Comitato Termotecnico Italiano Energia e Ambiente
Ente Federato all'UNI
Iscritto c/o la Prefettura di Milano nel Registro delle Persone Giuridiche al n. 604
Via Scarlatti 29 - 20124 Milano - P.IVA 11494010157
Tel. +39.02.266.265.1 Fax +39.02.266.265.50
cti@cti2000.it – www.cti2000.it

03/03/2016	**CT 271 "Contabilizzazione del calore"** Coordinatore: ing. Terenzio Poeta Project Leader: dr. Mattia Merlini – tel 02 26626527 – merlini@cti2000.it	**0 2 7 1 0 0 1 3 5** SC | CT | GL | N.DOC

Oggetto: **Rapporto prodotto dalla Commissione per la validazione di metodologie di determinazione della potenza dei corpi scaldanti esclusi dal campo di applicazione della UNI EN 442 e delle norme tecniche previgenti - Synthesis of the analysis of reference data for the reliability assessment of the dimensional method in accordance to UNI 10200**

Commissione per la validazione di metodologie di determinazione della potenza dei corpi scaldanti esclusi dal campo di applicazione della UNI EN 442 e delle norme tecniche previgenti

Comitato Termotecnico Italiano

Synthesis of the analysis of reference data for the reliability assessment of the dimensional method in accordance to UNI 10200

Date, 3rd March 2016

Authors

Renzo Marchesi – Politecnico of Milano (Coordinator)
Marco Dell'Isola – University of Cassino and Lazio Meridionale
Jörg Schmid – HLK Stuttgart Gmbh

Technical support

Fausto Arpino – University of Cassino and Lazio Meridionale
Mattia Merlini – CTI (Secretary)

Comitato Termotecnico Italiano Energia e Ambiente
Ente Federato all'UNI
Iscritto c/o la Prefettura di Milano nel Registro delle Persone Giuridiche al n. 604
Via Scarlatti 29 - 20124 Milano - P.IVA 11494010157
Tel. +39.02.266.265.1 Fax +39.02.266.265.50
cti@cti2000.it – www.cti2000.it

1 Introduction

This document has been prepared by the "Commission for the validation of methodologies for the determination of the thermal output of radiators installed before the coming in force of the standard EN 442 and of other previous standards"[1] (Referred as "Commission" in the following) established by the Commissione Centrale Tecnica of CTI (Referred as "CCT" in the following) with Decision n. 2/2015.

The Commission has been established in order to validate available and submitted non experimental methods as referred to by the following hierarchy defined by CCT and relevant the determination of the thermal output of radiators within the heat cost allocation procedure.

As stated by CCT, the determination of the thermal output of a radiator shall comply the following hierarchy:

Level 1) the thermal output of a radiator must be determined in conformity with EN 442;

Level 2) if data compliant to EN 442 are not available because the radiator has been installed before EN 442 came into force, the thermal output of that radiator may be determined in conformity with national standard (UNI or other technical standards issued by a EU Member);

Level 3) if data compliant with Level 2 are not available because the radiator does not fall within the scope of the relevant national standards, the thermal output of that radiator may be determined in conformity with non experimental methods provided that they have been validated.

Up to now the only method submitted to validation is the dimensional method defined by UNI 10200. The Commission is aware that additional methods and data catalogues are employed in other countries, as reported in annex 1, but up to now it has not been possible to proceed to their validation since sufficient information or procedures have not been submitted.

[1] The members of the Commission are:

- Renzo Marchesi – Politecnico of Milano
- Marco Dell'Isola – University of Cassino and Lazio Meridionale
- Jörg Schmid – HLK Stuttgart Gmbh
- Fausto Arpino - University of Cassino and Lazio Meridionale
- Mattia Merlini – CTI (Secretary)

The established Commission, within the framework of the previous decision taken on 20/11/2015, has:

- to check available methodologies defining, for each of them, "pros and cons" and the presumptive uncertainity,
- to define minimum criteria for the application of the above methodologies by laboratories.

For the above reasons in this document a synthesis of the main observations that arises from the analysis of reference data aimed at the reliability assessment of the dimensional method in accordance to UNI 10200 is presented.

After a very brief recall of main equations of the method, remarks from the analysis of the two available set of data are discussed in par. 3.1 and 3.3.

2 Description of the Dimensional Method (UNI 10200)

The dimensional method for the calculation of the radiators thermal output, with specific reference to panels and radiators, which exchange energy by natural convection and radiations, is described by the Standard UNI 10200:2015.

According the calculation procedure, the thermal output exchanged by a radiator for a temperature difference Δt of 60°C is given by the following relation:

$$\phi_{\Delta t60} = 314 \cdot S + k \cdot V \qquad (1)$$

where:

$\Phi_{\Delta t60}$ (W) is the radiator thermal output referred to a temperature variation of 60°C;

S (m^2) is the radiator external surface;

V (m^3) is the radiator volume;

k (W/m^3) represents a specific coefficient which depends from the radiator typology.

The radiator surface, S (m^2), and the volume, V (m^3), are calculated, respectively, as:

$$\begin{gathered} S = 2 \cdot h \cdot l + 2 \cdot p \cdot l + 2 \cdot p \cdot h \\ V = h \cdot p \cdot l \end{gathered} \qquad (2)$$

where:

h (m), is the radiator height;

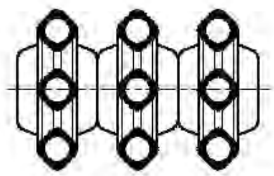
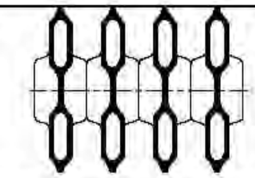
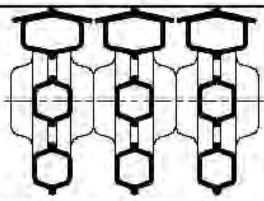
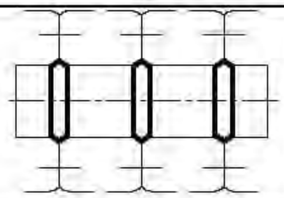
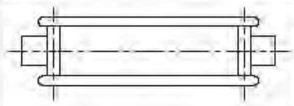
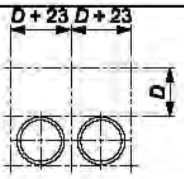
p (m) represents the radiator depth;

l (m) is the radiator width.

The quantity $314 \times S$ in (1) is an average evaluation of the radiative thermal output (W), while $k \times V$ is an average evaluation of the convective thermal output of the radiator.

The coefficient, k, has been estimated experimentally and is reported in Table 1, for different typologies of heating bodies analysed.

Table 1. Values of the coefficient k for different radiators typologies for hub in the range within 50mm e 60mm. Table extracted from the technical documentation submitted with the dimensional method (doc.027100113)

Material	Typology	Description		$k\ [W/m^3]$[2]	Typology
Cast iron		Small columns (section ≤ 30 × 30 mm)	hub 50 mm	18'000	1
			hub 55 mm	16'900	2
			(hub 60 mm)[3]	15'500	3
		Large columns (section > 30 × 30 mm)	hub 55 mm	18'600	4
			hub 60 mm	17'600	5
Cast iron or steel		Columns united by a diaphragm		16'900	6
Plates of cast iron		Smooth o rimmed columns		20'300	7
		Finned columns		21'400	8
Aluminium		Very finned		28'100	9
		Average finned		24800	10
		Little finned		21'400	11
Steel		Plate not finned		20'300	12
		Plate back finned		23'600	13
		Plates with fins between ranks		22'500	14
Bare pipe[4]		Vertical or horizontal pipes		7'000	15

[2] Data experimentally obtained for different typologies of heating bodies. *k* is a function almost exclusively on the shape and is little dependent on the material.

