

# **Suffolk Coastal District Council**

## **Sulphur Dioxide Monitoring at the Port of Felixstowe**

Results of the six month survey

November 2002

Entec UK Limited



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**Report for**

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# Suffolk Coastal District Council

## Sulphur Dioxide Monitoring at the Port of Felixstowe

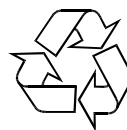
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November 2002

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## Executive Summary

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Suffolk Coastal District Council has commissioned Entec to assist in undertaking a survey of ambient sulphur dioxide (SO<sub>2</sub>) concentrations in the vicinity of the port of Felixstowe. The survey has been undertaken as part of the Stage 3 review and assessment of local air quality.

In consultation with DEFRA, the Council identified the port of Felixstowe as potentially experiencing elevated SO<sub>2</sub> concentrations due to the number of ship movements within the port. A monitoring programme was implemented to assess the likelihood of the SO<sub>2</sub> objectives not being achieved at residential areas close to Felixstowe Port.

Monitoring of ambient SO<sub>2</sub> concentrations was undertaken between 21<sup>st</sup> March and 20<sup>th</sup> September 2002. 15 minute, hourly and 24 hour mean concentrations were recorded and compared against the relevant AQS objectives.

From the results of the monitoring programme, it was concluded that ambient concentrations of SO<sub>2</sub> are well within the relevant air quality criteria. The port and surrounding residential area would therefore not require declaration of an air quality management area due to emissions of SO<sub>2</sub> associated with the operation of the port.

The derived concentrations of PM<sub>10</sub> of 31 µg/m<sup>3</sup> 90<sup>th</sup> percentile of 24 hour means shows that at Felixstowe docks the potential for the air quality objectives for PM<sub>10</sub> to be exceeded is negligible. Therefore it would seem that further assessment for this pollutant at the relevant receptors will not be necessary.



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# 1. Introduction

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Suffolk Coastal District Council (SCDC) are currently undertaking a stage 3 review and assessment of local air quality. In consultation with DEFRA, SCDC identified the Port of Felixstowe as an area that is potentially experiencing elevated sulphur dioxide (SO<sub>2</sub>) concentrations. With a large number of ship movements within the port throughout the year, it was considered that SO<sub>2</sub> emissions, from shipping and onshore cranes, could adversely affect air quality in residential areas in close proximity to the dockside.

SCDC commissioned Entec to assist in a 6 month survey of sulphur dioxide (SO<sub>2</sub>) in the port of Felixstowe to establish ambient concentrations for comparison against set objectives in the Air Quality Strategy.

## 1.1 Scope

SCDC commissioned Entec to undertake site servicing, routine equipment calibration of the SO<sub>2</sub> monitoring equipment and assessment of the monitoring results. Envirotechnology (ET) on behalf of SCDC, installed a SO<sub>2</sub> fluorescence monitor equipped with remote download modem connection in the Port Health Authority building. ET was responsible for the technical servicing of the equipment.



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## 2. Air Quality

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### 2.1 The Air Quality Strategy (AQS) and Air Quality Standards

The 2000 AQS<sup>1</sup> contains air quality objectives for eight pollutant species that are based on standards in the EU daughter directives, the Expert Panel on Air Quality Standards (EPAQS) and the World Health Organisation (WHO) recommendations. The objectives are due to be achieved by a range of dates from 2003 to 2008. With the exception of ozone, which is considered a regional pollutant, it is the responsibility of Local Government to enforce action plans so that the objectives for the remaining seven pollutants are achieved “*in areas where people are likely to be exposed over the relevant averaging period.*” These objectives were made statutory through the 2000 Air Quality (England) Regulations.

