ISTA 3 Series General Simulation Performance Test PROJECT*

VERSION DATE January 2011 Initial Release

Last EDITORIAL Change: JANUARY 2017

For complete listing of Procedure Changes and Version Dates go to www.ista.org

ISTA, Distributing Confidence, Worldwide™

ISTA® 3-Series tests are advanced tests and are designed to:

- Challenge the capability of the package and product to withstand transport hazards, **but**
- Utilize general simulation of actual transport hazards, **and**
- Do not necessarily comply with carrier packaging regulations.

When properly executed, ISTA procedures will provide tangible benefits of:

- Product to market time reduction
- Confidence in product launch
- Reduction in damage and product loss
- Balanced distribution costs
- Customer satisfaction contributing to increased market share

There are two sections to this procedure: Overview and Testing

- **Overview** provides general knowledge required before testing **and**
- **Testing** presents the specific instructions to undertake laboratory testing.

Weights and measures system - Familiarity with the following units and symbols used in this document is required:

For measuring	Metric units and symbols
Weight	kilograms (kg) or grams (gm)
Distance	metres (m) or millimetres (mm)
Volume	Cubic centimetres (cm^3)
Density	kilograms per cubic metre (kg/m^3)
Temperature	Celsius (°C)

VERY IMPORTANT:

The entire document shall be read and understood before proceeding with a test.

*** Notes Regarding ISTA "Projects" and "Procedures"**

- ISTA 3K is currently an ISTA "Project", first released in January 2011. New ISTA test protocols are given the designation "Project" during their implementation phase. After a minimum one-year period and required evaluation, a "Project" will either be adopted as an established "Procedure", revised and kept as a "Project" for another period of time, or be dropped. Therefore, a "Project" is potentially subject to greater and more frequent revision than a "Procedure".
- Comments regarding this Project and its use are encouraged and welcome. Please contact ista@ista.org.
- ISTA members may use either Procedures or Projects for package certification.

Project History:

The testing detailed in this procedure is as per methods first developed through a multi-client research project that was established and managed by Smithers Pira. The Smithers Pira research project examined real life supply chain conditions and processes, and included a program of laboratory validation testing to benchmark test results against real life packaged product performance. Smithers Pira shares these methods with ISTA in order to support the packaging and testing communities in assessing packaging performance, and to support progression towards greater sustainability in packaged grocery products distribution. Smithers Pira and ISTA acknowledge the co-sponsors of the original Smithers Pira research project in allowing this test method to be published by ISTA.

OVERVIEW OF PROJECT 3K

Preface

Project 3K is a general simulation test for fast moving packaged consumer products shipped through the multiple-retail supply chain environment in Europe. Project 3K is appropriate for the range of packages commonly merchandised through large retailer stores and large retail chain convenience stores, *and where retailer operations include shipment of store-specific mixed loads in roll cages or as mixed pallets*. This retail environment is common within western European countries, including (but not exclusive to) Sweden, Norway, Denmark, UK, France, Belgium, Netherlands, Germany, Austria, Switzerland, Spain and Italy; thus the scope of this project applies primarily to these countries. The scope also applies to similarly developed European states that are not listed but where large multiple-retail environment infrastructure is developed. Note large multiple-retail environment infrastructure involving shipment of mixed-loads is growing in other European countries and so this project may also apply in those cases. Many European grocery packages are in shelf-ready format; this method applies equally to shelf ready and non-shelf ready packages.

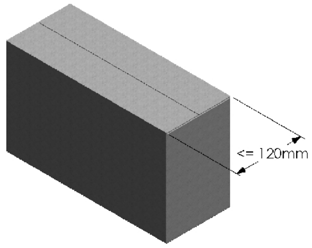
In this procedure the term ‘package’ is used to describe a collation of primary packs. Common package formats that appear in the retail supply chain are presented below to clarify the scope of this method (this list is not exhaustive):

Package Formats

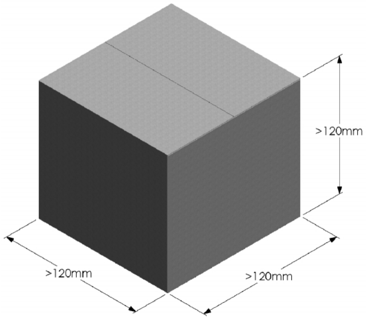
- Small shrink wrap tray, for example
  - collation of 6 or 12 deodorant aerosols
  - collation of 6 glass jars of a sauce product
- Large shrink wrap trays, for example
  - tray of 24 cans of a beverage product
  - tray of 12 stand-up-pouches of washing detergent product
- Small corrugated cases or wraps, for example
  - shelf ready corrugated case for a snack product
- Large corrugated cases or wraps, for example
  - collation of 20 glass bottles of a beverage product
  - tray of 12 aseptic drinks cartons
- Shrink wrap without tray, for example
  - collation of 6 large bottles of mineral water
  - collation of rolls of an absorbent kitchen towel product
- Bags, for example
  - 10kg or 20kg bag of pellet pet food product
  - Collation of 12 bags of flour or sugar product.

The following package *type* definitions are required for selecting specific tests where test options are detailed:

Type 1: Single hand lift/carry – closed ends
Weight ≤ 4.5kg
AND
One principal dimension ≤ 120mm
AND
No opening in the outer package materials ≥ 60 x ≥40mm with flexibility or space behind so at least 3 fingers could be inserted (i.e. the package is a closed corrugated case or carton, or is a shrink wrap collation that can’t be lifted by inserting the hand in to the opening in the wrap at one end of the package).



Type 2: Double hand lift/carry – closed ends
All principal dimensions > 120mm
AND / OR
Weight > 4.5kg
AND
No opening in the outer package materials ≥ 60 x ≥40mm with flexibility or space behind so at least 3 fingers could be inserted (i.e. the package is a closed corrugated case or carton, or is a shrink wrap collation that can’t be lifted by inserting the hand in to the opening in the wrap at one end of the package).



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OVERVIEW OF PROJECT 3K

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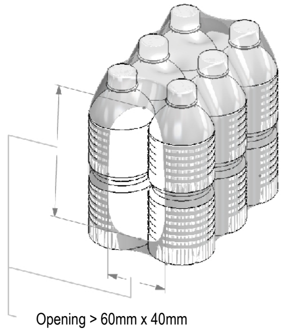
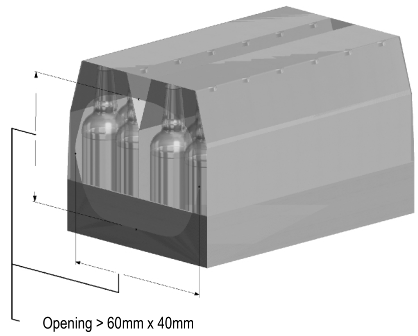
Type 3: Single hand lift/carry - open ended
Weight ≤ 7kg
AND
Opening at one (or more ends) > 60mm x >40mm with flexibility or space behind so at least 3 fingers can be where there is sufficient space to insert the hand within an opening in the wrap) inserted for lifting (i.e. normally a shrink wrap collation).



