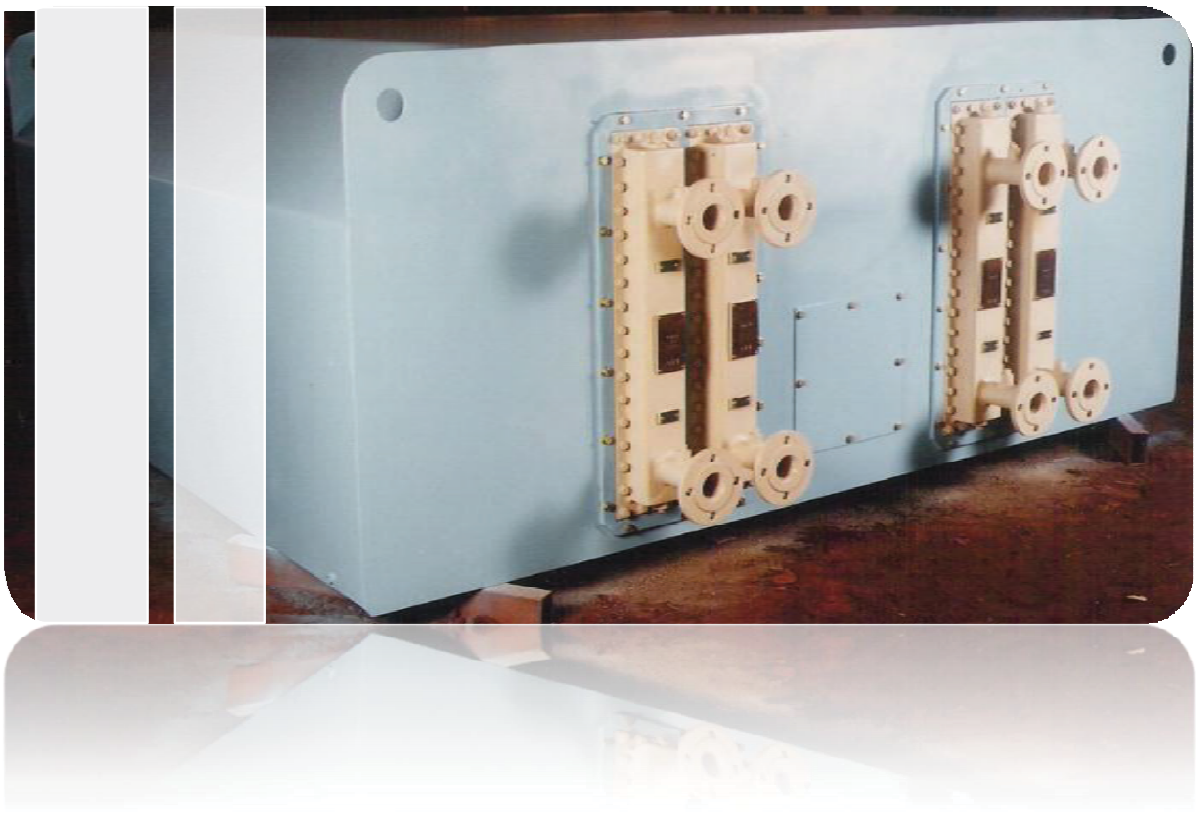
OPERATION AND MAINTENANCE MANUAL

Air to Water Heat Exchanger



Symbols used:

	This symbol indicates a danger ignoring which causes serious damage to the equipment
	This symbol denoted situation with possibility of personal injury
	This symbol indicates when EXTREME caution has to be exercised
	This symbol indicates any additional details.

This user manual describes the functions, operating procedures, precautions and basic trouble shooting for the Air to Water Cooler for Electrical Machines.

Note that some of the illustrations of the assembly used here maybe different from what you actually see on your machine.

Please contact us for any further queries you might have with respect to this manual.

This equipment has been designed according to the technical parameters and material of construction as specified by the manufacturer of the electric machine.

OUR COMPANY IS NOT LIABLE FOR ANY DIRECT, SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES, PENALTIES, COST AND EXPENSES OR DAMAGES OF ANY KIND, INCLUDING BUT NOT LIMITED TO INJURY, LOSS OF USE OR PROFITS AND LIFE ARISING FROM USE OF OUR PRODUCTS.

Warranty:

Products are guaranteed for duration of 12 months from date of commissioning or 18 months from date of dispatch whichever is earlier, unless otherwise agreed upon.

All warranty claims are void if:

- ➔ Any part of the assembly is modified or changed in any manner without first seeking our advice.
- ➔ The procedures described in the manual are not strictly adhered to.
- ➔ The operating parameters are not maintained as stated in the technical parameters
- ➔ The procedures are carried out by untrained personnel.

