KANUPP - IAEA Training

Boiler Feedwater / Condensate
Chemistry Control

Boiler Feedwater / Condensate

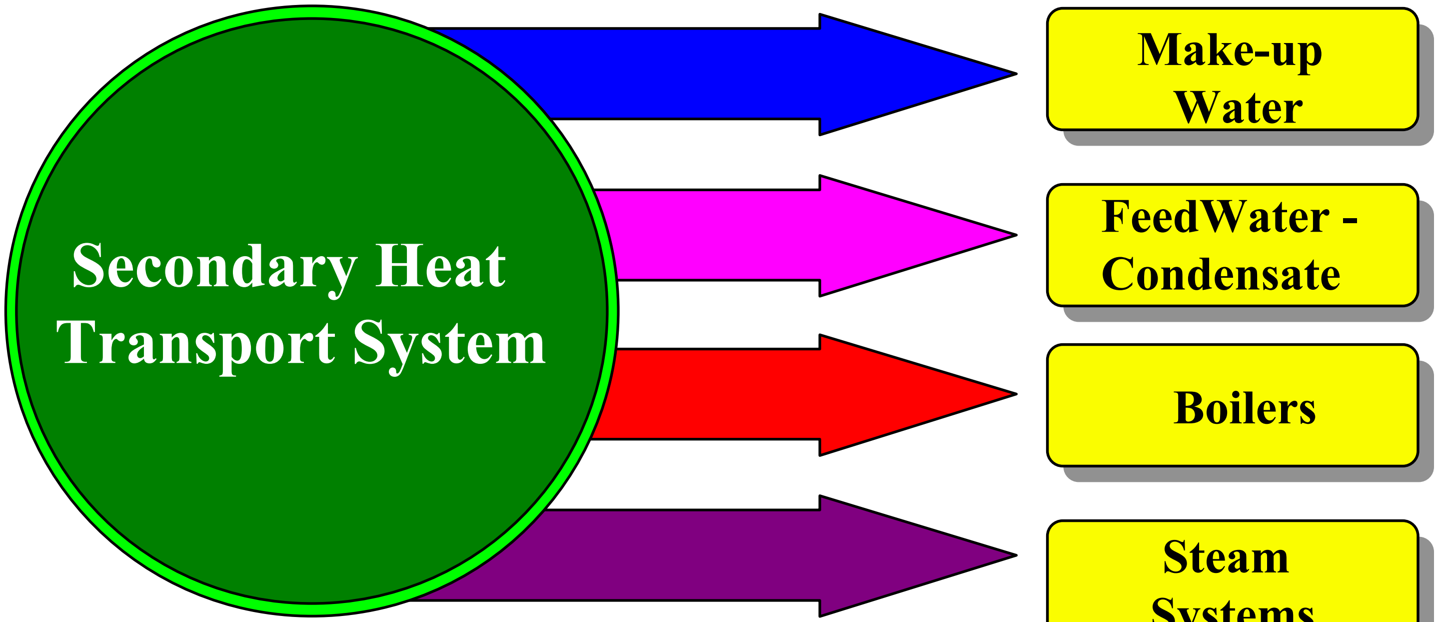
Course Objectives

- **State the purpose of secondary side chemistry control.**
- **State what chemicals are added to the secondary side, the purpose of each chemical, and where each chemical is added.**
- **State the chemical parameters monitored in the secondary side by plant instrumentation, their sampling points, approximate values and what alarms/indications are available in the MCR.**
- **Appreciate the need for good communication between the CRO and Chemical Maintainer with respect to alarms received in the MCR, i.e., out of spec parameters, low tank levels, power changes, bypassing of flow through the condensate polishers, etc.**

Course Objectives

- **State the consequences of out of spec parameters on Secondary Side plant systems and components.**
- **Recognize condenser sea water leak indications; state the concerns and general procedure to follow in the event of a condenser sea water leak**
- **State what indications are in place to give indication of a Steam Generator Tube leak.**
- **State the main concerns associated with a Steam Generator Tube leak.**

