TECHNICLA PAPER OF FIN TUBE COOLER CLEANING

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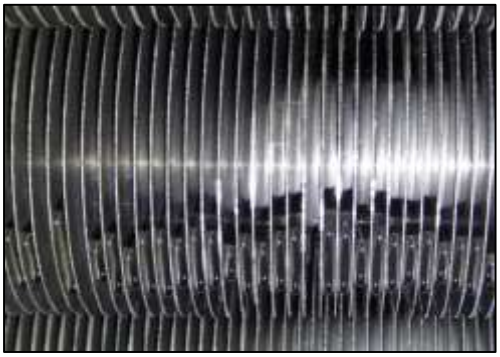
- Summary
- Finned tubes Fouling and its effect
- Examples of Tube and fins damages due to improper cleaning methods
- Chemical Cleaning Procedure
- Chemical cleaning work Gallery
- Deposits proceeds dissolved cleaning with the ECOS-R1
- Fin Tube cleaning result and effect evaluation by temperature Trend
- Carbonate formation by cooling water spray
- The mechanism of corrosion of aluminum alloy



■ Summary

SKP Chemical Cleaning offers the following benefits and results.

- ❖ Cleaning is performed On-Line during normal operating of the unit, there is no need to shut it down.
- ❖ Removal of scale and fouling from external tube surface, forced and induced

type coolers, thereby increasing thermal efficiency (heat transfer).

If several fans are running, you can turn off some of them.

As a result, reducing process outlet temperature, increasing production rate and in case of variable speed motors reducing operating energy consumption (fan power).

1. No jet water (no physical damage to fins)
2. No dry-Ice (no thermal shock to tubes and fins, especially to aluminum or copper fins)
3. No use foam or soap (no caustic stress corrosion and chemical damage)
4. No clean-up and disposal to WWT(lowest COD & neutral pH)
5. No harmful chemicals (no negative environmental impact)
6. No damage to tubes, fins, electrical motors, instrumentation.
7. Evaluated and proven results in industrial filed
8. Removes all debris and corrosive elements
9. pH balanced chemical formula that dose not react with all metal materials (Aluminum, copper , steel and it's alloy)

<u>Major Benefits</u>

- ➢ Improved cooling performance and unit efficiency
  Increase of throughput / production (Increase product yield)
- ➢ Prolonged unit life
- ➢ Energy saving by reduced fan power (in a variable speed & pitch control motors)
- ➢ Reduce temperature profile of the column O/H and easy to control
- ➢ Reduced maintenance costs

<u>Cleaning Process is SAFE and Environmental Friendly</u>
<u>On-Line , Off-Line execution</u>

- Developed over years of R&D and field experience
- Cleaning chemicals are Non-toxic, Non-hazardous, Non-corrosive, Non-poisonous, Non-flammable, Non-transport regulated
- No damage to metallurgy, electrical motors, instrumentation
- Chemicals completely dispersed, appear like steam (When on- line cleaning)
- Chemicals are compatible with all types of air coolers

Why should we keep AFC clean?

- Dirty fin tubes reduce the cooling efficiency of heat exchangers.
- SKP's cleaning agent & methods removes deposits safely and thoroughly.
- After cleaning the cooling equipment begins to operate at optimal levels and the result bring multiple financial benefits.
- Clean exchangers results in less energy requirements allowing fans to be turned off or run more slowly.
- Equipment life is extended and most importantly, production can be increased
- Deposit is long-term exposure to air pollution and moisture causes the surface corrosion deepening of Fin.

Profits from proper management (cleaning) of the fan cooler

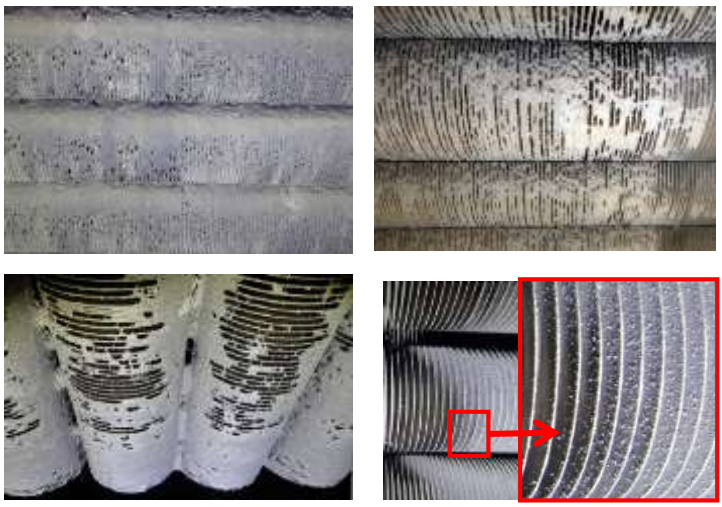
- Energy saving cost can be calculated accurately by operating data.
- If the clean heat exchanger operates at the optimum condition, you can turn off the fan or reduce to half power.
- True return is due to increased production capacity.
- SKP's clients can save a lot of money when equipment returns to peak efficiency.
- Based on energy savings and production yield, ROI can be determined quickly.