Contents :

1. SAFETY:

General

	Physical Damage: Physical damage to the assembly can be caused by • Improper Transportation • Improper Handling • Improper Installation • Corrosion/Fatigue
 	Possible Injuries: • Cuts and Bruises from sharp edges • Electrocution • Trapping of cloth or any other loose objects • Injury • Burns • Death

Precautions:

- Make sure that water is flowing through the tubes when the machine is in operation.
- Do not touch hot parts of the heat exchanger during operation or immediately after shutdown.
- Secure any loose articles, jewellery or clothing on person.
- Wear adequate noise protection gear to avoid damage to hearing during operation.
- Do not subject the assembly to shock or sudden loads.
- Make sure all electrical circuits are adequately earthed to prevent shock.
- Do not drastically alter operating conditions.
- Always safety helmets to prevent any injuries.

2. GENERAL INFORMATION:

2.1 Introduction:

The Closed Air Circuit Water (CACW) / Totally Enclosed Water Air Cooler (TEWAC) Heat exchanger cools the circulating air of the electrical machine (A.C Generator/ A.C Motor /Alternator / DC machine). The circulating air absorbs the heat losses of the machine and dissipates it to the cooling water through the Heat exchanger / Tube bundle.

The Heat exchanger consists of finned tube bundle. The hot air from the machine is made to flow over finned tube bundle, which is cooled by the cooling water flowing inside the tubes.

The Tube bundle is housed in a Shroud/ Housing /Air Guide Cover with air inlet and outlet ducting to direct the air to and from the tube bundle.

2.2 Construction:

The tube bundle consists of finned tubes which are expanded into the holes in the tube plates at both ends. The tube plates are fitted with Header/Water boxes with inlet / outlet flanges which direct the flow of water. The side frames fitted between tube plates at the end of tube bundle prevents air leakage in the lateral direction. The headers are generally of removable type to facilitate cleaning of tubes.

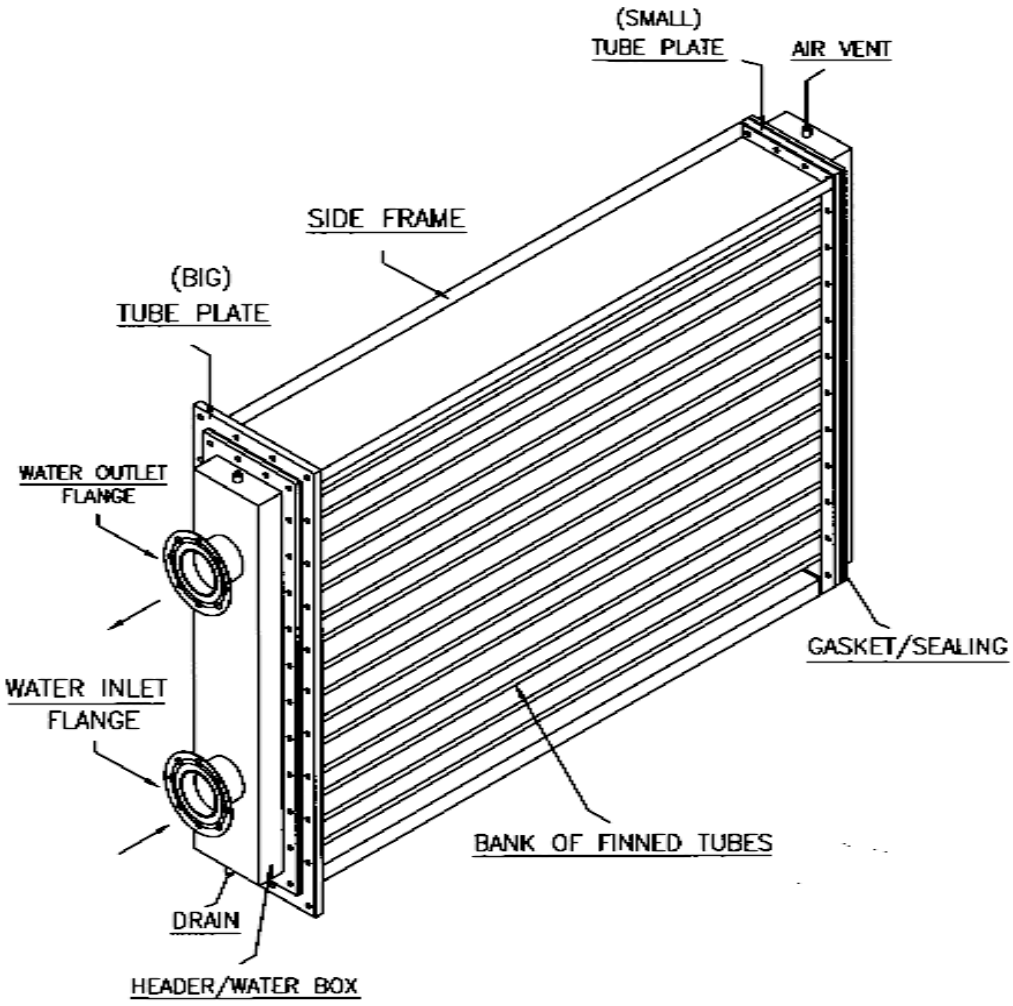


Figure 1-Tube Bundle

The selection of materials for construction of tubes, fin, tube plate and headers depends on customer's specific requirements and cooling water quality.

