Part 6-1   Appendix 10

Forms for Inspection and Testing by Splitting Maintenance Works

Inspection Records (Turbines)

Dept.: ________________

Date: Name: ________________

No.	Inspection Items	Judgment			
		Francis	Pelton	Kaplan	Propeller
1	Inspection of Runner	OK - Non	OK - Non	OK - Non	OK - Non
2	Inspection of Speed Ring of casing	OK - Non	-----	OK - Non	OK - Non
3	Inspection of Casing	-----	OK - Non	-----	-----
4	Inspection of Deflector	-----	OK - Non	-----	-----
5	Inspection of Balancing Piston	-----	OK - Non	-----	-----
6	Inspection of Jet Break	-----	OK - Non	-----	-----
7	Inspection of Liners and similar	OK - Non	OK - Non	OK - Non	OK - Non
8	Inspection of Main Shaft and Bearing	OK - Non	OK - Non	OK - Non	OK - Non
9	Inspection of Sealing facilities	OK - Non	OK - Non	OK - Non	OK - Non
10	Inspection of Runner Boss	-----	-----	OK - Non	OK - Non
11	Inspection of Pressure Oil Unit	-----	-----	OK - Non	-----
12	Inspection of Water Leak Protection Device	-----	-----	OK - Non	OK - Non
13	Inspection of Draft Tube	OK - Non	-----	OK - Non	OK - Non
14	Inspection of Automatic Valves	OK - Non	OK - Non	OK - Non	OK - Non
15	Inspection of Piping works and valves	OK - Non	OK - Non	OK - Non	OK - Non
16	Inspection of Protection Relays	OK - Non	OK - Non	OK - Non	OK - Non
17	Inspection of Control Equipment	OK - Non	OK - Non	OK - Non	OK - Non
18	Measurement of gap of Runner	OK - Non	-----	OK - Non	OK - Non
19	Measurements of gap and opening of Guidevanes	OK - Non	-----	OK - Non	OK - Non
20	Measurement of opening of Servomotor/ Needle Deflector	-----	OK - Non	-----	-----
21	Measurement of angle of Runner Vanes	-----	-----	OK - Non	-----
22	Measurement of oil pressure and oil level	-----	-----	OK - Non	-----
23	Measurement of wear and erosion	OK - Non	OK - Non	OK - Non	OK - Non
24	Measurement of Opening-Output	OK - Non	OK - Non	OK - Non	OK - Non
25	Measurement of Vibration and Shaft swing	OK - Non	OK - Non	OK - Non	OK - Non
26	Operation test of Protection Relay	OK - Non	OK - Non	OK - Non	OK - Non
27	Operation test of Control Equipment	OK - Non	OK - Non	OK - Non	OK - Non
28	Calibration test of Meters	OK - Non	OK - Non	OK - Non	OK - Non
29	Measurement of Insulation Resistance	OK - Non	OK - Non	OK - Non	OK - Non

Unit of P.S.

Record of Opening-Output Test (1/2)

Date: Dept.: ____________________

Date of last test: Name: ____________________

Target Values																
Opening of Servomotor	[%]															
	[mm]															
Output	Standard meter															
[ ]	Distribu-tion Panel															
Guidevane opening	[mm]															
Runner vane opening	[ ]															
Power factor	[%]															
Water pressure at Casing	[mAq]															
Water pressure at Draft Tube	[mAq]															
Rear pressure of Runner	[mAq]															
Side pressure of Runner	[mAq]															
WL of Head Tank	[m]															
WL of Tailrace	[m]															
Opening of Air Valve	[ ]															

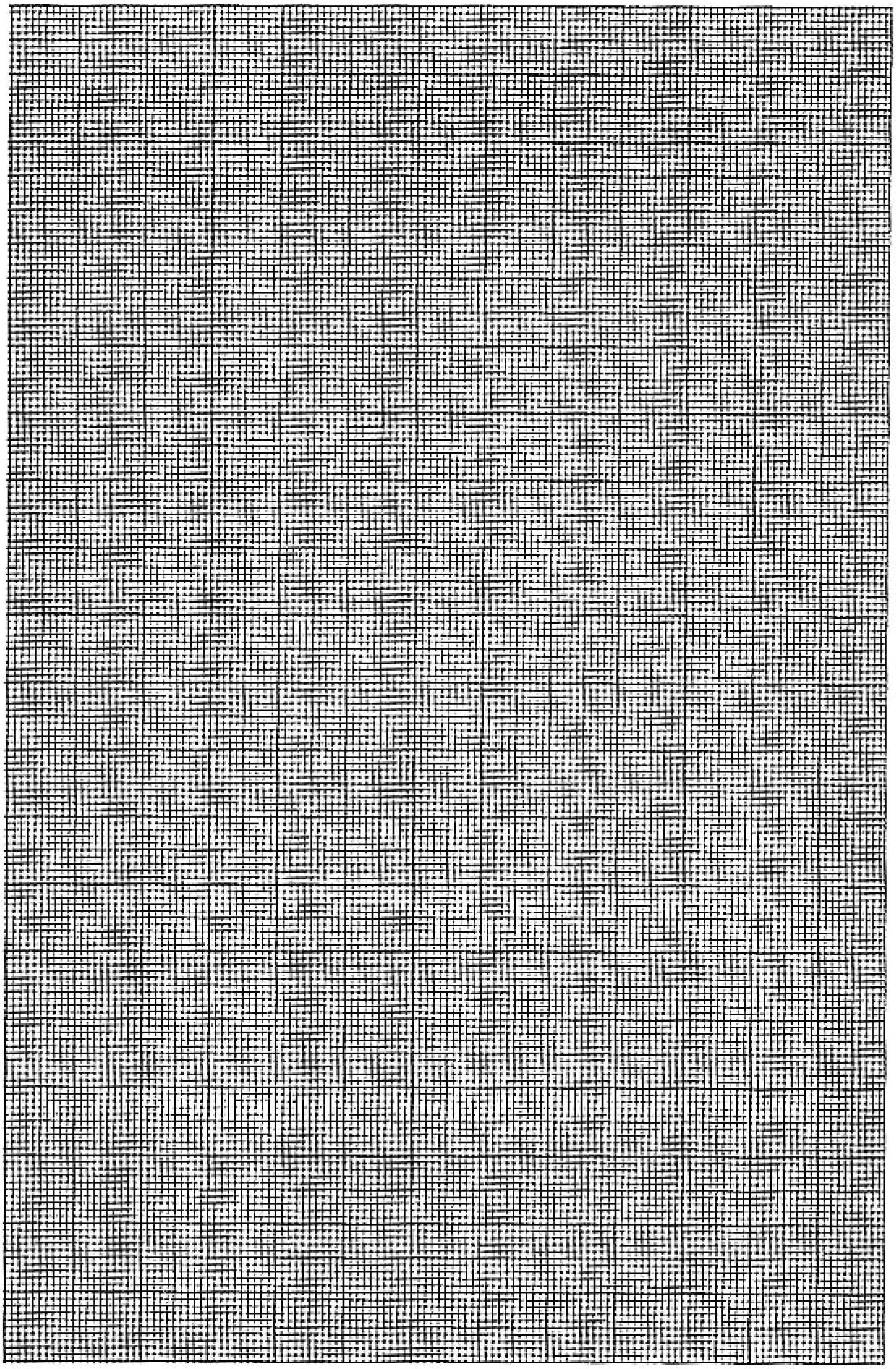
1 Standard Power Meter	Class	4 Particulars and Inspector's Observation:
2 Opening at output 0 kW		
at increasing	[ ]	
at reducing	[ ]	
3 Conditions of other units		
Stop or Operation		
Unit	[kW]	
Unit	[kW]	
Unit	[kW]	

