APPENDIX-7 TESTING ITEMS AND PROCEDURES

TESTING ITEMS AND PROCEDURES

I. Testing Items

Generally, testing items to be carried out during overhauling should include at least boiler safety valve, steam turbine emergency shut-down device, auxiliary oil pump and emergency oil pump for steam turbine, condenser, feed water pumps, forced draft fans, gas recirculation fan, air preheaters and feed water heaters.

Overhauling records should be reported in detail, and covers dismantling, reassembling records and its method, scope of repair works, calibration and adjusting records including data and information and test records.

Testing items to be carried out during overhauling are as follows:

1) Hydraulic test
2) Safety valve test
3) Boiler tripping interlock test
4) Feed water pump test
5) Fuel oil pump test
6) Air preheater test
7) Soot blower test
8) Light off and pressurization test
9) Turbine major valve test
10) Turbine tripping interlock test
11) Vacuum up test
12) Turbine stretch out test
13) Turbine acceleration test

14) Lubricating oil system test

15) Feed water heater leak test

16) Condensate pump test

17) Circulating water pump test

18) Generator

19) Transformer

II. Testing Procedures

II - 1. Hydraulic test

a) Apply pressure to boiler with the aid of boiler feed water pump.

b) Use pure water of temperature at about 40°C.

c) Pressure increase and decrease rates should be 3~5 kg/cm^2/minute, and pressurize at the slower rate in proximity to maximum working pressure.

d) Safety valve should be mechanically locked with the aid of gag at pressure of about 80% of maximum working pressure.

e) 1.15 times of maximum working pressure should be kept for about 30 minutes to 1 hour.

Check items

_____ Leak from any portion of boiler

_____ Distortion and deformation of tubes, headers, etc.

II - 2. Safety valve test

a) Pressurize boiler up to spouting pressure setting with small capacity burner.

b) In case of drum type boiler, keep the drum level low since the level increases after spouting of safety valve.

c) Another safety valve except testing safety valve should be mechanically locked with gag so as not to be spouted.

d) After safety valve spouting, decrease firing rate and open the drain valves so that the boiler pressure decreases.

e) Close the drain valves at adequate pressure for next safety valve tests.

f) Use precise pressure gauge temporarily installed for safety valve test.

g) Safety valve test can be carried out with use of hydraulic jack.

Check items

_____ Popping pressure

_____ Reset pressure

_____ Blowing down pressure

_____ Safety valve lift

_____ Working condition

II - 3. Boiler tripping interlock test

All of actual unit trip may not be carried out in accordance with the test items described below, some of them can be tested only by relay.

a) Both FDFs trip test:

1) Trip the FDF by manual operation. FDF should be tripped one by one.

2) When one FDF tripped, confirm the damper conditions (opened or closed).

3) Trip another FDF by manual operation. Confirm the damper conditions.

Check items

_____ Alarm annunciation

_____ Damper interlock

b) Reheater protection interlock test:

1) Decrease fuel flow gradually up to interlock setting.

2) Confirm setting point and alarm annunciation.

Check items

_____ Alarm annunciation

_____ Fuel flow setting and timer setting

_____ Air flow

c) Furnace draft high interlock test:

1) Increase furnace draft gradually by closing gas side damper.

2) Confirm pressure setting and alarm annunciation.

Check items

_____ Alarm annunciation

_____ Pressure setting point

d) Fuel oil low pressure interlock test:

1) Decrease fuel oil header pressure by gradual closing fuel oil flow control valve.

2) Confirm pressure setting point.

Check items

_____ Alarm annunciation

_____ Confirm the pressure setting point and timer setting point

_____ Fuel oil pumps stoppage

_____ Fuel oil shut-off valve closed

_____

e) Purge interlock test:

1) Operate FDFs.

2) Confirm the damper conditions.

3) Purge the furnace for about 5 minutes at about 30% air flow up to MFT reset.

Check items

_____ Air flow

_____ Purge timer setting

_____ Alarm annunciation reset

_____ Fuel oil system interlock after MFT reset

Fuel oil shut-off valve
Light oil shut-off valve
Fuel oil pump
Light oil pump
Fuel oil burner valve
Light oil burner valve

II - 4. Feed water pump test (motor-driven)

a) Auxiliary oil pump auto start test.

b) Start BFP-M keeping discharge valve fully closed.

c) Open the discharge valve gradually.

d) Adjust the feed water flow until the minimum flow control valve closes.

