Quality Assurance in solar thermal heating and cooling technology

Keeping track with recent and upcoming developments

Summary report
Mechanical load resistance testing

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1. Introduction

Mechanical load induced by wind and/or Snow or Ice is one of the severe influences on functionality and long time durability of collector installations. Resulting forces for the collector components (e.g. frame, transparent cover), the fixings (e.g. clamps, slot nuts), the mounting equipment (e.g. frames for flat roof installation) and the roof fixings (e.g. roof anchor, clamps, screws) are strongly influenced by the mounting angle, the surrounding of the building, the weather and climate and the mounting situation (e.g. on-roof, in-roof, façade integrated or attached). The standards EN1992 to EN1996, EN1998 and EN1999 provide assumptions and equations to calculate snow/ice loads and wind loads in several mounting situations. Most of the above mentioned influences can be taken into account within these standards. But especially the consecutive forces resulting from wind on a roof-mounted solar field are not easy to describe with mathematical models. Defined correlation factors are as well not provided for the case of *Solar Thermal collectors and Applications,* so one has to “translate” the standard to these situations. This is to some extent possible, especially for snow loads. For wind loads it is much vaguer.

The process of harmonizing the standard EN 12975 towards EU regulations (CPD = construction products directive, 89/106/EWG) includes the aspect of structural safety. This process is paving the way to base a CE marking for solar thermal applications on the CPD. For this an Annex ZA will be prepared to reference all necessary documents, which define how the relevant aspects are dealt with within the harmonized EN 12975. For this reason it is important to fulfil the requirements of state of the art “structural safety”. The recent way to deal with this is to improve the methodology for the collector itself within EN 12975 and place other specific standards for all other parts not covered with the EN 12975.

The technical committee (TC) of the European Standardisation Committee for solar thermal (CEN/TC 312) is not the only TC working on these issues. As well TC 128, TC 82 and TC 254 are dealing with this topic. From their point of view the topic is summarized with “Roof and Façade integration of renewable energies”. The mentioned TCs accepted a liaison with TC 312 and so a joint group is holding meetings on the topic, within a 2011 founded ad-hoc working group (CEN/TC 128 WG 3). The group holds several official liaisons with other related TCs (as TC 82, TC 312, TC 254). Within this working group a draft document was developed, which is recently sent to the CEN board as a proposal for placing an official work item for mechanical load testing and calculation rules for building attached renewable energies to TC 128 WG3. From this process a TS may result which later is possibly suggested to become an EN.

Experiences from the mass market of PV in regards of problems/failures as well as the benefits of standardisation (e.g. cost savings by effects of economy of scales) are available. This information will be taken into account when improving the requirements and methodologies for solar thermal products.

There are other branches as well, dealing with similar problems, as roof-integrated windows manufacturer, whose experiences were partly taken into account.

Last but not least there is some diffuse pressure resulting out of the insurance branch, which is at least in some EU countries asking for more proof on safety and more clear regulation on the issue of wind and snow/ice load (e.g. England recently introducing the Micro Certification Scheme MCS).

The following summary report summarizes and guides the recent discussion on this topic.

2. Mechanical load resistance test in EN 12975 (resp. EN 12976)

The mechanical load resistance test procedure is described for testing a collector horizontally mounted. A normal oriented positive and negative load of min. 1000Pa in steps of 250Pa is applied on the transparent cover. The test is judged on the resulting behaviour of the collector box, cover, and fixings to the mounting structure. This implies the following deficits:

- No temperature influence represented
- No slope forces
- No dynamic forces
- No un-even distributed load
- No mounting equipment
- No mounting situation (except from horizontal, which is not realistic)
- No roofing equipment
- No interaction between rain and wind
- Minimal load only 1000Pa
- No requirement on repetition of the load steps or the duration the load level shall be maintained
- Restricted in application for evacuated tubular collectors
- Restricted for collectors with relevant shapes (e.g. mirrors, reflectors, etc.)
- Not applicable for “not separable” systems (tubes directly connected with the heat storage tank)

3. Main results

Within the QAiST project some substantial improvements were prepared as a suggestion for TC 312 WG1. Some of them were implemented in the new draft of the international collector standard (prEN ISO 9806) some were included in the guidelines from WP 2 and some will be comments to the revision process of EN 12976 (ending with 21. June 2012).

