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GRAPHILOR® POLYTUBE® HEAT EXCHANGERS

INSTALLATION
COMMISSIONING
MAINTENANCE

REF: GRAPHILOR_S&TrevB.doc

GRAPHILOR® POLYTUBE® HEAT EXCHANGER

WE STRONGLY RECOMMEND THAT YOU READ THIS MANUAL CAREFULLY AND FOLLOW THE INSTRUCTIONS TO ENSURE SAFE AND RELIABLE OPERATION OF THE UNIT.

Model #: _____

Type of Impregnation: _____

Carbone Drawing No.: _____

Customer/Ultimate owner: _____

& address : _____

_____

P.O. number: _____

Project No.: _____

Equipment tag number(s): _____

Vessel Serial number(s): _____

Diameter (shell) : _____

Height or length: _____

Weight empty: _____

Weight full of water: _____

IMPORTANT INFORMATION FOR PROPER OPERATION OF CARBONE IMPERVIOUS GRAPHITE HEAT EXCHANGERS HEATED

WITH STEAM OR THERMAL OIL.

1. PROPER SEQUENCE ON START UP:

A. Start acid circulation first.
B. Gradually open steam (or thermal oil) valve, increasing flow rate to design conditions over a period of approximately 5 minutes. Prevent steam (or thermal oil) or water hammer.

2. PROPER SEQUENCE ON SHUTDOWN:

A. Shut down steam (or thermal oil) flow first. Prevent steam (or thermal oil) or water hammer.
B. Allow acid to circulate several minutes in order to stabilize the temperature in the exchanger, then shut off flow.

3. PREVENT BOIL UP OF ACID IN THE HEAT EXCHANGER.

This can cause excessive fouling in the blocks and may result in damage to internal parts of the exchanger. Provide safety interlocks – If acid flow stops for any reason the steam (or thermal oil) must shutdown automatically. Upon shut-down, the steam (or thermal oil) valve should be reset to the closed position to prevent auto wind up or a "wide open position" upon restart.

4. STEAM (OR THERMAL OIL) LEAKING ON STARTUP & 1st THERMAL CYCLES: (for further details refer to section 3 b of manual).

The seal ring (at the flange gland) may be braided TFE which has a tendency to "cold flow" during the initial operation of the equipment. The flange gland nuts tend to become loose during the 1st few thermal cycles and steam (or thermal oil) may leak out between the "top" flanges of the exchanger. ("top" means upper flange sets for vertical installations; it is the "spring" end of the exchanger for horizontal installations.)

To stop leaks at this location, tighten the nuts on "top" of the flange gland (which is the flange between the top compression plate and the top shell flange.) Tighten nuts in ¼ turn increments using a diagonal sequence pattern to a max. value of 10 ft-lbs (13.5 N·m) above the specified value on the assembly drawing.

Do not overtighten the nuts such that the flange gland contacts the top shell flange.

5. OTHER GENERAL NOTES:
. Never exceed the design conditions labeled on the exchanger nameplate.
. Inspect steam traps periodically to prevent backup of condense in the exchanger; this will reduce the performance of the exchanger.
. Refer to the Carbone exchanger assembly drawing for proper bolt torque information when tightening or adjusting nozzle and shell flanges. Damage to graphite parts may result if overtorqued! Always use Carbone TFE expansion joints at or near graphite nozzle connections to lessen nozzle loading.

READ AND UNDERSTAND THE INSTRUCTION MANUAL PROVIDED WITH THE EXCHANGER.

FOR FURTHER ASSISTANCE, CONTACT YOUR LOCAL CARBONE REPRESENTATIVE OR: 1-800-839-7535 (or direct 1-540-389-7535) (IN THE USA ONLY) OR PHONE 1-450-455-5728 (IN CANADA)

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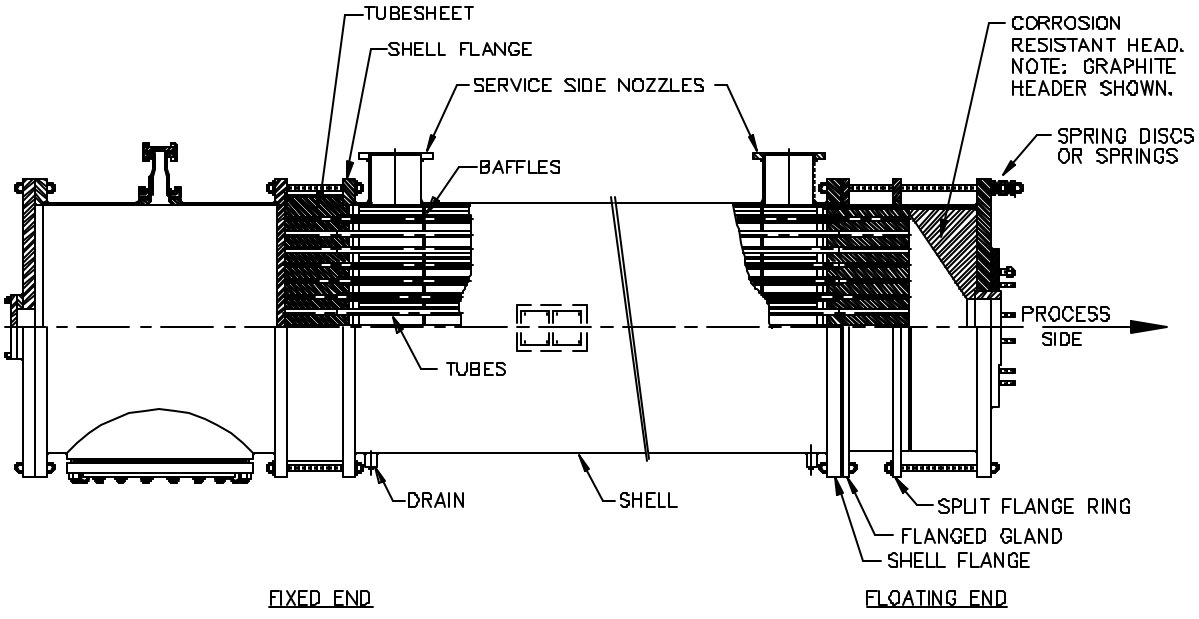
INTRODUCTION

In order to ensure a reliable and durable operation of your heat exchanger, we recommend that you follow these instructions carefully.

