



INSTALLATION, OPERATION AND MAINTENANCE MANUAL

For

SHELL AND TUBE ACID COOLER

Company Name : M/s. IFFCO, Paradeep unit.
Place : Paradeep
P.O. No. & Date : 6525/252004173330 date - 15/03/2017
Product : Alloy Acid Cooler for IAT
Our Job No. : AC 16/17 - 18B
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1. PREAMBLE

This manual is designed to guide the plant personnel during activities like Acid Cooler installation, commissioning, regular production, maintenance, routine startups, shut down and how to improve the life of the Acid Cooler.

The attempts have been made to describe most of the activities from the Acid Cooler installation to stoppage. If any required areas or activities remain undescribed, the plant personnel may point it out.

Galiakotwala Engineering Co. Pvt. Ltd. welcomes the customer to improve the quality of instructions and also point out additional areas to be covered in the manual.

In case any problem with Acid Cooler, **M/s. Galiakotwala Engineering Co. Pvt. Ltd.** may be contacted at contact information given on the title page.



2. INTRODUCTION

The Acid Cooler is shell and tube type, horizontally or vertically installed unit. It is designed to cool the hot Sulphuric Acid using cooling water.

Hot Acid is fed to the Acid Cooler through inlet acid nozzle, it gets cooled and leaves via exit acid nozzle provided on the shell. The cooling water enters in the tubes from water nozzle, gets heated and leaves via exit nozzle. The acid and water flow pattern can be cocurrent or countercurrent in the Acid Cooler.

One drain and one vent nozzles, are provide on the shell side of the Acid Cooler. Also one vent and one drain nozzles are provided on tube side. The Acid Cooler will be installed on the saddle supports.



3. ADVANTAGES OF THE SHELL AND TUBE TYPE ACID COOLER OVER SERPENTINE (TROMBON) ACID COOLER AND PLATE TYPE HEAT EXCHANGERS.

As stated earlier shell and tube type Acid Cooler is provided to cool the Sulphuric Acid. Traditionally Serpentine (Trombon) Acid Coolers and Plate type Heat Exchangers (PHE) were used to cool the acid. However the shell & tube type of Acid Coolers have many advantages over Serpentine (Trombon) Acid Coolers and PHE heat exchangers.

3.1) Advantages of Shell & Tube type Acid cooler over Serpentine (Trombon) type acid cooler:

- a) Longer life** : The corrosion rate at given temperature and concentration is low provided proper concentration (98.5%) is maintained. The expected life is 5 years or more.
- b) Low Maintenance** : There is practically no regular maintenance required on this type of Acid Coolers. Only once a year inspection, to observe if any fouling has taken place.
- c) Leak free design** : There are only two connections for acid, one for the inlet and other for the outlet, minimizing possibilities of leaks. The Acid Cooler has all welded construction.
- d) Self cleaning** : The water side of the Acid Cooler is self cleaning when the right quantity of water is maintained through Acid Cooler.
- e) Vertical design** : The plot area required is very small because of compact design. The vertical installation on the side of the tower eliminates plot area requirement.
- f) Heat recovery** : It is possible to recover energy from acid circuit by heating feedwater.
- g) Quick installation** : There are only few connections required, two for acid and two for water.
- h) Clean operation** : Since there is no possibility of acid leaking outside, the operating is very clean.



3.2) Advantages of Shell & Tube type Acid cooler over Plate Heat Exchanger:

There are many advantages of this type of coolers over Plate to Plate Type heat exchangers:

- a) Longer life** : The corrosion rate at given temperature and concentration is low provided proper acid concentration is maintained.
- b) Low maintenance** : There is practically no regular maintenance required on this type of coolers – no changing of expensive gaskets. Only once a year inspection by removing end covers to observe if there is any fouling has taken place inside tubes.
- c) Leak free design** : There are only two connections for acid, one for the inlet and other for the outlet, minimizing possibilities of leaks. The heat exchanger has all welded construction, compared to many gaskets and joints for plate type cooler where each joint is potential for leakage.
- d) Self cleaning** : The water side of the heat exchanger is self-cleaning when; the right quantity of water is maintained through heat exchanger. The clearance within tubes is much higher compared to the tight clearance between plates. This helps in minimizing chances of plug gage / blockage.
- e) Heat recovery heating** : It is possible to recover energy from acid circuit by process water.
- f) Clean Operation** : Since there is no possibility of acid leaking outside, the operating is very clean.
- g) Vertical Installation** : Significantly reduces piping requirement from Pump discharge to Tower Inlet; This results into lower space requirements, savings in capital and Maintenance costs. Due to reduction of overall pressure drop operating cost is also reduced.



