19.5.4 Rate of net income

The rate of net income which is the ratio of net income to the fixed assets in operation of the project is as follows:

- For the first 10 years after completion of the project:
  27.91 million R.O./3,707.18 million R.O. = 0.75%

- For the whole service life of 20 years:
  279.57 million R.O./4,481.89 million R.O. = 6.2%

19.5.5 Conclusion

There is no universal criteria on the rate of net income, but examples in some industrial countries and developing countries show that the rate of net income in the public utilities is generally ranged from around 2% to 4.4%.

Therefore, the rate of net income of 6.2% for the whole service life means that the Barka project, as far as it is operated under the new tariffs proposed on the cost basis, is very feasible from financial viewpoint.

Table 19.1 Procurement of funds and repayment schedule

(Electric power and desalination)

(Million R.O.)

No.	Year	Funds procurement (Construction cost)			Repayment schedule								Remarks
					Foreign currency				Local currency				
		Foreign currency	Local currency	Total	Interest	Principal	Total	Out-standing balance	Interest	Principal	Total	Out-standing balance	
	1986	25.75	5.19	30.94	(0.88)				(0.21)				Capital recovery factor:
	1987	88.79	23.18	111.97	(5.12)				(1.35)				- Foreign currency (interest rate of 7.3% and repayment period of 15 years):
	1988	99.90	14.71	114.61	(12.00)				(2.85)				
	1989	76.06	5.55	81.61	(18.43)				(3.67)				0.11188
	1990	22.22	3.20	25.42	(22.01)				(4.01)				- Local currency (interest rate of 8% and repayment period of 10 years):
	1991	7.52	1.90	9.42	(23.10)			320.24	(4.20)			53.73	
1	1992				23.38	12.45	35.83	307.79	4.30	3.71	8.01	50.02	0.14903
2	1993				22.47	13.36	35.83	294.43	4.00	4.01	8.01	46.01	
3	1994				21.49	14.34	35.83	280.09	3.68	4.33	8.01	41.68	
4	1995				20.45	15.38	35.83	264.71	3.33	4.68	8.01	37.00	
5	1996				19.32	16.51	35.83	248.20	2.96	5.05	8.01	31.95	
6	1997				18.12	17.71	35.83	230.49	2.56	5.45	8.01	26.50	
7	1998				16.83	19.00	35.83	211.49	2.12	5.89	8.01	20.61	
8	1999				15.44	20.39	35.83	191.10	1.65	6.36	8.01	14.25	
9	2000				13.95	21.88	35.83	169.22	1.14	6.87	8.01	7.38	
10	1				12.35	23.48	35.83	145.74	0.60	7.38	7.98	0	
11	2				10.64	25.19	35.83	120.55					
12	3				8.80	27.03	35.83	93.52					
13	4				6.83	29.00	35.83	64.52					
14	5				4.71	31.12	35.83	33.40					
15	6				2.41	33.40	35.81	0					
	Total	320.24	53.73	373.97	217.19	320.24	537.43		26.34	53.73	80.07		

Note: Figures in parentheses are interest during construction.

Table 19.2 Details of operating revenues
(Electric power and desalination)

(Million R.O.)

No.	Year	Electric power: Energy sold (GWh) (A)	Electric power: Unit price (Baizas/kWh) (B)	Electric power: Revenues (A)x(B) x 0.8	Desalination: Water sold (1,000 m3) (A)'	Desalination: Unit price (Baizas/m3) (B)'	Desalination: Revenues (A)'x(B)' x0.9
	1988	415	28.0	9.30	-	-	-
	1989	1,380	"	30.91	21,106	598	11.36
	1990	2,333	"	52.26	24,603	"	13.24
1	1991	4,078	"	91.35	30,686	"	16.52
2	1992	4,209	"	94.28	34,563	"	18.60
3	1993	4,339	"	97.19	38,442	"	20.69
4	1994	4,469	"	100.11	42,319	"	22.78
5	1995	4,601	"	103.06	44,676	"	24.04
6	1996	4,601	"	103.06	44,676	"	24.04
7	1997	4,601	"	103.06	44,676	"	24.04
8	1998	4,601	"	103.06	44,676	"	24.04
9	1999	4,601	"	103.06	44,676	"	24.04
10	2000	4,601	"	103.06	44,676	"	24.04
11	1	4,601	"	103.06	44,676	"	24.04
12	2	4,601	"	103.06	44,676	"	24.04
13	3	4,601	"	103.06	44,676	"	24.04
14	4	4,601	"	103.06	44,676	"	24.04
15	5	4,601	"	103.06	44,676	"	24.04
16	6	4,601	"	103.06	44,676	"	24.04
17	7	4,601	"	103.06	44,676	"	24.04
18	8	4,601	"	103.06	44,676	"	24.04
19	9	4,601	"	103.06	44,676	"	24.04
20	2010	4,601	"	103.06	44,676	"	24.04
	Total	94,839	28.0	2,124.36	906,535	598	487.83

Table 19.3 Details of operating expenses

(Electric power and desalination)

(Million R.O.)

No.	Year	Electric power sector: Operation and maintenance	Electric power sector: Administration cost	Electric power sector: Fuel cost	Electric power sector: Depreciation	Electric power sector: Total	Desalination sector: Steam cost	Desalination sector: Power cost	Desalination sector: Chemicals cost	Desalination sector: Personnel Administration Materials	Desalination sector: Depreciation	Desalination sector: Total	Fixed assets account: Yearly	Fixed assets account: Accumulated (A)	Fixed assets: Book Value (B)	Fixed assets: Outstanding balance (B)-(A)
	1988	2.47	0.33	6.20	4.13	13.13	-	-	-	-	-	-	4.13	4.13	82.59	78.46
	1989	4.94	0.66	20.60	8.26	34.46	2.40	1.12	1.10	0.78	3.54	8.94	11.80	15.93	235.91	219.98
	1990	7.90	1.06	29.40	13.22	51.58	4.40	1.30	1.30	1.25	4.95	13.20	18.17	34.10	363.29	329.19
1	1991	9.88	1.32	49.40	16.52	77.12	6.70	1.62	1.60	1.56	7.07	18.55	23.59	57.69	471.80	414.11
2	1992	9.88	1.32	49.50	16.52	77.22	7.50	1.83	1.80	1.56	7.07	19.76	23.59	81.28		390.52
3	1993	9.88	1.32	49.60	16.52	77.32	8.30	2.03	2.00	1.56	7.07	20.96	23.59	104.87		366.93
4	1994	9.88	1.32	49.60	16.52	77.32	9.20	2.24	2.20	1.56	7.07	22.27	23.59	128.46		343.34
5	1995	9.88	1.32	50.00	16.52	77.72	9.70	2.36	2.30	1.56	7.07	22.99	23.59	152.05		319.75
6	1996	9.88	1.32	50.00	16.52	77.72	9.70	2.36	2.30	1.56	7.07	22.99	23.59	175.64		296.16
7	1997	9.88	1.32	50.00	16.52	77.72	9.70	2.36	2.30	1.56	7.07	22.99	23.59	199.23		272.57
8	1998	9.88	1.32	50.00	16.52	77.72	9.70	2.36	2.30	1.56	7.07	22.99	23.59	222.82		248.98
9	1999	9.88	1.32	50.00	16.52	77.72	9.70	2.36	2.30	1.56	7.07	22.99	23.59	246.41		225.39
10	2000	9.88	1.32	50.00	16.52	77.72	9.70	2.36	2.30	1.56	7.07	22.99	23.59	270.00		201.80
11	1	9.88	1.32	50.00	16.52	77.72	9.70	2.36	2.30	1.56	7.07	22.99	23.59	293.59		178.21
12	2	9.88	1.32	50.00	16.52	77.72	9.70	2.36	2.30	1.56	7.07	22.99	23.59	317.18		154.62
13	3	9.88	1.32	50.00	16.52	77.72	9.70	2.36	2.30	1.56	7.07	22.99	23.59	340.77		131.03
14	4	9.88	1.32	50.00	16.52	77.72	9.70	2.36	2.30	1.56	7.07	22.99	23.59	364.36		107.44
15	5	9.88	1.32	50.00	16.52	77.72	9.70	2.36	2.30	1.56	7.07	22.99	23.59	387.95		83.85
16	6	9.88	1.32	50.00	16.52	77.72	9.70	2.36	2.30	1.56	7.07	22.99	23.59	411.54		60.26
17	7	9.88	1.32	50.00	16.52	77.72	9.70	2.36	2.30	1.56	7.07	22.99	23.59	435.13		36.67
18	8	9.88	1.32	50.00	12.39	73.59	9.70	2.36	2.30	1.56	7.07	22.99	19.46	454.59		17.21
19	9	9.88	1.32	50.00	8.26	69.46	9.70	2.36	2.30	1.56	3.53	19.45	11.79	466.38		5.42
20	2010	9.88	1.32	50.00	3.24	64.44	9.70	2.36	2.30	1.56	2.18	18.10	5.42	471.80		0
	Total	212.91	28.45	1,054.30	330.34	1,626.00	193.70	47.90	46.80	33.23	141.46	463.09	471.80	-		4,481.89

Note: Annual disbursement of fixed assets is as follows:

(Million R.O.)

	1988	1989	1990	1991
Power	82.59	165.17	264.27	330.34
Desalination	-	70.74	99.02	141.46
Total	82.59	235.91	363.29	471.80

Table 19.4 Profit and loss statement

(Electric power and desalination)

(Million R.O.)

No.	Year	Operating revenues			Operating expenses			Operating income	Financial expenses			Net income
		Power	Desalination	Total	Power	Desalination	Total		Foreign currency	Local currency	Total	
	1988	9.30	-	9.30	13.13	-	13.13	-3.83				-3.83
	1989	30.91	11.36	42.27	34.46	8.94	43.40	-1.13				-1.13
	1990	52.26	13.24	65.50	51.58	13.20	64.78	0.72				0.72
1	1991	91.35	16.52	107.87	77.12	18.55	95.67	12.20				12.20
2	1992	94.28	18.60	112.88	77.22	19.76	96.98	15.90	23.38	4.30	27.68	-11.78
3	1993	97.19	20.69	117.88	77.32	20.96	98.28	19.60	22.47	4.00	26.47	-6.87
4	1994	100.11	22.78	122.89	77.32	22.27	99.59	23.30	21.49	3.68	25.17	-1.87
5	1995	103.06	24.04	127.10	77.72	22.99	100.71	26.39	20.45	3.33	23.78	2.61
6	1996	103.06	24.04	127.10	77.72	22.99	100.71	26.39	19.32	2.96	22.28	4.11
7	1997	103.06	24.04	127.10	77.72	22.99	100.71	26.39	18.12	2.56	20.68	5.71
8	1998	103.06	24.04	127.10	77.72	22.99	100.71	26.39	16.83	2.12	18.95	7.44
9	1999	103.06	24.04	127.10	77.72	22.99	100.71	26.39	15.44	1.65	17.09	9.30
10	2000	103.06	24.04	127.10	77.72	22.99	100.71	26.39	13.95	1.14	15.09	11.30
11	1	103.06	24.04	127.10	77.72	22.99	100.71	26.39	12.35	0.60	12.95	13.44
12	2	103.06	24.04	127.10	77.72	22.99	100.71	26.39	10.64		10.64	15.75
13	3	103.06	24.04	127.10	77.72	22.99	100.71	26.39	8.80		8.80	17.59
14	4	103.06	24.04	127.10	77.72	22.99	100.71	26.39	6.83		6.83	19.56
15	5	103.06	24.04	127.10	77.72	22.99	100.71	26.39	4.71		4.71	21.68
16	6	103.06	24.04	127.10	77.72	22.99	100.71	26.39	2.41		2.41	23.98
17	7	103.06	24.04	127.10	77.72	22.99	100.71	26.39				26.39
18	8	103.06	24.04	127.10	73.59	22.99	96.58	30.52				30.52
19	9	103.06	24.04	127.10	69.46	19.45	88.91	38.19				38.19
20	2010	103.06	24.04	127.10	64.44	18.10	82.54	44.56				44.56
	Total	2,124.36	487.83	2,612.19	1,626.00	463.09	2,089.09	523.10	217.19	26.34	243.53	279.57

Table 19.5 Cash flow sheet
(Electric power and desalination)

(Million R.O.)

No.	Year	Cash inflow				Cash outflow					Balance	
		Funds procurement	Net income	Depreciation	Total	Construction	Repayment of principal: Foreign currency	Repayment of principal: Local currency	Interest during construction	Total	Yearly	Accumulated
	1986	30.94			30.94	30.94			1.09	32.03	-1.09	-1.09
	1987	111.97			111.97	111.97			6.47	118.44	-6.47	-7.56
	1988	114.61	-3.83	4.13	114.91	114.61			14.85	129.46	-14.55	-22.11
	1989	81.61	-1.13	11.80	92.28	81.61			22.10	103.71	-11.43	-33.54
	1990	25.42	0.72	18.17	44.31	25.42			26.02	51.44	-7.13	-40.67
1	1991	9.42	12.20	23.59	45.21	9.42			27.30	36.72	8.49	-32.18
2	1992		-11.78	23.59	11.81		12.45	3.71		16.16	-4.35	-36.53
3	1993		-6.87	23.59	16.72		13.36	4.01		17.37	-0.65	-37.18
4	1994		1.87	23.59	21.72		14.34	4.33		18.67	3.05	-34.13
5	1995		2.61	23.59	26.20		15.38	4.68		20.06	6.14	-27.99
6	1996		4.11	23.59	27.70		16.51	5.05		21.56	6.14	-21.85
7	1997		5.71	23.59	29.30		17.71	5.45		23.16	6.14	-15.71
8	1998		7.44	23.59	31.03		19.00	5.89		24.89	6.14	-9.57
9	1999		9.30	23.59	32.89		20.39	6.36		26.75	6.14	-3.43
10	2000		11.30	23.59	34.89		21.88	6.87		28.75	6.14	2.71
11	1		13.44	23.59	37.03		23.48	7.38		30.86	6.17	8.88
12	2		15.75	23.59	39.34		25.19			25.19	14.15	23.03
13	3		17.59	23.59	41.18		27.03			27.03	14.15	37.18
14	4		19.56	23.59	43.15		29.00			29.00	14.15	51.33
15	5		21.68	23.59	45.27		31.12			31.12	14.15	65.48
16	6		23.98	23.59	47.57		33.40			33.40	14.17	79.65
17	7		26.39	23.59	49.98						49.98	129.63
18	8		30.52	19.46	49.98						49.98	179.61
19	9		38.19	11.79	49.98						49.98	229.59
20	10		44.56	5.42	49.98						49.98	279.57
	Total	373.97	279.57	471.80	1,125.34	373.97	320.24	53.73	97.83	845.77	279.57	

ANNEX 1

RESULTS

OF

SEA WATER QUALITY

AND

SEA BOTTOM SOIL ANALYSIS

Table 1 Result of Sea-Water Quality Analysis (1)

Item \ Sampling Station / Sampling Date / Unit		⑧				⑦
		Feb. 6				Feb. 3
Sampling Depth	m	1.0	3.0	5.0	8.0	3.5
Temperature	℃	24.3	24.2	24.1	24.1	—
Turbidity		2.2	1.4	1.4	2.1	0.5
pH	—	8.1_3	8.1_7	8.1_6	8.1_7	8.1_6
Electric Conductivity	mS	56.0	56.1	56.0	56.2	55.5
Acid Consumption (Alkalinity)	$mgCaCO_3/l$	116	116	116	116	116
Total Hardness	$mgCaCO_3/l$	6,740	6,760	6,760	6,770	6,710
Suspended Matter(SS)	mg/l	1.8	1.2	0.8	2.0	< 0.5
TDS(110℃)	mg/l	39,600	39,600	39,700	39,700	39,400
TDS(480℃)	mg/l	35,600	35,500	35,700	35,500	35,200
COD_{Mn}	mg/l	1.3	1.1	0.9	0.8	0.8
COD_{OH}	mg/l	0.2	0.1	0.2	0.3	0.1
TOC	mgC/l	0.8	0.8	0.7	0.6	0.7
Cl	‰	20.44	20.42	20.50	20.50	20.36
SO_4	mg/l	2,940	2,920	2,950	2,950	2,930
NH_4-N	μg-at/l	2.4	2.7	2.9	3.0	4.9
NO_2-N	μg-at/l	< 0.05	0.06	< 0.05	< 0.05	0.06
NO_3-N	μg-at/l	0.07	< 0.05	0.06	0.07	0.13
T-N	μg-at/l	16.7	15.6	15.8	14.5	16.1
PO_4-P	μg-at/l	0.53	0.56	0.63	0.64	0.83
T-P	μg-at/l	1.10	1.08	1.16	1.19	1.14
SiO_4-Si	μg-at/l	5.0	4.8	4.5	3.7	4.2
Na	mg/l	10,700	11,700	12,300	12,400	12,100
Ca	mg/l	433	431	425	423	425
Mg	mg/l	1,370	1,380	1,380	1,390	1,370

Note: Number of sampling station above shows in Fig. 6.4.

Table 1 Result of Sea-Water Quality Analysis (2)

Item	Unit	⑤			②
Sampling Station / Sampling Date		Feb. 3			Feb. 3
Sampling Depth	m	1.0	3.0	5.0	1.5
Temperature	℃	24.4	24.3	24.2	——
Turbidity		< 0.5	< 0.5	< 0.5	0.9
pH	——	8.1_8	8.1_8	8.1_7	8.1_8
Electric Conductivity	mS	55.8	55.4	55.9	55.8
Acid Consumption (Alkalinity)	$mgCaCO_3/l$	116	116	116	116
Total Hardness	$mgCaCO_3/l$	6,730	6,720	6,740	6,740
Suspended Matter (SS)	mg/l	< 0.5	< 0.5	0.6	0.6
TDS(110℃)	mg/l	39,200	39,400	39,300	39,200
TDS(480℃)	mg/l	35,200	35,100	35,200	35,200
COD_{Mn}	mg/l	0.9	0.6	0.9	0.9
COD_{OH}	mg/l	0.2	0.1	0.1	0.2
TOC	mgC/l	0.7	0.7	0.9	1.0
Cl	‰	20.36	20.37	20.35	20.42
SO_4	mg/l	2,930	2,930	2,930	2,940
NH_4-N	μg-at/l	2.5	2.9	4.3	2.7
NO_2-N	μg-at/l	0.06	0.06	0.06	< 0.05
NO_3-N	μg-at/l	0.13	0.11	0.11	0.06
T-N	μg-at/l	13.4	13.6	16.7	16.1
PO_4-P	μg-at/l	0.63	0.70	0.82	0.63
T-P	μg-at/l	1.07	1.08	1.21	1.12
SiO_4-Si	μg-at/l	4.2	4.3	4.6	4.6
Na	mg/l	10,700	10,500	10,500	10,500
Ca	mg/l	421	423	427	421
Mg	mg/l	1,380	1,380	1,380	1,380

Table 2 Result of Sea Bottom Soil Analysis

Item		Unit \ Sampling Station / Sampling Date	①	④	⑧	⑪
			Feb. 3	Feb. 3	Feb. 3	Feb. 3
Appearance		——	Shell in Sand	Sand	Shell in Sand	Shell in Sand
Odor		——	Non	Non	Non	Non
Color Specification		——	Dark Olive Gray	Dark Green Gray	Olive Black	Olive Black
Water Contain Ratio		Wet	21.4	24.6	20.9	17.2
Ignition Loss		Dry	7.4	7.3	5.8	3.7
COD		Dry	1.2	0.3	2.1	1.8
Sulfide	Free Sulfide	Dry	〈 0.02	〈 0.02	〈 0.02	0.02
	Total Sulfide	Dry	〈 0.02	〈 0.02	〈 0.02	0.04
Specific gravity		——	2.82	2.79	2.77	2.79
Size and Soil Structure	Conglomerate 2.0mm 以上	%	0.5	0.5	5.5	19.0
	Co Sand 2.0 ~0.42mm	%	0.5	5.5	27.5	64.0
	Fine Sand 0.42~0.074mm	%	94.0	70.5	55.5	13.0
	Silt 0.074 ~0.005mm	%	5.0	20.5	9.5	4.0
	Clay, Colloidal Matter 0.005mm and less	%		3.0	2.0	
Particle Size Distribution	60%	mm	0.120	0.105	0.30	1.15
	30%	mm	0.092	0.080	0.110	0.58
	10%	mm	0.078	0.044	0.067	0.22
	50%	mm	0.110	0.095	0.21	0.90
Uniformity Coefficient		——	1.5	2.4	4.5	5.2
Curnature Coefficient		——	0.9	1.4	0.6	1.3

Note: Number of sampling station above shows in Fig. 6.4.

ANNEX 2

NATURAL CONDITION

2.1 RECORDED CLIMATE SUMMARY

2.2 GHUBRAH POWER STATION SEA WATER TEMPERATURE

ANNEX 2.1

2.1 RECORDED CLIMATE SUMMARY

Observer	:	Directorate General of Meteorology, Ministry of Communication
Station	:	Mina Quboos Buoy No. 1 Lat. 23°41'N, Long. 58°33'E
Period	:	March 1983 - October 1983, 8 months January 1984 - April 1984, 4 months

STATION: MINA QABOOS BUOY NO.1

MONTH: MARCH 1983

SULTANATE OF OMAN
Directorate General of Meteorology
Ministry of Communication
CLIMATE SUMMARY

* ALL VALUES BASED ON 8 SYNOPTIC HOURS.

