Report

Benzene Monitoring in Loddon – Final Report

Report to South Norfolk District Council

Netcen/AEAT/ENV/R/2057/Issue 1
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1 Introduction

Netcen, an operating division of AEA Technology plc, has been contracted by South Norfolk District Council to undertake a survey of ambient benzene concentrations in the village of Loddon. The survey was required to determine the concentrations of benzene in air within the area, in order to inform on matters arising from the possible impact of any local sources of benzene on estimates of exposure to the local population, as determined by procedures outlined in the requirements for Local Authority Review and Assessment.

The survey has been undertaken using a combination of passive monitoring and automatic real-time monitoring. This hybrid-monitoring programme is consistent with the requirements of Local Air Quality Management – Technical Guidance LAQM. TG(03).

The monitoring programme covers a period of 12 months and commenced on 29 June 2004. This final report provides a summary of the results obtained from the monitoring programme. The results of the first six-months have been reported separately in report netcen/ED48316/Issue 1.

Presented here are hourly concentration data from the automatic analyser, together with the results of fortnightly exposure of benzene diffusion tubes.

The Air Quality Strategy for the UK has set Air Quality Objectives for benzene. The Air Quality Objective for benzene in the UK is 16.25 μg/m^3 expressed as a running annual mean to be met by 31 December 2003. In England and Wales there is an additional objective for benzene of 5 μg/m^3 expressed as an annual mean to be met by the end of 2010.

The Directive 2000/69/EC of the European Parliament and of the Council of Ministers, which came into force on the 13 December 2000, defined a limit value for benzene. The defined limit value for benzene of 5 μg/m^3, expressed as an annual mean, is to be achieved by 1st January 2010. The limit value was given a margin of tolerance of 5 μg/m^3 (100%) on 13 December 2002, reducing on 1 January 2006 and every 12 months thereafter by 1 μg/m^3 to reach 0% by 1 January 2010 (i.e. member states may exceed the limit value by the indicated margin). By January 2010 the limit value must be achieved.

2 Benzene

Benzene (C_6H_6) is a volatile monocyclic aromatic hydrocarbon. Benzene is one of a number of chemicals that are commonly found together in crude petroleum and petroleum products such as petrol. These chemicals are also produced on the scale of mega tonnes per year as bulk chemicals for industrial use as solvents and starting materials for the manufacture of pesticides, plastics, and synthetic fibres.

Benzene is a stable colourless liquid at room temperature and normal atmospheric pressure. It has a characteristic aromatic odour, a relatively low boiling point and a high vapour pressure, which causes it to evaporate rapidly at room temperature. It is highly flammable and is formed by both natural processes and human activities.

Benzene is a minor constituent of petrol (about 2% by volume). The main sources of benzene in the atmosphere in Europe are the distribution and combustion of petrol. Combustion by petrol vehicles is the largest component (70% of total emissions) whilst the refining, distribution and evaporation of petrol from vehicles accounts for approximately a further 10% of total emissions. Benzene is emitted in vehicle exhaust not only as un-burnt fuel but also as a product of the decomposition of other aromatic compounds. Benzene is a known human carcinogen.

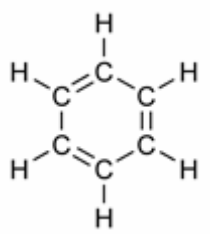


Figure 2.1: Chemical structure of benzene

3 Automatic Monitoring Data

The automatic analyser used for collection of benzene data in Loddon was a Chrompack CP-7001 BTX analyser. This instrument operates in accordance with the requirements of the EU CEN reference standard for the sampling and analysis of benzene concentrations in ambient air.

The analyser was housed in Netcen's purpose built mobile monitoring station located in the garden of 31 Beccles Road, Loddon.

The analyser was operated to generate hourly data with regular calibrations using a certified calibration standard supplied by The National Physical Laboratory (NPL). Table 3.1 below summarises the results of the automatic monitoring.

Table 3.1: Summary of automatic benzene monitoring data for the period 29 June 2004 to 29 June 2005.

