NTPC	LMI	LARA
TITLE	Cycle Chemistry Guidelines for the Start Up, Shut Down and Lay Up Practices	
REF. NO.	LMI 017/CHEM/OGN/OPS/CHEM/004	

NTPC LIMITED

OPERATION AND DOCUMENTATION SYSTEM

LMI 017-R01/OPN/OGN/OPS/SYST/004

Issue No.01: Rev. 01 March, 2011

Cycle Chemistry Guidelines for the Start Up, Shut Down and Lay Up Practices

All locations are required to comply with this Directive

Approved for Implementation by .....HOP (LARA)

Date :.....9/12/12.....

Enquiries to : HOD(Chemistry & Environment)

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1.0 INTRODUCTION

Improper start up shut down and lay up practices usually lead to serious damage in the form of pitting, oxidation and corrosion. Corrosive attack during off-load can also render the plant susceptible to subsequent on-load corrosion or fatigue damage. To preserve the long term integrity of boiler components require careful chemical control during start up, shut down and lay up condition as well. This guidance note covers the above aspects of the plant including the important factors regarding the choice of the optimum procedures, which will depend on the type of plant, its metallurgy and outage time.

2.0 SUPERSEDED DOCUMENTS :- Nil

3.0 SCOPE

This LMI covers the Start Up, Shut Down and Lay Up Practices for the super-critical units. The startup and shut down consideration and storage requirements, procedures for the above have been outlined. Water chemistry, metallurgy, design and operating aspects are profoundly interwoven and strongly interact with each other. In this document our focus will be on water and steam chemistry guidelines during start up, shut down and lay up practices.

4.0 RESPONSIBILITIES

The HOD (Chemistry) or his nominee is responsible for ensuring all administrative, safety and operational procedures are correctly implemented during the startup, shut down & layup practices.

The Area-In- Charge or Shift Chemist is responsible for co-ordination of all activities during the start up, shut down & lay up practices with Shift-In-Charge. They will monitor and maintain chemical parameters, ensure all safety and operational procedures are correctly implemented during the startup, shutdown & layup practices.

5.0 START UP PROCEDURE

It involves the following steps :-

Step – 1:

If the system has been stored dry, then it should be filled with makeup water with following specification :-

Parameter	Limiting Values
Silica	< 20 ppb
Sp. Cond.	< 0.5 to 1.0 µs/cm
Dissolved Oxygen	<100 ppb (if the water is deaerated)

Step-2:

If the system has been stored using low oxygen scavenger procedure, the boiler can be fired immediately. The boiler vents are to be kept open to 25 psi to remove any excess ammonia.

Step-3:

If the system has been stored wet with a surplus ammoniated hydrazine, it must be drained and refilled with water meeting the specification as mentioned in step-1.

Step-4:

The following limits for the boiler feed water are required prior to firing the boiler:

Oxygen	< 20 ppb
Iron	< 50 ppb

During start up, the level of corrosion products (iron and its oxides) can be very high initially and silica may also be a problem. But at this juncture 100 % condensate polishing comes in quite handy in achieving the above limits.

Step – 5:-

After firing the boiler, monitoring must be fully implemented, both for chemistry parameters, and to ensure that temperature ramps are maintained according to the turbine and boiler manufacturer's specification.

During start up, the concentration versus pressure curves are to be utilized to control sodium and silica. Boiler pressure should remain at reduced levels such that these limits are maintained before pressure can be increased to the next stage.
Adjust boiler chemical feed to take advantage of tolerance for higher alkalinity at lower pressure (refer figure – 1).

Anticipate boiler start up and begin pumping chemicals so that target treatments are in place when boiler is fired.

Steam side i.e. shell side of L.P. and H.P. heater needs to be flushed before taking their drip into system.

Maximum use of condensate polishing will minimize start up times.

Steam dumping to be carried out till the steam parameters meet the following specs:-

Parameters	Limiting values
After Cation Conductivity	$\leq 0.25 \mu S/cm$
Sodium	≤ 6 ppb
Chloride	≤ 6 ppb
Sulfate	≤ 6 ppb
Silica	≤ 20 ppb
Total Organic Carbon	>100 ppb

Once main steam parameters attain the above mentioned limits, then only steam should be allowed to enter the turbine.
A protocol jointly signed by representative of Operation and Chemistry to this effect is to be maintained in SCE's log book.

