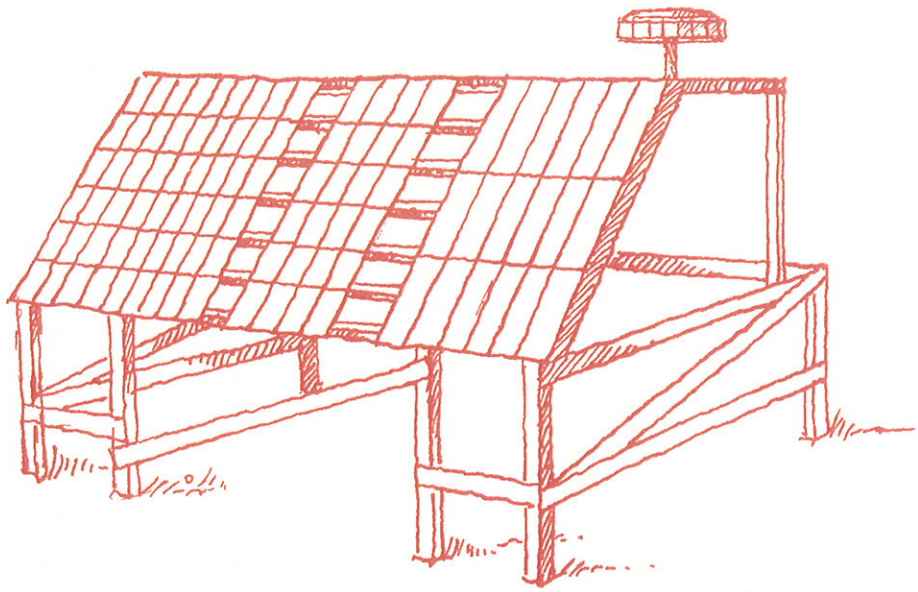
# CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION

## UN/ECE INTERNATIONAL CO-OPERATIVE PROGRAMME ON EFFECTS ON MATERIALS, INCLUDING HISTORIC AND CULTURAL MONUMENTS



**Report No 66:**

# Trends in pollution, corrosion and soiling 1987-2009

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**PREPARED BY THE MAIN RESEARCH CENTRE**

swerea|KIMAB Swerea KIMAB AB, Stockholm, Sweden

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**ON EFFECTS ON MATERIALS,**
**INCLUDING HISTORIC AND CULTURAL MONUMENTS**

Report No 66
Trends in pollution, corrosion and soiling 1987-2009

Compiled by
Johan Tidblad[1], Martin Ferm[2], Terje Grøntoft[3], Katerina Kreislova[4], Markus Faller[5], Tim Yates[6] and Tiziana Lombardo[7]

[1]Swerea KIMAB AB, Stockholm, Sweden
[2]IVL Swedish Environmental Research Institute, Gothenburg, Sweden
[3]Norwegian Institute for Air Research (NILU), Kjeller, Norway
[4]Svuom Ltd., Prague, Czech Republic
[5]Swiss Federal Laboratories for Materials Testing and Research (Empa), Dübendorf, Switzerland
[6]Building Research Establishment Ltd. (BRE), Watford, United Kingdom
[7]Laboratoire Interuniversitaire des Systèmes Atmosphérique (LISA), Paris, France

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# 1 Introduction

Early in the discussions on the "Convention on Long-range Transboundary Air Pollution" it was recognized that a good understanding of the harmful effects of air pollution was a prerequisite for reaching agreement on effective pollution control. To develop the necessary international cooperation in the research on and the monitoring of pollutant effects, the Working Group on Effects (WGE) was established under the Convention in 1980 and held its first meeting in 1981. The Convention involves countries in the UNECE region and has its secretariat with the UNECE [1].

The Working Group on Effects provides information on the degree and geographic extent of the impacts on human health and the environment of major air pollutants, such as sulphur and nitrogen oxides, ozone and heavy metals. Its six International Cooperative Programmes (ICPs) and the Task Force on Health identify the most endangered areas, ecosystems and other receptors by considering damage to human health, terrestrial and aquatic ecosystems and materials. An important part of this work is long-term monitoring. The work is underpinned by scientific research on dose-response, critical loads and levels and damage evaluation [1].

The International Co-operative Programme on Effects on Materials including Historic and Cultural Monuments (ICP Materials) is one of the six ICPs. During the course of the programme, which had its first exposure in 1987, the special importance of trend effects has become more and more evident. The aims of ICP Materials are now to

- perform a quantitative evaluation of the effects of multi-pollutants such as S and N compounds, ozone and particles as well as climate parameters on the atmospheric corrosion of important materials, including materials used in objects of cultural heritage;

- describe and evaluate long-term corrosion trends attributable to atmospheric pollution in order to elucidate the environmental effects of pollutant reductions achieved under the Convention and in order to identify extraordinary environmental changes that result in unpredicted materials damage;

- use the results for mapping areas with increased risk of corrosion, and for calculation of cost of damage caused by deterioration of materials.

The present report addresses the second of these aims and gives a summary of results obtained since the first exposure in 1987. During this time, exposure sites, exposed materials and measured environmental parameters have partly changed. On the other hand, some of the sites erected in 1987 are still running and provide an excellent basis for evaluation of trends.

One should note that the focus is on the most recent results, especially the 2002-2003, 2005-2006 and 2008-2009 trend exposures. The corrosion results for the 2008-2009 trend exposure was presented in report 62 and the Environmental results from the 2008-2009 trend exposure in report 67.

# 2 Overview

What is a "trend exposure"? Within ICP Materials, this has been defined as a one-year exposure of materials within the network of test sites accompanied by characterization of the environment. The exposure has always started in the fall, typically from October one year to September the next year. For example, the exposure performed during the period October 1987 to September 1988 is typically denoted the 1987/88 trend exposure or, even shorter, the 1987 trend exposure emphasizing the exposure start.

## 2.1 Test sites

The list of test sites is shown in table 1. The network of test sites originally consisted of 39 test sites, which were all part of the original 8-year exposure between 1987 and 1995. In the multi-pollutant exposure programme, a 4-year exposure programme between 1997 and 2001, only part of the original test sites were kept and in addition, eight new test sites were started. After that, new test sites have joined. Compared to the 2008-2009 exposure, the sites Lahemaa and Lincoln have withdrawn from the 2011-2012 exposure while there will be a new site in St Petersburg

All data is given in Appendix 2.

## 2.2 Environment

Note first that, as for corrosion data, environmental data is reported with a broken year starting in the fall so that, for example, 1987/88 or simply 1987 data refers to annual averages from the period October 1987 to September 1988.

At or nearby each site environmental data were continuously measured. This includes data for gaseous pollutants, precipitation, climatic parameters and in recent exposures particulate matter. All environmental measurements were reported and compiled by the Norwegian Institute for Air Research (NILU), Norway, which also controlled the quality of the data. Environmental data have been compiled in separate reports in the official ICP Materials report series. A complete list of ICP Materials reports is given in Appendix 1.

The gaseous parameters measured include $SO_2$, $NO_2$, $O_3$ and in recent years also $HNO_3$. With the new data, results from three exposure periods are now available, 2002-2003, 2005-2006 and 2008-2009. This presents a unique opportunity to present for the first time trends in $HNO_3$ concentrations. Trends of $SO_2$, $NO_2$ and $O_3$ were discussed in report 56 and trends are updated but not discussed in great detail.

Table 1. List of all ICP Materials test sites showing number, name, country site type, year with available data and participation in the 2011-2012 trend exposure.

| No | Name | Country | Site type | Available data | 2011-2012 Exposure |
|---|---|---|---|---|---|
| 1 | Prague-Letnany | Czech Republic | Urban | 1987 – 2009 | X |
| 2 | Kasperske Hory | Czech Republic | Rural | 1987 – 1995 | |
| 3 | Kopisty | Czech Republic | Industrial | 1987 – 2009 | X |
| 4 | Espoo | Finland | Urban | 1987 – 1995 | |
| 5 | Ähtäri | Finland | Rural | 1987 – 2003 | |
| 6 | Helsinki-Vallila | Finland | Industrial | 1987 – 1995 | |
| 7 | Waldhof-Langenbrügge | Germany | Rural | 1987 – 2003 | |
| 8 | Aschaffenburg | Germany | Urban | 1987 – 1995 | |
| 9 | Langenfeld-Reusrath | Germany | Rural | 1987 – 2003 | |
| 10 | Bottrop | Germany | Industrial | 1987 – 2009 | X |
| 11 | Essen-Leithe | Germany | Rural | 1987 – 1995 | |
| 12 | Garmisch-Partenkirchen | Germany | Rural | 1987 – 1995 | |
| 13 | Rome | Italy | Urban | 1987 – 2009 | X |
| 14 | Casaccia | Italy | Rural | 1987 – 2009 | X |
| 15 | Milan | Italy | Urban | 1987 – 2009 | X |
| 16 | Venice | Italy | Urban | 1987 – 2009 | X |
| 17 | Vlaardingen | Netherlands | Industrial | 1987 – 1995 | |
| 18 | Eibergen | Netherlands | Rural | 1987 – 1995 | |
| 19 | Vredepeel | Netherlands | Rural | 1987 – 1995 | |
| 20 | Wijnandsrade | Netherlands | Rural | 1987 – 1995 | |
| 21 | Oslo | Norway | Urban | 1987 – 2009 | X |
| 22 | Borregard | Norway | Industrial | 1987 – 1995 | |
| 23 | Birkenes | Norway | Rural | 1987 – 2009 | X |
| 24 | Stockholm South | Sweden | Urban | 1987 – 2009 | X |
| 25 | Stockholm Centre | Sweden | Urban | 1987 – 1995 | |
| 26 | Aspvreten | Sweden | Rural | 1987 – 2009 | X |
| 27 | Lincoln Cathedral | United Kingdom | Urban | 1987 – 2009 | |
| 28 | Wells Cathedral | United Kingdom | Urban | 1987 – 1995 | |
| 29 | Clatteringshaws Loch | United Kingdom | Rural | 1987 – 1988 | |
| 30 | Stoke Orchard | United Kingdom | Industrial | 1987 – 1993 | |
| 31 | Madrid | Spain | Urban | 1987 – 2009 | X |
| 32 | Bilbao | Spain | Industrial | 1987 – 1995 | |
| 33 | Toledo | Spain | Rural | 1987 – 2009 | X |
| 34 | Moscow | Russian Federation | Urban | 1987 – 2003 | |
| 35 | Lahemaa | Estonia | Rural | 1987 – 2009 | |
| 36 | Lisbon | Portugal | Urban | 1987 – 2003 | |
| 37 | Dorset | Canada | Rural | 1987 – 2006 | |
| 38 | Research Triangle Park | USA | Rural | 1987 – 1995 | |
| 39 | Steubenville | USA | Industrial | 1987 – 1995 | |
| 40 | Paris | France | Urban | 1997 – 2009 | X |
| 41 | Berlin | Germany | Urban | 1997 – 2009 | X |
| 43 | Tel Aviv | Israel | Urban | 1997 – 2001 | |
| 44 | Svanvik | Norway | Rural | 1997 – 2009 | X |
| 45 | Chaumont | Switzerland | Rural | 1997 – 2009 | X |
| 46 | London | United Kingdom | Urban | 1997 – 2003 | |
| 47 | Los Angeles | USA | Urban | 1997 – 2001 | |
| 49 | Antwerpen | Belgium | Urban | 1997 – 2003 | |
| 50 | Katowice | Poland | Industrial | 2000 – 2009 | X |
| 51 | Athens | Greece | Urban | 2005 – 2009 | X |
| 52 | Riga | Latvia | Urban | 2005 – 2009 | X |
| 53 | Vienna | Austria | Urban | 2008 – 2009 | X |
| 54 | Sofia | Bulgaria | Urban | 2008 – 2009 | X |
| 55 | St Petersburg | Russian Federation | Urban | - | X |

Precipitation data include total amount, conductivity and concentration of the ions $H^+$, $SO_4^{2-}$, $NO_3^-$, $Cl^-$, $NH_4^+$, $Na^+$, $Ca^{2+}$, $Mg^{2+}$ and $K^+$. Only data of the total amount and $H^+$ / pH are given in this report. Measured climatic parameters include temperature, relative humidity and in the beginning of the project time of wetness, sunshine hours and sunshine radiation. Only data of temperature and relative humidity are given in this report.

Only annual averages of the indicated parameters are given. Monthly values are also available in the individual environmental data reports. Up until 2000, when large exposure programs were running with samples exposed for more than one year, environmental data were collected each year but after that only in connection with the 2002 and 2005 trend exposures.

## 2.3 Materials

A wide range of materials has been exposed over the years. The first one-year exposure started in 1987 and many different materials were exposed including stone materials, structural metals, paint systems on wood and metal and electric contact materials. Later exposures included also patinated and waxed bronzes, glass materials of medieval and modern composition and polymer materials. The 1-year exposure of zinc was first repeated in 1989 and in 1992 for both carbon steel and zinc, which for a long time was considered the only "trend materials". In connection with the multi-pollutant exposure programme (1997-2001), carbon steel, zinc and limestone were proposed as indicator materials and in 2002, limestone was added to the list of trend materials. This report is limited to describing corrosion attack of carbon steel, zinc and limestone as official trend materials and table 2 shows an overview of performed exposures. Two variants of zinc samples have been exposed, one "traditional", with SVUOM Ldt. as sub-centre, suitable for corrosivity classification and one that was blasted as a surface preparation prior to exposure, with EMPA as sub-centre, resulting in slightly higher corrosion rates.

Table 2 One-year (trend) exposures of carbon steel, zinc and limestone performed within ICP Materials (1987-2009).

| | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Carbon steel* | X | | | | | X | | X | | X | X | | | X | | X | | | X | | | X |
| *Zinc*[a] | X | | X | | | X | | X | | X | | | | X | | | | | | | | X |
| *Zinc*[b] | | | | | | | | | | | X | | | X | | X | | | X | | | X |
| *Limestone* | X | | | | | | | | | | X | | | | | X | | | X | | | X |

[a]With SVUOM Ltd., Czech Republic as responsible sub-centre
[b]With EMPA., Switzerland as responsible sub-centre

For each exposure, material and site, three identical samples were exposed and individual corrosion values for these three samples have been reported in the respective reports in the official ICP Materials report series (Appendix 1). The present report is complete in the respect that it compiles all data given in previous reports, but only averages of triplicates are given. In general, the spread between triplicates are minor.