Unit of P.S.

Record of Opening-Output Test (2/2)

This Test ——— made on

Last Test - - - - made on



Unit of P.S.

Record of Periodical Inspection of Turbine (Form-1)

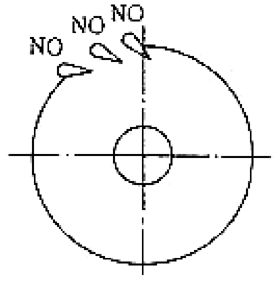
Date: Dept.:

Date of last test: Name:

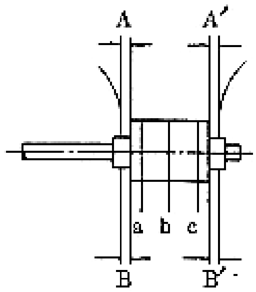
Measurement of gap of Guidevanes

Guide Vane No.	at Full Close (1/100 mm)							at Full Open ()		
	Upper (G)		Lower (shaft end)		Vane tip (no closing allowance)			Vane tip		
	A	B	A'	B'	a	b	c	a	b	c
1	xx									
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
Average										
Last test										

Direction of inflow



Measuring point



Closing allowance of guidevane
(mm)
Standard: 1% of servomotor stroke
Allowable 1 mm

Measurement of opening of Guidevane (mm) Total stroke of Servomotor (mm)

Servomotor stroke	with closing allow.													
Opening of Guidevane (mm) No. - No.														
No. - No.														
No. - No.														
No. - No.														
Average														
Average at last test														

Particulars and Inspector's Observation:

Unit of P.S.

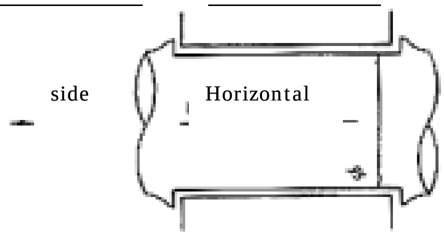
Record of Periodical Inspection of Turbine/Generator (Form-2)

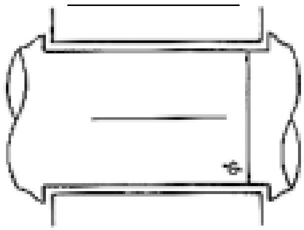
Date: Dept.: ____________________

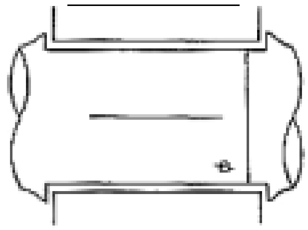
Date of last test: Name: ____________________

Gap of Shaft Bearing, horizontal axis machine

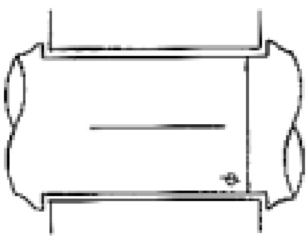
Name of shaft bearing	__________	__________	__________
Diameter gap (1/100 mm)	__________	__________	__________
Level (1/100 mm)	__________	__________	__________

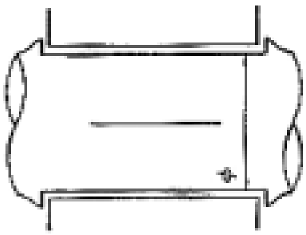


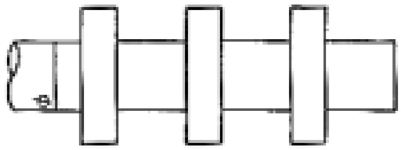




__________	__________	__________
__________	__________	__________
__________	__________	__________



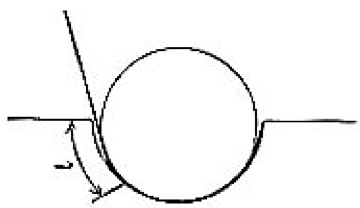




Standard: Centering at 3/100 mm, Level at 3/100 mm

Particulars and Inspector's Observation:

Note: The gap of lower metal is to be expressed by the depth in mm of a thickness gauge to be inserted as illustrated below:



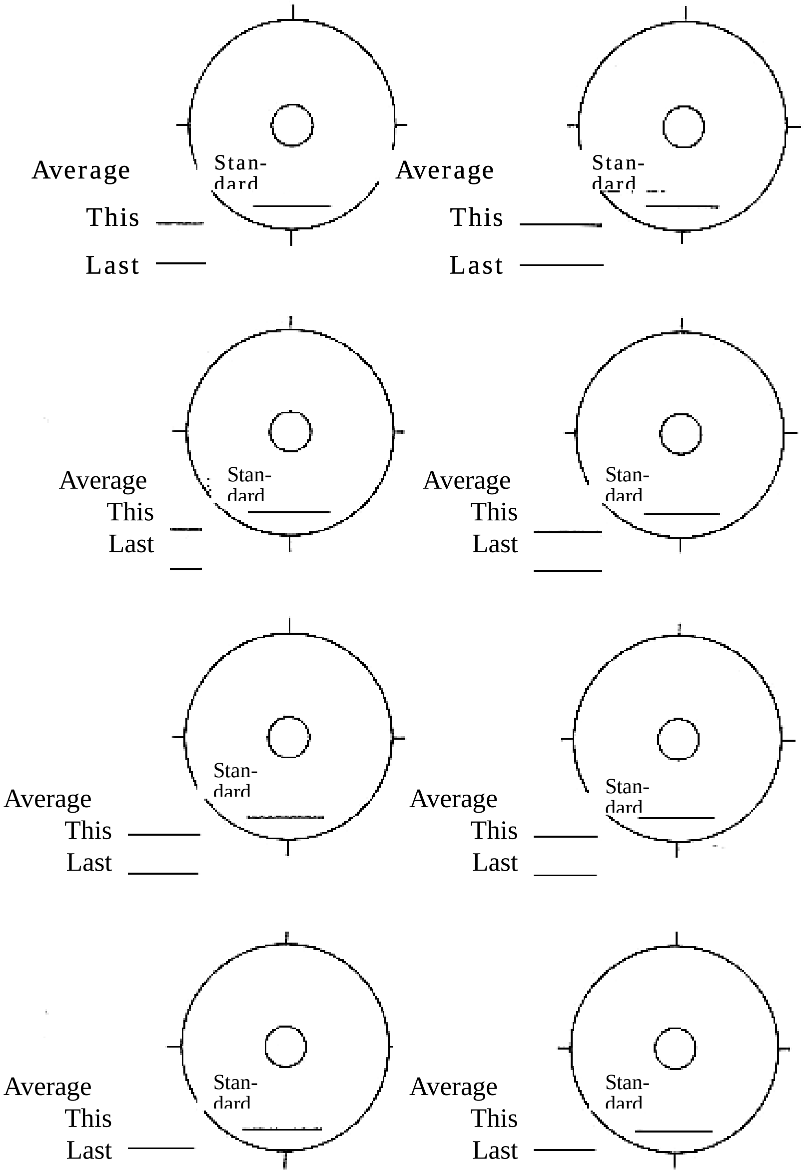
Unit of P.S.

Record of Periodical Inspection of Turbine (Form-4)

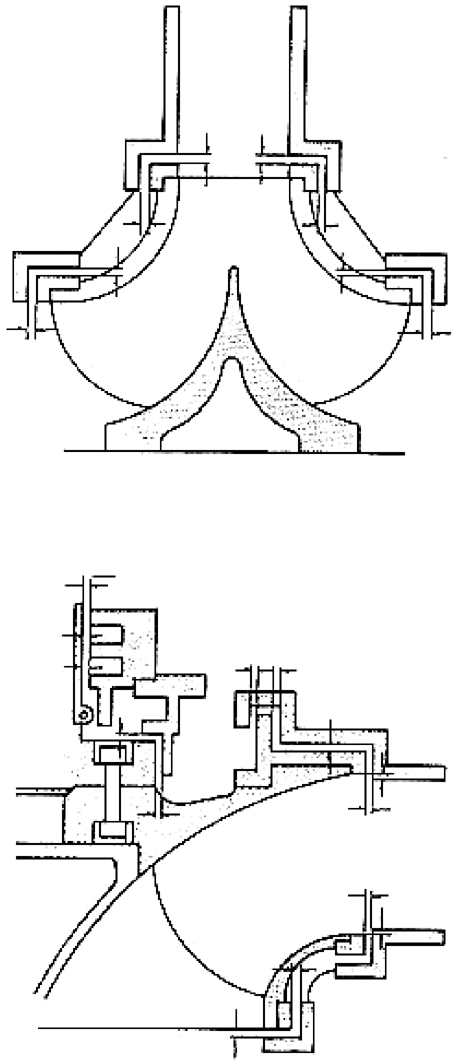
Date: Dept.:

Date of last test: Name:

Measurement of liner gap (mm)



Points of measurement



Particulars and Inspector’s Observation:

Unit of P.S.

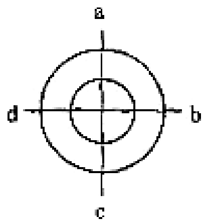
Record of Periodical Inspection of Turbine (Form-5)

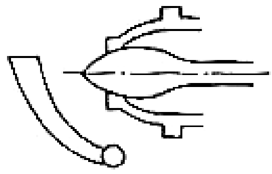
Date: Dept.: ____________________

Date of last test: Name: ____________________

Measurement of opening of Servomotor/Needle Deflector

by Needle	Servo Opening	Needle Opening	Deflector Servo Opening	Gap (mm)							Deflector Opening
				a	b	c	d	Mean	Last Mean		





Particulars and Inspector's Observation:

Unit of P.S.

Record of Periodical Inspection of Inlet Valve

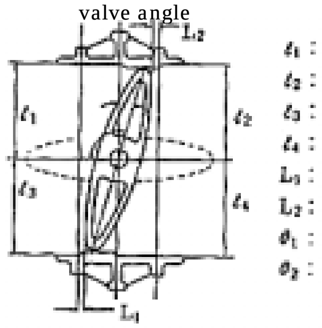
Date: Dept.: ______________________

Date of last test: Name: ______________________

Test of operation time of Inlet Valve Controller (sec)

Items		Without Water			With Water		
		Base			Base		
OPening	21 start	0	0	0	0	0	0
	Bypass Valve opening started						
	Bypass Valve opening completed						
	Main Valve opening started						
	Main Valve opening completed						
Closing	21 start	0	0	0	0	0	0
	Main Valve closing started						
	Main Valve closing completed						
	Bypass Valve closing started						
	Bypass Valve closing completed						
Bypass Valve	Current for opening (A)						
	Current for closing (A)						
Main Valve	Current for opening (A)						
	Current for closing (A)						
Oil temperature (^oC)							

Measurement of valve angle



Measurement of leakage water at Full Close

Items		This Test	Last Test
Pen-stockpressure	Beg. (mAq)		
	End (mAq)		
Time of measurement			
Leakage (l/min)			

Operation test of pressure-respond valve (mAq)

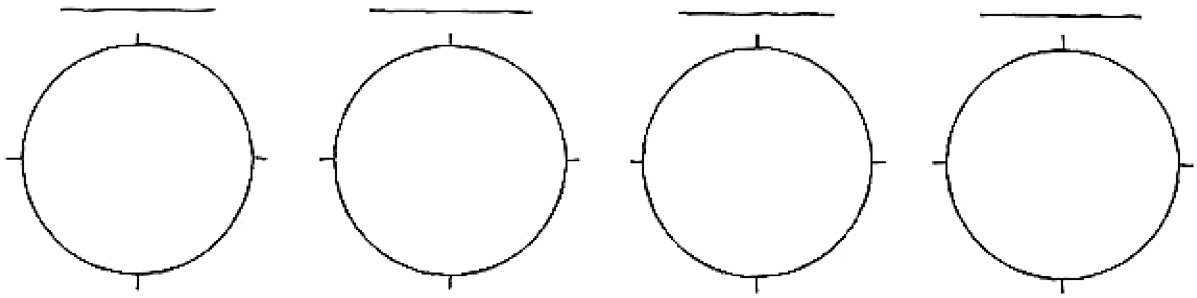
Item	Operate	Return
Casing pressure		
Penstock pressure		

Standard: less than 80% of spec. pressure

Insulation resistance test (MΩ) Weather _________ Temp. _____°C R.H.______ %

Point	Motor		Control Circuit		Control Equipment	
	Main Valve	Bypass V.	Main Valve	Bypass V.	Main Valve	Bypass V.