Check items

_____ Abnormal sound and vibration

_____ Bearing lubricating oil temperature and pressure

_____ Auxiliary oil pump auto-start pressure set point

_____ Cooling water flow

_____ Motor current

_____ Inlet and outlet feed water pressure

_____ Minimum flow control flow set point

_____ Leakage from pump gland

II - 5. Fuel oil pump test

a) Start fuel oil pump after formation of fuel oil line from pump discharge to fuel oil storage tank.

Check items

_____ Abnormal sound, vibration

_____ Bearing temperature

_____ Motor current

_____ Fuel oil temperature

_____ Differential pressure between inlet and outlet of oil strainer

_____ Operating condition of pump discharge relief valve

_____ Oil leakage from the pump and pipings

II - 6. Air preheater test

a) Operate the AH with motor or air motor.

Check items

_____ Abnormal sound, vibration

_____ Bearing temperature

_____ Lubricating oil temperature

_____ Lubricating oil flow

_____ Cooling water flow

_____ AH balancing

_____ Motor current

_____ Gas side differential pressure

_____ Air side differential pressure

_____ Inlet and outlet temperature of AH

II - 7. Soot blower test

a) Confirm normal operation of auxiliary steam pressure control valve.

b) Confirm the drainage before blowing test.

c) Blowing test from remote control panel in the central control room.

Check items

_____ Abnormal sound, vibration

_____ Blowing steam pressure

_____ Travelling speed, blowing time

_____ Emergency extraction

_____ Steam leakage from head valve and pipings

II - 8. Light off and pressurization test

a) After the confirmation of boiler protection device functions, operate the equipments necessary for unit start-up.

Check items

_____ Burner operating condition

_____ Burning condition

_____ Water, steam and gas temperature

_____ Temperature increase rate

_____ Steam quality

_____ Furnace expansion

_____ Expansion of pipe hanger

_____ Gas, water, drain and steam leakage

II - 9. Turbine major valve test

a) Main stop valve:

This valve should be tested at turbine start-up, unit loading and unit shut-down.

Check items

_____ Stroke of valve lift

_____ Full stroke operating time

_____ Operating condition

_____ Interlock

_____ Indicating lamps and positioner

_____ Limit switches

b) Governing valve:

This valve should be tested at turbine start-up, unit loading and unit shut-down.

Check items

_____ Oil cylinder stroke and opening

_____ Operating condition

_____ Indicating lamps and positioner

_____ Balancing valve

_____ Lead pipe, drain valve

_____ Valve lift

_____ Limit switches

c) Reheat stop valve:

This valve should be tested at turbine start-up, unit loading and unit shut-down.

Check items

_____ Valve stroke

_____ Operating condition

_____ Interlock

_____ Indicator and positioner

_____ Limit switches

d) Intercept valve:

This valve should be tested at turbine start-up, unit loading and unit shut-down.

Check items

_____ Valve stroke

_____ Full stroke operating time

_____ Operating condition

_____ Interlock

_____ Balancing valve

_____ Limit switches

_____ Indicator and positioner

II - 10. Turbine tripping interlock test

All of actual unit trip may not be carried out in accordance with the test items described below, some of them can be tested only by relay.

a) Manual trip lever test:

This test should be carried out before turbine start-up.

Check items

_____ Operating condition

_____ Alarm annunciation

_____ Indicating lamps

_____ Interlock with turbine major valves

b) Vacuum trip test:

1) Operate air ejector, and vacuum up to about 700mmHg.

2) Open gradually vacuum break valve.

Check items

_____ Confirmation of low vacuum set point

_____ Alarm annunciation

_____ Interlock with turbine major valves

II - 11. Vacuum up test

Operate gland steam regulator and air ejectors, and vacuum up. If the vacuum up rate will be slow, check the leakage.

Check items

_____ Vacuum up rate

_____ Leakage and extraction air

_____ Gland steam regulator

II - 12. Turbine stretch out test

After steam admission to turbine, turbine casing should be heated uniformly changing condenser vacuum.

Check items

_____ Casing expansion

_____ Uniform expansion

_____ Eccentricity

_____ Bearing oil temperature and pressure

_____ LP turbine exhaust steam temperature

_____ Vacuum

_____ Abnormal sound

_____ Chest metal temperature

II - 13. Turbine acceleration test

When the turning gear is disengaged, stop the steam admission to turbine and carry out rub check. Confirm that there is no abnormality, then accelerate turbine revolution. Pay attention to bearing oil temperature and adjust the oil cooler.