# 3 Trends in pollution, corrosion and soiling

This section contains a summary of trend analysis presented in [2] with focus on quantitative results.

## 3.1 Trends in $SO_2$, $NO_2$, $O_3$

Figure 2 shows average relative $SO_2$, $NO_2$ and $O_3$ concentrations at ICP Materials sites, corrected for site selection. The average trends are quite different for the gases. $O_3$ increased during the 1990's, but has been relatively constant after this period. $NO_2$ has decreased and continues to decrease over the entire period, while the decrease in $SO_2$ ceased during 2000 to 2006 with a slight decrease in the most recent exposure in 2008-2009. Important to note is that although $O_3$ have not decreased substantially during the period 1998 to 2009, the average $O_3$ values for the periods 2002-2003, 2005-2006 and 2008-2009 show a decreasing trend. This difference between short term and long-term perspective is important to remember when judging the results of trends in $HNO_3$ presented in the next section.

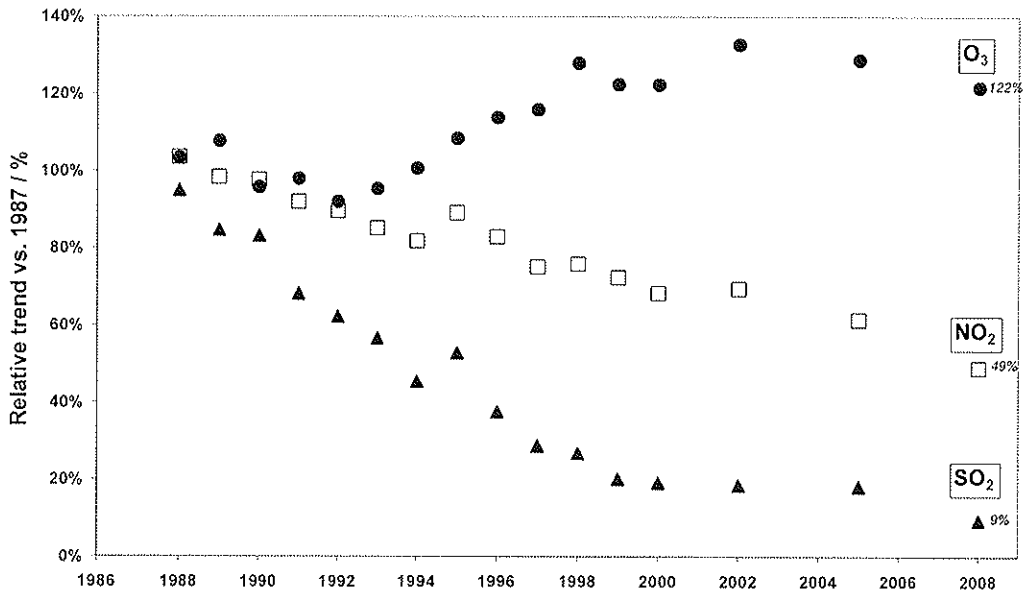


**Figure 1.** Average $SO_2$, $NO_2$ and $O_3$ trends relative to the year 1987 at ICP Materials test sites.

## 3.2 Trends in N pollutants ($HNO_3$, $NO_2$ and particulate $NO_3^-$)

$HNO_3$ was measured with diffusive samplers, and nitrate of water soluble deposited particles with a surrogate surface, as explained in previous reports. The exposure time was generally 2 months for the periods 2002-2003, 2005-2006 and 2008-2009. Figure 2 shows $HNO_3$ concentrations for these three years, compared two-by-two years at a time. The results are well correlated between the campaigns except for a few odd sites, which were excluded in the linear regression lines. The decrease in nitric acid concentrations seems to be substantial, on the average about 20% per three-year period, which would correspond to about 50% for a 10-year period, should the decrease continue at the same rate.

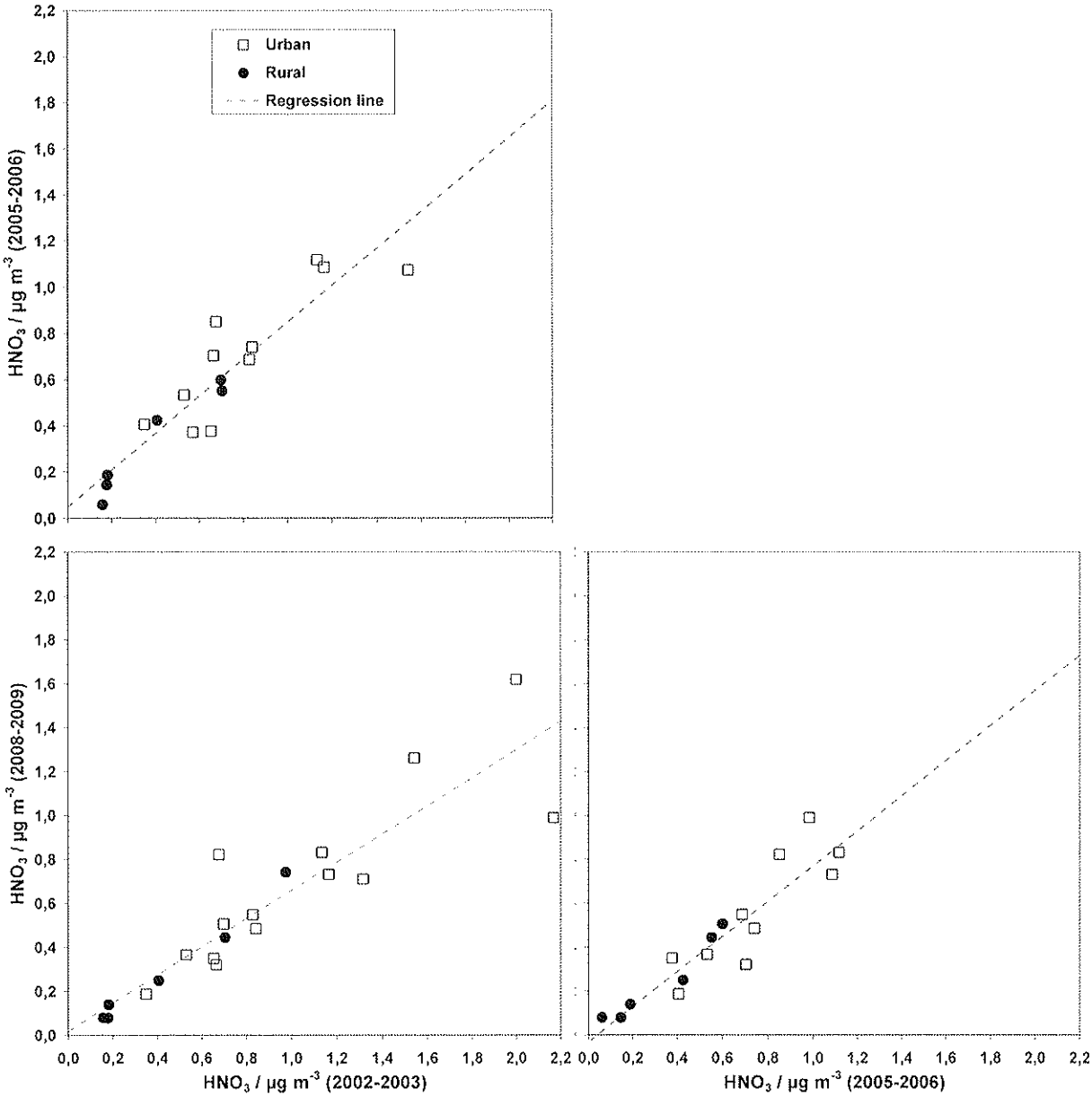


**Figure 2**. Annual average $HNO_3$ concentration at ICP Materials test sites for the three one-year exposures 2002-2003, 2005-2006 and 2008-2009. The grey squares have been excluded when calculating the linear regression lines y=0.80x+0.05 (2005-2006 *vs.* 2002-2003), y=0.80x-0.03 (2008-2009 *vs.* 2005-2006), y=0.64x+0.02 (2008-2009 *vs.* 2002-2003).

The concentrations of the precursors $NO_2$ and $O_3$ were also lower during the campaign 2008-2009 compared to 2002-2003, see Figure 3. As can be seen from the figure the annual average concentration of these precursors has also decreased during this period (Figure 1). Since particulate nitrate requires a counter ion, it is not likely that the deposited particulate nitrate formation rate is proportional to the nitric acid concentration in air. A small decrease in particulate nitrate deposition was, however, observed between the first and latest campaigns.

At four places in the network a rural site is quite close to a corresponding urban site. At these sites (Toledo-Madrid, Birkenes-Oslo, Aspvreten-Stockholm and Casaccia-Rome) the $HNO_3$ concentrations are much higher at the urban sites than the rural except for Casaccia –Rome where they are quite similar. The $NO_2$ concentrations were always much lower at the nearby rural sites.

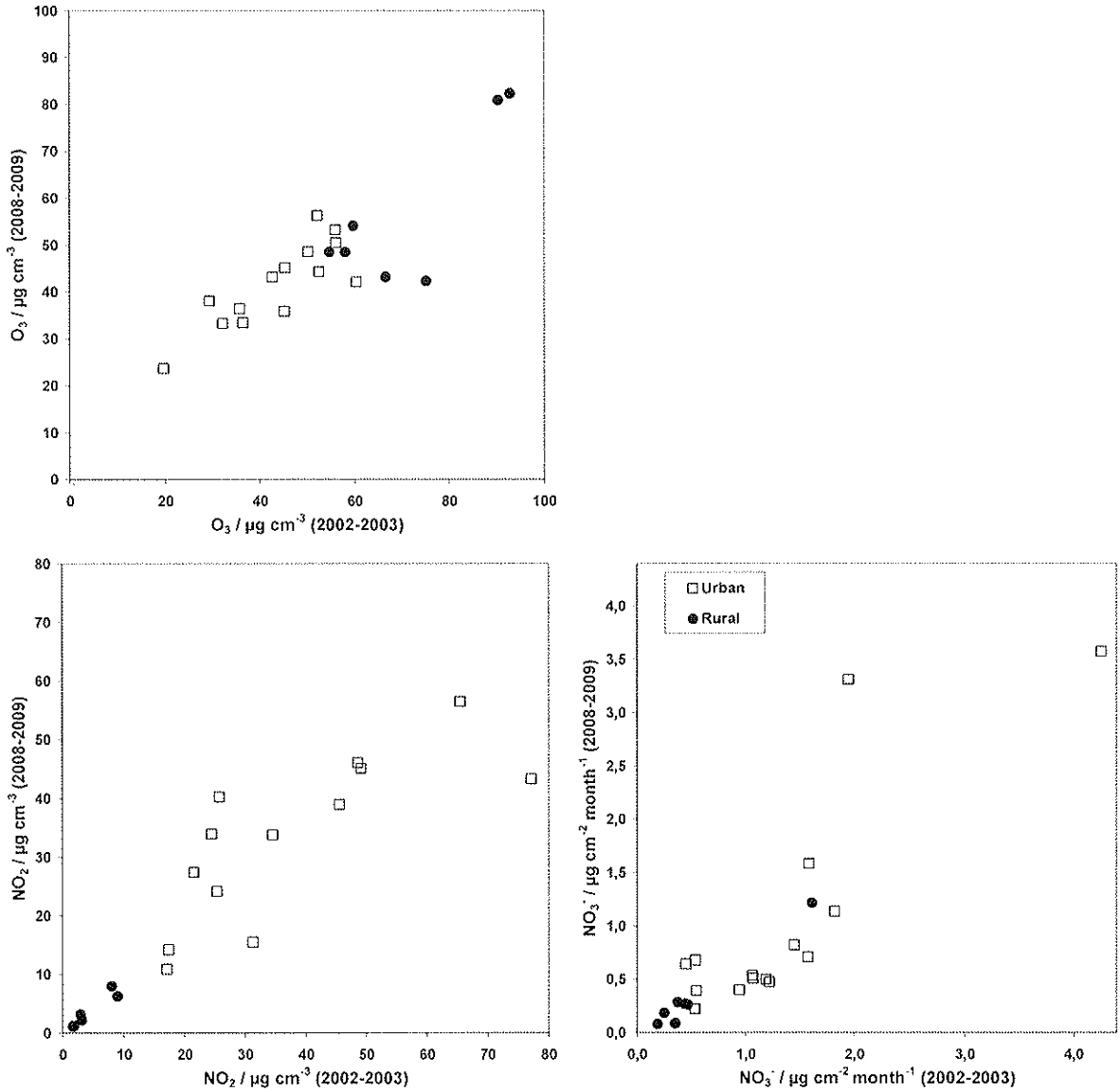


**Figure 3**. Annual average $O_3$ concentration, $NO_2$ concentration and $NO_3^-$ deposition at ICP Materials test sites for the two one-year campaigns 2002-2003 and 2008-2009.

## 3.3 Trends in corrosion

Corrosion of materials has decreased during 1987-2009, mainly due to the decreasing $SO_2$ concentration, but to varying degrees depending on the material. Figure 4 shows the surface recession of limestone for the exposure periods 1987-1988, 1997-1998, 2002-2003, 2005-2006 and 2008-2009.