The installation, operation and maintenance instructions which follow are believed to be reliable general guidelines for usage of the equipment described herein. Graphilor® Polytube® heat exchangers are uniquely designed corrosion resistant units consisting of impregnated graphite tubes attached to a tube sheet and placed inside a steel shell. The process fluid flows in the graphite tubes and the service fluid flows around them in the steel shell. For specifics on corrosion resistance, consult Carbone of America's corrosion guide or one of our representatives.

The installation, operation and maintenance instructions which follow are believed to be reliable general guidelines for usage of the equipment described herein. In order to ensure a reliable and durable operation of your heat exchanger, we recommend that you follow these instructions carefully. CARBONE OF AMERICA **expressly disclaims any warranty, expressed or implied, of fitness for any specific purpose in connection with the information contained herein.**

Unless otherwise specifically provided in the contract of sales, CARBONE OF AMERICA does not provide project engineering or process design and, accordingly, the information presented herein is general in nature and should not be considered applicable to any specific process or application. While equipment is designed and manufactured in accordance with applicable codes and good manufacturing practices, it is the responsibility of the user to locate and install the equipment and provide those safety and warning devices which are appropriate for the specific application intended by the user.



POLYTUBE GRAPHILOR HEAT EXCHANGER TERMINOLOGY
(HORIZONTAL INSTALLATION SHOWN)

FIGURE "1"

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B		June 20, 2002	CP	WM

1. RECEIVING INSPECTION

All equipment produced by CARBONE OF AMERICA is carefully inspected and hydrostatically tested at the specified test pressure as indicated on the Carbone assembly drawing. The method of packing the exchangers on skids has proven satisfactory over many years, and is approved by the carriers when accepting the units for shipment. However, damage in transit is always possible, and the exchanger should be inspected immediately upon receipt, before removing from the packing skid. Do not give the carrier a clear receipt or put the unit in storage before performing the following:

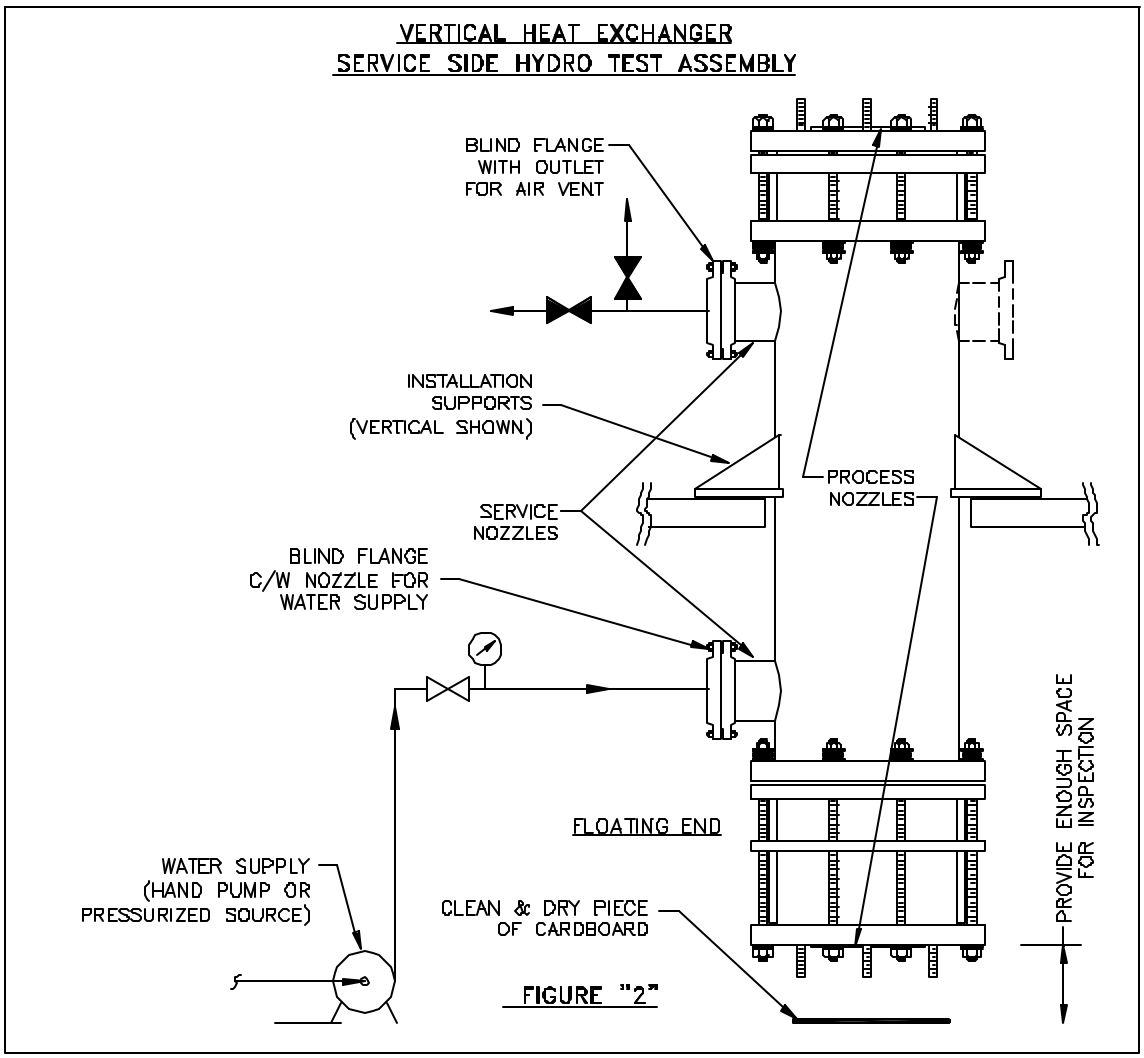
a) Examine the skid and crating carefully for evidence of damage in transit.

