



ASTM D 4169-23^{E1} (March 2024) Transport Simulation Protocol Standard Practice for Performance Testing of Shipping Containers and Systems

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Version V1.6



To make a Test Protocol our Accredited* Laboratory need following information

1. **Testing Format:** Should the package be tested as a single shipment box or as a fully loaded pallet?
2. **Test Objectives:** What is the purpose of the test? What are the specific objectives?
3. **Package Dimensions and Weight:** What are the dimensions and weight of the test items?
4. **Quantity of Test Items:** How many items need to be tested? Should it include both test items and reference items?
5. **Distribution Cycle Extent:** Where is the package being distributed (e.g., West Europe, East Europe, Worldwide)?
6. **Climate Conditions:** Are environmental factors like temperature and humidity relevant? See page 7 for more info!
7. **Transport Mode:** How will the package be transported (e.g., train, airplane, boat, lorry, or delivery vehicle)?
8. **Other important info:** Use a slipsheet, fixation during air transport, under pressure sensitivity for example

Important: which Test Should I Choose for Ocean Freight Shipments?

When preparing your ocean freight shipments, it is crucial to test your packaging against the challenges of transportation. Standards like ASTM, ISTA, and ISO do **not include vibration profiles** (PSD) specifically for ocean transport, as studies show that vertical vibrations during sea transport are minimal. However, other factors can damage your products, such as shifting of goods during loading and unloading, extreme temperatures, high humidity, and compression forces caused by stacking.

Since ocean freight shipments often involve **road, rail, or air transport** to and from ports, it is common practice to simulate vibrations from these other transport methods. This covers the more intense vibrations that can occur in seaports and during distribution.

Shock Risks During Ocean Transport

At Sebert Trillingstechniek, we have extensive **field measurements** with 5T and 20T loaded sea containers in the ports of Rotterdam. Our data shows that the greatest shock risks occur.

During the loading and unloading of containers from the frame to the ship (and vice versa).

To mitigate these risks, we recommend the following tests:

- Increased impact forces and drop heights to **simulate port handling**.
- Flat drop tests, for example, to test **handling with cargo** nets.
- Rotational flat drop tests for enhanced robustness and **pallet stability** (Rolling and pitching).
- **Stacking** under severe conditions, by increasing the "F-factor" (compensation factor).
- Extreme atmospheric simulations, including (salt)water spray, to test for damage caused by **moisture and temperature**.



Climate test (additional tests) pre-conditioning before the mechanical tests

Configuration	Time	Temperature	Humidity
A) Extreme Cold	72 hours	-29°C	Uncontrolled RH
B) Cold, Humid	72 hours	+5°C	85% RV
C) Lab Environment	72 hours	+23°C	50% RV
D) Hot, humid	72 hours	+38°C	85% RV
E) Hot, Humid then Extreme Heat, Moderate RH	72 hours then 6 hours	+38°C then +60°C	85% RV then 30% RV
F) Elevated Temperature, Uncontrolled RH	72 hours	+50°C	Uncontrolled RH
G) Severe Cold, Uncontrolled RH	72 hours	-18°C	Uncontrolled RH



A pre-conditioning of 12 hours in a laboratory environment is recommended at +23°C ($\pm 10^\circ\text{C}$) and 50% relative humidity ($\pm 20\%$), before conducting mechanical tests, unless specific climate conditions are required.

Test procedure possibilities from box to pallet

Test Plan A

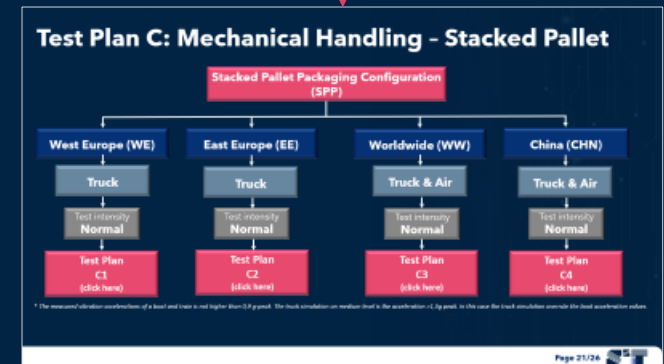
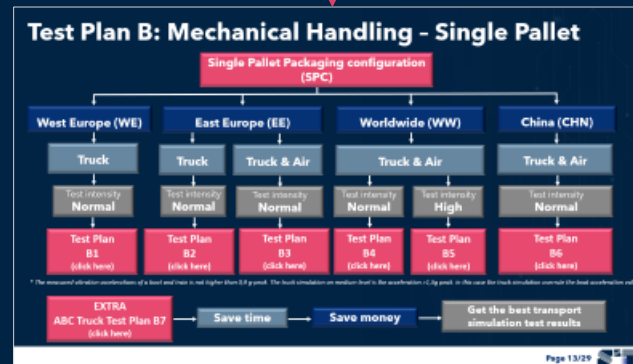
Single Shipment Box Packaging
Manual handling

