Getting the Copper Out – Will It Pay Back?

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ABSTRACT

Copper tubing in your condensers or feedwater heaters can be a problem when optimizing the cycle chemistry to protect the carbon and alloy steels. Ammonia additions for increasing pH also attack copper's protective layer, decreasing the tubes life. Copper alloys have been thought to have higher thermal conductivity than stainless or titanium alloys, so the assumption has been that if a plant switches, it will have a negative impact on heat rate. That may not be the case as the copper protective layer is much thicker and more thermally resistive than the other alloys. Additionally, copper alloys have a limited lifespan and can be easily damaged by a number of mechanisms causing forced outages and derates. This paper provides a tool and options using financial justifications when considering replacing your copper based condenser tubing. It is based on the HEI 10th Edition Standard for Condenser Performance. It also provides an option for cooling water uprates that can provide a very significant performance payback that would not be possible with the copper alloy.

Introduction

Copper alloys maintain their corrosion resistance by growing a relatively porous copper oxide hydrate. With time, copper ions diffuse into the through the layer and go into solution in the condensate. This mechanism is called general corrosion and under ideal conditions, the tubing can last 25 to 30 years. However, conditions in the power plant can be less than ideal for copper based alloys. EPRI document EPRI TR-108460[1] identifies "It is difficult and sometimes impossible to control corrosion of both carbon steel and copper alloys in the feedwater."

- "Control of corrosion of carbon steel requires higher pH than corrosion control of copper alloys."
- "In copper corrosion, there is a strong synergistic effect of ammonia plus oxygen and carbon dioxide; ammonium carbonate is strongly corrosive to copper alloys."

Therefore general corrosion of copper based alloys can be significantly accelerated if the steam chemistry is optimized for FAC protection of the carbon steel (typically pH of 9.5+). Conversely, if the condensate pH is optimized to protect the copper alloy (pH 8.6 to 9.1), the corrosion rates of the carbon steel can increase by an order of magnitude. When copper dissolves from the tubing, it can collect in several locations in the steam system, such as boiler tubes (figure 1), turbine blades (figure 2), or feedwater heaters. Depending on the design of the plant, one of these locations is preferred over the other two.

This layer is easily damaged either by several mechanisms that can occur quite rapidly:

1. Ammonia attack – Ammonia can depassivate the protective patina and cause localized corrosion and stress corrosion cracking. It is quite common near the air removal section of the condenser where the ammonia collects and dissolves into the condensate which runs down the support plates. This mechanism dissolves grooves on both sides of the support plate which is visible in figure 3. This is called ammonia grooving.
2. Erosion corrosion – Erosion corrosion occurs when the water velocity is too high for the bonding of the protective patina. It can occur in high velocity lamellar flow or in areas where turbulence is high. It can often be recognized by the "horse shoe" shaped tracks on the surface such as can be seen in figure 4.

3. Pitting, MIC attack, and crevice corrosion – All three of these attack mechanisms are localized phenomenon that are driven an electrochemical mechanism. They are initiated by localized depassivation and then driven by an electrical cell. The depassivation can be chemically initiated (such as H_2S, sulfuric acid), pH initiated, or temperature initiated. Once the pit is started (figure 5), propagation can be rapid. Penetration is possible in a few weeks.

Significant additional performance and reliability gains can be obtained by looking toward alternative materials, such as high performance stainless steels or CP titanium, for the condenser that are resistant to these failure mechanisms and allow condensate control chemistry that is optimized to protect the carbon steel components in the system. Following is a tool that can be utilized to estimate future performance gains and financial payback when evaluating alternative materials.

THE VALUE COMPARISION

For an effective valuation, the choice should be based on long-term cost analysis. The data can be developed into a defendable Value Comparison summary based on the specific history and needs for that unit. The summary should depend upon a life-cycle basis and the team needs to select the length of the life-cycle calculation. Many coal-fired plants that have operated for 30 years may have another 20 years of expected operating life remaining.

The life-cycle cost calculation will have several cost items that can be developed, including:

- Initial tube cost
- Installation costs
- Fuel savings/cost based on expected thermal performance
- Cooling water chemical treatment costs and identify techniques to keep tubing clean
- Effect of lost generation due to turbine efficiency losses
- Reduction or elimination of boiler tube and high-pressure turbine cleaning costs
- Cost of emergency outages and/or derates to plug leaking tubes.

