Coal to Water Efficiency at GCWW River Station

Greater Cincinnati Water Works
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Because terms used to describe the efficiency of a steam driven water pump can be confusing, this writing is to clarify the issues involved with those descriptions and to describe efficiency for the River Station steam driven water pumps. Much of the confusion results from different and unrelated definitions for brake horsepower and boiler horsepower.

Causing confusion today, unfortunately, are the terms used in the early days of steam when a Boiler Horsepower was roughly comparable to the horsepower of engines fed by the boiler. Thus by old standards a 1,000 brake HP engine required a 1,000 Boiler HP boiler, and the four engines at River Station required a 4,000 HP boiler house. source You could also define the boiler room (although not common) as 23,304 brake HP of coal to produce 18,180 brake HP of process steam to power four 1,000 brake HP engines. Confusing, yes, read on.

Adding to that confusion is a third definition used today. Traditional system efficiency is defined by comparing input power to output power and expressed as a percent of input/output power. There are different standards and types of horsepower. The most common horsepower—especially for electrical power is 1 HP = 746 Watts. However, for boilers, the horsepower term describing a boiler (the power required to evaporate 34.5 lb of fresh water at 212° F in one hour or 33,475 BTU/hour) and expressed as boiler HP (BHP), is not the same as engine brake horsepower (550 ft-lb/s) also described as BHP. A boiler horsepower can be more than 13 times larger than engine brake horsepower. source We lack sufficient data to calculate boiler HP from the boiler house for the 1902 engines by today's standard.

At River Station, eight Sterling water tube boilers (4-drum; 3-steam, 1-mud) with Foster super heaters were each rated by the Sterling Company at 294 BHP and tested to be 78% efficient. The addition of a feedwater pre-heater and a Green Economizer added another 200 HP. It would be fair to state the boiler house horsepower as (294 + 200) x 8, or 3,950 HP, a.k.a. 4,000 BHP*.

Because the 1,000 HP engine was about 22% efficient it required 4,545 brake HP of steam, and at 78% efficient, the boiler required a coal input of 5,826 brake HP/engine. Thus, you could say the boiler house required (4 x 5,825) or 23,304 brake HP of coal to produce 18,180 brake HP of process steam to supply four 1,000 HP engines operating at 22% efficiency. Average daily coal usage at River Station was 26 tons of Pittsburgh Nut & Slack.

To eliminate the confusion with horsepower rating systems between an engine and its boiler, a better description was devised using the term *Duty*, which are pounds of water lifted one foot per bushel coal. The metric for a bushel of coal was defined as not the tradition 84 pounds/bushel but instead, 100 pounds/bushel.

The coal to water efficiency for the triple expansion, double acting crank and flywheel water pumping steam engines (condensing) (with steam jackets and receiver re-heaters) at River Station, tested at a *Duty* of 156,315,138 lb-ft/100# coal or 1,883,000 gallon-ft/100# coal.

*A ninth Sterling water tube boiler was used to power the other 17 ancillary steam engines used at River Station, causing the boiler house to be rated at 4,500 Boiler HP (old standard) and requiring 26,217 brake HP of coal.

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