Intercalibration Report for the Automatic Urban Network, Jan - Mar 2002

Brian Stacey

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Customer reference

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<tbody>
<tr>
<td>Author</td>
<td>Brian Stacey</td>
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<tr>
<td>Reviewed by</td>
<td>Steve Telling</td>
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<tr>
<td>Approved by</td>
<td>Ken Stevenson</td>
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Executive Summary

In January to March 2002, netcen conducted an intercalibration audit of 81 sites in the Automatic Urban Network. The tests were undertaken to cross-reference the individual data sets to common traceable calibration standards. This enabled the consistency of measurements throughout the network to be determined.

The results of the intercalibration are summarised in the table below:

<table>
<thead>
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<th>Parameter</th>
<th>Number of outliers</th>
<th>Number in network</th>
<th>% outliers in total</th>
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</thead>
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<td>Ozone analyser</td>
<td>17</td>
<td>47</td>
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<td>NOx analyser</td>
<td>18</td>
<td>77</td>
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<td>CO analyser</td>
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<td>60</td>
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<td>SO₂ analyser</td>
<td>8</td>
<td>63</td>
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<tr>
<td>TEOM analyser</td>
<td>3</td>
<td>53</td>
<td>6%</td>
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<tr>
<td>Partisol analyser</td>
<td>-</td>
<td>6</td>
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<td><strong>Total</strong></td>
<td><strong>48</strong></td>
<td><strong>306</strong></td>
<td><strong>16%</strong></td>
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</table>

An outlier is defined as an analyser that shows a deviation from the network mean of greater than 10% for NOx, CO and SO₂, 5% for O₃ and a k₀ deviation of more than 2.5% for TEOM.

In addition, 5 of the 203 site cylinders (2.5%) used to scale instrument data into concentrations appeared to have drifted by more than 10% from their certificated values. Four NOx converters were found to be outside the 95% acceptance limit.

The number of analyser outliers identified is broadly similar to the previous exercise. At the summer 2001 intercalibration, 15% of the analysers in use were identified as outliers.

The performance of the network analysers is graded in terms of how their performance could impact on data quality. This process has again highlighted that the majority of outliers are very minor in nature and should have minimal consequences for data capture or data quality.

The performance of 43 of the 66 Local Site Operators was also assessed during this exercise. All the LSO’s that were assessed remain keen, and continue to perform their tasks to high standards.

Appended to this report is the UKAS Certificate of Calibration. The certificate presents the results of the individual analyser calibration factors on the day of the audit visit, as calculated by netcen using the audit transfer standards, in accordance with our UKAS accreditation to ISO 17025.

In summary, the network continues to operate at a high standard, providing data that are accurate, consistent and traceable to national metrology standards. This report presents the findings from the intercalibration exercise, listing outliers and identifying causes for any poor performance.
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Appendix 1 Certificate of Calibration
1 Introduction

netcen has undertaken an intercalibration of air quality monitoring sites in the Automatic Urban Network (AUN) in January to March 2002. These intercalibrations are used to complete a wide range of tests to evaluate the performance of each monitoring station. The following major checks are made:

1. **Analyser accuracy and precision**, as a basic check to ensure reliable datasets from the analysers.
2. **Instrument linearity**, to check that doubling a concentration of gas to the analyser results in a doubling of the analyser signal response. If an analyser is not linear, data cannot be reliably scaled into concentrations.
4. **Analyser response time**, to check that the analyser responds quickly to a change in gas concentrations.
5. **Leak and flow checks**, to ensure that ambient air reaches the analysers, without being compromised in any way.
6. **NOx analyser converter efficiency**, to ensure reliable operation. This is the device that allows the measurement of NO₂ to be undertaken, so it must work acceptably.
7. **TEOM k₀ evaluation**. The analyser uses this factor to calculate mass concentrations, so the value is calculated to determine its accuracy.
8. **SO₂ analyser hydrocarbon interference**, as certain hydrocarbons are known to interfere with the SO₂ detector.
9. **Evaluation of site cylinder concentrations**, using a set of NPL certified cylinders that netcen takes to all the sites. The concentrations of the site cylinders are used to scale pollution datasets, so it is important to ensure that the concentration of gas in the cylinder does not change.
10. **Competence of Local Site Operators (LSO) in undertaking calibrations**. As it is the calibrations by the LSO’s that are used to scale pollution datasets, it is important to check that these are undertaken competently.

