TEST REPORT

PM 83996/06

2006-09-22

ROUND ROBIN TEST REGARDING TEST-METHOD AND REQUIREMENTS FOR IMPACT FROM SWING ELEMENTS IN EN 71-8

Commissioned by ANEC and the Swedish Consumer Agency

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REPORT

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Background

In EN 1176-2: 1999 "Playground equipment – Part 2: Additional specific safety requirements and test methods for swings", requirements and test methods for "impact from swing elements" are given. Parts of these requirements were copied into EN 71-8 "Safety of Toys – Part 8: Swings, sides and similar activity toys for indoor and outdoor family domestic use" (harmonised under the Safety of Toys-directive).

The method and requirements were questioned by many experts in CEN/TC 52/WG 3 "Safety of Toys – Mechanical and Physical Properties" arguing that the test method had not been verified for the new application in EN 71-8 and that it did not give reproducible results.

Similar criticism had previously been made against EN 1176-2. In document TC136/SC1 N459 (from 011030) a reference is made to a round robin test carried out in 1998 which it is said that *"There was found to be a wide variation in results between test houses, 34% in the worst case.".* In document TC136/SC1 N469 (from 011216), it is stated that *"although the round robin tests in the early days had shown up big differences, it was much better now. It was agreed that a better defined reproducible test method should be developed during the revision of the standard."*
However, during the recent revision of 1176-2, this issue has, to our knowledge, not been brought up by any expert or organisation.

The criticism against the method and requirements in EN 71-8 resulted in the adoption of a resolution (majority decision) in CEN/TC 52 to delete the swing impact test and corresponding requirements from EN 71-8. The amendment to EN 71-8 was published by CEN in December 2005 but has not yet (September 2006) been referenced in the OJEU since a formal objections has been launched against it.

The resolution to delete the method also stated that a small task group was to be established with the task to study the requirements and test methods, including a comparison with EN 1176, and to validate the test methods and thereafter, if appropriate, propose WG 3 to include a revised method this in EN 71-8. For this reason, a small Nordic Project was carried out with the aim to apply the present test method at two laboratories, one in Denmark and one in Sweden, and to identify any unclear parts of the standard text and thereafter, if possible, propose improvements to the method.
SMP carried out the project in which some 50 tests were carried out to gain an overall impression of the repeatability of the method and to identify factors that have an affect on the test results.

The outcome of the Nordic project (see Appendix 3) was a revised text for the test method and requirements, which could be used as a basis for a round-robin test, involving several test laboratories from different European countries. Prior to a proposal for re-introducing requirements and test methods for swing impact in EN 71-8, it is necessary to validate the test method as suggested by the Nordic project.

SMP therefore obtained financing for a round robin-test from ANEC and from the Swedish Konsumentverket in Sweden.

Purpose and scope of the project
The purpose of the project was to carry out a round-robin test, involving test laboratories from different European countries, in order to validate the revised proposal for the requirements and test methods for impact from swing elements, which in its turn can provide a basis to propose a re-introduction in EN 71-8.

The scope of the round robin test was to focus on validation of the proposal for revised method and requirements for impact from swing elements (resulting from the Nordic project which was carried out in 2005 by SMP).

Participants
At a meeting of CEN/TC52/WG (26-28 October 2005) three testing laboratories expressed their interest in participating in the round robin test and later a fourth laboratory was added to the list of participating laboratories:

1.   SMP Svensk Maskinprovning AB – Sweden
2.   Consumer Agency/Customs Laboratory (Tullilaboratorio) - Finland
3.   IISG - Istituto Italiano Sicurezza dei Giocattoli – Italy
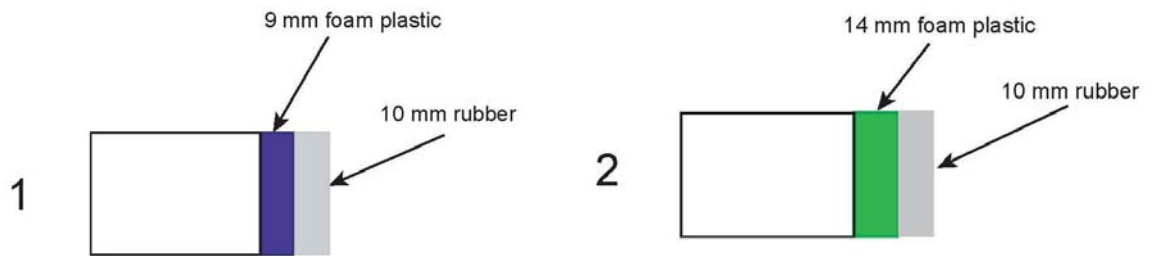4.   Bureau Veritas CPS – France

SMP was coordinator of the project and Mr Christian Wetterberg was the project leader.

Preparations

Testing equipment and measurement equipment
SMP designed the equipment for measurement including software (head-probe, accelerometer, amplifier with filter, computer with software for calculations) and also the equipment to be tested. The basis was a normal swing-set for private use including one single-seat and one double-seat swing. The swing seats were modified by SMP so that they would give cause to various levels of impact.

The double-seat swing was designed so that one seat could be replaced by two different especially designed seats in order to simulate different resilience in the seat material. The single-seat was designed to have a different resilience on each of the two sides (see illustrations below).

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9 mm foam plastic

10 mm rubber

1

14 mm foam plastic

10 mm rubber

2

3a

10 mm rubber

10 mm rubber

3b

10 mm rubber
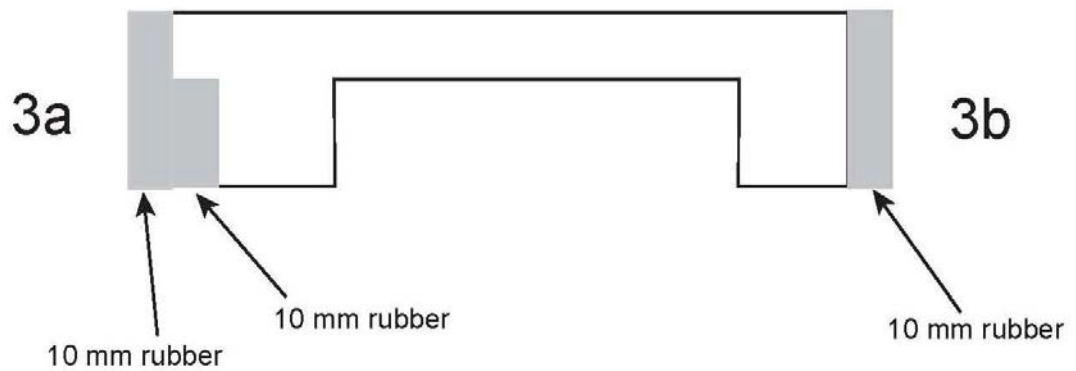
All testing equipment, including the frame for the swings, and measuring equipment was sent to each participating laboratory prior to the tests, together with assembly instructions (see Appendix 1).

The weight of the double swing was 3,75 kg including suspending rods and the free-hanging swing weighed 1,32 kg with ropes and 1,15 kg without. The rope-length from the suspension point to the centre of the seat was 1 430 mm.

Test equipment and procedure

Test equipment

The dimensions of the test-mass are shown in the figure below. A tri-axial accelerometer (range ± 500 g, 10 kHz butterworth-filter, sampling frequency 10 kHz) was mounted in the centre of the test-mass and connected to the amplifier and computer.
See Appendix 4 for specification of accelerometer Endevco 7264B-500 and Appendix 5 for specification of amplifier Endevco Model 136.
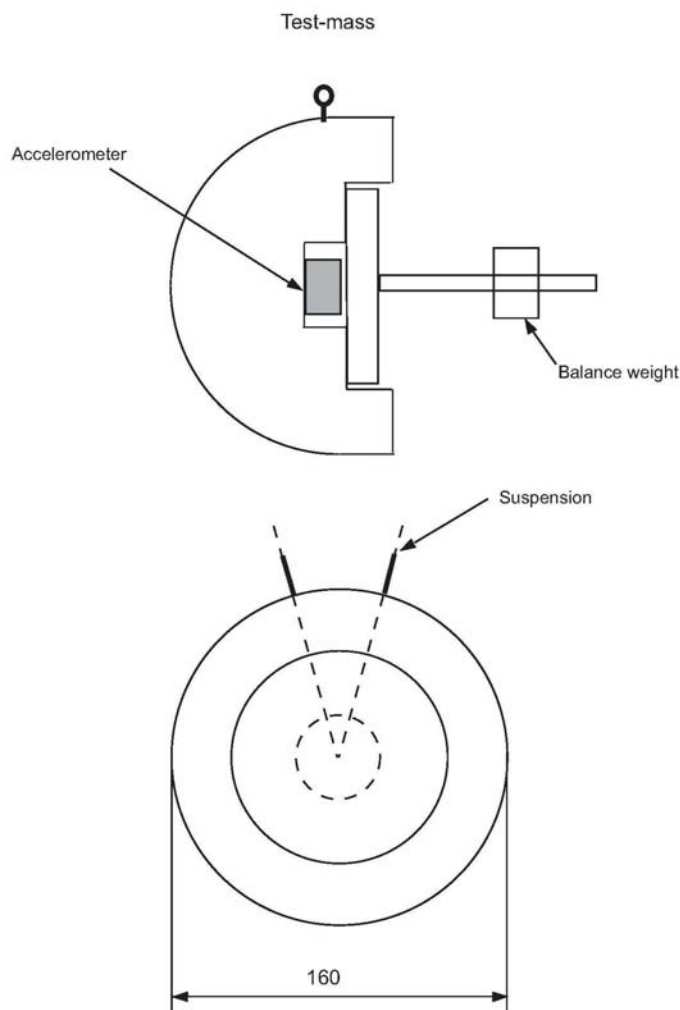
An example of a typical impact curve (in the z-direction) is shown in the figure below.

Z acceleration [G]

The g-force was calculated as the RMS (Root Mean Square) of the g-force in the three measured directions.

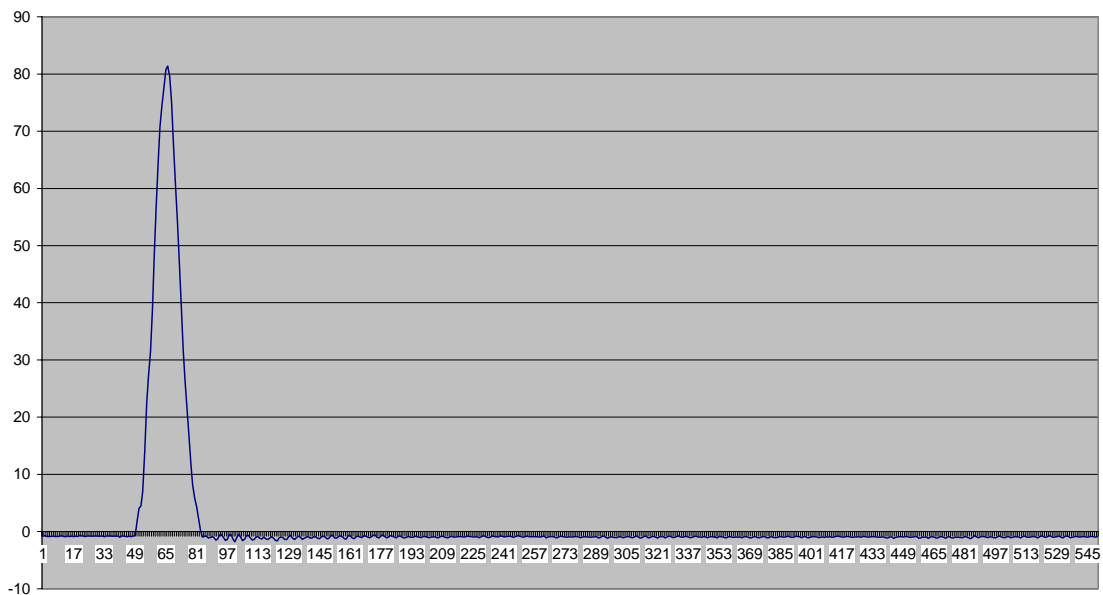<u>Test procedure for swing and test-mass set-up and release</u>
- The swing was adjusted according to the instructions
- The swing was suspended with the means of suspension that was supplied with the swing and at the maximum height that these permitted
- The test mass was suspended and adjusted so that the contact points of the swing element and the centre of the test mass were in the same horizontal plane as the centre of gravity of the test mass
- The seat was raised along its arc of travel until the side view projection of a straight line through the pivot point and index mark, formed an angle of 60 degrees to the vertical.
- The seat was supported in the raised position by a mechanism that provided release without the application of external forces (which would disturb the trajectory of the suspended object)
- It was ensured that the seat and suspending elements were motionless and thereafter the seat was released so that the assembly travelled in a smooth downward arc without any visible oscillations or rotations of the seat (which would prevent it from striking the test mass at the impact point)

Prior to the start of each series of measurement, it shall be secured that the intended point of impact is achieved: Mark the centre of the test-mass, (+), with a suitable marker (chalk) so that an imprint is obtained on the impact surface of the seat.

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Check and, if necessary, make fine adjustments of the test mass in the vertical and horizontal directions. Repeat the procedure until repeatability has been obtained for the intended point of impact.

Pilot study
When all adjustments had been made and everything was set for the respective test series, measurements and documentation of each set-up was made in accordance with the SMP-instructions.

For each impact and test-series, the registered peak acceleration was copied from the computer sceen to the test-result sheet (supplied by SMP).
Each impact result was also saved in the computer (carried out by SMP).

All deviances such as "impure" or "slanted" impacts or any other indications that the impact has not been correctly carried out was noted in the test-result sheet.

In order to avoid that the marking used for measurement of impact-surface (series II, seat 2) would influence the result, chalk was used as marker.

Test procedure for measurement of surface compression
The exposed impact area (the area of the seat that has made contact with the test mass) was be measured by applying chalk to the test mass and by measuring the coloured (chalked) surface on the swing element after the impact. A transparent celluloid-film (such as that used for OH-projectors) was used in order to make a copy of the impact-area. Thereafter, a "millimetre-paper" was placed under the film and the exact area calculated.

Testing programme
SMP developed a testing programme that was circulated to the participating laboratories, together with detailed instructions for the test procedure (see Appendix 2).

The programme consisted of the following tests:

I. Seat 1 (double-swing): 20 impacts with the aim to have the point of impact in the centre.

II: Seat 2 (double-swing): 10 impacts with the aim to have the point of impact in the centre. Determination of impact surface after every single impact.

III. Seat 3 b) (free-hanging swing): 25 impacts with the aim to have the point of impact in the centre. Measurement of the vertical point of impact after every single impact.

IV. Seat 3 a) (free-hanging swing): Three series of 7 impacts each where the aim is to have the point if impact in the centre in the first series, 10 mm above the centre in the second series and 10 mm below the centre in the third series. Measurement of the vertical point of impact after every single impact.

Results

<u>Tests with seat 1 (double swing with 9 mm plastic foam and 10 mm rubber)</u>

The results from the 20 impacts (each country) showed that the average g-force varied as follows:

	Sweden	Finland	Italy	France	Sweden II
Average 20 impacts	**57,4**	**54,69**	**56,37**	**58,48**	**55,70**
Min:	56,3	53,5	54,3	56,6	53,1
Max.	59,3	55,8	59,4	61,7	59,0
Deviation Min-Max:	5,3%	4,3%	9,4%	9,0%	11,1%
Excluding Min-Max of the 20 impacts:					
Min:	57,1	54,2	54,4	57,2	54
Max.	57,8	55,3	58,3	59,9	57,6
Deviation Min-Max:	1,2%	2,0%	7,2%	4,7%	6,7%

Note. Sweden I, only includes 10 impacts. The others include 20 impacts.

Deleting the two extreme values in every set of tests to see how the deviation min-max changes, gives an idea of whether any "outlyers" have had great effect on the deviation. The results from the tests with the double swing with a thin (9 mm) plastic-foam layer show the following variations:

Min-Max variation in tests made within one country:
All values included: Always less than approx. 11 % (see table above)
Two extreme values deleted: Always less than approx. 7 % (see table above)

Min-Max variation in all tests regardless of country (total 90 tests)
All values included: Approx 16 % (see appendix 7)
Two extreme values deleted: Approx 11 % (see appendix 7)

Tests with seat 2 (double swing with 14 mm plastic foam and 10 mm rubber)

The results from the 10 impacts (each country) showed that the average g-force varied as follows:

	SWEDEN Measured value g	SWEDEN Area cm²	SWEDEN Surface compression N/cm²	FINLAND Measured value g	FINLAND Area cm2	FINLAND Surface compression N/cm²	ITALY Measured value g	ITALY Area cm²	ITALY Surface compression N/cm²	FRANCE Measured value g	FRANCE Area cm²	FRANCE Surface compression N/cm²	SWEDEN II Measured value g
Average 10 impacts													
Min:	48,1	27,4	76,0	45,7	26,5	75,4	45,5	27,0	75,9	45,6	24,8	83,3	44,4
Max.	50,3	28,7	83,2	47,9	27,6	80,2	52,7	28,0	87,5	51,0	26,8	89,9	50,2
Deviation Min-Max:	4,6%	4,7%	9,5%	4,8%	4,2%	6,4%	15,8%	3,7%	15,3%	11,8%	8,1%	7,9%	13,1%
Excluding Min-Max of the 10 impacts:													
Min:	49,0	27,5	76,8	45,9	26,8	77,7	46,2	27,2	76,1	49,7	25,3	85,5	45,2
Max.	50,0	28,6	82,6	47,4	27,6	79,6	50,7	27,9	85,1	50,9	26,5	89	48,2
Deviation Min-Max:	2,0%	4,0%	7,6%	3,3%	3,0%	2,4%	9,7%	2,6%	11,8%	2,4%	4,7%	4,1%	6,6%

g-force results (columns with white background)
The results from the tests with the double swing with a thicker (14 mm) plastic-foam layer show the following min-max variation for the g-force:

Min-Max variation in tests made within one country
All values included: Always less than approx. 16 % (see table above)
Two extreme values deleted: Always less than approx. 10 % (see table above)

Min-Max variation in all tests regardless of country (total 50 tests)
All values included: Approx 19 % (see appendix 7)
Two extreme values deleted: Approx 13 % (see appendix 7)

It can be concluded that the variation in the results is on approximately the same the same for the two different impact surfaces of the double swing and that the variation in the results was significantly reduced when outlying values were deleted. Note that all values (regardless of whether the impact was "clean" or not) have been included in the calculations.

It can also be noted that g-forces from a double swing with a resilient material as impact surface can be below 50 g.

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Impact-area results (columns with green background)
When analyzing the data from the impact-area results, there has been some uncertainty regarding the values from France since they were calculated based on the weight of the area of transparent paper that corresponded to the impact area. Since it is difficult to assess the effect of this method for alternative method for measurement (however, the obtained values are lower than for the tests in the other countries), calculations for the variation have been made both including and excluding the French values.

Min-Max variation in tests made within one country (including French values)
All values included: Always less than approx. 8 % (see table above)
Two extreme values deleted: Always less than approx. 5 % (see table above)

Min-Max variation in all tests regardless of country (total 40 tests –France <u>included</u>)
All values included: Approx 16 % (see appendix 7)
Two extreme values deleted: Approx 13 % (see appendix 7)

Min-Max variation in all tests regardless of country (total 30 tests – France <u>excluded</u>)
All values included: Approx 8 % (see appendix 7)
Two extreme values deleted: Approx 7 % (see appendix 7)

Surface compression (columns with grey background)
The surface compression (force per impact-area) is calculated by multiplying the mass of the test-mass (4,62 kg) with the g-force and the acceleration due to gravity 9,81 and by dividing this by the measured impact-area. Therefore, the variation in the results depends on the variation in the g-force and impact-area measurements.

Again, the calculations regarding variation have been made both including and excluding the results from France.

Min-Max variation in tests made within one country (including French values)
All values included: Always less than approx. 15 % (see table above)
Two extreme values deleted: Always less than approx. 12 % (see table above)

Min-Max variation in all tests regardless of country (total 40 tests –France <u>included</u>)
All values included: Approx 20 % (see appendix 7)
Two extreme values deleted: Approx 17 % (see appendix 7)

Min-Max variation in all tests regardless of country (total 30 tests – France <u>excluded</u>)
All values included: Approx 16 % (see appendix 7)
Two extreme values deleted: Approx 12 % (see appendix 7)

Tests with seat 3 b (free-hanging swing with homogenous impact surface)

In these tests, 25 impact-tests were performed in each country (total 125 tests) and any deviation from the horizontal line (up-down from the centre) was registered. In the diagram below, the results have been plotted to show the registered values in relation to the measured deviation in millimetres from the horizontal line.

