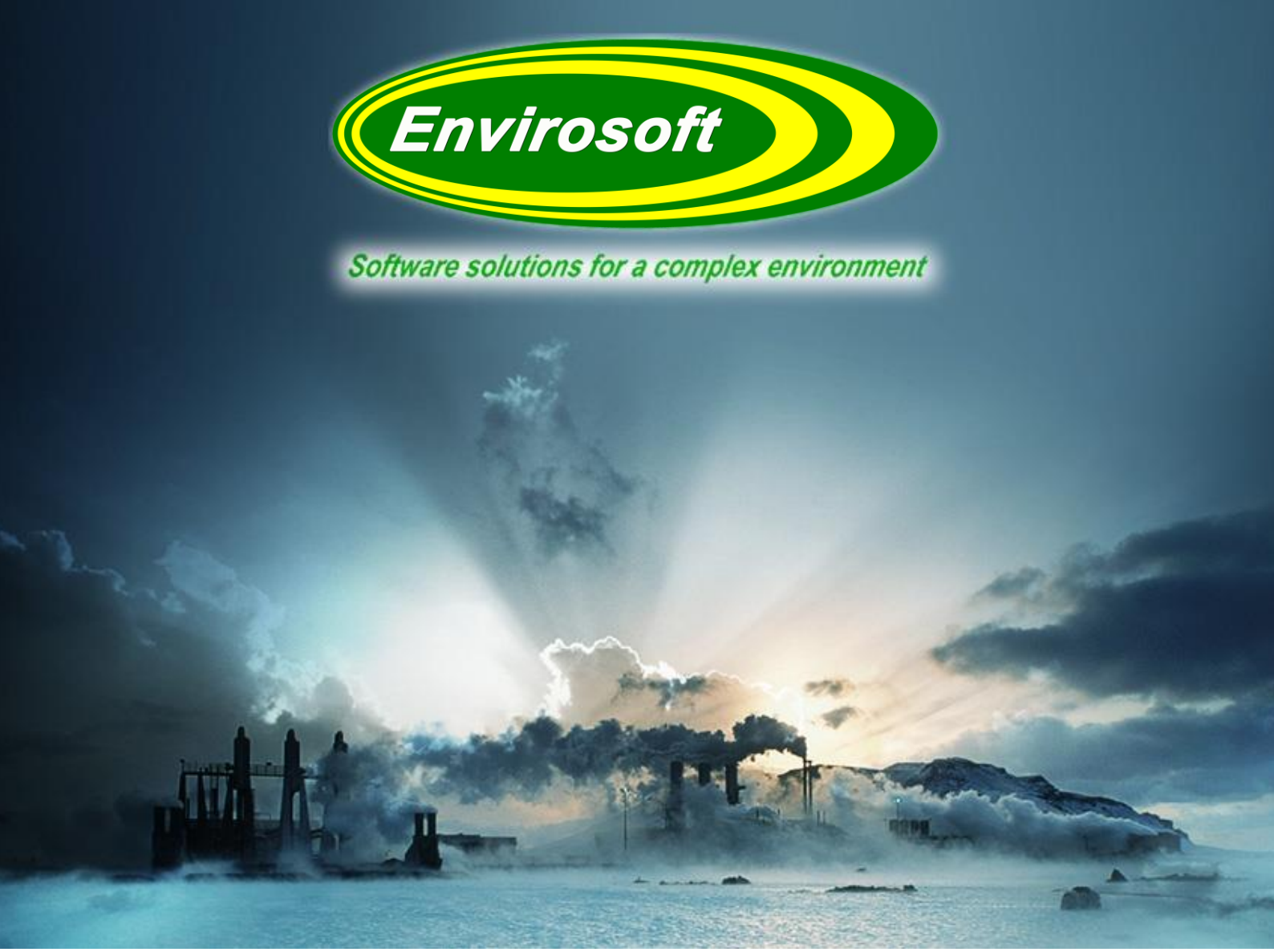

CEMPact User Manual
Ver. 1.05

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1 CONTENTS

2 INTRODUCTION

2.1 THE CEMPACT PROGRAM

The CEMPact program has been designed to operate in parallel with a Continuous Emission Monitoring System (CEMS), to provide an estimate of the ground level gas concentrations resulting from the release of exhaust gases from one or more point sources (chimneys) at a site.

It is a PC based program, designed to operate under practically all Windows operating systems. Selections and information are available from several pages each accessed as a 'tabbed notebook' Windows style. Operation is performed by using simple mouse instructions.

2.2 BASIC PRINCIPLES OF OPERATION

2.2.1 GENERAL

Dispersion of the gases from a stack has been investigated for many years. CEMPact calculates the mass emission (kg/hr) from the raw emissions data and then uses the wind speed and direction, ambient temperature, stability class (see below), stack gas temperature etc, to calculate the predicted level over a selected area.

2.2.2 DATA ACCESS

Emission and meteorological data may be accessed over the site network or from a Continuous Emission Monitoring System directly.

2.2.3 DISPERSION

CEMPact assumes a spreading plume from a point source and uses US EPA coefficients for both horizontal and vertical dispersion. It assumes a Gaussian distribution about the centreline of the plume.

2.2.4 AIR STABILITY

Air stability is divided into 6 categories, based on the 'Pasquill atmospheric stability classes'. These are selected automatically by CEMPact, but may be overridden manually if required.

2.2.5 PLUME TRAJECTORY

CEMPact calculates the plume trajectory as closely as possible to Briggs equations for hot, bent-over, buoyant plumes.

2.2.6 AVERAGING

CEMPact can use from 1 to 1440 samples (1 minute to 1 day) to estimate the dispersion. Envirosoft recommend that an averaging time of ½ hour or more is used for a meaningful dispersion prediction.

2.3 KEY FEATURES

1. Operates in parallel with existing emission monitoring systems.
2. Predicts plume in real-time and historically (selected using simple mouse operations).
3. Automatically updates the prediction from the latest data available.
4. Manages calls of 'incidences' and plots these straight onto the dispersion prediction.
5. Selectable colours plotted on to maps.
6. Two maps available as standard (close and long range).
7. Summarises and graphs meteorological data and plume trajectory.

2.4 THE CEMPACT MANUAL

This manual describes the operation of the CEMPact program.

For information concerning any of the other CEMSuite programs, please refer to the relevant documentation.

