NSIP-KBG-015214#P1-18

CONTENTS

CHAPTER 7 METEOROLOGY

TABLES

FIGURES

DRAWINGS

CHAPTER 7 METEOROLOGY

7.1. General

The Weather Bureau of the Department of Environment Affairs has classified the area surrounding Koeberg into the "Western Cape, Mediterranean Climate" sector. Within this sector Eskom has erected five automatic weather stations to assist with the meteorological plume dispersion model. These station locations are indicated on ***Drawing No. 27*** and are all located within 23 kms of Koeberg. At Koeberg there are two towers, 120 m and 50 m in height, with instruments on the 10 m, 50 m, 85 m and 120 m level. The 50 m tower is a backup of the main 120 m tower.

TABLE T-7-1
TABLE OF ESKOM'S METEOROLOGICAL SITES AROUND KOEBERG

Name	Latitude	Longitude	Distance from KOEBERG
KOEBERG	33°41'	18°27'	-
Bokpoint	33°34'	18°19'	16.5 kms
Atlantis	33°35'	18°30'	11.5 kms
Rondekuil	33°44'	18°37'	16.5 kms
Milnerton	33°53'	18°30'	22.5 kms
Robben Island	33°48'	18°22'	14.5 kms
D.F.Malan Airport	33°58'	18°36'	35 kms

The published data for the above stations cover varying periods, and only figures until 1984 are included for D.F.Malan Airport. This station is also the closest meteorological station to Koeberg which records data on a 24 hour basis and remains the only station for any possible correlation with readings taken at Koeberg. All data refered to in this report covers the period January 1980 to December 1995 unless otherwise stated.

The meteorological station at Koeberg is operated by Koeberg personnel who also maintain the network of automatic weather stations and the two instrumented towers.

A general description of the function of the meteorological monitoring system, the staffing, schedule of work, operating, Quality Assurance, calibration procedures, and data processing can be found in the Radiation Protection Standard, OPS7000, (***Reference 1***) and the Koeberg Procedure KAE003 (***Reference 2***).

The meteorological system began operations in mid-November 1979. It has continued to function despite a meteorological tower having been destroyed in a wind storm in May 1987. Monthly printed reports are forwarded to the Council for Nuclear Safety (CNS) as per OPS7000 (***Reference 1***) nuclear licence requirements. The format of the reports changed very little until the beginning of 1994, when a new condensed format was accepted by the CNS.

7.2. Wind Speed and Direction

Statistics of surface winds for Koeberg are given in ***Table 7-2***. These observations were made with R M Young U & V sensors at an effective height of 10 m. All speeds are given in metres/second. Note the high percentage of winds from the southerly sector in summer. In contrast the northerly winds dominate in winter.

TABLE T-7-2
SEASONAL WIND FREQUENCY TABLES FOR KOEBERG 1980 - 1995

JANUARY

SPEED	0 - 4.0	4.1 - 8.0	8.1-12.0	> 12.1	Total %
N	2.119	0.369	0.000	0.000	2,488
NNE	1.625	0.063	0.006	0.000	1.694
NE	1.438	0.019	0.000	0.000	1.456
ENE	0.956	0.044	0.000	0.000	1.000
E	1.100	0.219	0.000	0.000	1.319
ESE	2.069	1.400	0.031	0.000	3.500
SE	2.488	8.469	1.238	0.094	12.288
SSE	1.738	9.431	6.731	0.450	18.350
S	2.700	4.569	3.156	0.431	10.856
SSW	2.344	5.313	0.694	0.000	8.350
SW	2.119	6.706	0.119	0.000	8.944
WSW	3.519	3.413	0.050	0.000	6.981
W	4.975	2.863	0.006	0.000	7.844
WNW	3.294	3.031	0.031	0.000	6.356
NW	2.988	2.244	0.394	0.000	5.625
NNW	2.175	0.613	0.050	0.000	2.838
Totals	37.644	48.763	12.506	0.975	99.888

