



So I Need to Chemical
Clean My HRSG.

Now what?

Why am I cleaning?

- Preoperational clean?
- Deposit weight analysis indicates the presence of high internal deposits?
- Underdeposit corrosion tube failure?

Preoperational clean

- To remove mill scale and any cutting oils that maybe present.
- To remove any preservation agent used if sections stored prior to install
- To remove any corrosion cells present and to passivate surface prior to initial startup of unit.

Preoperational Chemical Clean

Stranded Asset



After Preoperational
Chemical Clean



High Deposit Weight

- To remove iron deposits from HP evaporator section of HRSG.
- Deposit analysis important to ensure what constituents make up deposits? Is there high copper, high silica, high calcium in deposit?
- A dynamic and/or static chemical cleaning test may need to be performed by chemical cleaning contractor if deposit analysis indicates an unusual deposit.



Underdeposit Corrosion Tube Failure

If a corrosion cell is available, then a dynamic test will need to be performed to determine the length of time needed to completely remove corrosion cell.

Expect at a minimum of 24 hours of chemical circulation time to remove corrosion cell.

Chemical circulation time can be much longer (72-100 hrs.) then this minimum time.

Corrosion cells must be completely removed to stop the progress of underdeposit corrosion.





Chemical Cleaning – The Basics

The four criteria needed for a successful chemical cleaning

- A solvent that will remove the deposit
- Proper temperature
- Proper flow
- Time

Chemical Cleaning – The Basics

Proper Solvent

Organic Solvents

- EDTA (Diammonium/tetra ammonium)
- Citric Acid (some utilities will not use because of effectiveness concerns)

Inorganic

- Hydrochloric (has potential to increase risk for corrosion fatigue failures in the future)
- Hydrofluoric (silica removal)

Chemical Cleaning – The Basics

Proper Solvent

Organic Solvents

- Less Aggressive
- No stress corrosion cracking concerns with austenitic steels
- Less aggressive to base metal
- Need circulation
- Safer to handle than mineral acids but safety precautions the same.
- Complexes iron