Check items

_____ Turbine speed

_____ Eccentricity

_____ Expansion

_____ Differential thermal expansion

_____ Vibration

_____ Abnormal sound

_____ Bearing oil temperature and pressure

_____ Governing oil pressure and control oil pressure

_____ Metal temperature inside and outside of chest

_____ Oil pressure set point of auxiliary oil pump stop

_____ Operating conditions of governor

II - 14. Lubricating oil system test

(Turning oil pump, auxiliary oil pump and emergency oil pump)

a) Automatic start-up of the oil pumps should be tested after reassembling of the oil units.

b) Confirm that the oil pumps start at the normal set point pressure.

Check items

_____ Abnormal sound

_____ Vibration

_____ Oil pressure

_____ Set point of automatic start-up

_____ Leakage from oil pipings and flanges

II - 15. Feed water heater leak test

Apply pressure to water chamber of feed water heater, and confirm that there is no leakage from heating tube.

Check items

_____ Leakages

_____ Test pressure

II - 16. Condensate pump test

Check items

_____ Abnormal sound

_____ Vibration

_____ Bearing temperature

_____ Motor current

_____ Suction and discharge pressures

_____ Leakage from pump gland

II - 17. Circulating water pump test

Check items

_____ Abnormal sound

_____ Vibration

_____ Bearing temperature

_____ Motor current

_____ Suction and discharge pressure

_____ Bearing cooling water flow

_____ Lubricating water flow

_____ Cooling water solenoid valve

_____ Interlock

II - 18. Generator

a) Leak test of generator:

Leak test should be carried out after reassembly of generator and seal oil unit.

1) Operate seal oil unit including stand-by of back-up system.

2) Supply the generator with freon gas by 0.5 or 1.0% of generator capacity and with air up to specified pressure.

3) Check leakage at valve flange and other places completely by soap method and freon gas detector.

4) After leak check, pressurize up to specified pressure then close the air supply valve.

5) Read the generator pressure by mercury manometer and temperature.

6) Keep the above condition for 6 hours at least.

7) Compute leakage quantity by the following formula:

$$L=0.0316\frac{V}{H}\left[(M1-M2) - \frac{T1-T2}{273+T1}(M1+B1) + (B1-B2)\right]$$

L: Leakage quantity at 760mHg and T1 $\left[m^3/day\right]$

H: Time [hour]

V: Capacity of generator and pipeline $\left[m^3\right]$

B1, B2: Atmospheric pressure before/after test [mmHg]

M1, M2: Generator pressure before/after testing [mmHg]

T1, T2: Generator air temp. before/after testing $\left[^0C\right]$

Air quantity dissolved into oil:

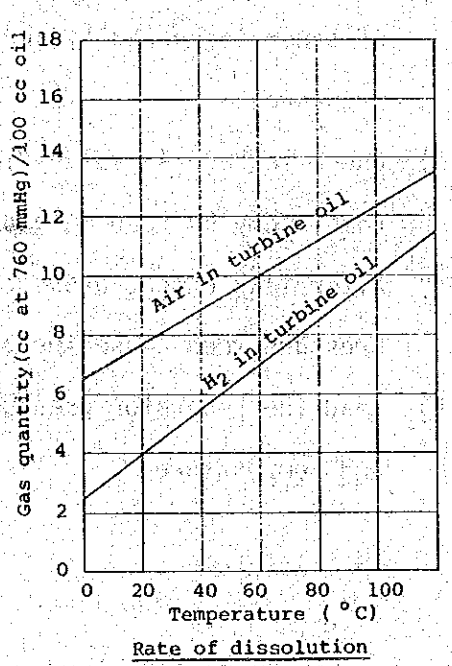
$a = 1.44\ QAP$

a: dissolved air into air $\left[m^3/day\right]$

Q: return flow of oil [l/min]

A: rate of dissolution (See Figure shown below)

P: Absolute gas pressure [atm]



Rate of dissolution

Actual gas leak:

Lair = L-a

$$Lh = 3.75 \times \sqrt{\frac{Ph}{Pair}} \cdot Lair$$

Lair: Leakage quantity at Pair of air (760 mmHg at T1) m^3/day

Lh: Leakage quantity at Ph of hydrogen (760 mmHg at T1) m^3/day

Pair: Air press. (kg/m^2abs)

