CARON

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TABLE OF CONTENTS

WARNING

You have the responsibility to ensure that installation, operating and servicing the heat exchangers comply with your Jurisdiction's laws and regulations.

Failure to observe all safety rules, regulations, instructions and precautions applicable to your industry, your plant and the heat exchanger you are installing, operating and servicing may result in serious injury to you or others.

You must be a suitably trained and qualified operator, familiar with the correct operation, maintenance and use of the heat exchangers and the tools and equipment with which the installation will be performed. If you are not suitably trained and qualified, you should not attempt to install, operate and / or service this heat exchanger.

You have the responsibility to ensure that all personnel using or servicing the unit, or working in an area of the unit, have the appropriate safety training and are equipped with the appropriate safety equipment.

You must read and thoroughly understand these installation procedures before proceeding with any work.

The information contained in these installation procedures does not create any expressed or implied warranty or guarantee with respect to the heat exchanger or its use. Information comes from different sources that may not have been controlled.

Caron et fils reserves the right to modify or improve these installation procedures at any time without notice.

INSTALLATION

Following are general recommendations for installation of the heat exchanger.

NOZZLES

All exchanger openings should be inspected for foreign material. Protective plugs and covers should not be removed until just prior to installation. In all installations, care should be taken to eliminate or minimize transmission of fluid pulsations, mechanical vibrations and any other mechanical stress to the heat exchangers.

Inlet/Outlet

Inlet and outlet connections of the heat exchanger are shown on the "As Built" drawing. These connections shall be used as stated in order to assure proper thermal performances.

Vents
Vent valves should be provided so units can be purged to prevent vapor or gas binding. Special consideration must be given to discharge of hazardous or toxic fluids.

Drains
Drains may discharge to atmosphere, if permissible, or into a vessel at lower pressure. They should not be piped to a common closed manifold.

Test connections
When not integral with the exchanger nozzles, thermometer well and pressure gage connections should be installed close to the exchanger in the inlet and outlet piping.

Safety relief devices
The ASME Code defines the requirements for safety relief devices. When specified by the purchaser, the manufacturer will provide the necessary connections for the safety relief devices. The size and type of the required connections will be specified by the purchaser. The purchaser will provide and install the required relief devices.

CLEARANCE FOR DISMANTLING

For **straight tube exchangers** fitted with removable bundles, provide sufficient clearance at the stationary head end to permit removal of the bundle from the shell and provide adequate space beyond the rear head to permit removal of the shell cover and/or floating head cover.

For **fixed tubesheet exchangers**, provide sufficient clearance at one end to permit withdrawal and replacement of the tubes and enough space beyond the head at the opposite end, to permit removal of the bonnet or channel cover.

For **U-tube heat exchangers**, provide sufficient clearance at the stationary head end to permit withdrawal of the tube bundle, or at the opposite end to permit removal of the shell.

FOUNDATIONS

Foundations must be adequate so that the exchangers will not settle and impose excessive strains on the exchanger. Foundation bolts should be set to allow for setting inaccuracies. In concrete footings, pipe sleeves at least one size larger than bolt diameter slipped over the bolt and cast in place are best for this purpose, as they allow the bolt center to be adjusted after the foundation has set.

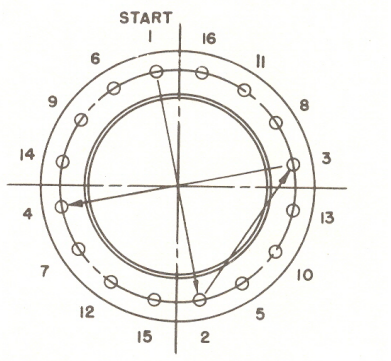
FOUNDATION BOLTS
Foundation bolts should be loosened at one end of unit to allow free expansion of shells. Slotted holes in supports are provided for this purpose.

LEVELING
Exchangers must be set level and square so that pipe connections may be made without forcing.

BOLTED JOINTS
Heat exchangers are pressure tested before leaving the manufacturer's shop in accordance with ASME Code requirements. However, normal relaxing of the gasketed joints may occur in the interval between testing in the manufacturer's shop and installation at the jobsite. Therefore, all external bolted joints may require retightening after installation and, if necessary, after the exchanger has reached operating temperature.

RECOMMENDED BOLT TIGHTENING PROCEDURE
For recommended torque, see following drawing.