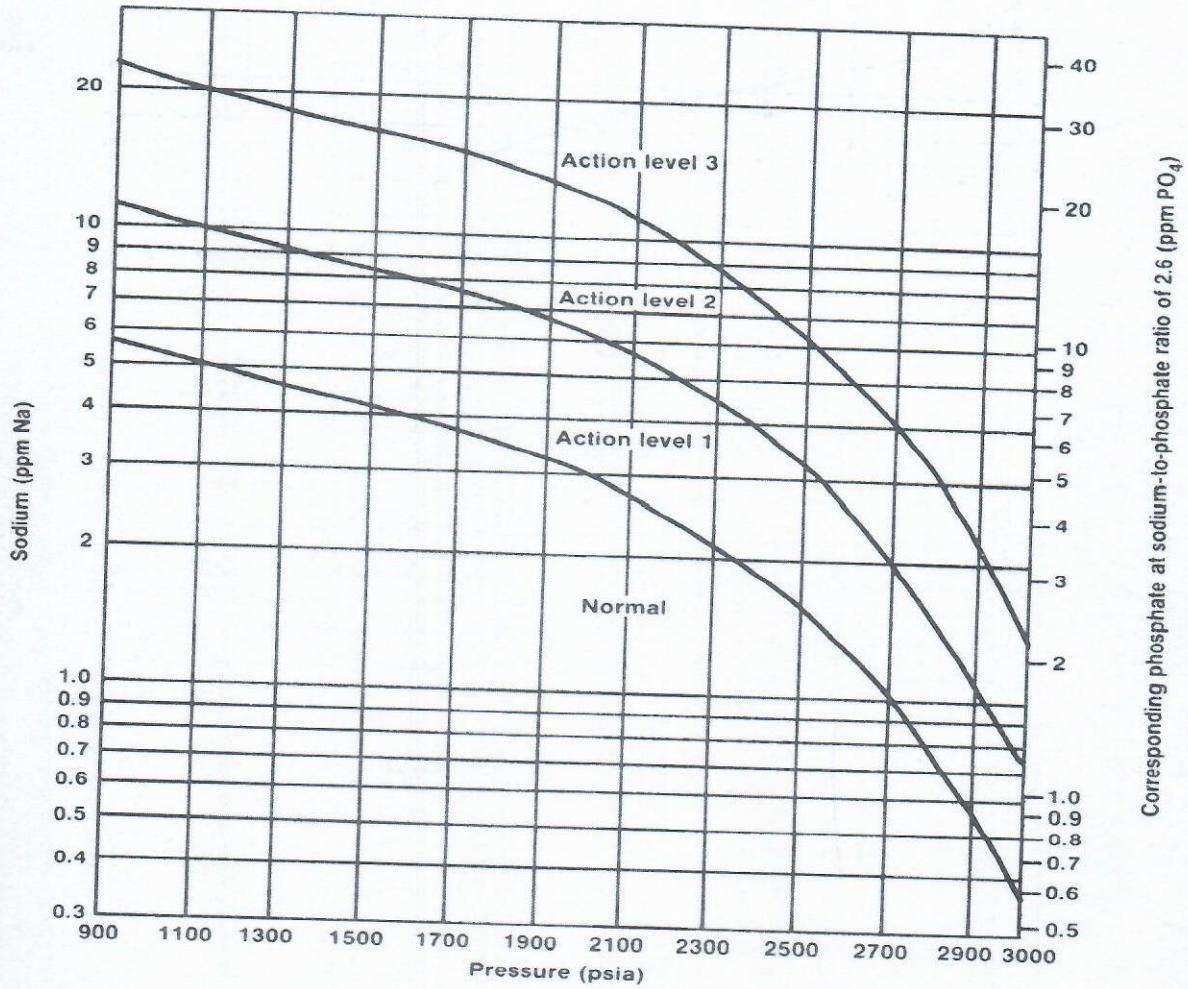

Figure 4-2

DRUM BOILERS/PHOSPHATE TREATMENT:
BOILER WATER SODIUM AND PHOSPHATE
VERSUS OPERATING PRESSURE
(PLANTS WITH REHEAT)

Normal	Normal Operating Value
Action Level-I	Return to Normal Value within 1 week
Action Level-II	Return to Normal Value within 24 hours
Action Level-III	Return to Normal Value within 04 hours

Table-1 Chemistry parameters to be monitored in Units

Sample	Parameter	Frequency
Feed	pH	Continuous
	Ammonia	Grab
	Cation conductivity	Continuous
	Iron, ppb	Grab
	Dissolved Oxygen, ppb	Continuous
Main Steam	pH, Sodium	Continuous
	Silica and chloride	Grab
Saturated Steam	pH, Sodium	Continuous
	Silica	Grab
Deaerator Inlet	Dissolved Oxygen	Continuous
Deaerator Outlet	Dissolved Oxygen	Continuous
Condensate	Cation conductivity	Continuous
	Sodium	Continuous
	Dissolved Oxygen	Continuous
CPU Outlet	Cation conductivity	Continuous
	Sodium	Continuous
Make up water	Sp. Conductivity	Continuous

