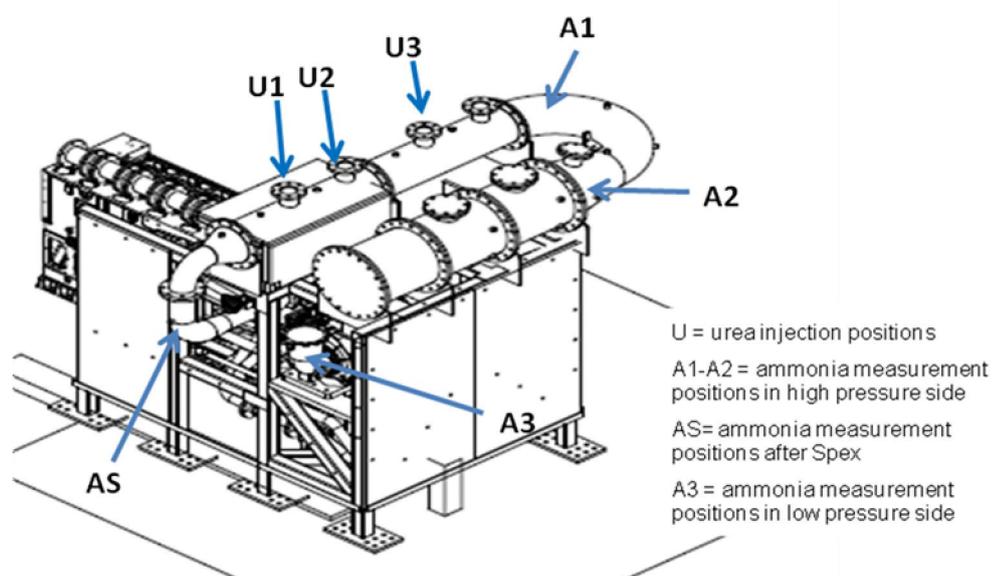


Figure 1. Ammonia concentration sampling locations in Wärtsilä Finland Oy on May 31<sup>st</sup> to Jun 8<sup>th</sup> 2011 in Vaasa. Picture from Wärtsilä Finland Oy.

Sampling locations before SCR at each measurement day were:

May 31 <sup>st</sup>	A1, in-line with flow, stratification tests
Jun 1 <sup>st</sup>	A1, against flow, stratification tests
Jun 2 <sup>nd</sup>	A1, against flow, stratification tests
Jun 3 <sup>rd</sup>	A2, outside and inside curve
Jun 8 <sup>th</sup>	AS, one sampling point

Stratification tests from sampling location A1 were made by turning the probe to four positions. Measurement points were agreed with the client before the measurement. Principle of distribution tests with different probe positions are shown in Figure 2.

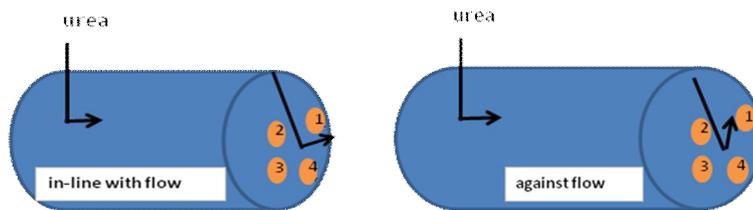


Figure 2. Principle of A1 distribution tests in Wärtsilä Finland Oy on May 31<sup>st</sup> to Jun 2<sup>nd</sup> 2011 in Vaasa. Figures are from Wärtsilä Finland Oy.

## 2.2 Measurement arrangements

Sample before SCR was led to the analyzer through temperature controlled sampling probe and heated metallic filter. Total sample flow was divided into two parts; by-pass flow and sample flow to analyzer. Sample flow to analyzer was about 5 litres per minute (lpm) and by-pass flow was about 10 lpm, except with engine load of 25 % there was no by-pass flow. Temperature of the sampling line was adjusted to be 180°C. Length of the sample line was about 2 meters. Sampling arrangement before SCR is shown in Figure 3.