Type 4: Double hand lift/carry - open ended
Weight > 7kg
AND
Opening at two opposing ends > 60mm x >40mm with flexibility or space behind so at least 3 fingers can be inserted for lifting (i.e. normally a shrink wrap collation where there is sufficient space to insert at least 3 fingers within an opening in the wrap at either end of the package).



NOTE:
Within this procedure the term 'sample' is also used as a common description for the various types of packages described above (i.e. one 'sample' is the same as one 'package', consisting of a number of primary packs in a collation).

General

- Testing can be used to evaluate the fitness for purpose of a packaged-product or the protective performance of packaging with respect to the common hazards of the European retail supply chain.
- Tests and test levels are based on observation of various brand owner and retailer distribution and in-store systems, and correlation between specific damage occurrences observed in the field and damage produced using laboratory testing during a validation exercise; however the test may not represent any specific distribution system.
- The package and product are considered together and not separately.
- Some conditions of transit, such as moisture, pressure, careless handling or unusual handling may not be covered.

Other ISTA Procedures or Projects may be appropriate for different conditions or to meet different objectives.

Refer to *Guidelines for Selecting and Using ISTA Test Procedures and Projects* for additional information.

NOTE:
Hazardous material packaging that passes this test procedure may not meet international, national or other regulatory requirements for the transport of dangerous goods or hazardous materials. **This test is not a substitute** for United Nations and/or any other required test standards for the transport of dangerous goods or hazardous materials, but may be used as an additional test in conjunction with them.

OVERVIEW OF PROJECT 3K

Scope

Project 3K covers the testing of packaged-products prepared for sale through multiple-retail environments. From the point of manufacture of finished packaged goods, this supply chain commonly involves unit load (full pallet) storage, unit load shipment and unit load handling within the brand owner controlled part of the supply chain, leading to delivery of unit loads of product to a retailer distribution centre. This is commonly followed by a series of steps controlled by the retailer, involving order picking and mixed load building at the retailer distribution centre, mixed load delivery to store and in-store handling leading to loading of packaged-products on to the store shelf.

This test method relates only to the retailer controlled parts of this supply chain. Separate testing should be undertaken at the unit load level to determine fitness with respect to full pallet shipment commonly controlled by the brand owner.

Research shows that the hazards of distribution are commonly more severe in the retailer controlled parts of the supply chain (largely due to the complex product mix); however successful performance in this test method does not eliminate the need for evaluating packaged-product performance at the unit load level.

Specifically the test investigates the following processes occurring at the package (case or tray) level:

- Pyramid-pick/Overhang stack (representing the way a package is often partially supported on the unit load at the pick face at retailer distribution centre, occurring as a result of the way other packages are selected from the unit load)
- Drag (representing pulling of a package from a unit load at the pick face at retailer distribution centre)
- Carry (representing lifting and carrying of a package over short distance from the pick face to the mixed load, including, as appropriate to the pack design/format, carrying packs without supporting the base and carrying using openings in shrink wrap)
- Placement-drop and Drop–on impact (representing impacts occurring to packages during building of the mixed load)
- Package horizontal impacts (representing impacts occurring through automated conveyor operations at automated retailer distribution centres) - where it is known or possible that packages will pass through a retailer distribution centre with conveyoring/package level automated systems this test should be conducted.

Specifically the test investigates the following processes occurring for mixed loads (mixed pallets or roll cages):

- Both mixed pallet and mixed roll cages are commonly used in retailer distribution in Europe. Based on observation it is deemed that roll cage mixed loads experience more significant hazards because packs are able to press against the roll cage sidewalls as well as other packs (other than this, mixed load hazards are similar between the mixed load pallet and mixed load roll cage formats); the presence of sidewalls provides a horizontal load on packs that is less significant in mixed pallets. Because both mixed pallet and roll cage formats are used widely, the worst case of the two formats was selected for the test.
- Horizontal impact of mixed load (representing horizontal cage to cage (or mixed pallet to mixed pallet) impacts, or impacts between a mixed load and other fixed object, occurring during vehicle loading, road journey and handling at store)
- Vibration of mixed load (representing the road journey segment of the mixed load life cycle, but also representing more aggressive vibration occurring during loading/unloading where mixed loads are moved over chequer-plate ramps or rough surfaces within receiving bay areas, normally at the store)
- Vertical impact of mixed load (representing higher level transient shocks occurring during road shipment and vertical shocks occurring during marshalling/movement of mixed loads over rough surfaces or over door thresholds, normally at the store).

Product Damage Tolerance and Package Degradation Allowance

The shipper shall determine the following prior to testing:

- what constitutes damage to the product **and**
- what damage tolerance level is allowable, if any, **and**
- the correct methodology to determine product condition at the conclusion of the test **and**
- acceptable package condition at the conclusion of the test.

For additional information on these determinations refer to *Guidelines for Selecting and Using ISTA Test Procedures and Projects*.

OVERVIEW OF PROJECT 3K

Samples

Samples should be untested actual package and product, but if one or both are not available, the substitutes shall be as representative as possible to actual items.

Multiple test samples are required, but they should be identical. The exact number is dependent on the size of the sample. To provide an indication of the *total* number of samples needed for testing, establish the number of samples required to build a stack measuring at least 0.8m x 0.8m x 1.6m without significant gaps in the stack. Take this number and multiply it by 2; the resultant provides a guide to the *total* number of samples required. For example for a sample measuring 0.4m x 0.4m x 0.2m, 16 samples would be required to build the stack described above, so a total of 32 samples would be required for testing.

For this procedure the samples are classified and utilized in three (3) ways:

- **Test packages** are used from the start through to the end of testing; when multiple identical test packages are tested, all test packages must pass all tests.
- **Dummy packages** are used in various parts of the procedure to allow effective simulation of the real life hazard in the test (so that the real life hazard is correctly applied to the test package). Specifically, dummy packages are used in Test Blocks 1, 2, 3, 6 and 13. If a dummy package becomes degraded to the point that it does not maintain its shape or provide resistance to test packages it should be replaced with another dummy package, but dummy packages are not subject to inspection or pass/fail assessment as part of the test. Note: dummy packages are different from Roll Cage Fill packages described below.
- **Roll Cage Fill packages** are used only in Test Blocks 8, 9 and 10 to enable building of the mixed load in the roll cage around the test packages. Dummy packages used during Test Blocks 1- 6 should not be used as Roll Cage Fill packages for Test Blocks 8, 9 and 10. Upon completion of Test Block 10 Roll Cage Fill packages are set aside for later assessment (and pass/fail judgment), so should not be used as Dummy packages in Test Blocks 11-13.

To enable effective tracing of samples throughout the procedure, Test package samples should be identified with “TP”, Dummy package samples as “DP” and Roll Cage Fill package samples with “RCF”. The exact number of each classification will vary depending on the size and type/format of package, so this identification is to be applied to each pack during testing at the point where a Test package, Dummy package or Roll Cage Fill package is required according to the details in the Test Block.

Refer to *Guidelines for Selecting and Using ISTA Test Procedures and Projects* for additional information on statistical sampling.

NOTE:
In order to ensure testing in perfect condition, products and packages shipped to an ISTA Certified Laboratory for testing shall be:

- Adequately over-packaged for shipment **or**
- Repackaged in new packaging at the laboratory.