Maintaining a stable temperature in the reflux Fractionator column is brought an increase in the yield, and produces a condensate of the correct specification. Moreover, If you lower temperature, the feed rate can be increased. In some processes, it is possible to reduce the off-gas emitted to the Flare, thereby achieving enormous cost savings. (see the temp' trend dada)

SKP provide an eco- friendly, safe and effective cleaning process.

- Our chemical cleaner dose not damage the material of Fin tube and dose not affect the exposure to human body.
- The low pressure circulating cleaner penetrates into the crevices of the fin tubes and continuously removes and dissolves the deposits.
- Our chemical cleaning completely removes dirt, debris and corrosive elements without damaging equipment.
- Our chemicals are non-hazmat, non-toxic, not regulated for transport
- The chemical consists of a safe cleaning composition based on food additives.
- SKP's fin tube cleaners have been tested and proven in a variety of industrial facilities. →.(HDO, ExxonMobil, LOTTE chemical etc.)

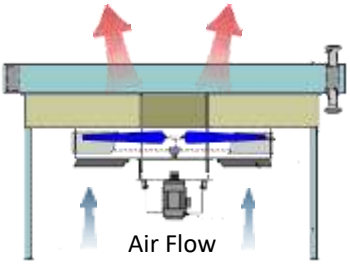
■ Finned tubes Fouling and its effect



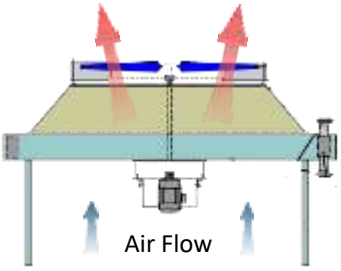
Various types of deposits on finned tubes

Temperature control by Louver, fan pitch inverter motor. Overload due to fouling will cause a damage to the device and the current consumption.

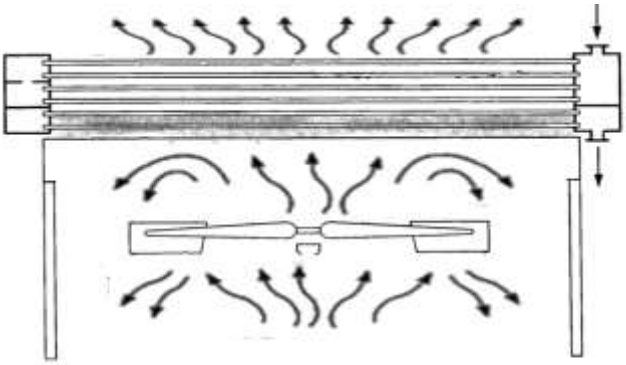
Deposits cause corrosion both directly and indirectly. If deposits contain corrosive substance, attack is direct; interaction with the aggressive deposits cause wastage. A clean surface will not only improve thermal efficiency, and also extend the life of the equipment.

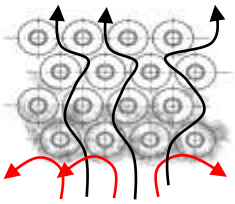


Forced draft fan



Induced draft fan





Air Flow under partially plugged bundle

In a forced - draft air cooler , cool air is blown through the underside of the fin tube bundle . In an induced - draft air cooler , cool air is drawn through the underside of the fin tubes .
Either way , road dust , dead moths , catalyst fines , and greasy dirt accumulate along the lower row of tubes . As the tubes foul they other more resistance to the airflow .
The cooling efficiency is reduced by interrupting the air flow between the tube arrays.