It is important that all bolted joints be tightened uniformly and in a diametrically staggered pattern as shown on following picture.



Procedure:

1. Visually examine and clean flanges, bolts, nuts and washers. Replace components if necessary.
2. Lubricate bolts, nuts and flange surface around bolt holes or use hardened steel washers.
3. Install new gasket. Do not reuse old gasket.
4. Hand tighten then pre-tighten bolts to 10/20 FT-LBS torque, but do not exceed 20% of Target Torque.
5. Check gap for uniformity.

6. Following the staggered pattern for every round:
   . Round 1–Tighten to 30% of final torque value
   . Round 2-Tighten to 60% of final torque value
   . Round 3-Tighten to 100% of final torque value

   Check gap around the circumference between each of these rounds, measured at every other bolt. If the gap is not reasonably uniform around the circumference, make the appropriate adjustments by selective bolt tightening before proceeding.
7. Final Rotational Round – 100% of Final Torque. Use rotational clockwise tightening sequence for one complete round and continue until no further nut rotation occurs at 100% of the Final Torque value for any nut.

Short-term bolt preload loss can occur between four to twenty-four hours after initial tightening due to bolt relaxation. Consider retightening to help recover this loss.

OPERATION

DESIGN AND OPERATING CONDITIONS

Equipment must not be operated at conditions that exceed those specified on the nameplate and datasheet.

OPERATING PROCEDURES

Before placing any heat exchanger in operation, reference should be made to the exchanger drawings, specifications sheet and nameplate for any special instructions. Local safety and health regulations must be considered. Improper start-up or shutdown sequences, particularly of fixed tubesheet units, may cause leaking of tube-to-tubesheet and/or bolted flange joints.

START-UP OPERATION

Most exchangers with removable tube bundles may be placed in service by first establishing circulation of the cold medium, followed by the gradual introduction of the hot medium. During start-up all vent valves should be opened and left open until all passages have been purged of air and are completely filled with fluid. For fixed tubesheet exchangers, fluids must be introduced in a manner to minimize differential expansion between the shell and tubes.

SHUTDOWN OPERATION

For exchangers with removable tube bundles, the units may be shut down by first gradually stopping the flow of the hot medium and stopping the

flow of the cold medium. If it is necessary to stop the flow of the cold medium, the circulation of hot medium through the exchanger should also be stopped. For fixed tubesheet exchangers, the unit must be shut down in a manner to minimize differential expansion between shell and tubes. When shutting down the system, all units should be drained completely when there is the possibility of freezing or corrosion damage. To guard against water hammer, condensate should be drained from steam heaters and similar apparatus during start-up or shutdown.

TEMPERATURE SHOCKS

Exchangers should not be subjected to abrupt temperature fluctuations. Hot fluid must not be suddenly introduced when the unit is cold, nor cold fluid suddenly introduced when the unit is hot.

MAINTENACE

INSPECTION OF UNIT

At regular intervals and as frequently as experience indicates, an examination should be made of the interior and exterior condition of the unit. Neglect in keeping all tubes clean may result in complete stoppage of flow through some tubes that could cause severe thermal strains, leaking tube joints, or structural damage to other components. Sacrificial anodes, when provided, should be inspected to determine whether they should be cleaned or replaced.

If epoxy coating is applied, it is recommended to measure thickness to validate remaining coating and, if required, use a repair kit of a different color to monitor repair and additional coating.

INDICATIONS OF FOULING

Exchangers subject to fouling or scaling should be cleaned periodically. A light sludge or scale coating on the tube greatly reduces its efficiency. A marked increase in pressure drop and/or reduction in performance usually indicate cleaning is necessary. The unit should first be checked for air or vapor binding to confirm that this is not the cause for reduction in performance. Since the difficulty of cleaning increases rapidly as the scale thickness or deposit increases, the interval between cleanings should not be excessive.

DISASSEMBLY FOR INSPECTION OR CLEANING

Before disassembly, the user must assure himself that the unit has been depressurized, vented and drained, neutralized and/or purged hazardous material on both sides.