NOTE:
It is important to thoroughly document the configuration, materials, and construction of the tested product and package. Significant variations in performance can sometimes be caused by seemingly insignificant differences. Photo documentation is strongly recommended to supplement detailed written descriptions.

Basis Weight

Basis Weights of Corrugated Board
When the outer package is a corrugated box, it is strongly recommended that the basis weights of the papers/paperboards used to make the box be determined and documented. If the nominal basis weights change, even if the board is rated for the same performance, a retest is appropriate.

Refer to *Guidelines for Selecting and Using ISTA Procedures and Projects* for additional information on documentation and basis weight determination.

OVERVIEW OF PROJECT 3K

Test sample selection and sample flow through the test sequence are detailed within the TESTING part of this PROJECT

Format	Test Category	Test Type	Test Level	For ISTA Certification
Package	Atmospheric Preconditioning TEST BLOCK 1	Temperature and Humidity	Ambient, frozen or chilled (to be selected as appropriate for the distribution and merchandising channel for the packaged product being tested)	Required
Package	Picking TEST BLOCK 2	Pyramid Pick (Overhang stack)	5 minute test duration	Required
Package	Picking TEST BLOCK 3	Drag	900mm drag distance at 1.0 m/s	Required
Package	Picking TEST BLOCK 4	Carry	10 seconds static plus 5 cycles carry-oscillation	Required
Package	Shock TEST BLOCK 5	Placement drop	5 impacts in various orientations, 150mm	Required
Package	Shock TEST BLOCK 6	Drop-on	Impacting top of lower package, base of upper package, 150mm	Required
Package	Shock (OPTIONAL) TEST BLOCK 7	Impact	8 impacts at 1.35m/s	Optional
Mixed load	Shock TEST BLOCK 8	Impact	4 impacts at 0.91m/s	Required
Mixed load	Vibration TEST BLOCK 9	Random Vibration	Overall G_{rms} level of 0.28 for 40 minutes followed by 0.517 for 60 seconds	Required
Mixed load	Shock TEST BLOCK 10	Flat drop	1 drop from 60mm	Required
Package	Shock TEST BLOCK 11	Placement drop	4 impacts in various orientations, 150mm	Required
Package	Shock (INVESTIGATIVE) TEST BLOCK 12	Drop	4 impacts in various orientations, 300mm	Advised (Optional)*
Package	Shock (INVESTIGATIVE) TEST BLOCK 13	Drop-on	Impacting top of lower package, base of upper package, 300mm	Advised (Optional)*
Assessment	Package Assessment BLOCK 14	No testing involved	Inspection and assessment of test and roll cage fill packages	Required

* In certain situations, the 300mm drop or drop-on test may not be appropriate. 300mm drops represent 'worst of normal' handling and should be conducted to investigate the perfromance of packages under more severe (but still within the range of normal) conditions; not every package will experience free fall impact from 300mm, but a small quantity of packages will be exposed to this level of hazard such that its effect should be investigated. If the drops are NOT performed, this should be shown in the test report.

3K

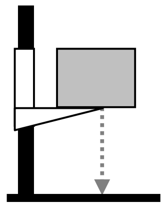
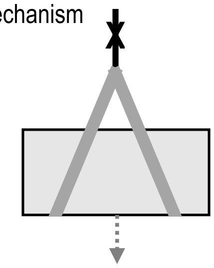
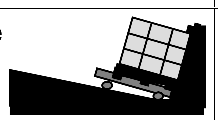
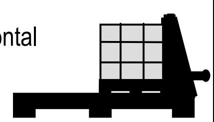
EQUIPMENT REQUIRED FOR PROJECT 3K

Equipment Required Atmospheric Conditioning

Atmospheric Conditioning:

- Humidity recorder complying with of the apparatus section of ISO 2233 **or** ASTM D 4332.
- Temperature recorder complying with the apparatus section of ISO 2233 **or** ASTM D 4332 .
- Chamber and Control apparatus complying with the apparatus section of ISO 2233 **or** ASTM D 4332 .

Equipment Required Shock

Type of Shock Test	Type of Equipment	In compliance with the apparatus sections of…	Comments
Free-Fall Drop Tests	**Fork-type** free-fall drop tester 	ISO 2248 **or** ASTM D 5276	If available, use this drop apparatus as the preferred option for **all package drop tests (from 150mm and 300mm)** and for the **60mm mixed load drop test**. Some drop tester designs do not allow for drops as low as 150mm or 60mm – in this case use alternative apparatus described below.
Free-Fall Drop Tests (Alternate)	Drop by hand using a reference measure to maximise repeatability of drop height	N/A	Preferred **alternative** option for **150mm package drop tests**
Free-Fall Drop Tests (Alternate)	Slings and Quick-Release mechanism 	ISO 2248 **or** ASTM D 5276	Preferred **alternative** option for **60mm mixed load drop test**
Impact Tests	Incline  Horizontal 	ISO 2244 **or** ASTM D 880 **or** ASTM D 4003	

Equipment Required Vibration

Random Vibration:

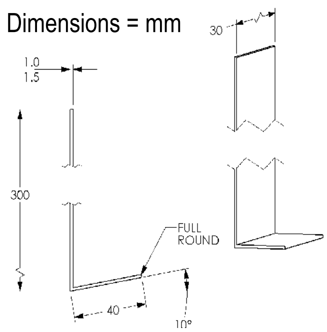
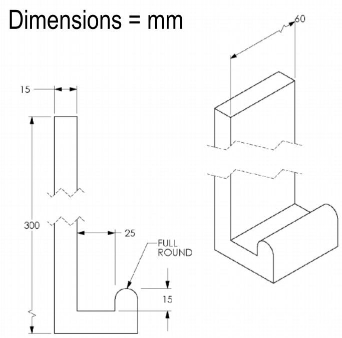
- Vertical Random Vibration Test System complying with the apparatus section of ISO 13355 **or** ASTM D 4728 .
- Means must be provided to prevent the test item from moving off the vibration system's platform, without restricting the vertical motion of the test item.

Equipment Required Mixed Load

Mixed Load:

- A four wheeled metal roll-cage measuring approximately 800mm X 700mm in the horizontal axes and 1800mm in height (from the underside of the wheels to the top of the metal cage). A mid-shelf in the roll cage may be required – see bottom of page 11 for further details.
- Cage to have three fixed sides and one open side, plus two elastic or fabric straps to contain product on the open side face.

