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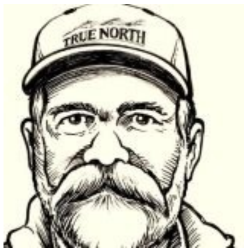

Deceiving Deduction?

by Frank Todd, Manager, Thermal Performance

Have you ever had a situation where you were so sure of yourself that even the laws of physics had to bow to your superior intellect? In my experience, the little engineer alarm bells always go off when I think I have it nailed too early in the game. This article is an example of how sometimes we can let our own assumptions get in the way of the facts.

Ritchie Reynolds and Christopher Carnot came into my office just as I was getting ready to wind up my clock from my last trip away from the confines of New Jersey. When these two brains came at me simultaneously, I knew that something was running amok in the world of flow or efficiency. I put down my clock and greeted them with an air of expectation – or maybe it was anxiety. While our last expedition ended well, the razor wire took its toll on my sense of well being and I was not ready for another foray into the depths of some lonely, cold and dangerous locale.

"We got a call from Northern Mining and Power Inc. this morning and they have a problem with some leaking valves," Chris told me.

After musing on the physiological implications of naming your plant NMPI, I asked for the details.

Ritchie and Chris had just received survey results from the plant. They had a good list developed with some significant leakers. I reviewed the survey (Figure 1) and asked them why they were not doing the ceremonial victory dance – since it seemed like a no brainer – but the look on their faces indicated consternation and confusion.

They were about to call the plant after they had calculated the loss, but Chris had the good sense to look at the plant's last loss report and the list of leakers added up to a lot more than the plant was actually losing. Ritchie reminded me of that old adage: if it is too good to be true, you'd better check it out. So, looking forlornly at my clock, I grabbed my hard hat and fountain pen and we headed out the door.

The Plant in question is a 400 MW natural gas-fired combined cycle located in the center of Cerebellum City. NMPI has one combustion turbine and generator, one steam turbine and generator, and one heat recovery steam generator (HRSG). The combustion turbine requires a steady supply of steam to cool the combustor transition pieces. The source for this cooling steam is intermediate pressure steam produced in the IP section of the HRSG. Subsequent to cooling combustion turbine components, this heated steam mixes with the hot reheat (HRH) steam from the HRSG and is eventually reintroduced into the steam turbine.

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Plant 4 - Valve Leakage Summary
Walkdown 069 - Monday, 07 January 2012

Valve ID	Description	Type	Size (inches)	System Code	Temperature Limit (deg F)	Downstream Temperature (deg F)	Average Leakage (lbm/hr)	Average Loss (MWe)
23HV07	GLAND SEAL SUPPLY SYSTEM DUMP VALVE	Ball	2.066		149.0	648.0	47371.0	6.49
22RD36	22W MAIN STMCOIL DRN TK TO CNDENSR AOV VPI (middle)	Globe	3.068		145.0	191.0	2710.0	0.11
21TB20	TURBINE BYPASS VA 21 TB 20	Globe	7.980		115.0	124.0	513.6	0.05
21TB40	TURBINE BYPASS VA 21 TB 40	Globe	7.980		155.0	159.0	523.2	0.05
21CN155	24A F.W. HTR RELIEF VLV TAIL PIPE	Globe	1.610		***	***	***	***
22CN155	24B F.W. HTR RELIEF VLV TAIL PIPE	Globe	1.610		***	***	***	***
22MS7	22 MN STMLINE MSIV BODY & UPSTRM DRN HDR AOV VPI	Globe	2.066		400.0	***	***	***
23CN155	24C F.W. HTR RELIEF VLV TAIL PIPE	Globe	1.610		***	***	***	***
24MS7	24 MN STMLINE MSIV BODY & UPSTRM DRN HDR AOV VPI	Globe	2.066		460.0	***	***	***

Valve Leakage Summary 1 of 1 Monday, 09 January 2012

Figure 1. Valve leakage summary, Plant 4

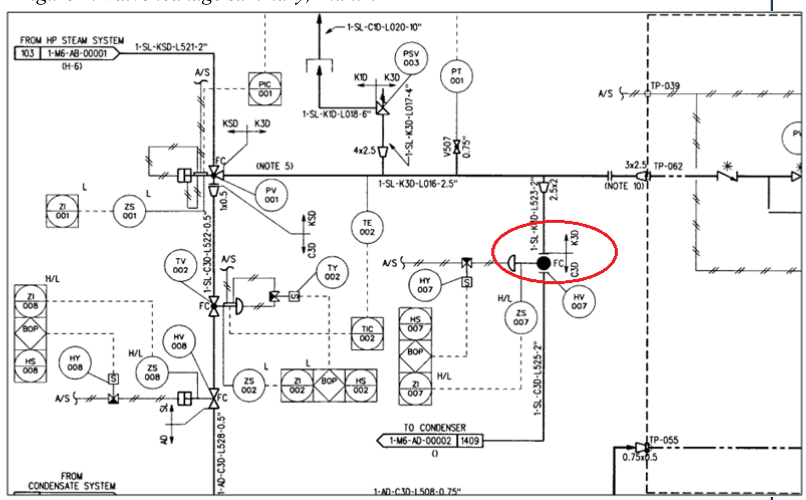

Figure 2. Schematic of the piping arrangement

The steam turbine for this plant is a two case reheat unit with a single flow HP section and a single flow IP/LP section.

The HRSG is a horizontal gas flow natural circulation heat exchanger that converts the Combustion Turbine exhaust energy into steam. This steam is produced at three separate pressure levels and includes a reheater section. All of the steam generated in the HRSG expands through the steam turbine.