Ph : H_2 press. (kg/m^2abs)

8) Compare data with past record and guaranteed figure by manufacturer.

b) Test of seal oil unit:

1) Alarm test

2) Back-up test

3) Adjustment of seal oil pressure

c) Stator coil cooling water system:

1) Megger test before filling water

2) Performance check of ion exchanger

3) Leak test of stator cooling water system

4) Characteristic test of cooling water pump

5) Performance test of temperature control valve and pressure reducing valve

6) Check of thermocouple and conductivity meter

7) Measurement of flow rate and pressure of each part

8) Annunciator and interlock test

II - 19. Transformer

a) Megger test

b) Operation test of cooling fan and cooling oil pump

c) Automatic start-stop test of cooling fan

d) Annunciator test

e) Insulation oil breakdown test

Circuit breaker (230 KV and 115 KV):

a) Operation test

b) Megger test

c) Alarm test

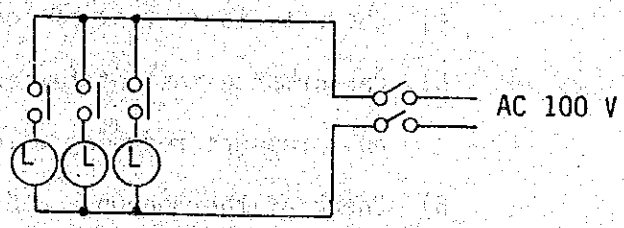
d) Insulation oil test (115 KV)

(breakdown test and measurement of neutralization number)

e) Open-close test

- Measurement of contact timing

All contacts to be closed simultaneously should be confirmed by lamp test method while moving contact slowly by hand.



- Measurement of switching time

Time for open and close can be measured by oscillo-graph.

APPENDIX-8 RECORD OF FORCED OUTAGE

RECORD ON FORCED OUTAGES

RECORD OF FORCED OUTAGES

Attached sheets indicate the actual trouble records for each unit and these will be understood as reference data to grasp actual situation, tendency and cause of trouble.

I. Historical Record of Trouble for Each Unit

	Gardner Unit 1	Gardner Unit 2	Snyder Unit 1	Snyder Unit 2	Malaya Unit 1	Malaya Unit 2
Commercial Operation	8/01/68	1/15/70	07/01/71	07/31/72	09/04/75	06/26/79
1968	10	-	-	-	-	-
1969	10	-	-	-	-	-
1970	8	11	-	-	-	-
1971	10	9	8	-	-	-
1972	23	15	23	9	-	-
1973	9	16	17	24	-	-
1974	7	18	25	22	-	-
1975	7	24	13	20	11	-
1976	4	22	23	18	18	-
1977	9	21	21	15	19	-
1978	16	34	20	28	36	-
1979	14	29	23	33	14	10
1980	16	23	25	26	21	16
1981	12	19	28	23	24	21
1982	3	13	6	4	9	7
Total	158	254	232	222	152	54
Record of Forced Outage	147	243	229	222	128	54

SUMMARY RECORD OF FORCED OUTAGES

	Gardner Unit 1	Gardner Unit 2	Snyder Unit 1	Snyder Unit 2	Malaya Unit 1	Malaya Unit2	Total
1. Boiler and Auxiliary	84	102	72	106	32	16	412
1) Boiler	17	49	25	39	23	4	157
2) Fuel oil System	3	3	5	7	4	5	27
3) Air heater	45	33	30	43	0	0	151
4) Forced draft fan	9	3	0	3	0	0	15
5) Gas recirculation fan	2	0	1	0	0	0	3
6) Valve and piping	7	14	9	14	4	0	47
7) Control system	1	0	2	0	1	7	11
2. Turbine and Auxiliary	31	45	66	60	39	12	253
1) Main turbine	2	14	39	22	27	7	111
2) Condenser	14	6	9	17	7	2	55
3) Circulating H_2Opump	5	2	3	0	1	3	14
4) Control system	10	23	15	21	4	0	73
3. Condensate and feed water system	2	59	54	45	25	3	188
1) Condensate and make-up system	0	2	6	3	0	1	12
2) Motor driven BFP	1	23	12	3	1	1	41
3) Turbine driven BFP	-	24	15	7	7	0	53
4) Low press. heater	0	0	6	2	1	1	10
5) High press. heater	1	8	15	28	15	0	67
6) Control system	0	2	0	2	1	0	5
4. Electrical Equipment	21	15	15	4	9	15	79
1) Generator & Exciter	4	7	3	3	2	5	24
2) Transformer and Substation	10	6	6	0	4	5	31
3) Station service system	0	1	4	0	0	5	10
4) Control system	7	1	2	1	3	0	14
5. Others	9	22	22	7	23	8	91
1) B-T interlock	0	7	6	0	7	2	22
2) Generator Back-up	0	4	6	3	1	1	15
3) Outside trouble	9	11	10	4	15	5	91
TOTAL	147	243	229	222	128	54	1023