CONDENSATE FEEDWATER - BOILER SYSTEM



Chemistry Objectives

- **Minimize Corrosion in order to preserve system integrity and ensure the long term availability of equipment.**

- **Minimize Local Corrosion of Boiler materials which can occur in regions of restricted flow, particularly under deposits and within crevices.**

- **Minimize transport of corrosion products into the Boilers (condensate - feedwater corrosion).**

- **Minimize erosion in steam - turbine - feedwater - condensate.**

Condensate - Feedwater - Boiler System Chemistry Control

Corrosion Concerns

- **Sodium**: ***Can produce alkaline conditions under deposits or in crevices which can result in stress corrosion cracking of boiler tubes. (All Volatile Chemistry Treatment)***

- **Sulfate:** ***Can produce acidic conditions under deposits or in crevices which can result in stress corrosion cracking of boiler tubes.***

- **Chloride:** ***High levels in combination with oxygen can cause pitting of boiler tubes and carbon steel components. Can also result in generalized corrosion of carbon steel support plates which can cause boiler tube "Denting".***

- **Products:** ***Corrosion of materials in the Condensate/Feedwater system - Corrosion products are transported to the boilers where they accumulate on the tubesheet and tube support plates - increased boiler deposits. Increased deposits can also result in decreases in heat transfer at the boiler tube surfaces which in severe cases can result in power derating.***

- **Calcium & Magnesium :** ***Increased boiler deposits.***

- **Silica:** ***Increased boiler deposits.***

Specific Conductivity - conductivity of the solution contributed by all the dissolved ionic species.

e.g. cations (Na^+, Li^+, Cu^{++}, Ca^{++}, Mg^{++}, NH_4^+, $N_2H_4^+$, C_4H_9ON+ , etc)

anions (Cl^-, F-, NO_3^-, SO_4--,PO_4^{---} etc)

Cation Conductivity - conductivity of solution contributed by dissolved ionic impurities/contaminants.

e.g. cations (Na^+, Cu^{++}, Ca^{++}, Mg^{++}) are exchanged with H^+. The anions that remain (Cl^-, F-, NO_3^-, SO_4--, PO_4^{---}) now are in the for of mineral acids and are highly conductive giving a rise in the conductivity of the solution

(Sample stream of feedwater passed through a cation resin in the R-H^+ form)

Cation Conductivity Measurement

Color indicating resin

brown- exhausted

purple - fresh

Duplicate

Resin Cartridges

Measuring element

Condensate Chemistry Control

- **Maintain Dissolved Oxygen Levels Low:** Location and elimination of sources of air in-leakage in the sub-atmospheric portions of the turbine/condenser system. Hydrazine addition.

- **Maintain Alkaline pH Conditions:** Addition of Morpholine. Plants with copper alloys in the condensate system operate at slightly lower than optimum pH conditions (for carbon steel). High amine concentrations can result in stress corrosion cracking and condensate grooving of copper containing components. Hydrazine concentrations also limited to the minimum necessary for oxygen scavenging due to ammonia formation due to hydrazine decomposition. <u>**Since Point Lepreau system does not have copper components, high morpholine & hydrazine concentrations can be tolerated ...... morpholine is maintained at @ 15 mg/Kg & hydrazine is maintained between 60 - 80 ug/Kg.**</u>

Chemistry Control with Condensate Polishers

Condensate polishers are employed to remove impurities from the condensate/feedwater system. They are also used to provide protection of the Boiler - condensate - feedwater system from ionic impurities that would result from a sea water leak in the condensers.

Condensate Polishers can however, be a source of ionic contamination to the Boiler - Feedwater system. Improper regeneration of the ion exchange resin or resin exhaustion can result in ions being eluted from these vessels and finding their way into the Steam Generators where they will become concentrated. For this reason, stringent chemistry monitoring of the effluent from the polishers must be performed.

Parameter	Specification
Cation Conductivity	0.04 mS/m
Sodium	2 ppb
Sulfate	2 ppb

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OM 78210, Appendix 1. Actions upon Detection Of a Condenser leak

Sodium *or* Cation Conductivity in alarm on one or more Condensers.
AND
Sodium *or* Cation Conductivity in alarm on the CEP Discharge

CRITERIA 1.