One wet surface axial flow condenser converts the steam turbine exhaust into condensate. Heat absorbed by the condenser cooling water is removed in the direct contact mechanical draft cooling tower circuit. A portion of the natural gas fired in this plant is heated. The heat source for the fuel gas heat exchanger is IP drum water from the HRSG, which is nominally at 490°F. This water is cooled to approximately 140°F and is recirculated to the condensate system. The throttle conditions are 1,024°F, 1,888 psia and 1,493.3 Btu/lbm.

The Gland Seal Supply System of the turbine has a dump valve to prevent over pressurization. The plant reported

Continued

that the temperature downstream of the valve was 648°F, which would normally be an indication of a significant leak. Having played this game before, we immediately started looking closely at the configuration. Figure 2 shows the schematic of the piping arrangement.

In the spirit of "trust but verify" we decided to check the valve out by using our acoustic listening device. Unfortunately, as we were walking around the plant the acoustic gun fell and all the king's men cold not put it back together again. So I broke out my back-up stethoscope and took a listen.

Figure 3. Pipe running under grate

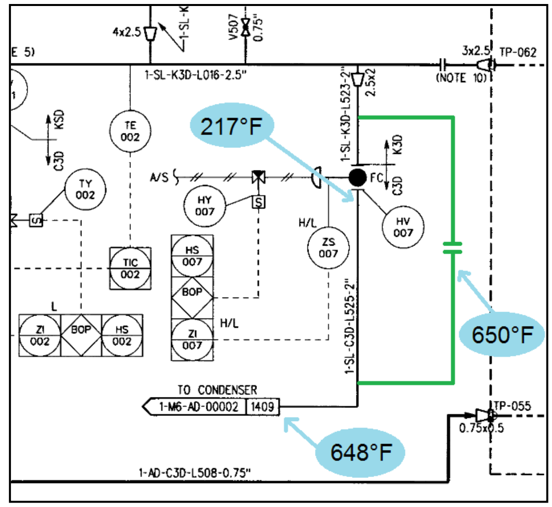

Figure 4. Revised drawing

Having listened to a lot of leaking valves during the past 30 years, my internal FFT calculator did not detect what was to be expected. We located a similar valve to see if it sounded the same as this one, and they both were as quiet as church mice can be in a noisy power plant. Another tried and true technique is to measure the temperature at various locations downstream of the valve. The temperature the plant measured was very near the condenser, so we started measuring the temperature along the pipe moving toward the valve. The temperature started increasing as we got closer to the valve. The plant engineer had that look on his face when the deer walks right under your tree and stands in the position for a perfect shot.

Ritchie suggested that we check the temperature right at the valve, we all looked at him dubiously, but went to the valve and measured the temperature just downstream of the valve. Ritchie aimed the thermal gun at the pipe and hollered back "217°F."

The plant engineer had that deer-looked-up-and-ran-off look and said, "That can't be." We double-checked it with a surface temperature probe at a couple of locations, and the temperature was indeed lower than it was near the condenser. As we walked out of the plant, we knew that unless we solved this problem the poor plant engineer would be sent for another one of those 500 question psychological exams. Something was tickling in my brain from years ago when I was a wee megawatt hunter and I mistakenly suggested a valve be reworked, so I asked Ritchie if he could go back and have another look.

While Ritchie crawled around, Chris and I sat down with the plant engineer and started pouring through the drawings. I asked him if he had the isometrics, and we noticed that the configuration was different on the isometrics than the drawing he had sent us earlier. Chris asked the engineer if our drawing was the latest revision, so he looked up the Drawing Change Packages and saw that there was a change the had not made it into the drawings yet. About that time, Ritchie came sauntering in, looking like he just figured out how to really explain entropy.

"Bet there is another drawing," he said. We looked at him and all three of us dropped our jaws to the ground simultaneously.

"How did you know?!" we exclaimed.

"Well, as I was walking down the pipe I noticed that it dipped below the deck plates (see Figure 3) just a few feet after the valve then popped back up again," Ritchie explained. "I immediately wondered what was under that deck plate.

"I went down to the lower level and noticed a nice shiny new pipe coming into the pipe we were monitoring," he said. "I walked it all the way down and found the bypass line with the orifice."

I asked Ritchie if the temperature at the orifice was around 650°F and his nodding indicated I was correct. So I whipped out the new drawing (Figure 4), and there it was: a nice little orifice bypassing the valve we thought was leaking.

Cycle isolation is the nemesis of many a power plant.

What's worse is that often valves are leaking, and because you can't see the steam that is flowing to a condenser, significant leaks go unnoticed.

Repairs to leaking valves can provide significant payback, but it also has been the case where valve were identified to be leaking, but they actually were as tight as a drum. It only takes one of these non-leaking events to significantly decrease the confidence of any leakage monitoring program. This story is one example of how a good engineer can be fooled.

Thanks to the questioning attitude of Mr. Reynolds and Mr. Carnot, we were able to save the maintenance guys a lot of work and the engineer a lot of embarrassment, thus preserving his credibility and avoiding a visit with the plant shrink. And I was finally able to get back to my forlorn clock that was aching for a good wind.

Mr. Megawatt is Frank Todd, manager of Thermal Performance for True North Consulting. True North serves the power industry in the areas of testing, training and plant analysis. Todd's career, spanning more than 30 years in the power generation industry, has been centered on optimization, efficiency and overall Thermal Performance of power generation facilities.

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