b) Note: Carbone of America usually installs a "shock watch" device on the packaged shipment which if broken (indicates red in the glass vial) is immediate evidence of mishandling during transit.

c) Visually inspect all nozzles, flanges, support brackets, etc. for damage.

d) Check the torque of the springs or Belleville washers at the shell flange, and the torque loading of all other bolts. Retorquing may be necessary due to gasket set during transportation. Refer to your assembly drawing for the proper torque values or heights.

e) perform an initial hydro test by following these steps : (refer to figure below).



Rev. No.	Document Ref : GRAPHILOR_S&T.ED	Date	Written by	Checked by
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i) Rig and support the unit in a vertical position.

ii) Connect pressure piping & valving to the ~~service~~ nozzles.

iii) Put a dry clean piece of cardboard under the exchanger which will serve as a leak detector.

iv) Fill the shell with water through the service connections. Vent air through an outlet vent valve.

v) Pressurize the service side gradually up to the test pressure noted on the assembly drawing. Check for leaks while under pressure. Pressure should be held for a minimum of one hour. For a multipass process exchanger, the test should last at least 2 hours. If a leak develops, this will show up as drops of water coming out of the bottom of the exchanger.

vi) TEST PRESSURE MUST NEVER EXCEED THE DESIGN OR TEST PRESSURE AS MARKED ON THE NAMEPLATE OR ON THE ASSEMBLY DRAWING.

vii) If leaks occur after the preceding procedure, a claim should be filed immediately with the shipper, and Carbone of America should be notified of the problem. Remove the corrosive resistant heads to determine the exact nature of the leak and follow the instructions of steps vi to viii.

viii) If the exchanger is not to be installed immediately, be sure to drain the test water completely in order to prevent freeze damage during cold weather.

ix) If a leak appears between the tubesheet and the shell flange, make sure that the spring discs are at the specified torque value or height (refer to assembly drawing).

x) If a leak appears at the face of the tubesheet, this would indicate one or several broken tubes. Visually check along the inside of the tubes for damage. Refer to section 4 for tube replacement or plugging.

2. INSTALLATION

a. Handling

The heat exchanger must be handled carefully. It should be lifted either by the support brackets or by lifting lugs (if so provided) attached to the shell. NEVER LIFT THE EXCHANGER BY THE SPRING ASSEMBLIES OR BY THE NOZZLES.

b. Clearance for dismantling

Polytube® heat exchangers can be repaired on site. Unless adequate provisions can be made for taking down the complete exchanger, it is recommended that sufficient clearance be allowed for dismantling and repair. The tube bundle is removable from the fixed end of the exchanger. Minimum clearance should be the length of the exchanger plus one (1) foot (300 mm) at one end for tube bundle removal.

c. Foundation

Any concrete foundation or floor or structure must be adequately designed to support the Polytube® heat exchanger and its contents. The weight of your heat exchanger either empty or full of water is indicated at the beginning of this manual and on the assembly drawing.

d. Vertical installation

Vertical installation is usually recommended. This position minimizes air entrapment. The Polytube® may be supported on any rigid steel frame or stand suitable for the loads by its integral supports. Do not fix the spring end compression plates, since this will prevent expansion and cause potential damage.

e. Horizontal installation

The Polytube® may be operated horizontally only if originally designed for this arrangement. Special provisions must be made at the design stage to maximize draining and venting of the unit.

The Polytube® may rest on suitable saddles without bolting the shell directly to the saddles. This allows for free expansion of the shell. For fixed horizontally mounted exchangers, one support has drilled mounting holes and the other support has slotted holes (refer to figure 3). Tighten and “fix” the bracket with the “holes” and use double nuts at the slotted bracket so there is clearance between the bolts and the slotted holes to allow the bracket to slide as the shell thermally expands and contracts.

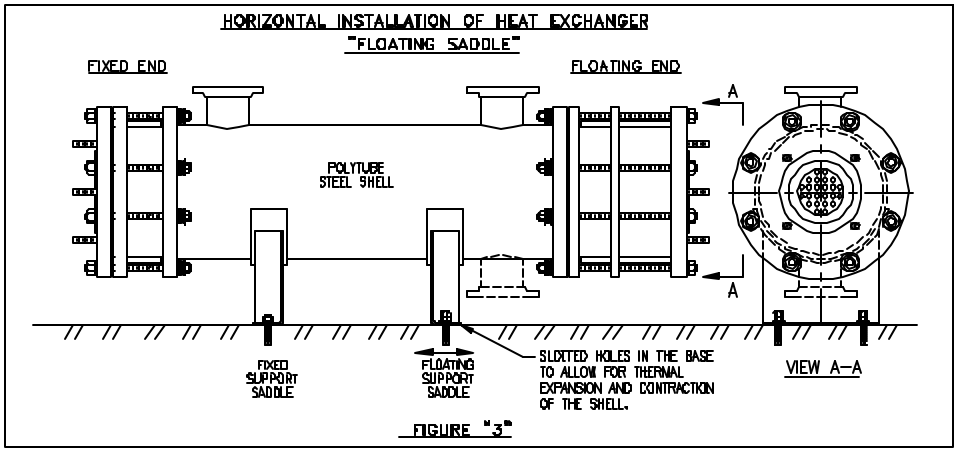


FIGURE "3"

f. Leveling

Polytube® heat exchangers should be set level and square so that all piping connections may be made without excess force. The use of expansion joints (see sections h and i for details) is recommended.