[3] 60 mm hub determines a slight increment of radiating thermal output, and the convective thermal output increases negligibly because the volume increment is compensated by a reduction of the k coefficient.

[4] In the case of base pipe (relevance pipes in rooms that can be considered a fictitious heating body) the following sized must used: height of the heating body (h)=height of the pipe, [m]; width of the heating body (l)=(D+23)/1000, [m]; depth of the heating body (p)=D/1000, [m], where D (mm) is the pipe diameter dove D.

3 Analysis of available data

In order to asses, the reliability of the dimensional method, three sets of data have been analysed:

i) the first set of data (3.1) arises from measurements performed in conformity with UNI 6514 by Politecnico di Torino (referred as "PoliTO" in the following);

ii) the second set of data (3.2) arises from measurements performed in conformity with EN 442 by Politecnico di Milano (referred as "PoliMI" in the following);

iii) the third set of data (3.3) has been confidentially supplied by a private organization, member of UNI/CT 271. In this set, data are indicated as compliant to DIN 4703 and EN 442, even though the source of such data is not explicitly declared at present.

The dimensional method, in accordance to UNI 10200, has been applied to available set of data to evaluate the total thermal output exchanged by each heating body calculating the percentage deviation with respect to reference data. The following main cases have been found:

- ✓ reference data and recalculated data are in good accordance;
- ✓ value of k wrong in the reference data and a correct value has been adopted in the recalculated total thermal output of the heating body;
- ✓ necessary information for the application of the dimensional method are not available in the reference data and no assessment of the method is then possible.

3.1 Data from measurements performed in conformity with UNI 6514. PoliTO data.

A synthesis of available data from Politecnico of Torino (PoliTO) for each typology in terms on number of heating bodies, minimum deviation, maximum deviation and average deviation is available in Table 2. Only heating bodies of typologies 2, 5, 7 and 8 are available, which refers to radiators made up of cast iron.

The total number of available data is equal to 127 records. No cases have been evidenced for which necessary information are not available for the application of the dimensional method in accordance to UNI 10200.

As regards the reliability of the dimensional method, in Figure 1 it is possible to see that about 80% of available heating bodies presents a deviation in the range +/-5%. Looking at the Figure 2 it can be also seen that the dimensional method tends to overestimate the total thermal output for typologies 2, 5 and 7 while the for typology 8 the deviation is uniformly distributed about the zero. It is interesting to notice that overestimating of reference data could evidence a systematic deviation of dimensional method with respect to reference data.

It is important to underline that the PoliTO data refers to heating bodies manufactured before EN 442 came into force.

Table 2. Number of heating bodies, minimum deviation, maximum deviation and average deviation as a function of typology. (NA stands for Not Available). PoliTO data.

Deviation of UNI10200 method with respect to measurements in conformity to UNI 6514															
	Typology of heating body														Required info not available or wrong
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Cases number	0	11	0	0	39	0	36	41	0	0	0	0	0	0	0
Min. dev (%)	NA	1.8	NA	NA	-2.4	NA	-5.0	-6.4	NA	NA	NA	NA	NA	NA	
Max. dev (%)	NA	23.2	NA	NA	22.2	NA	18.5	3.4	NA	NA	NA	NA	NA	NA	
Average dev (%)	NA	4.8	NA	NA	3.9	NA	1.2	-1.0	NA	NA	NA	NA	NA	NA	

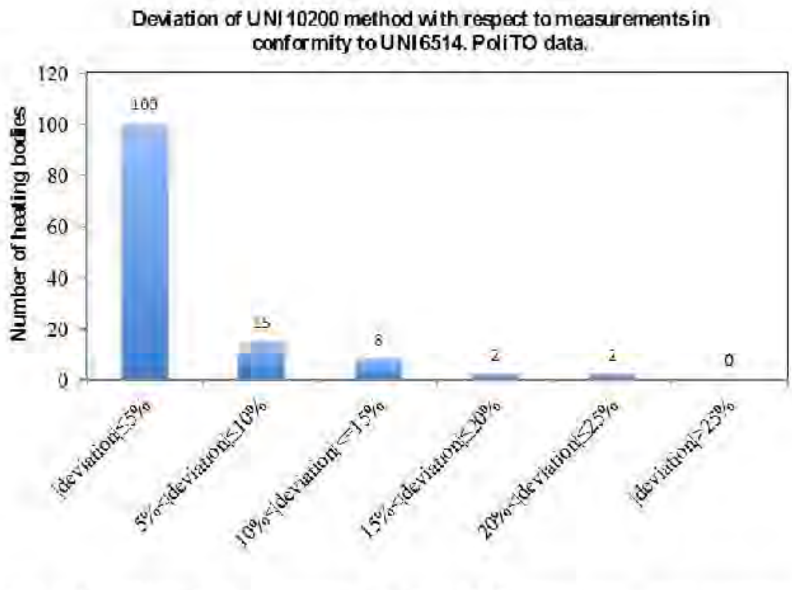


Figure 1. Number of heating bodies associated to different deviation ranges. PoliTO data.

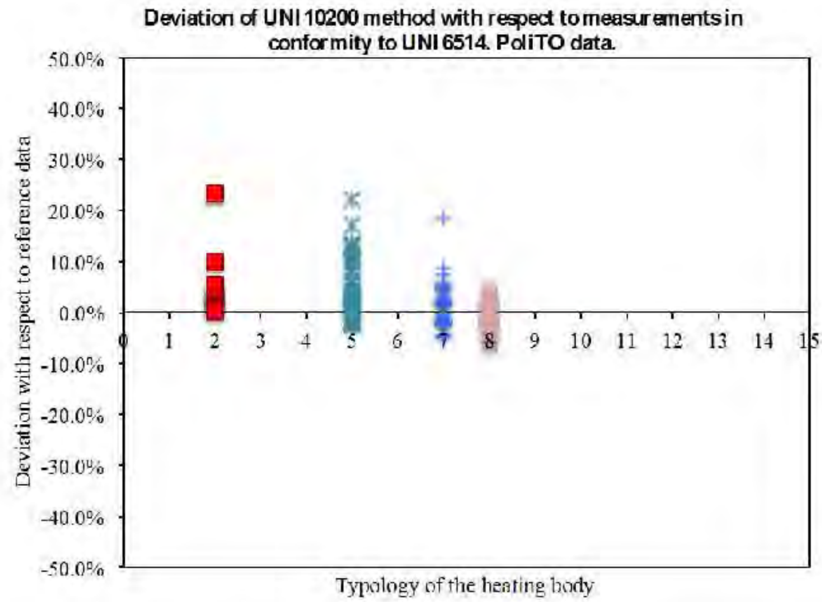


Figure 2. Percentage deviation of heating bodies as a function of heating body typology. PoliTO data.

Figure 3, Figure 4 and Figure 5 shows, respectively, the dependence of the percentage deviation (left) and thermal output (right) from measurements of the heating bodies as a function of the height, the surface and the volume. From the analysis of such figure it is evident that the thermal output depends almost linearly from both the heating body surface and volume, as hypothesized by the UNI 10200 method according to equation (1).

