PRICEWATERHOUSECOOPERS

Demo Project

Appendix 12b - Verification report

2004-01-20

Summary

The emission reductions achieved by Stena Jutlandica the 13th-14th August 2003 that can be verified and reported to a potential EU Registry are 1563 kg NOX. A 10 % deduction from the reductions reported in the IVL report (1737±347 kg NOX) has been done as a result from the presumed materiality level, the reported uncertainty and reviewed uncertainty calculations. The final verification reporting from this test (with the limited scope) is an Audit report (attached to this report).

The emission reductions achieved by Manon the 18th-19th July 2003 that can be verified and reported to a potential EU Registry are 620 kg NO_X. A 6 % deduction from the reductions reported in the IVL report (660±106 kg NO_X) have been done as a result from the presumed materiality level, the reported uncertainty and reviewed uncertainty calculations. The final verification reporting from this test (with the limited scope) is an Audit report (attached to this report).

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1 Stena Jutlandica – Planning, execution and completion

The scope in this test was to simulate a full scale Review as far as possible considering the scope of the Demo Project. However, since the ship owners are not producing emission reports the audit assertions will be used solely on the data received from the monitoring equipment. This section follows the steps outlined in chapter 13 of the Demo Project Phase 1 Draft report.

1.1 Planning verification on Stena Jutlandica

1.1.1 General risk assessment

General risk assessment performed based on the knowledge obtained during Demo Project Phase 1. Emphasis was put on the monitoring equipment and data generation. Key risks identified and evaluated as significant:

- Disruptions in the continuous monitoring or logging (equipment difficulties)
- Calibration and accuracy of emission monitoring equipment
- Monitoring of the "correct" engine effect
- Monitoring during periods with altering engine effect level
- The existing internal controls and possibility to perform additional internal controls
- The existing internal controls and possibility to perform
- Abatement technology functioning (Functioning, unstable or stable, etc)
- Position and time reporting

1.1.2 Materiality

Materiality is a key issue for the verification. The materiality is normally defined in the rules for each emission trading system set up. Since no rules so far are set for a future trading system we have assumed an overall materiality level on 10 % (95%-confidance interval) for the reported NO_x-emissions/reductions. This materiality level is in line with (or somewhat more demanding than) the level for corresponding market-based instruments for land-based sources[1]. This results in that factors or parameters that has the ability to influence the reported emissions/reductions with at least a couple of percentage has to be reviewed more thoroughly. The possibility to influence can be a result of statistical & systematic uncertainties (human errors) in the monitoring process as well as non-functioning monitoring or abatement equipment. Statistical uncertainty from factors (taken from Chapter 4 of the Phase 1 draft report) to be considered as possible to influence materiality for the Stena Jutlandica monitoring test is:

- NOx ppm
- P (kWh)
- GFUEL from (P (kWh))
- CO2D (CO_2 ppm)
- BET
- Pa (Ta)
- Pb & Ra
- Sample Switching
- Position
- Time

[1] The Swedish NO_x-system, Ontario emission trading system

1.1.3 Scope and sample selection

The scope is based on the verification instructions in chapter 13 of the Phase 1 draft report and the uncertainty risks identified in this report. Main focus has been on monitoring equipment and data collection, but time and geographical parameters has also been covered.

In a future emissions trading scheme the emissions/emission reductions will probably be reported annually. In this case the verification will start with the selection of a number of samples to review in detail. In Phase 3a of the Demo Project the reported emissions/emission reductions cover only a couple of days. In this case the samples cover more or less the whole reporting period and all the underlying parameters.

1.1.4 Assessment of the Control Environment

The main control environment to be checked in the Stena Jutlandica case is the control environment of the persons and equipment involved in the monitoring. Consequently the verification will focus mainly on the control environment of IVL and only to some extent of Stena Line and the ferry Stena Jutlandica.

Some questions regarding the control environment of already implemented systems, like: Safety Management System, Quality Management System, Environmental Management System, etc have been put to the Ship Owners (since the Control Environment for emissions reductions is not widely spread).

1.2 Execution Stena Jutlandica

1.2.1 Ship visit Stena Jutlandica

The auditor Ola Hansén, PricewaterhouseCoopers visited Stena Jutlandica during the monitoring test (14 August 2003) and joined for on of Stena Jutlandica's daily runs back and forth to Fredrikshavn from Gothenburg. Interviews with key personnel such as technical chef, electrician and operational staff person responsible for the NO_x monitoring (IVL) were conducted.

Review of monitoring equipment

Review included the following checks on the monitoring equipment in the funnel cap:

- Sampling probes mounted on exhaust funnels (main engine 2 and 4) in about 60 % of the distance between SCR and top of funnel. Sampling probes with sampling holes all across the funnel diameter (observed after probe demounted) to correct for heterogeneity in CO_2 and NO_X concentrations in the exhaust gas.
- Exhaust gas samples continuously extracted running in heated tubes to analysing instruments (NO_X, CO_2, CO and O_2) via filters gas-switching systems (switched every 4^{th} minute between ME2 and ME4) and de-watering unit→ OK!
- Gas-switching system is in fact switching periodically (every 4^{th} minute)→ OK!
- Calibration of CO_2 and NO_X level is done twice a day and calibration gases being used are certified (by SWEDAC).
- Instrument display on NOx ppm and computer input correspond to noticeable (by engine sound and vibrations) adjustments of engine effect. → OK!
- Electrical cables running from analysing instruments to two independent loggers and one PC-computer. All monitoring parameters stored in PC, logger and back-up logger → OK!

Review included the following checks on the monitoring equipment in the engine room:

- Fuel pump index signals from ME2 and ME4 are continuously logged in PC and loggers → OK!
- Fuel pump index signal on PC correspond with fuel pump index display meters on control panel in engine room → OK!
- Inlet charge air temperatures for ME2 and ME4 are taken from ships engine control system → OK!
- Separate instrument used to measure temperature and humidity (moisture content) of inlet air for ME2 and ME4 in engine room (SWEDAC certified instrument used) → OK!

Executed counter checks

- Emission reduction (qualitative): SCR mounted on the funnels and urea consumed during operation (urea meters in engine room checked) → OK!
- Engine effect/Fuel consumption (qualitative): Fuel pump index can be compared with other parameters corresponding to engine effect. Fuel consumption measured continuously with existing fuel flow meter (for ME2 and ME4), which is manually read every 24 h. Resulting consumption is registered in logbook. Bunker notes can also be used to verify fuel consumption (but not relevant in this case due to short testing period). → OK!

1.2.2 Interview with key persons, etc

During the ship visit the person responsible for the monitoring test (David Cooper, IVL), the engine chief, the ships electrician, and operational staff in the engine control room were interviewed briefly. Issues discussed were existing practices/operations and suitable routines or management system to fit potential future monitoring routines in. During the ship visit observations of practices/operations was also conducted → OK!

A more thoroughly follow-up interview with David Cooper, IVL, was conducted 19 September 2003.

1.2.3 Review of documents, systems and control environment

The control environment of IVL is assessed as being very good. The Swedish Board for Accreditation and Conformity Assessment (SWEDAC) has accredited IVL to conduct monitoring of all the gases monitored in the Phase 2a test and to perform monitoring based on the Technical NOx Code[2] and ISO 8178. The method used by IVL comply with the rules the Swedish Maritime Administration has set up regarding monitoring of NOx emissions on board ships[3] → OK!

The documents, systems and control environment of the ship not relevant in this case since a continuous monitoring system and corresponding monitoring routines for the purpose of emissions trading is not implemented. However, some documents regarding routines for reading of meters and instruments and resulting metered data in logbook and computer files were reviewed during the ship visit → OK!

[2] Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines, MARPOL, Annex VI
[3] SJÖFS 1998:13

1.3 Completion - Document review and examination of measuring results and calculations - Stena Jutlandica

1.3.1 Analysis of verification data - Stena Jutlandica

Interview with key persons, etc

A thoroughly interview with David Cooper, IVL, was conducted 19 September 2003. All raw data, calculation models and background documents (electronic & paper) were reviewed.

Analysis of verification data

In the process of calculating the emissions and emission reductions as presented in the report "Continual NOx emission monitoring on board Manon and Stena Jutlandica"[4] IVL has used the instructions in the IMO NO_X code. The following steps has been used (according to methods described in the draft Phase 1 report[5]) to convert raw emissions data to reported emissions/emissions reductions: conversion of raw data (in mV) to correct unit (ppm), correction for drift of instruments (from calibrations, correction for CO_2 quenching, correction for non-linearity of monitoring equipment, correction for interference (NO_X interference), check of NO_2 converter and adjustments needed to take the gas switching into account (emissions while monitoring switched to the other engine). All steps demonstrated and documents reviewed. Assumptions and methods reasonable and in line with relevant standards (as presented in the Phase 1 draft report) → OK!

In order to convert raw data form fuel pump index to engine effect and fuel consumption the following steps has been used (according to methods described in the draft Phase 1 report): engine test bed protocols, consultations with engine manufacture (regarding TSC_{ref}, etc) and fuel receipts (specific heating values). All steps demonstrated and documents reviewed. Assumptions, values and methods reasonable and in line with relevant standards→ OK!

Recalculation of spot checked data

To test the unbroken audit trial three spot checks was taken from the logging data on ME4 (2003-08-13 11:56:49-11:57:49 and 12:30:49-12:31:49). Recalculation of these random samples and review of the calculation steps verify the calculations conducted by IVL → OK!

The conversion from semi continuous monitoring with the sample switcher (Monitoring cycle 8 min: Min 1-3: monitoring ME2, Min 4: switching & clearing ME2 exhausts, Min 5-7: monitoring ME4, Min 8: switching & clearing ME4 exhausts) was also checked. The last minute value of the 3-minute ME4 monitoring (Min 7 in the cycle) was used as default until the new 3-minute ME4 monitoring begins (Min 5 in the next 8 minute cycle). → OK!

As another spot check the accumulative additions of emissions and emission reductions was recalculated. Also these recalculations verify the calculations conducted by IVL → OK!

Uncertainty calculations

The uncertainty calculation for the monitoring performed on Stena Jutlandica is identical with the one in chapter 8.4 (Summary of parameter uncertainty and IMO QA

[4] Cooper, D. and Flodström, E. (2003-08-21) 'Continual NOx emission monitoring on board Manon and Stena Jutlandica', IVL report U 826.

[5] Hansén, O., Gavelius, M., Jämttjärn, J., Cooper, D. and Flodström, E. (2003) 'Feasilibity of emission trading at sea – Phase 1 draft document 2003-08-28'

routines) of the Phase 1 draft report. These calculations generate an estimated uncertainty on ± 20 % (95% confidence level) according to the Phase 2a report. In order to achieve the materiality level selected for the verification a deduction of the reported emissions have to be done to be sure (95% confidence level) that the reduction is not overestimated with more than the selected materiality level. Since the reported uncertainty is ± 20 % a deduction with 10 % will be done due to uncertainty when the reported emissions are verified.

1.3.2 Management representations - Stena Jutlandica

Management representations have not been included in this test. In this test the management representations is replaced by the emissions/emission reductions reported for Stena Jutlandica in the monitoring report of IVL. In the IVL report reductions of 1737±347 kg NO_X during six voyages (3 h 15 min/voyage) the 13th-14th August 2003 is reported.

In the future trading system the management representations will probably be in the form of monthly emission reports for each ship (if selected as operational entity). An annual emission report/statement with summarised emissions/emission reductions and key information regarding ship, abatement technology and monitoring technique would probably be the document the verifiers would express an opinion on. The annual emission report/statement should be signed by a person authorised to sign for the ship owner of the particular ship.

1.3.3 Verification results & reporting - Stena Jutlandica

The emission reductions achieved by Stena Jutlandica the 13th-14th August 2003 that can be verified and reported to a potential EU Registry[6] are 1563 kg NO_X. A 10 % deduction from the reductions reported in the IVL report (1737±347 kg NO_X) have been done as a result from the presumed materiality level, the reported uncertainty and reviewed uncertainty calculations. The final verification reporting from this test (with the limited scope) is an Audit report (attached to this report).

In the future trading system the verification reporting will probably cover the emissions/emission reductions reported annually and the assurance engagement will consider both the verification of data and management systems as well as the behaviour of key personnel. In this specific case we have emissions reported for a couple of days and an assurance engagement mainly considering the verification of data, since management systems and thus the behaviour of key personnel regarding emissions monitoring and reporting are not yet implemented. In the future the monitoring systems will most probably be able to report emissions data with less uncertainty.

1.3.4 Management reporting- Stena Jutlandica

In this test the management reporting will be to the steering committee of the Demo project.

In the future emissions trading system an add-on value of the verification will be the recommendations of improvements that the verifier will communicate to the management of the ship and the ship owner.

[6] Or other equivalent authority or organisation that will be responsible for keeping track on all created and transferred emission reductions/credits.

2 Manon – Planning, execution and completion

The scope in this test was to simulate a full scale Review as far as possible considering the scope of the Demo Project. However, since the ship owners are not producing emission reports the audit assertions will be used solely on the data received from the monitoring equipment. This section follows the steps outlined in chapter 13 of the Demo Project Phase 1 Draft report.

2.1 Planning verification on Manon

2.1.1 General risk assessment

General risk assessment performed based on the knowledge obtained during Demo Project Phase 1. Emphasis was put on the monitoring equipment and data generation. Key risks identified and evaluated as significant:

- Disruptions in the continuous monitoring or logging (equipment difficulties)
- Calibration and accuracy of emission monitoring equipment
- Monitoring of the "correct" engine effect
- Monitoring during periods with altering engine effect level
- The existing internal controls and possibility to perform additional internal controls
- The existing internal controls and possibility to perform
- Abatement technology functioning (Functioning, unstable or stable, etc)
- Position and time reporting

2.1.2 Materiality

Materiality is a key issue for the verification. The materiality is normally defined in the rules for each emission trading system set up. Since no rules so far are set for a future trading system we have assumed an overall materiality level on 10 % (95%-confidance interval) for the reported NO_x-emissions/reductions. This materiality level is in line with (or somewhat more demanding than) the level for corresponding market-based instruments for land-based sources[7]. This results in that factors or parameters that has the ability to influence the reported emissions/reductions with at least a couple of percentage has to be reviewed more thoroughly. The possibility to influence can be a result of statistical & systematic uncertainties (human errors) in the monitoring process as well as non-functioning monitoring or abatement equipment. Statistical uncertainty from factors (taken from Chapter 4 of the Phase 1 draft report) to be considered as possible to influence materiality for the Manon monitoring test is:

- NOx ppm
- P (kWh)
- GFUEL from (P (kWh))
- CO2D (CO_2 ppm)
- BET
- Pa (Ta)
- Pb & Ra
- Position
- Time

[7] The Swedish NO_x-system, Ontario emission trading system

2.1.3 Scope and sample selection

The scope is based on the verification instructions in chapter 13 of the Phase 1 draft report and the uncertainty risks identified in this report. Main focus has been on monitoring equipment and data collection, but time and geographical parameters has also been covered.

In a future emissions trading scheme the emissions/emission reductions will probably be reported annually. In this case the verification will start with the selection of a number of samples to review in detail. In Phase 3a of the Demo Project the reported emissions/emission reductions cover only a couple of days. In this case the samples cover more or less the whole reporting period and all the underlying parameters.

2.1.4 Assessment of the Control Environment

The main control environment to be checked in the Manon case is the control environment of the persons and equipment involved in the monitoring. Consequently the verification will focus mainly on the control environment of IVL and only to some extent of Wallenius Lines and the ship Manon.

Some questions regarding the control environment of already implemented systems, like: Safety Management System, Quality Management System, Environmental Management System, etc have been put to the Ship Owners (since the Control Environment for emissions reductions is not widely spread).

2.2 Execution Manon

2.2.1 Ship visit Manon

No ship visit was performed for Manon. Monitoring equipment set up checked during interview with Davis Cooper IVL → OK!

2.2.2 Interview with key persons, etc

A more thoroughly follow-up interview with David Cooper, IVL, was conducted 19 September 2003.

Sara Gorton, Wallenius Lines (responsible for environmental issues at Wallenius Lines) was interviewed 19 December 2003. Issues discussed were the possibilities to prove that the ship travelled the route Gothenburg-Oslo 18th-19th July 2003 (logbook, harbour receipts, etc) and the possibilities to counter-check that the low NOx slide valves had been installed. Existing practices/operations and suitable routines or management system to fit potential future monitoring routines in was also discussed → OK!

With Stefan Lemieszewski of the Swedish Maritime Administration the possibilities to counter-check a ships position afterwards was also discussed. For spot checks the ships logbook or harbour receipts could be used, but in the future the AIS-system (if used for recording) could be a more effective and convenient way to conduct this counter-check.

2.2.3 Review of documents, systems and control environment

The control environment of IVL is assessed as being very good. The Swedish Board for Accreditation and Conformity Assessment (SWEDAC) has accredited IVL to conduct monitoring of all the gases monitored in the Phase 2a test and to perform

monitoring based on the Technical NOx Code[8] and ISO 8178. The method used by IVL comply with the rules the Swedish Maritime Administration has set up regarding monitoring of NOx emissions on board ships[9] → OK!

2.3 Completion Manon

2.3.1 Analysis of verification data - Manon

Interview with key persons, etc

A thoroughly interview with David Cooper, IVL, was conducted 19 September 2003. All raw data, calculation models and background documents (electronic & paper) were reviewed.