3 SOFTWARE OPERATION

3.1 COMPUTER REQUIREMENTS

PC Requirements (minimum):

Processor: Intel i5
Memory: 4GB Ram
Graphics: Intel HD 3000
Display: 1920x1080 pixel resolution. 21" monitor or greater.
Hard disk: 250 GB
Modem/3G Dongle: Required for support
Operating system: Windows 7/8/10

The software will operate on PCs with lesser specifications. However, some operations involve lengthy calculations and the time taken to perform them may become tiresome.

3.2 INSTALLATION

CEMPack will be automatically installed on the PC prior to operation.

Should the software need to be re-installed it can be done via a USB stick containing the CEMPack program.

3.3 ASSOCIATED PROGRAMS

CEMPact is a stand-alone program and requires no other associated programs to run.

4 PROGRAM OPERATION

4.1 STARTING THE PROGRAM

Start the program by 'double-clicking' on the CEMPact icon; this should reside on the PC desktop.

If a shortcut to CEMPact cannot be found on the desktop, the main executable can be found in C:\Program Files\Envirosoft\CEMSuite.

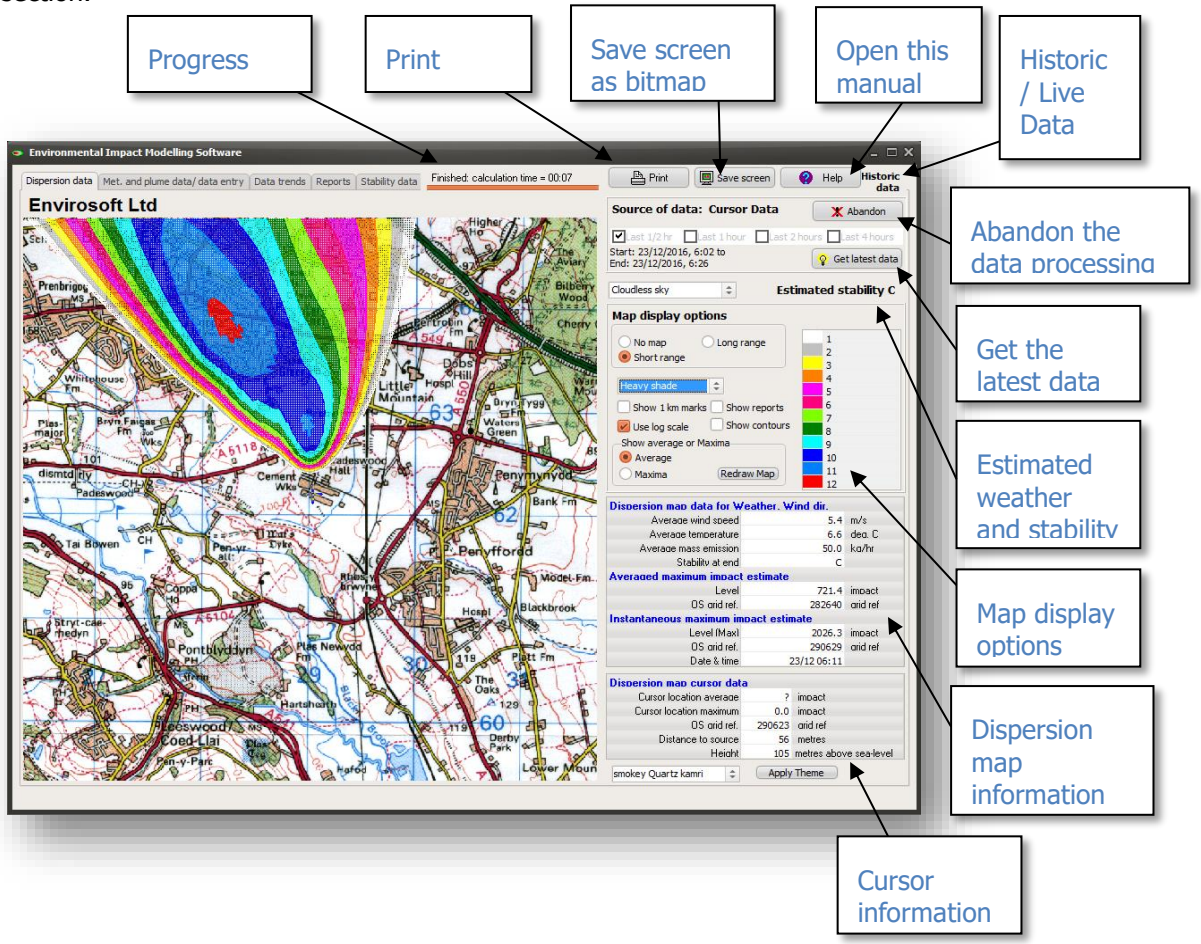
4.2 INITIAL SCREEN

Once started, the program will default to a close range estimate of the plume gases from the last 30 minutes of data; this calculation will commence approximately 30 seconds after the CEMPact program is started. While the data is being analysed, a bar at the top of the screen will indicate the progress, on completion.

Should the source of the data be set to 'Latest', the program will update the estimate every 10 minutes. However, if the dispersion has been analysed between times selected from the trends page, this automatic update is turned off.

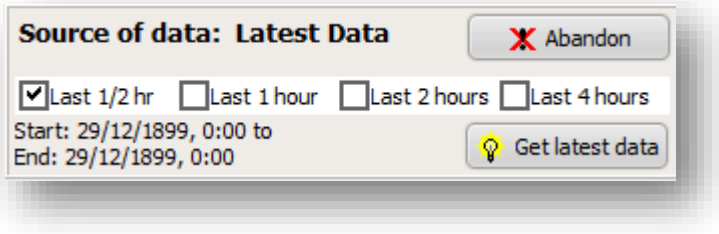
A cursor is available to examine the ground level concentrations at any point on the map.

Other information is available by selecting a different page at the top of the screen: Met. And Plume Data/Data Entry, Data Trends, Reports and Stability data; these displays are described within this section.



4.2.1 SOURCE OF DATA FOR DISPERSION ESTIMATE

This area of the screen indicates the times that the data has been analysed from and to, and whether the data is the latest available, or has been selected using the cursors on the trend page.