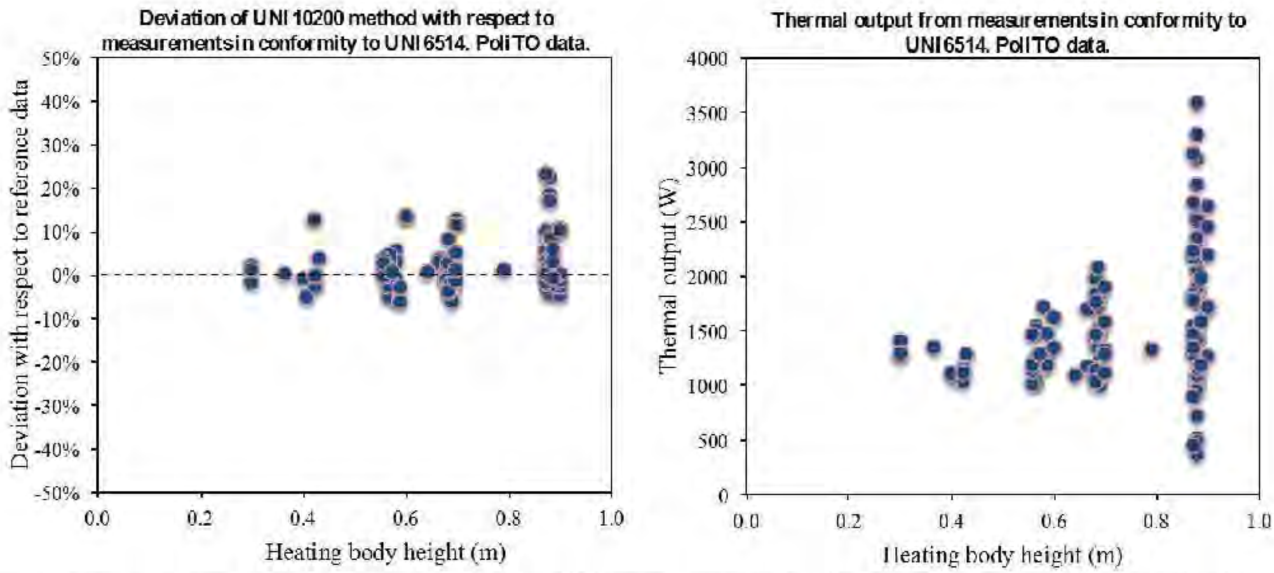


Figure 3. Percentage deviation (left) and thermal output (right) as a function of heating body height. PoliTO data.

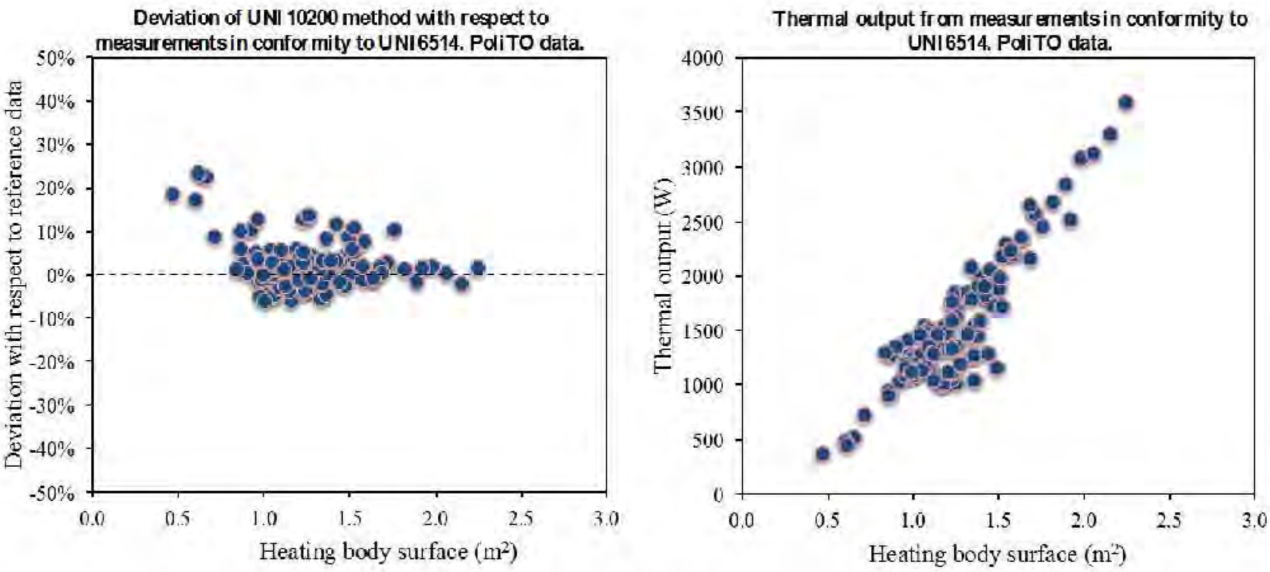


Figure 4. Percentage deviation (left) and thermal output (right) as a function of heating body surface. PoliTO data.

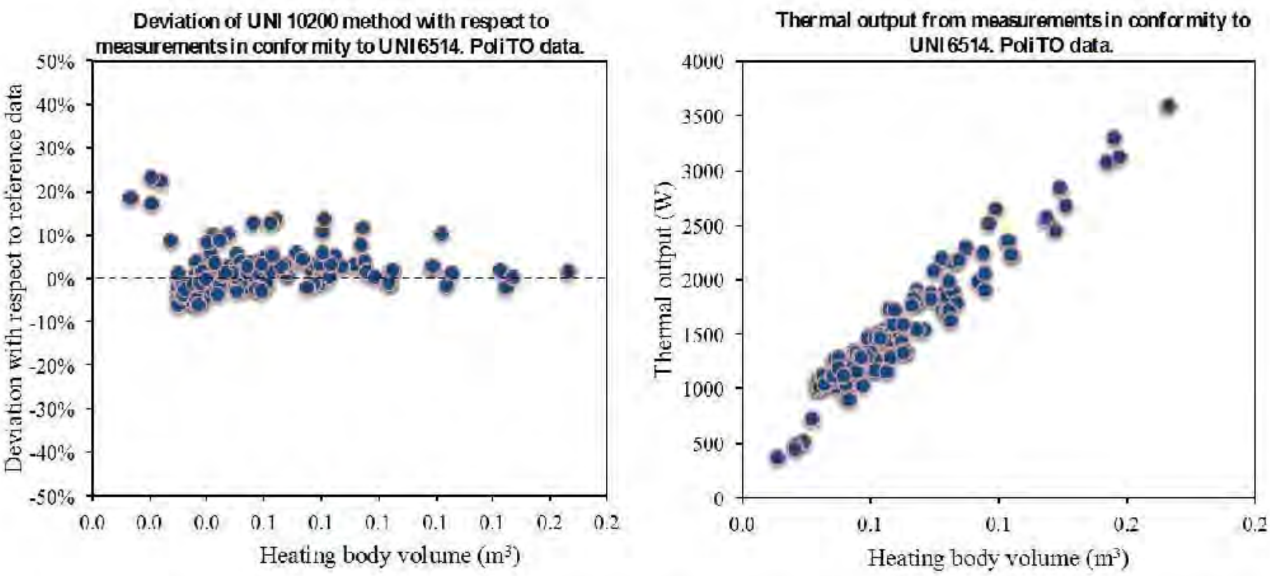


Figure 5. Percentage deviation (left) and thermal output (right) as a function of heating body volume. PoliTO data.

3.2 Data from measurements in conformity with EN 442. PoliMI data.

Table 3 shows a synthesis of available data from Politecnico of Milano (PoliMI) for each typology in terms on number of heating bodies, minimum deviation, maximum deviation and average deviation. On a total of 396 records, 63 cases corresponding to 16 % have been found for which a corresponding typology was not available for the application of the dimensional method in accordance to UNI 10200 (e.g. wave shaped plate).

Table 3. Number of heating bodies, minimum deviation, maximum deviation and average deviation as a function of typology. (NA stands for Not Available). PoliMI data.