4. PRE INSTALLATION CHECK UPS

Acid Cooler is pneumatically and hydrostatically tested in workshop of **Galiakotwala Engineering Co. Pvt. Ltd.**

After receipt of the Acid Cooler, it should be checked that –

1. All the nuts, bolts used for tightening flanges of the Acid Cooler are available.
2. All the weldings of the supports, flanges, shell etc. are proper and not damaged at any place.
3. The supports, flanges of the Acid Cooler are in their position and are not damaged due to improper handling during the transportation.
4. The saddles for supporting the Acid Cooler are ready; and matches with the mating external supports.
5. All the nozzles as indicated in the Acid Cooler drawing are in their proper place & orientation.
6. The external supports, on which the Acid Cooler is to be installed, are in their proper place and orientation.
7. Piping with instrumentation related to Acid Cooler is ready, the piping flanges including their bolts holes match with the Acid Cooler flanges.
8. Lifting arrangement such as chain pulley blocks, scaffolding etc. are ready.

The Acid Cooler is tested hydraulically before dispatch and it is ensured that the Acid Cooler is leak proof. Hence, the ends of the Acid Cooler need not be opened. After any test involved water, The water on shell and tube side should be drained totally. Shell side should be ***dried** by passing the ***‘air’ or *‘Nitrogen gas’** through the shell (***Please Note: ‘Air’ or ‘Nitrogen gas’ should be absolute dry i.e. no residual moisture should be present after drying.**)

In case any major fabrication defect is noted, the **M/s. Galiakotwala Engineering Co. Pvt. Ltd.** should be contacted immediately.



5. INSTALLATION OF THE ACID COOLER

After pre-commissioning check ups the Acid Cooler is lifted using suitable lifting arrangements. Its lifting lugs are used to place Acid Cooler in its position.

There should be enough space around the Acid cooler for Inspection & Maintenance purpose, in case required in future. At Least 1 meter space should be left from bottom of vertical cooler.

The nozzles of the Acid Cooler are connected to their respective piping using suitable gaskets and the flange bolts are tightened properly so that there is no leakage through the joints.

First, **water on tube side is circulated** and it must be observed that the water flow is at a proper rate through the Acid Cooler, also confirm that there are no leakages in flange joints from the Acid Cooler, piping etc.

Now the Acid Cooler is ready to perform the duty.



6. OPERATION OF ACID COOLER

If Acid Cooler is to operate continuously. The following start up procedure should be adopted for the start up.

1. START UP PROCEDURE:-

Prior to feeding the acid, **the water circulation in all the tubes of the Acid Cooler shall be established.** For this the vent valves of the Acid Cooler on water side is opened. The drain valve on tube sheet sides is closed. By starting the cooling water pump, the water is fed to the Acid Cooler. The vent valve is closed as soon as the water starts coming out of the vent nozzle. The air trapped on tube side is thus totally removed, there is no airlock & water starts flowing through all the tubes.

After this the drain valve on the shell side of the Acid Cooler are closed, vent valve is opened. The acid is fed slowly to the Acid Cooler, by starting the acid circulation pump & opening slowly the valve at the discharge of pump. Acid vent valve is closed immediately as soon as the acid comes out of the vent valve. Care should be taken for any leakages while feeding the acid first time to the Acid Cooler. Acid may leak through the flanges or the welding joints of the piping. What actions are to be taken if the leakage is noticed in the Acid Cooler is given in Chapter 9 under E. **The acid pressure should be greater than water pressure throughout the Acid Cooler to identify tube to tube sheet leakage.** If required, orifice should be installed in the Acid Cooler exit in the acid line.

THE OPERATING PROBLEMS:-

If there are no leakage problems, the acid circulation can be continued. Initially for a few minutes the unsteady acid exit temperature will be noticed and subsequently become steady. The Acid Cooler thus starts cooling the circulating acid.

By controlling the fluid inlet / outlet valves in the process lines the acid exit temperature is controlled to the desired value. **The water valve settings should not be changed.**

The Acid Cooler operation has thus started.

RECORDING PROCESS VARIABLES DURING THE COOLING OPERATIONS:-

The pressures, temperature at inlet and exit of the process fluids are monitored regularly say weekly or fortnightly and a record of these data are kept to understand the operational problems of Acid Cooler. The PH of circulating water is also



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monitored regularly to confirm that there is no acid leakage into water from tube to tubesheet joints.

2. SHUTDOWN PROCEDURES:-

If the operation of the Acid Cooler is to be stopped due to plant problem, it should first be decided if the stoppage is of short (for a few hours to maximum 48 hours) or is long (i.e. more than 48 hours) in nature. Following procedures should be adopted for temporary stoppages.

SHORT SHUTDOWN:-

The acid inlet valve – outlet valves of the Acid Cooler are closed. The acid circulation pump is stopped. The cooling water inlet – outlet valves are closed and the cooling water circulation pump is stopped. All the drain and the vent valves are still closed. The Acid Cooler tubes and shell thus remain full with water and acid respectively.