APRIL

SPEED	0 - 4.0	4.1 - 8.0	8.1-12.0	> 12.1	Total %
N	3.394	1.919	0.119	0.000	5.431
NNE	3.850	1.156	0.088	0.006	5.100
NE	4.500	0.225	0.000	0.000	4.725
ENE	6.219	0.700	0.006	0.000	6.925
E	4.681	0.944	0.088	0.019	5.731
ESE	4.319	2.525	0.188	0.025	7.056
SE	4.013	6.944	0.425	0.006	11.388
SSE	2.406	6.144	1.838	0.031	10.419
S	1.731	2.013	0.625	0.050	4.419
SSW	2.106	2.881	0.175	0.000	5.163
SW	2.400	1.906	0.081	0.000	4.388
WSW	3.625	1.000	0.069	0.006	4.700
W	4.225	1.094	0.125	0.019	5.463
WNW	3.931	2.525	0.131	0.000	6.588
NW	3.344	3.519	0.500	0.000	7.363
NNW	3.381	1.588	0.131	0.000	5.100
Totals	58.125	37.081	4.588	0.163	99.956

JULY

SPEED	0 - 4.0	4.1 - 8.0	8.1-12.0	> 12.1	Total %
N	3.556	6.475	1.544	0.006	11.581
NNE	5.825	3.419	0.475	0.006	9.725
NE	7.713	1.119	0.000	0.000	8.831
ENE	12.775	2.131	0.000	0.000	14.906
E	5.431	0.756	0.000	0.000	6.188
ESE	4.281	1.144	0.031	0.000	5.456
SE	3.163	2.500	0.006	0.000	5.669
SSE	1.531	2.350	0.100	0.000	3.981
S	0.906	0.625	0.044	0.000	1.575
SSW	1.644	1.044	0.088	0.000	2.775
SW	2.525	1.188	0.306	0.000	4.019
WSW	2.163	0.925	0.400	0.025	3.513
W	2.000	1.363	0.613	0.100	4.275
WNW	1.950	2.069	0.613	0.113	4.744
NW	1.756	3.206	1.006	0.050	6.019
NNW	2.281	3.025	1.206	0.119	6.631
Totals	59.700	33.338	6.431	0.419	99.888

OCTOBER

SPEED	0 - 4.0	4.1 - 8.0	8.1-12.0	> 12.1	Total %
N	2.000	1.331	0.175	0.000	3.506
NNE	2.194	0.581	0.006	0.000	2.781
NE	2.619	0.144	0.013	0.000	2.775
ENE	2.800	0.244	0.000	0.000	3.044
E	2.775	0.769	0.031	0.000	3.575
ESE	3.813	2.569	0.288	0.119	6.788
SE	3.431	7.644	0.738	0.056	11.869
SSE	2.594	10.025	4.119	0.238	16.975
S	1.781	3.950	1.956	0.125	7.813
SSW	1.581	4.638	0.513	0.000	6.731
SW	2.044	4.775	0.219	0.019	7.056
WSW	2.844	2.669	0.019	0.006	5.538
W	3.688	2.456	0.238	0.025	6.406
WNW	2.813	3.119	0.150	0.013	6.094
NW	2.013	2.719	0.625	0.050	5.406
NNW	2.219	1.181	0.131	0.000	3.531
Totals	41.206	48.813	9.219	0.650	99.888

Table T-7-3 gives the frequency of wind direction in categories of wind speed.

