Solar Keymark

Peter Kovács
SP Swedish National Testing and Research Institute
Box 857 501 15 Borås, Sweden
Tel: 033-16 56 62 Fax: 033-13 19 79 E-mail: peter.kovacs@sp.se

2002-05-24

Interlaboratory comparison on evaluation of collector test data

General
A dataset involving six days of measurements on a large flat plate collector was sent to the participants in the network of collector test institutes. The measurements were made according to paragraph 6.3 of EN 12 975 (Quasi dynamic testing). A guide for the evaluation, describing the purpose of the exercise and the contents of the dataset (appendix 1) and a general reporting format (appendix 2) was also sent to the participants. In all, seven laboratories took part in the work and presented some end results.

Aims
The purpose of the comparison was first to reveal any differences in the calculation models used at the different institutes. For this purpose, the participants made the required intermediate calculations and then performed the regression to the complete dataset.

Secondly, the aim was to reveal any unclear points concerning the data evaluation and selection in the standard. Several selection criteria's are included in the standard. How were they interpreted? Did everyone find all the criteria?

In order to encourage a discussion about outliner treatment two datapoints were manipulated and the participants were instructed to treat outliners as they considered appropriate.

Results
The results of the seven contributions can be summarized in figure 1.

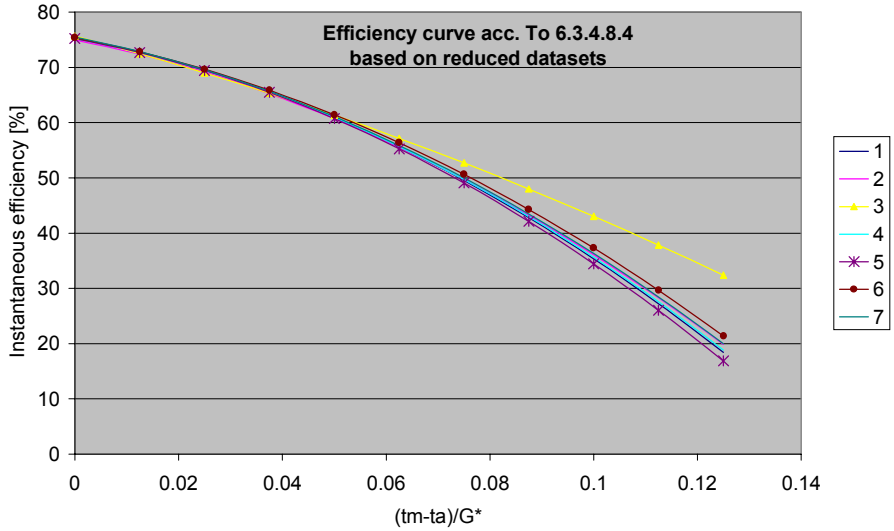

Fig. 1. Efficiency curves based on parameters from seven reduced datasets.

The results in terms of an efficiency curve based on reference conditions according to 6.3.4.8.4 of EN 12975-2 shows good agreement for six of seven parameter sets (within ± 0.5% at tm-ta=50 °C). With the exception of participant no. 3, all parameters except c5 (figure 2) the thermal capacitance showed similar good agreements. Participant no. 3 did not do any selection in the dataset, but did some corrections in the reduced dataset.