Sheet surface: gap of Shaft Bearing (1/100 mm), add last test in ().



General inspection of interior

Judgment / Inspection	Main Valve	Bypass Valve	Remarks	Judgment / Inspection	Main Valve	Bypass Valve	Remarks
Valve body			Wear, erosion	Piping and valves			
Valve leaf			Wear, erosion	Motors			
Connecting pipe of bypass valve			Wear, erosion	Movable seal			incl. operation test
Opening/closing mechanism				Control equipment			
Water sealing				Servomotor			
Control mechanism			Pressure distribution valve, Switching valve, Pressure respond valve				
Weight			Greasing	Overall Judgment			

Particulars and Inspector's Observation:

Unit of P.S.

Record of Periodical Inspection of Governor (Form-1)

Date: Dept.: ______________________

Date of last test: Name: ______________________

Measurement of opening/closing time of Servomotor (s, mm) oil temp: ___°C

	Auxi. Servomotor		Main Servomotor (electric motor)				
	FO→FC	FC→FO	Closing Characteristics				O. Cha.
			Start	1st Close	2nd Close	Full Open	FC→FO
This test			0				
Last test			0				
Stroke							

General inspection of outside/inside

Inspection Items	Judgment (OK--Non)
Return mechanism	
Control motor	
Control equipment	
Converter	
Printed board	
Constants & adjusted parameters	
Protection relay	
Cooling fan	
Load limiter	
Pressure Distribution Valve	
Pressure oil driven Servomotor	
Electric motor driven Servomotor	
Emergency closing equipment	
Locking equipment	
Electro-magnetic valve	
Piping and valves	
Overall Judgment	

Record of adjusted dimensions:

	Closing Convenience
This test	
Last test	
Stroke	

Measurement of lap of Pressure Distribution Valve (mm)

	Primary	Secondary
Base value		
This test		
Last test		

Standard: Primary PDV 0 mm
Secondary PDV 0.5
w/o secondary 0.5

Particulars and Inspector's Observation:

Unit of P.S.

Record of Periodical Inspection of Generator (Form-1)

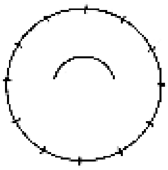
Date: Dept.: ____________________

Date of last test: Name: ____________________

Calibration test of thermometers

Standard / Points	20		30		40		50		60		70		80	
	I	E	I	E	I	E	I	E	I	E	I	E	I	E

Note: I for Indication, and E for Error.



Shared voltage $= \dfrac{\text{Applied Voltage}}{\text{nos. of Pole}} =$ 〔V〕

Measurement of resistance of Rotor

	Weather	Room Temp.	R.H.	Machine temp.	Measured resistance	Resistance converted to 75ºC
		ºC	%	ºC	Ω	Ω
Basic value upon installation						
This test						
Last test						

Particulars and Inspector's Observation:

Unit of P.S.

Record of Periodical Inspection of Generator (Form-2)

Date: Dept.: ____________________

Date of last test: Name: ____________________

Specifications of Generating Equipments

Name & No. of Equipment	Rated Voltage (kV) and Rated Current (A)	Capacity (kVA and kW)	Revolution Speed (rpm)	Model	Insu-lation Class	S. No.	Year of Manu-facturing	Manu-facturer (Modify)

General inspection of inside/outside

Inspection Items	Judgment (OK--Non)	Inspection Items	Judgment (OK--Non)	Inspection Items	Judgment (OK--Non)
Stator, Rotor, Collector Ring		Main Shaft, Shaft Bearing, etc.		Detection generator for Governor	
Air duct, dumper		Cooling Water		Magnetic field resistor and magnetic field open/close switch	
Relay of water stop		Excitor			
		Relay of oil cut			
		Piping and valves			
				Overall Judgment	

Particulars and Inspector's Observation, and spare parts replaced:

Unit of P.S.

Record of Periodical Inspection of Generator (Form-3)

Date: Dept.: ____________________

Date of last test: Name: ____________________

Measurement of insulation resistance (MΩ)

Date of Measurement	Wea-ther	Air Temp. ºC	R.H. %	Room temp ºC	Machine temp. ºC	Generator		Main Excitor		Sub- Excitor		Static Excitor Circuit-E	Magnetic Field Resistor-E		
						S-E	R-E	S-E	R-E	S-E	R-E				
on ___________ after stopping						( )									
on ___________ after inspection						( )									
on ___________ after drying						( )									
on ___________ before operation						( )									

Measurement of insulation resistance (MΩ)

Items / Equip.	Main circuit-E	DC control circuit-E	AC control circuit-E	Remarks
PMG (for speed)				
Search coil				

Unit of P.S.

Record of Drying and Test Operation of Generator

Date: Dept.: ____________________

Date of last test: Name: ____________________

Items / Time	Insulation Resistance		Room temp. °C	R.H. %	Mach-ine temp. °C	Curre-nt A	Revolution speed rpm	Temperature of Metals (°C)						Remarks
	S-E (MΩ)	R-E (MΩ)												

Particulars and Inspector's Observation:

Unit of P.S.

Record of Periodical Inspection of Safety Valves

Date: Dept.: ____________________

Date of last test: Name: ____________________

Operation test of Safety Valves (pressure oil, grease oil, water supply & drain, cooling water supply)

Results \ Purpose														
	Set	Test	Set	Test	Set	Test	Set	Test	Set	Test	Set	Test	Set	Test
Start p. (kg/cm^2)														
Full Open (kg/cm^2)														
Return (kg/cm^2)														
Judgment (OK--Non)														

Inspection of equipments

Equipments	Description on caring works and adjustments

Particulars and Inspector’s Observation:

Unit of P.S.

