Report
Comparison test

Concerning:
Turtle box yellow vs. Turtle box green

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Abstract	:	This report details the methods, specifications and results for the comparison test of the Turtle box yellow and the Turtle box green.

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1.Approvalsilnatures

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2. Test overview

2.1 Objective

The objective of this test is to research the influence of shocks, vibrations and climatic conditions, as occur during transport, on the revised Turtle box green. The revised Turtle box green has vacuum insulating panels to improve the insulation performance. As a reference the Turtle box yellow is also tested.
As an extra, the Turtle box green with thicker corner pieces to hold the painting, is also tested on vibration and drop.

2.2 Conclusions

Temperature conditions

To simulate the packing of the Turtle boxes in the museum (conditioned room temperature of 20°C and 50% RH) and then shipping of the Turtle boxes worldwide (controlled conditions, but short spikes are possible), two temperature tests are performed: one up to 30°C and one down to 10°C.

Reached	Turtle box yellow	Turtle box green
+30°C	After 21,5 hours	After >48 hours
+10°C	After 20,0 hours	After >48 hours

The Turtle box green performed twice as good as the Turtle box yellow.

Humidity conditions

During worldwide transport the relative humidity conditions differ. To research the influence of changing humidity conditions on the Turtle box, more specific, the painting inside the Turtle box, a climate test with increasing relative humidity (from 50% RH to 70% RH) is performed.

Reached	Turtle box yellow	Turtle box green
60% RH	After 37,5 hours	After >48 hours

The Turtle box green performed better than the Turtle box yellow.

Vibration

To investigate the influence of vibration on the Turtle boxes, a sine sweep from 3 Hz to 200 Hz at 0,5 G is performed. These frequencies are chosen because they are most likely to occur during regular truck and air transport.

Turtle box yellow	Turtle box, green, standard corners	Turtle box, green, thicker corners
2,35 G @ 31 Hz	1,13 G @ 49 Hz	1,19 G @ 24,5 Hz
Amplification of 5	Amplification of 2	Amplification of 2

The amplification of the Turtle box green is 2, against the amplification of 5 of the Turtle box yellow. The Turtle box green performed much better on the vibration.
There is no difference between the standard and thicker corners.

Drop

This test is performed to research the impact of drops and little vertical shocks, that might occur during handling of the Turtles boxes or on bumpy roads.

Side	Drop height (mm)	Turtle box yellow	Turtle box green, standard corners	Turtle box green, thicker corners
		G-value (g's)	G-value (g's)	G-value (g's)
Right	152	15,1	16,4	12,9
Right	229	21,2	21,0	20,4
Left	152	9,5	10,3	11,1
Left	229	11,9	14,2	15,1

No significant differences between the green and yellow Turtle box are measured. And also the thicker corner pieces did not make any difference.
All three configuration performed the same.

Overall

On temperature, humidity and vibration conditions the Turtle box green performed almost twice as good as the Turtle box yellow.
On drop both Turtle boxes performed the same.
The use of thicker corner pieces does not affect (positive nor negative) the performance of the Turtle box.

3. Test product

The test product consists of three Turtle boxes.

Turtle box yellow	147,5 x 43,0 x 123,5 cm	81,8 kg
Turtle box green, standard corners	158,0 x 39,0 x 158,5 cm	118,6 kg
Turtle box green, thicker corners	158,0 x 39,0 x 158,5 cm	118,4 kg

A wooden dummy painting is placed in each Turtle box.

Fig.1 – Turtle box yellow

Fig. 2 – Turtle box green

Fig. 3 – Painting in Turtle box

Fig. 4 – Top: standard corner, bottom: thicker corner

4. Test procedure

The testing procedure consists of the following parts:

During the climate tests both the green and yellow Turtle box are tested at the same time.

4.1 Temperature tests

To investigate the insulating performance of the Turtle box, two temperature tests are performed. The Turtle box is packed at the start temperature and after closing the temperature is increased/decreased.
The temperature and relative humidity in the Turtle box and on the dummy painting is monitored by loggers. The test is stopped as soon as both Turtle box has achieved the final temperature (30°C or 10°C). The procedure is based on ASTM-standard D4332-14.

Test run	Start temperature	Go to ...
1	20°C and 50% RH	30°C & 50% RH in 30 minutes
2	20°C and 50% RH	10°C & 50% RH in 30 minutes

4.2 Climate test

To investigate the resistance to humidity of the Turtle box a climate test is performed. The Turtle box is packed at the start temperature of 20ºC and 50% RH and after closing the temperature and relative humidity are increased in 30 minutes to 35°C and 70% RH and kept for 24 hours.
The temperature and relative humidity in the Turtle box and on the dummy painting is monitored by loggers. The procedure is based on ASTM-standard D4332-14.

4.3 Sine vibration test

To determine the resonance frequency of the painting in the Turtle box a sweep test is conducted in accordance with ISO test standard 2247. The Turtle box is strapped down to the vibration table and subjected to a sine sweep from 3 to 200 Hz at 0,5 G with 1 oct/min. With an accelerometer on the dummy painting the resonance frequency is determined.

4.4 Flat drop test

A rotational flat drop test is conducted to simulate handling of the Turtle box. Four drops are conducted; two drops on the left side of the Turtle box and two drops on the right side of the Turtle box. The two drops on each side are performed from two different drop height: 152 mm and 229 mm. This test is based on ASTM-standard D4169-14 & D6179-07 (assurance level II).
With an accelerometer on the dummy painting the impact is measured.