6.0 SHUT DOWN PROCEDURE

The road map to develop shutdown& Lay Up guidelines common to most units is as follows :-

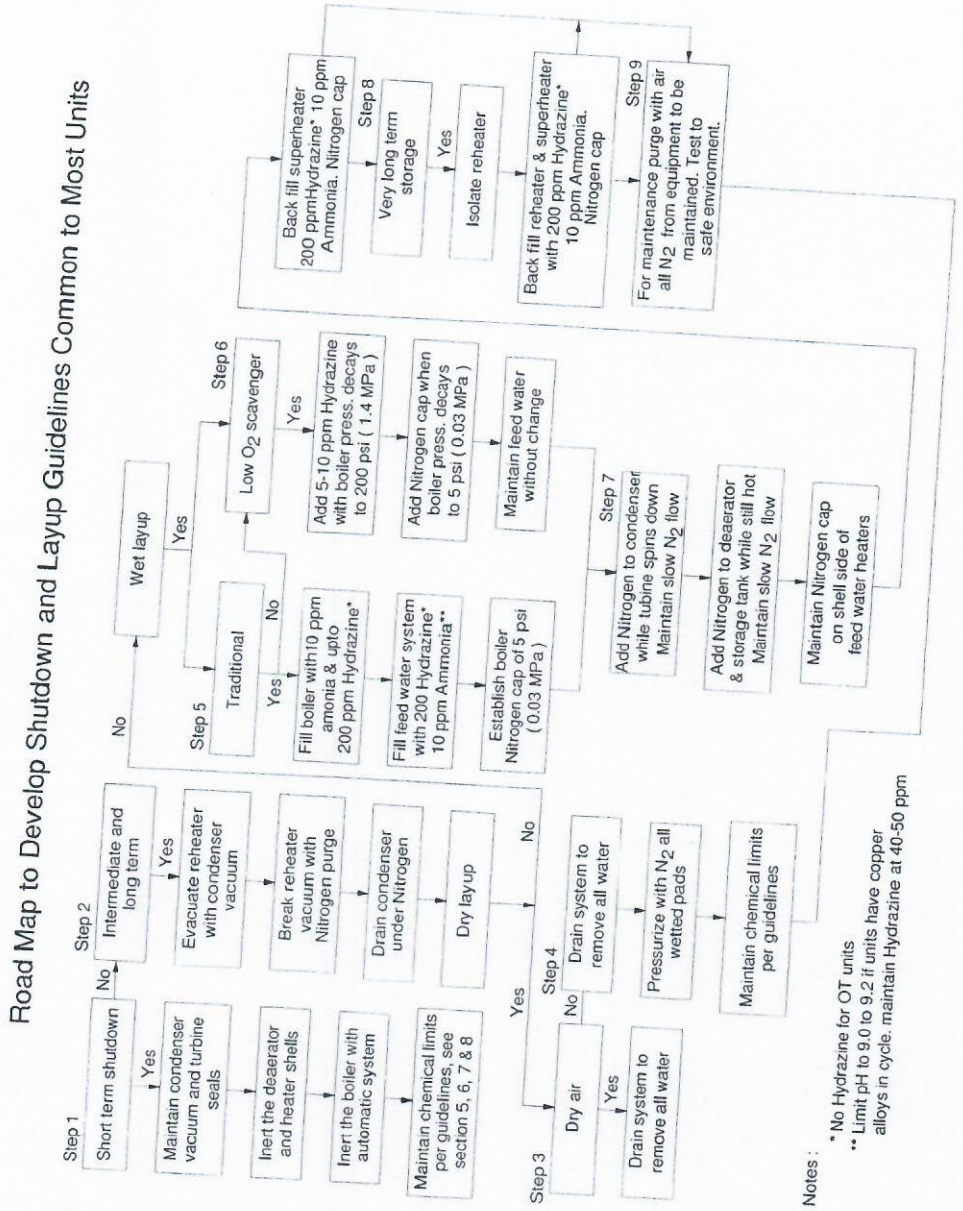

Fig. 2 : Shutdown & layup road map

The above figure may be divided into nine (9) considerations which have been further elaborated as follows:

Step-1:- Short term shut down

This very term itself implies that the unit will be required to operate within a relatively short time frame. Thus no major changes are required from normal operating conditions except the fact that it must be protected from air ingress. The condenser vacuum and turbine seals are maintained, the de-aerator, the heater shells and boiler are inert with nitrogen or steam and the feed water chemistry is maintained as follows:

Units with oxygenated treatment

Parameter	Limiting Values
pH	8.0 – 8.5
After Cation Conductivity	< 0.1 µS/cm
Oxygen, ppb	20 – 200 ppb
Iron	<10 ppb

Step-2:- Intermediate and long term shut down

Intermediate and long term shut down require additional steps to be taken to prevent corrosion during intermediate periods of layup, such as for maintenance and indeterminate cycling requirements; and during long shut down up for indefinite period of time. It may be noted that certain procedures are common regardless of whether the units are laid up dry or wet.

During shutdown, the turbine, condenser (steam side) and re-heater are generally considered together because, unless special facilities are incorporated, there is no practical way to isolate them. These equipment are normally stored dry.

During shut down, the re-heater should be evacuated by utilizing the vacuum in the condenser. If the turbine steam is supplied from a header system, all valves must be tight to prevent moisture entrance into the turbine.

Step-3:- Dry air lay up

The dry air layup procedure requires that all components of the system be drained by maintaining dry air flow through the equipment.

Step-4:- Dry air layup with Nitrogen

Nitrogen is used for Blanketing Equipment, which is drained but not completely dry, or for blanketing equipment either filled with water or not to prevent air- ingress. Step-4 is similar to step-3 except nitrogen is used for a positive small pressure on all component rather than dry air-purge. A small continuous purge of nitrogen is required to protect the turbine, de-aerator & de-aerator storage tank.

Step-5:- Wet lay up

Traditional method (Boiler and Feed water heaters) The traditional method of wet layup involves filling the boiler, feed water cycle and super heater with de-mineralized water containing 10 ppm of ammonia and up to 200 ppm of hydrazine. But for oxygenated treatment, hydrazine should be eliminated.

Step-6:- Wet lay up: Low oxygen scavenger method (Boiler and Feed water Heaters)

One of the procedures uses 5-10 ppm of hydrazine equivalent is injected through normal chemical feed system into the boiler when the boiler pressure decays to 200 psi (Usually, it takes about 3days) thereby facilitating homogenization of these chemicals in the boiler.

Step-7:- Wet lay up (Balance of cycle)

The super heater is back filled with a solution up to 200 ppm of hydrazine and 10 ppm ammonia and a nitrogen cap maintained. (In case of O.T. hydrazine solution is not required)

Step-8:- Very long outage

For very long storage periods, the re-heater is isolated from the turbine, and back filled with a solution of 200 ppm hydrazine and 10 ppm of ammonia capped with nitrogen. The super heater is treated similarly.

Step-9:- Maintenance

Only equipment requiring maintenance needs to be drained (in case of wet storage), and nitrogen (If used) purged with air to provide an environment suitable for entry of personnel. Since nitrogen does not support human life, it is extremely important to ensure that nitrogen is completely displaced by air. The atmosphere within the equipment should be tested with suitable devices to ensure that the equipment is safe for personnel entry. However if the unit is planned to be taken under overhauling after shutdown, it advisable to hot drain the unit at 3-5 kg/cm^2 pressure before shut down.

7.0 LAY UP PRACTICES

The shut down and lay up period should be regarded as a continuum of the good practices used during operation. The key objective of cycle chemistry is to provide protective oxide surfaces on all components throughout the steam and water circuits whereas the primary purpose of layup practice is to maintain those protective surfaces during offload condition.
The layup procedure generally fall under two categories i.e. the wet and dry procedures.

Wet layup requires filling of most of the system with an alkaline reducing solution (ammonia and hydrazine) and preventing air ingress by nitrogen capping.
Dry layup requires drainage while hot, and removal of all water followed by pressurizing with a moisture free inert gas or by use of dehumidified air to maintain a low moisture environment.

In selecting a proper layup procedure for a specific boiler and its equipment, the following factors come into play:

- compatibility between the chemistry required for layup and that used
- during operation, maintenance of protective oxides formed during operation.
- possibility of the steam generator may be required for operation.
- facilities for disposal of layup solution
- practicality of maintaining all the required conditions of a given procedure
- local atmospheric condition.
- availability of various inputs as envisaged in the layup procedure.

The various advantages and disadvantages of dry and wet layup

Is following :-

Wet storage with Ammonia/hydrazine with nitrogen capping

Advantages

a) Independent of relative humidity.
b) Ease of testing and maintenance.
c)Super heaters and re heaters covered.

Disadvantages

a) Pollution hazard.
b) Needs to be re –circulated.
c) Regular monitoring.
d)High D.M. water consumption.
e) Nitrogen capping is very dangerous; asphyxiation of workers if not properly vented before access.

Dry Storage

Advantages

a) Readily available basic constituent.
b) Ease of monitoring and maintenance.
c) No risk to personnel.