■ Examples of Tube and fins damages due to improper cleaning methods

❖ Physical damage to fins due to usage of high pressure water jet

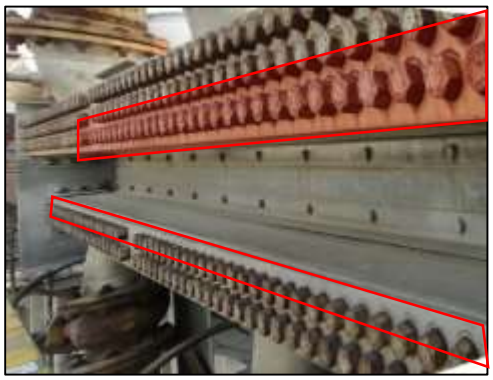
- ✓ High pressure jet water cleaning causes that become distorts or broken the cooling fins.
- ✓ Particularly in the case of long-used Fin tubes, some oxidized fins break and cause serious damage.
- ✓ In visual inspection, the surface areas may appear clean but deposits remains the center of the cooling unit. It will be interrupt the flow of air through the bundle and significantly reduce cooling efficiency.
- ✓ In the water jet method, metal oxides and hydroxides (aluminum oxide, aluminum hydroxide) formed on the surface of the metal Fin are not fundamentally removed. These residual oxides and hydroxides are factors that increase corrosion.
- ✓ The CO2 blasting method has a disadvantage similar to water jetting, It is not suitable for the cleaning of the fin tube inside the cooling unit.

❖ Cleaning with alkaline detergent

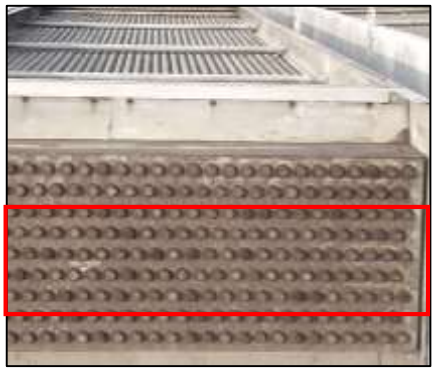
- ✓ In general, a cleaning agent using a foam cleaner is a method of spraying a cleaning agent containing a surfactant in a strong alkaline solution at the top of a fin tube. Then, immediately rinse with plenty of water.
- ✓ Components of the detergent (caustic soda) penetrates through the deposits, reacts with the surface of the aluminum fins to generate more bubbles, and the surface is etched and simultaneously the deposit materials are removed.
- ✓ Aluminum materials are amphoteric metal and are easily corroded in acid or alkaline environments.
  It may appear to be clean when viewed from the outside after cleaning, but it is actually metal corrosion and shortens the life of the equipment.

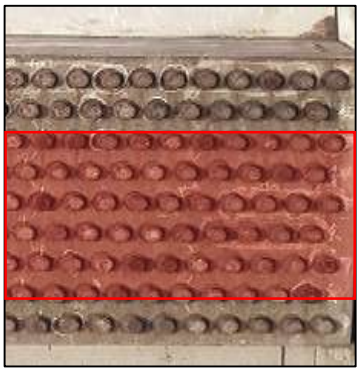
<Caution> Fin material is generally made of aluminum alloy (or copper alloy), especially since aluminum is an amphibious metal that is vulnerable to acid and alkaline chemicals, the choice of the wrong detergent will result in serious equipment damage.

❖ Conventional cleaning method according to the type of the bundle can not perform perfect cleaning



tube heat of the red line part of the double-bundle using the physical cleaning methods such as high pressure washing, It can not be cleaned.





In the conventional cleaning method, the middle position tube rows of the fin tube bundle can not be completely cleaned.

■ Chemical Cleaning Procedure

preparation

- Check the specifications and conditions of fin tube, and calculates the amount of chemical. In the case of on-line cleaning, the cleaning procedure is planned considering the operation condition. (turn off part of fan and perform partial cleaning stepwise)
- The cleaning work team obtains a permit for the safety work instructions and cleaning procedures of the process, and prepares the cleaning tools and cleaning agent.
- Prepare a cleaning agent and a utility (water, power) for cleaning, and install a barricade around the unit and work space. If necessary, install a scaffold. Install the water pool under the fin tube bundle for the circulating cleaning method of the cleaning agent.
- Wear safety goggles, masks and protective clothing when cleaning.
- Before starting the cleaning operation, turn off the fan motor power breaker and local switch and attach off tag. Further, disconnect or tie the fan belt pulleys.