LAT: 23°41'N
LONG: 58°33'E

DATE	Air Temperature (°C)			Sea Temp (°C)			Rel. Humidity (%)			Wind (Dir./speed kts)		H Mean (Meters)			H Sig (M)		H max		T Sig		T mean		
	Max.	Min.	Mean	Max.	Min.	Mean	max	min	mean	Prev.	Max.	max	min	mean	max	mean	max	mean	max	mean	max	min	mean
1	20.7	18.4	19.4	23.0	22.8	22.9	67	59	62	31519	30027						2.2	1.8					
2	21.1	19.2	20.0	22.9	22.7	22.8	73	53	60	31513	29521						2.4	1.8					
3	21.1	20.3	20.8	23.0	22.7	22.9	70	59	65	31507	32512						2.0	0.9					
4	23.3	20.5	21.8	23.5	23.0	23.2	84	76	80	09011	11021						1.8	1.1					
5	22.8	21.7	22.4	23.1	22.6	22.9	90	75	84	13514	11027						2.3	1.5					
6	23.8	22.1	22.8	22.9	22.2	22.5	100	86	92	13515	11027						2.6	1.6					
7	23.0	22.3	22.6	22.7	22.1	22.5	100	69	86	27013	27520						2.7	1.3					
8	22.2	20.6	21.3	22.8	22.5	22.7	76	62	68	31513	31017						1.6	1.3					
9	23.5	21.3	22.3	22.9	22.6	22.8	74	57	66	27008	32014						1.2	0.8					
10	23.8	22.7	23.2	23.0	22.7	22.8	70	51	61	27008	32016						1.8	1.2					
11	23.4	22.0	22.4	23.1	22.6	22.8	80	49	68	13506	33511						1.6	1.0					
12	23.1	22.1	22.5	22.9	22.6	22.7	99	59	71	31511	32516						1.6	1.1					
13	23.3	21.9	22.6	23.6	22.8	23.1	92	62	80	04505	09510						1.2	0.7					
14	22.9	22.4	22.5	23.6	22.9	23.2	92	84	88	27005	33011						0.8	0.7					
15	23.7	22.3	23.1	24.0	23.1	23.5	96	73	88	27008	29515						1.4	0.7					
16	23.5	22.4	22.9	24.0	23.0	23.4	100	76	89	04504	02509						0.9	0.7					
17	23.7	22.8	23.2	24.1	23.1	23.5	100	95	99	36002	24510						0.6	0.5					
18	23.3	21.5	22.7	23.5	22.8	23.3	100	61	72	31518	30023						2.8	1.7					
19	21.4	20.6	21.1	23.1	22.6	22.9	71	66	69	31514	29025						2.7	1.5					
20	22.6	21.3	22.1	23.8	22.8	23.2	71	49	61	27006	35511						0.7	0.6					
21	23.2	21.9	22.6	24.1	23.1	23.5	82	58	70	31505	12017						1.2	0.8					
22	23.7	22.3	23.2	24.3	23.3	23.7	100	78	92	09011	10514						1.3	0.7					
23	24.5	22.8	23.7	23.9	23.2	23.5	100	79	97	09012	11520						2.3	1.2					
24	23.7	22.2	23.1	22.9	22.4	22.8	100	52	71	31517	30025						2.3	1.8					
25	21.4	20.7	21.1	23.1	22.7	22.9	73	60	64	27008	31020						2.6	1.3					
26	23.3	21.2	22.5	23.9	22.8	23.2	72	44	62	09011	07013						1.1	0.7					
27	23.4	22.3	22.8	24.0	22.9	23.1	66	46	60	36005	04509						0.9	0.6					
28	25.1	23.1	23.9	24.6	23.0	23.6	74	43	60	13510	12512						1.1	0.6					
29	25.9	23.7	24.2	23.6	23.1	23.3	91	56	73	09011	09014						1.2	0.7					
30	24.4	21.6	23.6	23.8	22.6	23.1	96	74	87	13512	13023						2.0	1.2					
31	22.9	21.0	22.1	22.8	22.6	22.7	98	72	88	13510	12516						1.2	1.0					
Mean	23.1	21.7	22.4	23.4	22.8	23.1	86	64	75	31513							1.7	1.1					
Max.	25.9	23.7	24.2	24.6	23.3	23.7	100	95	99		11027						2.8	1.8					
Min.	20.7	18.4	19.4	22.7	22.1	22.5	66	43	60									0.5					

STATION: MINA QABOOS (BUOY NO.1)

MONTH: APRIL 1983

SULTANATE OF OMAN
Directorate General of Meteorology
Ministry of Communication
CLIMATE SUMMARY

* ALL VALUES BASED ON 8 SYNOPTIC HOURS.

LAT: 23°41'N
LONG: 58°33'E

DATE	Air Temperature (°C)			Sea Temp (°C)			Rel. Humidity (%)			Wind (Dir./speed kts)		H Mean (Meters)			H Sig (M)		H max		T Sig		T mean		
	Max.	Min.	Mean	Max.	Min.	Mean	max	min	mean	Prev.	Max.	max	min	mean	max	mean	max	mean	max	mean	max	min	mean
1	23.5	21.7	22.8	23.6	22.6	23.1	81	72	80	22506	11013						1.1	0.9					
2	25.9	22.4	23.9	25.2	22.7	23.7	92	61	77	27007	26512						2.0	0.9					
3																							
4																							
5	23.6	22.1	23.0	23.7	23.6	23.7	100	84	94	09014	11019						2.0	1.1					
6	23.3	22.3	23.1	25.6	23.4	24.4	99	81	90	27004	29509						1.1	0.7					
7	23.8	23.1	23.5	23.9	23.6	23.7	85	71	78	27008	33517						1.3	0.9					
8	25.3	23.5	24.2	24.3	23.6	24.0	86	53	71	31506	31515						1.1	0.8					
9	25.6	24.0	24.7	25.2	23.9	24.5	100	58	74	31506	31511						1.0	0.6					
10	25.6	19.5	24.0	25.7	23.7	24.5	99	70	85	09003	13517						1.5	0.8					
11	25.5	24.3	24.9	25.0	23.7	24.4	100	74	89	27008	28517						1.6	1.0					
12																							
13																							
14	26.1	24.2	25.4	24.4	24.3	24.3	62	49	55	31515	30021						2.5	1.9					
15	24.5	23.0	23.9	25.0	24.1	24.5	79	64	70	27009	28509						1.9	1.1					
16	26.3	23.8	24.9	25.1	24.4	24.7	86	42	67	27007	32013						1.1	0.7					
17	26.1	24.7	25.4	25.5	24.5	24.9	85	56	70	09008	12515						1.1	0.7					
18	27.9	25.2	25.9	25.8	24.6	25.2	96	39	76	09009	11013						1.3	0.8					
19	26.4	24.7	25.5	26.0	24.8	25.3	92	70	84	09009	12015						1.0	0.8					
20	25.3	23.9	24.6	25.8	24.1	24.9	100	90	95	18003	32509						0.8	0.6					
21	26.8	24.5	25.9	26.6	25.1	25.8	100	65	78	13502	12511						1.1	0.6					
22	26.8	25.7	26.3	27.4	25.6	26.3	96	72	88	09005	11011						0.8	0.6					
23	28.8	25.2	27.1	27.1	26.0	26.5	100	59	83	13505	35008						0.5	0.4					
24	29.5	27.9	28.6	27.4	26.1	26.7	86	53	65	22504	30007						1.0	0.6					
25	30.9	28.6	29.6	27.1	26.1	26.5	71	50	59	27005	26508						0.9	0.6					
26	29.8	27.4	28.8	27.1	25.9	26.5	77	51	65	31506	30511						0.9	0.5					
27	30.8	28.4	29.3	27.9	26.5	27.0	79	41	62	27006	25509						0.8	0.6					
28	31.3	27.9	29.9	27.3	26.8	27.0	71	47	56	27010	26517						1.6	1.1					
29	33.9	28.8	30.7	27.5	26.5	26.8	76	31	58	27010	27520						1.9	1.3					
30	30.8	27.7	28.8	27.0	26.2	26.4	86	48	67	27010	27019						2.3	1.3					
31	-	-	-	-	-	-	-	-	-	-	-						-	-					
Mean	27.1	24.8	25.9	25.9	24.7	25.2	88	60	74	27008							1.3	0.8					
Max.	33.9	28.8	30.7	27.9	26.8	27.0	100	90	95		30021						2.5	1.9					
Min.	23.3	19.5	22.8	23.6	22.6	23.1	62	31	55									0.4					

STATION: MINA QABOOS BUOY NO. I

MONTH: MAY 1983

SULTANATE OF OMAN
Directorate General of Meteorology
Ministry of Communication
CLIMATE SUMMARY

* ALL VALUES BASED ON 8 SYNOPTIC HOURS.

LAT: 23°41'N
LONG: 58°33'E

DATE	Air Temperature (°C)			Sea Temp (C)			Rel. Humidity (%)			Wind (Dir./speed kts)		H Mean (Meters)			H Sig (M)		H max		T Sig		T mean		
	Max.	Min.	Mean	Max.	Min.	Mean	max	min	mean	Prev.	Max.	max	min	mean	max	mean	max	mean	max	mean	max	min	mean
1	31.6	28.7	29.9	27.7	26.2	26.7	72	43	59	27009	31513	-	-	-	-	-	1.4	0.9	-	-	-	-	-
2	32.1	29.3	30.6	29.9	27.4	28.4	79	55	65	27006	13013	-	-	-	-	-	0.8	0.6	-	-	-	-	-
3	36.6	28.7	30.7	29.1	27.8	28.4	79	26	63	18011	20023	-	-	-	-	-	1.3	0.9	-	-	-	-	-
4	28.7	27.8	28.2	28.5	27.6	28.1	73	52	62	31507	31513	-	-	-	-	-	1.5	1.0	-	-	-	-	-
5	27.9	26.6	27.2	28.9	28.0	28.4	100	79	89	09008	10512	-	-	-	-	-	1.5	0.8	-	-	-	-	-
6	28.9	26.8	27.9	29.0	28.2	28.5	100	84	94	09007	11515	-	-	-	-	-	0.9	0.6	-	-	-	-	-
7	32.9	28.0	30.3	29.2	27.9	28.7	100	60	75	27006	26010	-	-	-	-	-	0.5	0.4	-	-	-	-	-
8	30.4	29.8	30.1	28.3	27.8	28.0	79	61	69	27007	31013	-	-	-	-	-	1.3	0.9	-	-	-	-	-
9	32.0	30.9	31.4	28.3	27.9	28.1	66	57	61	31505	31509	0.2	0.2	0.2	0.3	0.3	0.5	0.3	8.5	5.3	11.5	7.0	9.4
10	34.3	30.1	32.5	28.9	28.3	28.5	80	39	54	27010	27517	0.4	0.2	0.3	0.6	0.4	0.9	0.7	6.0	5.2	8.0	5.5	6.3
11	31.6	28.7	30.5	29.4	28.4	28.8	100	49	75	31506	31011	0.4	0.2	0.3	0.6	0.4	1.1	0.7	7.0	5.5	10.0	5.5	6.5
12	29.0	27.5	28.6	29.3	28.5	28.9	100	100	100	09009	10016	0.3	0.2	0.2	0.4	0.4	0.6	0.5	6.5	5.2	9.5	4.0	6.3
13	28.7	28.0	28.5	29.4	28.5	29.0	100	100	100	09008	10015	0.3	0.3	0.3	0.5	0.4	0.9	0.7	6.5	5.6	7.5	5.5	6.2
14	28.7	28.2	28.5	29.7	28.6	29.3	100	100	100	09006	25015	0.3	0.2	0.2	0.4	0.3	0.8	0.5	9.0	6.6	12.0	5.5	8.9
15	29.7	28.6	29.2	30.0	29.7	29.9	100	100	100	09009	10015	0.3	0.2	0.2	0.4	0.2	0.5	0.3	9.0	6.9	16.4	6.0	10.5
16	31.0	28.6	29.9	30.0	29.6	29.9	100	100	100	09007	10511	0.3	0.2	0.3	0.4	0.3	0.5	0.4	9.0	7.5	21.4	7.0	13.1
17	32.2	30.0	31.6	30.0	29.5	29.9	100	66	85	23504	16008	0.3	0.2	0.2	0.3	0.3	0.5	0.3	10.0	8.1	25.9	7.5	14.5
18	35.6	33.3	34.2	30.0	30.0	30.0	71	48	61	27006	24510	0.2	0.2	0.2	0.3	0.3	0.3	0.3	9.5	8.3	20.9	9.5	14.5
19	34.9	31.9	33.2	30.0	29.8	29.9	77	52	63	27008	26012	0.2	0.2	0.2	0.3	0.3	0.5	0.4	7.0	6.4	16.0	6.5	9.1
20	36.2	31.7	33.4	30.0	29.6	29.9	76	39	58	27006	27015	0.4	0.2	0.3	0.5	0.4	0.9	0.6	6.5	5.2	10.5	5.0	6.7
21	34.4	32.3	33.4	30.0	29.7	29.9	62	46	57	27006	25510	0.4	0.2	0.3	0.5	0.4	0.9	0.6	7.0	5.4	10.0	6.0	7.2
22	34.5	31.8	33.2	30.0	29.8	29.9	82	50	65	09005	03011	0.3	0.2	0.2	0.4	0.3	0.5	0.4	7.5	6.1	12.5	6.5	10.1
23	36.0	32.6	33.8	30.0	30.0	30.0	69	38	52	13506	19012	0.3	0.2	0.2	0.3	0.2	0.5	0.3	8.5	7.1	19.9	8.0	12.7
24	38.3	32.2	34.6	30.0	29.9	29.9	72	25	54	13506	16512	0.2	0.2	0.2	0.3	0.3	0.4	0.3	8.0	6.7	16.9	7.5	10.9
25	35.8	33.1	34.2	30.0	30.0	30.0	65	33	53	22506	21513	0.2	0.2	0.2	0.3	0.3	0.4	0.3	9.0	7.3	19.9	8.5	13.1
26	36.5	33.2	34.2	30.0	30.0	30.0	78	39	57	27006	20526	0.2	0.2	0.2	0.3	0.2	0.5	0.3	13.0	8.0	23.9	4.5	13.7
27	35.1	32.5	34.3	30.0	30.0	30.0	69	36	53	22504	35511	0.4	0.2	0.3	0.5	0.4	0.9	0.6	8.0	6.1	10.5	6.5	7.7
28	35.6	32.2	33.8	30.0	30.0	30.0	71	47	56	27009	27517	0.4	0.3	0.4	0.6	0.5	1.0	0.8	7.0	5.3	8.0	5.5	6.1
29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	32.6	31.0	31.7	30.0	30.0	30.0	100	76	89	09006	11009	0.3	0.2	0.2	0.3	0.3	0.4	0.3	10.5	8.8	19.9	9.5	13.1
31	31.9	31.2	31.4	30.0	30.0	30.0	100	93	97	09005	12515	0.2	0.2	0.2	0.4	0.3	0.5	0.4	8.5	6.8	30.9	4.5	13.6
Mean	32.8	30.2	31.4	29.5	28.9	29.2	84	60	72	27007		0.3	0.2	0.2	0.4	0.3	0.8	0.5	8.3	6.5	15.5	6.4	10.0
Max.	38.3	33.3	34.7	30.0	30.0	30.0	100	100	100		20526	0.4		0.4	0.6	0.5	1.5	1.0	13.0	8.8	30.9		14.5
Min.	30.4	26.6	27.2	27.7	26.2	26.7	62	25	53				0.2	0.2		0.2		0.3		5.2		4.0	6.1

STATION: MINA QABOOS (BUOY NO.1.)

MONTH: JUNE 1983

SULTANATE OF OMAN
Directorate General of Meteorology
Ministry of Communication
CLIMATE SUMMARY

* ALL VALUES BASED ON 8 SYNOPTIC HOURS.

LAT: 23°41'N
LONG: 58°33'E

DATE	Air Temperature (°C)			Sea Temp (C)			Rel. Humidity (%)			Wind (Dir./speed kts)	
	Max.	Min.	Mean	Max.	Min.	Mean	max	min	mean	Prev.	Max.
1	32.1	30.5	31.1	30.0	30.0	30.0	98	64	87	13505	03511
2	31.9	30.0	31.2	30.0	30.0	30.0	96	70	84	09008	11513
3	32.7	31.1	31.9	30.0	30.0	30.0	100	78	90	09008	11010
4	36.1	31.4	33.3	30.0	30.0	30.0	100	65	85	27006	28511
5	35.5	33.2	34.5	30.0	30.0	30.0	78	51	64	27006	26511
6	34.4	32.7	33.5	30.0	30.0	30.0	77	56	69	27006	26011
7	37.5	32.6	34.3	30.0	30.0	30.0	85	43	67	27005	30509
8	36.6	34.0	35.1	30.0	30.0	30.0	76	49	64	27005	34511
9	34.4	32.9	33.9	30.0	30.0	30.0	98	74	83	09006	24011
10	35.2	32.7	33.7	30.0	30.0	30.0	100	59	77	09006	10011
11	34.0	32.0	32.8	30.0	30.0	30.0	100	70	93	09007	09513
12	33.3	31.5	32.3	30.0	30.0	30.0	100	98	100	09011	11518
13	31.6	30.1	30.7	30.0	30.0	30.0	100	100	100	09014	11523
14	29.9	28.0	29.1	29.4	27.4	28.3	100	100	100	09012	10516
15	31.3	27.6	29.4	30.0	26.9	29.0	100	100	100	31505	12008
16	31.4	29.6	30.7	30.0	28.8	29.7	100	99	100	09005	09009
17	32.9	30.6	31.5	30.0	29.9	30.0	100	86	98	09006	35011
18	32.5	31.3	31.9	30.0	30.0	30.0	100	99	100	31508	12014
19	35.8	31.1	32.1	30.0	30.0	30.0	100	49	90	09008	12018
20	31.4	30.8	31.1	30.0	30.0	30.0	100	96	99	09009	10513
21	37.4	30.9	33.8	30.0	30.0	30.0	100	52	79	27005	05013
22	35.5	32.9	34.4	30.0	30.0	30.0	95	41	68	27003	29006
23	35.8	33.0	33.7	30.0	30.0	30.0	81	36	68	27005	24510
24	34.1	32.1	33.3	30.0	30.0	30.0	99	72	86	27006	32009
25	36.3	32.7	34.5	30.0	30.0	30.0	98	50	74	27005	34015
26	35.6	32.2	34.0	30.0	30.0	30.0	100	59	81	27005	26007
27	36.0	33.2	34.8	30.0	30.0	30.0	89	60	67	27008	31512
28	35.8	33.4	34.7	30.0	30.0	30.0	90	58	73	27009	25013
29	35.8	33.0	34.4	30.0	30.0	30.0	94	58	77	13508	31016
30	32.5	31.5	31.8	30.0	30.0	30.0	100	93	98	27011	27516
31	-	-	-	-	-	-	-	-	-	-	-
Mean	34.2	31.6	32.8	30.0	29.8	29.9	95	69	84	27006	
Max.	37.5	-	35.1	30.0	-	30.0	100	-	100		11523
Min.	-	27.6	29.1	-	26.9	28.3	-	36	64		

DATE	H Mean (Meters)			H Sig (M)		H max		T Sig		T mean		
	max	min	mean	max	mean	max	mean	max	mean	max	min	mean
1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	7.7	9.5	20.4	8.5	13.4
2	0.2	0.2	0.2	0.3	0.2	0.5	0.3	9.0	6.7	20.4	-	11.8
3	0.2	0.2	0.2	0.3	0.3	0.4	0.3	8.5	7.4	11.5	7.0	11.5
4	0.3	0.2	0.2	0.3	0.3	0.5	0.4	10.5	8.4	21.9	9.0	13.9
5	0.2	0.2	0.2	0.3	0.2	0.4	0.3	9.5	8.1	19.9	7.5	11.3
6	0.3	0.2	0.2	0.5	0.3	0.8	0.5	8.5	6.1	12.5	5.0	7.6
7	0.3	0.2	0.2	0.4	0.3	0.6	0.4	9.0	6.9	10.0	7.5	8.6
8	0.3	0.2	0.2	0.3	0.3	0.4	0.3	10.0	8.4	16.0	9.0	11.5
9	0.3	0.2	0.2	0.4	0.3	0.5	0.3	10.5	8.0	17.4	7.5	11.0
10	0.3	0.2	0.3	0.4	0.4	0.7	0.5	7.0	6.2	9.0	6.5	7.6
11	0.3	0.2	0.2	0.4	0.3	0.6	0.4	8.5	7.1	13.5	6.5	9.6
12	0.3	0.2	0.2	0.4	0.3	0.5	0.5	10.0	6.6	10.0	5.5	7.5
13	0.4	0.2	0.3	0.7	0.5	1.6	0.9	7.5	5.1	9.0	4.5	5.7
14	0.5	0.3	0.4	0.7	0.5	1.1	0.8	5.5	5.2	7.0	5.0	5.9
15	0.3	0.2	0.2	0.4	0.3	0.6	0.4	10.5	7.7	15.0	7.0	10.5
16	0.3	0.2	0.3	0.5	0.4	0.8	0.6	8.0	6.5	9.0	6.0	7.7
17	0.3	0.2	0.2	0.4	0.3	0.5	0.4	10.0	7.4	10.5	7.5	9.0
18	0.3	0.2	0.2	0.4	0.3	0.5	0.4	10.5	7.7	11.5	8.0	9.6
19	0.3	0.2	0.2	0.4	0.3	0.6	0.5	8.0	6.7	10.0	5.5	7.2
20	0.4	0.2	0.3	0.5	0.4	0.9	0.6	10.5	6.7	13.5	5.5	8.6
21	0.3	0.2	0.3	0.4	0.4	0.7	0.5	9.5	8.0	14.0	7.5	10.2
22	0.3	0.3	0.3	0.5	0.4	1.0	0.6	9.0	7.0	10.5	6.5	8.5
23	0.5	0.3	0.4	0.7	0.5	1.2	0.9	6.0	5.7	8.5	6.0	6.7
24	0.4	0.3	0.4	0.6	0.5	1.1	0.8	6.5	5.9	7.5	6.0	6.7
25	0.3	0.3	0.3	0.4	0.4	0.7	0.6	6.0	5.9	8.5	6.0	6.9
26	0.3	0.2	0.3	0.4	0.4	0.6	0.5	8.0	6.8	10.0	7.0	8.3
27	0.3	0.2	0.3	0.4	0.3	0.6	0.5	9.0	7.6	12.0	7.0	9.1
28	0.5	0.2	0.4	0.8	0.6	1.5	1.0	7.0	5.7	8.5	5.0	5.9
29	0.5	0.4	0.4	0.7	0.6	1.3	1.0	5.5	5.4	6.0	5.5	5.9
30	0.4	0.3	0.4	0.6	0.5	1.1	0.9	6.5	5.6	6.5	5.0	5.6
31	-	-	-	-	-	-	-	-	-	-	-	-
Mean	0.3	0.2	0.3	0.5	0.4	0.7	0.5	8.4	6.9	12.0	6.5	8.8
Max.	0.5		0.4	0.8	0.6	1.6	1.0	10.5	9.5	21.9	-	13.9
Min.		0.2	0.2		0.2		0.3		5.1		4.5	5.6

SULTANATE OF OMAN
Directorate General of Meteorology
Ministry of Communication
CLIMATE SUMMARY

* ALL VALUES BASED ON 8 SYNOPTIC HOURS.

STATION: MINA QABOOS (BUOY NO. 1.)

