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A&R

SERVICE INSTALLATION MAINTENANCE

Volume 3 Number 2

Supplement to Air Conditioning and Refrigeration Journal

# Condenser Descaling

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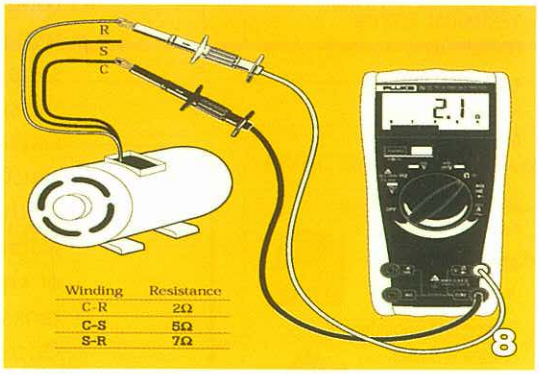


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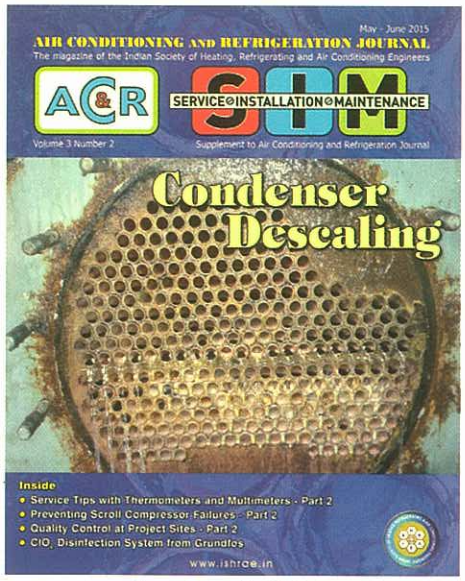


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# FROM THE TECHNICAL EDITOR


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Hard water scale build-up in equipment like heat exchangers and cooling towers reduces their efficiency, and consequently increases the power consumption of the system of which they form a part. Scale deposition is generally caused by the lack of an appropriate water treatment plan, or its improper implementation. Equipment such as steam generators, cooling towers and evaporative condensers normally include some kind of external water treatment devices, such as a water softener, deioniser or reverse osmosis device to remove the salts of calcium and magnesium, which cause hardness, from the water before they enter the equipment. Such prevention is the only long term satisfactory means of ensuring scale free conditions, and is successful if and till the equipment is maintained properly and monitored regularly. If external water treatment equipment is not used, scale formation is inevitable. Examples of equipment that experience scale problems are heat exchangers, process tanks, humidifiers, water cooled machinery and plastic moulding machines. Once the scale formation has taken place, acid washing is the most widely used method of removing the deposits. Heat exchangers using sea or river water for cooling are also susceptible to formation of scale deposits due to biological or suspended matter fouling. Such deposits are removed using specially formulated alkaline cleaners. Descaling, therefore, is a specialised operation that is best left to agencies that have the knowledge, experience and equipment to address the problem competently. The cover story of this issue, which focuses on condenser descaling, gives an overview of the equipment and processes used in this operation.

In the last issue we had started a three-part article on quality control at project sites, containing typical checklists for inspection of M&E installations. In international practice, such checklists form the bases for preparation of snag lists prior to project hand-over. Following this practice will certainly enhance the quality of project work in India. We now bring you the second part of this article.

The concluding part of the article on preventing scroll compressor failures explains the reasons for and consequences of loss of oil, system contamination and electrical failures, showing how such failures may be prevented. We also conclude the article on troubleshooting tips using thermometers and multimeters in this issue. In our regular department *In the News*, we bring you recent events that have a bearing on field activities. And *My Business*, as usual, is a valuable resource for aspirants who wish to set up and manage their own little business empires.

In addition, we carry all the usual departments that hone your skills as a field professional.

***Rakesh Kumar**, Technical Editor*

# Condenser Descaling

Scaled condenser tubes

**By Mahesh R. Mehta**
*Ecochem Plus, Mumbai*

## Introduction

Heat exchangers (HEs) are used in a variety of systems, including air conditioners, chillers, furnaces, boilers and condensers. Shell-and-tube and plate HEs work to cool air compressors, oil pumps, extruders, food processing and other equipment.

Water is widely used as a medium for heat exchange. Water is a scarce resource. Since it has a low cost, it is widely used as a coolant. During the last few decades, water quality has deteriorated faster than ever. This is due to its uncontrolled demand and use. Water borne contamination build-up takes place in such conditions, seriously retarding HE performance. HVAC system performance and efficiency are directly related to water quality.