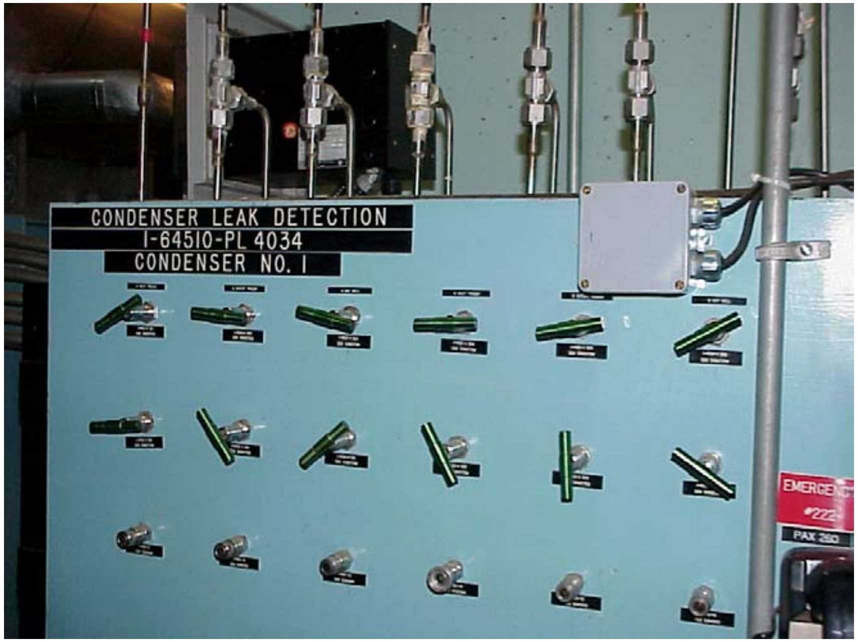
Condenser	CD01	CD02	CD03
Condenser Indications (Any Of)	WII-6 CI 1873 NA^+ AI 2764 Cat Con AI 2766	WII-6 CI 1873 AI 0551 AI 0564	WII-6 CI 1873 AI 2765 AI 2767
		AND	
CEP (Either of)	Cat Con AI 1014 Na^+ AI 1015		

OR

CRITERIA 2.