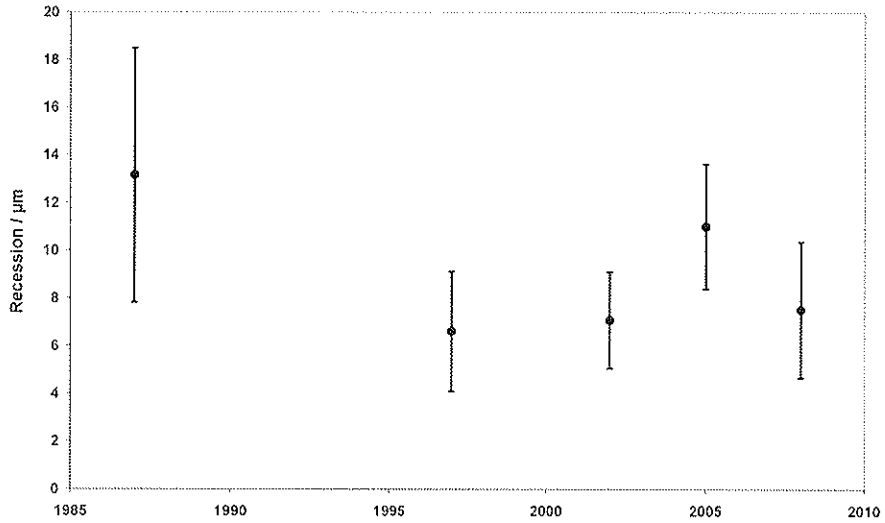


**Figure 4**. Averages and ranges (standard deviations) of limestone surface recession at ICP Materials test sites (one year exposures).

Compared to the first exposure the values today are obviously lower, but there is significant year to year variation and there is no obvious decrease since 1998. The same is true for zinc (Figure 5). In figure 5 it is an obvious difference between traditional and blasted zinc, use of the latter resulting in corrosion values on average almost twice that of traditional zinc. Therefore blasted zinc values are shown in a different scale (Figure 5, right) in order to make a complete visual impression of the relative zinc trends. For carbon steel, however, the decrease in corrosion is in principle following an exponential decay with corrosion halving its value each 12$^{th}$ year in industrial/urban areas and each 16$^{th}$ year in rural areas (Figure 6).

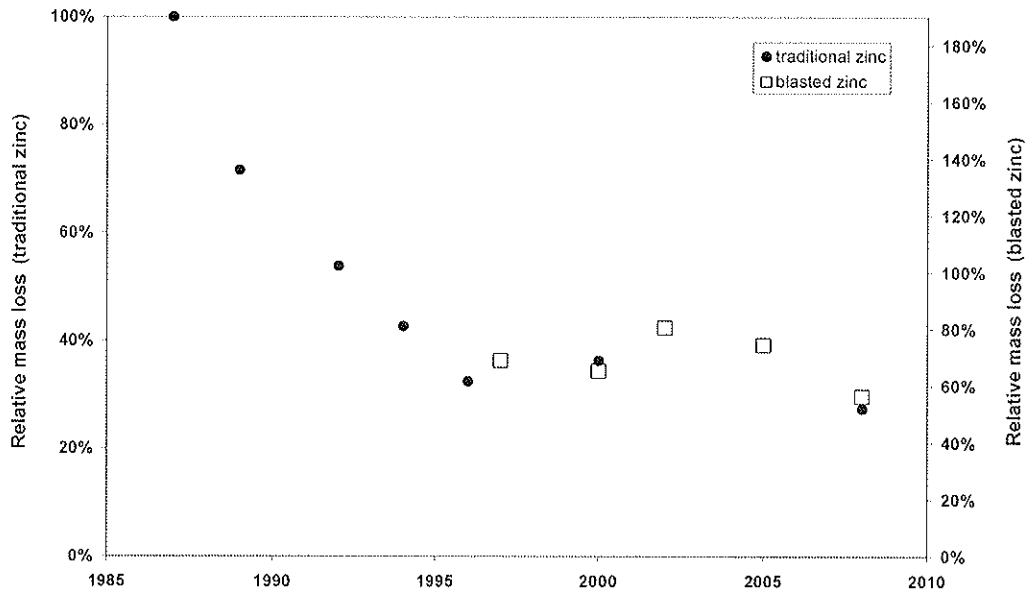


**Figure 5**. Average relative zinc corrosion at ICP Materials test sites. Values for both traditional and blasted zinc have been normalised to the 1987-1988 value for traditional zinc before averaging.

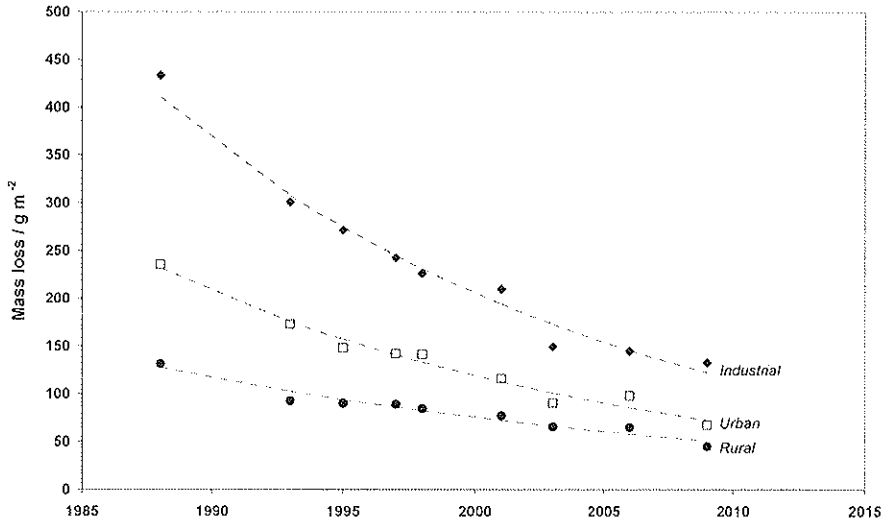


**Figure 6** Carbon steel corrosion for industrial, urban and rural ICP Materials test sites.

## 3.4 Trends in soiling of modern glass

Due to the increasing importance of particulate matter, modern glass was officially included as a trend material for soiling of materials in the 2005-2006 exposure, so this means that only two exposure periods are available. Dose-response functions are currently being evaluated, but the final functions will not be available until end 2013 and will include results also after four years of exposure (2008-2012). Figure 7 shows soiling of modern glass measured by the haze parameter, which is the ratio between the diffuse and direct transmitted light. Taking into account the accuracy of the measurements, it is not possible to say that soiling, on average, has increased or decreased when comparing the two exposure periods 2005-2006 and 2008-2009.

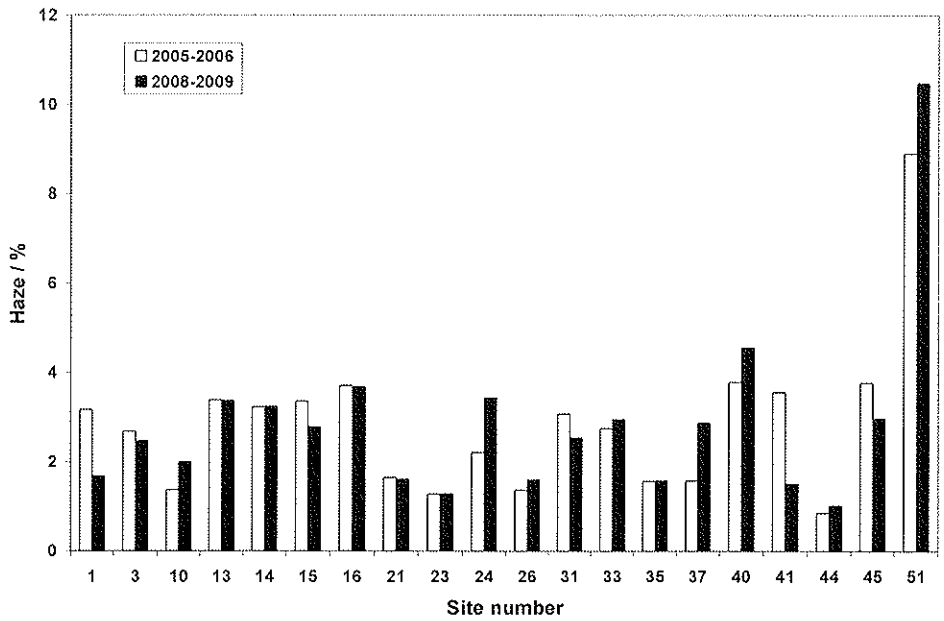


**Figure 7**. Soiling of modern glass at ICP Materials test sites (see Table 1)

# 4 Black carbon (BC)

Effects on stone materials were observed in the 1950's and 1960's, when high levels of $SO_2$ attacked the surface dissolving black carbon into the surface and building a 2-3 cm thick black crust. Black carbon levels could possible influence the time of wetness of metals and thus, indirectly, the corrosion of metals. However, in the present European situation the main effect of black carbon is expected to be related to soiling of materials. At the 27$^{th}$ meeting of the ICP Materials Task Force it was decided to include a report on the effect of black carbon (BC) on soiling of materials to the 2012 work plan.

# 5 Summary

The present report has compiled annual data of environment (pollution and climate), corrosion of carbon steel, zinc and limestone and soiling of modern glass for the period 1987-2006 based on individual ICP Materials reports. It has further discussed the trends with special emphasis on the most recent results.

$SO_2$, $NO_2$ and $O_3$ has decreased compared to the latest trend exposure in 2005-2006 and the values for $SO_2$ and $NO_2$ are now on average only about 10% and 50%, respectively, of the values in 1987. $O_3$ increased during the 1990's and even though it decreased during the period 2002-2009 the average values are still higher compared to those in 1987.

Nitric acid concentrations were measured in 2002-2003, 2005-2006 and 2008-2009. When comparing these three periods the relative decrease was about the same from 2002-2003 to 2005-2006 as it was from 2005-2006 to 2008-2009, corresponding to about 50% for a 10-year period, should the decrease continue at the same rate. However, only three exposure periods are not sufficient to rule out that this apparent trend is not instead part of a natural year-to-year variation.

Carbon steel corrosion has since the beginning of exposures (1987) decreased exponentially at industrial, urban and rural sites so that the corrosion has been halved about each 12$^{th}$ year for industrial/urban sites and each 16$^{th}$ year for rural sites.

Zinc and limestone corrosion have decreased substantially compared to the levels in 1987, but since the turn of the century there is no obvious average trend in the ICP Materials network of test sites.

Modern glass as an indicator for soiling has only been exposed for two periods so far, 2005-2006 and 2008-2009, and when comparing the results from these periods there is no average difference in the results. However, more exposures are needed before long-term trends can be established.

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**ANNEX: TABLES OF ENVIRONMENTAL, CORROSION AND SOILING DATA MEASURED AT ICP MATERIALS TEST SITES:**


*Table A1* *Annual $SO_2$ averages ($\mu g\ m^{-3}$)*
*Table A2* *Annual $NO_2$ averages ($\mu g\ m^{-3}$)*
*Table A3* *Annual $O_3$ averages ($\mu g\ m^{-3}$)*
*Table A4* *Annual $HNO_3$ averages ($\mu g\ m^{-3}$)*
*Table A5* *Annual temperature averages ($^oC$)*
*Table A6* *Annual relative humidity averages (%)*
*Table A7* *Annual precipitation averages (mm)*
*Table A8* *Annual pH averages of precipitation*
*Table A9* *Corrosion of carbon steel ($g\ m^{-2}$)*
*Table A10* *Corrosion of zinc from sub-centres SVUOM and EMPA ($g\ m^{-2}$)*
*Table A11* *Corrosion of limestone ($\mu m$)*
*Table A12* *Soiling of modern glass (Haze in %)*

Table A1 Annual $SO_2$ averages ($\mu g\ m^{-3}$) measured at ICP Materials test sites