LONG SHUTDOWN:-

For a long shutdown the acid inlet – outlet valves of the Acid Cooler are closed. The acid circulation pump is stopped. The cooling water inlet – outlet valves on shell side and the cooling water circulation pump is stopped. The drain valves on shell side and the tube side of the Acid Cooler are opened. The acid and water in the Acid Cooler is completely drained. Immediately after the draining of the fluids, the drain valves on the Acid Cooler should be closed.

The humidity of the air may dilute the acid and form a dilute acid which may corrode the Acid Cooler parts at a rapid rate, due to this entry of moisture laden air on acid side should be prevented by closing all the valves in the inlet and the exit acid lines of the Acid Cooler. To extend the Acid Cooler life it is advisable to introduce ***dry Nitrogen gas** through the acid vent line during the draining of the Acid Cooler (***Please Note: ‘Nitrogen gas’ should be absolute dry i.e. no residual moisture should be present after drying.**)

After draining the cooling water, all surfaces in contact with water may be rinsed with fresh water, in order to remove any scale deposited due to the dirt in the circulating water.





7. PERFORMANCE TESTS

M/s. Galiakotwala Engineering Co. Pvt. Ltd. recommends the performance test within a month after the start up of the Acid Cooler or within the twelve months from the date of dispatch whichever is earlier. Performance involves pressure drops, inlet, outlet temperatures of the process fluids at a specified flow rates. In case the specified performance is reached the guarantee is considered fulfilled. If the specified duty is not reached, **M/s. Galiakotwala Engineering Co. Pvt. Ltd.** must be notified. **M/s. Galiakotwala Engineering Co. Pvt. Ltd.** will take necessary corrective steps.



8. WATER QUALITY

The quality of the cooling water is important for trouble free operation of the plant. Poor cooling water can lead to corrosion of the piping and equipment, fouling of Acid Cooler surfaces leading to reduced heat transfer, plugging of Acid Coolers, etc.

A cooling water treatment program will usually involve addition of chemicals to maintain water quality within the required limits. The treatment program may include addition of an acid or base to control pH, addition of a biocide to prevent the growth of algae and corrosion inhibitors.

The design of a cooling water treatment program should consider the circulating water quality, The quality of the make up water and the materials of construction of the piping system and equipment.

A typical water quality is given in below Table for cooling water used in shell and tube type Acid cooler.

Water Quality Parameters for circulating water in Heat Exchanger

S. No.	Parameters	Limit
1	pH	6.5 to 7.5 (or as recommended by water treatment consultant)
2	Total Dissolved Solids (TDS)	Maximum 800 - 1000 mg/L
3	Total Suspended Solids (TSS)	Maximum 100 mg/L
4	Chlorides (as Nacl) mg/L	Maximum 100 mg/L



9. OPERATING PROBLEMS

- A. Acid exit temperature is higher than the specified value.
- B. Acid exit temperature is lower than the specified value.
- C. Pressure drop on shell side is too high.
- D. Pressure drop on tube side is too high.
- E. Leakage is noted on shell or Tube side.
- F. Acid does not flow in the Acid Cooler.
- G. Water does not flow in the Acid Cooler.
- H. Scale is deposited on the shell side.
- I. Scale is deposited on the tube side.
- J. Hammering is noticed on the shell or tube side.



10. OPERATING PROBLEMS, CAUSES AND THEIR SOLUTIONS

A) ACID EXIT TEMPERATURE IS HIGHER THAN THE SPECIFIED

VALUE:-

The reasons for this could be:

- a) Adequate cooling water may not be passing through the Acid Cooler.
- b) Hot fluid flow passing through the Acid Cooler at a rate higher than the designed.
- c) The cooling water or the hot acid inlet temperatures are higher than the specified value.
- d) The cooling surface of the Acid Cooler tubes might have fouled.
- e) The Acid Cooler surface may be inadequate to perform the duty.

The solutions for this problem are as follows:-

In the startup there is no fouling of the tubes. The Acid Cooler is tested in workshop before dispatch and therefore there is no chance of water short circuiting. Inadequate flow of cooling water or excess acid flow could be the first reasons to suspect. The process and utility fluids inlet outlet valves of the Acid Cooler should be checked first and it is ensured that these fluids are fed to the Acid Cooler at a proper rate.

Sometimes it is noticed that initially acid is cooled properly but subsequently the exit acid temperature increases even though water inlet and exit valve are full open. In such case, the reason for this could be that there may be fouling of Acid Cooler. This possibility can be checked and the corrective action can be taken when the Acid Cooler is stopped.



Galiakotwala Engineering Co. Pvt. Ltd. should be contacted immediately if the problem persists after trying all the solutions.