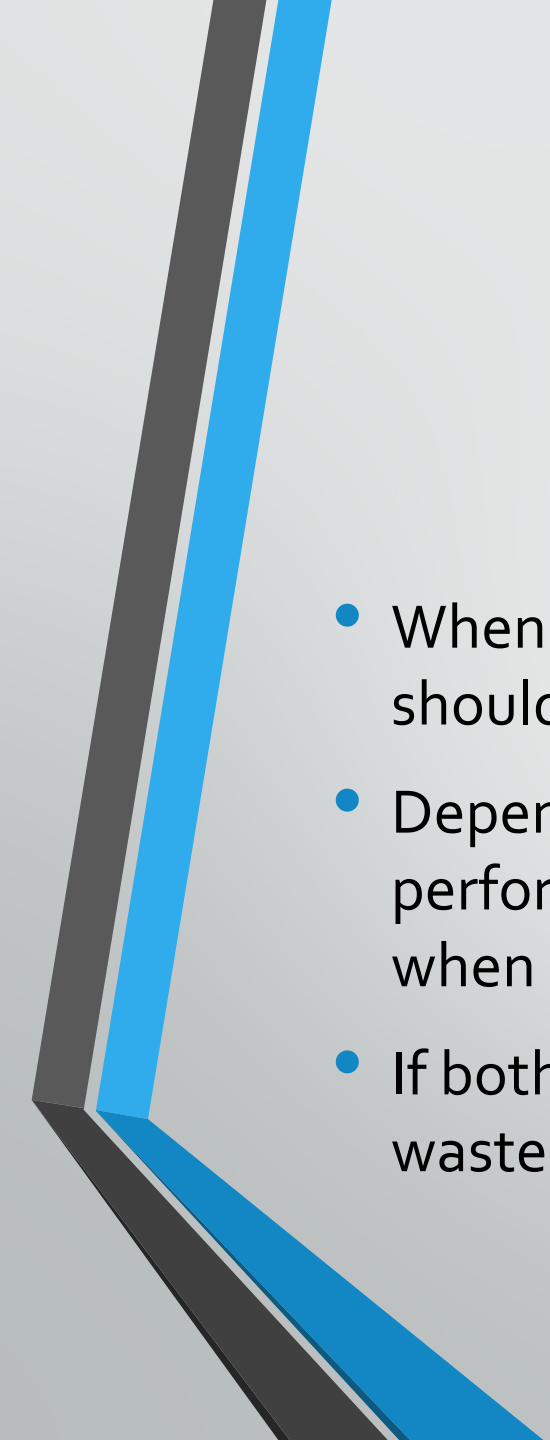
Mineral Acids

- Aggressive
- Generally cheaper
- Effective at lower temperatures
- No circulation required
- Dissolves deposit

Chemical Cleaning – The Basics

Solvent Selection

- Deposit analysis needed to determine constituents in deposit.
- Tube samples can be used to perform a static test by chemical cleaning contractor for screening of solvents.
- Once proposed solvent is determined, a dynamic test can be performed by chemical cleaning contractor for verification of solvent selection.
- Typically, this testing is not performed if iron is only constituent in deposit.
- Warning if deposit weight is high ($> 50 \text{ g/ft}^2$), or the unit is being cleaned to remove underdeposit corrosion cells, or unit operated with numerous condenser leaks, a static/dynamic test should be performed to determine the best solvent and time needed to remove the deposit.



Chemical Cleaning – The Basics

Solvent Selection - Waste Disposal

- When choosing a solvent, the method of disposal of the spent solvent should be reviewed.
- Depending on regulations in the state where the chemical clean is to be performed, sometimes certain solvent waste disposal cost will be cheaper when compared to another solvent.
- If both solvents are shown to be as effective in removing the deposit, then waste disposal costs should be factored into solvent selection.

Chemical Cleaning Process Waste Disposal

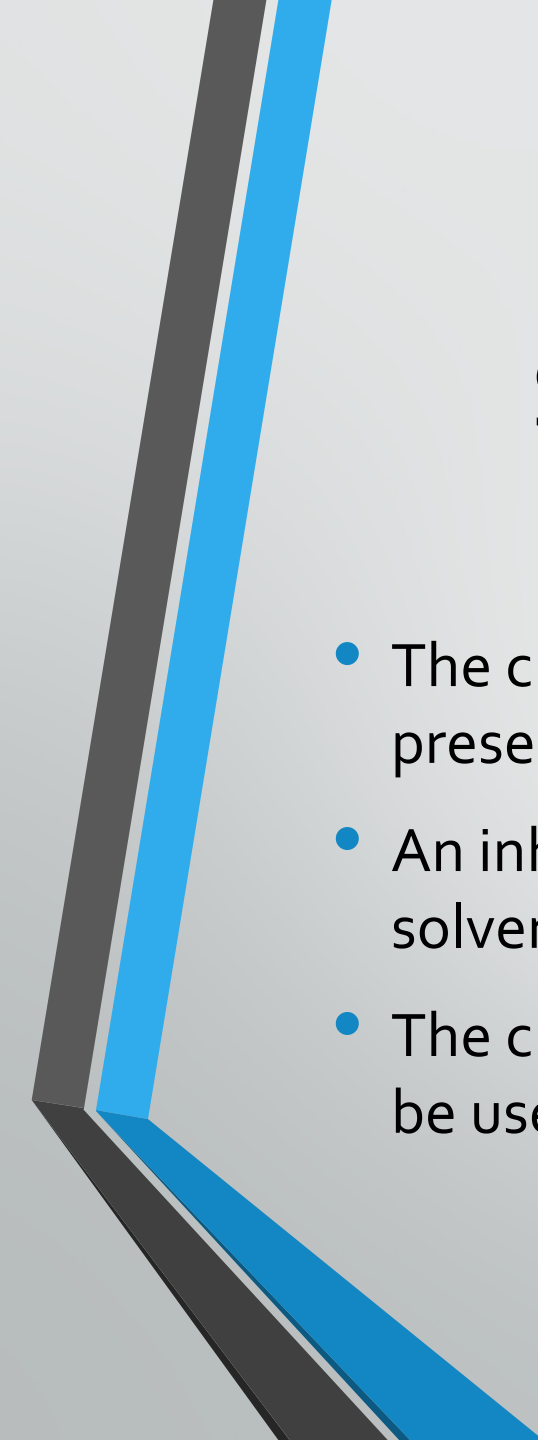
- Your environmental subject matter expert needs to be intimately involved in the waste disposal decisions. Regulations changing continuously.
- The method of waste disposal needs to be planned up front. Included in this is any necessary approvals or permits needed.
- What if scenarios need to be discussed and action plans developed.

