**TECHNICAL PAPERS SUPPORTING SAP 2012**



# Changes to the treatment of heating and hot water systems with boilers in SAP 2012

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## Summary

This paper deals with changes to the treatment of heating and hot water systems with boilers in SAP 2012. The subjects that have been examined are:

1) prospective introduction of the eco-design regulations for gas and oil boilers, replacing the Boiler Efficiency Directive (BED)
2) heat losses from storage combi boilers for which hot water performance test data is not available
3) rejected hot water from instantaneous combi boilers
4) heating controls.

**Preparation for the Eco-design regulations**

The eco-design regulations have not been finalised but are expected to require laboratory efficiency tests at full- and part load, as is the case at present. Some changes are to be made in the test conditions, and so the details of the proposed regulations were examined to see if they can be allowed for in SAP 2012. The significant changes expected are:

a. expression of efficiency results on a gross calorific value basis
b. a return temperature of 30ºC in the tests on oil-fired condensing boilers
c. obligatory hot water performance tests for combi boilers.

It was concluded that a convenient way to deal with (a) is to amend the annual efficiency calculations in SAP Appendix D so that all test results are converted to gross figures (if they need to be) as the first step in the procedure. This necessitates some changes to the steps that currently precede the conversion. When registering boilers in the Product Characteristics Database (PCDB) it will be necessary to confirm on what basis the test data has been given by the test laboratory so that it can be converted if necessary.

Examination of (b) showed that no changes to the SEDBUK formulae or theoretical maximum efficiencies for oil condensing boilers in SAP are required. This is because

- the underlying principle in the SEDBUK method assumed the most popular part-load test for oil boilers was the indirect method, and the return temperature is consistent with that now expected in the eco-design proposal
- the maximum theoretical efficiency for an oil condensing boiler operating at the new temperature conditions is not significantly higher than that in the calculation in SAP 2009.

SAP 2009 already allows for the inclusion of hot water performance test data as an option. Allowance for energy figures on a gross calorific value basis will be made here too.

**Storage combi boilers**

Heat losses from storage combi boilers have been measured in recent test programmes and found to be considerably higher than currently assumed in SAP. The default figures in SAP for heat losses should therefore be raised. This does not affect boilers for which individual hot water performance test data is available.

**Rejected hot water from combi boilers**

Rejected hot water from instantaneous combi boilers may be systematically under-estimated in the standard tests, and evidence from field trials and laboratory tests was compared. Although the standard hot water performance tests produce very low results, this is partly explained by the far lower water content of modern boilers. In regard to the field trials it was concluded that the difference between combis and regular

boilers, although measurable, was not statistically significant in the sample and may be due to natural variation. Consequently no adjustment to assumptions about rejected hot water have been recommended for SAP.

**Heating controls**

There has not been sufficient time for a full review of heating controls, although this is considered necessary in the near future in view of the evidence that has emerged in the last 2 years. The only controls that have been considered for variation in treatment in SAP 2012 are room thermostats, weather compensators, enhanced load compensators, and time and temperature zone control.

It was concluded no change should be made, for the present, to assumptions about the benefit of room thermostats. For weather compensators and enhanced load compensators it is considered that conformance to the SAP definitions in regard to method of working can be assured only by means of authenticated entries in the Product Characteristics Database (PCDB). Claims that products are conformant have been found, in some cases, to be untrue. It is proposed that time and temperature zone control should be recognised as a significant benefit only in larger dwellings, and evidence is being sought on the floor area below which it should not apply. The definition of time and temperature zone control should be expanded to include communicating TRV systems with a central controller, subject to certain conditions. As in the case of weather/load compensators, SAP should recognise them only from authenticated entries in the PCDB confirming that they operate as envisaged.

## Contents

# 1 Introduction

Eco-design regulations under the Energy Related Products Directive[1] (ErPD) for boilers and water heaters are not finalised, but are expected to be introduced early in 2012, coming into effect one year later. To some extent, where it is safe to do so, the new regulations can be anticipated and allowed for in SAP[2] (2012 edition) insofar as they change the test methodology for domestic gas and oil boilers.