The SO<sub>2</sub> monitoring survey is being undertaken as part of SCDCs’ obligations under the UK Air Quality Strategy, Local Air Quality Management. The local authority is obliged to ascertain whether there is a significant risk of any of the seven pollutants covered by the Air Quality Strategy 2000 not being achieved in the objective year in the area. These obligations and air pollution objectives are set out in two key pieces of UK legislation:

- **The Air Quality (England) Regulations 2000.** This made statutory standards and objectives set out in the Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland 2000.
- **The Air Quality Limit Values Regulations 2001.** This has recently superseded the Air Quality (England) Regulations 2000. This document set up the framework for additional air quality standards to be implemented, although the existing air quality standards remained the same.

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<sup>1</sup> The Air Quality Strategy for England, Scotland, Wales and Northern Ireland - Working together for clean air. DETR January 2000

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## 2.2 United Kingdom Air Quality Objectives

Table 2.1 details the UK air quality standards and dates of target achievement for SO<sub>2</sub> and relevant to the protection of human health.

**Table 2.1 United Kingdom Air Quality Objectives for SO<sub>2</sub>**

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<b>Objective Concentration</b>	<b>Measured as</b>	<b>Date to be achieved by</b>
350µg/m <sup>3</sup> (132 ppb) not to be exceeded more than 24 times a year	1 hour mean	31/12/2004
125µg/m <sup>3</sup> (47 ppb) not to be exceeded more than 3 times a year	24 hour mean	31/12/2004
266µg/m <sup>3</sup> (100 ppb) not to be exceeded more than 35 times a year	15 minute mean	31/12/2004

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## 3. Background

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### 3.1 Background to the Port

Felixstowe is one of the largest commercial ports in Europe. Primarily the shipping movements at the port are commercial and container ships, rather than ferries or liners. In terms of total freight handled the port is ranked ninth largest in the UK, handling a total of 29.7 million tonnes in 2000<sup>2</sup>.

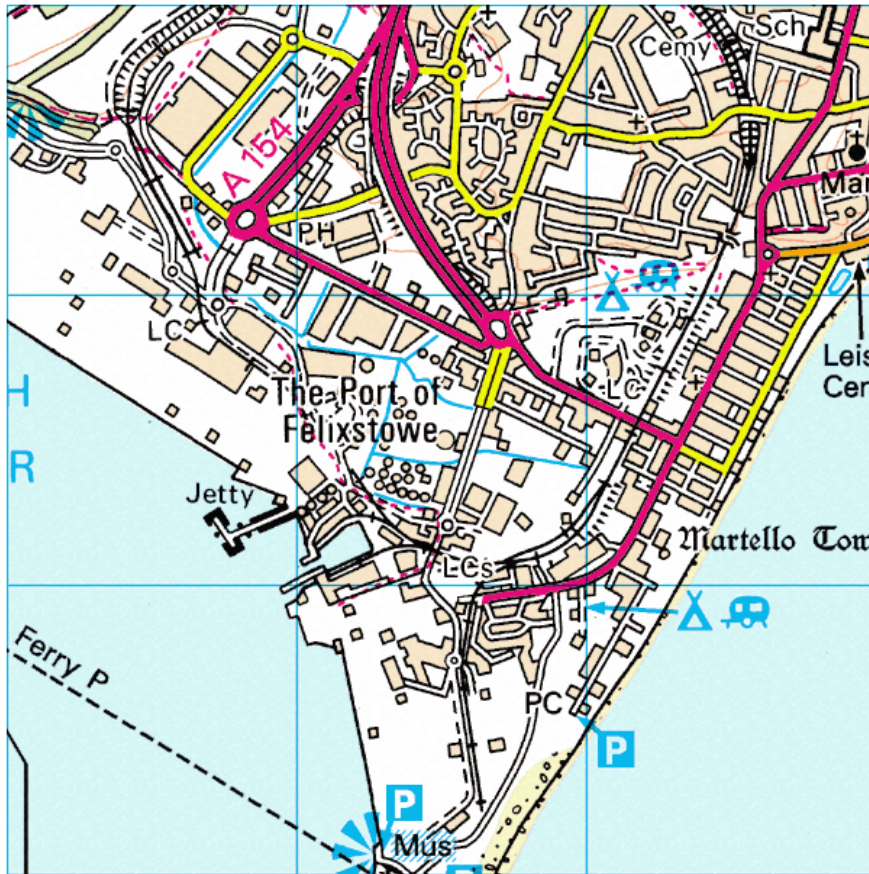
#### 3.1.1 Location Description

The port is situated on the southern outskirts of the town of Felixstowe, occupying the southern tip of the peninsula on which the town sits, bordered on one side by the North Sea and on the other by the River Orwell. Felixstowe is located in South Eastern Suffolk, approximately 12 miles from Ipswich. A location plan can be seen in Figure 3.1.