Deviation of UNI10200 method with respect to measurements in conformity to EN 442															
	Typology of heating body														Required info not available or wrong
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Cases number	0	0	0	0	0	68	0	0	0	86	7	52	120	0	63
Min. dev. (%)	NA	NA	NA	NA	NA	-13.3	NA	NA	NA	-18.3	6.1	-25.3	-30.5	NA	
Max. dev. (%)	NA	NA	NA	NA	NA	14.3	NA	NA	NA	25.7	12.8	19.2	37.5	NA	
Average dev. (%)	NA	NA	NA	NA	NA	-3.1	NA	NA	NA	-5.3	5.7	3.4	-3.2	NA	

An overview of the reliability of the dimensional method is available in Figure 6 and Figure 7.

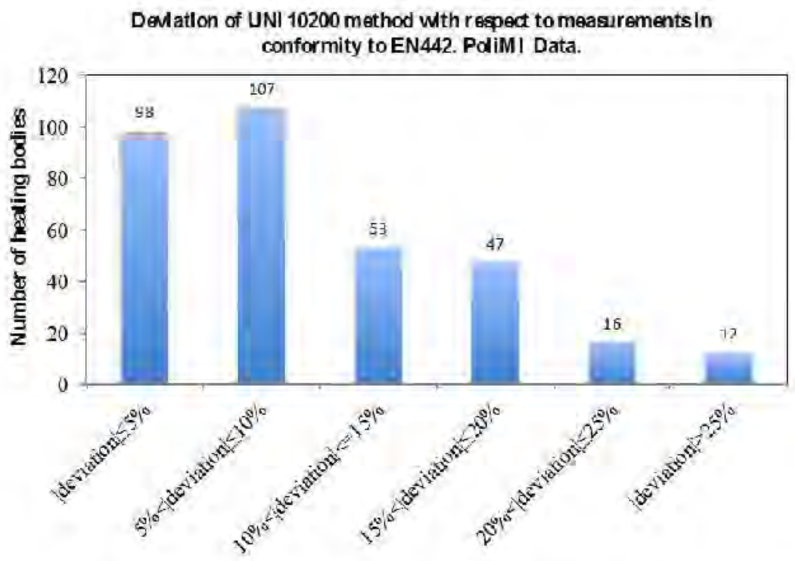


Figure 6. Number of heating bodies associated to different deviation ranges. PoliMI data.

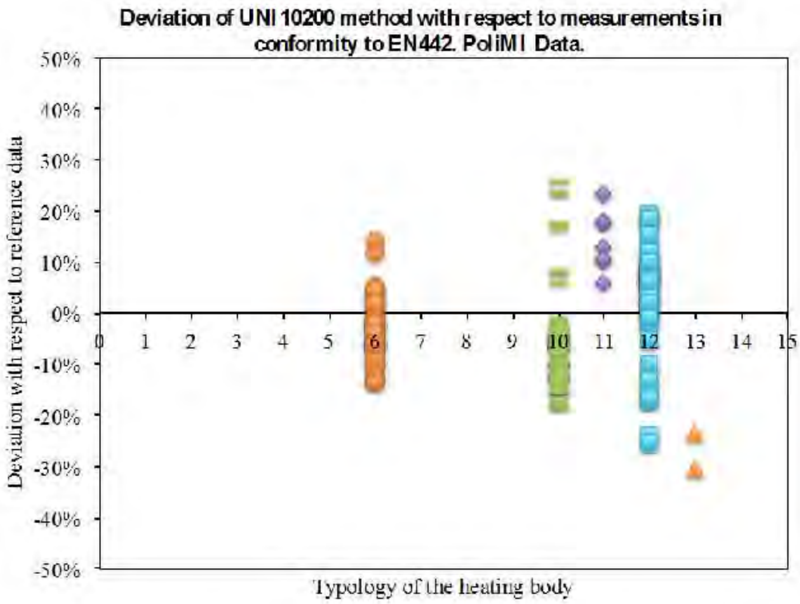


Figure 7. Percentage deviation of heating bodies as a function of heating body typology. PoliMI data.

Figure 8, Figure 9 and Figure 10 show, respectively, the dependence of the percentage deviation (left) and thermal output (right) from measurements of the heating bodies as a function of the height, the surface and the volume. As for the PoliTO data, also in this case it can be observed that thermal output linearly depends on the heating body surface and volume.

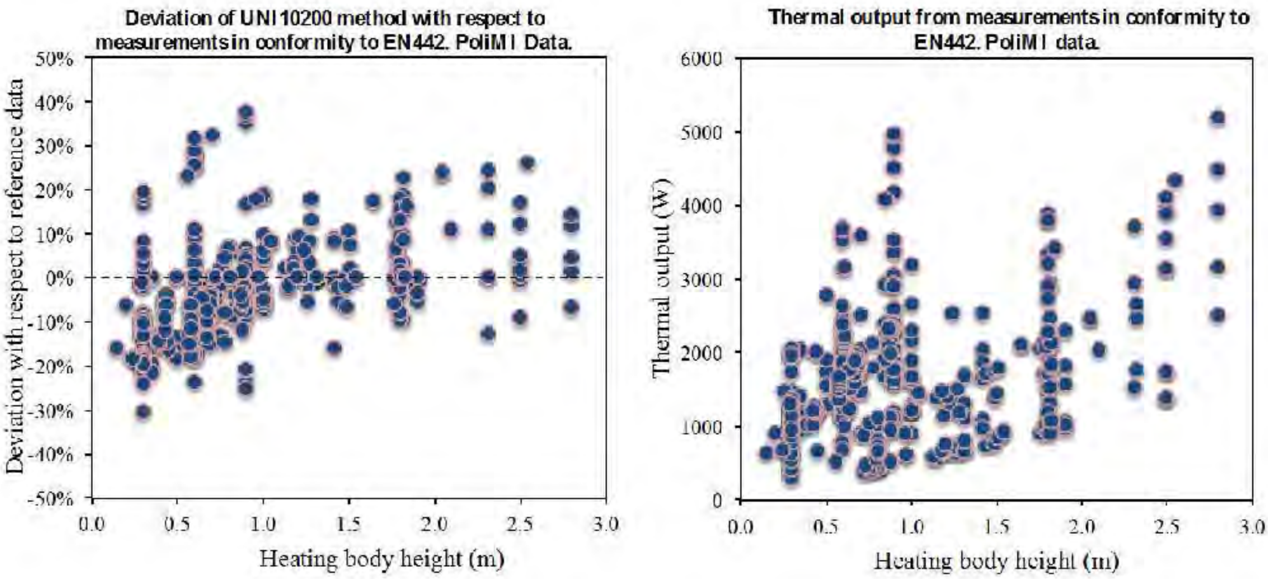


Figure 8. Percentage deviation (left) and thermal output (right) as a function of heating body height. PoliMI data.

Nevertheless, looking at the Figure 9 it can be seen that data are more scattered denoting that discrepancies in the prediction thermal output with respect to measurements could be mainly related to radiative thermal output.

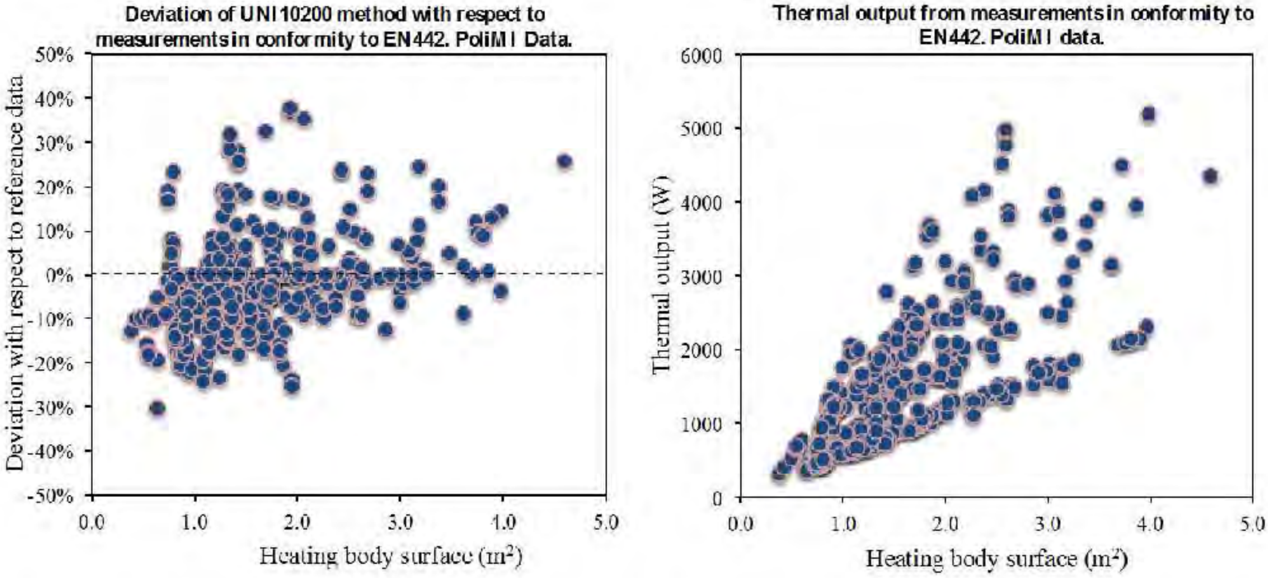


Figure 9. Percentage deviation (left) and thermal output (right) as a function of heating body surface. PoliMI data.

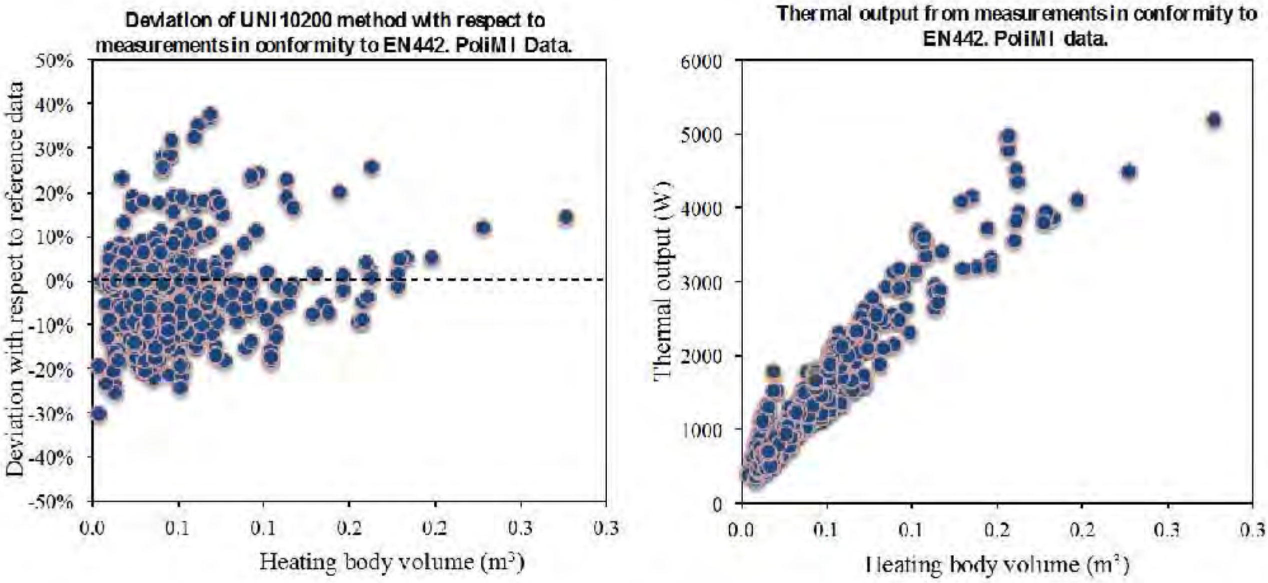


Figure 10. Percentage deviation (left) and thermal output (right) as a function of heating body volume. PoliMI data.

From the analysis of the figure it can be seen that about 60% of available heating bodies presents a deviation in the range +/-10%, and about 80% if analysed cases presents a deviation within +/-15%. Looking at the Figure 7 it can also be seen that the dimensional method overestimates the total thermal output for typology 11, while the opposite behaviour is observed for typology 13. For the other analysed typologies the deviation is uniformly distributed about the zero.

It is important to underline that the majority of analysed data refers to heating bodies recently manufactured and so not perfectly matching with old typologies present in the UNI 10200.

On the other hand, the dimensional method it not actually required for such radiators typologies since experimental thermal output is available from EN 442.

3.3 Data indicated as compliant to DIN 4703 or EN 442

A synthesis of available data for each typology in terms on number of heating bodies, minimum deviation, maximum deviation and average deviation is available in Table 4. Reference data are available for all the typology of heating bodies except of typology 8.

Table 4. Number of heating bodies, minimum deviation, maximum deviation and average deviation as a function of typology. (NA stands for Not Available).

Deviation of UNI10200 method with respect to reference data indicated as conform to DIN 4703 or EN 442															
	Typology of heating body														Required info not available or wrong
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Cases number	6	7	4	4	44	78	2	0	7	3	17	12	4	23	57
Min. dev. (%)	-7.8	4.2	-25.9	11.8	-31.4	-31.3	-20.4	NA	-13.2	-21.2	-46.0	-34.6	-14.0	-31.2	
Max. dev. (%)	13.2	36.0	6.3	29.0	29.3	26.6	-19.2	NA	25.4	-14.1	13.2	41.6	24.4	12.6	
Average dev. (%)	2.8	18.0	-6.0	20.7	-6.4	6.2	-19.8	NA	2.3	-17.0	-15.2	-3.3	3.2	-9.6	

The total number of available data is equal to 268 records. It has been observed that for 52 heating bodies a wrong value of the k coefficient was adopted and a correct value of such coefficient has then been used in the calculations, chosen in accordance to the material and the size of the hub. For 50 cases (about 19% of total number) available information was not sufficient for the calculation of the total heat power according to UNI 10200 (even though related deviations were comparable with other cases), while for 7 cases a wrong choice of typology was made and calculated heat power was then not correct and the related deviation was unacceptable. As a consequence a total of 268-57=211 records have been analysed for the data set under consideration.

Figure 1 shows the deviation distribution of different heating bodies analysed, while Figure 12 shows the deviation of the dimensional method with respect to reference data grouped as a function of heating bodies typology.

From the analysis of Figure 11 emerges that 73% of total presents a deviation ≤ ±20%. Comparing Figure 11 to Figure 12 emerges that the method tends to overestimate reference data for typology 2 and 4, while underestimate reference data for typology 7 and 10. For other typology nor overestimation or underestimation tendency of reference data are observed.

Compared to data set described in 3.1 and 3.2 a significantly larger discrepancy between UNI 10200 calculation method and submitted data is observed. Nevertheless, as already mentioned, it is important to underline that the source of relevant reference data, at the present, is still not declared.