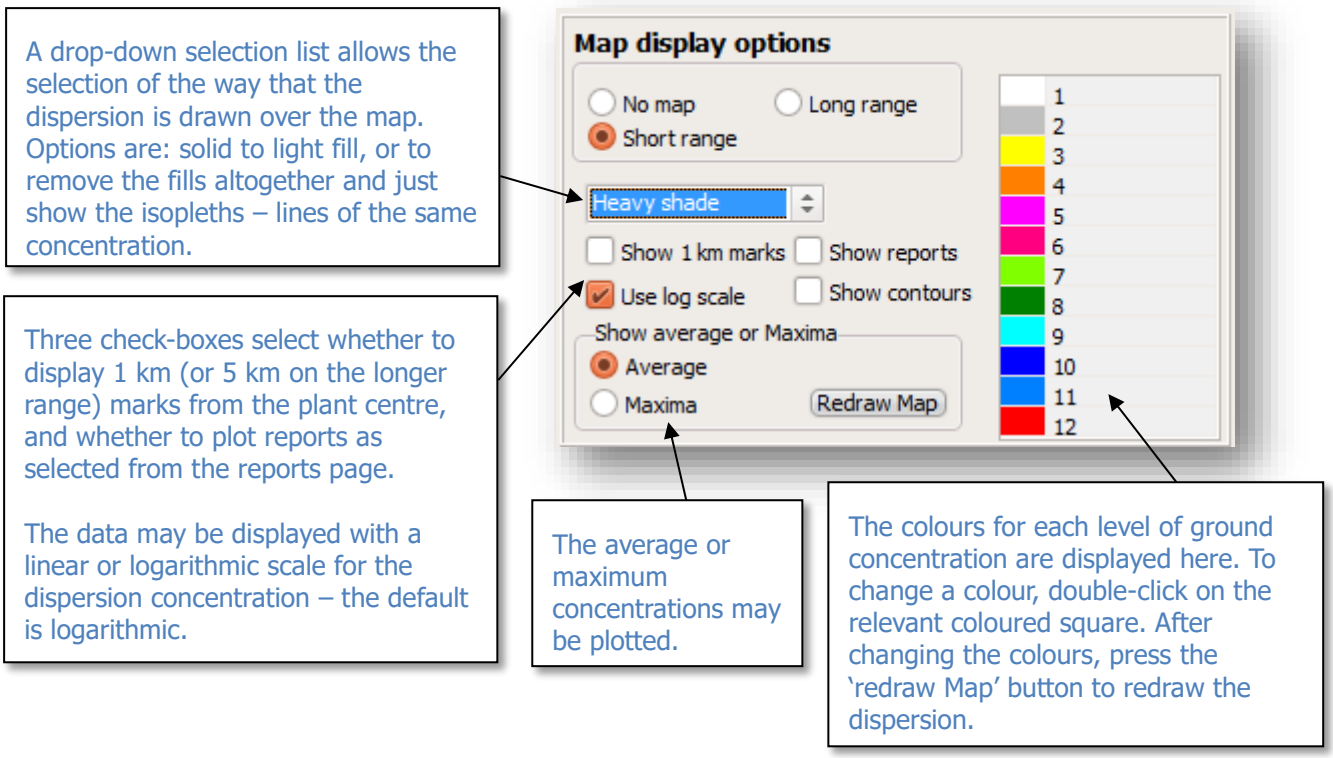
Four checkboxes select the time over which the latest data is analysed; should the data have been selected from the trends page, these are redundant.

Large time periods may take many minutes to process; the 'Abandon' button will stop any lengthy calculations if required.

The button 'Get Latest Data' may be used to analyse the latest data immediately, pressing this button also returns the program to automatic updates of the dispersion every 10 minutes.

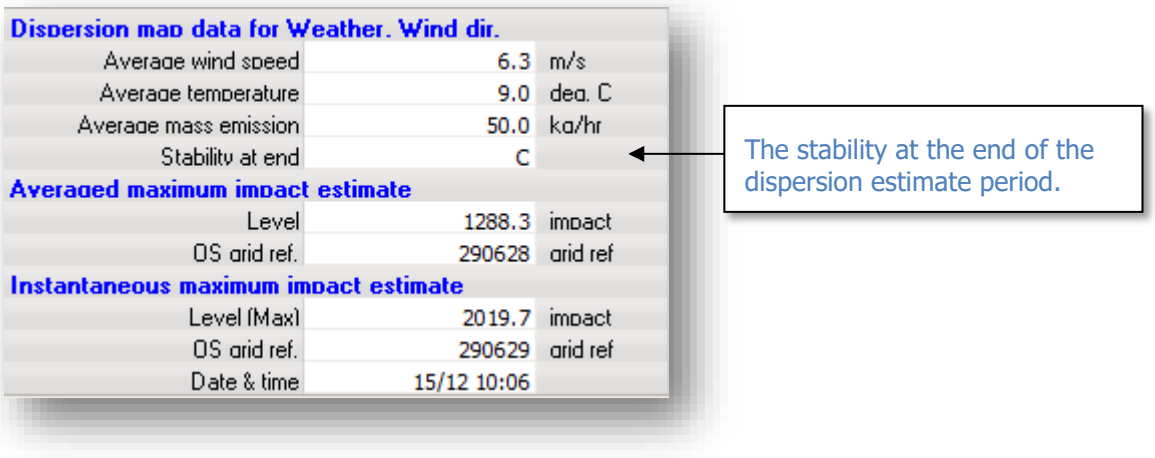
4.2.2 MAP DISPLAY OPTIONS

Three 'radio buttons' allow the user to select which map is to be used (long or short range), or to remove the map altogether. Should the map range be changed, the data will be re-analysed – a warning screen will be displayed and the operator must confirm if this is required.



4.2.3 DISPERSION INFORMATION

The dispersion information shows the average wind speed, ambient temperature and emission release at source over the dispersion estimate period.

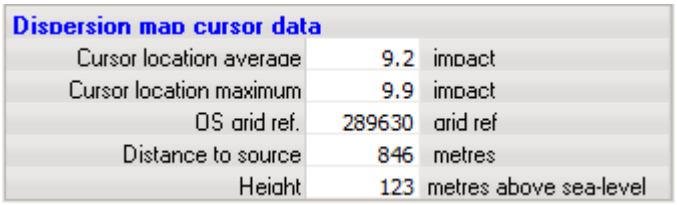


The maximum ground level impact is shown, either as an average over the estimate period, or as an instantaneous maximum. Grid references refer to a standard map reference. The time at which the instantaneous maximum may have occurred is estimated taking the time taken for the gases to reach the location according to the wind strength.

Double-click on the heading line to drive the cursor location of either the averaged or instantaneous maximum location.

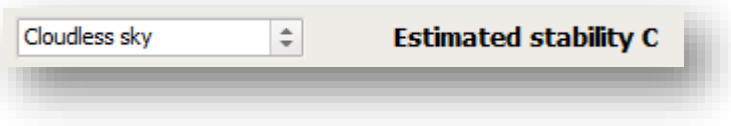
4.2.4 CURSOR INFORMATION

Relative impact at the cursor location in terms of both an average and a maximum over the analysis period.