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Test III Seat 3b
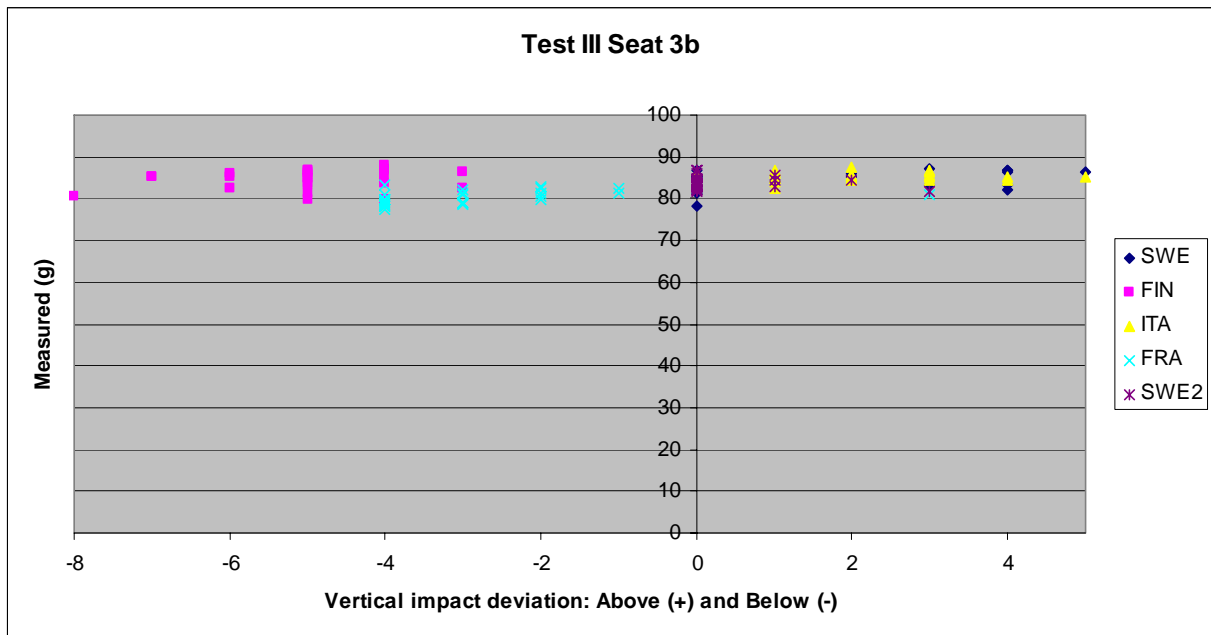
Tests with seat 3 a (free-hanging swing with non-homogenous impact surface)

In these tests, 21 impact-tests were performed in each country (total 105 tests) with the aim to hit in the centre 7 times, 10 mm above the centre 7 times and 10 mm below the centre 7 times. The deviation from the centre was measured for each impact.

The thickness of the resilient impact area was greater below the centre than above the centre and therefore it was expected that impacts above the centre would result in higher g-values than for those below the centre. The diagram below shows the results related to deviation from the horizontal line (up-down) and a trend-line has been inserted.

Test IV Seat 3a - Trend

y = 0,4145x + 62,628
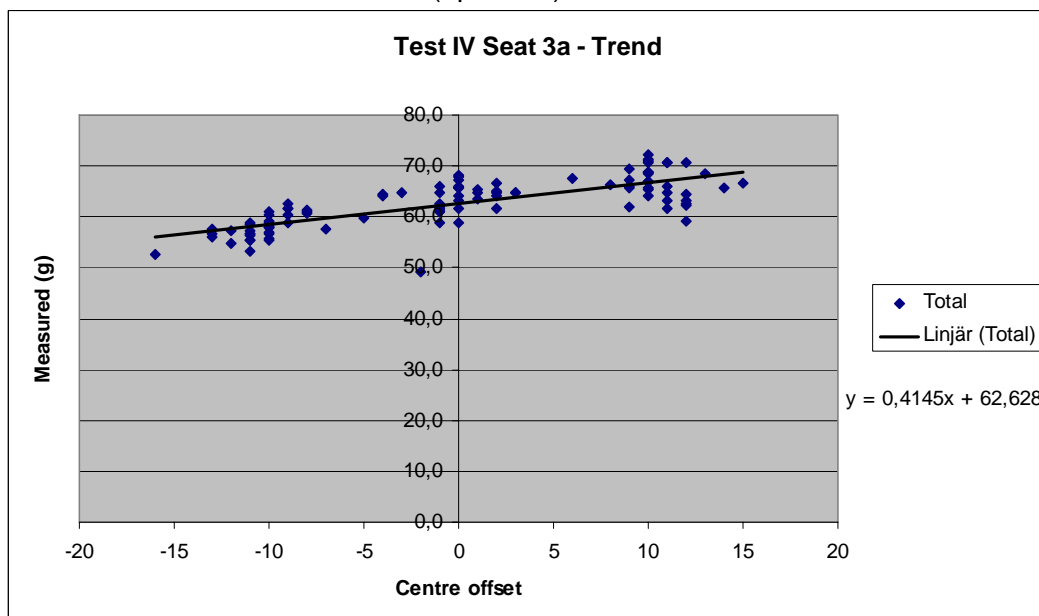
It can be noted that g-forces from the free-hanging swing (regardless of which part of the swing is hit by the test mass) is above the requirement limit of 50 g.

Summary of test-results and variation in the average results

The table below summarizes the test results from the various tests performed. The tests with seat 3 b (25 tests) have been divided in groups of five.

		Sweden	Finland	Italy	France	Sweden II	Min	Max	Variation
Test I (seat 1 = double swing seat with thin - 9 mm - plastic-foam)									
	Measured value g	57,37	54,69	56,37	58,48	55,70	54,69	58,48	**6,94%**
Test II (seat 2 = double swing seat with thick - 14 mm - plastic-foam)									
	Measured value g	49,33	47,09	48,89	49,83	46,60	46,60	49,83	**6,93%**
	Area cm²	27,95	27,19	27,47	25,96		25,96	27,95	**7,67%**
	Surface compression	80,0	78,5	80,7	87,0		78,50	87,00	**10,82%**
Test III (seat 3 b = free-hanging swing with homogenous impact surface)									
201-205	Measured value g	84,06	86,34	85,24	80,46	83,42	80,46	86,34	**7,31%**
206-210	Measured value g	84,34	85,44	84,98	81,08	83,68	81,08	85,44	**5,38%**
211-215	Measured value g	82,62	83,46	85,50	79,98	83,24	79,98	85,50	**6,90%**
216-220	Measured value g	84,38	85,86	85,52	79,96	83,28	79,96	85,86	**7,38%**
221-225	Measured value g	86,35	82,85	84,70	81,65	83,85	81,65	86,35	**5,76%**
201-225	Measured value g	84,35	84,79	85,19	80,63	83,49	80,63	85,19	**5,66%**
Test IV (seat 3 a = free-hanging swing with non-homogenous impact surface)									
Centre	Measured value g	64,70	66,50	63,34	60,80	61,44	60,80	66,50	**9,38%**
10 Above	Measured value g	68,76	69,89	66,96	62,03	65,34	62,03	69,89	**12,67%**
10 Below	Measured value g	58,41	61,17	56,44	55,97	57,43	55,97	61,17	**9,29%**

Conclusions and analysis

From the table "Summary of test-results" it is apparent that for swings 3 a and 3 b, the results from tests in France are lower than in the other countries. This of course adds to the overall impression of the variation in the results. One minor difference when testing in France was that the suspension elements were of a different length than during the tests in other countries. It was at the time of testing not regarded as being of importance but was noted.

The results for seat 3 a relate to the intended point of impact (centre, 10 mm above or 10 mm below) and not to the actual point of impact. This should be considered when evaluating the variation since during "real" testing according the detailed, revised method results from "slanted" hits would not be included in the calculation of the test-results. The detailed test results are appended to this report (see Appendix 7).

The test-results show that the variation in the <u>average results</u> for the g-value obtained at the different laboratories, from tests of "impact from swing-elements", is below 8 % for all tested swings except for swing 3 a (which had an inhomogeneous impact surface) when the revised specification of the method is applied. A further reduction of the variation can be achieved by further revision of the method based on experience from this project. Since single measurements can have rather a great influence on the min-max variation, it is unsuitable to use only the maximum registered value from a set of measurements for checking of compliance with the required g-value. It is therefore recommended that the average value of e.g. 5 registrations of peak values is used for checking of compliance. The surface compression has a min-max variation of approx. 13 % (all included).

Examples of modifications that should be made to the test method are:
- To define that the aim shall always be to hit the centre point and that only tests where this intended point of impact (e.g centre ± 5 mm vertically and ± 10 mm horizontally) has been hit are used as valid results
- The average value of the peak value from e.g. 5 impact tests shall be used for comparison with the requirement for the g-value
- To define that the impact-area shall be calculated as the average from two measurements
- Other details that during the round-robin tests have proven to be unclear in the present instructions

A revised proposal for test method is enclosed to this report (Appendix 6).

Continued use of the report
The report including the proposal for revised test-method has been commented by the participants in the round robin tests and will be presented to CEN/TC 52/WG 3/TG 4 and to CEN/TC 52/WG 10 for consideration.

SMP Svensk Maskinprovning AB

Christian Wetterberg

<u>Appendices:</u>

Appendix 1: Assembly instructions for swing
Appendix 2: Instructions for test-procedure
Appendix 3: Report from Nordic project (2005)
Appendix 4: Specification of accelerometer
Appendix 5: Specification of amplifier
Appendix 6: Proposal for revised test-method (to be completed)
Appendix 7: Detailed test-results from round robin test 2006

CanCan Swing - Specifications
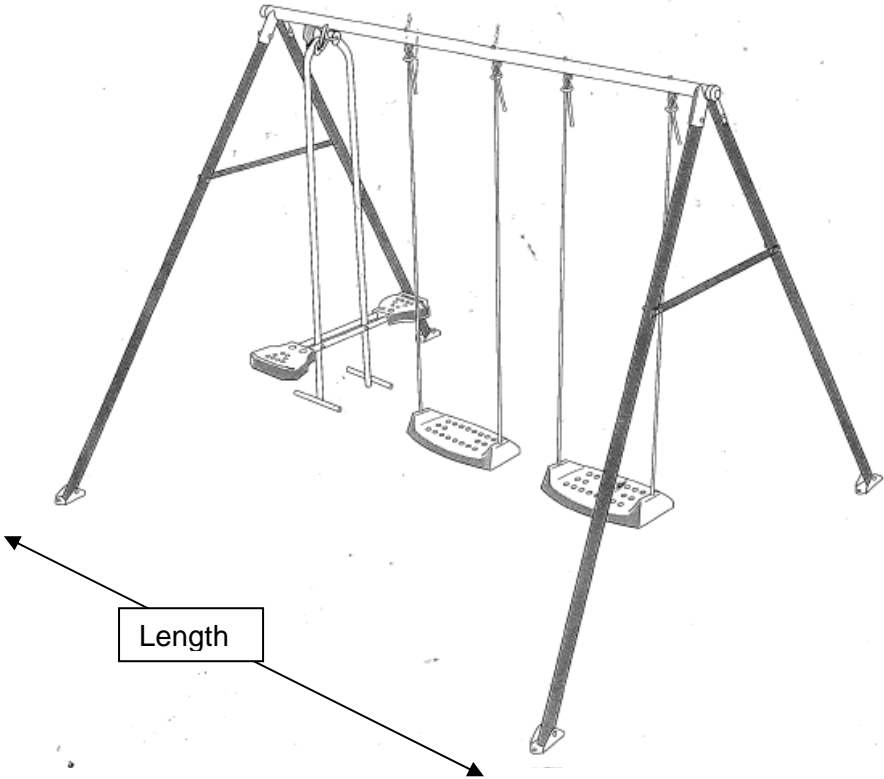
Length

Dimensions

Length: 2800 mm
Depth: 1900 mm (with planks)
Height: 1900 mm
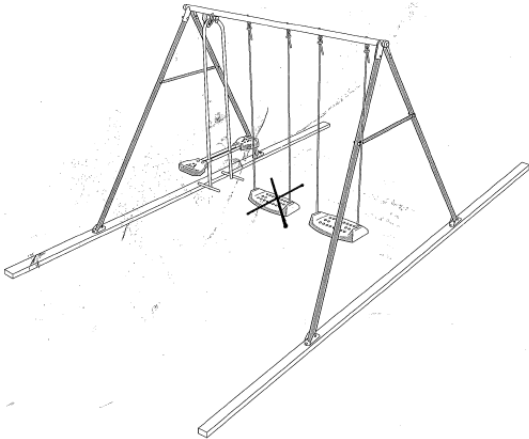
Note that arrangements will be needed to assure that the "planks" are secured/fixed to the floor (or downloaded with heavy weights).

CanCan Swing - Parts

| Del Nr. Item No.	Antal Qty	Beteckning Description
1	1	BOM *TOP BEAM*
2	4	BEN *LEGS*
3	2	TVÄRSTAG *CROSS BARS*
4	4	FOTPLATTA *FOOT PLATES*
5	2	PLASTLOCK *END CAPS*
6	2	GUNGSITS *SWING SEATS*
7	2	REP *SWING ROPES*
8	2	VERTIKALA RÖR TILL DUBBELGUNGA *SKYRIDE VERTICAL TUBES*
9	2	TVÄRRÖR TILL DUBBELGUNGA *SKYRIDE SEAT TUBES*
10	2	SITS TILL DUBBELGUNGA *SKYRIDE SEAT*
A	12	57 mm SKRUV (M 8) *57 mm SLOT HEAD SCREWS (M 8)*
B	21	LÅSMUTTER (M 8) *LOCKING NUTS (M 8)*
C	4	J-KROK (M 8) *J-HOOKS (M 8)*
D	4	S-KROK *S-HOOKS (M 8)*
E	1	BYGEL (M 8) *MOUNTING-CLAMP (M 8)*
F	8	NYLONLAGER *NYLON BEARINGS*
G	2	80 mm BULT (M 8) *80 mm CUP-HEADED BOLTS (M 8)*
H	2	HATTMUTTER MED LÅS (M 8) *DOMED NUTS (M 8)*
I	4	SKYDDSBRICKA *SKYRIDE PROTECTION PLATES*
J	4	32 mm BULT (M 8) *32 mm CUP-HEADED BOLTS (M8)*
K	4	ÄNDAVSLUTNING *TUBE PLUGS*
L	4	ÄNDAVSLUTNING *TUBE PLUGS*

0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180

3

Anvisning för åtdragning av skruv / Bolt Tightening Guide

Fel:
Muttern sitter inte fast.
Dra åt ytterligare.

Wrong:
Nut is not secure.
Tighten even if tube is
squashed a little.
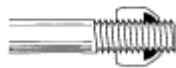
Fel:
Skruven sticker ut.
Kan skada barnet.

Wrong:
Bolt protrudes.
Dangerous, could
scratch your child.
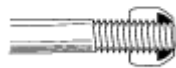
Rätt:
Skruven fäster väl
i mutterns plastdel.

Correct:
Bolt bites into
plastic insert, but
does not protrude.

Verktyg för montering (medföljer ej)
Tools needed for assembly (not supplied)

Skruvmejsel
Slot Screwdriver
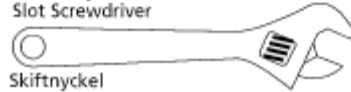
Skiftnyckel
10 mm spanner

Item no 6 *SWING SEAT* and item no 10 *SKYRIDE SEAT* are replaced by seats of other "design".

Assembly, step 1-4

A x 4
57 mm

B x 4
M 8

5 x 2
Plastlock
End caps

1340 mm

540 mm

Notera:
Avståndet mellan hålen
för korrekt montering.

Note:
Distance between holes
for correct assembly.

①

②

A x 8
57 mm

B x 8
M 8

4 x 4
Fotplatta
Footplates

④

③

Assembly, step 5-8

Picture and instruction no 5, 6 and 7 are not applicable.

Assembly, step 9-13

G x 2
80mm

J x 4
32mm

B x 5
M 8

H x 2
M 8

I x 4   Skyddsbricka
Protection Plates

F x 8
Nylonlager
Nylon Bearings

K x 4
Ändavslutning
Tube Plugs

L x 4
Ändavslutning
Tube Plugs

E x 1
Mounting Clamp

Picture and instruction no 13 is not applicable. Other type of "seats" will be used.

Test mass
Required free distance from the floor to the suspension points

RHS Profile

60°

2800 mm

Floor
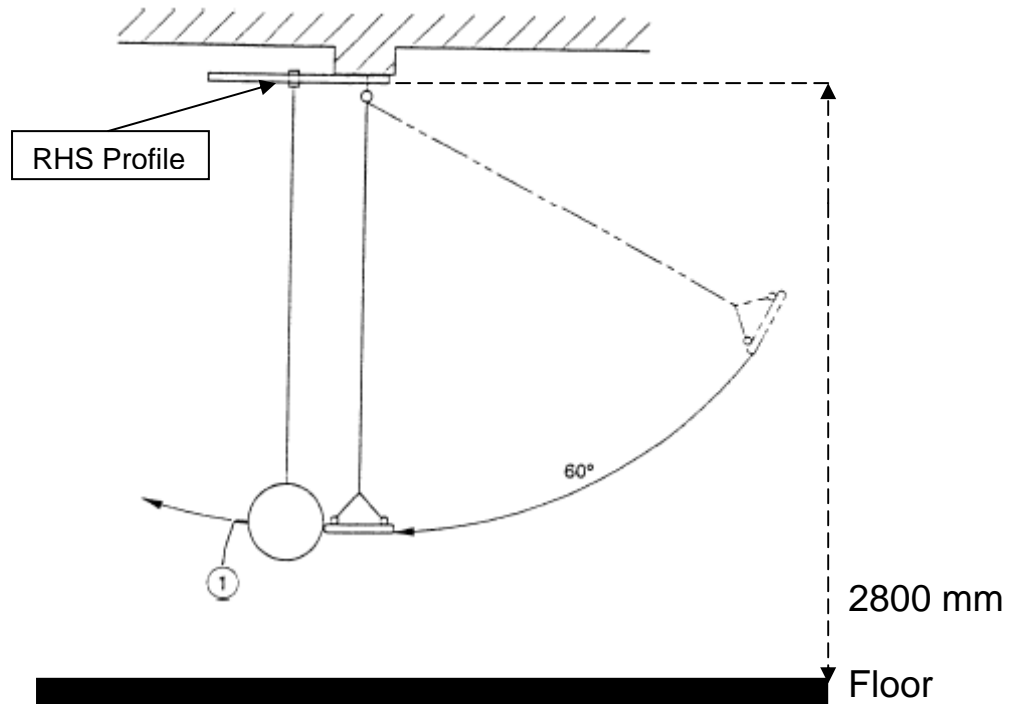
No 1: The test mass

The RHS Profile (view from its end): 50x50x4 mm, Length 800 mm

The instrumented test mass is delivered with it's suspension chains. The chains are fitted with rigging screws for smaller height adjustments. It's pivot points, 600 mm apart, are fixed to a RHS profile.This RHS profile has to be fixed in a proper way. There are several holes in the profile. SMP used two 12 mm bolts to fix the RHS profile to a bar above.

Arrangements at SMP
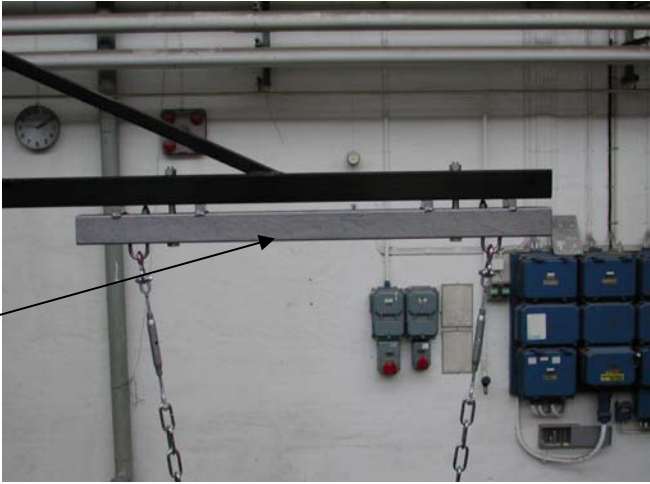
Delivered RHS Profile

Instruction for Round Robin tests of swing impact

General information
The objective of the round-robin test is to
- check whether the modification of the methods supplied in EN 71-8 and EN 1176 regarding "impact from swing elements" has resulted in increased repeatability
- obtain information regarding any further possible improvement of the method and the repeatability

Test will be performed at 4 different test-labs in accordance with the instructions below and the enclosures 1 and 2.

All equipment except the computer will be sent in advance to each test laboratory and after the tests the same equipment will be sent to the next laboratory in line. SMP will bring the computer and also material for measurement of impact-surface and test-result sheets.

SMP's personnel will not carry out the tests (but will take care of the amplifier and computer) but will be present during the tests in order to observe where more detailed instructions are needed and in order to be able to intervene if there is a risk that any misunderstanding of the instructions may lead to that the test-results cannot be used.