Test Plan B

Single Pallet Packaging
Mechanical handling

Test Plan C

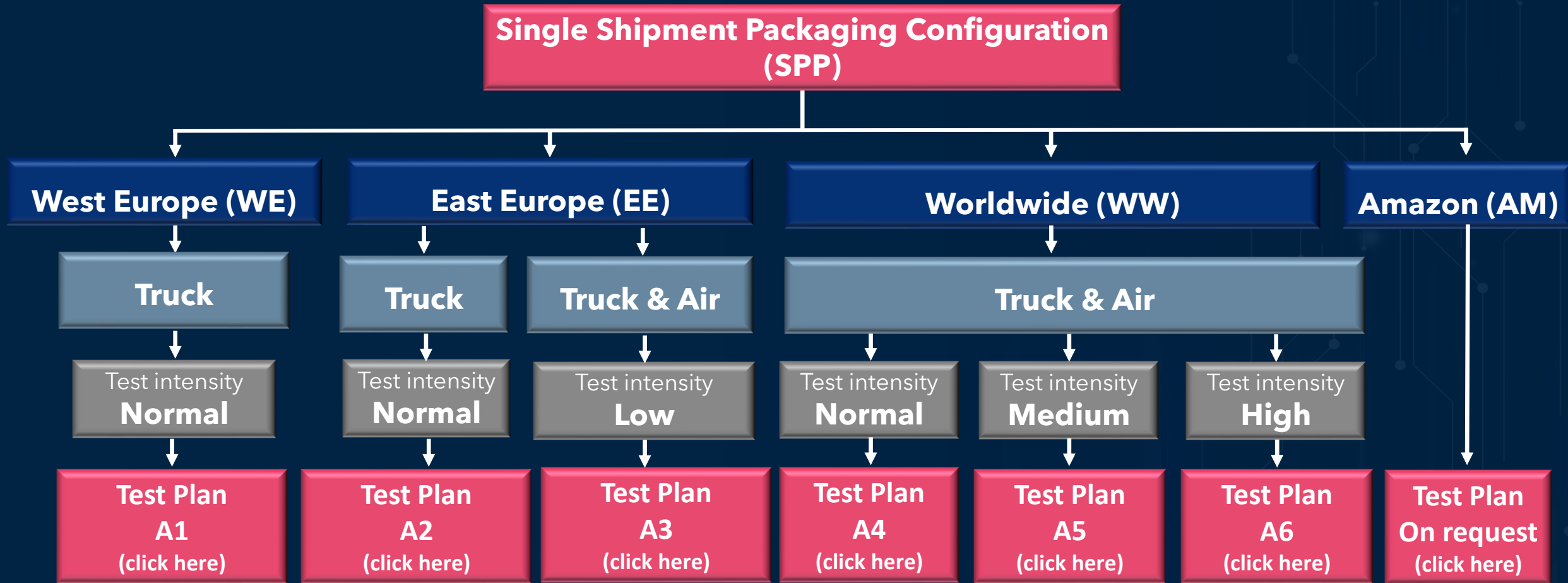
Stacked Pallet Packaging
Mechanical handling



Within this document the test-procedure for a single-packaging and a (combination) of pallet-packaging's will be determined and clarified. Section 8 of the ASTM D 4169 describes the complete procedure to achieve a uniform basis of evaluating, in a laboratory, the ability of shipping units to withstand the distribution environment.



Test Plan A: Manual Handling - Single Shipment box



The measured vibration accelerations of a boat and train is not higher than 0,9 g-peak. The truck simulation on medium level is the acceleration >1,5g peak. In this case the truck simulation overrule the boat acceleration values.



Test plan A1

Single Shipment packaging - West Europe - Truck

Test Plan:	Manual Handling	Vehicle Stacking	Random Vibration	Concentrated Impact	Manual Handling
A1 SSP WE	Drop test during loading	Compression during loading	Truck transport	sorting operations	drop test during loading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D5276	ASTM D642	ASTM D4728	ASTM D6344	ASTM D5276
Assurance level	II	II	Low, medium & high	5,4 Joules	II
Test Spec.	H38cm (<9kg) H33cm (<18 kg) H31cm (<27kg) 6 impacts	F7.0 no support any load F4.5 with stress bearing F3.0 product support load H=2,7 or 1,4m <13,6kg	120 min normal road 0,40 Grms 2x 40min 0,52 Grms, 2x20min 0,70 Grms, 1x5min	H80cm min 4 sides <6mm on content ➤ 6mm middle point Remark A	38cm (<9kg) 33cm (<18 kg) 31cm (<27kg) 6 impacts Last drop 2xheight

Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified, see page 6

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised

Remark A: Concentrated impact test: The test is only applicable to lightweight single wall corrugated shipping containers (under 275 Burst or 44 ECT) and plastic film wrapped packages and unitized loads.

Test plan A2

Single Shipment packaging - East Europe - Truck

Test Plan:	Manual Handling	Vehicle Stacking	Random Vibration	Concentrated Impact	Manual Handling
A2 SSP EET	Drop test during loading	Compression during loading	Truck transport	Sorting operations	Drop test during loading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D5276	ASTM D642	ASTM D4728	ASTM D6344	ASTM D5276
Assurance level	II	II	Low, medium & high	5,4 Joules	II
Test Spec.	H38cm (<9kg) H33cm (<18 kg) H31cm (<27kg) 6 impacts	F7.0 no support any load F4.5 with stress bearing F3.0 product support load H=2,7 or 1,4m <13,6kg	180 min rough road 0,40 Grms 3x 40min 0,52 Grms, 3x15min 0,70 Grms, 3x5min	H80cm min 4 sides <6mm on content > 6mm middle point Remark A	H38cm (<9kg) H33cm (<18 kg) H31cm (<27kg) Last drop 2x height

Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified, see page 6

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised

Remark A: Concentrated impact test: The test is only applicable to lightweight single wall corrugated shipping containers (under 275 Burst or 44 ECT) and plastic film wrapped packages and unitized loads.

Test plan A3

Single Shipment packaging - East Europe - Truck/Air

Test Plan:	Manual Handling	Vehicle Stacking	Low pressure	Random Vibration	Random Vibration	Concentrated Impact	Manual Handling
A3 SSP EEA	Drop test during loading	Compression during loading	High altitude aircraft & mountain passes	Truck (and boat) transport	Air transport	Sorting operations	Drop test during loading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D5276	ASTM D642	ASTM D6653	ASTM D4728	ASTM D4728	ASTM D6344	ASTM D5276
Assurance level	II	II	4267m	Low, medium & high	Low, medium & high	5,4 Joules	II
Test Spec.	H38cm (<9kg) H33cm (<18 kg) H31cm (<27kg) 6 impacts	F7.0 no support any load F4.5 with stress bearing F3.0 product support load H=2,7 or 1,4m <13,6kg	60 min low pressure (595 mbar) Remark A	120 min rough road 0,40 Grms 2x 40min 0,52 Grms, 2x15min 0,70 Grms, 2x5min	40 min 0,16 Grms 1x 27min 0,22 Grms, 1x10min 0,29 Grms, 1x3min	H80cm min 4 sides <6mm on content > 6mm middle point Remark B	H38cm (<9kg) H33cm (<18 kg) H31cm (<27kg) 6 impacts Last drop 2xheight

Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified, see page 6

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised

Remarks A: Low pressure test: Test should be included for products & packages that could be sensitive to low-pressure environment, fa: sealed flexible non-porous packages, liquid containers, or porous packages that may be packed in such a manner as to be adversely affected by low pressure environments

Remarks B: Concentrated impact test: The test is only applicable to lightweight single wall corrugated shipping containers (under 275 Burst or 44 ECT) and plastic film wrapped packages and unitized loads.