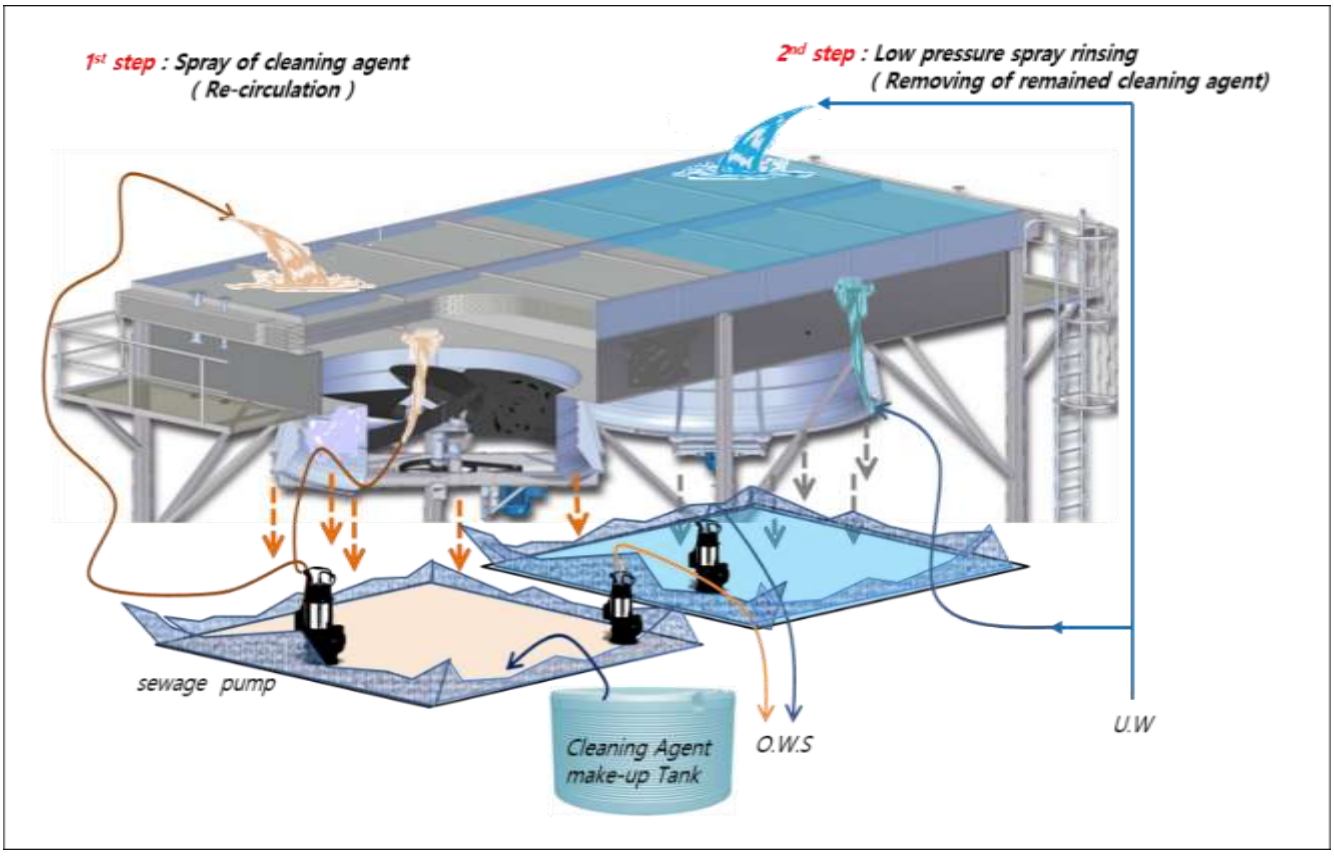
Cleaning Step

1. Spray cleaner down over the entire surface of the top of the fin tube bundle with low pressure to let it flow down and allow the fin tube to wet in enough to dissolve the contaminants and flow down to the water pool below.
2. When the upper spray cleaning is completed, the lower pin tube bundle should be spray-cleaned in the same way. The cleaning state is carried out while visually confirmed in real time.

Rinsing

When finishing of the fin tubes is completed, low pressure water is sprayed to remove any residual cleaning agent and impurities, Cleaning chemical and wash water are treated according to regulations.

In general, eco-friendly our cleaning agents are not difficult to treat wastewater. They are drained to Sewer (O.W.S) and sent to the wastewater treatment process.