Condenser Case Study Example

A relatively simple thermal and vibration analysis can be performed using the current 10th Edition of the HEI Condenser Standard[2].

Our example is an older 2 pass condenser for a 300-MW coal-fired plant that currently uses 16,400 one-inch OD x 18 BWG (0.049 average wall thickness) 90-10 copper nickel tubes that have an effective length of 42.2 feet. The longest unsupported span was 46 inches, not uncommon for that vintage. This design is similar to a number of plants built in the late 1960's. The plant is operated as a base loaded unit and has an 85% annual load factor. The steam load is 1,480,000 lb per hour with an enthalpy of 950 Btu/lb. On this unit, the turbine exhaust area is 375 square feet. The circulating pumps provide a design flow of 114,000 gpm through the tubes. Scaling is minimized by water chemistry control providing an HEI cleanliness factor of 85%. The condenser was designed for an inlet water temperature of 85^{o}F.

In our model calculation, repair of tube leaks of copper tubes are occurring twice per year, predominately during the earlier years of the condenser lifetime. When nearing the end of the tube life, the leaks develop much more often. Every four to five years, the high-pressure steam turbine must be cleaned due to copper plating on the turbine blades.

The original tubes lasted 20+ years, but because of change in cooling tower operation and water source changes, the expected life of the new 90-10 Cu-Ni tubing may only be 10 to 15 years. The cooling water is treated with ferric sulfate to assist re-passivation of the Cu/Ni. Because of this water's aggressiveness, picking an alloy resistant to high chlorides and MIC is paramount. The candidates that are considered are titanium grade 2, AL6XN® high-performance austenitic stainless steel (UNS N08367), and SEA-CURE® (UNS S44660) high-performance ferritic stainless steel. All have proven track records in both high-chloride waters, or those with MIC potential. TP 304 and TP 316 are not candidates for this condenser, as the chloride levels commonly climb over 700 ppm, and high Mn and Fe levels provide high potential for MIC related corrosion.

The HEI Standards for Steam Surface Condensers are an excellent basis for comparing the thermal and mechanical performance of the various tube materials. In addition to determining backpressure and the potential for vibration damage, changes in uplift can also be evaluated. Results of the analysis are included in Table 1. Following is a description to the items in the table.

Wall Thickness: With today's improvement in tube-to-tubesheet joint preparation and rolling techniques, and improved-design stakes, wider options for replacement tube wall thickness are possible. Both the stainless steels and titanium have higher strength than copper alloys and do not require any corrosion allowance. Therefore, the use of a thinner wall is possible. Two factors need to be considered: the tube-to-tubesheet joint pullout strength, and vibration potential. Traditionally, 22 BWG (Birmingham Wire Gauge) or 0.028 inch has been the chosen for titanium or stainless steel retubing. Pullout loads of 1200 lbs to 1600 lbs are considered minimum. Higher-modulus/higher-strength tube alloys can have higher pullout loads than those with lower properties, even in softer tubesheets such as Muntz metal. For example, with controlled tube hole preparation and torque controlled rolling, tests have shown that 24 BWG (.022") S44660 stainless develops loads in a carbon steel tubesheet exceeding 2300 lbs![3] Tests should be performed to consider thin material. A consultant should be used for the final vibration analysis. In many cases, partial staking should be used.

Cleanliness Factor. HEI uses a cleanliness ranging to 100%, where 100% is a perfectly clean tube. The value has a very significant impact on this analysis. Both OD and ID tube oxides act as thermal barriers and can lowering the cleanliness factor. In addition to the tube cleanliness, a number of condenser operational factors affect the value, including air binding, restricted cooling water flow and the impact of incompletely filled water boxes. Once in service, copper alloys have thicker OD and ID patina than the oxide films of stainless steels and titanium. When scaling or fouling is not considered, the thicker copper alloy patina requires the designer to use lower cleanliness factors than stainless steels or titanium tubes. After a few months of use, unscaled, copper alloys with the OD and ID patina often exhibit 85% cleanliness while a number of stations that have used the stainless steels and titanium exhibit cleanliness of 90% or better. In many cases, the stencil on stainless and titanium tubes that have been in service for several years may still be visible. For this analysis, 85% for copper alloys and 90% is used for the others.