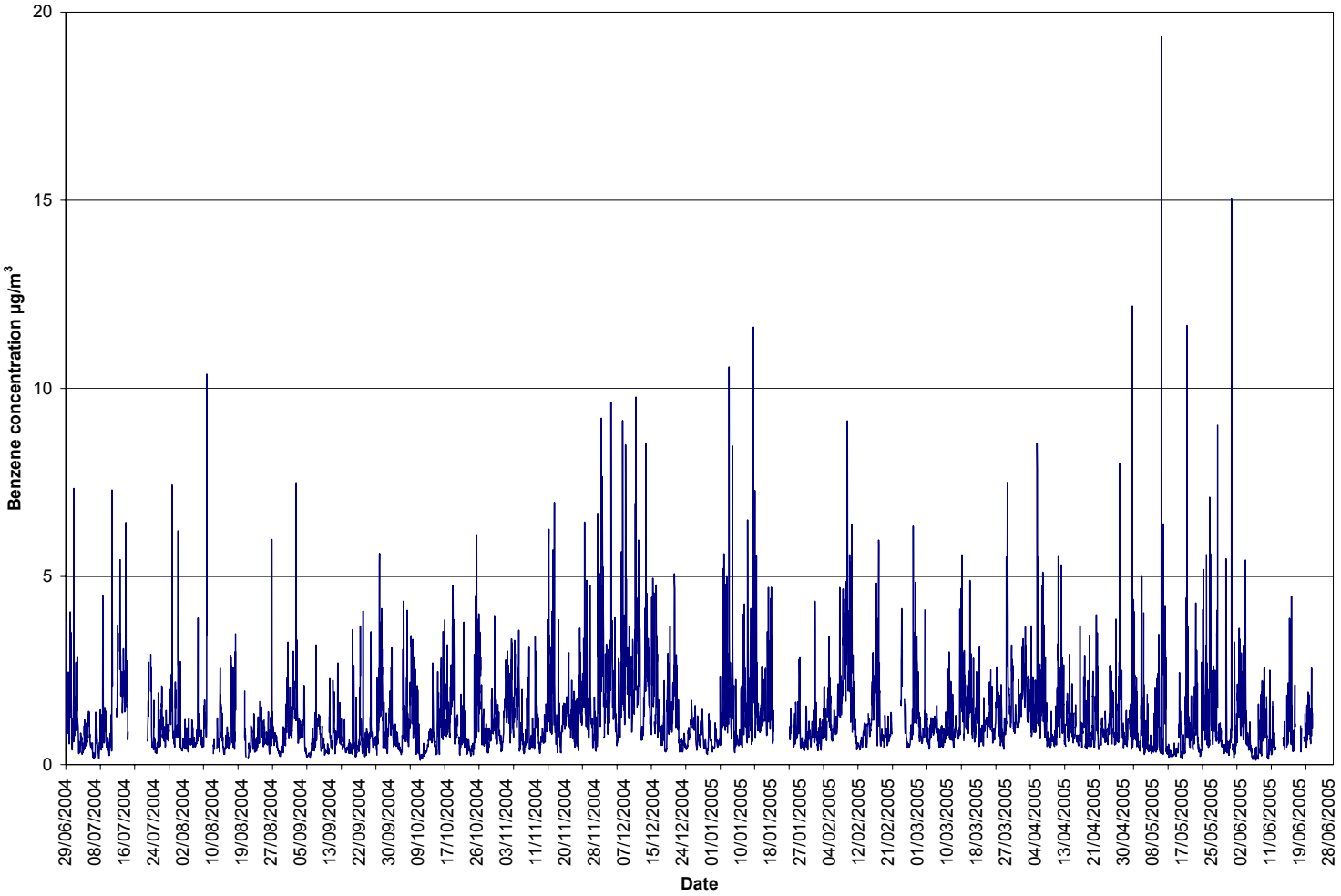
Mean hourly benzene concentration	1.19 $\mu g/m^3$
Max hourly benzene concentration	19.4 $\mu g/m^3$
Data capture *	90 %

* Valid measurement data was collected for 7851 hours out of a possible 8766 hours.

Gaps in the continuous dataset represent periods when the analyser was not functioning, mostly following power failures. The Technical Guidance specifies a data capture target of 90%, this allows for routine servicing and calibration visits as well as some down time due to power outages.

The data are presented graphically in Figure 3.1.

Figure 3.1: Time series plot of hourly benzene concentrations for 29th June 2004 to 29th June 2005.



4 Meteorological Data

The following two figures summarise the meteorological data collected during the survey and how this is related to benzene concentrations. For the duration of the survey the meteorological parameters wind speed and wind direction were recorded using sensors at the automatic monitoring location. In analysing the data, 36 segments of 10° arc were used to characterise the data.

Figure 4.1 is a radial plot of the frequency of wind direction for each of the 36 segments. From this plot it can be seen that the wind was incident on the monitoring station predominantly from the south-west direction. Specifically, wind was from the segment bounded by 180° to 270° for 54% of the monitoring period.