Check List for Periodical Inspection of Power Station

Date: Dept.: __________

Date of last test: Name: __________

Governor	Hydraulic Servomotor	Point of Inspection							
		Wear of screw							
		Foreign sounds							
		Smoothness of movement							
Generator	**Collector Ring**	Point of Inspection							
		Conditions of terminal of lead wire							
		Conditions of Rectifier surface							
		Conditions of surface of **Collector Ring**							
		Wearing condition of Brush							
Head Tank	Water Level Gauge/Sensor	Point of Inspection							
		Rusting and erosion of pole							
		Conditions of float-suspending wire							
		Relaxation of fixing parts							
		Adhesion of scale and oil							
		Free board of float							
		Conditions of electric cables and terminals							
		Condition of sensor of pressure type gauge							
		Response and stability at Level Control operation							
		Conditions and WL indication of water level gauge							
Others		Point of Inspection							

Unit _____ of __________ P.S.

Record of Periodical Inspection of Protection Relays

Date: Dept.: ____________________

Date of last test: Name: ____________________

Operation test of Protection Relays (Turbine, Generator, Governor, Pressure Oil Unit, Lubricant Oil Unit, Water Supply & Drain Unit)

Close Relay	Indication	Alarm	Name of Relay to Function	Sequence No.	Judgment (OK--Non)	Remarks

Particulars and Inspector's Observation:

Unit of P.S.

Record of Fault-Stop Test of Power Generation

Date: Dept.: ____________________

Date of last test: Name: ____________________

Testing Items	86-1A	86-1B	86-2	86-3	86-5
43GPAC	used	used	used	used	used
Generator output before testing (kW)					
Servomotor stroke at above (mm)					
Penstock pressure (mAq)					
Name of Relay to function					
Protection Relay function (s)	0	0	0	0	0
Time till exit from parallel operation (s)			Servomotor opening at no load		
Time till Full Close of Servomotor (s)	-		-	-	-
Time till Full Close of Main Valve (min-s)	-		-	-	-
Time till Full Close of Bypass Valve (min-s)	-		-	-	-
Time till start of breaking operation (min-s)	-		-	-	-
Revolution speed at above (rpm)	-		-	-	-
Time till stop of Turbine (min-s)	-		-	-	-
Command to restart (86-1B and 86-3 to return) (min-s)	-		-	-	-
Start **(“4”)**	-		-	-	-
Time till starting Parallel operation **(min-s)**	-		-	-	-
Indicator (OK--Non)					
Results (OK--Non)					

Water level of Head Tank/Regulating Pond m		Water level of Tailrace m	
Outside air temp. °C	Turbine room temperature °C	Generator room temperature °C	Cooling water temperature °C
Oil temperature of Reverse Oil Tank °C			

Particulars and Inspector’s Observation:

Unit ________ of ________________ P.S.

Record of Periodical Inspection of Protection Relays & Control

Date: 　　　　　　　　　　　　　　　　　　　　Dept.: ____________________

Date of last test: 　　　　　　　　　　　　　　Name: ____________________

Operation test of Protection Relay

Name of Relay	Value Set (unit)		Value Tested (unit)		Indication		Alarm BL/BZ	Judg-ment OK-Non
	Activated	Return	Activated	Return	Site	Distri-bution Panel		

Operation test of Control Equipment

Purposes	Sequence No.	Contact No.	Opening										

Unit 　　　of 　　　　　　　　　　P.S.

Record of Load Shutdown Test (Form-1)

Date: Dept.:

Date of last test: Name:

Test No.									
Time of Load Shutdown									
Generator		Load shutdown	(kW)						
Generator	Voltage	before Shutdown	(kV)						
Generator	Voltage	Max.	(kV)						
Generator	Voltage	after stabilized	(kV)						
Generator	Voltage	Ratio of Voltage Change	(%)						
Generator		Load current	(A)						
Generator		Power factor	(%)						
Generator		Frequency	(Hz)						
Turbine	Revolution Speed	before Shutdown	(rpm)						
Turbine	Revolution Speed	Max.	(rpm)						
Turbine	Revolution Speed	after stabilized	(rpm)						
Turbine	Revolution Speed	Ratio of Voltage Change	(%)						
Turbine	Penstock Pressure	before Shutdown	(mAq)						
Turbine	Penstock Pressure	Max.	(mAq)						
Turbine	Penstock Pressure	Static head at no operation	(mAq)						
Turbine	Penstock Pressure	Max. pressure rise	(mAq)						
Turbine		Casing pressure	(mAq)						
Turbine		Draft pressure	(mAq)						
Turbine		Rear pressure of Runner	(mAq)						
Turbine		Side pressure of Runner	(mAq)						
Turbine		Water pressure of Draft Tube	(mAq)						
Turbine	Opening	Guide-vane (Nozzle) before Shutdown	(mm)						
Turbine	Opening	Guide-vane (Nozzle) after stabilized	(mm)						
Turbine	Opening	Runner Vane before Shutdown	(mm)						
Turbine	Opening	Runner Vane after stabilized	(mm)						
Turbine	Guidevane (Nozzle)	Dead Time τ	(s)						
Turbine	Guidevane (Nozzle)	Equivalent closing time Tc	(s)						
Turbine	Guidevane (Nozzle)	1st closing time T1	(s)						
Turbine	Guidevane (Nozzle)	2nd closing time T2	(s)						
Turbine	Guidevane (Nozzle)	Closing time Th	(s)						
Turbine	Runner Vane (Deflector)	Dead Time τ	(s)						
Turbine	Runner Vane (Deflector)	Closing time	(s)						
Pressure Regulator		Opening	(mm)						
Pressure Regulator		No Move Time	(s)						
Pressure Regulator		Opening time	(s)						
Pressure Regulator		Closing time	(s)						

Unit of P.S.