Objects to be tested
Tests shall be carried out on three different objects;
- Double-swing (seat 1)
- Double-swing (seat 2)
- Free-hanging swing (seat 3) with two contact surfaces a) and b) (see enclosure 1)

Order of testing

I.   Seat 1 (Double-swing, seat with *blue* foam plastic)
II.   Seat 2 (Double-swing, seat with *green* foam plastic)
III.   Seat 3 b) (Free-hanging swing with homogeneous edge)
IV.   Seat 3 a (Free-hanging swing)

Scope of test

I. Seat 1 (double-swing): A series of 20 impacts shall be carried out with the aim to have the point of impact in the centre.

II: Seat 2 (double-swing): A series of 10 impacts shall be carried out with the aim to have the point of impact in the centre. Furthermore, the impact surface on the seat shall be determined after every single impact.

III. Seat 3 b) (free-hanging swing): A series of 25 impacts shall be carried out with the aim to have the point of impact in the centre. The vertical position of the point of impact shall be measured and registered after every single impact.

IV. Seat 3 a) (free-hanging swing): Three series of 7 impacts each (total 21) shall be carried out. The aim shall be to have the point of impact 22 (first series), 12 (second series) and 32 mm (third series) below the upper edge of the rubber. The vertical position of the point of impact shall be measured and registered after every single impact.

Preparations

1. Mount the frame for the swing(s) and anchor/fix the planks in a suitable way so that the frame remains stable/steady throughout the test.
2. Mount seat 1 (double-swing with *blue* foam plastic)
3. Ensure that the vertical position of the RHS-profile (see enclosure 2) can be adjusted approx 300 mm vertically in order to allow for the correct height for both swing-types (double-swing and free-hanging swing) to be obtained (there is a 300 mm vertical height difference between the two swing-types)
4. Adjust the test-mass so that the centre of the swing-seat
5. Rig up and arrange the release-device so that the swing can be released at an angle of 60 degrees to the vertical

General

The acceleration (measured in "g") shall be registered with one decimal.
The average value for the measured impact-surface (cm^2) shall be registered with one decimal.

For the free-hanging swing, it shall be secured that the seat surface is perpendicular to its suspension devices when the swing is released.
It shall also be secured that the swing performs a continuous pendulum motion without slack in the suspension devices and without the seat swaying in any direction.

Before each individual impact, it shall be secured that the test-mass is at complete rest and that it is correctly 3-axially adjusted.

Pilot study

Prior to the start of each series of measurement, it shall be secured that the intended point of impact is achieved: Mark the centre of the test-mass, (+), with a suitable marker (chalk) so that an imprint is obtained on the impact surface of the seat.
Check and, if necessary, make fine adjustments of the test mass in the vertical and horizontal directions. Repeat the procedure until repeatability has been obtained for the intended point of impact.

Testing

When all adjustments have been made and everything is set for the respective test series, measurements and documentation of each set-up shall be made in accordance with points A-F in enclosure 1 pages 2 - 5.

For each impact and test-series, the registered peak acceleration shall be read on the computer and be recorded in the test-result sheet (will be supplied by SMP).
Each impact shall also be saved in the computer under individual file-names (will be carried out by SMP).

All deviances such as "impure" or "slanted" impacts or any other indications that the impact has not been correctly carried out shall be noted in the test-result sheet.

In order to avoid that the marking used for measurement of impact-surface (series II, seat 2) will influence the result, chalk shall be used as marker.

Detailed test procedure

Procedure

- Adjust the swings according the instructions above
- Suspend the swing with the means of suspension that has been supplied with the swing and at the maximum height that these permit
- Suspend and adjust the test mass so that the contact points of the swing element and the centre of the ball are in the same horizontal plane as the centre of gravity of the test mass
- Raise the seat along its arc of travel until the side view projection of a straight line through the pivot point and index mark, forms an angle of 60 degrees to the vertical. Release it so that the swing element collides with the test mass

Support and release of seat
Support the seat in the raised position by a mechanism that provides release without the application of external forces which would disturb the trajectory of the suspended member. Ensure that the seat and suspending elements are motionless. Release the seat so that the assembly travels in a smooth downward arc without any visible oscillations or rotations of the seat which would prevent it from striking the test mass at the impact point.

Surface compression
The exposed impact area (the area of the seat that has made contact with the test mass) shall be measured by applying chalk to the test mass and by measuring the coloured (chalked) surface on the swing element after the impact. Use a transparent celluloid-film (such as that used for OH-projectors) in order to make a copy of the impact-area. Thereafter, place a "millimetre-paper" under the film and calculate the exact area.

Seat elements

9 mm foam plastic

10 mm rubber

1

14 mm foam plastic

10 mm rubber

2

3a

3b

10 mm rubber

10 mm rubber

10 mm rubber
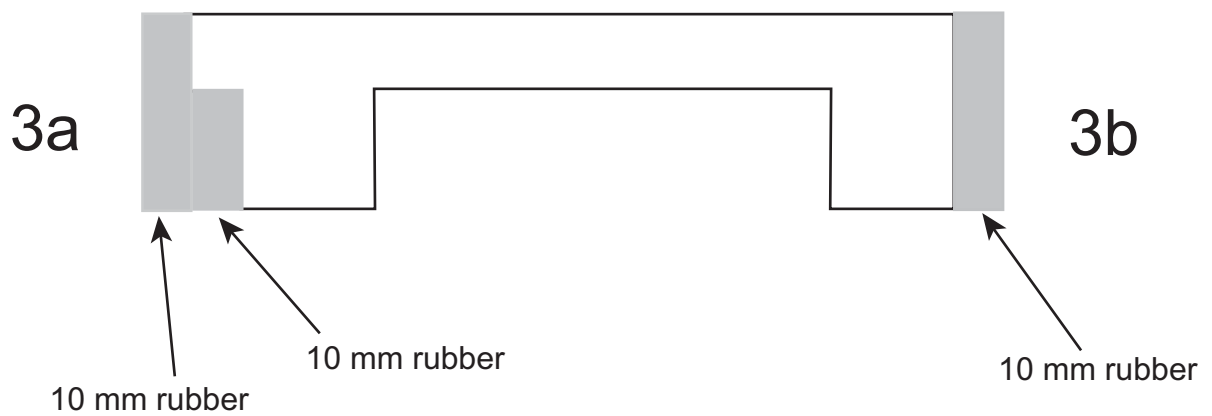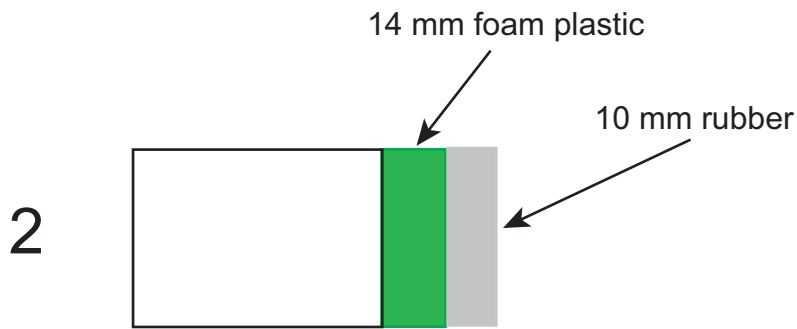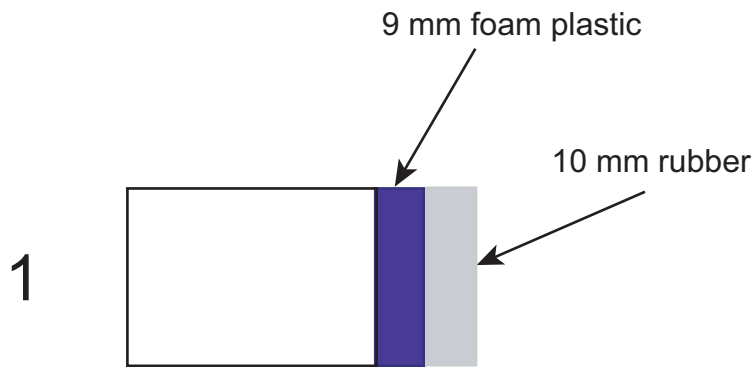
Double-seat swing