Schematic of cleaning method with ECOS-R1

■ Chemical cleaning work Gallery



Waterproof canvas and water pool (Preparation for circulating cleaning)

Top spraying

bottom spraying

bottom spraying

Top spray , online-cleaning


Chemical dosing work

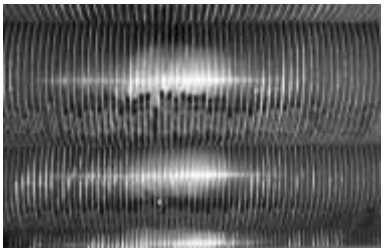

Top side water rinsing

Waste water drain

■Deposits proceeds dissolved cleaning with the ECOS-R1

1. The pin tube is fouled with deposits

2. Deposits are dissolved down by ECOS-R1

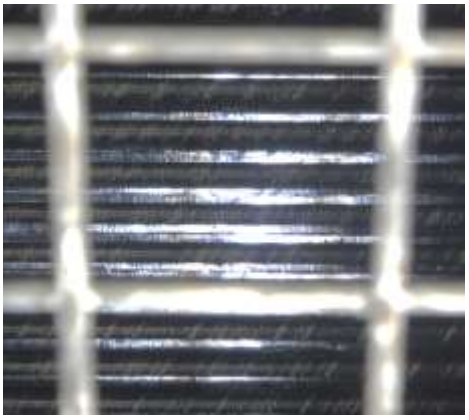


3. Cleaned finned tubes after cleaning

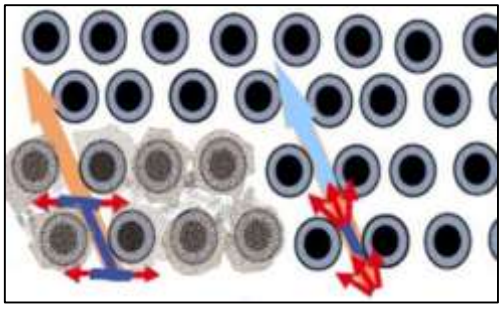
The fin tube cleaning should be free from damage by physical and chemical methods, and it is preferable to dissolve and remove the deposits by acting on all the tube rows of the bundle

You can visually confirm the state of light passing through the fin tubes.

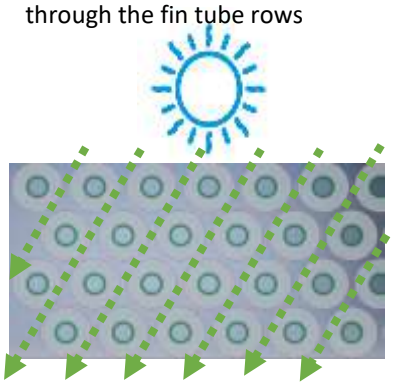
Before cleaning : Light does not
Pass through accumulated deposits