Disadvantages

a) Drying equipment and blowers required.
b) Depend on climatic condition.
c) Hermetical sealing required.
d) System must be completely dry
e) Sediments may cause corrosion if hygroscopicSO_2 and dust free air required.
f) Even draining hot and under pressure may not ensure complete water removal because of complex geometry

7.1 Wet lay up

This generally involves filling the unit with D.M. water containing an excess of N2H4. Circulation may be used coupled with positive nitrogen pressure. A nitrogen cap allows

(a) boiler and feed water equipment to remain full.
(b) requires no excessive addition of chemicals.
(c) permits nitrogen to rush in where steam collapses, preventing oxygen from entering the system.

The following procedure for nitrogen addition will be handy:

Main Condenser and Turbine

1. Nitrogen addition starts while turbine is spinning down.
2. Nitrogen is added quickly at first, then slowly as the vacuum approaches zero.

De-aerator and Storage Tank

1.Nitrogen is added when the de-aerator is still hot.

2. Nitrogen is purged for about 20 minutes followed by maintenance of a small nitrogen positive flow.

Feed Water Heaters

Nitrogen is supplied through shell-side vent line.

The boiler and economizer water should be circulated routinely to prevent stagnant condition developing.

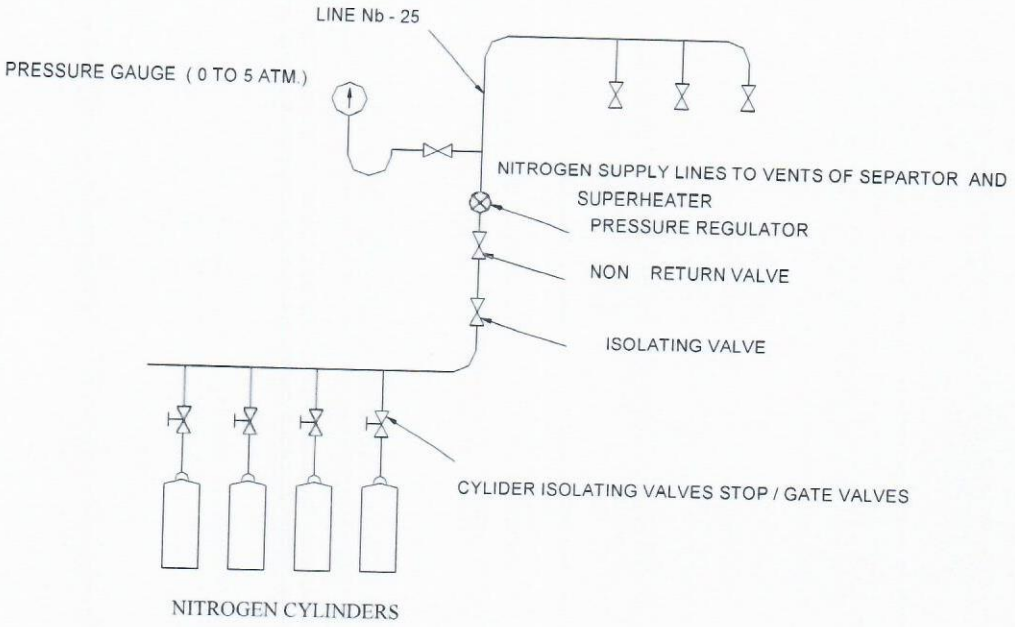

Figure – 3

Scheme for Nitrogen Blanketing

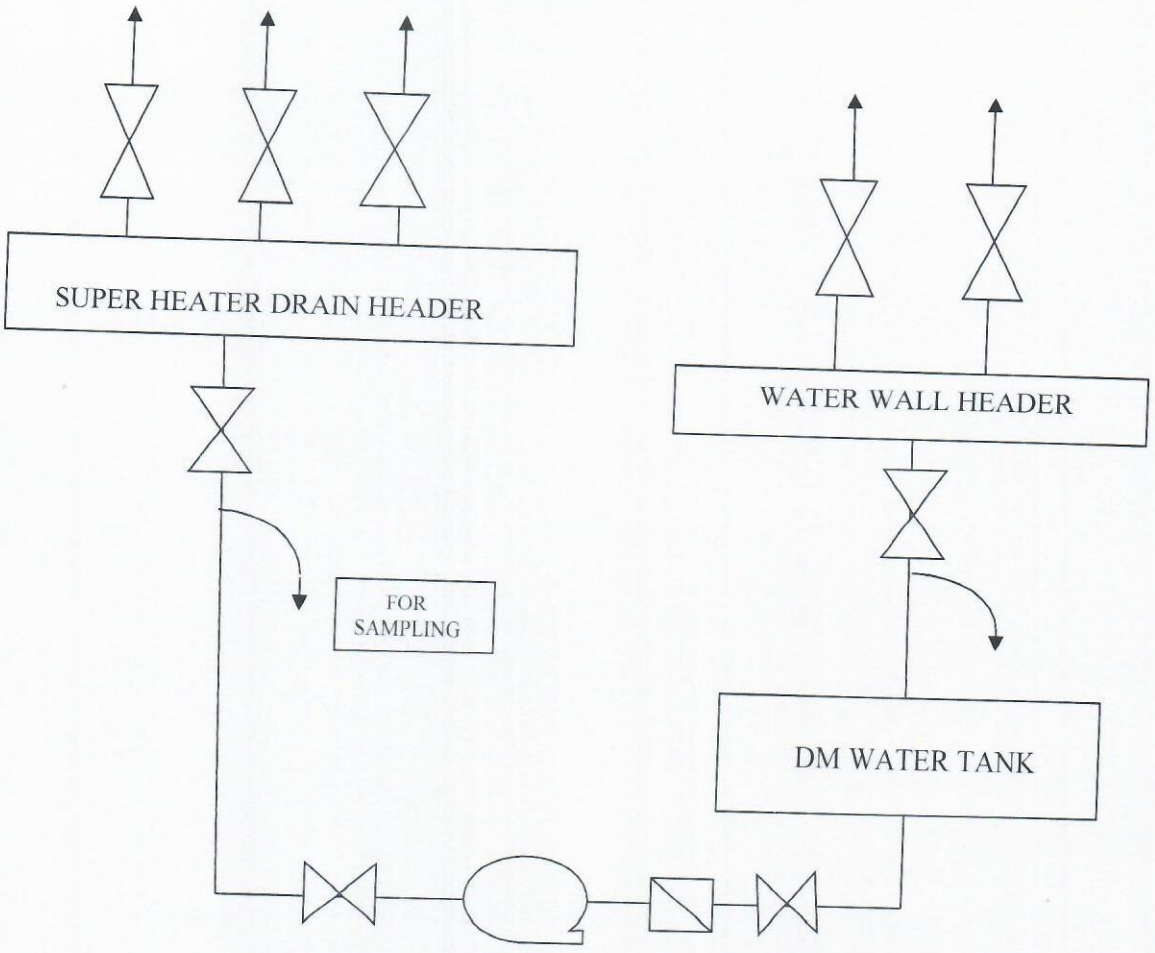

Figure-4 :- Scheme for Wet lay-up

Nitrogen does not support human life, hence the relevant safety precautions are extremely important. Before any equipment that has been laid-up with nitrogen can be entered by personnel, all nitrogen supply lines must be disconnected, the equipment purged with air, and oxygen levels verified as safe by proper oxygen test procedures like using ORSAT/portable oxygen analyzer. Minimum oxygen percentage should be 18% before entry of working personnel.

7.2 Dry Lay up