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<sup>2</sup> <http://www.transtat.dtlr.gov.uk/tables/2001/provport/provport.htm>

Figure 3.1 Location of Felixstowe Docks



A large area of the shipping berths is in close proximity to residential areas in the town of Felixstowe, the closest being approximately 400 m from the dockside.

The SO<sub>2</sub> monitor was located in the port health building situated centrally in the port. The building is approximately 400 m from the dockside, a comparable distance to the residential areas surrounding the port. The monitor is situated in a temperature controlled room, with a 10 m sample tube running from an external port to the sampler.

50 meters to the south of the port health building is a truck loading area, where heavy goods vehicles queue to load containers. Between this area and the dockside are several container storage areas, up to 15 m in height. However there are 'corridors' between the storage areas, through which air movements will occur. The port is operational continuously throughout the day and night, and during the weekend. In addition to shipping movements there are HGV movements and support vehicle movements at all times. However with little heavy industry in the vicinity of Felixstowe, shipping will be the predominant source of SO<sub>2</sub> in the port area.

#### Activities During Monitoring Period

SCDC has provided details of the vessels arriving and departing Felixstowe port during the monitoring period. Approximately 18 vessels arrive and depart each day. Using movements data as supplied by SCDC no correlation was found between elevated SO<sub>2</sub> concentration and vessel arrivals and departures.

### **3.1.2 Local Meteorology**

The local meteorology will determine the dispersion characteristics of ship emissions. Primarily, wind speed and wind direction will determine whether the emission plume from the dock area disperses towards the town and residential areas. The wind rose in Appendix A illustrates that the prevailing wind direction in Felixstowe is south-westerly and emissions from the port are likely to disperse in the direction of the town for the majority of the year.





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## 4. Monitoring

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### 4.1 Programme

The six month monitoring programme was undertaken from 21<sup>st</sup> March 2002 until 20<sup>th</sup> September 2002. Data were logged at 15 minute and hourly intervals, to allow comparison against the AQS objectives 24 hour averages were calculated from the recorded hourly concentrations.

### 4.2 Monitoring Equipment

The SO<sub>2</sub> monitor used was a API Model 100A SO<sub>2</sub> UV fluorescence analyser. -The operating principle involves excitation of SO<sub>2</sub> molecules with UV light, followed by detection of UV fluorescence as the molecules decay from their excited state. The unit features an internal volatile organic compound (VOC) scrubber, as these compounds will interfere with accuracy of the equipment.

#### 4.2.1 Internal Calibration

The equipment is set-up to undertake an internal span calibration and zero check once every 24 hours. This option allows span drift between external calibration tests to be assessed and the data manipulated accordingly.

The USEPA state that hourly data is only valid when based upon a 45 minute period in any one hour. The calibration takes 30 minutes, and is therefore set up to occur 15 minutes in 1 hour and 15 minutes in the next hour.

#### 4.2.2 External Calibration

External calibration occurs every four weeks throughout the monitoring programme. Appendix B illustrates the calibration protocol. The external calibration allows the user to ascertain both the zero error and the span error, as these are likely to alter marginally throughout the monitoring period.

The zero calibration is performed by passing 'zero air', generated internally through the scrubber in the monitor, and ascertaining the recorded SO<sub>2</sub> level identified at an actual concentration of zero. The external span check uses a calibration gas of known concentration passing through the monitor. The SO<sub>2</sub> readings are then noted so that the data can be scaled to take into account any drift in the readings from the absolute values.