After cleaning : Light is transmitted
through the fin tube rows



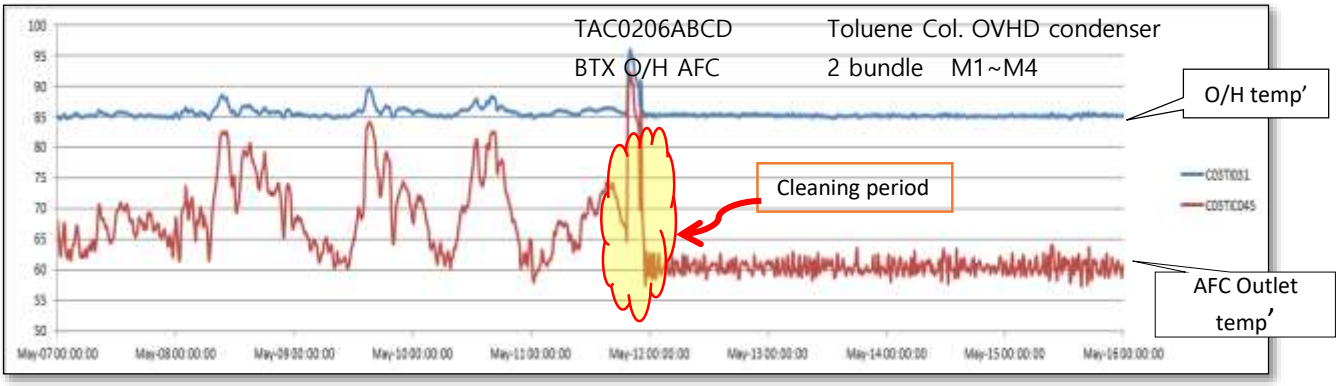
Air flow : Fouled tubes vs clean tubes



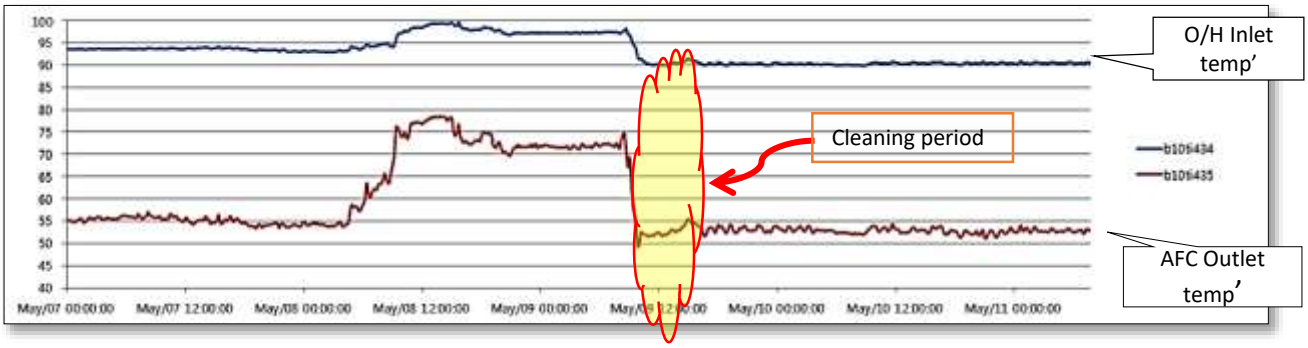
You can see the cleaning status
as a diagonal line

■ Fin Tube cleaning result and effect evaluation by temperature Trend

❖ Examples of Toluene column Cleaning performance : Temperature data analysis confirmed the stable trend, No bouncing



❖ Examples of CDU overhead Cleaning performance : O/H and COND out showing temperature down trend



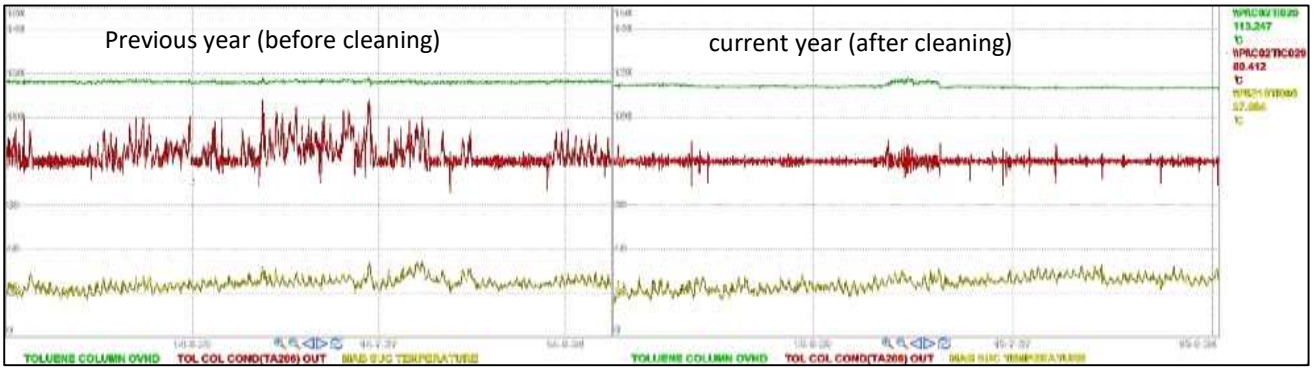
➢ Column O / H Confirmation of Reflux Flow Rate and Feed Rate Increase: Sufficient O / H Reflux Flow is essential to increase feed rate, The column O / H reduces the vapor load and enables stable operation, which is a source of increased production.

➢ Stable temperature control of Column O / H is confirmed : Over Load causes Temp 'Bouncing. It also has the effect of improving the quality of the accumulator product.

