Treatment of FGHRS with close-coupled heat store in Appendix Q of SAP

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1 Introduction

A close-coupled heat store fitted to a passive flue gas heat recovery device (PFHRD) is being marketed making it a flue gas heat recovery system (FGHRS).

The close-coupled store is a primary hot water store at 65°C or less connected to primary circuit. Domestic cold water is pushed through the store pre-warming it before it enters a combi boiler. The cold water is also pre-warmed as it passes through the PFGHRD before entering the close-coupled store.

This close-coupled store is only suitable for an instantaneous combi with a keep hot facility and connected to a specific PFGHRD model. Its purpose is to improve hot water service, but it has a knock-on effect in terms of energy efficiency.

This document describes the energy efficiency treatment in appendix Q, SAP 2005 implemented in November 2008.

The heat store characteristics can only be included in the FGHRS coefficients on the worksheet, if and only if, the close-coupled store is tested as an integral part of the flue gas heat recovery system (i.e. the charging, discharging and cooling tests are undertaken with the close-coupled store active).

If the heat store is not tested as an integral part of the FGHRS, the thermal characteristics of the store are treated like any other from hot water store within SAP. This technical note describes this case only.

2 Method

The thermal losses from the close-coupled store will contribute to the internal gains partly reducing space heating demand. It is not possible to enter the store characteristics into the SAP, Appendix Q progress *before* the space heating calculation is undertaken, so the final result from appendix Q ready to input into the main SAP needs adjusting taking into the account the heat loss from store loss; that is a degree of reserve engineering is required.

It is possible to calculate a revised heat gain and hence a revised base temperature, number of degree-days, and revised space heating requirement from only three additional parameters:

- Specific heat loss (W/°C)
- Total heat gains (W)
- Efficiency of the main heating system after adjustment for controls

The database in the appendix Q worksheet contains the two additional parameters linked to the FGHRS with the close-coupled store that are required and are:

- Close-coupled store volume
- Close-coupled store loss when tested with an electric boiler producing a steady 45K temperature rise above ambient conditions

2.1 Thermal loss from heat store.

The thermal heat loss from the close-couple store and hence extra water heating requirement is calculated as follows in line with SAP 2005.

Heat loss from close-coupled store = daily store loss x table 2b factor x 365

Table 2b factor = 0.54

This assumes a separate timer channel for and thermostat of the close coupled store set to 65°C [1]

daily storage loss = manufacturer's declared value

Extra combi loss = + additional combi loss due to close-coupled store
- combi loss from instantaneous combi (SAP table 3a)
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Extra combi loss = + Table 3a using close-coupled store volume
- combi loss from instantaneous combi (SAP table 3a)

Note the comb loss from instantaneous combi is depended on daily water usage (see table 2). This is calculated from the floor area which already requested as part of the FGHRS Appendix Q worksheet.

Close-coupled store are treated thermal as secondary store as temperature characteristics very similar to a secondary store (see footnote 1)

[1] Secondary store assumes cylinder thermostat placed at 1/3rd the height of the cylinder and set at 60°C. This means 2/3rd of cylinder will be warmed. Here the thermostat is assumed to be placed halfway so arise half the volume will be warmed to 65°C. Making the loss from the closed-cylinder lower than an equivalent secondary cylinder with thermostat set at 60°C.

Extra primary pipe loss = 0

This assumes the close-coupled is connected within 1.5m of the boiler (see table 3) and insulated to the standard specific in the Building Regulations.

2.2 Extra water heating

The extra hot water heating consumptions is:

Extra hot water consumption = (Heat loss from the close-coupled store + Extra combi loss) ÷ 0.91

0.91 is the efficiency of the water heating assumed elsewhere in the FGHRS Appendix Q procedure (see section 2.1 for the other right hand terms).

2.3 Extra water heating gains

The extra hot water gains are:

Extra hot water internal gains = (Heat loss from close-coupled store x 0.8 + Extra combi loss x 0.25) ÷ 8.760

dividing by 8.760 converts from kWh/yr to Watts

0.8 and 0.25 are the utilisation factors applied in SAP 2005 (see box 52).

2.4 Whole house temperature

The extra water heating will reduce the base temperature for the degree-day calculation. First the whole house temperature without the extra water heating gains due to close couple store needs to be established. This could be simply asked for in the Appendix Q, sheet, but as the heating requirement is already asked for, it is possible to work backwards from the heating requirement and gains to loss ratio to worked out the useful gains, the number of degree-days, the base temperature and the whole house temperature (steps for boxes 81 to 77 in SAP 2005).

The revised useful gains can then be used to calculate a revised whole house temperature, base temperature, degree-days and revised heating requirement (steps for boxes 66 to 81 in SAP 2005). Steps for extra internal gains introduced by the close-coupled store simplify because out of boxes 70 to 80 only box 72 depends on the extra internal gains.

The details are:

Calculate the original gains/loss ratio

GLR = gains/loss

Calculate the original utilisation factor

$UF = 1 - e^{-18/GLR}$

Calculate the useful gains

UG = UF x Gains

Calculate the original degree days

Degree-days = heating requirement /(0.024 x Loss)

Calculate the original base temperature

Base temperature = Inverse DD function (degree-days)

Calculate the original mean temperature of whole dwelling

MIT = base temperature + UG/loss

2.5 Revised heating requirement

Based on the internal heat gains from the close-closed store (2.3) a revised heating required can be calculated.

First calculate the revised gains from the original gains

Gains' = gains + extra hot water internal gains (see part 2.3)

Calculated revised gains to loss ratio

GLR' = gains' / loss

Calculated the revised utilisation factor

$UF' = 1 - e^{-18/GLR'}$

Calculate the revised useful gains

UG' = UF' x Gains'

Calculate the revised mean internal temperature of the whole house due to the revised gains (box 72 only). *This assumes R=1 which is the case for radiators.*

MIT' = MIT + 0.2 x (UG' –UG) / loss

Calculate revised the base temperature

Base temperature' = MIT' – UG' / loss

Calculate the revised degree-days which is a function of the base temperature

Degree-days' = DD (base temperature') (see table 7, SAP)

Finally calculate the revise space heating requirement and change in space heating requirement.

Space heating requirement ' = degree-days' x loss

Change in space heating requirement = Space heating requirement '
- Space heating requirement

2.6 Revised space heating consumption

The change in the space heating requirement needs to be converted into the change in the energy consumption of the boiler.

This is:

Change in consumption = (Space heating requirement '
- Space heating requirement)
x (1 – secondary heating fraction) x 100 / efficiency

where efficiency is the boiler including any controls adjustment. This is the third additional parameter that is requested by appendix Q procedure for a close-coupled store. The secondary heating fraction is already asked for.

There will also be a change in consumption of any secondary heating, but as secondary heating fraction will be small it was decide to assume for the purposes of the close-coupled store space heating adjustment that this is 100% efficient; rather than ask for another parameter.

3 Overall change in boiler consumption

The overall savings is:

Savings due to PFGHRD + change in space heating consumption – change in water heating consumption (see part 2.2).

Note the saving due to the PFGHRD with a close-coupled store is calculated as if the PFGHRD was connected to storage combi because this is what the combination has become.