# THE COST OF VACUUM LOSS FOR A CONDENSING STEAM TURBINE

*By Sydney Gross*

I was asked recently by a customer to quantify the penalty on horsepower for a given loss of vacuum. The machine was a six stage condensing impulse design that operated between 600 psig and 25 inches of Mercury vacuum. I was familiar with rule of thumb for such instances but had never verified it for myself. What I found was interesting and, with a little work, practical for application.

The first question I needed to answer for myself was the effect of the inlet conditions. I started by taking a survey of the inlet conditions of approximately 55 surplus condensing machines and using a representative sample of five. I then calculated the gas horsepower for each of these at several exhaust pressures assuming a nominal 75% efficiency. The difference in horsepower between increments of ½ inch Hg was plotted and is shown below.

Regardless of the inlet steam conditions, the results were nearly identical. The inlet conditions had little to do with the penalty of vacuum loss.

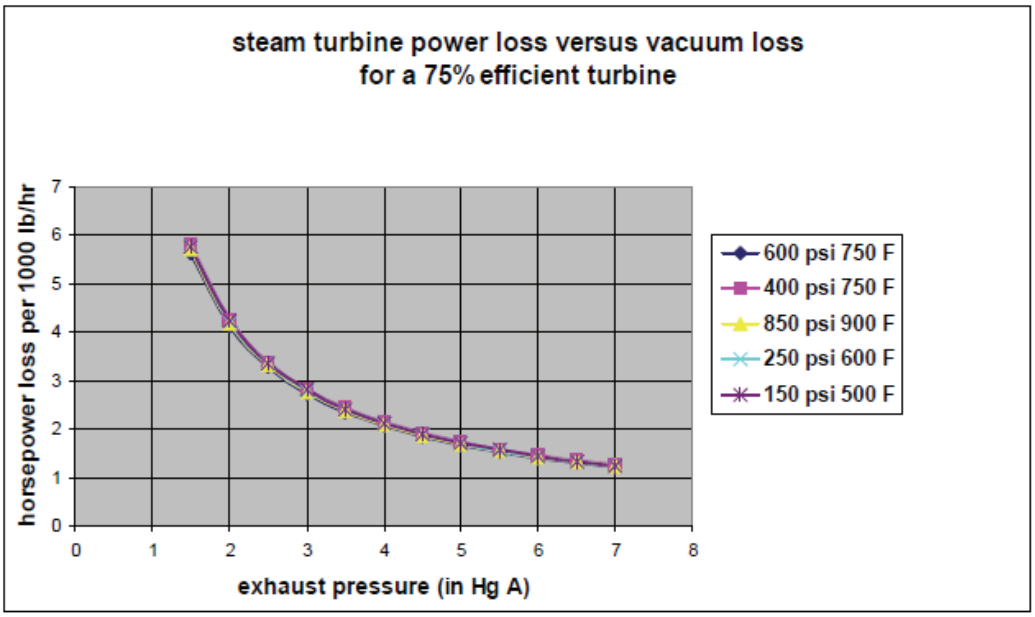
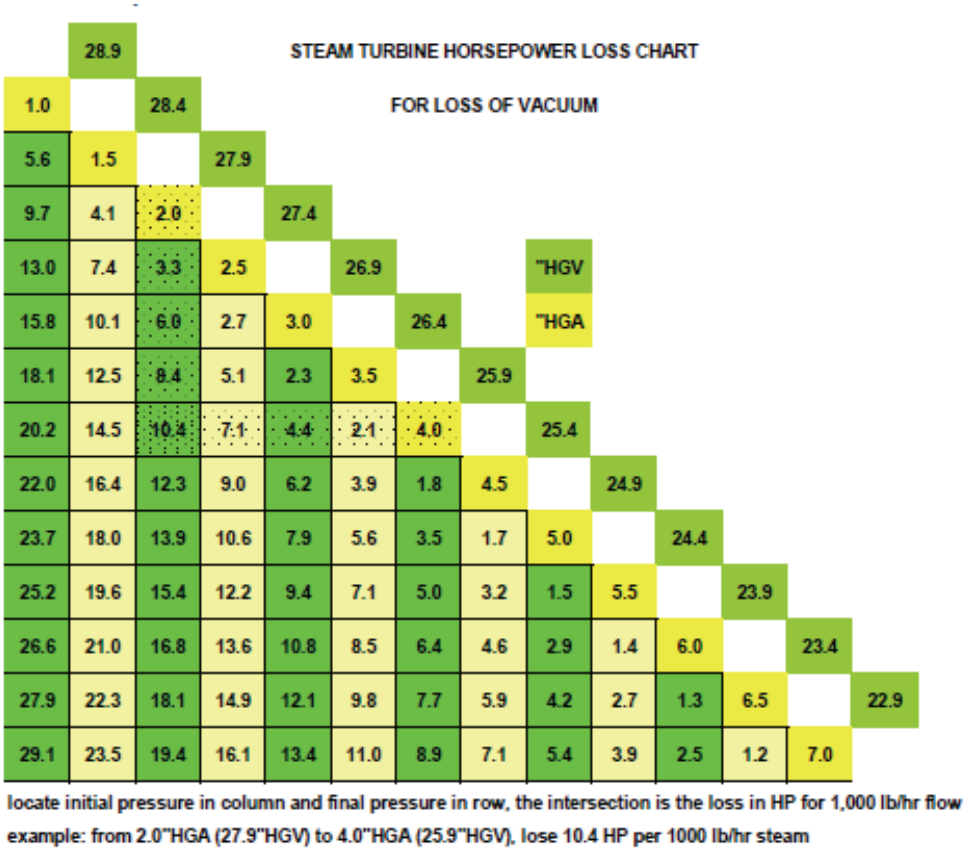