TABLE T-7-3
FREQUENCY OF WIND DIRECTION IN CATEGORIES OF WIND SPEED LONG TERM AVERAGES - JANUARY 1980 TO DECEMBER 1995

Direction	0 - 2.0	2.1 - 4.0	4.1 - 6.0	6.1 - 8.0	8.1 - 10.0	10.1- 12.0	12.1- 14.0	> 14.1	Totals	Ave Speed in m/s
N	0.775	2.057	1.452	1.104	0.326	0.068	0.005	0.000	5.788	3.591
NNE	0.986	2.307	0.847	0.376	0.091	0.016	0.001	0.001	4.624	2.751
NE	1.197	2.889	0.278	0.071	0.005	0.000	0.000	0.000	4.440	2.116
ENE	1.226	4.336	0.660	0.079	0.004	0.001	0.000	0.000	6.306	2.327
E	0.869	2.722	0.507	0.125	0.034	0.006	0.002	0.000	4.265	2.736
ESE	0.618	2.922	1.685	0.336	0.136	0.029	0.014	0.003	5.743	3.370
SE	0.475	2.946	4.346	2.187	0.444	0.095	0.015	0.001	10.509	4.307
SSE	0.374	1.759	2.987	4.036	2.316	0.800	0.148	0.027	12.447	5.812
S	0.345	1.383	1.348	1.295	0.947	0.343	0.116	0.016	5.793	5.032
SSW	0.336	1.548	1.889	1.425	0.277	0.029	0.004	0.000	5.508	4.468
SW	0.427	1.905	2.153	1.382	0.114	0.011	0.005	0.001	5.998	4.134
WSW	0.591	2.530	1.579	0.428	0.116	0.039	0.009	0.001	5.293	3.615
W	0.735	3.004	1.632	0.397	0.196	0.100	0.054	0.013	6.132	3.769
WNW	0.601	2.202	1.949	0.831	0.205	0.069	0.032	0.012	5.899	4.147
NW	0.545	1.914	1.732	1.346	0.596	0.121	0.023	0.002	6.278	4.696
NNW	0.612	1.958	1.094	0.781	0.311	0.093	0.028	0.005	4.882	3.742
TOTAL	10.713	38.381	26.138	16.200	6.117	1.820	0.455	0.078		3.788
								99.903	99.903	

Table T-7-4 gives the extreme wind speed and gusts.

TABLE T-7-4
HIGHEST WIND GUSTS MEASURED AT KOEBERG 1980-1995. All wind speeds are in metres/second

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NNW 30.2	NNW 28.8	NNW 32.0	S 37.1	WSW 38.3	E 35.9	WSW 29.3	W 31.5	W 30.6	NNW 27.2	SSE 27.8	NNW 30.9

7.3. Atmospheric Dispersion

Koeberg, which is situated along the western coast of the South Western Cape, is located between the mid-latitudes and the sub-tropics and is influenced by the quasi stationary Atlantic anticyclone from which cells migrate eastwards south of the country during the summer months. This results in steep pressure gradients along the west coast with a strong southerly flow. These months are characteristically warm to hot and dry. During the winter months May to September the westerly belt displaces the Atlantic anticyclone northwards and the area falls under the influence of the westerly frontal weather. The mountains are occasionally snow capped but the snow layer never persists throughout winter. Thunderstorms do occur but are limited to the occasional west coast trough or a strong frontal system.

Another factor that must also be taken into consideration, is the microclimatology of the Koeberg area and specifically the occurrences of land and sea breezes. These occur in the transitional periods between the sub-tropical high and the mid-latitude low. The warm to hot offshore flow is replaced by a cooler onshore flow. The depth of the cooler flow varies. This results in windshear and the formation of a stable layer.

At present Koeberg has an atmospheric dispersion model based on the Gausian Puff model. Data from the local network of automatic stations surrounding Koeberg and from the main meteorological tower is fed into the HP3000 mini computer dispersion program. The program has various variable inputs and extra data can be fed to supplement the existing data. A radiological plume is then calculated and displayed on the screen or a hard copy can be plotted.

Dispersion plume modelling around Koeberg has used the models suggested by Pasquill(1961) (***Reference 3***) and modified by Gifford(1962). (***Reference 4***). Taking these models into consideration, the ratio of the concentration of gas or aerosols from a continous source (X) and the emission rate of pollutants (Q) has being calculated using actual data from the Koeberg Weather Station. To achieve this the following assumptions have been made:

- The plume has a Gausian distribution in both the horizontal and vertical planes.
- There is no building wake effect.
- The effective release was from an elevated source

The data below was used in the calculation:

- Effective stack height is 64 m.
- The 50 m mean hourly wind speed and direction.

- The lapse rate for vertical stability.
- The 50 m sigma theta for horizontal stability.