The tubes may be of Copper, Copper alloys like Cupro-Nickel 90/10, 70/30, Admiralty Brass, Aluminium Brass , Mild Steel or Stainless Steel.

The fin materials may be of Copper, Stainless Steel, Carbon Steel or Aluminium

The tube plates may be of Carbon Steel, Stainless Steel, Copper Alloy like 60/40 Brass, Naval Brass etc

The Header / Water box is usually made of plain Carbon Steel and in special requirements it is made up of Naval Brass, Brass, Bronze, Gunmetal, Stainless Steel or Cupro-Nickel.

2.3 Shroud / Air Guide Cover / Housing:

The Housing or the Shroud for the tube bundle is fabricated with Steel plates and other structurals to make it a rigid and vibration free structure.

Each tube bundle housed in the shroud is provided with drain tray or a baffle arrangement to prevent any the leakage of water, in case of tube failure, from entering the generator or motor. The drain tray is provided with a probe connected to Leakage Detector mounted on the outer wall of shroud which signals the leakage if any (optional accessory).

The inside of the housing is aerodynamically designed for the air stream to pass across the tube bundle with minimum pressure loss and for effective distribution of air flow over the face of tube bundle.

For large and heavy tube bundles sliding arrangement (with bearings) is provided in the shroud for easy insertion and removal of tube bundle for maintenance purpose.

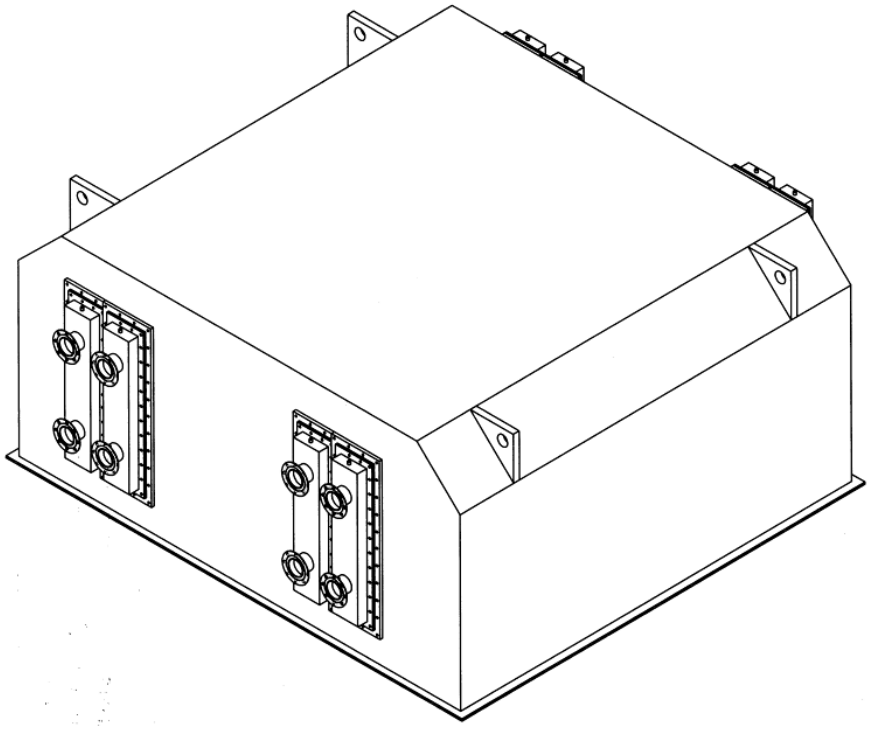


Figure 2 - Shroud / Air Guide Cover

3. TRANSPORTATION HANDLING AND STORAGE:

3.1 General:

Lifting lugs/ hooks are provided on the heat exchanger and shroud/ air guide cover for handling.

The lifting lugs *should not* be used to lift the electrical machine assembly once the cooler assembly is bolted to the machine.

3.2 Handling of large cooler assemblies:

Because of the large size and weight, each tube bundle is provided with rollers on the bottom of the side frame and handles on the front header. The tube bundle slides in and out smoothly when pushed / pulled with the handles and can be used for taking out bundles for maintenance purpose.