Although changes to the test methodology can be anticipated in SAP this does not extend to the annual energy performance calculations. The current eco-design proposal is to introduce a method to compare thermal performance called the “seasonal heating efficiency”, based on efficiency test results at full- and part-load. This seasonal heating efficiency is calculated by adjusting the weighted average efficiency at full- and part-load taking into account a wide range of factors including turn down ratio, controls, auxiliary electricity consumption, standby heat loss, and pilot flame consumption. The proposal is very different to the definition of the seasonal efficiency within SAP, and hence incompatible. SAP models the energy use of a dwelling, including the heating and hot water services, and is governed largely by specific building data. The eco-design methodology, however, models energy usage of an appliance assuming typical building characteristics, temperatures, climate, and heating usage. It also combines electricity and heating fuel (gas, LPG, or oil) within a single performance index.

The eco-design regulations are intended to replace the Boiler Efficiency Directive[3] (BED) and will still require laboratory measurements of boiler efficiency at full- and part-load. These basic measurements remain essential for SAP. There are three proposed changes that need consideration:

i) Efficiency measurements will be quoted on a gross calorific value basis.
ii) The part-load efficiency test for oil-fired condensing boilers will be carried out at a return temperature of 30ºC
iii) Hot water consumption tests according to EN13203:2 or OPS 26 (or European equivalent) will become obligatory for combi boilers.

The implications for SAP of these proposed changes are discussed in section 2.

In section 3 the treatment of the hot water performance of gas and oil storage combi boilers in regard to heat loss is re-assessed following recent laboratory measurements.

In section 4 the question of rejected hot water from combi boilers is considered in the light of field trial data on hot water usage and recent laboratory measurements.

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[1] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (recast)

[2] The Government’s Standard Assessment Procedure for Energy Rating of Dwellings

[3] Council Directive 92/42/EEC of 21 May 1992 on efficiency requirements for new hot-water boilers fired with liquid or gaseous fuels

# 2 Preparation for the Eco-design regulations

## 2.1 Gross calorific value basis for efficiency

Proposed Eco-design regulations under the Energy Related Products Directive (ErPD) are likely to introduce a requirement to quote boiler efficiencies calculated on the basis of the gross calorific value (CV) of the fuel. Current practice, in conformity with European standards, is to quote boiler efficiency test results calculated on the basis of the net CV of the fuel.

In anticipation of the change, which is expected to be introduced within the lifetime of SAP 2012, arrangements are being made to accept boiler efficiency test results based on either net or gross CV. SAP[4] includes a net-to-gross conversion factor as part of the boiler efficiency calculations set out in SAP Appendix D, section D2.

It is intended to change section D2 so that net-CV test results are converted to gross-CV as the first step in the calculation. This will require changes in the efficiency correction terms (table D2.1) and maximum efficiency values (table D2.2). However, the final result from the calculation will be no different, nor will there be a difference between results obtained from net- or gross-CV test data input from boiler test results submitted in future.

## 2.2 Change in temperature of the condensing oil boiler test

### 2.2.1 Maximum theoretical efficiency

The present requirement under the Boiler Efficiency Directive for efficiency testing of condensing oil-fired boilers is that the average of the flow and return temperatures should be 40°C. This is unlike the requirement for efficiency testing of condensing gas-fired boilers, which is that the return temperature should be 30°C. Proposed Eco-design regulations under the ErPD are expected to introduce a requirement to test condensing oil-fired boilers under the same temperature conditions as condensing gas-fired boilers.

SAP Appendix D, table D2.3, provides an extra check on the credibility of the efficiency results by limiting them to a theoretical maximum. For gaseous fuels the theoretical maxima for condensing boilers is calculated at flow, return and flue temperatures of 36ºC, 30ºC and 33ºC respectively. For oil condensing boiler the theoretical maximum efficiencies are based on temperatures of 50ºC, 30ºC and 33ºC respectively.

Changing the test temperatures as above for oil boilers does not alter the theoretical maximum significantly. The standby loss at mean flow and return temperature of 40ºC is higher than a mean of 33ºC, but that alters the theoretical maximum by less than 0.1 percentage points and hence the maximum efficiency is still 104% net (to be expressed as the equivalent gross figure in SAP 2012). Therefore it is concluded that no changes to maximum efficiency figures for oil boilers are required.