Test plan A4

Single Shipment packaging - Worldwide - Low

Test Plan:	Manual Handling	Vehicle Stacking	Low pressure	Random Vibration	Random Vibration	Concentrated Impact	Manual Handling
A4 SSP WWL	Drop test during loading	Compression during loading	High altitude aircraft & mountain passes	Truck (and boat) transport	Air transport	Sorting operations	Drop test during loading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D5276	ASTM D642	ASTM D6653	ASTM D4728	ASTM D4728	ASTM D6344	ASTM D5276
Assurance level	II	II	4267m	Low, medium & high	Low, medium & high	5,4 Joules	II
Test Spec.	H38cm (<9kg) H33cm (<18 kg) H31cm (<27kg) 6 impacts	F7.0 no support any load F4.5 with stress bearing F3.0 product support load H=2,7 or 1,4m <13,6kg	60 min low pressure (595 mbar) Remark A	60 min rough road 0,40 Grms 1x 40min 0,52 Grms, 1x15min 0,70 Grms, 1x5min	120 min 0,16 Grms 3x 27min 0,22 Grms, 3x10min 0,29 Grms, 3x3min	H80cm min 4 sides <6mm on content >6mm middle point Remark B	H38cm (<9kg) H33cm (<18 kg) H31cm (<27kg) 6 impacts Last drop 2x height

Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified, see page 6

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised

Remarks A: Low pressure test: Test should be included for products & packages that could be sensitive to low-pressure environment, fa: sealed flexible non-porous packages, liquid containers, or porous packages that may be packed in such a manner as to be adversely affected by low pressure environments

Remarks B: Concentrated impact test: The test is only applicable to lightweight single wall corrugated shipping containers (under 275 Burst or 44 ECT) and plastic film wrapped packages and unitized loads.

Test plan A5

Single Shipment packaging - Worldwide - Normal

Test Plan:	Manual Handling	Vehicle Stacking	Loose Load Vibration	Low pressure	Random Vibration	Random Vibration	Concentrated Impact	Manual Handling
A5 SSP WWN	Drop test during loading	Compression during loading	Truck simulation	High altitude aircraft & mountain passes	Truck (and boat) transport	Air transport	Sorting operations	Drop test during loading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D5276	ASTM D642	ASTM D999	ASTM D6653	ASTM D4728	ASTM D4728	ASTM D6344	ASTM D5276
Assurance level	II	II	II	4267m	Low, medium & high	Low, medium & high	5,4 Joules	II
Test Spec.	H38cm (<9kg) H33cm (<18 kg) H31cm (<27kg) 6 impacts	F7.0 no support any load F4.5 with stress bearing F3.0 product support load Max 2000kg	40 min extreme road 2-5Hz 1"DA 20 min side 3 10 min side 2 15 min side 5	60 min low pressure (595 mbar) Remark A	60 min rough road 0,40 Grms 1x 40min 0,52 Grms, 1x15min 0,70 Grms, 1x5min	120 min 0,16 Grms 3x 27min 0,22 Grms, 3x10min 0,29 Grms, 3x3min	H80cm min 4 sides <6mm on content > 6mm middle point Remark B	H38cm (<9kg) H33cm (<18 kg) H31cm (<27kg) 6 impacts Last drop 2x height

Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified, see page 6

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised

Remarks A: Low pressure test: Test should be included for products & packages that could be sensitive to low-pressure environment, fa: sealed flexible non-porous packages, liquid containers, or porous packages that may be packed in such a manner as to be adversely affected by low pressure environments

Remarks B: Concentrated impact test: The test is only applicable to lightweight single wall corrugated shipping containers (under 275 Burst or 44 ECT) and plastic film wrapped packages and unitized loads.

Test plan A6

Single Shipment packaging - Worldwide - High

Test Plan:	Manual Handling	Vehicle Stacking	Loose Load Vibration	Low pressure	Random Vibration	Random Vibration	Concentrated Impact	Manual Handling
A6 SSP WWH	Drop test during loading	Compression during loading	Truck simulation	High altitude aircraft & mountain passes	Truck (and boat) transport	Air transport	Sorting operations	Drop test during loading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D5276	ASTM D642	ASTM D999	ASTM D6653	ASTM D4728	ASTM D4728	ASTM D6344	ASTM D5276
Assurance level	I	I	I	4267m	Low, medium & high	Low, medium & high	5,4 Joules	I
Test Spec.	61cm (<9kg) 53cm (<18 kg) 46cm (<27kg) 6 impacts	F10 no support any load F6 with stress bearing F4 product support load H=2,7 or 1,4m <13,6kg	60 min extreme road 2-5Hz 1"DA 30 min side 3 15 min side 2 15 min side 5	60 min low pressure (595 mbar) Remark A	60 min rough road 0,40 Grms 1x 40min 0,52 Grms, 1x15min 0,70 Grms, 1x5min	120 min 0,16 Grms 3x 27min 0,22 Grms, 3x10min 0,29 Grms, 3x3min	H80cm min 4 sides <6mm on content > 6mm middle point Remark B	61cm (<9kg) 53cm (<18 kg) 46cm (<27kg) 6 impacts Last drop 2xheight