Centerline dilution factors (X/Q) were then calculated using the equation below:

$$\frac{X}{Q} = \frac{1}{2\pi\sigma_y\sigma_z\bar{\upsilon}} \exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right]$$

Where:

σ_y = Horizontal dispersion value

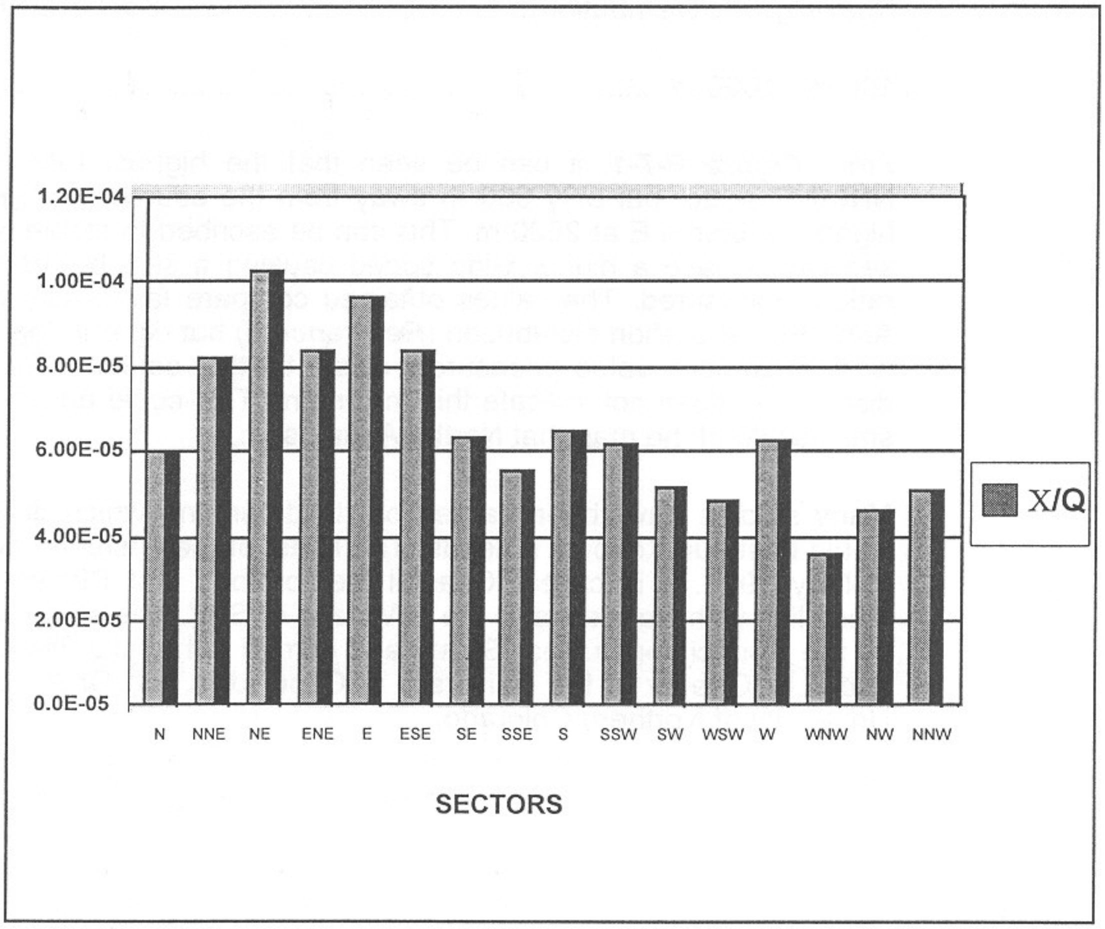
σ_z = Vertical dispersion value

$\bar{\upsilon}$ = Average wind speed

H = Height of release.

The X/Q was then calculated for each hour for the period January 1994 till December 1996. The values were tabulated into 16 wind sectors and distances from 100 m to 5 000 m from the source. The values given in ***Table T-7-5*** are averaged totals for each sector.