At each corner of the bundle, gussets with holes are provided. After the tube bundle is partially driven out, the lifting hook can be bolted to the corner gussets with proper fasteners.

All lifting hooks have to be assembled for each tube bundle before lifting.

Care should be taken to ensure that proper shackle and wire ropes are assembled before lifting.

The lifting hooks have to be dismantled and kept aside, when not in use as they interfere with the shroud / housing.

3.3 Storage:

If the heat exchanger assembly is to be stored for short term upto 2 months, it is recommended to cover the assembly with a suitable material like tarpaulin or any other water proof material. All water must be completely drained out. Periodic inspections must be carried out to prevent rust and mildew formation.

For long term storage from 2 months and longer, the heat exchanger should be completely drained out of water and thoroughly dried before preparing for storage. It should be made completely air tight and water absorbent material like silica gel must be placed inside. Periodic inspections must be carried out to prevent rust and mildew formation.

The heat exchanger must not be stored continuously for more than 1 year from the date of manufacture. The heat exchanger must be replaced before the device is put into operation.

When the assembly is going to be installed after being stored for more than 2 months, the entire assembly must be thoroughly inspected and cleaned as per Sec 6.

Any assembly must be subjected to hydro pressure test before installation as per Sec 0 if in storage for more than 2 months.

4. INSTALLATION:

4.1 Pre-Installation Checklist:

- Ensure adequate space around the machine for installation/disassembly.
- Ensure adequate space so that the heat exchanger can be slid in and out of the housing.
- Ensure there is no transit damage to the assembly.
- Check and remove any dirt, dust and loose particles in the assembly.
- Clean the assembly.
- Visually inspect all gaskets.
- Replace the gaskets if they are more than 24 months old than the date of manufacture irrespective of the fact that the tube bundle might have been in storage
- **Check and retighten all bolts using a torque wrench**.
- The coolers are dispatched after thorough hydraulic pressure testing at our works. It is mandatory that cooler is subjected to hydro pressure test before installation, if stored for more than 2 months. The procedure to carry out the hydro pressure test is given separately in Sec 0.

4.2 Installation:

1. Remove any blind/blanking flanges if provided on the water inlet and outlet nozzles.
2. The coolers are supplied as complete unit, fully assembled with instruments and accessories. They are to be mounted and bolted on to the electrical machines.

- Gasket must be provided between the cooler housing and the machine before bolting.
- It is recommended to use anti vibration mounts to isolate the vibration of machine from the cooler.

Lifting of the cooler assembly should only be done using the lifting lugs. Ensure that all the provided lifting lugs are used for hoisting.

3. Connect the water pipes to the inlet and outlet nozzles. Check that the supply and return lines are connected to the appropriate inlet and outlet nozzles/flange.
4. If the heat exchanger has to operate in freezing conditions, ensure that anti-freeze is added to the water supply.
5. Connect any other accessories like water leakage detector, flow indicator etc. to the electric supply.

The following precautions must be taken during installation:

- ➔ The pipes and flanges must be mounted stress-free to the heat exchanger and should have gaskets suitable for the type of water, temperature and pressure.
- ➔ The cooling water used should be neutral and free of suspended solid particles. To prevent fouling of tubes, a suitable strainer may be provided at the inlet of the cooler.
- ➔ Ensure that air is not trapped in the system as this causes pulsation and hence a non-uniform flow. The pipe layouts should therefore be free from air locks.
- ➔ It should be ensured that cooling water supply is under positive pressure so as to completely flood the unit under all operating conditions.

4.3 Start-up:

1. Ensure that cooler assembly / shroud is properly assembled on the electric machine with suitable gaskets and fasteners to avoid any air leakage.
2. Flush out the cooling water piping system leading to the cooler with clean water. Connect the inlet/outlet pipes to the cooler.
3. Open-air vent plug which is provided at the highest point of the cooler header/water box.
4. Open the cooling water inlet valve gradually to avoid water hammer. The flow of the cooling water should be controlled by regulating the outlet valves while keeping inlet valves fully open. When all the air trapped has been removed with smooth and continuous flow of water, close the air vent plug.
5. Ensure that the water leakage detector, water flow indicators and other safety devices are connected to the proper electrical supply.
6. Before starting, ensure proper pressure and flow rate of cooling water to the cooler.

4.4 After Start-up and Routine Inspection Checklist:

Check for the following:

- Water leakages in all connections and areas.
- Water pressure and flow rate
- Any vibrations and unusual noises

5. OPERATION:

The cooler can perform efficiently only when the flow rate and temperature of air and water entering the cooler are at the specified values, particularly the temperature difference between the cold-water inlet and air outlet.