To inspect the inside of the tubes and also make them accessible for cleaning, the following procedures should be used:

Stationary Head End
Type A, C, D & N, remove cover only
Type B, remove bonnet

Rear Head End
Type L, N & P, remove cover only
Type M, remove bonnet
Type S & T, remove channel cover or bonnet
Type W, remove channel cover or bonnet

CLEANING METHODS

The heat transfer surfaces of heat exchangers should be kept reasonably clean to assure satisfactory performance. Convenient means for cleaning should be made available.

Heat exchangers may be cleaned by either chemical or mechanical methods. The method selected must be the choice of the operator of the plant and will depend on the type of deposit and the facilities available in the plant. Following are several cleaning procedures that may be considered:

1. Circulating hot wash oil or light distillate through tubes or shell at high velocity may effectively remove sludge or similar soft deposits.
2. Some salt deposits may be washed out by circulating hot fresh water.
3. Commercial cleaning compounds are available for removing sludge or scale provided hot wash oil or water is not available or does not give satisfactory results.
4. High pressure water jet cleaning.
5. Scrapers, rotating wire brushes, and other mechanical means for removing hard scale, coke, or other deposits.
6. Employ services of a qualified organization that provides cleaning services. These organizations will check the nature of the deposits to be removed, furnish proper solvents and/or acid solutions containing inhibitors, and provide equipment and personnel for a complete cleaning job.

CLEANING PRECAUTIONS

1. Tubes should not be cleaned by blowing steam through individual tubes since this heats the tube and may result in

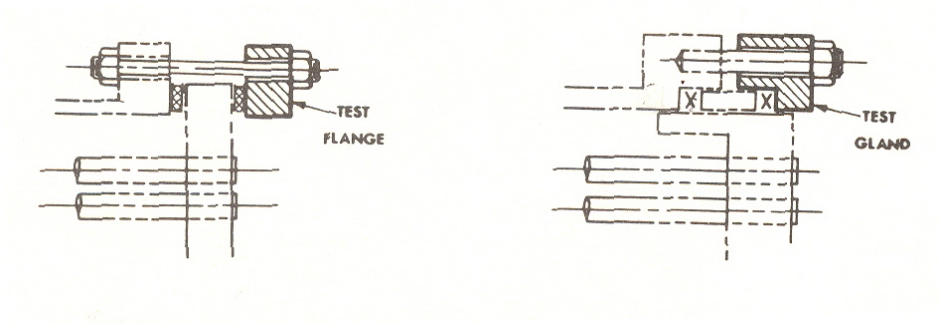
severe expansion strain, deformation of the tube, or loosening of the tube-to tubesheet joint.
2. When mechanically cleaning a tube bundle, care should be exercised to avoid damaging the tubes.
3. Cleaning compounds must be compatible with the metallurgy of the exchanger.

LOCATING TUBE LEAKS

The following procedures may be used to locate perforated or split tubes and leaking joints between tubes and tubesheets. In most cases, the entire front face of each tubesheet will be accessible for inspection. The point where the water escapes indicates a defective tube or tube-to-tubesheet joint.

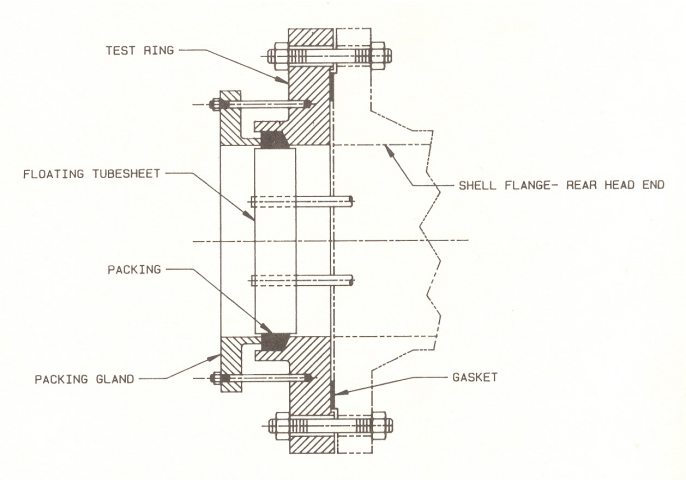
Units with removable channel cover: Remove channel cover and apply hydraulic pressure in the shell.

Units with bonnet type head: For fixed tubesheet units where tubesheets are integral part of the shell, remove bonnet and apply hydraulic pressure in the shell. For fixed tubesheet units where tubesheets are not an integral part of the shell and for units with removable bundles, remove bonnet, re-bolt tubesheet to shell or install test flange or gland, whichever is applicable, and apply hydraulic pressure in the shell. See following picture for typical test flange and test gland.



