“Innovative tube repair technology keeps the USNS Comfort ready for the call of duty”
INTRODUCTION

An innovative tube repair technology by EST Group aboard the Naval hospital ship, USNS Comfort, helped keep the ship in full operating condition and ready for active service. Corroded tubes in one of the ships main A/C condenser units were repaired using “tube sleeves” fitted to the host tubes by EST’s service team. This innovative solution has heat exchanger applications in chemical, pharmaceutical, utility, and industrial facilities. Utilizing this technique, tubes can be repaired from the inlet, up to full tube length applications.

HISTORY OF THE SHIP

T-AH 20 Comfort is one of two hospital ships belonging to the Military Sealift Command. Converted from an old San Clemente class tanker by The National Steel and Shipbuilding Company, the USNS Comfort was christened on August 15th, 1987. The Comfort has a distinguished record, and served in both Gulf wars, Operation Desert Storm and Operation Iraqi Freedom, where it provided critical combat medical care from its station in the Arabian Gulf. It was also activated the afternoon of September 11th, 2001 to serve as a 250-bed hospital facility at Pier 92 in midtown Manhattan. It is 894 ft in length, 69,360 tons, and serviced by 61 civilians and 1,214 military personnel during active duty.
THE PROBLEM

Three 400-ton A/C condensers located forward of the engine room handle air conditioning for the Comfort. The vessel is divided into three segments, and during full operating condition each unit is responsible for one segment. Unit #3 is a 400-ton centrifugal chiller manufactured by York International. And it is comprised of 700 90/10 copper nickel tubes, with an OD of 3/4" of an inch and wall thickness of 18 BWG. This unit is responsible for Zone B of the ship. Due to significant leakage through out the exchanger it had to be shut down until the leaking tube could be replaced or repaired. This left the majority of the aft end of the ship, including the general medical ward, blood bank, and intensive care unit, with stagnant air.

Through eddy current and shell side hydrostatic testing, it was determined that this unit had serious problems. Almost 10% of the tubes had been plugged, and the majority of the remaining tubes had significant “wall thinning”. At this point, a decision needed to be made for repair/replacement of the bundle.

POSSIBLE SOLUTIONS

Some possible solutions considered by the Military Sealift Command:
- Replace the entire unit
- Plug leaking tubes and delay repairs
- Leave unit out of operation
- Re-tube
- Sleeve leaking tubes

Replacing the entire unit would require prohibitive manpower, time, and expense. In addition, replacing a 400-ton chiller potentially meant cutting a significant opening in the hull of the ship, large enough to fit the entire unit. There would also be a problem in negotiating the new unit around other mechanical systems on the ship.

Plugging the tubes, and delaying a more permanent solution was also considered. With 10% of the tubes already plugged, additional plugging would make the unit so inefficient, it would not be capable of supplying adequate cooling.

Leaving the unit out of operation, if possible, was considered. During inactive duty, this was an option, however during active duty, all units must be operating, in order to meet the cooling load requirements of the medical units operating theaters.

Another solution the Military Sealift command considered was re-tubing the entire unit. It was determined that re-tubing this unit on site would be difficult, expensive and require a long repair cycle, as the tubes had OD fins, which are troublesome to remove, and re-install.
THE ANSWER

Finally, a tube sleeving technique, offered by EST was considered. Many tube failures in heat exchangers usually occur with in the first 6” inches on the inlet side. Sleeving incorporates a thin walled tube that bridges over areas of a tube that have erode, and lost wall thickness. In most applications, tube sleeves are 6”-8” inches long, however, in regards to the USNS Comfort, full length sleeving was required. Sleeving techniques can be used to repair tube inlets that have corrosion problems, such as general corrosive attack, stress corrosion cracking, crevice corrosion, and pitting. Sleeves generally are constructed of thin wall tubing, between .020 and .035 inches thick and of a similar or more durable material as the host tube. First the tube ends are inspected and measured. After thorough cleaning and brushing of the host tube to ensure a proper connection, the tube sleeve is inserted into the host. The sleeve is then hydraulically expanded until it is in intimate contact with the host tube. During expansion, the sleeve is placed in plastic deformation, while the host tube remains in an elastic state. The interference fit between the host tube and the sleeve provides excellent heat transfer for heating and cooling. The tube then undergoes post-inspection (either hydrostatic, nitrogen, or helium leak detection) to confirm tube integrity.

The Military Sealift Command decided the best solution to the problem was to sleeve all the tubes in unit #2.

HOW EST GOT IT DONE

EST Field Services team formulated a plan to have the unit up and running again in seven 10-hour shifts:
The unit comprised of 700 straight through tubes of 90/10 copper nickel 13ft in length and an ID of .652-.662 inches

- 700 fifteen-foot long sleeves of 90/10 copper nickel to line the ID of the old corroded tubes
- Before installation of the sleeves, each tube was cleaned and dried to ensure a intimate fit with the sleeve
- Each tube joint is hand machine brushed to ensure roundness for hard rolling
- Once placed in the tubes, the sleeves were filled with clean water to remove all the residual air from the sleeve ID
- Sleeves were then expanded hydraulically to create intimate contact with the host tube
- After expanded hydraulically, each sleeve is hard rolled to ensure total contact with host tube at the tube sheet area
- Each sleeve was then cut and fitted to the end of the tube sheet and measured to verify sleeve integrity
Each end of the sleeves were then mechanically hard rolled to ensure intimate contact in the tube sheet area.

**THE RESULTS**

Repairs were completed in the forecasted amount of time. And after final testing, ship engineer personnel reported the unit was operating flawlessly and the USNS Comfort, when called upon, is available for active duty.

**CONCLUSION**

Tube sleeves, either near end, or full length, are utilized as a less expensive alternative to a complete re-tube. The installation of full-length sleeves is an extension of the more common inlet tube sleeving operation. Tube sleeving has practical applications in chemical, industrial, utility, and pharmaceutical industries, and are available in a variety of materials, to match tubing in many tubular exchangers.