Seat 1
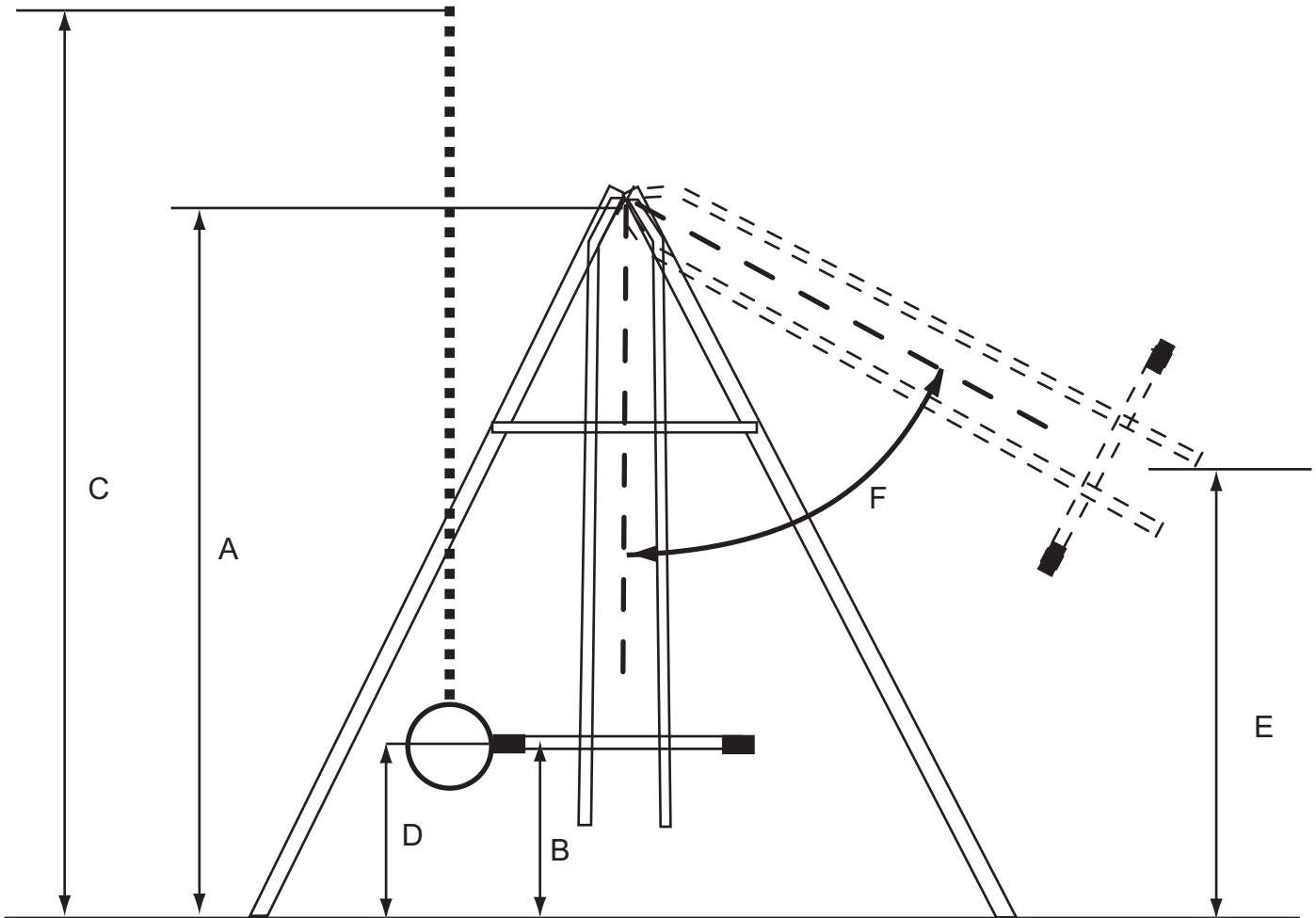
MeasurementsA

A	B	C	D	E	F
mm	mm	mm	mm	mm	degree

Double-seat swing

Seat 2
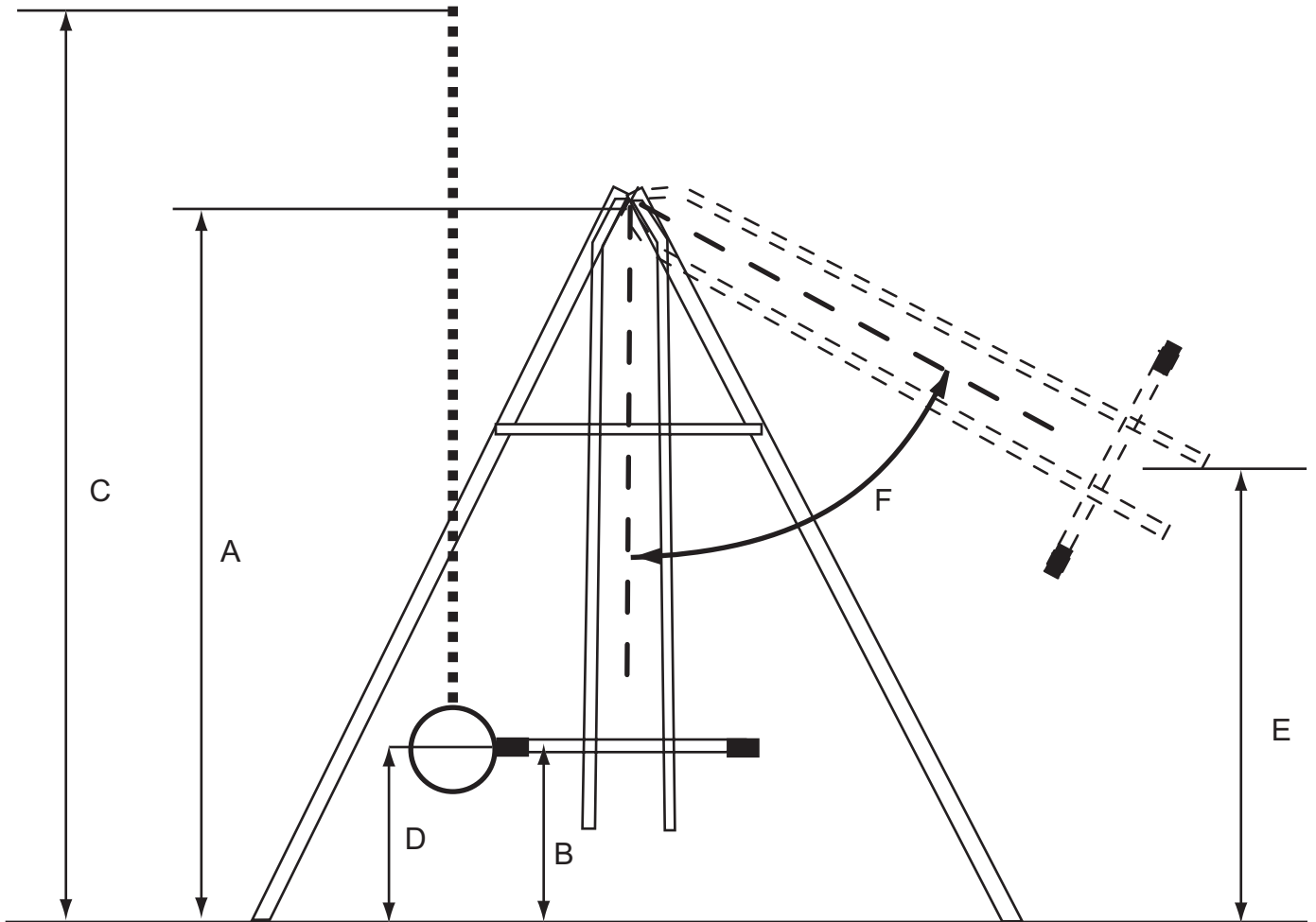
MeasurementsAppendix 2 -

A	B	C	D	E	F
mm	mm	mm	mm	mm	degree

Single-seat swing

Seat 3b
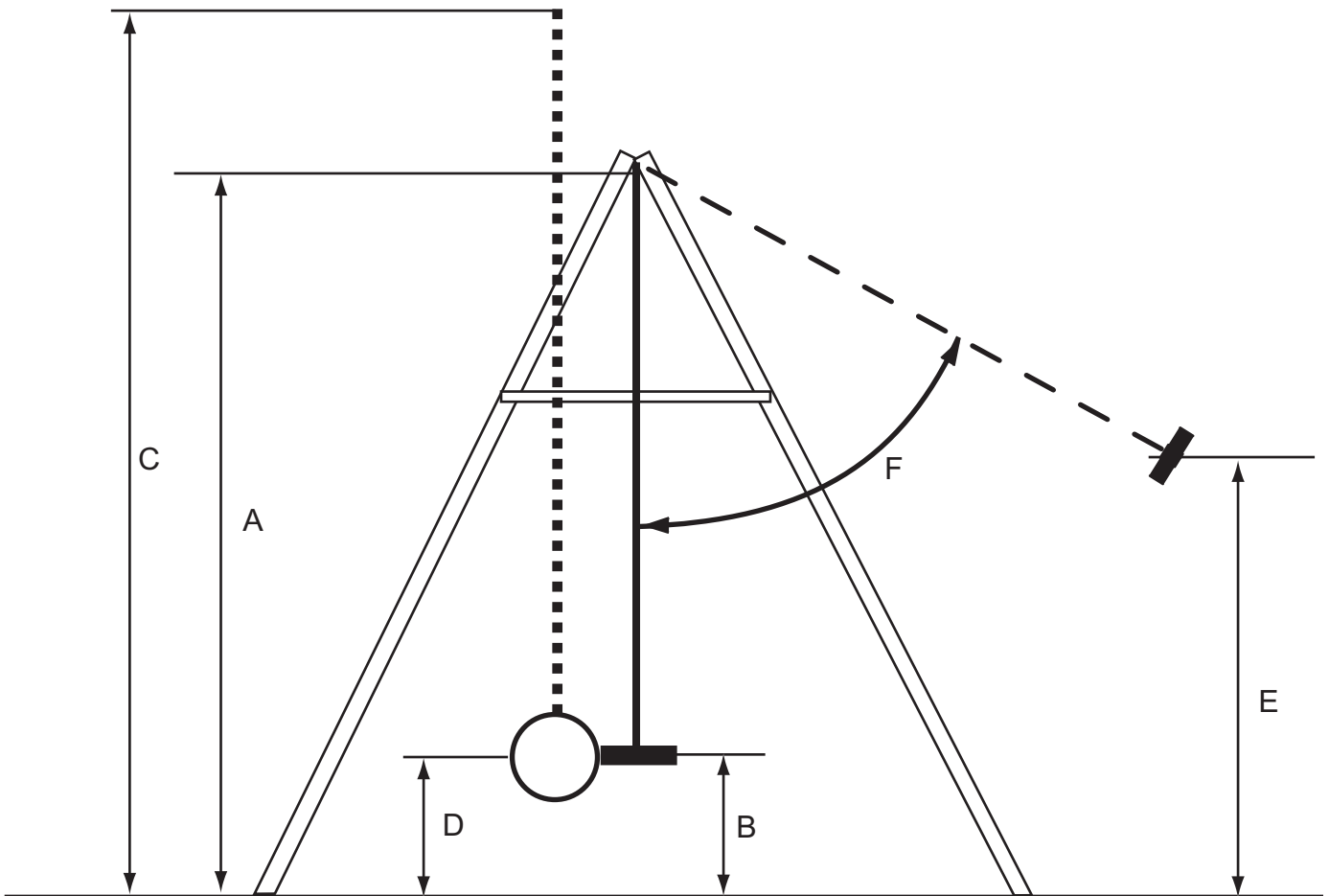
Measurements

A	B	C	D	E	F
mm	mm	mm	mm	mm	degree

Single-seat swing

Seat 3a
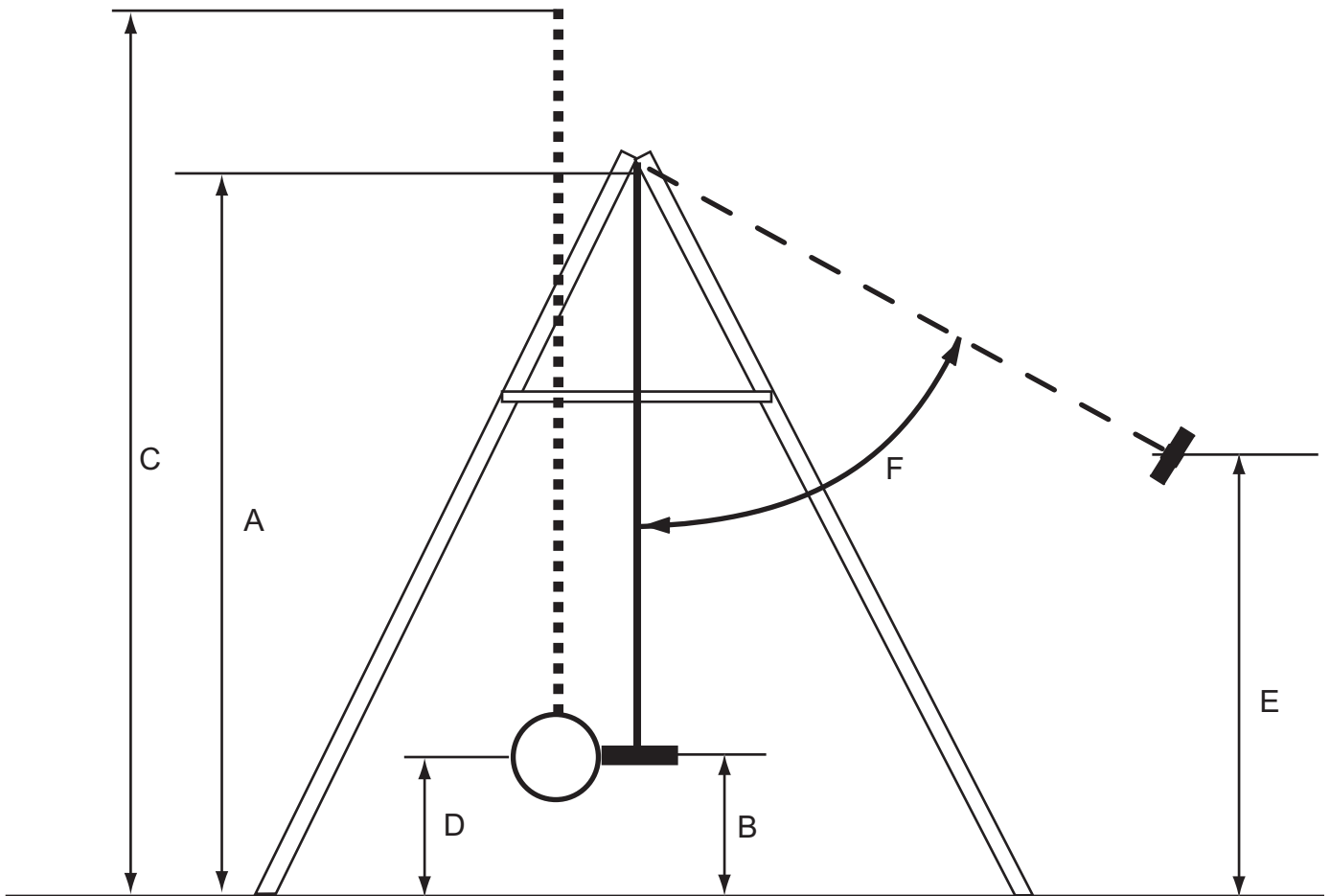
Measurements

A	B	C	D	E	F
mm	mm	mm	mm	mm	degree

REPORT

G1/2005
June 2005

EVALUATION AND VALIDATION OF TEST-METHODS AND REQUIREMENTS REGARDING IMPACT FROM SWING-ELEMENTS

CONTENTS

1. Summary

In connection with a decision in CEN/TC 52 to delete the requirement and test method for "impact from swing elements" from EN 71-8, a task group was asked to look at the requirements and test methods, including a comparison with EN 1176, and validate the test methods and thereafter, if appropriate, propose TC 52/WG 3 to include the method in EN 71-8. This report is part of the group's task.

The project was carried out by SMP Svensk Maskinprovning in Sweden and also included a visit, discussions and some tests at Dansk Teknologisk Institut in Denmark. At SMP some 50 tests were carried out in order to gain an overall impression of the repeatability of the method and to identify factors that have an affect on the test results.

Conclusions from the discussions and tests are (regarding EN 71-8):

- several improvements to the test method can be made. This will greatly reduce the variation in test results from different laboratories (this conclusion applies also to EN 1176-2)
- a more precise text and/or a theoretical calculation regarding exemption of certain light swings, which do not have rigid means of suspension, would be helpful in assessing which swings need to be tested. However, if the requirement for surface-compression is introduced in EN 71-8, such a calculation must be combined with an assessment of the impact area
- having made these improvements to the method, it should be possible to validate it by performing round-robin tests according to the revised method at a couple of European test-laboratories and thereafter, if the results are satisfactory, to reintroduce the requirement and method in EN 71-8
- it ought to be possible to design also double-seated swings with rigid means of suspension that pass both the g-value requirement and the surface-compression requirement. This, however, requires resilient material in the seat or in a covering of the seat as well as increased impact area. If it is not possible to adapt these types of swings to the requirements it should be questioned whether they are to be considered safe in the meaning of the toy directive

Furthermore, it is noted in the report that during the revision of EN 1176-2, hardly any changes have been proposed or made to the requirements and test methods regarding impact from swing elements.

In Annex 2 to this report, a revised text for the test method and requirements is presented. It is proposed that this Annex 2 is used as a basis for a round-robin test on a voluntary basis, involving e.g. 3 test laboratories from different European countries.

2. Background

In EN 1176-2 *"Playground equipment – Part 2: Additional specific safety requirements and test methods for swings"* requirements and test methods for "impact from swing elements" are given. The requirements and test methods for swing-seats, with an exception for the requirement regarding surface compression, in 1176-2 were copied into the EN 71-8 *"Safety of Toys – Part 8: Swings, sides and similar activity toys for indoor and outdoor family domestic use"* before the publication of this standard in December 2003.

However, the requirements and test methods were questioned by many experts in CEN/TC 52/WG 3 "Safety of Toys – Mechanical and Physical Properties" arguing that the test method had not been validated. At a CEN/TC 52-meeting in Stratford-upon Avon in the following resolution was therefore adopted:

> **Resolution No 113 (Stratford-upon-Avon, UK, March 2004)**
> *Re: Impact from swing elements in EN 71-8*
>
> *The experts present decided to propose TC 52 to register a new work item according to the UAP procedure proposing to delete clause 4.6.4 "Impact from swing elements" and 6.4 "Determination of impact from swing elements".*
>
> *A task group with experts from Italy (Natale Consonni), Sweden, France, the Netherlands and Germany (Armin Hensel) will look at the requirements and test methods, including a comparison with EN 1176, and validate the test methods. If appropriate they will then propose WG 3 to include this in EN 71-8.*
>
> *The group will choose a convenor among the participants.*

Christian Wetterberg, Sweden, has later been appointed convenor of the group.

I order to carry out the work of the task group an application for financing of a small project, involving Swedish and Danish test institutes was sent to the Nordic Council who approved the application. The aim of the project was to apply the present test method at two laboratories, one in Denmark and one in Sweden, with the aim to identify any unclear parts of the standard text and thereafter, if possible, to propose improvements to the method.

3. Studies of standards and documents

3.1.   Comparison of existing standards

An introductory, theoretical comparison of three standards that include impact-tests for swing elements was made: EN 1176-2, EN 71-8 and ASTM F1148-3. The comparison shows that there are discrepancies between the methods/requirements in the standard. It is notable that the full text from EN 1176-2 has not been implemented in EN 71-8 which is unfortunate since the method is then less precise than the already criticised method in EN 1176-2. On the other hand, the fact that a method for testing impacts from swing-elements has been incorporated both in the American standard for home playground equipment and in the European standard for playground equipment indicates that swings do present a hazard for those children who play in the vicinity of swings that are in use. The comparison also shows that there is room for improvements in the text of the test-method in EN 1176-2. A summary of the comparison is given in Annex 3 of this report. It should be noted that ASTM only covers "single-seat swings" and that EN 71-8 covers also swings for use by more than one child (since they are not specifically exempted).

3.2. Previous discussions regarding EN 1176-2

In connection to the discussion which preceded the adoption of the above resolution No 113, it was also argued that the corresponding requirement and method in EN 1176-2 had been questioned in the responsible committee: CEN/TC 136/SC 1. This is confirmed in two reports from meetings with CEN/TC 136/SC 1:

A. Document CEN/TC 136/SC 1 N 459, dated October 30, 2001:

Swing Seat Impact Test
In 1998 a round robin test was carried out by WG2 to check the consistency of swing seat impact tests. There was found to be a wide variation in results between test houses 34% in the worst case. At a meeting of WG2 in July 1999 it was decided that work should be done to try and make the test more consistent, however with no funding available for test houses to do this work no further progress since that date has been made. The opinion of the leader of WG2 Robin Sutcliffe, is that since the introduction of these tests by DIN and BS there have not been any recorded accidents resulting from impact with swing seats, therefore the need to fund further work does not seem urgent. If SC1 do wish to proceed they will need to obtain funding.

B. Document CEN/TC 136/SC 1 N 469, dated December 16, 2001, clause 7.2 b:

Swing seat impact test
Mr Brady referred to N459 and noted that if further impact tests were required there was a need for some funding. Mr Jensen stated that test houses should ensure that their equipment was in good working order. Mr Settelmeier noted that different results could be obtained if the chain and/or the head forms were changed. There were now a set of 10 tests. Mr Danner stated that although the round robin tests in the early days had shown up big differences, it was much better now. It was agreed that a better defined reproducible test method should be developed during the revision of the standard.

It seems that two conclusions can be drawn from the text in the above documents:

1) When the impact test was introduced by DIN and BSI the number of accidents were reduced
2) It is important that the test method is followed in detail in order for reproducible results to be obtained.

3.3. Revision of EN 1176-2

EN 1176-2 is presently (2005) under revision and a first draft has been issued. In this first draft only one change of importance has been proposed with regard to the requirements and methods regarding impact from swing-elements. The proposal is that the resulting "Peak-acceleration" shall be calculated as the mean value of 10 peak-acceleration measurements. In the present version of the standard the peak acceleration shall be calculated as the highest reading from any of the 10 performed tests.

The fact that the method itself has not been revised in this first draft indicates that the methods and requirements for determination of impact from swing-elements for playground-swings are at present considered to be acceptable and repeatable.

4. Practical evaluation

Personnel from SMP visited Dansk Teknologisk Institut (DTI) in Århus, Denmark on February 16, 2005. DTI has long experience from impact-testing according to EN

1176-2 and is of the opinion that the method gives reproducible results provided that the method is followed.

During the visit, impact-tests were performed both according to EN 1176-2 and according to EN 71-8 and the methods were discussed in detail. The basis for the discussion was the method specified in EN 1176-2 in Annex B since this is the "original" method, of which parts have been copied into EN 71-8.

In addition, several practical tests were performed at SMP's test laboratory at Alnarp outside Malmö, Sweden, with the ambition to pin-point any unclear passages of the text in the standard and also to evaluate the parts of the testing procedure that will have the greatest effect on the results.
The following was noted after the above visit, discussions and tests:

- <u>EN 71-8 Exemption of swings < 2 kg *and* made of resilient material</u>

The 2 kg limit is set for the swing-element only (the seat itself) but since the standard contains no definition of resilient material it is difficult to know which swings to exclude from the requirements. The reason for the lack of a definition of resilient material is probably that it requires a test to determine whether a material is resilient or not.

A possibility to clarify which swings to exempt would be to make a theoretical calculation using formulae for "ideal impact" and to exempt swings that, according to the calculation, cause a lower g-force than 50 g.

The speed of the swing-seat at the moment of impact will be directly related to the height from which it is dropped (the potential energy will in the ideal situation be fully converted to kinetic energy). Since the swing is raised 60 degrees and co sinus 60 is 0,5 the drop height will be equal to 0,5 x "length of suspending ropes/chains".

Since $g \times h = v^2/2$ the speed at the moment of impact will be the square root of ($2 \times g \times h$). Since, in an ideal case, $m_1 \times v_1 = m_2 \times v_2$ and since the mass of the test mass is known, the speed of the test mass v_2 can be calculated as $(m_1 \times v_1)/m_2$.

Tests at SMP indicate that the time from impact until the peak acceleration of the test mass is reached can typically be in the range of 1,2 to 1,8 ms. Since $a = v/t$ the acceleration at an impact time of e.g. 1,5 ms can be calculated and divided by 9,8 in order to obtain the theoretical g-force as (see Annex 4 for detailed calculations):

The calculations in Annex 4 show that swings with a mass of less than 1 kg should be tested since at this mass the theoretic g-force will exceed 50.

Formula used: $g = m_1 \times 45 \times$ Square root ($length_{suspension}$)

In order to check that the requirement for surface compression is also fulfilled, the theoretical g-value from the calculation can be used to calculate the theoretical necessary impact surface.

The requirement is that the force per cm^2 shall be 90 or less.
$F = m * a$ and,
$a = 10 * g$
$m = 4,6$ kg
thus, the minimum impact surface shall be $F = (4,6 \times 10 \times g)/90$ which means that the surface shall be at least $0,5 \times g$ cm^2.

Thus, if g is 50 the impact surface must be 25 cm². If the impact area is assessed to be smaller, the swing will have to be tested regardless of its weight.

Proposal: *Exempt swings for which documentation shows that the calculated g-force is lower than 50 and the surface compression is lower than 90 when the above calculations are made.*

- EN 1176-2, B. 2.2 Test mass

It is not stated in the standard whether a balanced semi-sphere is accepted as a test mass (see example in figure to the left), only that it should be a ball.
In practice this semi-sphere is commonly used as test mass since it allows placing of the accelerometer in the centre of gravity of the test mass. The important part of the specification is that the impacting part between the surface struck and the accelerometer shall be homogeneous and free from voids.

With regard to the requirement for a very high accuracy of the mass of the test-body (± 0,05 kg) it should be specified whether the accelerometer and any wires shall be included or excluded.

Proposal: *Change the specification in order to allow for a balanced semi-sphere to be used as a test mass, provided that it fulfils the requirements regarding mass, dimension of the spherical part, and a homogeneous impacting part. Specify also that the mass shall be within the tolerance when the accelerometer is mounted and that any wires to the accelerometer shall be mounted so that the effect on the mass of the test mass is minimised.*

- EN 1176-2, B 2.3 Accelerometer and B 3.7 Peak acceleration

It is stated in B 2.3 that the accelerometer shall be capable of measuring acceleration triaxially. However, it is not stated in the B 3.7 how the peak acceleration shall be calculated. It can be presumed that the acceleration from one impact shall be calculated as the root-mean-square of the accelerations in the three directions. If not, there is no meaning in requiring an accelerometer which measures triaxially.

Furthermore, the proposed change in the first draft for the revision of EN 1176-2 (that the peak acceleration shall be calculated as the mean value of the 10 measurements rather than the highest value of the 10 measurements) has a vital influence on the results. Tests show that the mean value from 10 impacts can differ e.g. 15 % from the highest single value. Since there is a risk that the material in the swing seat is gradually affected by the impact tests, the results may also change. Having regarded the fact that in 4.6.1, it is stated that *"there shall be no peak values of acceleration greater than ......"* it does not seem correct to start using the mean value when checking fulfilment of this requirement. The requirement for the surface compression, however, is *"the average surface compression shall not exceed....."* which is contradictory with the philosophy that the peak value shall be registered.

Proposal: *Clarify that the peak acceleration from one impact shall be calculated as the root-mean-square of the highest values in each direction of measurement, and*

that the highest value from the 10 calculated root-mean-squares shall be used when checking fulfilment of the requirement.

- EN 1176-2, B 2.5 Chains

The requirement for chains "two 6 mm gauge" is not completely clear. It could mean either that the chain links should have a thickness of material of 6 mm, or that the inner or outer dimension of the chain-link should be 6 mm or that the partition shall be 6 mm. From a testing point of view, the important thing is not the dimension chosen but rather that the specification is unambiguous.

The specification in EN 1176-2 is clear regarding how the chains shall be placed and that they shall both connect to the point of connection such that the chains form the letter "V". However, this specification has not been included in EN 71-8.

Proposal: *Clarify that the chain links shall have a thickness of material (diameter) of 6 ± 0,5 mm and an outer major dimension of 47 ± 2 mm.*

- EN 1176-2, B 3.1 and B 3.2 Flat swing seats and cradle seats

The means of suspension will affect the result from an impact-test. In EN 1176-2 the text is confusing since in B 3.1 and B 3.2 it is stated that the swings shall hang on 6 mm chains (i.e. not necessarily be suspended by the means of suspension that have been supplied with the swing). However, in Note 1, it is left open whether the swing is suspended by chains or ropes and the impression is therefore that the test can be performed with whatever the swing has been supplied with.

For activity toys it is probably best to perform the test using the means of suspension that is supplied together with the swing since they are seldom equipped with 6 mm gauge chains.

It should also be specified that the swing shall hang at the maximum height permitted by the means of suspension delivered by the manufacturer.

Note: EN 71-8 specifies that the suspended length of the swing device shall be 1 800 mm or as given by the manufacturer. It must be presumed that the length of the suspension connectors of the test mass shall be of approximately the same length but adjusted so that the point of contact will be correct.
In EN 1176-2, the suspended length of the swing device is not specified

Proposal: *Clarify that the tests shall be performed when the swing is suspended with the means of suspension that has been supplied with the swing and at the maximum height that these permit.*

Another confusing text is that of Note 3. It is allowed to use a brace if the seat material is of a flexible nature. Furthermore, this brace must not have a mass exceeding 10 % of the mass of the seat after test.

This text raises two questions:

1. Is it correct to allow an increase of the mass of the swing seat by adding a brace (a 10 % increase of the mass will affect the result)?
2. Is the mass of the swing expected to change during the test? If not – then why is the comparison between the mass of the brace made with the mass of the seat after test?

Proposal: *Delete the words "after test" in Note 3. Add in the Note that if a brace is used the requirement for maximum 50 g may be increased by the same percentage as the mass increase caused by the brace (which is max 10 %).*

- EN 1176-2, B 3.8 Surface compression

It should be noted that this part of the method has not been included in EN 71-8. The standard is not clear on this point. It must be presumed that the surface compression shall be calculated as the force/area as measured on the test mass (the child's head/body, which in B 3.9 is inaccurately called the test weight). Therefore, the force F should be calculated as:

$F = m \times a$

where *m* is the test mass (4,6 kg) and
where *a* is the peak acceleration measured at the 10 impacts.

Furthermore, the surface (area) used in the calculation (F/A where A is the area) should be the exposed area of the test mass which has been hit by the swing. For practical reasons, this area may be measured on the swing seat, for example by colouring the test mass and thereafter measuring the coloured area of the swing seat. It is of great importance that this measurement is made accurately, for example by using millimetre paper.

In EN 1176-2, 4.6.1, it is stated that the peak value of the acceleration shall be used for checking fulfilment of the impact-requirement but that the *"average surface compression"* shall be used for checking fulfilment of the surface-compression requirement.
Since this is not very clear it would be better to specify that the area used in the calculation shall be the average of two measurements made when the geometric centre of the seat hits the test mass. This is further explained below under the point *"Contact point of test mass and swing seat"*.
The figure in EN 1176-2, B 3.9 shows a flat seat when raised to the 60 º position. It could be a help if the figure also showed a double-seat swing raised to the 60 º position.

Proposal: *Clarify in B 3.8 how the exposed area shall be measured and that the compression shall be calculated as F/A where F = m * a, where "m" is test mass and "a" is the peak acceleration of the test mass in a single impact test.*
Specify that the area shall be measured twice when the geometric centre of the leading edge of the swing seat hits the test mass (see also "Contact point of test mass and swing seat"). Complete the figure in B 3.9 with a double-seat swing raised to the 60 º position.

- EN 1176-2 and EN 71-8, Accuracy

It is not clear with what accuracy the various measurements shall be made. In EN 71-8, for example, the requirement is that the impact shall not exceed *"500 m/s² (or 50 g)"*. If g is set to 9,81 m∕s², 50 g corresponds to 490 m/s².

Proposal: *Clarify, where necessary, the required accuracy of measuring equipment and measurements.*

-

<u>EN 1176-2 and EN 71-8 Contact point of test mass and swing seat</u>

It should be obvious to all testers that the swing seat shall hit the test mass at a point which lies along a horizontal line through the centre of gravity of the test mass (even though the text in EN 1176-2, B 3.3 is not very clear).

It is, however, not clearly specified which part of the swing seat that shall hit this point of the test mass. The leading edge of the swing seat will always have a certain height and tests show that the results can vary up to 10 % depending on the height adjustment of the swing. It would therefore seem logical to perform the first two impact tests so that geometric centre of the leading edge hits the test mass, and thereafter to adjust the height of the test mass during the remaining 8 impact tests so that the tests cover also the most onerous point (highest g-force) of impact on the swing seat.

When assessing the surface compression it would be appropriate to use the average area measured during the first two impact test, i.e. when the geometric centre of the leading edge hits the test mass.