| No | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2002 | 2005 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 77.5 | 74.2 | 58.1 | 61.4 | 41.9 | 41.2 | 40.2 | 32.1 | 31.5 | 23.6 | 15.3 | 13.1 | 12.6 | 8.8 | 6.4 | 11.1 | 6.5 |
| 2 | 19.7 | 14.5 | 25.6 | 18.4 | 12.0 | 17.9 | 16.4 | 12.2 | | | | | | | | | |
| 3 | 83.3 | 94.6 | 78.4 | 75.9 | 56.9 | 49.0 | 49.5 | 49.2 | 41.1 | 30.6 | 18.3 | 17.8 | 16.0 | 17.9 | 11.2 | 18.1 | 13.5 |
| 4 | 18.6 | 11.8 | 13.9 | | 2.4 | 2.3 | 5.7 | 2.6 | | | | | | | | | |
| 5 | 6.3 | 5.3 | 1.8 | 1.8 | 0.8 | 0.9 | 1.3 | 0.8 | 1.0 | 0.6 | 0.9 | 0.9 | 0.5 | 0.8 | 0.8 | | |
| 6 | 20.7 | 17.4 | 15.3 | 18.2 | 6.0 | 4.8 | 6.8 | 5.5 | 6.3 | 5.2 | | | | | | | |
| 7 | 13.7 | 11.4 | 11.0 | 12.9 | 7.3 | 8.2 | 7.8 | 3.9 | 5.9 | 2.9 | 2.1 | 1.5 | 0.9 | 2.3 | 2.2 | | |
| 8 | 23.7 | 14.6 | 14.2 | 18.9 | 15.6 | 12.6 | 11.6 | 9.6 | | | | | | | | | |
| 9 | 24.5 | 25.7 | 20.3 | 23.7 | 19.7 | 16.3 | 13.6 | 11.1 | 12.8 | 10.5 | 8.3 | 6.5 | 5.3 | 5.0 | 6.0 | | |
| 10 | 50.6 | 48.6 | 48.5 | 53.0 | 51.5 | 41.6 | 35.5 | 30.2 | 33.8 | 29.4 | 24.6 | 20.4 | 18.3 | 17.9 | 16.9 | 15.8 | 12.6 |
| 11 | 30.3 | 27.6 | 25.6 | 24.4 | 25.7 | 22.9 | 18.5 | 16.2 | | | | | | | | | |
| 12 | 9.4 | 13.4 | 6.1 | 5.2 | 4.6 | 3.2 | 2.2 | 2.4 | | | | | | | | | |
| 13 | 29.4 | 44.9 | 38.5 | 24.4 | 2.4 | 6.8 | 14.4 | 5.8 | | | 3.7 | | | | | | 13.5 |
| 14 | 8.3 | 8.3 | 7.4 | 6.4 | 4.7 | 7.5 | 4.7 | 5.2 | | | 5.2 | 3.0 | 3.4 | | 0.7 | 0.2 | 0.0 |
| 15 | 72.2 | 82.7 | 65.4 | 50.3 | 58.5 | 39.4 | 32.4 | 22.1 | | | 15.4 | | 15.1 | 12.9 | 12.3 | 7.8 | 4.4 |
| 16 | 21.1 | 25.7 | 20.2 | 16.4 | 18.6 | 11.0 | 7.1 | 6.3 | | | 7.4 | 5.5 | 6.4 | 7.8 | 2.5 | 2.2 | 4.3 |
| 17 | 35.3 | 31.8 | 32.5 | 30.6 | 27.8 | 25.5 | 21.5 | 20.5 | | | | | | | | | |
| 18 | 10.1 | 8.0 | 8.5 | 9.5 | 8.0 | 7.4 | 5.6 | 4.7 | | | | | | | | | |
| 19 | 13.0 | 10.2 | 9.9 | 10.4 | 8.1 | 8.3 | 6.7 | 4.5 | | | | | | | | | |
| 20 | 13.7 | 11.2 | 10.3 | 12.9 | 11.0 | 9.3 | 7.8 | 5.8 | | | | | | | | | |
| 21 | 14.4 | 12.6 | 7.9 | 8.6 | 6.6 | 6.0 | 5.2 | 2.9 | | | 4.1 | 5.2 | 3.4 | 3.1 | 1.7 | 1.3 | 2.0 |
| 22 | 35.8 | 54.0 | 41.5 | 30.7 | 31.1 | 26.4 | 22.8 | 31.3 | | | | | | | | | |
| 23 | 1.3 | 1.1 | 0.9 | 1.1 | 0.8 | 0.7 | 0.9 | 0.7 | 0.8 | 0.4 | 0.2 | 0.3 | 0.2 | 0.3 | 0.3 | 0.5 | 0.1 |
| 24 | 16.8 | 12.6 | 8.4 | 6.3 | 5.7 | 5.7 | 5.4 | 4.2 | | 3.3 | 2.6 | 3.2 | 2.2 | 1.9 | 1.6 | 1.8 | 0.8 |
| 25 | 19.6 | 20.0 | 10.3 | 2.7 | 3.9 | 4.7 | 5.2 | 3.4 | | | | | | | | | |
| 26 | 3.3 | 1.9 | 2.0 | 2.6 | 1.8 | 1.3 | 1.8 | 1.1 | 1.4 | 0.8 | 0.6 | 0.8 | 0.5 | 0.6 | 0.6 | 0.6 | 0.4 |
| 27 | 17.7 | 19.6 | 15.5 | 20.2 | 20.4 | 17.8 | 10.9 | 6.8 | | | | 9.8 | 8.0 | 7.5 | 4.9 | | 1.9 |
| 28 | 7.2 | 6.6 | 6.9 | 5.0 | 6.4 | 3.2 | 5.0 | 3.3 | | | | | | | | | |
| 29 | 4.3 | 3.2 | 3.5 | 5.2 | | | | | | | | | | | | | |
| 30 | 15.0 | 9.1 | 12.1 | 27.4 | 8.7 | 9.3 | 14.6 | 14.6 | | | | | | | | | |
| 31 | 18.4 | 18.1 | 15.3 | 10.3 | 8.6 | 8.2 | 7.6 | 7.8 | | 11.4 | 11.8 | 6.5 | 4.2 | 1.2 | 2.6 | 1.6 | 3.7 |
| 32 | 35.2 | 49.1 | 41.4 | 23.5 | 7.1 | 9.3 | 8.5 | 6.3 | | | | | | | | | |
| 33 | 3.3 | 8.6 | 13.5 | 6.0 | 4.6 | 1.7 | 3.5 | 4.2 | | 1.1 | 1.5 | 2.3 | 1.9 | 1.2 | 1.1 | 0.9 | 0.4 |
| 34 | 19.2 | 25.5 | 30.8 | 26.0 | 28.0 | 28.7 | 18.9 | 16.4 | | | | 23.6 | | | 4.1 | | |
| 35 | 0.9 | 0.3 | 0.6 | | 0.6 | 0.6 | 0.6 | 0.6 | 1.1 | 0.8 | | 1.7 | 1.4 | 1.3 | 1.7 | 3.9 | 1.1 |
| 36 | 6.8 | 11.9 | 6.6 | 11.3 | 41.1 | 16.1 | 10.0 | 4.7 | | | 17.7 | 15.2 | | | 11.0 | | |
| 37 | 3.3 | 4.2 | 3.0 | 2.8 | 2.1 | 2.1 | 1.5 | 3.3 | 3.4 | | 2.4 | | | | 0.6 | 1.3 | |
| 38 | 9.6 | 10.0 | 9.2 | 7.9 | 13.0 | 10.1 | 8.9 | 9.3 | | | | | | | | | |
| 39 | 58.1 | 59.4 | 55.2 | 64.3 | 33.9 | 43.1 | 44.3 | 38.3 | | | | | | | | | |
| 40 | | | | | | | | | | | 14.2 | 11.1 | 11.1 | 10.1 | 11.2 | 6.6 | 3.1 |
| 41 | | | | | | | | | | 16.3 | 10.9 | 10.9 | 7.0 | 9.8 | 8.6 | | 2.8 |
| 43 | | | | | | | | | | | 35.0 | 60.3 | 9.8 | 6.6 | | | |
| 44 | | | | | | | | | 7.4 | 9.6 | 7.5 | 7.6 | 5.9 | 5.2 | 6.5 | 6.9 | 6.9 |
| 45 | | | | | | | | | | 1.5 | 1.3 | 1.3 | 1.0 | 1.0 | 1.3 | 1.1 | 0.7 |
| 46 | | | | | | | | | | | | 7.6 | 5.9 | 5.8 | 5.8 | | |
| 47 | | | | | | | | | | | 0.6 | | | | | | |
| 49 | | | | | | | | | | | 22.8 | 16.5 | 16.8 | 13.5 | 13.8 | | |
| 50 | | | | | | | | | | | | | | 34.4 | 38.6 | 36.1 | 15.3 |
| 51 | | | | | | | | | | | | | | | | 20.1 | 14.2 |
| 52 | | | | | | | | | | | | | | | | 1.8 | 3.5 |
| 53 | | | | | | | | | | | | | | | | | 2.5 |
| 54 | | | | | | | | | | | | | | | | | 13.5 |

Table A2 Annual $NO_2$ averages ($\mu g\ m^{-3}$) measured at ICP Materials test sites

| No | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2002 | 2005 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 42.4 | 32.6 | 34.2 | 34.9 | 20.5 | 24.9 | 22.5 | 23.3 | 24.4 | 21.1 | 23.7 | 22.1 | 23.4 | 21.7 | 24.5 | 40.0 | 33.8 |
| 2 | 17.9 | 14.2 | 8.8 | 9.4 | 8.1 | 8.1 | 7.2 | 8.1 | | | | | | | | | |
| 3 | 42.2 | 39.1 | 36.0 | 35.1 | 30.6 | 35.6 | 28.1 | 27.4 | 32.8 | 34.9 | 32.6 | 32.1 | 28.0 | 24.8 | 25.3 | 25.2 | 23.8 |
| 4 | 20.0 | 17.6 | 20.7 | 24.9 | 24.1 | 20.8 | 30.3 | 23.7 | | | | | | | | | |
| 5 | 5.0 | 4.9 | 4.4 | 5.6 | 2.0 | 2.0 | 4.0 | 7.1 | | | 3.0 | 3.2 | 2.5 | 3.1 | 3.0 | | |
| 6 | 30.5 | 27.4 | 38.9 | 38.3 | 41.2 | 39.4 | 36.8 | 30.4 | 34.8 | 27.4 | | | | | | | |
| 7 | 11.3 | 13.0 | 11.6 | 11.9 | 11.5 | 10.9 | 9.3 | 8.0 | 9.1 | 9.2 | 8.7 | 8.8 | 8.2 | 8.4 | 9.8 | | |
| 8 | 33.2 | 44.8 | 39.5 | 38.0 | 41.2 | 38.8 | 40.2 | 38.8 | | | | | | | | | |
| 9 | 42.8 | 49.9 | 44.4 | 45.8 | 40.2 | 37.3 | 35.6 | 35.9 | 36.4 | 35.4 | 33.5 | 31.7 | 31.2 | 30.5 | 32.0 | | |
| 10 | 47.9 | 49.5 | 46.4 | 46.8 | 43.8 | 37.9 | 37.6 | 38.0 | 38.4 | 39.5 | 38.2 | 36.4 | 32.7 | 32.6 | 34.6 | 33.0 | 33.8 |
| 11 | 46.8 | 44.3 | 41.7 | 41.9 | 40.5 | 37.2 | 33.7 | 32.6 | | | | | | | | | |
| 12 | 12.1 | 14.0 | 14.3 | 12.6 | 15.1 | 16.6 | 11.0 | 11.3 | | | | | | | | | |
| 13 | 69.2 | 69.5 | 62.5 | 73.3 | | 33.1 | 28.5 | 30.4 | | | 37.8 | 42.8 | 47.1 | | 48.8 | 28.7 | 46.1 |
| 14 | 13.7 | 13.7 | 8.3 | 18.8 | 16.6 | 14.6 | 11.1 | 8.9 | | | 21.0 | 31.1 | | | 8.4 | 4.8 | 8.0 |
| 15 | 109.2 | 99.1 | 120.9 | 107.8 | 110.0 | 108.3 | 86.6 | 85.3 | | | 83.9 | | 72.7 | 72.8 | 66.6 | 66.3 | 56.5 |
| 16 | 40.9 | 40.7 | 51.0 | 47.7 | | | | | | | | | | | | 35.6 | 27.8 |
| 17 | 52.1 | 57.2 | 56.7 | 53.8 | 47.3 | 46.6 | 45.4 | 46.5 | | | | | | | | | |
| 18 | 23.2 | 26.9 | 26.5 | 24.6 | 23.5 | 22.8 | 21.4 | 19.6 | | | | | | | | | |
| 19 | 28.7 | 33.4 | 33.1 | 33.4 | 32.5 | 29.4 | 27.9 | 25.8 | | | | | | | | | |
| 20 | 28.9 | 32.0 | 26.9 | 31.7 | 29.1 | 26.8 | 25.4 | 25.7 | | | | | | | | | |
| 21 | 51.7 | 51.9 | 46.8 | 51.9 | 47.1 | 53.4 | 55.2 | 62.9 | | 42.3 | 27.5 | 32.5 | 32.0 | 20.8 | 25.9 | 26.9 | 40.2 |
| 22 | 19.2 | 18.3 | 16.4 | 18.0 | 16.6 | 17.8 | 20.1 | 19.5 | | | | | | | | | |
| 23 | 3.9 | 4.0 | 3.1 | 3.1 | 1.8 | 1.8 | 2.3 | 2.0 | 2.5 | 2.0 | 1.1 | 1.6 | 1.7 | 1.8 | 1.9 | 1.6 | 1.3 |
| 24 | 26.5 | 31.2 | 31.6 | 27.3 | 28.1 | 25.2 | 25.0 | 21.4 | 22.8 | 22.9 | 20.3 | 19.5 | 18.8 | 17.5 | 17.0 | 13.1 | 10.9 |
| 25 | 45.8 | 45.4 | 40.2 | 26.1 | 25.3 | 26.3 | 25.5 | 25.4 | | | | | | | | | |
| 26 | 5.1 | 4.5 | 4.8 | 3.8 | 3.6 | 3.2 | 3.6 | 2.9 | 3.2 | 3.0 | 2.9 | 2.6 | 2.4 | 2.7 | 2.3 | 2.1 | 1.8 |
| 27 | 68.6 | 54.2 | 33.0 | 28.3 | 29.9 | 21.2 | 7.8 | 8.4 | | | | 22.5 | 22.1 | 22.6 | 16.3 | | 14.2 |
| 28 | 21.5 | 24.7 | 25.1 | 22.1 | 22.1 | 22.6 | | | | | | | | | | | |
| 29 | 2.3 | 4.1 | 4.2 | 4.6 | | | | | | | | | | | | | |
| 30 | 86.0 | 34.2 | 30.0 | 39.2 | 25.1 | 27.6 | 38.1 | 38.1 | | | | | | | | | |
| 31 | 24.3 | 31.9 | 22.8 | 20.1 | 21.9 | 32.1 | 29.6 | 20.6 | | | 22.1 | 24.8 | 16.5 | 11.0 | 28.4 | 21.5 | 15.5 |
| 32 | 34.7 | 43.0 | 41.8 | 31.6 | 32.8 | 21.4 | 32.0 | 25.9 | | | | | | | | | |
| 33 | 9.1 | 14.8 | 16.3 | 16.1 | 14.9 | 24.0 | 19.3 | 10.5 | | 8.4 | 11.3 | 11.0 | 9.1 | 3.1 | 2.8 | 4.1 | 3.2 |
| 34 | 74.9 | 69.5 | 50.1 | 53.2 | 38.7 | 37.1 | 31.5 | 29.5 | | | 28.0 | 21.4 | 21.5 | | 18.0 | | |
| 35 | 2.9 | 3.8 | 6.5 | | 3.8 | 3.8 | 3.8 | 3.8 | 0.8 | 0.6 | 0.7 | 1.7 | 2.3 | 2.2 | 3.1 | 3.7 | 2.2 |
| 36 | 36.8 | 21.5 | 32.9 | 30.1 | 45.7 | 35.0 | 33.3 | 35.0 | | | 42.0 | 31.2 | | | 24.4 | | |
| 37 | 1.6 | 2.0 | 2.0 | 1.0 | | | 1.7 | 1.7 | 7.5 | | 9.7 | 4.2 | 6.6 | | 6.9 | 1.7 | |
| 38 | 26.9 | 25.3 | 25.3 | 25.2 | 26.2 | 25.7 | 26.6 | 22.9 | | | | | | | | | |
| 39 | 41.8 | 44.8 | 40.5 | 50.9 | 25.5 | 43.3 | 40.8 | 39.8 | | | | | | | | | |
| 40 | | | | | | | | | | | 70.0 | 52.2 | 51.0 | 45.6 | 45.7 | 39.3 | 38.9 |
| 41 | | | | | | | | | | 52.9 | 37.7 | 43.9 | 41.3 | 44.2 | 49.1 | | 44.8 |
| 43 | | | | | | | | | | | 38.3 | 44.9 | 20.7 | 17.8 | | | |
| 44 | | | | | | | | | 1.9 | 2.4 | 0.9 | 1.5 | 1.8 | | 1.7 | 1.9 | 1.2 |
| 45 | | | | | | | | | | 7.5 | 7.7 | 8.0 | 7.5 | 6.9 | 9.0 | 6.9 | 6.3 |
| 46 | | | | | | | | | | | | 48.2 | 46.4 | 44.0 | 37.3 | | |
| 47 | | | | | | | | | | | 21.7 | | | | | | |
| 49 | | | | | | | | | | | 52.8 | 48.6 | 49.0 | 47.2 | 50.0 | | |
| 50 | | | | | | | | | | | | | | 22.7 | 21.6 | 43.2 | 27.2 |
| 51 | | | | | | | | | | | | | | | | 67.8 | 43.3 |
| 52 | | | | | | | | | | | | | | | | 21.4 | 24.8 |
| 53 | | | | | | | | | | | | | | | | | 24.0 |
| 54 | | | | | | | | | | | | | | | | | 57.1 |