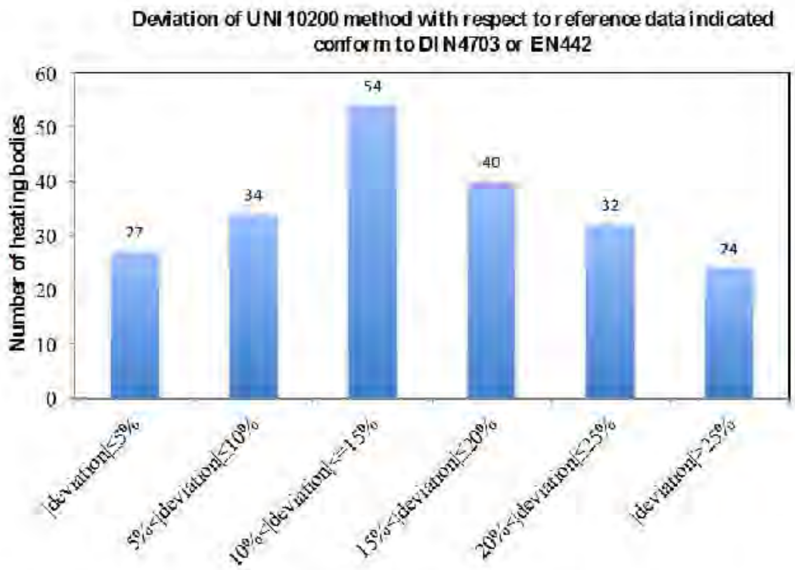


Figure 11. Number of heating bodies associated to different deviation ranges.

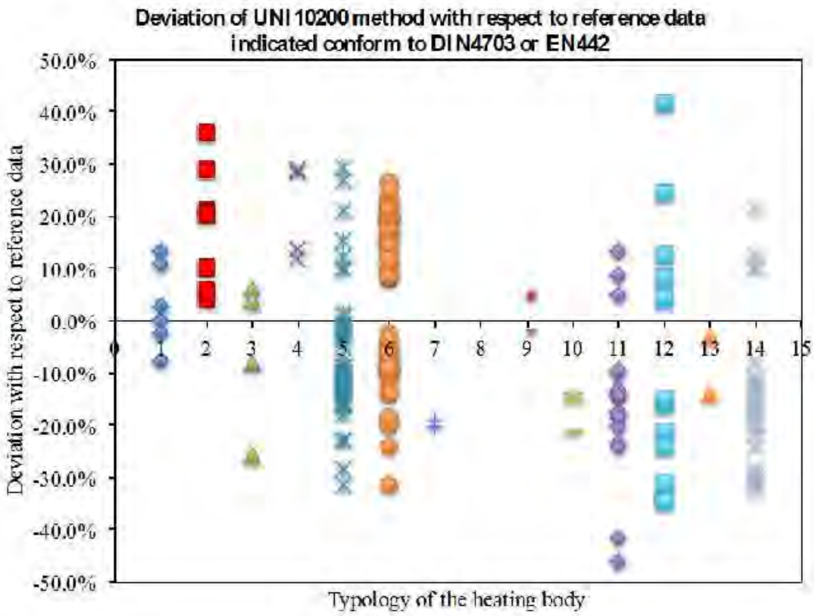


Figure 12. Percentage deviation of heating bodies as a function of heating body typology.

Figure 13, Figure 14 and Figure 15 shows, respectively, the dependence of the percentage deviation (left) and thermal output (right) from measurements of the heating bodies as a function of the height, the surface and the volume. As for the PoliTO and PoliMI data, also in this case it can be observed that thermal output linearly depends on the heating body surface and volume, as hypothesized by the UNI 10200 method according to equation (1).

Comparing with the PoliMI data, in this case thermal output dependence on heating bodies surface can be better approximated as linear.

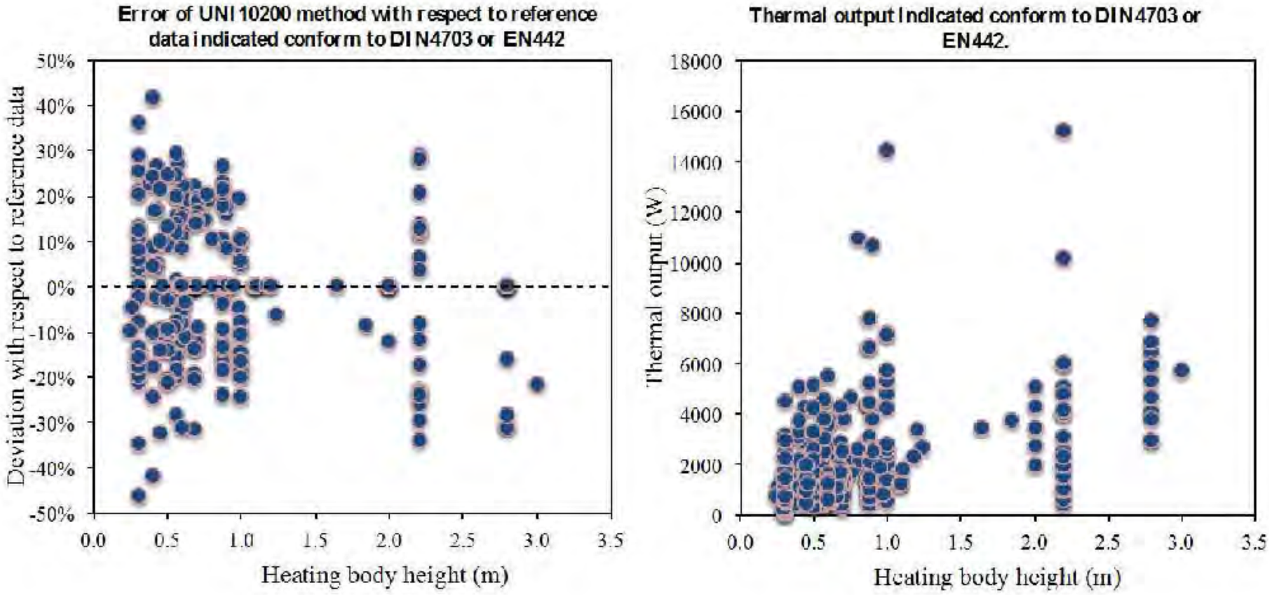


Figure 13. Percentage deviation (a) and thermal output (b) as a function of heating body height. Data indicated as conform to DIN4703 or EN442.

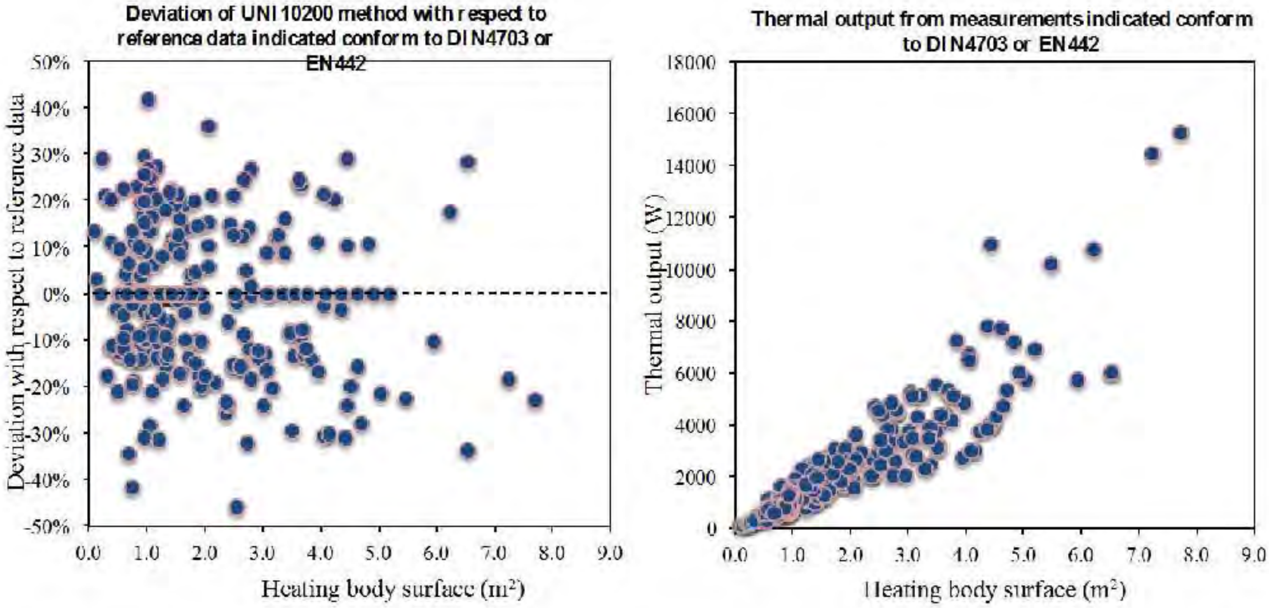


Figure 14. Percentage deviation (a) and thermal output (b) as a function of heating body surface. Data indicated as conform to DIN4703 or EN442.