MONTH: JULY 1983

LAT: 23°41'N
LONG: 58°33'E

DATE	Air Temperature (°C)			Sea Temp (C)			Rel. Humidity (%)			Wind (Dir./speed kts)		H Mean (Meters)			H Sig (M)		H max		T Sig		T mean		
	Max.	Min.	Mean	Max.	Min.	Mean	max	min	mean	Prev.	Max.	max	min	mean	max	mean	max	mean	max	mean	max	min	mean
1	32.5	31.4	32.0	30.0	30.0	30.0	100	88	97	27007	29012	0.3	0.3	0.3	0.5	0.4	0.8	0.6	8.5	7.2	10.0	6.0	7.8
2	32.5	31.3	32.0	30.0	30.0	30.0	100	94	97	27007	16512	0.4	0.3	0.3	0.5	0.5	0.9	0.7	8.0	7.4	9.0	6.0	7.3
3	33.6	31.8	32.8	30.0	30.0	30.0	100	82	95	18005	29013	0.4	0.3	0.3	0.5	0.5	0.9	0.7	8.5	7.3	9.5	7.5	8.3
4	34.6	32.0	32.9	30.0	30.0	30.0	100	92	96	18007	29014	0.5	0.4	0.4	0.7	0.6	1.4	1.0	8.5	7.8	7.5	6.5	7.0
5	34.2	31.7	33.3	30.0	30.0	30.0	100	85	93	27007	30013	0.4	0.4	0.4	0.7	0.6	1.3	1.0	9.0	7.9	8.0	7.0	7.3
6	32.9	31.6	32.2	30.0	30.0	30.0	100	100	100	27013	30019	0.4	0.3	0.4	0.7	0.6	1.1	0.9	7.0	5.7	8.0	4.5	5.7
7	31.0	30.2	30.6	30.0	30.0	30.0	100	100	100	27011	26018	0.5	0.4	0.5	0.8	0.6	1.3	1.1	6.5	5.9	7.5	5.0	5.9
8	31.0	30.0	30.4	30.0	30.0	30.0	100	100	100	22506	23011	0.4	0.4	0.4	0.6	0.5	1.3	0.9	7.0	6.5	7.0	6.0	6.5
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	31.5	30.4	31.0	30.0	30.0	30.0	100	90	98	27003	18509	0.4	0.3	0.4	0.5	0.5	0.9	0.7	8.0	6.7	9.5	6.5	7.6
11	33.6	31.1	32.3	30.0	30.0	30.0	100	92	98	27005	16010	0.3	0.3	0.3	0.4	0.4	0.7	0.5	8.5	7.5	11.0	7.5	8.9
12	31.8	30.0	31.3	30.0	30.0	30.0	100	100	100	27009	28517	0.4	0.3	0.3	0.5	0.4	0.9	0.6	7.5	6.3	10.0	4.5	7.7
13	30.3	29.6	29.8	30.0	29.0	29.8	100	100	100	27015	28521	0.4	0.3	0.4	0.6	0.5	1.2	0.9	5.0	4.6	5.5	4.5	4.7
14	29.3	28.5	28.8	29.3	27.0	28.3	100	100	100	27013	29018	0.3	0.2	0.3	0.5	0.4	0.8	0.6	6.0	5.3	7.0	4.5	6.0
15	30.5	27.9	29.5	30.0	26.2	28.1	100	100	100	27007	30015	0.3	0.2	0.2	0.4	0.3	0.5	0.5	9.5	7.7	14.0	6.5	9.5
16	33.1	29.8	31.2	30.0	28.0	29.5	100	70	92	09005	29009	0.3	0.2	0.2	0.4	0.3	0.5	0.4	9.5	8.4	22.4	8.0	12.1
17	32.5	29.8	31.0	30.0	29.5	29.9	100	92	97	31505	31011	0.3	0.2	0.2	0.4	0.3	0.5	0.4	13.0	9.5	20.9	6.5	12.9
18	31.7	30.3	31.1	30.0	30.0	30.0	100	100	100	27009	31015	0.3	0.2	0.3	0.4	0.4	8.0	1.8	8.0	6.8	10.0	5.5	7.7
19	30.7	29.8	30.2	30.0	30.0	30.0	100	100	100	27007	25015	0.3	0.3	0.3	0.4	0.4	0.7	0.6	7.5	6.4	9.0	5.5	7.3
20	31.0	30.2	30.6	30.0	29.0	29.8	100	100	100	27009	28014	0.3	0.2	0.3	0.4	0.4	0.6	0.5	8.0	7.3	10.0	6.5	7.6
21	30.3	28.9	29.9	29.9	27.9	28.9	100	100	100	27010	29517	0.3	0.2	0.3	0.4	0.4	0.6	0.5	8.0	6.3	7.0	6.0	6.4
22	31.6	29.3	30.2	30.0	27.3	28.9	100	100	100	27009	29017	0.3	0.2	0.3	0.4	0.4	0.8	0.6	6.5	5.9	7.5	5.5	6.5
23	31.2	29.0	30.2	29.1	27.3	27.8	100	78	96	27010	29016	0.4	0.3	0.3	0.5	0.4	0.8	0.6	7.0	5.6	7.0	5.0	5.9
24	28.7	27.5	28.1	27.3	26.5	26.9	100	100	100	31510	29018	0.4	0.3	0.3	0.5	0.5	0.9	0.8	5.5	5.0	7.0	4.5	5.6
25	8.0	27.2	27.7	26.7	26.0	26.3	100	100	100	27010	29014	0.4	0.3	0.3	0.5	0.4	0.8	0.6	6.0	5.0	6.5	5.5	6.3
26	28.1	27.1	27.6	26.8	25.4	26.2	100	100	100	27008	28513	0.3	0.3	0.3	0.4	0.4	0.8	0.6	6.5	5.9	7.5	5.5	6.5
27	28.5	27.1	27.6	27.1	25.6	26.5	100	100	100	27008	27015	0.4	0.3	0.3	0.5	0.4	1.2	0.7	7.5	6.1	8.5	6.0	6.7
28	27.1	26.5	26.9	26.4	24.8	25.9	100	100	100	27009	27512	0.4	0.3	0.4	0.6	0.5	1.0	0.8	6.0	5.5	7.0	0.7	5.4
29	27.1	25.3	26.3	26.6	23.9	25.1	100	100	100	27012	28018	0.4	0.3	0.3	0.6	0.5	1.1	0.8	5.5	5.1	7.0	5.0	5.9
30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mean	31.0	29.5	30.3	29.3	28.3	28.9	100	95	99	27009		0.4	0.3	0.3	0.5	0.4	1.1	0.7	7.6	6.5	9.3	5.7	7.3
Max.	34.6	32.0	33.3	30.0	30.0	30.0	100	100	100		28521	0.5		0.5	0.8	0.6	8.0	1.8	13.0	9.5	22.4		12.9
Min.	27.1	25.3	26.3	26.4	23.9	25.1	100	70	92				0.2	0.2		0.3		0.4		4.6		0.7	4.7

STATION: MINA QABOOS (BUOY NO. I.)

MONTH: AUGUST 1983

SULTANATE OF OMAN
Directorate General of Meteorology
Ministry of Communication
CLIMATE SUMMARY

* ALL VALUES BASED ON 8 SYNOPTIC HOURS.

LAT: 23°41'N
LONG 58°33'E

DATE	Air Temperature (°C)			Sea Temp (C)			Rel. Humidity (%)			Wind (Dir./speed kts)		H Mean (Meters)			H Sig (M)		H max		T Sig		T mean		
	Max.	Min.	Mean	Max.	Min.	Mean	max	min	mean	Prev.	Max.	max	min	mean	max	mean	max	mean	max	mean	max	min	mean
1	27.4	26.4	27.0	26.5	25.4	26.0	100	100	100	28009	30513	0.3	0.2	0.3	0.4	0.4	0.7	0.5	7.5	6.7	9.0	5.0	7.3
2	28.2	26.3	27.2	26.9	25.0	26.1	100	100	100	29008	27007	0.2	0.2	0.2	0.3	0.3	0.6	0.5	7.5	6.6	10.0	5.5	7.0
3	26.5	25.3	26.1	25.8	24.7	25.5	100	100	100	31512	30520	0.3	0.2	0.3	0.4	0.4	0.8	0.6	7.5	5.8	7.0	5.0	6.4
4	25.9	24.4	25.4	24.6	23.4	23.9	100	100	100	27010	29019	0.3	0.3	0.3	0.5	0.5	1.0	0.8	6.0	5.4	7.5	4.5	6.2
5	27.3	25.1	26.2	26.2	24.5	25.2	100	100	100	27011	28023	0.6	0.4	0.4	0.9	0.6	1.4	1.1	6.5	5.7	7.0	4.5	5.7
6	27.3	25.3	26.4	26.3	24.3	25.5	100	100	100	18003	29008	0.5	0.3	0.4	0.7	0.6	1.2	0.9	6.5	6.1	7.5	6.0	6.4
7	27.5	25.6	26.5	26.5	24.8	25.7	100	100	100	04505	22511	0.4	0.3	0.3	0.6	0.5	0.9	0.8	7.0	6.0	8.5	5.5	6.7
8	27.7	25.6	26.8	27.1	25.1	26.4	100	100	100	27008	24511	0.3	0.2	0.3	0.4	0.3	0.6	0.5	9.0	7.7	11.5	6.0	9.1
9	29.2	26.7	28.1	27.3	25.9	26.8	100	100	100	09007	09014	0.2	0.2	0.2	0.3	0.3	0.4	0.3	10.5	8.4	21.4	8.0	11.8
10	28.0	26.0	27.3	27.4	24.6	26.3	100	100	100	27018	27025	2.3	1.0	1.8	3.8	2.8	5.9	4.5	11.5	8.7	10.5	6.5	7.6
11	26.0	25.1	25.5	25.1	23.5	24.3	100	100	100	27014	28520	1.1	0.6	0.8	1.7	1.3	2.7	2.0	7.0	6.4	6.0	5.0	5.7
12	26.8	24.9	26.1	26.4	24.3	25.3	100	100	100	27006	28510	0.5	0.3	0.4	0.8	0.5	1.3	0.7	8.5	7.5	9.5	6.0	7.6
13	28.3	25.3	26.6	26.4	24.5	25.4	100	100	100	09005	09007	0.4	0.2	0.3	0.5	0.4	0.7	0.5	9.0	7.7	17.4	7.5	10.4
14	30.1	26.8	28.6	29.8	25.3	27.8	100	100	100	27006	05012	0.3	0.2	0.3	0.4	0.3	0.5	0.4	10.5	8.9	16.4	8.0	11.4
15	31.8	28.1	30.3	29.8	27.7	28.5	100	90	96	18002	31009	0.3	0.2	0.3	0.4	0.3	0.5	0.4	11.0	8.7	16.9	0.6	10.2
16	34.5	29.2	31.7	30.0	27.7	29.0	100	69	88	31508	30011	0.3	0.2	0.2	0.4	0.3	0.5	0.4	14.5	9.9	18.4	8.5	12.6
17	33.9	30.4	32.4	30.0	28.6	29.6	97	52	73	06007	06010	0.3	0.2	0.2	0.3	0.3	0.5	0.4	9.5	8.3	12.0	9.0	10.7
18	33.0	29.4	30.6	30.0	29.0	29.6	100	86	98	27007	26012	0.3	0.2	0.2	0.4	0.3	0.5	0.4	9.5	7.1	12.0	5.5	8.6
19	29.9	28.8	29.5	29.3	28.3	29.0	100	100	100	27010	28015	0.3	0.2	0.3	0.4	0.4	0.7	0.6	6.0	5.6	7.5	6.0	6.6
20	29.3	28.4	29.0	28.2	27.0	27.6	100	100	100	27009	29015	0.3	0.2	0.2	0.4	0.3	0.6	0.5	7.5	6.0	10.5	5.0	7.2
21	29.5	28.3	28.9	28.4	27.0	27.7	100	100	100	27009	29015	0.4	0.2	0.3	0.6	0.4	0.9	0.7	6.5	5.6	7.0	5.0	6.1
22	29.6	28.1	28.7	28.4	26.9	27.7	100	100	100	27009	29016	0.3	0.2	0.3	0.4	0.4	0.6	0.5	7.5	6.1	9.5	5.5	7.0
23	28.6	28.0	28.2	27.3	26.6	26.9	100	100	100	27009	30015	0.3	0.3	0.3	0.5	0.4	0.9	0.7	6.0	5.4	7.5	5.5	6.5
24	29.1	27.6	28.6	28.9	26.6	27.8	100	100	100	31507	30011	0.4	0.3	0.3	0.5	0.4	0.9	0.6	6.5	6.1	7.5	6.5	6.9
25	34.8	28.4	30.6	29.8	27.8	29.0	100	54	94	09003	31014	0.3	0.2	0.3	0.4	0.4	0.7	0.6	7.5	6.8	8.5	7.5	8.1
26	30.9	29.4	30.1	30.0	29.0	29.5	100	96	99	30010	28517	0.4	0.3	0.4	0.6	0.5	1.0	0.8	6.5	5.7	7.5	5.5	6.4
27	30.7	28.8	29.4	29.5	28.9	29.3	100	100	100	27010	28017	0.5	0.3	0.5	0.8	0.7	1.7	1.2	6.0	5.4	7.0	4.5	5.6
28	29.8	28.3	29.2	30.0	29.0	29.8	100	92	99	31511	30515	0.4	0.3	0.3	0.6	0.5	0.9	0.7	6.5	5.8	8.0	5.0	6.4
29	30.4	29.1	29.7	30.0	30.0	30.0	100	100	100	27009	30511	0.3	0.2	0.3	0.5	0.4	0.7	0.6	6.5	5.8	7.5	6.0	6.7
30	30.9	29.7	30.5	30.0	30.0	30.0	100	93	97	27007	29512	0.3	0.2	0.3	0.4	0.3	0.6	0.5	7.5	6.4	8.5	6.0	7.5
31	31.1	29.7	30.6	30.0	30.0	30.0	100	98	99	27008	27513	0.3	0.2	0.3	0.4	0.3	0.5	0.5	8.5	6.9	11.0	5.5	8.1
Mean	29.5	27.4	28.4	28.1	26.6	27.5	100	95	98	27009		0.4	0.3	0.4	0.6	0.5	1.0	0.8	8.0	6.7	10.2	5.8	7.7
Max.	34.8	30.4	32.4	30.0	30.0	30.0	100	100	100		27025	2.3		1.8	3.8	2.8	5.9	4.5	14.5	9.9	21.4		12.6
Min.	25.9	24.4	25.4	24.6	23.4	23.9	97	52	73				0.2	0.2		0.3		0.3		5.4		4.5	5.6

STATION: MINA QABOOS (BUOY NO.I)

MONTH: SEPTEMBER 1983

SULTANATE OF OMAN
Directorate General of Meteorology
Ministry of Communication
CLIMATE SUMMARY

* ALL VALUES BASED ON 8 SYNOPTIC HOURS.

LAT: 23°41'N
LONG: 58°33'E

DATE	Air Temperature (°C)			Sea Temp (C)			Rel. Humidity (%)			Wind (Dir./speed kts)		H Mean (Meters)			H Sig (M)		H max		T Sig		T mean		
	Max.	Min.	Mean	Max.	Min.	Mean	max	min	mean	Prev.	Max.	max	min	mean	max	mean	max	mean	max	mean	max	min	mean
1	33.1	30.2	31.7	30.0	30.0	30.0	100	63	87	27003	01509	0.3	0.2	0.2	0.3	0.3	0.4	0.3	14.0	9.3	27.4	8.0	15.0
2	34.3	30.5	32.3	30.0	30.0	30.0	100	62	80	27005	27508	0.2	0.2	0.2	0.3	0.3	0.5	0.4	11.5	9.1	21.9	7.0	12/7
3	30.0	28.8	29.4	30.0	30.0	30.0	100	100	100	27010	29016	0.4	0.2	0.3	0.6	0.5	1.1	0.8	8.0	5.4	11.5	5.0	6-2
4	29.8	29.1	29.3	30.0	29.4	29.9	100	100	100	27012	29517	0.3	0.2	0.3	0.5	0.4	0.9	0.7	5.5	4.8	7.0	4.5	5.6
5	30.1	29.1	29.6	30.0	29.3	29.6	100	99	100	27006	28513	0.3	0.2	0.3	0.4	0.4	0.7	0.6	6.5	5.9	7.5	5.0	6.6
6	30.3	29.4	29.7	30.0	29.8	29.9	100	100	100	27007	29512	0.3	0.2	0.3	0.4	0.4	0.6	0.5	7.0	6.5	8.5	6.5	7.4
7	29.9	29.2	29.5	30.0	28.7	29.4	100	100	100	27010	33017	0.4	0.2	0.3	0.5	0.4	1.0	0.7	7.0	5.7	9.0	5.0	6.4
8	29.3	28.6	28.9	29.6	28.4	28.9	100	98	100	31511	30017	0.5	0.4	0.4	0.7	0.6	1.3	1.1	5.5	5.3	6.0	5.0	5.6
9	29.5	28.4	29.0	29.7	28.1	29.0	100	97	99	31507	29012	0.5	0.3	0.4	0.7	0.6	1.3	1.0	6.0	5.5	7.0	5.5	6.3
10	28.8	28.4	28.6	30.0	28.9	29.5	100	100	100	-	25510	0.5	0.4	0.4	0.8	0.7	1.2	1.1	5.5	5.5	6.0	5.5	5.9
11	29.3	28.9	29.0	29.8	29.5	29.7	100	100	100	-	30015	0.4	0.4	0.4	0.7	0.6	1.3	1.0	6.5	5.6	7.0	5.0	6.0
12	28.9	28.3	28.6	30.0	29.5	29.8	100	100	100	27010	30020	0.5	0.4	0.4	0.8	0.6	1.5	1.2	6.0	5.1	6.0	5.0	5.4
13	29.1	28.2	28.4	30.0	29.1	29.6	100	98	99	27008	28012	0.4	0.3	0.3	0.6	0.5	1.0	0.7	6.0	5.7	8.0	5.5	6.5
14	29.8	28.7	29.1	30.0	29.6	29.9	100	87	97	27006	24009	0.3	0.2	0.3	0.4	0.4	0.8	0.5	9.5	6.9	13.0	7.0	8.9
15	30.2	28.7	29.7	30.0	29.8	29.9	100	81	95	09005	09513	0.3	0.2	0.3	0.4	0.3	0.5	0.5	9.5	7.8	12.0	7.5	9.7
16	31.1	29.6	30.4	30.0	29.9	30.0	100	90	97	09005	29010	0.3	0.2	0.3	0.5	0.4	0.9	0.6	7.0	6.1	8.0	6.5	7.1
17	29.8	29.7	29.8	30.0	30.0	30.0	100	94	99	27009	27013	0.3	0.2	0.3	0.4	0.4	0.6	0.5	8.5	6.7	11.5	5.0	7.4
18	31.0	29.2	30.4	30.0	30.0	30.0	100	77	94	13504	30012	0.3	0.2	0.3	0.4	0.3	0.5	0.5	8.0	7.2	9.5	8.0	8.7
19	33.9	30.0	31.8	30.0	30.0	30.0	100	62	77	04506	05009	0.3	0.2	0.2	0.3	0.3	0.5	0.4	10.0	8.4	16.4	8.5	11.4
20	33.0	30.6	31.7	30.0	30.0	30.0	99	62	80	09008	08017	0.2	0.2	0.2	0.3	0.3	0.5	0.4	10.0	7.8	16.9	5.0	10.7
21	34.9	30.0	31.4	30.0	30.0	30.0	100	47	88	09007	09017	0.3	0.2	0.3	0.4	0.4	0.7	0.5	7.0	6.3	9.5	5.5	7.1
22	32.6	30.7	31.3	30.0	30.0	30.0	100	71	93	13504	28010	0.3	0.2	0.3	0.4	0.4	0.5	0.4	8.0	6.7	11.5	7.0	8.9
23	32.1	30.3	31.1	30.0	30.0	30.0	100	84	91	18006	16510	0.3	0.2	0.2	0.3	0.3	0.5	0.4	8.5	7.1	9.5	7.0	8.8
24	31.7	29.9	30.5	30.0	30.0	30.0	100	87	95	27008	30020	0.3	0.2	0.2	0.4	0.3	0.8	0.5	8.5	6.5	21.4	5.0	11.0
25	31.9	29.8	30.6	30.0	30.0	30.0	96	64	85	31512	30017	0.3	0.2	0.3	0.5	0.4	0.9	0.6	7.5	4.9	8.5	5.0	5.9
26	33.0	30.1	31.2	30.0	30.0	30.0	96	60	77	31509	30514	0.3	0.2	0.2	0.4	0.3	0.6	0.4	12.0	8.1	43.9	4.5	16.1
27	33.4	31.0	31.8	30.0	30.0	30.0	86	62	75	09002	13009	0.3	0.2	0.3	0.4	0.3	0.5	0.4	9.5	7.2	33.4	7.5	14.7
28	33.5	30.9	31.7	30.0	30.0	30.0	94	59	77	31510	29013	0.3	0.3	0.3	0.4	0.4	0.7	0.5	7.5	6.1	8.5	6.5	7.6
29	31.4	30.2	30.9	30.0	30.0	30.0	98	63	81	31507	08511	0.4	0.3	0.3	0.6	0.5	1.0	0.7	6.5	6.2	8.5	6.0	7.3
30	31.3	29.8	30.7	30.0	30.0	30.0	92	775	85	-	36010	0.3	0.3	0.3	0.4	0.4	0.9	0.6	9.0	6.5	9.0	6.0	7.6
31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mean	31.2	29.5	30.3	30.0	29.7	29.8	99	81	92	27008		0.3	0.2	0.3	0.5	0.4	0.8	0.6	8.1	6.5	12.8	6.0	8.5
Max.	34.9	31.0	32.3	30.0	30.0	30.0	100	100	100		30020	0.5		0.4	0.8	0.7	1.5	1.2	14.0	9.3	43.9		16.1
Min.	28.8	28.2	28.4	29.7	28.1	28.9	86	47	75				0.2	0.2		0.3		0.3		4.8		4.5	5.4

SULTANATE OF OMAN
Directorate General of Meteorology
Ministry of Communication
CLIMATE SUMMARY

* ALL VALUES BASED ON 8 SYNOPTIC HOURS.