The main results in particular were:

- ✓ Mechanical load testing for factory made systems shall not be done according to EN 12975 anymore
- ✓ An adopted method for EN 12976 has been developed
- ✓ Guide for testing according to EN 12976 gives clear explanation on how to do mechanical load resistance test within EN 12976
- ✓ The liaison to TC 128/254 could be supported, so interaction and synchronisation with other branches could be reached
- ✓ For collectors the test procedure was described in a more precise way to avoid any misunderstandings
- ✓ The possible testing for ETC was discussed and precised

- ✓ A new reporting of the test results was introduced. Now a table of loads reached has to be given to show the maximum load the resistance was proven by test
- ✓ The limits of the test has been raised from 1000 Pa to 2400 Pa, to come closer to reality values and to harmonize with the requirements of IEC 61215
- ✓ The text for the revision of the EN 12975 respectively prEN ISO 9806 has been précised
- ✓ Roofing equipment was transferred to the working group CEN TC 128 WG 3

4. Pre-view on future work

Recently other projects are running to answer more fundamental questions in respect to the behaviour of solar installations towards mechanical loads induced by wind and snow. New standards or technical rules are published (e.g. ÖNorm M7778, NVN 7250, MSC, CEN/TC128 WG 3 N 023 E). New aspects are under examination in R&D projects (e.g Fraunhofer ISE, “mechLoad”). There might be a clear need for a more consistent and well defined standardisation on the issues mentioned above. Especially when installations become larger in area and larger in number, there is a risk for insurance companies. So they ask for more detailed information.

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Annex A "Working paper for mechanical load resistance test"

1. Introduction

The following working paper summarizes and guides the recent discussion on this topic within CEN/TC 312 WG1 and QAiST.

Mechanical load induced by wind or Snow/Ice is one of the severe influences on the long time durability of collector installations. Especially the consecutive forces resulting from wind are not easy to calculate. Over all the resulting forces for the collector components, the fixings, the mounting equipment and the roof fixings are strongly influenced by the mounting angle, surroundings the weather and climate and the mounting situation. The standards (EN 199x series) provide assumptions and equations to calculate snow/ice loads (part 5) and wind loads (part 4). Most of the above mentioned influences can be taken into account within the standard. The assumptions on the other hand are not provided for the case of *Solar Thermal collectors and Applications,* so one has to "translate" the standard to these situations. This is to some extent possible, especially for snow loads. For wind loads it is much more vague.

The process of harmonizing the standard EN 12975 towards EU regulations ("construction products", = dt. Bauproduktenrichtlinie 89/106/EWG) includes the aspect of structural safety. This process is paving the way to base a CE marking for solar thermal applications on the CPD. For this an Annex ZA will be prepared to reference all necessary documents, which define how the relevant aspects are dealt with within the harmonized EN 12975. For this reason it is important to fulfil the requirements of state of the art structural safety. The recent way to deal with this is to improve the methodology within EN 12975.

TC 312 is not the only TC working on these issues. As well TC 128 and TC 254 and maybe others are dealing with this topic. From their view the topic is summarized in "Roof and Façade integration of Renewable energies". The mentioned TC 128 accepted a liaison with TC 312 and is holding meetings on the topic within a 2011 founded ad-hoc working group. This group is called WG3 and is located within TC 128. The group holds several official liaisons with other related TCs (as TC 82, TC 312, TC 254). Within this working group a draft document was developed, which is recently send to the CEN board as a proposal for placing an official work item for mechanical load testing and calculation rules for building integrated renewable energies to TC 128 WG3. From this process a TS may result which later is possibly suggested to become an EN.

Experiences from the mass market of PV in regards of problems/failures as well as the benefits of standardisation are available. This information should be taken into account when improving the requirements and methodologies for solar thermal products.

There are other branches as well, dealing with similar problems, as roof-integrated windows manufacturer.

Last but not least there is some diffuse pressure resulting out of the insurance branch, which is at least in some EU countries asking for more safety and regulation on the issue of wind and snow/ice load.

2. EN 12975

The recent standard EN 12975 gives the following information regarding mechanical load tests:

2.1. Part 1:

“EN 12975-1:2006, 5.3.8. Mechanical load test

When tested in accordance with 5.9 of EN 12975-2:2006 **the cover, the collector box and the fixings between collector box and mounting system** shall not show any major failure as defined in 5.3.1 and 5.9.1.3 of EN 12975-2:2006. The **permissible** and the **maximum positive and negative pressure shall be recorded in the installer manual**.

NOTE Individual country’s safety requirements may prevail.”

2.2. Part 2:

“EN 12975-2:2006, 5.9 Mechanical load test

5.9.1. Positive pressure test of the collector

5.9.1.1. Objective

This test is intended to assess the extent to which the transparent cover of the collector and the collector box are able to resist the positive pressure load due to the effect of wind and snow.

5.9.1.2. Apparatus and procedure

The collector shall be placed horizontally on an even ground. On the collector a foil shall be laid and on the collector frame a wooden or metallic frame shall be placed, high enough to contain the required amount of gravel or similar material (see Figure A.12).

The gravel, preferably type 2-32 mm, shall be weighed in portions and distributed in the frame so that everywhere the same load is created (pay attention to the bending of the glass), until the desired height is reached.