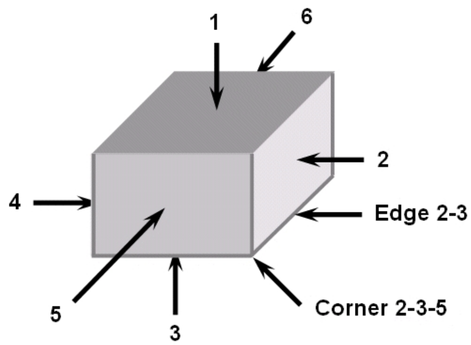
EQUIPMENT REQUIRED FOR PROJECT 3K

Type of Package/Carry	Type of Equipment	Drawing/Detail	Comments
Picking Drag	Wedge	A wedge approximately 70 mm wide, 150mm long, with one end 2 mm high and the other end 20 mm high.	Ensures the front edge of top package is supported by the *test* package
Single hand lift/carry packages (Type 3 package, as defined in the Preface)	One single-dummy hand required	Dimensions = mm 	It is most suitable to construct this dummy hand in mild or stainless steel. To undertake the oscillation part of the lift/carry tests using the single dummy hand, secure the single hand to a rigid frame or assembly (described below in "For the oscillatory part of the carry test". Drill a hole at the top of the single dummy hand to enable the dummy hand to be hung freely on the rigid frame/assembly.
Double hand lift/carry packages (Type 4 package, as defined in the Preface)	A pair of double-dummy hands required	Dimensions = mm 	It is most suitable to construct this dummy hand in hardwood timber or in aluminium or stainless steel. To undertake the oscillation part of the lift/carry tests using the double dummy hands, secure the dummy hands to a rigid frame or assembly (described below in "For the oscillatory part of the carry test"). Drill a hole at the top of each dummy hand to enable the dummy hand to be hung freely on the rigid frame/assembly.
For the oscillatory part of the carry test	Oscillation may be effected using a vibration table with fixed frequency sinusoidal control, and with the package supported on a rigid frame or assembly such that the test item hangs clear of the table platform during the test. The rigid frame/assembly can be of any construction as long as there is no flex in the construction as a result of the oscillation during test, and as long as the frame and vibration table platform do not interfere with the test package during oscillation.	Complying with the apparatus section of ISO 13355 **or** ASTM D 4728 would be suitable – other smaller scale sinusoidal oscillation producing apparatus may also be suitable	Will require displacement and frequency to achieve peak acceleration of 0.2g, delivered with peak to peak displacement of no less than 40mm and no more than 80 mm (corresponds to frequency no more than 1.6Hz and no less than 1.1Hz)

BEFORE YOU BEGIN PROJECT 3K

Identification of Faces, Edges and Corners (Test Specimen Members)

Prior to beginning the tests identify the faces, edges and corners (or other members) of the samples according to the procedure below.

Step	Action
1	**Place the package in its intended shipping orientation.** If there are sufficient reasons for identifying the Faces, Edges, and Corners with the package in other than its intended shipping orientation, they must be documented and justified on the Test Report. For some situations it may be appropriate to place the package in its most stable orientation (if different from the shipping orientation), or to perform multiple tests using different package member identifications.
2	**Label the faces in accordance with the diagram shown (with the shorter of the vertical side faces being labeled as faces 5 and 6).** Identify edges using the numbers of the two faces forming that edge. Example: Edge 1-2 is the edge formed by face 1 and face 2 of the package. Identify corners using the numbers of the three faces that meet to form that corner. Example: Corner 2-3-5 is the corner formed by face 2, face 3, and face 5 of the package. Identify orientation of the product inside the package. 

Packaged-Product Weight and Size Measurement

The weight and size of the package shall be determined:

- Gross weight in kilograms (kg)
- Exterior dimensions of Length, Width and Height (L x W x H) in millimeters (mm).

Before You Begin Atmospheric Conditioning

Required Preconditioning:

- All samples shall be preconditioned to conditions appropriate to the distribution and merchandising retail channel for the product being tested: chilled products shall be pre-conditioned to chilled conditions; ambient products to standard laboratory conditions; frozen products to frozen conditions.
- **The table below details the specific conditions to be used.**
- Pre-conditioning shall be conducted for a minimum period of twelve (12) hours prior to testing. The best approach is to perform all tests directly in the conditioned atmosphere; if this is not possible, tests should be performed quickly after removal of test items from the conditioned atmosphere (and as required, samples shall be re-conditioned between test stages to ensure package conditions are best maintained throughout testing).
- If more than one conditioning sequence is selected, a new and complete test should be performed following each condition**.**

Conditions	Minimum Time in Hours	Temperature in °C ±2°C	Humidity in % (RH) ±5%
Ambient distribution and retail channel	12	23	50
Chilled distribution and retail channel	12	2 to 8	Uncontrolled RH
Frozen distribution and retail channel	12	-18	Uncontrolled RH

Before You Begin
Shock Testing

Incline or Horizontal Impacts

- The required impact tests may be accomplished with either an incline or horizontal machine. If an incline-impact machine is used, the minimum required *impact velocity* must be 0.91 m/sec. If a horizontal-impact machine is used, the minimum required *velocity change* must be 0.91 m/sec and the required shock must be a nominal 10 millisecond half sine pulse.
- If any velocity of an impact test is below the required minimum, that test must be repeated until the velocity meets the minimum.

Free Fall Shock

- A free-fall drop test apparatus is the preferred option for **all package drop tests (from 150mm and 300mm)** and for the **60mm mixed load drop test**.
- Some drop tester designs do not allow for drops as low as 150mm or less – in these cases use alternative apparatus described the Equipment Required Shock section.

Before You Begin
Vibration Testing

Random Vibration Spectrum

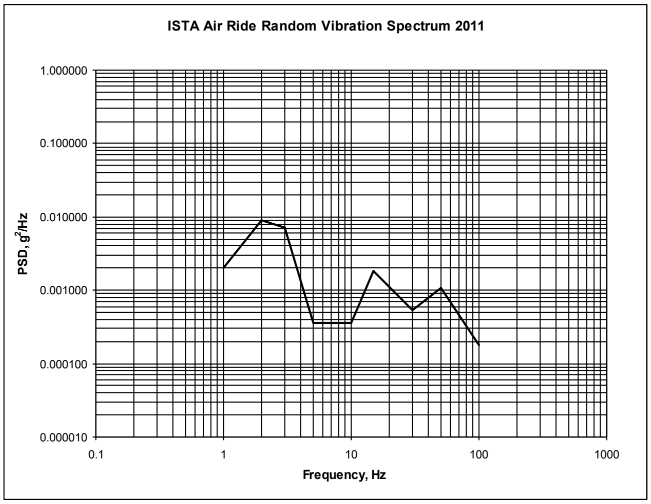
Two random vibration spectra are used in this procedure:

- A road random vibration spectrum (representing road delivery of mixed loads on large or articulated air-sprung vehicles from DC to store) – for this testing ISTA's Air Ride Random Vibration Spectrum is used.
- A more general broadband random vibration spectrum (to cover the range of rough surfaces that mixed loads may be handled over, including rough concrete floors, chequer plate surfaces, loading ramps, etc) – for this testing a more generic random vibration spectrum is used.

The acceleration vs. frequency break points for these two spectra and the overall Grms levels are shown below. For the Air Ride Random Vibration Spectrum the theoretical stroke required is 54mm peak-to-peak. For the rough surface Random Vibration Spectrum the theoretical stroke required is 20mm peak-to-peak.