Not enough frac tanks

Waste is deemed hazardous

Major spill that leaves the site

Management of spills



Chemical Cleaning – The Basics

Solvent Selection - Corrosion Inhibitor

- The chemical cleaning solvents do not distinguish between iron deposits present and base metal iron during the chemical cleaning.
- An inhibitor is used during a chemical cleaning to drastically reduce the solvent attack of base metal.
- The chemical cleaning contractor will recommend the corrosion inhibitor to be used.

Chemical Cleaning – The Basics

Temperature

- Generally, the higher the temperature the more effective the chemical reaction. But the higher the temperature the more reactive with the base metal.
- Degreasing/Oil removal 150 – 200 F (Preoperational)
- Citric acid 180-275 F
- Diammonium EDTA 160 -200 F
- Tetra ammonium EDTA 284- 347 F
- Hydrochloric Acid 150- 160 F

Chemical Cleaning – The Basics

Flow

- Minimum flow should be 2 ft/sec in all circuits being chemically cleaned.
- At flow rates above 5 ft/sec, the effectiveness of the corrosion inhibitor to maintain low corrosion rates of the base metal to be cleaned needs to be verified acceptable.

Chemical Cleaning – The Basics

Flow

- Hydrogen gas will be generated during the chemical clean.
- Venting of gas at high points of cleaning circuit is necessary
- Need to ensure chemicals only going to places on cycle to be cleaned.
- Don't assume valves will hold.
- Flow diagram should be used to highlight cleaning path, all dead legs that will need to be flushed and places where isolation may leak by during chemical clean.
- Telltales downstream of isolation should be used to determine if isolation valves are holding.
- Provisions need to be made to allow for flushing of all dead legs and where isolation valves leaked by.

Chemical Cleaning – The Basics

Time

- If a proper solvent is chosen and the solvent comes in contact with the deposit, then the deposit will be removed if enough time is allowed for dissolution of deposit.
- You can spend months planning and setting up for the clean, and the first question that will be asked after chemicals are injected and circulating for 2 to 3 hours will be are we done yet?

Chemical Cleaning

The Details

- You need to pump a solution round and round.
- You need to heat up the solution.
- You need to pump heated solution round and round.
- You need to drain solution to waste and dispose of waste.
- But remember as easy as this sounds, the devil is in the details!!



Chemical Cleaning -The Details

You need to pump a solution round and round.

- What section of the HRSG are you going to chemical clean? Typically (if not a preoperational clean) only need to clean the HP evaporator circuit.
- All chemical clean piping will be temporary and needs to be installed and insulated.
- Need to determine a flow path for where the solvent will enter the HRSG and where it will leave the HRSG. This includes all the temporary external piping for the contractor's equipment.

Chemical Cleaning-The Details

You need to heat up the solution.

- Unless a source of steam is available at the site, then a temporary auxiliary boiler will need to be brought to the site to provide steam to the temporary chemical cleaning heat exchanger.
- This will typically require approval for a temporary air permit from the EPA.
- Sizing of the auxiliary boiler will be important to ensure the time needed to heat up the circulating path is reasonable.
- Remember that the chemical cleaning process happens at the metal surface. It is the metal temperature at the surface that is the important temperature. Not the fluid temperature. If fluid temperature is 200 F at the return but thermocouples on evaporator tubes are reading 180 F you are not hot enough to clean.