Any increase in temperature difference would indicate blocked cooler tubes or improper flow rates of air and/or water.

	➔ If the heat exchanger is going to be idle for more than 48 hours without any flow, all the water in the heat exchanger must be drained out to prevent any corrosion. ➔ The heat exchanger must also not be exposed to freezing temperatures while idle as the tubes, pipes etc might burst and the headers might deform. All the water in the heat exchanger must be drained out if there is a danger of freezing.

	**The following precautions have to be observed during the operation of the cooler:** ➔ Control the cooling water supply by regulating the outlet valves only. Never throttle the inlet valves to control the flow of water .Always use the outlet valves for this purpose. ➔ At start up, open the air vent plug to expel entrapped air. Never allow the cooler to run with entrapped air. ➔ Whenever there is a leakage of water in the tube bundle, isolate the cooler at once and repair / plug the leaking tube as per Sec 0 at the first opportunity. ➔ Don't allow the cooler to have stagnant water in the tubes during shut down. Drain out water using drain provided and by blowing compressed air. ➔ Do not operate the cooler if water leakage is detected. ➔ The satisfactory performance and efficiency of the cooler will considerably reduce if there is excessive fouling (scaling) inside the tubes and accumulation of dust on the outer surfaces of the tube bundle. Hence periodic cleaning of the tubes is to be carried out. The period between successive cleaning will depend upon the quality of the cooling water and the surrounding atmosphere. Hence actual time can be determined from the experience only. However as a routine practice, inspection and maintenance of the coolers should be carried out ***once at least every 6 months.***

6. PERIODIC INSPECTION AND MAINTENANCE CHECKLIST:

As a routine practice, inspection and maintenance of the coolers should be carried out once at least every 6 months.

The period between successive cleaning will depend upon the quality of the cooling water and the surrounding atmosphere. Hence the heat exchanger must be inspected more frequently if the surrounding atmosphere is dusty or if the water quality is bad.

The following must be inspected:

- General condition and visual check
- Check for any fallen debris, dirt etc.
- Fin surface for blockage and damage.
- Tube fouling, blockage or leakage
- Water leakages in all connections and areas.
- Water pressure and flow rate
- Removal of dust and debris from air filter if provided
- Any vibrations and unusual noises
- Corrosion
- Operation of accessories and safety devices

7. SHUT DOWN:

1. Shut down the electric machine
2. Continue water supply to the tube bundle for some time until the heat exchanger cools down sufficiently.

Extreme caution must be exercised when touching the heat exchanger when it is still hot as it might result in scalding and burn injuries.

3. Slowly close the water outlet valves to the heat exchanger followed by the inlet valves.
4. Turn off any other accessories like water leakage detector etc.

8. MAINTENANCE:

It is strongly recommended that this procedure not be carried out by untrained personnel as there are chances of catastrophic failure.