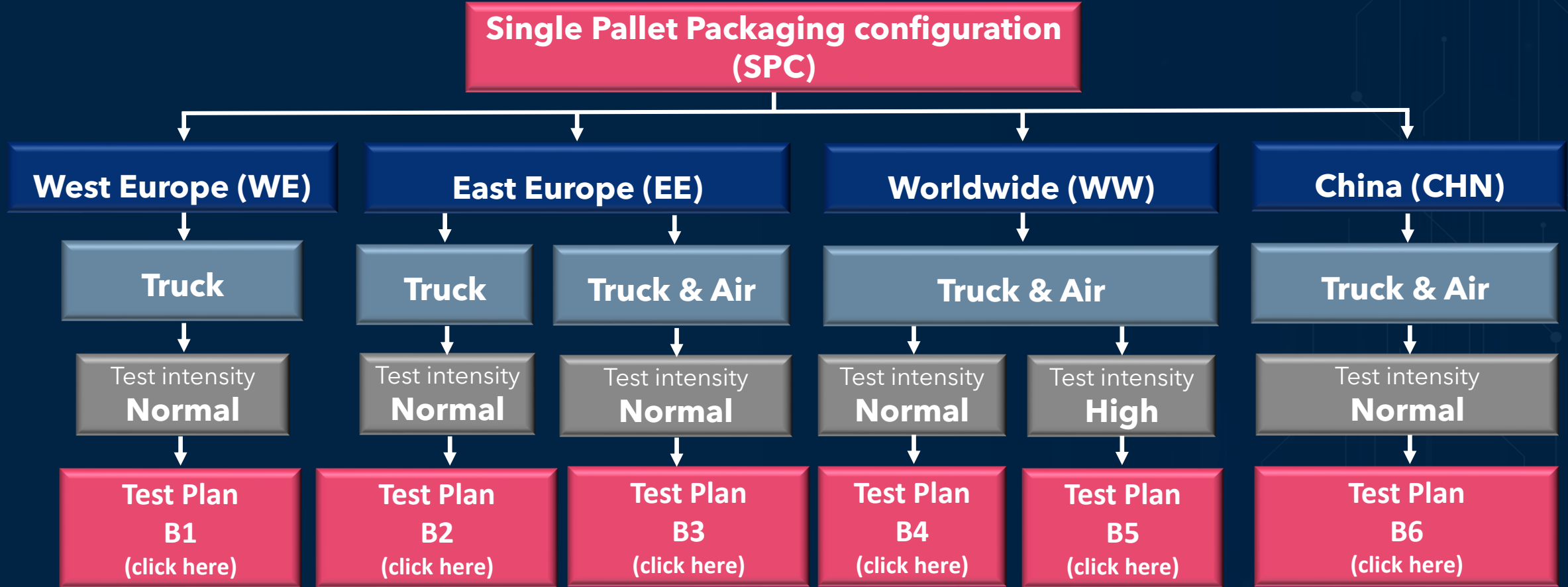
Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified, see page 6

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised

Remarks A: Low pressure test: Test should be included for products & packages that could be sensitive to low-pressure environment, fa: sealed flexible non-porous packages, liquid containers, or porous packages that may be packed in such a manner as to be adversely affected by low pressure environments

Remarks B: Concentrated impact test: The test is only applicable to lightweight single wall corrugated shipping containers (under 275 Burst or 44 ECT) and plastic film wrapped packages and unitized loads.

Test Plan B: Mechanical Handling - Single Pallet



* The measured vibration accelerations of a boat and train is not higher than 0,9 g-peak. The truck simulation on medium level is the acceleration >1,5g peak. In this case the truck simulation overrule the boat acceleration values.



Test Plan B1

Single Pallet configuration - West Europe - Truck

Test Plan: B1 SPC WE T	Random Vibration Truck (and boat)transport	Mechanical Handling Horizontal impact during loading	Mechanical Handling Forklift truck handling during loading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D4728	ASTM D880	ASTM D6179
Assurance level	Low & medium	II	III
Test Spec.	180 min ≈1500km 0,40 Grms 3x 40min 0,52 Grms, 3x20min 0,70 Grms, 3x5min	V=1,22m/s Impact all 4 sides	H=15cm (<227g) H=8cm (>227 kg) Impact all 4 edges



Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified.