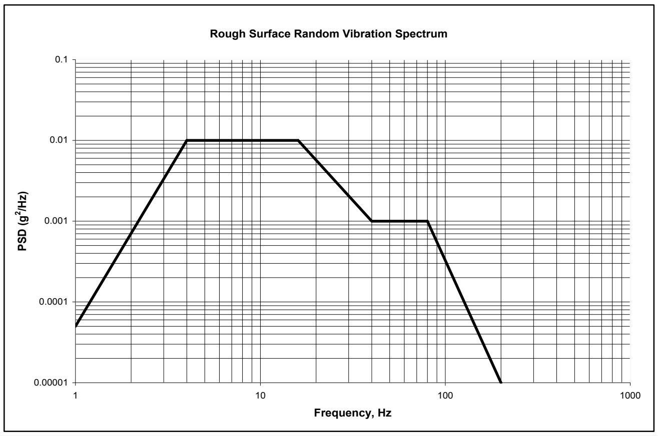
Air Ride Random Vibration Spectrum
(overall G_{rms}, 0.28)

Frequency (Hz)	PSD (g^2/Hz)
1.0	0.002
2.0	0.009
3.0	0.0072
5.0	0.00036
10.0	0.00036
15.0	0.0018
30.0	0.00054
50.0	0.00108
100.0	0.00018



Rough Surface Random Vibration Spectrum
(overall G_{rms}, 0.52)

Frequency (Hz)	PSD (g^2/Hz)
1.0	0.00005
4.0	0.01
16.0	0.01
40.0	0.001
80.0	0.001
200.0	0.00001



BEFORE YOU BEGIN PROJECT 3K

Roll cage assembly

A significant portion of this procedure is based on testing of packages collated as a mixed load, within a metal roll cage. The notes in this section should be used as *guidance* for assembling the filled roll cage, using *test* and *dummy* (spare) samples. Alternative arrangements may be required subject to the overall size of the package being tested. The configuration of each layer of packages should be photographed as the load is being built in order to create a record of the sample configuration for future reference (and to support repeatability between tests undertaken on samples of a similar size but at different points in time).

1. Fill the bottom layer of the cage with packages in their normal shipping orientation, and arranged to give the best fit in the cage
   - An overhang at the front of the cage up to 25mm is preferred to a significant under-fill
   - For large packages (12 or fewer per layer) position the packages against the roll cage sides, and fill any gaps > 25mm with densely wrapped bundles of stretch-film (or similar). The fill does not need to be level with the tops of adjacent packages – it is to stop the load shifting horizontally into the gap. Continue to fill gaps in all layers
   - For small packages (more than 12 per layer) do not leave gaps between packages. Fill against the back and one side of the cage. If a gap > 25mm is left against the other cage side fill this gap with a tightly wrapped bundle of stretch-film AND / OR one or more sheets of plywood or MDF or chip-board

2. Fill the next layer with 3 packages inverted, with the remainder of packages in their normal shipping orientation
   - If the packages are small invert 6 packages (not 3)
   - If the pattern of the first layer is asymmetrical fill the second layer with a mirror image of the first

3. If the fill height is less than 500mm add a further layer, or layers, of packages all in their normal shipping orientation until the fill level is 500mm or more

4. Fill the next layer with half the packages (towards the rear of the cage) on their long side face and the remainder in their normal shipping orientation - this should create a non-level surface
   - The number of packages on their side should be at least 2, and chosen to give as simple a boundary line as possible between the 'sideways' and 'upright' packages

5. Typically there will be a step between the sideways and upright packages. Add either one or more layers of sideways packages OR one or more layers of upright packages (but not both) in order to return the upper facing surfaces to as near level as is possible - If needed (to build the next layer) level the top of the build by adding pieces or layers of corrugated board and / or thin sections of timber to the lower areas of the build.
6. Build the next layer with 3 packages on their short side faces (ideally at back left, front left and right centre of the cage) and fill any gaps with further packages in their normal shipping orientation.
7. Add either further packages on top of the previous layer on their short side faces or further packages in normal orientation in order to reduce the step size created in the previous layer, but not to completely eliminate any step. The step between the packages will be used to build 'diamond' stacks in the next layer. Also, try to incorporate at least one 'gap' in the layer – the gap (approximately 2/3 the overall size of one packages) will be used in the next layer
8. Add a further layer of packages in their normal shipping orientation, but arrange them so they are inclined across the steps in the layer below, and so that one packages spans the gap left in the layer below (so this one package forms a bridge over the gap)
9. Continue to build the cage with further packages until the cage reaches the desired height overall fill height (see notes below). Arrange these further packages in any orientation, but preferably in normal shipping orientation, but with objective to best fill the cage and impart load on to previous layers.

<u>Fill level</u>

The fill level should be as near to 1.6m as is possible, but should not exceed 1.6m (this is the maximum fill level regularly observed for roll cage and mixed pallets). Lower fill levels may be used where evidence has been collected that a lower fill is appropriate and more representative of the conditions in a specific chain to be represented in the test.

Where the supply chain (to be represented in the test) employs roll cages with mid-shelf, then a mid shelf should be used in the test. Under this circumstance the lower half of the cage should be assembled in accordance with the roll cage assembly instructions given above up to the point where the load reaches the shelf. The build should then be repeated for the upper half of the cage with packages being assembled on the shelf, starting the assembly instructions from the beginning, up to or as near as is possible (but not exceeding) 1.6m from the inside base of the cage (the base of the lower layer) to the top of the load above the mid shelf.

TEST SEQUENCE FOR PROJECT 3K

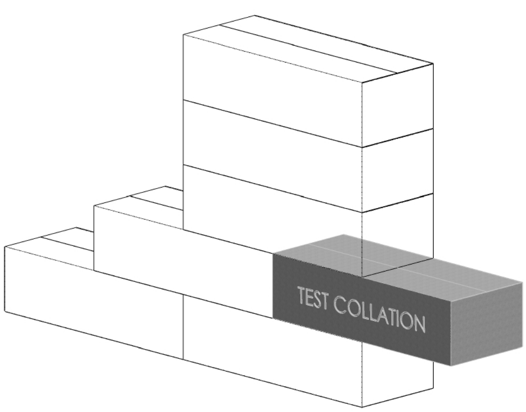
The following TEST BLOCKS contain tables indicating the required steps for each test in the project. The *Type* of package (as defined in the Preface in the Overview part of this procedure) determines which TEST BLOCKS are required.

TEST BLOCK 1
Atmospheric Conditioning

TEMPERATURE AND HUMIDITY	
Step	**Action**
1	This TEST BLOCK applies to all package Types. The samples must be stored at the selected condition appropriate to the distribution and merchandising of the product as denoted in *Before You Begin Atmospheric Conditioning*, for not less than twelve (12) hours prior to testing.
2	Check the conditioning apparatus to insure that the temperature and humidity are at the required levels.
3	Place *all* the samples for testing in the conditioning apparatus (using the number of samples as determined in the Samples section of the Overview of this document)
4	At the completion of the selected conditioning and 12 hour period, remove the samples from the conditioning apparatus in accordance with the requirements for testing as detailed in each test Block. Where samples are not required immediately for a Test Block, leave the samples within the conditioning environment.
5	When testing starts, record the ambient temperature and humidity immediately before starting the test. At the end of all testing record the ambient temperature and humidity.
6	Perform the remaining test sequences as quickly as possible.
7	Atmospheric Conditioning is now complete. Go to TEST BLOCK 2 [Picking – Pyramid Pick (Overhang stack)].

