

SECONDARY WATER CHEMISTRY

Monitoring Program

For

San Onofre Nuclear Generating Station

Units 2 and 3

November, 1980

8011280

011

Secondary Water Chemistry Monitoring Program

San Onofre Nuclear Generating Station Units 2 and 3

1.0 Identification of Critical Control Points, their Parameters and Sampling Frequencies.

1.1 Normal Chemistry Control

1.1.1 Steam generator secondary side water chemistry control is accomplished in accordance with manufacturer's requirements by:

1.1.1.1 A close control of the feedwater to limit the amount of impurities that can be introduced into the steam generator.

1.1.1.2 A continuous blowdown of the steam generator to reduce concentrating effects of the steam generator.

1.1.1.3 Chemical addition to establish and maintain an environment that minimizes system corrosion.

1.1.1.4 By preoperational cleaning of the feedwater system.

1.1.1.5 Minimizing feedwater oxygen content prior to entry into the steam generator.

1.1.2 Secondary water chemistry is based on the zero solids treatment method. This method employs the use of volatile additives to maintain system pH and to scavenge dissolved oxygen present in the feedwater.

1.1.2.1 Ammonium hydroxide is added to the secondary system to establish and maintain alkaline conditions in the condensate/feedwater heater trains and in the steam generators. Since, ammonium hydroxide is a volatile substance it will not concentrate in the liquid phase of the steam generators, but will quickly reach an equilibrium level that will provide a protective alkaline environment throughout the secondary water/steam cycle.

1.1.2.2 Hydrazine is added to scavenge dissolved oxygen present in the feedwater; and to promote the formation of a protective oxide layer on metal surfaces by keeping these layers in a reduced chemical state.

1.1.2.3 Pumps are provided to inject ammonium hydroxide and hydrazine into the feedwater heater trains at a point downstream of the condensate pump discharge. Hydrazine must be injected continuously to maintain

feedwater residual as a result of thermal decomposition in the steam generators; whereas, ammonium hydroxide is injected only as necessary, since it is thermally stable and loss from the system is minimal.

1.1.2.4 Operating chemistry limits for steam generator water and steam, and for condensate/feedwater are given in Tables 1.1-1, -2, -3, -4 and -5.

1.1.3 Effectiveness of Normal Chemistry Control

1.1.3.1 Alkaline conditions within the feedwater trains and steam generators reduce general corrosion at elevated temperatures and tend to decrease the release of soluble corrosion products from metal surfaces. These conditions promote formation of a protective metal oxide film and thus reduce the transport of corrosion products into the steam generators.

1.1.3.2 Hydrazine also promotes formation of a metal oxide film by the reduction of ferric oxide to magnetite. Ferric oxide may be loosened from the metal surfaces and be transported by the feedwater. Magnetite, however, provides an adhesive, protective layer on carbon steel surfaces. Hydrazine also promotes formation of protective metal oxide layers on copper surfaces.

1.1.3.3 Removal of oxygen from the secondary waters is also essential in reducing corrosion. Oxygen dissolved in water causes general corrosion that can result in pitting of ferrous metals, particularly carbon steel. Oxygen is removed from the steam cycle condensate in the main condenser deaerating section. Additional oxygen protection is obtained by chemical injection of hydrazine into the condensate stream. Maintaining a residual level of hydrazine in the feedwater ensures that any dissolved oxygen not removed by the main condenser is scavenged before it can enter the steam generator.

1.1.3.4 The presence of free hydroxide (OH) can cause rapid corrosion (caustic stress corrosion) if it is allowed to concentrate in a local area. Free hydroxide is avoided by maintaining proper pH control and by minimizing impurity ingress into the steam generator.

Zero solids treatment is a control technique whereby both soluble and insoluble solids are kept at a minimum within the steam generator. This is accomplished by maintaining strict surveillance over

the possible sources of feedtrain contamination (e.g., main condenser cooling water leakage, air inleakage, and subsequent corrosion product generation in the low pressure drain system, etc.). Solids are also excluded, as discussed above, by injecting only volatile chemicals to establish conditions that reduce corrosion and, therefore, reduce transport of corrosion products into the steam generator.

- 1.1.3.5 In addition to minimizing the sources of contaminants entering the steam generator, continuous blowdown is employed to reduce their concentration. With the low solids level that results from employing the above procedures, the accumulation of scale and deposits on steam generator heat transfer surfaces and internals is limited. Scale and deposit formations can alter the thermal hydraulic performance in local regions to such an extent that they create a mechanism that allows impurities to concentrate to high levels, and thus could possibly cause corrosion. Therefore, by limiting the ingress of solids into the steam generator, the effect of this type of corrosion is reduced.
- 1.1.3.6 Because they are volatile; the chemical additives do not concentrate in the steam generator and do not represent chemical impurities that can themselves cause corrosion.
- 1.1.3.7 System design and operating practices are directed toward the goal of corrosion protection which, at the same time, provides an excellent environment for the suppression of iodine emissions in steam. Secondary water chemistry suppresses formation of volatile species of iodine in the steam generators, and converts volatile iodine to non-volatile iodine compounds.
- 1.1.3.8 The condenser air ejector iodine partition factor used for radionuclide release analysis is discussed in subsection 11.3.3, SONGS 2/3 FSAR.

TABLE 1.1-1
 OPERATING CHEMISTRY LIMITS
SECONDARY SYSTEM - STEAM GENERATOR BLOWDOWN

<u>Parameter</u>	<u>Normal*</u>	<u>Analysis Frequency</u>	<u>Transient Limit**</u>	<u>Consider Immediate Shutdown#</u>
pH @ 25°C	8.2-9.2	1/shift	7.5 to 9.5	≤6.5 or ≥10.5
Conductivity @ 25°C	<7 µmho/cm	1/shift	≥15 µmho/cm	NA
Chloride	<100 µg/l***	1/shift	NA	NA
Suspended Solids	<1 mg/l	1/week	≥10 mg/l	NA
Free Hydroxide	(Analyze when pH is outside normal range)			≥5 mg/l
Silica	<1 mg/l	1/week	10 mg/l	NA
Dose Equivalent I-131	(Not yet established)			

* The normal chemistry conditions can be maintained by a coastline plant using sea water cooling but with little or no condenser leakage. If the normal specifications are exceeded, immediate investigation of the problem is initiated, sampling frequency increased to the abnormal level (at least once per 2 hours), and blowdown increased. If condenser leakage is indicated, leak isolation procedures are instituted.

** The transient steam generator limits are allowed to permit operations with minor system fault conditions until the affected component can be isolated and/or repaired. If the abnormal limits are exceeded for greater than 4 hours, shutdown procedures are considered.

*** CE recommended limit.

NA indicates that no action other than correcting parameters back to acceptable limits is required.

TABLE 1.1-2
 OPERATING CHEMISTRY LIMITS
SECONDARY SYSTEM - MAIN STEAM

<u>Parameter</u>	<u>Normal</u>	<u>Analysis Frequency</u>	<u>Transient Limit</u>	<u>Consider Immediate Shutdown</u>
Cation Conductivity @ 25°C	<0.5 µmho/cm	1/shift	NA	≥2 µmho/cm

TABLE 1.1-3
 OPERATING CHEMISTRY LIMITS
SECONDARY SYSTEM - CONDENSATE STORAGE TANK

<u>Parameter</u>	<u>Normal</u>	<u>Analysis Frequency</u>	<u>Transient Limit</u>	<u>Consider Immediate Shutdown</u>
pH @25°C	6.0 - 8.0	1/day	NA	NA
Conductivity @ 25°C	<5 µmho/cm	1/day	NA	NA
Suspended Solids	<1 mg/l	1/week	NA	NA
Chloride	<0.15 mg/l	1/day	NA	NA
Silica	<10 µg/l	1/day	NA	NA

TABLE 1.1-4
OPERATING CHEMISTRY
SECONDARY SYSTEM - CONDENSATE PUMP DISCHARGE

<u>Parameter</u>	<u>Normal*</u>	<u>Analysis Frequency</u>	<u>Transient Limit**</u>	<u>Consider Immediate Shutdown</u>
pH @ 25°C	8.8 - 9.2	1/shift	<8.8 or> 9.2	NA
Conductivity @ 25°C	<5 µmho/cm	1/shift	NA	NA
Cation Cond. @ 25°C	<0.5 µmho/cm	1/shift	1.5 µmho/cm	NA
Dissolved O ₂	<10 µg/l	1/shift	≥10 µg/l	100 µg/l
Sodium	<10 µg/l	1/day	20 µg/l	NA
Turbidity	(Not yet established)		NA	NA
Ammonia	<1 µg/l	1/day	NA	NA
Chloride	≤1 µg/l***	1/shift	NA	NA
Iron	<10 µg/l	1/day	≥30 µg/l	NA
Copper	<5 µg/l***	1/day	≥10 µg/l	NA
Silica	<10 µg/l	1/week	NA	NA

* The normal chemistry conditions can be maintained by a coastline plant using sea water cooling but with little or no condenser leakage. If the normal specifications are exceeded, immediate investigation of the problem is initiated, sampling frequency increased to the abnormal level (at least once per 2 hours), and blowdown increased. If condenser leakage is indicated, leak isolation procedures are instituted.

** The abnormal condensate/feedwater limits are allowed to permit operations with minor system fault conditions until the affected component can be isolated and/or repaired. If the abnormal limits are exceeded for greater than 4 hours, shutdown procedures are considered.

*** CE recommends that chloride concentrations be less than the Lower Detectable Limit (LDL).

CE also recommends that copper be eliminated from the system and that copper concentrations be less than the lower detectable limit. Since Units 2/3 feedwater heaters contain copper alloy tubing, limits for copper have been temporarily established at 5 µg/l.

TABLE 1.1-5
 OPERATING CHEMISTRY LIMITS
SECONDARY SYSTEM - FEEDWATER HEATER TRAIN

<u>Parameter</u>	<u>Normal*</u>	<u>Analysis Frequency</u>	<u>Transient Limit**</u>	<u>Consider Immediate Shutdown</u>
pH @ 25°C	8.8 - 9.2	1/shift	<8.8 or> 9.2	NA
Conductivity @ 25°C	<5 µmho/cm	1/shift	NA	NA
Cation Cond. @ 25°C	<0.5 µmho/cm	1/shift	NA	NA
Dissolved O ₂	<10 µg/l	1/shift	≥10 µg/l	≥100 µg/l
Hydrazine	10-50 µg/l	1/day	NA	NA
Ammonia	<1 mg/l	1/day	NA	NA
Dissolved Solids	<1 mg/l	1/week	NA	NA
Copper	<5 µg/l***	1/day	10 µg/l	NA
Iron	<10 µg/l	1/day	30 µg/l	NA
Silica	<10 µg/l	1/week	NA	NA

* The normal chemistry conditions can be maintained by a coastline plant using sea water cooling but with little or no condenser leakage. If the normal specifications are exceeded, immediate investigation of the problem is initiated, sampling frequency increased to the abnormal level (at least once per 2 hours), and blowdown increased. If condenser leakage is indicated, leak isolation procedures are instituted.

** The abnormal condensate/feedwater limits are allowed to permit operations with minor system fault conditions until the affected component can be isolated and/or repaired. If the abnormal limits are exceeded for greater than 4 hours, shutdown procedures are considered.

*** CE recommends that chloride concentrations be less than the Lower Detectable Limit (LDL).

CE also recommends that copper be eliminated from the system and that copper concentrations be less than the lower detectable limit. Since Units 2/3 feedwater heaters contain copper alloy tubing, limits for copper have been temporarily established at 5 µg/l.

1.2 Outage Protection - Chemistry Control

The most common form of corrosion encountered in the steam generator and feedwater/condensate system results from oxygen attached in the presence of water. During secondary plant operation, continual deaeration and continuous feed of a chemical oxygen scavenger will effectively eliminate oxygen from the system. However, during outages the techniques required to prevent corrosion must often be modified. Outage protection as described in this section consists of applying the proper safeguards to minimize such corrosion.

1.2.1 Startup Conditions

In preparation for unit startup, two or more condensate pumps are used to circulate treated (N_2H_4 & NH_3) demineralized water (at 7,500 gpm) from the four main condenser hot well quadrants through the feedwater trains, and back to the main condenser. The purpose of this operation is to remove loosely adherent ferric oxide (Fe_2O_3) that may have accumulated during the unit outage period.

The condensate pumps are then shutdown, the condensate/feedwater system is drained, and then refilled with treated demineralized water. It is at this stage that startup protection chemical limits will have an influence on the progress of the unit startup.

Following the pre-startup flush, dump and refill, circulation of the condensate/feedwater system is re-established at 7,500 gpm; hydrazine and ammonia feeds are initiated; gland sealing steam from the auxiliary boiler is valved to the main turbine seals and to the seals of both feedwater pump turbines; vacuum is established on the main condenser; and steam (from auxiliary boiler) is admitted to the shell side of the 4th point heaters to bring the condensate/feedwater system to a temperature of $180^{\circ}F$. The purpose of these operations is to purge the system of dissolved oxygen, convert ferric oxide (Fe_2O_3) to magnetite (Fe_3O_4) and to stabilize the system pH.

To aid in system cleanup, a side stream flow of 1,250 gpm is passed through the blowdown ion-exchanger to remove Fe_3O_4 and other contaminants before returning the processed effluent to the main condenser hotwells.

Coincidental with the cleanup of the condensate/feedwater system, the steam generators are filled, and their volumes maintained, with treated (N_2H_4 and NH_3) demineralized water by way of the auxiliary feedwater system.

Upon completion of unit startup, the entire system should be operating within normal chemical limits (See Section 1.1).

1.2.1.1 Hotwells

Prior to system startup each hotwell quadrant is sampled and analyzed for pH, conductivity, chloride and suspended solids to determine if the water therein is acceptable for circulation through the feedwater heater trains.

All hotwells which do not meet feedwater specifications given in Table 1.2-1 are pumped down to minimum level--overboarding the water to the circulating water outfall--and refilled with demineralized water from the secondary plant condensate storage tank.

1.2.1.2 Feedwater Systems

Each feedwater train will be analyzed for dissolved oxygen, hydrazine, pH, conductivity (specific and cation) and suspended solids. The concentration of hydrazine in the feedwater system will be maintained at a concentration ratio of 4:1 (N_2H_4 to O_2) in order to inhibit the corrosive effects of oxygen and to assure a reducing environment for the conversion of ferric oxide to magnetite.

The feedwater system will not be allowed to feed the steam generators until the water meets the startup specifications for both systems as stated in Table 1.2-1.