TABLE T-7-5
AVERAGE TOTAL X/Q VALUES FOR EACH WIND SECTOR. JANUARY 1994 TO DECEMBER 1996



The sector with the highest X/Q is the NE sector. This can be ascribed to the colder air moving in from the sea (the South South Westerly Sea breeze) over the land. This would cause a temperature inversion thus preventing vertical dispersion. The sectors with the lowest X/Q values correspond to the winds which occur from the South East. Here maximum dispersion takes place both horizontally and vertically.

The following Figures indicate the isopleths around Koeberg.

Figure F-7-1 ....Figure F-7-2

Koeberg X/Q Distribution ....Koeberg X/Q Distribution

100 m - 1000 m.. 500 m - 5000 m

From ***Figure F-7-1***, it can be seen that the highest ratio occurs in the NNE/NE sector but only 300 m away from the source. In ***Figure F-7-2*** the highest sector is E at 2000 m. This can be ascribed to stable winds from the sea which have a higher wind speed causing a skip before the maximum ratio is measured. The values obtained compare favourably with the North Anna Power Station distribution (***Reference 5***) but differ in the fact that there is a maximum value measured close to the source. The North Anna distribution does not indicate this maximum. This could be as a result of the small scale of the map that Northa Anna used.

Many studies have been carried out to determine which dispersion model would best suit Koeberg's needs. The latest of these studies was completed in May 1994. It is called "Coastal Meteorology and Dispersion Prediction Modelling with Reference to the SW Cape of S.A". The study was contracted by the Council for Nuclear Safety and carried out by J.J. Barclay, M.R. Jury and E.E. Griener of the University of Cape town and Dr A. Erasmus of the University of Northern Colorado.

7.4. Temperature

As can be seen from ***Table T-7-6***, temperatures measured at Koeberg are largely influenced by the close proximity of the cold ocean current which has a moderating effect on the temperatures. Please note that the temperatures are measured at a height of 10 m which also has a moderating effect. The lowest temperature recorded at Koeberg is above freezing and was 2.2 ºC and the maximum temperature was 37.2 ºC.

Jan 80 – Dec 95

TABLE T-7-6
MEANS AND EXTREMES OF TEMPERATURE IN ºC AT KOEBERG MEASURED AT 10 m AGL

Month	Average Daily maximum	Extreme Maximum	Average daily Minimum	Extreme Minimum
Jan	23.07	34.8	15.79	10.4
Feb	23.64	35.9	15.97	9.0
Mar	22.80	35.8	15.24	3.0
Apr	20.71	34.6	13.48	7.4
May	18.83	33.6	11.51	5.9
Jun	17.26	31.4	9.91	4.1
Jul	16.83	29.0	9.23	3.1
Aug	16.95	32.2	9.41	2.2
Sept	17.78	33.1	10.44	2.3
Oct	19.41	37.2	11.99	5.4
Nov	20.90	35.2	13.68	7.4
Dec	22.12	35.3	15.21	9.6
Annual	20.02	37.2	12.66	2.2

7.5. Precipitation

Precipitation falls throughout the year but generally the summers are dry while the winters are wet. This pattern is typical of the Mediterranean type climate regions of the world.

The maximum 24 hour rainfall measured at Koeberg was 57.4 mm on 25/1/1981.

TABLE T-7-7
MEANS AND EXTREMES OF PRECIPITATION IN mm MEASURED AT KOEBERG

Month	Average monthly (mm)	Maximum Monthly	Minimum Monthly
Jan	13.7	67.6	0.8
Feb	8.0	29.6	0.0
Mar	23.1	51.0	0.0
Apr	39.4	105.4	8.8
May	49.7	98.2	11.4
Jun	67.9	112.8	25.8
Jul	77.3	147.2	25.6
Aug	61.1	134.4	13.8
Sept	38.0	75.0	10.4
Oct	16.0	43.6	1.6
Nov	12.0	52.4	0.2
Dec	15.5	32.8	2.4
Annual	421.7	147.2	0.0

7.6. Thunder and Hail

Although thunder and hail occur at Koeberg they are not officially recorded. Records of thunder and hail are presented in ***Table T-7.8***. The data shown is measured at D F Malan and not at Koeberg.

