

Test Report No. 4786/20

Package performance tests on one crate - 6 shipping crates for works of art -

| Client: | Dr. Kracht Vibrationsmanagement Markgrafenweg 1 |
|---------------------|--|
| | 19230 Setzin |
| | GERMANY |
| | |
| Date of order: | 08 th December 2020 |
| Reference: | Quotation signed by Dr. Kerstin Kracht |
| | |
| Test sample: | 6 shipping crates |
| Received on: | 7 th December 2020 |
| Date of testing: | 8 th and 9 th December 2020 |
| Test reference: | ASTM D999-08 (tailored) and ASTM D4728 – 17, see Table 7 |
| | |
| Official in charge: | B. Eng. P. Gasch |
| Number of pages: | 18 |
| Number of figures: | 24 |
| Appendices: | 1 |
| | |
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1 Scope and object

The BFSV Hamburg Institute of Packaging was authorized to perform packaging performance tests according to ASTM D999-08 (tailored) and ASTM D4728-17 on six shipping crates. These tests are intended to verify the ability of the packaging to resist dynamical distribution hazards during a shipment.

2 Test samples

For testing, six shipping crates were delivered by the client at the packaging institute. A specification of the test samples is given in <u>Table 1</u> to <u>Table 6</u>.

The test samples were prepared in presence of the client by the BFSV staff, see $\underline{Fig 1}$ to $\underline{Fig. 3}$ and $\underline{Fig. 6}$ to $\underline{Fig. 24}$.

3 Testing

The test sequence specified in <u>Table 2</u> was performed on the test samples. Not all test sequences were performed with each crate. An overview is given in Table 1 to Table 6. Prior to testing additionally positioned acceleration sensors were applied to the crate and the painting. For example, see <u>Fig. 2</u> and <u>Fig. 3</u>. The test setups are shown in <u>Fig. 4</u> (sine sweep, random vibration) and <u>Fig. 5</u> (drop test). The used test and measuring equipment are listed in <u>Table 3</u>.

4 Test results

The packaging performance test sequence according to ASTM D999-08 (tailored) and ASTM D4728-17 as well as the drop test were performed on the shipping crates specified in Table 1 to Table 6.

The vibration tests were performed without any packaging defect. The exemplary vibration test spectra are shown in <u>Appendix 1</u>.

Official in charge

B. Eng. Philipp Gasch





| Sample description (given by the client) | Weight of the packed samples | Sweep test | Vibration Truck | Vibration Air | Drop test |
|---|------------------------------|------------|--------------------|------------------|--------------|
| # 30 (Fig. 6) | 8.6 kg | ~ | \checkmark | ~ | ✓ |
| # 30 (Fig. 7) | 8.6 kg | ✓ | \checkmark | \checkmark | \checkmark |
| # 9 (Fig. 8) | 34.6 kg | ✓ | \checkmark | \checkmark | \checkmark |
| # 1 (Fig. 9) | 1.16 kg | ✓ | \checkmark | \checkmark | \checkmark |
| # 1 (Fig. 10) | 1.16 kg | ✓ | \checkmark | \checkmark | \checkmark |
| # 1 and # 10 (Fig. 11) | 1.16 kg + 2.3 kg | - | ~ | ~ | \checkmark |
| # 11 and # 10 (Fig. 12) | 3.05 kg + 2.3 kg | - | ~ | ~ | - |
| # 2 and # 10 (Fig. 13) | 4.9 kg + 2.3 kg | - | ~ | ~ | - |
| # 12 and # 10 (Fig. 14) | 3.16 kg + 2.3 kg | - | ~ | ~ | ✓ |
| # 3 (Fig. 15) | 12 kg | - | \checkmark | ~ | ✓ |
| # 5 (Fig. 16) | 13.9 kg | - | \checkmark | \checkmark | - |
| # 6 (Fig. 17) | 18.8 kg | - | \checkmark | \checkmark | - |
| # 4 (Fig. 18) | 25.9 kg | - | \checkmark | \checkmark | \checkmark |

 Table 1: Specification of the test sample - Turtle Box - Type uNLtd - U099



Table 2: Specification of the test sample - Wooden crate - Type A

| Sample description (given by the client) | Weight of the packed samples | Sweep test | Vibration Truck | Vibration Air | Drop test |
|--|------------------------------|------------|--------------------|------------------|--------------|
| # 9 (Fig. 19) | 34.6 kg | - | \checkmark | \checkmark | \checkmark |

Table 3: Specification of the test sample - Turtle Box - Type uNLtd 125 - S009

| Sample description (given by the client) | Weight of the packed samples | Sweep test | Vibration Truck | Vibration Air | Drop test |
|---|------------------------------|------------|--------------------|------------------|--------------|
| # 1 and # 11 (Fig. 20) | 1.16 kg + 3.05 kg | - | ~ | ~ | \checkmark |