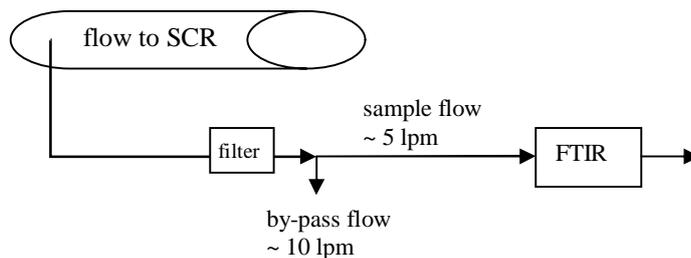


Figure 3. Sampling arrangement before SCR in Wärtsilä Finland Oy on May 31<sup>st</sup> to Jun 8<sup>th</sup> 2011 in Vaasa.

Sampling arrangement after SCR consisted of heated metallic filter, heated pump and analyzer. Temperature of the sampling line was 180°C and total length of the line was about 2,2 meters. Sample flow was all the time about 3 lpm. Sampling arrangement after SCR is shown in Figure 4.

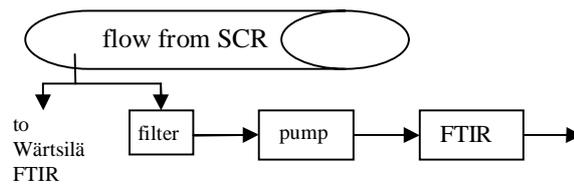


Figure 4. Sampling arrangement after SCR in Wärtsilä Finland Oy on May 31<sup>st</sup> to Jun 8<sup>th</sup> 2011 in Vaasa.

### 3 Methods

Ammonia concentrations were analysed using two Gaset Dx4000N-analysers which are based on Fourier Transform Infra Red (FTIR) –technique. Both analyser’s sample cell absorption length was 5 meters and temperature of the cuvette was 180°C.

### 4 Results

Ammonia concentration results are shown in Table 1 and 2. These tables include following operational parameters given by Wärtsilä Finland Oy; ID, date, time, engine load, engine output, urea injection and probe position.

Table 1. Ammonia concentration results May 31<sup>st</sup>- Jun 1st 2011 in Wärtsilä Finland Oy.  
Results are given in NTP (101,3 kPa, 0°C), wet.

