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INSTALLATION AND OPERATING INSTRUCTIONS FOR ARMSTRONG SHELL AND TUBE HEAT EXCHANGERS

INTRODUCTION

Armstrong Heat Exchangers are designed for highest efficiency and trouble-free service, based on many years of technical and operational research. Careful supervision and inspection of materials and workmanship are important factors in the manufacturing of each unit.

In any correspondence relating to Armstrong units, please refer to the serial number which is stamped on the nameplate.

CONSTRUCTION

A shell-and-tube heat exchanger consists of a shell with inlet and outlet connections which carries one fluid, and a tube bundle with inlet and outlet connections for the handling of another fluid. The wall of the tubes is the boundary between the two fluids and is known as the heat transfer surface.

When the temperatures of the two fluids are such as to cause difference in linear expansion of the shell and tubes, means are provided to prevent this expansion damaging the unit. These means vary with the type of exchanger. A U-tube bundle can move independently of the shell and no other precautions in design need to be taken to take care of expansion. Straight tube bundles requiring consideration for expansion are usually provided with a floating rear head. In lieu of this, the shell may be fitted with a suitable expansion joint. The various uses to which heat exchangers are put, and the economics of each particular application dictate the method most suitable.

For heating of oils and other liquids of low specific heat and low thermal conductivity, exchangers with fixed tube sheets and no expansion joints are often used. In these cases, the tube wall temperature and the shell temperatures are relatively close, so that it is not considered essential to allow for difference in expansion of these parts when the heating medium is in the shell. If the heating medium were in the tubes, of course, means to take care of expansion would be necessary.

Every care is taken in design to provide a heat exchanger most suitable to meet each situation, consistent with reasonable cost. Various industries and processes have special preferences and requirements which S. A. Armstrong Limited is most anxious to provide. Standard designs may be modified to embody special features and materials as required. All Armstrong heat exchangers are built to ASME Code. If specified, special requirements of Lloyds Register, Tubular Exchanger Manufacturers' Association (TEMA) Class C and Class R can be incorporated.

INSTALLATION

1. In selecting a location for the heat exchanger, provide sufficient clearance at the head end of the exchanger to permit removal of the tube bundle from the shell. In the case of straight tubes with fixed tube sheets, allow room to remove the heads for inspection and cleaning tubes, if and when it should become necessary.

2. Provide valves and bypasses in the piping system so that both the shell side and the tube side may be by-passed to permit isolating the unit for inspection and repairs.

3. Provide, as considered necessary, means for cleaning the unit periodically. See also information under Maintenance.

4. Provide thermometer wells and pressure gauge connections in all piping to and from the unit and located as near the unit as practicable.

5. Provide necessary air vent cocks so that gas vapor may be purged to prevent binding. A vacuum breaker in a steam spacer or in piping close to the steam spacer is desirable to minimize the effect of water-hammer.

6. Foundations must be adequate so that the exchanger will not settle and cause piping strains. In concrete footings, foundation bolts set in pipe sleeves of larger size than the bolt size will allow for adjustment after the foundation has set.

7. Loosen foundation bolts at one end of unit to allow free expansion and contraction of the heat exchanger shell.

8. Set the exchanger level and square so that piping connections may be made without forcing and also so that the tube bundle and shell of the exchanger do not trap gas, vapor or condensate. Steam to water heat exchangers should be installed at a 3 to 4 deg incline (towards the shell outlet), in order to facilitate the drainage of the condensate.

9. Before piping up, inspect all openings in exchanger for foreign material. Remove all shipping plugs and flange covers just before installing, and do not expose the unit to the weather with openings uncovered, since water may freeze and cause damage.

10. Be sure entire system is clean before starting operation, to prevent plugging of tubes with sand or foreign material. The use of a strainer or a settling tank in pipe line leading to the exchanger is recommended.

11. Drain connections should not be piped to a common closed manifold.

12. A gauge glass should be installed in a vapor or gas space to indicate possible flooding due to faulty trap operation.

13. To guard against pulsation of fluid due to reciprocating pumps or other equipment, a surge drum is recommended.

14. Quick-opening and closing valves controlling fluids to or from an exchanger may cause water-hammer, and care should be taken for proper selection of such equipment. Water-hammer can cause serious damage to heat exchanger tubes.

OPERATION OF HEAT EXCHANGERS

1. **START-UP:** When placing a unit in operation, open the vent connections and start to circulate the cold medium only. Be sure the passages in the exchanger are entirely filled with cold fluid before closing the vents. The hot medium should then be introduced gradually until all passages are filled with the liquid or vapor, as the case may be. Then close the vents and slowly bring the units up to temperature.

2. BOLTED JOINTS: Heat exchangers are hydrostatically tested in accordance with Code requirements and are certified as satisfactory by inspection agencies agreed upon by the manufacturer and the purchaser. However, normal yielding of gaskets will occur in the interval between hydrostatic testing in the manufacturer’s shop and installation at the job site. Therefore, all external bolted joints should be properly re-tightened after installation and again after the exchanger has been heated, to prevent leaks and blowing out of gaskets.