[4] The Government's Standard Assessment Procedure for Energy Rating of Dwellings, 2009 Edition

### 2.2.2 SEDBUK equations for oil boilers

The SEDBUK equations for oil boilers (nos. 201, 202 and 203 in table D2.6 of SAP Appendix D) were originally developed in 1998. At the time most oil boilers were tested using the indirect method for the part-load efficiency, which required measuring the full-load efficiency at flow and return temperatures of 50ºC and 30ºC and then making an adjustment based on the measured case losses at the average of the flow and return temperature; ie 40ºC.

The equations for condensing boilers for all fuels were derived on the assumption that the mean return temperature in the field was equivalent to the mean return temperatures of the full- and part-load tests. For gaseous fuels this was straightforward, being the mean of 60ºC and 30ºC. For oil boilers this was not straightforward as it depended on the part-load test method: direct or indirect. As the most popular test method for oil boilers at the time was the indirect method, and it used the same return temperature as gaseous fuels, the assumption that the mean return temperature in the field is the mean of 60ºC and 30ºC could reasonably be made for oil too.

However, the direct part-load test method for oil boilers uses a higher return temperature (a return/flow of 43ºC/37ºC) than 30ºC and so the SEDBUK efficiency for condensing oil boilers was marginally underestimated for boilers tested by the direct method. The only way to resolve that would have been to produce different equations for direct and indirect methods, which was considered excessively complicated.

The proposals in the ErPD to change the oil condensing test conditions from a mean flow and return temperature of 40ºC to a return temperature of 30ºC illuminates this marginal underestimate and corresponds to underlying assumptions in SEDBUK equations. Therefore it is concluded that no changes to the SEDBUK equations for oil boilers are necessary.

## 2.3 Hot water performance tests for combi boilers

It is anticipated that the Eco-design regulations under the ErPD will require a hot water performance test for combi boilers according to European standard EN13203[5] for gas-fired boilers or OPS 26[6] (or European equivalent) for oil-fired boilers. SAP 2009 already accepts data from these test methods in conjunction with draw-off schedule number 2 and (optionally) schedule number 1 or 3. The data provided by the tests includes the normalised gas or oil consumption expressed in energy units based on net CV. It is not yet clear whether the Eco-design regulations will require this to be expressed on a gross CV basis instead. Arrangements will be made to accept data based on either net or gross CV and convert where necessary.

EN13203:2 and OPS 26 are not efficiency tests but energy consumption tests (the subtitle of EN13203:2 is “Part 2: Assessment of energy consumption” and does not mention efficiency). The comparative hot water efficiency recorded in the Product Characteristics Database (PCDB) and shown on the Boiler Efficiency Database website is the useful energy produced during the test divided by the gas or oil consumption for draw-off schedule number 2.

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[5] BS EN 13203-2:2006, Gas-fired domestic appliances producing hot water — Appliances not exceeding 70 kW heat input and 300 litres water storage capacity — Part 2: Assessment of energy consumption

[6] Oil Firing Technical Association: Oftec Oil Firing Product Standard OPS 26: Guidance for the use of BS EN 13203-2: 2006 for liquid fuel fired combination boilers up to 70kw rated input and with up to 100 litres hot water storage capacity (OPS 26 Issue 1 December 2009)

# 3 Storage combi boilers

## 3.1 Hot water energy consumption measurements

Laboratory tests of gas storage combi boilers[7] and oil storage combi boilers[8] were commissioned to investigate how their hot water energy performance compares to that predicted in SAP. Boilers considered to be the market leaders were purchased anonymously off-the-shelf for these tests. The tests carried out are shown in table 1 below.