1.2.1.3 Steam Generators

Each steam generator will be sampled and analyzed for dissolved oxygen, hydrazine, pH, conductivity, suspended solids and chloride. Blowdown through the blowdown ion exchangers will be initiated as required to clean up the system.

TABLE 1.2-1
OUTAGE PROTECTION - STARTUP CONDITIONS

	<u>Hotwells</u>	<u>Feedwater</u>	<u>Steam Gens.</u>	<u>Steam Gen. Aux. Fdwtr.</u>	<u>Aux. Blr.</u>	<u>Aux. Blr. Deaerator</u>
pH @ 25°C	9.0 ± 0.2	9.0 ± 0.2	9.0 ± 0.5	9.0 ± 0.2	9.0 ± 0.5	9.0 ± 0.2
Conductivity (Specific) @ 25°C	<10 µmho/cm	<10 µmho/cm	<15 µmho/cm	<15 µmho/cm	<15 µmho/cm	<10 µmho/cm
Conductivity (Cation) @ 25°C	<1.5 µmho/cm	1.5 µmho/cm	NA	NA	NA	NA
Chloride	<0.1 mg/l	NA	<0.1 mg/l	NA	<1.0 mg/l	NA
Suspended Solids	<10 mg/l	<10 mg/l	<10 mg/l	<10 mg/l	<10 mg/l	<10 mg/l
Dissolved Oxygen	<10 µg/l	<10 µg/l	<10 µg/l	<10 µg/l	<10 µg/l	<10 µg/l
Hydrazine	NA	4xO ₂ µg/l	NA	4xO ₂ µg/l	NA	4xO ₂ µg/l

1.2.2 Shutdown Conditions

1.2.2.1 Feedwater System

Increase hydrazine feed to maximum as soon as shutdown operations commence. Hydrazine should be maintained at a concentration 1.5 times (or greater) the dissolved oxygen concentration.

TABLE 1.2-2
OUTAGE PROTECTION - SHUTDOWN CONDITIONS

	<u>Feedwater</u>	<u>Steam Gens.</u>	<u>Aux. Blr.</u>	<u>Aux. Blr. Deaerator</u>
pH @ 25°C	9.0 ± 0.2	9.0 ± 0.5	9.0 ± 0.5	9.0 ± 0.2
Hydrazine	≥1.5x0 ₂ µg/l	≥1.5x0 ₂ µg/l	≥1.5x0 ₂ µg/l	≥1.5x0 ₂ µg/l

Shutdown limits for the auxiliary feedwater (to steam generators) system are the same as the startup limits stated in Table 1.2-1.

1.2.3 Outage Conditions

The type and extent of outage protection to be utilized for a given outage will depend upon the duration of that outage, the type of maintenance to be performed during the outage and the requirements for unit availability.

Outage conditions exist whenever the steam generators are at a temperature less than 227°F and/or 5 lb/in² gauge, while the pressure of the system is in the process of being reduced. Outage conditions are defined for two situations--wet storage and dry storage; and for durations--short and extended. Short duration is defined as four days or less; and extended duration is defined as greater than four days, up to two months. For outages greater than two months, dry storage is the only method of outage protection that should be utilized.

Outage protection for systems ancillary to the major components of the secondary system are given in Table 1.2-6.

1.2.3.1 Wet Storage - Short Duration ($t_{\text{outage}} \leq 4$ days)

Wet storage methods should be applied during short term outages or whenever unit availability must be maintained.

Vacuum should be maintained on the main condenser and on the shell side of the 5th and 6th point heaters. The main circulating water pumps should also be operating.

Pegging steam should be maintained on the shell side of the 1st through 4th point heaters and on the steam generators.

Wet storage outage conditions will be monitored no less than twice weekly; and samples taken from the hotwells will be analyzed for pH, conductivity and chloride, and those taken from the feedwater and steam generators for pH, conductivity, dissolved oxygen and hydrazine. Normal operating limits will be maintained for wet storage outage protection of short duration. The system will be circulated for 30 minutes prior to sampling -- if at all possible.

TABLE 1.2-3
OUTAGE PROTECTION
Wet Storage - Short Duration ($t_{out} \leq 4\text{days}$)*

	<u>Hotwells</u>	<u>Feedwater Heaters</u>	<u>Steam Generators</u>	<u>Aux. Blr.</u>	<u>Aux. Blr. Deaerator</u>
pH @ 25°C	9.0 ± 0.2	9.0 ± 0.2	9.0 ± 0.5	9.0 ± 0.5	9.0 ± 0.2
Conductivity (Specific) @ 25°C	<10 µmho/cm	<10 µmho/cm	<15 µmho/cm	<15 µmho/cm	<10 µmho/cm
Chloride	<0.15 mg/l	NA	<0.15 mg/l	<1.0 mg/l	NA
Dissolved Oxygen	<100 µg/l	<10 µg/l	<10 µg/l	<10 µg/l	<10 µg/l
hydrazine	NA	≥1.5 x O ₂	≥1.5 x O ₂	≥1.5 x O ₂	≥1.5 x O ₂

* Vacuum on main condenser; steam pegging on shell side of feedwater heaters and steam generators.

1.2.3.2 Wet Storage - Extended Duration (4 days < t_{outage} < 2 months)

If vacuum cannot be maintained on main condenser and on the shell side of the 5th and 6th point heaters, then these systems must be drained while still hot (>90°F). Also, if the main circulating water pumps are shutdown, the water boxes should be drained.

If steam pegging protection is not available, then a nitrogen overpressure of 5 psig should be applied to the steam generators; and the shell sides of the 1st through 4th point heaters should be flooded with demineralized water treated with 200 µg/l hydrazine.

These protective measures should be done prior to breaking vacuum on the main condenser and prior to the attainment of ambient temperature.

Wet storage outages of extended duration should be monitored at least twice weekly; and samples taken from the steam generators and feedwater heaters shell side should be analyzed for pH, conductivity and hydrazine; and checked for nitrogen overpressure. The pH, hydrazine and nitrogen overpressure within these systems should be maintained at 10.0 ± 0.2 , 200 ± 50 N₂H₄, and 3.0 ± 2.0 psig N₂, respectively. Prior to sampling, the system should be circulated for 30 minutes -- if at all possible.

TABLE 1.2-4
OUTAGE PROTECTION
Wet Storage - Extended Duration (4days < t_{outage} < 2 months)*

	Feedwater Heaters		Steam	Aux. Blr.	Aux. Blr.
	Tube Side	Shell Side	Generators	Aux. Blr.	Deaerator
pH @ 25°C	10.0 ± 0.2	10.0 ± 0.2	10.0 ± 0.2	10.0 ± 0.2	9.0 ± 0.2
Hydrazine	200 ± 50 mg/l	200 ± 50 mg/l	200 ± 50 mg/l	200 ± 50 mg/l	100 ± 50 mg/l
Dissolved Oxygen	100 µg/l	NA	100 µg/l	100 µg/l	100 µg/l

* No vacuum on main condenser, hotwells drained; N₂ overpressure on shell side of feedwater heaters and on steam generators.

1.2.3.3 Dry Storage (t_{outage} > 2 months)

Hotwells should be drained while above ambient temperature (~ 92°F) and access panels opened to allow thorough drying of internal condenser surfaces.

Feedwater heaters tube side and shell side should be drained while above ambient temperature (6th, 5th and 4th @ > 115°F; 3rd and 2nd @ > 220°F; and 1st @ 240°F).

In addition, heater shell sides should be drained under a nitrogen overpressure atmosphere of 5.0 psig.

Steam generators must be drained hot--beginning at 240°F.--under a nitrogen overpressure atmosphere.

Monitor and record, at least once per week, the nitrogen pressure on all heat exchange equipment under nitrogen atmosphere protection. Make adjustments as required to maintain N₂ limits of 1.0 to 5.0 psig.

TABLE 1.2-5
OUTAGE PROTECTION
Dry Storage - Extended Duration (t_{out} > 2 months)

All systems drained under following condition:

	Hotwells	Feedwater Heaters		Steam Generators	Aux. Blr.	Aux. Blr. Deaerator
		Tube Side	Shell Side			
pH @ 25°C	9.0 ± 0.2	9.0 ± 0.2	9.0 ± 0.2	9.3 ± 0.3	9.3 ± 0.3	9.0 ± 0.2
Hydrazine	NA	>4xO ₂ µg/l	NA	>4xO ₂ µg/l	>4xO ₂ µg/l	>4xO ₂ µg/l
Temp. °F	≈90	(Between 90 & 240)		~240	90 - 240	~240
N ₂ overpress. (1.0-5.0 psig)	No	No	Yes	Yes	No	No

1.2.4 Outage Protection - Ancilliary Systems

TABLE 1.2-6
OUTAGE PROTECTION - ANCILLIARY SYSTEMS

<u>System Designation</u>	<u>System</u>	<u>Internal Clean. Class*</u>	<u>Tentative Flush Method***</u>	<u>Outage Protection</u>	
				<u>Pre-Startup</u>	<u>Post Startup</u>
MAIN POWER CYCLE					
ADA/AEA	Condensate/Feedwater Sys.	C/D	PF	(See	6.2.3)
ALA	Auxiliary Feedwater	C	PF	1	2
AQA	Condensate & FW Chemical Feed	C	PF	1	3
APA	Condensate Transfer & Storage	C	WC/PF	2	2
CGA	Condenser Air Removal	D	SF	1	None
ANA	Deminerlized Wtr. M.U & Transfer	B	PF	2	2
AFA	Feedwater Heaters Extractions	C	WC/PF	1	None
ABA-B	Main Steam	C	WC	1	None
ACA	Main Turbine	C	WC	1	None
ACA	Main Turbine L.P. Exhaust Spray	C	PF	1	None
BMA	Steam Gen. Blowdown Processing	C/D	SF	1	None
RCA	Turbine Plant Sampling	C/D	PF	1	None
TURBINE-GENERATOR CONTROLS					
CAA	Steam Seals	C	PS	1	None
CBA	Main Turbine & Gen. Lube Oil	C	PF	1/3	3
CCA	Generator H ₂ & CO ₂	C	PF	1/3	3
CDA	Hydrogen Seal Oil	C	PF	1/3	3
CFA	Lube Oil Storage, Transf. & Purif.	C	PF	1/3	3
CHA	Main Turbine Controls	C	PF	1/3	3

System Designation	System	Internal Clean. Class*	Tentative Flush Method***	Outage Protection	
				Pre-Startup	Post Startup
CEA	Stator Water Cooling	C	PF	1/2	2
	CIRCULATING WATER				
DAA	Main Circ. Water	D	HC	1/3	None
DCA	Traveling Screens & Fish Handlg.	D	PF	1/3	3/4
DDA	Chlorine Injection	D	HC/SF	1/3	None
DEA	Amertap	D	HC/SF	1/3	None
	COOLING & CHILLED WATER				
EBA	Turbine Plant Cooling Water	D	PF	2/***	2
EPA	Salt Water Cooling	D	HC	1/3	None
GBA/GJA/ GND	Chilled Water (Normal and emergency, all systems)	D	PF	2/***	2
	AUXILIARY STEAM				
FAA	Auxiliary Boiler	C	CC	(See	1.2.3)
FBA	Auxiliary Steam	C	PS/SF	1	None
FCA-B	Auxiliary Turbines	C	SF	1	None
	ANCILLIARY SERVICES				
KAA	Compressed Air (Service)	D	PB	1/3	3
KBA	Critical Compressed Air (Instr.)	C	PB	1/3	3
KDA	Domestic Water	D	PF	1/3	3
EAA	Service Water	D	PF	1/3	3
KCA	Fire Protection, Water	D	PF/PB	1/3	3
KCB	Fire Protection, Halon	D	PB	1/3	3
KCC	Fire Protection, CO ₂	D	PB	1/3	3
KHA	Services, Nitrogen, L.P.	B/C	PB	1/3	3
KHA	Services, Nitrogen, H.P.	B/C	PB	1/3	3

System Designation	System	Internal Clean. Class*	Tentative Flush Method***	Outage Protection	
				Pre-Startup	Post Startup
KLA	Service Hydrogen	B/C	PB	1/3	3
KJA-B	Standby Diesel Eng. Water	C	PF	1/3	3
KJA-B	Standby Diesel Eng. Air	C	PB	1/3	3
MISCELLANEOUS					
JAA	Aux. Boiler Fuel Oil	C	PF/PB	1/3	3
JEA	Standby Diesel Fuel Oil	C	PF/PB	1/3	3
NON-RADIOACTIVE DRAINS;					
LEA	Oily Waste	D	HC	1/3	None
LFA	All Turbine Plt., Gravity	D	DF	1/3	None
LFB	Diesel Bldg. Gravity	D	DF	1/3	None

* INTERNAL CLEANNESS CLASS:

A, B, C and D: ANSI Standard N45.2.1-1973

** TENTATIVE FLUSH METHOD:

CC Chemically Cleaned by Startup
DF Drains Flushed Open
HC Manually Cleaned Before Filling -- No Wiping
PB Gas Blown Procedure
PF Proof Flush Procedure
PS Steam Blown Procedure
SF Flushed or Blown as a Part of Startup Procedure
WC Manually Cleaned and Wiped

OUTAGE PROTECTION:

1. Lay up clean and dry; ANSI Standard N45.2.1.
2. Use normal operating limits for outage protection control; Station Order S023-E-2 and Chemical Procedure S023-III-2.3.
3. Normal system fluid.
4. Wash screens with service water.

*** A Procedure Change Notice (PCN) may be required for outage protection of various in-service subsystems -- such as the Units 2/3 air compressor cooling loop -- prior to plant startup. These PCN's will be issued by the Units 2/3 Chemical/Radiation Protection Supervisor or Operations Supervisor, as required.

1.3 Attachment

1.3.1 Chemical Procedure S023-III-2.3 "Secondary System Chemical Limits and Sampling Frequencies; (currently under revision).

1.3.2 Chemical Procedure S023-III-2.38 "Secondary System Outage Protection;" (currently under revision).

2.0 Identification of Procedures Used to Measure Critical Parameters.

2.1 San Onfore Nuclear Generating Station - Secondary System Analyses (All test procedures are currently under revision).