Figure 4.1: Wind rose plot for 29th June 2004 to 29th June 2005

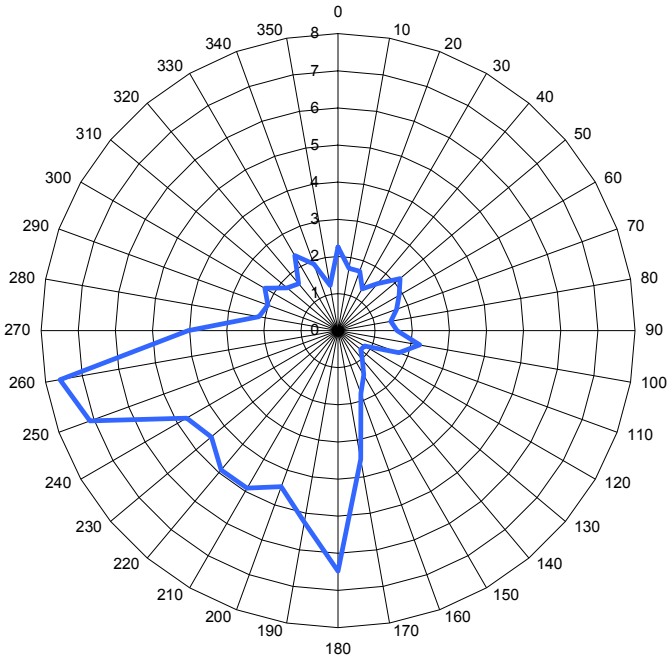
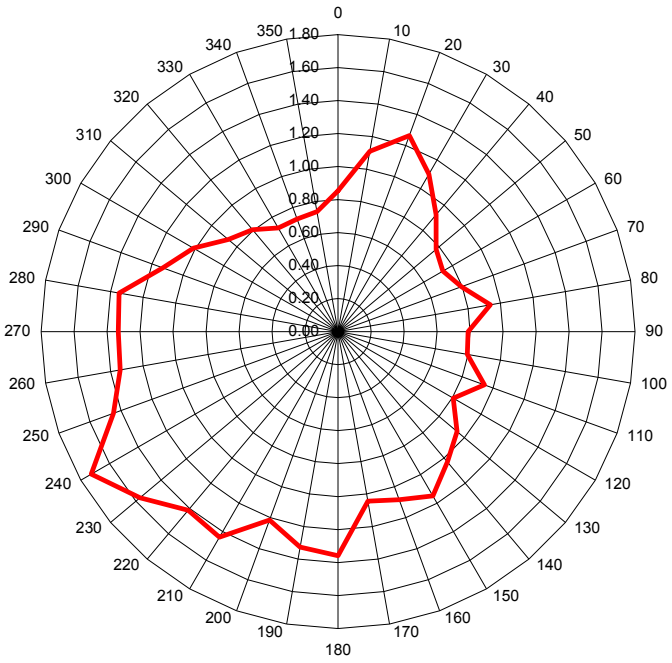


Figure 4.2 shows a radial plot of average benzene concentrations against wind direction. The average concentrations are greater when the wind is between 180° and 280° and also at approximately 20°. The sector bounded by 180° to 280° corresponds to the region where Beccles Road is closest to the monitoring station. The enhancement at 20° coincides with the direction of the property on which the monitoring enclosure was positioned.

Figure 4.2: Benzene pollution rose plot for 29th June 2004 to 29th June 2005



5 Episode Data

Hourly measurements greater than 10 µg/m^3 have been used as an indicator of pollution 'episodes'. The value of 10 µg/m^3 was chosen, as this is numerically equal to the EU Directive annual limit value plus margin of tolerance. It must be noted here that an annual mean limit value is used as a metric to identify enhanced hourly average concentrations and this does not indicate an exceedance of the annual limit value. Measurements, which meet this criterion are summarised in Table 5.1 together with the date, time and meteorological conditions at the time of the measurement.

Table 5.1: Hourly benzene concentrations greater than 10 µg/m^3

Date	Time	Wind Direction	Wind Speed	Concentration
9-Aug-04	4:00	147	0.8	10.4
6-Jan-05	14:00	227	1.2	10.6
13-Jan-05	14:00	278	5.3	11.6
2-May-05	16:00	185	4.0	12.2
11-May-05	9:00	5	5.5	19.4
18-May-05	9:00	8	3.7	11. 7
31-May-05	5:00	262	2.4	15.1

From the table it can be seen that benzene concentrations exceeded 10 µg/m^3 on seven occasions during the period of monitoring. There were no instances of prolonged episode concentrations as none of the values are for consecutive hours. There is also no clear pattern both in terms of time of episode or wind direction.