**Table 1: Storage combi boilers and tests carried out on them**

| Boiler | Storage Volume | EN13203:2 measurement performed |
|---|---|---|
| Gas boiler A | 47 litres | Tapping Schedule 2 and 3 |
| Gas boiler B | 74 litres | Tapping Schedule 2 and 3 |
| Oil boiler Y | 48.5 litres (primary) | Tapping Schedule 2 |
| Oil boiler Z | 74 litres (primary) | Tapping Schedule 2 |

The amount of thermal energy stored in the hot water vessel within the boiler at the start and end of the measurement period may differ, so temperature measurements of the store at a number of locations were taken. This enabled the amount of energy gained or lost by the store during the tests to be determined. The tests were also repeated for two successive days (three days in total) to improve the reliability of the results.

[7] STP10/B08, 28 June 2010, Laboratory tests on domestic gas and oil boilers
[8] STP09/B04, 26 March 2009, Analysis of results from energy performance tests on combi boilers

The measurements for the gas storage combi boilers are shown in table 2 below.

**Table 2: Gas storage combi results**

| | Storage combi A | | Storage combi B | |
|---|---|---|---|---|
| | Tapping cycle 2 | Tapping cycle 3 | Tapping cycle 2 | Tapping cycle 3 |
| Measured results | | | | |
| A. Useful heat delivered (kJ) | 21096 | 42092 | 21130 | 42116 |
| B. Net heat input (kJ) | 38258 | 59661 | 32301 | 56297 |
| C. % of water wasted by volume | 2.15 | 0.98 | 1.3814 | 0.83 |
| Calculated results | | | | |
| D. Change in store's energy (kJ)[9] | -12 | -180 | +732 | -39 |
| E. Store adjusted useful heat delivered (kJ) = A + D | 21084 | 41912 | 21862 | 42077 |
| F. Standard[10] useful heat delivered (kJ) | 21042 | 41958 | 21042 | 41958 |
| G. Net heat input (corrected to the standard useful heat delivered) (kJ) = B x F ÷ E | 37813 | 59726 | 31088 | 56137 |
| H Net Efficiency | 55.6% | 70.3% | 67.7% | 74.7% |

[9] This is the store volume (litres) x (temperature at end – temperature at start) x 4.19 kJ/litre/K

[10] Target heat delivered as required by EN13203:2

The measurements for the oil storage combi boilers are shown below.

**Table 3: Oil storage combi results**

| | Storage combi Y | Storage combi Z |
|---|---|---|
| | Tapping cycle 2 | Tapping cycle 2 |
| Measured results | | |
| A. Useful heat delivered (kJ) | 21243 | 21049 |
| B. Net heat input (kJ) | 52856 | 57047 |
| C. % of water wasted by volume | 0 | 0 |
| Calculated results | | |
| D. Change in store's energy (kJ) | -644 | +59.7 |
| E. Store adjusted useful heat delivered (kJ) = A + D | 20600 | 21109 |
| F. Standard useful heat delivered (kJ) | 21042 | 21042 |
| G. Net heat input (corrected to the standard useful heat delivered) (kJ) = B x F ÷ E | 53990 | 56867 |
| H. Net efficiency G÷ F | 39.0% | 37.0% |

## 3.2 Data required by SAP

In SAP the predicted water heating energy consumption is given by:

Cons = (energy of the hot water delivered + storage heat loss + rejected water energy content) / SAP hot water efficiency

Hence there are three performance indicators concerning water heating required in SAP:

a) SAP hot water efficiency:

$\eta_s$= (useful energy delivered + storage heat loss) ÷ (fuel used)

(Note that measured hot water efficiency is often calculated elsewhere as:
$\eta$ = (useful energy delivered) ÷ (fuel used)
which is not the same.)

b) Storage heat loss before the SAP hot water efficiency is applied

c) Proportion of energy rejected because the water is too hot or too cold.

Item c) is dealt with in more detail in section 4 and for the oil storage boilers it is zero.

In SAP there are three ways to derive parameters a) and b) depending on the supporting hot water data, if any. They are:

1) Boilers with no supporting hot water performance data:

SAP defaults apply and storage loss is based on the storage volume, insulation type and thickness, and efficiency is based on space heating efficiency.

2) Boilers with schedule number 2 hot water performance data:

SAP hot water efficiency is the full-load efficiency after the high value correction, capping and conversion (See SAP Appendix D, D2.1)

Storage loss is:

Standard heat delivered × [(SAP hot water efficiency ÷ measured efficiency) - 1 - rejected energy proportion]

The rejected energy proportion is set at half of the rejected water volume when expressed as a fraction of the useful volume produced in the tests.