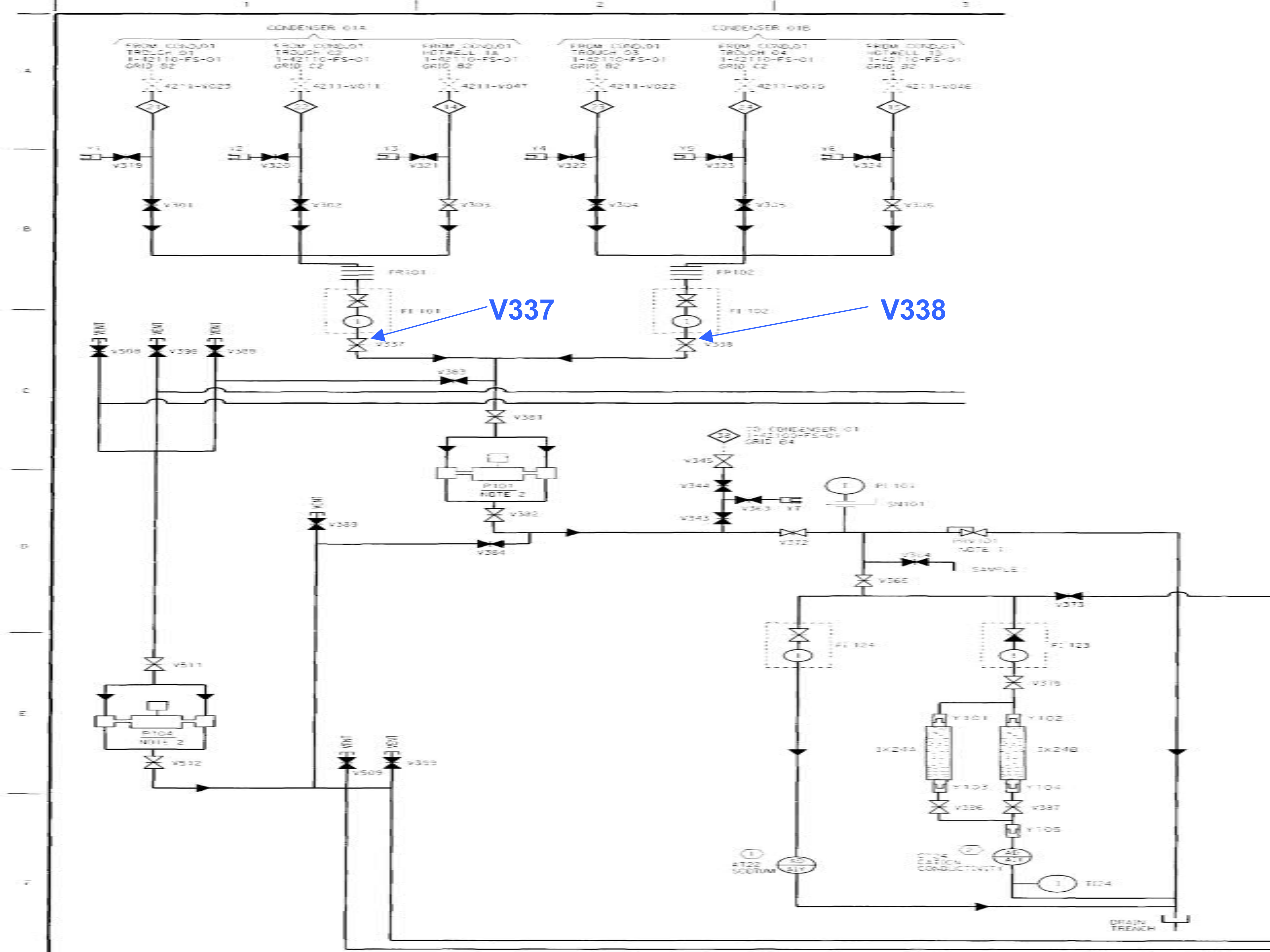
Any single alarm and trending that indicates we are approaching a CRITERIA 1 situation as monitored by the Chemistry Department