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised



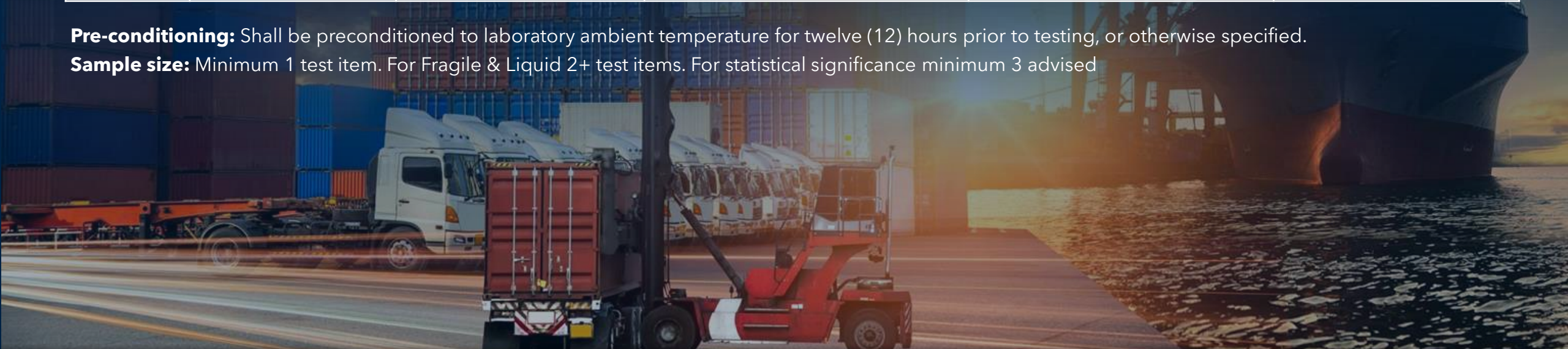
Test Plan B2

Single Pallet packaging - East Europe - Truck

Test Plan: B2 SPC EE T	Mechanical Handling Horizontal impact during loading	Mechanical Handling Forklift truck handling during loading	Random Vibration Truck (and boat) transport	Mechanical Handling Horizontal impact during unloading	Mechanical Handling Forklift truck handling during unloading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D880	ASTM D6179	ASTM D4728	ASTM D880	ASTM D6179
Assurance level	III	III	Low, medium & high	II	II
Test Spec.	V=0,91m/s Impact all 4 sides	H=15cm (<227g) H=8cm (>227 kg) Impact all 4 edges	240 min ≈2000km 0,40 Grms 4x 40min 0,52 Grms, 4x 15min 0,70 Grms, 4x 5min	V=1,22m/s Impact all 4 sides	H=23cm (<227g) H=15cm (>227 kg) Impact all 4 edges

Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified.

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised



Test Plan B3

Single Pallet packaging - East Europe - Truck and Air

Test Plan: B3 SPC EE T	Mechanical Handling Horizontal impact during loading	Mechanical Handling Forklift truck handling during loading	Random Vibration Truck (and boat) transport	Random Vibration Air transport	Mechanical Handling Horizontal impact during unloading	Mechanical Handling Forklift truck handling during unloading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D880	ASTM D6179	ASTM D4728	ASTM D4728	ASTM D880	ASTM D6179
Assurance level	III	III	Low, medium & high	Low, medium & high	II	II
Test Spec.	V=0,91m/s Impact all 4 sides	H=15cm (<227g) H=8cm (>227 kg) Impact all 4 edges	120 min ≈1000km 0,40 Grms 2x 40min 0,52 Grms, 2x 15min 0,70 Grms, 2x 5min	60 min 0,16 Grms 1x 27min 0,22 Grms, 1x10min 0,29 Grms, 1x3min	V=1,22m/s Impact all 4 sides	H=23cm (<227g) H=15cm (>227 kg) Impact all 4 edges

Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified.

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised

Test Plan B4

Single Pallet packaging - Worldwide- Normal

Test Plan: B4 SPC WW N	Mechanical Handling Horizontal impact during loading	Mechanical Handling Forklift truck handling during loading	Random Vibration Truck (and boat) transport	Random Vibration Air transport	Mechanical Handling Horizontal impact during unloading	Mechanical Handling Forklift truck handling during unloading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D880	ASTM D6179	ASTM D4728	ASTM D4728	ASTM D880	ASTM D6179
Assurance level	II	II	Low, medium & high	Low, medium & high	II	II
Test Spec.	V=1,22m/s Impact all 4 sides	H=23cm (<227g) H=15cm (>227 kg) Impact all 4 edges	60 min ≈500km 0,40 Grms 1x 40min 0,52 Grms, 1x 15min 0,70 Grms, 1x 5min	120 min 0,16 Grms 3x 27min 0,22 Grms, 3x10min 0,29 Grms, 3x3min	V=1,22m/s Impact all 4 sides	H=23cm (<227g) H=15cm (>227 kg) Impact all 4 edges

Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified.

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised

Test Plan B5

Single Pallet packaging - Worldwide- High

Test Plan: B5 SPC WW H	Mechanical Handling Horizontal impact during loading	Mechanical Handling Forklift truck handling during loading	Vehicle Stacking Vertical compression during loading	Random Vibration Truck (and boat) transport	Random Vibration Air transport	Mechanical Handling Horizontal impact during unloading	Mechanical Handling Forklift truck handling during unloading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D880	ASTM D6179	ASTM D642	ASTM D4728	ASTM D4728	ASTM D880	ASTM D6179
Assurance level	I	I	I	Low, medium & high	Low, medium & high	I	I
Test Spec.	V=1,75m/s Impact all 4 sides	H=31cm (<227g) H=23cm (>227 kg) Impact all 4 edges	F10 no support any load F6 with stress bearing F4 product support load Max 2000kg	60 min ≈500km 0,40 Grms 1x 40min 0,52 Grms, 1x 15min 0,70 Grms, 1x 5min	120 min 0,16 Grms 3x 27min 0,22 Grms, 3x10min 0,29 Grms, 3x3min	V=1,75m/s Impact all 4 sides	H=31cm (<227g) H=23cm (>227 kg) Impact all 4 edges

Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified.

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised

Test Plan B6

Single Pallet packaging - China simulation

Test Plan: B6 SPC WW H	Mechanical Handling Horizontal impact during loading	Mechanical Handling Forklift truck handling during loading	Vehicle Stacking Vertical compression during loading	Climate Conditioning Hong Kong	Random Vibration Truck (and boat) transport	Random Vibration Air transport	Mechanical Handling Horizontal impact during unloading	Mechanical Handling Forklift truck handling during unloading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D880	ASTM D6179	ASTM D642	ASTM D4332	ASTM D4728	ASTM D4728	ASTM D880	ASTM D6179
Assurance level	III	III	I	-	Low, medium & high	Low, medium & high	II	II
Test Spec.	V=0,91m/s Impact all 4 sides	H=15cm (<227g) H=8cm (>227 kg) Impact all 4 edges	F10 no support any load F6 with stress bearing F4 product support load Max 2000kg	>12 hours 38°C RH not controlled >60 hours 38°C at 85%RH	240 min ≈2000km 0,40 Grms 4x 40min 0,52 Grms, 4x 15min 0,70 Grms, 4x 5min	40 min 0,16 Grms 1x 27min 0,22 Grms, 1x10min 0,29 Grms, 1x3min	V=1,22m/s Impact all 4 sides	H=23cm (<227g) H=15cm (>227 kg) Impact all 4 edges

Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified.