g. Dirt removal

The entire piping system connected to the heat exchanger should be isolated and then cleaned and flushed prior to the start of operation to prevent plugging of tubes or damage to the heat exchanger. The use of strainers or settling tanks in the pipe line up-stream of the exchanger is strongly recommended.

h. Process Piping (see figure 1)

Piping to Polytube® corrosive resistant heads connections should be planned carefully to prevent undue stresses from being transmitted to the exchanger, especially if the heads are made of graphite. TFE expansion joints, installed as close to the exchanger as possible, are recommended to isolate the unit from vibration, misalignment and thermal expansion of the piping or other loads which can impose stress on the heat exchanger. Carbone of America can supply Armylor® corrosion resistant TFE expansion joints for this purpose. Contact Carbone of America for assistance in sizing and selection. The heat exchanger is not a pipe support. Make sure to respect the torque values indicated on the assembly drawing when connecting the process piping to the heat exchanger. ~~Torques exceeding the indicated values can crush or crack the graphite and create unwanted process leaks.~~

Note: Use gaskets which are easy to seal and require low torque values for process nozzle connections. Woven PTFE tape gaskets or suitable elastomeric gaskets are recommended.

i. Shellside Piping / Service (see figure 1)

Piping connections can be made to the steel shell using standard pipefitting techniques. (Refer to piping handbook by Crocker and King). Expansion joints, installed as close to the exchanger as possible, are recommended to isolate the unit from vibration, misalignment and thermal expansion of the piping or other loads which can impose stress on the heat exchanger. Steam lines should be properly trapped and provisions made to drain all water legs which might develop in the supply line on shutdown. Use slow opening valves to prevent water or steam hammer. Water or steam hammer can cause damage and create a leak between the process and the service fluids. Automatic control valves, when closed or almost closed, can allow steam to enter the exchanger without providing enough pressure to discharge the condense. Therefore, condense lines should be arranged so there is no back pressure after the trap, and a vacuum breaker should be provided at the highest point in the piping system. This will permit condense to drain by gravity.

j. Pressure Relief Devices/Thermowells

If the heat exchanger is to be operated under pressure, the installation of pressure relief devices on both process and service sides of the exchanger are recommended or may be required by law. Check with local jurisdictions for laws or codes that apply. Refer to ASME Code Section VIII, Division I for recommendations on these devices. Impervious graphite (Graphilor®) rupture disks are available from CARBONE OF AMERICA to alleviate pressure safely from corrosive process lines.

For added convenience, Graphilor® thermowells can be installed on the inlet and outlet process piping to permit temperature indication and transmission. Carbone of America can supply these thermowells if required.

Installation of a valved bypass lined across the heat exchanger nozzles will permit disassembly of the exchanger itself without shutting down the line if multiple heat exchangers are plumbed in series or parallel.

k. Belleville Discs or Springs

Belleville discs or springs are used at the floating end to maintain a constant pressure on the gasketing material between the tubesheet and the head connected to it. The springs account for the thermal expansion in the steel shell relative to the graphite bundle. Thus, the disc springs allow for thermal growth of the shell and some cold flow of the PTFE gaskets, while maintaining proper gasket compression. The correct torque for the springs is shown on your specific assembly drawing.

3. COMMISSIONING AND OPERATION

a. Warnings

i) **Danger:** Do ~~**not**~~ operate the unit at pressure or temperature conditions exceeding those specified on the nameplate or the assembly drawing. Exceeding the values could result in an explosion and bodily harm. (Note: The lowest value listed must be respected. Note that the process side rating can be different from the service side rating).

ii) **Danger:** Do ~~**not**~~ use compressed air to clean the unit if fluids normally handled are flammable. Dissipating these fluids could result in fire and bodily harm.

iii) PREVENT BOIL UP OF PROCESS FLUIDS IN THE HEAT EXCHANGER. This can cause excessive fouling in the tubes ~~and~~ may result in damage to internal parts of the exchanger. Provide safety interlocks with the control system. If the process fluid flow stops for any reason, the steam or thermal oil ~~must~~ shutdown automatically.

iv) Inspect steam traps periodically to prevent backup of condense in the exchanger. Condense flooding will reduce the performance of the heat exchanger.

v) Refer to the Carbone exchanger assembly drawing for proper bolt torque information when tightening or adjusting nozzle and shell flanges. Always use Carbone TFE expansion joints at or near corrosive resistant head connections to lessen nozzle loadings. Expansion joints if used should always employ safety shields to avoid splashing in case of rupture. Safety shields are available from Carbone of America.

vi) Torquing of any section of the exchanger must be done when the unit is shut down and "cold".

b. Commissioning

i) If you are commissioning a new unit or one that has been re-assembled for service, make sure that all nuts and springs (spring discs) are at the design torque value or height. Torque values are indicated on the assembly drawing. Gaskets may compress (or cold flow) over time. This will cause a loss of compression of the springs (spring discs). The compression of the springs (spring discs) should thus be checked periodically and always after the 1st few thermal cycles.

ii) To start the unit, run the cold fluid first. Open valves slowly to flood the unit and to vent all air before allowing full flow. Once steady flow conditions are reached, introduce the hot fluid in the same manner.

iii) For steam service; the steam trap bypass valve should be open when starting a steam-heated unit. This valve can be closed when a steady flow of steam has been attained. STEAM OR HOT THERMAL OIL MUST NEVER BE ALLOWED TO CIRCULATE ALONE IN THE EXCHANGER. If the flow of the cold fluid is stopped for any reason, the steam or hot thermal oil must be stopped automatically. (We recommend a flow switch interlock).