Table 4: Specification of the test sample – Wooden crate - Type double walled crate

| Sample description (given by the client) | Weight of the packed samples | Sweep test | Vibration Truck | Vibration Air | Drop test |
|---|------------------------------|------------|--------------------|------------------|--------------|
| # 9 (Fig. 21) | 34.6 kg | - | \checkmark | ~ | \checkmark |

Table 5: Specification of the test sample - Wooden crate - Type single walled crate

| Sample description (given by the client) | Weight of the packed samples | Sweep test | Vibration Truck | Vibration Air | Drop test |
|---|------------------------------|------------|--------------------|------------------|--------------|
| # 9 (Fig. 22) | 34.6 kg | - | \checkmark | \checkmark | \checkmark |

Table 6: Specification of the test sample - Turtle Box - Type LITE - U020

| Sample description (given by the client) | Weight of the packed samples | Sweep test | Vibration Truck | Vibration Air | Drop test |
|--|------------------------------|------------|--------------------|------------------|-----------|
| # 30 (Fig. 23) | 8.6 kg | - | ~ | ~ | ~ |
| # 9 (Fig. 24) | 34.6 kg | - | ~ | ~ | - |



| Schedule | Type of Test | Test Parameter | Test Load | Reference |
|----------------------|---|--|----------------|---------------|
| - | Atmospheric conditioning | + 22°C ≤ T ≤ + 26°C | During testing | ASTM D4332 |
| Sine sweep | Vibration | Frequency range: 3 Hz | 1 Octave / min | ASTM D999-08 |
| Vehicle Vibration | Vehicle vibration Truck Spectrum | Random Vibration Truck Spectrum, Ass. Level II : frequency range 1200 Hz g _{RMS} = 0.54 | 5 min | ASTM D4728-17 |
| Vehicle Vibration | Vehicle vibration Air Spectrum | Random Vibration Air Spectrum, Ass. Level II : frequency range 2300 Hz g _{RMS} = 1.06 | 5 min | ASTM D4728-17 |
| Drop test | Tip over | Tilting the test sample until it will drop on the floor | 1 drop | - |

Table 7: Vibration test sequence

Table 8: Test and measuring equipment

| Description, Manufacturer, Type | BFSV registration no. |
|--|-----------------------|
| Servo-Hydraulic Vibration Test Equipment, L.A.B. – HV 60X60 | Vp 933 |
| Vibration control system, L.A.B VR 9500 Controller | Vp 973 |
| Acceleration sensor, DYTRAN, 3055D2, 25629, Channel 1 (control sensor) | Vp 937 |
| Acceleration sensor, DYTRAN, 3055D2, 25629, Channel 2 | Vp 938 |





Fig. 1: Exemplary corner blocks of the painting inside the crate



Fig. 2: Exemplary test setup of the positioned acceleration sensor at the crate





Fig. 3: Exemplary test setup of the positioned acceleration sensors at the painting





Fig. 4: Exemplary test setup for the vibration tests, standing crate



Fig. 5: Exemplary test setup for the drop tests



Turtle Box - Type uNLtd - U099



Fig. 6: No. 30 - with 4 corner and 4 straight blocks



Fig. 7: No. 30 – with 4 corner blocks





Fig. 8: No. 9 – with 4 corner and 10 straight blocks



Fig. 9: No. 1 – with 4 corner blocks





Fig. 10: No. 1 – with 4 corner blocks (old version)



Fig. 11: Left side: No. 1 – with 2 corner and 1 straight block Right side: No. 10 – with 4 straight blocks





Fig. 12: Left side: No. 11 – with 4 straight blocks Right side: No. 10 – with 4 straight blocks



Fig. 13: Left side: No. 2 – with 4 straight blocks Right side: No. 10 – with 4 straight blocks





Fig. 14: Left side: No. 12 – with 4 straight blocks Right side: No. 10 – with 4 straight blocks (rhombs arrangement)



Fig. 15: No. 3 – with 4 corner and 1 straight blocks





Fig. 16: No. 5 – with 4 corner and 1 straight blocks



Fig. 17: No. 6 (No. 5 + No. 2) – with 4 corner and 3 straight blocks





Fig. 18: No. 4 (No. 5 + No. 3) – with 4 corner and 3 straight blocks (without front fixation part)



Wooden crate - Type A



Fig. 19: No. 9

Turtle Box - Type uNLtd 125 - S009



Fig. 20: Left side: No. 1 – with 2 corner and 1 straight block Right side: No. 11 – with 4 straight blocks



Wooden crate - Type double walled crate





Wooden crate - Type single walled crate



Fig. 22: No. 9



Turtle Box - Type LITE - U020



Fig. 23: No. 30 – 5 straight blocks



Fig. 24: No. 9 – with 4 corner and 10 straight blocks

Appendix



Fig. 1: Test spectrum of the sine sweep 3 Hz to 300 Hz



Fig. 2: Test spectrum on completion of the Random Vibration Test – Truck spectra



Fig. 3: Test spectrum on completion of the Random Vibration Test - Air spectra