1300 Sumner Avenue • Cleveland, Ohio 44115-2851 • 216-241-7333 • Fax: 216-241-0105 • www.heatexchange.org

Specification of Tube Hole Sizes and Tolerances for Support and Baffle Plates

In an effort to limit the potential for damaging tube vibrations, customers sometimes specify tube hole sizes tighter than the HEI standards. This requirement leads to a significant increase in cost of the feedwater heater and could shorten instead of extend the life of the tube. Tube damage can occur during assembly when the tube is inserted into the bundle cage, if manufacturing tolerances were not allowed, as a result of undersized tube holes. The tube hole sizing provided in the HEI Standards was developed through technical requirements, manufacturing tolerances, and manufacturing experience.

Ideally, each tube would fit in each tube hole with almost no clearance left over. In reality, tube holes and the tubes themselves are not perfectly round. Tube diameters have tolerances. Baffle plates and supports are stack drilled to insure proper alignment when pushing the tubes. Twist drills used to drill stacked baffles have a tendency to drift off line. Depending on the number and spacing of the supports and/or baffles, some clearance is required in the tube hole to prevent forcing the tube into the bundle cage due to friction from all of the supports and/or baffles. Even the tube legs are not perfectly straight. Consider the following example:

Use a standard 0.625" OD SA-688 TP304 tube in a feedwater heater. Per Section 3.7.2.1 of the HEI *Standards for Closed Feedwater Heaters* and TEMA paragraph RCB-4.2, the following would be the maximum permissible tube hole size for a condensing zone support plate:

Tube OD	0.6250"
HEI Standard per Section 3.7.2.1	+ 0.0156"
TEMA per paragraph RCB-4.2	+ 0.0100"
Maximum Permissible Tube Hole Size	= 0.6506" (for 96% of the tube holes per TEMA)
Total Permissible Over-Tolerance	= 0.0256" (for 96% of the tube holes per TEMA)

The ASME specifications for SA-688 calls for the tubes to conform to SA-1016. Per Table 3 of SA-1016, the tube diameter is permitted to have 0.004" over-tolerance.

Referring to the note under Table VI in Section 3.8.3 of the HEI *Standards for Closed Feedwater Heaters*, one can calculate the expected drill drift for a stack of supports and/or baffles. Typically, supports are stacked no deeper than five times the drill diameter. For our case, the drill diameter is 0.6406" and the standard support thickness in the condensing zone is 0.6250". Therefore, a maximum of 5 support plates would be drilled at one time. The bottom support plate in one stack would be expected to be offset from the top support plate in the next stack by the following amount:

[(5 x 0.6250") / 0.6406"] x 0.0016" = 0.0078"

Adding this manufacturing tolerance to the permissible ASME tube OD tolerance of 0.004" brings the total over-tolerance to 0.0118". This would leave only 0.0138" tolerance (0.0256" – 0.0118") left to account for any additional variances such as tolerances in straightness of the tubes, final bundle assembly alignment, and the matching of the bundle cage tube layout with the tubesheet layout which is drilled to tighter specifications due to tube to tubesheet considerations.

Slightly tighter holes for the support plates and/or baffles are possible; however, the tighter tube hole sizes usually require additional shop operations, special tooling, increased labor, and increased quality control. The tube metallurgy should also be taken into consideration, as some tube materials are more prone to damage than others. If special care is not taken, the potential for damage to the tubes from denting, scoring, galling, or scratching is greatly increased.

There are more cost effective methods of protecting the tubes from damaging tube vibrations. In reality, specifying a tighter tube hole size and tolerance than HEI or TEMA is the least effective method available to protect against damaging tube vibrations. The potential increase of the natural frequency of the tube by specifying a realistic tighter tube hole tolerance is essentially negligible. The following methods are significantly more effective (and less expensive) than specifying a tighter tube hole tolerance in a feedwater heater:

1. Zone design. Controlling flow through baffle design and spacing within each zone is the single most effective way to decrease the potential for damaging tube vibrations.

2. Increase Shell Side Entrance and Exit Areas. For the condensing zone in a heater, this would relate to a larger dome area in the heater, which would allow for lower steam velocities.

3. Increased Tube Pitch. Increasing the tube pitch lowers the shell side velocities, but it also increases the size of the tube bundle.

4. Thicker Baffles. Thicker baffles assist in lowering fretting damage to tubes. While this method is less complicated than specifying tighter tube hole tolerances, it is still inferior to making modifications as suggested in items 1 through 3 listed immediately above.

In conclusion, there are often competing concerns when designing a feedwater heater. The advantages of tightening up the size and tolerances in the tube holes must be weighed against the potential disadvantages. Consideration should also be given to other procedures that provide the same benefit with less exposure to the disadvantages.