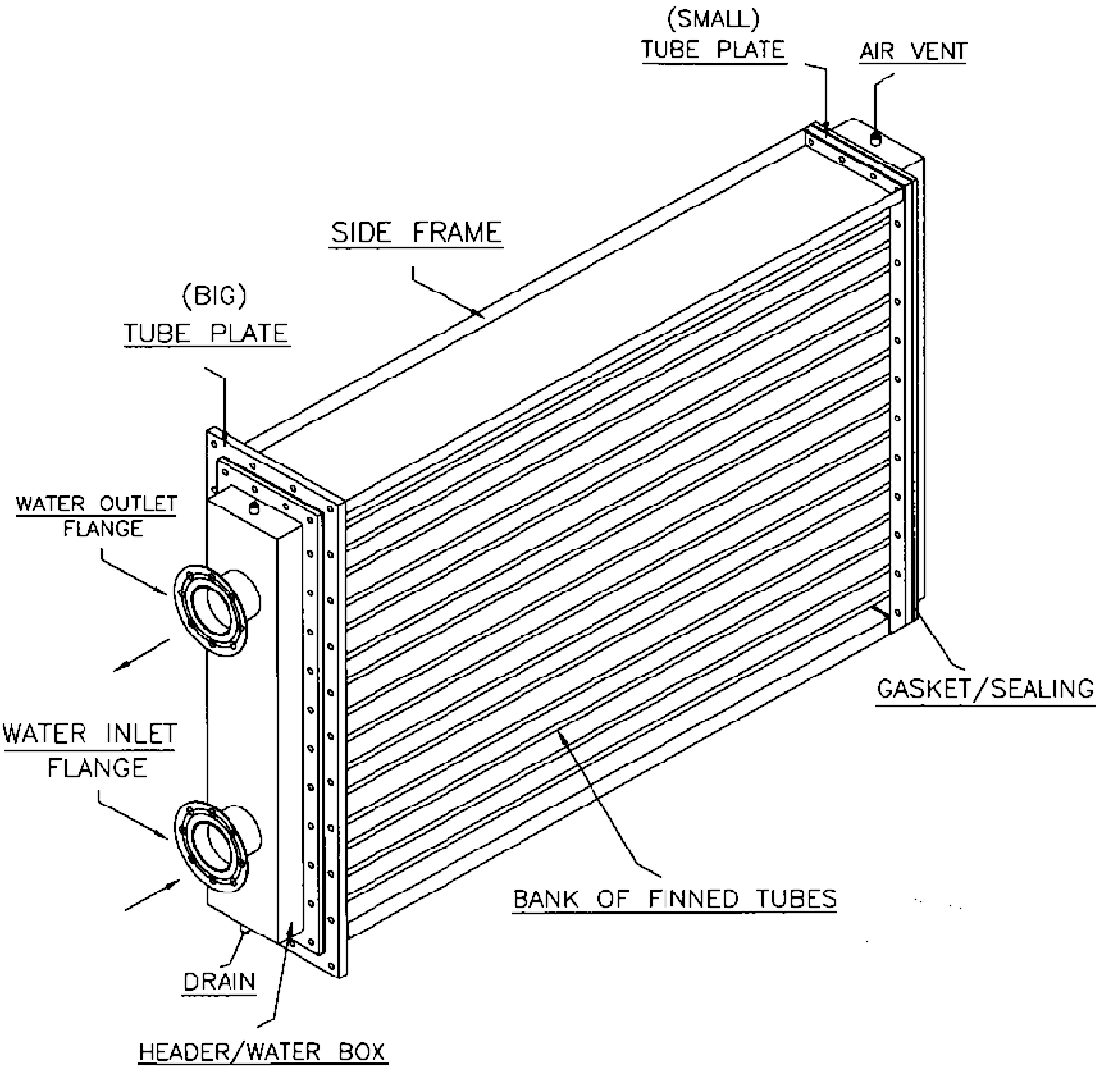


Figure 3 - Tube Bundle

8.1 Disassembly of the Air-Water Cooler:

1. Follow the shut-down procedure as described in Sec 7
2. Wait for the heat exchanger to sufficiently cool down.
3. Open the air vent and drain valves to drain out the water. It might be necessary to provide a drip tray to collect the drained water.
4. Disconnect supply and return lines.
5. Remove the bolts on the tube plate which connect the tube bundle to the air guide cover/shroud.
6. Remove the bolts which connect the header/water box to the tube plates
7. Remove the gasket.

8.2 Cleaning the heat exchanger on the Air-side:

1. Disassemble the cooler from the shroud as per Sec 0
2. Blow compressed air in the *opposite direction* to the normal airflow and *parallel* to the fins

Caution must be exercised when blowing compressed air so as not to damage the fins

8.3 Cleaning of Tubes:

1. Disassemble the cooler from the shroud as per Sec 8.1
2. Disassemble the header / water boxes at both the ends by loosening the bolts. This will expose the tube ends.
3. If considerable accumulation of deposits is visible in the tubes, tubes should be flushed out using high-pressure water jet, in the direction opposite to the normal water flow.
4. If reversed flow method proves to be inadequate, clean the insides of tubes by bristle brush or a brush made out of soft brass wire or nylon in a direction opposite to the normal flow of water.
5. Chemical treatment is recommended for hard scale deposits.

The chemical treatment should be carried out under the supervision of chemist, who will decide the nature and strength of cleaning solution suitable for the type of scale present and tube material. Ensure that after cleaning with chemical all the traces of chemicals are removed by thorough flushing out with water

6. Reassemble the Header / Water boxes with a new set of gaskets and tighten the bolts using a torque wrench.
7. Conduct a Hydro pressure test as per Sec 0 to ensure leak proof assembly.

8.4 Cleaning the Shroud:

1. Disassemble the air cooler as per Sec 8.1.
2. Use compressed to clean the insides.
3. Reassemble the cooler and shroud with new set of gaskets.

9. RECTIFICATION, REPAIR & TESTING:

Problem	Cause	Solution
Performance of the heat exchanger is not satisfactory	The operating conditions are different from design conditions	➔ The incorrect conditions have to be altered ➔ The heat exchanger has to be replaced with one which suits the current operating conditions.
	Tubes are fouling frequently	➔ Increase the frequency of cleaning of tubes ➔ Soften the water before it enters the heat exchanger by using a water softener.
	Fins foul frequently	Increase the frequency of cleaning of fins.
Heat Exchanger is leaking	Water Leakage Detector is tripping or tube is leaking.	➔ Check heat exchanger for tube leakage. ➔ Follow procedure in Sec 0 to arrest tube expansion leakage. ➔ If tube is leaking in the middle, identify and plug the tube. Get in touch with us immediately
	Weld Leakage	Follow procedure in Sec 0 to arrest weld leakage.
	Gasket Leakage	Replace with a new set of gaskets and tighten all bolts
	Bolts tightened insufficiently	Tighten bolts with torque wrench