Chemical Cleaning-The Details

Proper Temperature/Time

- Remember that the chemical cleaning process happens at the metal surface. It is the metal temperature at the surface that is the important temperature. Not the fluid temperature. If fluid temperature is 200 F at the return but thermocouples on evaporator tubes are reading 180 F you are not hot enough to clean.

Chemical Cleaning -The Details

You need to pump heated solution round and round.

You need to drain solution to waste and dispose of waste.

- A chemical cleaning contractor will provide the pump needed to circulate the solution, the heat exchanger to heat the solution, the auxiliary boiler (subcontracted) to provide the steam, and the waste disposal tanks (frac tanks) to collect the waste, and dispose of the waste per your requirements.
- The chemical cleaning contractor will provide the necessary technical support to ensure a successful chemical cleaning.

Temporary Chem Clean Piping



Chem Clean Heating Station

Chem Clean Mixing Station

Chem Clean Pumps

Frac Tank Farm

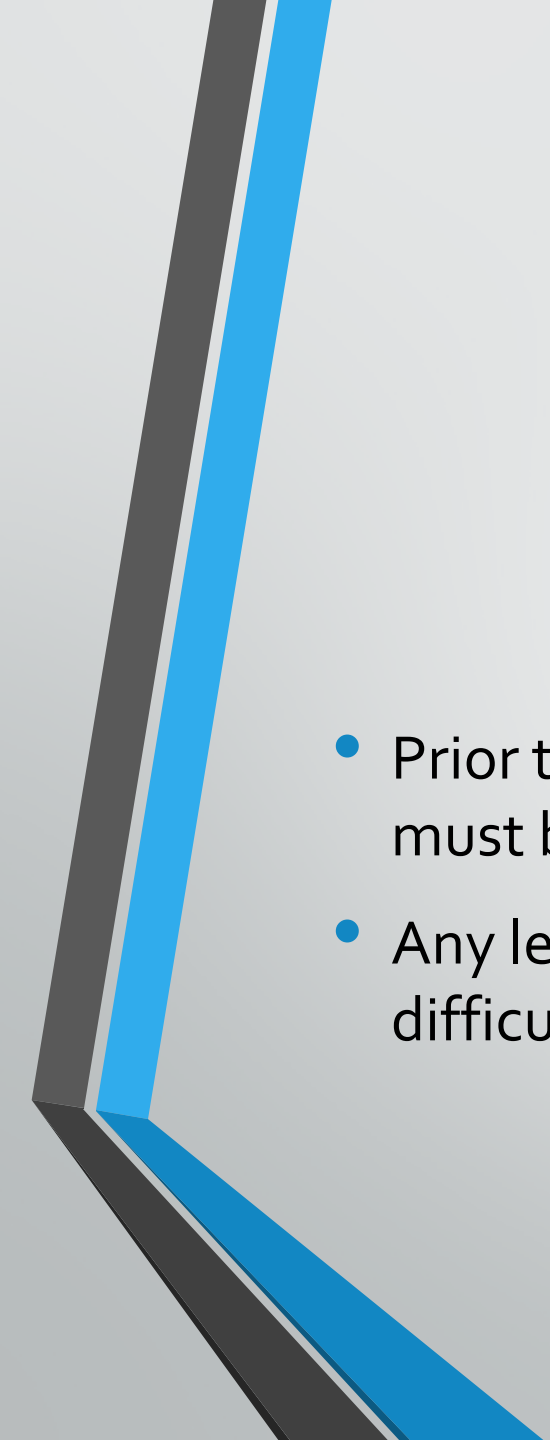


Rejected Frac Tank



Chemical Cleaning Process

- Hydro
- Fill cleaning circuits including backfilling superheat with ammoniated condensate.
- Start circulation and heat circuit.
- Inject chemical and circulate
- Flush/rinse chemical cleaning solvent to frac tanks
- Passivation
- Waste Disposal



Chemical Cleaning Process Hydro

- Prior to starting a chemical cleaning, the evaporator circuits to be cleaned must be checked for leaks.
- Any leaks that occur once chemicals are injected become much more difficult to manage.