Table A3 Annual $O_3$ averages ($\mu g\ m^{-3}$) measured at ICP Materials test sites

| No | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2002 | 2005 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | 55 | 51 | 48 | 48 | 50 | 41 | 49 | 47 | 45 |
| 2 | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | 46 | 55 | 58 | 57 | 40 | 49 | 48 | 42 |
| 4 | | | | | | | | | | | | | | | | | |
| 5 | 52 | 54 | 52 | 51 | 66 | 60 | 58 | 55 | 58 | 60 | 60 | 64 | 60 | 57 | 60 | | |
| 6 | | | | | | | | | | 43 | | | | | | | |
| 7 | 59 | 69 | 64 | 45 | 53 | 57 | 55 | 54 | 52 | 51 | 48 | 55 | 54 | 51 | 60 | | |
| 8 | 27 | 26 | 31 | 29 | 36 | 33 | 37 | 37 | | | | | | | | | |
| 9 | 30 | 27 | 33 | 32 | 36 | 34 | 34 | 32 | 27 | 32 | 33 | 36 | 31 | 36 | 34 | | |
| 10 | | | | 27 | 33 | 34 | 32 | 34 | 28 | 30 | 30 | 33 | 31 | 33 | 36 | 37 | 33 |
| 11 | | | | | | | | | | | | | | | | | |
| 12 | 50 | 49 | 55 | 57 | 55 | 49 | 61 | 52 | | | | | | | | | |
| 13 | 26 | 27 | 23 | 19 | 14 | 12 | 9 | 11 | | | 33 | 31 | 24 | 35 | 36 | 19 | 36 |
| 14 | 34 | 34 | 56 | 45 | 38 | 27 | 15 | 19 | | | 30 | 38 | 28 | | 72 | 51 | 42 |
| 15 | 18 | 16 | 22 | 21 | 17 | 22 | 26 | 29 | | | 38 | | 40 | 40 | 39 | 28 | 42 |
| 16 | 21 | 29 | 31 | 14 | | | | | | | | 45 | 32 | | 39 | 42 | 40 |
| 17 | 28 | 33 | 32 | 28 | 26 | 24 | 29 | 33 | | | | | | | | | |
| 18 | 40 | 46 | 47 | 38 | 39 | 33 | 38 | 40 | | | | | | | | | |
| 19 | 36 | 39 | 45 | 37 | 38 | 35 | 36 | 39 | | | | | | | | | |
| 20 | 39 | 42 | 45 | 39 | 36 | 34 | 38 | 39 | | | | | | | | | |
| 21 | | | | | | | | | | | 36 | 39 | 38 | 36 | 31 | 36 | 33 |
| 22 | | | | | | | | | | | | | | | | | |
| 23 | 60 | 53 | 54 | 55 | 64 | 58 | 53 | 56 | 58 | 56 | 55 | 59 | 55 | 53 | 54 | 61 | 48 |
| 24 | 44 | 47 | 52 | 39 | 45 | 43 | 49 | 43 | 48 | 50 | 44 | 51 | 48 | 47 | 55 | 58 | 53 |
| 25 | | | | | | | | | | | | | | | | | |
| 26 | 55 | 61 | 59 | 54 | 58 | 58 | 38 | 50 | 64 | 65 | 51 | 63 | 59 | 57 | 66 | 66 | 43 |
| 27 | | | | | | | | | | | | 51 | 51 | 49 | 52 | | 44 |
| 28 | | | | | | | | | | | | | | | | | |
| 29 | 49 | 62 | 57 | 45 | | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | | | | | | |
| 31 | 26 | | | | | | | | | | 56 | 54 | 53 | 54 | 56 | 49 | 56 |
| 32 | | | | | | | | | | | | | | | | | |
| 33 | 77 | 77 | 77 | 77 | 77 | 76 | 74 | 82 | | 88 | 89 | 79 | 88 | 92 | 93 | 88 | 82 |
| 34 | | | | | | | | | | | 42 | | | | 36 | | |
| 35 | | | | | | | | | | 57 | 55 | 63 | 61 | 60 | 59 | 62 | 54 |
| 36 | | 35 | 29 | 42 | 25 | 37 | 34 | 49 | | | 12 | 11 | 18 | | 14 | | |
| 37 | 59 | 60 | 64 | 52 | 61 | 56 | 59 | 46 | 60 | | 62 | 62 | 59 | | 61 | 53 | |
| 38 | 54 | 50 | 57 | 52 | 48 | 41 | 49 | 55 | | | | | | | | | |
| 39 | 42 | 36 | 33 | 44 | 30 | 36 | 40 | 42 | | | | | | | | | |
| 40 | | | | | | | | | | | 31 | 35 | 30 | 35 | 45 | 38 | 36 |
| 41 | | | | | | | | | | 21 | 22 | 25 | 27 | 29 | 31 | | 40 |
| 43 | | | | | | | | | | | 40 | 50 | 21 | 24 | | | |
| 44 | | | | | | | | | 45 | | 54 | 62 | 57 | 49 | 57 | 67 | 49 |
| 45 | | | | | | | | | | 85 | 86 | 84 | 82 | 82 | 91 | 86 | 81 |
| 46 | | | | | | | | | | | | 39 | 33 | 35 | 46 | | |
| 47 | | | | | | | | | | | 48 | | | | | | |
| 49 | | | | | | | | | | | 28 | 29 | 31 | 30 | 33 | | |
| 50 | | | | | | | | | | | | | | 56 | 62 | 38 | 39 |
| 51 | | | | | | | | | | | | | | | | 20 | 24 |
| 52 | | | | | | | | | | | | | | | | 43 | 44 |
| 53 | | | | | | | | | | | | | | | | | 49 |
| 54 | | | | | | | | | | | | | | | | | 35 |

Table A4 Annual $HNO_3$ averages ($\mu g\ m^{-3}$) measured at ICP Materials test sites

| No | 2002 | 2005 | 2008 |
|---|---|---|---|
| 1 | 0.68 | 0.85 | 0.82 |
| 2 | | | |
| 3 | 0.83 | 0.69 | 0.55 |
| 4 | | | |
| 5 | 0.18 | | |
| 6 | | | |
| 7 | 0.53 | | |
| 8 | | | |
| 9 | 0.83 | | |
| 10 | 0.84 | 0.74 | 0.49 |
| 11 | | | |
| 12 | | | |
| 13 | 1.32 | | 0.71 |
| 14 | 0.97 | | 0.74 |
| 15 | 2.00 | | 1.62 |
| 16 | 0.70 | | 1.35 |
| 17 | | | |
| 18 | | | |
| 19 | | | |
| 20 | | | |
| 21 | 0.35 | 0.41 | 0.19 |
| 22 | | | |
| 23 | 0.18 | 0.19 | 0.14 |
| 24 | 0.67 | 0.70 | 0.32 |
| 25 | | | |
| 26 | 0.18 | 0.15 | 0.08 |
| 27 | 1.04 | | 0.27 |
| 28 | | | |
| 29 | | | |
| 30 | | | |
| 31 | 1.13 | 1.12 | 0.83 |
| 32 | | | |
| 33 | 0.70 | 0.60 | 0.51 |
| 34 | 0.77 | | |
| 35 | 0.40 | 0.43 | 0.25 |
| 36 | | | |
| 37 | 0.57 | 0.37 | |
| 38 | | | |
| 39 | | | |
| 40 | 2.17 | 0.98 | 0.99 |
| 41 | 0.53 | 0.53 | 0.37 |
| 43 | | | |
| 44 | 0.16 | 0.06 | 0.08 |
| 45 | 0.70 | 0.55 | 0.45 |
| 46 | | | |
| 47 | | | |
| 49 | | | |
| 50 | 1.16 | 1.09 | 0.73 |
| 51 | 1.54 | 1.07 | 1.26 |
| 52 | 0.65 | 0.38 | 0.35 |
| 53 | | | 0.87 |
| 54 | | | |

Table A5 Annual temperature averages (°C) measured at ICP Materials test sites

| No | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2002 | 2005 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 9.5 | 9.8 | 10.3 | 8.5 | 10.0 | 9.1 | 9.9 | 9.8 | 7.7 | 8.6 | 9.9 | 9.6 | 10.1 | 9.5 | 9.3 | 9.3 | 10.1 |
| 2 | 7.0 | 7.0 | 7.4 | 5.8 | 7.2 | 6.6 | 7.2 | 7.2 | | | | | | | | | |
| 3 | 9.6 | 9.7 | 9.9 | 8.6 | 9.9 | 8.9 | 9.6 | 9.7 | 7.7 | 8.5 | 9.9 | 9.4 | 10.1 | 9.2 | 8.7 | 8.3 | 9.3 |
| 4 | 5.9 | 6.0 | 6.4 | 5.2 | 6.2 | 5.6 | 4.0 | 6.0 | | | | | | | | | |
| 5 | 3.1 | 4.0 | 3.9 | 2.9 | 4.2 | 3.4 | 1.7 | 3.9 | 1.9 | 3.2 | 3.5 | 4.6 | 5.0 | 4.8 | 4.5 | | |
| 6 | 6.3 | 6.7 | 6.8 | 5.8 | 6.9 | 6.2 | 4.7 | 6.6 | 4.5 | 6.5 | | | | | | | |
| 7 | 9.3 | 10.0 | 10.2 | 8.9 | 10.2 | 8.9 | 8.9 | 9.5 | 7.6 | 8.9 | 9.5 | 9.4 | 9.8 | 9.4 | 8.8 | | |
| 8 | 12.3 | 11.8 | 12.2 | 10.9 | 11.7 | 11.4 | 11.4 | 11.6 | | | | | | | | | |
| 9 | 10.8 | 11.2 | 11.7 | 9.8 | 11.2 | 10.7 | 10.7 | 11.4 | 9.4 | 10.0 | 10.9 | 11.2 | 11.2 | 11.6 | 11.4 | | |
| 10 | 11.2 | 11.6 | 12.0 | 10.2 | 11.5 | 10.3 | 10.8 | 11.8 | 9.7 | 10.5 | 11.5 | 11.6 | 11.6 | 11.7 | 11.3 | 11.2 | 10.8 |
| 11 | 10.5 | 10.9 | 11.5 | 9.8 | 13.1 | 10.1 | 10.3 | 10.9 | | | | | | | | | |
| 12 | 8.0 | 7.9 | 7.3 | 6.4 | 7.3 | 7.1 | 8.1 | 7.4 | | | | | | | | | |
| 13 | 15.4 | 16.1 | 17.4 | 16.3 | 22.2 | 17.9 | 19.5 | 18.4 | | | 19.4 | 19.1 | 19.2 | 17.9 | 17.6 | | 16.9 |
| 14 | 14.6 | 14.0 | 14.3 | 15.1 | 14.9 | 15.2 | 15.2 | 14.9 | | | 14.5 | 16.4 | 16.7 | | 16.3 | 14.5 | 15.9 |
| 15 | 15.3 | 14.9 | 15.4 | 14.2 | 14.4 | 14.7 | 14.9 | 14.3 | | | 14.5 | | 14.2 | 15.9 | 15.1 | 14.0 | 15.0 |
| 16 | 14.9 | 14.7 | 13.5 | 12.9 | 13.2 | 13.2 | 13.8 | 13.2 | | | 13.5 | 13.9 | 15.2 | 14.9 | 14.7 | 13.9 | 13.7 |
| 17 | 10.5 | 11.0 | 11.3 | 9.7 | 10.7 | 10.3 | 10.1 | 11.0 | | | | | | | | | |
| 18 | 9.9 | 10.2 | 10.9 | 9.1 | 10.2 | 9.5 | 9.4 | 10.3 | | | | | | | | | |
| 19 | 10.3 | 10.8 | 11.0 | 9.4 | 10.4 | 10.0 | 10.0 | 10.9 | | | | | | | | | |
| 20 | 10.3 | 10.8 | 11.1 | 9.5 | 10.5 | 10.1 | 10.2 | 11.1 | | | | | | | | | |
| 21 | 7.6 | 7.9 | 8.8 | 7.0 | 8.5 | 7.7 | 6.7 | 7.5 | 5.3 | 6.8 | 6.6 | 7.0 | 7.4 | 7.2 | 6.4 | 7.2 | 6.9 |
| 22 | 6.0 | 6.9 | 6.8 | 6.7 | 7.8 | 7.0 | 6.5 | 7.4 | | | | | | | | | |
| 23 | 6.5 | 7.5 | 7.4 | 6.1 | 7.1 | 5.9 | 4.9 | 6.4 | 4.4 | 5.6 | 6.2 | 6.2 | 7.1 | 6.6 | 5.9 | 6.2 | 4.2 |
| 24 | 7.6 | 8.4 | 8.7 | 7.3 | 8.6 | 7.0 | 6.7 | 7.5 | 5.4 | 7.4 | 6.7 | 8.0 | 7.9 | 8.1 | 7.1 | 8.9 | 7.8 |
| 25 | 7.6 | 9.1 | 8.7 | 7.3 | 8.6 | 7.0 | 6.7 | 7.5 | | | | | | | | | |
| 26 | 6.0 | 6.9 | 7.6 | 6.1 | 7.2 | 6.0 | 5.6 | 6.8 | 4.8 | 6.5 | 5.9 | 6.5 | 6.8 | 7.2 | 5.6 | 6.3 | 7.1 |
| 27 | 9.2 | 10.7 | 11.1 | 10.0 | 11.0 | 9.6 | 9.4 | 10.5 | | | 10.2 | 10.1 | 9.8 | 9.7 | 10.4 | | |
| 28 | 10.8 | 12.2 | 12.7 | 12.0 | 12.9 | 10.5 | 9.7 | 11.2 | | | | | | | | | |
| 29 | 9.8 | 10.9 | 10.7 | 6.7 | | | | | | | | | | | | | |
| 30 | 10.2 | 9.2 | 10.3 | 10.3 | 10.3 | 10.3 | 10.3 | 10.3 | | | | | | | | | |
| 31 | 14.1 | 15.0 | 15.2 | 14.4 | 13.8 | 14.3 | 15.0 | 15.7 | | 14.8 | 12.9 | 14.0 | 15.8 | 15.0 | 15.3 | 15.3 | 15.1 |
| 32 | 15.2 | 15.3 | 16.2 | 13.9 | 14.2 | 14.2 | 13.6 | 14.8 | | | | | | | | | |
| 33 | 14.0 | 15.1 | 15.5 | 13.9 | 13.6 | 13.4 | 13.9 | 14.8 | | 14.0 | 14.0 | 14.0 | 13.7 | 12.2 | 12.2 | 12.1 | 14.7 |
| 34 | 5.5 | 7.0 | 5.7 | 6.0 | 7.2 | 5.7 | 4.0 | 5.6 | | | 6.5 | 7.0 | 6.1 | 7.4 | 5.9 | | |
| 35 | 5.5 | 6.9 | 6.7 | 5.5 | 6.1 | 6.1 | 6.1 | 6.1 | 4.1 | 6.0 | 5.4 | 6.3 | 6.8 | 6.9 | 5.0 | 5.2 | 8.8 |
| 36 | 12.1 | 17.8 | 19.3 | 18.2 | 18.2 | 18.0 | 18.3 | 19.1 | | | 17.9 | 17.1 | 17.1 | | 17.4 | | |
| 37 | 5.5 | 4.8 | 5.0 | 5.9 | 3.8 | 4.3 | 3.2 | 5.2 | 3.4 | 4.0 | 7.4 | 8.3 | 6.5 | 6.5 | 7.2 | | |
| 38 | 14.6 | 15.0 | 16.3 | 15.5 | 15.4 | 15.5 | 15.6 | 15.8 | | | | | | | | | |
| 39 | 12.3 | 10.9 | 11.2 | 13.6 | 11.6 | 11.8 | 10.6 | 11.8 | | | | | | | | | |
| 40 | | | | | | | | | | | 13.4 | 13.7 | 12.7 | 12.7 | 13.3 | 12.6 | 12.7 |
| 41 | | | | | | | | | | 8.4 | 10.4 | 10.7 | 11.1 | 11.1 | 11.7 | | 10.1 |
| 43 | | | | | | | | | | | 24.6 | 26.5 | 21.5 | 22.0 | | | |
| 44 | | | | | | | | | -1.1 | -0.1 | 0.2 | 1.8 | 2.4 | 1.0 | 0.1 | 0.3 | 0.4 |
| 45 | | | | | | | | | | 6.2 | 6.9 | 6.3 | 6.8 | 7.2 | 7.3 | 6.2 | 6.3 |
| 46 | | | | | | | | | | | 12.2 | 12.3 | 12.1 | 12.1 | 12.7 | | |
| 47 | | | | | | | | | | | 17.4 | 16.4 | 17.2 | 16.4 | | | |
| 49 | | | | | | | | | | | 11.4 | 12.0 | 11.9 | 11.7 | 11.9 | | |
| 50 | | | | | | | | | | | | | | 9.4 | 8.2 | 7.5 | 7.7 |
| 51 | | | | | | | | | | | | | | | | 18.3 | 18.7 |
| 52 | | | | | | | | | | | | | | | | 7.0 | 8.2 |
| 53 | | | | | | | | | | | | | | | | | 11.2 |
| 54 | | | | | | | | | | | | | | | | | 11.5 |