The grid reference and distance to the source of the cursor location is also shown.

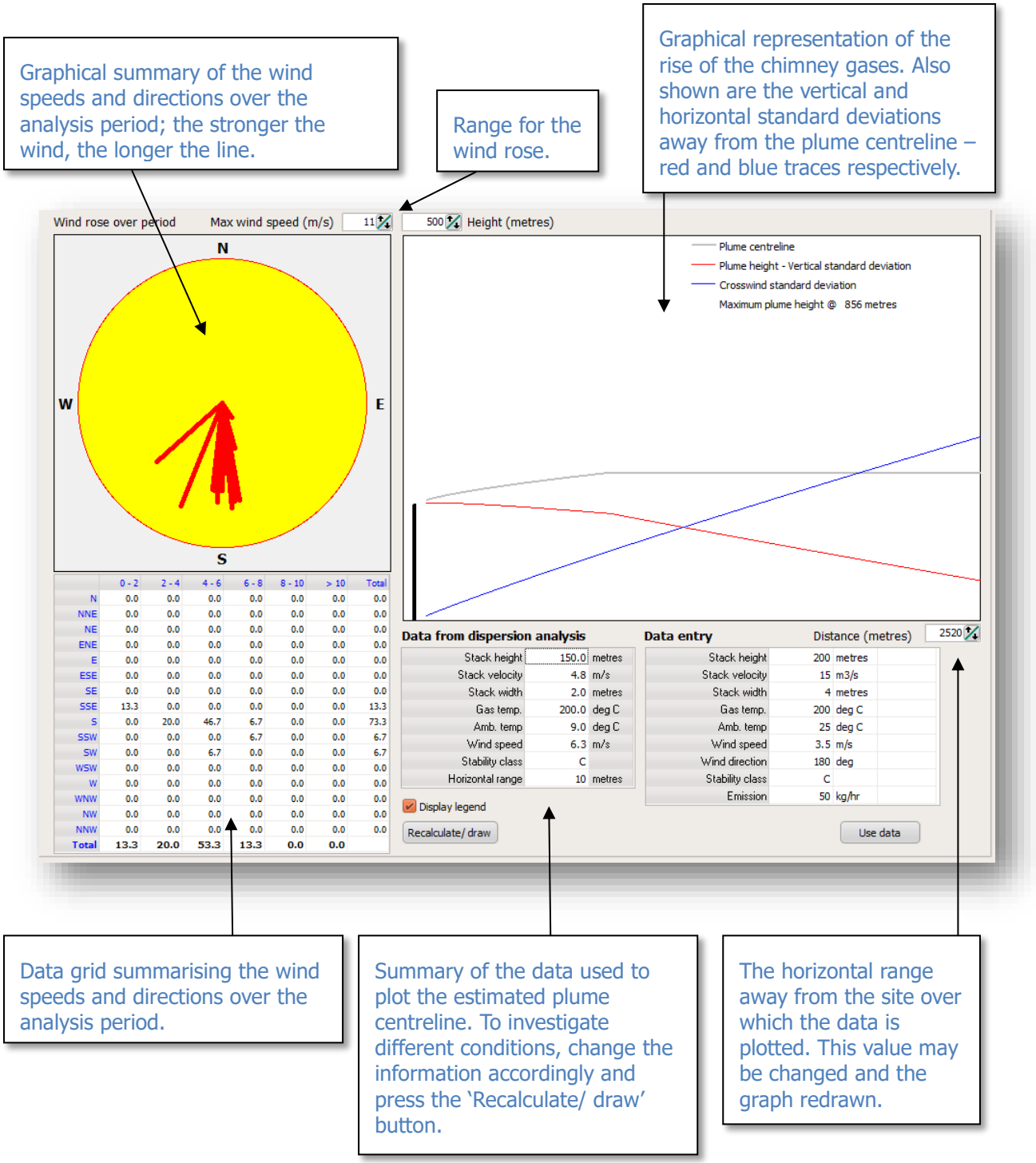
4.2.5 CURRENT WEATHER AND STABILITY



In order for the air stability to be estimated, the current weather conditions should be selected as closely as possible from a drop down list. CEMPact will use this information alongside the current wind speed, to update the air stability class at the end of every hour. This data may be viewed from the 'Stability Data' screen and changed should the weather updates not have been conducted.

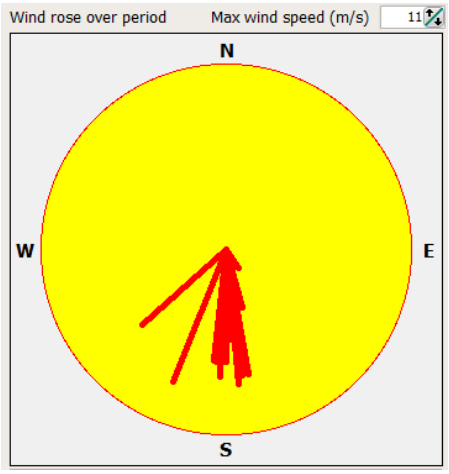
4.3 METEOROLOGICAL AND PLUME DATA SCREEN

After any dispersion estimate has been calculated (either latest data or from historical data driven from the trends page), this page summarises the meteorological data into a wind rose and a data grid. It also illustrates, under the average conditions during the estimate, how the gases leave the chimney.



	0 - 2	2 - 4	4 - 6	6 - 8	8 - 10	> 10	Total
N	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NNE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SSE	13.3	0.0	0.0	0.0	0.0	0.0	13.3
S	0.0	20.0	46.7	6.7	0.0	0.0	73.3
SSW	0.0	0.0	0.0	6.7	0.0	0.0	6.7
SW	0.0	0.0	6.7	0.0	0.0	0.0	6.7
WSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WNW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NNW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**13.3**	**20.0**	**53.3**	**13.3**	**0.0**	**0.0**	

4.3.1 WIND ROSE AND SUMMARY



For each minute of the analysis period, the wind direction is plotted, the length of the line representing the wind strength.

Changing the value in the box indicated changes the range; after making a change here, press the 'Recalculate/ draw button'.