A steam or thermal oil leak can develop during the first few thermal cycles. The seal ring at the flange gland may be TFE which has a tendency to "cold flow" during the intitial operation of the equipment. The flange gland nuts, the nuts compressing the flange gland to the shell flange, which are between the floating head flange (spring end) and the flange gland itself, tend to become loose during the first few thermal cycles, and stem or thermal oil may leak out between the shell flange and the flange gland.

iv) Operation of all valves must always be slow and gradual to avoid water or steam hammer. Automatic valves require special attention. Upon shut down, the steam or thermal oil valve should be reset to the closed position to prevent a wide open position upon restart and possible "hammer".

c. Shutting down the Polytube®

The hot fluid should be gradually shut off first in all cases. If it is necessary to stop the circulation of the cooler medium, the hot medium should also be stopped immediately or the Polytube® bypassed accordingly. Once the hot fluid has stopped, let the cold fluid circulate for several minutes in order to stabilize the temperature and then close the valve gradually. For prolonged shutdowns, fluids should be drained from the unit to prevent corrosion, crystallization or precipitation. In addition, in cold environments where freezing may occur, all fluids must be drained. As indicated above, condensation in a steam system should also be drained to prevent water hammer, both when starting up and when shutting down the unit.

4. MAINTENANCE

a. Fouling

The Polytube® heat exchanger should be periodically cleaned by chemical means to keep fouling (sludge or scale formation) to a minimum. This fouling greatly reduces the efficiency of the Polytube®, even though an estimated fouling factor is included in the original design. In addition to the reduction in efficiency, there is generally a marked increase in the pressure drop across the process & service nozzles. The impregnated graphite tubes can be cleaned with a wide assortment of acids and bases, except highly oxidizing ones. Contact Carbone of America if there are any questions on the cleaning agent. The shell, which is generally carbon steel, should be cleaned taking into account the corrosion resistant properties of steel. The different chemical and mechanical means of cleaning the exchanger are explained in the following sections.

b. Carbone Factory Service

Carbone of America provides complete heat exchanger servicing, including complete unit overhauling at its Vaudreuil-Dorion, Quebec and Salem, Virginia facility and other facilities worldwide.

Carbone of America can also provide the services of a field service technician or engineer to supervise in an advisory capacity, customers' routine heat exchanger cleaning and maintenance.

c. Chemical Cleaning

Note: Make sure that chemicals listed below are compatible with your process piping system.

i) Sulfuric Acid Cleaning (Process side)
- Feed and flood 10% to 15% sulfuric acid (H_2SO_4) solution (by weight) through process side.
- Bring solution to boil by introducing steam on the shell side. Do not exceed the pressure and temperature rating of the exchanger. (We usually recommend 15 psig (100 kPag) steam or lower).
- Stop cycle after two to four hours and drain sulfuric acid solution.
- Rinse heat exchanger for 30 minutes with clean water.
- Check torque values of connections and return unit to normal operation.

ii) Caustic Cleaning (Process side)
- Same as above except use a max. 15% caustic solution (NaOH); we recommend a 10 % caustic solution.
- Since caustic can attack impregnated graphite materials above 15% and 212ºF (100ºC), the cleaning cycle should not exceed 2 hours duration and the temperature should not exceed 212ºF (100ºC).
- Rinse heat exchanger with clean water, as above and check torque values of connections.
- Return unit to normal operation.

iii) Other solutions such as organic solvents can be used to clean Polytube® exchangers, but it is strongly suggested that the customer be thoroughly familiar with the properties of the particular solvent, and with the chemical manufacturer's recommended precautions. Carbone of America can only make recommendations regarding the compatibility of the solvent with the graphite impregnation and not surrounding piping.

iv) ~~Chemical cleaning of the service side~~

Water scale and lime can accumulate on the service side of the exchanger. Many cleaners are available commercially to remove these deposits without any detrimental affect on the steel portions of the exchanger.

Refer to the chemical supplier's instructions for these cleaners for proper cleaning procedures. Beware that Graphilor® graphite is attacked by strong oxidizing agents. These must be avoided.

d. Mechanical Cleaning

Mechanical cleaning is generally used only for the inside of the tubes. Rodding the tubes by ramming a steel rod through **is not permissible**. However, water flushing presents no problems and can be facilitated by specifying the installation of clean-out ports on the shell. The corrosion resistant heads must be removed. Dismantling and re-assembly will be explained in the following sections of this manual. Several techniques can be used to clean the exchanger tubes. Precautions must be taken to avoid damage to the tubes, tube nuts and tubesheet.

i) ~~Pressure cleaning (or water blasting)~~
The channels are cleaned using long nozzles and a warm water pressure cleaning machine (below 1500 psi, 10300 kPa). Remember that the tube wall temperature must remain within the allowable temperature range. Refer to the assembly drawing. The lance should be positively centered in the tube and restrained from whipping.

Regardless of which method is used, an hydrostatic test of the Polytube® is required after cleaning. Refer to section 1 and figure 2 for procedure.

e. Disassembly of the Polytube®

Caution: Graphilor® tubing is fragile and can suffer mechanical damage if mishandled, dropped or subjected to bending loads. Therefore, take extreme care when disassembling the bundle from the shell.

Procedure

The tube bundle of most Graphilor® shell & tube heat exchangers can be removed from the shell for inspection or cleaning, although removal is not necessary for normal maintenance, cleaning or repair. For shellside mechanical cleaning or inspection, it will be necessary to remove the bundle from the shell.

