

## INTRODUCTION

All over the world, condensers and heat exchangers have an important role at the energy production in steam electric stations burning fossil fuels, in nuclear power plants, refineries, ships and the industry.

More than 85% of the tubes in condensers and heat exchangers, usually made of Copper-Nickel alloy (90/10) or (90/30), they are damaged in the first 15 centimeters of their entire length where an eddy-current exists. Other main causes of damages are regional crevices, crevices due to mechanical strains, and creviced corrosions that may appear in both ends of any kind of material.

Historically the only given method of repairing those damages was the complete replacement of the tubes of the condenser or the exchanger. This process, obviously solves the problem but its cost in terms of money and time is restrictive. A typical replacement of the tubes in a condenser consisted of 15.000 tubes costs about 1,5 million Euros and at the best case could last from four (4) to six (6) weeks.

During the 80's CTI Industries started to deal with this critical problem. The result was the development of a *Restoration Process* which is now covered by U.S. Patent No.: 4.941.512 – Jul. 17.1990, and which allows an 80% to be saved in terms of money and time that is demanded for the replacement of the tubes in condensers and exchangers.

Today, government, military, naval and industrial organizations in more than forty (40) countries all over the world, are using CTI in order to come up to the increased request for energy production.

In the following pages follows a description of the CTI's *Restoration Process* which has been developed and performed by a company devoted to innovation, higher quality and the value of service.

## **THE CONDENSER: A SHORT DESCRIPTION**

Within the heavy industry, meaning thermal power plants, nuclear units, ships, refineries, etc, condensers and heat exchangers are common and very important components of the equipment.

The steam condenser for example, converts the steam into water “passing” it through a dense “set” of tubes in which flows recycling coolant water. The condenser under a 600 MW turbine is consisted of 25.000 tubes, each having a length of 15 meters. It converts 250 tons of steam into feed water during an hour. The main parts of the condenser are the water box (input and output), the tube plates and the tubes.

In order to achieve the fast conversion of steam into water the quantity of the recycling coolant water that is passing through the tubes reaches the amount of 1.400 cubic meters per minute (1400 m<sup>3</sup>/min).

As time lapses the water has destructive effects on the input tube plates and the tube inputs. Additionally, the tubes get polluted and eventually become occluded.

### **The Problem**

The water volume that enters the input chamber (box) created an excessive eddy-current in the first centimeters of the tubes, before the flow becomes “linear”.

This phenomenon, also known as “input corrosion”, is the most common cause of problems and damages to the condensers developed with copper alloys. Through time the problem becomes extremely serious. It causes structural weakness to the tube joints with the tube plate, water leaks in the steam chamber, drop of the vacuum and eventually unavoidable seizure of operation. The unit must be set out of operation, get evacuated and opened. The leaking tubes must be located and “sludged”. All this is an extremely expensive procedure while at the same time the tubes must get disengaged.

The more tubes disengaged, the more the efficiency of the condenser falls. Additionally, the coolant water speed in the remaining tubes increases resulting to the acceleration of the corrosion in those tubes. Since the condenser is an important component of the whole production process, it reaches a point where it has to be reconstructed in order for the unit to continue its efficient operation.

## CTI's Contribution to the Restoration

In the mid 70's, CTI's engineers proceeded to large scale researching for aged condensers. The findings of the research where widely accepted by the industry: 85% of the damages in tubes made of copper alloys occurs at the joint of the tube with the tube plate and within the first 15 centimeters of the water input.

CTI based on this research has developed the insert **Shield/Seal™** and the "*Restoration Process*" on working condensers that present leaks or are about to, without the need of disassembly of the condenser and without the need for "**retubing**". It is also important that the restoration process includes the watertight connection of the tubes with the tube plate.

The installed **Shield/Seal™** is aligned to the tube plate and rounded at the input. At the same time due to its thinness and the applied pressure relief at the inner end of **Shield/Seal™** there is no difference of the internal diameter and thus the danger of eddy-current reappearance, which leads to corrosion, is avoided. CTI offers guarantees on this important issue.

**Shield/Seal™** is made of high quality alloys, made especially with very thin walling. It's extremely durable and after the relief it becomes monolithic with the existing pipe.

The usual alloys include 90/10 and 70/30 CuNi, AL6X(Cr, Ni, Mo) and various stainless steels. Other "exotic" alloys are also offered such as Titanium, Hastalloy and Duplex 2205 just to name a few. Those materials have high endurance to corrosion and to thrusts from hovering solids in a variety of environmental conditions.

CTI is usually featuring higher quality alloys than the existing ones but always galvanically compatible. Additionally they are superior and more resistant in:

- ❖ Exfoliation and corrosion from accumulations
- ❖ Attacks from ammonia
- ❖ Oscillations and mechanical strains
- ❖ Creviced corrosions

Since 1976, more than eight million **Shield/Seal™** have been installed worldwide in condensers and heat exchangers in power plants, refineries, petrochemical units, desalting units and commercial naval enterprises. **Shield/Seal™** is also the exclusive method of condensers repair in the US Navy ships.