STATION : MINA QABOOS (BUOY NO. 1)
MONTH : OCTOBER 1983

LAT: 23°41'N
LONG: 58°33'E

DATE	Air Temperature (°C)			Sea Temp (C)			Rel. Humidity (%)			Wind (Dir./speed kts)		H Mean (Meters)			H Sig (M)		H max		T Sig		T mean		
	Max.	Min.	Mean	Max.	Min.	Mean	max	min	mean	Prev.	Max.	max	min	mean	max	mean	max	mean	max	mean	max	min	mean
1	31.2	29.8	30.4	30.0	30.0	30.0	97	73	89	09005	09509	0.3	0.2	0.3	0.4	0.3	0.5	0.5	9.0	7.1	11.0	8.5	9.6
2	33.7	31.1	32.4	30.0	30.0	30.0	76	53	60	09004	13511	0.3	0.2	0.2	0.3	0.3	0.5	0.4	11.0	8.6	15.0	7.0	10.3
3	33.2	31.7	32.3	30.0	30.0	30.0	66	53	60	09007	08013	0.3	0.2	0.2	0.4	0.3	0.6	0.4	8.0	6.7	11.5	6.5	8.6
4	33.2	31.8	32.5	30.0	30.0	30.0	64	37	54	09006	07514	0.3	0.2	0.3	0.4	0.3	0.7	0.5	8.0	6.4	17.4	6.0	8.6
5	35.9	31.1	32.3	30.0	30.0	30.0	74	33	55	13504	05512	0.2	0.2	0.2	0.3	0.3	0.4	0.3	9.5	7.7	14.5	8.5	11.0
6	33.4	31.1	32.0	30.0	30.0	30.0	81	35	58	09005	07010	0.2	0.2	0.2	0.3	0.2	0.5	0.3	10.0	7.9	22.4	9.0	13.9
7	31.8	30.3	31.1	30.0	30.0	30.0	89	54	71	22505	23508	0.2	0.0	0.2	0.3	0.2	0.4	0.3	8.0	5.9	66.8	0.0	21.0
8	31.2	29.5	30.5	30.0	30.0	30.0	94	64	81	18005	16511	0.2	0.0	0.1	0.3	0.2	0.4	0.2	8.0	3.9	28.4	0.0	8.4
9	31.4	29.2	30.3	30.0	30.0	30.0	89	41	69	09009	12518	0.3	0.2	0.2	0.4	0.3	0.8	0.5	7.0	5.2	12.5	4.0	7.3
10	31.1	29.6	30.4	30.0	30.0	30.0	82	49	67	09008	07513	0.3	0.2	0.2	0.4	0.3	0.6	0.4	8.0	6.6	16.0	5.0	8.9
11	31.3	29.4	30.6	30.0	30.0	30.0	72	54	63	09005	07511	0.2	0.0	0.2	0.3	0.2	0.3	0.2	12.5	6.7	50.8	0.0	14.5
12	32.0	30.2	31.1	30.0	30.0	30.0	66	34	52	31506	17510	0.2	0.2	0.2	0.2	0.2	0.2	0.2	12.0	8.2	52.8	9.0	30.5
13	31.2	29.9	30.7	30.0	30.0	30.0	66	39	56	09006	08015	0.4	0.2	0.3	0.5	0.4	0.9	0.6	6.0	5.0	7.5	5.0	5.8
14	31.1	29.1	30.2	30.0	30.0	30.0	82	48	65	09007	08018	0.3	0.2	0.3	0.4	0.4	0.9	0.6	6.0	4.9	8.0	4.0	6.1
15	31.5	29.7	30.5	30.0	30.0	30.0	71	36	59	09006	16512	0.2	0.2	0.2	0.3	0.2	0.4	0.3	7.0	5.9	19.9	7.5	12.2
16	30.6	29.0	29.8	30.0	29.9	30.0	80	61	70	13510	15013	0.4	0.2	0.3	0.6	0.4	1.1	0.6	5.5	4.8	7.0	5.0	5.9
17	30.4	28.7	29.4	30.0	29.7	29.9	79	62	68	13508	15012	0.3	0.2	0.2	0.4	0.3	0.5	0.4	6.0	5.3	12.5	5.0	6.7
18	29.1	28.1	28.7	30.0	29.6	29.8	82	68	76	31510	31017	0.4	0.2	0.2	0.5	0.3	1.0	0.4	13.0	6.3	49.8	4.5	14.7
19	29.3	28.0	28.6	29.9	29.6	29.7	77	58	67	31514	30019	0.4	0.3	0.3	0.6	0.5	1.3	0.9	5.0	4.6	6.0	4.5	5.1
20	29.6	27.5	28.7	29.9	29.4	29.6	75	44	59	27010	29015	0.3	0.2	0.2	0.4	0.3	0.6	0.5	6.0	5.2	8.5	5.0	6.5
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	29.5	28.3	28.8	29.4	29.0	29.1	68	56	62	27006	29509	0.2	0.2	0.2	0.3	0.3	0.4	0.3	7.0	6.4	10.5	6.0	8.0
23	28.7	28.0	28.4	29.2	28.8	29.0	76	60	69	27008	29512	0.2	0.2	0.2	0.2	0.2	0.3	0.3	11.0	6.5	42.4	5.5	13.0
24	31.6	27.6	29.2	30.0	28.8	29.3	73	53	66	09003	10510	0.2	0.2	0.2	0.3	0.2	0.4	0.2	8.0	6.9	57.3	7.5	15.5
25	30.1	27.7	28.5	29.6	28.9	29.1	79	58	68	09002	16514	0.2	0.2	0.2	0.3	0.2	0.3	0.3	16.0	7.7	29.9	7.0	14.7
26	28.7	27.8	28.2	29.4	28.9	29.2	81	63	73	09007	12512	0.2	0.2	0.2	0.3	0.2	0.5	0.4	6.5	5.2	17.4	4.5	8.2
27	29.2	27.1	27.9	29.8	29.1	29.3	75	61	67	27007	29511	0.2	0.0	0.1	0.2	0.1	0.2	0.1	7.5	2.6	26.9	0.0	7.2
28	28.6	26.6	27.4	29.4	28.8	29.0	73	62	67	31507	30511	0.2	0.0	0.1	0.2	0.1	0.2	0.1	10.0	4.1	76.8	0.0	21.3
29	29.6	27.2	28.4	28.9	28.5	28.6	73	41	59	09010	09013	0.2	0.2	0.2	0.4	0.3	0.5	0.4	9.5	5.6	16.0	4.5	7.7
30	29.1	27.0	28.0	28.6	28.3	28.5	78	36	65	09010	07013	0.2	0.2	0.2	0.3	0.3	0.5	0.5	8.0	5.9	10.0	4.5	7.2
31	27.8	26.5	27.2	28.5	28.0	28.3	85	64	71	27010	29515	0.3	0.2	0.2	0.4	0.3	0.7	0.5	8.0	6.3	9.5	4.5	7.4
Mean	30.8	28.9	29.8	29.7	29.5	29.6	77	52	65	09006		0.3	0.2	0.2	0.3	0.3	0.5	0.4	8.6	6.0	24.5	4.9	10.9
Max.	35.9	31.8	32.5	30.0	30.0	30.0	97	73	89		30019	0.4		0.3	0.6	0.5	1.3	0.9	16.0	8.6	76.8	9.0	30.5
Min.	27.8	26.5	27.2	28.5	28.0	28.3	64	33	52				0.0	0.1		0.1		0.1		2.6		0.0	5.1

STATION: MINA QABOOS - BUOY NO.I

MONTH: JANUARY 1984

SULTANATE OF OMAN
Directorate General of Meteorology
Ministry of Communication

CLIMATE SUMMARY

* ALL VALUES BASED ON 8 SYNOPTIC HOURS.

LAT: 23°41'N
LONG: 58°33'E

DATE	Air Temperature (°C)			Sea Temp (C)			Rel. Humidity (%)			Wind (Dir./speed kts)		H Mean (Meters)			H Sig (M)		H max		T Sig		T mean		
	Max.	Min.	Mean	Max.	Min.	Mean	max	min	mean	Prov.	Max.	max	min	mean	max	mean	max	mean	max	mean	max	min	mean
1	23.6	21.8	22.7	24.5	24.2	24.3	66	53	59	15005	07513	0.4	0.2	0.3	0.6	0.4	1.3	0.8	6.0	5.1	9.5	4.5	6.3
2	23.4	21.5	22.7	24.3	24.2	24.2	67	59	61	06006	28519	0.4	0.2	0.2	0.5	0.2	1.0	0.4	10.0	6.6	61.8	5.0	23.5
3	23.1	22.4	22.8	24.1	23.9	24.1	65	57	62	18009	07015	0.4	0.3	0.3	0.5	0.5	1.0	0.7	6.0	4.9	8.0	4.5	5.7
4	22.8	22.3	22.6	24.2	24.1	24.1	69	61	66	09010	09014	0.4	0.2	0.3	0.6	0.5	1.0	0.9	5.5	5.1	7.0	5.0	5.8
5	22.9	21.3	22.3	24.2	24.1	24.1	74	65	53	12009	11015	0.3	0.2	0.2	0.4	0.3	0.8	0.5	6.0	5.3	9.0	5.0	6.3
6	23.1	21.6	22.4	24.3	24.0	24.1	60	53	57	09006	09011	0.3	0.2	0.2	0.4	0.3	0.5	0.5	8.0	6.6	9.5	6.5	8.2
7	22.9	21.9	22.5	24.2	24.0	24.1	64	55	60	12006	17512	0.4	0.2	0.3	0.6	0.4	0.9	0.5	7.0	6.0	13.0	6.0	8.3
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	23.8	23.3	23.5	24.3	24.0	24.1	63	51	59	33005	33011	0.6	0.4	0.5	0.9	0.7	1.3	1.1	7.0	6.0	6.5	6.0	6.4
10	24.3	22.8	23.4	24.2	23.9	24.0	74	53	59	09006	16511	0.6	0.5	0.6	1.0	0.9	1.6	1.5	7.0	6.9	7.0	6.5	6.8
11	24.0	22.0	23.0	24.2	23.8	23.9	82	60	69	12005	06511	0.5	0.3	0.4	0.7	0.5	1.2	0.8	6.5	6.0	8.0	6.5	7.2
12	23.1	22.0	22.5	24.1	23.8	23.9	68	59	63	12007	29513	0.6	0.3	0.4	0.9	0.7	1.4	1.1	7.0	5.9	7.5	5.5	6.0
13	22.8	21.6	22.1	24.0	23.7	23.8	68	59	63	25006	25013	0.5	0.3	0.4	0.7	0.6	1.1	0.9	6.5	6.1	7.5	6.5	6.9
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	23.1	21.6	22.5	24.1	23.8	24.0	76	66	69	09006	09011	0.3	0.2	0.2	0.4	0.3	0.6	0.5	7.5	5.7	10.5	5.5	7.3
16	23.3	22.4	22.9	24.0	23.7	23.8	79	56	70	30010	29521	0.4	0.2	0.3	0.7	0.4	1.3	1.0	10.5	6.3	20.4	4.5	8.2
17	24.3	22.0	22.8	24.2	23.8	23.9	87	61	74	09005	06010	0.3	0.3	0.3	0.5	0.4	0.9	0.8	5.5	5.0	8.0	6.0	6.9
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	22.7	22.0	22.3	24.0	23.6	23.8	75	66	70	18005	16509	0.2	0.2	0.2	0.3	0.3	0.5	0.5	6.0	5.6	8.0	6.5	7.4
20	22.3	21.3	21.9	23.7	23.6	23.6	77	55	65	12013	12023	0.9	0.2	0.5	1.4	0.7	2.2	1.2	7.5	5.6	11.0	4.5	6.4
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	21.4	21.0	21.2	23.6	23.3	23.5	64	61	63	30010	29515	0.4	0.3	0.3	0.5	0.4	0.9	0.7	6.0	5.3	7.5	4.5	5.9
24	21.5	20.9	21.2	23.8	23.2	23.4	80	61	67	06007	07012	0.3	0.2	0.3	0.4	0.4	0.5	0.5	7.5	6.1	12.0	6.5	8.1
25	22.2	20.7	21.7	23.6	23.2	23.4	67	52	63	27007	31513	0.2	0.2	0.2	0.3	0.2	0.4	0.2	9.0	6.5	50.8	10.5	24.6
26	22.6	21.3	21.9	23.8	23.2	23.5	65	60	62	09004	09009	0.2	0.0	0.2	0.2	0.2	0.2	0.2	12.5	7.5	42.4	0.0	23.0
27	22.5	21.1	21.9	23.5	23.2	23.4	76	63	69	06006	31511	0.3	0.2	0.2	0.4	0.3	0.5	0.4	10.0	5.7	12.5	6.0	8.3
28	22.6	20.9	22.0	23.6	23.2	23.3	78	72	74	30009	29520	0.3	0.0	0.2	0.5	0.3	0.9	0.4	7.0	4.5	43.4	0.0	11.8
29	24.5	21.7	22.7	23.6	23.2	23.4	73	62	67	30010	30521	0.5	0.2	0.3	0.8	0.5	1.3	0.7	6.5	5.4	10.0	4.5	6.4
30	22.6	21.4	22.0	23.3	23.2	23.3	71	54	64	15012	07521	0.7	0.3	0.5	1.2	0.7	2.0	1.2	5.5	5.3	6.0	4.5	5.3
31	21.0	19.2	20.2	23.1	23.0	23.1	64	56	60	12018	11525	1.0	0.6	0.8	1.6	1.3	3.0	2.3	6.0	5.4	5.5	4.5	5.0
Mean	22.9	21.6	22.3	23.9	23.7	23.8	71	59	64	12010		0.4	0.2	0.3	0.7	0.5	1.1	0.8	7.3	5.8	15.5	5.2	8.9
Max.	24.5	23.3	23.5	24.5	24.2	24.3	87	72	74		11525	1.0		0.8	1.6	1.3	3.0	2.3	12.5	7.5	61.8	10.5	24.6
Min.	21.0	19.2	20.2	23.1	23.0	23.1	60	51	53				0.0	0.2		0.2		0.2		4.5		0.0	5.0

STATION: MINA QABOOS BUOY NO. I

MONTH: FEBRUARY 1984

SULTANATE OF OMAN
Directorate General of Meteorology
Ministry of Communication
CLIMATE SUMMARY

* ALL VALUES BASED ON 8 SYNOPTIC HOURS.

LAT: 23°41'N
LONG: 58°33'E

DATE	Air Temperature (°C)			Sea Temp (C)			Rel. Humidity (%)			Wind (Dir./speed kts)		H Mean (Meters)			H Sig (M)		H max		T Sig		T mean		
	Max.	Min.	Mean	Max.	Min.	Mean	max	min	mean	Prev.	Max.	max	min	mean	max	mean	max	mean	max	mean	max	min	mean
1	21.3	19.1	20.0	23.0	22.9	22.9	62	50	56	12016	09023	0.6	0.4	0.5	1.1	0.9	2.0	1.6	5.0	4.7	5.0	4.0	4.6
2	20.2	18.8	19.7	22.9	22.7	22.9	64	57	61	12016	12524	0.9	0.3	0.5	1.3	0.8	2.7	1.5	6.0	4.9	6.5	4.5	5.1
3	20.8	19.8	20.1	22.9	22.8	22.8	69	42	52	21007	07513	0.4	0.2	0.3	0.6	0.5	1.0	0.8	5.5	5.0	6.5	4.5	5.6
4	21.7	19.4	20.8	23.2	22.7	22.9	59	45	50	27007	32013	0.5	0.3	0.4	0.8	0.5	1.3	0.9	6.5	5.7	7.5	6.0	6.4
5	21.5	20.0	20.9	23.0	22.7	22.8	65	48	57	30011	29514	0.4	0.2	0.3	0.6	0.5	1.0	0.7	6.5	5.8	7.5	6.0	6.6
6	23.7	20.6	22.2	23.4	22.6	22.9	70	45	59	30007	07510	0.4	0.2	0.3	0.6	0.4	1.0	0.5	8.5	7.3	12.0	8.5	10.5
7	21.5	21.5	22.2	23.2	22.6	22.8	78	73	75	30013	31515	0.4	0.3	0.3	0.6	0.4	1.0	0.7	7.5	6.2	9.5	5.0	7.6
8	22.7	20.8	22.0	23.1	22.6	22.8	88	74	81	30010	31516	0.4	0.2	0.3	0.5	0.4	0.9	0.6	6.5	5.6	8.0	5.0	6.5
9	24.6	22.2	23.2	23.6	22.6	23.0	99	61	75		09007	0.2	0.0	0.2	0.3	0.2	0.4	0.2	8.5	6.8	11.9	0.0	23.6
10	22.8	21.3	22.1	23.0	22.7	22.8	83	68	73	12011	13017	0.4	0.2	0.3	0.6	0.4	1.6	0.8	5.0	4.6	6.0	4.5	5.2
11	22.7	20.8	21.9	23.0	22.6	22.8	88	46	75	09007	31512	0.3	0.2	0.2	0.4	0.3	0.5	0.5	6.5	5.6	9.0	4.5	6.9
12	22.3	21.2	21.9	23.4	22.7	22.9	91	82	86	30010	28513	0.2	0.2	0.2	0.3	0.2	0.5	0.3	10.5	6.7	34.9	4.0	12.3
13	22.9	20.4	22.3	23.0	22.6	22.8	84	69	75	30012	28915	0.3	0.2	0.2	0.4	0.3	0.7	0.4	8.0	5.6	45.9	4.0	11.7
14	23.5	22.0	22.9	23.5	22.7	23.0	83	56	66	30004	09008	0.4	0.3	0.4	0.7	0.5	1.2	0.9	7.0	6.6	8.0	7.5	7.9
15	25.4	22.8	23.8	23.4	22.7	23.0	66	31	55	03004	03507	0.3	0.3	0.3	0.5	0.4	0.7	0.5	8.0	7.4	10.0	7.5	9.0
16	23.9	22.8	23.3	23.2	22.9	23.0	73	59	65	09008	10513	0.4	0.2	0.3	0.6	0.4	0.9	0.6	9.5	6.3	13.0	5.0	7.7
17	22.4	21.9	22.1	23.1	22.8	22.9	77	63	69	15011	14016	0.6	0.4	0.5	0.9	0.6	2.1	1.2	5.5	5.1	5.5	5.0	5.3
18	22.3	20.7	21.3	23.0	22.8	22.9	69	41	55	21011	13023	0.7	0.3	0.5	1.1	0.9	1.9	1.5	5.5	5.1	5.5	4.5	4.9
19	19.0	17.8	18.4	22.8	22.6	22.7	49	35	45	24010	23524	1.6	0.7	1.1	2.5	1.9	5.2	3.0	7.5	6.9	6.5	5.5	6.2
20	18.6	17.8	18.3	22.6	22.4	22.5	41	27	36	24010	21017	1.2	0.4	0.8	1.9	1.2	3.4	2.1	6.5	5.9	6.0	5.5	5.7
21	20.3	18.5	19.7	22.7	22.3	22.5	57	37	46	27007	24011	0.6	0.4	0.5	0.9	0.7	1.5	1.1	5.5	5.3	7.0	5.0	5.9
22	21.1	19.7	20.7	22.6	22.3	22.5	65	50	59	30010	28515	0.5	0.2	0.4	0.8	0.5	1.2	0.9	6.5	5.7	7.5	5.5	6.3
23	21.7	20.4	21.1	22.5	22.2	22.4	70	53	62	30009	28916	0.3	0.3	0.3	0.4	0.4	0.8	0.7	6.0	5.3	7.5	5.5	6.4
24	22.1	20.7	21.6	22.7	22.2	22.4	76	62	67	30010	30913	0.4	0.4	0.4	0.6	0.5	1.0	0.9	7.5	6.5	8.0	6.5	7.1
25	22.8	22.2	22.5	22.9	22.2	22.5	89	63	80	30013	30517	0.3	0.3	0.3	0.5	0.5	0.9	0.7	7.5	6.1	10.0	5.0	7.3
26	22.6	21.4	22.2	23.0	22.3	22.6	94	78	84	30015	29020	0.4	0.3	0.3	0.7	0.5	1.3	0.9	6.0	5.1	7.5	4.5	5.7
27	22.6	21.7	22.1	23.2	22.4	22.7	90	80	84	30013	30516	0.4	0.3	0.3	0.5	0.4	1.3	0.8	6.5	5.6	8.0	5.0	6.2
28	22.5	21.3	21.9	23.1	22.4	22.7	89	71	81	33008	09011	0.3	0.3	0.3	0.4	0.4	0.7	0.6	8.0	6.9	10.0	8.0	8.7
29	23.0	22.0	22.4	23.2	22.6	22.9	89	80	83	15008	10514	0.3	0.2	0.3	0.4	0.4	0.6	0.5	8.0	7.3	9.0	6.5	8.1
30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mean	22.2	20.7	21.5	23.0	22.6	22.8	75	57	66	30010		0.5	0.3	0.4	0.7	0.5	1.3	0.9	6.9	5.9	11.3	5.3	7.6
Max.	25.4	22.8	23.8	23.6	22.9	23.0	99	82	86		12524	1.6		1.1	2.5	1.9	5.2	3.0	10.5	7.4	45.9	8.5	23.6
Min.	18.6	17.8	18.3	22.5	22.2	22.4	41	27	36				0.0	0.2		0.2		0.2		4.6		0.0	4.6

STATION: MINA KABOOS (BUOY NO I)

MONTH: MARCH 1984

SULTANATE OF OMAN
Directorate General of Meteorology
Ministry of Communication
CLIMATE SUMMARY

* ALL VALUES BASED ON 8 SYNOPTIC HOURS.

LAT: 23°41'N
LONG: 58°33'E

DATE	Air Temperature (°C)			Sea Temp (C)			Rel. Humidity (%)			Wind (Dir./speed kts)		H Mean (Meters)			H Sig (M)		H max		T Sig		T mean		
	Max.	Min.	Mean	Max.	Min.	Mean	max	min	mean	Prev.	Max.	max	min	mean	max	mean	max	mean	max	mean	max	min	mean
1	23.8	21.3	22.5	23.6	22.7	23.2	93	59	79	06006	04511	0.3	0.2	0.2	0.4	0.3	0.5	0.5	10.0	8.7	11.5	7.0	8.9
2	23.1	21.8	22.4	23.4	22.9	23.1	88	62	77	09007	09013	0.3	0.2	0.2	0.4	0.3	0.6	0.5	7.0	6.5	7.0	6.0	6.6
3	23.9	21.8	23.0	23.3	22.9	23.1	83	53	73	09007	16013	0.3	0.3	0.3	0.4	0.4	0.8	0.6	7.0	5.8	8.5	5.5	6.9
4	24.8	22.6	23.8	23.3	22.9	23.1	76	43	58	09010	07513	0.3	0.2	0.2	0.4	0.3	0.5	0.4	8.0	6.1	9.5	6.0	8.0
5	25.9	22.5	24.1	24.2	22.9	23.5	80	43	63	15005	15009	0.2	0.0	0.2	0.3	0.2	0.4	0.2	10.0	7.3	42.4	0.0	16.3
6	24.9	22.4	23.9	24.0	23.1	23.5	99	54	73	12005	09011	0.2	0.0	0.2	0.2	0.2	0.3	0.2	14.0	6.9	28.4	0.0	12.6
7	25.4	22.8	24.4	24.2	23.3	23.6	84	61	71	30007	28509	0.2	0.0	0.1	0.3	0.1	0.3	0.2	13.5	6.0	42.4	0.0	12.3
8	25.3	23.2	23.9	24.8	23.4	23.9	100	75	89	30006	28510	0.3	0.2	0.2	0.3	0.2	0.3	0.3	15.0	11.6	28.9	14.0	21.0
9	26.1	24.0	25.2	25.0	23.8	24.4	93	63	82	21003	19507	0.2	0.2	0.2	0.3	0.2	0.3	0.2	27.9	15.2	89.2	17.9	35.5
10	28.8	24.7	26.0	26.3	24.3	25.1	94	58	72	09003	12505	0.2	0.0	0.1	0.2	0.1	0.2	0.1	28.9	12.8	74.3	0.0	25.2
11	26.3	23.0	25.1	25.8	24.0	24.7	100	64	86	06008	31012	0.2	0.2	0.2	0.3	0.2	0.4	0.3	11.0	9.0	20.5	9.0	14.9
12	26.1	23.8	25.1	25.0	23.9	24.5	100	75	93	30010	31513	0.2	0.2	0.2	0.3	0.2	0.3	0.2	11.5	8.0	21.9	11.5	15.5
13	28.0	24.9	25.9	25.1	23.5	24.2	100	44	77	27006	25513	0.2	0.2	0.2	0.3	0.2	0.5	0.3	13.0	8.3	47.9	4.0	23.4
14	28.6	24.6	26.1	25.1	24.3	24.6	96	47	76	27012	03519	0.4	0.2	0.3	0.5	0.4	0.9	0.6	7.0	5.5	9.5	4.5	6.7
15	28.2	23.9	26.1	24.4	23.6	24.0	95	42	71	03016	04524	0.2	0.3	0.4	1.1	0.6	1.6	1.0	6.5	5.9	6.0	5.0	5.5
16	25.2	23.7	24.6	24.8	23.8	24.2	100	93	98	30007	31014	0.5	0.2	0.3	0.8	0.5	1.2	0.7	7.0	6.4	7.5	6.0	5.6
17	27.1	24.4	25.5	25.8	24.0	24.8	100	51	87	12007	10514	0.3	0.2	0.2	0.4	0.3	0.8	0.4	9.0	7.2	14.0	6.0	9.4
18	28.2	24.6	25.8	25.8	24.6	25.3	100	39	85	12011	11521	0.4	0.2	0.3	0.5	0.3	0.9	0.5	9.5	6.7	16.4	4.5	8.5
19	26.1	24.4	25.0	25.5	25.0	25.1	94	70	82	12011	12519	0.5	0.3	0.4	0.7	0.6	1.5	1.1	6.5	5.1	7.0	4.5	5.6
20	26.1	23.6	25.1	26.2	25.0	25.6	98	78	89	09004	31519	0.3	0.2	0.2	0.5	0.3	0.8	0.6	7.0	5.9	8.5	4.5	7.1
21	25.3	24.6	24.9	26.3	25.6	26.0	100	100	100	09008	09010	0.2	0.2	0.2	0.3	0.2	0.6	0.3	11.5	6.4	16.4	5.0	9.3
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	27.8	26.5	27.0	26.5	25.3	25.9	94	51	77	30012	30015	0.2	0.2	0.2	0.4	0.3	0.5	0.3	7.0	5.5	16.0	4.5	8.1
27	30.5	25.5	27.0	26.1	25.4	25.6	100	37	87	30008	30514	0.2	0.2	0.2	0.4	0.3	0.5	0.4	6.0	5.6	8.5	5.0	6.6
28	27.1	24.5	26.3	26.9	25.5	26.1	100	82	94	06009	06012	0.2	0.0	0.1	0.3	0.2	0.5	0.2	7.0	4.6	54.8	0.0	16.2
29	27.4	26.5	27.1	26.6	25.9	26.3	90	69	80	06007	07514	0.2	0.2	0.2	0.3	0.3	0.5	0.3	6.5	5.6	17.4	4.5	7.7
30	31.3	26.8	28.3	22.8	25.4	26.5	78	24	61	06005	07009	0.2	0.2	0.2	0.3	0.2	0.3	0.3	9.0	6.6	40.4	7.0	16.7
31	28.8	26.6	27.6	27.4	26.1	26.7	100	69	81	09001	12007	0.2	0.0	0.2	0.3	0.2	0.3	0.2	9.5	6.2	25.4	6.6	12.9
Mean	26.7	24.0	25.2	25.3	24.2	24.7	94	59	80	09006		0.3	0.2	0.2	0.4	0.3	0.6	0.4	10.6	7.2	25.2	5.5	12.4
Max.	31.3	26.8	28.3	27.8	26.1	26.7	100	100	100		04524	0.7		0.4	1.1	0.6	1.6	1.1	28.9	15.2	89.2	17.9	35.5
Min.	23.1	21.3	22.4	23.3	22.7	23.1	76	24	58				0.0	0.1		0.1		0.1		4.6		0.0	5.5

SULTANATE OF OMAN
Directorate General of Meteorology
Ministry of Communication
CLIMATE SUMMARY

* ALL VALUES BASED ON 8 SYNOPTIC HOURS.