Proposal: Specify *that:*
- *during the impact-measurements the first two tests shall be performed with the seat adjusted so that the geometric centre of the leading edge hits the test mass at a point along the horizontal line through the centre of gravity of the test-mass*
- *that the average impact area measured during this two tests shall be used for calculation of surface compression*
- *that the remaining 8 impact tests shall be made with the test mass adjusted to various height so as to cover the most onerous (highest g-value) point of impact on the swing seat*

- <u>EN 1176-2 and EN 71-8 Impact from other parts of the swing</u>

It should be noted that for, for example, a double-seat swing (as shown in the figure) also other parts than the seat could hit a passing child. The foot-rests, for example, would present a higher risk of injury than the seat itself since the material is non-resilient and since the area of contact is much smaller.

Proposal: *No action at present but should be discussed for the future. Perhaps a requirement for resilient, protective material on parts that could hit a child could be appropriate?*

5. Discussion and conclusions

At SMP, some 50 impact tests have been carried out on a flat-seat swing and a double-seat swing, both for domestic use. The tests did not aim specifically at determining the impact (g-force) for the individual samples, but rather to give an

overall impression of the repeatability of the method and to identify factors that have an affect on the test results. Therefore, the data from the tests have not been included in this report.

It was quite clear from the tests that the flat-seat swing caused g-forces which were well below the requirement (approximately 10- 15 g). The seat weighed 300 g but since it was not clear whether the material was to be considered as "resilient" the swing was considered to be encompassed by the requirements in EN 71-8. The double-seat swing weighed 3 780 g including the two rigid suspension connectors.

A type of swing which probably more often fails the requirements in the impact tests is the double-seat swing. The measured g-value in tests with the double-seat swing varied from approximately 50 g to 80 g depending on the height adjustment of the seat.

A general opinion that has been expressed by experts in the field is that the above type of double-seat swings will always fail the impact test. However, the tests at SMP show that the result is highly affected by the type of material in the seat. In order to study (on a very basic level) the effect of various resilient materials, three different types of rubber-material were fastened to the leading edge of the seat and the tests were repeated.
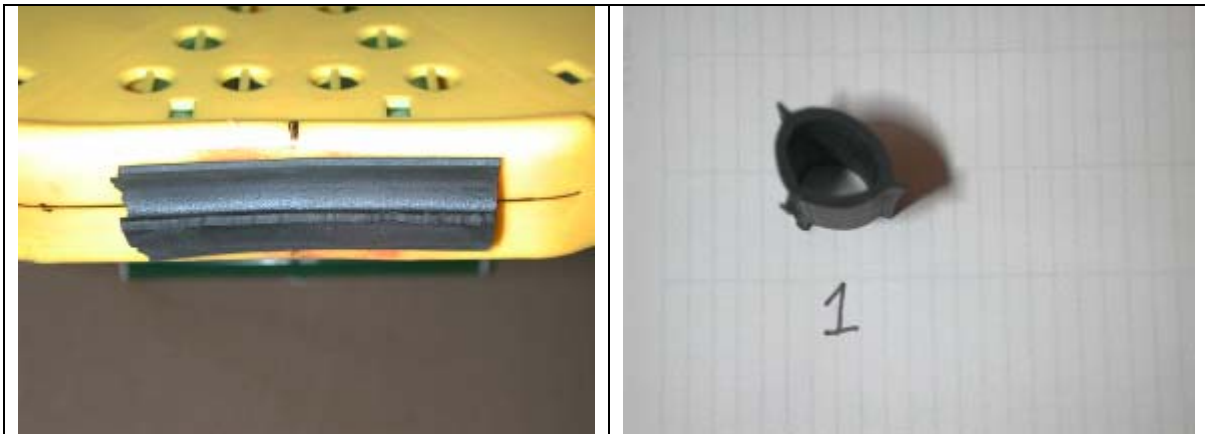
1. Rubber-strip from truck-door
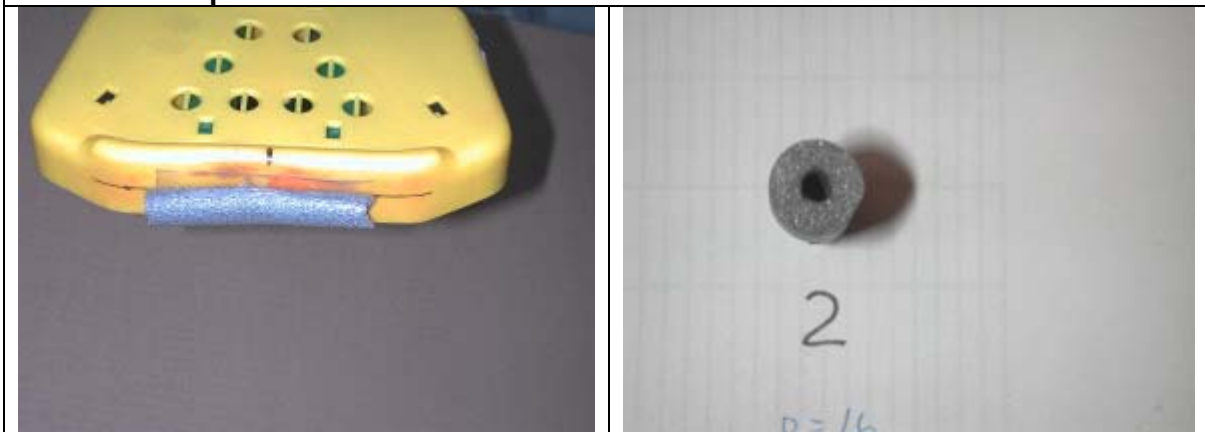
2. Strip of foam-rubber

3. Fabric-reinforced hose for compressed air

The results showed that the average g-values were affected as follows:

Resilient material	Average g-value
None	74
Rubber-strip from truck-door	58
Strip of foam-rubber	57
Fabric-reinforced hose for compressed air	34

These simple experiments show that the g-value can be significantly reduced if a more resilient material is used for the seat or at least for the edge of the seat.

On the other hand, since the exposed impact area of the seat (without addition of resilient material) was approximately 8 cm^2, a reduction of the g-force to 35 will not be enough to fulfil the requirement of max. 90 N/cm^2 surface compression. Given that the exposed impact area remains the same for a resilient seat, the impact area would need to be at least approx. 16 cm^2:

F = m * a where,
m = 4,6 kg, and
a = 9,81 * 35
thus, F = 1 579 N and 1 579/90 = 15,5 cm^2.

If the total weight of the swing cannot be reduced (in order to achieve a further reduced g-value) the seat would need to be more resilient and the impact area would need to be increased if both requirements are to be fulfilled (g-value and surface compression).

Some conclusions regarding swings for domestic use:

- several improvements to the test method can be made. This will greatly reduce the variation in test results from different laboratories (this conclusion applies also to EN 1176-2)
- a more precise text and/or a theoretical calculation regarding exemption of certain light swings, which do not have rigid means of suspension, would be helpful in assessing which swings need to be tested. However, if the requirement for surface-compression is introduced in EN 71-8, such a calculation must be combined with an assessment of the impact area
- having made these improvements to the method, it should be possible to validate it by performing round-robin tests according to the revised method at a couple of European test-laboratories and thereafter, if the results are satisfactory, to reintroduce the requirement and method in EN 71-8
- it ought to be possible to design also double-seated swings with rigid means of suspension that pass both the g-value requirement and the surface-compression requirement. This, however, requires resilient material in the seat or in a covering of the seat as well as increased impact area. If it is not possible to adapt these types of swings to the requirements it should be questioned whether they are to be considered safe in the meaning of the toy directive

ANNEXES

1. Pictures from impact test of a double-seat swing with rigid suspension
2. Proposal for a revised text for requirements and test-methods regarding impact from swing elements
3. A comparison of three standards (EN 71-8, EN 1176-2 and ASTM F1148-3)
4. Calculations
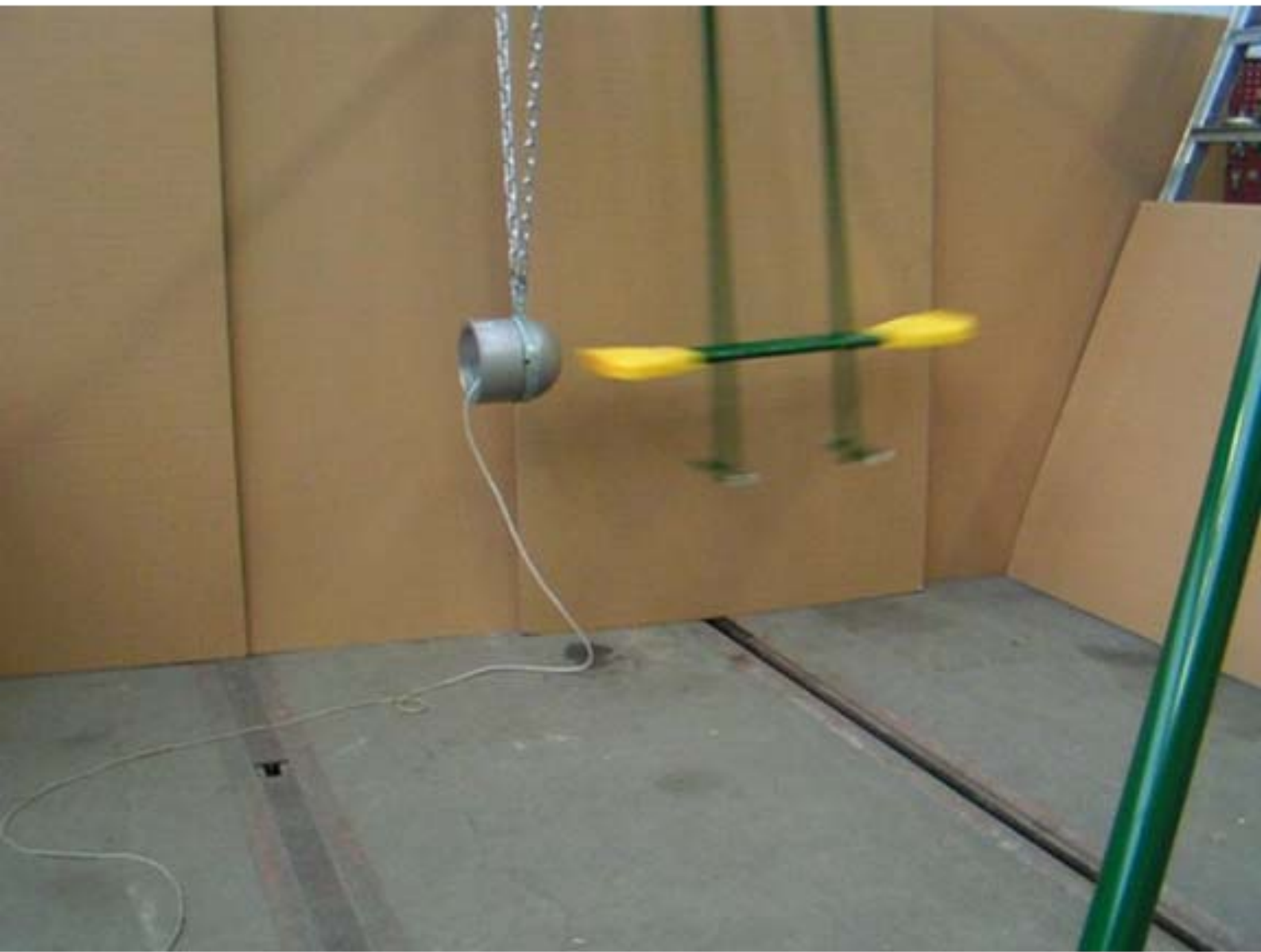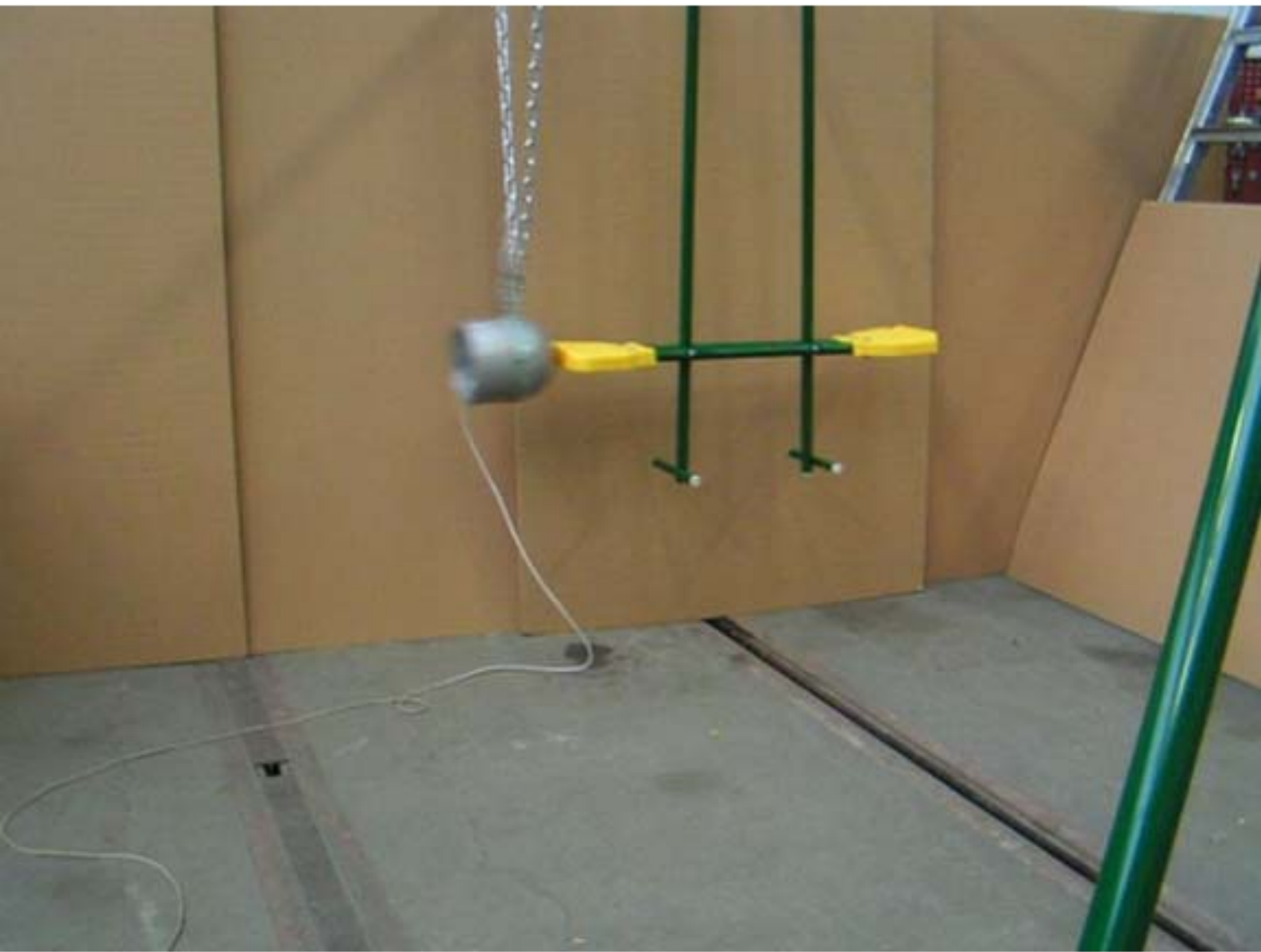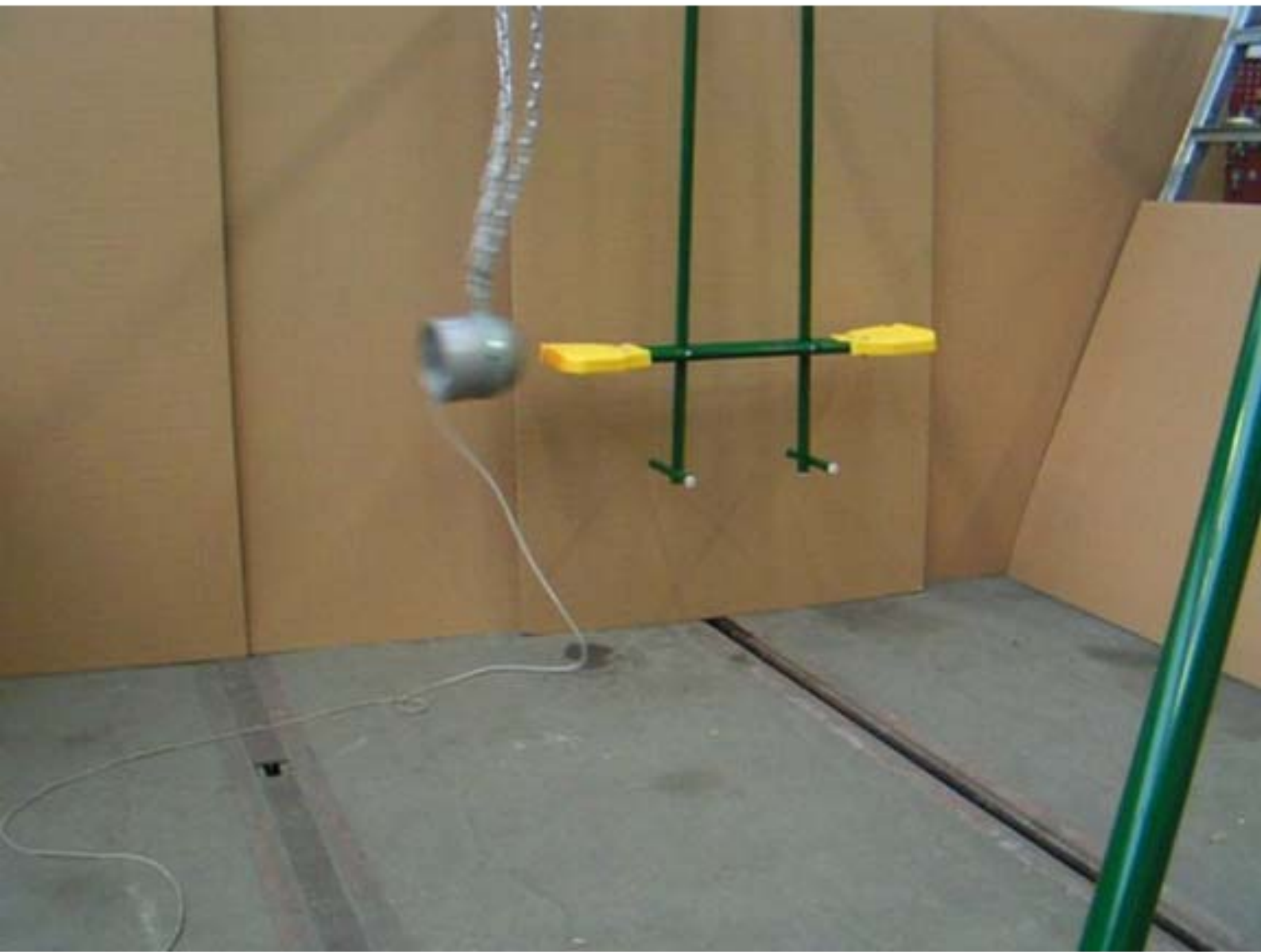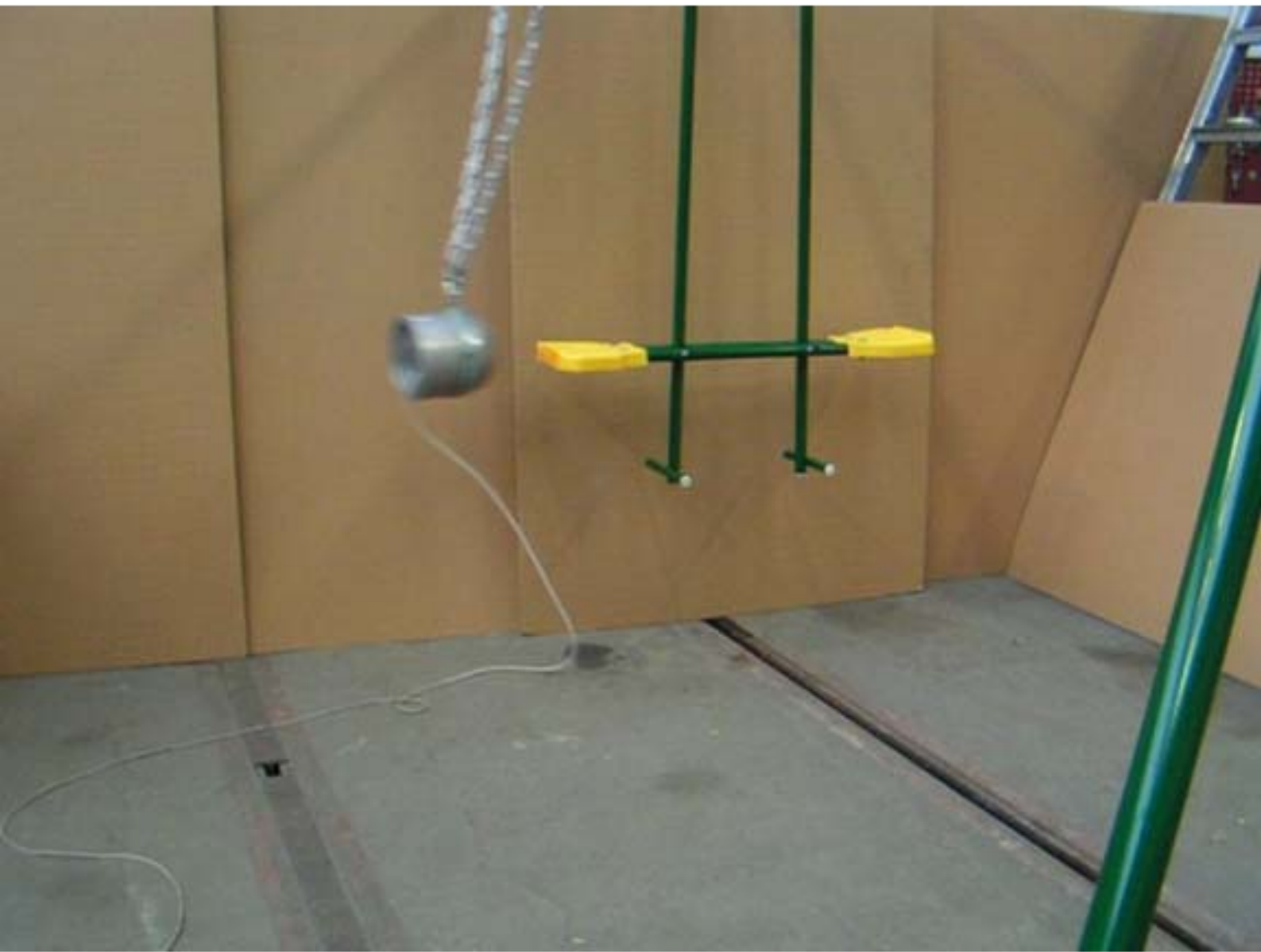
Requirement

X Impact from swing elements

When tested in accordance with Y, there shall be no peak values of acceleration greater than 50 g, measured with a cut-off frequency of 10 kHz, and the average surface compression shall not exceed 90 N/cm^2.