## Fouling and Scaling

When contamination deposits on the surface, it accumulates and reduces heat transfer while increasing the pressure drop. These deposits can be biological in nature or solid mineral deposits, if water is used as the primary heat exchange medium. Fouling can be caused by any particles that are able to 'cling' to the heat transfer surface. This can be removed relatively easily by mechanical means such as hydro-blasting or scrubbing with a soft bristle brush. Some types of fouling (such as the typical cooling tower fouling) also respond well to caustic cleaning-in-place (CIP) treatments, if opening the heat exchanger is not practical or frequent treatment is needed.

Scaling is a different phenomenon. It occurs when a mineral film coats the entire surface of a heat exchanger. The most common forms of scale are usually calcium based salts such as calcium sulfate or calcium carbonate. Scale on a surface greatly affects heat transfer, reducing equipment efficiency and increasing energy consumption.

Poor water quality or ineffective chemical dosing (i.e. using less than the quantity of chemical required to prevent scaling) leads to scale formation in heat exchanger tubes, reducing heat transfer. New sites prefer water cooling due to its higher energy efficiency. At the same time, poor water quality requires frequent descaling. Choosing the right descaling chemical is most important, when options are limited.

### *Fouling*

Any deposit buildup that affects heat transfer leads to inefficiency, increasing energy costs, creating wear and tear

## About the Author

**Mahesh Mehta** entered HVAC industry accidentally, being a Textile Engineer. He started by marketing eco-friendly non-toxic imported chemicals in Western India in 1999, conforming to standards like RoHS and MIL. He then began executing turnkey orders for coil cleaning in industrial AC plants with imported specialized equipment, using a combination of mechanical and chemical cleaning. He has worked with multinationals and Indian companies in pharmaceutical, food, hotel and IT industries for deep coil cleaning, descaling, fin coating, environmental corrosion control, power saving, etc. He likes to work at challenging sites.

on the system and increasing plant downtime. Even a light coating of buildup can reduce heat exchange. Fouling materials can consist of living organisms (bio-fouling) or non-living substances (inorganic or organic).

Fouling can be caused by the following factors:

- Crystallization
- Decomposition of organic products resulting in tar or cokes
- Polymerization or oxidation
- Settlement of sludge, rust or dust particles
- Biological deposits
- Mineral deposits (lime scale)
- Corrosion
- Pre-site construction deposits

***Scaling***

Scaling is an issue as water quality varies when supplies are from unknown sources (e.g. tanker supplies). It may be caused by water fouling or uncontrollable bio growth. There are no effective chemicals and no specifications for dosing treatments. It is aggravated by season related water problems (e.g. scarcity in summer, muddy water in monsoon, etc.).

To address fouling, the following three methods are used:

i. Mechanical cleaning (brushing, scraping, etc.)
ii. Chemical cleaning (solvent or chemical reaction)
iii. High velocity water jets

Chemical descaling is the most widely used process in our industry due to the common use of copper tubes. The problems faced under such circumstances are:

- Finding the right chemicals
- Finding the right team to carry out the job
- Finding the right equipment for the job

An old age practice is to circulate a chemical from a large drum for certain hours, mostly depending on the team leader's experience, followed by opening of both sides of condenser covers and carrying out manual brushing. This is followed by gasket changing and closing back the system. The entire operation takes 1-2 days or longer, depending on site conditions. The drawbacks of this method are:

i. New generation energy efficient condenser tubes are grooved internally or from both sides for better heat exchange. They trap scale, which is difficult to remove with this method.
ii. Major chemicals turn the chemical bath black, showing that the chemical is attacking various metals inside the condenser. This chemical has to be drained after use and cannot be re-used. This is costly, and harmful for the ecology and equipment life. Raw corrosive chemicals cause copper tube corrosion, affecting its life.
iii. Removal of scale from internal grooving is nearly impossible with manual brushing operation. Scale from the tube's lowers ends cannot be removed by brush bristles. Special equipment and brushes are required.
iv. Space costs being high, it is generally not practicable to leave 10m space for manual brushing in front of the condenser cover. Mechanical brushing hardly requires 1-2 people for the entire cleaning operation, and requires much less space.
v. The entire cleaning operation depends on the team leader's experience, which can be inadequate.
vi. Labour requirement is very high for brushing, cover and pipeline removal, gasket making, etc. Availability of trained manpower is an issue in India.