Table A6 Annual relative humidity averages (%) measured at ICP Materials test sites

| No | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2002 | 2005 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 79 | 75 | 74 | 75 | 71 | 73 | 76 | 77 | 80 | 78 | 76 | 76 | 72 | 79 | 72 | 74 | 74 |
| 2 | 77 | 77 | 76 | 79 | 73 | 73 | 73 | 74 | | | | | | | | | |
| 3 | 73 | 73 | 72 | 73 | 71 | 71 | 73 | 75 | 78 | 73 | 76 | 77 | 76 | 80 | 73 | 76 | 80 |
| 4 | 76 | 77 | 80 | 82 | 79 | 79 | 81 | 80 | | | | | | | | | |
| 5 | 78 | 79 | 80 | 80 | 78 | 81 | 80 | 83 | 79 | 76 | 80 | 79 | 78 | 82 | 80 | | |
| 6 | 78 | 78 | 80 | 81 | 80 | 78 | 76 | 76 | 78 | 74 | | | | | | | |
| 7 | 80 | 81 | 80 | 81 | 78 | 81 | 82 | 81 | 82 | 82 | 83 | 78 | 79 | 81 | 75 | | |
| 8 | 77 | 72 | 67 | 65 | 66 | 64 | 64 | 65 | | | | | | | | | |
| 9 | 77 | 78 | 80 | 80 | 76 | 79 | 82 | 81 | 78 | 78 | 80 | 78 | 81 | 79 | 76 | | |
| 10 | 75 | 76 | 76 | 77 | 76 | 78 | 79 | 80 | 78 | 79 | 81 | 80 | 82 | 81 | 77 | 76 | 81 |
| 11 | 79 | 78 | 77 | 79 | 78 | 79 | 80 | 78 | | | | | | | | | |
| 12 | 82 | 84 | 82 | 84 | 83 | 84 | 82 | 83 | | | | | | | | | |
| 13 | 66 | 62 | 65 | 67 | 58 | 60 | 67 | 68 | | | 65 | 65 | 64 | 66 | 65 | | 67 |
| 14 | 71 | 70 | 72 | 72 | 74 | 73 | 74 | 76 | | | 74 | 66 | 62 | | 63 | 67 | 69 |
| 15 | 72 | 79 | 72 | 69 | 73 | 68 | 67 | 69 | | | 69 | | 71 | 71 | 66 | 56 | 56 |
| 16 | 77 | 82 | 79 | 80 | 86 | 86 | 84 | 82 | | | 83 | 80 | 80 | 83 | 82 | 76 | 79 |
| 17 | 84 | 83 | 81 | 84 | 85 | 83 | 83 | 84 | | | | | | | | | |
| 18 | 83 | 82 | 79 | 79 | 79 | 82 | 83 | 83 | | | | | | | | | |
| 19 | 81 | 81 | 81 | 80 | 80 | 82 | 83 | 83 | | | | | | | | | |
| 20 | 81 | 80 | 77 | 83 | 82 | 81 | 82 | 82 | | | | | | | | | |
| 21 | 70 | 70 | 70 | 75 | 72 | 68 | 71 | 69 | 75 | 76 | 79 | 78 | 74 | 75 | 74 | 74 | 76 |
| 22 | 78 | 74 | 76 | 77 | 73 | 76 | 76 | 76 | | | | | | | | | |
| 23 | 80 | 76 | 77 | 80 | 77 | 75 | 79 | 76 | 84 | 75 | 79 | 82 | 83 | 83 | 81 | 79 | 81 |
| 24 | 78 | 67 | 70 | 72 | 70 | 70 | 70 | 73 | 72 | 68 | 76 | 77 | 77 | 81 | 80 | 74 | 76 |
| 25 | 78 | 67 | 70 | 72 | 70 | 70 | 70 | 73 | | | | | | | | | |
| 26 | 83 | 77 | 77 | 80 | 77 | 81 | 82 | 82 | 86 | 83 | 86 | 84 | 83 | 86 | 82 | 84 | 82 |
| 27 | 84 | 83 | 81 | 87 | 86 | 82 | 80 | 78 | | | 81 | 80 | 81 | 81 | 78 | | |
| 28 | 86 | 77 | 83 | 88 | 88 | 82 | 80 | 79 | | | | | | | | | |
| 29 | | | 96 | | | | | | | | | | | | | | |
| 30 | 78 | 75 | 76 | 76 | 76 | 76 | 76 | 76 | | | | | | | | | |
| 31 | 66 | 52 | 56 | 57 | 59 | 67 | 72 | 68 | | 67 | 61 | 55 | 56 | 62 | 60 | 56 | 53 |
| 32 | 74 | 73 | 71 | 74 | 77 | 75 | 75 | 73 | | | | | | | | | |
| 33 | 64 | 59 | 61 | 56 | 58 | 61 | 58 | 57 | | 61 | 59 | 55 | 60 | 71 | 78 | 69 | 61 |
| 34 | 73 | 75 | 76 | 75 | 72 | 74 | 74 | 71 | | | 74 | 70 | 70 | 69 | 71 | | |
| 35 | 83 | 80 | 81 | 83 | 82 | 82 | 82 | 82 | 79 | 79 | 82 | 79 | 80 | 81 | 81 | 80 | 81 |
| 36 | 64 | 61 | 63 | 62 | 60 | 62 | 65 | 67 | | | 63 | 68 | 67 | | 66 | | |
| 37 | 75 | 73 | 79 | 79 | 75 | 80 | 81 | 80 | 75 | 76 | 75 | 73 | 76 | 78 | 76 | | |
| 38 | 69 | 66 | 66 | 69 | 66 | 64 | 66 | 68 | | | | | | | | | |
| 39 | 67 | 64 | 61 | 59 | 61 | 65 | 68 | 69 | | | | | | | | | |
| 40 | | | | | | | | | | | 67 | 67 | 72 | 74 | 69 | 73 | 70 |
| 41 | | | | | | | | | | 76 | 77 | 74 | 77 | 82 | 71 | | 88 |
| 43 | | | | | | | | | | | 83 | 88 | 70 | 70 | | | |
| 44 | | | | | | | | | | | | 78 | 80 | 80 | 79 | 78 | 78 |
| 45 | | | | | | | | | | 77 | 77 | 80 | 79 | 80 | 75 | 80 | 80 |
| 46 | | | | | | | | | | | 70 | 70 | 72 | 69 | 66 | | |
| 47 | | | | | | | | | | | 61 | 62 | 64 | 68 | | | |
| 49 | | | | | | | | | | | 76 | 75 | 77 | 75 | 65 | | |
| 50 | | | | | | | | | | | | | | 81 | 76 | 76 | 84 |
| 51 | | | | | | | | | | | | | | | | 70 | 62 |
| 52 | | | | | | | | | | | | | | | | 76 | 77 |
| 53 | | | | | | | | | | | | | | | | | 73 |
| 54 | | | | | | | | | | | | | | | | | 70 |