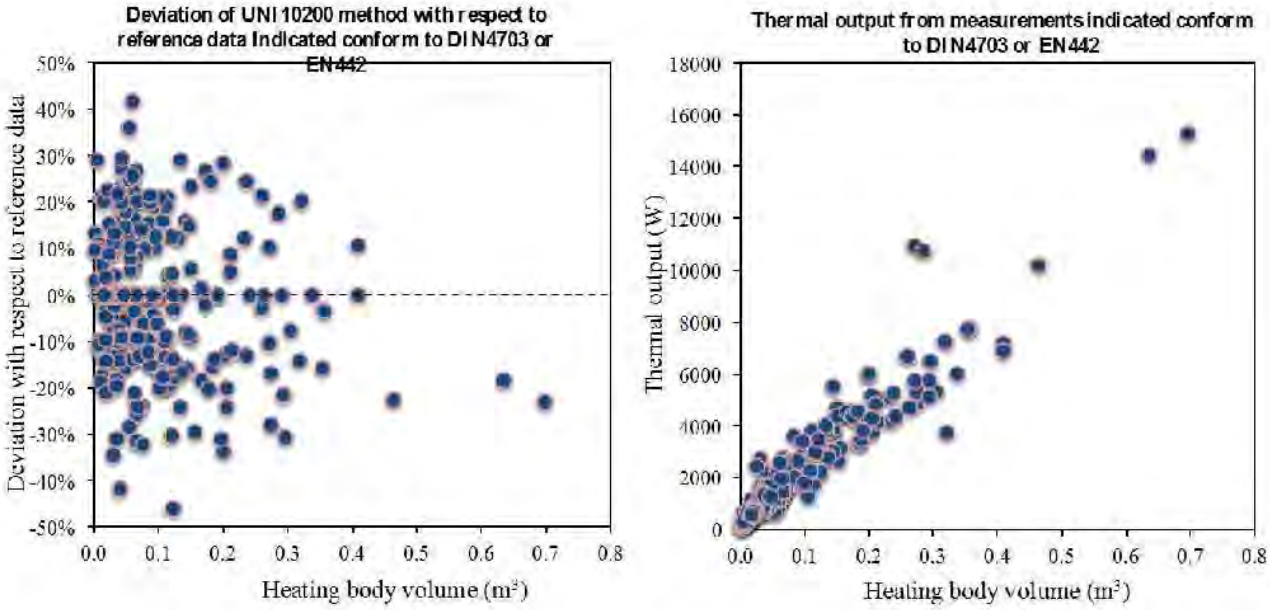


Figure 15. Percentage deviation (a) and thermal output (b) as a function of heating body volume. Data indicated as conform to DIN4703 or EN442.

4 Influence of deviation on thermal output determination on cost allocation

As known, indirect heat accounting is based on the estimation of thermal energy emitted by single radiators/convectors or in certain thermoregulated zones of the heating/cooling plant. However, it is not aimed to get a precise measurement of the thermal energy emitted, but to the allocation of costs within a building. Therefore, allocation unit (UR_{cs}) are non-dimensional and proportional to the energy emitted by the single heating element and they are function of:

i) the temperature difference between the element itself and the environment,

ii) the rated thermal power of the heating element and

iii) the time of use.

To get the allocation unit of the jth apartment of the building ($UR_{app,j}$) the allocation unit of each ith heating element of the apartment ($UR_{cs,i,j}$) are simply summed:

$$UR_{app,j} = \sum_{i=1}^{n_{cs,j}} UR_{cs,i,j} \quad (3)$$

As a consequence, the allocation of the so-called "voluntary" heat consumptions of each j^{th} apartment is given by the following equation:

$$\frac{UR_{app,j}}{UR_{edif}} = \frac{\sum_{i=1}^{n_{cs,j}} UR_{cs,i,j}}{\sum_{j=1}^{n_{app,j}} \sum_{i=1}^{n_{cs,j}} UR_{cs,i,j}} \quad (4)$$

where:

i) UR_{app} and UR_{edif} are the allocation units of the single apartment and of the entire building, respectively;

ii) $n_{cs,j}$ e n_{app} are the number of the heating element in the j^{th} apartment and the total number of apartments in the building.

The standard EN 834:2013 defines two methods for the URcs calculation:

i) not rated displayed reading;

ii) rated displayed reading.

In the first, the accounting units of each heating element are estimated on the basis of the integral over time of only the temperature difference between the heating element surface and the ambient (and only subsequently corrected); in the second, allocation units are obtained by means of specific rating factors K for each heating element, through the following equation:

$$UR_{cs} = K_C K_Q K_T \int_\theta \left(\frac{\Delta T}{60}\right)^n d\theta \quad (5)$$

where K_C, K_Q and K_C represent respectively, at reference laboratory conditions, rating factors of:

i) the temperature sensors coupling;

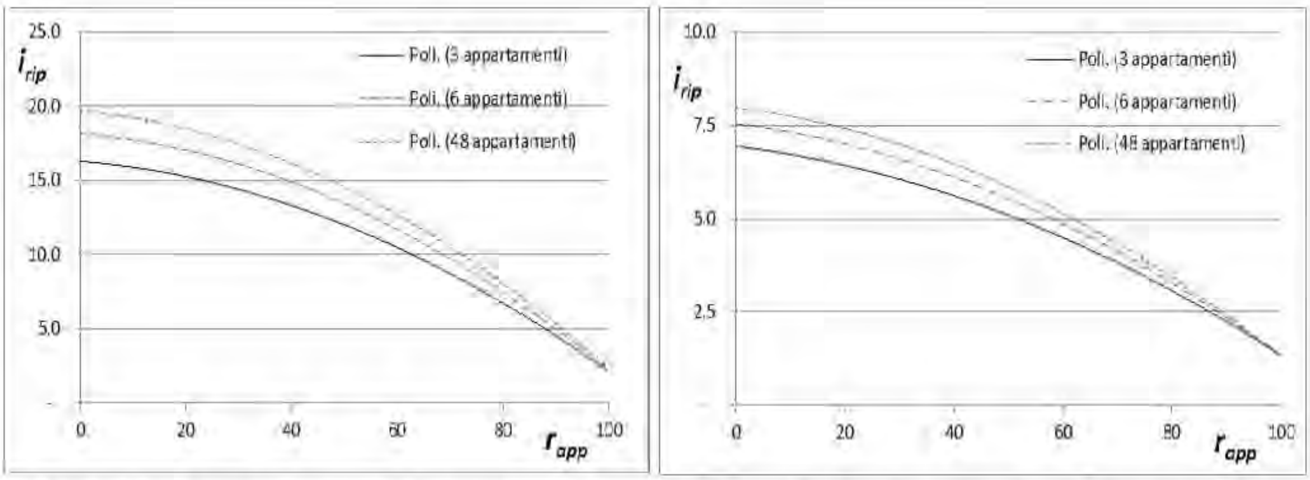
ii) the rated thermal power of the heating element;

iii) when indoor temperature is less than the ambient reference one (to be used only for single sensor HCAs).