For Test Blocks 2 to 7, three (3) *test* packages are required. These *test* packages form the focus of testing for these blocks, but further *dummy* packages are required in selected test blocks to support the test. All samples should be identified so that their use through these test blocks is traceable.

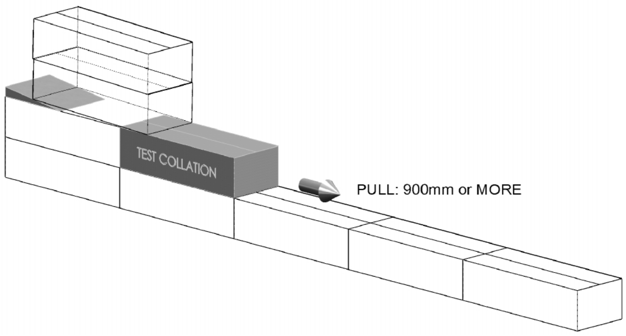
TEST BLOCK 2
Picking: Pyramid Pick (Overhang Stack)

PICKING: PYRAMID PICK (OVERHANG STACK)	
Step	**Action**
1	This TEST BLOCK applies to all package Types. Take 6 or more *dummy* packages and build a stack (as illustrated) around one *test* package, on a rigid and level floor, with the *test* package being assessed in its longest horizontal axis. Set the *test* package to overhang by 1/2 its length. 
2	Leave the stack for 5 minutes once built, then un-build the stack removing the *test* package to one side.
3	Repeat such that all 3 *test* packages are assessed. The *dummy* packages making up the stack around the *test* package (supporting the *test* package) need not be changed.
4	Repeat Steps 1 to 3 in the short horizontal axis of the package using the same 3 *test* samples.
5	Picking – Pyramid Pick (Overhang stack) testing is now complete. For package Types 3 & 4 go to TEST BLOCK 3 (Picking: Drag). For package Types 1 & 2, go to TEST BLOCK 4 (Picking: Carry).

TEST BLOCK 3
Picking: Drag

Types 3 & 4 Only

TEST SEQUENCE FOR PROJECT 3K

PICKING: DRAG	
Step	**Action**
1	This TEST BLOCK applies to package Types 3 & 4 only (for Types 1 & 2 proceed to TEST BLOCK 4). Build a stack of *dummy* packages (as shown), with the two upper packages being positioned 1/3 over the *test* package. The back of the two upper packages are inclined by 10mm to ensure the front edge is supported by the *test* package. 
2	Drag the *test* package forward 900mm (on to the front package) by inserting a hand into the opening at the end of the package and pulling. Drag the test package at approximately 1 m/s. The two upper packages should not be dragged along with the *test* package.
3	If the package has an opening on its side (as well as its end), repeat the test pulling the side and using the same *test* sample.
4	Repeat steps 1 to 3 so that all 3 *test* packages are assessed.
5	Picking: Drag testing is now complete. Go to TEST BLOCK 4 (Picking: Carry).

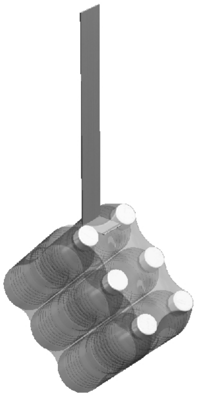
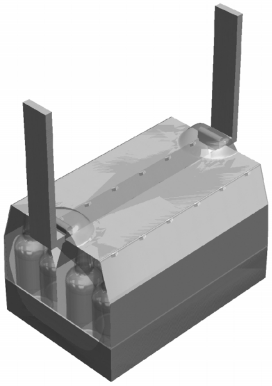
TEST BLOCK 4
Picking: Carry

PICKING: CARRY	
Step	**Action**
1	This TEST BLOCK applies to all package Types. Place one *test* package with its vulnerable face downwards - the most vulnerable face is the most likely to fail, open or tear on loading. For example the most vulnerable face would normally be the closing flaps for a wrap around case, or the bulls-eye end for a shrinkwrap tray.
2	Apply a length of 50mm wide strong adhesive tape vertically along each vertical face extending each length of tape to 600 mm above the top of the package. Bring the tops of the lengths of tape together to form a carry handle. 
3	Set the vibration system: The amplitude of vibration should be between 20mm and 40mm (i.e. peak to peak between 40mm and 80mm), and the frequency should be set to deliver a peak acceleration of 0.2g. The exact frequency and displacement should be established using the formula: **peak acceleration = f x f x 2d** where f=frequency in Hz; d=peak to peak displacement in metres.

Continued on next page

TEST SEQUENCE FOR PROJECT 3K

Continued from previous page

Step	Action
4	Lift the carry handle onto a hook (attached to a vibration test machine) such that the package is hanging clear of the floor or vibration table platform. Leave for 10 seconds then vibrate the package continuing to support it by the hook through 5 vibration cycles.
5	If the *test* package has two distinguishable vulnerable faces, assess each vulnerable face using the same sample.
6	Repeat steps 1 to 5 so that all 3 *test* packages are assessed.
7	Is the package a Type 3 package? • If YES go to the next Step. • If No, go to Step 10.
8	Using the 3 *test* packages, assess the packages according to the method detailed in Steps 3, 4 and 5, but supporting the packages using a dummy-single-hand, with the dummy-hand placed under the opening in the package at one end. 
9	Picking: Carry testing is now complete. Go to TEST BLOCK 5 (Shock: Placement Drop).
10	Is the package a Type 4? • If YES go to the next Step. • If No, go to Step 12.
11	Using the 3 *test* packages, assess the secondary collations according to the method detailed in Steps 3, 4 and 5, but supporting the packages using a pair of dummy-hands, with the dummy-hands placed in the opening at each end of the sample. 
12	Picking: Carry testing is now complete. Go to TEST BLOCK 5 (Shock: Placement Drop).

TEST SEQUENCE FOR PROJECT 3K

TEST BLOCK 5
Shock: Placement Drop

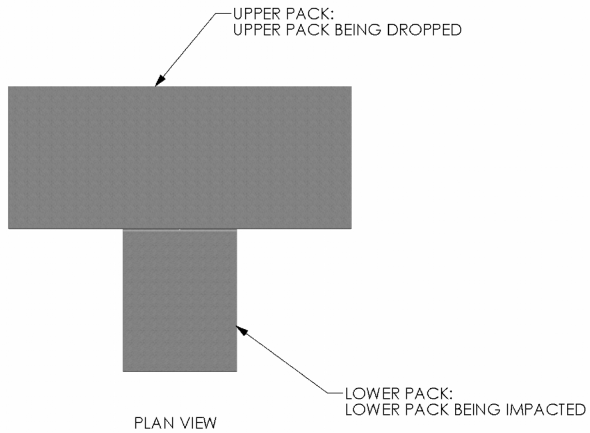
SHOCK: PLACEMENT DROP	
Step	**Action**
1	This TEST BLOCK applies to all package Types. Assess the 3 *test* packages according to the sequence in Step 2 using a drop height of 150mm.
2	Using the drop test method selected in the Equipment Required Shock section, perform free-fall drop tests from the specified height and in the order listed:

Sequence #	Face, Edge to Impact
1	Flat on base (face 3)
2	Diagonally on long base edge (2,3)
3	Flat on top (face 1)
4	Diagonally on long top edge (1,4)
5	Flat on long side face (face 2)

Step	Action
3	Shock: Placement Drop testing is now complete. Go to TEST BLOCK 6 (Shock: Drop-on Packages).

