HRSG Lay-Up Practices

Attn: HRSG Plants

Re: HRSG Lay-Up Procedures

Observation: One of the most effective means of ensuring plant longevity and reliability is to implement sound Lay-Up procedures on your HRSG(s) to limit corrosion by removing and preventing the introduction of oxygen.

There are two sets of Lay-Up procedures depending on the desired time of shutdown of said HRSG.

One set of procedures is for short term, the other for indefinite shutdown of the HRSG.

Short Term:
Internal protection is required if the steam generator is out of service for more than 24 hours.

A wide variety of boiler shutdown lay-up procedures are in use with combined cycle plants. Caustic for pH control and sulfite for oxygen are used in some cases but on most stations, hydrazine is used, in some cases supplemented with ammonia to raise the pH. Hydrazine levels range from 100 ppb to 200 ppm and no differences on their effectiveness was reported.

The choice of concentration ranges and chemicals used must be related to those used while the boiler is in service and whether or not the boiler is to be drained and refilled before restarting.

A hydrazine concentration of 100 ppb has been reported to give excellent protection and should be supplemented with sufficient ammonia or morpholine to give a pH of 10.

In recent studies in the United States, by ASME and others, it has been recommended that 200 ppm hydrazine and 10 ppm ammonia be present in the water for wet lay-up. If such concentrations are used, the boiler will have to be drained and refilled with water contained the operational levels of boiler chemicals before restarting.

The Vogt HRSG is a natural circulation type, and it is not possible to circulate water through the tubes during standby periods. Accordingly, very high concentrations of hydrazine, 200 ppm, are used to assure an excess in all sections of the boiler throughout the shutdown. A short shutdown, where the pressure in the boiler does not decay below 5 psig(.34 bar), can be accommodated by maintaining the pressure in the boiler, vacuum on the condenser and sealing steam on the steam turbine.

This procedure prevents oxygen from entering the system, minimizing the load on the deaerator system at start-up. Boiler, condenser, and steam turbine corrosion is minimized.

If the shutdown is to be extended, so that pressure decay below 5 psig will occur, one of the two courses below is to be followed:

1. If freezing can occur, the boiler should be drained under nitrogen and the entire boiler pressurized with 5 psig nitrogen. During draining, care must be taken that air is not pulled into the boiler.

2. If freezing will not occur, the boiler should be filled with clean deaerated condensate containing 100 - 200 ppb hydrazine and sufficient ammonia to give a pH of 10. Hydrazine and ammonia can be injected through the chemical connections
on the drums. During standby conditions, the pH and hydrazine content must be checked. If depletion has occurred, the recommended concentration levels must be restored by adding chemicals.

Figure 1 illustrates these recommended procedures in schematic form.

Nitrogen Sources:
Nitrogen Bottles
Nitrogen Generator

Note: Nitrogen Generators are devices requiring Low Pressure Air Compressors (LPAC’s) and 110v current. They are more economical than nitrogen bottles (~2 year payout). These devices remove the available nitrogen from ambient air and require very little maintenance (periodic change of filters). NOTE: Vogt-Power International, Inc. can help in the proper selection and acquisition of these nitrogen generators.

Long Term:
The suggested methods of boiler lay-up for indefinite shutdown of the HRSG are as follows:

1. **Wet**- Under the wet method, the boiler is held full of water, which is treated to render it non-corrosive.
2. **Hot-Dry**- Under the hot-dry method, the boiler and internal liner are kept warm by admitting live steam of available pressure into the steam drum. The required time to put the unit back into operation is kept to a reasonable minimum.
3. **Cold-Dry**- When a boiler is to stand idle in an exposed location for any indefinite period, it should be drained completely, being particularly careful to blow or otherwise remove all water from such places in drums, tubes, headers, superheaters, water columns, gauge glasses, etc., which are drainable. The unit can then be dried using chemicals, mechanical methods or nitrogen.
4. **Hot-Wet**- Under the hot-wet method, the boiler water level is maintained close to low level but not low enough to sound alarms. Steam pressure is maintained.
5. **Short Term “Hot Wet”**- When HRSG units are used in cyclic operation, long term storage methods cannot be used. In this application, the following should be considered.

5.1 **Stored Energy**

The large mass of steel inside HRSG and inventory of water means that there is a large quantity of stored energy available in the HRSG boiler after shutdown. By minimizing the draft through the HRSG by use of an outlet damper, this stored energy may keep the unit warm for 24 hours or more.

5.2 **Pressure Equalization**

A hot shutdown will allow the pressure to drop rapidly if the stack and duct are opened to allow cool air and gasses to circulate through the gas side of the boiler.

If instead the HRSG is bottled up (not allowing outside to the HRSG), the entire HRSG will try to equalize in temperature. If the low pressure boiler has been operating at say 5 psig (.34 bar), the temperature will be about 225°F (107°C). The average temperature of the economizer may be about 315°F(157°C) and the high pressure boiler may be approximately 550°F(287°C).
If it were possible to "bottle-up" the unit, it would equalize out at about 325 psig (22.4 bar) or 425°F (218°C). A more reasonable estimate might be 350°F (176°C). (this will vary due to how fast the stack is capped and the ambient temperature) or 120 psig (8.3 bar), still enough to over pressure the low pressure boiler relief valve.

5.3 Stratification

In addition to temperature and pressure equalization within the multi-pressure unit, as soon as the natural circulation ceases (when the normal siphon is no longer driven by temperature difference), the system will stratify. Without circulation, the hottest boiler water will move to the top of the tubes and drums while cooler water will gravitate to the lower headers and tubes. This is natural and should be of no concern unless the ambient temperature is below freezing and the stack is not capped.

5.4 Field Testing

The best plan is to try a set of conditions and record all data effecting the shutdown. If after the "off period" the HRSG still has positive pressure, a re-start can be made by draining the superheater and adjusting the water level in the drums.

5.5 Re-Start

With the water levels adjusted and the condensate drained from the superheater(s), re-start the CT. Quickly open each blowdown valve for a two (2) second blowdown and bring the unit up on automatic control. Monitor water levels and flow during the re-start.

If Vogt Power International, Inc. can assist you in the proper selection of a lay-up procedure or selection of a nitrogen generator, do not hesitate to contact us.

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Figure 1: Recommended Lay-Up Flowchart

START OUTAGE

SHORT TERM

OUTAGE LENGTH

LONG TERM

MAINTENANCE

FREEZING

HOT FREEZING

CIRCULATE WEEKLY

DRAIN AND OPEN

DRAIN WITH N2 BLANKET (INDEFINITE)

WET WITH N2 BLANKET (INDEFINITE)

CHECK WATER CHEMISTRY

ADJUST AS NECESSARY

REPAIRS

No

Yes

SHORT TIME INSPECTION ONLY

INTERNAL REPAIR

HYDRO

ACID CLEAN

REFILL

END OUTAGE

BEFORE START WATER CHEMISTRY CHECK

Not Acceptable

Acceptable

START OUTAGE

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START OUTAGE