RECORD OF FORCED OUTAGES

II. Gardner Unit No. 1
July 2, 1968 - June 30, 1982

Equipment/System	Nature of Trouble	No. of Time
1. Boiler and Auxiliary		84
1) Boiler	a) Tube leak	14
	b) Fire at burner	2
	c) Leak at burner flex hose	1
2) Fuel oil system	a) CDFOP leakage	1
	b) MFOP discharge line leakage	2
3) Air heater	a) AH burned elements	3
	b) AH drive mechanism trouble	2
	c) AH clogging	29
	d) SAH clogging	8
	e) Replacement of G1 AH elements	3
4) Forced draft fan	a) Excessive vibration	7
	b) Defective discharge damper	2
5) Gas recirculation fan	a) Overload and heating up of motor	2
6) Valve and piping	a) Valve leak	6
	b) Main stop valve leakage at sealring	1
7) Control system	a) Control air contamination with oil	1
2. Turbine and Auxiliary		31
1) Main turbine	a) Burned turbine asbestos insulation	1
	b) Crossover pipe leak	1
2) Condenser	a) Condenser tube leak	11
	b) Hotwell recirculation valve malfunction	2
	c) Air ejector leakage	1
3) Criculating water pump	a) Defective of rubber expansion joint	2
	b) Leakage at discharge pipe	3
4) Contro system	a) Main trubine control valve trouble	2
	b) Main turbine control mechanism trouble	8

Equipment/System	Nature of Trouble	No. of Times
3. Condensate and Feedwater System		2
1) Condensate and make-up system		0
2) Motor driven BFP	a) Suction strainer clogging	1
3) Turbine driven BFP		0
4) Low Press, Heaters		1
5) High Press. heaters	a) Tube leak	0
6) Control system		21
4. Electrical Equipment		4
1) Generator and Exciter	a) Loss of excitation	3
2) Transformer & Substation	a) Main transformer, defective jumper	1
	b) Main transformer, oil leak	2
	c) Bank tapping	2
	d) Power cable trouble	2
	e) Disconnect switch failure	0
3) Station service system		4
4) Control system	a) Voltage regulator trouble	3
	b) Over exictation relay trouble	9
5. Others		0
1) B-T, interlock		0
2) Generator back-up		2
3) Outside trouble	a) Tripping of 115 KV line	6
	b) Frequency disturbance	1
	c) Typhoon	

RECORD OF FORCED OUTAGES

III. Gardner Unit No. 2
October 11, 1969 - June 30, 1982

Equipment/System	Nautre of Trouble	No. of Times
1. Boiler and Auxiliary		102
1) Boiler	a) Tube leak	36
	b) Reheater flushing	1
	c) Burner trouble	2
	d) Uncontrollable steam & metal temp.	10
2) Fuel oil system	a) MFOP seal leakage	3
3) Air Heater	a) Clogging	27
	b) Burned element	5
	c) Damaged parts	1
4) Forced draft fan	a) Excessive vibration	3
5) Gas recirculation fan		0
6) Valve and piping	a) Valve leak	14
7) Control system		0
2. Turbine and Auxiliary		45
1) Main turbine	a) Auxiliary oil failure	9
	b) Bearing damage	3
	c) Excessive vibration	1
	d) Turbine blade failure	1
2) Condenser	a) Tube leak	5
	b) Damaged condenser diaphragm	1
3) Circulating water pump	a) Planetary gear failure	2
4) Control system	a) Main turbine control mechanism failure	16
	b) Main turbine control valves failure	7
3. Condensate and Feedwater System		56
1) Condensate and make-up system	a) Contamination of CST	1
	b) Low Dem. water reserve	1