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised

Test Plan B7

Single Pallet configuration - ABC Quick Program - Truck

Test Plan: B7 SPC ABC	Random Vibration Truck (and boat)transport	Mechanical Handling Horizontal impact during loading	Mechanical Handling Forklift truck handling during loading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D4728	ASTM D880	ASTM D6179
Assurance level	Low, medium & high	II	II
Test Spec.	240 min ≈2000km 0,40 Grms 4x 40min 0,52 Grms, 4x15min 0,70 Grms, 4x5min	V=1,22m/s Impact all 4 sides	H=23cm (<227g) H=15cm (>227 kg) Impact all 4 edges



Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified.

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised

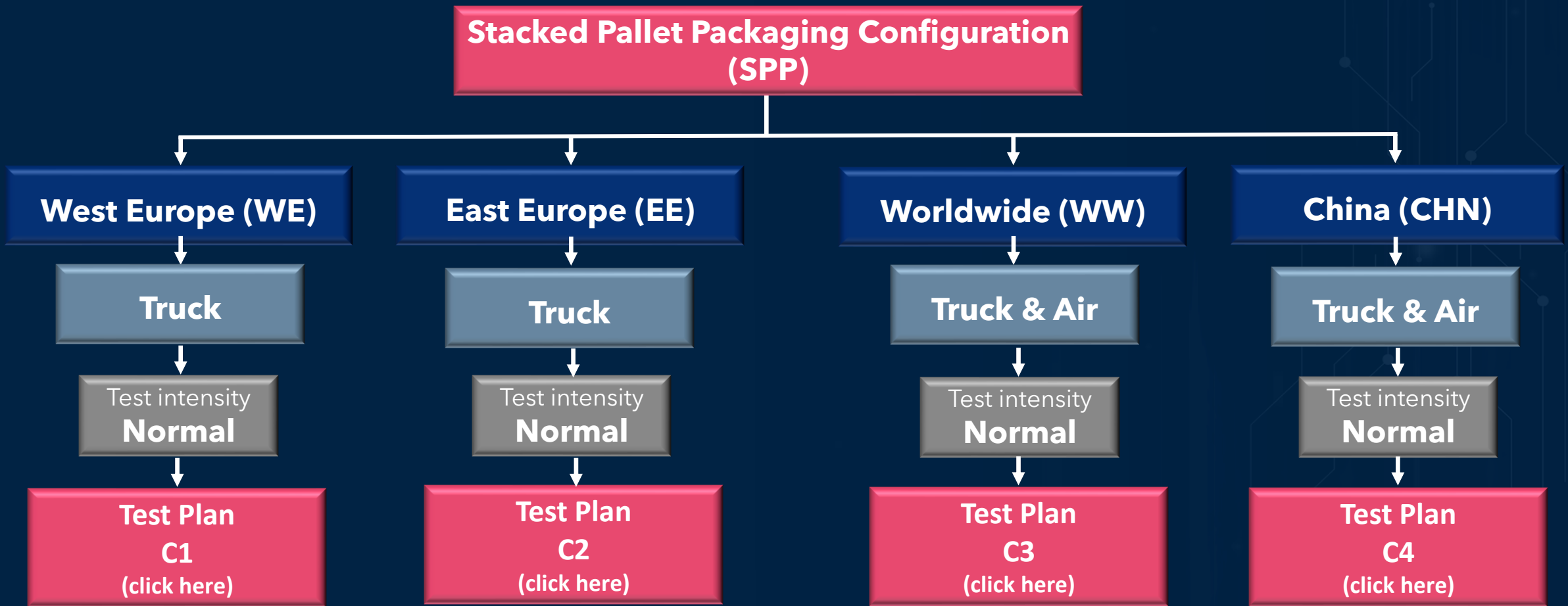
Save Time and Costs with Our ABC Pallet Testing Program B7

With our advanced pallet testing program, you can quickly identify weak points in your pallets before they go into transport. This reduces damage, prevents delays, and saves you money in the long run. This **ABC** program is cost-effective, providing excellent value for its price.

Major companies already use this technology for its reliable results and rapid insights.



Test Plan C: Mechanical Handling - Stacked Pallet



* The measured vibration accelerations of a boat and train is not higher than 0,9 g-peak. The truck simulation on medium level is the acceleration >1,5g peak. In this case the truck simulation overrule the boat acceleration values.



