Condenser Performance Optimization and Life Extension
- A Case Study -

In 2007 Intek was presented with performance enhancement requirements imposed on an existing Westinghouse condenser. The objective was to determine if the condenser performance could be improved from design capability and to estimate the achievable amount of improvement. The principal drivers for the retrofit were load limiting conditions in the summer time and a desire to switch tube material from Admiralty to SS. The results of the initial study were positive and led to a second effort for Intek to design the retrofit to achieve the projected performance level during a retubing outage whereby the copper bearing tubes would be replaced with stainless steel tubes (a lower heat transfer coefficient material).

The retrofit was engineered to include parts manufacturing and assembly drawings along with an assembly guideline document. The results, after implementing the retrofit during an outage in Spring 2008, are provided in the following Figures 1-4.

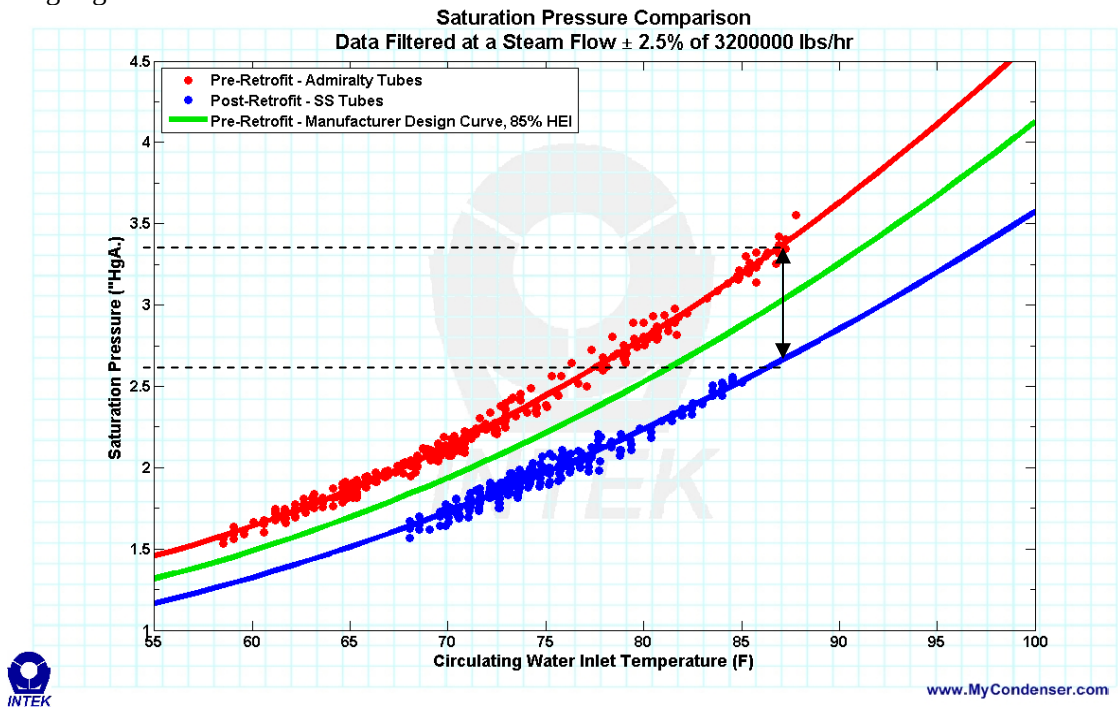

Figure 1. Condenser Pressure Reduction

The projected key measured performance enhancements with new SS tubes were met or exceeded and included:

- compared to 1998-2007 data, the condenser project contributed to a 1-2% heat rate reduction,
- compared to 1998-2007 data, the condenser project contributed to a 1-2% emissions reduction,
- back pressure reduction of ~0.7"Hg at 85°F inlet circulating water temperature; shown in Figure 1,
- reduced condenser condensate DO, from 20ppb to as low as 2 ppb,
- increased air in-leakage removal effectiveness (for no excess back pressure or DO) from <25SCFM to >100SCFM at 90°F inlet circulating water temperature (no change in vacuum equipment), and
- condensate cation conductivity down from 0.16µS/cm to 0.11-0.12µS/cm (attributed to reduced circulating water in-leakage, less condenser corrosion solids, as well as less CO_2 and its by products in condensate) with measured powdex resin polisher run time increase of >300%.