## 5. Results

### 5.1 Statistical Results Summary

Table 5.1 summarises the monitored and calculated SO<sub>2</sub> concentrations for the six months monitoring from 21<sup>st</sup> March until 20<sup>th</sup> September. Time series of the concentrations are shown in Figures 5.1 to 5.3. Data capture over the six month period was above 90% and this is considered sufficient to enable comparison against the AQS objectives.

**Table 5.1 Summary SO<sub>2</sub> concentrations from 21 March to 20 September 2002 (µg/m<sup>3</sup>)**

Criteria		15 Minute Averages	Hourly Averages	24 Hour Averages
Maximum		177	154	52
Minimum		0	0	1
Mean		17	18	18
AQS Percentile	99.9 <sup>th</sup> (266)	142	-	-
	99.7 <sup>th</sup> (350)	-	108	-
	99.1 <sup>st</sup> (125)	-	-	51
% of AQS Objective		53	31	41
% Data Capture		90	95	92

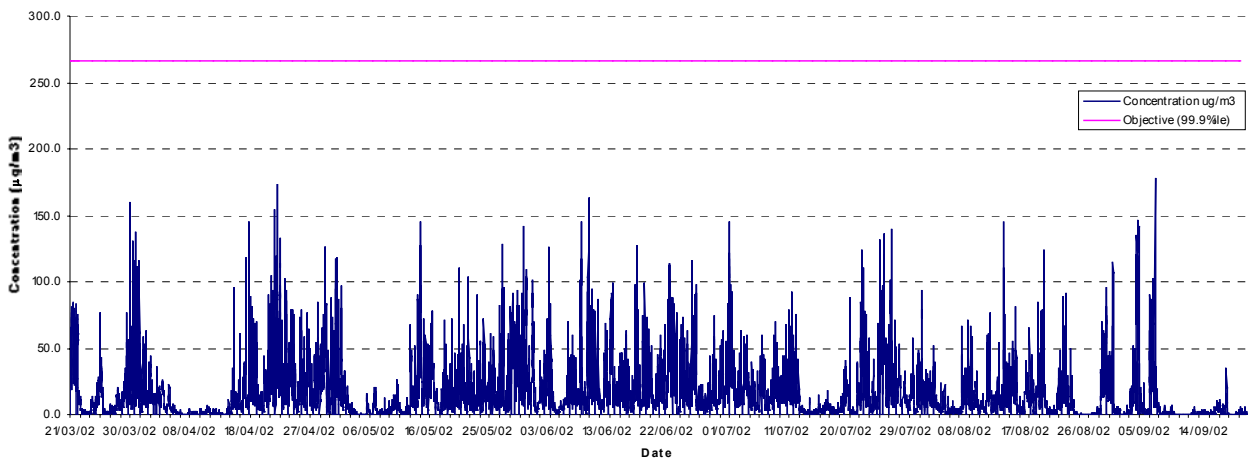
#### 5.1.1 Comparison of the SO<sub>2</sub> Concentrations at Felixstowe with the Air Quality Objectives

The maximum recorded 15 minute mean SO<sub>2</sub> concentration was 177 µg/m<sup>3</sup> on 6 September. The AQS specifies a maximum objective of 266 µg/m<sup>3</sup> with 35 exceedences permitted in a calendar year, this is equivalent to the 99.9<sup>th</sup> percentile. The calculated 99.9<sup>th</sup> percentile was 142 µg/m<sup>3</sup> and represents 53% of the objective.

The maximum recorded hourly mean SO<sub>2</sub> concentration was 154 µg/m<sup>3</sup> on 10 June. The AQS specifies a maximum objective of 350 µg/m<sup>3</sup> as an hourly mean, 24 exceedences of the objective are permitted in a calendar year resulting in the objective being relative to the 99.7<sup>th</sup> percentile. The calculated concentration of 108 µg/m<sup>3</sup> represents 31% of the objective.