Condenser Leak Cation Conductivity and Sodium Local Meters



Condenser Leak Detection CD01

-16’ elev. T/B

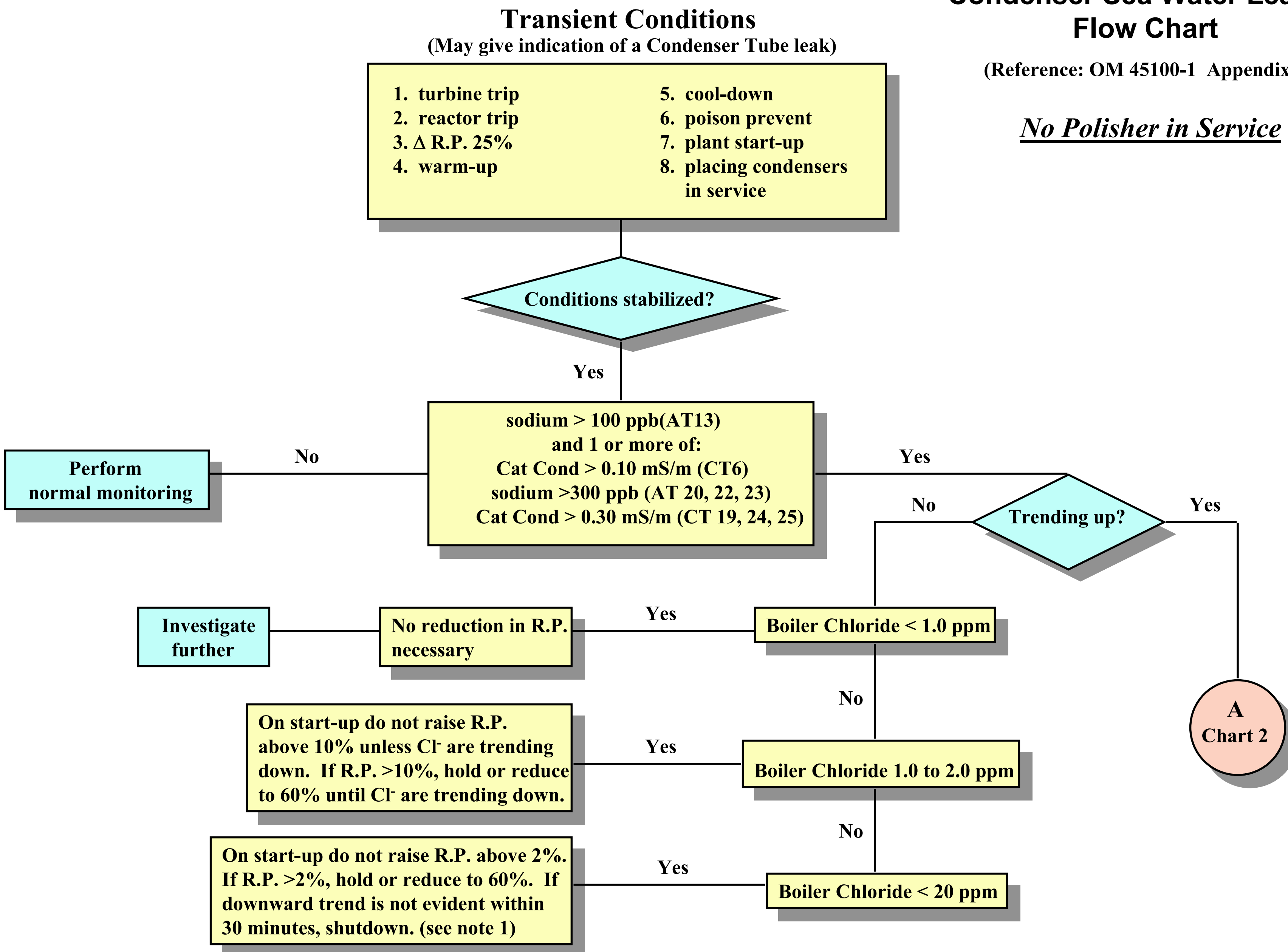


CONDENSER 01A
CONDENSER 01B
FROM COND.01 TROUGH 01 1-42110-FS-01 GRID B2
FROM COND.01 TROUGH 02 1-42110-FS-01 GRID C2
FROM COND.01 HOTWELL 1A 1-42110-FS-01 GRID B2
FROM COND.01 TROUGH 03 1-42110-FS-01 GRID B2
FROM COND.01 TROUGH 04 1-42110-FS-01 GRID C2
FROM COND.01 HOTWELL 1B 1-42110-FS-01 GRID B2
V319
V320
V321
V322
V323
V324
V301
V302
V303
V304
V305
V306
FR101
FR102
FI 101
FI 102
V337
V338
VENT
V383
V381
P101 NOTE 2
V382
V384
TO CONDENSER 01 1-42100-FS-01 GRID B4
V345
V344
V343
SN101
V372
V364
SAMPLE
V365
V373
FI 124
FI 123
V379
IX24A
IX24B
V511
P104 NOTE 2
V512
V509
V399
AT22 SODIUM
DRAIN TRENCH

Condenser Sea Water Leak Flow Chart

(Reference: OM 45100-1 Appendix 2)