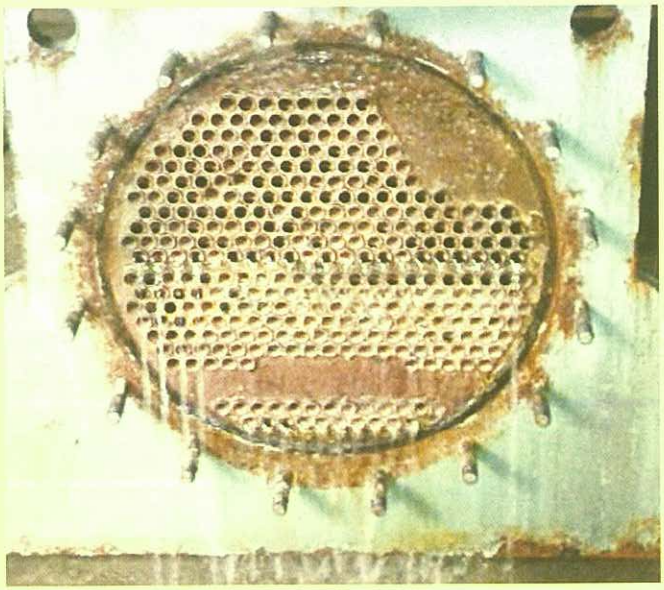

*Figure 1: Descaled tubes*

A majority of the above issues can be avoided by using automated mechanical processes. Let us take each item individually.

## Chemicals

Use industrial biodegradable chemicals, which dissolve rust, scale and oxides (including calcium, lime, rust, lithium carbonate, etc.) as they are safe on metals, paint, plastics and rubber gaskets. It is advisable to have both acid and alkali products for use. Generally, white calcium based scales are removed by acidic products; they are used for descaling and alkaline products for neutralization. The reverse is recommended when scales are green or yellow in colour due to specific water treatment chemicals in use.

Modern descaling chemicals are available in liquid and powder form. The latter is useful from the storage and logistics viewpoint. Powder products can be made into 20-30% solution with a working pH of 1.5. A safe biodegradable chemical bath does not change its colour even after 10-12 hours of working. Such baths can be reused – just maintain the desired pH by adding more chemicals; remove scale traces that may have settled in storage drums.

Certain chemicals allow heating of the chemical bath. This is a great advantage as it helps reduce the descaling process time. The bath can be heated up to 50-60°C. Scales migrate from low to high temperature, thus easing the process. Such baths do

not have overpowering fumes and are fire-safe for in-plant use.

Some chemicals are available in powder form and have the following advanced properties:

- Colour indicator: the bath is red in colour; when pH reduces below the desired level, it turns orange indicating more chemicals need to be added to the bath. The ordinary layman knows 'top-up' time for extra chemical addition. Such chemical also works in hard water up to 500 ppm.
- Heating: The chemical can be heated up to 60°C to hasten the descaling process.
- Concentrated powder: 30% dilution gives 1.5 pH.
- Reducing transportation, storage and handling cost.

## Equipment

### *Automated Circulation System*

There are portable systems available; when attached to the condenser inlets and outlets, they take control of the chemical, storage, circulation, pH checking and maintenance, and automate dosing when pH has reduced, thereby maintaining process consistency and eliminating human errors.

### *Mechanical Tube Cleaning*

The tubes can be mechanically cleaned after chemical circulation. It helps in reducing working space by 90%, tube cleaning time by 50% or more, and labour requirement. In addition, condenser cover of only one side needs to be opened; it avoids opening of the header and all the pipelines and gasket changing. It is possible to have better control on draining of water from the other side, leading it directly to the drain system via pipes or hoses. This avoids the mess of spilling of water and scales on the floor, minimizing the after-cleaning operation of the work area.

*Figure 2: Mechanical tube brushing after chemical circulation*

After chemical circulation, plain tube scales may be removed even by plain water flushing, but water usage is abnormally high in this crude process. Manual labour and space requirement is also high. Mechanical brushing is a better process. Two operations need to be carried out at the time of brushing:

a) Detachment of soft scale from the tube walls.
b) Flushing out of scales from the tubes and internal grooving.

Mechanical tube cleaning system is trolley mounted and comprises a motor, flexible hose and rotating brush connected with the motor through a flexible shaft. The running water from the hose displaces the soft scales and leads them out from the entire length of the tube.

For plain tube cleaning, one maysimply use a flexible hose connected to a high pressure pump gun, and a cleaning nozzle attached to the other end. When trigger of the gun is released, water from the nozzle is ejected through the nozzle opening; one of the straight jets pulls it inside the tube and the side nozzles, sprays the water jet with pressure, displacing the soft scales and deposits and flushing them out from the other end. The nozzles and flexible tube come as extra attachments with pressure jets. One size is suitable to clean upto maximum 6" ID tubes, or as the case may be.