The test can also be carried out installing the collector in accordance with 5.9.2.2 and loading the cover using suction cups, gravel or other suitable means (e.g. water).

As a further alternative, the necessary load may be created by applying an air pressure on the collector cover.

The load may also be created by applying a negative pressure on the collector cover. In this case, apparatus in accordance to EN 12211 can be used. However this method cannot be applied on all collector types.

5.9.1.3. Test conditions

The test pressure shall be increased at maximum steps of 250 Pa until a failure occurs or up to the value specified by the manufacturer. The test pressure shall be at least 1000 Pa. A failure can be the destruction of the cover and also the permanent deformation of the collector box or the fixings.

NOTE A permanent deformation should be assigned to a load value, while it is completely relieved after every load increment of 250 Pa and the distortion is measured compared to the beginning of the test sequence. The value of an inadmissible permanent deformation amounts to max. 0,5 %. (Example: 10 mm distortions at 2 m length of collector frame).

5.9.1.4. Results

The pressure at which any failure of the collector cover or the box or fixings occurs shall be reported together with details of the failure. If no failure occurs, then the maximum pressure which the collector sustained shall be reported.

The maximum positive pressure is the pressure reached before occurring a failure. The permissible positive pressure is the maximum pressure divided by the safety factor SF+ = 1,5:

$F_{perm+} = F_{max+}$ / SF+ with SF+ = 1,5

NOTE When the test is done with an on-roof mounting system the test results are also valid for the roof integrated mounting system.

5.9.2. Negative pressure test of the collector

5.9.2.1. Objective

This test is intended to assess the extent to which the fixings between the collector cover and collector box are able to resist uplift forces caused by the wind.

For the design of the statics of the mounting system the national and European Guidelines for Structural Planning according to EN 1991 have to be applied.

5.9.2.2. Apparatus and procedure

The collector shall be installed horizontally on a stiff frame by means of its mounting fixtures. The frame which secures the cover to the collector box shall not be restricted in any way.

A lifting force which is equivalent to the specified negative pressure load shall be applied evenly over the cover. The load shall be increased in steps up to the final test pressure. If the cover has not been loosened at the final pressure, then the pressure may be stepped up until failure occurs. The time between each pressure step shall be the time needed for the pressure to stabilise.

Either of two alternative methods may be used to apply pressure to the cover:

- Method (a): The load may be applied to the collector cover by means of a uniformly distributed set of suction cups (see Figure A.13).
- Method (b): For collectors which have an almost airtight collector box, the following procedure may be used to create a negative pressure on the cover (see Figure A.14). Two holes are made through the collector box into the airgap between the collector cover and absorber, and an air source and pressure gauge are connected to the collector airgap

through these holes. A negative pressure on the cover is created by pressurising the collector box. For safety reasons the collector shall be encased in a transparent box to protect personnel in the event of failure during this test.

During the test, the collector shall be visually inspected and any deformations of the cover and its fixings reported. The collector shall be examined at the end of the test to see if there are any permanent deformations.

5.9.2.3. Test conditions

The test pressure shall be increased in steps of 250 Pa until a failure occurs or up the value specified by the manufacturer. The test pressure shall be at least 1000 Pa. A failure can be the destruction of the cover and also the permanent deformation of the collector box or the fixings.

NOTE A permanent deformation should be assigned to a load value, while it is completely relieved after every load increment of 250 Pa and the distortion is measured compared to the beginning of the test sequence. The value of an inadmissible permanent deformation amounts to max. 0,5 %. (Example: 10 mm distortions at 2 m length of collector frame).

5.9.2.4. Results

The pressure at which any failure of the collector cover or the box or fixings occurs shall be reported together with details of the failure. If no failure occurs, then the maximum pressure which the collector sustained shall be reported.

The maximum negative pressure is the pressure reached before occurring a failure. The permissible negative pressure is the maximum pressure divided by the safety factor SF- = 2:

$$F_{perm-} = F_{max-} \ / \ SF- \text{ with } SF- = 2\text{”}$$

3. EN 12976

Because the fact that EN 12976-1,2:2006 references EN 12975-1,2:2006 it is reasonable to consider the relevant section of EN 12976 here as well.

“4.3 Components and pipework

4.3.1 Collector

For systems the collector of which can be tested separately, the collector shall conform to EN 12975-1:2000, with the exception of:

- internal pressure tests for absorber (see 5.3.2 of EN 12975-1:2000);

- freeze resistance test (see 5.3.10 of EN 12975-1:2000);

- thermal performance measurement (see 5.3.9 of EN 12975-1:2000).

