composition by a stepper). Usually, it is deviation as shown in the following figure.

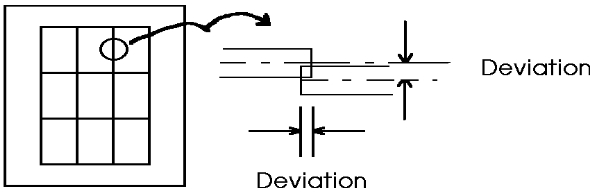


Figure 3
Stitching Error

5 Pattern Positioning Accuracy

5.1 *Pattern Positioning Accuracy* — Relation between the actual and desired locations of a printed pattern on a glass substrate.

5.2 *End Plane Reference* — Positioning accuracy of the printed pattern measured from the reference edge of a glass mask.

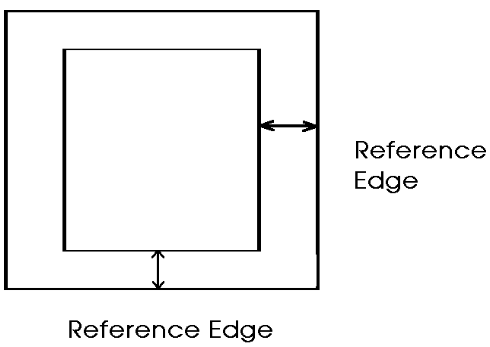


Figure 4
Pattern Positioning Accuracy

5.2.1 Reference Edge: Two adjacent edges are considered as the reference edge.

5.3 *Pattern Rotation* — Deviation of a printed pattern on a glass mask caused by rotation. Usually, it is expressed by the difference between two measured distances at separated points within one side as shown in the figure.

$\theta = (D_1 - D_2)/C_1$

Usually fix the value of C_1 and use the value of $D_1 - D_2$.

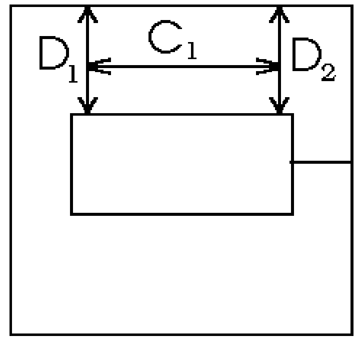


Figure 5
Pattern Rotation

5.4 *Cell Rotation in Multiimages* — Cell's slant rotation against axis of light in case of exposure by stepper and similar equipment. (Generally, it is measured by vernier outside of cells.)

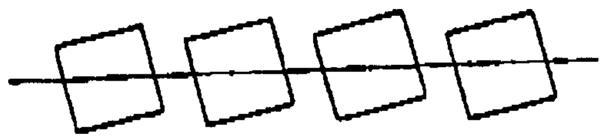


Figure 6
Cell Rotation in Multiimages

5.5 *Gaps of Cells in Multiimages* — X and Y directions' gaps of cells against designed grating which should be exposed primarily by stepper and similar equipment. (Generally, it is measured by gaps between cells which are next to each other with vernier outside of cells.)

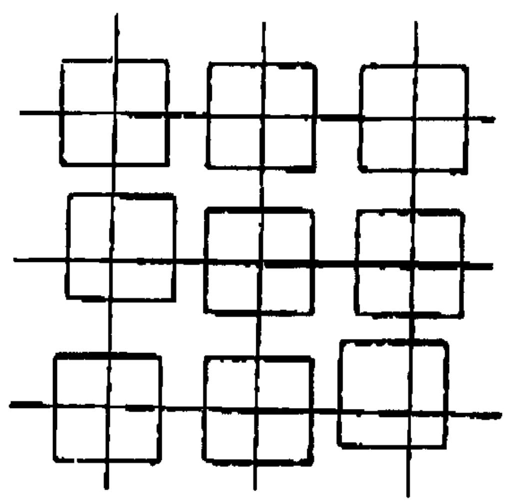


Figure 7
Gaps of Cells in Multiimages

NOTICE: The user's attention is called to the possibility that compliance with this standard may require use of copyrighted material or of an invention covered by patent rights. By publication of this standard, SEMI takes no position respecting the validity of any patent rights or copyrights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of any such patent rights or copyrights, and the risk of infringement of such rights, are entirely their own responsibility.

SEMI D22-1103
TEST METHOD FOR THE DETERMINATION OF COLOR, TRANSMITTANCE OF FPD COLOR FILTER ASSEMBLIES

This test method was technically approved by the Global Flat Panel Display Committee and is the direct responsibility of the Japanese Flat Panel Display Committee. Current edition approved by the Japanese Regional Standards Committee on August 8, 2003. Initially available at www.semi.org October 2003; to be published November 2003. Originally published September 1999.

NOTICE: This document was completely rewritten in 2003.

1 Purpose

1.1 This standard establishes practices for measuring selected characteristics of FPD color filters. These methods are applicable to manufacturing, quality control, and development operations.

2 Scope

2.1 This method is to be used by FPD color filter suppliers and users to evaluate quality of products as well as items under development.

2.2 This method shall be used in general to measure the color characteristics and transmittance of FPD color filter.

NOTICE: This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory or other limitations prior to use.