9.1 Hydro Pressure Test:

This procedure must be carried out only by trained personnel at our works. ***It is strongly recommended that this procedure not be carried out by untrained personnel as there are chances of catastrophic failure.***

The Hydro pressure test of cooler is carried out to ensure that there is no leakage through the expansion joints, gasket and welded joints and also to detect any leaking tubes. A water pump facility which is capable of pressurizing the cooler up to the specified test pressure and a calibrated pressure gauge are required to conduct this test.

The procedure for conducting the test is as follows:

1. Disconnect the water connections and dismantle the cooler.
2. Connect a calibrated pressure gauge to outlet water connection of the cooler.
3. Assemble other parts as shown in the **Error! Reference source not found.** *on Page* ***Error! Bookmark not defined.***
4. Slowly pressurize the cooler by pumping water through inlet connection to the specified test pressure.
5. Maintain the test pressure for at least 30 minutes.
6. Thoroughly examine all the welds, gasket joints for leakage through tube to tube plate joints. The cooler should not exhibit any drop in pressure.

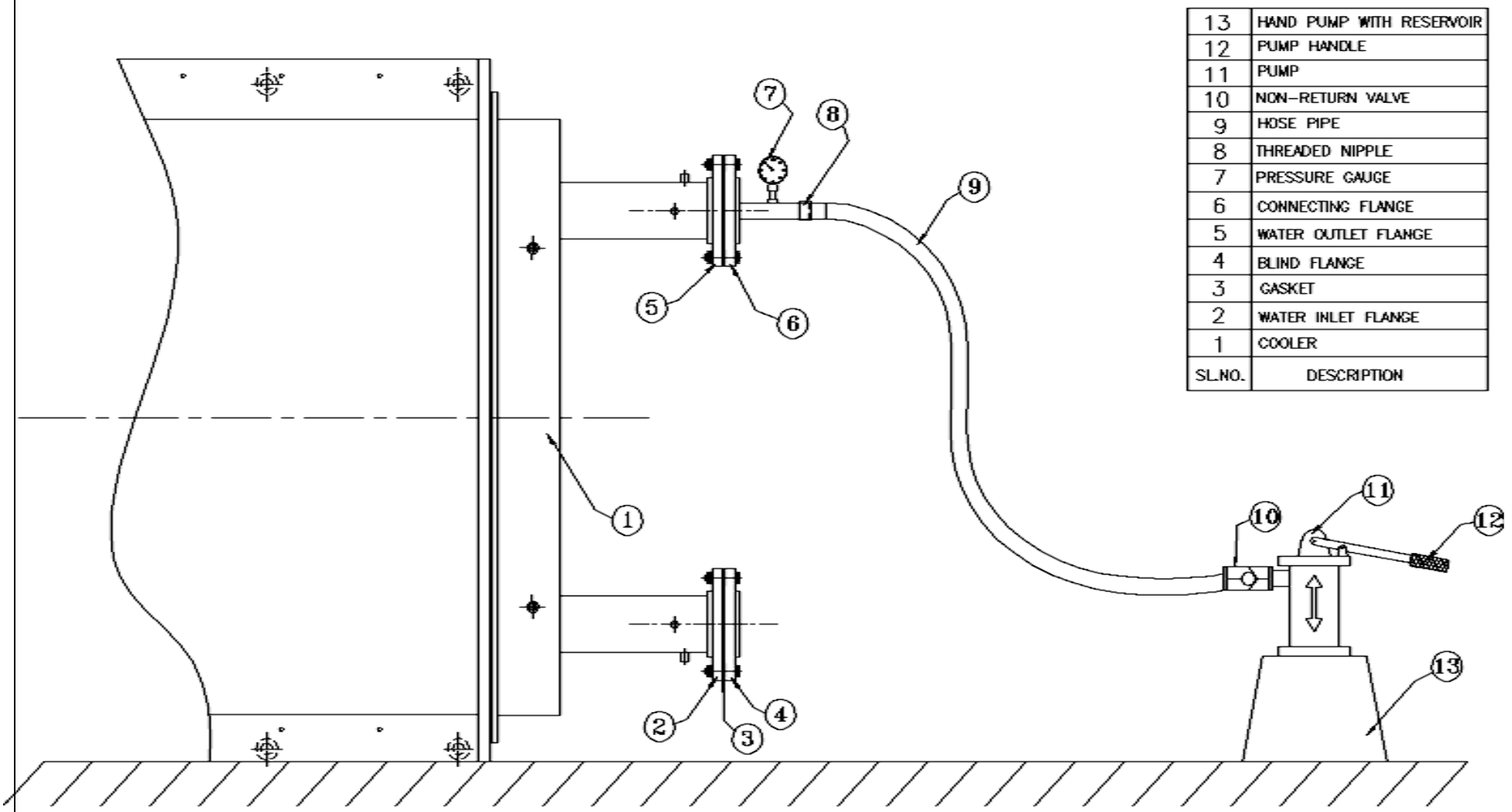


Figure 4 - Hydro Pressure Test

9.2 Weld Leakage:

DP test must be carried out only by qualified personnel

This procedure must be carried out only by trained personnel at our works. **It is strongly recommended that this procedure not be carried out by untrained personnel as there are chances of catastrophic failure.**

1. In the pressurized conditions, mark the leaking portion with a chalk or paint.
2. Release the pressure and drain out water. If required, blow out with compressed air to remove all moisture.
3. Ascertain if there is any crack. Grind / Gouge the defective portion and weld. Perform a DP test to check that the weld quality..
4. Assemble the cooler and subject it to hydro pressure test as per Sec 0.

9.3 Tube expansion leakage:

This procedure must be carried out only by trained personnel at our works. ***It is strongly recommended that this procedure not be carried out by untrained personnel as there are chances of catastrophic failure of tubes.***

During hydro pressure testing of the coolers, if the tube to tube plate joint is found to be leaking, the following procedure should be done to arrest the leakage:

1. Drain out water and dismantle the water boxes.