TABLE T-7-8
AVERAGE FREQUENCY OF THUNDER AND HAIL MEASURED AT D F MALAN AIRPORT: 1956 - 1984

Month	Average number of days with thunder	Average number of days with hail
Jan	0.1	0.0
Feb	0.6	0.1
Mar	1.0	0.0
Apr	0.9	0.2
May	1.0	0.2
Jun	0.9	0.2
Jul	0.5	0.3
Aug	0.8	0.0
Sept	0.4	0.0
Oct	0.5	0.1
Nov	0.6	0.0
Dec	0.2	0.0
Annual	7.5	1.1

7.7. Snow and Frost

Records of snow and frost are presented in ***Table T-7-9***. The data shown is measured at D F Malan and not at Koeberg. Snow has not fallen at Koeberg since the inception of the weather station at Koeberg. Frost has been observed on numerous occasions from May till late August.

TABLE T-7-9
AVERAGE FREQUENCY OF FROST AND SNOW MEASURED AT D F MALAN AIRPORT: 1956 - 1984

Month	Average number of days with Frost Temp < 0.0 °C	Average number of days with Snow
Jan	0.0	0.0
Feb	0.0	0.0
Mar	0.0	0.0
Apr	0.0	0.0
May	0.2	0.0
Jun	0.3	0.0
Jul	0.2	0.0
Aug	0.1	0.1
Sept	0.0	0.0
Oct	0.0	0.0
Nov	0.0	0.0
Dec	0.0	0.0
Annual	0.5	0.1

7.8. Fog

No record of fog occurrences exist at Koeberg but being situated on the coast, fog is a regular occurrence during the passage of a coastal low as it migrates south along the West Coast, around the peninsula and eastwards along the South Coast. During the summer the fog normally burns off very quickly but in winter the fog stays around till noon and moves again before the sun sets.

Days with "Fog" are considered as such if the maximum horizontal visibility is less than 1000 metres. This does not include shallow fog which has a depth of less than 2 metres on land and 15 metres on the sea.

Records of fog are given in ***Table T-7-10*** and are shown for D F Malan, Cape Point and Dassen Island.

TABLE T-7-10
AVERAGE FREQUENCIES OF FOG

Month	Average number of days with Fog D F Malan Airport	Average number of days with Fog Dassen Island	Average number of days with Fog Cape Point
Jan	0.8	5.8	5.3
Feb	2.2	8.5	7.5
Mar	4.6	9.5	9.3
Apr	6.0	9.5	7.7
May	7.1	4.3	7.6
Jun	6.3	3.9	5.4
Jul	6.6	4.3	5.8
Aug	3.5	3.4	4.8
Sept	2.8	2.4	5.5
Oct	1.8	4.6	6.3
Nov	1.5	4.3	6.3
Dec	1.0	5.3	5.5
Annual	44.2	65.8	77.0

7.9. Design Bases

The design bases recorded hereunder are the same as those indicated in the ISSR.

7.9.1 Wind Speed

The buildings were designed to the wind speeds stated in the Outline Enquiry and the South African Building Regulations.

Maximum 3 second gust velocity: 225 km/h

Maximum mean hourly velocity: 138 km/h

7.9.2 Temperature

Maximum and minimum ambient temperatures for summer and winter respectively - outdoors:

	Summer	Winter
Dry bulb	34 °C	5 °C
Wet bulb	22 °C	4 °C

7.9.3 Rainfall

The maximum rate of precipitation used in the design of sewers, downpipes, etc, was 80 mm/h. However, the safety of the plant is ensured under a maximum stormwater design rate of 200 mm/h.

REFERENCES

1) OPS 7000 - Radiation Protection Standard (KNPS) Rev 6.

2) KAE 003 - Koeberg Meteorological Programme (KNPS) Rev 0.

3) Pasquill F. 1961: The Estimation of the Dispersion of Windborne Materials. Meteorological Magazine No. 90

4) Gifford F. A. 1961: Uses of routine Meteorological Observations for estimating Atmospheric Dispersion. Nuclear Safety

5) Vepco, North Anna Power Station
Updated Final Safety Analysis Report. Rev 12 Vol I Section 2.3 Figure 2.3-23