Storage of plant under conditions of complete dry-out is the most satisfactory procedure for longer periods of storage however great care must be taken to
obtain complete dry-out, as the retention in the plant of localized small pools of water can lead to serious off-load corrosion.
If the dry storage is to be used ever effort shall be made to use the residual heat in the plant to assist in drying out process. As boiler is brought off load, it is normal to blow the boiler and associated circuit empty from 3-5 bar. However if it is operationally acceptable, considerable advantage can be gained by emptying from a higher pressure (e.g. 28 bar). If the drying is to be assisted by natural air, whilst the boiler is cooling, header caps and drum doors shall be removed as quickly as possible to establish satisfactory ventilation.

Even under these conditions complete dry-out of super-heaters, re-heaters and economizer tubing might not be achieved and it is now accepted that circulation of dehumidified air (Relative Humidity <30%) to purge the boiler and auxiliary equipment during layup period.

7.2.1 Feed Water heaters, condenser, reheater and turbine

These components are generally treated as one group, because they cannot be isolated without special provision. Particular care needs to be taken during shut down and lay up so that these equipment are protected properly. Generally all these components are stored dry.

7.2.2 Turbine

Turbine dry lay -up using dehumidified air can be combined with dry layup of the unit steam side circuits. Refer Figures 6 &7

7.2.3 Feed water side condensers and feed water heaters

Metallurgy of these devices are of paramount importance while deciding feed water chemistry for intermediate and long term storage.For all ferrous metallurgy system a wet layup is accomplished with a pH of up to 10.0 achieved with ammonia ,up to 200 ppm of hydrazine and a pressurized nitrogen blanket .It is to be noted that for units on oxygenated treatment use of hydrazine is not recommended.