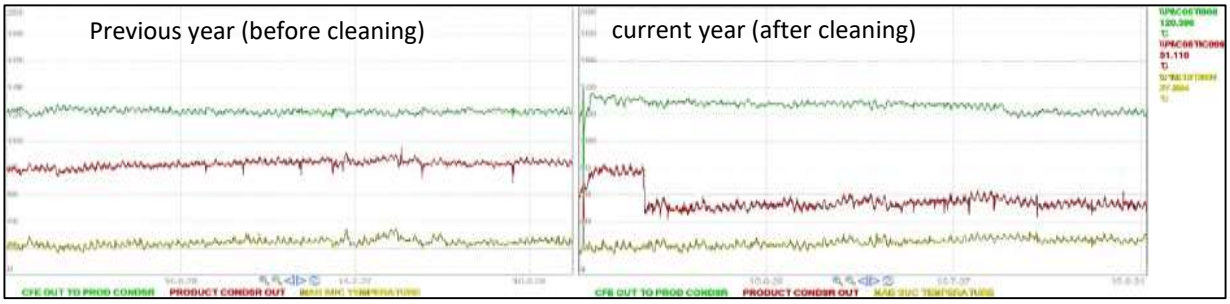
➢ Confirmation of out-let Temp 'of product cooler : Maintain proper temperature of products storage tank

Compared to the previous and current year

❖ OVHD Column before Vs After Cleaning → Temperature trend is stable, No bouncing



❖ Product Condenser Column before Vs After Cleaning→ Temperature is Down



Application example

Exxon Mobil OVHD AFC cleaning results and photos (ECOS-R1)

Below is the AFC Fin tube banks before Cleaning

Below is the AFC Fin tube banks after Cleaning

E-105	Max before	Max after	Delta T	Min before	Max after	Delta T
Bank 1	85.84	67.04	-18.80	51.74	44.19	-7.55
Bank 2	77.37	60.33	-17.04	48.06	41.29	-6.77
Bank 3	89.90	70.07	-19.82	56.24	51.94	-4.30
Bank 4	84.42	67.06	-17.36	48.89	47.31	-1.58
Bank 5	86.33	70.55	-15.78	65.15	62.87	-2.28
Bank 6	91.60	71.28	-20.31	71.35	62.17	-9.18

D-103 accumulator	Max before	Max after	Delta T
	80.73	70.08	-10.65
	Min before	Min after	Delta T
	55.69	57.97	2.27
	Average before	Average after	Delta T
	72.14	65.39	-6.76

*All temperature in °C

Data is the trend I pulled out from 2 days of observations.

ExxonMobil

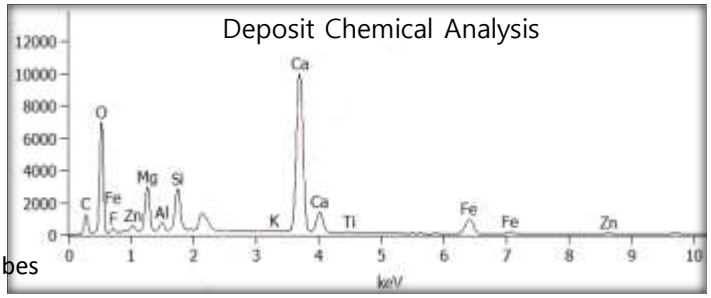
Customer Message

"The individual banks cleaning looks effective by the significant reduction in max outlet temperature.
I am convinced this is an important step to bringing down the D-103 accumulator temperature (Also shown).
Thank you for the hard work during this period!
This results has served us well to identify potential applications for this chemical cleaning."

■ Carbonate formation by cooling water spray

Surface of normal finned tubes

Carbonate deposits on finned tubes



Unusable finned tubes

Calcium (CaCO3)	--------	62.64wt%
Magnesium (MgCO3)	------	19.59wt%
Silicon (SiO2)	---------	9.40wt%
Aluminum (Al2O3)	----------	1.38wt%
Iron (Fe2O3)	---------	5.00wt%
Titanium (TiO2)	---------	0.40wt%
Zinc (ZnO)	----------	1.49wt%
Potassium (K2O)	---------	0.10wt%

Examples of Carbonate Formation

When water is sprayed on the top of the AFC bundle to prevent the temperature rise of the heat exchanger.
The minerals contained in the water accumulate on the surface of the fin tube, resulting in a rapid heat exchange efficiency Lower. When intensified and results in the loss of heat exchange.

When the water evaporates off the coil it will leave these minerals behind, and over time they will build and act like insulations on surface.
Even if it was possible to keep all minerals out of the water, the constant exposure of the fins to water over time will corrode the fins, leading to a loss of surface that can get rid of heat.