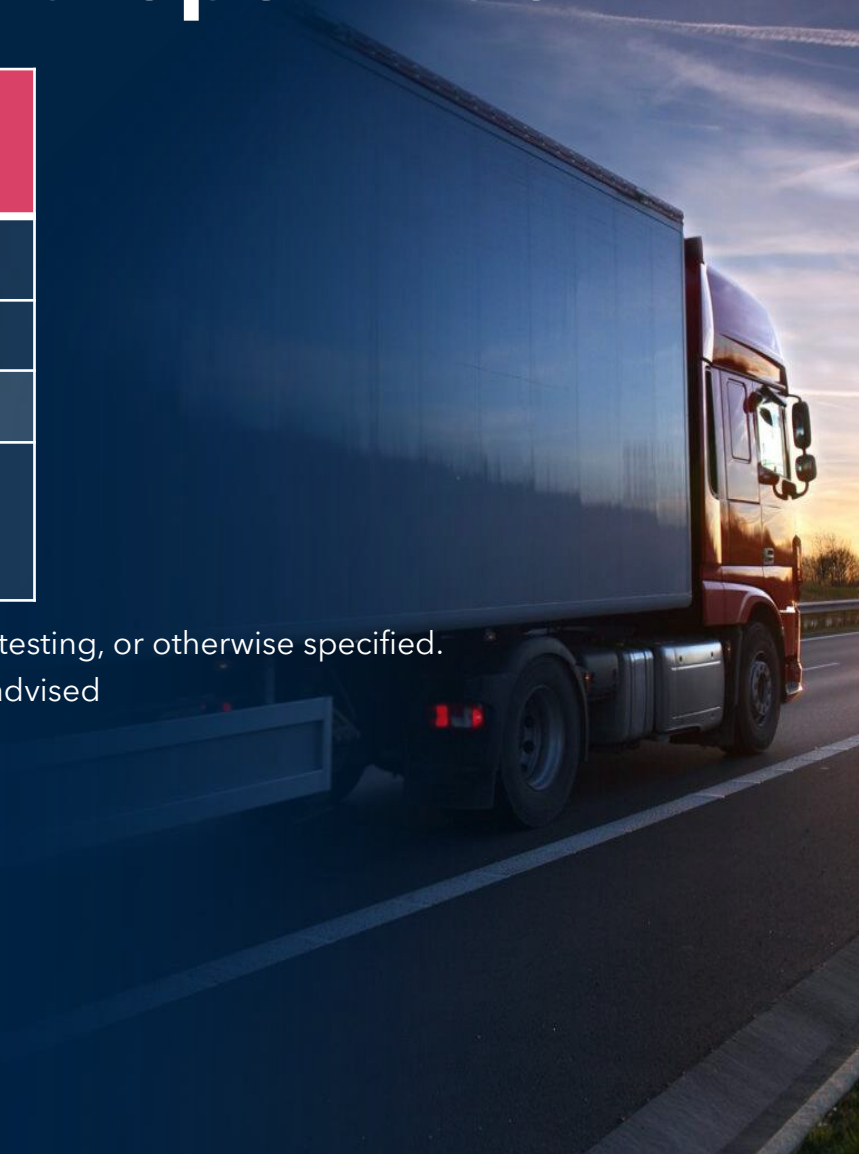
Test Plan C1

Stacked Pallet configuration - West Europe - Truck

Test Plan: C1 SPP WE T	Random Vibration Truck (and boat)transport	Mechanical Handling Horizontal impact during loading	Mechanical Handling Forklift truck handling during loading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D4728	ASTM D880	ASTM D6179
Assurance level	Low & medium	III	III
Test Spec.	180 min ≈ 1600km 0,40 Grms 3x 40min 0,52 Grms, 3x20min 0,70 Grms, 3x5min	V=0,91m/s Impact all 4 sides	H=15cm (<227g) H=8cm (>227 kg) Impact all 4 edges

Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified.

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised



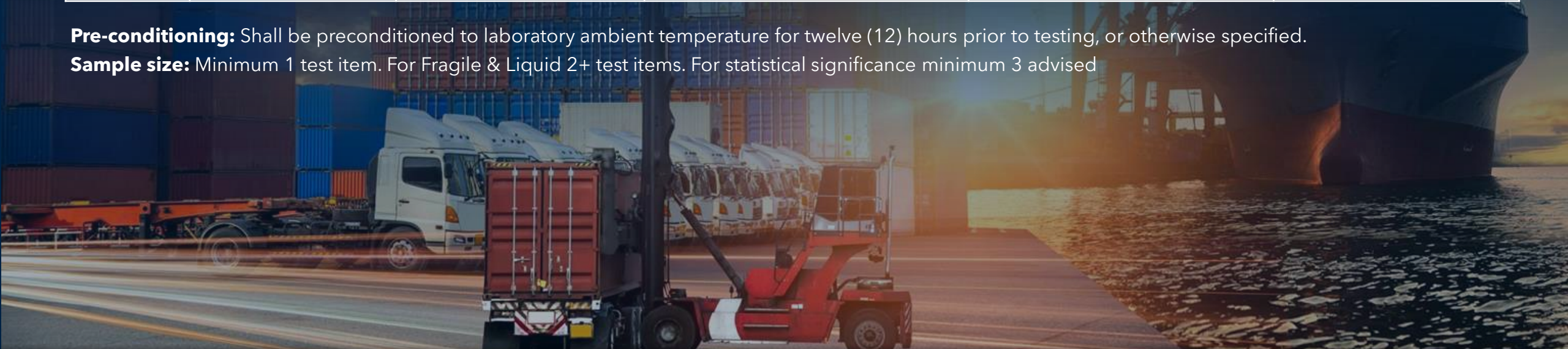
Test Plan C2

Stacked Pallet packaging - East Europe - Truck

Test Plan: C2 SPP EE T	Mechanical Handling Horizontal impact during loading	Mechanical Handling Forklift truck handling during loading	Random Vibration Truck (and boat) transport	Mechanical Handling Horizontal impact during unloading	Mechanical Handling Forklift truck handling during unloading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D880	ASTM D6179	ASTM D4728	ASTM D880	ASTM D6179
Assurance level	III	III	Low, medium & high	II	II
Test Spec.	V=0,91m/s Impact all 4 sides	H=15cm (<227g) H=8cm (>227 kg) Impact all 4 edges	240 min ≈2000km 0,40 Grms 4x 40min 0,52 Grms, 4x 20min 0,70 Grms, 4x 5min	V=1,22m/s Impact all 4 sides	H=23cm (<227g) H=15cm (>227 kg) Impact all 4 edges

Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified.

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised



Test Plan C3

Stacked Pallet packaging - Worldwide- Normal

Test Plan: C3 SPP WW N	Mechanical Handling Horizontal impact during loading	Mechanical Handling Forklift truck handling during loading	Random Vibration Truck (and boat) transport	Random Vibration Air transport	Mechanical Handling Horizontal impact during unloading	Mechanical Handling Forklift truck handling during unloading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D880	ASTM D6179	ASTM D4728	ASTM D4728	ASTM D880	ASTM D6179
Assurance level	II	II	Low, medium & high	Low, medium & high	II	II
Test Spec.	V=1,22m/s Impact all 4 sides	H=23cm (<227g) H=15cm (>227 kg) Impact all 4 edges	60 min ≈500km 0,40 Grms 1x 40min 0,52 Grms, 1x 15min 0,70 Grms, 1x 5min	80 min 0,16 Grms 2x 27min 0,22 Grms, 2x10min 0,29 Grms, 2x3min	V=1,22m/s Impact all 4 sides	H=23cm (<227g) H=15cm (>227 kg) Impact all 4 edges

Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified.