<u>Parameter</u>	<u>Procedure Number</u>	<u>Procedure Title</u>
Ammonia	S023-III-2.1	Spectrophotometric Determination of Ammonia with Nessler's Reagent
Oxygen, Low	S023-III-2.2	Dissolved Oxygen by Indigo Carmine
Limits, Normal Operation	S023-III-2.3	Secondary System Chemical Limits and Sampling Frequencies
Chloride	S023-III-2.5	Determination of Chloride Ion by Mercuric Nitrate Titration
Chromate	S023-III-2.7	Spectrophotometric Determination of Chromate by Color Density of CrO_4^{2-} Ion
Chromium	S023-III-2.8	Spectrophotometric Determination of Chromium with S-Diphenylcarbazide
Conductivity and Cation Conductivity	S023-III-2.9	Conductivity and Cation Conductivity
Copper	S023-III-2.11	Copper by Atomic Absorption
Copper	S023-III-2.13	Spectrophotometric Determination of Copper by DEDTC
Fluoride	S023-III-2.15	Spectrophotometric Determination of Fluoride Ion with Zirconium-SPADNS Complex
Hardness	S023-III-2.16	The Titrametric Determination of Calcium, Magnesium and Total Hardness
Hydrazine, Low	S023-III-2.17	Determination of Hydrazine with p-Dimethyl Aminobenzaldehyde
Hydrazine, High	S023-III-2.18	Titrametric Determination of High Concentrations of Hydrazine (10-100 mg/l)

<u>Parameter</u>	<u>Procedure Number</u>	<u>Procedure Title</u>
Hydroxide	S023-III-2.19	Determination of Hydroxide Ion by Titrametric Method
Iron	S023-III-2.20	Iron by Atomic Absorption
Iron	S023-III-2.21	Iron by Bathophenanthroline Method
Iron	S023-III-2.22	Spectrophotometric Determination of Iron by Orthophenanthroline
Iron	S023-III-2.23	Iron with TPTZ.
Oxygen, High	S023-III-2.26	Determination of Dissolved Oxygen by Thiosulfate Titration with Starch Indicator
pH	S023-III-2.27	pH, Hydrogen Ion Concentration, Potentiometric Determination
Silica	S023-III-2.28	Spectrophotometric Determination of Soluble Silica
Sodium	S023-III-2.29	Sodium by Atomic Absorption
Sulfate	S023-III-2.30	Determination of Sulfate in Water
Sulfide	S023-III-2.31	Sulfide by Spectrophotometric Method
Turbidity	S023-III-2.32	Turbidity Measurements
Sample Location	S023-III-2.34	Secondary System Local and Central Sample Points
Sodium	S023-III-2.35	Sodium by Specific Ion Electrode
Solids	S023-III-2.36	Total and Suspended Solids
Chloride	S023-III-2.37	Chloride Analysis by Specific Ion Electrode
Outage Protection	S023-III-2.38	Secondary System Outage Protection
Fluoride	S023-III-1.15	Fluoride Analysis by Specific Ion Electrode
Sulfide	S023-III-2.43	Sulfide Analysis by Specific Ion Electrode

2.2 Attachment

2.2.1 None

3.0 Identification of Process Sampling Points

3.1 Attachments

3.1.1 Chemical Procedure S023-III-2.34, "Secondary System Local and Central Sample Points;" (currently under revision).

3.1.2 P&I Diagrams

40193-6 Secondary Sampling System (Sheet 1 of 2)

40194-6 Secondary Sampling System (Sheet 2 of 2)

4.0 Procedure for the recording and management of data

4.1 The disposition of any analysis data form used in conjunction with any secondary system chemical procedure is stated in Section 7. RECORDS of each procedure.

4.1.1 Example - Section 7. RECORDS, Chemical Procedures S023-III-2.35, Sodium Analysis by Ion Selective Electrode:

The results of secondary (turbine) plant analyses -- specifically the hotwells and condensate pump discharge -- shall be recorded on PSSO (2/3)-1042-9 "Daily Turbine Plant Summary Sheet."

Copies of PSSO (2/3)-1042-8 data sheets shall be filed in the turbine plant file for future reference, after being reviewed by the Chemical-Radiation Protection Foreman.

All original PSSO (2/3)-1042-8 data sheets shall be transmitted to EDM* on a monthly basis and filed under encode number CN05-AX2 (S02/3).

*EDM - Edison Document Management.

4.2 Attachments (all currently under revision)

4.2.1 Chemical Procedure S023-III-2.21, "Spectrophotometric Determination of Iron with Bathophenanthroline."

4.2.2 Chemical Procedure S023-III-2.35, "Sodium Analysis by Selective Ion Electrode."

4.2.3 Chemical Procedure S023-III-2.36, "Total and Suspended Solids."

5.0 Procedure(s) Defining Off-Control Point Chemistry

Corrective Action, and Sequence and Timing Required to Initiate. Reference should be made to Section 1.0 and Tables 1.1-1 through 1.1-5; and to the following documents:

5.1 References

- 5.1.1 Combustion Engineering Power Systems, "Chemistry Manual CENPD-28," Rev. 2, January 1976.
- 5.1.2 Combustion Engineering Power Systems, "Criteria for Cleanliness and Cleaning of Nuclear Components," Rev. 2, March 1971.
- 5.1.3 ANSI (Standard N45.2.1, "Cleaning of Fluid Systems and Associated Components During Construction Phase of Nuclear Power Plants," 1973.
- 5.1.4 Bechtel Power Corporation, "Cleanness Verification and Control Manual," Rev. 1, Job 10079, May 1979.
- 5.1.5 San Onofre Nuclear Generating Station, Units 2 and 3 Final Safety Analysis Report (FSAR) Sections 9.2.3 "Make-up Demineralizer System," 9.3.2 "Process Sampling System," and 10.3.5 "Secondary Water Chemistry (PWR)."
- 5.1.6 Branch Technical Position MTEB 5-3, "Monitoring of Secondary Side Water Chemistry in PWR Steam Generators," Rev. 1.

6.0 Procedure(s) Identifying Authority Responsible for the Interpretation of Data

The authority ultimately responsible for the interpretation of secondary system chemistry is the site Chemical-Radiation Protection Engineer. The documents which delineate the various levels of responsibility are listed below:

6.1 References:

- 6.1.1 Station Order S023-E-2, "Operation, Maintenance and Control of Heat Exchange Equipment;" (currently under revision).
- 6.1.2 Station Order S023-E-3, "Outage Protection;" (currently under revision).
- 6.1.3 SONGS Units 2/3 Chemical Procedures S023-III-Series, Section 7. RECORDS; (All are currently under revision for reformatting and updating).
- 6.1.4 San Onofre Nuclear Generating Station Units 2 and 3, Final Safety Analysis Report (FSAR), Section 16.6 ADMINISTRATION CONTROLS.

ATTACHMENTS

1. Chemical Procedure S023-III-2.3, "Secondary System Chemical Limits and Sampling Frequencies (currently under revision)."
2. Chemical Procedure S023-III-2.38, "Secondary System Outage Protection (currently under revision)."
3. Chemical Procedure S023-III-2.34, "Secondary System Local and Central Sample Points (currently under revision)."
4. P&I Diagrams --
 - 40193-6 Secondary Sampling System (sheet 1 of 2)
 - 40194-6 Secondary Sampling System (sheet 2 of 2)
5. Chemical Procedure S023-III-2.21, "Spectrophotometric Determination of Iron with Bathophenanthroline."
6. Chemical Procedure S023-III-2.35, "Sodium Analysis by Selective Ion Electrode."
7. Chemical Procedure S023-III-2.36, "Total and Suspended Solids."

SECONDARY SYSTEM CHEMICAL LIMITS AND SAMPLING FREQUENCIES

1. OBJECTIVE

This procedure specifies the chemical limits and routine sampling and analysis frequencies deemed necessary to adequately monitor and control all turbine plant and auxiliary water systems during normal and abnormal plant operation. These limits and sampling frequencies are generally in agreement with the recommendations of Combustion Engineering and are in specific agreement with the applicable Technical Specifications.

2. REFERENCES

- 2.1 Combustion Engineering Power Systems Chemistry Manual CENPD-28, Revision 2, January, 1976.
- 2.2 San Onofre Nuclear Generating Station Units 2 and 3 Final Safety Analysis Report.

3. PREREQUISITES

Not applicable.

4. PRECAUTIONS

- 4.1. Adherence to the following chemical control limits is necessary if the plant is to attain the design lifetime.

5. CHECK-OFF

Not applicable.

6. PROCEDURE

- 6.1 Method; Not applicable.
- 6.2 Calculations; Not Applicable.
- 6.3 Acceptance Criteria

Following are the chemical limits and analysis frequencies for normal, abnormal and immediate shutdown conditions. Operation in the transient limit range for any chemical parameter is permissible for up to four (4) hours. Shutdown should be commenced if the chemical parameter cannot be returned to the normal range within four (4) hours.

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6.3.1 Condensate Storage Tank

<u>PARAMETER</u>	<u>NORMAL</u>	<u>ANALYSIS FREQUENCY</u>	<u>TRANSIENT LIMIT</u>	<u>IMMEDIATE SHUTDOWN</u>
pH @25°C.	6.0-8.0	1/day	-	-
Conductivity @25°C.	<5 umho/cm	1/day	-	-
Suspended Solids	<1 mg/l	1/week	-	-
Chloride	<0.15 mg/l	1/day	-	-

6.3.2 Hotwells

Cation Cond. @25°C.	<0.5 umho/cm	1/week	1.5 umho/cm	-
Sodium	<10 ug/l	1/day	≥20 ug/l	-

6.3.3 Condensate Pump Discharge

pH @25°C.	8.8-9.2	1/shift	<8.8 or >9.2	-
Conductivity @25°C.	<5 umho/cm	1/shift	-	-
Cation Cond. @25°C.	<0.5 umho/cm	1/shift	1.5 umho/cm	-
Dissolved O ₂	<10 ug/l	1/shift	≥10 ug/l	100 ug/l
Sodium	<10 ug/l	1/day	20 ug/l	-
Turbidity	Not yet available.			
Ammonia	< 1 mg/l	1/day	-	-
Chloride	< 0.5 mg/l	1/day	-	-
Iron	<10 ug/l	1/day	≥30 ug/l	-
Copper	<10 ug/l	1/day	≥10 ug/l	-
Silica	<10 ug/l	1/week	-	-


<u>PARAMETER</u>	<u>NORMAL</u>	<u>ANALYSIS FREQUENCY</u>	<u>TRANSIENT LIMIT</u>	<u>IMMEDIATE SHUTDOWN</u>
6.3.4 High Pressure Feedwater Heater Outlet				
pH @25°C.	8.8-9.2	1/shift	<8.8 or >9.2	-
Conductivity @25°C.	<5 umho/cm	1/shift	-	-
Cation Cond. @25°C.	<0.5 umho/cm	1/shift	-	-
Dissolved O ₂	<10 ug/l	1/shift	≥10 ug/l	≥100 ug/l
Hydrazine	10-50 ug/l	1/day	-	-
Ammonia	<1 mg/l	1/day	-	-
Dissolved Solids	<1 mg/l	1/week	-	-
Copper	<10 ug/l	1/day	10 ug/l	-
Iron	<10 ug/l	1/day	30 ug/l	-
Silica	<10 ug/l	1/week	-	-
6.3.5 Steam Generator Blowdown				
pH @25°C	8.2-9.2	1/shift	7.5 to 9.5	≤6.5 or ≥10.5
Conductivity @25°C.	<7 umho/cm	1/shift	≥15 umho/cm	-
Suspended Solids	<1 mg/l	1/week	≥10 mg/l	-
Free Hydroxide	Analyze when pH is outside normal range.			≥5 mg/l
Silica	<1 mg/l	1/week	10 mg/l	-
Dose Equivalent I-131	Not yet available.			

<u>PARAMETER</u>	<u>NORMAL</u>	<u>ANALYSIS FREQUENCY</u>	<u>TRANSIENT LIMIT</u>	<u>IMMEDIATE SHUTDOWN</u>
6.3.6 <u>Main Steam</u>				
Cation Cond. @25°C.	< 0.5 umho/cm	1/day	-	≥2 umho/cm
6.3.7 <u>Auxilliary Feedwater</u>				
pH @25°C.	8.8-9.2	1/day	<8.8 or>9.2	-
Conductivity @25°C.	<5 umho/cm	1/day	-	-
Chemical limits to be the same as for the high pressure feedwater heater outlet (6.3.4) when this system is in service.				
6.3.8 <u>Turbine Plant Cooling Water</u>				
pH @25°C.	8.3-10.5	3/week	-	-
K ₂ CrO ₄	500-1000 mg/l (as CrO ₄ ⁼)	3/week	-	-
6.3.9 <u>Chilled Water Systems (Containments, Auxiliary Building, Emergency Loops A and B)</u>				
pH @25°C	8.3-10.5	1/week during recirculation	-	-
K ₂ CrO ₄	500-1000 mg/l (as CrO ₄ ⁼)	1/week, during recirculation	-	-

7. RECORDS

Results of all secondary system analyses shall be recorded on the appropriate data sheets and shall be transmitted to EDM on a monthly frequency. These data shall be filed as follows by EDM:

Steam Generators.	CN05-AX5 (S02/3)
Turbine Plant, Daily.	CN05-AX2 (S02/3)
Turbine Plant, Weekly	CN05-AX3 (S02/3)



H. E. MORGAN
SUPERINTENDENT UNITS 2/3

APPROVED BY:



J. M. CURRAN
PLANT MANAGER

RVW/yc

SECONDARY SYSTEM OUTAGE PROTECTION

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I. OBJECTIVE

1.1 Purpose

The purpose of this Chemical Procedure is to outline methods to be utilized to minimize corrosion of the various secondary plant sub-systems during periods of startup, shutdown and outage. It is essential that this procedure be stringently complied with in order to maintain operating integrity of all system components.

1.2 Background

The most common form of corrosion encountered in the steam generator and feedwater/condensate system results from oxygen attack in the presence of water. During secondary plant operation, continual deaeration and continuous feed of a chemical oxygen scavenger will effectively eliminate oxygen from the system. However, during outages, the techniques required to prevent corrosion must often be modified. Outage protection as described in this Chemical Procedure consists of applying the proper safeguards to minimize such corrosion.

2. REFERENCES

- 2.1 S-E-2, "Operation, Maintenance and Chemical Control of Heat Exchange Equipment."
- 2.2 S-E-3, "Outage Protection."
- 2.3 S023-III-2.3, "Secondary System Chemical Limits and Sampling Frequencies."
- 2.4 ANSI N45.2.1, "Cleaning of Fluid Systems and Associated Components During Construction Phase of Nuclear Power Plants;" American National Standards Institute, Feb. 1973.
- 2.5 "Chemistry Manual CENPD-28," Nuclear Power Systems, Combustion Engineering, Inc., Inc., Winsor, CT 06095; Revision No. 2, Jan. 1976.