No Polisher in Service



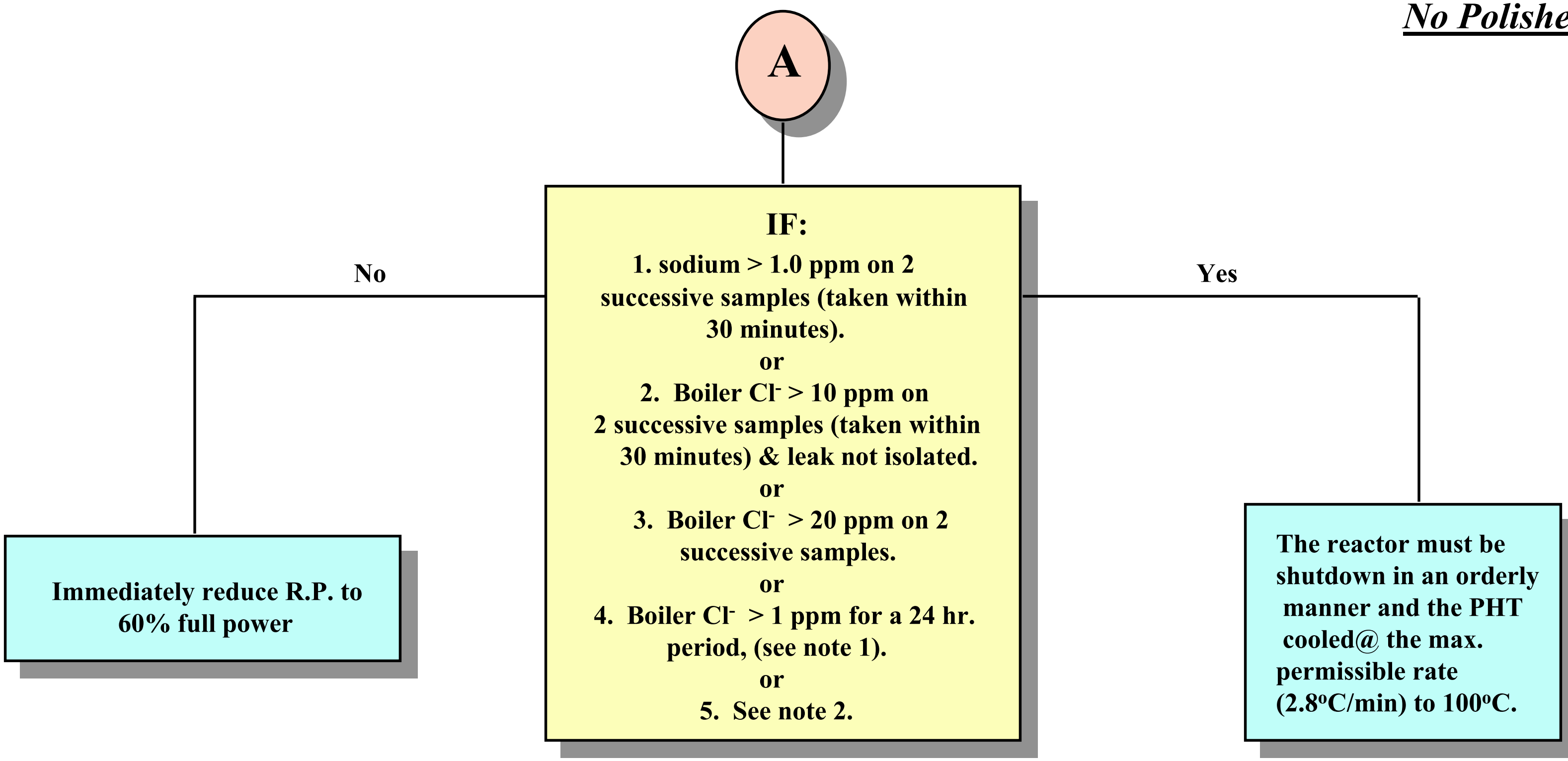
Note 1: *The reactor must be shutdown in an orderly manner and the PHT cooled @ the max permissible rate (2.8°C/min) to 100°C.*

Condenser Sea Water Leak Flow Chart

(Reference: OM 45100-1 Appendix 2)

No Polisher in Service

Steady State Conditions



NOTE 1: ***Shutdown can be waived or postponed by Station Management***

NOTE 2: ***If the boiler pH is < 8.0 after 1 hour and the pH is not returning to normal, derating and/or shutdown may be required after consulting with the Station Chemist. If boiler pH is <7.0 and the Station Chemist can not be contacted, shutdown.***