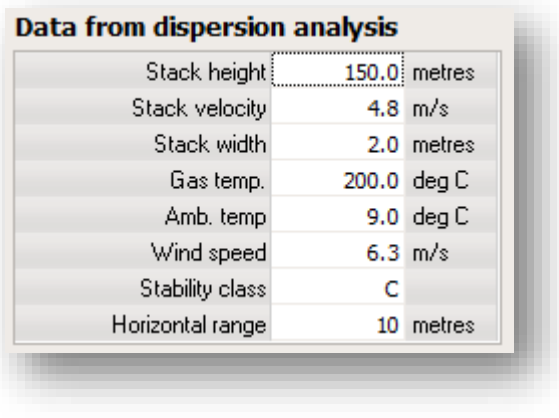
This information is also summarised in a data grid – see below.

	0 - 2	2 - 4	4 - 6	6 - 8	8 - 10	> 10	Total
N	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NNE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ENE	0.1	0.3	0.0	0.0	0.0	0.0	0.4
E	1.6	0.0	0.0	0.0	0.0	0.0	1.6
ESE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SE	0.4	0.6	0.0	0.0	0.0	0.0	1.0
SSE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SSW	1.1	15.2	9.1	1.0	0.4	0.0	26.9
SW	0.3	3.8	5.0	4.4	0.0	0.6	14.1
WSW	0.0	0.0	1.3	0.0	0.0	0.0	1.3
W	0.0	1.8	11.4	21.5	11.0	9.1	54.8
WNW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NNW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**3.6**	**21.8**	**26.7**	**26.9**	**11.4**	**9.7**	

Percentage times over which the wind speed and strength falls into each category. In this example, for 54.8% of the analysis time, the wind has been from the west, and for 26.9% of the time at a strength of between 6 and 8 m/s.

Double click on this grid to save the data as a CSV file; the user may define the location of the file.

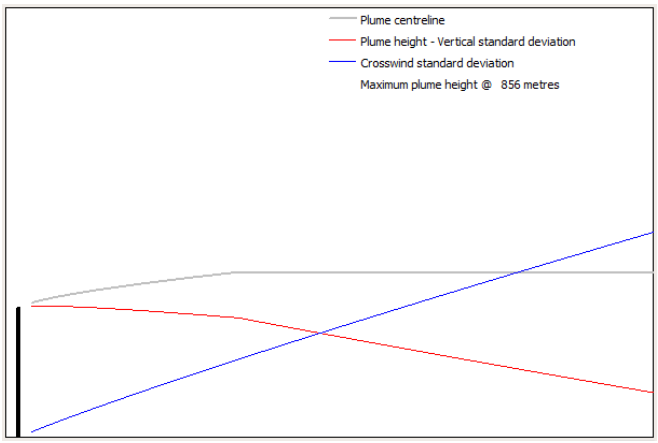
4.3.2 AVERAGED STACK, WEATHER AND FLUE GAS PARAMETERS



The height of the stack is held in the configuration and will not be changed for calculation of the plume dispersion. It may be changed here to investigate how the height affects the impact of the flue gases.

All other data here are averages of the data over the analysis period and again, may be modified on a temporary basis to examine their effects. Any changes will not be reflected on the plume graph until the 'Recalculate/ draw button is pressed.

The stability class here is that at the end of the analysis period.



The grey line here represents the estimated centreline of the plume, according to the averaged conditions and the stability class as indicated in the grid above.

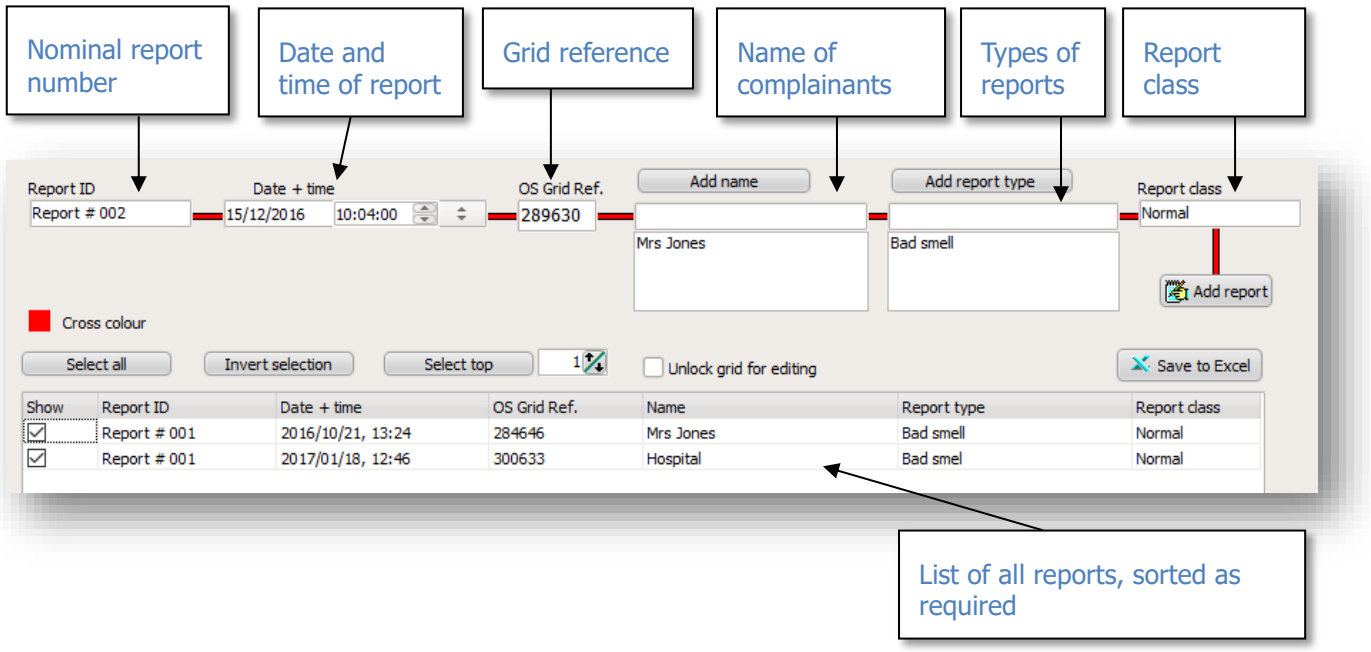
Standard deviations for the calculation of the dispersion are shown as red and blue traces for the vertical and horizontal spread of the plume. Note that the vertical deviation line (red) has been taken away from the plume centreline to reflect the estimated spread of the gases.

The graph may be redrawn using different horizontal and vertical ranges by changing the appropriate values and redrawing.

4.4 TRENDS SCREEN

4.5 REPORTS SCREEN

The reports screen allows all reports or complaints to be logged.