The maximum calculated 24 hour mean SO<sub>2</sub> concentration was 52 µg/m<sup>3</sup> on 2 July. The AQS specifies a maximum objective of 125 µg/m<sup>3</sup> as a 24 hour mean, 3 exceedences of the objective are permitted in a calendar year resulting in the objective being relative to the 99.1<sup>st</sup> percentile. The calculated concentration of 51 µg/m<sup>3</sup> represents 41% of the objective.

**Figure 5.1** 15 minute mean SO<sub>2</sub> concentrations µg/m<sup>3</sup>



**Figure 5.2** Hourly mean SO<sub>2</sub> concentrations µg/m<sup>3</sup>

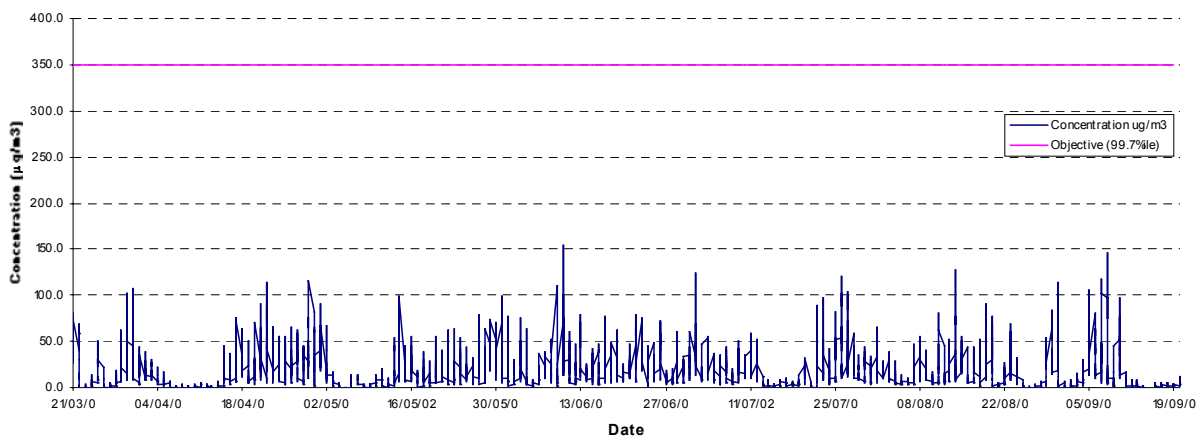
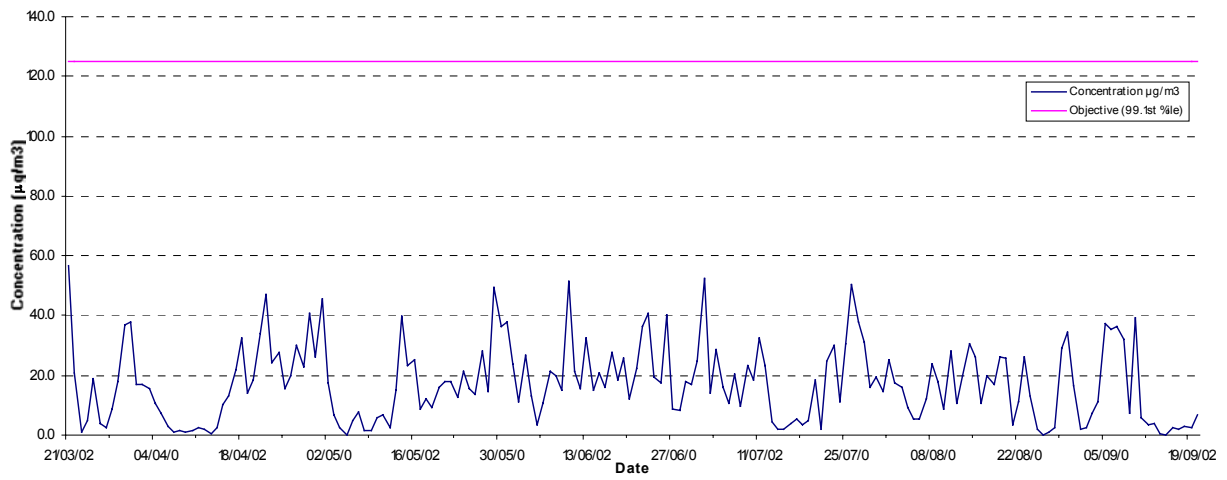