STATION: BUOY NO.1 (MINA QABOOS)

MONTH: APRIL 1984

LAT: 23°41'N
LONG: 58°33'E

DATE	Air Temperature (°C) Max.	Min.	Mean	Sea Temp (C) Max.	Min.	Mean	Rel. Humidity (%) max	min	mean	Wind (Dir./speed kts) Prev.	Max.	H Mean (Meters) max	min	mean	H Sig (M) max	mean	H max max	mean	T Sig max	mean	T mean max	min	mean
1	27.5	26.6	27.1	27.7	26.5	27.3	100	87	95	27005	12011	0.2	0.2	0.2	0.3	0.2	0.3	0.2	22.9	10.5	73.8	11.0	24.5
2	31.0	27.6	28.3	27.9	27.0	27.4	90	56	71	12006	13509	0.2	0.2	0.2	0.3	0.2	0.3	0.2	14.5	10.9	37.4	8.5	19.9
3	28.6	26.9	27.5	27.1	26.3	26.8	77	46	64	09009	09013	0.3	0.2	0.2	0.4	0.3	0.5	0.5	12.5	6.5	34.9	5.0	10.3
4	28.3	26.5	27.3	26.6	26.1	26.3	80	43	59	15006	14011	0.5	0.2	0.3	0.7	0.5	1.3	0.7	8.0	5.8	8.0	5.0	6.2
5	29.2	26.2	27.3	26.7	25.9	26.3	94	47	64	12007	07513	0.3	0.2	0.2	0.4	0.3	0.6	0.4	6.5	5.8	24.4	5.5	9.9
6	28.8	26.0	28.1	27.4	26.0	26.8	93	55	72	30005	27009	0.2	0.0	0.1	0.3	0.1	0.3	0.1	12.5	5.1	21.4	0.0	9.5
7	29.8	27.7	28.4	28.3	26.7	27.2	86	65	80	30006	29509	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	31.1	26.0	28.4	28.0	26.9	27.5	100	66	77	27003	36007	0.2	0.0	0.2	0.2	0.2	0.3	0.2	13.5	7.9	58.3	0.0	23.8
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	27.4	26.4	27.1	27.0	25.7	26.5	100	100	100	27008	27012	0.3	0.2	0.2	0.4	0.3	0.6	0.5	7.0	5.4	9.0	4.5	6.3
11	27.6	25.5	26.7	26.8	24.8	25.9	100	100	100	06015	06518	0.3	0.2	0.2	0.4	0.3	0.5	0.5	7.0	5.9	10.0	5.5	7.6
12	27.6	26.5	27.2	27.2	26.3	26.8	100	100	100	27008	27010	0.3	0.2	0.2	0.3	0.3	0.5	0.4	6.5	5.9	10.0	7.5	8.7
13	30.9	26.8	29.0	29.3	26.7	27.9	100	60	87	06009	11515	0.2	0.0	0.1	0.2	0.1	0.3	0.1	9.0	3.5	52.3	0.0	13.6
14	31.3	29.7	30.3	28.0	27.2	27.6	68	37	57	12007	10513	0.2	0.2	0.2	0.4	0.3	0.5	0.3	6.0	5.6	13.5	5.5	8.5
15	30.9	29.1	30.1	28.5	27.3	27.8	78	51	62	12007	09016	0.2	0.2	0.2	0.4	0.3	0.5	0.4	7.5	5.6	14.0	4.5	6.9
16	30.8	28.7	29.6	28.0	27.5	27.7	76	45	63	12007	12512	0.4	0.2	0.3	0.7	0.4	1.4	0.6	6.5	5.3	28.4	5.0	9.4
17	31.6	28.7	30.0	29.3	27.4	28.2	80	48	65	30007	30510	0.3	0.0	0.1	0.3	0.1	0.4	0.2	11.5	5.0	18.9	0.0	8.8
18	34.0	29.3	31.2	28.5	27.5	28.1	74	31	59	18004	23507	0.2	0.2	0.2	0.3	0.2	0.5	0.3	10.0	6.7	38.9	5.0	13.0
19	28.8	27.5	28.1	28.1	27.6	27.9	82	56	67	12013	11520	0.7	0.2	0.5	1.1	0.8	1.9	1.4	5.5	5.3	10.5	5.0	5.8
20	29.4	27.5	28.4	27.9	27.4	27.7	79	50	71	15008	07017	0.3	0.2	0.3	0.5	0.4	0.9	0.6	8.5	5.7	10.0	5.0	6.7
21	31.0	28.4	29.7	29.1	27.6	28.2	87	39	67	30005	31007	0.2	0.0	0.2	0.3	0.2	0.3	0.2	16.4	10.9	29.4	0.0	11.6
22	32.4	28.5	30.1	30.0	27.7	28.7	84	45	68	27003	07007	0.4	0.2	0.2	0.5	0.2	0.6	0.3	21.9	12.4	67.8	17.4	38.7
23	32.2	28.9	30.1	29.0	28.2	28.6	98	42	77	27003	29509	0.2	0.0	0.2	0.3	0.2	0.3	0.2	15.0	10.9	74.8	0.0	28.6
24	33.8	29.7	31.2	30.0	28.4	29.2	76	16	59	30005	30009	0.3	0.2	0.2	0.3	0.2	0.3	0.2	20.9	15.1	91.2	29.9	51.4
25	33.4	29.5	31.1	29.7	28.5	29.0	73	50	59	33005	31010	0.2	0.0	0.2	0.2	0.2	0.2	0.2	21.9	13.2	78.8	0.0	37.1
26	32.6	30.2	31.6	30.0	28.5	29.1	62	46	54	09006	16511	0.2	0.0	0.1	0.3	0.2	0.4	0.2	20.9	8.3	62.8	0.0	17.4
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	30.8	28.8	30.0	28.5	28.2	28.4	65	49	58	12007	07511	0.4	0.3	0.3	0.5	0.5	1.0	0.8	5.5	5.0	7.0	5.0	5.9
29	31.8	28.2	30.4	28.8	28.3	28.5	62	34	50	09011	08019	0.4	0.3	0.3	0.7	0.5	1.3	0.9	6.0	4.9	7.5	4.5	5.3
30	34.3	31.0	32.1	29.6	28.5	28.9	55	22	41	09010	09021	0.3	0.2	0.2	0.4	0.3	0.7	0.4	8.5	6.1	21.9	5.0	9.5
31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mean	30.6	28.0	29.1	28.3	27.2	27.7	83	53	69	12008	X	0.3	0.1	0.2	0.4	0.3	0.6	0.4	11.1	7.1	32.7	5.1	14.5
Max.	34.3	31.0	32.1	30.0	28.5	29.2	100	100	100	X	09021	0.7	X	0.5	1.1	0.8	1.9	1.4	22.9	15.1	91.2	29.9	51.4
Min.	27.4	25.5	26.7	26.6	24.8	25.9	55	16	41	X	X	X	0.0	[illegible]	X	0.0	X	0.0	X	0.0	X	0.0	0.0

2.2 GHUBRAH POWER STATION

SEA WATER TEMPERATURE

Ghubrah Power Station Sea Water Temperature - 1/2

1984		1983	
MONTH, DATE	S.W. TEMPERATURE (°C)	MONTH, DATE	S.W. TEMPERATURE (°C)
1. 4	23.7	1982.12.27	22.3
1.12	23.8	1. 9	23.3
1.18	23.5	1.12	23.0
2. 4	22.2	1.19	22.9
2.MIDDLE	23.6	1.25	22.4
2.25	22.5	2. 5	21.6
3. 5	24.4	4.15	25.0
3.11	24.0	4.MIDDLE	25.5
3.18	25.5	4.END	27.5
3.END	25.5	5.19	30.0
4. 3	27.0	6. 5	32.4
4.18	28.2	7. 4	33.5
5.11	29.0	7.12	31.4
5.END	30.5	7.19	31.0
6. 7	32.1	7.26	24.1
6.20	33.7	8. 4	21.5
6.25	32.2	8.11	22.3
7. 5	30.5	8.18	26.5
7.17	27.2	8.27	27.0
8.14	27	9. 5	27.0
8.26	28.4	10.18	30.0
2.END	23.6	10.END	29.0
		11.MIDDLE	27.0
		11.MIDDLE	26.8

Ghubrah Power Station Sea Water Temperature - 2/2

1982		1981	
MONTH, DATE	S.W. TEMPERATURE (°C)	MONTH, DATE	S.W. TEMPERATURE (°C)
2. 2	23.3	1980.12.26	23.4
4.17	28.3	2.25	22.6
4.26	28.7	4.25	28.5
5. 5	28.5	7.18	30.5
5.10	30.4	7.28	32.0
5.18	30.3	9. 5	29.4
6.26	32.2		
7.17	32.5		
7.28	27.5		
8. 4	31.2		
8.11	31.3		
8.20	30.2		
8.28	27.6		
9. 3	27.3		
9.11	30.5		
9.17	30.4		
9.25	30.6		
12.11	23.4		
12.19	23.8		

ANNEX 3

REVERSE OSMOSIS PROCESS

FOR

POWER AND DESALINATION COMPLEX PLANT

IN

THE SULTANATE OF OMAN

1. OUTLINE OF REVERSE OSMOSIS PROCESS

(1) Principle

In general, it is said that a membrane, which allows water to pass through and retards the passage of dissolved ions and molecules, is a semipermeable membrane. A tank is devided into two parts with this semipermeable membrane. And pure water and aqueous solution, which contains ions and molecules are fed into each side of the tank respectively. This produces a force to eliminate the concentration difference, thus allowing the pure water to permeate into the aqueous solution through the semipermeable membrane (osmosis phenomenon). This flow continues until the pressure difference between two sides developed by the above permeation reaches the pressure (force) produced by the concentration difference. This pressure difference is called "osmotic pressure". If a pressure higher than the osmotic pressure is applied to the aqueous solution side in the above system, the flow is from the aqueous solution to the pure water which is in the opposit direction to the osmosis phenomenon.

This is called reverse osmosis.

(2) Features of Reverse Osmosis (RO) Process

RO process has following advantages.

a) Less energy consumption

Because of non-phase-change property, which is shown above, RO is less energy consumption process.

b) Cheaper construction cost

c) Smaller required space and shorter construction period

d) Easier operation and shorter start up time

(3) Application of RO Process

The process such as Evaporation, RO, electrodialysis (ED) and freezing are applied for a process to produce potable water from sea water and brackish water. And each rough market share in land based desalination plant is 76% for evaporation, 20% for RO, 4% for ED.

And in the view point of raw water source, evaporation process is mainly applied for sea water desalination and RO/ED process are mainly applied for brackish water desalination.

There are easily understood with the differences in principles between evaporation and RO, and the most effective application, which can realize the features of RO process, is for a desalination of brackish water which contains salt between 2000 and 5000 ppm.

However, recently, RO process has been rated as a competitive process against evaporation, because RO membrane, which has high salt rejection and high permeability, and which can realize the single stage desalination from sea water, has been developed and been operated more than five years.

Especially in countries difficult to get cheap energy source and in single purpose desalination plant, RO process has been adopted widely.

These can be clearly understood with the event that the RO process occupied 6 plants among 8 of more than 1 MGD desalination plants contracted in 1984.

2. PLANT DESCRIPTION

(1) Plant Specification

System	:	Single stage desalination by RO
Production capacity	:	*180,000* m^3*/day*
Nos. of Unit	:	15,000 m^3/day x 12 Units
Quality of product water	:	WHO Guideline

Water balance	:	Sea water intake 540,000 m^3/day
	:	RO module feed 515,000 m^3/day
	:	Product water 180,000 m^3/day
	:	Brine & waste 360,000 m^3/day
RO module	:	for Single stage sea water desalination
Module operating condition	:	Raw sea water TDS 39,600 ppm
	:	Operating pressure 60 - 65 kg/cm^2
	:	Recovery ratio 35%
	:	Feed FI 4 and less
		(FI is abbreviation of Fouling Index and it means index of very small solids & particles of module feed water in RO process.)
	:	Feed pH 6 - 6.5
	:	Feed Chlorine 1.0 mg/l and less
	:	Feed temperature 22 - 35 °C
Electric power supplied	:	38,700 kW
Required overall space	:	48,000 m^2 (160 m x 300 m)
Building	:	11,950 m^2
for RO operation	:	5,000 m^2 (50 m x 100 m)
for Pump station	:	1,350 m^2 (30 m x 45 m)
for Waste water treatm.	:	250 m^2 (10 m x 25 m)
for Substation	:	400 m2 (20 m x 20 m)
for Office	:	500 m2 (20 m x 25 m)
for Warehouse & work shop	:	1,200 m^2 (30 m x 40 m)

Organization

Plant manager	:	1
Administration section	:	9
Operating section	:	48
Maintenance section	:	26
Total	:	84 persons

Construction period	:	24 months (excluding design and engineering period)
Annual operating days	:	330 days
Plant life	:	20 years

(2) System Configuration

Pretreatment section	Coagulation & sedimentation basin Gravity dual media filter 48 filters (8 filters x 6 units)
RO section	Safety cartridge filter High press. pump & power recovery turbine RO module (12 units)
Post treatment section	Lime dosing unit
Membrane cleaning section	
Chemical dosing section	Ferric chloride dosing unit Sulfuric acid dosing unit (Sodium hypochloride will be dosed in the sea water intake section) Polyelectrolyte dosing unit (for waste water treatment)
Waste water treatment section	Coagulation clarifier Thickener Dewatering Decanter

(3) Process Description

a) Pretreatment section

Raw sea water is transferred to flocculation basin after dosage of ferric chloride. In the basin, the flock of ferric hydroxide is formed, and colloidal and suspended solids in raw sea water will be caught in the flock. And flocculated sea water is introduced into gravity dual media filter, and filtrated completely and then stored in filtered water basin.

Each dual media filter will be backwashed once a day using raw sea water and scouring air, and backwash waste water is transferred to waste water treatment section.

And chlorine to prevent the growth of microorganisms in raw sea water is expected being doesd in raw sea water intake section, and the residual chlorine concentration at the inlet of pretreatment section will be expected to remain in the level of 1 through 2 mg/l.

b) RO Section

Filtered sea water, which is stored in filtered water basin, is transferred by booster pump to the suction side of high pressure pump after it is polished by safety cartridge filter.

In the piping just before the filter, sulfuric acid is dosed in order to control automatically the pH value of raw sea water between 6 and 6.5.

Polished raw sea water is pressurized by high pressure pump in the level between 60 and 65 kg/cm^2 and fed to RO module after the feed flow rate is controlled in the predetermined level.

In RO module, raw sea water is separated into desalinated water (product water) and concentrated sea water. The concentrated sea water, which still has residual pressure of 58 through 63 kg/cm^2, is transferred into power recovery turbine and the energy contained in it is recovered. After that, concentrated sea water is discharged together with the effluent of waste water treatment section.

c) Post treatment section

Slaked lime is doesed to product desalinated water from RO section in order to control the pH value and to add minerals for it, because the value of pH and minerals of product water is in relatively low level.

d) Membrane cleaning section

RO membrane is cleaned once per 6 months in maximum using citric acid and aqueous ammonia.

e) Waste water treatment section

Backwash waste water from pretreatment section is stored in backwash waste basin in order to uniform the concentration of suspended solids in it, and then transferred to coagulation clarifier.

In the clarifier, anionic polyelectrolyte is dosed and suspended solids concentration of over flow is reduced to less than 20 ppm.

After that, over flow of clarifier is discharged together with concentrated sea water from RO section.

Sludge drain of clarifier is transferred to thickener in order to concentrate the sludge and then transferred to dewatering decanter. In the piping, cationic polyelectrolyte is dosed in order to improve efficiency of dewatering in decanter.

And over flow and filtrated water from decanter is returned to coagulation clarifier.

(4) Materials for Major Part

RO process has a feature of non-phase-change, which can be understood with principles of the process, and all part of the plant can be operated under the normal temperature. Therefore, it is not necessary in RO process to apply high grade materials like titanium or copper-nickel alloy, which is applied to the high temperature part of evaporation process.

Materials to be applied for RO process are as follows.

Equipment (Contact to sea water) : 316 SS/CS + rubber lining

Equipment (Contact to fresh water): 304 SS or C.I.

Piping (Contact to sea water)

[Large size / High pressure]	:	CS + PE lining (Sch.80)
[Large size / Low pressure]	:	CS + PE lining or FRP
[Small size / High pressure]	:	316 SS
[Small size / Low pressure]	:	FRP

Piping (Contact to fresh water) : FRP

(5) Chemicals list

Ferric chloride	:	37%	sol.	[Coagulant for pretreatment]
Sulfuric acid	:	98%	sol.	[pH control]
Slaked lime	:	100%	powd.	[Post treatment]
Polyelectrolyte (A)	:	100%	powd.	[Coagulant for waste treatment]
Polyelectrolyte (C)	:	100%	powd.	[Coagulant for waste treatment]
Citric acid	:	100%	powd.	[Membrane cleaning]
Aqueous ammonia	:	25%	sol.	[Membrane cleaning]
Formalin	:	40%	sol.	[Membrane preservation]

(6) Maintenance Items

Following periodical maintenance items shall be considered.

a) Daily items

Patrol and visual check for equipment
Check for chemicals quantity

b) Monthly items

Replacement of cartridge filter elements
Replenishment of chemicals

c) Annual items

Replacement of spare parts and overhaul for equipment
Membrane cleaning and replacement

3. CONSTRUCTION COST

[Overall construction cost] : 95.760 MRO

(Items)	
CIF	47.606 MRO
Erection	10.944 MRO
Civil & Building	37.210 MRO

4. OPERATING COST

[Overall operating cost] : 0.1557 RO/m^3 product

	(Items)	(Consumption)	(Unit price)	(Operating cost)
(1)	Electricity	4.27 kWh/m^3	@0.020 RO/kWh	0.0854 RO/m^3
(2)	Chemicals			0.0393 RO/m^3
	Ferric chloride	33.2 g/m^3	@0.182 RO/kg	0.0060
	Sulfuric acid	171.4 g/m^3	@0.176 RO/kg	0.0302
	Slaked lime	26.0 g/m^3	@0.0715 RO/kg	0.0019
	Polyelectrolyte	0.266 g/m^3	@0.266 RO/kg	0.0001
	Citric acid	1.21 g/m^3	@0.847 RO/kg	0.0010
	Aq. Ammonia	0.364 g/m^3	@0.364 RO/kg	0.0001
(3)	Cartridge filter	0.0066 pcs/m^3	@1.5 RO/pc	0.0099 RO/m^3
(4)	RO membrane	--	--	0.0211 RO/m^3
	Total			0.1577 RO/m^3

ANNEX 4

CALCULATION FOR
AIR POLLUTION IN ENVIRONMENT PROBLEM

Calculation for Air Pollution in Environment Problem

Type-A So 1% Chimney 80 m

1. Fuel Consumption

Basic Specification	Abbreviation/Unit		Applying value of this project
1. Output at Generator end	Po	MW	120
2. Power plant thermal efficiency	ηp	%	25
3. Fuel combustion ratio	α	%	100
4. High heat value of fuel	Hh'	kcal/kg	10,700

Calculation Form

° Fuel consumption — Fo — T/H

$$Fo = \frac{Po \times 860 \times \frac{\alpha}{100}}{\frac{\eta p}{100} \times Hh'}$$ 38.6 T/H

2. Combustion Gas Volume

Basic Specification	Abbreviation/Unit		Applying value of this project
1. Hydrogen	ho'	%	12.5
2. High heat value of fuel	Hh'	kcal/kg	10,700
3. O_2 content in flue gas	O_2	%	4.0

Calculation Form

° Low heat value of Fuel Hl' — Hl' — kcal/kg

$Hl' = Hh' - 6 (9 \times ho')$ 10,025

° Excess air ratio m — m — -

$$m = \frac{21}{21 - O_2}$$ 1.24

° Combustion Gas Volume

. Theorethical air volume — Ao' — Nm^3/kg-fuel

$Ao' = 0.85 \times Hl' \times 10^{-3} + 2.0$

. Theorethical combustion gas volume — Go' — Nm^3/kg-fuel

$Go' = 1.11 \times Hl' \times 10^{-3}$ 11.13

	. Actual combustion gas volume	G		
	at Wet gas condition	G'w		
	$G'w = Go' + (m-1)Ao'$			13.65
	at Dry gas condition	G'd		
	$G'd = Gw' - \frac{0.224}{18} (9 \times ho + W')$			12.25
3.	Flue Gas Volume at Boiler End	Qb	Nm^3/H	
	at wet condition			
	$QwB = (Fo \times G'w) \times 10^3$	QwB	Nm^3/H	527×10^3
	at dry condition			
	$QdB = (Io \times G'd) \times 10^3$	QdB	Nm^3/H	473×10^3
4.	Effective Height of Chimney			
	(apply equation of Bosanquet)			
	<u>Basic Condition</u>			
1.	Flue gas volume	QwB	Nm^3/H	527×10^3
2.	Ambient temperature	ta	°C	30
3.	Flue gas temperature	tg	°C	135
4.	Diameter of Chimney	D	m	2.16
5.	Wind velocity	U	m/s	6
6.	Temperature reducing rate	$d\theta/dz$	°C/m	0.0033
7.	Design height of chimney	Ho	m	80
	Calculation of effective chimney height			
	. exhaust gas volume	Qt	m^3/s	162
	$= \frac{Qw\beta \times (273 + ta)}{3,600 \times 273}$			
	. exhaust gas velocity at chimney nozzle	Vg	m/s	60
	$= \frac{Qw \times (273 + tg)}{3,600 \times 273 \times \frac{\pi}{4} D^2}$			