For systems the collector of which **cannot be tested separately** (for instance integrated collector-store systems),

the whole system shall conform to EN 12975-1:2006, with the exception of:

- internal pressure tests for absorber (see 5.3.2 of EN 12975-1:2000);

- exposure test (see 5.3.4 of EN 12975-1:2000), on the condition that the installation manual for the system

specifies that the empty system shall be protected against prolonged exposure to solar radiation;

- internal thermal shock test (see 5.3.6 of EN 12975-1:2000);

- freeze resistance test (see 5.3.10 of EN 12975-1:2000);

- thermal performance measurement (see 5.3.9 of EN 12975-1:2000).

4.3.2 Supporting frame

Manufacturer shall state the maximum possible loads for their supporting frame, in accordance with EN 1993(Steel) and EN 1999 (Aluminium).

This shall be mentioned in the documents for the installer

Allowance of installing the system is depending on national requirements. Guidelines can be found in new Eurocodes for wind and snowloads."

4. Load Classes

4.1. Wind classes and Snow/Ice classes

Eurocodes Wind (Germany)

Windzone	v_{ref}	q_{ref}
WZ 1	22,5 m/s	0,32 kN/m²
WZ 2	25,0 m/s	0,39 kN/m²
WZ 3	27,5 m/s	0,47 kN/m²
WZ 4	30,0 m/s	0,56 kN/m²

Figure 1 Wind load distribution in classes for Germany

Eurocodes Snow/Ice (Germany)

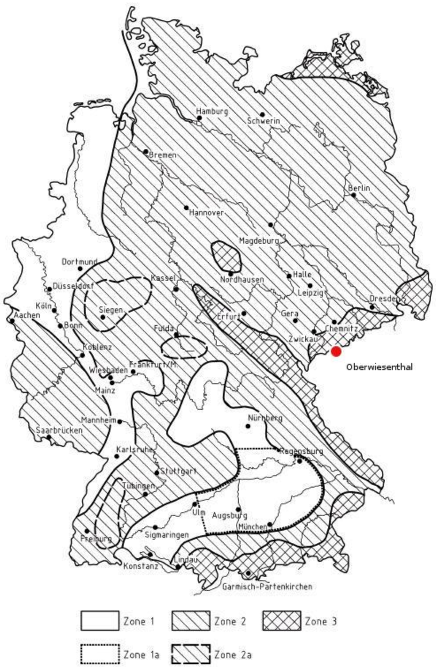

Figure 2: Snow load distribution in classes for Germany

4.2. Boundary conditions and resulting forces/ effects

Incident angle

The angle of slope is influencing the load situation basically. This is true for wind and snow induced loads.

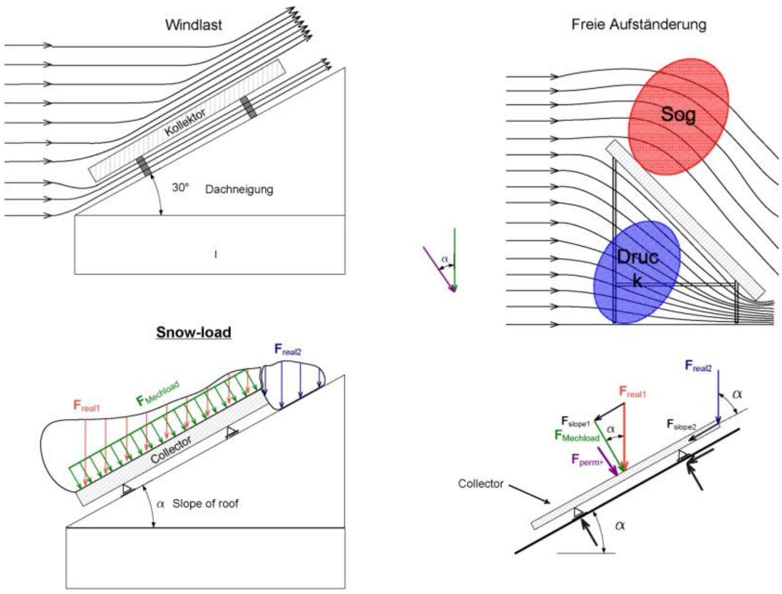

Figure 3: Different load situations resulting from wind and snow

Temperature

The temperature of collector parts is correlated to their strength, adhesion strength, brittleness and stiffness. So it makes a difference if the resistance against mechanical forces is tested at elevated or at very low temperatures.

The effects of this are very difficult to simulate because many of the used materials and components can not be described with parameters detailed enough. As well the combination of different forces and lots of components along the mounting are limiting the simulation.

Surrounding buildings and collector fields

Indeed the wind speeds and snow loads are as well strongly influenced by the surrounding of the location where the collector(s) is/are installed. For example collectors can be mounted at a façade of a building and depending on its height they can be exposed to very high wind speeds.