The tube bundle should be removed in vertical position although horizontal removal is possible. Bundles with Graphilor® baffle assemblies should be pulled out with great caution to protect the baffles. Refer to your assembly drawing for specific construction details, and Figure 1 for general arrangement. The suggested dismantling procedure follows:

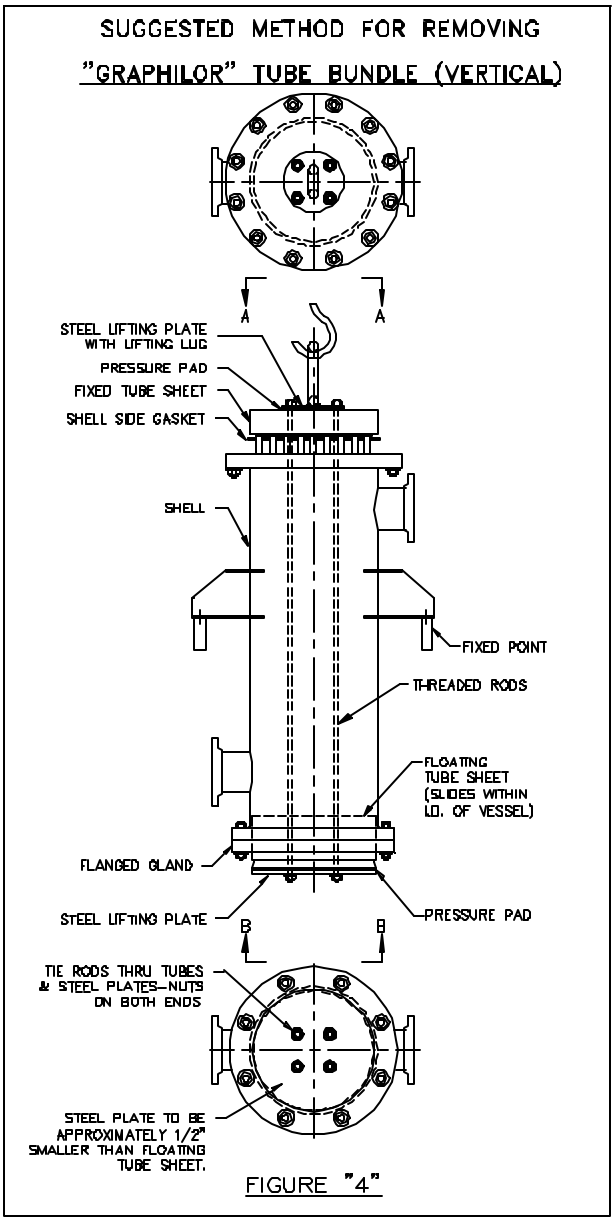


FIGURE "4"

i) Move the exchanger to a convenient working area, where hoist or crane facilities are available.

ii) Put the heat exchanger in the vertical position, with the floating end (spring end) at the bottom. The heat exchanger must be perfectly level before you begin disassembly, to prevent any undue stress on the tube bundle while lifting it out. The space available underneath the shell should allow for easy access to the floating end.

iii) With the heat exchanger in the vertical position, slowly remove all the floating end hardware: Compression plate & flange, header block, flange gland, shell seal ring or packing, gaskets.

iv) Slowly remove all the fixed end hardware.

v) Slide down the threaded rod and the fixed end support plate with the lifting lug. Attach the threaded rods to the floating end support plate and pressure pad. This should have a diameter slightly smaller than the floating tube sheet. (See figure 4)

vi) Attach the bundle to the hoist or crane.

vii) Make sure the shell is firmly held in place.

viii) For exchangers that have been in operation for an extended period, it might help to apply a soapy solution to the shell side prior to the lift to help the bundle slide out. (Soap should only be

used if compatible with the chemicals used in service and for cleaning.)

ix) Slowly lift the bundle out of the shell and place the tubesheets on rigid cradles (wood beams or blocks are recommended). See figure 7 below.

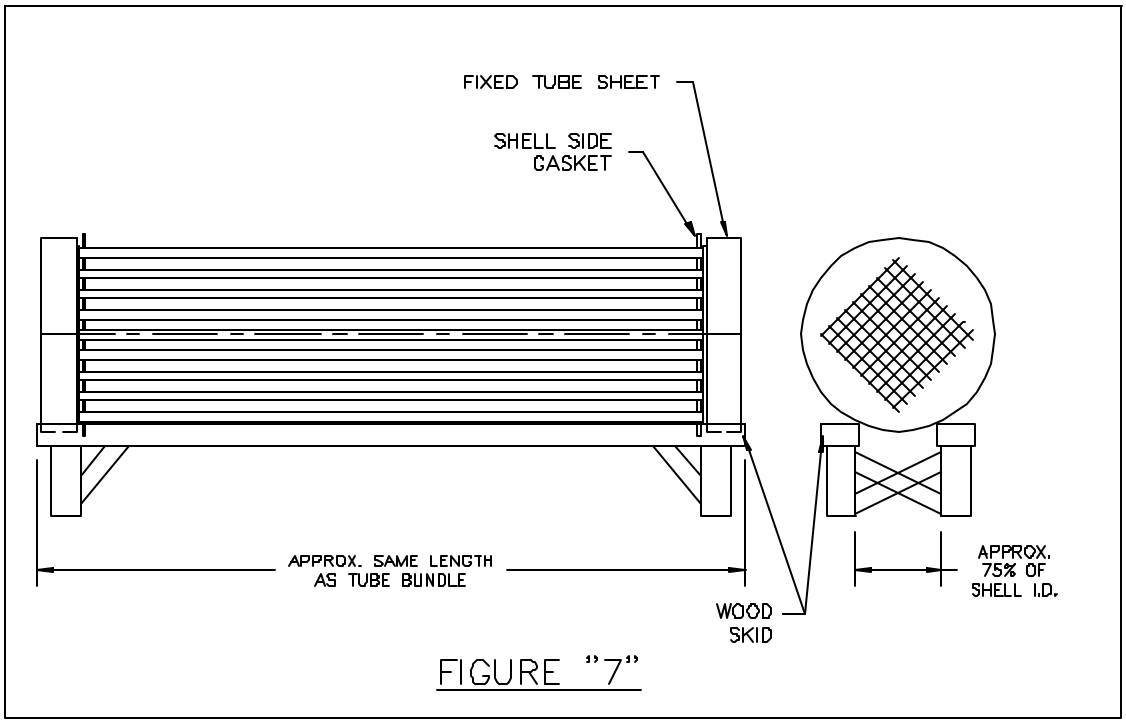


FIGURE "7"

x) The disassembly is now complete. Clean or repair the shellside components as required.