TEST BLOCK 6
Shock: Drop-on Pack

SHOCK: DROP-ON PACKAGE	
Step	**Action**
1	Position one *dummy* package on the ground below the drop apparatus so it is level and with face 3 down.
2	Position one *test* package on the drop apparatus at 90º to the package on the ground. The position of the *test* package should be such that the package overhangs the *dummy* package equally on both sides in the *test* package long axis, and overhangs half the *dummy* package in the *dummy* package long axis:



Step	Action
3	Using the drop test method selected in the Equipment Required Shock section, drop the *test* package (with face 3 down) on to the top surface of the *dummy* package resting on the ground such that the *test* package falls 150mm.
4	Using the same *test* package, repeat Steps 1 to 3, but with the test package being dropped in the same orientation as the *dummy* package on the ground, and with the *test* package overhanging 1/3 of the *dummy* package.
5	Repeat Steps 1 to 4, but swapping the *dummy* and *test* packages, such that the *dummy* package is dropped and the *test* package is impacted, using the same package.
6	Repeat steps 1 to 5 so that all 3 *test* packages are assessed.
7	Shock: Drop-on Packages testing is now complete. Go to TEST BLOCK 7 (Shock: Impact).

TEST SEQUENCE FOR PROJECT 3K

TEST BLOCK 7
Shock (Optional): Horizontal or Incline Impact

SHOCK: IMPACT (HORIZONTAL OR INCLINE)	
Step	**Action**
1	Is the package going to experience automated conveyor movement/handling at the package level (i.e. at the case or tray level)? • If YES go to the next Step. • If NO, go to TEST BLOCK 8 (Shock: Impact)
2	Assess the 3 *test* packages according to the test sequence in Step 3, below, using an impact speed of 1.35m/s. For each impact position the package on the carriage such that the package will be impacted immediately before the carriage contacts the machine backstop.
3	Using an inclined or horizontal impact machine (see Equipment Required Shock), perform impact tests at the specified impact speed and in the order listed::
4	Shock: Impact (Horizontal or Incline) testing is now complete. Go to TEST BLOCK 8 (Shock: Impact).

Sequence #	Face, Edge to Impact
1	Face 2
2	Face 4
3	Face 5
4	Face 6
5	Edge 2-5
6	Edge 4-5
7	Edge 2-6
8	Edge 4-6

NOTE:
The project now progresses to roll-cage testing. Build a mixed roll-cage assembly in accordance with the instructions detailed in Before You Begin, placing the 3 *test* packages (subjected to testing in Test Blocks 2 to 7) within the cage, in the lower 2 cage layers and in normal shipping orientation. The mixed roll-cage assembly should be built using Roll Cage Fill packages (previously unused samples, not Dummy package samples used in earlier Test Blocks). All samples contained within the cage (both Test packages and Roll Cage Fill packages) are the focus of testing for Test Blocks 8, 9 and 10 and Package Assessment in Block 14. The Roll Cage Fill packages will need to pass these tests along with the Test packages. Set aside all Roll Cage Fill packages at the end of Test Block 10 for later assessment. Use Dummy packages where required in Test Blocks 11-13 (not Roll Cage Fill packages). See the Samples section of this project for additional details.

The filled roll cage should be tested according to the sequence described in Test Blocks 8, 9 and 10 without disassembling the cage during or between test blocks (unless otherwise instructed in the procedure).

TEST BLOCK 8
Shock: Horizontal or Incline Impact

SHOCK: IMPACT (HORIZONTAL OR INCLINE)	
Step	**Action**
1	For each impact as per Step 2 below, position the rollcage on the carriage such that the cage will be impacted immediately before the carriage contacts the machine backstop. Secure the cage so it does not move adversely (during movement of the impact sled) from the intended impact orientation.
2	Impact each vertical face of the cage in turn with an impact speed of 0.91m/s. Each of the four faces will receive one impact.
3	Inspection of the packages for visible damage is allowed, provided inspection does not alter, in any way, the current condition of the packages or the position of the packages within the roll cage.
4	Shock (Impact) testing is now complete. Go to TEST BLOCK 9 (Vibration - Random).

TEST SEQUENCE FOR PROJECT 3K

TEST BLOCK 9
Vibration: Random

VIBRATION: RANDOM	
Step	**Action**
1	Set the vibration table to produce the Air ride road random vibration spectum indicated in Before You Begin Vibration Testing and place the rollcage on the vibration table.
2	Commence vibration testing. Stop the test after 40 minutes.
3	Without moving the roll cage, set the vibration table to produce the rough surface Random Vibration Spectrum indicated in Before You Begin Vibration Testing. Start the test - if the table is programmed to incrementally increase in amplitude stepwise up to the full test level (equalise) then allow this to proceed.
4	Stop the vibration testing at the end of 60 seconds of vibration at the full test level.
5	Inspection of the packages for visible damage is allowed, provided inspection does not alter, in any way, the current condition of the packages or the position of the packages within the roll cage.
6	Vibration: Random testing is now complete. Go to TEST BLOCK 10 (Shock: Flat Drop).

TEST BLOCK 10
Shock: Flat Drop

SHOCK: FLAT DROP	
Step	**Action**
1	Position the rollcage on a drop test machine (or sling the rollcage with straps and a quick release drop test apparatus) with the rollcage base level.
2	Drop the rollcage flat on to its base from 60mm.
3	Dismantle the roll cage, package by package, inspecting all packages externally for visible damage and recording any damage witnessed. Put the *roll cage fill* packages used to build the roll cage to one side for later assessment, and do not use these for further testing. Refer to BLOCK 14 (Package Assessment) for further explanation.
4	Shock: Flat Drop testing is now complete. Go to TEST BLOCK 11 (Shock: Placement Drop).

NOTE:
The project now returns to testing of samples at the individual package level. Identify the 3 *test* packages assessed through Blocks 2 to 7 (the same packages positioned within the lower 2 cage layers and in normal shipping orientation) and use these packages for the remainder of the test procedure.

TEST BLOCK 11
Shock: Placement Drop

SHOCK: PLACEMENT DROP	
Step	**Action**
1	Test the 3 *test* packages according to the test sequence in Step 2 using a drop height of 150mm.
2	Using the drop test method selected in the Equipment Required Shock section, perform free-fall drop tests from the specified height and in the order listed:
3	Shock: Placement Drop testing is now complete. Go to TEST BLOCK 12 [Shock (Investigative): Drop].

Sequence #	**Face, Edge to Impact**
1	Flat on base (face 3)
2	Diagonally on short base edge (3-5)
3	Diagonally on short top edge (1-6)
4	Flat on short side face (face 5).