In addition to the above tests, a “Network Intercomparison” is conducted. This exercise utilises audit gas cylinders transported to each site in the AUN. These cylinders have been recently calibrated by NPL, and allow us to examine how different site analysers respond when they are supplied with the same gas used at other sites.

The technique used to process the intercomparison results is broadly as follows:

- The analyser responses to audit gas are converted into concentrations, using provisional calibration factors obtained on the day of the intercalibration. This factor is also used for the provisional data supplied to the web/teletext.
- These individual results are tabulated, and statistical analyses undertaken (e.g. network average result, network standard deviation, deviation of individual sites from the network mean etc.)

These results are then used to pick out problem sites, or “outliers”, which are investigated further to determine reasons and investigate possible remedies for the outliers. The definition of an outlier is a site result that falls outside the following limits:

- ±10% of the network average for NOx, CO and SO₂ analysers,
- ±5% of the reference standard photometer for Ozone analysers,
- ±2.5 % of the stated k₀ value for TEOM analysers,
As stated, any outliers that are identified are rigorously checked to determine the cause, and corrective action taken, if necessary. Further details of the typical causes can be found in Section 2.

The procedures used to determine network performance are documented in netcen Work Instructions. These methods are regularly updated and improved and have been evaluated by the United Kingdom Accreditation Service (UKAS). netcen holds UKAS accreditation for the on-site calibration of all the analyser types (NOx, CO, SO2, O3 and PM10) used in the AUN. A UKAS Certificate of Calibration (Calibration Laboratory number 0401) for the urban sites in the AUN is appended to the report.

A total of 81 sites were audited in this exercise. The 82nd site at Walsall Alumwell was not visited as a result of newly imposed safety restrictions at netcen; the site is currently awaiting improved safety measures to allow us to revisit.

This report presents the results for each pollutant, identifies analysers that did not meet performance standards, investigates the possible causes of these results and recommends any remedial action required.

### 2 Analyser Performance

As with previous intercalibration reports, individual analyser performance has been graded, to provide an indication of how data quality may be affected by the intercalibration results.

The performance grades are as follows:

- **A** This grade is indicative of an analyser performing very well. All of the tests undertaken were within the required limits, and the quality of the ratified dataset produced by this instrument should be of a high standard. No data should be lost.

- **B** This grade is indicative of an analyser performing well. The results of the tests have highlighted a minor outlier (for example as a result of minor drift in calibration factor, or a result slightly outside acceptance criteria). This type of outlier is not likely to be easily detected by the Local Site Operator or the CMCU. The quality of the ratified dataset produced by this analyser should be of a high standard. No data should be lost.

- **C** This grade indicates an analyser performing acceptably. The results of the tests have highlighted a significant outlier (for example as a result of severe drift in calibration factor, or a result significantly outside acceptance criteria). Close examination of the performance history of the analyser may show that data could be retained, but may require substantial adjustments to the dataset to be performed. It is possible that this type of outlier could be detected by the LSO or CMCU during the scheduled calibrations, but it is likely that the fault will remain undetected until the network intercalibration visit. The LSO should compare the current results with those from previous visits, and carefully examine the progress of the current analyser calibration, to ensure “expected normal” behaviour. Any deviations from these patterns should be reported to CMCU immediately. The quality of the ratified dataset produced by this
analyser should be of an acceptable standard. It is possible that some data could be rejected during the ratification process.

D This grade indicates a poorly performing analyser. The results of the tests have highlighted a serious fault or outlier (for example, a poor NOx converter result, or significant losses of calibration gas to the sampling system), which will have serious implications for the quality of the instrument dataset. Again, the LSO and CMCU might be able to detect this type of poorly performing analyser during the scheduled calibration visits, but it is possible that the fault remains undetected until the network intercalibration visit. The LSO should report any “abnormal” behaviour to the CMCU immediately, who will then decide whether any remedial action is required. Depending upon the cause of the outlier, it is possible that much of the dataset will be salvageable during ratification, but it is likely that significant portions of data will be rejected as a result.

E This grade indicates either a very poorly performing analyser, or that the analyser was not available for testing. The results of the tests have highlighted a very serious fault, or the analyser has completely malfunctioned during the course of the tests, preventing any meaningful results being obtained. Data from this type of analyser will be seriously compromised, and it will be clear to both the LSO and CMCU that there is a fault with the equipment. Depending upon the exact nature of the fault, it may be possible to save data from the analyser, but it is most likely that large portions of the dataset will need to be rejected.

- In the event of an analyser not being tested, a “-“ result is presented. It may be that the analyser had been removed for repair, or broken down during testing. Depending upon the exact nature of the fault, it should be possible to save data from the analyser, but it is possible that large portions of the dataset will need to be rejected.

To further aid the readability of the report, the grades are colour coded: GREEN for grade A and B analysers, YELLOW for grade C and D analysers, and RED for grade E analysers. The Table below presents a summary of the network intercalibration:
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**Note:** The Wrexham site was not audited due to vandalism.

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From the above table, it is clear that the vast majority of analysers (290 of the 306 analysers, 95%) in the network are functioning well. This compares well with the summer exercise, where 93% of the analysers were grade A or B. This reflects an improving trend in analyser performance: over the last 2 years, the number of grade A/B analysers has improved continuously from 91%.

Of the remaining analysers, it is likely that data from the majority can be retained, but some investigation into the causes of the outliers needs to be undertaken. The following sections consider each pollutant in turn.
3 Nitrogen Oxides

Eighteen of the 77 analysers tested (23%) were identified as outliers, giving calculated values that were more than 10% from the network mean response. This result is much better than the previous intercalibration, when 26% of the analysers were found to be outliers.

Close investigation of the results showed that 14 of these outliers were of minor grade B, 2 of grade C and 2 of grade D. A further 2 Grade D sites, at Blackpool and Coventry Memorial Park, arose as a result of poor converter tests.

The grade B outliers were all seen as a result of minor drifts or step changes in analyser response between scheduled LSO calibrations, which will be easily corrected during ratification, without any loss of data.

The analyser at Portsmouth was seen to exhibit some differences in response when gas was introduced through the sample inlet, as opposed to the dedicated cylinder inlet. This may well have significant consequences for ambient data, as the results from the scheduled calibrations do not appear to accurately represent what the analyser samples from ambient air. The data from the site will be closely examined during ratification, and action taken as necessary.

The analyser calibration factor at Exeter Roadside appears to have drifted significantly between LSO visits, causing the outlier result. This should be easily correctable, and is unlikely to affect data capture for the site.

The analysers at Barnsley Gawber and Glasgow Centre broke down during the audit visit; thus their performance could not be fully evaluated. It is unlikely that data will need to be rejected as a result of these findings.

Due to safety restrictions, the Walsall Alumwell site was not audited.

Comparison of the network average results against the actual cylinder concentrations showed that the network underestimates NO concentrations by approximately 2% of actual concentrations, with a percentage standard deviation around this value of 4.2%. This is a very good result, which demonstrates that measurements are accurate, consistent and traceable to metrology standards.

The result of the network NO₂ intercomparison shows that the network appears to underestimate concentrations by an average of 4%, with a percentage standard deviation around this value of 4.9%. This is also a good result, which demonstrates that measurements of NO₂ are accurate, consistent and traceable to metrology standards.

The NOx converters at four sites (5%) were found to have fallen below the 95% acceptance limit:

1. Blackpool 94%
2. Coventry Memorial Park 91%
3. Manchester Piccadilly 93%
4. Rotherham 92%

The performance of the analysers at these sites will be closely scrutinised during ratification, and it is possible that some data will need to be rejected as a result. The
ESUs should continue to undertake three monthly converter tests at these sites to ensure optimal performance.

**Recommendation:** ESU to undertake three monthly converter tests at the above sites

## 4 Carbon Monoxide

Just two of the 60 analysers (3%) were identified as an outlier. This is similar to the previous exercise, when only one analyser was found to be outside the acceptance limits.

The analyser at Hull Centre was found to have an excessively noisy response, which contributed to its poor result. The data from the site will be closely examined during ratification, but it is possible that some data will need to be rejected as a result of this finding.

The analyser at Wolverhampton Centre was seen to exhibit considerable differences in response when gas was introduced through the sample inlet, as opposed to the dedicated cylinder inlet. This may well have significant consequences for ambient data, as the results from the scheduled calibrations do not appear to accurately represent what the analyser samples from ambient air. The data from the site will be closely examined during ratification, but it is possible that some data will need to be rejected as a result of this finding.

Comparison of the network average results against the actual cylinder concentrations showed that, overall, the network continues to measure concentrations of CO to within 1% of actual values, with a percentage standard deviation of 2.9%. This is an excellent result, demonstrating that measurements are accurate, consistent and traceable to metrology standards.

**Recommendation:** Stanger to replace the CO analyser at Hull Centre when the site is recommissioned.

## 5 Sulphur Dioxide

The analysers at eight of the 62 sites (13%) were identified as outliers, giving calculated values that were more than 10% from the network mean response. All these outliers were grade B. This result is similar to the previous intercalibration, when six analysers were found to be outliers.

The outliers at Liverpool Centre and Portsmouth were seen as a result of minor drifts or step changes in analyser response between scheduled LSO calibrations, which will be easily corrected during ratification, without any loss of data.

The outliers at London Cromwell Road 2 and Norwich Centre were seen as a result of changes in site cylinder concentration. This is easily correctable, and will not affect data capture for the sites.
The analysers at Derry, Leicester Centre and Southampton Centre were all seen to exhibit slight differences in response when gas was introduced through the sample inlet, as opposed to the dedicated cylinder inlet. This may well have some consequences for ambient data, as the results from the scheduled calibrations do not appear to accurately represent what the analysers sample from ambient air. The data from the sites will be closely examined during ratification, but it is possible that some data will need to be rejected as a result of these findings.

The analyser at Barnsley Gawber broke down during the audit visit; thus its performance could not be fully evaluated. It is unlikely that data will need to be rejected as a result of this finding.

Comparison of the network average results against the actual audit cylinder concentrations showed that, overall, the network continues to measure SO₂ concentrations to within 1%, with a percentage standard deviation of 3.3%. This is an excellent result, and demonstrates that measurements are accurate, consistent and traceable to metrology standards.

The efficiency of the hydrocarbon “kicker” was evaluated with a 1 ppm m-xylene cylinder. The kicker selectively removes hydrocarbons from the sample inlet prior to analysis. This is an important test, because m-xylene behaves in a similar manner to SO₂ when exposed to UV light, and could therefore interfere with the analyser response, if the kicker does not function properly.

To pass the test, the analyser must not respond by more than 1% (10 ppb) of the m-xylene cylinder concentration. However, it should be noted that this particular test is very demanding; typical ambient hourly maximum concentrations of this pollutant rarely exceed 50 ppb, and annual concentrations rarely exceed 5 ppb.

The following 10 analysers were outside the required standard:

1. Belfast East (11 ppb)
2. Blackpool (16 ppb)
3. Derry (19 ppb)
4. Exeter Roadside (16 ppb)
5. London Brent (16 ppb)
6. London Westminster (17 ppb)
7. Manchester Piccadilly (23 ppb)
8. Manchester South (20 ppb)
9. Plymouth (19 ppb)
10. Wolverhampton Centre (23 ppb)

The kickers at Belfast East, Derry, Exeter Roadside and Wolverhampton Centre were all identified as outliers at the summer 2001 intercalibration. The kicker at Manchester South was identified as an outlier at the previous two exercises.

These results are similar to the previous intercalibration, when 9 analyser kickers were identified as outliers. However the magnitude of the responses to m-xylene was lower; none of these results give immediate cause for concern.

To put these results into perspective, at the expected maximum ambient concentrations of m-xylene (50ppb), the worst kicker would show an interference response of around 1 ppb.
6 Ozone

The calibration of the ozone analysers was performed using netcen photometers certified against the Standard Reference Photometer (SRP), held at the National Physical Laboratory (NPL).

The results from 17 of the 47 analysers (36%) were found to be greater than 5% from the netcen standard at this intercalibration. The overall result is two analysers worse than the previous exercise, when 32% of the analysers were identified as outliers. Of the 17 outliers, 14 were minor grade B; the analysers at Norwich Centre, Stoke on Trent Centre and Wirral Tranmere were grade C. It is most likely that the grade C outliers arose from the pressure dependency that has been observed for these analysers before. netcen will make use of all the available data from these sites and rescale the data as necessary during ratification.

Subsequent investigations revealed instrument response drift as the main reason for all of the grade B outlying analysers. Ratification of the data from these sites should be relatively straightforward, no data loss should occur.

The analyser at Salford Eccles was not available for testing.

Despite the fact that a large number of outliers were identified, all were relatively minor in nature. The ratification process should produce reliably scaled datasets, with only minimal consequences for data capture.

7 Particulates

7.1 TEOM ANALYSERS

Evaluation of the TEOM instrument $k_0$ calibration constants, using a series of pre-weighed filters, showed that three analysers were outside the ± 2.5% acceptance limit:

1. Coventry Memorial Park  
   (-4.7%)
2. London Bloomsbury  
   (+2.6%)
3. Preston  
   (-2.9%)

The analysers at Coventry Centre and Preston were repeat outliers, having been identified at the previous 2 intercalibrations. The Preston analyser has been adjusted a number of times, but it seems that these adjustments have not been completely successful. It should be possible to rescale the data from all these sites with no loss of data.

These $k_0$ results should be verified by the appropriate ESU, and remedial action taken as necessary.

Recommendation: ESUs to verify the results at the above sites, and take remedial action as necessary
The flow rates of the analysers at Bury Roadside, Glasgow Centre and Norwich Centre were all found to be significantly below the required 16.67 l/min. Data from these instruments will be carefully examined, and it is possible that some data will need to be rejected as a result. No significant flow errors or leaks were found at any of the other sites.

netcen and the equipment suppliers have been investigating possible reasons for the significant number of \( k_0 \) outliers identified at recent audits. These investigations have examined every aspect of the \( k_0 \) determination, from procedures used, through multi filter tests and the calculation itself, to the symmetry of the filter / tapered element union.

Tests to examine the variance of calculated \( k_0 \) using a large number of different filters was undertaken. The investigation revealed that the original metal foil backed filters (which have been used since the analysers were first operated in the network) gave significantly variable responses. This variability can be attributed in part to the manual nature of the production of these filters.

The latest long-life filters are assembled in plastic, using fully automated methodologies, which reduces the amount of variability in the finished product. Tests using these filters have been very encouraging, with reduced variability in the calculated results.

**Recommendation:** To improve data quality, all site TEOM filters should be changed to the newer plastic filter cartridges.

### 7.2 BAM ANALYSER

The flow rate of the analyser at Belfast Clara Street was found to be within acceptable limits.

### 7.3 PARTISOL ANALYSERS

These gravimetric daily samplers have been installed at the following sites in the network:

1. Dumfries
2. Inverness
3. Wrexham
4. Bournemouth
5. Northampton
6. London Westminster

Flow tests were undertaken at Bournemouth, Northampton, Wrexham and Dumfries, and all were found to be within limits.

The Inverness analyser was awaiting repair at the time of the intercalibration visit, while safety restrictions prevented tests at London Westminster.
8 Site Cylinder Concentrations

During the intercalibration, the concentrations of the on-site cylinders were evaluated using the audit cylinder standards. The calculated results showed that 5 of the 203 cylinders (2.5%) used to scale analyser data into concentrations (NO, CO and SO₂) appear to be outside the ±10% acceptance criterion. In addition, the concentrations of 19 NO₂ cylinders appear to have drifted by more than 10%. This is similar to the previous intercalibration, where 9% of the cylinders were found to be out of specification. The site cylinder evaluations are performed by calibrating the analysers with audit and site cylinder gas through the same inlet system, and using the conditioned site cylinder regulators, thus minimising any possible errors due to contaminated tubing or regulators.

2 NO cylinder outliers were identified. Of these, the cylinder at Stoke-on-Trent Centre is of most concern, as the concentrations have changed significantly, suggesting the cylinders may have become contaminated. This should be returned to NPL for replacement at the earliest opportunity.

**Recommendation:** NPL to replace the Stoke-on-Trent Centre NO cylinder

19 NO₂ outliers were found. Of the outliers identified, the cylinder at Aberdeen gives cause for concern, as it was again found to be significantly different from its certified value. However, as NO₂ cylinders are not routinely used to scale NOx data, the requirement for replacement is not urgent.

**Recommendation:** NPL to replace the Aberdeen NO₂ cylinder

3 SO₂ outliers were identified. The calculated concentration of the cylinder at London Cromwell Road 2 again appears to have drifted significantly (by 19%) from its stated values, and should be replaced as soon as possible. The cylinders at Norwich Centre and Stoke-on-Trent Centre will be carefully checked at the next intercalibration.

**Recommendation:** NPL to replace the London Cromwell Road 2 SO₂ cylinder

As with earlier exercises, the site cylinder concentrations evaluated at the on-site audit are not used to update the cylinder databases. This is because the certified values provided by the Calibration Laboratories at NPL and netcen have much better uncertainties associated with their calculations. The field calculation is used as a check to identify possible outlier cylinders, which can be subsequently assessed by returning the cylinder for re-certification.

All of the revised calculations will be carefully assessed at the next intercalibration exercise, and any recurring outlier cylinders will be reported to NPL.

9 Assessment of sampling inlets

During this intercomparison exercise, the potential losses of sample gas to the inlet systems were assessed, using audit cylinder gas.
At a scheduled fortnightly calibration, the LSO introduces gases into the analysers through dedicated, clean gas cylinder inlets. These calibrations are then used to scale raw data from the analysers.

Audit cylinder gases and site cylinder gases were introduced to the analysers at the sample inlet, and the responses compared to the previous LSO calibration, to determine any significant differences between the two methods.

In previous intercalibrations, affected analysers were seen to exhibit pressure sensitivity when audit gases were introduced into the sample inlets. This meant that if the excess flows to the analyser were increased, even by a small amount, the analyser responses would increase, and vice versa. As a result, it has proved extremely difficult to reliably estimate losses to the manifolds for the analysers at affected sites.

At this exercise, the vast majority of the sites showed losses of less than 10% to the sample inlet. The following analysers exhibited apparent losses to the sampling / calibration system:

- NOx analyser at Portsmouth
- CO analyser at Wolverhampton Centre
- SO₂ analysers at Derry, Leicester Centre and Southampton Centre
- O₃ analysers at Norwich Centre, Stoke-on-Trent Centre and Wirral Tranmere

This is somewhat worse than the summer 2001 result, where only one analyser was seen to behave in this manner. The ESU's are reminded of the importance of cleaning the entire sample inlet system (manifold, tubes, and solenoids), and the requirement to do this every six months at the scheduled service.

10 LSO Audits

During the intercalibration, 43 of the 66 Local Site Operators were audited; to assess their performance in undertaking scheduled calibrations. As with previous audit exercises, the majority of LSO's undertake calibrations competently, and are very knowledgeable about the equipment used on site and procedures employed in the network. The audits were very successful, with very few adjustments of their operating techniques required to fully conform to the Operator Manual.

This LSO audit exercise once again demonstrates that operators are generally competent, enthusiastic and knowledgeable about their sites, which is a major contributing factor in ensuring the continued high performance of the network.

11 Safety

netcen has undertaken extensive risk assessments of all its activities on site, to ensure that its staff and Local Site Operators are not exposed to unsafe practices while working. In conjunction with Stanger, we have identified a number of areas that require attention in order to minimise operator risk. These are:
• Safe access to particulate analyser inlets to test flow rates, chiefly at the following sites:
  1. Bolton
  2. Canterbury
  3. Coventry Memorial Park
  4. Edinburgh Centre
  5. Glasgow Roadside
  6. Grangemouth
  7. Leamington Spa
  8. London A3 Roadside
  9. London Bloomsbury
 10. London Brent
 11. London Westminster
 12. Manchester Piccadilly
 13. Plymouth Centre
 14. Scunthorpe
 15. Southend-on-Sea
 16. Stockport
 17. Thurrock

• Safe access, lifting facilities and security barriers at the Walsall Alumwell site

Many of these upgrades are in progress. As they are completed, netcen will reassess the risk to operators and update as necessary.

12 Certification

Appended to this report is the Network Certificate of Calibration. This certificate presents the results of the individual analyser scaling factors on the day of the audit visit, as calculated by netcen using the audit cylinder standards, in accordance with our UKAS accreditation.

13 Summary

The intercalibration exercise has demonstrated its value as an effective tool in determining overall site performance and assessing the reliability and traceability of air quality measurements from a large scale network. The results from this intercalibration have been used to assess data quality during the ratification of the network datasets for the 6-month period July to December 2001.
Appendices

CONTENTS

Appendix 1    Network Certificate of Calibration
Appendix 1
Certificate of Calibration
**Certificate of Calibration**

**Certificate No:** 00706  
**AEA Identification Number:** 20568104

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**Customer Name and Address:** Dr Janet Dixon  
**Department for Environment, Food and Rural Affairs**  
**Ashdown House (Zone E14)**  
**123 Victoria Street**  
**London SW1E 6DE**

**Date of issue:** 1 August 2002

**Description:** Calibration factors for monitoring stations in the Automatic Urban Monitoring Network

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The certificate is issued in accordance with the requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to recognized national standards, and to units of measurement realized at the National Physical Laboratory or other recognized national standards laboratories. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.
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AEA Identification Number: 20568104  
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AEA Identification Number: 20568104

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The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

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The above factors have been calculated using certified standards. The analysers listed above have been tested for zero response, calibration factor, linearity, converter efficiency (NOx analysers), m-xylene interference (SO₂ analysers), k₀ / main flow rate (for TEOM analysers) and total flow rate (for particulate analysers), by documented methods. Note that the test results are valid on the day of test only, as analyser drift over time cannot be quantified.

The calibration results for NOₓ, NO, CO, SO₂, O₃ and Particulates are those that fall within our scope of accreditation. Results marked with an asterisk (*) on this certificate are not UKAS accredited, but have been included for completeness.
1 The zero response is the zero reading on the logging system of the analyser when audit zero gas was introduced to the analysers under test.

2 The calibration factor is the multiplying factor required to scale the reading on the data logging system into concentration units (ppb for NO, NOx and SO2, ppm for CO – 1ppm = 1000 ppb). It should be used in conjunction with the analyser output and the zero response, according to the following equation:

\[
\text{Concentration} = (\text{output} - \text{zero response}) \times \text{Calibration factor}
\]

3 The calculated main flow rate (where this is applicable) is the flow rate through the sensor unit of a TEOM analyser. The calculated total flow rate is the flow rate through a particulate analyser.

4 The k₀ accuracy value (specifically for TEOM analysers) indicates the closeness of the calculated result to the manufacturer’s specified value of k₀.

*R² is the correlation coefficient of linearity

*Converter is the measured efficiency of the NO₂ to NO converter in the Oxides of Nitrogen analyser

*meta-xylene interference is the response of the SO₂ analyser when supplied with approx 1ppm meta-xylene

This certificate is an electronic representation of a master copy, signed by Ken Stevenson on 4 November 2002, that is held at AEA Technology Environment. Hard copies of this document are available on request.