ID	Date	Time	Load	Engine Output	Urea injection	NH3 sampling	Probe position	urea mass flow	NH3	
									before SCR	after SCR
			%	kW	location	before+after	before SCR	kg/h	ppm, wet	ppm, wet
13348	31.5.2011	15:25	50	600	U1	A1 + A3	1 - in-line with flow	6,5	280	1
13349	31.5.2011	15:50	50	600	U1	A1 + A3	1 - in-line with flow	7	340	0
	31.5.2011	16:00	50	600	U1	A1 + A3	2 - in-line with flow	7	355	0
	31.5.2011	16:10	50	600	U1	A1 + A3	3 - in-line with flow	7	380	0
	31.5.2011	16:30	50	600	U1	A1 + A3	4 - in-line with flow	7	400	0
	31.5.2011	16:40	50	600	U1	A1 + A3	1 - in-line with flow	7	400	0
	31.5.2011	17:40	50	600	U1	A1 + A3	1 - against flow	7	360	0
13350	31.5.2011	18:12	50	600	U1	A1 + A3	2 - against flow	7	370	0
	31.5.2011	18:25	50	600	U1	A1 + A3	3 - against flow	7	360	0
	31.5.2011	18:40	50	600	U1	A1 + A3	4 - against flow	7	360	0
13352	1.6.2011	9:40	50	600	U1	A1 + A3	4 - against flow	7		2
13353	1.6.2011	10:20	100	1200	U1	A1 + A3	4 - against flow	0		0
13354	1.6.2011	11:05	100	1200	U1	A1 + A3	4 - against flow	12	390	1
13355	1.6.2011	11:12	100	1200	U1	A1 + A3	4 - against flow	14	465	0
	1.6.2011	11:35	100	1200	U1	A1 + A3	4 - against flow	15	500	0
	1.6.2011	13:25	100	1200	U1	A1 + A3	4 - against flow	16	580	0
	1.6.2011	13:30	100	1200	U1	A1 + A3	4 - against flow	16,5	620	0
	1.6.2011	13:38	100	1200	U1	A1 + A3	4 - against flow	17	610	0
	1.6.2011	13:45	100	1200	U1	A1 + A3	4 - against flow	18	750	0
	1.6.2011	13:50	100	1200	U1	A1 + A3	4 - against flow	18,5	780	0
13356	1.6.2011	13:50	100	1200	U1	A1 + A3	4 - against flow	18,5	780	0
	1.6.2011	14:10	100	1200	U1	A1 + A3	4 - against flow	18,5	835	0
	1.6.2011	14:50	100	1200	U1	A1 + A3	4 - against flow	18	755	0
	1.6.2011	15:00	100	1200	U1	A1 + A3	4 - against flow	14,5	510	0
13357	1.6.2011	15:05	100	1200	U1	A1 + A3	3 - against flow	14,5	510	0
	1.6.2011	15:15	100	1200	U1	A1 + A3	2 - against flow	14,5	510	0
	1.6.2011	15:40	100	1200	U1	A1 + A3	1 - against flow	14,5	580	0
13358	1.6.2011	16:10	75	900	U1	A1 + A3	1 - against flow	0		0
	1.6.2011	16:30	75	900	U1	A1 + A3	1 - against flow	7,5	325	0
	1.6.2011	16:33	75	900	U1	A1 + A3	1 - against flow	8,5	370	0
	1.6.2011	16:33	75	900	U1	A1 + A3	1 - against flow	9,7	390	0
13359	1.6.2011	16:40	75	900	U1	A1 + A3	2 - against flow	9,7	445	0
13360	1.6.2011	17:00	75	900	U1	A1 + A3	2 - against flow	10,5	490	0
	1.6.2011	17:30	50	600	U1	A1 + A3	2 - against flow	7	430	0
13361	1.6.2011	17:40	25	300	U1	A1 + A3	2 - against flow	0		0
	1.6.2011	18:10	25	300	U1	A1 + A3	2 - against flow	3	215	0
13362	1.6.2011	18:15	25	300	U1	A1 + A3	2 - against flow	3,5	265	0
13363	1.6.2011	18:30	25	300	U1	A1 + A3	2 - against flow	4	315	0

Table 2. Ammonia concentration results Jun 2<sup>nd</sup>- 8<sup>th</sup> 2011 in Wärtsilä Finland Oy. Results are given in NTP (101,3 kPa, 0°C), wet.