3) Boilers with schedule number 2 and either schedule number 1 or 3 hot water performance data:

The SAP hot water efficiency, storage loss and rejected energy proportion are derived directly and only from the hot water performance data.[11]

Table 3 shows hot water storage data used by SAP in the three different situations. The penultimate right column shows how SAP would underestimate the storage heat loss if the default SAP 2009 value were applied. The correction factor is the multiple required to make the SAP default equal to the measured value.

**Table 3: Water storage heat loss**

| Boiler | Hot water performance data provided | Heat loss (W) | SAP under estimated by | Correction Factor |
|---|---|---|---|---|
| Gas storage boiler A | None - SAP default | 76.0 | 59% | 2.43 |
| Gas storage boiler A | Tapping cycle 2 | 182.4 | | |
| Gas storage boiler A | Tapping cycle 2 &3 | **184.4** | | |
| Gas storage boiler B | None - SAP default | 47.3 | 17% | 1.20 |
| Gas storage boiler B | Tapping cycle 2 | 102.8 | | |
| Gas storage boiler B | Tapping cycle 2 &3 | **56.9** | | |
| Oil storage boiler Y | None - SAP default | 111.1 | 71% | 3.48 |
| Oil storage boiler Y | Tapping cycle 2 | **386.3** | | |
| Oil storage boiler Z | None - SAP default | 112.6 | 70% | 3.37 |

[11] STP09/B04, 26 March 2009, Analysis of results from energy performance tests on combi boilers

| | | | | |
|---|---|---|---|---|
| Oil storage boiler Z | Tapping cycle 2 | **378.9** | | |

It is clear that there is a substantial underestimate by SAP for three of the four storage boilers tested. The storage heat loss model in SAP was originally developed for direct and indirect hot water cylinders, and table 3 shows that when applied to storage combis it seriously under-estimates the heat loss in the default SAP case.

### 3.3 Recommended change to SAP

The default heat loss in SAP 2012 for storage combi boilers should be raised by the average correction factor of 3.1, as found for the three boilers A, Y and Z whose default losses in SAP are seriously underestimated This applies only when hot water performance data from a test on the boiler has not been made available to SAP.

It could be argued that a distinction should be drawn between gas and oil storage combis, and that a correction factor of 2.4 applied to gas and 3.4 to oil is better than a single correction factor for both fuels. As the correction factor would only apply in the default case with no supporting hot water performance data, and as 80% of the stored heat loss is potentially useful to offset space heating when the boiler is installed in the heated space, it is recommended this degree of separation is not warranted.

# 4 Rejected hot water from combi boilers

This section concerns the amount of domestic hot water from combi boilers rejected by home occupants because it is not hot enough.

## 4.1 Treatment in SAP 2009

In SAP 2009 a default penalty amounting to 600kWh per year is assigned to an instantaneous combi boiler without a keep-hot facility. This applies only when hot water performance data from a test on the boiler has not been made available to SAP. When hot water performance data has been made available, an amount called the 'proportion of energy rejected' is determined from the hot water performance data and set to half the measured wasted water volume.

## 4.2 Understanding the operation of modern combi boilers

Modern instantaneous combi boilers have lower water content (less than 4 litres in their hot water and central heating circuits) and higher power than the models over 10 years old. 28kW output rating is now typical. Modern boilers also have low water content plate heat exchangers rather than coils. Therefore the amount of rejected water will be substantially less than from earlier models.

Table 5 shows laboratory test results of rejected water from two condensing combi boilers purchased new in 2008 and 2009, tested under EN13203:2 with draw-off schedule 2.