The retrofit project payback was met in less than one year and included costs for engineering construction, (excluding the retubing costs), and was installed in ~2.5 weeks, mostly in parallel with the retubing schedule, and having minimum impact on the outage schedule. When compared to the cost of an HP turbine dense pack replacement project, this type of condenser improvement has a ~20 times greater $ return per Btu/kWhr reduction.

Additional information regarding condenser pressure and DO, with respect to air in-leakage (AIL), is shown in Figures 2, 3 and 4. The red trace on these figures show air in-leakage purposely introduced into the condenser. As annotated, it is in an amount greater than the large baseline leak value of about 40 SCFM. The initial measured DO, shown in Figures 3, was found to be associated with variations of air in-leakage below the waterline and not associated with the air introduced into the condenser shell hood. Intek identified the under water leaks by spraying condensate water on the condensate suction valve stem packing and observing the measured DO response. DO decreases in value during periods when water is sprayed onto leakage points and increases in value when the packing gland progressively becomes dry and therefore air enters through the gland and into the condensate. Figure 4 shows a reduction of condensate DO from 16ppb to 4ppb, data after tightening the condensate suction valve's packing glands.

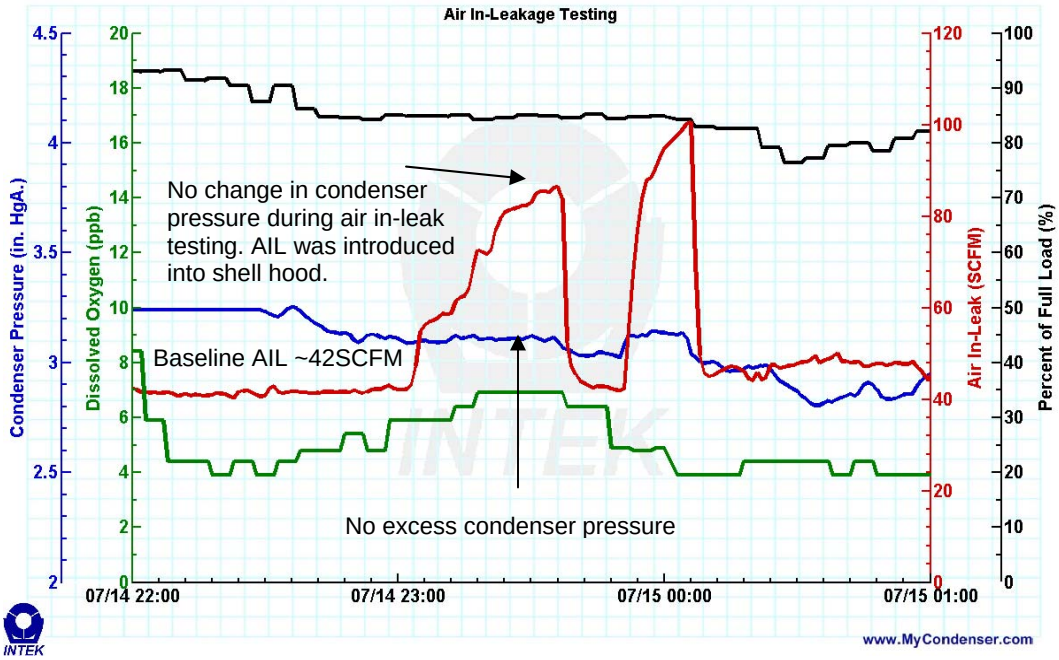

Figure 2. Air in-leakage up to 105 SCFM with no significant excess back pressure

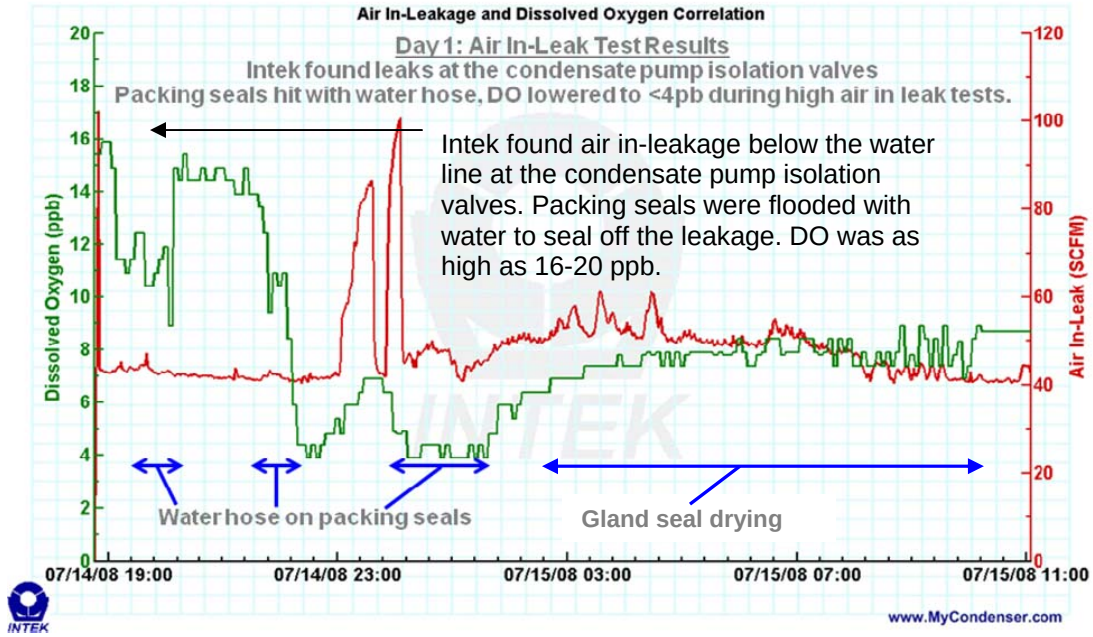

Figure 3. Air in-leakage up to 105 SCFM with no increase in condensate pump discharge DO

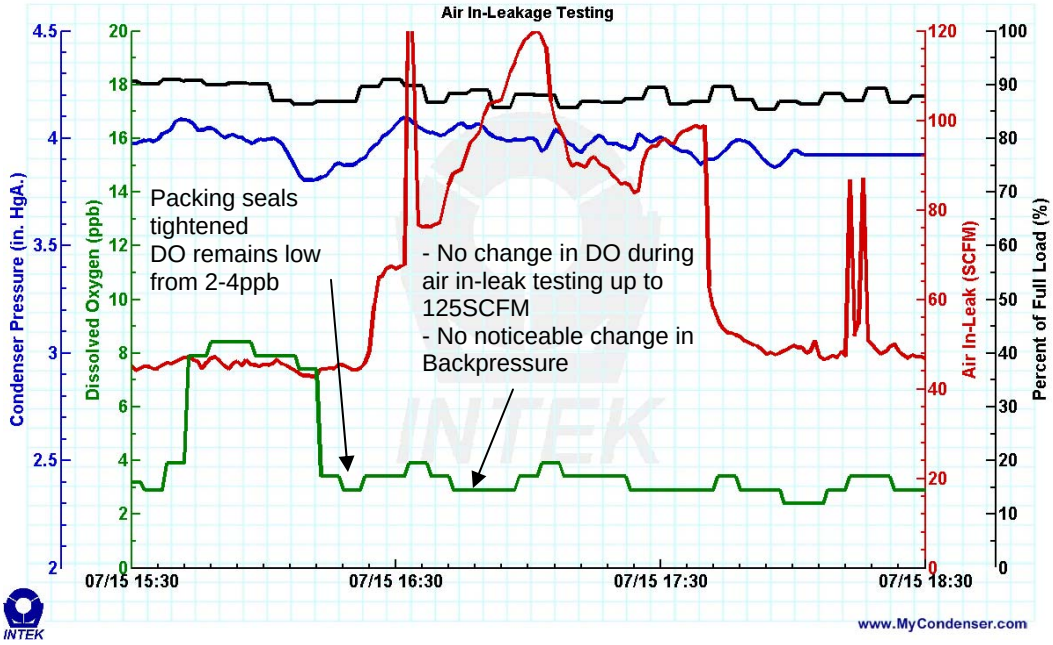

Figure 4. Air in-leakage up to 125SCFM with no increase in condensate dissolved oxygen measured at the condensate pump and no significant increase in back pressure