ID	Date	Time	Load %	Engine Output kW	Urea injection location	NH3 sampling before+after	Probe position before SCR	urea mass flow kg/h	NH3	NH3
									before SCR ppm, wet	after SCR ppm, wet
13364	2.6.2011	14:40	100	1200	U2	A1 + A3	2 - against flow	0		0
13365	2.6.2011	14:40	100	1200	U2	A1 + A3	2 - against flow	14,5	460	0
	2.6.2011	15:05	100	1200	U2	A1 + A3	3 - against flow	14,5	520	0
	2.6.2011	15:20	100	1200	U2	A1 + A3	4 - against flow	14,5	590	0
	2.6.2011	15:30	100	1200	U2	A1 + A3	1 - against flow	14,5	490	0
13366	2.6.2011	15:40	75	900	U2	A1 + A3	1 - against flow	9,7	440	0
	2.6.2011	15:55	75	900	U2	A1 + A3	2 - against flow	9,7	505	0
	2.6.2011	15:55	75	900	U2	A1 + A3	3 - against flow	9,7	500	0
	2.6.2011	16:05	75	900	U2	A1 + A3	4 - against flow	9,7	470	0
13367	2.6.2011	16:10	75	900	U2	A1 + A3	4 - against flow	0		0
13368	2.6.2011	16:45	50	600	U2	A1 + A3	4 - against flow	0		0
13369	2.6.2011	16:55	50	600	U2	A1 + A3	4 - against flow	7	400	0
	2.6.2011	17:05	50	600	U2	A1 + A3	3 - against flow	7	420	0
	2.6.2011	17:10	50	600	U2	A1 + A3	2 - against flow	7	460	0
	2.6.2011	17:15	50	600	U2	A1 + A3	1 - against flow	7	420	0
	2.6.2011	17:22	25	300	U2	A1 + A3	1 - against flow	7	420	0
13370	2.6.2011	17:35	25	300	U2	A1 + A3	2 - against flow	4	330	0
	2.6.2011	17:45	25	300	U2	A1 + A3	3 - against flow	4	295	0
	2.6.2011	17:50	25	300	U2	A1 + A3	4 - against flow	4	310	0
13371	2.6.2011	17:50	25	300	U2	A1 + A3	4 - against flow	0		0
13372	3.6.2011	9:15	100	1200	U2	A2 + A3	outside curve	0		0
13373	3.6.2011	10:00	100	1200	U2	A2 + A3	outside curve	14,5	505	0
13374	3.6.2011	10:25	75	900	U2	A2 + A3	outside curve	9,7	475	0
13375	3.6.2011	10:45	50	600	U2	A2 + A3	outside curve	7	460	0
13376	3.6.2011	11:25	25	300	U2	A2 + A3	outside curve	4	340	0
	3.6.2011	11:50	25	300	U2	A2 + A3	inside curve	4	320	0
	3.6.2011	12:00	50	600	U2	A2 + A3	inside curve	7	460	0
13377	3.6.2011	12:10	75	900	U2	A2 + A3	inside curve	9,7	515	0
13378	3.6.2011	12:25	100	1200	U2	A2 + A3	inside curve	14,5	565	0
13379	3.6.2011	14:15	100	1200	U3	A2 + A3	inside curve	0		0
13380	3.6.2011	14:50	100	1200	U3	A2 + A3	inside curve	14,5	585	0
13381	3.6.2011	15:00	75	900	U3	A2 + A3	inside curve	9,7	525	0
13382	3.6.2011	15:20	50	600	U3	A2 + A3	inside curve	7	490	0
13383	3.6.2011	15:45	25	300	U3	A2 + A3	inside curve	4	325	0
	3.6.2011	16:05	25	300	U3	A2 + A3	outside curve		325	0
13384	3.6.2011	16:15	50	600	U3	A2 + A3	outside curve	7	445	0
	3.6.2011	16:30	75	900	U3	A2 + A3	outside curve	9,7	470	0
13385	3.6.2011	16:40	100	1200	U3	A2 + A3	outside curve	14,5	515	0
13386	3.6.2011	17:00	100	1200	U3	A2 + A3	outside curve	0		0
13425	8.6.2011	9:30	100	1200	Spex, urea 50 bar	AS + A3	Low engine cycle	1,6	450	8
13427	8.6.2011	10:15	75	900	Spex, urea 25 bar	AS + A3	Low engine cycle	2,7	345	5
13428	8.6.2011	11:00	50	600	Spex, urea 20 bar	AS + A3	Low engine cycle	2,1	400	4
13429	8.6.2011	14:10	25	300	Spex, urea 14 bar	AS + A3	Low engine cycle	2,5	270	5
13430	8.6.2011	15:10	50	600	Spex, urea 14 bar	AS + A3	Low engine cycle	2,6	375	6