6 Diffusion Tube Results

Passive monitoring using diffusion tubes was conducted for the duration of the automatic monitoring campaign. Diffusive samplers were exposed for two-week periods for the duration of the survey period at five locations. A set of three tubes was exposed, collocated at the site of the automatic analyser (31 Beccles Road). Comparison of the results from these tubes and the data of the automatic analyser has been used to 'bias correct' the results of the wider diffusion tube survey, in accordance with the methodology described in Technical Guidance TG(03) and the review and assessment helpdesk.

The tubes located at 37 Lower Bungay Road have been sited to provide a background representation of benzene concentrations under prevailing weather conditions. Table 6.1 below summarises the benzene diffusive sampler data.

Table 6.1: Average benzene concentrations derived from diffusive samplers (bias corrected), for the period 29 June 2004 to 29 June 2005.

Tube Location	Benzene Concentration $\mu g/m^3$
31 Beccles Road	1.17
2 Norton Road	1.34
12 Norton Road	1.16
37 Lower Bungay Road	1.16
Lamp post 182, Littlemoney Road	1.33

In general the results from the diffusion tube survey show similar concentrations at each monitoring location. Concentrations at all locations are below both the UK air quality objective and EU limit value.

The technical guidance and review and assessment helpdesk do not recommend the correction of individual tube results, only the correction to the annual mean result. For this reason the uncorrected period results are presented graphically in Figure 6.2. From this figure the annual seasonal trend in concentration variations can be observed.