**Table 5: Rejected water and energy measurements**

| | Water rejected | Energy rejected |
|---|---|---|
| Gas Combi 1 | 0.3 litres (0.3%) | 0.07% |
| Gas Comb 2 | 2 litres (1.76%) | 0.70% |

The amount of rejected water is very small. Detailed examination of the results showed that in both boilers the gas flow started 9 seconds after the start of the water draw-off. Over the 23 draw-offs of schedule 2 the average flow rate was approximately 3 litres/min, indicating the volume of water draw-off before the gas boiler fired was 10 litres, which is considerably more than the volume of water rejected. This shows that the primary water circuit within the combi boilers is staying warm enough between draw-offs to reach 25ºC (in EN13203:2 the minimum temperature rise required for most draw-offs is 15ºC and the test cold water temperature is 10ºC.)

This is confirmed by the detailed results in table 6. For gas combi 1 water is only rejected on the first draw-off. For gas combi 2 water is only rejected on 1$^{st}$, 2$^{nd}$, 14$^{th}$ and 17$^{th}$ draw-off. The 1$^{st}$, 14$^{th}$ and 17$^{th}$ draw-offs are the only ones that are more than an hour after the preceding draw-off. The 2$^{nd}$ draw-off is a shower draw-off with a higher temperature threshold of 40ºC.

**Table 6: Rejected energy by draw-off**

| | Draw-off number and type | Draw-off minimum temperature rise | Energy rejected |
|---|---|---|---|
| **Gas combi 1** | | | |
| | 1 - Small | 15K (25ºC) | 15.3 in 368.5 KJ (4.2%) |
| **Gas combi 2** | | | |
| | 1 – Small | 15K (25ºC) | 24.1 in 364.3KJ (6.6%) |
| | 2 – Shower | 30K (40ºC) | 99.2 in 5114KJ (1.9%) |
| | 14 – Small | 15K (25ºC) | 11.7 in 354.5 KJ (3.3%) |
| | 16 - Small | 15K (25ºC) | 11.7 in 357.5 KJ (3.1%) |

## 4.3 Field trials

Table 4 of the report on the EST hot water field trials[12] showed that combi boilers used more hot water on average than regular boilers. Further analysis of the source data is shown in table 7 below. The analysis in table 7 is restricted to dwellings with combi or regular boilers and at least 8 out 12 monthly records from July 2007 to June 2008.

**Table 7: Measured hot water usage in field trials**

| | Regular | Combi | Difference |
|---|---|---|---|
| Sample number | 56 | 31 | |
| Average number of occupants | 3.1 | 3.0 | |
| Daily volume (litres/day) | | | |
| Mean | 81.2 | 105.3 | 23 |
| Median | 105.9 | 128.9 | 24 |
| Standard deviation | 78.0 | 77.0 | |
| Standard error | 10.4 | 13.8 | 17.3 |
| 95% confidence interval | ± 20.8 | ± 27.6 | ± 34.6 |
| 90% confidence interval | ±17.0 | ± 22.6 | ± 28.3 |

On average, combi boilers are using 24 litres/day more than regular boilers in dwellings that have a similar number of occupants (the dominant factor influencing hot water usage). Average temperature rises delivered by the combi boilers or hot water cylinders are also similar (37K on average).

As the standard deviations of samples are similar we may conclude that the difference is within two standard errors of the difference between the samples, that is: 24 ± 34.6 litres with 95%

[12] Measurement of Domestic Hot Water Consumption in Dwellings, EST, 2008

confidence. Using the less restrictive confidence of 90% the population mean is estimated to lie between 24 ± 28.3.

Although there is a difference in mean between the two samples it could be concluded it is not statistically significant and may be due to natural variation between samples. The distribution of the hot water usage is skewed towards the higher values in both samples, making this conclusion less robust because it assumes an approximately normal distribution (a symmetrical distribution). A further statistical test that compares the median values of two similarly distributed, but not necessarily normally distributed, samples was carried out (a Mann-Whitney test that compares medians). It showed that the 95% confidence of difference in the median values of combi and regular boilers is between -50.6 and + 3.18 litres/day. That confirms the evidence is not strong enough to conclude that the daily usage of hot water differs between combi and regular boilers in the general population.

The EST trial data also gives important field evidence on hot water draw-off patterns. They can be compared with the EN13203 schedule, which is crucial for realistic predictions of rejected water. The average number of draw-offs for homes with 1 to 5 occupants is 25. Correcting to the average household size of 2.4 occupants per household[13] brings this down to 23, which is identical to number in EN13203 tapping schedule 2.