The requirements do not apply to swing elements for which the theoretical impact is < 50 g, when calculated as below, and for which the estimated impact surface in cm^2 is > 0,5 g (where g is calculated as below and where the impact surface is visually estimated;

$g = m_1 \sqrt{L} \cdot 45$, where m$_1$ is the mass of the swing element and where L is the length of the means of suspension.

Test method

Y. Method for determination of impact from swing elements

Principle

Swing seats are raised and allowed to swing to strike a test mass. The signal emitted by an accelerometer during each impact is processed (cut-off frequency 10 kHz) to determine the peak value of acceleration and the surface compression.

Apparatus
- Test mass, consisting of an aluminium sphere or semi-sphere of radius 80 mm ± 3 mm, and a total mass (including accelerometer) of 4,6 kg ± 0,05 kg. The impacting part between the surface struck and the accelerometer shall be homogeneous and free from voids. Cables connected to the accelerometer shall be placed in such a way that the effect on the mass of the test-mass is minimized

- Accelerometer, mounted at the centre of gravity of the test mass assembly with the sensitivity axis aligned to within 2° of the direction of travel of the test mass, capable of measuring acceleration triaxially with an accuracy of ± 2 %.

- Chains, two chains where the chain links have a thickness of material (diameter) of 6 ± 0,5 mm and an outer major dimension of 47 ± 2 mm. The chains shall be of equal length suspended from pivots 600 mm apart at the same height as the suspension connectors, such that they meet at the point of connection to the test mass.

Procedure
- Suspend the swing with the means of suspension that has been supplied with the swing and at the maximum height that these permit
- Suspend and adjust the test mass so that the contact points of the swing element and the centre of the ball are in the same horizontal plane as the centre of gravity of the test mass
- Raise the seat along its arc of travel until the side view projection of a straight line through the pivot point and index mark, forms an angle of 60 degrees. Release it so that the swing element collides with the test mass
- Record the peak acceleration and (for the first two tests) the exposed area of impact.
- Repeat the test so that a total of 10 tests have been performed and record the peak acceleration as the highest reading from 10 impacts
- Determine whether the toy still complies with the relevant requirements of EN 71

NOTE 1: When the seat is suspended from ropes or chains etc, some curvature will be produced in the suspending elements. Adjust the seat position to determine the curvature which provides a stable trajectory.

NOTE 2: Caution should be exercised to prevent damage to the test equipment. Where there is any possibility of the accelerometer range being exceeded, preliminary tests should be made at lower angles (e.g. 10 , 20 and 30 degrees). If there is doubt concerning the seat trajectory or stability, the test mass and/or guidance structure trial releases should be made without impacting the test mass.

NOTE 3: Some seats of a flexible nature will require a brace to maintain the seat configuration during the test procedure. The mass of brace should not exceed 10 % of the mass of the seat. If a brace is used, the requirement for maximum 50 g may be increased by the same percentage as the mass increase caused by the brace (max 10 %)

Support and release of seat
Support the seat in the raised position by a mechanism that provides release without the application of external forces which would disturb the trajectory of the suspended member. Ensure that the seat and suspending elements are motionless. Release the seat so that the assembly travels in a smooth downward arc without any visible oscillations or rotations of the seat which would prevent it from striking the test mass at the impact point.

Impact tests
Once satisfactory system operation and calibration are obtained, collect data from ten impacts.
The first two impact tests shall be performed with the seat adjusted so that the geometric centre of the leading edge hits the test mass at a point along the horizontal line through the centre of gravity of the test-mass.

The remaining 8 impact tests shall be made with the test mass adjusted to various height so as to cover the most onerous (highest g-value) point of impact on the swing seat

Surface compression
The average exposed impact area (the area of the seat that has made contact with the test weight) shall be measured with an accuracy of ± 5 % during the first two impact tests. The mean of these two measurements shall be used for calculation of surface compression and for checking of fulfilment of the surface-compression requirement.

NOTE: The ± 5 % accuracy can be obtained by the application of colour to the test mass and by measuring the coloured surface on the swing element after the impact. The surface shall be measured using transparent "millimetre-paper".

Calculate the surface compression in N/cm^2 using the formula F/A where F = m * a, and where:
"m" is the test mass (4,6 kg ± 5 %), and
"a" is the highest, single peak acceleration-value measured during the 10 impact tests.

Peak acceleration
Measure the peak acceleration for each impact (total 10 impacts).

The peak acceleration from one impact shall be calculated as the root-mean-square of the highest values in each direction of measurement "SQR (X2+Y2+Z2)". The highest value from the 10 calculated root-mean-squares shall be used when checking fulfilment of the requirement for maximum impact.

Figure: Figure of test set-up to be completed with double swing

"Impact test"

	Angle of travel	Length of members	Test mass			
			Weight and shape	Direction of movement of test mass	Set up/Fixation	Instru-mentation
F1148-3	60 degrees	Max length	<10,5 lb (4,8 kg) Size C acc.to FMVSS No 218	Horizontal	Special carriage/track	Acclerometer
EN71-8	60 degrees	1800 mm +/- 10 mm	Alu. Sphere diam. 160 +/- 5 mm. 4,6 kg +/- 0,05 kg	Radial	Chain (6 mm gauge)	Acclerometer
EN1176-2	60 degrees	2400/1800 mm +/- 10 mm	Alu. Sphere diam. 160 +/- 5 mm. 4,6 kg +/- 0,05 kg	Radial	Chain (6 mm gauge)	Acclerometer

	Requirements/evaluation		
	Requi. for max. accel	Maximum of x measurements	Other requirements
F1148-3 [4]	< 100 G (980 m/s^2)	[2]	
EN71-8	< 500 m/s^2 [1] (50 G) (<10 kHz)	10	
EN1176-2 Swings Type 3: - Flat seats[7] - Cradle seat (seat section)[7] - Superstructure of cradle seat[5],[8] - Platforms (diameter > 90 cm)[6] - Platforms (diameter < 90 cm)[6]	< 50 G < 50 G < 50 G < 120 G < 50 G	10	Calculate the surface compression (N/cm2): [3] < 90 N/cm2 < 90 N/cm^2 < 90 N/cm^2 Unclear if applicable for platforms with diameter >90 cm < 90 N/cm^2

[1] Exception for swings weighing less than 2 kg and made of resilient material unless provided with rigid means of suspension

[2] "If the data for any two of the ten impacts do not meet the requirements", (< 100 G), "the suspended member fails the test "

[3] (Based on the contact area of the seat relative the test mass, the weight of the seat and the measured acceleration F= m x a)

[4] Impact requirements apply to "Single-Occupancy Swings" only (one occupant, two hangers)

[5] Applicable only if superstructure protrudes beyond a vertical line when the seat is tipped at a 30 degree angle

[6] Applicable to "Type 3" swings only (single point swing) if platform is primarily intended for use in a standing position

[7] Chain-length 2 400 mm +/- 10 mm

[8] Chain-length 1 800 mm +/- 10 mm

Other comments

F1148-3 X 1.1.1.2 Misprint in standard (in standard it says 4,8 k**N** instead of k**g**)

EN1176-2 3.12. Unclear which requirements apply if a "type 3 swing" is equipped with seat not primarily intended for use in standing position

4.6. Heading unclear. "(Type 3)" should be deleted since it refers to the word "platform" only and not to "seats".

4.6.2 Unclear (what is "seat section of cradle-seat").

4.6.3 Unclear heading. Are all "Type 3 swing"-seats included or only "platforms". Do 4.6.1 and 4.6.2 apply regardless of the swing-type?

4.6.3 Why is requirement lower for platforms with large diameter? The child´s head does note know the diameter of the platform

4.6.3 Unclear if the surface compression requirement applies to platforms with radius > 90 cm

B.2.3 "Aligned within in 2 degrees of the direction of travel of the test mass". 2 degrees is a very strict requirement (5 degrees in ASTM)

B.2.3 The text states "place accelerometer at c.o.g. of test mass. Figure B.1 shows accelerometer placed at opposite side to impact point

B.3.9 NOTE 3. The allowance for a 10 % extra mass is in fact equal to a 10%-increase of the "surface compression"-requirement

B.3.6 and B.3.9. No method supplied for measurement of the "area of contact" between seat and test weight

General: Cut-off frequency for for registration of accelaration is not specified

EN 71-8 Gondoles are encompassed regardless of their weight since they have rigid means of suspension

In the case of rigid means of suspension, the weight of the means of suspension will affect the result. The 2 kg limit does not take this into consideration.

4.6.4 Procedure and requirements identical to those for cradle seats in 1176-2 apart from the fact that the surface compression is not measured and is not part of requirement. The fact that no surface compression requirement has been set makes the requirement "easier" than that for playground swings since a lower weight (likely for home-equipment) causes lower impact.

Assume that the centre of gravity of the swing coincides with the geometrical centre of the swing seat. In that case the drop height of the mass will correspond to co sinus 60 (= 0,5) of the length of the suspension connectors.

h = cos 60 * L
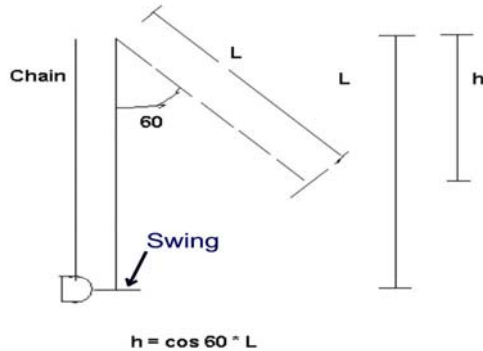
Energy: $mgh = \dfrac{mv^2}{2}$ $\Leftrightarrow$ $v = \sqrt{2g\,0{,}5L}$ $\Leftrightarrow$ $v \approx \sqrt{10L}$ = the speed of the swing at the moment of impact

Ideal impact: $m_1 v_1 = m_2 v_2$. Therefore, the speed of the test-mass after impact will be:

$$v_2 = \frac{m_1 v_1}{m_2} = \frac{m_1 \sqrt{10L}}{m_2}$$

Also: $a = \dfrac{v_2}{2}$ and $g \approx 10$. Therefore, $g = \dfrac{v_2}{10t}$ where t is the time from impact to peak acceleration.

Thus: $g = \dfrac{m_1 \sqrt{10L}}{10 m_2 t}$ m_2 = test mass = 4,6 kg.

         t = 1,5 ms (estimated from practical tests)

Thus: $g = \dfrac{m_1 \sqrt{10L}}{10 \cdot 4{,}6 \cdot 1{,}5 \cdot 10^{-3}}$ $\Rightarrow$ $g \approx m_1 \sqrt{L} \cdot 45$

For surface compression the requirement is that F/ impact surface < 90 N / cm^2

Since $F = m_2 \cdot a$ and $a \approx g \cdot 10$ the minimum impact surface will be $\dfrac{m_2 \cdot g \cdot 10}{90}$ where g is the measured g-value in the test.. Since m_2 is 4,6 kg the surface must be > 4,6 * 100/90 = approx 0,5 g

If the length L is 1,5 metres g will be approx. 50 when m_1 = 1 kg.

The conclusion would be that swings of a mass of less than approx. 1 kg have to be tested. However, even if the mass is less than 1 kg, the swing in question would have to be tested if the estimated impact surface is less than 0,5 (g*0,5) cm^2 (minimum 25 cm^2 if measured g = 50, minimum 12,5 cm^2 if measured g = 25 etc.)

Piezoresistive Accelerometer

Model 7264B

* **Mechanical Overtravel Stops**
* **Small Size, Rugged**
* **500 g and 2000 g Full Scale Ranges**
* **DC Response - Long Duration Transients**
* **Crash and Shock Testing**

Actual size

DESCRIPTION

The ENDEVCO® Model 7264B is a very low mass piezoresistive accelerometer weighing only 1 gram. This accelerometer is designed for crash testing, flutter testing, rough road testing and similar applications that require minimal mass loading and a broad frequency response. Used for shock testing of lightweight systems or structures, the Model 7264B-2000 accelerometer also meets SAEJ211 specifications for anthropomorphic dummy instrumentation.

The Model 7264B utilizes an advanced micromachined sensor which includes integral mechanical stops. This monolithic sensor offers improved ruggedness, stability and reliability over previous designs. The Model 7264B has minimum damping, thereby producing no phase shift over the useful frequency range. With a frequency response extending down to dc or steady state acceleration, this accelerometer is ideal for measuring long duration transients as well as short duration shocks.

The Model 7264B offers excellent linearity and a wide frequency response. Further, this accelerometer offers stable performance over the temperature range of 0°F to +150°F (-18°C to +66°C) and has a full bridge circuit with fixed resistors for shunt calibration. This accelerometer has a full scale output of 400 mV with 10 Vdc excitation (sensitivity of 0.80 mV/g for -500 and 0.20 mV/g for -2000). It is also available with less than 1% transverse sensitivity ("T" option) on special order.

ENDEVCO Model 136 Three-Channel System, Model 4430A or OASIS 2000 Computer-Controlled System are recommended as signal conditioner and power supply.

U.S. Patents 4,498,229 and 4,605,919

SCHEMATIC

STANDARD TOLERANCE
INCHES   (MILLIMETERS)
.XX = +/- .03   (.X = +/- .8)
.XXX = +/- .010   (.XX = +/- .25)
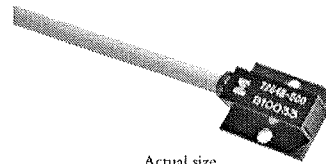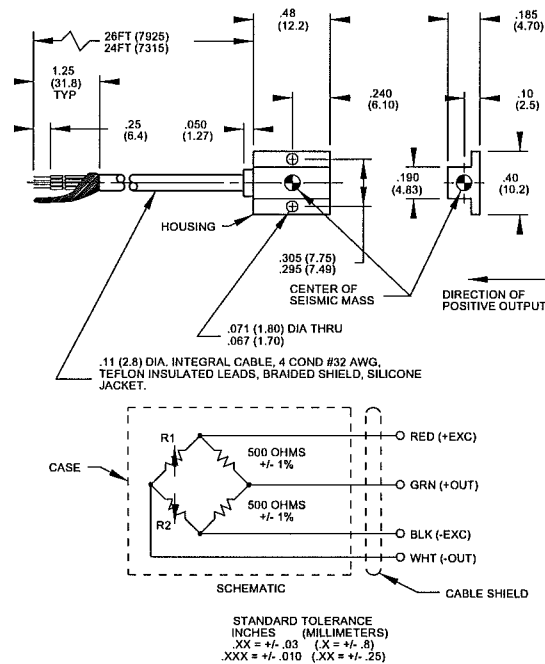
SPECIFICATIONS

CERTIFIED PERFORMANCE: All values are typical at 75°F (+24°C), 100 Hz and 10 Vdc excitation unless otherwise specified. Calibration data, traceable to the National Institute of Standards (NIST), is supplied.

	Units	7264B-500	7264B-2000
RANGE	g	±500	±2000
SENSITIVITY (at 100 Hz)	mV/g Typ	0.80	0.20
	(Min)	(0.60)	(0.15)
AMPLITUDE RESPONSE			
±5%	Hz	0 to 3000	0 to 5000
±1dB	Hz	0 to 5000	0 to 7000
MOUNTED RESONANCE FREQUENCY	Hz	17 000	28 000
DAMPING RATIO		0.005	0.005
NON-LINEARITY AND HYSTERESIS			
(% of reading, to full range)	% Max	±1	±1

CERTIFIED
ISO 9001

MEGGITT

APPLIES TO CALIFORNIA FACILITY

ENDEVCO Σ

DC Amplifier

ENDEVCO MODEL 136

Model 136

- **Three-Channel DC Differential Voltage Amplifier**
- **200 kHz Bandwidth (-3dB Corner)**
- **Auto-Zero and Shunt Calibration**
- **Gain Range 0 to 1000**
- **Four Selectable Excitation Voltage Levels**
- **RS-232 Serial Interface**
- **12 VDC Power Option**
- **Built-in 4-Pole Butterworth Low-Pass Filter**
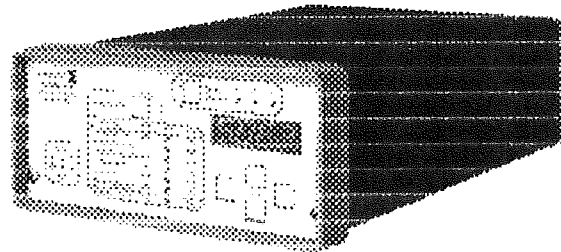
Not actual size

DESCRIPTION

The ENDEVCO® Model 136 is a three-channel, DC amplifier that is manually or computer programmable. Manual control is accomplished at the front panel by means of a "Select Channel" push-button, three (3) "Channel LEDs", one "Select Function" push-button, five "Function LEDs", a four character LED display, showing the state of each function/channel, and four "Edit" push-buttons to change the entries in the LED display. There are three LEDs used as fault status indicators for the auto zero function. Computer control is accomplished using the standard RS-232 port and optional Application Software.

There are two modes of operation, Normal and Programming/Setup. Both modes of operation utilize the front panel LED Display. In the Normal Mode, there are two states, Monitoring Mode and No-Monitoring. In the Monitoring Mode the LED display indicates the RMS reading of the signal present at the output of the selected channel. The Non-Monitoring Mode turns off the LED display for lower noise applications and to minimize power consumption. In the Programming Mode, the unit is ready for manual programming or editing of existing channel setups. The unit will automatically return to the Normal Mode of operation after 20 seconds of inactivity of the front panel or after pressing the "Select Function" push-button while the "Monitoring State" function LED is flashing.