. Raising height of flue gas by flue gas energy (momentum)	Hm	m	
$= \dfrac{4.77}{1 + \dfrac{0.43 \times U}{Vg}} \times \dfrac{\sqrt{Qt \times Vg}}{U}$			
$= \dfrac{0.795 \sqrt{Qt \times Vg}}{1 + \dfrac{2.58}{Vg}}$			47
. Raising height of flue gas by temperature difference between flue gas and ambient	Ht	m	
$= 6.37 \times g \times \dfrac{Qt\ (tg - ta)}{U^3\ (273 + ta)} \times (LnJ^2 + \dfrac{2}{J} - 2)$			56.3
$= 1.91 \times 10^{-3} \times Qt\ (tg-ta) \times (2.3\ \log J + \dfrac{1}{J} - 1)$			
$J = \dfrac{U_2}{\sqrt{Qt \times Vg}} \times 0.43 \sqrt{\dfrac{(273 + to)}{g(d\theta/dz)}}$			
$- 0.28\ \dfrac{Vg\ (273 + ta)}{g\ (tg - ta)} + 1$			
$= \dfrac{1}{\sqrt{Qt \times Vg}} (1{,}498 - \dfrac{312 \times Vg}{tg - ta}) + 1$			14.4
. Effective height of chimney	He	m	165
$= Ho + 0.65\ (Hm + Ht)$			

5. Calculation of air polutant

<u>Basic Specification</u>

1. Fuel consumption	Fo	T/H	38.6
2. Sulphur component	So	%	1.0
3. Flue gas volume at dry state	QdB	Nm^3/H	473×10^3
4. Effective height of chimney	He	m	165
5. O_2 content in flue gas	O_2	%	4.0

Calculation of SO_x emission

° SO_x volume at boiler end	q'	Nm^3/H	270.2
$= 7\ (Fo \times So)$			
° SO_x density at chimney nozzle	qc	ppm	570
$= \dfrac{q'}{QdB} \times 10^6$			

6. Maximum SO_x Landing Density and Distance

6-1	Maximum SO_x landing density (apply equation of Sutton)	Cmax	ppm	0.017
	$= 1.72 \times \frac{q'}{Hc^2}$			
6-2	Maximum SO_x landing distance (apply equation of Sutton)	Xmax	km	7.1
	$= 20.8 \times He^{1.143} \times 10^{-3}$			

Calculation for Air Pollution in Environment Problem

Type-A So 1% Chimney 100 m

1. Fuel Consumption

Basic Specification	Abbreviation/Unit		Applying value of this project
1. Output at Generator end	Po	MW	120
2. Power plant thermal efficiency	ηp	%	25
3. Fuel combustion ratio	α	%	100
4. High heat value of fuel	Hh'	kcal/kg	10,700

Calculation Form

° Fuel consumption	Fo	T/H	
$Fo = \dfrac{Po \times 860 \times \frac{\alpha}{100}}{\frac{\eta p}{100} \times Hh'}$			38.6 T/H

2. Combustion Gas Volume

Basic Specification

1. Hydrogen	ho'	%	12.5
2. High heat value of fuel	Hh'	kcal/kg	10,700
3. O_2 content in flue gas	O_2	%	4.0

Calculation Form

° Low heat value of Fuel Hl'	Hl'	kcal/kg	
$Hl' = Hh' - 6\ (9 \times ho')$			10,025
° Excess air ratio m	m	–	
$m = \dfrac{21}{21 - O_2}$			1.24
° Combustion Gas Volume			
. Theorethical air volume	Ao'	Nm^3/kg-fuel	
$Ao' = 0.85 \times Hl' \times 10^{-3} + 2.0$			
. Theorethical combustion gas volume	Go'	Nm^3/kg-fuel	
$Go' = 1.11 \times Hl' \times 10^{-3}$			11.13

. Actual combustion gas volume	G		
at Wet gas condition	G'w		
$G'w = Go' + (m-1)Ao'$			13.65
at Dry gas condition	G'd		
$G'd = Gw' - \frac{0.224}{18}(9 \times ho + W')$			12.25

3. Flue Gas Volume at Boiler End	Qb	Nm^3/H	
at wet condition			
$QwB = (Fo \times G'w) \times 10^3$	QwB	Nm^3/H	527×10^3
at dry condition			
$QdB = (Io \times G'd) \times 10^3$	QdB	Nm^3/H	473×10^3

4. Effective Height of Chimney

(apply equation of Bosanquet)

<u>Basic Condition</u>

1. Flue gas volume	QwB	Nm^3/H	527×10^3
2. Ambient temperature	ta	°C	30
3. Flue gas temperature	tg	°C	135
4. Diameter of Chimney	D	m	2.16
5. Wind velocity	U	m/s	6
6. Temperature reducing rate	$d\theta/dz$	°C/m	0.0033
7. Design height of chimney	Ho	m	100

Calculation of effective chimney height

. exhaust gas volume	Qt	m^3/s	162
$= \frac{QwB \times (273 + ta)}{3,600 \times 273}$			
. exhaust gas velocity at chimney nozzle	Vg	m/s	60
$= \frac{Qw \times (273 + tg)}{3,600 \times 273 \times \frac{\pi}{4} D^2}$			

- Raising height of flue gas by flue gas energy (momentum) | Hm | m |

$$= \frac{4.77}{1 + \frac{0.43 \times U}{Vg}} \times \frac{\sqrt{Qt \times Vg}}{U}$$

$$= \frac{0.795\sqrt{Qt \times Vg}}{1 + \frac{2.58}{Vg}}$$ 75

- Raising height of flue gas by temperature difference between flue gas and ambient | Ht | m |

$$= 6.37 \times g \times \frac{Qt\ (tg - ta)}{U^3\ (273 + ta)} \times (LnJ^2 + \frac{2}{J} - 2)$$ 56.3

$$= 1.91 \times 10^{-3} \times Qt\ (tg-ta) \times (2.3\ \log J + \frac{1}{J} - 1)$$

$$J = \frac{U_2}{\sqrt{Qt \times Vg}} \times \ 0.43\sqrt{\frac{(273 + to)}{g(d\theta/dz)}}$$

$$- 0.28\ \frac{Vg\ (273 + ta)}{g\ (tg - ta)} + 1$$

$$= \frac{1}{\sqrt{Qt \times Vg}}\ (1{,}498 - \frac{312 \times Vg}{tg - ta}) + 1$$ 14.4

- Effective height of chimney | He | m |

$$= Ho + 0.65\ (Hm + Ht)$$ 185

5. Calculation of air polutant

<u>Basic Specification</u>

1. Fuel consumption	Fo	T/H	38.6
2. Sulphur component	So	%	1.0
3. Flue gas volume at dry state	QdB	Nm^3/H	473×10^3
4. Effective height of chimney	He	m	185
5. O_2 content in flue gas	O_2	%	4.0

Calculation of SO_x emission

° SO_x volume at boiler end	q'	Nm^3/H	270.2
= 7 (Fo x So)			
° SO_x density at chimney nozzle	qc	ppm	570

$$= \frac{q'}{QdB} \times 10^6$$

6. Maximum SO_x Landing Density and Distance

6-1 Maximum SO_x landing density (apply equation of Sutton)	Cmax	ppm	0.014
$= 1.72 \times \frac{q'}{Hc^2}$			
6-2 Maximum SO_x landing distance (apply equation of Sutton)	Xmax	km	8.1
$= 20.8 \times He^{1.143} \times 10^{-3}$			

Calculation for Air Pollution in Environment Problem

Type-A So 1% Chimney 120 m

1. Fuel Consumption

Basic Specification	Abbreviation/Unit		Applying value of this project
1. Output at Generator end	Po	MW	120
2. Power plant thermal efficiency	ηp	%	25
3. Fuel combustion ratio	α	%	100
4. High heat value of fuel	Hh'	kcal/kg	10,700

Calculation Form

° Fuel consumption	Fo	T/H	
$Fo = \dfrac{Po \times 860 \times \frac{\alpha}{100}}{\frac{\eta p}{100} \times Hh'}$			38.6 T/H

2. Combustion Gas Volume

Basic Specification			
1. Hydrogen	ho'	%	12.5
2. High heat value of fuel	Hh'	kcal/kg	10,700
3. O_2 content in flue gas	O_2	%	4.0

Calculation Form

° Low heat value of Fuel Hl'	Hl'	kcal/kg	
$Hl' = Hh' - 6 (9 \times ho')$			10,025
° Excess air ratio m	m	-	
$m = \dfrac{21}{21 - O_2}$			1.24
° Combustion Gas Volume			
. Theorethical air volume	Ao'	Nm^3/kg-fuel	
$Ao' = 0.85 \times Hl' \times 10^{-3} + 2.0$			
. Theorethical combustion gas volume	Go'	Nm^3/kg-fuel	
$Go' = 1.11 \times Hl' \times 10^{-3}$			11.13

. Actual combustion gas volume	G		
at Wet gas condition	G'w		
$G'w = Go' + (m-1)Ao'$			13.65
at Dry gas condition	G'd		
$G'd = Gw' - \frac{0.224}{18}(9 \times ho + W')$			12.25
3. Flue Gas Volume at Boiler End	Qb	Nm^3/H	
at wet condition			
$QwB = (Fo \times G'w) \times 10^3$	QwB	Nm^3/H	527×10^3
at dry condition			
$QdB = (Io \times G'd) \times 10^3$	QdB	Nm^3/H	473×10^3
4. Effective Height of Chimney			
(apply equation of Bosanquet)			
Basic Condition			
1. Flue gas volume	QwB	Nm^3/H	527×10^3
2. Ambient temperature	ta	°C	30
3. Flue gas temperature	tg	°C	135
4. Diameter of Chimney	D	m	2.16
5. Wind velocity	U	m/s	6
6. Temperature reducing rate	$d\theta/dz$	°C/m	0.0033
7. Design height of chimney	Ho	m	120
Calculation of effective chimney height			
. exhaust gas volume	Qt	m^3/s	162
$= \frac{Qw \times (273 + ta)}{3,600 \times 273}$			
. exhaust gas velocity at chimney nozzle	Vg	m/s	60
$= \frac{Qw\beta \times (273 + tg)}{3,600 \times 273 \times \frac{\pi}{4} D^2}$			

. Raising height of flue gas by flue gas energy (momentum)	Hm	m	
$= \frac{4.77}{1 + \frac{0.43 \times U}{Vg}} \times \frac{\sqrt{Qt \times Vg}}{U}$			
$= \frac{0.795\sqrt{Qt \times Vg}}{1 + \frac{2.58}{Vg}}$			75
. Raising height of flue gas by temperature difference between flue gas and ambient	Ht	m	
$= 6.37 \times g \times \frac{Qt\ (tg - ta)}{U^3\ (273 + ta)} \times (LnJ^2 + \frac{2}{J} - 2)$			56.3
$= 1.91 \times 10^{-3} \times Qt\ (tg-ta) \times (2.3\ \log J + \frac{1}{J} - 1)$			
$J = \frac{U_2}{\sqrt{Qt \times Vg}} \times 0.43\sqrt{\frac{(273 + to)}{g(d\theta/dz)}} - 0.28\ \frac{Vg\ (273 + ta)}{g\ (tg - ta)} + 1$			
$= \frac{1}{\sqrt{Qt \times Vg}}\ (1{,}498 - \frac{312 \times Vg}{tg - ta}) + 1$			14.4
. Effective height of chimney	He	m	
$= Ho + 0.65\ (Hm + Ht)$			205

5. Calculation of air polutant

<u>Basic Specification</u>

1. Fuel consumption	Fo	T/H	38.6
2. Sulphur component	So	%	1.0
3. Flue gas volume at dry state	QdB	Nm^3/H	473×10^3
4. Effective height of chimney	He	m	205
5. O_2 content in flue gas	O_2	%	4.0
Calculation of SO_x emission			
° SO_x volume at boiler end	q'	Nm^3/H	270.2
$= 7\ (Fo \times So)$			
° SO_x density at chimney nozzle	qc	ppm	570
$= \frac{q'}{QdB} \times 10^6$			

6. Maximum SO_x Landing Density and Distance

6-1	Maximum SO_x landing density (apply equation of Sutton)	Cmax	ppm	0.011
	$= 1.72 \times \frac{q'}{Hc^2}$			
6-2	Maximum SO_x landing distance (apply equation of Sutton)	Xmax	km	9.1
	$= 20.8 \times He^{1.143} \times 10^{-3}$			

Calculation for Air Pollution in Environment Problem

Type-F So 1% Chimney 80 m

1. Fuel Consumption

Basic Specification	Abbreviation/Unit		Applying value of this project
1. Output at Generator end	Po	MW	60
2. Power plant thermal efficiency	ηp	%	19
3. Fuel combustion ratio	α	%	100
4. High heat value of fuel	Hh'	kcal/kg	10,700

Calculation Form

° Fuel consumption	Fo	T/H	

$$Fo = \frac{Po \times 860 \times \frac{\alpha}{100}}{\frac{\eta p}{100} \times Hh'}$$ 25.4 T/H

2. Combustion Gas Volume

Basic Specification	Abbreviation/Unit		Applying value of this project
1. Hydrogen	ho'	%	12.5
2. High heat value of fuel	Hh'	kcal/kg	10,700
3. O_2 content in flue gas	O_2	%	4.0

Calculation Form

° Low heat value of Fuel Hl'	Hl'	kcal/kg	
$Hl' = Hh' - 6\ (9 \times ho')$			10,025
° Excess air ratio m	m	–	
$m = \frac{21}{21 - O_2}$			1.24
° Combustion Gas Volume			
. Theorethical air volume	Ao'	Nm^3/kg-fuel	
$Ao' = 0.85 \times Hl' \times 10^{-3} + 2.0$			
. Theorethical combustion gas volume	Go'	Nm^3/kg-fuel	
$Go' = 1.11 \times Hl' \times 10^{-3}$			11.13

. Actual combustion gas volume	G		
at Wet gas condition	G'w		
$G'w = Go' + (m-1)Ao'$			13.65
at Dry gas condition	G'd		
$G'd = Gw' - \frac{0.224}{18}(9 \times ho + W')$			12.25
3. Flue Gas Volume at Boiler End	Qb	Nm^3/H	
at wet condition			
$QwB = (Fo \times G'w) \times 10^3$	QwB	Nm^3/H	347×10^3
at dry condition			
$QdB = (Io \times G'd) \times 10^3$	QdB	Nm^3/H	311×10^3

4. Effective Height of Chimney

(apply equation of Bosanquet)

<u>Basic Condition</u>

1. Flue gas volume	QwB	Nm^3/H	347×10^3
2. Ambient temperature	ta	°C	30
3. Flue gas temperature	tg	°C	135
4. Diameter of Chimney	D	m	2.16
5. Wind velocity	U	m/s	6
6. Temperature reducing rate	$d\theta/dz$	°C/m	0.0033
7. Design height of chimney	Ho	m	80

Calculation of effective chimney height

. exhaust gas volume	Qt	m^3/s	107
$= \frac{QwB \times (273 + ta)}{3,600 \times 273}$			
. exhaust gas velocity at chimney nozzle	Vg	m/s	39
$= \frac{Qw \times (273 + tg)}{3,600 \times 273 \times \frac{\pi}{4} D^2}$			

• Raising height of flue gas by flue gas energy (momentum)	Hm	m	
$= \frac{4.77}{1 + \frac{0.43 \times U}{Vg}} \times \frac{\sqrt{Qt \times Vg}}{U}$			
$= \frac{0.795\sqrt{Qt \times Vg}}{1 + \frac{2.58}{Vg}}$			48
• Raising height of flue gas by temperature difference between flue gas and ambient	Ht	m	
$= 6.37 \times g \times \frac{Qt\ (tg - ta)}{U^3\ (273 + ta)} \times (LnJ^2 + \frac{2}{J} - 2)$			46.1
$= 1.91 \times 10^{-3} \times Qt\ (tg-ta) \times (2.3\ \log J + \frac{1}{J} - 1)$			
$J = \frac{U_2}{\sqrt{Qt \times Vg}} \times 0.43\sqrt{\frac{(273 + to)}{g(d\theta/dz)}} - 0.28\ \frac{Vg\ (273 + ta)}{g\ (tg - ta)} + 1$			
$= \frac{1}{\sqrt{Qt \times Vg}}\ (1{,}498 - \frac{312 \times Vg}{tg - ta}) + 1$			22.4
• Effective height of chimney	He	m	
$= Ho + 0.65\ (Hm + Ht)$			141

5. Calculation of air polutant

<u>Basic Specification</u>

1. Fuel consumption	Fo	T/H	25.4
2. Sulphur component	So	%	1.0
3. Flue gas volume at dry state	QdB	Nm^3/H	311×10^3
4. Effective height of chimney	He	m	141
5. O_2 content in flue gas	O_2	%	4.0

Calculation of SO_x emission

° SO_x volume at boiler end	q'	Nm^3/H	177.8
$= 7\ (Fo \times So)$			
° SO_x density at chimney nozzle	qc	ppm	570
$= \frac{q'}{QdB} \times 10^6$			

6. Maximum SO_x Landing Density and Distance

6-1	Maximum SO_x landing density (apply equation of Sutton)	Cmax	ppm	0.015

$$= 1.72 \times \frac{q'}{Hc^2}$$

6-2	Maximum SO_x landing distance (apply equation of Sutton)	Xmax	km	6.0

$$= 20.8 \times He^{1.143} \times 10^{-3}$$

Calculation for Air Pollution in Environment Problem

Type-F So 1% Chimney 100 m

1. Fuel Consumption

Basic Specification	Abbreviation	Unit	Applying value of this project
1. Output at Generator end	Po	MW	60
2. Power plant thermal efficiency	ηp	%	19
3. Fuel combustion ratio	α	%	100
4. High heat value of fuel	Hh'	kcal/kg	10,700

Calculation Form

° Fuel consumption — Fo — T/H

$$Fo = \frac{Po \times 860 \times \frac{\alpha}{100}}{\frac{\eta p}{100} \times Hh'}$$ 25.4 T/H

2. Combustion Gas Volume

Basic Specification	Abbreviation	Unit	Applying value of this project
1. Hydrogen	ho'	%	12.5
2. High heat value of fuel	Hh'	kcal/kg	10,700
3. O_2 content in flue gas	O_2	%	4.0

Calculation Form

° Low heat value of Fuel Hl' — Hl' — kcal/kg

$Hl' = Hh' - 6 (9 \times h\acute{o})$ 10,025

° Excess air ratio m — m — -

$$m = \frac{21}{21 - O_2}$$ 1.24

° Combustion Gas Volume

. Theorethical air volume — Ao' — Nm^3/kg-fuel

$Ao' = 0.85 \times Hl' \times 10^{-3} + 2.0$

. Theorethical combustion gas volume — Go' — Nm^3/kg-fuel

$Go' = 1.11 \times Hl' \times 10^{-3}$ 11.13

. Actual combustion gas volume	G		
at Wet gas condition	G'w		
$G'w = Go' + (m-1)Ao'$			13.65
at Dry gas condition	G'd		
$G'd = Gw' - \frac{0.224}{18}(9 \times ho + W')$			12.25
3. Flue Gas Volume at Boiler End	Qb	Nm^3/H	
at wet condition			
$QwB = (Fo \times G'w) \times 10^3$	QwB	Nm^3/H	347×10^3
at dry condition			
$QdB = (Io \times G'd) \times 10^3$	QdB	Nm^3/H	311×10^3
4. Effective Height of Chimney			
(apply equation of Bosanquet)			
Basic Condition			
1. Flue gas volume	QwB	Nm^3/H	347×10^3
2. Ambient temperature	ta	°C	30
3. Flue gas temperature	tg	°C	135
4. Diameter of Chimney	D	m	2.16
5. Wind velocity	U	m/s	6
6. Temperature reducing rate	$d\theta/dz$	°C/m	0.0033
7. Design height of chimney	Ho	m	100
Calculation of effective chimney height			
. exhaust gas volume	Qt	m^3/s	107
$= \frac{QwB \times (273 + ta)}{3,600 \times 273}$			
. exhaust gas velocity at chimney nozzle	Vg	m/s	39
$= \frac{Qw \times (273 + tg)}{3,600 \times 273 \times \frac{\pi}{4} D^2}$			

• Raising height of flue gas by flue gas energy (momentum)	Hm	m	
$= \frac{4.77}{1 + \frac{0.43 \times U}{Vg}} \times \frac{\sqrt{Qt \times Vg}}{U}$			
$= \frac{0.795 \sqrt{Qt \times Vg}}{1 + \frac{2.58}{Vg}}$			48
• Raising height of flue gas by temperature difference between flue gas and ambient	Ht	m	
$= 6.37 \times g \times \frac{Qt\ (tg - ta)}{U^3\ (273 + ta)} \times (LnJ^2 + \frac{2}{J} - 2)$			46.1
$= 1.91 \times 10^{-3} \times Qt\ (tg-ta) \times (2.3 \log J + \frac{1}{J} - 1)$			
$J = \frac{U_2}{\sqrt{Qt \times Vg}} \times 0.43 \sqrt{\frac{(273 + to)}{g(d\theta/dz)}} - 0.28 \frac{Vg\ (273 + ta)}{g\ (tg - ta)} + 1$			
$= \frac{1}{\sqrt{Qt \times Vg}} (1{,}498 - \frac{312 \times Vg}{tg - ta}) + 1$			22.4
• Effective height of chimney	He	m	
= Ho + 0.65 (Hm + Ht)			161

5. Calculation of air polutant

<u>Basic Specification</u>

1. Fuel consumption	Fo	T/H	25.4
2. Sulphur component	So	%	1.0
3. Flue gas volume at dry state	QdB	Nm^3/H	311×10^3
4. Effective height of chimney	He	m	161
5. O_2 content in flue gas	O_2	%	4.0
Calculation of SO_x emission			
° SO_x volume at boiler end	q'	Nm^3/H	177.8
= 7 (Fo x So)			
° SO_x density at chimney nozzle	qc	ppm	570
$= \frac{q'}{QdB} \times 10^6$			

6. Maximum SO_x Landing Density and Distance

6-1	Maximum SO_x landing density (apply equation of Sutton)	Cmax	ppm	0.012
	$= 1.72 \times \frac{q'}{Hc^2}$			
6-2	Maximum SO_x landing distance (apply equation of Sutton)	Xmax	km	6.9
	$= 20.8 \times He^{1.143} \times 10^{-3}$			

Calculation for Air Pollution in Environment Problem

Type-F So 1% Chimney 120 m

1. Fuel Consumption

Basic Specification	Abbreviation/Unit		Applying value of this project
1. Output at Generator end	Po	MW	60
2. Power plant thermal efficiency	ηp	%	19
3. Fuel combustion ratio	α	%	100
4. High heat value of fuel	Hh'	kcal/kg	10,700

Calculation Form

° Fuel consumption	Fo	T/H	

$$Fo = \frac{Po \times 860 \times \frac{\alpha}{100}}{\frac{\eta p}{100} \times Hh'}$$ 25.4 T/H

2. Combustion Gas Volume

Basic Specification			
1. Hydrogen	ho'	%	12.5
2. High heat value of fuel	Hh'	kcal/kg	10,700
3. O_2 content in flue gas	O_2	%	4.0

Calculation Form

° Low heat value of Fuel Hl'	Hl'	kcal/kg	
$Hl' = Hh' - 6\ (9 \times ho')$			10,025
° Excess air ratio m	m	–	
$m = \frac{21}{21 - O_2}$			1.24

° Combustion Gas Volume

. Theorethical air volume	Ao'	Nm^3/kg-fuel	
$Ao' = 0.85 \times Hl' \times 10^{-3} + 2.0$			
. Theorethical combustion gas volume	Go'	Nm^3/kg-fuel	
$Go' = 1.11 \times Hl' \times 10^{-3}$			11.13

. Actual combustion gas volume	G		
at Wet gas condition	G'w		
$G'w = Go' + (m-1)Ao'$			13.65
at Dry gas condition	G'd		
$G'd = Gw' - \frac{0.224}{18}(9 \times ho + W')$			12.25
3. Flue Gas Volume at Boiler End	Qb	Nm^3/H	
at wet condition			
$QwB = (Fo \times G'w) \times 10^3$	QwB	Nm^3/H	347×10^3
at dry condition			
$QdB = (Io \times G'd) \times 10^3$	QdB	Nm^3/H	311×10^3
4. Effective Height of Chimney			
(apply equation of Bosanquet)			
Basic Condition			
1. Flue gas volume	QwB	Nm^3/H	347×10^3
2. Ambient temperature	ta	°C	30
3. Flue gas temperature	tg	°C	135
4. Diameter of Chimney	D	m	2.16
5. Wind velocity	U	m/s	6
6. Temperature reducing rate	$d\theta/dz$	°C/m	0.0033
7. Design height of chimney	Ho	m	120
Calculation of effective chimney height			
. exhaust gas volume	Qt	m^3/s	107
$= \frac{Qw \times (273 + ta)}{3{,}600 \times 273}$			
. exhaust gas velocity at chimney nozzle	Vg	m/s	39
$= \frac{QwB \times (273 + tg)}{3{,}600 \times 273 \times \frac{\pi}{4} D^2}$			

- Raising height of flue gas by flue gas energy (momentum) — Hm — m

$$= \frac{4.77}{1 + \frac{0.43 \times U}{Vg}} \times \frac{\sqrt{Qt \times Vg}}{U}$$

$$= \frac{0.795\sqrt{Qt \times Vg}}{1 + \frac{2.58}{Vg}}$$ 48

- Raising height of flue gas by temperature difference between flue gas and ambient — Ht — m

$$= 6.37 \times g \times \frac{Qt\ (tg - ta)}{U^3\ (273 + ta)} \times (LnJ^2 + \frac{2}{J} - 2)$$ 46.1

$$= 1.91 \times 10^{-3} \times Qt\ (tg-ta) \times (2.3\ \log J + \frac{1}{J} - 1)$$

$$J = \frac{U_2}{\sqrt{Qt \times Vg}} \times 0.43\sqrt{\frac{(273 + to)}{g(d\theta/dz)}}$$

$$- 0.28\ \frac{Vg\ (273 + ta)}{g\ (tg - ta)} + 1$$

$$= \frac{1}{\sqrt{Qt \times Vg}}\ (1{,}498 - \frac{312 \times Vg}{tg - ta}) + 1$$ 22.4

- Effective height of chimney — He — m

$$= Ho + 0.65\ (Hm + Ht)$$ 181

5. Calculation of air polutant

<u>Basic Specification</u>

1. Fuel consumption	Fo	T/H	25.4
2. Sulphur component	So	%	1.0
3. Flue gas volume at dry state	QdB	Nm^3/H	311×10^3
4. Effective height of chimney	He	m	181
5. O_2 content in flue gas	O_2	%	4.0

Calculation of SO_x emission

° SO_x volume at boiler end — q' — Nm^3/H — 177.8

$$= 7\ (Fo \times So)$$

° SO_x density at chimney nozzle — qc — ppm — 570

$$= \frac{q'}{QdB} \times 10^6$$

6. Maximum SO_x Landing Density and Distance

6-1	Maximum SO_x landing density (apply equation of Sutton)	Cmax	ppm	0.009
	$= 1.72 \times \frac{q'}{Hc^2}$			
6-2	Maximum SO_x landing distance (apply equation of Sutton)	Xmax	km	7.9
	$= 20.8 \times He^{1.143} \times 10^{-3}$			

Calculation for Air Pollution in Environment Problem

Type-A So 1.6% Chimney 80 m

1. Fuel Consumption

Basic Specification	Abbreviation/Unit		Applying value of this project
1. Output at Generator end	Po	MW	120
2. Power plant thermal efficiency	ηp	%	25
3. Fuel combustion ratio	α	%	100
4. High heat value of fuel	Hh'	kcal/kg	10,700

Calculation Form

° Fuel consumption — Fo — T/H

$$Fo = \frac{Po \times 860 \times \frac{\alpha}{100}}{\frac{\eta p}{100} \times Hh'}$$ 38.6 T/H

2. Combustion Gas Volume

Basic Specification			
1. Hydrogen	ho'	%	12.5
2. High heat value of fuel	Hh'	kcal/kg	10,700
3. O_2 content in flue gas	O_2	%	4.0

Calculation Form

° Low heat value of Fuel Hl' — Hl' — kcal/kg

$Hl' = Hh' - 6 (9 \times ho')$ 10,025

° Excess air ratio m — m — -

$$m = \frac{21}{21 - O_2}$$ 1.24

° Combustion Gas Volume

. Theorethical air volume — Ao' — Nm^3/kg-fuel

$Ao' = 0.85 \times Hl' \times 10^{-3} + 2.0$

. Theorethical combustion gas volume — Go' — Nm^3/kg-fuel

$Go' = 1.11 \times Hl' \times 10^{-3}$ 11.13

. Actual combustion gas volume	G		
at Wet gas condition	G'w		
$G'w = Go' + (m-1)Ao'$			13.65
at Dry gas condition	G'd		
$G'd = Gw' - \frac{0.224}{18}(9 \times ho + W')$			12.25
3. Flue Gas Volume at Boiler End	Qb	Nm^3/H	
at wet condition			
$QwB = (Fo \times G'w) \times 10^3$	QwB	Nm^3/H	527×10^3
at dry condition			
$QdB = (Io \times G'd) \times 10^3$	QdB	Nm^3/H	473×10^3
4. Effective Height of Chimney			
(apply equation of Bosanquet)			
Basic Condition			
1. Flue gas volume	QwB	Nm^3/H	527×10^3
2. Ambient temperature	ta	°C	30
3. Flue gas temperature	tg	°C	135
4. Diameter of Chimney	D	m	2.16
5. Wind velocity	U	m/s	6
6. Temperature reducing rate	$d\theta/dz$	°C/m	0.0033
7. Design height of chimney	Ho	m	80
Calculation of effective chimney height			
. exhaust gas volume	Qt	m^3/s	162
$= \frac{QwB \times (273 + ta)}{3,600 \times 273}$			
. exhaust gas velocity at chimney nozzle	Vg	m/s	60
$= \frac{Qw \times (273 + tg)}{3,600 \times 273 \times \frac{\pi}{4} D^2}$			

- Raising height of flue gas by flue gas energy (momentum) — Hm — m

$$= \frac{4.77}{1 + \frac{0.43 \times U}{Vg}} \times \frac{\sqrt{Qt \times Vg}}{U}$$

$$= \frac{0.795\sqrt{Qt \times Vg}}{1 + \frac{2.58}{Vg}}$$ 75

- Raising height of flue gas by temperature difference between flue gas and ambient — Ht — m

$$= 6.37 \times g \times \frac{Qt\ (tg - ta)}{U^3\ (273 + ta)} \times (LnJ^2 + \frac{2}{J} - 2)$$ 56.3

$$= 1.91 \times 10^{-3} \times Qt\ (tg - ta) \times (2.3\ \log J + \frac{1}{J} - 1)$$

$$J = \frac{U_2}{\sqrt{Qt \times Vg}} \times 0.43\sqrt{\frac{(273 + to)}{g(d\theta/dz)}}$$

$$- 0.28\ \frac{Vg\ (273 + ta)}{g\ (tg - ta)} + 1$$

$$= \frac{1}{\sqrt{Qt \times Vg}} (1{,}498 - \frac{312 \times Vg}{tg - ta}) + 1$$ 14.4

- Effective height of chimney — He — m

$= Ho + 0.65\ (Hm + Ht)$ 165

5. Calculation of air polutant

<u>Basic Specification</u>

1. Fuel consumption	Fo	T/H	38.6
2. Sulphur component	So	%	1.6
3. Flue gas volume at dry state	QdB	Nm^3/H	473×10^3
4. Effective height of chimney	He	m	165
5. O_2 content in flue gas	O_2	%	4.0

Calculation of SO_x emission

° SO_x volume at boiler end — q' — Nm^3/H — 432.3

$= 7\ (Fo \times So)$

° SO_x density at chimney nozzle — qc — ppm — 914

$$= \frac{q'}{QdB} \times 10^6$$

6. Maximum SO_x Landing Density and Distance

6-1	Maximum SO_x landing density (apply equation of Sutton) $= 1.72 \times \frac{q'}{Hc^2}$	Cmax	ppm	0.027
6-2	Maximum SO_x landing distance (apply equation of Sutton) $= 20.8 \times He^{1.143} \times 10^{-3}$	Xmax	km	7.1

Calculation for Air Pollution in Environment Problem

Type-A So 1.6% Chimney 100 m

1. Fuel Consumption

Basic Specification	Abbreviation/Unit		Applying value of this project
1. Output at Generator end	Po	MW	120
2. Power plant thermal efficiency	ηp	%	25
3. Fuel combustion ratio	α	%	100
4. High heat value of fuel	Hh'	kcal/kg	10,700

Calculation Form

° Fuel consumption — Fo — T/H

$$Fo = \frac{Po \times 860 \times \frac{\alpha}{100}}{\frac{\eta p}{100} \times Hh'}$$ 38.6 T/H

2. Combustion Gas Volume

Basic Specification			
1. Hydrogen	ho'	%	12.5
2. High heat value of fuel	Hh'	kcal/kg	10,700
3. O_2 content in flue gas	O_2	%	4.0

Calculation Form

° Low heat value of Fuel Hl' — Hl' — kcal/kg

$Hl' = Hh' - 6 (9 \times ho')$ 10,025

° Excess air ratio m — m — –

$$m = \frac{21}{21 - O_2}$$ 1.24

° Combustion Gas Volume

. Theorethical air volume — Ao' — Nm^3/kg-fuel

$Ao' = 0.85 \times Hl' \times 10^{-3} + 2.0$

. Theorethical combustion gas volume — Go' — Nm^3/kg-fuel

$Go' = 1.11 \times Hl' \times 10^{-3}$ 11.13

. Actual combustion gas volume	G		
at Wet gas condition	G'w		
$G'w = Go' + (m-1)Ao'$			13.65
at Dry gas condition	G'd		
$G'd = Gw' - \frac{0.224}{18} (9 \times ho + W')$			12.25

3. Flue Gas Volume at Boiler End — Qb — Nm^3/H

at wet condition			
$QwB = (Fo \times G'w) \times 10^3$	QwB	Nm^3/H	527×10^3
at dry condition			
$QdB = (Io \times G'd) \times 10^3$	QdB	Nm^3/H	473×10^3

4. Effective Height of Chimney

(apply equation of Bosanquet)

Basic Condition

1. Flue gas volume	QwB	Nm^3/H	527×10^3
2. Ambient temperature	ta	°C	30
3. Flue gas temperature	tg	°C	135
4. Diameter of Chimney	D	m	2.16
5. Wind velocity	U	m/s	6
6. Temperature reducing rate	$d\theta/dz$	°C/m	0.0033
7. Design height of chimney	Ho	m	100

Calculation of effective chimney height

. exhaust gas volume	Qt	m^3/s	162

$$= \frac{Qw \times (273 + ta)}{3,600 \times 273}$$

. exhaust gas velocity at chimney nozzle	Vg	m/s	60

$$= \frac{QwBx\ (273 + tg)}{3,600 \times 273 \times \frac{\pi}{4} D^2}$$

- Raising height of flue gas by flue gas energy (momentum) — Hm — m

$$= \frac{4.77}{1 + \frac{0.43 \times U}{Vg}} \times \frac{\sqrt{Qt \times Vg}}{U}$$

$$= \frac{0.795\sqrt{Qt \times Vg}}{1 + \frac{2.58}{Vg}}$$ 75

- Raising height of flue gas by temperature difference between flue gas and ambient — Ht — m

$$= 6.37 \times g \times \frac{Qt\ (tg - ta)}{U^3\ (273 + ta)} \times (LnJ^2 + \frac{2}{J} - 2)$$ 56.3

$$= 1.91 \times 10^{-3} \times Qt\ (tg-ta) \times (2.3\ \log J + \frac{1}{J} - 1)$$

$$J = \frac{U_2}{\sqrt{Qt \times Vg}} \times 0.43\sqrt{\frac{(273 + to)}{g(d\theta/dz)}} - 0.28\ \frac{Vg\ (273 + ta)}{g\ (tg - ta)} + 1$$

$$= \frac{1}{\sqrt{Qt \times Vg}}\ (1{,}498 - \frac{312 \times Vg}{tg - ta}) + 1$$ 14.4

- Effective height of chimney — He — m

$$= Ho + 0.65\ (Hm + Ht)$$ 185

5. Calculation of air polutant

Basic Specification

1. Fuel consumption	Fo	T/H	38.6
2. Sulphur component	So	%	1.6
3. Flue gas volume at dry state	QdB	Nm^3/H	473×10^3
4. Effective height of chimney	He	m	185
5. O_2 content in flue gas	O_2	%	4.0

Calculation of SO_x emission

° SO_x volume at boiler end — q' — Nm^3/H — 432.3

$$= 7\ (Fo \times So)$$

° SO_x density at chimney nozzle — qc — ppm — 914

$$= \frac{q'}{QdB} \times 10^6$$

6. Maximum SO_x Landing Density and Distance

6-1 Maximum SO_x landing density (apply equation of Sutton)	Cmax	ppm	0.022

$$= 1.72 \times \frac{q'}{Hc^2}$$

6-2 Maximum SO_x landing distance (apply equation of Sutton)	Xmax	km	8.1

$$= 20.8 \times He^{1.143} \times 10^{-3}$$

Calculation for Air Pollution in Environment Problem

Type-A So 1.6% Chimney 120 m

1. Fuel Consumption

Basic Specification	Abbreviation/Unit		Applying value of this project
1. Output at Generator end	Po	MW	120
2. Power plant thermal efficiency	ηp	%	25
3. Fuel combustion ratio	α	%	100
4. High heat value of fuel	Hh'	kcal/kg	10,700

Calculation Form

° Fuel consumption — Fo — T/H

$$Fo = \frac{Po \times 860 \times \frac{\alpha}{100}}{\frac{\eta p}{100} \times Hh'}$$ 38.6 T/H

2. Combustion Gas Volume

Basic Specification			
1. Hydrogen	ho'	%	12.5
2. High heat value of fuel	Hh'	kcal/kg	10,700
3. O_2 content in flue gas	O_2	%	4.0

Calculation Form

° Low heat value of Fuel Hl' — Hl' — kcal/kg

$Hl' = Hh' - 6\ (9 \times ho')$ 10,025

° Excess air ratio m — m — -

$$m = \frac{21}{21 - O_2}$$ 1.24

° Combustion Gas Volume

. Theorethical air volume — Ao' — Nm^3/kg-fuel

$Ao' = 0.85 \times Hl' \times 10^{-3} + 2.0$

. Theorethical combustion gas volume — Go' — Nm^3/kg-fuel

$Go' = 1.11 \times Hl' \times 10^{-3}$ 11.13

. Actual combustion gas volume	G		
at Wet gas condition	G'w		
$G'w = Go' + (m-1)Ao'$			13.65
at Dry gas condition	G'd		
$G'd = Gw' - \frac{0.224}{18}(9 \times ho + W')$			12.25

3. Flue Gas Volume at Boiler End	Qb	Nm^3/H	
at wet condition			
$QwB = (Fo \times G'w) \times 10^3$	QwB	Nm^3/H	527×10^3
at dry condition			
$QdB = (Io \times G'd) \times 10^3$	QdB	Nm^3/H	473×10^3

4. Effective Height of Chimney

(apply equation of Bosanquet)

<u>Basic Condition</u>

1. Flue gas volume	QwB	Nm^3/H	527×10^3
2. Ambient temperature	ta	°C	30
3. Flue gas temperature	tg	°C	135
4. Diameter of Chimney	D	m	2.16
5. Wind velocity	U	m/s	6
6. Temperature reducing rate	$d\theta/dz$	°C/m	0.0033
7. Design height of chimney	Ho	m	120

Calculation of effective chimney height

. exhaust gas volume	Qt	m^3/s	162
$= \frac{Qw \times (273 + ta)}{3{,}600 \times 273}$			
. exhaust gas velocity at chimney nozzle	Vg	m/s	60
$= \frac{Qw_B \times (273 + tg)}{3{,}600 \times 273 \times \frac{\pi}{4} D^2}$			

. Raising height of flue gas by flue gas energy (momentum)	Hm	m	
$= \frac{4.77}{1 + \frac{0.43 \times U}{Vg}} \times \frac{\sqrt{Qt \times Vg}}{U}$			
$= \frac{0.795 \sqrt{Qt \times Vg}}{1 + \frac{2.58}{Vg}}$			75
. Raising height of flue gas by temperature difference between flue gas and ambient	Ht	m	
$= 6.37 \times g \times \frac{Qt\ (tg - ta)}{U^3\ (273 + ta)} \times (LnJ^2 + \frac{2}{J} - 2)$			56.3
$= 1.91 \times 10^{-3} \times Qt\ (tg - ta) \times (2.3\ \log J + \frac{1}{J} - 1)$			
$J = \frac{U_2}{\sqrt{Qt \times Vg}} \times 0.43 \sqrt{\frac{(273 + to)}{g(d\theta/dz)}} - 0.28 \frac{Vg\ (273 + ta)}{g\ (tg - ta)} + 1$			
$= \frac{1}{\sqrt{Qt \times Vg}} (1{,}498 - \frac{312 \times Vg}{tg - ta}) + 1$			14.4
. Effective height of chimney	He	m	
= Ho + 0.65 (Hm + Ht)			205

5. Calculation of air polutant

Basic Specification

1. Fuel consumption	Fo	T/H	38.6
2. Sulphur component	So	%	1.6
3. Flue gas volume at dry state	QdB	Nm^3/H	473×10^3
4. Effective height of chimney	He	m	205
5. O_2 content in flue gas	O_2	%	4.0
Calculation of SO_x emission			
° SO_x volume at boiler end	q'	Nm^3/H	432.3
= 7 (Fo x So)			
° SO_x density at chimney nozzle	qc	ppm	914
$= \frac{q'}{QdB} \times 10^6$			

6. Maximum SO_x Landing Density and Distance

6-1 Maximum SO_x landing density (apply equation of Sutton)	Cmax	ppm	0.018
$= 1.72 \times \frac{q'}{He^2}$			
6-2 Maximum SO_x landing distance (apply equation of Sutton)	Xmax	km	9.1
$= 20.8 \times He^{1.143} \times 10^{-3}$			

Calculation for Air Pollution in Environment Problem

Type-F So 1.6% Chimney 80 m

1. Fuel Consumption

Basic Specification	Abbreviation/Unit		Applying value of this project
1. Output at Generator end	Po	MW	60
2. Power plant thermal efficiency	ηp	%	19
3. Fuel combustion ratio	α	%	100
4. High heat value of fuel	Hh'	kcal/kg	10,700

Calculation Form

° Fuel consumption — Fo — T/H

$$Fo = \frac{Po \times 860 \times \frac{\alpha}{100}}{\frac{\eta p}{100} \times Hh'}$$ 25.4 T/H

2. Combustion Gas Volume

Basic Specification	Abbreviation/Unit		Applying value of this project
1. Hydrogen	ho'	%	12.5
2. High heat value of fuel	Hh'	kcal/kg	10,700
3. O_2 content in flue gas	O_2	%	4.0

Calculation Form

° Low heat value of Fuel Hl' — Hl' — kcal/kg

$Hl' = Hh' - 6\ (9 \times ho')$ 10,025

° Excess air ratio m — m — –

$$m = \frac{21}{21 - O_2}$$ 1.24

° Combustion Gas Volume

. Theorethical air volume — Ao' — Nm^3/kg-fuel

$Ao' = 0.85 \times Hl' \times 10^{-3} + 2.0$

. Theorethical combustion gas volume — Go' — Nm^3/kg-fuel

$Go' = 1.11 \times Hl' \times 10^{-3}$ 11.13

. Actual combustion gas volume	G		
at Wet gas condition	G'w		
$G'w = Go' + (m-1)Ao'$			13.65
at Dry gas condition	G'd		
$G'd = Gw' - \frac{0.224}{18} (9 \times ho + W')$			12.25

3. Flue Gas Volume at Boiler End

Flue Gas Volume at Boiler End	Qb	Nm^3/H	
at wet condition			
$QwB = (Fo \times G'w) \times 10^3$	QwB	Nm^3/H	347×10^3
at dry condition			
$QdB = (Io \times G'd) \times 10^3$	QdB	Nm^3/H	311×10^3

4. Effective Height of Chimney

(apply equation of Bosanquet)

Basic Condition

1. Flue gas volume	QwB	Nm^3/H	347×10^3
2. Ambient temperature	ta	°C	30
3. Flue gas temperature	tg	°C	135
4. Diameter of Chimney	D	m	2.16
5. Wind velocity	U	m/s	6
6. Temperature reducing rate	$d\theta/dz$	°C/m	0.0033
7. Design height of chimney	Ho	m	80

Calculation of effective chimney height

. exhaust gas volume	Qt	m^3/s	107
$= \frac{Qw \times (273 + ta)}{3,600 \times 273}$			
. exhaust gas velocity at chimney nozzle	Vg	m/s	39
$= \frac{QwB \times (273 + tg)}{3,600 \times 273 \times \frac{\pi}{4} D^2}$			

- Raising height of flue gas by flue gas energy (momentum) — Hm — m

$$= \frac{4.77}{1 + \frac{0.43 \times U}{Vg}} \times \frac{\sqrt{Qt \times Vg}}{U}$$

$$= \frac{0.795 \sqrt{Qt \times Vg}}{1 + \frac{2.58}{Vg}}$$ 48

- Raising height of flue gas by temperature difference between flue gas and ambient — Ht — m

$$= 6.37 \times g \times \frac{Qt\ (tg - ta)}{U^3\ (273 + ta)} \times (LnJ^2 + \frac{2}{J} - 2)$$ 46.1

$$= 1.91 \times 10^{-3} \times Qt\ (tg-ta) \times (2.3\ \log J + \frac{1}{J} - 1)$$

$$J = \frac{U_2}{\sqrt{Qt \times Vg}} \times \ 0.43\sqrt{\frac{(273 + to)}{g(d\theta/dz)}}$$

$$- 0.28\ \frac{Vg\ (273 + ta)}{g\ (tg - ta)} + 1$$

$$= \frac{1}{\sqrt{Qt \times Vg}} (1{,}498 - \frac{312 \times Vg}{tg - ta}) + 1$$ 22.4

- Effective height of chimney — He — m

$= Ho + 0.65\ (Hm + Ht)$ 141

5. Calculation of air polutant

Basic Specification

1. Fuel consumption	Fo	T/H	25.4
2. Sulphur component	So	%	1.6
3. Flue gas volume at dry state	QdB	Nm^3/H	473×10^3
4. Effective height of chimney	He	m	141
5. O_2 content in flue gas	O_2	%	4.0

Calculation of SO_x emission

° SO_x volume at boiler end	q'	Nm^3/H	284.5
$= 7\ (Fo \times So)$			
° SO_x density at chimney nozzle	qc	ppm	601
$= \frac{q'}{QdB} \times 10^6$			

6. Maximum SO_x Landing Density and Distance

6-1 Maximum SO_x landing density (apply equation of Sutton)	Cmax	ppm	0.025
$= 1.72 \times \frac{q'}{Hc^2}$			
6-2 Maximum SO_x landing distance (apply equation of Sutton)	Xmax	km	6.0
$= 20.8 \times He^{1.143} \times 10^{-3}$			

Calculation for Air Pollution in Environment Problem

Type-F So 1.6% Chimney 100 m

1. Fuel Consumption

Basic Specification	Abbreviation/Unit		Applying value of this project
1. Output at Generator end	Po	MW	60
2. Power plant thermal efficiency	ηp	%	19
3. Fuel combustion ratio	α	%	100
4. High heat value of fuel	Hh'	kcal/kg	10,700