Record of Load Shutdown Test (Form-2)

Date: Dept.:

Date of last test: Name:

Test No.								
Pressure Oil Tank		Oil pressure before load shutdown (kgf/cm^2)						
		Oil level before load shutdown (mm)						
Water Level		Head Tank/Regulating Pond (Reservoir) (m)						
	Surge Tank	before load shutdown (m)						
		Max. (m)						
		Min. (m)						
	Tailrace	before load shutdown (m)						
		after stabilized (m)						
Temperature		Oil temperature of Reverse Oil Tank (℃)	Turbine room (℃)	Generator room (℃)	Outside air (℃)	Cooling water (℃)		

FSL of Head Tank/Regulating Pond (Reservoir)		(m)	
Zero elevation of water level gauge of Head Tank/Regulating Pond (Reservoir)		(masl)	
Zero elevation of water level gauge of surge tank		(masl)	
Center elevation of turbine inlet or center elevation of nozzle junction (horizontal axis turbine)		(m)	
Elevation of turbine center		(m)	
Elevation at center of pressure gauge		(m)	
Zero elevation of water level gauge of Tailrace		(m)	
Guaranteed Values	Ratio of Voltage Change	(%)	
	Ratio of Speed Change	(%)	
	Ratio of Pressure Change	(%)	
	Max. water pressure	(mAq)	
Max. output of Generator		(kW)	
Rated voltage of Generator		(kV)	
Rated revolution speed		(rpm)	
Servomotor full stroke	Guidevane (Needle) (mm)	Runner Vane ( )	Pressure Regulator (mm)

Particulars and Inspector's Observation:

Unit of P.S.

Record of Loading Test

Date: Dept.:

Date of last test: Name:

b	Time of Measurement									
	Time elapsed			(h-min)						
	Generator load			(kW)						
	Generator current			(A)						
Temperature	Search Coil	Stator Coils	U phase	(°C)						
			V phase	(°C)						
			W phase	(°C)						
		Shaft Bearing		(°C)						
				(°C)						
				(°C)						
				(°C)						
				(°C)						
	Dial	Air Cooler	Inlet	(°C)						
			Outlet	(°C)						
		Shaft Bearing		(°C)						
				(°C)						
				(°C)						
				(°C)						
				(°C)						
				(°C)						
				(°C)						
				(°C)						
	Cooling Water	Inlet		(°C)						
		Outlet		(°C)						
		Outlet		(°C)						
		Outlet		(°C)						
		Outlet		(°C)						
		Air Cooler Outlet		(°C)						
Opening	Guidevane (Nozzle) Servomotor			(mm)						
	Runner Vane			( )						
Water Pressure	Penstock			(mAq)						
	Casing			(mAq)						
	Draft Tube			(mAq)						
	Rear pressure 1 of Runner			(mAq)						
	Rear pressure 2 of Runner			(mAq)						
	Side pressure of Runner			(mAq)						
Water Level	Head Tank/Regulating Pond			(m)						
	Tailrace			(m)						
Temperature	Turbine Room			(°C)						
	Generator Room			(°C)						
	Outside air			(°C)						

Particulars and Inspector’s Observation:

Unit of P.S.

Record of Temperature Raising Test of Shaft Bearing

Date: Dept.:

Date of last test: Name:

Time of Measurement									
Time elapsed			(h-min)						
Revolution speed			(rpm)						
Temperature	Dial	Shaft Bearing	(℃)						
			(℃)						
			(℃)						
			(℃)						
			(℃)						
		Shaft Bearing	(℃)						
			(℃)						
			(℃)						
			(℃)						
			(℃)						
	Cooling Water	Inlet	(℃)						
		Outlet	(℃)						
		Outlet	(℃)						
		Outlet	(℃)						
		Outlet	(℃)						
		Outlet	(℃)						
		Outlet	(℃)						
Open- ing	Guidevane (Nozle) Servomotor		(mm)						
	Runner Vane		(　　)						
Water Pressure	Penstock		(mAq)						
	Casing		(mAq)						
	Draft Tube		(mAq)						
	Rear pressure 1 of Runner		(mAq)						
	Rear pressure 2 of Runner		(mAq)						
	Side pressure of Runner		(mAq)						
Water Level	Head Tank/Regulating Pond		(m)						
	Tailrace		(m)						
Air Temperature	Turbine Room		(℃)						
	Generator Room		(℃)						
	Outside air		(℃)						

Particulars and Inspector’s Observation:

Unit of P.S.

Record of Automatic Start and Stop Tests of Power Generation

Date:

Date of last test:

Dept.:

Name:

Test Items				Measured Values
Start	Inlet Valve	Time from Start Operation till completion of Bypass Valve opening	(min-s)	
		Time from Start Operation till completion of Main Valve opening	(min-s)	
	Start	Time from Start Operation till rotation start of Turbine	(min-s)	
		Opening of Servomotor at the time above	(mm)	
		No Load Opening **at rated revolution speed**	(mm)	
	Excitation	Revolution speed at activation of 13Ry	(rpm)	
		Time from Start Operation till **put 41 into operation**	(min-s)	
	Sychronizing	Time from Start Operation till activation of automatic synchronizing equipment	(min-s)	
		Time from Start Operation till put into parallel (synchronized) operation	(min-s)	
		Servomotor stroke at the synchronization above	(mm)	
		Penstock pressure at the synchronization above	(mAq)	
	Load	Time from Start Operation till planned load	(min-s)	
		Generator output at achieving the planned load	(kW)	
		Servomotor stroke at achieving the planned load	(mm)	
		Penstock pressure at achieving the planned load	(mAq)	
Stop	De-synchronizing	Generator output before making Stop Operation	(kW)	
		Servomotor stroke at above	(mm)	
		Penstock pressure at above	(mAq)	
		Time from start of Stop Operation till De-synchronizing	(min-s)	
		Generator output at above	(kW)	
	Inlet Valve	Time from start of Stop Operation till Full Close of Main Valve	(min-s)	
		Time from start of Stop Operation till Full Close of Bypass Valve	(min-s)	
	Stop	Time from start of Stop Operation till start of breaking operation	(min-s)	
		Revolution speed at above	(rpm)	
		Time from start of Stop Operation till Full Stop of Turbine	(min-s)	

Water level of Head Tank/Regulating Pond m		Water level of Tailrace m	
Outside air temp. ^{o}C	Turbine room temperature ^{o}C	Generator room temperature ^{o}C	Cooling water temperature ^{o}C
Oil temperature of Reverse Oil Tank ^{o}C			

Particulars and Inspector's Observation:

Unit of P.S.