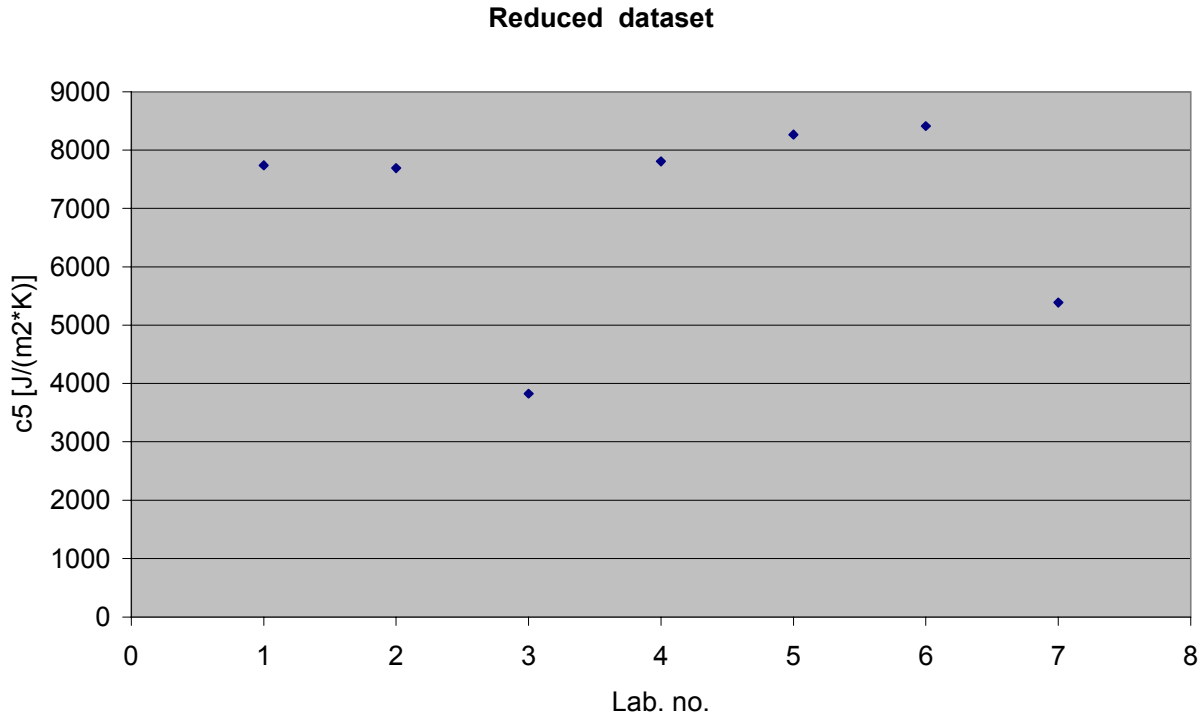

Fig. 2 Parameter c5, the thermal capacitance was the parameter showing the largest variations when derived from the reduced datasets.

Looking at the parameters resulting from the unreduced datasets rather large differences among the participants are revealed. The main reason is probably that some labs made “corrections” to the dataset in order to have all inputs physically correct. So was e.g. beam irradiance set to 0 if, in a datapoint, diffuse

irradiance was larger than global irradiance. Similarly the term $(1/\cos(\theta_l)-1)$ was set to zero for angles >85 degrees or set equal to the value at 80 degrees for angles larger than 80.

The remaining number of datapoints after reduction are shown in figure 3. Even after excluding no. 3 who made no selection at all, the spread indicates that the selection criteria given in the standard are not clear.

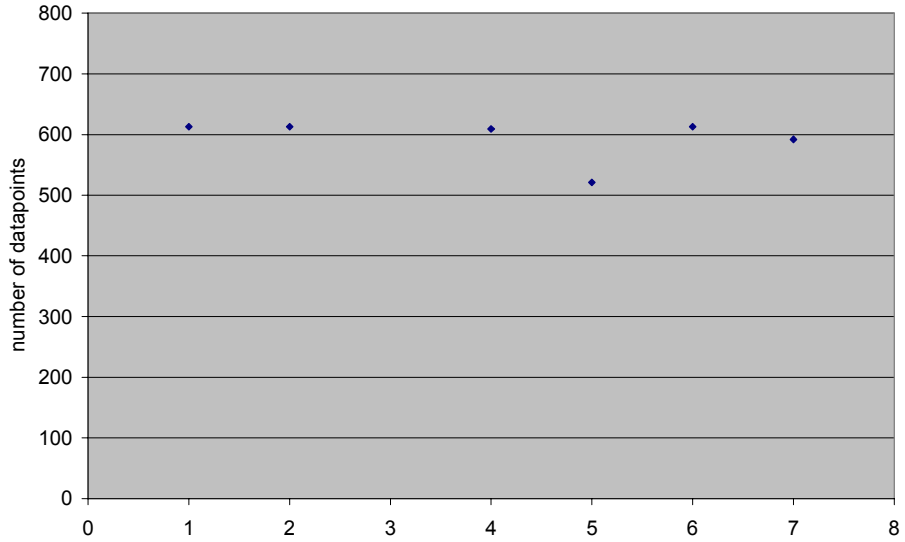

Fig. 3 Number of data points used in the regressions after selecting data according to the standard's requirements. Participant no.3 left out because no selection was made.

The following selection criteria were used of the different participants. Criteria that might be questioned are written in bold.

- Qout<0; dT<1'C; G<300W/m2; Gd/G>0.5?
- Qout<0; dT<1'C; G<300W/m2; **One obvious outliner (Residual power > 100 W)**
- Qout<0; dT<1'C; G<300W/m2; **Tinlet < +1% of set value**
- dT<1'C; G<300W/m2; **|Tin – Ta| < 3 K**; **DTin > 1 K during "Step-change" period; Residual power > 40**
- Qout<0; dT<1'C; G<300W/m2
- dT<1'C; G<300W/m2; **wind speed >2 m/s**

The complete parameter sets based on unreduced and reduced data and diagrams showing the different parameter values are available in the excel-file "QDT testdata summary.xls".

Questions
Some questions posed by the participants might be useful to discuss in the group.

- Many datapoints with Tm<Tamb in the data set: Dew on absorber? Need for RH measurements?
- To low temp.diff Tm-Ta?
- Sign convention for c1,c2,c5?
- Unit c5?
- Which parameters to include in the regression?
- Number of significant figures in reported parameter values?
- Parameter standard deviations resulting from regression to be presented with parameter values?
- Reporting b0 instead of $K\theta b(\theta)$?

Conclusions
Some conclusions can be drawn so far:

- Some participants “corrects” measurement data on a routine basis in order to have all inputs physically correct and some don’t. This will in general have some effect on the final results.

