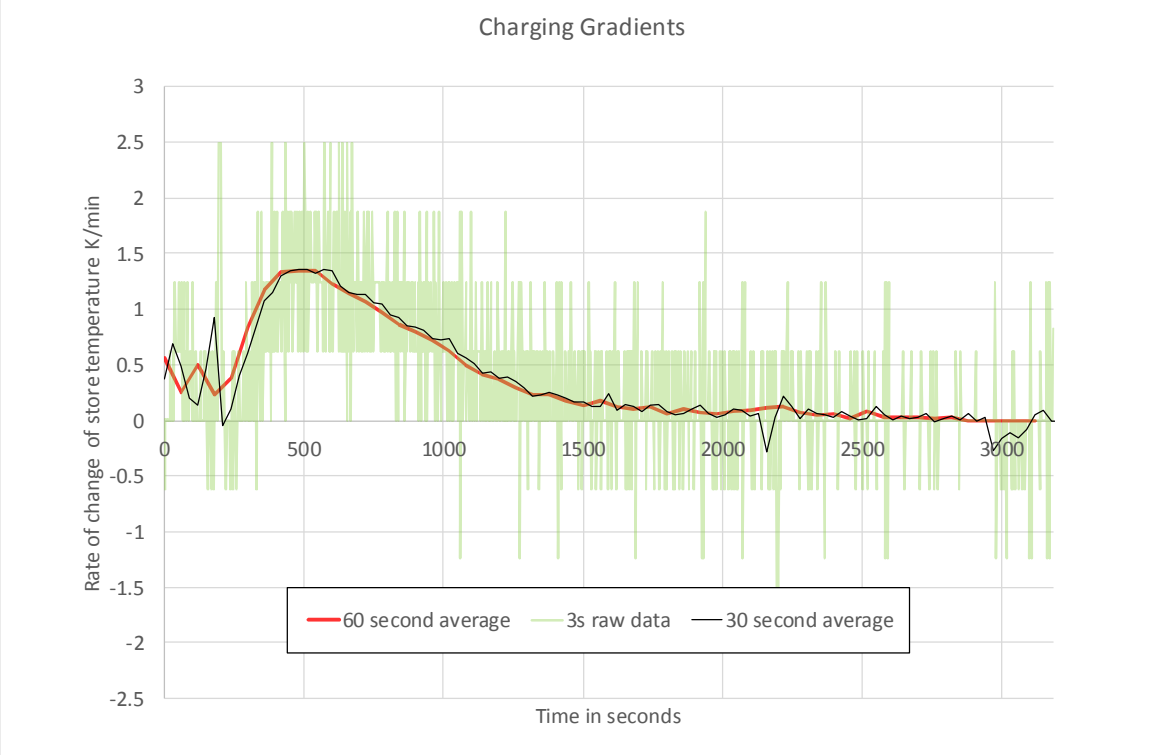
Processing of laboratory test data for FGHRS recognition in SAP

This document describes the procedure undertaken to process test data supplied in accordance with the Flue Gas Heat Recovery (FGHRS) test and calculation method[1], which is used by the Standard Assessment Procedure (SAP). This procedure has been used since inception of the FGHRS test and calculation method for FGHRS devices that feature a heat store.

The calculation method requires FGHRS coefficients to be calculated for use in SAP Appendix G. These characterise the rate of change in heat store temperature (or gradient function) whilst charging, cooling or discharging as function of the store temperature. The gradient function is calculated from temperature measurements during the cooling, charging or discharging tests. Measurement uncertainty between successive measurements of the recorded temperatures can cause large fluctuations in the gradient functions.

To avoid anomalous fluctuations in these gradients, the temperature data is processed by averaging the data over a time interval (e.g. 15s, 30s, 60s, 6 minutes). The averaging time interval depends on the characteristics of the FGHRS product and the test data supplied. By time-averaging test results, fluctuations in the calculated gradient are reduced so that it does not swing from negative to positive, or visa versa, over successive time intervals.

The plot below shows a charging test data example. It shows that the gradient for the raw data (green line) collected every 3s swings widely due to measurement uncertainty. It also shows two time-averaged lines: one averaged over 30s and the other over 60s. In this example, the 60s time average data would be utilised within the FGHRS test method, since it avoids negative gradients.



[1] http://www.ncm-pcdb.org.uk/sap/filelibrary/pdf/calculation_methodology/SAP_2009/FGHRS_calculation_method_28_10_10.pdf

Processing data procedure:

The procedure for processing test data prior to entry within the calculation method is as follows:

1. The temperature of the FGHRS heat store measured at several points as a function of time will be supplied. Take the average of the temperature measured at these points for each timestep to obtain a single average store temperature as a function of time.

2. Calculate the rate of change in the average store temperature (or temperature gradient) as a function of time i.e. $(Ts(t_n) – Ts(t_{n-1})) / (t_n – t_{n-1})$ where Ts is average temperature of the store at indicated time, t; t_n is time in seconds at given timestep n and t_{n-1} is the time at previous timestep; n is an integer.

3. Review the calculated gradients either graphically plotted against time or within a list. The gradients should all be negative (for the discharging or cooling test data) or all positive (for charging test data).

   If this is not the case (i.e. not consistently negative or positive) then time averaging is necessary. Average the mean store temperature over a multiple of the measurement intervals. Select a small multiple at first (e.g. five for data recorded every 3s) and then recalculate and re-examine the temperature gradient looking for consistent negative or positive gradients. Repeat with progressively larger multiples until the gradients are consistently negative or positive.

   In some cases, as the gradient function begins to approach zero there may be one or two points where the gradient abruptly switches sign and back again. Rather than increasing the multiple, the odd value is replaced with the average of the neighbouring gradient functions.

4. Gradient function temperature ranges

   The implementation of the FGHRS calculation method is via Microsoft Excel. When temperature ranges in the test data do not fully span the mean store temperature range required by the FGHRS calculation method, the lowest and highest points of the Lookup array (used by Excel) are set as follows:

   a. Charging test – this gradient function is required between 20°C and the maximum temperature reached during the charging test. If the lowest recorded mean store temperature does not reach 20°C, then the gradient function for the lowest measured mean store temperature is used for all values between the minimum mean store temperature and 20°C.

   b. Cooling test – this gradient function is required between the maximum recorded store temperature during the charging test and 20°C. If the lowest recorded mean store temperature does not reach 20°C, then the gradient function for the lowest measured mean store temperature, and corresponding laboratory temperature, is used for all values between the minimum mean store temperature and 20°C.

      If the highest recorded mean store temperature during the cooling test does not reach the maximum recorded temperature during the charging test[2], the gradient

[2] Since the FGHRS heat store is charged twice during the test programme, this relates to charge test data submitted for processing and upon which the performance declaration is based.

function at the highest recorded mean store temperature, and the corresponding laboratory temperature, is applied.

c. Discharging test – this gradient function is required between the maximum recorded store temperature during the charging test and 20°C. If the lowest recorded mean store temperature does not reach 20°C, the gradient function at the lowest measured mean store temperature is used for all values between the minimum mean store temperature and 20°C.

   If the highest recorded mean store temperature during the discharge test does not start from the maximum recorded temperature during the charging test[2], the gradient function at the highest recorded mean store temperature for the discharge test is applied within the calculation method.