Calculation Form

° Fuel consumption	Fo	T/H	
$Fo = \dfrac{Po \times 860 \times \frac{\alpha}{100}}{\frac{\eta p}{100} \times Hh'}$			25.4 T/H

2. Combustion Gas Volume

Basic Specification			
1. Hydrogen	ho'	%	12.5
2. High heat value of fuel	Hh'	kcal/kg	10,700
3. O_2 content in flue gas	O_2	%	4.0

Calculation Form

° Low heat value of Fuel Hl'	Hl'	kcal/kg	
Hl' = Hh' − 6 (9 x ho')			10,025
° Excess air ratio m	m	−	
$m = \dfrac{21}{21 - O_2}$			1.24
° Combustion Gas Volume			
. Theorethical air volume	Ao'	Nm^3/kg-fuel	
$Ao' = 0.85 \times Hl' \times 10^{-3} + 2.0$			
. Theorethical combustion gas volume	Go'	Nm^3/kg-fuel	
$Go' = 1.11 \times Hl' \times 10^{-3}$			11.13

. Actual combustion gas volume	G		
at Wet gas condition	G'w		
$G'w = Go' + (m-1)Ao'$			13.65
at Dry gas condition	G'd		
$G'd = Gw' - \frac{0.224}{18}(9 \times ho + W')$			12.25
3. Flue Gas Volume at Boiler End	Qb	Nm^3/H	
at wet condition			
$QwB = (Fo \times G'w) \times 10^3$	QwB	Nm^3/H	347×10^3
at dry condition			
$QdB = (Io \times G'd) \times 10^3$	QdB	Nm^3/H	311×10^3
4. Effective Height of Chimney			
(apply equation of Bosanquet)			
<u>Basic Condition</u>			
1. Flue gas volume	QwB	Nm^3/H	347×10^3
2. Ambient temperature	ta	°C	30
3. Flue gas temperature	tg	°C	135
4. Diameter of Chimney	D	m	2.16
5. Wind velocity	U	m/s	6
6. Temperature reducing rate	$d\theta/dz$	°C/m	0.0033
7. Design height of chimney	Ho	m	100
Calculation of effective chimney height			
. exhaust gas volume	Qt	m^3/s	107
$= \frac{Qw \times (273 + ta)}{3,600 \times 273}$			
. exhaust gas velocity at chimney nozzle	Vg	m/s	39
$= \frac{Qw \times (273 + tg)}{3,600 \times 273 \times \frac{\pi}{4} D^2}$			

• Raising height of flue gas by flue gas energy (momentum)	Hm	m	
$= \frac{4.77}{1 + \frac{0.43 \times U}{Vg}} \times \frac{\sqrt{Qt \times Vg}}{U}$			
$= \frac{0.795\sqrt{Qt \times Vg}}{1 + \frac{2.58}{Vg}}$			48
• Raising height of flue gas by temperature difference between flue gas and ambient	Ht	m	
$= 6.37 \times g \times \frac{Qt\ (tg - ta)}{U^3\ (273 + ta)} \times (LnJ^2 + \frac{2}{J} - 2)$			46.1
$= 1.91 \times 10^{-3} \times Qt\ (tg-ta) \times (2.3\ \log J + \frac{1}{J} - 1)$			
$J = \frac{U_2}{\sqrt{Qt \times Vg}} \times 0.43\sqrt{\frac{(273 + to)}{g(d\theta/dz)}} - 0.28\ \frac{Vg\ (273 + ta)}{g\ (tg - ta)} + 1$			
$= \frac{1}{\sqrt{Qt \times Vg}}\ (1{,}498 - \frac{312 \times Vg}{tg - ta}) + 1$			22.4
• Effective height of chimney	He	m	
$= Ho + 0.65\ (Hm + Ht)$			161

5. *Calculation of air polutant*

<u>Basic Specification</u>

1. Fuel consumption	Fo	T/H	25.4
2. Sulphur component	So	%	1.6
3. Flue gas volume at dry state	QdB	Nm^3/H	473×10^3
4. Effective height of chimney	He	m	161
5. O_2 content in flue gas	O_2	%	4.0
Calculation of SO_x emission			
° SO_x volume at boiler end	q'	Nm^3/H	284.5
$= 7\ (Fo \times So)$			
° SO_x density at chimney nozzle	qc	ppm	601
$= \frac{q'}{QdB} \times 10^6$			

6. Maximum SO_x Landing Density and Distance

6-1	Maximum SO_x landing density (apply equation of Sutton) $= 1.72 \times \frac{q'}{Hc^2}$	Cmax	ppm	0.019
6-2	Maximum SO_x landing distance (apply equation of Sutton) $= 20.8 \times He^{1.143} \times 10^{-3}$	Xmax	km	6.9

Calculation for Air Pollution in Environment Problem

Type-F So 1.6% Chimney 120 m

1. Fuel Consumption

Basic Specification	Abbreviation/Unit		Applying value of this project
1. Output at Generator end	Po	MW	60
2. Power plant thermal efficiency	ηp	%	19
3. Fuel combustion ratio	α	%	100
4. High heat value of fuel	Hh'	kcal/kg	10,700
Calculation Form			
° Fuel consumption	Fo	T/H	
$Fo = \dfrac{Po \times 860 \times \frac{\alpha}{100}}{\frac{\eta p}{100} \times Hh'}$			25.4 T/H

2. Combustion Gas Volume

Basic Specification			
1. Hydrogen	ho'	%	12.5
2. High heat value of fuel	Hh'	kcal/kg	10,700
3. O_2 content in flue gas	O_2	%	4.0
Calculation Form			
° Low heat value of Fuel Hl'	Hl'	kcal/kg	
$Hl' = Hh' - 6\ (9 \times ho')$			10,025
° Excess air ratio m	m	-	
$m = \dfrac{21}{21 - O_2}$			1.24
° Combustion Gas Volume			
. Theorethical air volume	Ao'	Nm^3/kg-fuel	
$Ao' = 0.85 \times Hl' \times 10^{-3} + 2.0$			
. Theorethical combustion gas volume	Go'	Nm^3/kg-fuel	
$Go' = 1.11 \times Hl' \times 10^{-3}$			11.13

. Actual combustion gas volume	G		
at Wet gas condition	G'w		
$G'w = Go' + (m-1)Ao'$			13.65
at Dry gas condition	G'd		
$G'd = Gw' - \frac{0.224}{18}(9 \times ho + W')$			12.25

3. Flue Gas Volume at Boiler End	Qb	Nm^3/H	
at wet condition			
$QwB = (Fo \times G'w) \times 10^3$	QwB	Nm^3/H	347×10^3
at dry condition			
$QdB = (Io \times G'd) \times 10^3$	QdB	Nm^3/H	311×10^3

4. Effective Height of Chimney

(apply equation of Bosanquet)

<u>Basic Condition</u>

1. Flue gas volume	QwB	Nm^3/H	347×10^3
2. Ambient temperature	ta	°C	30
3. Flue gas temperature	tg	°C	135
4. Diameter of Chimney	D	m	2.16
5. Wind velocity	U	m/s	6
6. Temperature reducing rate	$d\theta/dz$	°C/m	0.0033
7. Design height of chimney	Ho	m	120

Calculation of effective chimney height

. exhaust gas volume	Qt	m^3/s	107
$= \frac{Qw \times (273 + ta)}{3{,}600 \times 273}$			
. exhaust gas velocity at chimney nozzle	Vg	m/s	39
$= \frac{Qw \times (273 + tg)}{3{,}600 \times 273 \times \frac{\pi}{4} D^2}$			

- Raising height of flue gas by flue gas energy (momentum) — Hm — m

$$= \frac{4.77}{1 + \frac{0.43 \times U}{Vg}} \times \frac{\sqrt{Qt \times Vg}}{U}$$

$$= \frac{0.795\sqrt{Qt \times Vg}}{1 + \frac{2.58}{Vg}}$$ — 48

- Raising height of flue gas by temperature difference between flue gas and ambient — Ht — m

$$= 6.37 \times g \times \frac{Qt\ (tg - ta)}{U^3\ (273 + ta)} \times (LnJ^2 + \frac{2}{J} - 2)$$ — 46.1

$$= 1.91 \times 10^{-3} \times Qt\ (tg-ta) \times (2.3\ logJ + \frac{1}{J} - 1)$$

$$J = \frac{U_2}{\sqrt{Qt \times Vg}} \times 0.43\sqrt{\frac{(273 + to)}{g(d\theta/dz)}}$$

$$- 0.28\ \frac{Vg\ (273 + ta)}{g\ (tg - ta)} + 1$$

$$= \frac{1}{\sqrt{Qt \times Vg}}\ (1{,}498 - \frac{312 \times Vg}{tg - ta}) + 1$$ — 22.4

- Effective height of chimney — He — m

$= Ho + 0.65\ (Hm + Ht)$ — 181

5. Calculation of air polutant

<u>Basic Specification</u>

1. Fuel consumption	Fo	T/H	25.4
2. Sulphur component	So	%	1.6
3. Flue gas volume at dry state	QdB	Nm^3/H	473×10^3
4. Effective height of chimney	He	m	181
5. O_2 content in flue gas	O_2	%	4.0

Calculation of SO_x emission

° SO_x volume at boiler end — q' — Nm^3/H — 284.5

$= 7\ (Fo \times So)$

° SO_x density at chimney nozzle — qc — ppm — 601

$$= \frac{q'}{QdB} \times 10^6$$

6. Maximum SO_x Landing Density and Distance

6-1	Maximum SO_x landing density (apply equation of Sutton) $= 1.72 \times \frac{q'}{Hc^2}$	Cmax	ppm	0.015
6-2	Maximum SO_x landing distance (apply equation of Sutton) $= 20.8 \times He^{1.143} \times 10^{-3}$	Xmax	km	7.9

ANNEX 5

STUDY ON FUELS

APPLICABLE TO GAS TURBINES

ANNEX 5 Study on Fuels Applicable to Gas Turbines

Generally, gas fuel and liquid fuel are used for gas turbines. Also, either single type fuel or multi-fuel is used. In this section, impacts of three types of fuel - gas fuel, distillate fuel and heavy oil fuel - on equipment design and fuel changeover on load condition were studied.

Gas Turbine - Application of multi fuel

<u>Case - one</u>

(1)	Fuel	Distillate - Gas are available
(2)	Type of combustion chamber	Respective type at proven design
(3)	Operation mode	Fuel changeover available on load condition.

<u>Case - two</u>

(1)	Fuel	Distillate - Heavy oil are available
(2)	Type of combustion chamber	Respective type at proven design
(3)	Operation mode	Fuel changeover are available on load condition.

<u>Case - three</u>

(1)	Fuel	Gas - Heavy oil are available.
(2)	Type of combustion chamber	Respective type at proven design
(3)	Operation mode	Fuel changeover are available on load condition.

<u>Case - four</u>

(1)	Fuel	Gas - Distillate - Heavy oil are available
(2)	Type of combustion chamber	Respective type peculiar design
(3)	Operation mode	Fuel changeover are available on load condition.

ANNEX 6

OPERATION OF POWER STATIONS AT LIGHT LOAD

Operation of Power Stations at Light Load

When the Barka P.S. (740 MW) goes into operation in 1989, the output of the MEW power stations will increase from 1,008 MW to 1,748 MW and the number of generators from 30 to 40. These generators must be operated in a highly reliable way coping with fluctuations of the network demands in the season and hourly. Studies were made on the operating methods of the generators to satisfy the power and water demands of the MEW's Capital area and Batinah coast area and to minimize the frequency drop even if a generator should fail and drop out of the system. The investigation period is for 1988 - 1992 and two stages in every year, June (peak demand) and February (lowest demand).

The preconditions for the investigation were set as follows:

(1) In April 1989, the Capital area and Batinah coast power systems will make an unified system.

(2) Capital area and Batinah coast area should maintain their own supply and demand balance by each area in principle.

(3) For the Barka P.S., No.1 and No.2 generators are scheduled to go into operation in July 1988, and the peak demand in June 1988 will be covered by the power generated through the trial operation of these generators.

(4) As a rule, the output of the single generator will be limited to less than 10% of the total demand. But the generator output of the Rusail P.S. and Barka P.S. will be decreased to 40 MW (about 50% of the rating).

(5) At the time of low-load, the load share by the large-capacity generators will be minimized as much as possible. However, each power station should have at least one generator connected to the system.

(6) The generators provided with the desalination plant should be operated in accordance with the water demand.

(7) The supply and demand adjustment should be made by these method in principle:

1) When the generator output of the Rusail and Barka Power Stations is limited to 40 MW at the time of low-load, the supply and demand adjustment should be made by Ghuborah's 27.5 MW and 17.5 MW units.

2) In such a demand scale where the generator output of Rusail and Barka can be more than 40 MW, balance in the supply and demand should be made by Rusail's generators.

3) The gas turbine generators of 30 MW or more in summer and 10 MW or more in winter should be operated governor-free.

Table 1 and Table 2 respectively show the maximum demand (June) and the minimum demand (February) of each power station.

Table 3 shows the generator output at each power station to satisfy the demands described in Table 1 and Table 2. If each power station is carried out the operation as shown in Table 3, the conditions for water demand can be satisfied as well as the conditions for electric power demand.

The output of each generator shown in Table 3 is just one example. It is therefore necessary to make further consideration on 1) performance of generator, 2) operation expenses, and 3) system conditions (regulation of voltage, loss of electric power-transmission, and distribution of demands).

If the maximum output generator should trip at the minimum demand, the frequency will decrease to 47.52 Hz in 1989. After that time, the frequency drop will be gradually decreased in the inverse proportion to the demand's increase. Decreasing value of frequency after 1993 can be maintained within 1.5 Hz, a tolerance limitation value of continuous operation.

At the off-peak period from 1989 to 1992, frequency can not be maintained within a tolerance limitation (48.5 Hz) only by controlling the output per generator. Therefore, a partial load shedding by a frequency relay has to be carried out to maintain a supply - demand balance of the system.

Table 1 Demand Forecast at Each Substation in June

(MW)

Year / Substations	Peak Load (100%)								Minimum Load (53.5%)								Remarks
	1988	1989	1990	1991	1992	1993	1994	1995	1988	1989	1990	1991	1992	1993	1994	1995	
Al Falaj	84	94	105	114	122	129	136	143	45	50	56	61	65	69	73	77	
Wadi Khabir	84	94	105	114	122	129	136	143	45	50	56	61	65	69	73	77	
Wadi Adai	83	94	104	114	121	129	135	143	44	50	56	61	65	69	72	77	
Qaboos	76	81	95	110	120	131	136	141	41	43	51	59	64	70	73	75	
Khuwair	50	65	85	105	120	131	136	141	27	35	45	56	64	70	73	75	
Ghubrah	89	96	103	110	115	120	125	130	48	51	55	59	62	64	67	70	
Air Port Heights	40	80	95	110	117	124	132	141	21	43	51	59	63	66	71	75	
Rusail	187	191	196	203	211	220	228	237	100	102	105	109	113	118	122	127	
Seeb Palace	48	50	53	56	59	62	65	69	26	27	28	30	32	33	35	37	
Barka	40	46	50	55	61	68	76	84	21	25	27	29	33	36	41	45	
Musanna	17	19	22	25	29	33	38	44	9	10	12	13	16	18	20	24	
Rustaq	21	24	27	32	36	42	48	55	11	13	14	17	19	22	26	29	
Suwaiq	21	24	28	32	37	42	49	56	11	13	15	17	20	22	26	30	
Khabourah	13	16	18	20	24	27	31	36	7	9	10	11	13	14	17	19	
Saham	23	27	32	37	43	49	56	65	12	14	17	20	23	26	30	35	
Sohar	30	37	44	50	57	66	76	87	16	20	24	27	30	35	41	47	
Shinas	8	10	11	13	15	17	20	23	4	5	6	7	8	9	11	12	
Copper Mine	17	17	17	17	17	17	17	17	9	9	9	9	9	9	9	9	
Buraimi	56	66	75	83	95	106	116	131	30	35	40	44	51	57	62	70	
Ibri	44	52	61	68	78	87	96	109	24	28	33	36	42	47	51	58	
Capital Area	840	958	1,068	1,180	1,270	1,360	1,440	1,527	449	512	571	631	681	726	772	818	(Including Musanna, Rustaq, Suwaiq)
Batinah Area	191	225	258	288	329	369	412	468	102	120	139	154	176	197	221	250	
Grand Total	1,031	1,183	1,326	1,468	1,599	1,729	1,852	1,995	551	632	710	785	857	923	993	1,068	

Table 2 Demand Forecast at Each Substation in February

(MW)

Substations \ Year	Peak Load (32.8%)								Minimum Load (16.5%)								Remarks
	1988	1989	1990	1991	1992	1993	1994	1995	1988	1989	1990	1991	1992	1993	1994	1995	
Al Falaj	28	31	34	37	40	42	45	47	14	16	17	19	20	21	23	24	
Wadi Khabir	28	31	34	37	40	42	45	47	14	16	17	19	20	21	22	24	
Wadi Adai	27	31	34	37	40	42	44	47	14	15	17	19	20	21	22	23	
Qaboos	25	27	31	36	39	43	45	46	12	13	16	18	20	22	22	23	
Khuwair	16	21	28	34	39	43	45	46	8	11	14	17	20	22	22	23	
Ghubrah	29	31	34	36	38	40	41	43	15	16	17	18	19	20	21	21	
Air Port Heights	13	26	31	36	38	41	43	46	7	13	16	18	19	20	22	23	
Rusail	61	63	64	67	69	72	75	78	31	31	32	33	35	36	38	39	
Seeb Palace	16	16	17	18	19	20	21	23	7	8	9	9	10	10	11	11	
Barka	13	15	16	18	20	22	25	28	7	8	8	9	10	11	13	14	
Musanna	5	6	7	8	10	11	12	14	3	3	4	4	5	5	6	7	
Rustaq	7	8	9	11	12	14	16	18	4	4	5	5	6	7	8	9	
Suwaiq	7	8	9	11	12	14	16	18	4	4	5	5	6	7	8	9	
Khabourah	4	5	6	7	8	9	10	12	2	3	3	3	4	4	5	6	
Saham	7	9	10	12	14	16	18	21	4	4	5	6	7	8	9	11	
Sohar	10	12	14	16	19	22	25	29	5	6	7	8	9	11	13	14	
Shinas	3	3	4	4	5	6	7	8	1	2	2	2	2	3	3	4	
Copper Mine	6	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	
Buraimi	18	22	25	27	31	35	38	43	9	11	12	14	16	17	19	22	
Ibri	14	17	20	22	26	29	31	36	7	9	10	11	13	14	16	18	
Capital Area	275	314 (319)	348	386	416	446	473	501	140	158 (161)	177	193	210	223	238	250	(Including Musanna, Rustaq, Suwaiq)
Batinah Area	62	74 (69)	85	94	109	123	135	155	31	38 (35)	42	47	54	60	68	78	( ): Khabourah
Grand Total	337	388	433	480	525	569	608	656	171	196	219	240	264	283	306	328	

Table 3 Power Generation Program

(MW)

P.S.	Demand (Capital)			1988 Jun.		1989 Feb.		1989 Jun.		1990 Feb.		1990 Jun.		1991 Feb.		1991 Jun.		1992 Feb.		1992 Jun.		1993 Feb.		Remarks
				Peak	Min.	Peak	Min.	Peak	Min.	Peak	Min.	Peak	Min.	Peak	Min.	Peak	Min.	Peak	Min.	Peak	Min.	Peak	Min.	
				840	449	319	161	958	512	348	177	1,068	571	386	193	1,180	631	416	210	1,270	681	446	223	
GHUBRAH (285 MW)	1	Steam	50 MW	50	50	40	40	50	50	40	40	50	50	40	40	50	50	40	40	50	50	40	40	Except steam 7.5 MW x 3
	1	Gas	17.5	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	
	2	"	"	17	17	17		17	17	17	17	17	17	17		17	17	17	17	17	17	17		
	3	"	"	17	17			17	17	17		17	17	17		17				17	17			
	4	"	"	17	17			17	17	17		17		17		17								
	5	"	"	17	17			17	17	17		17		17		17								
	6	"	"	17	17			17		17		17				17								
	7	"	"	17	17			17				*17				10								* to Batinah
	8	"	"									*16				10								
	9	"	"																					
	1	Gas	27.5	27	20	27	24	27	27	27	23	27	27	21	16	27	27	22	16	27	27	27	27	
	2	"	"	24	20	18		27		19		27	27							*24	27	25	19	
		Total		220	209	119	81	223	162	188	97	239	155	146	73	199	111	96	90	152	155	126	103	
RUSAIL (498 MW)	1	Gas	83 MW	80	40	40	40	83	50	40	40	83	60	40	40	83	60	40	40	83	60	40	40	
	2	"	"	80	40	40		83	50	40		83	60	40		83	60	40		83	60	40		
	3	"	"	80	40	40		83	50			83	56			83	60	40		83	60	40		
	4	"	"	80	40			83	50			83				83	40			83	46			
	5	"	"	80	40			83				70				69				83				
	6	"	"	80												*63				67				
		Total		480	200	120	40	415	200	80	40	402	176	80	40	464	220	120	40	482	226	120	40	
BARKA (740 MW)	1	Gas	80 MW	70	40	40	40	80	50	40	40	80	60	40		80	60	40		80	60	40		
	2	"	"	70		40		80	50	40		80	60	40		80		40		80	60	40		
	3	"	"					80	50			80				80				80				
	4	"	"					80				80				80				80				
	5	"	"																	*80				
	1	Steam	80									80	60			80	60			80		40		
	2	"	"																	80				
	1	"	60									60	60	40	40	60	60	40	40	60	60	40	40	
	2	"	"											40	40	60	60	40	40	60	60	40	40	
	3	"	"													60	60			60	60			
		Total		140	40	80	40	320	150	80	40	460	240	160	80	580	300	200	80	740	300	200	80	
Demand (Batinah)				191	102	69	35	225	120	85	42	258	139	94	47	288	154	109	54	329	176	123	60	
COPPER MINE (165 MW)	1	Gas	17 MW	17	17	17	10	17	15			17	17	17		17	10	11		17	17	17		
	2	"	"	17		12	10	17	15			17	17	17		17		11		17	17			
	3	"	"	13				17				17				17				17				
	1	"	27	27	25	20		27		25		27	27			27	27	27		27	27	23		
	2	"	"	27				27				27	18			27	27			27	27	23		
	1	"	30	30	30			30	30	30	21	30		30	23	30	30	30	27	30	28	30	30	
	2	"	"					30				30				30				30				
SOHAR (60 MW)	1	Gas	30 MW	30	30	20	15	30	30	30	21	30	30	30	24	30	30	30	27	30	30	30	30	
	2	"	"	30				30	30			30	30			30	30			30	30			
		Total		191	102	69	35	225	120	85	42	225	139	94	47	225	154	109	54	225	176	123	60	
Frequency Drop (HZ)	Largest generator unit drops			49.05	49.11	48.75	47.52	49.30	49.21	49.08	48.17	49.37	49.15	49.17	48.33	49.43	49.24	49.24	48.48	49.48	49.30	49.30	48.59	
	120 MW drops in June			48.57	47.33			48.99	48.10			49.10	48.31			49.18	48.47			49.25	48.60			reference value
	60 MW drops in February					48.12	46.27			48.61	47.26			48.75	47.50			48.86	47.73			48.95	47.88	

Fig. I POWER GENERATION PROGRAM