TEST SEQUENCE FOR PROJECT 3K

TEST BLOCK 12 Shock (Investigative): Drop

SHOCK (INVESTIGATIVE): DROP

Step	Action
1	***NOTE:*** 300mm drops represent 'worst of normal' handling and should be conducted to investigate the perfromance of packages under more severe (but still within the range of normal) conditions; not every package will experience free fall impact from 300mm, but a small quantity of packages will be exposed to this level of hazard such that its effect should be investigated.
2	Test the 3 *test* packages according to the test sequence in Step 3 using a drop height of 300mm.
3	Using the drop test method selected in the Equipment Required Shock section, perform free-fall drop tests from the specified height and in the order listed:

Sequence #	Face, Edge to Impact
1	Flat on base (face 3)
2	Diagonally on long base edge (3-4)
3	Diagonally on short base edge (3-6)
4	Flat on top (face 1).

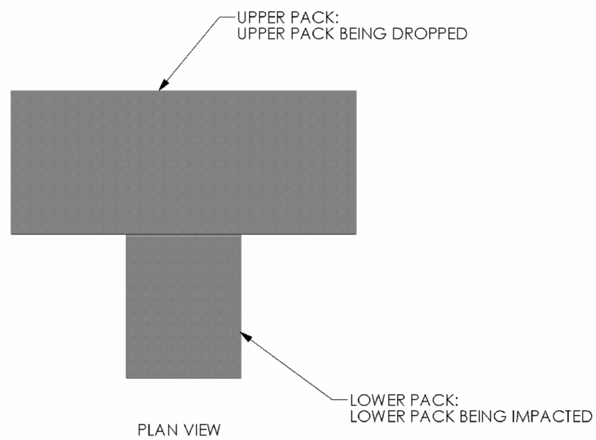
NOTE: General experience shows packages of light-weight glass beer bottles will fail at drops greater than 150mm. Evidence indicates glass packages are handled with some degree of care over and above the norm, so packages of glass containers would not necessarily be expected to withstand 300mm drops.

Step	Action
4	Shock (Investigative): Drop testing is now complete. Go to TEST BLOCK 13 [Shock (Investigative): Drop on Packages]

TEST BLOCK 13 Shock (Investigative): Drop on Packages

SHOCK (INVESTIGATIVE): DROP-ON PACKAGE

Step	Action
1	NOTE: 300mm drops represent 'worst of normal' handling and should be conducted to investigate the perfromance of packages under more severe (but still within the range of normal) conditions; not every package will experience free fall impact from 300mm, but a small quantity of packages will be exposed to this level of hazard such that its effect should be investigated.
2	Position one *dummy* package on the ground below the drop apparatus so it is level and with face 3 down.
3	Position one *test* package on the drop apparatus at 90° to the package on the ground. The position of the *test* package should be such that the package overhangs the *dummy* package equally on both sides in the *test* package long axis, and overhangs half the *dummy* package in the *dummy* package long axis.



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TEST SEQUENCE FOR PROJECT 3K

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TEST BLOCK 13 Continued Shock (Investigative): Drop on Packages

Step	Action
4	Drop the *test* package (level and with face 3 down) on to the top surface of the *dummy* package resting on the ground such that the *test* package falls 300mm.
5	Using the same *test* package, repeat Steps 2 to 4, but with the *test* package being dropped in the same orientation as the *dummy* package on the ground, and with the *test* package overhanging 1/3 of the *dummy* package.
6	Repeat Steps 2 to 5, but swapping the *dummy* and *test* packages, such that the *dummy* package is dropped and the *test* package is impacted.
7	Repeat steps 2 to 6 such that all 3 *test* packages are assessed.
8	All testing is now complete. Complete a Package Assessment according to BLOCK 14.

BLOCK 14 Package Assessment

PACKAGE ASSESSMENT

NOTE: Inspection should cover the condition of all 3 t*est* packages that were used through **<u>all</u>** test blocks ***AND*** the condition of all *Roll Cage Fill* packages that were used to build the roll cage for test blocks 8 to 10. *Dummy* packages should not be assessed.

Step	Action
1	Inspect and assess the condition of one of the *test* or *roll cage fill* packages used during testing. Have the Package Degradation Allowance and Product Damage Tolerance, determined prior to testing, been met or exceeded? (see Product Damage Tolerance and Packaging Degradation Allowance section at the beginning of this project for further details) • If **YES**, then packaged-product is considered passing. Go to next step. • If **NO**, then packaged-product is considered failed. Go to next step.
2	Repeat Step 1 until all *test* and *roll cage fill* packages have been inspected and assessed. **<u>ALL</u>** *test* and *roll cage fill* packages must be determined to be passing in order to for a final Project 3K PASS result.
3	Go to Reporting an ISTA Test at the end of this project.

REPORTING AN ISTA TEST

ISTA Test Report Forms may be downloaded from **www.ista.org**. Custom forms with additional information are acceptable, but information on an official ISTA Report Form is considered to be the minimum.

The packaged-product has satisfactorily passed the test if, upon examination, it meets the Product Damage Tolerance and Package Degradation Allowance.

ISTA Certified Testing Laboratories:

- Should file a test report on all ISTA Test Procedures or Projects conducted.
- Shall file a test report on all ISTA Test Procedures or Projects conducted to obtain Transit Tested Package Certification or Acknowledgement.

For additional information, refer to *Guidelines for Selecting and Using ISTA Test Procedures and Projects.*

ISTA Transit Tested Program

The ISTA Transit Tested Certification Mark as shown is a:

- registered certification mark **and**
- can only be printed on certified packages **and**
- can only be used by license agreement **and**
- by a member of the International Safe Transit Association.

When a member prints this certification mark on a packaged-product, with their license number, they are showing their customer and the carrier that it has passed the requirements of ISTA preshipment testing.

In order to maintain its certified status and eligibility for identification with the TRANSIT TESTED Certification Mark, each packaged-product must be re-tested whenever a change is made in the:

- Product or
- Process or
- Package.

Changes in the product can include changes in:

- Design (configuration, components, accessories, etc.) **or**
- Size / weight (dimensions, shape, mass, center of gravity, etc.) **or**
- Materials (type, construction, fabrication, gage, etc.)

Changes in the process can include changes in:

- Manufacturing / assembly (vendor, location, automation, etc.) **or**
- Filling (equipment, speed, automation, etc.) **or**
- Distribution system (parcel delivery, LTL, intermodal, etc.)

Changes in the package can include changes in:

- Configuration (individual package or unit load, container type and sub-type, style, design, interior packaging, etc.) **or**
- Size / weight (dimensions, shape, mass, caliper, gage etc.) **or**
- Materials (corrugated, plastic, metal, glass, etc.) **or**
- Components (closures, labels, straps, pallets, skids, wraps, etc.)

If corrugated packaging is used, it is recommended that the basis weights of the constituent papers/paperboards be determined after testing and documented to provide the best indicator of equivalence or change.

As a quality control procedure, packaged-products should be re-tested frequently, for example, yearly.

This Test Protocol is published by:
International Safe Transit Association
1400 Abbot Road, Suite 160, East Lansing, Mi 48823-1900 USA

Order Information: Additional copies of this Test Project and the ISTA® *RESOURCE BOOK* may be ordered online at www.ista.org or by contacting ISTA at (+1) 517.333.3437. A listing of current procedure version dates is available at www.ista.org.