## 4.4 Conclusion

There is insufficient evidence to change the assumptions in SAP regarding the amount of rejected energy in the hot water from combi boilers because:

(a) Tests results on two modern instantaneous combis show that both water volumes and heat quantities rejected are very small. Most of the draw-offs from EN13203:2 occur at intervals at 1 hour or less, and in most cases the boilers can deliver water above a minimum of 25ºC.

(b) Whilst field trial results seem to indicate that combis use more hot water than regular boiler systems and this could be attributed to more rejected water, the comparison is not statistically significant. The difference in results may be due to natural variation between samples.

[13] A simple regression gives number of draw-offs = 12.1+4.47 x number of people

# 5 Heating controls

## 5.1 Recent field studies

Two significant field studies on the value of heating controls in practice have been published since the previous edition of SAP. The Shipworth paper[14] is part of the work done for the CaRB[15] project, and reports on heating measurements in 358 homes. Contrary to expectation, the use of controls did not reduce average maximum living room temperatures or the duration of heating operations. A study[16] commissioned by the Energy Saving Trust examined the effect of installing a Time-Proportional Integral (TPI) room thermostat in homes which formerly had conventional controls. It was concluded that the TPI controls did not result in a clear improvement in efficiency.

In SAP 2009 the absence of a room thermostat invokes an upward adjustment to internal temperature, and the CArB project findings challenge this assumption. TPI controls are not currently distinguished from conventional room thermostats in SAP. The field study findings need to be weighed against the justification for the present assumptions about heating controls in SAP. At present, however, they are considered not sufficiently conclusive to introduce changes until a wider review of the treatment of heating controls in SAP has been undertaken. It is recommended that such a review is carried out in time for the following edition of SAP.

## 5.2 Weather compensator and enhanced load compensator

It is proposed that SAP 2012 should recognise weather compensator and enhanced load compensator controls only where an entry can be found for authenticated products in the Product Characteristics Database (PCDB). A table would be created within the PCDB to hold product details of heating controls of these types. The reasons are:
(i) the detailed technical characteristics of complex products cannot be established by a SAP assessor;
(ii) there is a need to confirm that the product specification complies with SAP definitions, and conformant products should be identified by a unique product name linked to a specification;
(iii) in some cases such controls have to rely on co-operating logic in the boiler or other parts of the heating system, and that would have to be another qualifying condition.

## 5.3 Time and temperature zone control

The benefit from time and temperature zone control applies to large dwellings but reduces with floor area and becomes insignificant in smaller dwellings. In a future edition of SAP (not SAP

[14] Michelle Shipworth et al, Central heating thermostat settings and timing: building demographics, Building Research & Information (2010) 38(1), 50–69

[15] A UK research consortium called ‘Carbon Reduction in Buildings: A Socio-technical, Longitudinal Study of Carbon Use in Buildings’ (CaRB)

[16] Energy Saving Trust: Final Report for in-situ monitoring of efficiencies of condensing boilers – TPI control project extension

2012) it is proposed that the benefit of time and temperature zone control should be related to floor area using a formula as follows:

- floor area greater than $A_U$ : as in SAP 2009
- floor area below $A_L$ : no benefit
- floor area between $A_L$ and $A_U$ : tapering uniformly between the two conditions.

Evidence is being sought on suitable values for $A_L$ and $A_U$, expressed as floor areas in $m^2$ .

For wet heating systems, it is proposed to extend the current specification in SAP to include communicating TRVs that have the ability to respond to commands from a central controller. The central controller must be able to turn off TRVs completely at times when heating in the zone is not required, and all radiators in the zone must be subject to such control. When all TRVs are turned off in all zones the central controller must also turn off the boiler (electrically), unless there is a call for heat from a separate service (eg, water heating). Failure to meet the last condition means that a seasonal efficiency reduction is applied for a system without boiler interlock. To check compliance with these conditions it is proposed that SAP 2012 should recognise communicating TRV systems only where an entry can be found for them as authenticated products in the Product Characteristics Database (PCDB).