For each report, the following information is required:

1. Report ID – generated automatically
2. Date and time – defaults to the time cursor was placed on the dispersion map, but may be edited as required.
3. Grid reference of complaint location.
4. Name of complainant – either selected if used before or entered as required.
5. Type of report – selected from a drop down list or entered as required.
6. Class of report – used for selection purposes and to indicate the potential severity of the complaint.

4.5.1 ADDING A NEW REPORT

To add a new report, conduct the following:

1. Go to the Dispersion page and locate the report on the map.
2. Press the left mouse button while the cursor is over the location.
3. Go to the reports page, the first three information requirements will have been filled in on the action of point 2. If incorrect, repeat 1 and 2.
4. Edit the date and time as required, and enter the other details either from the available options or by typing in the available boxes.
5. Press the 'Add report' button and confirm if correct.

4.5.2 DELETING OR EDITING A REPORT

Before a report may be deleted or edited, the 'unlock grid for editing' check box must be ticked. After this has been conducted, each report may be edited or deleted as required; confirmation is necessary before a report is deleted.

4.5.3 SELECTING REPORT(S) FOR DISPLAY

Using the three selection buttons, the reports may be selected for display as required, each will be displayed on the dispersion estimate if the 'Show' check box is ticked. Should a group of reports be required, they may first be sorted by the information in any of the columns, by clicking on the heading of that column; this is indicated by a small yellow triangle within the heading. Note that multiple sort selections are available by holding the 'Shift' key down while clicking on the next column of data to sort to.

Once the desired reports have been selected for display, return to the dispersion page and either tick the 'Show reports' box if not already checked, or press the 'redraw' button.

4.5.4 CHANGING THE COLOUR OF THE REPORT CROSS LOCATION

To change the colour of the reports as displayed on the dispersion page, simply double-click on the 'Cross colour' square and select the desired colour. Note that the selection here is stored should the program be shut down.

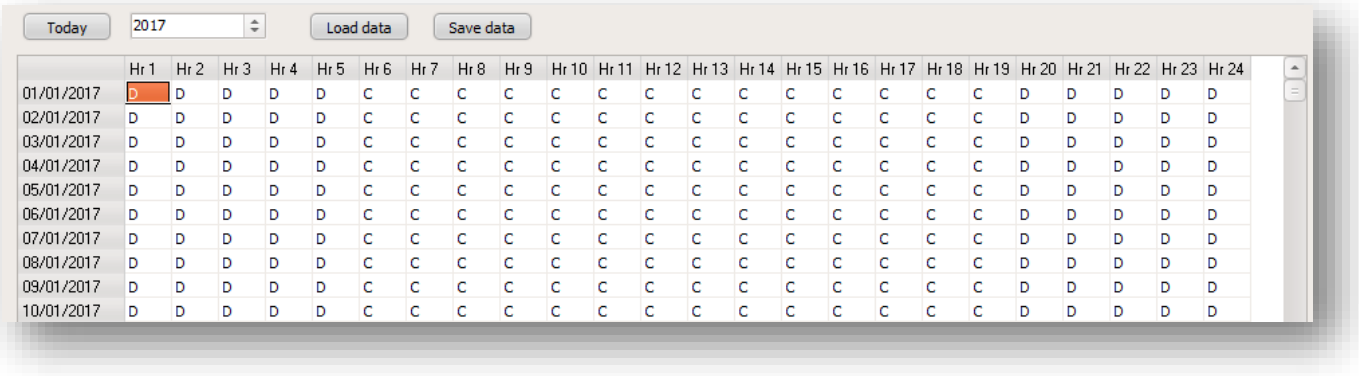
4.5.5 GRID REFERENCES

Grid references are used to identify locations on a map. They are described on most maps but are explained below as a reference.

A small area of a map is examined below. To provide the grid reference for a location, first find the number on the nearest vertical grid line to the left of that location, and then estimate in tenths the distance between that and the next gridline; this will provide a 3 digit number. Repeat this for the vertical direction from the horizontal lines to provide a full 6 digit number.

4.6 STABILITY DATA SCREEN

During normal operation, the program will estimate the stability class at the end of every hour and place this data in a spreadsheet style grid, as below. The stability is estimated from the current weather conditions. The data is initially generated by the turn of each year and defaults to stability class C – a typical stability. Should the program not have been in operation, or the estimate of stability is deemed incorrect, the data may be changed directly within the grid. After making any changes, save the data using the indicated button.



	Hr 1	Hr 2	Hr 3	Hr 4	Hr 5	Hr 6	Hr 7	Hr 8	Hr 9	Hr 10	Hr 11	Hr 12	Hr 13	Hr 14	Hr 15	Hr 16	Hr 17	Hr 18	Hr 19	Hr 20	Hr 21	Hr 22	Hr 23	Hr 24
01/01/2017	D	D	D	D	D	C	C	C	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D
02/01/2017	D	D	D	D	D	C	C	C	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D
03/01/2017	D	D	D	D	D	C	C	C	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D
04/01/2017	D	D	D	D	D	C	C	C	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D
05/01/2017	D	D	D	D	D	C	C	C	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D
06/01/2017	D	D	D	D	D	C	C	C	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D
07/01/2017	D	D	D	D	D	C	C	C	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D
08/01/2017	D	D	D	D	D	C	C	C	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D
09/01/2017	D	D	D	D	D	C	C	C	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D
10/01/2017	D	D	D	D	D	C	C	C	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D

5 HOW TO USE THE PROGRAM

This section is intended to help the operator get the best results and interpretation of the information provided by the CEMPact program. The calculations for the dispersion are lengthy and complex but the program will always produce the best estimate from the information available.

5.1 HOW TO PLOT THE DISPERSION FROM THE LATEST DATA

After starting the program, this calculation will be conducted automatically. Should the data have been examined from the trends page, this automatic update will be held, to restart it, simply press the 'Get latest data' button.

5.2 HOW TO PLOT THE DISPERSION BETWEEN SELECTED TIMES

Select the 'Trends' page and plot the data over the day required. Use the left and right mouse buttons to select the start and end times required, then press the 'Calculate Dispersion' button. CEMPact will automatically select the dispersion page and begin the calculation; on completion, the estimate will be drawn onto the map.

Should this data be used as an indication of a valid complaint at an appreciable distance from the site, remember that the gases will take some time to reach the location from the chimney. In such cases, the cursors should be placed at times before the complaint time. It will take a little trial and error to determine the best selections, but bear in mind that the lighter the wind, the longer the time for the gases to travel. To 'zoom' in on the best times it is suggested that short (~5 minutes) averaging periods are used and the time taken to reach the maximum location examined from the dispersion information grid.