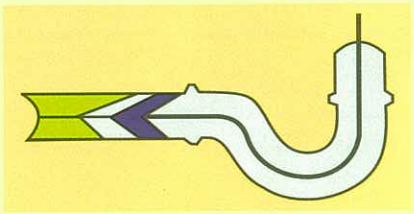

*Figure 3: Plain tube cleaning system*

## Process

### *Pre-Checks*

It is ideal to carry out pre-checks before starting descaling:

- Ensure the valves are holding water effectively, or else the entire operation would be futile.
- Check the effectiveness of the descaling chemical on the scales by using a small quantity, or by simply mixing both in a test tube. The scale should dissolve.
- The circulation pump should preferably be chemical resistant. Ensure that it has sufficient pressure to reach all the condenser tubes, and is ready to work for long hours continuously.
- Eco-friendly green chemicals may be initially costly, but they are cheaper on dilution since they have high dilution ratio. Moreover, being re-useable, they are more economical. Comply with the chemical supplier's instructions.
- Accessories like brush, bristles, etc., should be preferably new. Bristle height should be at the most the size of tube ID.
- Mechanical tube cleaners are the correct choice for internally grooved tubes. Otherwise, 100% scale cleaning is not possible and scale remnants will once again rise from the groove bottom and get attached to the tube walls.

*continued on page 13*

dry throats, dry skin, or excessive static electricity if the relative humidity is too low. If the humidity is too high, condensation may form on windows and the air will feel damp. Humidity should usually be between 35% and 65% for reasonable comfort.

The relative humidity in an environment can be determined by measuring wet-bulb and dry-bulb temperatures. Model 51, 52 or 16 can be used to make these measurements.

Take the dry bulb measurement by recording the temperature as you fan air past the thermocouple with a newspaper or other object. Do not blow on the thermocouple because your breath is warmer than the air you are trying to measure.

Take the wet-bulb measurement by placing a clean 3" (7 cm) piece of wet cotton shoelace over the thermocouple (the lace serves as a simple and inexpensive sock). The sock should be saturated but not dripping with clean water, preferably distilled. If the sock is not saturated, an inaccurate reading may result. The thermocouple should be inserted about half way into the sock.

Fan air around the sock. The temperature reading displayed on the thermometer will slowly decrease until the wet-bulb temperature is reached. This typically takes a minute or two. Record the temperature. Now use the psychrometric chart to find the relative humidity. Start on the bottom axis at the dry bulb temperature. Move vertically along the dry bulb temperature line corresponding to your reading. Locate the intersection of the diagonal line that represents the wet bulb temperature. The relative humidity is indicated by the curved line that runs through the intersection of the two temperature lines.



## Condenser Descaling

*continued from page 7*

- In case of doubt, ask for OEM/expert help.

***Descaling Process***

Ensure everything is in place and order. First, start circulation with plain water. Check water level after approximately 15 minutes. If water level is stable, slowly add chemical to the bath. It is safer to add chemical slowly to water, rather than water to chemical. Change in water level indicates that valves are not holding. Stop the process and rectify this problem. Ensure all the instructions of the chemical supplier are adhered to. Ensure constant pH level is maintained, so descaling time is not extended. In case of pH change, top up the bath with chemical and maintain constant recommended pH. It is normal practice that if pH remains constant for long time, it is assumed that scales are softened. In case of doubt, increase circulation time. If there is no change of bath colour, ensure that chemicals are not attacking metals inside the condenser. Once the acidic circulation is over, collect the re-useable type of chemical in drums. It is advisable to have a neutralizing circulation of eco-friendly, metal safe, alkaline chemical after acidic circulation. Ensure the final bath has neutral pH for 15-30 minutes before stopping the process.

Open any one of the side covers and start the mechanical tube cleaning operation. Follow the supplier's instructions and advice. While cleaning the entire length of tubes, the other closed side outlet will be flushing out the water and scales. Attach tubes to this opening, so the slurry finds its direct final destination in the drain outlet.

HEs with non-copper tubes can be descaled with scale cutters (instead of rotating brush), which can clean 100% choked tubes without chemical circulation.

To confirm if optimum results have been achieved, use a video probe, which is slipped inside the tubes. Internal conditions can be monitored and recorded for viewing. This will be very useful for internal grooved tubes.

### Conclusion

The best energy saving HVAC systems and designs can underperform due to poor maintenance. This is unfortunate, since more than one third of the energy used in a building is for HVAC. Heat exchangers use a major part of this energy. Equipment owners, engineers, contractors, and other specialists devote a great deal of effort, time and money to reduce energy costs, maintenance costs and complaint calls. They would do well to use proper descaling methods to ensure that the plant keeps working at the design energy efficiency. Annual cleaning will maintain heat exchange efficiency. Whether you have straight or spiral enhanced chiller tubes, tube cleaners clean them faster and better. Tube cleaning machines make tough tube cleaning a simple, one- or two-person operation. They clean soft scale, biological and other buildup in chiller tubes quickly. They are ideal for cleaning tubes and pipes from 1/4" to 1" (6.4 - 25.4mm) ID in chillers, condensers, evaporators, absorption machines and heat exchangers.