Cooling Water Flow Rate Adjustments. Although the original design flow was 114,000 gpm, flow will vary as the head changes. Low-head/high-volume circulating water pumps have high flow rate sensitivity to head. For example, the head decrease by changing to 0.028-inch wall thickness tubing from 0.049-inch wall original tubing can often result in 3% increase in mass flow. We included 3% in our calculations for .028" wall tubing and 4% on the .022" wall tubing. If available, the specific pump curve(s) for the plant should be used.

Cooling Water Velocity. The cooling water velocity is calculated from the cooling water mass flow. Although the cooling water velocity is normally considered to have a significant impact on the condenser performance, the cooling water mass flow is the key factor for removing heat. Many older plants were designed with a 6.0 to 6.5 feet per second (fps) to prevent erosion-corrosion of copper based tubing. With modern alloys, much higher velocities are possible. We also included an option using a pump upgrade increasing cooling water mass flow 20% from design. This is included in the right column.

Cooling Water Inlet Temperature. In this analysis, we used the design inlet water temperature for the basis of the calculations. When the plant has a marginal condenser that limits megawatt production during peak summer conditions, this calculation should be done using the maximum inlet water temperature for your analysis, as the material choice could have a significant impact on payback.

Condenser Back Pressure. After the cooling water, steam flow, and tube alternative parameters have been determined, the saturation temperature is calculated and the back pressure is found via steam tables. A lower back pressure, or better vacuum is increases turbine efficiency. HEI formula predicts back pressure improvements of 0.12", 0.04", and 0.10" for 22 BWG titanium, N08367, and S44660 respectively. In this analysis, the greatest gains without the pump upgrade was found using 24 BWG S44660 showing an improvement of 0.16" Hg. HEI calculations show 0.36" reduction for the upgraded pump option. These last two are considered to be quite significant.

Tube Span Calculation. Over the years, many different vibration methodologies have been developed to calculate a "safe span" that results in no tube damage. The HEI Tenth Edition utilizes two methods, the first one referred to as the tube spacing (ligament) method. In the tube spacing method, HEI assumes that the steam will achieve sonic velocity (either by very cold water, or shutting down a waterbox, etc), causing tube vibration. The span is adjusted to keep the vibration amplitude equal to or less than one-third of the tube spacing. The design allows for an additional clearance of one-third of the ligament preventing tube-to-tube collisions. The second method, extracted from the MacDuff and Fegler method (M-F), it compares the natural frequency of the tube vs. vortex shedding and fluid elastic whirling. To be conservative, the designer should use the shorter of the two spans.

The two HEI methods calculated significantly shorter spans and are much more conservative than earlier methods. For this condenser, the M-F method developed the shortest span of all the tube choices. As the original condenser span was 46 inches, both HEI methods suggest that staking will be required of all alloys, including the 90-10. However, possibly because of a larger steam dome common in older condensers, vibration in many was not a problem.

Uplift Force. Copper-nickel has the highest metal density of the common tube materials. Combined with the wall thickness, all of the alternatives will result in a condenser of significantly less weight. The difference in pressure across the large turbine exhaust area can create significant uplift. When this condenser is at 1.5” of backpressure, the uplift due to the vacuum is approximately 700,000 lbs. If another tube is selected, the drop in tube weight could overload the supports and possibly damage the turbine. Switching to titanium tubing results in a weight reduction of 260,000 lbs. A specialist should be consulted to check if modifications are needed in the anchoring areas.

Estimated Fuel Savings. The change in backpressure will have an impact on heat rate and, ultimately, the amount of fuel that will be used. As this is a coal-fired plant, we assumed that the delivered cost for the coal over a 20-year period will average $2.50 per million BTU. For this plant, we determined that for each 0.1 inches of Hg change in backpressure, the plant will save or require 15 Btu for each kWh. A fuel savings of $100,000 per year is estimated if 22 BWG titanium was chosen. When switching to the super-austenitic N08367, the model shows a $33,000 per year savings. The model reports that S44660 produces a $83,000 to $133,000 per year savings respectively if 22 BWG or 24 BWG superferritic is the choice without a pump upgrade. Adding the pump upgrade to the 22 BWG S44660 creates a savings of $300,000/yr vs. the original Cu/Ni. An real example of the financial improvements of a pump upgrade can be seen in the paper by G.Tiffin, K. Schweiss, J. Jones, D. Robertson, and S. Nurnberger[4].