5.3 WHAT IS THE BEST AVERAGING TIME?

Other than for interest, no weight should be placed on predictions over periods of less than 30 minutes; at these short time periods, errors over a few minutes will affect the dispersion greatly.

Under stable weather conditions (looking predominantly at wind speed and direction) the dispersion estimate will not change greatly over the analysis period, and fairly short periods will produce meaningful information. However, under unstable conditions (gusting wind speeds and directions), this will not be the case and longer averaging times (60 minutes plus) should be used. Also note whether to observe the maximum or averaged data.

5.4 AVERAGED OR MAXIMUM DISPERSION DATA?

Should a fairly long analysis period be used (>4 hours), over which time the weather conditions are likely to have changed, the averaged and maximum dispersion pictures may be extremely different; some wind directions may only have been present for a few minutes and effectively be 'diluted out' of an averaged data dispersion. Selecting maximum under such circumstances will reveal the effects from all wind speeds and directions throughout the analysis period.

Short periods (or longer periods of stable wind conditions) will reveal similar pictures for the averaged and maximum data.

5.5 WHAT ARE THE 'IMPACT' NUMBERS?

CEMPact may have been set to operate in one of two modes: quantative or relative ground level concentrations. Should quantative have been selected, then units of ug/m3 will be seen for all dispersion information, and the range of the each dispersion colour may be selected. A selection of relative will produce only numbers scaled 1 to 12; 12 being the highest ground levels and 1 the lowest. The maximum level (12) for the coloured dispersion plot with this selection is scaled automatically to 95% of the maximum concentration within the plot area.

5.6 WILL THE DISPERSION ESTIMATE ALWAYS BE RELIABLE?

Under particular weather conditions, it is almost impossible to predict the dispersion of a plume with any kind of confidence. These times are associated with the presence of stable air conditions (stability class E & F). Stable air is always accompanied by low or near zero wind speeds, and errors from many sources will affect the calculations; not least is the wind direction – at very low wind speeds, the weather vane may not respond correctly. In addition, these stable conditions may result in an 'inversion layer' – a height at which the plume may become trapped. These conditions may be accounted for in later versions of the program, for particular site locations.

CEMPact should produce reasonable dispersion estimates at reasonable wind speeds (>2 m/s). Paradoxically, under these conditions, the stability of the air is unstable, and the spread of the plume can be estimated.

5.7 THERE IS NO DISPERSION PICTURE ON THE MAP

There are two possibilities here: either the wind speed is very low (<0.5m/s) in which case the plume is practically vertical and an estimate is not practical; or the mass release figure is very low. It will not be possible for the program to predict ground level concentrations at low wind conditions, however, for low mass emissions the user may select another measurement channel from the trends page and recalculate again.

6 CALCULATION PRINCIPLES

Calculations for the dispersion of a chimney plume are complex, but may be broken down into a few main influences. This document discusses each of these factors in general terms within this section, and examines the mathematical detail in the following section.

6.1 METEOROLOGICAL

Obviously the wind speed and direction are fundamental requirements for any plume dispersion calculations; a wind from the east will drive the plume towards the west. The wind speed also plays a large part; the stronger the wind the less the plume rises and the faster it is driven away from the plant, the weaker the wind the higher the plume rises and the less it is driven away from the plant. The wind speed used for the dispersion is adjusted to account for the difference in height between the meteorological station and the stack exit – this always increases the effective wind speed. All quoted wind speeds are those from the met station.

Ambient temperature also has an effect on the way the plume behaves by way of the 'buoyancy' of the plume gases. The cooler the surrounding air, the greater the difference between this and the flue gas temperatures, and the more buoyant the flue gases, driving the plume higher; the opposite being seen on warm days.

A less obvious factor is also taken into account – the air stability. This, as the name suggests, is a measure of how the air is behaving, and is broken down into a number of 'Stability Classes', from extremely stable to extremely unstable. Wind speed and sunlight and are the largest influences here, and, generally speaking, the less wind and clearer the sky the more stable the air. Under stable air conditions, it becomes harder to predict the plume trajectory, culminating in the chance of an inversion layer – a height at which the plume becomes trapped. These conditions may be seen on frosty, still mornings; when the air closer to the ground is much colder than the air a little bit higher up (the reverse of normal conditions).

Unfortunately, inversion layer heights are very difficult to calculate from the data available to CEMPact, and, for them to be used correctly, some extra corrections may be required on a site-by-site basis. Should data be available on this subject, this may be added to the CEMPact algorithms.

During the day, sunlight also affects the stability – it tends to make the air unstable.

6.2 GEOGRAPHICAL

At any point on a map within the analysis range, for a given wind direction and speed, three measurements are required relative to the calculated plume trajectory: downwind distance, crosswind distance and vertical drop. These three factors form the basis of the dispersion estimate, and generally speaking, the larger these distances, the more the plume has dispersed and the lower the ground level concentrations.

For practically every site there will be unique local influences that may need to be accounted for – for example: the plant is in a valley and under certain conditions the plume is driven to ground much more than would normally be expected. In order for these to be taken into account, some third party modelling measurements must have been conducted; an area of the dispersion modelling within the CEMPact software has been reserved to allow these unique influences to be accounted for.

6.3 EMISSION LEVELS

Most environmental monitoring systems only calculate the density of the pollutant gases – ppm, mg/m3 etc. To measure the dispersion, these parameters must be converted to mass flow (kg/hr) – the ground level concentrations are directly proportional to this measurement. CEMPact can use a gas flow if this is available (m/s or m3/s), or it can assume a constant flow for these calculations.

6.4 A WORD ABOUT ACCURACY & PRECISION

Modern PCs are powerful and capable machines, able to provide results to many decimal places, and are ideal for complex calculations such as plume dispersion predictions. CEMPact can only use the data available to it to estimate the dispersion, any errors in this data will affect the prediction considerably. Occasionally, CEMPact allows levels of less than 1 ug/m3 to be used for display selections. This does not imply that the prediction is accurate to these concentration levels; these fine adjustments are to allow the most informative dispersion picture to be drawn.

CEMPact will produce the best estimate of the plume dispersion at ground levels. It would be nonsense to quote these values to several decimal places with any kind of certainty; no matter how precise the computer is – there are always some factors that affect the measurement which are unknown to the program.