The rear panel contains (on a per-channel basis) a BNC output connector, a 9-pin "D" input connector, the RS-232 connector, and the input power connector. Three Model 136 units may be configured in a 19-inch rack mount adapter. The standard unit is powered by 90-264 VAC, 50/60 Hz. The -1 option is powered by 9 to 18 VDC, making it ideal for portable use or for automobile test applications.
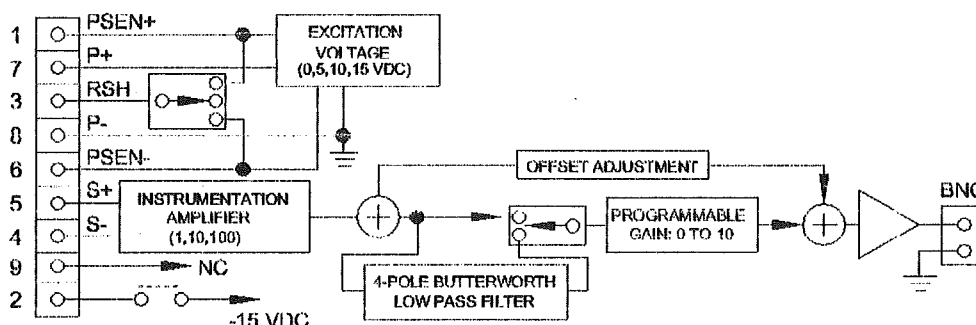
Technical Illustration

ENDEVCO MODEL 136

DC Amplifier

SPECIFICATIONS

INPUTS

INPUT IMPEDANCE	1 Meg Ohm minimum
INPUT RANGE, DIFFERENTIAL	0 to ± 10 VDC or peak VAC, 9 pin "D" connector for each bridge sensor
COMMON MODE	± 10 VDC or pk VAC, inclusive of signal 50 Vpk without damage
COMMON MODE REJECTION	70 dB minimum, 200Ω or less input imbalance, DC to 60kHz
INPUT IMBALANCE ADJUSTMENT	± 100 mVDC, 100 ≤ gain ≤ 1000
	± 1 VDC ,10 ≤ gain ≤ 100
	± 10 VDC, 0 ≤ gain ≤ 10

OUTPUTS

AC/DC VOLTAGE	Single ended, short circuit protected
OUTPUT IMPEDANCE	0.2 Ohm maximum
LINEAR OUTPUT	10 Vpk
CURRENT OUTPUT	10 mA, minimum
OUTPUT DC BIAS STABILITY TEMP.	± 5 µV/°C RTI or ± 0.1 mV/°C RTO
OUTPUT DC BIAS STABILITY TIME	+ 20 µV RTI or + 5 mV RTO, whichever is greater, for 24 hours, after a 1 hour warmup
EXCITATION VOLTAGE	0, 5.0, 10.0, or 15.0 VDC, Front Panel or computer selected; 1 selection for all 3 channels.
EXCITATION VOLTAGE ACCURACY	± 1%
EXCITATION CURRENT	30 mA maximum, short circuit protected
NOISE & RIPPLE	1 mVRMS maximum, 10 Hz to 50 kHz, with 1 kOhm load

TRANSFER CHARACTERISTICS

GAIN

RANGE	Programmable from 0 to 1000
RESOLUTION	0.0025, 0 ≤ gain ≤10
	0.025,10 ≤ gain ≤ 100
	0.25, 100 < gain < 1000
ACCURACY	± 0.5% of full scale maximum, DC to 1 kHz, filters disabled
LINEARITY	0.1% of full scale, best fit straight line at 1 kHz reference
STABILITY	± 0.2% of full scale, 0°C to + 50°C
NOISE	20 µVRMS RTI plus 1 mVRMS RTO, whichever is greater, DC to 50 kHz, with a 1k Ohm source resistance unit in Non-Monitoring State, 10 kHz internal lowpass filter enabled
BROADBAND FREQUENCY RESPONSE	DC to 200 kHz -3dB referenced to 1 kHz

FILTER CHARACTERISTICS

FILTER TYPE	4-Pole Butterworth
CORNER FREQUENCY (-3 dB)	10 kHz ±12 % (other corners available by changing internal module 31875: 10 Hz to 80 kHz)
CROSSTALK BETWEEN CHANNELS	80 dB RTI

POWER REQUIREMENTS

VOLTAGE	Standard unit: 90-264 VAC 50 to 60 Hz; -1 Option: 9-18 VDC
POWER DISSIPATION	10 Watts typical
ISOLATION	No isolation channel to channel or signal ground to caseground

PHYSICAL CHARACTERISTICS

DIMENSIONS	5.57" X 2.52" X 12"
WEIGHT	4 lbs typical
CASE MATERIAL	Black Aluminum Cover, Medium Grey Plastic Bezel

ACCESSORIES

IM136	INSTRUCTION MANUAL
EW599	POWER CORD
31875-1000	10 KHZ, 4-POLE, BUTTERWORTH LOWPASS FILTER MODULE

OPTIONS

35933	APPLICATION SOFTWARE
EJ847	RJ11 (6X4) STRAIGHT WIRED INLINE COUPLER
EW1077	RJ11 4 CONDUCTOR MODULAR FLAT CABLE, STRAIGHT WIRED, 2 FEET LONG
EW1027	RJ11 4 CONDUCTOR MODULAR FLAT CABLE, STRAIGHT WIRED, 7 FEET LONG

OPTIONS CONTINUED

EJ807	SERIAL DB9F/RJ11 ADAPTER
EJ822	MODULAR SPLITTER ADAPTER, 1 (6X4) MALE TO 3 (6X4) FEMALE
136-1	9 - 18 VDC INPUT POWER OPTION
31875-XXXX	LOWPASS FILTER MODULES (SEE 31875 DATA SHEET)
31979	RACK MOUNT KIT
EHM1471	BLANK PANEL
EHM1413	DESKTOP DC POWER SUPPLY
EHM1409	AUTOMOTIVE POWER PLUG
29719-2	DB9M CONNECTOR KIT

WARNING! USE OF RJ11 CABLE OTHER THAN THAT SPECIFIED HEREIN WILL CAUSE CATASTROPHIC FAILURE OF THE UNIT.

Notes
Maintain high levels of precision and accuracy using Endevco's factory calibration services. Call Endevco's inside sales force at 800-982-6732 for recommended intervals, pricing and turn-around time for these services as well as for quotations on our standard products.

Continued product improvement necessitates that Endevco reserve the right to modify these specifications without notice. Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and compulsory corrective action procedures. These measures, together with conservative specifications have made the name Endevco synonymous with reliability.

Proposal for revised requirements and test method for "Impact from swing elements" in EN 71-8

<u>**Definitions**</u>

Add a definition:

3.x
impact area
the area of the swing seat that comes in contact with the test mass during an impact test

Consider revising the definition of swing (see e.g. 1176-2).

<u>**Requirement**</u>

X Impact from swing elements

When tested in accordance with Y, swing elements shall not impart an average peak acceleration (average calculation to be based on the 5 specified measurements) peak values of acceleration, measured with a cut-off frequency of 10 kHz, shall not be greater than 50 g, and the average of the two measured values of surface compression shall not be greater than 90 N/cm^2.

The requirements do not apply to swing elements weighing less than 1,0 kg, including the weight of the means of suspension as defined in figure x (diagrammatic representation f a swing) and for which the estimated *impact area* is larger than 20 cm^2.

<u>**Test method**</u>

Y. Method for determination of impact from swing elements

Principle
Swing seats are raised and allowed to swing to strike a test mass. The signal emitted by an accelerometer during each impact is processed (cut-off frequency 10 kHz) to determine the peak value of acceleration. The impact area between the swing and the test mass is measured and the surface compression is calculated
.
Apparatus
- Test mass, consisting of an aluminium sphere or semi-sphere of radius 80 mm ± 3 mm, and a total mass (including accelerometer) of 4,6 kg ± 0,05 kg. The impacting part between the surface struck and the accelerometer shall be homogeneous and free from voids. Cables connected to the accelerometer shall be placed in such a way that the effect on the mass of the test-mass is minimized (for example of a test-mass design, see figure X1)
- Accelerometer, mounted at the centre of gravity of the test mass assembly with the sensitivity axis aligned to within 2° of the direction of travel of the test mass, capable of measuring acceleration triaxially in the range of ± 500 g with an accuracy of ± 0,1 g and with a frequency range from 0 to 10 000 Hz.
- Amplifier, with a sampling frequency of 10 kHz and a cut-off frequency of 10 kHz
- Two chains where the chain links have a thickness of material (diameter) of 6 ± 0,5 mm and an outer major dimension of 47 ± 2 mm. The chains shall be of equal length suspended from pivots 600 mm apart at the same height as the suspension connectors, such that they meet at the point of connection to the test mass. The fictive prolongations of the chains shall meet in the centre of the test-mass (see figure X1).

Preparations
- Assemble and install the swing element to be tested in accordance with the manufacturer's instructions
- Suspend the swing element with the means of suspension that has been supplied with the swing and at the maximum height that these permit. If ropes or cables are the means of suspension they may need to be stretched in order to allow smooth travel when the swing is released during the test. If needed, apply a load of e.g. 5 kg to the end of each rope or cable and leave it for 6 hours or until the ropes or cables have been "straightened"
- Adjust all parts of the set-up so that the suspending chains for the test mass are parallel to the means of suspension for the swing seat
- Suspend and adjust the test mass so that the contact point of the swing element and the centre of the ball are in the same horizontal plane as the centre of gravity of the test mass. Ensure that the chains for the test mass are not twisted and that the test mass hangs in a vertical line
- Affix an index mark to the side of swing seats that are supported by chains, ropes, cables, or other non rigid suspending elements. The index mark may be on any part of the suspended member that is immediately below the pivot point in the free-hanging rest position.
- Swing seats that are supported by chains, ropes, cables, or other non rigid suspending elements shall be raised along their arc of travel until the side-view projection of a straight line through the pivot point and index mark forms an angle of 60° ± 1° with the vertical. Once the suspended member is raised to the test position, some curvature will be produced in the suspending elements. Adjust the suspended member position to determine that curvature which provides a stable trajectory.
- Swing seats that are supported by rigid suspending elements shall be elevated along their arc of travel until the side-view projection of the suspending element, which was vertical in the rest position, is at an angle of 60° ± 1° to the vertical or at the maximum angle attainable, whichever is less.

Note 1: Caution should be exercised to prevent damage to the test equipment. If an unusually heavy or hard swing seat is to be tested, preliminary tests should be made at lower test angles (for example, 10°, 20°, 30°, etc.) If the requirements are exceeded at a lower test angles than specified above, the member fails and no further tests are necessary.

- The swing seat shall be supported in the test position by a mechanism that provides release without the application of external forces which would disturb the trajectory of the seat. Prior to release, the swing seat and means of suspension shall be motionless. Upon release, the assembly shall travel in a smooth downward arc without any visible oscillations or rotations of the swing seat which will prevent it from striking the test mass at the impact point. If any obvious oscillations or rotations are noted the test result shall not be registered but another test shall be performed.

Testing
Note 2: Prior to the start of a series of measurement, it shall be secured that the intended point of impact is achieved: Mark the centre of the test-mass, (+), with a chalk marker so that an imprint is obtained on the impact surface of the seat. Check and, if necessary, make fine adjustments of the test mass in the vertical and horizontal directions. Repeat the procedure until repeatability has been obtained for the intended point of impact.

Note 3: Some seats of a flexible nature will require a brace to maintain the seat configuration during the test procedure. The mass of brace should not exceed 10 % of the mass of the seat. If a brace is used, the requirement for maximum 50 g may be increased by the same percentage as the mass increase caused by the brace (max 10 %)

The intended point of impact is defined as the geometrical centre of the impact surface of the swing.

- Mark the centre of the test-mass, (+), with a chalk marker so that an imprint is obtained on the impact surface of the seat.
- Ensure that the test-mass is at complete rest and that it is correctly 3-axially adjusted.
- Elevate the seat and release it as specified above so that the swing element collides with the test mass.
- Check that the imprint on the impact surface of the seat lies within ± 5 mm (vertical direction) and ± 10 mm (horizontal direction) from the intended point of impact.
- Collect data from 5 impacts (free from obvious oscillations or rotations). Measure the peak acceleration in g for each impact. Calculate the average peak acceleration and check whether the requirement is met. The peak acceleration from one impact shall be calculated as the root-mean-square of the highest values in each direction of measurement: $SQR[(max\ X)^2+(max\ Y)^2+(max\ Z)^2]$. Note that the maximum value in each direction shall be measured regardless of at which time it occurs (max X may occur at a different moment than max Y)
- In two of the five impact tests, the impact area shall be measured as follows. Apply chalk to the test mass before the impact test and measure the chalked surface on the swing element after the impact. Use a transparent celluloid-film (such as that used for OH-projectors) in order to make a copy of the impact-area. Thereafter, place a "millimetre-paper" under the film and calculate the exact area. Calculate the average impact area for the two tests and thereafter the surface compression in N/cm^2 using the formula F/A where F = m * a, and where:
  "m" is the test mass (4,6 kg ± 5 %), and
  "a" is the average peak acceleration-value calculated from the 5 impact tests

Note 4: If the swing is deformed during testing, a new sample shall be used for the remaining tests.
Note 5: It may be necessary to clean the test mass with spirits and to

General
- The acceleration in "g" shall be registered with one decimal.
- The average value for the measured impact-surface (cm^2) shall be registered with one decimal.

Figure X1: Example of test mass and connection points for chains

Test-mass

Accelerometer

Balance weight

Suspension

160
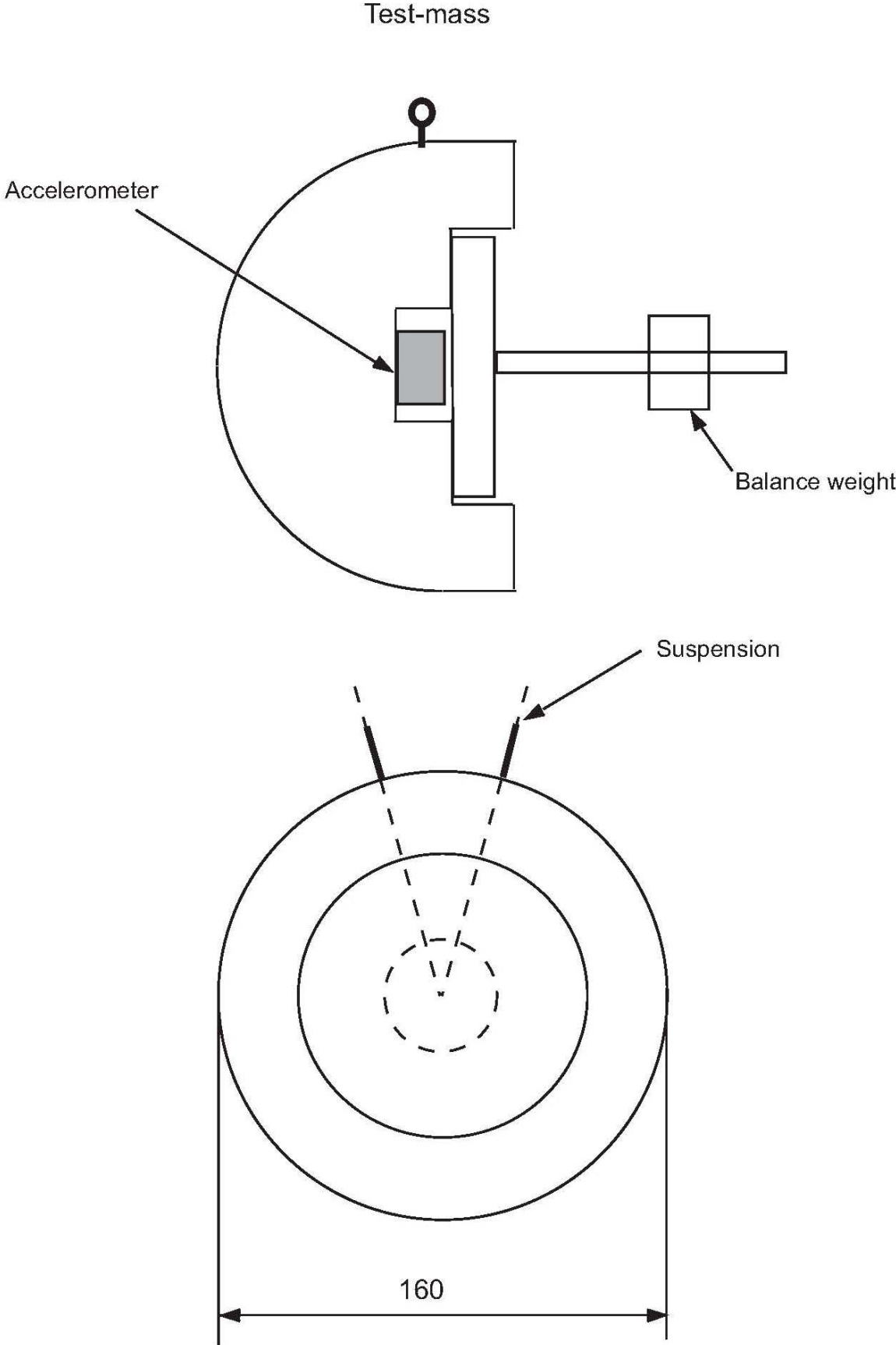
IMPACT FROM SWING ELEMENTS
Round Robin 2006

Test serie I

Type of swing	Type of seat	Point of impact
Double-seat	**Seat 1**	**Centre**

Test no:	*Sweden* Measu-red value g	Point of impact, mm Measu-red *)	Devia-tion **)	Deviation from horizontal line, mm	Finland Measu-red value g	Point of impact, mm Measu-red *)	Devia-tion **)	Deviation from horizontal line, mm	Italy Measu-red value g	Point of impact, mm Measu-red *)	Devia-tion **)	Deviation from horizontal line, mm	France Measu-red value g	Point of impact, mm Measu-red *)	Devia-tion **)	Deviation from horizontal line, mm	Sweden II Measu-red value g	Point of impact, mm Measu-red *)	Devia-tion **)	Deviation from horizontal line, mm
1	57,1				54,3				58,1	16	1+		61,7	14		0	57,4			
2	56,3				54,7				57,6	20	3-		59,9	13,5		0	59			
3	56,3				54,3				56,8	21	4-		59,8	17		0	56,1			
4	57,5				55,0				55,3	19	2-		59,5	16		0	56,7			
5	56,3				55,8				56,2	20	3-		58,8	16,5		0	55,2			
6	57,8				54,8				55,9	19	2-		59,4	14,5		0	56			
7	58,1				54,9				57,9	19	2-		58,1	16		0	54,6			
8	59,3				55,0				54,9	18	1-		58,7	17		0	54,8			
9	57,5				53,5				59,4	19	2-		58,7	15,5		0	55,5			
10	57,5				54,9				55,8	20	3-		59,3	15,5		0	55,5			
11					54,5				57,2	19	2-		58,2	16,5		0	56,7			
12					54,9				56,5	18	1-		57	17		0	54,5			
13					54,9				54,5	18	1-		58,7	14,5		0	55,3			
14					54,3				54,4	20	3-		57,7	16,5		0	54,5			
15					54,2				58,3	17	0		57,2	16,5		0	56,9			
16					54,7				54,3	19	2-		57,9	16,5		0	57,6			
17					54,6				55,1	20	3-		57,2	15		0	54			
18					54,5				56	18	1-		57,7	15,5		0	54			
19					54,6				54,9	17	0		56,6	17,5		0	53,1			
20					55,3				58,3	18	1-		57,5	16,5		0	56,5			
	57,37				**54,69**				**56,37**				**58,48**				**55,70**			

MAX (ave)	58,48
MIN (ave)	54,69
Deviation	6,9%

*) Distance measured from the upper edge of the rubber
**) Above +   and - below

	Sweden	*Finland*	*Italy*	*France*	*Sweden II*		
Average	**57,4**	**54,69**	**56,37**	**58,48**	**55,70**		
Min:	56,3	53,5	54,3	56,6	53,1	MIN	53,1
Max.	59,3	55,8	59,4	61,7	59,0	MAX	61,7
Deviation Min-Max:	5,3%	4,3%	9,4%	9,0%	11,1%	Dev	16,2%
Excluding Min-Max of the 20 impacts:							
Min:	57,1	54,2	54,4	57,2	54	MIN	54,0
Max.	57,8	55,3	58,3	59,9	57,6	MAX	59,9
Deviation Min-Max:	1,2%	2,0%	7,2%	4,7%	6,7%	Dev	10,9%

IMPACT FROM SWING ELEMENTS
Round Robin 2006

*) Distance measured from the upper edge of the rubber
**) Above + and - below
***) The area determined by weighing

Test serie II

Type of swing	Type of seat	Point of impact
Double-seat	**Seat 2**	**Centre**

Test no:	Sweden Measured value g	Point of impact mm Measured *)	Devia-tion **)	Area cm²	Surface compression N/cm²	Finland Measured value g	Point of impact mm Measured *)	Devia-tion **)	Area cm²	Surface compression N/cm²	Italy Measured value g	Point of impact mm Measured *)	Devia-tion **)	Area cm²	Surface compression N/cm²	France Measured value g	Point of impact mm Measured *)	Devia-tion **)	Area cm² ***	Surface compression N/cm²	Sweden II Measured value g	Point of impact mm Measured *)	Devia-tion **)	Area cm²	Area cm²
101	48,1			28,7	76,0	45,7			26,5	78,2	50,5	--		28,0	81,7	45,6			24,8	83,3	44,4				
102	48,1			28,4	76,8	46,6			26,8	78,8	45,5	--		27,1	76,1	50,0			26,5	85,5	45,6				
103	49,3			28,6	78,1	47,4			26,8	80,2	48,7	--		27,6	80,0	50,9			26,8	86,1	45,2				
104	49,0			27,7	80,2	47,9			27,4	79,2	50,4	--		27,9	81,9	50,5			26,3	87,0	45,8				
105	49,6			28,3	79,4	47,7			27,5	78,6	47,2	--		27,1	78,9	50,6			26,2	87,5	46,6				
106	50,0			27,9	81,2	47,6			27,3	79,0	46,2	--		27,6	75,9	49,7			25,3	89,0	47,5				
107	49,1			27,4	81,2	47,0	Yta ej säker		27,4	77,7	50,7	--		27,0	85,1	51,0			26,5	87,2	46,8				
108	50,3			27,4	83,2	45,9	Sne		27,6	75,4	48,4	--		27,2	80,6	50,2			25,3	89,9	50,2				
109	50,3			27,6	82,6	47,7			27,6	78,3	48,6	--		27,9	78,9	49,7			25,8	87,3	45,7				
110	49,5			27,5	81,6	47,4			27	79,6	52,7	--		27,3	87,5	50,1			26,1	87,0	48,2				
	49,3			**28,0**	**80,0**	**47,1**			**27,2**	**78,5**	**48,9**			**27,5**	**80,7**	**49,83**			**26,0**	**87,0**	**46,6**				