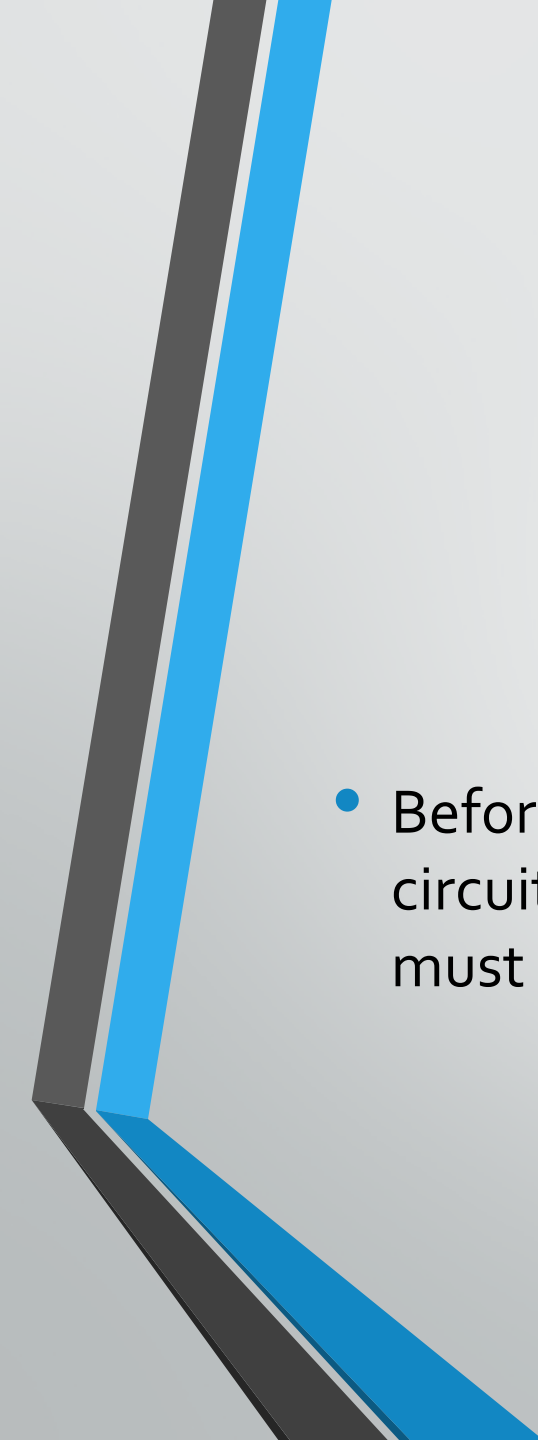
Chemical Cleaning Process

Filling of Circuits

- All temporary piping at this time needs to be checked for leaks.
- Any leaks that occur once chemicals are injected become much more difficult to manage.
- The superheater needs to be backfilled with ammoniated condensate. This protects the superheat from chemicals that may enter superheat from HP drum. Also controls chemical fumes from entering building via the turbine.

Chemical Cleaning Process Circulation/Heating

- System needs to be walked down during heat up to ensure no leaks have developed.
- Any leaks that occur once chemicals are injected become much more difficult to manage.
- Venting of high points of the circuit must be performed every hour to remove any air from cleaning path.