Reactor Shutdown Conditions

Polisher Vessels in Service

Average sodium > 1.0 ppm @ polisher discharge on 2 successive samples taken within 30 min.

or

Average Cat. Cond. > 1.0 mS/m @ polisher discharge on 2 successive samples taken within 30 min.

or

Boiler Cl^- > 10.0 ppm on 2 successive samples & the leak has not been isolated.

or

Boiler Cl^- > 20.0 ppm on 2 successive samples.

or

Boiler Cl^- > 1.0 ppm for a 24 hour period. (See note 1)

or

See note 2.

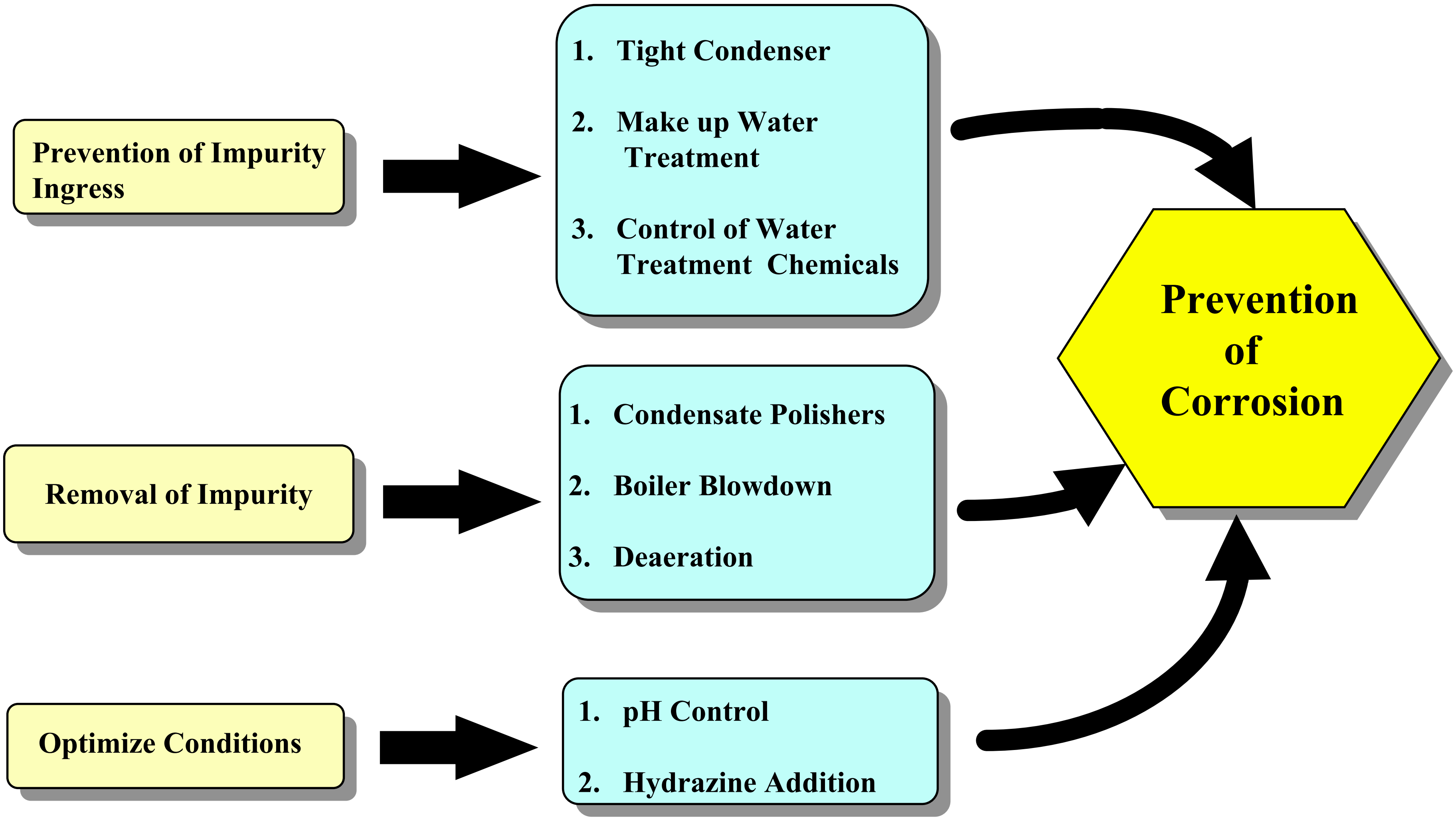
↓

The reactor must be shutdown in an orderly manner and the PHT cooled @ the max. permissible rate (2.8^{o} C/min) to 100^{o} C.

Note 1: *Shutdown can be waived or postponed by Station Management.*

Note 2: *If the boiler pH is < 8.0 or > 10.5 after 1 hour and the pH is not returning to normal, derating and/or shutdown may be rerquired after consulting with the Station Chemist. If boiler pH <7.0 or > 11.0 and the Station chemist can not be contacted, shutdown.*

BASIC PHILOSOPHY OF SECONDARY WATER CHEMISTRY CONTROL



Feedwater Chemistry Control

- **Maintain Dissolved Oxygen Levels Low:** Accomplished by Dearation and by Hydrazine addition.
- **Maintain Alkaline pH Conditions:** High pH conditions minimizes carbon steel corrosion. Accomplished by Morpholine addition. Morpholine concentration maintained by operating the Condensate Polishers in the Morpholine form.

Condensate - Feedwater - Boiler System
Chemistry Control

Standard Conditions

FLUID	CONTROL PARAMETER	DESIRED CONDITION	CONTROLLED BY
Condensate	pH (all-ferrous systems)	9.8	Adding ammonia[1].
	pH (ferrous/copper systems)	9.1	Adding morpholine[1].
	Dissolved O_2	ALARA	Minimizing air inleakage. Degassing in the condenser. Deaerator removes O_2. Adding hydrazine[2].
	Sodium (a diagnostic parameter)	ALARA	Monitoring to detect and minimize effects of condenser tube leaks.
Feedwater	Dissolved O_2	ALARA	Minimizing air inleakage. Deaerator removes O_2. Adding hydrazine[2].