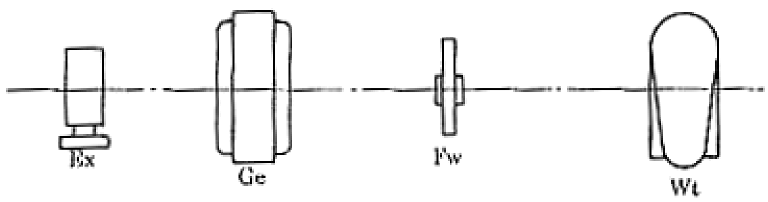
Record of Measurements of Vibration and Shaft Swing

Date: Dept.: ____________________

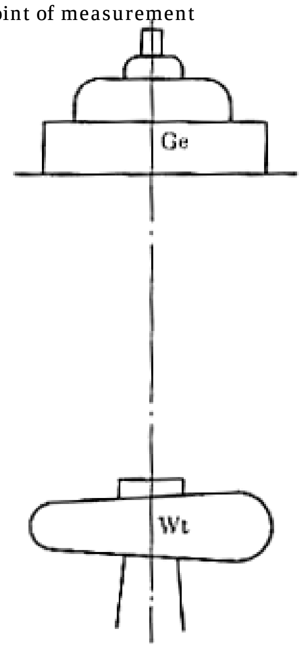
Date of last test: Name: ____________________

Test No.										
Output		(kW)								
Revolution speed		(rpm)								
Open - ing	Guidevane (Nozzle) Servomotor	(mm)								
	Runner Vane	( )								
Water Pressure	Penstock	(mAq)								
	Casing	(mAq)								
	Draft Tube	(mAq)								
	Rear pressure 1 of Runner	(mAq)								
	Rear pressure 2 of Runner	(mAq)								
	Side pressure of Runner	(mAq)								
Water Level	Head Tank/ Regulating Pond	(m)								
	Tailrace	(m)								
Opening of Air Valve		( )								
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Point measured



Point of measurement



Notes:

1. Unit
   Shaft swing
   Vibration
2. Type of vibration meter
   one side amplitude/both side amplitude
3. Allowance
   Vibration 15/100 mm

Unit of P.S.

Appendix 11 Design of Water Rheostat[*1]

1. Usage of Water Rheostat

The speed regulators of hydraulic turbines/ generators are generally to be tested in measurement of the respective water pressure rise and speed rise to the load shedding at the ratios of 4/4, 3/4, 2/4 and 1/4 and confirm whether such a result as tested for water pressure rise and speed rise is within a range of safety guarantee as expected.

The method to carry loads consists of; (i) a method to carry real loads in parallel with electric power system in business, and (ii) a method to increase directly the voltage of generators by use of water rheostat. The former method is subject to the voltage and the cycle of electric power system apart from expectations of persons in charge of testing but it is able to provide sufficiently practical data. Owing to such a big capacity of electric power system as is recently ranged between hundreds of thousand of kW and several million kW, there are no fears in the former method as to whether it will affect the electric power system in business except power stations having an extremely big installed capacity. Therefore, such a situation has reduced necessities to prepare water rheostats. It is the fact almost all power stations were temporarily or permanently facilitated with water rheostat well previously.

There are examples of power stations where control of speed rise of hydraulic turbines/ generators was carried out by connecting a water rheostat to a generator circuit together with load shedding by protective relay.

Such a test on speed regulators of hydraulic turbines/ generators as uses water rheostat can keep voltages and cycles at the specified values.

In addition, it can confirm the range possible to adjust the speed regulators through increase or decrease of cycles and whether the design of runners of hydraulic turbines is mostly in conformity with the specified cycle. The water rheostat has such a shape as shown in Figure 1 or Figure 2 and material properties will be steel plates or steel pipes.

Note:

*1: Source: 'Electricity Magazine OHM' (pp.276-277), Shigeru TAMANUKI

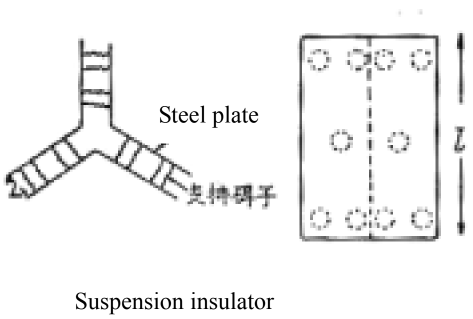


Figure 1 Flat Electric Pole with Triple Pole

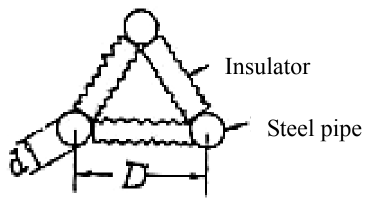


Figure 2 Cylinder Electric Pole with Triple Pole

The water rheostat will be installed in tailraces or special wells and loads will be adjusted by raising and lowering water rheostats. In the case when the water rheostat is installed in tailraces, it is advised to use stays for prevention of water rheostat from being run out or rotated by flow.

In addition, in the case when variations of tailrace water levels which may be caused by loads become problems as compared with the height of water rheostat, it is advised to pay careful attentions to adjustment of loads. It is said that ‘Flat electric pole’ is fit with low voltage and small output of generators and ‘Cylinder electric pole’ is useful for high voltage of generators. On the other hand, ‘Flat electric pole’ is easy for manufacturing in the case of power output bigger than 50 MW/ unit.

The current density of electric pole surface more than 0.6 A/ cm^2 will let flowing water on electric pole surface boiled, which may give rise to an arc state and a subsequent short circuit.

Therefore, it is advised to design the current density of electric pole surface less than 0.6 A/ cm^2. Also it is advised to pay attentions to the case when electric pole is a little inside of water, which is apt to cause short circuit due to boiling of flowing water. Also, it is advised not to lower water rheostat imposing voltage, because of the reasons mentioned above.

2. Design of Water Rheostat

In respect of design of water rheostat, it is advised to measure the resistivity of flowing water by use of a Kohlraush Bridge. Resistivities of ρ (Ω-cm) of river flows are different, depending on each river. However, in the case of no measuring data of the resistivity it is advised to use a practical method applying 5000 Ω-cm for the resistivity of flowing water and carry out the design of water rheostat with some allowance. Namely, it is necessary to design the current density to be small (i.e. to design the distance of electric pole (L) to be long), as the current density becomes big in the case when the resistivity of flowing water is about 3000 Ω-cm. Also, it is necessary to design the height of electric pole to be big so as to bear the whole load even though the resistivity of flowing water is about 8000 Ω-cm.

It is useful for the design on distance of electric pole to apply pin type suspension insulator, disc type suspension insulator, cylinder type suspension insulator, cone type suspension insulator, etc. in accordance with the voltage of generator. Accordingly, the distance of electric pole results in some limited ranges. It is a common way to regard the withstanding pressure inside water for suspension insulators as four times of voltage of generator which is equivalent to the multiplied for twice of voltage of generator by two (2) of the safety factor. Based on such a consideration as discussed above, appropriate suspension insulators for several kinds of voltage are shown in Table 1.

