TABLE 2 EXHAUST-PRESSURE DATA

Exh press, in. Hg abs	Exh press divided by opt exh press	Uncorrected increase in heat rate, per cent	Corrected increase in heat rate, per cent	Corrected increase in heat rate Btu/kwhr	Heat rate, Btu/kwhr	Decrease in kw output, per cent	Decrease in output, kw	Kw output
0.72	1.0	Base	Base	Base	8101	Base	Base	80810
1.0	1.4	0.2	0.2	16	8117	0.2	160	80650
1.5	2.1	0.9	1.0	81	8182	1.0	810	80000
2.0	2.8	2.2	2.6	211	8312	2.5	2020	78790
2.5	3.5	3.6	4.2	340	8441	4.0	3230	77580
3.0	4.2	5.0	5.8	471	8572	5.5	4450	76360
3.5	4.9	6.3	7.3	592	8693	6.8	5490	75320

Decrease in kilowatt output equals

$$\frac{2.6}{1 + \frac{2.6}{100}} = 2.5 \text{ per cent}$$

of the kilowatt output at optimum.

Decrease in kilowatt output = 2.5 per cent 80,810 = 2020 kw
Kilowatt output at 2.0 in. Hg abs = 80,810 — 2020 = 78,790 kw

(4) A tabulation, Table 2, may be easily calculated following the procedure outlined in item (3) from which an exhaust-pressure correction curve may be drawn.

Discussion

H. R. Reese.[5] The authors are to be commended for a paper that should be very useful in power-plant economic studies for variable exhaust pressures and turbine-casing arrangements.

The paper is excellent for determining the correction to "heat rate and change in load" for a given number of exhaust ends and turbine-casing arrangements. However, unless other factors are included, errors may be introduced when correcting a given design to a design with a different number of exhaust ends and casing arrangement.

The number of exhaust ends and casing arrangements affects the blade leakage, blade aspect ratio, and packing leakage of the elements, which may have a total effect on the heat rate and kilowatt output, ranging to approximately 1 per cent. The speed of the elements also affects the element efficiency when considering 3600 or 1800-rpm intermediate or low-pressure elements.

It is suggested that a construction factor for turbine-casing arrangement be included with the other correction factors in determining the final heat rate and kilowatt output. Construction factors can be determined for the single, tandem, and cross-compound units with varying number of exhaust ends, and the difference in these factors can be used to correct the heat rate and kilowatt output.

In defining the optimum exhaust pressure for the feedwater-heating cycle, it is well to emphasize "part 2" where it points out the additional steam extracted for lower exhaust pressure and corresponding lower saturation temperature, results in a loss in kilowatt generation which results in a poorer heat rate. This factor often is overlooked when evaluating extra kilowatts for improved vacua when using leaving-loss curves for the correction.

H. J. Rubinstein.[6] This paper will be of much value to the purchasers and users of large steam turbines. Heretofore, it behooved the steam-plant designer to rely heavily upon the turbine manufacturer for this kind of information for studies made previous to the actual purchase of a new machine.

This paper will prove useful in the evaluation of the whole interdependent problem of condenser size, cooling-tower size, plant location (with reference to the temperature of cooling water available) and turbine exhaust-annulus area. These matters can now be investigated in the light of value received in the form of changes in turbine economy.

TABLE 3 COMPARISON OF RESULTS

Per cent increase in heat rate in going from 2 in. Hg to 3.5 in. Hg exhaust pressure			
Per cent maximum capability	100%	60%	40%
Valley Steam Plant No. 3 machine...	3.92	7.2	11.7
Authors' values....................	3.51	5.5	6.7
Per cent decrease in heat rate in going from 2 in. Hg to 1.5 in. Hg exhaust pressure			
Valley Steam Plant No. 3 machine...	1.25	2.11	3.38
Authors' values....................	0.79	2.03	2.76

A check has been made to compare the information presented with the information available to us after the purchase of a large turbine. To perform this check we used the heat-rate correction curves given to us by the manufacturer of our Valley Steam Plant unit No. 3, which is a General Electric 156,250-kw maximum capability, 1800 psig, 1000 F throttle, 1000 F reheat machine. We calculated the change in heat rate in going from 2 in. Hg exhaust pressure to 3.5 in. Hg, and also in going from 2 in. Hg exhaust pressure to 1.5 in. Hg. We did this for 40 per cent, 60 per cent, and 100 per cent of maximum capability. Table 3 gives the results of our calculations.

Assuming that our calculations are correct we would appreciate knowing which method is considered more accurate.

We as purchasers and users of large steam turbines are grateful to the authors for making this kind of information available.

Authors' Closure

Mr. Reese properly points out that additional data is required if the user of this paper wishes to determine differences in heat rate between turbines with different exhaust-end arrangements. Such data may be obtained from the paper by C. W. Elston and P. H. Knowlton, published in 1952.[7] Data on comparative performance of turbines with different casings and exhaust-end arrangements may be obtained from this reference at one exhaust pressure. This paper will then readily furnish comparative heat rates at other exhaust pressures. The authors agree with Mr. Reese's caution that additional steam extracted at the lower exhaust pressures must be properly accounted for.

Mr. Rubinstein points out differences between exhaust-pressure corrections furnished by the authors' company some time ago for a turbine being built for the Valley Steam Plant and exhaust-pressure corrections calculated from this paper. Only recently has test data been obtained on modern reheat turbines and the organization of these data for this paper revealed that changes in heat rate were less as exhaust pressure was changed than had been previously expected. The exhaust-pressure corrections furnished for the Valley Steam Plant were based on tests on nonreheat turbines before these reheat test data were available. As can be seen in Fig. 8, the method contained in this paper agrees quite well with the test data.

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[7] "Comparative Efficiencies of Central-Station Reheat and Nonreheat Steam-Turbine-Generator Units," by C. W. Elston and P. H. Knowlton, Trans. ASME, vol. 74, 1952, pp. 1389–1399.