Calculating the 20 Year Cost Savings

For this case study, the plant used a 20 year remaining life for the life-cycle economics calculation. We assumed that our chemists had a good handle on cooling water on cooling water chemistry that would keep the tubes free from scale and biological slime.

For this case study, budgetary tube costs were obtained as shown in Table II. During discussions with potential tube installers, we found that the cost to install the various alloys was not significantly different: approximately $600,000 for all tube materials. The consultant recommended some staking, due to the lower stiffness of the titanium and the N08367 tubing, and the 24 BWG S44660. Our installers quoted an average of $250,000 for the titanium, $50,000 for the super-austenitic and $75,000 24 BWG super-ferritic stainless steels, proportional to the amount of staking. The consultant was also concerned about the additional uplift if titanium were chosen. We included $50,000 in the budget for reinforcement of anchor points. With today’s high scrap prices for copper and nickel, the scrapped tubing has significant value. Assuming a thinner wall than originally installed, we provided a $1,000,000 credit for this scrap.

The high conductivity of the cooling water can result in galvanic differences between tubing and the Muntz metal tubesheets. To prevent attack of the tubesheet we included installing a premium coating of a multi-layer high solids epoxy, estimated at $165,000 for this power plant. When planned during installation, this type of coating combined with a small flare can also help to increase pull-out loads at the tube-to-tubesheet joint. Cu/Ni is galvanically similar to the Muntz metal; coating it is not required for that alloy.

We for pump upgrade cost, we’ve included a $400,000 capital cost for rewinding of the motors for more horsepower. An alternative which is more expensive, but much more flexible is to switch to variable frequency drives. The total capital expense is summed at this point.

At this point, we must include an estimate for operation and maintenance costs for the various tube candidates. In Table II, based on the calculated back pressure differences in Table I, we expect a fuel savings of $2.0 million over 20 years for 22 BWG titanium, $665k for N08367 and approximately $1.75 million and $2.67 million respectively for 22 BWG and 24 BWG S44660, compared with 18 BWG copper nickel as the base line amount. Because of copper nickel’s sensitivity to erosion-corrosion and H_2S related pitting, we expect to get an occasional tube leak, possibly from erosion-corrosion due to entrapped debris. Our estimate is this will occur once per year during the first five years and twice per year after five years. Fortunately, this condenser is of a divided flow configuration, so we do not need to completely shut the plant down to fix the leak. To locate the leaks and plug the tubes, it normally takes us 24 to 36 hours. During a 50% derate, we lose $225,000 of income on average using $35 per MW-hour. Since the other tube candidates are not susceptible to erosion corrosion, no cost assignment is needed.

Our traditional cost for chemical treatment (pH adjustment, ferrous sulfate treatments, and others) to protect the copper tubing has been about $100,000 per year. These will not be required, or will be minimal, with the other alternatives.

As mentioned earlier, the dissolved copper can plate in other regions, such as boiler tubes, desuperheating zones of feedwater heaters and on HP turbine blades. In lower pressure units the copper seems to favor boiler tubes, while the higher pressure units the turbine blades are preferred. The team needs to evaluate the specific cost related to the plant. In either case, a regular cleaning of the boiler to prevent unplanned outages, or cleaning of the turbine to reduce MW loss should be included in the evaluation. In this analysis, we’ve included a $250,000 cleaning every four years to cover the impact. It is not needed with the other options.

Table 2 sums the installation, operation, and maintenance costs in a singular 20 year format. In this analysis, we addressed the impact on fuel costs by assuming that fuel for the original 90-10 copper-nickel as the base, and the fuel adjustments reported in Table I are included as either credits or debits.

The combination of the derate costs required to fix tube leaks, water chemistry control, and additional cleaning required due to copper transport adds over $10 million to the cost directly related to using copper-nickel condenser tubing. Although the installation and tubing costs of the alternate materials are significantly higher, this is mitigated by a significant fuel saving (compared to the Cu-Ni option). After 20 years, the overall savings range from approximately $10 million to $16.7 million. Note that this analysis assumes that the replacement copper-nickel tubing will last an additional 20 years, which is becoming less common due to today's more aggressive water sources and the decrease in high quality Cu-Ni tube sources.