	MIN	46,6	27,2	78,5
	MAX	49,83	28,0	80,7
	Dev	6,9%	2,8%	2,8%

	SWEDEN Measured value g	Area cm²	Surface compression N/cm²	FINLAND Measured value g	Area cm²	Surface compression N/cm²	ITALY Measured value g	Area cm²	Surface compression N/cm²	FRANCE Measured value g	Area cm²	Surface compression N/cm²	SWEDEN II Measured value g
Average 10 impacts													
Min:	48,1	27,4	76,0	45,7	26,5	75,4	45,5	27,0	75,9	45,6	24,8	83,3	44,4
Max.	50,3	28,7	83,2	47,9	27,6	80,2	52,7	28,0	87,5	51,0	26,8	89,9	50,2
Deviation Min-Max:	4,6%	4,7%	9,5%	4,8%	4,2%	6,4%	15,8%	3,7%	15,3%	11,8%	8,1%	7,9%	13,1%
Excluding Min-Max of the 10 impacts:													
Min:	49,0	27,5	76,8	45,9	26,8	77,7	46,2	27,2	76,1	49,7	25,3	85,5	45,2
Max:	50,0	28,6	82,6	47,4	27,6	79,6	50,7	27,9	85,1	50,9	26,5	89	48,2
Deviation Min-Max:	2,0%	4,0%	7,6%	3,3%	3,0%	2,4%	9,7%	2,6%	11,8%	2,4%	4,7%	4,1%	6,6%

	g	Area	Comp	
MIN	44,4	24,8	75,4	incl FR
MAX	52,7	28,7	89,9	incl FR
Devia	18,7%	15,7%	19,3%	incl FR
MIN		26,5	75,4	Excl. FR
MAX		28,7	87,5	Excl. FR
Devia		8,3%	16,1%	Excl. FR
MIN	45,2	25,3	76,1	incl FR
MAX	50,9	28,6	89,0	incl FR
Dev	12,6%	13,0%	17,0%	incl FR
MIN		26,8	76,1	Excl. FR
MAX		28,6	85,1	Excl. FR
Dev		6,7%	11,8%	Excl. FR

IMPACT FROM SWING ELEMENTS
Round Robin 2006

Test serie III

Type of swing	Type of seat	Point of impact
Single-seat	**Seat 3b**	**Centre**

Test no:	Sweden Measured value g	Point of impact, mm Measured *)	Deviation **)	Deviation from horizontal line, mm	Finland Measured value g	Point of impact, mm Measured *)	Deviation **)	Deviation from horizontal line, mm	Italy Measured value g	Point of impact, mm Measured *)	Deviation **)	Deviation from horizontal line, mm	France Measured value g	Point of impact, mm Measured *)	Deviation **)	Deviation from horizontal line, mm	Sweden II Measured value g	Point of impact, mm Measured *)	Deviation **)	Deviation from horizontal line, mm
201	81,5				87,9	26	4-		86,7	19	3+		77,6	28	6-		85,5	21	1+	
202	84,6				86,8	27	5-		85,2	17	5+		80,8	25	3+		82,7			
203	86,6			Slanted	86,2	27	5-		85,6	19	3+		81,0	28	6-		83,6			
204	85,5			Slanted	85,5	27	5-		84,4	18	4+		83,2	27	5-		83,1			
205	82,1			Slanted	85,3	29	7-		84,3	20	2+		79,7	26	4-		82,2			
206	82,9			Slightly slanted	83,4	27	5-		85,4	21	1+		80,7	24	2-		86,8			
207	85,3			Slightly slanted	87,3	26	4-		85,5	22	0		79,1	25	3-		86,7			
208	85,3				79,7	26	4-	40	86,2	19	3+		79,5	26	4-		86,7			
209	84,5				86,7	27	5-		85,2	20	2+		78,9	26	4-		84,7			
210	85,7			Slightly slanted	86,5	25	3-		84,4	19	3+		79,7	26	4-		81,6			
211	78,2			Very slanted	84,9	27	5-		85	20	2+		78,6	28	6-		83,9			
212	82,9			Slightly slanted	79,7	27	5-	28	87,6	20	2+		83,0	24	2-		83,0	21	1+	
213	82,2			Slightly slanted	85,6	26	4-		84,5	20	2+		80,8	25	3-		83,3			
214	84,6			Very slanted	83,6	26	4-		84,5	20	2+		78,5	25	3-		82,7			
215	85,2				83,5	27	5-		85,9	21	1+		79,0	25	3-		83,3			
216	82	18	4+		86,6	26	4-		85,3	19	3+		78,2	26	4-		81,7	19	3+	
217	83,4	18	4+		85,9	28	6-	15	85,6	20	2+		78,1	26	4-		84,6			
218	86,4	18	4+	Slanted	85,4	29	7-		85,3	18	4+		81,5	24	2-		82,9			
219	83,2	19	3+		86	27	5-		86,7	21	1+		79,8	26	4-		82,9			
220	86,9	18	4+		85,4	28	6-		84,7	21	1+		82,2	25	3-		84,3	21	1+	
221	85,3	20	2+		82,4	28	6-	15	86,2	21	1+		79,9	24	2-		85,8			
222	85,9	20	2+	Slanted	82,6	25	3-	15	82,5	21	1+		82,5	24	2-		82,7			
223	86,2	17	5+		81,4	27	5-	12	85	21	1+		81,5	23	1-		82,0			
224	86,7	18	4+		80,6	30	8-	13	84,2	21	1+		81,2	25	3-		83,7			
225	87,1	19	3+		84,7	27	5-		85,6	20	2+		82,6	23	1-		84,6	20	2+	

*) Distance measured from the upper edge of the rubber
**) Above + and - below

Average for 5 tests

	Sweden	Finland	Italy	France	Sweden II
201-205	**84,06**	**86,34**	**85,24**	**80,46**	**83,42**
206-210	**84,34**	**85,44**	**84,98**	**81,08**	**83,68**
211-215	**82,62**	**83,46**	**85,50**	**79,98**	**83,24**
216-220	**84,38**	**85,86**	**85,52**	**79,96**	**83,28**
221-225	**86,35**	**82,85**	**84,70**	**81,65**	**83,85**
201-225	84,3	86,3	86,15	80,1	85,05

Test III Seat 3b
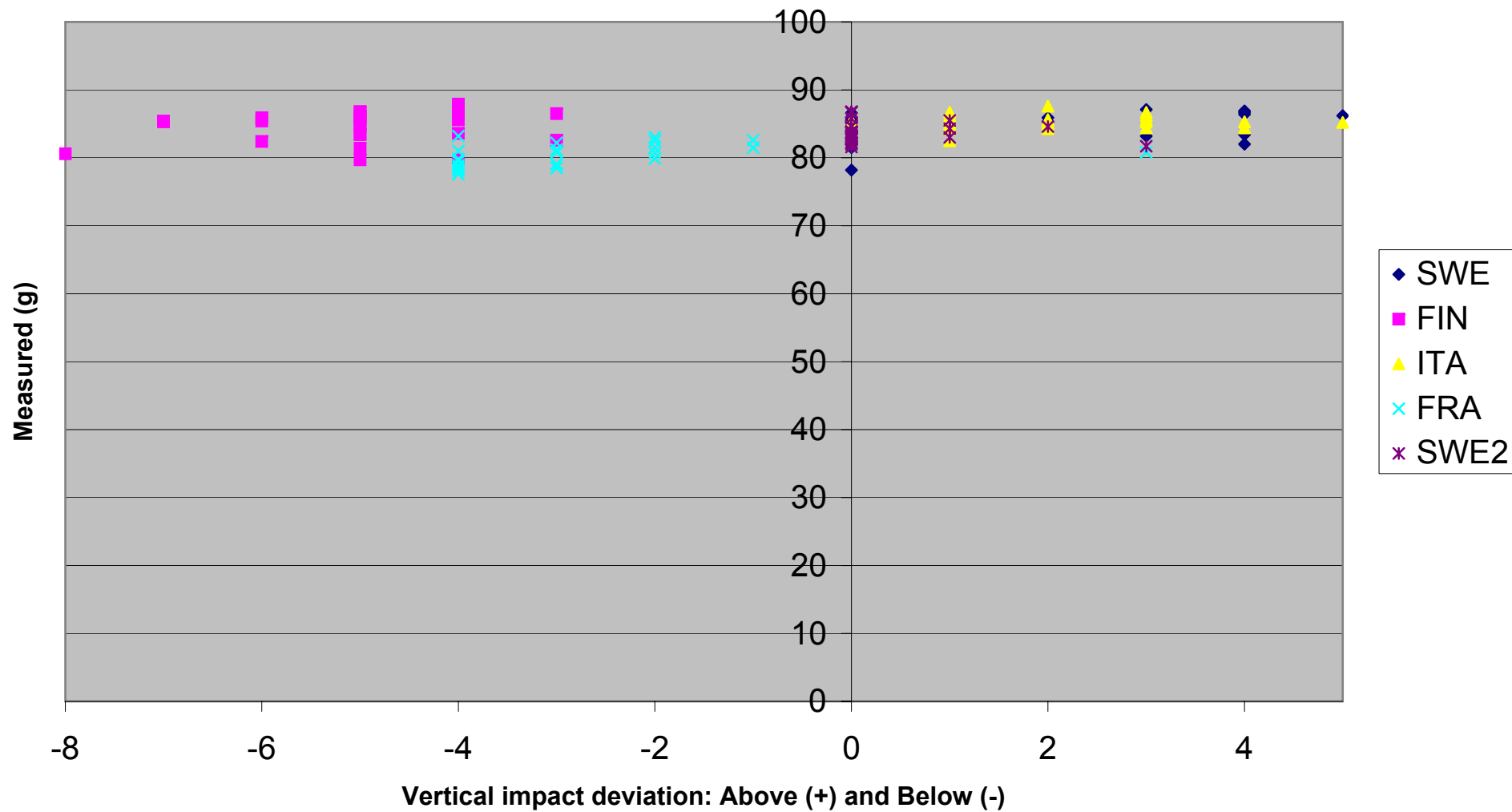
IMPACT FROM SWING ELEMENTS
Round Robin 2006

Test serie IV

Type of swing	Type of seat	Point of impact
Single-seat	**Seat 3a**	**Centre, Above and Below**

	Test no:	Sweden Measured value g	Point of impact, mm Measured *)	Point of impact, mm Deviation **)	Deviation from horizontal line, mm	Finland Measured value g	Point of impact, mm Measured *)	Point of impact, mm Deviation **)	Deviation from horizontal line, mm	Italy Measured value g	Point of impact, mm Measured *)	Point of impact, mm Deviation **)	Deviation from horizontal line, mm	France Measured value g	Point of impact, mm Measured *)	Point of impact, mm Deviation **)	Deviation from horizontal line, mm	Sweden II Measured value g	Point of impact, mm Measured *)	Point of impact, mm Deviation **)	Deviation from horizontal line, mm
Centre	301	66,7	20	2+		65,9	23	1-		64,1	22	0		61,3	23	1-	8 L	64,8	21	1+	
	302	62,7	23	1-		68,2	22	0		65,7	22	0		61,6	22	0	10 L	63,3	22	0	
	303	64,3	26	4-		66,1	22	0		59,9	27	5-		61,5	23	1-	11 L	49,2	24	2-	
	304	64,1	26	4-		67,2	22	0	10	61,1	23	1-		61,9	23	1-	14 L	64,8	19	3+	
	305	64,6	23	1-		68	22	0	10	65,1	20	2+		61,7	20	2+	6 R	61,1	23	1-	
	306	65,7	22	0		65,3	21	1+		63,4	21	1+		58,9	23	1-	7 L	64,7	19	3+	
	307	64,8	25	3-		64,8	20	2+		64,1	20	2+		58,7	22	0	14 L	62,2	23	1-	
		64,7				**66,5**				**63,3**				**60,8**				**61,4**			
10 mm Above	308	67,4	16	4-		66,9	12	0		66,8	12	0		59	10	2+	27 R	66	11	1+	
	309	70,8	10	2+		68,7	12	0	10	66,8	12	0		62,1	13	1-	5 R	66,7	7	5+	
	310	68,5	9	3+		70,9	12	0		65,7	13	1-		61,7	11	1+	28 L	65,6	12	0	
	311	70,6	11	1+		71,2	12	0		67,2	13	1-		62,3	10	2+	7 L	64,8	11	1+	
	312	68,7	12	0		68,6	12	0		66,2	14	2-		62,6	10	2+	12 L	64,2	12	0	
	313	66,0	13	1-		70,6	12	0	10	65,3	12	0		63,2	10	2+	10 L	65,7	8	4+	
	314	69,3	13	1-		72,3	12	0		70,7	11	1+		63,3	11	1+	13 L	64,4	10	2+	
		68,8				**69,9**				**67,0**				**62,0**				**65,3**			
10 mm Below	315	58,9	33	1-		62,6	31	1+		57,9	32	0		57,5	30	3+	5 R	60,3	32	0	
	316	58,2	32	0		60,9	32	0		56,3	33	1-		56,7	32	0	8 L	58,6	33	1-	
	317	61,6	31	1+		61,7	31	1+		56,6	33	1-		55,3	33	1-	2 L	59	32	0	
	318	57,4	34	2-		60,6	30	2+		55,3	33	1-		58,7	31	1+	0	52,7	38	6-	
	319	57,5	35	3-		61,2	30	2+		55,4	32	0		54,8	34	2-	13 L	58,7	32	0	
	320	57,3	33	1-		60,9	30	2+		57,1	32	0		55,6	32	0	2 L	56,1	35	3-	
	321	58,0	32	0		60,3	31	1+		56,5	33	1-		53,2	33	1-	7 L	56,6	35	3-	
		58,4				**61,2**				**56,4**				**56,0**				**57,4**			

*) Distance measured from the upper edge of the rubber

**) Above + and - below

	Sweden	Finland	Italy	France	Sweden II
Above:	4,1	3,4	3,6	1,2	3,9
Centr:	**64,7**	**66,5**	**63,3**	**60,8**	**61,4**
Below:	-6,3	-5,3	-6,9	-4,8	-4,0

Test IV Seat 3a - Trend

y = 0,4145x + 62,628

Proposed permitted deviation from centre (vertical direction)

Total
Linjär (Total)

Measured (g)

Centre offset
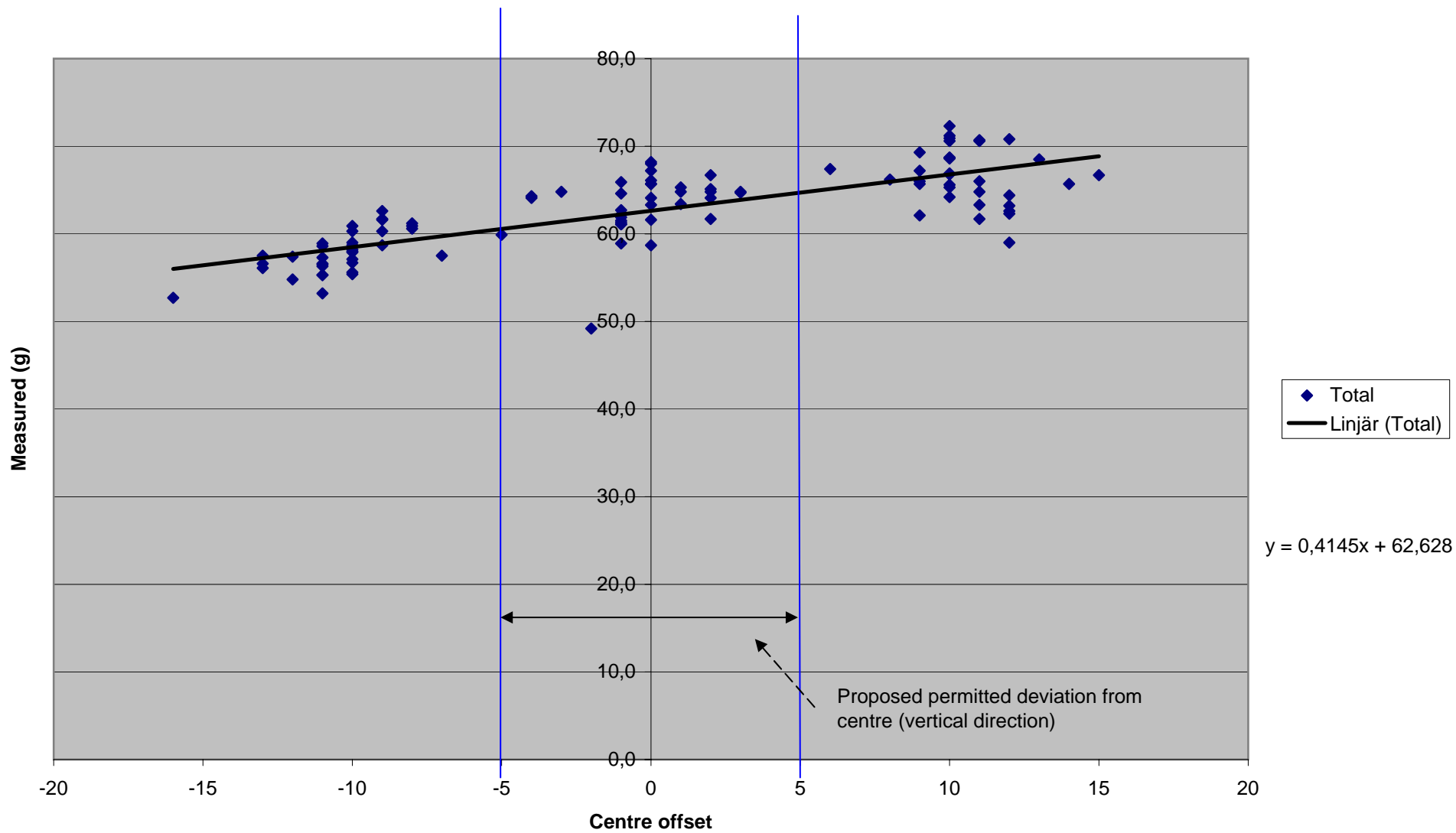
Compilation of average values

		Sweden	Finland	Italy	France	Sweden II	Min	Max	Variation
Test I (seat 1 = double swing seat with thin - 9 mm - plastic-foam)									
	Measured value g	57,37	54,69	56,37	58,48	55,70	54,69	58,48	**6,94%**
Test II (seat 2 = double swing seat with thick - 14 mm - plastic-foam)									
	Measured value g	49,33	47,09	48,89	49,83	46,60	46,60	49,83	**6,93%**
	Area cm^2	27,95	27,19	27,47	25,96		25,96	27,95	**7,67%**
	Surface compression	80,0	78,5	80,7	87,0		78,50	87,00	**10,82%**
Test III (seat 3 b = free-hanging swing with homogenous impact surface)									
201-205	Measured value g	84,06	86,34	85,24	80,46	83,42	80,46	86,34	**7,31%**
206-210	Measured value g	84,34	85,44	84,98	81,08	83,68	81,08	85,44	**5,38%**
211-215	Measured value g	82,62	83,46	85,50	79,98	83,24	79,98	85,50	**6,90%**
216-220	Measured value g	84,38	85,86	85,52	79,96	83,28	79,96	85,86	**7,38%**
221-225	Measured value g	86,35	82,85	84,70	81,65	83,85	81,65	86,35	**5,76%**
201-225	Measured value g	84,35	84,79	85,19	80,63	83,49	80,63	85,19	**5,66%**
Test IV (seat 3 a = free-hanging swing with non-homogenous impact surface)									
Centre	Measured value g	64,70	66,50	63,34	60,80	61,44	60,80	66,50	**9,38%**
10 Above	Measured value g	68,76	69,89	66,96	62,03	65,34	62,03	69,89	**12,67%**
10 Below	Measured value g	58,41	61,17	56,44	55,97	57,43	55,97	61,17	**9,29%**

The results for test IV are shown for the intended point of impact rather than the actual point