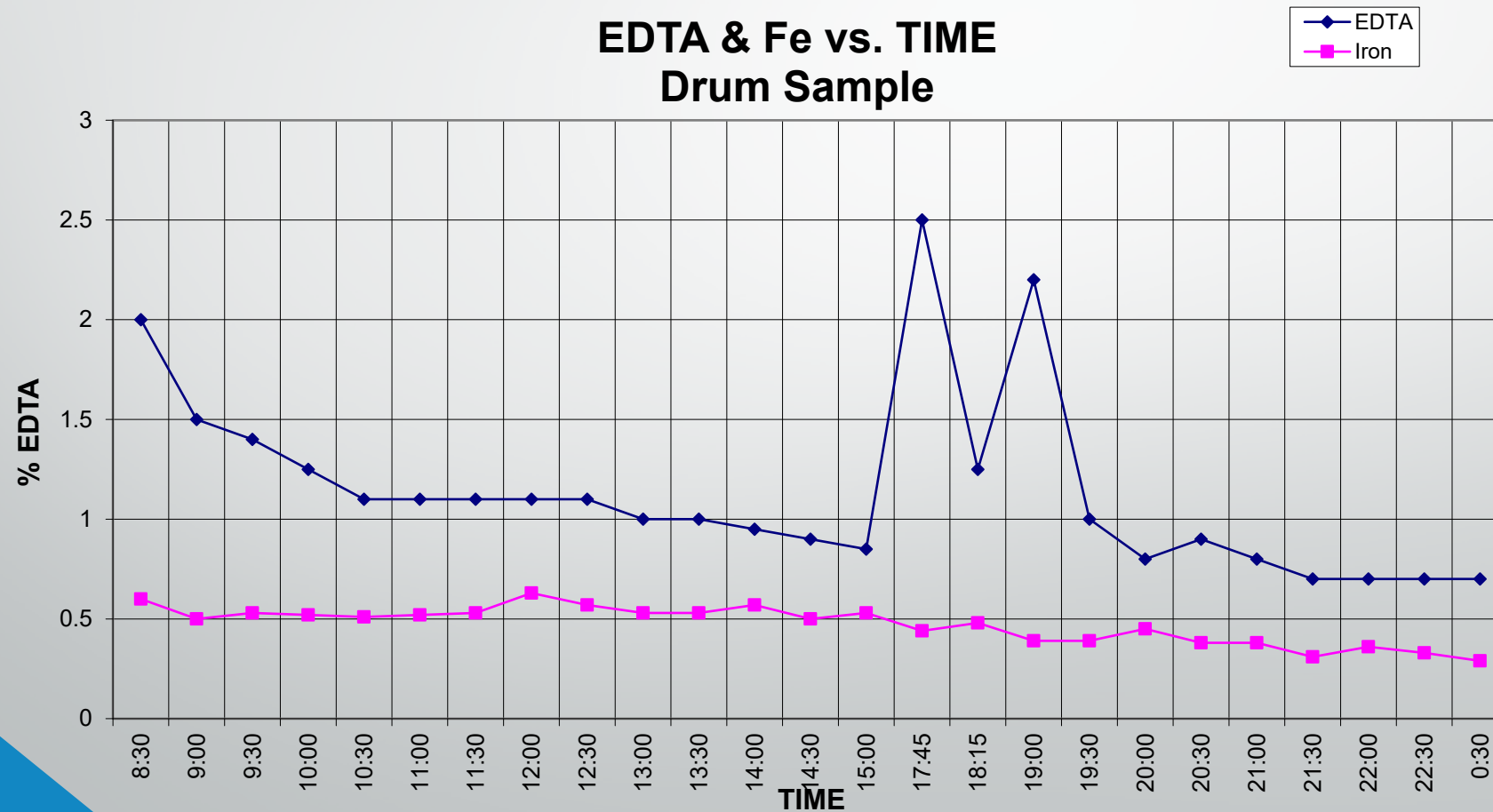


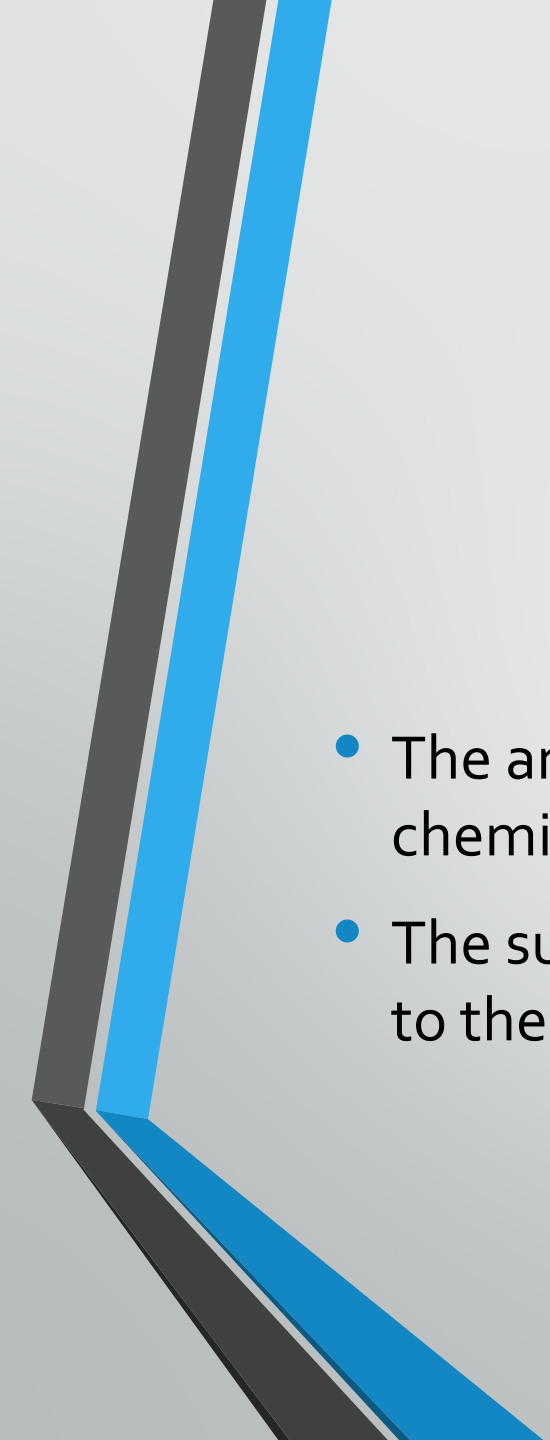
Chemical Cleaning Process

Chemical Injection/Circulation

- Before injection of chemicals all air needs to be removed from cleaning circuits, no leaks are observed, and return temperature from cleaning circuit must be at target temperature.

Typical Data during Chemical Cleaning





Chemical Cleaning Process

Flush/Rinse

- The amount of difficulty with chemistry holds on startup of unit after chemical cleaning is directly linked to the success of this step.
- The success of this step is directly linked to the preplanning of this step prior to the chemical cleaning.

Inadequate Flushing



Chemical Cleaning Process

Passivation

- Passivation layer formed during chemical cleaning process is a weak layer.
- It's intent is to protect the just cleaned surface just long enough to restore system to normal and startup unit.
- Unit should never be chemical cleaned and then left out of service not required.
- Unit needs to be returned to service and operated for a minimum of 76 hours to form more protective passive layer on evaporator tubes.

Chemical Cleaning Process

Waste Disposal Repeat

- Your environmental subject matter expert needs to be intimately involved in the waste disposal decisions.
- The method of waste disposal needs to be planned up front. Included in this is any necessary approvals or permits needed.
- What if scenarios need to be discussed and action plans developed.

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Final Note

Safety

- SDS will detail the necessary safety precautions needed.
- Temperature - everything over 140 F will need to be personnel protected.
- Hydrogen gas will be generated during the cleaning process. No smoking, welding, or cutting when chemicals are circulating.
- Lots of tripping hazardous
- Determine areas that safety equipment needs to be worn and what level of safety equipment is needed.
- Recommend a safety brief in control room at start of each shift. Safety brief to be given with assistance from chemical cleaning contractor.