Units with type S or T floating head: Remove channel cover or bonnet, shell cover and floating head cover. Install test ring and bolt in place with gasket and packing. Apply hydraulic pressure in the shell. A typical test ring is shown in next figure. When a test ring is not available it is possible to locate leaks in the floating head end by removing the shell cover and applying hydraulic pressure in the tubes. Leaking tube joints may then be located by sighting through the tube lanes. Care must be exercised when testing partially assembled exchangers to prevent overloading of tubes and/or tube-to-tubesheet joints.

Hydrostatic test should be performed so that the temperature of the metal is over 60^{o} F unless the materials of construction have a lower nil-ductility transition temperature.



TUBE PLUGGING PROCEDURES

Tube plugging procedure depends on the type of plug selected. You should contact your distributor of such plugs. As an example, here is a typical procedure:

1. Identify the leaking tube. **Inspect** the tube end to determine its size and whether there is any anomaly in the internal surface of the tube that would interfere with the successful installation of the plug. ***Longitudinal defects can prohibit an effective plug seal; make sure that no such defects exist.*** Mark the tube end to be plugged.

2. Measure the tube end with an inside tube micrometer or a gauging block to determine the actual diameter of the tube end. **Select** the tube plug of the correct size using your distributor guide based on that measurement.

3. Prepare the inner surface of the tube. Use an aggressive, power wire brush to thoroughly provide a bright metal surface to the tube. Be careful that you do not cut so deeply into the tube that you weaken the tube wall. The surface must be free of all loose scale and have no extraordinary pitting.

4. Clean the tube end thoroughly. Use a clean swab to remove all loose material including any remaining reaming remnants or scale, corrosion, deposits, or other anomalies that may have been loosened by the surface preparation process. As close to the time that the plug is to be inserted, wipe clean the newly prepared tube surface using a non-residue cleaning solution.

5. Inspect the tube end to assure cleanliness and the absence of any anomalies such as grooving (particularly longitudinal grooving), ovality, deep scratches, etc. that could keep the plug from sealing properly. When working on carbon or low alloy steel tubes or tube sheets, make sure that the newly prepared surface is free of rust, particularly if there any appreciable time has elapsed since the surfaces were prepared.

6. Install the plug as per the manufacturers recommendations.

7. Pressure Test the integrity of the plug seal by pressure testing the unit in the same manner that was used to identify the leaking tube. Once the plug seal has been tested and determined to be secure, vacate the unit, seal its channel end, and return the unit to service.

WARNING!

Pressure testing is inherently dangerous. Strictly adhere to these installation procedures and all industry safety practices. Such adherence could prevent injury to personnel. All personnel must be clear of plug being tested when pressure testing and when heat exchanger is under pressure.

STANDARD HYDROSTATIC TEST

The test pressure for every chamber of the heat exchanger is written on the data report. If such data report is not available, a value of 1.3 x MAWP can be taken. The Maximum Allowable Working Pressure (WAWP) is written on the nameplate.

Any non-hazardous liquid at any temperature may be used for the hydrostatic test if below its boiling point. Combustible liquids having a flash point less than 110^{o}F (43^{o}C), such as petroleum distillates, may be used only for near atmospheric temperature tests.

The pressure in the vessel shall be gradually increased to not more than one-half the test pressure. Thereafter, the test pressure shall be increased in steps of approximately one-tenth of the test pressure until the required test pressure has been reached.

Following the application of the hydrostatic test pressure, an inspection shall be made of all joints and connections. Leakage is not allowed at the time of the required visual inspection.

WARNING!

Air or gas is hazardous when used as a testing medium.

PNEUMATIC TEST IS NOT RECOMMENDED
for a test pressure over 15 psig (100 kPa relative)

SHORT AND LONG TERM OUTAGES

Before being installed for the first time, the heat exchangers may be stored as shipped.

For short and long term outages, it is suggested to drain both sections, to clean and dry sections in contact with water and to plug all nozzles. Both sections may be pressurized to no more that 15 psig using nitrogen.

Before future use, a complete inspection of the heat exchanger shall be done to detect corrosion.

In case of doubt, the heat exchangers may be returned to the manufacturer for a complete internal/external inspection.