■ The mechanism of corrosion of aluminum alloy

Aluminum materials are amphoteric alloy and easily corroded in acidic and alkaline environments. The surface of the finned tube is converted to Al2 (OH) 3 and Al2O3, which reduces the heat transfer rate and causes the heat transfer efficiency to drop rapidly with the deposit.

$$Al^{3+} + 3H2O = Al(OH)^3 + 3H^+$$

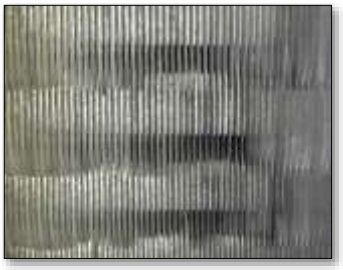
$$2Al(OH)3 = Al2O3 + 3H2O$$

The dust, greasy dirt accumulated in Finned rubes so promote corrosion by acid rain and alkalinity yellow dust , by carrying out periodic cleaning must be isolated from the corrosive environment factors.
Very important in performing cleaning is the use of chemicals that do not React with aluminum material at all and that do not cause corrosion at high and low temperatures, even if some cleaning chemicals remains after Rinsing.

❖ Comparison of Surface states → Rough surface easily accumulate debris

Bright surface after cleaning

Lose the Bright surface after cleaning

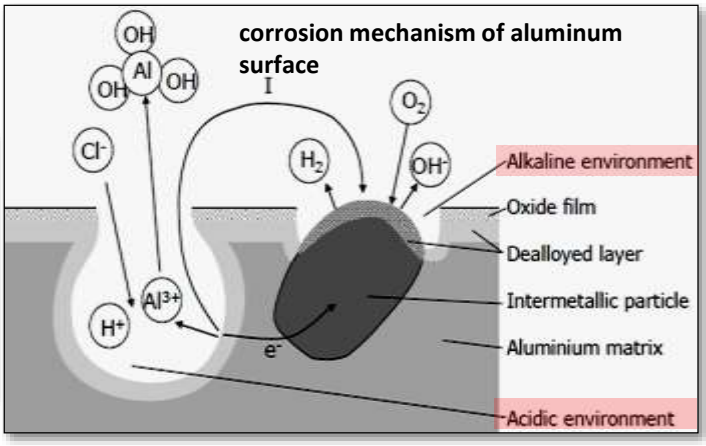


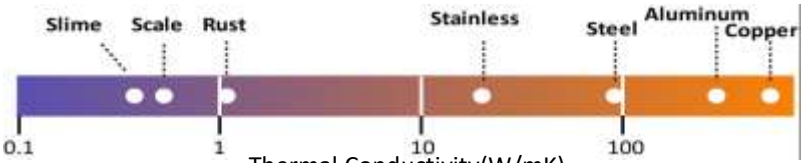
Damaged surface can not be restored by cleaning

thinned and easy to break fins due to corrosion

❖ Chemical properties of aluminum

Corrosive condition of the corroded Finned Tubes when the cleaning control is insufficient, or when an improper cleaning agent (e.g. caustic soda containing cleaning agent) is used





	Metal Aluminum alloy	: **235**
W/(m2・℃)	Deposits Aluminum Oxide, fused(Al2O3)	: **3.60**

$$Al^{3+} + 3H2O = Al(OH)^3 + 3H^+ \qquad 2Al(OH)3 = Al2O3 + 3H2O$$

When the heat exchanger are dirty, the fins corrosion is faster.

When the aluminum oxide film is brought into contact with air containing moisture, the oxide of the barrier layer is deteriorated to generate a gap, and the oxygen penetrated into the oxide film reacts with aluminum, so that a new porous oxide film is grown on the barrier oxide film.
In the case of high-purity aluminum, the reaction with water is very slow in ion-exchanged water at 20 to 30 ° C without impurities, and there is almost no change. However, when the water temperature is high, The oxide film changes to amorphous aluminum hydroxide and the corrosion layer thickness increases. Hydrated aluminum oxide has no effect on passivation, but rather promotes corrosion

Moisture content in the oxide film reaches 35 to 70% at 40 to 60 ° C and forms amorphous Al (OH) 3.
pH (Hydrogen Ion Index): Al proceeds at a faster rate in acid or alkali than in distilled water. And the rate of corrosion in acid depends on the nature of negative ions. The corrosion rate according to the pH of the aluminum alloy is drastically increased at pH values below 4.5 or above 7.
Hazardous ions: Al is greatly accelerated by cations such as Cu2 + and Fe + 3 as well as moisture and negative ions such as OH- and Cl-. Therefore, it is not desirable to spray an optionally refined water (especially containing Cl ions) in the AFC in anticipation of the cooling effect using latent heat of vaporization. Furthermore, when water containing Ca and Mg ions is used, carbonate should be avoided as it accumulates on the surface of the fin tubes.

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