3. PREREQUISITES

3.1 Equipment and Reagents

The equipment and reagents required for this procedure are specified in the following analytical procedures:

- 3.1.1 S023-III-2.1 "Spectrophotometric Determination of Ammonia with Nessler's Reagent"
- 3.1.2 S023-III-2.2 "Determination of Dissolved Oxygen by Indigo Carmine"
- 3.1.3 S023-III-2.9 "Conductivity and Cation Conductivity"

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3.1 Continued

- 3.1.4 S023-III-2.17 "Determination of Hydrazine with p-Dimethylaminobenzaldehyde"
- 3.1.5 S023-III-2.18 "Titrametric Determination of High Concentrations of Hydrazine"
- 3.1.6 S023-III-2.27 "pH by Potentiometric Determination"
- 3.1.7 S023-III-2.43 "Suspended Solids"

3.2 Treatment Chemicals

- 3.2.1 Ammonium hydroxide NH_4OH --pH control
- 3.2.2 Hydrazine, N_2H_4 -- oxygen scavenger

4. PRECAUTIONS

(None)

5. CHECK-OFF

- 5.1 Startup - Log all startup chemistry data on PSS0(2/3)-1042-12, "Unit Start-Up Sheet".
- 5.2 Shutdown - Log all shutdown chemistry data on PSS0(2/3)-1042-8, "Daily Turbine Plant Summary Sheet".
- 5.3 Outage Protection - Log all physical and chemical outage protection measures on the "Daily Turbine Plant Summary Sheet" on the day of shutdown and on the "Unit Start-Up Sheet".

6. PROCEDURE

6.1 Method

6.1.1 Startup Protection

In preparation for unit startup, two or more condensate pumps are used to circulate treated (N_2H_4 & NH_3) demineralized water (at 7500 gpm) from the four main condenser hot well quadrants through the feedwater trains, and back to the main condenser. The purpose of this operation is to remove loosely adherent ferric oxide (Fe_2O_3) that may have accumulated during the unit outage period.

6.1 (continued)

- 6.1.1 The condensate pumps are then shutdown, the condensate/feedwater system is drained, and then refilled with treated demineralized water. It is at this stage that startup protection chemicals limits will have an influence on the progress of the unit startup.

Following the pre-startup flush, dump and refill, circulation of the condensate/feedwater system is re-established at 7500 gpm; hydrazine and ammonia feeds are initiated; gland sealing steam from the auxiliary boiler is valved to the main turbine seals and to the seals of both feedwater pump turbines; vacuum is established on the main condenser; and steam (from aux. blr.) is admitted to the shell side of the 4th point heaters to bring the condensate/feedwater system to a temperature of 180°F. The purpose of these operations is to purge the system of dissolved oxygen, convert ferric oxide (Fe_2O_3) to magnetite (Fe_3O_4) and to stabilize the system pH.

To aid in system cleanup, a side stream flow of 1250 gpm is passed through the blowdown ion-exchanger to remove Fe_3O_4 and other contaminants before returning the processed effluent to the main condenser hotwells.

Coincidental with the clean up of the condensate/feedwater system, the steam generators are filled, and their volumes maintained, with treated (N_2H_4 & NH_3) demineralized water by way of the auxiliary feedwater system.

Upon completion of unit startup the entire system should be operating within normal chemical limits referenced in Procedure S023-III-2.3.

6.1.1.1 Hotwells

Prior to system startup each hotwell quarter shall be sampled and analyzed for pH, conductivity, chloride and suspended solids to determine if the water therein is acceptable for circulation through the feedwater heater trains.

All hotwells which do not meet feedwater specifications (see 6.2.1) shall be pumped down to minimum level--overboarding the water to the circulating water outfall--and refilled with demineralized water from the secondary plant condensate storage tank.

6.1.1.2 Feedwater Systems

Each feedwater train shall be analyzed for dissolved oxygen, hydrazine, pH, conductivity (specific and cation) and suspended solids. The concentration of hydrazine in the feedwater system shall be maintained at a concentration ratio of 4:1 (N_2H_4 to O_2) in order to inhibit the corrosive effects of oxygen and to assure a reducing environment for the conversion of ferric oxide to magnetite.

The feedwater system shall not be allowed to feed the steam generators until the water meets the startup specifications for both systems. (See 6.2.1)

6.1.1.3 Steam Generators

Each steam generator shall be sampled and analyzed for dissolved oxygen, hydrazine, pH, conductivity, suspended solids and chloride. Blowdown through the blowdown ion exchangers should be initiated as required to clean up the system.

6.1.2 Shutdown Protection

6.1.2.1 Feedwater System

Increase hydrazine feed to maximum as soon as shutdown operations commence. Hydrazine should be maintained at a concentration 1.5 times (or greater) the dissolved oxygen concentration.

6.1.3 Outage Protection

The type and extent of outage protection to be utilized for a given outage will depend upon the duration of that outage, the type of maintenance to be performed during the outage and the requirements for unit availability.

Outage conditions exist whenever the steam generators are at a temperature less than 227°F. and/or 5 lb/in² gauge, while the pressure of the system is in the process of being reduced. Outage conditions are defined for two situations--wet storage and dry storage; and for two durations--short and extended. Short duration is defined as four days or less; and extended duration is defined as greater than four days, up to two months. For outages greater than two months, dry storage is the only method of outage protection that should be utilized.

Outage protection for systems ancillary to the major components of the secondary system are given in 6.2.4.

6.1.3.1 Wet Storage - Short Duration ($t_{\text{outage}} \leq 4$ days)

Wet storage methods should be applied during short term outages or whenever unit availability must be maintained.

Vacuum shall be maintained on the main condenser and on the shell side of the 5th and 6th point heaters. The main circulating water pumps must be operating.

Pegging steam shall be maintained on the shell side of the 1st through 4th point heaters and on the steam generators.

Wet storage outage conditions shall be monitored no less than twice weekly; and samples taken from the hotwells shall be analyzed for pH, conductivity and chloride, and those taken from the feedwater and steam generators for pH, conductivity, dissolved oxygen and hydrazine. Normal operating limits shall be maintained for wet storage outage protection of short duration. System should be circulated for 30 minutes prior to sampling -- if at all possible.

6.1.3.2 Wet Storage - Extended Duration (4 days $< t_{\text{outage}} < 2$ months)

If vacuum cannot be maintained on main condenser and on the shell side of the 5th and 6th point heaters, then these systems must be drained while still hot ($\geq 90^{\circ}\text{F}$). Also, if the main circulating water pumps are shutdown, the water boxes should be drained.

If steam pegging protection is not available, then a nitrogen overpressure of 5 psig shall be applied to the steam generators; and the shell sides of the 1st through 4th point heaters shall be flooded with demineralized water treated with 200 ppm hydrazine. These protective measures should be done prior to breaking vacuum on the main condenser and prior to the attainment of ambient temperature.

Wet storage outages of extended duration shall be monitored at least twice weekly; and samples taken from the steam generators and feedwater heaters shell side shall be analyzed for pH, conductivity and hydrazine; and checked for nitrogen overpressure, pH, hydrazine and nitrogen overpressure within these systems should be maintained at 10.0 ± 0.2 , 200 ± 50 ppm N_2H_4 , and 3.0 ± 2.0 psig N_2 , respectively. Prior to sampling, the system should be circulated for 30 minutes -- if at all possible.

6.1.3.3 Dry Storage ($t_{\text{outage}} > 2$ months)

Hotwells should be drained while above ambient temperature ($\sim 92^\circ\text{F}$) and access panels opened to allow thorough drying of internal condenser surfaces.

Feedwater heaters tube side and shell side should be drained while above ambient temperature (6th, 5th and 4th @ $> 115^\circ\text{F}$; 3rd and 2nd @ $> 220^\circ\text{F}$; and 1st @ 240°F).

In addition heater shell sides should be drained under a nitrogen overpressure atmosphere of 5.0 psig.

Steam generators must be drained hot--beginning at 240°F .-- under a nitrogen overpressure atmosphere.

Monitor and record, at least once per week, the nitrogen pressure on all heat exchange equipment under nitrogen atmosphere protection. Make adjustments as required to maintain N_2 limits of 1.0 to 5.0 psig.

6.2 Limits

6.2.1 Startup Protection

	<u>HOTWELLS</u>	<u>FEEDWATER</u>	<u>STEAM GENS.</u>	<u>STEAM GEN AUX.FDWTR</u>	<u>AUX.BLR.</u>	<u>AUX. BLR. DEAERATOR</u>
pH	9.0 ± 0.2	9.0 ± 0.2	9.0 ± 0.5	9.0 ± 0.2	9.0 ± 0.5	9.0 ± 0.2
Conductivity (Specific)	$< 10 \mu\text{mhos}$	$< 10 \mu\text{mhos}$	$< 15 \mu\text{mhos}$	$< 10 \mu\text{mhos}$	$< 15 \mu\text{mhos}$	$< 10 \mu\text{mhos}$
Conductivity (cation)	$< 1.5 \mu\text{mhos}$	$< 1.5 \mu\text{mhos}$	--	--	--	--
Chloride	$\leq 0.1 \text{ ppm}$	--	$\leq 0.1 \text{ ppm}$	--	$< 1.0 \text{ ppm}$	--
Suspended Solids	$< 10 \text{ ppm}$	$< 10 \text{ ppm}$	$< 10 \text{ ppm}$	$< 10 \text{ ppm}$	$< 10 \text{ ppm}$	$< 10 \text{ ppm}$
Dissolved Oxygen	$< 10 \text{ ppb}$	$< 10 \text{ ppb}$	$< 10 \text{ ppb}$	$< 10 \text{ ppb}$	$< 10 \text{ ppb}$	$< 10 \text{ ppb}$
Hydrazine	--	$4 \times 10^{-2} \text{ ppb}$	--	$4 \times 10^{-2} \text{ ppb}$	--	$4 \times 10^{-2} \text{ ppb}$

6.2.2 Shutdown Protection

	<u>FEEDWATER</u>	<u>STEAM GENS.</u>	<u>AUX. BLR.</u>	<u>AUX. BLR. DEAERATOR</u>
pH	9.0 ± 0.2	9.0 ± 0.5	9.0 ± 0.5	9.0 ± 0.2
Hydrazine	2XO ₂ ppb	2XO ₂ ppb	2XO ₂ ppb	2XO ₂ ppb

Shutdown limits for the auxiliary feedwater (to steam generators) system are the same as the startup limits in 6.2.1.

6.2.3 Outage Protection

6.2.3.1 Wet Storage - Short Duration ($t_{out} \leq 4d$)

Vacuum on main condenser; steam pegging on shell side of feedwater heaters and on steam generators:

	<u>HOTWELLS</u>	<u>FEEDWATER HEATERS</u>	<u>STEAM GENERATORS</u>	<u>AUX. BLR.</u>	<u>AUX. BLR. DEAERATOR</u>
pH	9.0 ± 0.2	9.0 ± 0.2	9.0 ± 0.5	9.0 ± 0.5	9.0 ± 0.2
Conductivity (Specific)	<10 μmhos	<10 μmhos	<15 μmhos	<15 μmhos	<10 μmhos
Chloride	<0.15 ppm	--	<0.15 ppm	<1.0 ppm	--
Dissolved Oxygen	<100 ppb	<10 ppb	<10 ppb	<10 ppb	<10 ppb
Hydrazine	--	2 x O ₂	2 x O ₂	2 x O ₂	2 x O ₂

6.2.3.2 Wet Storage - Extended Duration ($4d < t_{out} < 2 mo$)

No vacuum on main condenser, hotwells drained; N₂ overpressure on shell side of feedwater heaters and on steam generators.

	<u>FEEDWATER HEATERS</u>		<u>STEAM GENERATORS</u>	<u>AUX. BLR.</u>	<u>AUX. BLR. DEAERATOR</u>
	<u>TUBE SIDE</u>	<u>SHELL SIDE</u>			
pH	10.0 ± 0.2	10.0 ± 0.2	10.0 ± 0.2	10.0 ± 0.2	9.0 ± 0.2
Hydrazine	200 ± 50 ppm	200 ± 50 ppm	200 ± 50 ppm	200 ± 50 ppm	100 ± 50 ppm
Dissolved Oxygen	<100 ppb	--	<100 ppb	<100 ppb	<100 ppb

6.2.3.3 Dry Storage - Extended Duration ($t_{out} > 2$ mo)

All systems drained under following condition:

	HOTWELLS	FEEDWATER HEATERS		STEAM GENERATORS	AUX. BLR.	AUX. BLR. DEAERATOR
		TUBE SIDE	SHELL SIDE			
pH	9.0 ± 0.2	9.0 ± 0.2	9.0 ± 0.2	9.3 ± 0.3	9.3 ± 0.3	9.0 ± 0.2
Hydrazine	--	> 4xO ₂ ppb	---	> 4xO ₂ ppb	> 4xO ₂ ppb	> 4xO ₂ ppb
Temp. °F	~90	(Between 90 & 240)		~240	90 - 240	~240
N ₂ overpress. (1.0-5.0 psig)	NO	NO	YES	YES	NO	NO

6.2.4 Outage Protection - Ancilliary Systems

SYSTEM DESIGNATION	SYSTEM	INTERNAL CLEAN. CLASS*	TENTATIVE FLUSH METHOD**	OUTAGE PROTECTION	
				PRE-STARTUP	POST STARTUP
MAIN POWER CYCLE					
ADA/AEA	Condensate/Feedwater Sys.	C/D	PF	(See	6.2.3)
ALA	Auxiliary Feedwater	C	PF	1	2
AQA	Condensate & FW Chemical Feed	C	PF	1	3
APA	Condensate Transfer & Storage	C	WC/PF	2	2
CGA	Condenser Air Removal	D	SF	1	NONE
ANA	Demineralized Wtr. M.U & Transf.	B	PF	2	2
AFA	Feedwater Heaters Extractions	C	WC/PF	1	NONE
ABA-B	Main Steam	C	WC	1	NONE
ACA	Main Turbine	C	WC	1	NONE
ACA	Main Turbine L.P. Exhaust Spray	C	PF	1	NONE
BMA	Steam Gen. Blowdown Processing	C/D	SF	1	NONE
RCA	Turbine Plant Sampling	C/D	PF	1	NONE