Analysis of verification data

In the process of calculating the emissions and emission reductions as presented in the report "Continual NOx emission monitoring on board Manon and Stena Jutlandica"[10] IVL has use the instructions in the IMO NO_X code. The following steps has been used (according to methods described in the draft Phase 1 report[11]) to convert raw emissions data to reported emissions/emissions reductions: conversion of raw data (in mV) to correct unit (ppm), correction for drift of instruments (from calibrations, correction for CO_2 quenching, correction for non-linearity of monitoring equipment, correction for interference (NO_X interference), check of NO_2 converter and adjustments needed to take the gas switching into account (emissions while monitoring switched to the other engine). All steps demonstrated and documents reviewed. Assumptions and methods reasonable and in line with relevant standards (as presented in the Phase 1 draft report) → OK!

In order to convert raw data form fuel pump index to engine effect and fuel consumption the following steps has been used (according to methods described in the draft Phase 1 report): engine test bed protocols, consultations with engine manufacture (regarding TSC_{ref}, etc) and fuel receipts (specific heating values). All steps demonstrated and documents reviewed. Assumptions, values and methods reasonable and in line with relevant standards→ OK!

Recalculation of spot checked data

To test the unbroken audit trial one spot check was taken from the logging data (2003-07-18 minute from 23:00 to 23:01). Recalculation of this random sample and review of the calculation steps verify the calculations conducted by IVL → OK!

As another spot check the accumulative additions of emissions and emission reductions was recalculated. Also these recalculations verify the calculations conducted by IVL → OK!

Uncertainty calculations

The uncertainty calculation for the monitoring performed on Manon is identical with the one in chapter 8.4 (Summary of parameter uncertainty and IMO QA routines) of the Phase 1 draft report. These calculations generate an estimated uncertainty on ± 16 % (95% confidence level) according to the Phase 2a report. In order to achieve the materiality level selected for the verification a deduction of the reported emissions have to be done to be sure (95% confidence level) that the reduction is not overestimated

[8] Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines, MARPOL, Annex VI
[9] SJÖFS 1998:13
[10] Cooper, D. and Flodström, E. (2003-08-21) 'Continual NOx emission monitoring on board Manon and Stena Jutlandica', IVL report U 826.
[11] Hansén, O., Gavelius, M., Jämttjärn, J., Cooper, D. and Flodström, E. (2003) 'Feasilibity of emission trading at sea – Phase 1 draft document 2003-08-28'

with more than the selected materiality level. Since the reported uncertainty is ± 16 % a deduction with 6 % will be done due to uncertainty when the reported emissions are verified.

2.3.2 Management representations - Manon

In this test the management representations is replaced by the emissions/emission reductions reported for Manon in the monitoring report of IVL. In the report reductions of 660 ±106 kg NO_X during 17 hours the 18th-19th July 2003 is reported.

In the future trading system the management representations will probably be in the form of monthly emission reports for each ship (if selected as operational entity). An annual emission report/statement with summarised emissions/emission reductions and key information regarding ship, abatement technology and monitoring technique would probably be the document the verifiers would express an opinion on. The annual emission report/statement should be signed by a person authorised to sign for the ship owner of the particular ship.

2.3.3 Verification results & reporting - Manon

The emission reductions achieved by Manon the 18th-19th July 2003 that can be verified and reported to a potential EU Registry[12] are 620 kg NO_X. A 6 % deduction from the reductions reported in the IVL report (660±106 kg NO_X) have been done as a result from the presumed materiality level, the reported uncertainty and reviewed uncertainty calculations. The final verification reporting from this test (with the limited scope) is an Audit report (attached to this report).

In the future trading system the verification reporting will probably cover the emissions/emission reductions reported annually and the assurance engagement will consider both the verification of data and management systems as well as the behaviour of key personnel. In this specific case we have emissions reported for a couple of days and an assurance engagement mainly considering the verification of data, since management systems and thus the behaviour of key personnel regarding emissions monitoring and reporting are not yet implemented.

2.3.4 Management reporting - Manon

In this test the management reporting will be to the steering committee of the Demo project.

In the future emissions trading system an add-on value of the verification will be the recommendations of improvements that the verifier will communicate to the management of the ship and the ship owner.

3 References

Cooper and Flodström (2003) 'Continual NO_x emission monitoring on board *Manon* and *Stena Jutlandica*, IVL report U826, 2003 (Phase 2a reporting).

Hansén, O., Gavelius, M., Jämttjärn, J., Cooper, D. and Flodström, E. (2003) *'Feasilibity of emission trading at sea – Phase 1 draft document 2003-05-16*'

[12] Or other equivalent authority or organisation that will be responsible for keeping track on all created and transferred emission reductions/credits.