2. Locate the leaking joint using a torch and mark the joint.
3. Check the bore of the tube and re-expand the joint. Recheck the bore to confirm that the expansion has taken place.
4. Reassemble the water boxes. Fill water and Hydro pressure test the cooler as per Sec 0
5. If joint continues to leak, dismantle the water boxes and plug the tube with tapered copper plug. The hole and plug should be brazed / welded. Suitable epoxy compound could also be used.

10. SPARE PARTS:

When ordering for spares, please provide us with the as much data as possible. The data required is:

- Project Name and Purchase order number with date.
- Serial number of the heat exchanger along with year of manufacture as on the name plate.
- Manufacturer, Rating and Frame Size of the Electric Machine.
- Heat Load to be dissipated.
- Water Flow rate and inlet temperature.
- Air Flow rate and temperatures.
- Allowable pressure drops.
- Dimensions of the heat exchanger.
- Type of fin and Material of Construction of the heat exchanger.
- Any accessories provided along with the assembly.

STANDARDS / DATA SHEET

RECOMMENDATION OF MINIMUM COOLING WATER QUALITY FOR CACW COOLERS USED ON GENERATORS

SCOPE:

Below table is a recommendation of minimum cooling water quality for CACW cooler used on generators for various tube materials

DESCRIPTION:

Values are tabulated referring to below books:

1. Corrosion handbook
2. Handbook of Heat Exchangers

Tube material	Admiralty Brass	SS304	SS316L	CuNi90/10	CuNi70/30
pH	> 7.5 - 9	6 - 8.5	> 5.5 - 9	6.5 - 9	-
Chloride (Cl)	< 25 ppm	< 200 ppm	< 500 ppm	-	-
Ferric Chloride (FeCl3)	-	< 500 ppm	< 500 ppm	-	-
Ammonia	< 1ppm	< 20 ppm	< 20 ppm	<1ppm	< 8 ppm
DO		<3 - 4 ppm	<3 - 4 ppm	<3 - 4 ppm	<3 - 4 ppm
Sulfid	-	-	-	< 0.05ppm	-
Suspended solids	< 25ppm	-	-	< 20ppm	< 40ppm
Bicarbonate, HCO_3	-	-	-	> 70ppm	-
HCO_3^{-1}/SO_4^{2}	-	-	-	> 1	-
H2S	< 1ppm	< 20 ppm	< 20 ppm	< 1ppm	<8ppm
Dissolved salts	< 2000ppm	-	-	< 3000ppm	< 10000ppm
Residual Chlorine	<20 ppm	< 2 ppm	< 2 ppm	< 2 ppm	< 2 ppm
Salt Water velocity	3 - 5 ft/s	5 - 12 ft/s	5 - 12 ft/s	< 9 ft/s	< 15 ft/s
Temperature	>200 - 450	30 - 140 degC	30 - 140 deg C	-	-
Free CO2	<15 ppm	-	-	-	-
Dissolved CO2	<7 ppm	-	-	-	-
Conductivity	<1000	-	-	-	-
Mn	NA	NA	NA	Preferred	Preferred

Note:

Above values are minimum requirement of water quality. However customer shall consult water treatment specialist for finalizing water treatment process.