Upper management often approves or denies projects based on the time required to pay back either the capital for the project, or the additional capital to do an upgrade over the initial project. Using a 10 year Net Present Value (NPV) method for evaluation of retubing the condenser with 22 BWG S44660 super-ferritic stainless combined with a pump uprate vs. replacement-in-kind of the original material is shown in Table 3. The interest rate chosen was 7%. The payback for the additional improvements over the like-in-kind was significantly less than one year and the 10 year payback was almost $5,000,000.

Copper-Free Turbine Drive Economics

One very significant performance penalty was not included in the 20- year analysis. In the last row of Table II, copper deposits on the HP turbine blades can have an enormous financial impact. Derates of 20 MW or greater are possible on a plant of this size after a four- or five-year period and must be accounted for in the economics of tube replacement[5]. Consider the following assumptions:

- The turbine is cleaned every four years.
- The average MW derate of the 4 years is 5 MW.
- The plant load factor is 85%.
- The average selling price is $35 per MW-hr.

In this situation, the total income lost over the 20-year period is more than $26 million and overpowers the other economic analysis factors. The results emphasize how important it is to keep the plant operating efficiently and the importance of keeping the turbine free from copper deposits.

CONCLUSIONS

As can be seen from the model, like-for-like replacement of copper tubing in a condenser can be far more costly long term than the initial price of the tubing. A utility needs to evaluate the effect of the forced outages that can be traced to the tubing and include the impact of the copper transport and the potential changes in thermal performance after the change. A multi-disciple project team needs to make realistic assumptions of which to include in their evaluation. This model can be used as a boiler plate to build and defend the justification. The considerations that should be included in the analysis could include:

- Alternative material choices including various wall thickness
- Impact on cooling water mass flow
- Expected fuel cost
- Investment in upgraded pumping
- Cost of forced outage/derates to plug the occasional leaking tube
- Change in cost for cooling water treatment needs, both new and potentially eliminated
- Cost of staking, tubesheet coating, and other modifications
- Will an additional retube be needed within the timeframe chosen
- Are pump upgrades possible and cost effective
- Cost of lost generation due to HP turbine deposits or marginal condenser capacity during high inlet water temperatures

The team should consider contracting a reputable consultant that has a track record of assisting with these retubing projects. Several of these have worked with dozens of condenser retubing projects and can provide insight to prevent many of the problems that others have had. They can also suggest other solutions to existing problems that can make the team's job easier.

AL6XN® is a registered trademark of Allegheny Technologies
SEA-CURE® is a registered trademark of Plymouth Tube.

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REFERENCES

[1] EPRI TR-108460 *State-of Knowledge of Copper in Fossil Plant Cycles*, Final Report September 1997, R.B Dooley, B.C Syrett, T.H. McCloskey, J, Tsou, K.J. Shields, and D.D. Macdonald.

[2] *Standards for Steam Surface Condensers, Tenth Edition*. Heat Exchanger Institute Inc, 2006

[3.] *Retubeco Procedure for Tube Joint Strength Test 8622-4*, September 15, 2006

[4.] G.Tiffin, K. Schweiss, J. Jones, D. Robertson & S. Nuernberger, *Ameren-Missouri's Merimac 3A, 3B Circulating Water Pump Flow Upgrades*, EPRI Condenser Technology Conference, August 3-4, 2011, Chicago, Il

[5.] Burck, Alan C. & Foster, Danny, "*Recovery of Lost Generating Capacity and Efficiency through Chemical Foam Cleaning of Cinergy's Beckjord #5 HP Turbine*", Southwest Chemistry Workshop, Dallas, TX, July 29-31, 2003.

Figure 1. Alternating layers of deposited copper metal and magnetite on a boiler tube. Courtesy of Gary Hoffmann of Pacificorp.

Figure 2. Examples of copper deposits on high pressure steam turbine blades, Source – Elise Ring, API PowerChem 2010 Conference, Caloundra, Australia, May 2010

Figure 3. Ammonia grooving of Admiralty brass. This damage occurred with less than 2 years of service.