Figure 5.3 Calculated 24 hour mean SO<sub>2</sub> concentrations µg/m<sup>3</sup>





## 6. Assessment of Particulate Matter

Particulate matter, with an aerodynamic diameter of less than 10 microns (PM<sub>10</sub>) at the Port of Felixstowe would have as its source marine aerosols, agriculture, road transport, construction activities as well as secondary particulate matter and shipping. Information from the NAEI<sup>3</sup> shows that approximately 16% of PM<sub>10</sub> can be attributable to industrial activities.

Therefore to get an indicative estimate of particulate matter at the port, it has been assumed that the predominate contributor to local PM<sub>10</sub> and SO<sub>2</sub> concentrations is that of shipping, thus allowing comparisons to be made with other ports within the UK. The Dibden Terminal Environmental Statement<sup>4</sup> contains PM<sub>10</sub> and SO<sub>2</sub> data suitable for this comparison.

Ambient annual mean PM<sub>10</sub> concentrations recorded at Hythe Marina ranged from 24-31 µg/m<sup>3</sup>, with a maximum 90<sup>th</sup> percentile of 43 µg/m<sup>3</sup>.

On the assumption that as Felixstowe and Hythe Marina have a common source of SO<sub>2</sub> and PM<sub>10</sub> in shipping, there will also be a correlation between the two, allowing an estimate of the background PM<sub>10</sub> concentrations at Felixstowe to be made. It has been assumed that 16% of the PM<sub>10</sub> emissions have shipping as their source. An adjustment has also been made to account for the difference in the number of vessels per day entering and leaving each location, 18 at Felixstowe, 150 at Dibden<sup>5</sup>.

Estimates have been made based on the relationship between the SO<sub>2</sub> 99.9<sup>th</sup> percentile and annual mean PM<sub>10</sub> data reported for Dibden Terminal and Felixstowe. The estimated relationship and concentrations at Felixstowe are detailed in Table 6.1 below;

**Table 6.1 Estimated PM10 concentrations (µg/m<sup>3</sup>)**

Site		SO <sub>2</sub> Concentration (99.9 <sup>th</sup> percentile of 15 minute averages) µg/m <sup>3</sup>	PM <sub>10</sub> Concentration (90 <sup>th</sup> percentile of daily averages) µg/m <sup>3</sup>
Hythe Marina	90 <sup>th</sup> percentile	117	43
Felixstowe	90 <sup>th</sup> percentile	142	31*

\*Derived

This indicative figure of 31 µg/m<sup>3</sup> 90<sup>th</sup> percentile of 24 hour means shows that at Felixstowe docks the potential for the air quality objectives for PM<sub>10</sub> to be exceeded is negligible.

<sup>3</sup> [www.naei.org.uk](http://www.naei.org.uk)

<sup>4</sup> Dibden Terminal Environmental Statement. Associated British Ports.

<sup>5</sup> [www.dibdenterminal.co.uk/facts/fact01.htm](http://www.dibdenterminal.co.uk/facts/fact01.htm)





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## 7. Conclusions

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Monitoring of ambient SO<sub>2</sub> concentrations has been undertaken at the port of Felixstowe from 21<sup>st</sup> March until 20<sup>th</sup> September 2002, as part of Suffolk Coastal District Council's review and assessment process. 15-minute and hourly and 24 hour mean concentrations have been compared against the relevant AQS objectives.

The monitored concentrations indicate that ambient concentrations are well below the relevant air quality criteria. The port and surrounding residential area would therefore not require a declaration of an air quality management area due to emissions of SO<sub>2</sub> associated with the operation of the port.