Equipment/System	Nature of Trouble	No. of Times
2) Motor driven BFP	a) Pump leakage	4
	b) Temperature, equalizing line leakage	7
	c) Main flow line trouble	9
	c) Leakage at suction valve	3
3) Turbine driven BFP	a) Balancing leak-off line trouble	5
	b) Defective vacuum trip device	6
	c) Main flow line trouble	5
	d) Clogging of suction strainer	1
	e) Damaged internal parts	5
	f) Leakage of steam/water pipe	2
4) Low Pressure Heaters		0
5) High Pressure Heaters	a) Tube leak	2
	b) Drip line leak	3
	c) Isolating valve leak	3
6) Control system	a) Malfunction of T-BFP control valve	1
	b) Trouble at feed water flow	1
4. Electrical Equipment		15
1) Generator and Exciter	a) Hydrogen leak	2
	b) Main exciter failure	3
	c) Oil circuit breaker failure	2
2) Transformer and Substation	a) Main transformer jumper wire heating up	1
	b) Tripping of differential lockout relay	5
3) Station service system	a) M-BFP trip-out breaker failure	1
4) Control system	a) Voltage regulator failure	1
5. Others		22
1) B-T interlock	a) MFO shut-off valve malfunction	1
	b) Malfunction of controls	6
2) Generator back-up	a) Back-up lockout switch	2
	b) Reverse power relay	2

Equipment/System	Nature of Trouble	No. of Times
3) Outside trouble	a) Tripping of 115 KV switch	2
	b) Frequency disturbance	8
	c) Typhoon	1

RECORD OF FORCED OUTAGES

IV. Snyder Unit No. 1
April 30, 1971 0 June 30, 1982

Equipment/System	Nature of Trouble	No. of Times
1. Boiler and Auxiliary		72
1) Boiler	a) Tube Leak	14
	b) Burner failure	2
	c) Burner windbox burned	2
	d) Uncontrollable steam temperature	6
	e) Gas leak	1
2) Fuel oil system	a) Leakage of F.O. Heater & pipe	2
	b) MFOP mechanical trouble	3
3) Air heater	a) Clogging	25
	b) Drive mechanism trouble	9
	c) Damaged main parts	2
4) Forced draft fan		0
5) Gas recirculation fan	a) Motor overload	1
6) Valve and piping	a) Boiler valve leak	9
7) Control system	a) F.O. Heater press, regulator trouble	2
2. Turbine and Auxiliary		66
1) Main turbine	a) Blade failure	7
	b) Excessive vibration	11
	c) Inspection internals and parts	3
	d) Tripping device trouble	11
	e) Blade washing	2
	f) Cross-over pipe & expansion bellows leakage	4
	g) Fire accident	1
2) Condenser	a) Tube leak	9
3) Circulating water pump	a) Planetary gear failure	3

Equipment/System	Nature of Trouble	No. of Times
4) Control system	a) Main turbine control valve trouble	5
	b) Hydraulic control system trouble	10
3. Condensate and Feedwater System		54
1) Condensate & make-up system	a) Leakage at condensate pump suction expansion joint	1
	b) Leakage at raw water	3
	c) Low demineralizing water reserve	1
	d) Busted condensate line	1
2) Motor driven BFP	a) Temp. Equalizing line trouble	2
	b) Tripping device trouble	2
	c) Leakage at discharge & suction of pump	4
	d) Motor overload	1
	e) Clogging of suction strainer	3
3) Turbine driven BFP	a) Balancing leak-off system trouble	3
	b) Clogging of suction strainer	1
	c) Temp. equalizing recirculation trouble	2
	d) Damage on pump parts	7
	e) Main flow system trouble	2
4) Low Pressure heaters	a) Tube leak	6
5) High Pressure Heaters	a) Tube leak	5
	b) Drip lines trouble	10
6) Control system		0
4. Electrical Equipment		15
1) Generator & Exciter	a) Oil circuit breaker (G3GG8) trouble	2
	b) Oil circuit breaker malfunction	1
2) Transformer & Substation	a) Main transformer jumper line faults	4
	b) Bursting of lightning arrester	1
	c) Differential lockout trouble	1
3) Station service system	a) Loss of 4160 V power supply	1
	b) 4160 V bus grounded	3