B) ACID EXIT TEMPERATURE IS LOWER THAN THE SPECIFIED VALUE:-

The reasons could be as follows:-

1. The cooling media flow is more than the adequate.
2. Acid flow less than specified value may be passing through the Acid Cooler.
3. The inlet acid temperature or the cooling media temperature is low.
4. In the startup there is no fouling of the tubes and the area required becomes more than adequate.
5. Acid Cooler may have been over designed.

The solution for this problem is:-

The process fluid - flows and their temperatures should be checked. A Bypass on the acid side should be provided.

C) PRESSURE DROP ON SHELL SIDE IS TOO HIGH:-

The reason could be as follows:-

There may be choking on the shell side or in the shell side nozzle.

The flow rate of process fluid is higher than the specified value.

The solution for this problem is:-

In the startup there may not be choking in the Acid Cooler. The flow rate of the acid on shell side should be checked. Subsequently after usage, choking as well as high flow probabilities should be checked. By throttling the acid inlet or exit valve the excess flow problem can be solved. On cleaning the Acid Cooler the choking problem can be solved.

D) PRESSURE DROP ON TUBE SIDE IS TOO HIGH.

The reasons and remedies for the above are similar to one for the shell side hence not described again.



E) LEAKAGE NOTED ON SHELL OR TUBE SIDE:-

Leakage on Tube side:-

If it is noticed that the PH of the cooling water starts dropping the reasons for this should be immediately identified. If it is concluded that the source of acidity is due to leakage of cooler tubes.

then the flow of Acid Cooler should be stopped and **M/s. Galiakotwala Engineering Co. Pvt. Ltd.** should be immediately contacted.

Leakage on Shell side:-

The leakage on shell side can be seen easily. The flow of the acid to Acid Cooler should be stopped and **M/s. Galiakotwala Engineering Co. Pvt. Ltd.** should be contacted immediately.

F) ACID DOES NOT FLOW IN THE SHELL:

The reason for this could be:

1. Acid pump is not pumping.
2. Failure of the acid inlet & outlet valves.
3. Air lock in the shell.
4. Choke in the shell or nozzle.

The corrective actions for above problems are as follows:

The reasons (1) & (2) are external factors, they can be easily established and corrective action can be taken accordingly.

For the removal of airlocks in the start up the vent valve on the shell should be kept open till all the air present in the shell is removed.

To avoid choking, the Acid Coolers may be cleared in every stoppage to remove dirt, deposits on the shell, baffles, etc.



G) WATER DOES NOT FLOW TUBE SIDE:

The reasons and remedies are similar to one for the shell side problem and hence not elaborated again.

H) SCALE DEPOSITS ON THE SHELL SIDE:

The scale settles when acid is passed through at a rate lower than the specified one or when there is a dead zone formation. If the stoppage is taken for a longer duration then also suspended dirt in the Acid Cooler settles. The Acid Cooler should preferably be operated at the rated capacity. If the shutdown is for a long duration then the Acid Cooler shall be chemically washed thoroughly.

I) SCALE DEPOSITS ON THE TUBE SIDE:

The reasons for this problem & remedies are similar to one for the shell side and therefore are not elaborated.

The circulating water quality should be checked and kept within limit such that there is no salting out.

J) HAMMERING NOTICED ON SHELL & TUBE SIDE:

This problem is also faced when there is air or vapour present in the circulating fluid. The air or vapour is normally observed during start up of the system or when the fluid pumps are operated at such low level as to suck air along with circulating fluid. In the start up the air should be vented out from the system. The pumps should be operated with proper fluid levels in the cooling tower basin.



11. MAINTENANCE

No special precautions are required for the regular maintenance of the Acid Cooler.

If required,

- Mechanical cleaning of the Water side (Tube side) of Acid Cooler can be done once in a year or during regular shutdown in case there is a reduction in heat transfer efficiency. Cleaning procedure can be supplied by **M/s Galiakotwala Engineering Co. Pvt. Ltd.**
- Checking the pressure drops, temperature at inlet and outlet of the process fluid once a month is adequate.
- Eddy current testing can be done after 5 years of operation to review condition of tubes.

The problem indicated in the chapter 9 can be attended by the client except shell or tube leakage.

IN CASE A SHELL OR TUBE LEAKS M/s. GALIAKOTWALA ENGINEERING CO. PVT. LTD. SHOULD BE CONTACTED IMMEDIATELY. CLIENT SHOULD NOT ATTEMPT TO RECTIFY THE LEAKAGE PROBLEM BECAUSE OF THE SPECIAL TECHNIQUE AND THE WELDING MATERIAL.

12. CLEANING PROCEDURE

If it is observed that the Acid Cooler is fouled on tube side or shell side due to dirt, **M/s. Galiakotwala Engineering Co. Pvt. Ltd.** should be contacted. Client should not make attempt to clean the Acid Cooler without advice from **M/s. Galiakotwala Engineering Co. Pvt. Ltd.**