Even rows of collectors in bigger installation affect the load within the field.

Dynamic forces

When installing collectors in areas with lots of wind gusts, there is the possibility of generating dynamic loads at the collector. This is of course a totally different situation which is not at all represented by the current test.

Mounting situations

Figure 4: Illustration of different mounting situations

4.3. CE-Marking and Classes

One has to take into account that CE will some how "ask" for at least a minimum of mechanical strength or better "structural safety" of the product taken under the regulation for building products. Two possibilities can be identified:

1. Define the lowest class to such a level that it is satisfying the requirements of CE-marking.
2. Define a minimum level in Annex ZA which has to be tested and passed to fulfil CE-marking requirements.

From the industry point of view it would be desirable that a Solar Keymarked product would automatically fulfil the requirements of the CE marking. From this point of view only the first solution seems possible.

4.4. Certification and Classes

As wind and snow/ice load is varying extremely around the world and it always an issue of local, national or regional requirements there has to be a very clear levelling up to which forces the collector was tested. The suggestion is not to correlate classes resulting from the outcome of the testing with the wind and snow load classes of existing standards. It would be to complicate to do this worldwide.

One first very simple draft for classes could be:

Table 1: Proposal how to document the results of the test (+ positive load, - negative load, < level of demage)

N/m^2	*1000*	*2400*	*5400*	<
Classes	*C*	*B*	*A*	
+				
-				

This draft (prISO9806) is really ignoring almost all influences resulting from wind and snow. On the other hand this approach could be introduced even not changing the methodology of testing (at least for flat plate collectors) and bringing a first connection to different wind and snow classes of the Eurocodes. So a manufacturer can decides the level he wants his product to be tested against in front or he can test until damaged occurs. The maximum level tested will always be given in the table above and it is easy to see which class was reached as well.

5. Collector approach

5.1. Mounting equipment and situations

Arguments to include mounting equipment:

- The mounting equipment and fixings are interacting with the collector during test (and in reality).
- As well the mounting equipment is included when testing compact systems.
- Mounting equipment and fixings are not tested anywhere else.
- The customer buys e.g. a Key-marked product and expects that safety things are checked, also of course one can argue that that is in the responsibility of the manufacturer.
- Especially when on-going work has shown that downhill-slope forces are essential to characterise durability of collectors, the fixings and mounting equipment will be in the focus again.
- Different mounting situations need different mounting equipment because different forces result. Testing has to represent this information in an easy way to the customer.

Arguments not to include fixings and mounting equipment:

- It is actually recently not the core competence of solar test labs
- The effort for industry would be increased time and financial wise

5.2. Testing equipment and results

Testing methodology and equipment have to adjust to the “new” situation. The recently used equipment is not suitable to fulfil the intention of the recent standards in many test labs. Doing this one can take an improvement of the equipment into account to develop testing capacities which are prepared for future branch development.

5.3. Proposed text for standard revision

The text was changed in the 2011/2012 draft of EN 12975-2 to the following text:

The collector shall be placed horizontally on an even ground using the manufacturers original equipment for mounting.

The report sheet in the annex of EN 12975 (formaly annex D) was changed to report the results of the testing using following default:

A.1 Mechanical load test

A.1.1 Positive pressure test of the collector cover

A.1.1.1 Method used to apply pressure:

- ☐ Loading with gravel or similar material
- ☐ Loading with water
- ☐ Suction cups
- ☐ Pressurisation of collector cover

A.1.1.2 Test conditions

Maximum pressure load:

A.1.1.3 Test results

The results shall be indicated and reported with a “not applied”, + = passed, or - = failed in a table as follows:

Test pressure	+1000 Pa /m²	+2400 Pa / m²	+5400 Pa / m²	Maximum positive mechanical load

Give details of any damage to the collector cover after the test, reporting the value of pressure load which caused the damage and any of the failures denoting “major failure”, defined in **Error! Reference source not found.** of EN 12975-1:2006

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A.1.2 Negative pressure test of fixings between the cover and the collector box

A.1.2.1 Method used to apply pressure:

☐Suction cups ☐ Pressurisation of collector box ☐ Other:

A.1.2.2 Test conditions

Maximum pressure load:

A.1.2.3 Test results

The results shall be indicated and reported with “not applied”, + = passed, or - = failed in a table as follows:

Test pressure	-1000 Pa /m²	-2400 Pa / m²	-5400 Pa / m²	Maximum negative mechanical load

Give details of any damage to the collector cover or cover fixings after the test, reporting the value of pressure load which caused the damage and any of the failures denoting “major failure”, defined in of EN 12975-1:2006

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A.1.3 Negative pressure test of collector mountings

A.1.3.1 Method used to apply pressure:

☐ Suction cups ☐ Air bags

A.1.3.2 Test conditions

Maximum pressure load:

Pa

A.1.3.3 Test results

Give details of any damage to the collector mounting fixtures or fixing points after the test, reporting the value of pressure load which caused the damage and any of the failures denoting “major failure”, defined**Error! Reference source not found.** in EN 12975-1:2006

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6. Compact systems approach

6.1. Mounting equipment and situations

Boundary conditions for testing according to EN 12975:

Collector to be horizontal, 1000 Pa in steps of 250 Pa.
Problem:

For thermo siphon systems almost always including a mounting device with a tilt angle it is not possible to test the collector following that procedure!