7 CEMPACT DISPERSION CALCULATIONS

The CEMPact software uses a map image on to which the dispersion prediction is overlaid. This map is centred on the site and is broken down into 640 x 640 areas, each represented by one image pixel – the smallest image area available to the computer. For any analysis period, the emission and meteorological data are examined at each pixel for each minute. This results in some long and complex math routines, for example, a 60-minute analysis results in 60 x 640 x 640 (~24.5 million) calculations. Each of these calculations involves many higher math routines (logs, sin, cos, tan etc) that effectively use more computer instructions than lower math routines (x, +, /, – etc). It is, therefore, essential that a good, late specification PC is selected to run the CEMPact software, and a suggested minimum specification is provided at the beginning of this document.

7.1 OVERALL CALCULATION

For each individual pixel area, for each minute in the analysis period, the following equation is used to calculate the ground level gas concentration.

ug/m3 = Q / (ws x hsd x vsd x pi) x exp (– cw2/2hsd2) x exp(– vd2/2vsd2)

Where:

Q	=	Emission rate in units of ug/s.
ws	=	Wind speed at the stack exit height (m/s).
hsd	=	Horizontal standard deviation.
vsd	=	Vertical standard deviation.
Cw	=	Crosswind distance (metres).
vd	=	Vertical distance (metres).

7.2 WIND SPEED

An adjustment is made to compensate for a greater wind speed at the stack exit height compared to the meteorological station. The following adjustment is applied:

Effective wind speed = wind speed x (Stack height / Met. Station height) z

Where z is a value based on the stability class; typically 0.1 to 0.2.

7.3 EMISSION RATE

To calculate the emission rate in terms of ug/s, the CEMPact program uses typically a gas measurement in units of parts per million (ppm), the stack temperature, and a measurement of the stack flow if available. Should a dynamic flow measurement not be available, a fixed flow is assumed. Emission rates (Q) are calculated using the following formula:

Q(ug/s) = 103 x ppm x mw x (273/273 + st) x f x cs

Where:

ppm	=	measured concentration of the gas (mg/m3 may be used if available).
mw	=	the molecular weight coefficient, ie., SO2 – 2.86, NOx – 2.05, CO – 1.25.
st	=	stack temperature C.
f	=	measured flow (m/s).
cs	=	cross section area of flow measurement position (m2).

7.4 DUST

Very fine dust particles will act largely as a gas; they will follow the gas flow in a homogenous mix. Larger particles, however, will fall out of the plume and will descend at their terminal velocity soon after stack exit. How quickly they start to fall and at what speed, depend upon the size of particle. At present, the CEMPact program only considers gases, so should dust deposition be in question, then the dispersion estimates produced by CEMPact must be moved towards the site.

7.5 GAUSSIAN DISPERSION COEFFICIENTS

CEMPact assumes a spreading plume from a point source and uses different coefficients for the crosswind and vertical dispersions. It assumes a Gaussian distribution about the centreline of the plume and the standard deviations derived from what are believed to be the most reliable set of coefficients. These are dependent on two factors: the downwind distance from the stack and the stability of the air at the time, and the resulting calculations are of the form:

Standard deviation for dispersion (metres) = exp [A + B (ln x) + C (ln x)2]

Where: A, B & C = Coefficients depending upon stability.
x = Downwind distance from the stack (km).

Depending upon the stability class at the time of analysis, different factors (A, B & C above) are used for the crosswind and the vertical dispersions. These are held in a simple text file for all stability classes and are read during the program start-up sequence. Should ground level measurements indicate it, they can be adjusted if required. As these have a large influence on the prediction, it is recommended that Envirosoft Ltd be involved during any adjustments here.

7.6 AVERAGING

Data is analysed on a minute-by-minute basis; the meteorological and emission data is not averaged prior to this analysis. Averaging is only conducted after the prediction has been calculated for each minute, for each pixel area. So, for each pixel, for each minute, the ground level concentrations are summed together, and after the last data point, divided by the number of valid samples found in the period – this is the information that is normally used to present the emission data.

7.7 PLUME TRAJECTORY

The direction of the plume is calculated as 180° away from the current wind direction – a wind from the east sends the plume to the west.

For the rise of the plume, Briggs 'equations for the rise of bent-over, buoyant plumes' are used. These generally use the following influences:

Stack height – the higher the stack, the higher the final plume rise.
Stack exit velocity – the faster the exit velocity, the higher the rise.
Stack width – the more gas, the more buoyancy, the higher the rise.
Stack gas temperature – more buoyancy as above.
Ambient temperature – lower temperatures result in more effective buoyancy.
Wind speed – the greater the wind, the less the influence of all the above factors.
Stability class – various influences for each stability class.

For any distance downwind of the stack, the resulting equation takes the form:

$$\Delta h = A \times F(B) \times D(C) \times w(-1)$$

Where:

	Δh	=	plume rise (metres),
	A, B & C	=	constants,
	F	=	calculated plume buoyancy (m4/s),
	D	=	downwind distance from the stack (metres),
	W	=	wind speed (m/s).

After a prediction has been calculated and displayed, the plume trajectory is available for viewing for the average wind speed and ambient temperature over the analysis period. This data may be changed to observe their effect on the plume trajectory calculations; these changes do not influence the dispersion calculation.

7.8 AIR STABILITY

Air stability can be divided into 6 classes which are referred to as A, B, C, D, E & F – A being the most unstable, and F being the most stable. Conditions E and F usually result in inversion layers – E being moderately defined and F being a pronounced inversion layer.

In normal operation, the CEMPact program analyses and redraws the latest plume prediction automatically every 10 minutes. Every hour, an assessment of the current air stability class is made from the ambient temperature, wind speed and an operator definable 'current conditions' entry (Clear, cloudy etc). This assessment is stored for each hour for each day on a spreadsheet style grid, and may be edited if required (for example, the weather conditions have not been updated reliably). Should no data be available, stability class C is assumed.

Surface Windspeed		**Daytime Incoming Solar Radiation**			**Night Time Cloud Cover**	
m/s	*mi/h*	*Strong*	*Moderate*	*Slight*	*>50%*	*<50%*
<2	<5	A	A-B	B	E	F
2-3	5-7	A-B	B	C	E	F
3-5	7-11	B	B-C	C	D	E
5-6	11-13	C	C-D	D	D	D
>6	>13	C	D	D	D	D

Note: Class D applies to heavily overcast skies, at any windspeed day or night.

8 DOCUMENT INFORMATION

8.1 MANUAL REVISION HISTORY

Revision Number	Date	Summary of Changes	Author
v1.00	28/05/01	1st Issue	R. Grant
v1.04	19/11/07	Updated to match Program Ver.	R.Grant
v1.05	30/01/17	Content and Format Update	P. Swindell

8.2 APPROVALS

This document requires the following approvals:

Name	Title
R. Grant	Managing Director
R. Swift	Technical Manager