3. DESIGN AND OPERATING CONDITIONS: Do not operate equipment under pressure and temperature conditions in excess of those indicated on the nameplate.

4. SHUTTING DOWN: In shutting down, flow of hot fluid should be shut off first. If it is necessary to stop circulation of cooling medium, the circulation of the hot medium should be stopped also, through bypassing or other means.

When shutting the system, all fluids should be completely drained to minimize the possibility of freezing and corrosion. To guard against water-hammer, condensate should be drained from steam heaters and similar units when starting up, as well as when shutting down.

To minimize water retention after drainage, the tube side of water-cooled exchangers may require blowing out with air.

5. WATER HAMMER: In the case of steam as the heating medium, the steam trap should be manually by-passed until the exchanger is switched to automatic control. Costly damage can result if care is not exercised in the start-up of a heat exchanger. Water-hammer often results when a large quantity of steam is allowed to condense rapidly in an enclosure. Thin-walled tubes are very vulnerable. Copper tubing is used extensively and is relatively soft metal.

Water-hammer is a type of implosion effect particularly pronounced when low pressure steam is used, one reason being the high volume ratio of steam and water at low pressure. For instance: Volume of 1 lb. of steam at 5 psig is about 20 Cu. ft. Volume of 1 lb. of water (condensate) is .0168 cu. ft.

This volume ratio of 1200 to 1 gives us some idea of how the tremendous hammer effect may be produced when there is enough transfer surface present to remove the latent heat of vaporization rapidly. Slugs of water are hurled about in the vacuum created by condensation, and one can visualize the damage possible to fragile tubes.

When this hammer effect has occurred in the shell of an exchanger, the damage pattern is quite regular. Tubes are crushed in on top of the tube bundle, usually at about two-thirds of the distance from the steam entry nozzle toward the other end of the tube bundle. So far, there seems to be no technical explanation for this phenomenon. From study and examination of damaged exchangers, and investigation of their operation, we have come to the conclusion the following is roughly what happens: In a water heater using steam in the shell, when the demand for hot water ends the steam control valve closes, but there is a good supply of steam left in the shell of the exchanger. As this steam condenses, the pressure drops, often below atmospheric or even practically to full vacuum. This prevents condensate from leaving the shell and sometimes even syphons in condensate from the line beyond the trap. Now, when the steam valve opens again and admits steam to the shell, the rapid condensation, as it strikes the cold condensate, causes streams of water to rise, hitting the top of the shell and bouncing onto the top tubes. Sometimes the breaks in the tubes look as though a 4” spike had been driven through the topside. Other times the tubes may be crushed as if with a blunt chisel over lengths of a few inches or up to two feet.

MAINTENANCE OF HEAT EXCHANGERS

1. **IMPORTANT:** Follow carefully the procedure recommended for operation. Quick start-up and shut-down without proper condensate removal is a major cause of heat exchanger damage.

2. Frequently, and at regular intervals, observe the interior and exterior condition of all tubes and keep them clean. Neglect in keeping all tubes clean may result in complete stoppage of flow through some tubes, causing over-heating of these tubes. This overheating may result in severe expansion strains and leaking tube joints.

3. When removing tube bundles from exchangers for inspection or cleaning, care should be taken to see that improper handling does not damage them. Tube bundles are often of great weight, yet the tubes are small and of relatively thin metal. The tube bundle should therefore never be supported on the tubes but should rest on parts designed to carry it, i.e., on tube sheets, baffles or support plates.

Do not handle tube bundles with hooks or other tools which might damage the tubes. They should be moved about on cradles or skids. Horizontal tube bundles should be lifted by means of suitable slings. Baffles can be easily damaged by dragging a bundle over a rough surface.

4. Provide convenient means as necessary for cleaning heat exchangers at regular intervals:

   (a) Circulating hot wash oil or light distillate through tubes or shell at high velocity will effectively remove sludge or other similar soft deposits.

   (b) Soft salt deposits may be washed out by circulating hot fresh water.

   (c) Some commercially available cleaning compounds may be used for removing sludge or coke, provided hot wash oil or water, as described above, do not give satisfactory results.

(d) Removal of various scales and foreign material by chemical cleaning is now being extensively practiced. Certain qualified organizations will check the nature of the deposits to be removed, furnish proper acid solutions containing inhibitors, arid provide equipment and personnel for a complete apparatus and piping cleaning job.
(e) If none of the above methods are effective for the removal of a hard scale, coke, or other deposits, mechanical means may be used for straight .tube heat exchangers.

5. CLEANING PRECAUTIONS

(a) Do not attempt to clean tubes by blowing steam through individual tubes. This overheats the tube and results in severe expansion strains and possible leaky tube joints.

(b) Do not blow out heat exchangers with air when fluids normally handled are inflammable.

(c) In cleaning a tube bundle, tubes should not be hammered on to remove hard scale. In case it is necessary to use scrapers, make sure that the scraper is not sharp enough to cut the metal of the tubes.

(d) If scaling or other fouling were expected, provisions in the piping could be made to allow connections for flushing out or chemical circulation cleaning; these openings, of course, would be normally plugged. In large plants where there are a number of exchangers, it may be profitable to have a tank of cleaning fluid available for periodic flushing of shell and/or tubes. Makers of commercial cleaning compounds would be glad to advise in this respect. Then, there are qualified organizations with experienced personnel who can furnish a complete service of apparatus for the removal of hard scale and sludge not easily removed otherwise. Small exchangers that can be easily removed from the line and small tube bundles can be sent to organizations that do such cleaning on their premises.

6. TUBE ROLLING

To tighten a loose tube joint, use a suitable roller type expander. Do not roll tubes that are not leaking as this needlessly thins the tube wall, and work hardens the metal which makes it brittle. Tubes are rolled in at our factory by means of roller type expanders, and the amount of expansion is controlled by means of a torquing device for uniformity and positive sealing. Do not over-roll the tubes as this would permanently damage the tubesheet.

7. GASKET REPLACEMENT:

Gaskets and gasket faces should be thoroughly clean and should be free of scratches and other defects. Gaskets should be accurately positioned before re-tightening bolts. It is recommended that when a heat exchanger is dismantled for any reason, it be re-assembled with new gaskets. Composition gaskets become dried out and brittle so that they do not always provide an effective seal when re-used. Metal or metal- jacketed gaskets, when compressed initially, flow to match their contact surfaces. In so doing, they are work-hardened, and when re-used, may provide an imperfect seal. Re-used metallic gaskets could result in deformation or damage to the gasket contact faces of the exchanger.

8. SPARE AND REPLACEMENT PARTS:

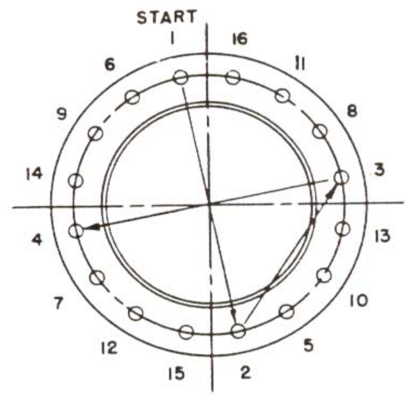
Spare or replacement parts may be obtained for Armstrong heat exchangers by reference to the part required and to the serial number of the exchanger appearing on the nameplate. Consideration should be given to stocking parts for exchangers used in a process as inconvenient shutdowns may be necessary until receipt of parts. Since some gaskets are made to order with a long lead-time, it may be desirable to have them on hand.

In situations where a shut-down for cleaning and/or repairs could not be conveniently arranged, a standby heat exchanger connected in parallel, or a complete replacement tube bundle on hand for emergency, is recommended.

9. BOLTING

It is important that all bolted joints be tightened uniformly and in a diametrically staggered pattern, as illustrated in the diagram, except for special high pressure closures when the instructions of the manufacturer should be followed.

Nominal Bolt Dia.	Std. Machine Bolts A-307 Torque in Ft/lbs.	High Tensile Bolts A-326 or A193-B7 Torque in Ft/lbs.
1/2	15	40
5/8	30	75
3/4	50	125
7/8	80	200
1	125	310
1-1/8	200	450
1-1/4	276-5	650
1-3/8	-	850
1-5/8	-	1000
1-1/2	-	1400
1-3/4	-	1900
1-7/8	-	2500
8	-	2800



Torque required to tighten new flange ring bolts

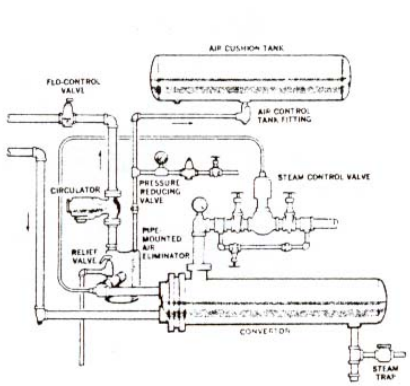
Parts of the above excerpts from the Standards of the Tubular Exchanger Manufacturers Association.

TYPICAL INSTALLATION OF "WS" HEAT EXCHANGER SHOWING RECOMMENDED METHOD OF INSTALLING CONVERTORS WITH ARMSTRONG AIR CONTROL SYSTEM

To establish air control in convertor or heat exchanger installations, a pipe mounted air eliminator is installed as shown in the accompanying diagram. The vortex air separator consists of a large cross-sectional area reducing the flow velocity and allowing air bubbles to rise into the air-line to the compression tank.

1. The air-line from the vortex air separator must pitch up to the air control tank fitting and compression tank.

2. The pump must be installed in the supply main, pumping to the system, regardless of the size of convertor or pump. In this way, pump head is added to the piping circuit.



CAUTION

Steam hammer can cause serious damage to the tubes of any heat exchanger. A careful consideration of the following points before an installation is made can prevent costly repairs which may be caused by a steam hammer.

1. A vacuum breaker and/or vent, should be used in accordance with the type of alarm system installed.

2. The proper trap should be used for the steam system installed.

3. The trap and one condensate return line to the trap should be properly sized for the total capacity of the convertor.

4. The trap should be sized for the pressure at the trap, not the inlet pressure to the steam controller.

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