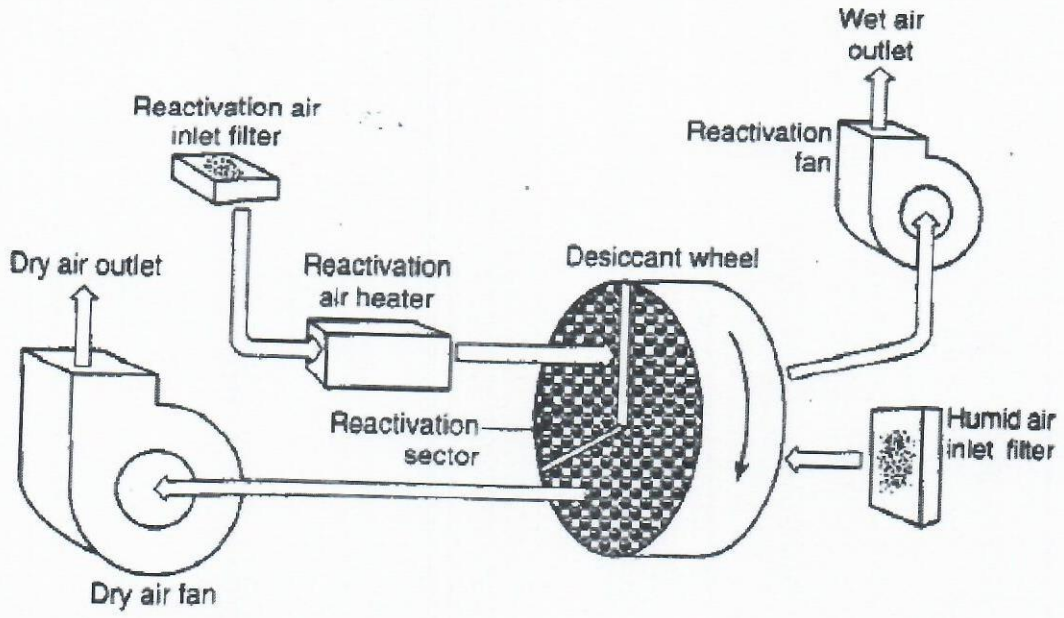

Fig. 5 : Rotary desiccant dehumidifier

Figure 5 depicts rotary desiccant dehumidifier. The system utilized to supply dry air to the various components of feed water heater, steam and boiler circuits may be customized to adapt to various heat cycles configurations.

7.2.4 Shell side feed water heaters

The shell side of feed water heaters should be protected by a nitrogen blanket or a steam blanket (short term layup) when the unit is out of service.

7.2.5 Super-Heater

For wet layup it should be back- filled either treated water of a composition identical to that used for layup of the boiler. A nitrogen cap comes in handy to prevent air-ingress.

7.2.6 Deaerator and Storage tank

The de-aerator and de-aerator storage tank should be protected by a small but steady nitrogen purge.