## **Advantages of CTI's Restoration Method Shield/Seal™**

Based on extensive researching and applications in the field, in power plants, commercial ships and warships as well, the repair method of CTI for aged and damaged tubes and the restoration back to operational mode for many years has proved to be quite efficient and economic in contrast to retubing.

### **Costs**

CTI's method offers to the customer important financial advantages. The restoration costs 80 – 85% less than the “retubing” method.

### **Time**

Restoration using CTI's method saves the customer very important time periods that the unit needs to be out of operation. The process is completed in a week or less. “Retubing” on the other hand, takes a lot more since it requires about 4 – 6 weeks or more.

### **Flexibility**

The customers enjoys greater certainty using the CTI's method. Restoration with the **Shield/Seal™** method are accompanied by guarantees against corrosion, malfunction of the tubes and leaks. The guarantee period depends on the type of work as well as the type of the Shield/Seal™ material. In any case it's longer than the Retubing guarantee time which is usually one year.

## **The Steps of CTI's Method**

### **Inspection**

Usually CTI is called to inspect the status of a condenser, when it is determined that it is not functioning satisfactory. CTI sends the inspection team to the site within 24 hours (for sites within USA) and in 48 hours for sites around the world. Four main inspection methods are applied:

- Micrometer of three spheres: measures in depth of 450mm
- Borescope: allows the rigorous optical examination in depth also 450mm
- Color Fiber Optic Video: Allows the observation and recording of the situation of the internal surface of the tubes in length of 7,5 meters.
- Tube Disassembly: for metallurgic (chemical and mechanical) and visual analysis of the attack.



In the case of special problems, a laboratory analysis is advised using for example super sonic inspection. CTI's trained personnel can quickly evaluate the condition and define in terms of quantity the required restoration work. After the measurement of the corrosion, the condition of the tubes is recorded. The rule is that after a loss of 40% of the tube's wall thickness in the relieved area are tapped or repaired.

CTI gives out a full report for the customer, which includes graphical representation of the condition, photographs as well as a video if asked from the condenser.

## **The Restoration Process**

If the restoration is decided using the CTI method the following procedure is strictly followed:

### **The Tube Plate**

The first step is the cleaning of the works area. The tube plate is cleaned (to remove accumulations). Later it is possible perform sand-blast in order to prepare the application of the protective coating.

### **Plastic Inserts**

Inserts made of plastic (Nylon) have been occasionally used and for a long period of time, in order to protect the tube's input. Although they could be applied they presented a series of problems. Those "cheap" materials in fact pushed the problem deeper into the tube. Due to their significantly thicker walling, as soon as the water passed throughout their whole length, eddy-currents started to present subsequently the same problem, the "Input Corrosion".

In contrast to the **CTI's Shield/Seal™** plastic inserts do not:

- Restore the tube's joint to the tube plate
- Connect to the internal walling of highly corroded tubes
- Set in operation "tapped" tubes
- Allow mechanical cleaning
- Restore other failures (e.g. creviced corrosions, etc)



## Cleaning the tubes

As time lapses, the tubes hold pollution from the coolant water. Those pollutants get concentrated to the internal walling of the tubes and decrease dramatically the heat exchange rate. The tubes get stuck with sea shells and other pollutants. All the tubes are cleaned with the ejection of cylindrical brushes (CTI Jet Brushes), boosted throughout the length of the tubes by high pressure water and air pistols.

## Tube Input

All the inputs of the tubes must be cleaned up to the metal. This is achieved by a power tool iron brush. The absolute cleaning is necessary in order to achieve the complete seal between the tube and the **Shield/Seal™**.

## Installation of the Shield/Seal™

The next step is the installation of the **Shield/Seals™** into the tubes. Those have been build according to each work. The **Shield/Seals™** that have been installed had length up to 1,8 meters but in most cases their length is 15 to 30 centimeters. A critical process is the relief of the **Shield/Seals™** inside the tube in order to achieve the joint with the tube plate. This is important for avoiding the possibility that the **Shield/Seal™** moves inside the tube and to ensure that no corrosion will occur up to its end.

## Flaring

Finally the **Shield/Seals™** inserts are aligned to the tube plate and the installation is completed with the hydraulic seal test.

A group of four people from CTI installs about 1.500 inserts in a shift of 10 hours. That means that besides the huge money saving in material the installation rate of the **Shield/Seals™** saves important resources to the customer comparing to the retubing method.

## Protective Coating

After the final step of the inserts installation, the tube plating is cleaned by sand-blasting, solvent for degreasing and coated with the necessary epoxy coating layers.





## Conclusion

With the development of new innovative solutions for its customers and with its dedication to quality, CTI enjoys the continuous recognition and the sales increase. The offered advantages are:

### Cost Decrease

Condensers and exchangers retubing cost is huge. By installing **Shield/Seals™** we can save 80 – 85% of this cost.

Example: The required tubes for retubing a condenser 300 MW weigh 110 tons in comparison to the 800 kg that weighs the CTI's solution. Additionally the required work hours are 6.000 and 600 respectively.

### Higher Guarantee

CTI offers better guarantees than its competitors that offer the solution of retubing. Installations of **Shield/Seals™** are covered by a three years guarantee or more according to the application. The usual guarantee for retubing is one year.