	Total Iron Total Copper	ALARA	Maintaining desired pH and low dissolved O_2. Blowdown.
	Hydrazine	Slight Excess	Addition control in response to chemical analysis.
Boiler Water	Cation Conductivity	ALARA	Using high purity makeup. Blowdown.
	pH (all-ferrous systems)	9.6	Adding ammonia[1].
	pH (ferrous/copper systems)	9.1	Adding morpholine[1].
	Chloride Sodium Silica Sulphate	ALARA	Minimizing condenser tube leaks. Using high purity makeup. Blowdown.

[1]The addition point for morpholine/ammonia is downstream of the CEP discharge.

[2]The hydrazine addition point is between the deaerator and the deaerator storage tank.

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Steam System Chemistry Control

- **Maintaining alkaline pH conditions in the water systems:** Accomplished with the addition of morpholine.

- **Reduction in Erosion/Corrosion in Two-Phase wet steam regions is particularly important.** The key is to maintain pH in the liquid phase high enough to minimize carbon steel corrosion. This is more easily achieved with Morpholine, which tends to remain in the liquid phase due to its more favourable distribution ratio, as compared to ammonia which favors the steam phase.

Steam Generator Tube Failures

- **During normal operation a very small quantity of tritium permeates through the steam generator tubing (diffusion). The permeation occurs with the hydrogen and deuterium escaping from the PHT system.**

- **Due to this diffusion, a small quantity of tritium will be present in the steam generator water and steam .... current tritium concentrations in the steam generator steam samples is about 3.0 x 10^4 Bq/Kg.**
  - during normal operation when there is no D_2O leakage, no noble gases or fission products will be found in the secondary side water (S/G, feedwater or steam).

- **This changes when there is a leakage of PHT water through the steam generator tubing. When a leakage occurs, the secondary side will have some noble gases, fission products and increased tritium concentrations.**