Table A7 Annual precipitation averages (mm) measured at ICP Materials test sites

| No | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2002 | 2005 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 639 | 386 | 381 | 470 | 409 | 684 | 563 | 581 | 550 | 475 | 522 | 405 | 525 | 601 | 513 | 491 | 525 |
| 2 | 850 | 752 | 703 | 832 | 573 | 921 | 809 | 941 | | | | | | | | | |
| 3 | 426 | 450 | 417 | 416 | 502 | 432 | 597 | 513 | 458 | 431 | 420 | 414 | 510 | 510 | 463 | 442 | 521 |
| 4 | 626 | 769 | 657 | 650 | 672 | 755 | 570 | 698 | | | | | | | | | |
| 5 | 801 | 666 | 671 | 544 | 698 | 610 | 506 | 675 | 578 | 618 | 742 | 614 | 651 | 845 | 713 | | |
| 6 | 673 | 691 | 666 | 637 | 622 | 702 | 509 | 649 | 535 | 521 | | | | | | | |
| 7 | 631 | 448 | 500 | 529 | 503 | 624 | 743 | 596 | 421 | 615 | 786 | 503 | 561 | 620 | 413 | | |
| 8 | 627 | 674 | 655 | 654 | 629 | 561 | 754 | 779 | | | | | | | | | |
| 9 | 783 | 686 | 698 | 662 | 697 | 619 | 839 | 841 | 595 | 781 | 930 | 796 | 949 | 997 | 647 | | |
| 10 | 874 | 734 | 697 | 619 | 681 | 707 | 843 | 913 | 661 | 806 | 1044 | 824 | 967 | 791 | 780 | 761 | 663 |
| 11 | 713 | 664 | 645 | 578 | 676 | 684 | 888 | 889 | | | | | | | | | |
| 12 | 1492 | 1185 | 1183 | 1118 | 1092 | 1552 | 1169 | 1503 | | | | | | | | | |
| 13 | 591 | 509 | 463 | 481 | 602 | 602 | 969 | 602 | | | 1125 | | | | 660 | | 823 |
| 14 | 650 | 674 | 626 | 721 | 973 | 659 | 717 | 717 | | | | | | | 600 | | 857 |
| 15 | 1125 | 1004 | 660 | 658 | 936 | 1041 | 1283 | 1092 | | | 1077 | | 971 | | 619 | 632 | 1179 |
| 16 | 714 | 536 | 488 | 810 | 511 | 400 | 539 | 500 | | | 742 | 624 | 722 | | 482 | 889 | 795 |
| 17 | 978 | 686 | 692 | 723 | 722 | 860 | 883 | 996 | | | | | | | | | |
| 18 | 904 | 711 | 706 | 702 | 687 | 873 | 969 | 987 | | | | | | | | | |
| 19 | 845 | 693 | 569 | 544 | 799 | 749 | 936 | 829 | | | | | | | | | |
| 20 | 801 | 642 | 609 | 647 | 542 | 680 | 914 | 790 | | | | | | | | | |
| 21 | 1024 | 577 | 527 | 433 | 614 | 440 | 698 | 680 | | | 523 | 888 | 898 | 1050 | 794 | 869 | 737 |
| 22 | 1116 | 535 | 518 | 286 | 674 | 628 | 688 | 819 | | | | | | | | | |
| 23 | 2144 | 1161 | 1762 | 1288 | 1272 | 1189 | 1542 | 1420 | 1228 | 1182 | 1744 | 1689 | 1819 | 2333 | 1390 | 1623 | 1392 |
| 24 | 531 | 412 | 473 | 643 | 496 | 577 | 392 | 581 | 415 | 556 | 463 | 479 | 454 | 635 | 384 | 273 | 270 |
| 25 | 531 | 412 | 473 | 643 | 496 | 577 | 392 | 581 | | | | | | | | | |
| 26 | 543 | 377 | 342 | 517 | 413 | 468 | 490 | 525 | 319 | 409 | 479 | 317 | 567 | 772 | 562 | 435 | 452 |
| 27 | 365 | 289 | 308 | 206 | 404 | 530 | 673 | 515 | | | 708 | 729 | 748 | 831 | 548 | | |
| 28 | 447 | 456 | 416 | 536 | 573 | 614 | 847 | 696 | | | | | | | | | |
| 29 | 1703 | 1684 | 2046 | | | | | | | | | | | | | | |
| 30 | 610 | 629 | 648 | 499 | 589 | 549 | 595 | 595 | | | | | | | | | |
| 31 | 398 | 322 | 332 | 308 | 310 | 360 | 339 | 224 | | | 765 | 360 | 334 | 560 | 447 | 399 | 267 |
| 32 | 1355 | 774 | 831 | 1111 | 1032 | 1560 | 1012 | 1082 | | | | | | | | | |
| 33 | 785 | 427 | 610 | 477 | 540 | 433 | 468 | 327 | | | 872 | 383 | 287 | 739 | 411 | 689 | 828 |
| 34 | 575 | 613 | 860 | 802 | 534 | 881 | 745 | 667 | | | 838 | 611 | 657 | 812 | 750 | | |
| 35 | 448 | 589 | 533 | 564 | 533 | 533 | 533 | 533 | 516 | 588 | 859 | 618 | 648 | 668 | 655 | 403 | 640 |
| 36 | 972 | 625 | 1103 | 955 | 504 | 545 | 798 | 443 | | | 252 | 188 | 148 | | 196 | | |
| 37 | 961 | 954 | 1103 | 1057 | 983 | 1080 | 1023 | 1023 | 1228 | | 788 | 970 | 898 | | 964 | | |
| 38 | 847 | 1413 | 1107 | 1093 | 940 | 982 | 973 | 1038 | | | | | | | | | |
| 39 | 733 | 933 | 967 | 938 | 730 | 729 | 1043 | 757 | | | | | | | | | |
| 40 | | | | | | | | | | | 572 | 557 | 742 | 731 | 490 | 571 | 427 |
| 41 | | | | | | | | | | | 486 | 415 | 501 | 489 | 473 | | 348 |
| 43 | | | | | | | | | | | 485 | 321 | 470 | 254 | | | |
| 44 | | | | | | | | | 354 | 298 | 344 | 472 | 432 | 361 | 377 | 711 | 364 |
| 45 | | | | | | | | | | | 1053 | 1204 | 1072 | 1281 | 1011 | 1404 | 950 |
| 46 | | | | | | | | | | | 706 | 651 | 657 | 907 | 494 | | |
| 47 | | | | | | | | | | | | | | | | | |
| 49 | | | | | | | | | | | | | 1008 | 993 | 674 | | |
| 50 | | | | | | | | | | | | | | 870 | 702 | 674 | 651 |
| 51 | | | | | | | | | | | | | | | | 374 | 461 |
| 52 | | | | | | | | | | | | | | | | 545 | 633 |
| 53 | | | | | | | | | | | | | | | | | 855 |
| 54 | | | | | | | | | | | | | | | | | 651 |

Table A8 Annual pH averages of precipitation measured at ICP Materials test sites

| No | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2002 | 2005 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.03 | 4.71 | 4.66 | 4.21 | 4.41 | 4.15 | 5.42 | 4.47 | 4.53 | 4.53 | 5.56 | 4.75 | 4.44 | 6.59 | 4.36 | 5.69 | 6.11 |
| 2 | 3.85 | 4.53 | 4.35 | 4.21 | 3.60 | 3.72 | 4.97 | 4.44 | | | | | | | | | |
| 3 | 4.39 | 4.88 | 4.62 | 4.31 | 4.39 | 4.24 | 4.97 | 4.25 | 4.01 | 4.41 | 4.62 | 4.40 | 4.47 | 4.41 | 5.19 | 5.61 | 5.56 |
| 4 | 4.24 | 4.39 | 4.41 | 4.36 | 4.43 | 4.64 | 4.39 | 4.48 | | | | | | | | | |
| 5 | 4.53 | 4.52 | 4.57 | 4.55 | 4.58 | 4.70 | 4.55 | 4.61 | 4.62 | 4.69 | 4.74 | 4.68 | 4.75 | 4.78 | 4.74 | | |
| 6 | 4.41 | 4.42 | 4.26 | 4.28 | 4.51 | 4.66 | 4.47 | 4.86 | | | | | | | | | |
| 7 | 4.26 | 4.35 | 4.45 | 4.47 | 4.55 | 4.47 | 4.50 | 4.58 | 4.70 | 4.79 | 5.04 | 5.23 | 5.00 | 4.85 | 4.84 | | |
| 8 | 4.96 | 4.61 | 4.39 | 4.94 | 5.79 | 4.74 | 5.12 | | | | | | | | | | |
| 9 | 4.54 | 4.54 | 4.44 | 4.41 | 4.56 | 4.54 | 4.74 | 4.56 | | | 4.92 | 5.44 | | 4.89 | 5.68 | | |
| 10 | 4.57 | 4.57 | 4.60 | 4.30 | 4.71 | 4.68 | 4.76 | 4.48 | 4.89 | 4.85 | 4.84 | 5.09 | | 4.80 | 4.73 | 5.83 | 5.70 |
| 11 | 4.58 | 4.58 | 4.38 | 4.43 | 4.69 | 4.60 | 4.81 | 4.61 | | | | | | | | | |
| 12 | 4.98 | 4.81 | 4.77 | 4.81 | 5.13 | 5.76 | 5.21 | | | | | | | | | | |
| 13 | 4.60 | 4.68 | 4.74 | 4.76 | 4.75 | 4.75 | 5.06 | 5.68 | | | | | | | 5.80 | | 4.70 |
| 14 | 4.94 | 4.80 | 5.38 | 5.05 | 5.47 | 5.30 | 4.82 | 5.08 | | | | | | | | | 4.97 |
| 15 | 4.22 | 4.50 | 4.19 | 4.54 | 4.68 | 4.66 | 4.42 | 4.43 | | | | | | | | | 4.89 |
| 16 | 5.02 | 4.90 | 5.24 | 6.12 | 6.49 | 6.36 | 6.52 | 6.24 | | | | | | | | | 5.19 |
| 17 | 4.44 | 4.41 | 4.42 | 4.59 | 4.65 | 4.41 | 4.61 | 4.67 | | | | | | | | | |
| 18 | 5.45 | 5.50 | 5.34 | 5.51 | 5.34 | 5.40 | 5.38 | 4.44 | | | | | | | | | |
| 19 | 5.32 | 5.33 | 5.31 | 5.80 | 4.90 | 5.68 | 5.09 | 5.36 | | | | | | | | | |
| 20 | 4.73 | 4.65 | 4.98 | 4.91 | 5.03 | 4.95 | 5.13 | 5.42 | | | | | | | | | |
| 21 | 4.48 | 4.66 | 4.49 | 4.71 | 4.65 | 4.81 | 4.80 | 4.87 | | | 5.20 | 4.61 | 4.63 | 4.72 | 4.65 | | 5.52 |
| 22 | 3.93 | 3.96 | 4.07 | 3.96 | 4.18 | 4.32 | 4.33 | 4.32 | | | | | | | | | |
| 23 | 4.25 | 4.26 | 4.38 | 4.35 | 4.35 | 4.43 | 4.39 | 4.49 | 4.44 | 4.51 | 4.50 | 4.52 | 4.58 | 4.59 | 4.57 | 4.64 | 4.77 |
| 24 | 4.35 | 4.28 | 4.44 | 4.57 | 4.58 | 4.37 | 4.49 | 4.64 | 4.67 | 4.61 | 4.63 | 4.68 | 4.77 | 4.75 | 5.00 | 5.26 | 5.25 |
| 25 | 4.35 | 4.28 | 4.44 | 4.57 | 4.58 | 4.37 | 4.49 | 4.64 | | | | | | | | | |
| 26 | 4.27 | 4.28 | 4.37 | 4.46 | 4.45 | 4.37 | 4.37 | 4.56 | 4.64 | 4.59 | 4.59 | 4.57 | 4.63 | 4.39 | 4.87 | 4.63 | 4.66 |
| 27 | 4.86 | 4.11 | 4.20 | 4.30 | 4.47 | 4.77 | 5.60 | 4.46 | | | 4.61 | | | | | | |
| 28 | 5.44 | 5.42 | 5.09 | 6.22 | 6.08 | 3.72 | 5.37 | 4.75 | | | | | | | | | |
| 29 | 4.82 | 4.61 | 4.84 | | | | | | | | | | | | | | |
| 30 | 4.12 | 4.13 | 3.84 | 3.18 | 4.66 | 4.31 | 3.75 | 3.75 | | | | | | | | | |
| 31 | 5.26 | 6.42 | 5.14 | 6.14 | 6.46 | 6.56 | 6.40 | 6.79 | | 5.46 | 6.05 | 6.17 | 6.57 | 6.33 | 6.42 | 6.29 | 6.45 |
| 32 | 4.73 | 5.32 | 4.71 | 5.00 | 5.02 | 5.10 | 5.51 | 5.31 | | | | | | | | | |
| 33 | 5.27 | 5.23 | 6.20 | 5.74 | 5.73 | 5.93 | 5.91 | 6.26 | | 5.05 | 5.80 | 5.91 | 6.10 | 6.44 | 6.11 | 6.11 | 6.01 |
| 34 | 6.18 | 4.89 | 6.22 | 6.12 | 6.07 | 6.04 | 6.06 | 6.08 | | | 6.68 | 6.52 | 6.66 | | 6.61 | | |
| 35 | 4.66 | 4.50 | 4.65 | 4.76 | 4.63 | 4.63 | 4.63 | 4.63 | 5.62 | 4.95 | 5.16 | 4.80 | 4.76 | 4.69 | 4.83 | 4.16 | 4.59 |
| 36 | 6.06 | 5.46 | 5.57 | 5.37 | 5.54 | 5.83 | 5.59 | 5.75 | | | 5.98 | 6.56 | 6.03 | | 6.02 | | |
| 37 | 4.27 | 4.33 | 4.38 | 4.34 | 4.40 | 4.32 | 4.34 | 4.34 | 4.44 | | 4.31 | | 4.55 | 4.09 | 4.43 | | |
| 38 | 4.29 | 4.29 | 4.45 | 4.43 | 4.54 | 4.46 | 4.42 | 4.32 | | | | | | | | | |
| 39 | 4.00 | 3.91 | 4.08 | 3.88 | 4.15 | 4.03 | 4.20 | 4.12 | | | | | | | | | |
| 40 | | | | | | | | | | | 5.71 | 5.87 | 5.18 | 5.17 | 5.35 | 6.21 | 6.23 |
| 41 | | | | | | | | | | | | | | | | | |
| 43 | | | | | | | | | | | | | | | | | |
| 44 | | | | | | | | | 4.72 | 4.70 | 4.77 | 4.87 | 4.69 | 4.89 | 4.97 | | 4.47 |
| 45 | | | | | | | | | | 5.04 | 4.99 | 4.93 | 5.09 | 5.13 | 5.21 | 5.15 | 5.23 |
| 46 | | | | | | | | | | | 5.65 | | | | | | |
| 47 | | | | | | | | | | | | | | | | | |
| 49 | | | | | | | | | | | | | 5.23 | 4.75 | 4.85 | | |
| 50 | | | | | | | | | | | | | | 4.41 | 4.34 | | |
| 51 | | | | | | | | | | | | | | | | | |
| 52 | | | | | | | | | | | | | | | | 6.42 | 6.03 |
| 53 | | | | | | | | | | | | | | | | | |
| 54 | | | | | | | | | | | | | | | | | 5.67 |