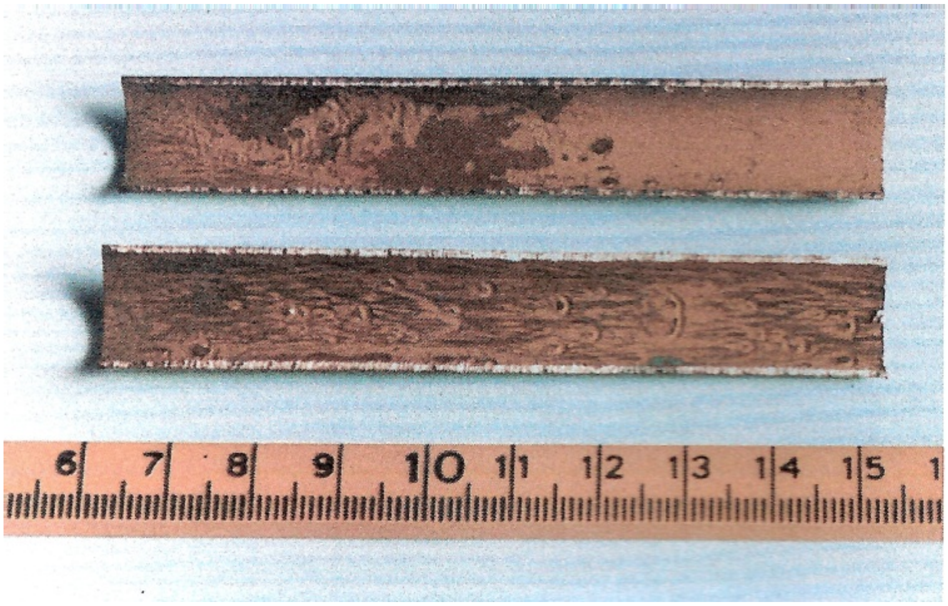

Figure 4. Erosion corrosion of copper- nickel alloy

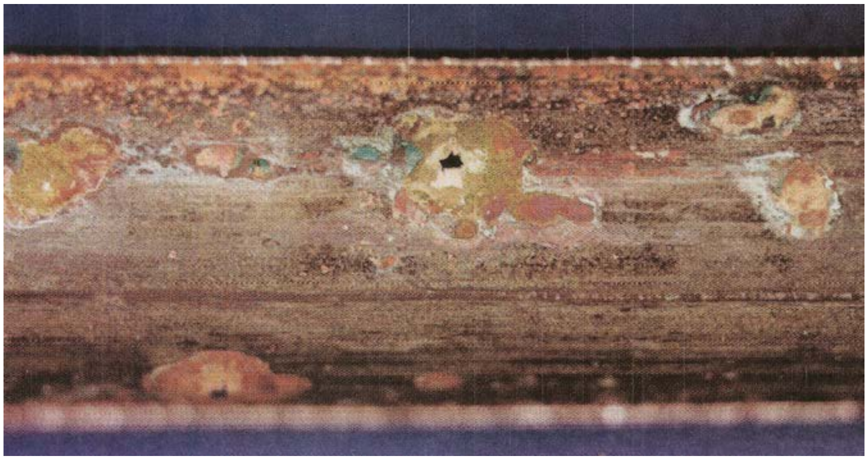

Figure 5. Pitting of Al Brass tubing exposed to H_2S.

Table I Thermal and mechanical comparison of the original Cu/Ni and alternative Ti Grade 2, N08367, and S44660 options.

Alloy		***90/10***	***Ti Gr 2***	***N08367***	***S44660***	***S44660***	***S44660***
Wall	**Inch**	**.049**	**.028**	**.028**	**.028**	**.022**	**.028**
Cleanliness		**.85**	**.90**	**.90**	**.90**	**.90**	**.90**
20% Pump Upgrade		**No**	**No**	**No**	**No**	**No**	**Yes**
Cooling Water	**Gal/min.**	**114,000**	**117,420**	**117,420**	**117,420**	**118,902**	**136,800**
	Feet/Sec	**6.98**	**6.56**	**6.56**	**6.56**	**6.48**	**7.65**
Inlet Temperature	**Degree F**	**85**	**85**	**85**	**85**	**85**	**85**
Back Pressure	**Inch Hg**	**2.93**	**2.81**	**2.89**	**2.83**	**2.77**	**2.57**
HEI Sonic Vel. Span	**Inch**	**36.87**	**31.39**	**36.26**	**37.56**	**35.57**	**37.56**
Vibration?			**Much more likely**	**More likely**	**Less likely**	**More likely**	**Less likely**
HEI M-F Span	**Inch**	**30.51**	**30.05**	**32.48**	**33.85**	**32.76**	**33.85**
Vibration?			**More likely**	**Less likely**	**Much less likely**	**Less likely**	**Much less likely**
Uplift from 90/10	**lbs**		**-258,692**	**-168,511**	**-177,032**	**-213,003**	**-177,032**
Est. Fuel Cost	**$/MMBTU**	**$2.50**					
Est. fuel saved - $ /year [a]			**$100,246**	**$33,415**	**$83,538**	**$133,661**	**$300,737**