New improved Proposal was prepared for the QAiST Guide for reliability test for EN 12976:

Mechanical load test

Purpose

This test is used to evaluate the carrying capacity of a (thermosiphon) system due to snow and wind loads. The following procedure is for systems comprising a rack with a tilt angle where either the collector is separable or not separable from the tank. In both cases the whole System has to undergo a mechanical load test, not only for systems with not separable collectors as described in EN-12976-1 Chapter 4.3.1. The mechanical load test is adopting the procedure according to EN 12975-2 Chapter 5.9.

Apparatus

plane surface to put the system on

sand sacks (stone plates,…)

measuring tape

stop watch

camera

straps for keeping single weights in position

Safety precaution

safety glasses

safety shoes

gloves

long-sleeved clothing and cap

During the test extreme caution should be exercised at any time since the system may collapse under the weight. Therefore, during the test no other person should stay on or in the immediate vicinity of the test object without proper safety equipment.

Calculation procedure for the mechanical load

The requested pressure on the system is charged with sand sacks (or stone plates) and should be raised in 250 Pa steps until 1000 Pa.

To determine these four weight classes, to charge the system with, first of all the system area $\mathbf{A_{sys}}$ has to be calculated.

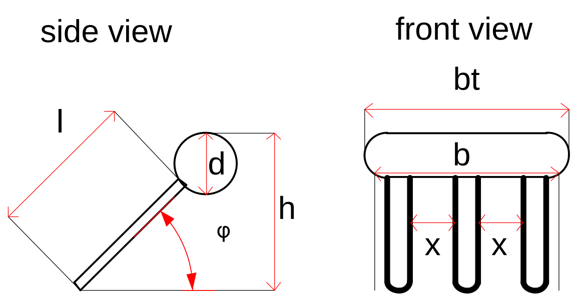


Figure 5: In red the dimensions of the system to be measured

$\mathbf{A_{sys} = A_T + A_{brutt} - A_x}$

$\mathbf{A_T = b_t * d}$ A_T = area tank

b_t = width tank

d = diameter

$\mathbf{A_{brutt} = l * b}$ A_{brutt} = gross collector area

l = length of collector/ length mounting device

b = width collector/ width mounting device

for vacuum tube collectors*:

$\mathbf{A_x = l * x * a}$ A_x = tube spacing area x = distance between tubes

a = number of gaps between tubes

**Note:*

In case there is a reflector located behind the tubes, then the tube spacing area A_x is set to zero (A_x =0).

Now the mass m, the system has to be charged with, can be determined with pressure

p = F/A p = [Pa] = N/m²

and force

F = m * g F = [N] = kg m /s² g = acceleration due to gravity = 9,81 m/s²

To calculate the force orthogonal to the surface of the system, the tilt angle ϕ of the system has to be taken into account (Fig. 2):

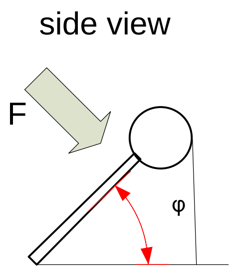


Figure 6: force orthogonal to surface of system

$m = p * A_{sys} / (g * \cos(\phi))$

This results in following equations for the different weight classes:

m_1 = 250 [Pa] * A_{sys} [m²]/(9,81 [m /s²] * cos (ϕ))

m_2 = 500 [Pa] * A_{sys} [m²]/(9,81 [m /s²] * cos (ϕ))

m_3 = 750 [Pa] * A_{sys} [m²]/ (9,81 [m /s²] * cos (ϕ))

m_4 = 1000 [Pa] * A_{sys} [m²]/ (9,81 [m /s²] * cos (ϕ))

Out of these masses, the number of sand sacks per weight class can be calculated.

The weight of each sand sack has to be checked.

$\mathbf{i = m_{1234}/m_S}$ I = number of sand sacks

m_{1234}= load to charge the system with

m_S = mass of sand sack

Procedure

The system has to be mounted according to the manufacturer.

Tank should be filled with water during the test.

Before testing, the whole system has to be checked for damages on the rack, tank or collector.