Equipment/System	Nature of Trouble	No. of Times
4) Control system	a) Wet generator control cubicle	1
	b) Voltage regulator trouble	1
5. Others		20
1) B-T interlock	a) Feedwater regulator malfunction	5
	b) Poor conbustion, drop in air flow	1
2) Generator Back-up	a) Shorted emergency trip relay and back-up relay	3
	b) Reverse power relay	3
3) Outside trouble	a) Tripping of 115 KV lines due to heavy down power	2
	b) Frequency disturbance	7
	c) Typhoon	1

RECORD OF FORCED OUTAGES

V. Snyder Unit No. 2
June 2, 1972 - June 30, 1982

Equipment/System	Nature of Trouble	No. of Times
1. Boiler and Auxiliary		106
1) Boiler	a) Tube leak	21
	b) Gas leak at casing	7
	c) Burner damage	1
	d) Uncontrollable temperature/pressure/ flow condition	10
2) Fuel oil system	a) Leakage of CDFOP pipe flange	1
	b) Header pressure regulator line leakage	5
	c) Fire accident at MFOP area	1
3) Air Heater	a) Clogging	37
	b) Replaced burned elements	3
	c) Damaged bearing and parts	2
	d) Sootblower failure	1
4) Forced draft fan	a) Excessive vibration	3
5) Gas recircualtion fan		0
6) Valve and piping	a) Boiler valve leak	9
	b) Leakage at auxiliary steam header	1
	c) Leakage at CRH end flange	2
	d) Leakage at extraction A-4 flange	2
7) Control system		0
2. Turbine and Auxiliary		59
1) Main turbine	a) Excessive vibration	13
	b) Broken blades	3
	c) Damaged bearing & turbine rotating parts	5
	d) Exhaust flange leakage	1
2) Condenser	a) Tube leak	15
	b) Leakage at drain line to condenser	2

Equipment/System	Nature of Trouble	No. of Times
3) Circulating water pump		0
4) Control System	a) Electro-Hydraulic governor failure	9
	b) Turbine control valve failure	11
	c) Hotwell level regulator failure	1
3. Condensate and Feedwater System		45
1) Condensate and make-up system	a) Ammonex exhaustion	2
	b) Low demineralized water reserve	1
2) Motor driven BFP	a) Clogging of suction strainer	1
	b) Temperature equalizing pump line leakage	2
3) Turbine driven BFP	a) Minimum Flow system trouble	3
	b) Low vacuum at auxiliary condenser	3
	c) Leakage at turbine gland steam	1
4) Low pressure heater	a) Tube leak	2
5) High pressure heater	a) Tube leak	16
	b) Drip lineleakage	8
	c) Leakage at isolating valve	4
6) Control system	a) Hotwell level regulator failure	1
	b) T-BFP control mechanism failure	1
4. Electrical Equipment		4
1) Generator and Exciter	a) Generator breaker control cable grounded	1
	b) DC Hi-pot test of stator	1
	c) Excitation loss	1
2) Transformer & Substation		0
3) Station service system		0
4) Control system	a) Voltage regulator trouble	1
5. Others		6
1) B-T interlock		0
2) Generator Back-up	a) Reverse power relay	2

Equipment/System	Nature of Trouble	No. of Times
3) Outside Trouble	a) Tripping of 115 KV line	1
	b) Frequency disturbance	2
	c) Typhoon	1

RECORD OF FORCED OUTAGES

VI. Malaya Unit No. 1
December 21, 1974 - June 30, 1982

Equipment/System	Nature of Trouble	No. of Times
1. Boiler and Auxiliary		32
1) Boiler	a) Tube leak	6
	b) Fire at air register assembly	2
	c) Uncontrollable steam temperature	15
2) Fuel oil system	a) Overload of MFOP-1A	1
	b) Tripping of MFOP-1A	2
	c) Leak at MFOP discharge line	1
3) Air heater		0
4) Forced draft fan		0
5) Gas recirculation fan		0
6) Valve and piping	a) CV - 101, expansion joint steam leak	2
	b) CV - 104, uncontrollable operation	1
	c) Leak on thermowell economizer inlet	1
7) Control system	a) Oil contamination of pneumatic control	1
2. Turbine and Auxiliary		39
1) Turbine	a) Crack turbine blades	1
	b) Excessive vibration	12
	c) Leak at HP admission sensing line	1
	d) Leak at HP, exhaust sensing line	1
	e) Leak at cold reheater flange	2
	f) IPCV, drain line leak	5
	g) Drain station leak	1
	h) Burst rupture diaphragm	1
	i) Jacking oil/seal oil leak	3
2) Condenser	a) Low vacuum	2
	b) Chloride contamination	3
	c) High conductivity	1