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised

Test Plan C4

Stacked Pallet packaging - China simulation

Test Plan: C4 SPP WW H	Mechanical Handling Horizontal impact during loading	Mechanical Handling Forklift truck handling during loading	Climate Conditioning Hong Kong	Random Vibration Truck (and boat) transport	Random Vibration Air transport	Mechanical Handling Horizontal impact during unloading	Mechanical Handling Forklift truck handling during unloading
Standard	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1	ASTM D4169-23^E1
Test Method	ASTM D880	ASTM D6179	ASTM D4332	ASTM D4728	ASTM D4728	ASTM D880	ASTM D6179
Assurance level	III	III	-	Low, medium & high	Low, medium & high	III	III
Test Spec.	V=0,91m/s Impact all 4 sides	H=15cm (<227g) H=8cm (>227 kg) Impact all 4 edges	>12 hours 38°C RH not controlled >60 hours 38°C at 85%RH	240 min ≈2000km 0,40 Grms 4x 40min 0,52 Grms, 4x 15min 0,70 Grms, 4x 5min	60 min 0,16 Grms 1x 27min 0,22 Grms, 1x10min 0,29 Grms, 1x3min	V=0,91m/s Impact all 4 sides	H=15cm (<227g) H=8cm (>227 kg) Impact all 4 edges

Pre-conditioning: Shall be preconditioned to laboratory ambient temperature for twelve (12) hours prior to testing, or otherwise specified.

Sample size: Minimum 1 test item. For Fragile & Liquid 2+ test items. For statistical significance minimum 3 advised

Why ASTM D 4169-23^E1 and not ASTM D 7386, ISTA or another standard

Sebert Trillingstechnik Laboratory has more than 20 years experience in simulation testing and we prefer the ASTM D4169-23 due to the realistic test levels and the possibilities of adjusting test schedules.

Below you will find the main reasons why we do not use the other standards:

- **ASTM D7386** special made for testing of packages for single parcel shipments, but no air simulation is available.
- **ISTA** last update was around 2018, air simulation test levels to extreme, top load combination with truck vibrations (incl loose load) gives a lot of unrealistic damages. Better to use compression test before the vibration simulation due to the increased levels. Test plan is ISTA is more detailed, but more restricted.
- **ISO 4180** the general test levels do not correspond with practical levels. Difficult to make a good test plan, because the standard gives less background information.
- **MIL STD 810** is a military standard, gives a lot of background info, but too rough for normal transport simulations.

This document does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.



Sebert Trillingstechniek (North Rotterdam)

Our laboratory is ISO/IEC17025*
accredited & ISTA® certified

- ✓ Transport simulation tests (e.g. ASTM, ISTA, IEC, MIL-STD and ISO)
- ✓ Vibration maritime testing (Lloyd's, DNV, Lloyd, Bureau Veritas)
- ✓ Shock, noise & vibration measurements incl. field (S.A.V.E.R.)
- ✓ Compression- and tensile testing
- ✓ Shock-, impact- and drop testing
- ✓ Fatigue testing
- ✓ Seismic simulations
- ✓ Horizontal impact testing of pallets (used in train)
- ✓ Temperature and humidity tests
- ✓ UV and Salt mist test
- ✓ Rain, Water Jets and Dust IP tests
- ✓ IK impact tests



*Refer to www.rva.nl for the current scope (registration number L540)



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Sebert Nord Gerätebau
Harpstedt, Bremen, Germany



SC Sebert Technologie S.R.L.
Sfathu Gheorge, Brasow, Romania)



Sebert Trillingstechnik
Bergschenhoek, Netherlands



Sebert Trillingstechnik
Bergschenhoek

Sebert Nord Gerätebau
Harpstedt, Bremen

Sebert Schwingungstechnik
Kirchheim, Teck

SC Sebert Technologie S.R.L.
Sfathu Gheorge, Brasow



Reference documents

Literature:

- Six step method from Lansmont Corporation
- Environmental Engineering Handbook from Swedish Environmental Engineering Society
- Transportation Stresses from Committee of European Environmental Engineering Societies Department of Defense Test Method Standard MIL-STD 810
- www.ISTA.org and Packaging Dynamics Professional (PDP) SAVER measurements Stedelijk Museum Amsterdam

ASTM Standards:

- D4169 Standard Practice for performance Testing of Shipping Containers and systems
- D880 Standard Test Method for Impact Testing for Shipping Containers and Systems
- D996 Standard Terminology of Packaging and Distribution Environments
- D999 Standard Methods for Vibration Testing of Shipping Containers
- D4728 Standard Test Method for Random Vibration Testing of Shipping Containers
- D5276 Standard Test Method for Drop Test of Loaded Containers by Free Fall
- D6179 Standard Test Methods for Rough Handling of Unitized Loads and Large Shipping Cases and Crates
- D6344 Standard Test Method for Concentrated Impacts to Transport Packages

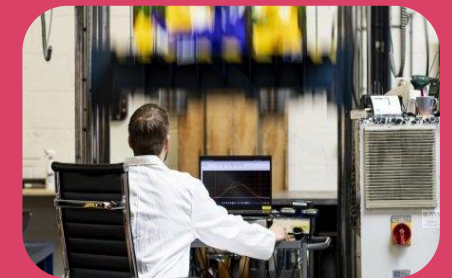
Remark: Monitor shipments

When possible, obtain feedback by monitoring shipments of the container that was tested to ensure that the type and quantity of damage obtained by the laboratory testing correlates with the damage that occurs in the distribution cycle. This information is very useful for the planning of subsequent tests of similar shipping containers.



QUESTIONS OR REMARKS

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*Refer to www.rva.nl for the current scope (registration number L540)

