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ScienceDirect

Energy Procedia 70 (2015) 371 – 378

Energy Procedia

International Conference on Solar Heating and Cooling for Buildings and Industry, SHC 2014

The effect of measurement uncertainty and environment on domestic solar water heating systems' energy efficiency grades

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Abstract

In China, two important national standards were implemented on Aug 1st, 2012, one is 'Specification of domestic solar water heating systems' (GB/T 19141-2011), the other is 'Minimum allowable values of energy efficiency and energy efficiency grades for domestic solar water heating systems' (GB 26969-2011). According to these two standards, the energy efficiency grades indicator CTP (coefficient of thermal performance) should be tested and calculated by daily useful energy and average heat loss factor of domestic solar heating system. Through experiment and calculation, the effect of measurement uncertainty and daily average ambient temperature on the migration of domestic solar water heating systems' (DSWHS) energy efficiency grades was discussed. The calculation and analysis methods may be helpful for data consistency co-verfication between different inspection organizations.

Peer-review by the scientific conference committee of SHC 2014 under responsibility of PSE AG

Keywords: Daily mean ambient temperature; Measurement uncertainty; DSWHS' energy efficiency grades

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Peer-review by the scientific conference committee of SHC 2014 under responsibility of PSE AG
doi:10.1016/j.egypro.2015.02.137

1. Introduction

In China, two important national standards were issued on September 29, 2011 and implemented on August 1, 2012 by General Administration of Quality Supervision, Inspection and Quarantine of the People' Republic of China and Standardization Administration of the People' Republic of China. One is 'Specification of domestic solar water heating systems' (GB/T 19141-2011) [1], the other is 'Minimum allowable values of energy efficiency and energy efficiency grades for domestic solar water heating systems' (GB 26969-2011) [2] which is the first compulsory standard in domestic solar water heaters' industry. These standards are very important and affect the future of solar manufacturers.

In traditional, measurement error is common to indicate the difference between the result and actual value of the measurand. The actual value is unknown in fact. In metrology, measurement error is a primarily a theoretical concept. In recent years, the measurement uncertainty is more popular to describe the measurement result. The measurement uncertainty is a parameter, associated with the result of a measurement, which characterizes the dispersion of the values that could reasonably be attributed to the measurand. A measured value without some indication of its uncertainty is useless [3] [4] .

Nomenclature

A_c	contour aperture area, m^2
a_1, a_2, a_3	coefficient derived by experiment results using least squares fitting method
C_{pw}	specific heat of water, J/(kg• °C)
H	amount of solar radiation, MJ/m^2
m_w	quality of water in water storage tank, kg
Q_s	heat energy gain of DSWHS, MJ
t_{ad}	daily average ambient temperature during experiment, °C
$t_{\mathrm{as(av)}}$	average ambient temperature during experiment, °C
t_{b}	temperature of water in water storage tank before experiment, °C
t_{e}	temperature of water in water storage tank after experiment, °C
Δt	temperature difference of water in water storage tank during experiment, $\Delta t=t_{\mathrm{e}}-t_{\mathrm{b}}$, °C
t_{i}	temperature of water in water storage tank before experiment, °C
t_{f}	temperature of water in water storage tank after experiment, °C
ρ_W	density of water, kg / m^3
$\Delta\tau$	time of experiment, s

According to GB/T 19141-2011 and GB 26969-2011, the energy efficiency grades indicator *CTP* (coefficient of thermal performance of solar water heating systems) should be tested and calculated with daily useful energy q_{17} and average heat loss factor U_{SL} of domestic solar heating system, as follows:

$$CTP = \frac{q_{17}(e)}{q_{17}(m)} - \alpha \cdot \frac{U_{SL}(e)}{U_{SL}(M)} \tag{1}$$

where $q_{17}(e)$ is daily useful energy per unit contour aperture area when the amount of solar radiation is 17 MJ/m^2; $q_{17}(m)$ is the minimum of daily useful energy per unit contour aperture area and is a constant, 7.7 MJ/m^2 in this paper; $U_{SL}(e)$ is average heat loss factor under experiments; $U_{SL}(M)$ is the maximum of average heat loss factor and is a constant, 16 W/(m^{3}K) in this paper; α is a weight coefficient of average heat loss factor in *CTP*, α=0.9.

Daily useful energy $q_{17}(e)$ is calculated as follows:

$$q_{17}(e) = \frac{C_{\mathrm{pw}} \mathrm{m}_{\mathrm{w}} \Delta t}{A_{\mathrm{c}}} \cdot \frac{17}{H} \tag{2}$$

Average heat loss factor $U_{SL}(e)$ is calculated as follows: