

### **PTC CASE 3**

#### **PTC 4 - 2013**

#### **Title: Clarifications on the use of efficiency corrections or curves for individual fuel constituents and HHV.**

*Inquiry:* PTC 4 - 2013, para. 5-18.3 discusses how to correct as-tested boiler efficiency for the differences in fuel constituents between the test and the standard/contract fuel. PTC 4 states that “Corrections to credits, losses (efficiency), and air and flue gas mass flow rates for differences in fuel constituents between the test and contract fuel are made by utilizing the standard or contract fuel analysis in the applicable computations”. However, PTC 4 does not provide procedures for developing corrections for deviations from design values of heating value and individual fuel constituents, such as hydrogen, sulfur, etc. What appropriate procedures should be used to develop efficiency corrections or curves for individual fuel constituents and HHV?

*Reply:* It is the opinion of the Committee that fuel constituents and/or HHV for solid or liquid fuels cannot be manipulated individually to create correction curves for off-design constituents or HHV. The mass fraction of the fuel’s constituents by definition must total to unity (1), thus variations in the mass fraction of one constituent of an actual fuel are accompanied by variations in all the other constituents. Although the HHV and the mass fraction of an actual fuel’s constituents can be observed to vary significantly from sample to sample, the large variations are primarily due to deviations in the inert matter (moisture and ash).

During a performance test, the chemical composition of the test fuels will vary from sample to sample and will be different from the design fuel. The variation in the HHV and individual chemical constituents (H<sub>2</sub>, N<sub>2</sub>, S, O<sub>2</sub>, and C) will vary enough to prevent making a meaningful comparison of tested versus guaranteed boiler efficiency, thus PTC 4 correction procedures shall be followed.

Efficiency correction curves that only consider variations in one (1) constituent independent of the others do not reflect an actual fuel, and correction curves that try to account for variations in all the constituents and their interdependencies would be impractical to generate and unnecessary. Only the procedures prescribed in PTC 4, para. 5-18.3 shall be used for correcting efficiency and fuel input for off-design fuel composition: i.e. substitute the design fuel’s ultimate analysis and HHV in the applicable computations to calculate corrected energy losses (subsection 5-14) and credits (subsection 5-15). For calculation of test and corrected efficiency, it is recommended that the calculations be performed separately for each fuel.

To validate a fuel analysis, the calculated theoretical air should be used. The theoretical air, expressed on a mass per unit energy input, does not vary significantly for a given fuel or rank of coal. When the theoretical air of a design or tested fuel does deviate from the empirical limits listed below:

1. It is either because of an error in the laboratory analysis of the fuel sample, or the design fuel analysis was artificially created and/or specified and does not represent an actual fuel.
2. The mass flow of air and gas, and associated efficiency losses and credits are not correct and should not be used for equipment design or evaluation. Boiler and auxiliary equipment design must be based upon a design fuel ultimate analyses that properly reflects the fuels that will actually be burned, i.e. they must fall within the theoretical air limits shown below.

Referencing PTC 4-2013 para. 5-11.3, when expressed on a lbm/million Btu (MBtu) basis, a valid fuel analysis should fall within the ranges of theoretical air shown below:

- (a) Coal (When moisture and ash free volatile matter > 30%): 735 lbm/MBtu through 775 lbm/MBtu
- (b) Oil: 735 lbm/MBtu through 755 lbm/MBtu
- (c) Natural Gas: 715 lbm/MBtu through 735 lbm/MBtu.

The theoretical air for carbon and hydrogen, 816 lbm/MBtu and 516 lbm/MBtu, respectively, are the practical maximum and minimum values for hydrocarbon fuels.