Since coming online in spring 2008, the following performance updates have been reported by the owner:

- The unit achieved record low condenser pressures for equivalent operating conditions.
- The unit achieved record low condenser condensate DO levels <4ppb (even with air in-leakage up to 125SCFM), down from 25-30 ppb initially (unit is on the OT program).
- New data shows the polisher runtime has increased from 30 days (pre-retrofit maximum) to 90 days (post retrofit). Polisher runtime could have been extended but it was taken out of service due to an auxiliary heat exchanger cooling water leak near the end of the 90 day run (reported October 2008). Intek is pursuing a long term condensate chemistry and cycle corrosion study with the plant chemist.
- The unit completed its second longest historical continuous run, ending with an unrelated component failure.
- The unit met load demands for the entire summer – this had not been achieved in recent history prior to the installation of the Intek condenser retrofit design.
- All benchmarks above were achieved despite the change from Admiralty to SS tubes.
- All benchmarks above were achieved despite having condenser air in-leakage ranging from 40-80SCFM for the entire run time.
- The unit also operated through the summer without load shedding, despite the tubes being macrofouled up to 30% (based on visual inspection) over 5 months of continuous run.

All results are the product of proprietary condenser design and retrofitting model and methods protected by International and USA patents that have been assigned to Intek, Inc.

An Added Note:

Obtaining achievable and optimized performance from existing operating condensers is the objective of condenser experts at Intek, Inc. Intek is unencumbered by historical design limitations, practices and measurements that have characterized this industry and is armed with contemporary science, engineering and technology measurement data obtained from over 400 condensers of different designs from around the world. Our engineers are instilled with novel scientific inquisitiveness for understanding of condenser shell side dynamics and have approached condenser performance analysis in a unique way. Design objectives are reached by applying in-house developed first principle scientific methods and by optimizing design rules. The limitations of computer aided programs to handle the complexities of condenser shell side behavior are well understood and various programs are used depending on the task. There is no one software package promoted by Intek. Further, modern measurements and

calibrated instruments are utilized to test and validate performance results. The methodology was applied to the above 37 year old condenser during a scheduled retubing operation, and as predicted, performance improvements of magnitudes never before seen were achieved. This condenser unit with the Intek condenser retrofit is now one of the best operating condensers in the world.

Intek's Power Industry Services:
Intek manufactures the *RheoVac* condenser and air in-leak monitor and the *Rheotherm* circulating water flow and fouling meter. These one-of-a-kind instruments provide continuous measurement of critical parameters that have historically been unavailable or inadequately measured since the beginning of steam surface condensers.

The obtained data has been used to gain a unique comprehensive understanding of steam surface condensers and of the condensation process. This understanding has enabled Intek to help customers troubleshoot condensers with greater speed and accuracy than ever before. Expanded service offerings have been achieved by developing an online diagnostic toolkit for steam surface condensers available at www.MyCondenser.com.

Intek has also taken advantage of our aerospace and nuclear Industry design tools and design expertise for the purpose of designing condenser retrofits for performance and condensate chemistry improvement. Intek has been involved in condenser retrofitting projects that have transformed underperforming condensers into some of the best performing condensers in the world.

The condenser services team, headed up by Dr. Joseph Harpster, has also sought to educate the industry by contributing volumes of material to ASME and EPRI regarding proper condenser measurement and steam flow dynamics. Intek also teaches a Condenser Operations and Management Workshop accredited by The Ohio State University for 1CEU and provides tutorials; case studies are also available at www.MyCondenser.com.

Intek’s Power Industry Motto
Intek is The Gateway to Improved Condenser Performance, Fast Response Maintenance and Optimized Operations.

Thank you for your interest in Intek’s Power Industry Instruments and Services.
For more information please contact us at (614) 895-0301 or refer to:
www.IntekFlow.com and www.MyCondenser.com