6.2.4 Outage Protection - Ancilliary System (Cont'd)

SYSTEM DESIGNATION	SYSTEM	INTERNAL CLEAN. CLASS*	TENTATIVE FLUSH METHOD**	OUTAGE PROTECTION	
				PRE-STARTUP	POST-STARTUP
TURBINE-GENERATOR CONTROLS					
CAA	Steam Seals	C	PS	1	NONE
CBA	Main Turbine & Gen. Lube Oil	C	PF	1/3	3
CCA	Generator H ₂ & CO ₂	C	PB	1/3	3
CDA	Hydrogen Seal Oil	C	PF	1/3	3
CFA	Lube Oil Storage, Transf. & Purif.	C	PF	1/3	3
CHA	Main Turbine Controls	C	PF	1/3	3
CEA	Stator Water Cooling	C	PF	1/2	2
CIRCULATING WATER					
DAA	Main Circ. Water	D	HC	1/3	NONE
DCA	Traveling Screens & Fish Handlg.	D	PF	1/3	3/4
DDA	Chlorine Injection	D	HC/SF	1/3	NONE
DEA	Amertap	D	HC/SF	1/3	NONE
COOLING & CHILLED WATER					
EBA	Turbine Plant Cooling Wtr.	D	PF	2/***	2
EPA	Salt Water Cooling	D	HC	1/3	NONE
GBA/GJA/GND	Chilled Water (Normal and emergency, all systems)	D	PF	2/***	2

6.2.4 Outage Protection - Ancilliary System (Cont'd)

SYSTEM DESIGNATION	SYSTEM	INTERNAL CLEAN. CLASS*	TENTATIVE FLUSH METHOD**	OUTAGE PROTECTION	
				PRE- STARTUP	POST STARTUP
AUXILIARY STEAM					
FAA	Auxiliary Boiler	C	CC	(See	6.2.3)
FBA	Auxiliary Steam	C	PS/SF	1	NONE
FCA-B	Auxiliary Turbines	C	SF	1	NONE
ANCILLIARY SERVICES					
KAA	Compressed Air (Service)	D	PB	1/3	3
KBA	Critical Compressed Air (Instr.)	C	PB	1/3	3
KDA	Domestic Water	D	PF	1/3	3
EAA	Service Water	D	PF	1/3	3
KCA	Fire Protection, Water	D	PF/PB	1/3	3
KCB	Fire Protection, Halon	D	PB	1/3	3
KCC	Fire Protection, CO ₂	D	PB	1/3	3
KHA	Services Nitrogen, L.P.	B/C	PB	1/3	3
KHA	Service Nitrogen, H.P.	B/C	PB	1/3	3
KLA	Service Hydrogen	B/C	PB	1/3	3
KJA-B	Standby Diesel Eng. Water	C	PF	1/3	3
KJA-B	Standby Diesel Eng. Air	C	PB	1/3	3

6.2.4 Outage Protection - Ancilliary System (Cont'd)

SYSTEM DESIGNATION	SYSTEM	INTERNAL CLEAN CLASS*	TENTATIVE FLUSH METHOD**	OUTAGE PROTECTION	
				PRE-STARTUP	POST-STARTUP
MISCELLANEOUS					
JAA	Aux. Boiler Fuel Oil	C	PF/PB	1/3	3
JEA	Standby Diesel Fuel Oil	C	PF/PB	1/3	3
NON-RADIOACTIVE DRAINS:					
LEA	Oily Waste	D	HC	1/3	NONE
LFA	All Turbine Plt., Gravity	D	DF	1/3	NONE
LFB	Diesel Bldg., Gravity	D	DF	1/3	NONE

* INTERNAL CLEANNESS CLASS:

A, B, C and D: Reference 2.4, ANSI Standard N45.2.1-1973

** TENTATIVE FLUSH METHOD:

CC Chemically Cleaned by Startup
 HC Manually Cleaned Before Filling -- No Wiping
 PB Gas Blown Procedure
 PF Proof Flush Procedure
 PS Steam Blown Procedure
 SF Flushed or Blown as a Part of Startup Procedure
 WC Manually Cleaned and Wiped

OUTAGE PROTECTION:

1. Lay up clean and dry (Ref. 2.4)
2. Use normal operating limits for outage protection control (Ref. 2.1 and 2.3).
3. Normal system fluid.
4. Wash screens with service water.

*** A temporary operating memorandum (TOM) may be required for outage protection of various in-service subsystems -- such as the Units 2/3 air compressor cooling loop -- prior to plant startup. These TOM's will be issued by the Units 2/3 Chemical/Radiation Protection Supervisor or Operations Supervisor, as required.

7. RECORDS

- 7.1 Shutdown, startup and outage protection data shall be recorded on the appropriate data sheet(s) as specified in paragraph 5. CHECK-OFF.
- 7.2 All PSSO(2/3)-1042-8 and PSSO(2/3)-1042-12 data sheets shall be transferred to the EDM Center on a monthly basis and filed under the following encode numbers: CNO5-AX2 (S02/3) and CNO5-AX startup (AA08-AX), respectively.
- 7.3 Copies of all data sheets should be made for retention in the secondary plant laboratory files prior to transfer to the EDM Center.


H. E. MORGAN
SUPERINTENDENT UNITS 2/3

APPROVED:



J. M. CURRAN
PLANT MANAGER

AJP:sf

SECONDARY SYSTEM LOCAL AND CENTRAL SAMPLE POINTS

1. OBJECTIVE

1.1 Function and Purpose

CONTROLLED INFORMATION

The function of the turbine plant sampling system is to deliver, on a continuous basis, turbine cycle fluids to the turbine plant laboratory for analysis of pH, conductivity, dissolved oxygen, ammonia, hydrazine, and sodium; and for the detection of condenser and steam generator tube leaks. The system provides signals for the automatic control of chemical injection and alarms for abnormal conditions. The system is also provided with local sample points for the purpose of identifying corrosion areas. The turbine plant sampling system, then, provides a means for sampling the following subsystems:

Steam generator blowdown samples
Main steam samples
Condensate hotwell sample system
Condensate pump discharge sample
First point heater discharge sample
Sample drains system
Local samples

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1.2 General Description

All continuous samples, except the condenser hotwell and turbidity analyzer sample, flow through sample nozzles from the sampling point to a pressure reduction rack (2/3 L-231) located on grade 30.0 ft. outside and juxtaposed to the west control building wall. Samples flow from this rack to a sample rack (2/3 L-27) located inside the turbine plant laboratory. The steam generator blowdown, main steam, and feedwater samples also flow through rough sample coolers located close to the points of sample origin. The rough coolers reduce the sample temperatures to 57°C (135°F) or less. Sample pressures are reduced by restriction orifices on the pressure reduction rack (2/3 L-231). The sample pressures at the entry to sample rack (2/3 L-27) are controlled to approximately 50 lb/in² gauge by means of backpressure regulators. The regulators also serve to bypass a portion of the total sample flow that is not required by the analyzers. This allows a larger total flow to be used, thus reducing the sample delay time. All the bypassed fluids, except that of the steam generator blowdown samples, flow into the sample drains system. The bypassed portion of the steam generator blowdown samples flows into waste drains.

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1.2 Continued

At the sample rack, the samples are cooled by an isothermal bath to 25°C (77°F) and then flow to individual analyzers through rotameters with needle valves. The desired flow through the analyzers is obtained by adjusting the needle valves. The steam generator blowdown samples flow into waste drains after they have been analyzed. All other samples are returned to the "sample drain system" except the portion that has passed through the sodium, dissolved oxygen, and hydrazine analyzers where chemicals are added during the analysis. This portion of the samples is made to flow into the waste drains.

Sample streams flowing out of the isothermal bath are also run to a grab sample station (2/3 L-245), located above a sample sink in the turbine plant laboratory.

The grab sample station consists of a rotameter with a needle valve and a three-way manual valve for each sample line. The samples flow continuously through the rotameters to the three-way valves, where they can be diverted to the sample drains system or to the sample sink. In this way, fresh samples are always available at this location.

The condenser hotwell samples are pumped to the hotwell sample racks 2L-31 (Unit 2) and 3L-31 (Unit 3) located on the west and east sides of the condensers on grade 7.0 ft. The samples flow through continuous analyzers on the rack and then back to the condenser.

1.3 Sample and Analyzer Location

The following is a list of the various samples that are available throughout the turbine plant system.

1.3.1 Turbine Plant Laboratory (Grade 30.0 ft.)

1.3.1.1 Laboratory Sink Grab Samples

- North Steam Generator Blowdown
- South Steam Generator Blowdown
- North Steam Generator Main Steam
- South Steam Generator Main Steam
- Combined First Point Heater Outlet
- Combined Condensate Pump Discharge

1.3 Continued

1.3.1.2 Laboratory Analyzer Samples

<u>Sample</u>	<u>pH</u>	<u>Analysis Performed</u>					<u>Radiation Leak Det.</u>
		<u>Cat. Cond.</u>	<u>Cond.</u>	<u>N₂H₄</u>	<u>O₂</u>	<u>Na⁺</u>	
N Stm. Gen.	X	X					X
S Stm. Gen.	X	X					X
N Main Stm.			X				
S Main Stm.			X				
Comb.1st Pt.Htr.	X	X	X	X	X	X	
Comb.Cond.Pp.Dis.	X	X	X		X	X	

1.3.2 Local Analyzer Samples

1.3.2.1 Condenser Hotwell Sample System (Grade 7.0 ft.)

Northeast Condenser -- Cation conductivity
 Northwest Condenser -- Cation conductivity
 Southeast Condenser -- Cation conductivity
 Southwest Condenser -- Cation conductivity

1.3.2.2 Combined Condensate Pump Discharge (Grade 7.0 ft.)
 Turbidity Analyzer

1.3.3 Local Samples

	<u>Grade, Ft.</u>	<u>Location</u>
North Steam Generator BD	30.0	Pipe Penetration Room Penetration No. 17
South Steam Generator BD	30.0	Pipe Penetration Room Penetration No. 44
North Main Steam	(To be added at a future date)	
South Main Steam	(To be added at a future date)	
West Reheat Main Steam	(To be added at a future date)	
East Reheat Main Steam	(To be added at a future date)	
West Reheat Bled Stm.	(To be added at a future date)	
East Reheat Bled Stm.	(To be added at a future date)	
West Reheat Moist Sep.	(To be added at a future date)	
East Reheat Moist Sep.	(To be added at a future date)	
Comb. Cond. Pp. Disch.	(To be added at a future date)	
Comb. Inlet 6th Pt. Htrs.	(To be added at a future date)	
North 6th Pt. Htr. Out	(To be added at a future date)	
Center 6th Pt. Htr. Out	(To be added at a future date)	
South 6th Pt. Htr. Out	(To be added at a future date)	

1.3.3 Continued

	<u>Grade, Ft.</u>	<u>Location</u>
North 5th Pt. Htr. Out		(To be added at a future date)
South 5th Pt. Htr. Out		(To be added at a future date)
North 4th Pt. Htr. Out		(To be added at a future date)
South 4th Pt. Htr. Out		(To be added at a future date)
North 3rd Pt. Htr. Out		(To be added at a future date)
South 3rd Pt. Htr. Out		(To be added at a future date)
North 2nd Pt. Htr. Out		(To be added at a future date)
South 2nd Pt. Htr. Out		(To be added at a future date)
Comb 1st Pt. Htr. Out		(To be added at a future date)
North 1st Pt. Htr. Drips		(To be added at a future date)
South 1st Pt. Htr. Drips		(To be added at a future date)
North 2nd Pt. Htr. Drips		(To be added at a future date)
South 2nd Pt. Htr. Drips		(To be added at a future date)
Comb 3rd Pt. Htr. Drips		(To be added at a future date)
North 4th Pt. Htr. Drips		(To be added at a future date)
South 4th Pt. Htr. Drips		(To be added at a future date)
North 5th Pt. Htr. Drips		(To be added at a future date)
South 5th Pt. Htr. Drips		(To be added at a future date)
North 6th Pt. Htr. Drips		(To be added at a future date)
Center 6th Pt. Htr. Drips		(To be added at a future date)
South 6th Pt. Htr. Drips		(To be added at a future date)
NE Cond. Circ. Wtr. In (C1 ₂)		(To be added at a future date)
NW Cond. Circ. Wtr. In (C1 ₂)		(To be added at a future date)
SE Cond. Circ. Wtr. In (C1 ₂)		(To be added at a future date)
SW Cond. Circ. Wtr. In (C1 ₂)		(To be added at a future date)
NE Cond. Circ. Wtr. Out (C1 ₂)		(To be added at a future date)
NW Cond. Circ. Wtr. Out (C1 ₂)		(To be added at a future date)
SE Cond. Circ. Wtr. Out (C1 ₂)		(To be added at a future date)
SW Cond. Circ. Wtr. Out (C1 ₂)		(To be added at a future date)
Turb. Plt. Cool Wtr. Ht. Xch. In (C1 ₂)		(To be added at a future date)
Turb. Plt. Cool Wtr. Ht. Xch. Out (C1 ₂)		(To be added at a future date)
Component Cool Wtr. Ht. Xch. In (C1 ₂)		(To be added at a future date)
Component Cool Wtr. Ht. Xch. Out (C1 ₂)		(To be added at a future date)
Turb. Plt. Cool Water		(To be added at a future date)
Service Wtr. Stor. Tank T-102&103		(To be added at a future date)
Condensate Stor. Tank T-120&121		(To be added at a future date)
Demineralsizers		(To be added at a future date)

2. REFERENCE

- 2.1 Station Manual System Descriptions, San Onofre Nuclear Generating Station: Units 2 and 3, Southern California Edison Company, San Diego Gas and Electric Company; Volume 2, Section 62 "Turbine Plant Sampling System"; December 1977.

3. PREREQUISITES

3.1 Equipment and Reagents

The equipment and reagents will be those which are described in the applicable Chemical or Radiation Protection Procedure.

4. PRECAUTIONS

Wear face and eye protection equipment when sampling local pressurized systems. Be sure (1) that continuously running laboratory sink samples are diverted to the sample drain tank when not required for analysis sampling and (2) that local samples are properly secured after samples have been obtained.

5. CHECK-OFF

Not applicable.

6. PROCEDURE

Laboratory sink sample flows should be adjusted to a flow rate of 500 ml per minute at a nominal temperature of 25°C.

Local sample flows should be adjusted to maintain sample temperature at $25 \pm 5^\circ\text{C}$ -- this usually results in a sample flow of approximately 500 ml per minute. However, some difficulty may be encountered in regulating sample temperature to less than 30°C for those local sample points located between the combined condensate pump discharge and the 6th point heater outlet.

7. RECORDS

Not applicable.