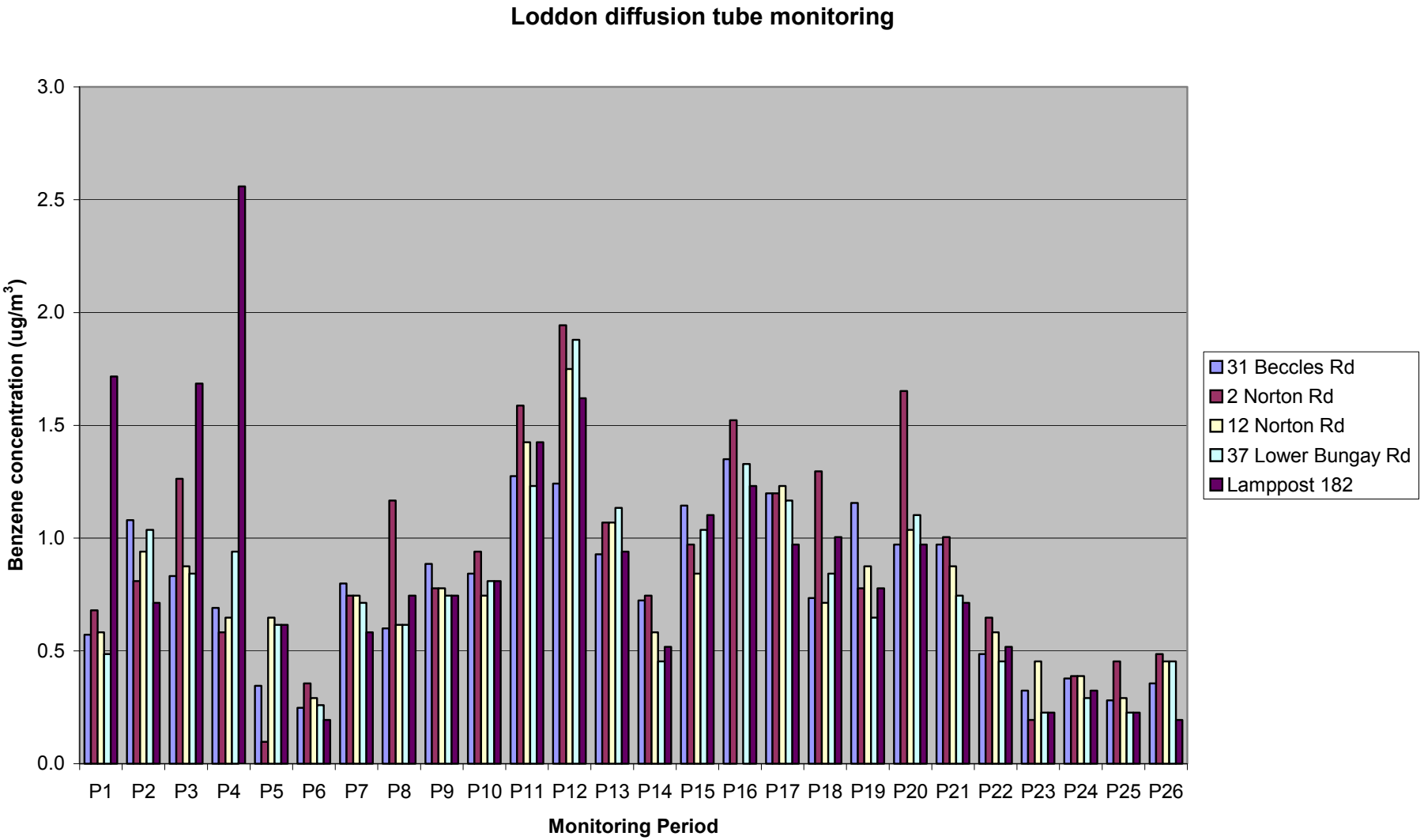


Figure 6.1: Uncorrected results of benzene diffusion tube monitoring.

7 Comparison With Other Data

The UK Ambient Automatic Hydrocarbon Air Quality Network monitors a range of hydrocarbon species at locations throughout the UK. These measurements are made using automatic analysers similar in design to that used in this study; therefore, direct comparisons can be made between the data recorded. The locations chosen for comparison represent a range of site categories from the UK network. These are:-

London Marylebone Road (Kerbside) – The sampling point is located at a height of 3m, around 1m from the kerbside on Marylebone Road. Traffic flows of over 80,000 vehicles per day pass the site on six lanes. The road is frequently congested. The surrounding area forms a street canyon and comprises of education buildings, tourist attractions, shops and housing.

London Eltham (Urban Background) – The site is located within an existing building in the grounds of an environmental education centre. The sampling point is over 25m from the road and at a height of around 2.5m. The surroundings consist of a mixture of habitats including parkland with areas of grass, ponds, a golf course and housing.

Harwell (Rural) – The monitoring station is within a self-contained, air-conditioned housing located within the grounds of the Harwell Science Centre. The nearest road is for access to buildings within the science park only. The manifold inlet is approximately 3 metres above ground level. The surrounding area is generally open with agricultural fields.

Table 7.1: Comparison with national network monitoring data.

Monitoring site	Mean benzene concentration (µg/m^3) 29 June 2004 to 29 June 2005
Loddon	1.19
London Marylebone Road	2.47
London Eltham	0.79
Harwell	0.40

From the above data it can be seen that concentrations of benzene in Loddon are lower than those measured at Marylebone Road (approximately half) and higher then those at both London Eltham and Harwell both of which are situated some distance from major roads.

8 Conclusions

In considering the monitoring data it should be borne in mind that the values presented are in terms of hourly average concentrations for the automatic data and two weekly average concentrations for the diffusion tubes. The standards or limit values are set in terms of an annual average. In this report the measurement data are compared with the standards. This is reasonable as the period of the survey covers 12 months of data, including both summertime and wintertime periods, and as such will reflect seasonal influences on the benzene concentration.

Considering first the automatic monitoring data, the average concentration of benzene in air for the survey period is 1.19 $\mu g/m^3$, this value is significantly below the Air Quality objective value of 5 $\mu g/m^3$ and the EU Directive value plus margin of tolerance value of 10 $\mu g/m^3$.

Generally, average concentrations from the diffusion tube exposures show similar values to those obtained from the automatic monitoring. All tubes show concentrations of approximately equal value, with the exception of the tubes exposed at lamppost 182 on Littlemoney Road. This location is within the industrial estate and therefore may be influenced by local processes and possibly vehicles parking or manoeuvring when visiting business units in the vicinity.

The monitoring period mean (12 month) diffusion tube data has been bias corrected using the most up to date methodologies, as described at the Defra review and assessment web site (http://www.uwe.ac.uk/aqm/review/). The corrected concentrations are all significantly below the UK Air Quality Objective value (5 $\mu g/m^3$) and the EU Directive limit value plus margin of tolerance (10 $\mu g/m^3$).

From the monitoring study, it has been demonstrated that the annual average benzene concentration in the area did not exceed the AQ Objective value of 5 $\mu g/m^3$ for 2010, or the EU limit value.