In particular, rating factor K_Q concerns the rated thermal output of the heating element, calculated on the basis of the EN442, if available. In any case, the accuracy of the method depends on installation and operating conditions. Unfortunately, rarely installation and operating conditions are equal to the rated ones, thus the effective heat emitted by the heating element is affected also by installation conditions, hydraulic connections and painting. As a matter of fact, the actual value of K_Q may differ from that estimated by the designer of the heat allocation system, both for the impossibility to accurately estimate rating factors at real actual conditions of installation and use of the single heating elements in a whole building, and for the lack of fair and traceable certification of existing heating elements.

Although the uncertainty affecting the determination of K_Q in rated operating conditions and the discrepancy with respect to real operating conditions, it is possible to demonstrate that a compensation of K_Q systematic deviations may occur and such compensation will be more relevant the more the heating bodies are similar for type, shape, dimensions, installation and operative conditions and so on (M. Dell'Isola *et al.*, AICARR Conference 2015).

To understand the compensation of systematic uncertainties in some typical applications, in Figure 16 the uncertainty of heat allocation is reported as a function of correlation coefficients r_{cs} (i.e. between the type of heating bodies installed in the same apartment) and r_{app} (i.e. between the type of heating bodies present in the entire building), in the following simplifying assumptions: i) $i_A = 3\%$; ii) $i_B = 15\%$; iii) $\mathbf{n_{cs}^{app} = 10}$.



a) Similar heating elements and installations (r_{cs}=90%) b) Different heating elements and installations (r_{cs}=10%)

Figure 16. Allocation uncertainties

From the analysis of the results it can be pointed out that the allocation uncertainty is greatly reduced as the correlation between the type of heating bodies installed in the apartment in the building increases, even though large systematic deviations (as the above mentioned value of 15%) are made in the K_Q evaluation, such as in the dimensional method.

This condition is typical of old buildings (e.g. built before '60s) where experimental data on thermal output is not available, but the same heating bodies are installed.

In cases where old heating bodies (installed before the entry into force of national standards) coexist with new heating bodies (installed after the introduction of such standard or EN 442), the standardized experimental methods have to be adopted for the thermal output determination of new heating bodies, and the dimensional method has to be adopted for the thermal output determination of old heating bodies.

6 Conclusions

The Commissione Centrale Tecnica (CCT) of CTI asked the following questions:

- to check available methodologies defining, for each of them, "pros and cons" and the presumptive uncertainty;
- to define minimum criteria for the application of the above methodologies by laboratories.

With reference to the first question, taking into account the analysis of the data submitted, the Commission concludes that:

- ✓ the dimensional method presents an acceptable deviation for typologies 1-8 (lower than ±15%) for the majority of the analysed heating bodies (more than 80%);
- ✓ the larger deviations have been observed for typologies 9-14 (up to about 45%);
- ✓ the lower calculated deviations of the dimensional method with respect to experiments has been observed for the oldest heating bodies, that obviously present a simple geometry already included in the existing UNI 10200;
- ✓ for other typologies of heating bodies, than those from 1-14, the dimensional method cannot be applied because the corresponding typology is not available in the UNI 10200.

Since such data must be applied in the cost allocation for indirect accounting systems, it is demonstrated in the available scientific literature (M. Dell'Isola *et al.*, AICARR Conference 2015;

L. Celenza *et al.*, AICARR Conference 2015) that the deviation in the thermal output evaluation in conformity with the dimensional method are compensated in the case of similar heating bodies are installed in the same building.

As stated in the introduction, for other methods adopted in EU countries, the Commission, at present, is not able to proceed to the validation since sufficient informations or procedures have not been submitted.

With reference to the second question, the Commission recognizes that the standard EN 834 at paragraph 5.3.1[5] states the reference conditions for measuring the thermal output of a radiator, but does not provide any indication for determining thermal output when the test can not be performed (e.g.: for technical and /or economical constraints) moreover the Commission recognizes that there is the need to determine the thermal output also in those cases where heat cost allocators are not installed and the building is not provided with any heat metering system , thus EN 834 is not the reference.

Consequently, in order to determine the thermal output of a radiator non experimental methods, and among them the dimensional method here described, validated by Technical/Scientific Institutions, shall be applied.

The Commission underlines that this is possible only in absence of experimental data obtained, following the subsequent hierarchy, by:

1. tests compliant to EN 442
2. tests compliant to national standards issued before EN 442 came into force;
3. tests qualified by Technical/Scientific Bodies.

As last possibility below this hierarchy, the commission underlines that for heating bodies of typologies 9-14, the application of the dimensional method may produce larger deviations with respect to measurements if compared to typologies 1-8. For this reason, the application of the

[5] "*The thermal output of a radiator in a thermally stable test booth at flow, return and air temperatures of 90 °C, 70 °C and 20 °C, the air temperature being measured at a height of 0,75 m above the floor and a distance of 1,5 m in front of the heating surface, is the reference output relevant for the rating factor 1CQ (reference system Q(60 K)). As an alternative, the standard thermal output given in EN 442-2 can be used as reference output, which is determined at flow, return and air temperatures of 75 °C, 65 °C and 20 °C in a closed test booth cooled on all sides (reference system Q(50 K)).*"

dimensional method for such heating bodies typologies (9-14) shall be carefully considered by designers of heat accounting system in order to avoid significant inaccuracies in the heat cost allocation[6].

In case of disputes, accredited Laboratories may refer to European or national standard or internal well defined procedures approved by the Accrediting Body and available for customers.

[6] In particular, for typologies 9-14 the dimensional method should not be applied when additional aleatory measurement conditions exist, such as: i) not-standard installation of heating bodies; ii) coexistence of heating bodies of different typologies (i.e. old and new heating bodies)

Annex 1 - Determination of the heat output of „old“ radiators without available catalogue data in the building stock in Germany (contribute by Joerg Schmid)

The system of test methods and test laboratories in Germany was founded in the mid-sixties. Before that time manufacturers of radiators mostly provided data about the heating surface and the specific heat transfer of their radiators to be sold and built in heating systems.

- It needs experience, old documents or a historical investigation to find and organize such data in a systematic data base. As far as such data even though is not available, another method of determination is requested.
- The most common method is basing on a couple of experience as well – probably supported by convenient software – and similarities of "old and unknown" to radiators, where test results either basing on former national standards or on the European standard EN 442 are available.

This method in particular is very convenient for radiators similar to those that have been standardized in DIN 4720 (*sectional cast iron; published in 1936; revised versions in 1961 and 1979*) and DIN 4722 (*sectional steel; published in 1938; revised versions in 1961 and 1979*) and later in DIN 4703[1]: tubular radiators, sectional cast iron and steel radiators, panel radiators without convectors (flat surface or profiled or mixed).

Table 5. Excerpts of DIN 4720 / 4722.

Hubs wheelbase (mm)	1000				600				500				300				200(*)	
Depth (mm)	100	150	200	250	100	150	200	250	100	150	200	250	100	150	200	250	300 to 320	200
Surface (steel) (m^2)	0.24	0.36	0.48	0.61	0.15	0.23	0.30	0.38	0.13	0.20	0.26	0.33	0.08	0.13	0.17	0.21	-	0.12
Surface (cast iron) (m^2)	0.25	0.37	0.49	0.63	0.16	0.24	0.31	0.40	0.14	0.21	0.27	0.35	0.09	0.14	0.18	0.22	0.21	-
Thermal output (steel) (W)	122	175	224	271	79	115	146	177	70	100	129	157	50	70	87	103	-	64
Thermal output (cast iron) (W)	128	180	229	289	85	121	151	187	75	107	133	166	50	75	93	109	106	-

(*) *Not standardized*

- The determination of sectional aluminium radiators should not be a problem as for them test or catalogue data should be available.
- For steel panel radiators the situation should be the same and test or catalogue data should be available as well.