H E Morgan

H. E. Morgan
Superintendent Units 2 and 3

Approved by:

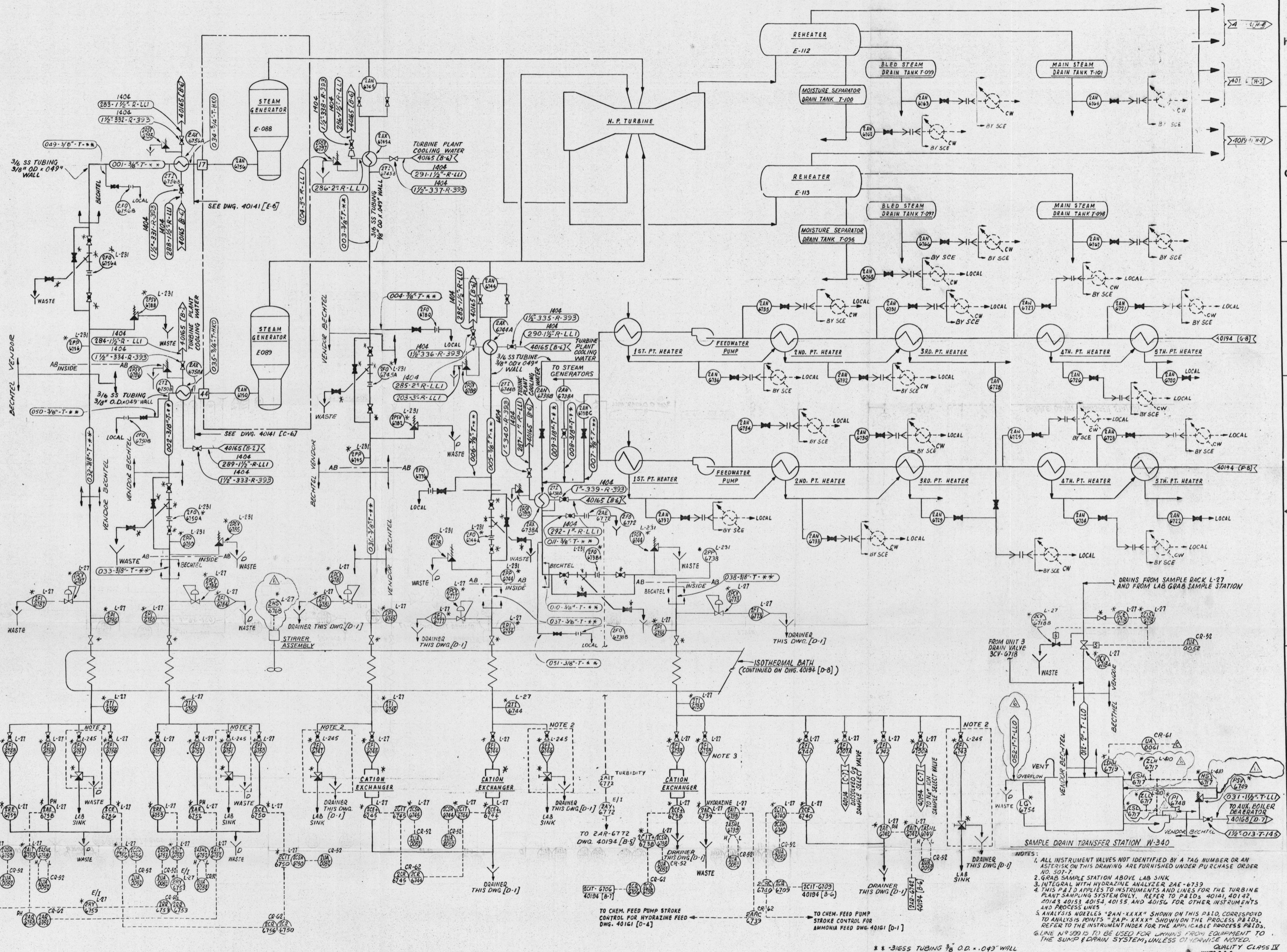
J. M. Curran

J. M. Curran
Plant Manager

AJP:sel

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BECHTEL CORPORATION
ENGINEERS & CONSTRUCTORS
LOS ANGELES, CALIF.

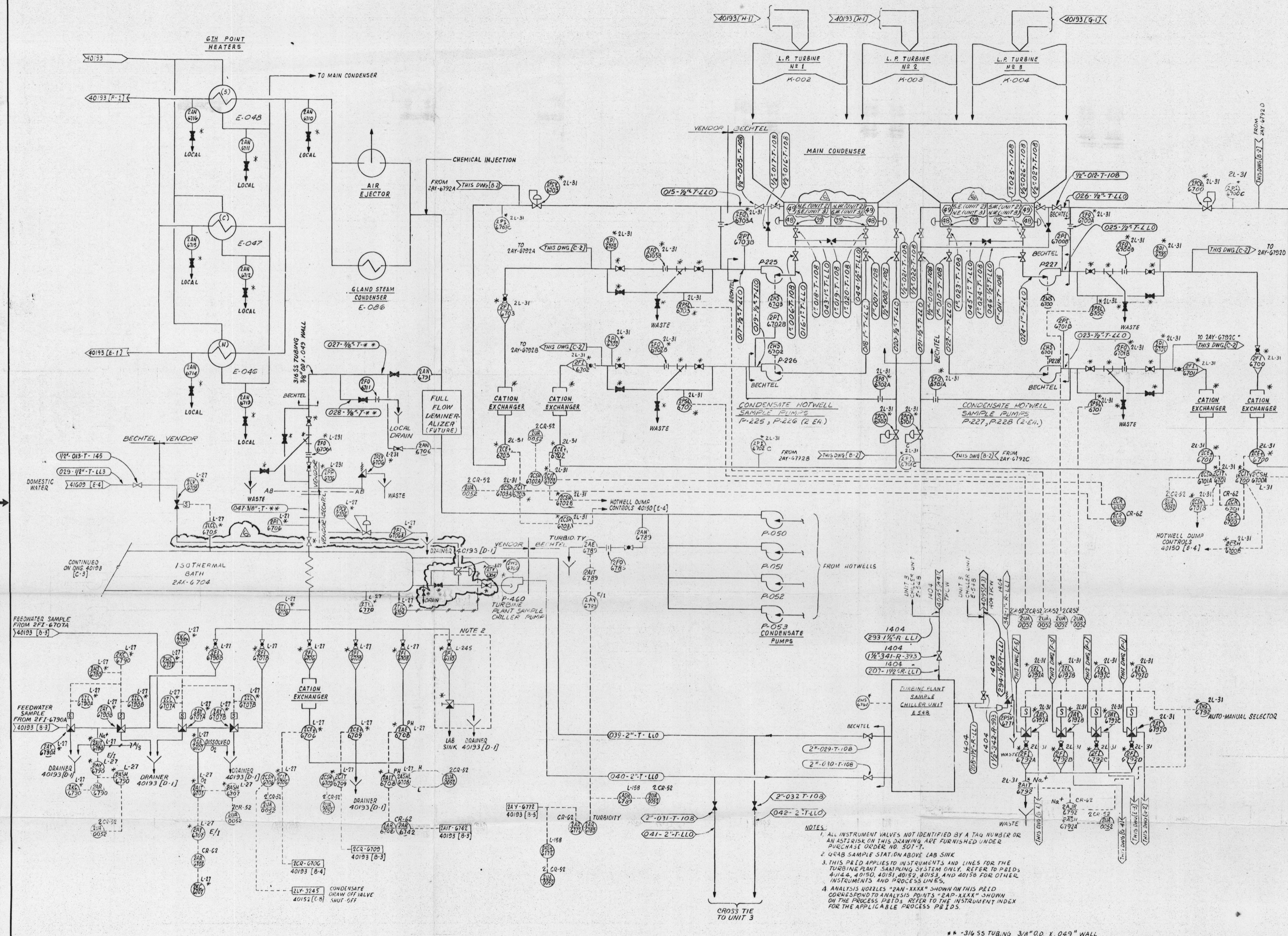
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3	INC. DCN #1	7-17-77	[Signature]	[Signature]	[Signature]
2	GENERAL REVISION	9-2-76	[Signature]	[Signature]	[Signature]
1	GENERAL REVISION	2-27-76	[Signature]	[Signature]	[Signature]
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2-27-76	[Signature]	[Signature]	[Signature]	[Signature]	[Signature]
5-28-75	[Signature]	[Signature]	[Signature]	[Signature]	[Signature]

I.O. NO. SAN ONOFRE NUCLEAR GENERATING STATION
P & I DIAGRAM
TURBINE PLANT SAMPLING SYS.
SYS. NO. 2415 - SHT. 1 OF 2
SOUTHERN CALIFORNIA EDISON COMPANY
SCALE LOS ANGELES, CALIF.



- NOTES:
1. ALL INSTRUMENT VALVES NOT IDENTIFIED BY A TAG NUMBER OR AN ASTERISK ON THIS DRAWING ARE FURNISHED UNDER PURCHASE ORDER NO. 507-T.
 2. GRAB SAMPLE STATION ABOVE LAB SINK
 3. THIS P&ID APPLIES TO INSTRUMENTS AND LINES FOR THE TURBINE PLANT SAMPLING SYSTEM ONLY. REFER TO P&IDs 4014A, 4015D, 4015I, 4015J, 4015K AND 4015B FOR OTHER INSTRUMENTS AND PROCESS LINES.
 4. ANALYSIS NOZZLES "2AN-XXXX" SHOWN ON THIS P&ID CORRESPOND TO ANALYSIS POINTS "2AP-XXXX" SHOWN ON THE PROCESS P&IDs. REFER TO THE INSTRUMENT INDEX FOR THE APPLICABLE PROCESS P&IDs.

** -3/4" S.S. TUBING 3/8" O.D. X .049" WALL

QC IV
UNITS 2 & 3

BECHTEL CORPORATION ENGINEERS & CONSTRUCTORS LOS ANGELES, CALIF.		JOB NO. 10079 DATE 10-03		APPROVED		INC. DCN # 7 # 8		REVISIONS		5 INC. DCN # 5 # 6 AS NOTED 4 INC. DCN # 3 # 2 GEN. REV. 3 INC. DCN # 1 # 2 CONSISTENCY CHK 2 GENERAL REVISION 1 GENERAL REVISION 0 ISSUED FOR CONSTRUCTION		J.O. NO. FILE		SAN ONOFRE NUCLEAR GENERATING STATION P & I DIAGRAM TURBINE PLANT SAMPLING SYS. SYS. NO. 2415 SHT. 2 OF 2 SOUTHERN CALIFORNIA EDISON COMPANY	
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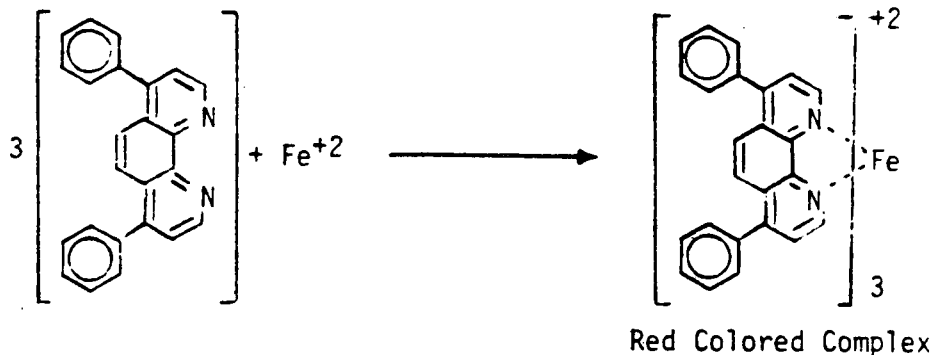
CONTROLLED
SPECTROPHOTOMETRIC DETERMINATION
OF IRON WITH BATHOPHENANTHROLINE

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1. OBJECTIVE

This procedure provides a very sensitive method for the determination of iron in feedwater systems.

Ferrous ions form a colored complex with bathophenanthroline (4,7-diphenyl-1,10-phenanthroline) in an acid solution --pH circa 3.0 to 3.7.



The red colored $[Fe-(bathophenanthroline)_3]^{+2}$ complex is extracted into a solution of n-hexyl and ethyl alcohols which is then read spectrophotometrically at its maximum absorbency of 533 nanometers. The molar absorbency at this wave length is 22,350, which makes it one of the most sensitive colorimetric iron determinations known. The extraction method employed also offers a method of concentrating the trace quantities of iron, normally found in power plant condensate and feedwater systems, into a small volume for precise determination.

2. REFERENCES

- 2.1 ASTM, "1977 Annual Book of ASTM Standards", Part 31, Water, pp 365-367, "Method B-Photometric Bathophenanthroline Method".
- 2.2 "The Iron Reagents: Bathophenanthroline, Bathophenanthroline disulfonic Acid, 2,4,6-Tripyridyl-s-triazine and phenyl-2-pyridyl ketoxime", by Smith, G.F. and D. Harvey, G. Frederick Smith Chemical Co., Columbus, Ohio, 2nd Edition, 1965.

SEE FILE COPY

3. PREREQUISITES

3.1 Equipment

3.1.1 Spectrophotometer

Use a Hitachi Model 40, Model 60 or equivalent spectrophotometer.

3.2 Reagents

3.2.1 Hydroxylamine Hydrochloride, 100 g/l

Dissolve 103 grams of 97% hydroxylamine hydrochloride in sufficient reagent water to produce 1 liter of solution.

3.2.2 Sodium Acetate, 500 g/l

Dissolve 829 grams of sodium acetate, trihydrate ($\text{CH}_3\text{COONa} \cdot 3\text{H}_2\text{O}$) crystals in sufficient reagent water to yield 1 liter of solution.

3.2.3 Bathophenanthroline Reagent, 0.002M

Dissolve 0.0664 gram of 4,7-diphenyl-1,10-phenanthroline in 100 ml reagent alcohol, anhydrous.

3.2.4 Hydrochloric Acid, A.R., (sp gr 1.19)

Obtain from J.T. Baker, Nos. 5-9535 or 3-9535.

3.2.5 Hydrochloric Acid, (1+1)

Cautiously add 500 ml of HCl (sp gr 1.19) to 500ml reagent water, and mix well.

3.2.6 Reagent Alcohol, Anhydrous (Ethyl Alcohol)

Obtain from J. T. Baker, No. 3-9229.

3.2.7 n-Hexyl Alcohol, A.R. (1-Hexanol)

Obtain from J. T. Baker No. 3-9307. Iso-amyl alcohol (3-methyl-1-butanol), J. T. Baker No. 3-9038.

3.2.8 pH Paper, (2.5-4.5)

Obtain from VWR Scientific, colorphast pH indicator strips, No. 60770-200.

4. PRECAUTIONS

- 4.1 All new glassware must be soaked in detergent, then (1+1) HCl and rinsed thoroughly with reagent water. All glassware used in the test should be isolated in a dust-free environment and rinsed with (1+1)HCl and reagent water just prior to use. If insoluble organic film builds up on any glassware, repeat detergent soak. Do not use chipped or scratched glassware.
- 4.2 A reagent blank must be run with each series of tests. If difficulty is encountered in obtaining iron free reagent water, the samples can be read against n-hexyl alcohol subtracting $2\mu\text{g}/\ell$ iron from each final answer.
- 4.3 Extreme care should be taken to avoid all sources of contamination due to the sensitivity of the test.