Following steps should be conducted:

Calculate the weight load -number of sand sacks- for the 4 steps according to 5.7.4

The sand sacks for the first weight class (250 Pa) have to be distributed, starting with tank, **equally over the system** (Fig.2)

After charging the load wait **5 minutes** and check the mounting device/system for damage or deformation after. **Take picture** for protocol.

Put the missing sand sacks for the second weight class (500 Pa) on the system and repeat step c. The same for the third (750 Pa) and fourth (1000 Pa) weight class.

Figure 7: four steps from left: 250 Pa, 500 Pa, 750 Pa and 1000 Pa

Figure 8: Example of a non separable system, mechanical load test with sand sack

Figure 9 Example of a separable system mechanical load test with “stone load”.

Reporting requirements

After every weight class minimum one picture from the front and the side of the system has to be taken to notice and document possible damage on the system.

weight-class	**Area and weight determination**	**Charged load, number of sand sacks**	**Pictures**	**Notes/ Evaluation**
1	m_1 = 250 [Pa] * A_{sys} [m²]/(9,81 [m /s²] * cos (ϕ)) Asys = cos (ϕ)= m_1=			

…4	m_4 = 1000 [Pa] * A_{sys} [m²]/(9,81 [m /s²] * cos (φ)) Asys = cos (ϕ)= m_4 =			

6.2. Testing equipment and results

Because it is often not possible (because of constructional reasons) to bring the filled system in a horizontal position, the test has to be done including the mounting structure and somehow handling the sloped collecting area. This can be done with sand sacks to some extend. It is strongly recommended to go for a more repeatable and trustable testing methodology.

7. Decisions been taken:

- The testing for not separable Systems should be discussed and implemented in EN`76

- Note: There is a standard for mounting equipment under inquiry in Austria

- Include the fixings for realistic testing conditions

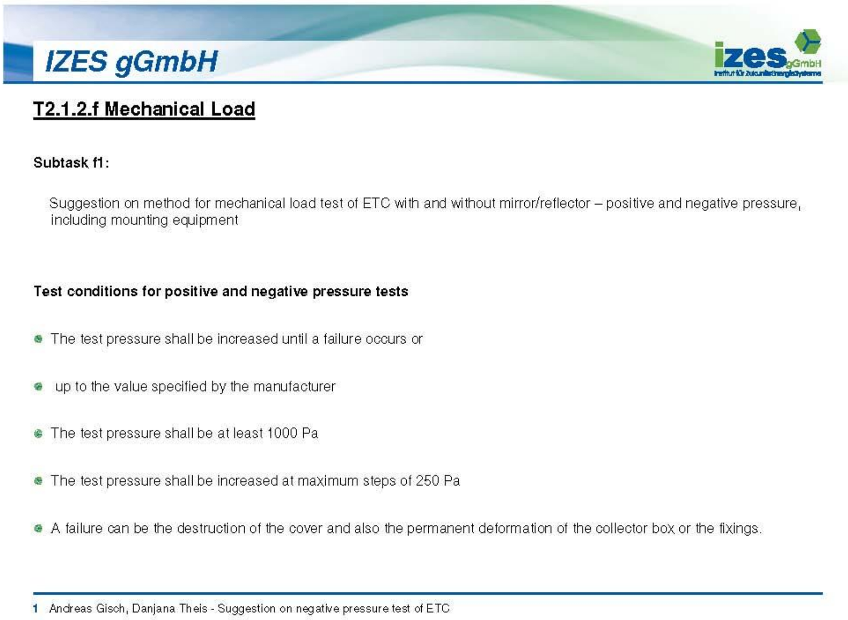
- Levels as defined in the table below.

One first very simple draft for classes could be:

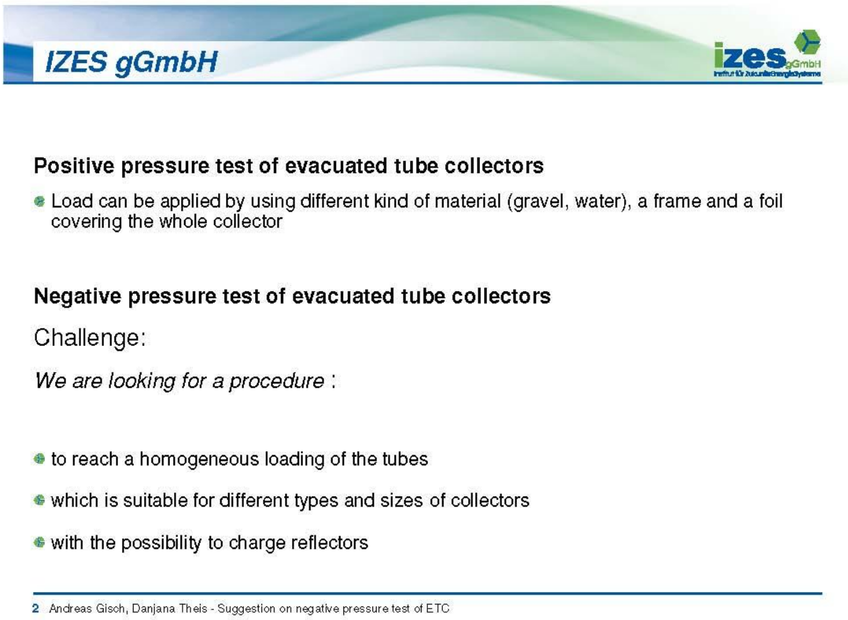
N/m²	*1000*	*2400*	*5400*	*Exact limit*
Classes	*C*	*B*	*A*	
+				
-				