[a] Based on difference from 18 BWG 90-10 on 0.1 in Hg = 15 BTU/KWHr, 85% load factor

Table 2. 20 year value comparison for the retubing using Cu/Ni vs. the alternative alloy options[A]

Alloy Option	90/10 Cu/Ni	Ti Gr 2	N08367	S44660	S44660	S44660
Wall	.049”	.028”	.028”	.028”	.022”	.028” Pump Upgrade
Estimated Tube Purchase Cost	$2,430,000	$2,200,000	$2,850,000	$2,000,000	$1,800,000	$2,000,000
Installation Charges	$600,000	$600,000	$600,000	$600,000	$600,000	$600,000
Scrap Recovery	-$1,000,000	-$1,000,000	-$1,000,000	-$1,000,000	-$1,000,000	-$1,000,000
Estimated Staking Cost		$250,000	$50,000		$75,000	
Anchoring Improvement		$50,000				
Tubesheet Coating for Galvanic		$165,000	$165,000	$165,000	$165,000	$165,000
Pump Upgrade						$400,000
Total Capital Cost	$2,030,000	$2,265,000	$2,665,000	$1,765,000	$1,640,000	$2,165,000
Fuel Cost Differences - 20 years	Base	-$2,000,000	-$665,000	-$1,650,000	-$2,673,220	-$6,000,000
Derate losses to fix tube leaks[B]	$7,875,000					
Chemical treatment $100,000 /yr	$2,000,000					
Turbine/Boiler cleaning every 4 years	$1,000,000					
20 year total cost basis	$12,905,000	$265,000	$2,000,000	$115,000	-$1,033,220	-$3,835,000
20 year savings vs. Cu/Ni		$12,640,000	$10,905,000	$12,790,000	$13,938,220	$16,740,000
Optional:						
Lost MW from Copper on HP Turbine -Avg 5 MW/yr loss @ $35 / MWHr, 85% operation time	$26,061,000	$0	$0	$0	$0	$0

Note[A] – Capital costs and savings are estimates at the assembly in summer 2011, and individual costs and savings will vary for each project. They are market driven, highly variable and should be verified.

Note[B] 1/ yr for 5 years, 2 / year after @ $225,000 derate each

Table 3 Ten year net present value (NPV) evaluation of the savings using 0.028" S44660 tubing with a 20% pump uprate vs retubing with the original 90-10 material.

Year	Initial Investment Difference	Fuel Savings	Derate Savings	Chemical Savings	Cleaning Savings	Total Savings	Present Value of Cash Flows	Cumulativ e Present Value
0	(135,000)					(135,000)	($135,000)	(135,000)
1		250,000	225,000	100,000		575,000	$537,383	402,383
2		250,000	225,000	100,000		575,000	$502,227	904,610
3		250,000	225,000	100,000		575,000	$469,371	1,373,982
4		250,000	225,000	100,000	200,000	775,000	$591,244	1,965,226
5		250,000	225,000	100,000		575,000	$409,967	2,375,193
6		250,000	450,000	100,000		800,000	$533,074	2,908,266
7		250,000	450,000	100,000		800,000	$498,200	3,406,466
8		250,000	450,000	100,000	200,000	1,000,000	$582,009	3,988,475
9		250,000	450,000	100,000		800,000	$435,147	4,423,622
10		250,000	450,000	100,000		800,000	$406,679	4,830,302
Total	(135,000)	2,500,000	3,375,000	1,000,000	400,000	7,140,000	4,830,302	
						Interest rate	7%	