The derived concentrations of PM<sub>10</sub> of 31 µg/m<sup>3</sup> 90<sup>th</sup> percentile of 24 hour means shows that at Felixstowe docks the potential for the air quality objectives for PM<sub>10</sub> to be exceeded is negligible. Therefore it would seem that further assessment for this pollutant at the relevant receptors will not be necessary.



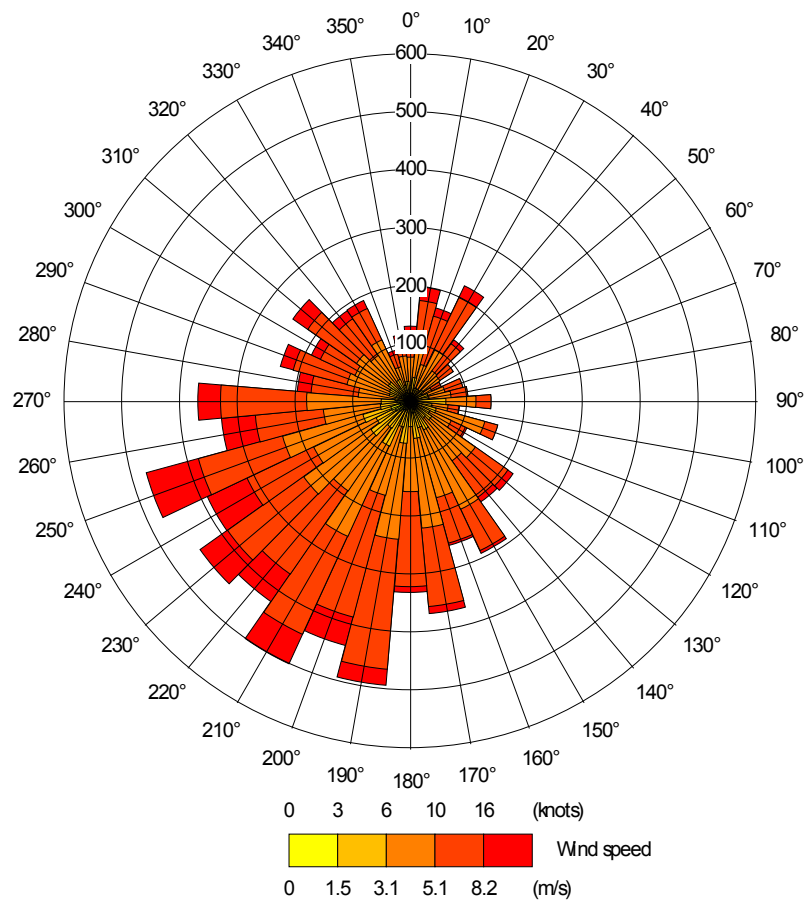
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# Appendix A

## Wind rose for Felixstowe

1 Page

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# Appendix B

## Calibration Protocol

4 Pages

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### Equipment

- Medium head Phillips screwdriver;
- Long Pliers;
- Mid-sized adjustable spanner;
- Laptop running APICOM, or Terminal; and
- RS232 cable with female socket both ends.

### Setting the internal daily zero and span calibration

1. Press “ACAL” on the main screen.
2. Press “SEQUENCE 1”.
3. Press “MODE”.
4. Use “NEXT” key until zero and span comes up on screen.
5. Press “ENTER”.
6. Press “SET”.
7. Change “TIMER” to “ENABLE”.
8. Change “DATE” to any date in the past (this will activate calibration from current date).
9. Set “TIME” to 0045\*.
10. The “DELTA DAYS” option allows the time at which calibration occurs to be changed for each day. This option will not initially be used, however will be assessed is it is currently unknown whether any peaks in activity occur during the night.
11. Set “DURATION” to 10 minutes.
12. Set “CALIBRATE” to “OFF”.

### Internal calibration schedule

- 0045-0055 Span calibration
- 0055-0105 Zero calibration
- 0105-0115 Hold to allow SO<sub>2</sub> levels to return to ambient

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## Software checks

Test values will allow the user to ascertain whether all components are operating within normal parameters.

- TIME: should display the correct time in GMT
- RANGE: 1000  $\mu\text{g}/\text{m}^3$
- STABILITY: (change in concentration measured over a period of time) 0.5 ppb, this should also be this during calibration
- PRESSURE: 27.6 inches
- SAMPLE FLOW: 689 cc/minute (+- 100)
- PMT (Photomultiplier tube): 30.3 mV
- Normalised PMT (after pressure and temperature allowance): 30.3 mV
- UV lamp: 4429 (mV?) [will drop to about 3500 (mV?) during the course of the first two months]
- STROBE LIGHT and DARK PMT: Measures background noise
- SLOPE: calibration slope 1.030 (1.0 +- 0.3)
- OFFSET: 26.3, any value below 250 is OK
- HVP: 600 volts, maximum 900 volts
- DC POWER SUPPLY: 2500 mV (+- 250 mV) this function measures power to all components.
- REACTION CELL: 50°C (+- 1.0)
- PMT TEMP: 7-8°C
- INTERNAL STANDARD: 50°C (+- 0.2)

The FAULT light will illuminate if any of the above are out of range. Press CLR button to clear fault. The light will re-illuminate if the fault is still occurring and requires attention.

## Calibration procedure

- CALZ- runs zero calibration
- CALS- runs span calibration
- CAL- Flags data for 30 minutes to indicate that calibration with standard gas is occurring.

## Procedure for four weekly calibration:

Do ZERO calibration first

- Press CALZ

- 
- Press TST until STABILITY is displayed. In the zero mode  $<0.5 \mu\text{g}/\text{m}^3$  indicates that the analyser is working OK.
  - Record value of  $\text{SO}_2$  concentration when stability  $<0.5 \mu\text{g}/\text{m}^3$ , three times. (i.e. 0.4, 0.4, 0.4).
  - Press EXIT
  - Remove sample line from back of analyser
  - Unscrew the cylinder cap and screw the regulator to the top of the cylinder.
  - On the gas cylinder turn the green tap on then off immediately to pressurise system, vent through the regulator, close all valves and repeat.
  - Turn green tap on
  - Turn regulator on and set pressure to 2 bar, and flow rate to 700, with excess venting (this means that no air will back flow into cylinder)
  - Plug tube into analyser input socket
  - Press CAL button
  - Record value of  $\text{SO}_2$  concentration when stability  $<0.5 \mu\text{g}/\text{m}^3$ , three times.
  - Recorded values are then used to scale the data as necessary.
  - Close all valves on cylinder and regulator
  - Take calibration tube out of sample port and replace the sample tube.
  - Press EXIT

### **Filter Change**

- Open front panel, the filter is on the left
- Loosen and remove the O-ring
- Remove Glass
- Remove white Teflon ring
- Remove filter
- Place in new filter (white) either way around
- Replace white Teflon ring with the notches facing upwards
- Replace glass plate
- Replace O-ring and tighten finger tight
- Shut front panel

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## Notes

SCDC will provide a log of ship movements, including times in and times out of port. This will allow us to assess whether peaks in hourly SO<sub>2</sub> levels are occurring as a result of specific shipping movements. This log will be kept in file at the port authority offices.

SCDC will install a mobile phone MODEM. ET are to provide MODEM and software to SCDC.

Unit password is 101.

When the ships enter the port they power down when alongside. The ships take, on average, 30 minutes to berth. During start up emissions of smoke and SO<sub>2</sub> increase.

The calibration gas is 535 ppb SO<sub>2</sub> in air, or at STP 25°C 1401.7 µg/m<sup>3</sup>.

On the 5<sup>th</sup> of February the modem is due to be installed, and Entec is due to perform scan and zero calibration with standard SO<sub>2</sub> gas from cylinder.

APICOM programme available from [www.advpol.com](http://www.advpol.com), download set-up and data.