Equipment/System	Nature of Trouble	No. of Times
	d) Tube leak	1
3) Circulating water pump	a) Tripped of both CWPs as a result of DC failure	1
4) Control	a) EHG control fault	2
	b) Malfunction of remote tripping solenoid valve	1
	c) Failure of thrust bearing safety device to reset	1
3. Condensate and Feedwater System		25
1) Condensate and make-up system		0
2) Motor driven BFP	a) Tripped when low deaerator level float control was actuated	1
3) Turbine driven BFP	a) Excessive steam leak	2
	b) Repair of minimum flow valve	2
	c) Trouble at planetary gear of booster pump	1
	d) Malfunction of speed adjuster	1
	e) Busted T-BFP condenser safety device diaphragm	1
4) Low pressure heater	a) Tube leak	1
5) High pressure heater	a) Tube leak	11
	b) Steam/water line leak	2
	c) Leak at drain valve	1
	d) High water level	1
6) Control system	a) Tripped due to extremely high level of LPH	1
4. Electrical Equipment		9
1) Generator and Exciter	a) Damaged bearings #2 and #8	1
	b) Loss of excitation	1
2) Transformer & Substation	a) Main transformer differential lockout	2
	b) Explosion of lightning arrester bushing	2

Equipment/System	Nature of Trouble	No. of Times
3) Station service system		0
4) Control system	a) over exictation	2
	b) Detachment of voltage regulator	1
5. Others		23
1) B-T interlock	a) LPH extreme high level	1
	b) Low feedwater flow	6
2) Generator back-up	a) Generator reverse power relay	1
3) Outside trouble	a) Failure of 230 KV line	3
	b) Malaya - Dolores 115 KV line	4
	c) Line fault at Dolores	4
	d) System distrubance	4

RECORD OF FORCED OUTAGES

VII. Malaya Unit No. 2
March 11, 1979 - June 30, 1982

Equipment/System	Nature of Trouble	No. of Times
1. Boiler and Auxiliary		16
1) Boiler	a) Tube failure	4
2) Fuel oil system	a) Leak one pre-heating discharge line	1
	b) Tripping of MFOP 2A	1
	c) Failure of MFOP 2B	1
	d) Low discharge pressure	1
	e) Low suction pressure	1
3) Air heater		0
4) Forced draft fan		0
5) Gas recirculation fan		0
6) Valve and piping		0
7) Control system	a) Tripped of MFO shut-off valve due to low control air supply	1
	b) Malfunction of drum level transmitter	1
	c) Low boiler drum level	4
	d) Leak at drum level sensing line	1
2. Turbine and Auxiliary		12
1) Main trubine	a) Excessive vibration	3
	b) Balancing due to vibration	1
	c) Bearing damage due to DC oil pump failure	1
	d) Oil leak at No. 2 bearing	1
	e) Uncontrollable temperature	1
2) Condensing system	a) Condenser low vacuum	2
3) Circulating water pump	a) Tripping of both CWPs due to low vacuum	3
4) Control system		0

Equipment/System	Nature of Trouble	No. of Times
3. Condensate and Feedwater System		3
1) Condensate and make-up system	a) Chloride contamination of Demineralized water	1
2) Motor driven BFP	a) Tripped during change-over	1
3) Turbine driven BFP		0
4) Low pressure heater	a) Leak at deaerator manhole cover	1
5) High pressure heater		0
6) Control system		0
4. Electrical Equipment		15
1) Generator & Exciter	a) Burnt-out carbon brushes	1
	b) Excitation system failure	2
	c) Malfunction of stator cooling regulator	2
2) Transformer & Substation	a) Tripped due to differential lock out	2
	b) Busting of relief diaphragm	1
	c) Oil pressure drop from relief diaphragm	1
	d) Explosion of lightning arrester	1
3) Station service system	a) Loss of station service, emergency feed fails to cut in.	1
	b) Loss of BACC power	3
	c) Failure of DC power supply	1
4) Control system		
5. Others		8
1) B-T interlock	a) Furnace pressure high	2
2) Generator back-up	a) Reverse power causedby malfunction of relay on AVR	1
3) Outside trouble	a) Tripping of Dolores line	3
	b) System disturbance	2