*Figure 1:Steam Turbine Power Loss Versus Vacuum Loss for a 75% Efficient Turbine*

In order to put this into a useful format, the results were charted and are shown below. It should be noted that these figures do not take into account any change in turbine efficiency resulting from operating off-design. Expect less accuracy at larger differences in vacuum. If you know the isentropic efficiency of the turbine, you can ratio with the 75% used for these calculations.




| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 28.9 | | | | | | | | | | | |
| 1.0 | | 28.4 | | | | | | | | | | |
| 5.6 | 1.5 | | 27.9 | | | | | | | | | |
| 9.7 | 4.1 | 2.0 | | 27.4 | | | | | | | | |
| 13.0 | 7.4 | 3.3 | 2.5 | | 26.9 | | | | | | | |
| 15.8 | 10.1 | 6.0 | 2.7 | 3.0 | | 26.4 | | | | | | |
| 18.1 | 12.5 | 8.4 | 5.1 | 2.3 | 3.5 | | 25.9 | | | | | |
| 20.2 | 14.5 | 10.4 | 7.1 | 4.4 | 2.1 | 4.0 | | 25.4 | | | | |
| 22.0 | 16.4 | 12.3 | 9.0 | 6.2 | 3.9 | 1.8 | 4.5 | | 24.9 | | | |
| 23.7 | 18.0 | 13.9 | 10.6 | 7.9 | 5.6 | 3.5 | 1.7 | 5.0 | | 24.4 | | |
| 25.2 | 19.6 | 15.4 | 12.2 | 9.4 | 7.1 | 5.0 | 3.2 | 1.5 | 5.5 | | 23.9 | |
| 26.6 | 21.0 | 16.8 | 13.6 | 10.8 | 8.5 | 6.4 | 4.6 | 2.9 | 1.4 | 6.0 | | 23.4 |
| 27.9 | 22.3 | 18.1 | 14.9 | 12.1 | 9.8 | 7.7 | 5.9 | 4.2 | 2.7 | 1.3 | 6.5 | |
| 29.1 | 23.5 | 19.4 | 16.1 | 13.4 | 11.0 | 8.9 | 7.1 | 5.4 | 3.9 | 2.5 | 1.2 | 7.0 |

*Figure 2: Steam turbine Horsepower Loss Chart for Loss of Vacuum*

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