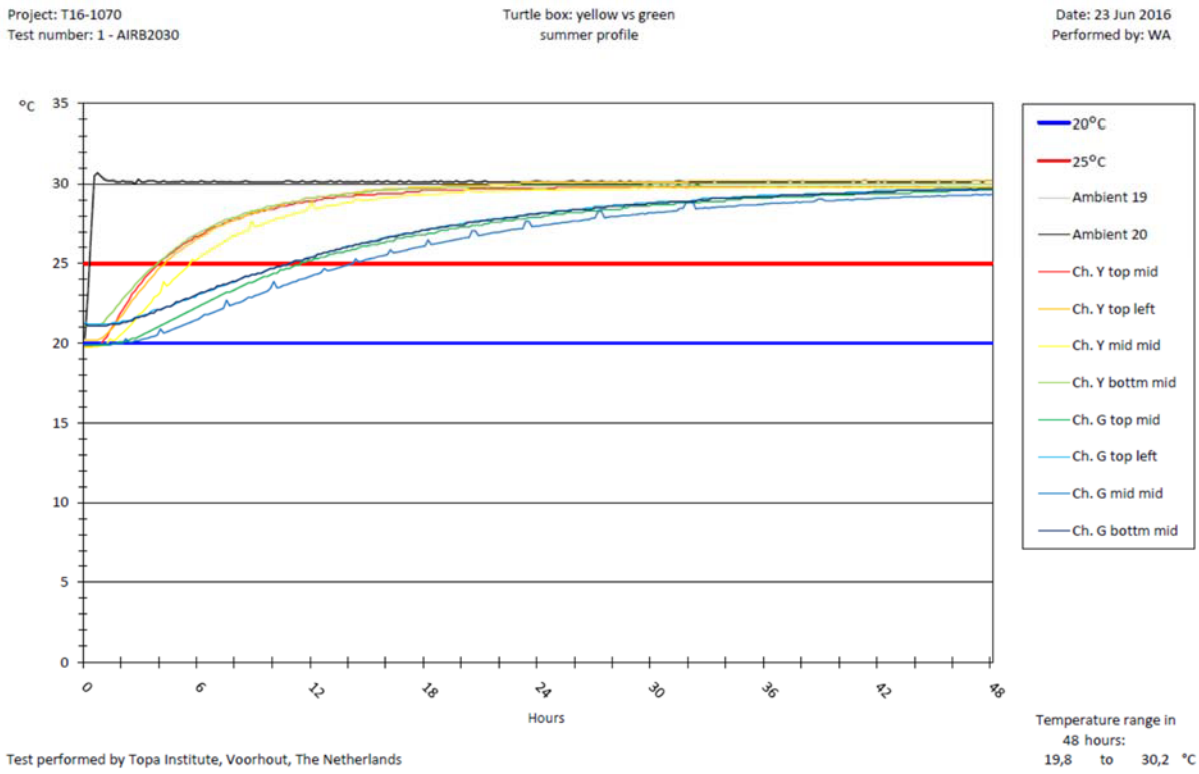
Fig. 5 – Vibration test set up

Fig. 6 – Flat drop test set up

5. Test results

5.1 Temperature test +20°C to +30°C

To simulate the packing of the Turtle boxes in the museum (conditioned room temperature of 20°C and 50% RH) and then shipping of the Turtle boxes worldwide (controlled conditions, but short spikes are possible), a temperature test starting at +20°C up to +30°C is performed.

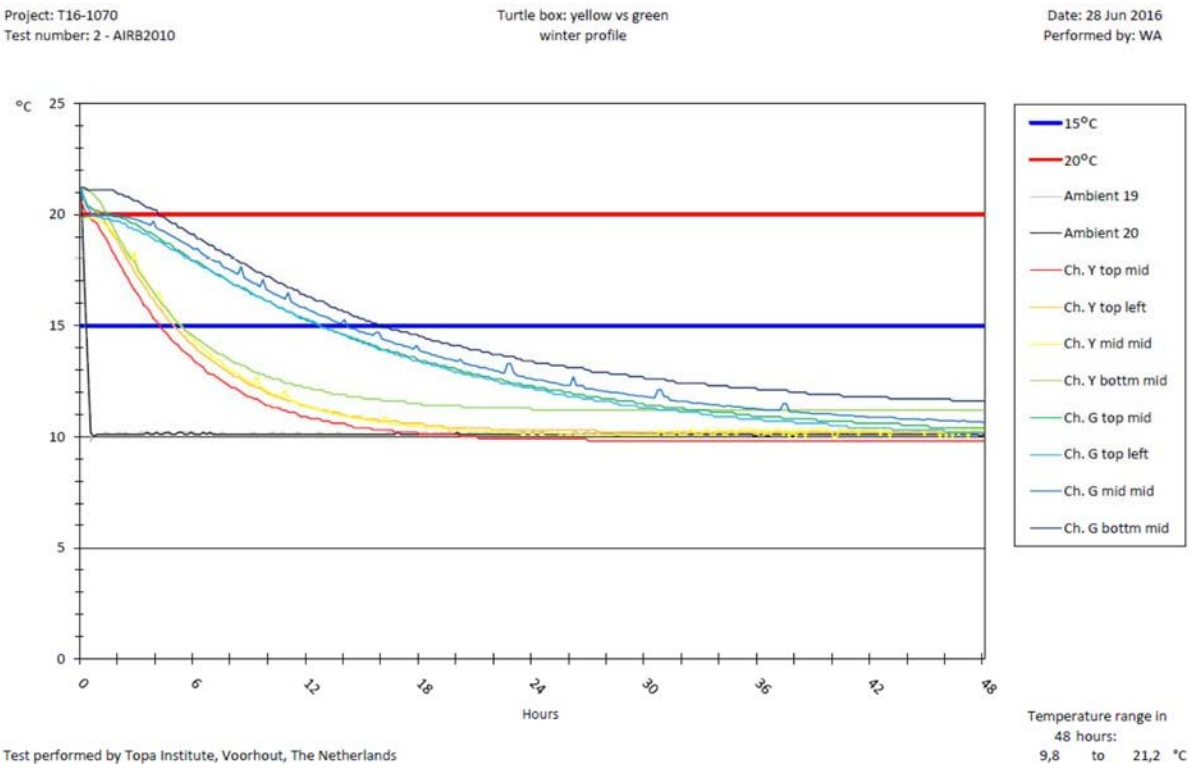


Reached	Turtle box yellow	Turtle box green
	After … hours	After … hours
20°C	0,0	0,0
22°C	1,5	3,5
24°C	3,0	8,0
26°C	5,0	13,5
28°C	8,0	23,0
30°C	21,5	>48,0

The worksheet and data of the temperature test are enclosed in appendix B.

5.2 Temperature test +20°C to +10°C

To simulate the packing of the Turtle boxes in the museum (conditioned room temperature of 20°C and 50% RH) and then shipping of the Turtle boxes worldwide (controlled conditions, but short spikes are possible), a temperature test starting at +20°C down to +10°C is performed.

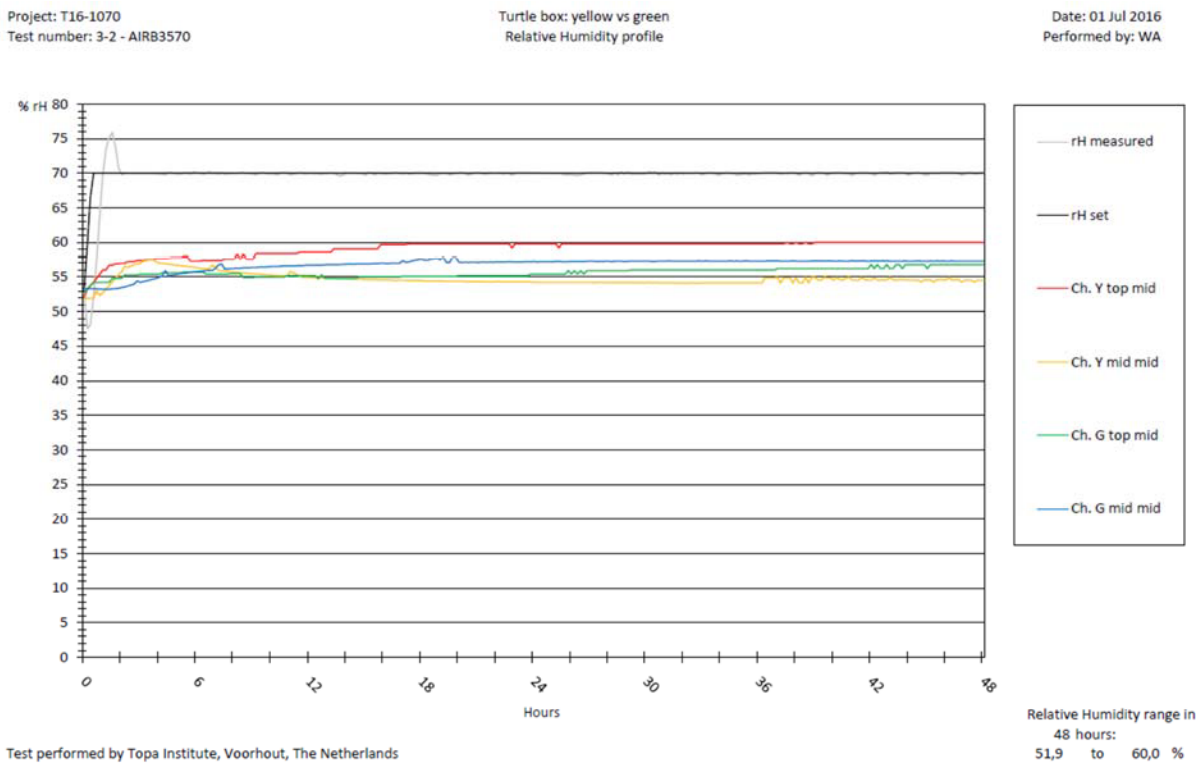


	Turtle box yellow	Turtle box green
Reached	After … hours	After … hours
20°C	0,0	0,0
18°C	1,5	5,5
16°C	3,3	10,0
14°C	5,0	15,5
12°C	8,5	25,0
10°C	20,0	>48,0

The worksheet and data of the temperature test are enclosed in appendix C.