- The selection criteria given in the standard are somewhat unclear and they are not efficiently organised in the document.

- There seem to be a few minor misunderstandings about sign conventions, units and number of significant figures in the parameter values reported.

Further conclusions and more specific recommendations should be developed after discussing these results within the group.

Appendix 1 QDT ILC guide 0203
Appendix 2 Report QDT to SP

Appendix 1 QDT ILC guide 0203

QDT data interlaboratory comparison

This document is a guide to an interlaboratory comparison within the Solar Keymark project, based on test data only. A dataset from measurements on a solar flat plate collector (Qdtsp1.xls) is to be evaluated at test institutes applying the dynamic test procedure according to EN 12975-2 paragraph 6.3. The purpose of the comparison is first to reveal any differences in the calculation models used at the different institutes. Secondly, the aim is to reveal any unclear points concerning the data evaluation in the standard.

Below you will find a description of the tested collector, the test location and the test conditions. You will also find some guidelines for the evaluation of data and how it should be reported. Finally a specification of the data file is included. Almost the same information can be found in the data file itself.

Test Conditions

The collector is a large flat plate collector. It was tested at SP after 13 years in service in a large collector field in Nykvarn where it was connected to a district heating grid. Due to the fact that three modules were tested at the same time and that the collectors were considered having negligible wind speed dependence in the heat loss term, only natural wind was used in the test. As a result the data includes wind speeds from 0 to 3 m/s with an average around 0.4 m/s. In all other respects the test shall fulfil the requirements of EN12975-2.

Collector data

Collector external dimensions:	5960*2270*180 mm
Collector aperture area:	12.50 m^2
Absorber:	Sunstrip selective (α=0.95/ ε=0.15)
Covers:	4 mm tempered low iron glass and two sheets of teflon film between glazing and absorber
Insulation back:	90 mm mineral wool
Insulation sides:	30 mm mineral wool

Test operational data

Nominal heat transfer fluid flowrate:	0.02 kg/s/m^2
Heat transfer fluid:	water
Collector orientation:	45 degrees tilt with respect to the horizontal (β=45), facing south (γ=0)
Test location:	Latitude= 57.7 degrees, Longitude= 12.9 degrees (Borås)
Longitude data time:	15 degrees (Stockholm)
Data time offset:	None (time=winter time)
Sampling rate:	6 seconds
Averaging interval	300 seconds

Data treatment and reporting

In order to investigate the effect of differences in calculation models used, a primary fit to data should be made. This should be done on the complete dataset, before any records have been removed. The results of the primary fit is reported together with the other results, se below.

According to the standard, a selection of data should be made prior to the fitting. In order to investigate how "outliners" in data are treated, some minor errors have been introduced. You should write down a record of all the data points that are excluded from the original dataset. An example is given in the table below. Due to the fact that only natural wind was used in the test no data points should be excluded due to wind speeds being too low. If you on the other hand decide to exclude a data point because you consider it somehow erroneous (in the wind speed reading or any other channel) it's of course ok.

Along with the record of data treatment, you should report the result of the two fits. Use the format according to Annex M of 12975-2, based on aperture area and including table M.1 (use the attached "reportqdtsp1.doc").

Table 1. Example of data selection record

Number of data points excluded	**Exclusion criteria**	**Comment**
45	Power output<X	
156	DT<Y	
1	Residual power>ZZZ	Noise in te at time qq
Etc…..		

Data file content

Table 2. Channel names and comments to data file QDTSP

Channel	**Quantity**	**Unit**	**Comment**
1	Time	Year	
2	Time	Day number	
3	Time	Hour minute	
4	Temperature	°C	Collector inlet temperature and temperature at flowmeter
5	Temperature	°C	Collector outlet temperature
6	Temperature	°C	Collector ambient (air) temperature
7	Flowrate	l/s	Collector fluid (water) flowrate
8	Global insolation	W/ m^2	Insolation in the plane of the collector
9	Diffuse insolation	W/ m^2	Insolation in the plane of the collector
10	Wind speed	m/s	Wind speed over collector aperture
11	Time derivative of t_m	K/s	(t_m new-t_m old)/sampling interval

Appendix 2 Report QDT to SP

Date: **Reporting institute:** **Contact person:**

Coefficients based on aperture area and on the complete data set (1642 data points):

$F'(\tau\alpha)_{en}$: **$K_{\theta d}$:**

c_1:

c_2:

c_5:

Collector incidence angle modifier, $K_{\theta b}(\theta)$

θ	10	20	30	40	50	60	70	80
$K_{\theta b}(\theta)$								

Coefficients based on aperture area and on the reduced data set (data points):

$F'(\tau\alpha)_{en}$: **$K_{\theta d}$:**

c_1:

c_2:

c_5:

Collector incidence angle modifier, $K_{\theta b}(\theta)$

θ	10	20	30	40	50	60	70	80
$K_{\theta b}(\theta)$								

Data selection record

Number of data points excluded	Exclusion criteria	Comment