Table A9 Corrosion of carbon steel (g $m^{-2}$) measured at ICP Materials test sites

| No | 1987 | 1992 | 1994 | 1996 | 1997 | 2000 | 2002 | 2005 | 2008 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 437 | 271 | 241 | 232 | 182 | 138 | 103 | 102 | 59 |
| 2 | 224 | 153 | 148 | | | | | | |
| 3 | 557 | 350 | 352 | 293 | 239 | 224 | 184 | 183 | 163 |
| 4 | 271 | 131 | 121 | | | | | | |
| 5 | 132 | 48 | 59 | 54 | 53 | 51 | 38 | | |
| 6 | 270 | 163 | 196 | | | | | | |
| 7 | 266 | 231 | 166 | 156 | 144 | 148 | 85 | | |
| 8 | 213 | 116 | 140 | | | | | | |
| 9 | 293 | 231 | 209 | 206 | 204 | 101 | 130 | | |
| 10 | 376 | 347 | 294 | 296 | 311 | 293 | 222 | | 216 |
| 11 | 342 | 293 | 241 | | | | | | |
| 12 | 138 | 90 | 85 | | | | | | |
| 13 | 178 | | 124 | 109 | 134 | 80 | 73 | 104 | 62 |
| 14 | 235 | | 148 | 135 | 125 | 98 | 68 | 85 | 51 |
| 15 | 366 | | 197 | 149 | 173 | 184 | 90 | 115 | 94 |
| 16 | 245 | | 212 | 188 | 211 | 149 | | | 104 |
| 17 | 344 | 303 | 256 | | | | | | |
| 18 | 254 | 204 | 144 | | | | | | |
| 19 | 283 | 239 | 180 | | | | | | |
| 20 | 260 | 205 | 172 | | | | | | |
| 21 | 229 | 135 | 101 | 99 | 93 | 97 | 56 | 75 | 59 |
| 22 | 430 | 346 | 335 | | | | | | |
| 23 | 194 | 132 | 109 | 113 | 101 | 114 | 65 | 107 | 77 |
| 24 | 267 | 120 | 103 | 107 | 125 | 116 | 81 | 92 | 61 |
| 25 | 263 | 103 | 95 | | | | | | |
| 26 | 147 | 75 | 81 | 69 | 62 | 69 | 40 | 41 | 28 |
| 27 | 315 | 309 | 237 | | 270 | 195 | 180 | | 111 |
| 28 | 253 | 204 | 198 | | | | | | |
| 29 | 235 | | | | | | | | |
| 30 | 307 | 230 | | | | | | | |
| 31 | 222 | 162 | 151 | 159 | 72 | 77 | 58 | 44 | 18 |
| 32 | 322 | 299 | 245 | | | | | | |
| 33 | 45 | 26 | 36 | 36 | 54 | 47 | 33 | 45 | 14 |
| 34 | 181 | 141 | 121 | 123 | 135 | 136 | 92 | | |
| 35 | 185 | | | | 106 | 95 | 96 | 88 | 58 |
| 36 | 224 | 308 | 204 | 308 | 214 | 226 | | | |
| 37 | 149 | 110 | 104 | 130 | 116 | 99 | 94 | 86 | |
| 38 | 214 | 185 | 38 | | | | | | |
| 39 | 176 | 290 | 51 | | | | | | |
| 40 | | | | | 137 | 143 | 94 | 91 | 59 |
| 41 | | | | 174 | 179 | 174 | 144 | 226 | 122 |
| 43 | | | | | 324 | 256 | | | |
| 44 | | | | 160 | 166 | 148 | 135 | 139 | 137 |
| 45 | | | | 93 | 67 | 58 | 36 | 41 | 26 |
| 46 | | | | | 177 | 170 | 150 | | |
| 47 | | | | | 136 | 159 | | | |
| 49 | | | | | 171 | 185 | 110 | | |
| 50 | | | | | | 271 | 242 | 226 | 223 |
| 51 | | | | | | | | | 79 |
| 52 | | | | | | | | | 83 |
| 53 | | | | | | | | | 82 |
| 54 | | | | | | | | | 70 |

Table A10 Corrosion of zinc from sub-centres SVUOM and EMPA (g $m^{-2}$) measured at ICP Materials test sites

| | SVUOM | | | | | | | EMPA | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No | 1987 | 1989 | 1992 | 1994 | 1996 | 2000 | 2008 | 1997 | 2000 | 2002 | 2005 | 2008 |
| 1 | 14.8 | 7.0 | 7.7 | 5.6 | 5.6 | 3.9 | 3.1 | 6.7 | 7.4 | 11.3 | 6.7 | 5.8 |
| 2 | 8.9 | 7.9 | 6.7 | 3.4 | | | | | | | | |
| 3 | 16.3 | 11.5 | 11.6 | 12.1 | 8.7 | 4.6 | 6.9 | 10.1 | 11.2 | 7.2 | 16.0 | 9.7 |
| 4 | 11.6 | 8.3 | 5.1 | 4.6 | | | | | | | | |
| 5 | 8.8 | 7.6 | 6.6 | 4.6 | 3.1 | 5.8 | | 6.8 | 11.1 | 4.7 | | |
| 6 | 14.4 | 9.2 | 5.7 | 5.5 | | | | | | | | |
| 7 | 20.9 | 7.8 | 9.0 | 4.2 | 3.5 | 4.6 | | 6.3 | 10.0 | 6.6 | | |
| 8 | 21.3 | 4.6 | 5.2 | 4.1 | | | | | | | | |
| 9 | 28.7 | 6.6 | 9.0 | 7.6 | 5.7 | 5.8 | | 8.9 | 9.0 | 7.3 | | |
| 10 | 61.4 | 10.6 | 15.2 | 7.8 | 8.6 | 9.2 | 7.0 | 12.1 | 15.7 | 10.3 | 10.7 | 10.5 |
| 11 | 30.1 | 9.6 | 11.4 | 7.0 | | | | | | | | |
| 12 | 8.3 | 7.2 | 7.2 | 3.7 | | | | | | | | |
| 13 | 7.7 | 9.6 | | 3.4 | 3.8 | 3.1 | | 8.4 | 4.5 | 7.5 | 9.5 | 6.6 |
| 14 | 8.8 | 9.9 | | 3.1 | 3.1 | 2.5 | | 7.7 | 3.8 | 8.6 | 5.4 | 4.2 |
| 15 | 11.3 | 12.1 | | 5.5 | 4.4 | 4.2 | | 10.4 | 10.3 | 7.0 | 7.1 | 7.5 |
| 16 | 13.5 | 7.6 | | 6.0 | 4.1 | 4.6 | | 6.7 | 5.4 | | | 7.2 |
| 17 | 14.4 | 11.3 | 10.6 | 5.8 | | | | | | | | |
| 18 | 9.9 | 8.1 | 7.8 | 4.7 | | | | | | | | |
| 19 | 16.5 | 9.0 | 11.0 | 6.2 | | | | | | | | |
| 20 | 20.1 | 10.2 | 11.3 | 6.3 | | | | | | | | |
| 21 | 27.5 | 5.6 | 6.6 | 3.5 | 2.3 | 3.4 | 0.7 | 4.7 | 6.2 | 9.5 | 12.4 | 6.5 |
| 22 | 43.4 | 16.7 | 15.8 | 12.0 | | | | | | | | |
| 23 | 27.4 | 8.4 | 10.5 | 5.0 | 3.5 | 8.5 | | 7.8 | 21.3 | 15.8 | 19.3 | 10.6 |
| 24 | 10.3 | 6.0 | 4.5 | 4.2 | 3.2 | 4.4 | | 7.6 | 5.9 | 9.7 | 8.0 | 4.8 |
| 25 | 9.7 | 5.6 | 3.5 | 3.5 | | | | | | | | |
| 26 | 8.2 | 6.7 | 4.8 | 6.0 | 2.6 | 3.5 | | 7.7 | 9.0 | 14.6 | 16.2 | 10.6 |
| 27 | 10.4 | 12.3 | 10.6 | 7.0 | | 5.2 | 2.3 | 11.7 | 8.5 | 11.0 | | 5.2 |
| 28 | 10.0 | 6.4 | 7.7 | 8.6 | | | | | | | | |
| 29 | 13.0 | 11.6 | | | | | | | | | | |
| 30 | 15.0 | 8.4 | 8.3 | | | | | | | | | |
| 31 | 7.7 | 4.8 | 3.5 | 2.3 | 2.4 | 2.1 | 1.3 | 4.5 | 4.8 | 11.8 | 3.7 | 4.6 |
| 32 | 13.1 | 10.6 | 8.7 | 6.4 | | | | | | | | |
| 33 | 3.3 | 3.9 | 3.8 | 1.7 | 2.2 | 2.3 | | 4.6 | 2.7 | 6.7 | 6.6 | 4.9 |
| 34 | 10.2 | 8.6 | 6.5 | 4.6 | 4.1 | 6.8 | | 6.9 | 8.1 | 6.7 | | |
| 35 | 7.1 | 9.4 | | | | 5.1 | 2.4 | 7.3 | 7.7 | 10.5 | 7.3 | 7.2 |
| 36 | 9.8 | | 10.4 | 5.6 | 4.1 | 8.0 | | 8.9 | 5.8 | 12.2 | | |
| 37 | 9.8 | 6.2 | 5.2 | 6.1 | 2.6 | 3.7 | | 5.4 | 7.4 | 9.2 | 7.2 | |
| 38 | 10.6 | 12.4 | 9.6 | 4.7 | | | | | | | | |
| 39 | 13.5 | 10.9 | 7.3 | 5.2 | | | | | | | | |
| 40 | | | | | | 4.9 | 2.0 | 11.3 | 5.9 | 8.1 | 6.4 | 4.5 |
| 41 | | | | | 6.3 | 5.8 | 2.1 | 6.5 | 7.2 | 10.4 | 12.0 | 5.3 |
| 43 | | | | | | 7.6 | | 12.0 | 9.6 | | | |
| 44 | | | | | 2.8 | 3.9 | | 6.3 | 9.3 | 6.1 | 6.7 | 7.1 |
| 45 | | | | | 3.0 | 5.0 | 1.9 | 4.2 | 9.0 | 7.1 | 14.3 | 5.4 |
| 46 | | | | | | 6.1 | | 8.9 | 8.3 | 8.5 | | |
| 47 | | | | | | 5.0 | | 7.1 | 5.1 | | | |
| 49 | | | | | | 8.1 | | 9.9 | 12.6 | 7.4 | | |
| 50 | | | | | | 9.9 | 6.3 | | 16.2 | 11.8 | 11.9 | 9.7 |
| 51 | | | | | | | 2.3 | | | | | 5.2 |
| 52 | | | | | | | | | | | | 5.7 |
| 53 | | | | | | | | | | | | 7.9 |
| 54 | | | | | | | | | | | | 3.6 |

Table A11 Corrosion of limestone (μm) measured at ICP Materials test sites

| No | 1987 | 1997 | 2002 | 2005 | 2008 |
|---|---|---|---|---|---|
| 1 | 22.9 | 6.1 | 5.3 | 7.7 | 4.5 |
| 2 | 9.5 | | | | |
| 3 | 19.4 | 7.3 | 7.9 | 11.8 | 11.1 |
| 4 | 9.5 | | | | |
| 5 | 15.0 | 4.7 | 5.5 | | |
| 6 | 22.5 | | | | |
| 7 | 9.1 | 3.3 | 7.0 | | |
| 8 | 8.5 | 6.3 | 7.6 | | |
| 9 | 14.1 | 6.3 | 7.6 | | |
| 10 | 17.4 | 11.6 | 11.9 | 15.2 | 8.6 |
| 11 | 16.8 | | | | |
| 12 | 9.0 | | | | |
| 13 | 10.9 | 5.9 | 6.4 | 8.9 | 5.4 |
| 14 | 6.7 | 6.1 | 6.7 | 9.9 | 5.9 |
| 15 | 19.5 | 9.0 | 8.7 | 15.1 | 11.6 |
| 16 | 8.8 | 9.7 | 7.1 | 9.6 | 7.0 |
| 17 | 14.8 | | | | |
| 18 | 7.9 | | | | |
| 19 | 12.0 | | | | |
| 20 | 6.7 | | | | |
| 21 | 11.7 | 8.4 | 7.3 | 10.7 | 4.3 |
| 22 | 36.7 | | | | |
| 23 | 17.0 | 7.5 | 7.7 | 14.7 | 11.9 |
| 24 | 14.0 | 8.1 | 7.3 | 12.8 | 9.6 |
| 25 | 14.5 | | | | |
| 26 | 6.8 | 3.7 | 4.3 | 7.8 | 6.9 |
| 27 | 9.9 | 9.8 | 7.6 | | 6.8 |
| 28 | 9.6 | | | | |
| 29 | 22.8 | | | | |
| 30 | 15.7 | | | | |
| 31 | 13.3 | 3.2 | 3.9 | 8.1 | 2.6 |
| 32 | 20.9 | | | | |
| 33 | 6.2 | 7.6 | 5.8 | 11.5 | 7.5 |
| 34 | 9.4 | 9.0 | 7.9 | | |
| 35 | 9.9 | 5.5 | 8.9 | 10.6 | 8.3 |
| 36 | 6.9 | 11.5 | 10.6 | | |
| 37 | 8.9 | 6.3 | | 14.3 | |
| 38 | 10.2 | | | | |
| 39 | 18.2 | | | | |
| 40 | | 8.8 | | 10.9 | 8.1 |
| 41 | | 3.4 | 2.0 | 8.6 | 2.2 |
| 43 | | | | | |
| 44 | | 6.6 | 9.1 | 9.8 | 12.8 |
| 45 | | 9.4 | 9.0 | 14.3 | 7.1 |
| 46 | | 7.4 | 9.0 | | |
| 47 | | | | | |
| 49 | | 14.2 | 8.4 | | |
| 50 | | | 14.6 | 15.4 | |
| 51 | | | | | 8.6 |
| 52 | | | | | 12.3 |
| 53 | | | | | 14.2 |
| 54 | | | | | 5.4 |

Table A12 Soiling of modern glass (Haze in %) measured at ICP Materials test sites

| No | 2005 | 2008 |
|---|---|---|
| 1 | 3.2 | 1.7 |
| 2 | | |
| 3 | 2.7 | 2.5 |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | 1.4 | 2.0 |
| 11 | | |
| 12 | | |
| 13 | 3.4 | 3.4 |
| 14 | 3.2 | 3.2 |
| 15 | 3.4 | 2.8 |
| 16 | 3.7 | 3.7 |
| 17 | | |
| 18 | | |
| 19 | | |
| 20 | | |
| 21 | 1.6 | 1.6 |
| 22 | | |
| 23 | 1.3 | 1.3 |
| 24 | 2.2 | 3.4 |
| 25 | | |
| 26 | 1.4 | 1.6 |
| 27 | | 1.8 |
| 28 | | |
| 29 | | |
| 30 | | |
| 31 | 3.1 | 2.5 |
| 32 | | |
| 33 | 2.7 | 3.0 |
| 34 | | |
| 35 | 1.6 | 1.6 |
| 36 | | |
| 37 | 1.6 | |
| 38 | | |
| 39 | | |
| 40 | 3.8 | 2.9 |
| 41 | 3.6 | 4.6 |
| 43 | | |
| 44 | 0.9 | 1.5 |
| 45 | 3.8 | 1.0 |
| 46 | | |
| 47 | | |
| 49 | | |
| 50 | 2.2 | 3.0 |
| 51 | 8.9 | 10.5 |
| 52 | 13.6 | |
| 53 | | 2.0 |
| 54 | | 3.0 |