Table 1 Voltage of Generator: 11 kV

Type of Suspension Insulator	Kind	Voltage	Flushing-over Withstand Voltage, Wet	Height of Insulator (cm)
Pin type	1	Nominal, 6 kV	40 kV	17
Pin type	2	Nominal, 10 kV	55 kV	24
Pin type	3	Nominal, 20 kV	70 kV	30
Cylinder type (Cone type)	Common	Rated, 7.5 kV	40 kV	19.1
Cylinder type (Cone type	Common	Rated, 15 kV	55 kV	25.4
Cylinder type (Cone type)	Common	Rated, 23 kV	75 kV	35.5

In the case of voltages being 6.6 kV or 3.3 kV, a type of suspension insulators may be adopted from the table shown above. In respect of cylinder type of electric pole, it is necessary to design the distance of electric poles to be further longer in due considerations to resistance, accordingly, a high suspension insulator may be connected or suspension insulators may be connected to each other.

A design example of water rheostat is given below for a generating unit having an installed capacity at 10000 kW (phase factor: 1.0) and the voltage of generator: 11 kV:

(1) Water Rheostat Having Flat Electrical Pole with Triple Pole

Presenting the current as I (A),

3 x 11 x I = 10000, ∴ I = 303 (A)

(The current of generator: 1.73 x 303 = 525 (A))

Accordingly, the resistance between electric poles is to be 11000/ 303 = 36.5 Ω. On the other hand, the following equation is to be satisfied with R (Ω), ρ (Ω- cm), L (cm) and A (cm^2):

R (Ω) = ρ (Ω- cm) x L (cm) / A (cm^2)

Where, ρ = 5000 (Ω- cm)

In the case of use of Pin type suspension insulator, L = 24 cm.

Accordingly,

R = 36.5 = 5000 x 24 / A, ∴ A = 3300 cm^2

The current density is I / A = 303 / 3300 = 0.092 A/ cm^2 , which is appropriate. The pole plate of 33 x 100 cm, for example, is applicable. It is advised to use steel plates available. On the other hand, as explained above, it is easy for adjusting loads to design the height to be longer. Accordingly, in the case when the plate is calculated to be 100 cm high and 33 cm x 2 wide, it is advised to design the plate to be 150 cm high x 33 cm wide, which is applicable for the case when the resistivity is unexpectedly big.

It is noted that the current density is constant for the given voltage and the given pole distance in the case of the same flowing water. Accordingly, in the case of power output: n x 10000 (kW), L and A are determined as follows:

L = 24 cm and A = 3300 x n (cm^2)

(2) Water Rheostat Having Cylinder Electrical Pole with Triple Pole

In the case of the water rheostat having cylinder electrical pole with triple pole, the resistance is obtained by the following equation:

$R = 1.1 \rho / l \text{ (cm)} \cdot \log_{10} (2D/d) \quad (\Omega)$

In the case of 2D/ d being less than 40, the current density of electric pole surface will not be constant and therefore adjustment factors shown below in Table 2 is necessary to be multiplied to the formula shown above.

Table 2 Adjustment Factor

2D/ d	10	15	20
Adjustment factor	1.10	1.06	1.03

In the case when the same example as mentioned above is applied, a steel pipe is 5 cm in dia. and the distance of electric pole is 51 cm (corresponding to the cylinder suspension insulator with strong type, nominal 34.5 kV), the adjustment factor becomes 1.03 in reference to Table 2.

By applying these values for the resistance equation mentioned above, the resistance: R is calculated as follows:

$R = 36.5 = 1.1 \times 1.03 \times 5000 / l \times \log_{10} 20$

$= 7400 / l, \ \therefore l = 203$ cm

Accordingly, the electric pole is 2.03 m high. However, taking into account some allowance, it is designed to be 2.6 m high. The surface area is calculated as $\pi \cdot d \cdot l = 3.14 \times 5 \times 203 = 3200$ cm^2. Accordingly, the current density is calculated as 303/ 3200 = 0.095 A/ cm^2 and that inside of cylinder is about 0.1 A/ cm^2.

As for the case of an installed capacity at 100000 kW, assuming that the size and the distance of electrical pole are constant, l is calculated to be 26 m long which is unrealistic for manufacturing.

In the case of application of a steel pipe (d = 10 cm and D = 51 cm), the resistance: R is calculated as follows:

$R = 36.5 = 1.1 \times 1.1 \times 5000 / l \times \log_{10} 10$

$= 6100 / l, \ \therefore l = 16700$ cm (This case requires a well for installation of water rheostat.)

Therefore, it is advised to design the plate electric pole with triple pole for such a plant as has a large installed capacity.

3. Temperature Rise of Flowing Water

When loads are carried on a water rheostat, the temperature of flowing water will increase. For achievement of an increase of water by 1 ℃, it is required to give a heat value of 4.17 watt-sec. In the case when the current density is 0.1 A/ cm^2, the heat value per sec for the water having a volume of 1 cc will be 5000×0.1^2 (= 50 watt-sec). Further, the subsequent temperature rise will be 12 ℃ (= 50/ 4.17). As the velocity of flowing water in tailrace is about 1 m/sec, it will take about 0.7 sec for the flowing water to pass a distance from a pole to a pole in the case of the example mentioned above in (1) and it will eventually have a temperature rise by about 8 ℃. Assuming the water temperature as 28 ℃, the resistivity is as calculated below by substituting t (= 28 ℃) to the following equation:

$\rho_t = 40 \cdot \rho_{20} / (20 + t)$, Where, ρ_t : Resistivity at temperature of 't' ℃

$\rho_t = (40/(20 + 28)) \times \rho_{20} = 0.84 \rho_{20} = 0.84 \times 5000 = 4180$ (Ω- cm)

This result means that the load is to be carried on the water rheostat of which depth under water is to be reduced by 10 % in order to obtain the load initially desired.

In addition, it is acceptable for such a flowing water as has about 1 m/ sec to adopt 0.2 A/ cm^2 – 0.3 A/ cm^2 for the current density.

In the case of the cylinder electric pole, the size of pole is slender. Accordingly its temperature rise is small and the variation of resistance is less. As is discussed above, the load carried on water rheostat is subject to variation of water level and variation of resistance due to temperature rise as well. Accordingly the wattmeter ('WM') has always a small swing which is almost the same degree as occurs in the wattmeter of the power stations having water level regulators.