5. CHECK-OFF

The results of each weekly analysis shall be recorded on PSS0(2/3)-1042-8, "Daily Turbine Plant Summary Sheet".

6. PROCEDURE

6.1 Method

- 6.1.1 Collect the sample in a clean 500-ml glass stoppered pyrex bottle to which 5.00 ml concentrated HCl, A.R., has been added. The bottle should be filled to the neck with sample, stoppered and mixed well.
- 6.1.2 Place 200.0 ml of sample in a 250-ml breaker and digest at low heat for 30 minutes. Avoid bumping while digesting.
- 6.1.3 Remove from heat and add 2.00 ml of refrigerated 100 g/ℓ hydroxylamine hydrochloride.
- 6.1.4 Transfer quantitatively to a 250-ml separatory funnel.
- 6.1.5 Add 7.00 ml sodium acetate solution, mix well. Adjust pH as necessary with 500 g/ℓ sodium acetate or (1+1)HCl to 3.0-3.7. Check with pH test paper.

- 6.1.6 Add 2.00 ml bathophenanthroline. Shake vigorously, venting separatory funnel occasionally, and allow 5 minutes for color development.
- 6.1.7 Extract once with one minute vigorous shaking into 25.00 ml n-hexyl alcohol. Allow 10 minutes for phase separation.
- 6.1.8 Discard aqueous phase and collect organic phase in a 50-ml Erlenmeyer flask. Rinse walls of separatory funnel into the Erlenmeyer flask with 5.00 ml reagent alcohol.
- 6.1.9 Mix well and transfer sample to a 50 mm cell. Determine sample absorbance on a spectrophotometer at 533 nm.
- 6.1.10 Iron concentration, in $\mu\text{g}/\ell$, may be determined from the attached standard curves -- or by direct calculation using the slope equation method below.

6.2 Calculations

- 6.2.1 Slope Equation Method, Percent Transmittance (%T)

$$\mu\text{g}/\ell, \text{Fe} = (65) \log \frac{\%T \text{ of Blank}}{\%T \text{ of Sample}}$$

- 6.2.2 Slope Equation Method, Absorbance (A)

$$\mu\text{g}/\ell, \text{Fe} = (65) (A \text{ of Sample} - A \text{ of Blank})$$

6.3 Acceptance Criteria

Normal condensate pump discharge and high pressure feedwater heater outlet iron levels are limited to $<10\mu\text{g}/\ell$. Abnormal levels of $\geq 30\mu\text{g}/\ell$ iron may exist for up to four hours before a unit shutdown should be initiated. These limits are established by S023-III-2.3 "Secondary System Chemical Limits and Sampling Frequencies".

7. RECORDS

- 7.1 The results of each daily analysis shall be recorded on PSSO(2/3)-1042-8, "Daily Turbine Plant Summary Sheet"; and shall be filed in the turbine plant laboratory for reference after being reviewed by the Chemical Radiation Protection Supervisor having the responsibility for turbine plant chemistry.

- 7.2 On a monthly basis all data sheets shall be transferred to the EDM Center and filed under the title "SONGS-2 (or SONGS-3) Turbine Plant Data", encode number CN05-AX3.
- 7.3 Copies of all data should be made for retention in the laboratory files prior to transfer to the EDM Center.

H E Morgan

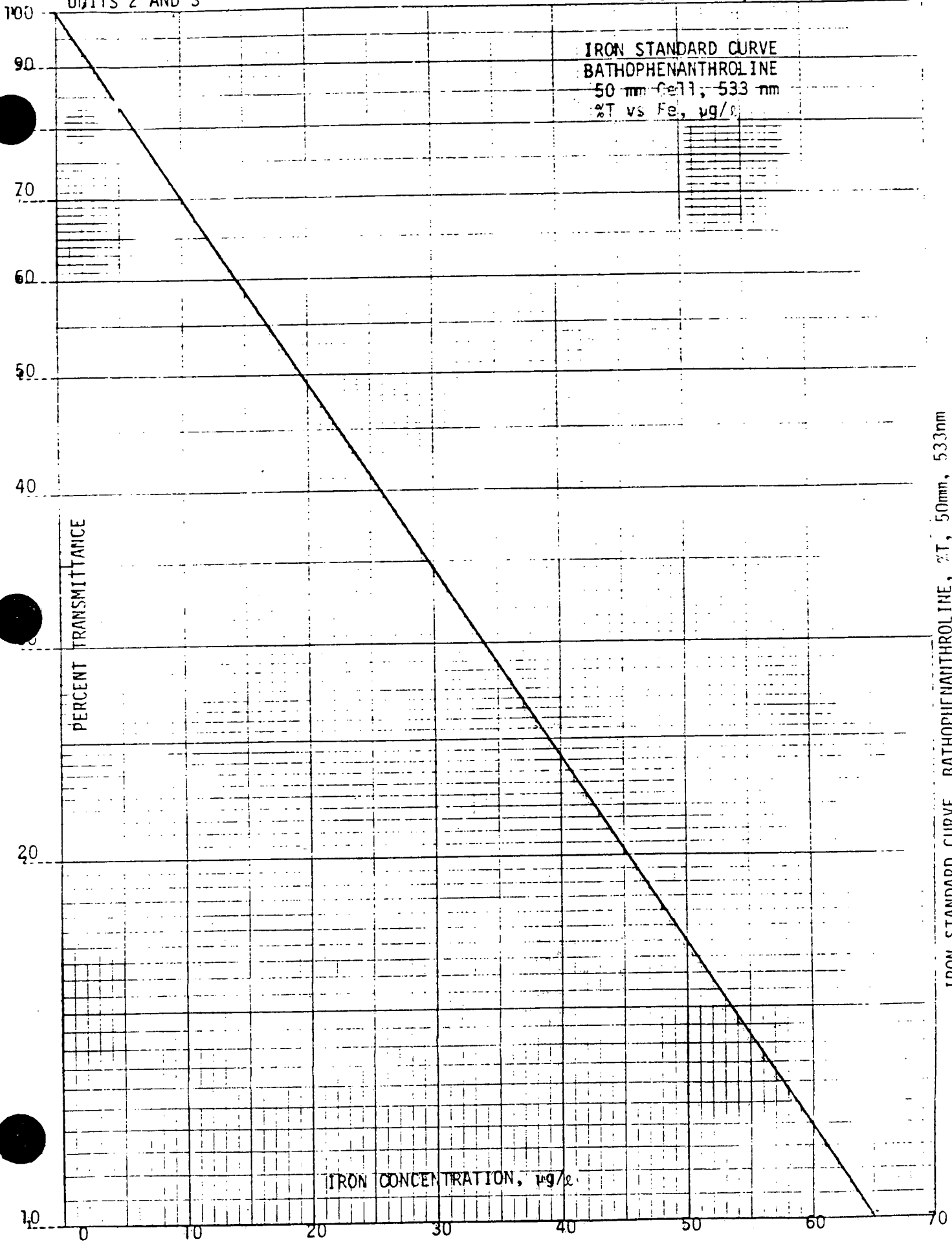
H. E. Morgan
Superintendent
Units 2 and 3

APPROVED BY

J. M. Curran

J. M. Curran
Plant Manager

AJP:dh



1.0

IRON STANDARD CURVE
BATHOPHENANTHROLINE
50mm Cell, 533nm
A vs Fe, mg/l

0.8

0.7

0.6

0.5

0.4

0.3

0.2

0.1

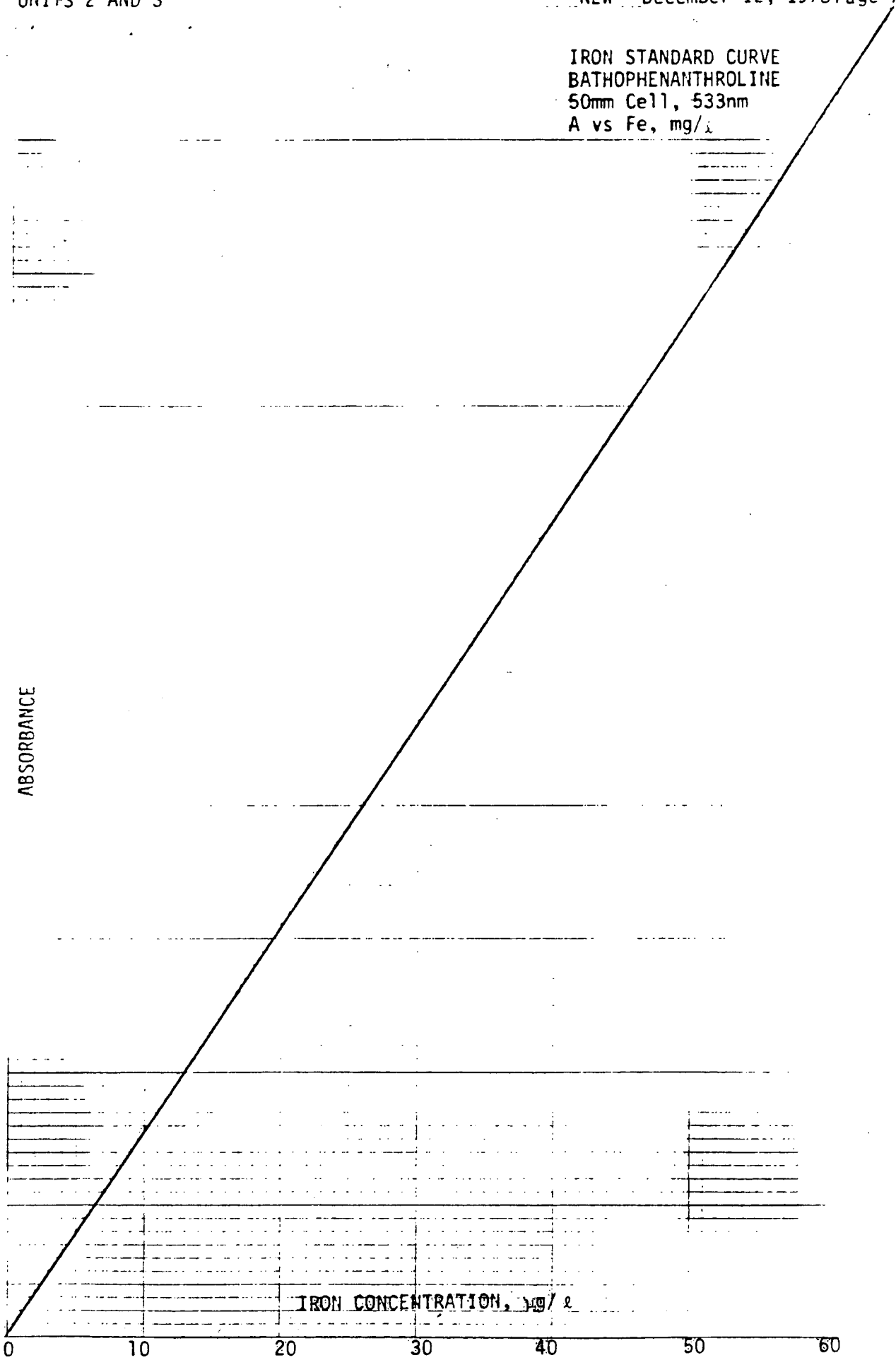
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ABSORBANCE

IRON CONCENTRATION, mg/l

0 10 20 30 40 50 60 70

IRON STANDARD CURVE, BATHOPHENANTHROLINE, A, 50mm, 533nm



SODIUM ANALYSIS
BY ION SELECTIVE ELECTRODE

1. OBJECTIVE

1.1 Purpose

The purpose of this analytical method is to present a method for the quantitative determination of sodium in aqueous solutions by means of an ion selective electrode.

1.2 Background

The sodium electrode consists of a sodium-containing glass membrane bonded into the tip of an epoxy electrode body. When the membrane is in contact with a sodium solution, a difference in electrode potential develops relative to the sodium concentration. This potential is measured against a constant reference potential with a digital specific ion meter. The measured potential corresponding to the level of the sodium ion in solution is described by the Nernst equation:

$$E = E_0 + S(\log A)$$

where:

E = measured electrode potential

E₀ = reference potential (a constant)

S = electrode slope

A = sodium ion level in solution

The level of sodium ion in solution, A, is the activity or "effective concentration." The sodium activity is related to the sodium ion concentration, C, by the ionic activity coefficient, γ :

$$A = \gamma C$$

Ionic activity coefficients are variable and largely depend on total ionic strength. However, if the background ionic strength is maintained at a large, constant value relative to the sensed sodium ion concentration, then, the activity coefficient of sodium will remain constant and the activity will be proportional to the sodium concentration. The range of sodium detection by this method is from saturated to 10^{-8} M (0.23 μ g/l).

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2. REFERENCES

- 2.1 "Instruction Manual: Sodium Electrode Model 94-11," Orion Research Incorporated, Cambridge, MA 02139, 1977.
- 2.2 "Instruction Manual: Model 901 Microprocessor Ionalyzer," Orion Research Incorporated, Cambridge, MA 02139, 1977.
- 2.3 Chemical Procedure S023-III-2.3, "Secondary System Chemical Limits and Testing Frequencies."

3. PREREQUISITES

3.1 Equipment

- 3.1.1 Potentiometer - use an Orion Model 901 microprocessor ionalyzer.
- 3.1.2 Measuring Electrode - use an Orion Model 94-11 solid state measuring electrode.
- 3.1.3 Reference Electrode - use an Orion Model 90-01 single junction reference electrode filled with lithium trichloroacetate solution, Orion Cat. No. 90-00-19.
- 3.1.4 Magnetic Stirrer - use a "Magnostir" stirring unit.
- 3.1.5 Measuring Labware - An assortment of polypropylene pipets are required for standard preparation; see Table-1 of procedure for specific requirements.

3.2 Reagents

- 3.2.1 Sodium standard solution, 10.0 mg/l
Dissolve 0.0256 ± 0.0001 grams of 99.5% NaCl--that has been dried at 105°C for at least 2 hours-- (J.T. Baker, Analyzed Reagent No. 1-3624), in 500 ml of reagent water and dilute, volumetrically, to one liter. Also, may be obtained from Orion as a 100 ppm Na⁺ standard solution; catalog No. 94-11-07.
- 3.2.2 Sodium Standard solution, 1.0 mg/l
Transfer, quantitatively, 100.00 ml of 10.0 mg/l sodium standard to a 1-liter volumetric flask and dilute to volume with reagent water.
- 3.2.3 Ionic strength adjustor (ISA)
The ISA reagent provides a constant strength ionic background and adjusts the pH of standard and sample solutions. To prepare ISA reagent, dissolve 220 grams of reagent-grade ammonium chloride in 500 ml reagent water; add 265 ml concentrated ammonium hydroxide (28-30%) and dilute to 1-liter.

4. PRECAUTIONS

- 4.1 Plastic labware (polypropylene or polyethylene) should be used for sample analysis and for standard preparation and storage because sodium can be absorbed by, or leached from, glassware.
- 4.2 Wear plastic gloves when working with low level sodium samples (<0.6 mg/l) to avoid salt (NaCl) contamination from skin.
- 4.3 Avoid sample and standard contamination from atmospheric dust and aerosols.
- 4.4 Do not smoke or allow smoking in the laboratory during low level sodium analysis.

5. CHECK-OFF

Not Applicable

6. Procedure

6.1 Electrode Step-up and check

6.1.1 To connect electrode to 901 ionalyzer:

6.1.1.1 Remove the protective rubber caps from the tip of the reference and sodium ion sensing electrodes.

6.1.1.2 Insert the reference electrode phone-tip connector and the sensing electrode connector into appropriate jacks on the back of the ionalyzer unit.

6.1.2 Checking Electrode Slope

Slope is defined as the change in potential observed when the concentration changes by a factor of ten. To assure proper electrode operation, slope check should be performed daily.

6.1.2.1 Add 100 ml reagent water and 2.0 ml ISA reagent to a 150 ml beaker. Place electrodes in solution to a depth of 3 cm and set MODE switch to REL MV.

6.1.2.2 Pipet 1.0 ml of 10.0 mg/l sodium standard into the solution. Stir and allow sufficient time to establish equilibrium, then press SET CONC.

6.1.2.3 Add 10.0 ml of 10.0 mg/l sodium standard to solution, stir thoroughly and read the mv difference directly from the digital meter. Correct electrode operation is indicated by a difference of 53-59 mv, assuming the solution temperature is between 20° and 25°C.

6. PROCEDURE (Cont'd)

If potential is not within the 53-59 mv range, see the trouble shooting list on page 14 and 15 of instruction manual for sodium electrode.

6.2 Analytical Methods

6.2.1 Low Level Sodium (<1.0 mg/l), Direct Method
 Direct measurement is a simple procedure for measuring a large number of samples. Only one meter reading is required for each sample. The temperature of the samples and standards should be the same and the ionic strength of standards and samples should be made the same by addition of ISA reagent to all solutions.

6.2.1.1 Prepare two standard solutions whose concentrations are near, or bracket, the sample's concentration (Table - 1). Add 2.0 ml ISA reagent to each 100 ml standard.

TABLE - 1

Standard Preparation

Sodium conc., mg/l	Measur.* Device To use	Volume of Sodium Standard Reg'd, ml		Volume Reagent Water, ml	Volume ISA Reagent, ml
		10 mg/l	1.0 mg/l		
10	A	100	-	0	2.0
5.0	A	50	-	50	2.0
1.0	B	10	-	90	2.0
0.50	B	5.0	-	95	2.0
0.20	B	2.0	-	98	2.0
0.10	C/B	1.00	10	99/90	2.0
0.05	C	-	5.00	95	2.0
0.020	C	-	2.00	98	2.0
0.010	C	-	1.00	99	2.0
0.005	D	-	0.500	100	2.0
0.002	D	-	0.200	100	2.0
0.001	D	-	0.100	100	2.0

- * A = Graduated cylinder
- B = Serological pipet
- C = Volumetric pipet
- D = Lambda or microliter pipet

6. PROCEDURE (Cont'd)

- 6.2.1.2 Set the STD VALUE switches to the concentration of the first standard. Set the slope switches to the slope value of the electrode as determined in the daily electrode check. Set the sign switch to plus. Turn MODE switch to CONC.
- 6.2.1.3 Place electrodes in 100 ml of the first standard. Press CLEAR/READ MV and wait for a stable reading. Press SET CONC. Rinse electrodes with reagent water.
- 6.2.1.4 Place electrodes in 100 ml of the second standard. Wait for a stable reading. If reading does not agree with second standard concentration value, then, slowly adjust the SLOPE switches until the correct concentration is displayed. Rinse electrodes thoroughly with reagent water.
- 6.2.1.5 Place electrodes in 100 ml of reagent water to which 2.0 ml ISA reagent has been added. Wait two minutes and then press SET BLANK.
- 6.2.1.6 Rinse electrodes and place in 100 ml of sample; add 2.0 ml ISA reagent; stir thoroughly; Wait for stable reading and record sample concentration directly from digital display meter.
- 6.2.1.7 The sodium electrode (Model 94-11) may be stored in a vertical position, either in air or in a standard sodium solution. If stored in air, replace the protective rubber cap.
- 6.2.1.8 Recalibrate every two hours. Compensate for any temperature change by increasing the slope setting by 1 mv for every 5°C increase in temperature.

6. PROCEDURE (Cont'd)

TABLE - 2

Values of Theoretical Slope vs. Temperature

T°C	Slope, mv	$\frac{\Delta S}{\Delta T}^*$	T°C	Slope, mv	$\frac{\Delta S}{\Delta T}^*$
0	54.20	-	30	60.15	0.99
10	56.18	0.99	40	62.13	0.99
20	58.16	0.99	50	64.11	0.99
25	59.16	1.00	100	74.04	0.99

* ΔT - 5°C

6.2.2 High Level Sodium (1.0 mg/l), Direct Method.

6.2.2.1 To determine high concentrations of sodium, follow low level method as outlined in 6.2.1 with the following exceptions: prepare only one sodium standard and omit steps 6.2.1.4 and 6.2.1.5.

6.2.3 Known Addition Method

Known addition is convenient for measuring occasional samples because no calibration is needed. Since an accurate measurement requires that the concentration double as a result of the addition, sample concentration must be known within a factor of three. The known addition method is a convenient check on the results of direct measurement.

The 901 ionalyzer has three known addition modes (KA/1, KA/5, and KA/10), each is designed for a specific volume of added standard solution. KA/1 is used when the added volume is one percent of the sample volume (e.g., 1 ml to 100 ml). KA/5 and KA/10 are used for the addition of five and ten percent of the sample volume (e.g., 5 or 10 ml to 100 ml).

6. PROCEDURE (Cont'd)

6.2.3.1 Set MODE switch to KA/1 (or KA/5 or KA/10). Prepare a standard solution about 100 times the expected sample concentration (20x with KA/5 or 10x with KA/10). Add 50 ml ISA reagent to each 100 ml standard.

6.2.3.2 Add 2.0 ml ISA reagent to 100 ml of sample, using a 150-ml polypropylene beaker as a container. Place on magnestir unit and set stir rate below the point of vortex formation.

NOTE: magnestir units tend to generate sufficient heat to raise sample temperature. To avoid this condition, place a piece of insulating material such as cork, cardboard or styrofoam between stirring unit and beaker

6.2.3.3 Set STD VALUE switches to the concentration of the standard. Set the SLOPE switches to the electrode slope value, and turn sign switch to plus.

6.2.3.4 Lower electrodes into sample to a depth of about 3 cm, stir thoroughly, and allow sufficient time for stable reading. Press CLEAR/READ MV, then SET CONC.

6.2.3.5 Add 1 ml of standard solution to sample (or 5 ml of 20x, or 10 ml of 10x); stir thoroughly and wait for reading to stabilize. Record sample concentration directly from digital read-out.

Between sample analysis, rinse electrodes thoroughly with reagent water and blot dry with kimwipes to prevent sample solution carryover. For proper electrode storage see step 6.2.1.7.

6.3 Acceptance Criteria


Sodium concentration at the condensate pump discharge shall be maintained at values less than 10 $\mu\text{g}/\text{l}$ (ppb).

7. RECORDS


The results of secondary (turbine) plant analyses -- specifically the hotwells and condensate pump discharge--shall be recorded on PSSO (2/3)-1042-8 "Daily Turbine Plant Summary Sheet."

Copies of PSSO (2/3)-1042-8 data sheets shall be filed in the turbine plant file for future reference, after being reviewed by the Chemical-Radiation Protection Foreman.

All original PSSO (2/3)-1042-8 data sheets shall be transmitted to EDM on a monthly basis and filed under encode number CN05-AX2 (S02/3).


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SUPERINTENDENT UNITS 2/3

APPROVED:


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TOTAL AND SUSPENDED SOLIDS

1. OBJECTIVE

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This procedure provides methods for the determination of suspended solids in condensate, feedwater and steam generator secondary side fluids during normal operation and start-up conditions. It also provides a method for determining total solids in make-up waters either produced on site or trucked on site from other facilities.

2. REFERENCES

- 2.1 "Methods for Chemical Analysis of Water and Wastes", U. S. Environmental Protection Agency 1976, pp. 268-272, Storet No.s 00530 and 00500.
- 2.2 "Particulate and Dissolved Matter in Water", ATSM Procedure D 1888-67, 1977 Annual Book of ASTM Standards.
- 2.3 "Determination of Iron by Membrane Filter", Steam Division Chemical Laboratory, SCE, Paramount, CA.

3. PREREQUISITES

3.1 Equipment

- 3.1.1 Filter Funnel - use a Gelman 47 mm diameter lexan magnetic filter funnel or its equivalent.
- 3.1.2 Vacuum Source - use a portable vacuum pump or sink eductor.
- 3.1.3 Filter Membrane - use a 47mm diameter filter membrane of 0.45 μ m pore size; Millipore No. HAWP 04700, Gelman No. 63020 or S/P No. F2933-3.
- 3.1.4 Filtration Flask - Use a 1-liter heavy walled filtration flask with vacuum tubulation.
- 3.1.5 Bottles - For sampling, use 1-liter polyethylene bottles.
- 3.1.6 Comparison Charts - Use the Babcock & Wilcox membrane filter comparison chart set. This set consists of the following charts: One $Fe_2O_3 \cdot H_2O$ chart, 10-5000 mg/l, Fe; one Fe_3O_4 chart, 10-1000 mg/l, Fe; and three $Fe_2O_3 \cdot H_2O / Fe_3O_4$ charts of the following ratios: 1:1, 1.5:1 and 2:1 all for the range of 10-500 mg/l, Fe. These charts are available from B & W Power Generation Division.
- 3.1.7 Drying oven - capable fo maintaining 105°C.
- 3.1.8 Desicator.
- 3.1.9 Analytical balance - 200g capacity, capable of weighing to 0.1 mg.
- 3.1.10 Evaporating dishes, platinum, 200 ml capacity.

4. PRECAUTIONS

Not Applicable

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5. CHECK-OFF-LIST

- 5.1 "Unit Startup Sheet", PSSO (2/3)-1042-12.
- 5.2 "Steam Generator Summary Sheet", PSSO (2/3)-1042-6.
- 5.3 "Weekly Turbine Plant Summary Sheet", PSSO (2/3)-1042-9.

6. PROCEDURE

- 6.1 Suspended solids filter comparison method: Provides rapid and relatively accurate results by comparing sample filter to the examples of the Babcock & Wilcox membrane filter comparison chart set.
 - 6.1.1 Collect sample to be analyzed from local sample point in a 1-liter polyethylene bottle.
 - 6.1.2 Place a 0.45 μ m, 47mm diameter filter membrane in the lexan filtration unit, moisten the filter with demineralized water and apply vacuum to the filtration flask.
 - 6.1.3 Pour sample into the funnel of the filtration unit. After the sample has passed through the filter membrane, remove the filter and allow to air dry at ambient temperature.
 - 6.1.4 Compare the filter with appropriate B & W membrane filter comparison chart and determine the suspended solids concentration of the sample. Express these results in terms of mg/l, Fe.
- 6.2 Suspended solids residue measurement method: A well mixed sample is filtered through a 0.45 μ m filter and the residue retained is dried to constant weight at 105°C.
 - 6.2.1 Place a 0.45 μ m filter in the filter apparatus and while vacuum is being applied, wash the filter with three successive volumes of water.
 - 6.2.2 Remove filter from the apparatus and dry in an oven at 105°C for one hour. Remove filter and place it in a desiccator for storage until needed. Weigh filter immediately before use.
 - 6.2.3 Select a volume of sample sufficient to yield a precipitate of at least 1mg.
 - 6.2.4 Assemble the filtering apparatus and apply vacuum. Shake the sample vigorously and rapidly transfer to the funnel.
 - 6.2.5 Carefully remove the filter from the filter funnel assembly. Dry for one hour at 105°C. Cool in a desiccator and reweigh.

6.3 Total solids determination method: A well mixed aliquot of the test sample is quantitatively transferred to a pre-weighed platinum evaporating dish and evaporated to dryness.

- 6.3.1 Transfer an aliquot of sample sufficient to contain a residue of at least 0.5mg, successive aliquots may be added, to the pre-weighed platinum dish.
- 6.3.2 Evaporate the sample to dryness in a drying oven. The temperature should be lowered to approximately 98°C to prevent boiling and splattering of sample.
- 6.3.3 Dry the evaporated sample for at least 1 hour at 105°C.
- 6.3.4 Cool in a desiccator and weigh. Repeat the cycle of drying at 105°C, desiccating and weighing until a constant weight is obtained.

6.4 Calculations

6.4.1 Suspended solids, mg/l = $\frac{(A-B) \times 1000}{C}$

where:

- A = weight of filter + residue in mg.
- B = weight of filter in mg.
- C = sample volume filtered in ml.

6.4.2 Total solids, mg/l = $\frac{(D-E) \times 1000}{C}$

where:

- D = weight of sample + dish in mg.
- E = weight of dish in mg.
- C = volume of sample in ml.

6.5 Acceptance criteria

- 6.5.1 Suspended solids will be maintained below 1.0 mg/l in the condensate, feedwater and steam generator blowdown.
- 6.5.2 Total solids will be maintained below 0.5 mg/l in plant make-up waters.

7. RECORDS

Record results of total or suspended solids on appropriate start-up or summary sheet, Transmission of these data sheets to E.D.M. shall be on a monthly basis and shall be filed under the applicable encode number shown below.

CN05-AX5 (SO 2/3) for "Steam Generator Summary Sheet", PSS0 (2/3)-1042-6.
CN05-AX3 (SO 2/3) for "Weekly Turbine Plant Summary Sheet", PSS0 (2/3)-1042-9.
CN05-AX startup (AA08-AX) for "Unit Start-up Sheet", PSS0 (2/3)-1042-12.

H E Morgan

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SUPERINTENDENT UNITS 2/3

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