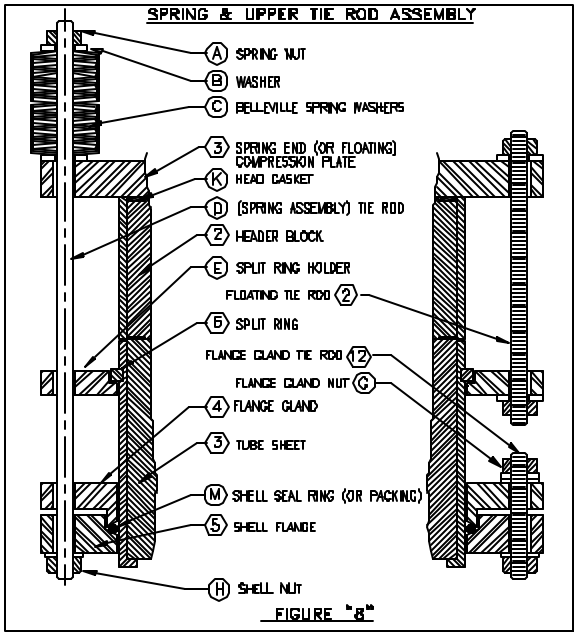
If the bundle must be stored without the shell for extended period of time. It should be protected against possible mechanical damage from foreign objects.

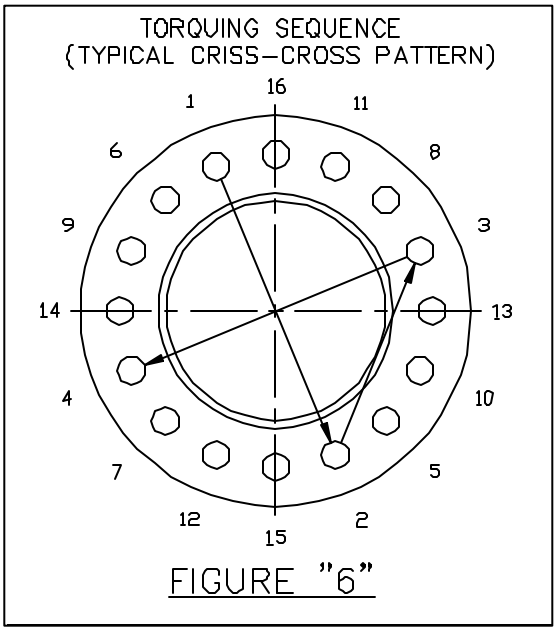
f. Reassembly of the Polytube®

After cleaning or repairs have been completed, the heat exchanger can be reassembled by sliding the tube bundle inside the vertical shell. The shell must be perfectly level to prevent undue stress on the bundle. Reassemble the unit, tightening all nuts by using a typical crisscross pattern (see figure 6).

Use the following procedure:

1. Tighten fixed-end nuts to 1/3 of maximum bolt torque (specified on the assembly drawing) in minimum two (2) incremental steps
2. Tighten floating-end nuts ("spring end") to minimum tightening position as per assembly drawing. If no tightening position is given, use recommended bolt torque from assembly drawing in a minimum of four (4) incremental steps
3. Retighten floating-end nuts to maximum tightening position
4. Torque fixed-end nuts to value on assembly drawing in two (2) additional incremental steps
5. Tighten flanged-gland nuts and split-ring nuts (when applicable) as per assembly drawing in a minimum of two (2) incremental steps for elastomeric glands and three (3) incremental steps for Teflon gland
6. Hydro-test the reassembled Polytube© before putting back in service and check for leaks
7. After hydro-testing and after the first few thermal cycles, it is ~~recommended~~ to check and re-torque all nuts and tightening positions on springs to the recommended values on the drawing





g. Tube replacement

Tubes can be replaced in the field. Replacement will be easier with the heat exchanger in a horizontal position and with proper tools. It is advisable to request the help and supervision of a Carbone technician for replacement of Graphilor® tubes on site. Specific instructions for tube replacement are available upon request.

h. Tube Plugging

If replacement tubes are not available, or other conditions warrant it, tubes can be plugged off in order to return the heat exchanger to service. All Graphilor® Polytube® are designed with excess exchange surface so that design capacity can be maintained with some tubes plugged. (Usually from about 10% to 25% of the tubes in any one pass.)

Non permanent rapid plugs are available for some processes and can be used for very short term, before replacement of a tube. Consult your Carbone representative for possible options. In most cases, permanent Graphilor® plugs should be cemented in place with phenolic based cement. The suggested plugging procedure is as follows:

~~Checking for the leaking tubes~~

1. Plugs can be installed with the heat exchanger installed in its field mounted position as long as there is access to the tubesheets at each end of the exchanger (by header removal or other).

2. Rig the unit for a low pressure hydrostatic test. Refer to figure 2.

3. Dismantle the floating end header (or bonnet) so that all the tubes in the tubesheet can be seen. This is generally done by removing the header to tubesheet springs, studs and nuts. If the headers are graphite lined take extra precautions not to scratch or damage the graphite surfaces.