8. Possible testing procedure for negative forces

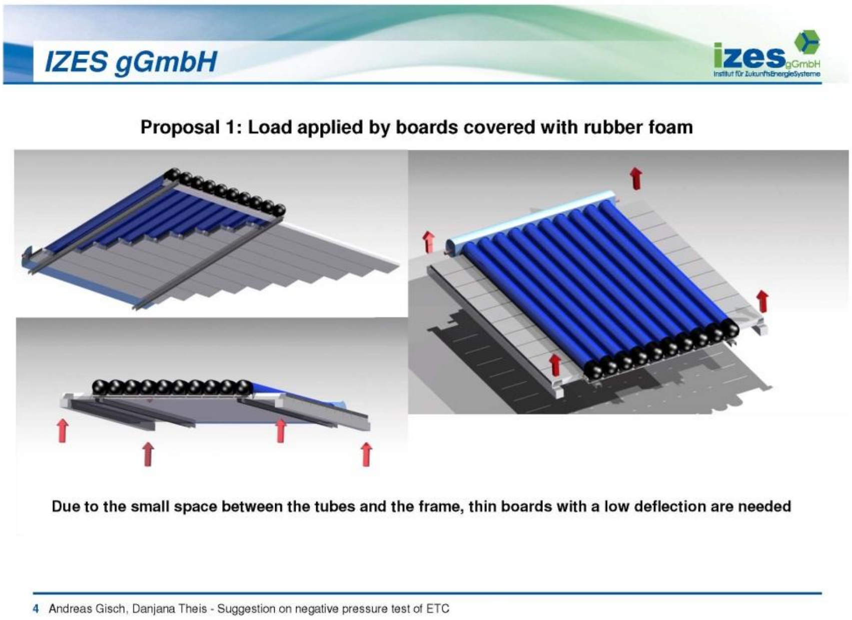
The following possible test method was presented at the project meeting in Munich. It describes how one can apply negative loads on a ETC



collector.




IZES gGmbH
izes gGmbH
Negative pressure test of an evacuated tube collector with reflector
Illustration of an ETC
3 Andreas Gisch, Danjana Theis - Suggestion on negative pressure test of ETC


IZES gGmbH
izes gGmbH
Proposal 1: Load applied by boards covered with rubber foam
Due to the small space between the tubes and the frame, thin boards with a low deflection are needed
4 Andreas Gisch, Danjana Theis - Suggestion on negative pressure test of ETC

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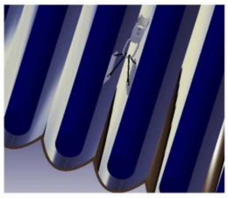
Proposal 2: Load applied by pulling tubes with various attachments

Attachments:

For the tubes
(using slopes)

For the reflector
(using heavy duty magnets)



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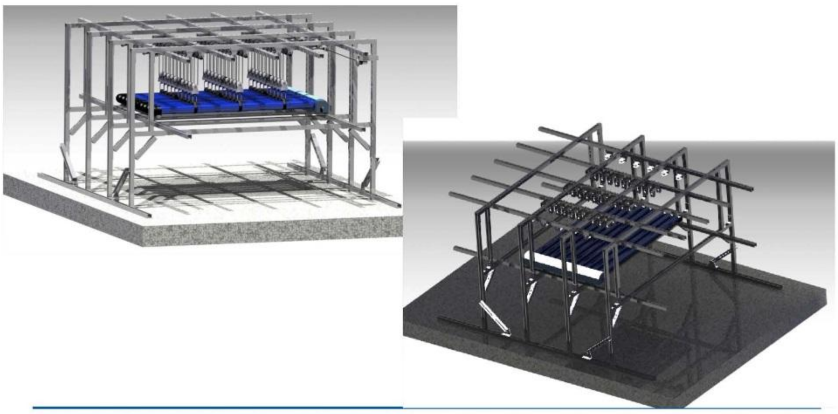
Test bench with collector mounted



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9. Literature

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