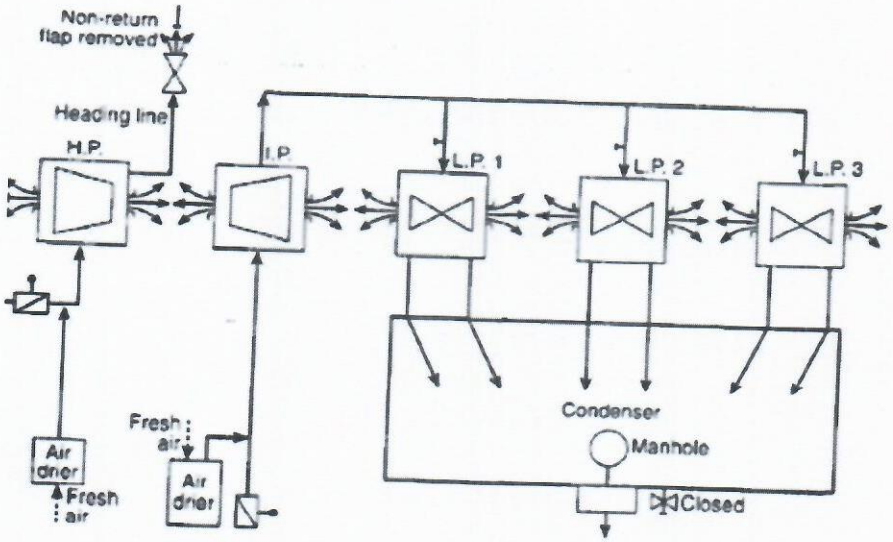

Fig. 6 : Turbine dry lay up using dehumidified air

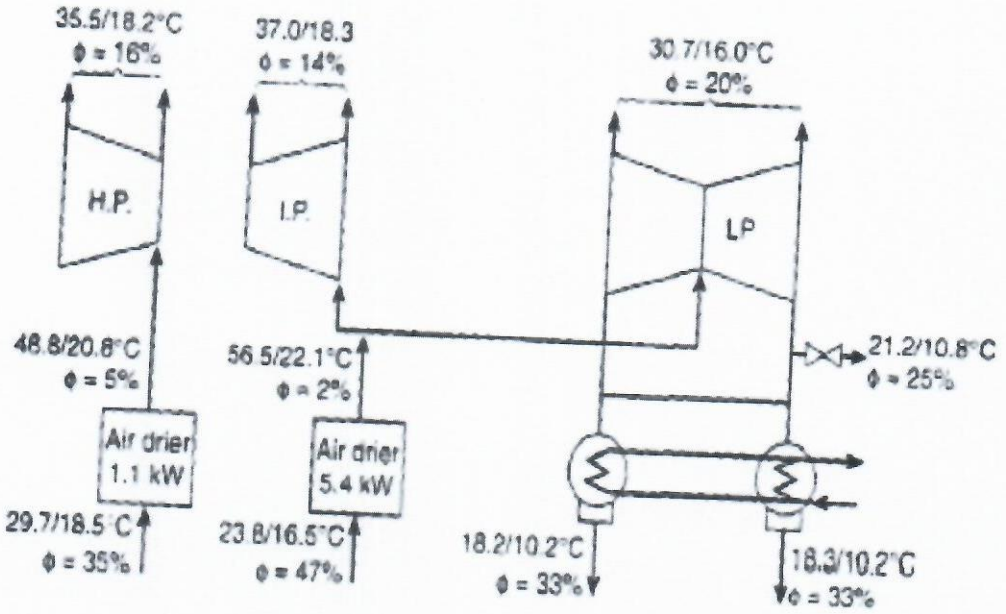

Fig. 7 : Block diagram for Dry lay up of turbine showing measured values of temperature (^{0}F / ^{0}C) and air humidity

7.3 Layup monitoring

All layup conditions, dry or wet should be monitored at regular interval to ascertain that the layup water / air quality (RH-30%) is maintained. In the event of deterioration of the layup and water chemistry to corrosive conditions in a particular component, either that component needs to be drained or if proper mixing can be provided requisite additional chemicals can be added. Protocol for all lay ups is to be maintained with SCE as per annexure –1.

7.4 Environmental consideration

The disposal of layup solution containing high concentration of ammonia and hydrazine needs to be carried out after treatment so that the final effluent conforms to the prescribed limits of the respective Pollution

control boards. This is why the most popular choice of layup procedure is the one which does not necessitate draining of boiler prior to start up which has been outlined as follows:

When the boiler is off-line, inject through normal chemical feed system around 5-10 ppm of hydrazine equivalent to the boiler when the boiler pressure decays to 200 psi. This will ensure sufficient mixing of chemicals in the boiler water. When the boiler pressure decays to 5 psi pressure a nitrogen cap is applied to the boiler. Upon requirement the boiler can be fired without draining the layup solution and the drum vents are opened until 25 psi is reached to remove excess ammonia from the system.

Because usually it takes 3 days before the pressure decays to 200 psi, an outage for three (3) days may not require a chemical injection treatment.

8.0 RESPONSIBILITY CENTRE FOR IMPLEMENTATION

The HOD (Chemistry) or his nominee is responsible for ensuring that all administrative, safety and operational procedures are correctly implemented during the startup, shutdown & layup practices. The HOD (Chemistry) or his nominee shall compile and preserve the records.

ACTIVITY	RESPONSIBILITY CENTRE	DOCUMENT REFERENCE
Availability & use of Safety appliances, Safety Shower, erection of temporary barrier	HOD (Chemistry)	Safety Check List
Availability & Handling of Chemicals	Area-In-Charge or Shift Chemist	Chemical Stock Register, Material Safety Data Sheet(MSDS)
Availability of lab Chemicals & Instruments	Area-In-Charge or Shift Chemist	Daily Lab Report, Chemical Stock Register
Monitoring & Maintaining of Chemical Parameters	Area-In-Charge or Shift Chemist	Main Plant Log Book, Boiler Preservation Record
Co-ordination With Shift In-Charge	Area-In-Charge or Shift Chemist	SCE Logbook

9.0 REFERENCE DOCUMENT :-

1) COS-ISO-00- OGN/OPS/CHEM/017 Rev. No. : 1 March,2011
2)9548-110-PVM-W--3015
3)9548-102-PVM-X-028

10.0 REVIEW

The HOD (Chemistry) will be responsible for reviewing this document on a 3-yearly basis or as necessary.

11.0 Annexure -1

PROTOCOL ON PRESERVATION STATUS

(To be filled every week)

Station :

Unit :

Date :

I. If under dry preservation

Relative Humidity (%) of dry air -
N_2 Pressure -

II. If under wet preservation

pH -
Hydrazine -
N_2 Pressure -

III. Quantity of makeup Chemicals (if required)

(Chemistry representative) (Operation Representative)

The protocol duly filled should be available with Shift Charge Engineer.

12.0 DISTRIBUTION LIST

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1		HOP, LARA
2		GM (O&M)
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