4. Perform an hydrostatic test on the unit. Mark the leaking tubes at the floating end with a paint pen.

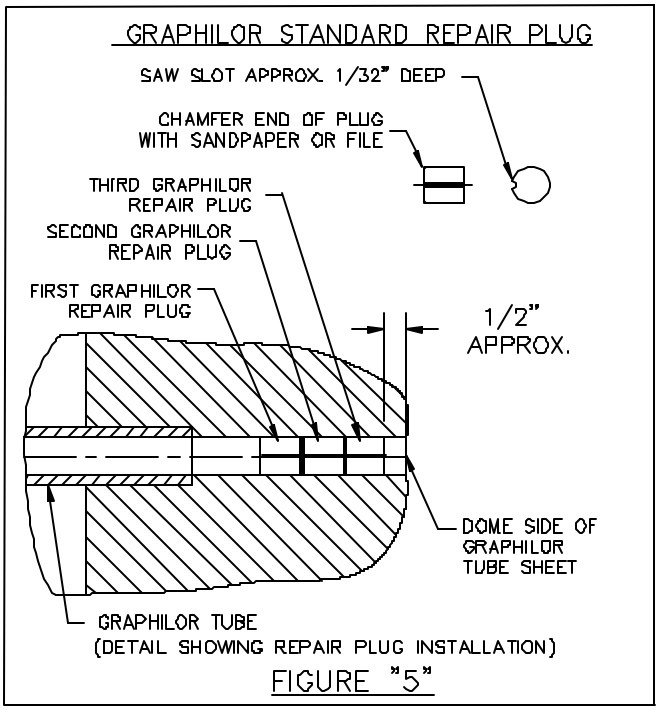
5. If the quantity of tubes PER PASS allows for it, prepare the material for plugging the tubes.

6. Prepare 6 Graphilor® plugs of approximately 1 in. long per leaking tube. These should be slightly chamfered for easy insertion. Use a file or sand paper. On all plugs, make a longitudinal slot about 1/32 in. deep. This will allow air escape while inserting the plugs. Refer to figure 5.

7. If the unit is installed horizontally, and it ~~has a bolt ring or "bonnet cover"~~ the fixed end header can be dismantled~~.~~ (A bolt ring is a flange which allows the removal of the header without loosening the tubesheet to shell flange connection.) If the unit is installed horizontlly and the fixed end tubesheet and header assembly does ~~not~~ have a bolt ring or bonnet cover ~~make sure that the tubesheet is fully supported at the bottom of the tubesheet~~ in the horizontal position so that the tube bundle does not fall onto the shell when the header to shell studs are removed. If this is not done, serious damage to the tube bundle could result.

8. If the unit is vertically installed and properly supported by the shell, one can now dismantle the fixed end header.

9. Using a long metal wire, go through each leaking tube from the floating end to the fixed end, and clearly identify the leaking tubes at the fixed end.



10. Clean the leaking tube holes in the tubesheet to allow the cement plugs to be inserted. They may have

to be drilled. The hole and plug should have a reasonably tight fit without cement.

11. Put some Carbone phenolic based graphite cement inside the leaking tube hole, and insert the first plug. It should be inserted deep enough to allow the insertion of the other two plugs and with an extra ½ in. left after complete plugging.

12. Put some more cement inside the tube and insert the second plug. Repeat for the third plug.

13. Make sure the plugs are inside of tube tube, at about ½ inch below the tube sheet face.

14. Remove excess cement around the tube hole, cure cement according to instructions.

15. Repeat at the other end of the tube.

16. Repeat for other leaking tubes.

17. Allow for complete curing before proceeding to reassemble the headers and gaskets, etc.

18. Proceed to a hydro test as per section 1 before putting the unit back in service.

5. SPARE PARTS

When ordering spare parts, please refer to the heat exchanger drawing supplied with the unit and order parts using the full part number (with suffix) from this drawing. This will ensure that the parts ordered will be the correct items and material of construction for your heat exchanger. As a minimum, one ~~complete set of gaskets~~ should be stocked at all times for each exchanger in service.

For replacement parts, field servicemen or exchanger repair, call your local Carbone representative, or the factories direct at:

CARBONE OF AMERICA (LCL) LTD.
225 HARWOOD BLVD
VAUDREUIL-DORION, QUEBEC
J7V 1Y3
TELEPHONE: (450) 455-5728
FACSIMILE: (450) 455-5052

CARBONE OF AMERICA CORP.
540, BRANCH DRIVE
SALEM, VA 24153
U.S.A.
TELEPHONE: (540) 389-7535
FACSIMILE: (540) 389-7538

6. CLEANING CARBONE EQUIPMENT BEFORE RETURNING IT TO CARBONE FOR REPAIRS.

Employee safety and the strict adherence to OSHA, EPA and other safety and pure air and water regulations are primary concerns to CARBONE OF AMERICA. To repair equipment in a safe and expedient manner, it is mandatory that the equipment be returned in a thoroughly cleaned condition.

It should be noted that there are no facilities at CARBONE OF AMERICA to discharge effluent from dirty equipment.

A Returned Equipment Questionnaire and Material Safety Data Sheets must be completed by the customer and sent prior to returning equipment to Carbone of America. Failure to comply may cause delays in processing the equipment or possible rejection of the equipment, with return of it to the customer at his expense. In general, the following should be carried out sequentially:

a. Remove all external insulation.

b. Clean equipment exterior and interior. The inside and outside of the equipment and related accessories must be free of any residue or other contaminants which may be toxic, flammable, explosive and irritating at any temperature from ambient up to and including welding temperatures.

c. Flush shell and tubeside of the exchanger to remove all heating or cooling medium and product residue. A thorough flushing of the unit with water or a non-harmful solvent is required.

d. All materials/items removed from the vessel should not be returned to CARBONE OF AMERICA. They should be disposed of in a manner consistent with the customer's safety or salvage policies.

e. Contact CARBONE OF AMERICA for an applicable Returned Equipment Questionnaire. A Material Safety Data Sheet will be required as well. Complete the forms and return them to CARBONE OF AMERICA.

f. After our review of the completed Questionnaire and Material Safety Data Sheets, Carbone will send you a "Return Authorization Tag" that you should attach to your unit before returning it to us.

7. ASSEMBLY DRAWINGS (attached) & NOTES