5.3 Climate test 50% RH to 70% RH

During worldwide transport the relative humidity conditions differ. To research the influence of changing humidity conditions on the Turtle box, more specific, the painting inside the Turtle box, a climate test with increasing relative humidity (from 50% RH up to 70% RH) is performed.



Reached	Turtle box yellow After … hours	Turtle box green After … hours
50% RH	0,0	0,0
52% RH	0,0	0,0
54% RH	0,5	0,5
56% RH	1,0	6,5
58% RH	5,5	>48,0
60% RH	37,5	>48,0

The worksheet and data of the temperature test are enclosed in appendix D.

5.4 Sine sweep test

To investigate the influence of vibration on both yellow and green Turtle boxes, a sine sweep from 3 Hz to 200 Hz at 0,5 G is performed. These frequencies are chosen because they are most likely to occur during regular truck and air transport.
During the sine sweep the resonance frequencies inside the Turtle box, on the dummy painting, are monitored with an accelerometer.

Turtle box yellow	Turtle box, green, standard corners	Turtle box, green, thicker corners
2,35 G @ 31 Hz	1,13 G @ 49 Hz	1,19 G @ 24,5 Hz

The graphs of the sine sweep tests are enclosed in appendix E.

5.5 Rotational flat drop test

This test is performed to research the impact of drops and little vertical shocks, that might occur during handling of the Turtles boxes or on bumpy roads.
Drop heights of 152 mm and 229 mm are used. One side of the Turtle box is lifted, the other side is supported by the floor and the lifted side is dropped back to the concrete floor.

The graphs of the flat drop tests are enclosed in appendix F.

Side	On dummy painting, Turtle box yellow			
	Drop height (mm)	G-value (g's)	Pulse time (ms)	Velocity (m/s)
Right	152	15,1	23,8	3,19
Right	229	21,2	50,4	4,37
Left	152	9,5	58,0	2,59
Left	229	11,9	55,8	3,03

On dummy painting, Turtle box green, standard corners			
Drop height (mm)	G-value (g's)	Pulse time (ms)	Velocity (m/s)
152	16,4	20,7	3,48
229	21,0	21,5	4,55
152	10,3	78,3	2,82
229	14,2	59,9	3,79

Table: Impacts flat drop test

Side	On dummy painting, Turtle box green, thicker corners			
	Drop height (mm)	G-value (g's)	Pulse time (ms)	Velocity (m/s)
Right	152	12,9	22,4	3,31
Right	229	20,4	55,1	5,60
Left	152	11,1	68,3	3,11
Left	229	15,1	68,5	4,03

Table: Impacts flat drop test

There is a big difference in impact between the left and right side of both Turtle boxes. This difference can be explained, because the accelerometer is located to the side of the painting and the painting is located to the right side of the Turtle box. Concluding: the accelerometer is located more to the right side of the Turtle box, resulting in higher impact on that side.

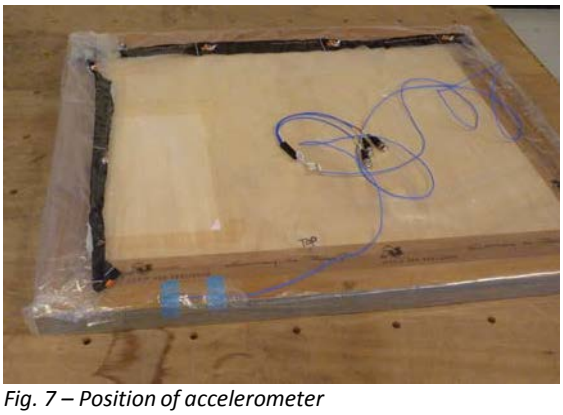


Fig. 7 – Position of accelerometer

Fig. 8 – Position of painting in Turtle box

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