3 Referenced Standards

3.1 *SEMI Standards*

SEMI D13 — Terminology for FPD Color Filter Assemblies

3.2 *CIE Standards*[1]

CIE 1931 — Standard Colorimetric System (Colorimetry – Official Recommendations of the CIE)

CIE 1976 (L*,a*,b*) — Color Space (Recommendations on Uniform Color Spaces)

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

4 Summary of Method

4.1 Turn on the apparatus, and input measurement parameters.

4.2 Warm up and stabilize the equipment.

4.3 Measure the reference quantity of light.

4.4 Set the sample on the measuring stage, and adjust the point of measurement into the measuring spot.

4.5 Measure the sample quantity of light.

4.6 Print the results (color characteristics and transmittance).

5 Apparatus

5.1 The measurement system shall have the following specifications.

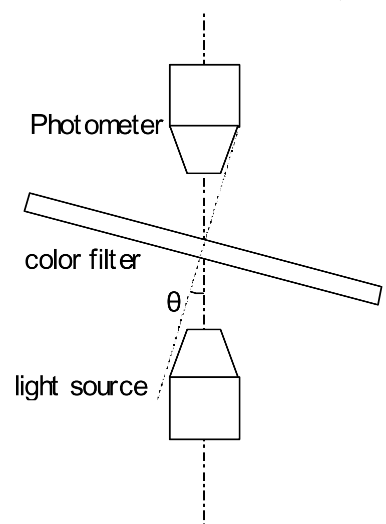
5.2 Wavelength range: variable between 380 and 780 mm, in increments of < 5nm.

5.3 Measuring area: Measuring spot size or the spot size of incident beam on the sample surface is smaller than the sub-pixel to be measured. (for example 2 to 50 micrometer in diameter).

5.4 Sample stage:

5.4.1 Sample surface can be set normal to the incident beam. (See Figure 1)

5.4.2 The sample stage shall have a sufficient mechanical travel to permit measurements within the color filter area and in the transparent area of the substrate outside the color filter material.



1 CIE International Commission on Illumination, Kegelgasse 27, A-1030 Vienna, Austria

Figure 1

6 Reference

6.1 Reference quantity of light shall be measured with a substrate without object layer.

6.1.1 For example, substrates described below can be adopted for reference.

Ex. A glass substrate for color filter

A glass substrate out of the color filter area

6.1.2 As for the definition of glass substrate, refer to D13.

7 Calibration

7.1 Calibrate the apparatus in accordance with manufacture' s instructions.

7.2 Record characteristics of the instrument observed during this calibration, e.g., linearity, wavelength shift, etc.

8 Procedure

8.1 Turn on the apparatus and input the measurement condition parameters.

Condition Wavelength range
Spot size
Gain, Integration time etc.

8.2 Before operation, warm up and stabilize the equipment for a specified period of time (according to the instruction manual of the apparatus).

8.3 Measure the reference data (dark quantity of light, reference quantity of light)

8.4 Set the sample onto the stage and adjust the sample to the measuring position.

8.5 Measure quantity of light of the sample.

8.6 Record the data.

9 Reporting Results

9.1 The report must contain the following items:

9.1.1 Date of the measurement and operator ID

9.1.2 Manufacturer, model, series of the apparatus, and the version of the software installed.

9.1.3 Reference material.

9.1.4 Measuring conditions (Wavelength range, Spot size)

9.1.5 An illustration of the measured points in the sample.

9.1.6 Color characteristics measurement;

9.1.6.1 Color characteristics

9.1.6.2 Graph

*Refer to the following standard
CIE 1931-x,y
CIE 1976-(L*,a*,b*) or (L*,u*,v*)

9.1.7 Transmittance

9.1.7.1 Graph
Wavelength(X-axis) vs.
Transmittance(Y-axis)

10 Correction Between Different Apparatus

10.1 To compare the data of different apparatus, you should take care about the apparatus difference.

10.2 To avoid the confusion, exchanging some common test pieces, and comparing of the measured data are recommended.

11 Related Documents

11.1 *ASTM Standards*[2]

E179-96 — Standard Guide for Selection of Geometric Conditions for Measurement of Reflection and Transmission Properties of Materials.

E1164-02 — Standard Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation.

E1345-98 — Standard Practice for Reducing the Effect of Variability of Color Measurement by Use of Multiple Measurements.

2 American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959, USA. Telephone: 610.832.9585, Fax: 610.832.9555, Website: www.astm.org

SEMI D23-0999
GUIDE FOR COST OF EQUIPMENT OWNERSHIP (CEO) CALCULATION FOR FPD EQUIPMENT

This guide was technically approved by the Global Flat Panel Display Equipment Committee and is the direct responsibility of the Japanese Flat Panel Display Equipment Committee. Current edition approved by the Japanese Regional Standards Committee on June 1, 1999. Initially available on SEMI OnLine August 1999; to be published September 1999.

1 Purpose

1.1 The purpose of this document is to provide a standard, simple CEO calculation method for evaluating FPD manufacturing equipment. With this document, the following merits can be expected:

1.1.1 Both panel and equipment manufacturers, as well as material manufacturers can work from the same standard with regard to cost.

1.1.2 Panel manufacturers' basis for equipment comparison will become clear, which will, in turn, help in equipment selection.

1.1.3 The document will serve to clarify cost reduction items as well as benchmark cost reduction activities.

1.1.4 Direction for improvement for equipment manufacturers will become clear.

1.1.5 By doing a separate analysis, comparison, and evaluation of lines, equipment for different substrate sizes will become simpler.

2 Scope

2.1 This standard focuses on each equipment in the FPD production line. It is used to define the calculation method for cost of installing/operating that equipment, to define the calculation method for productivity of that equipment, and to quantify CEO of that equipment.

2.2 It is necessary to clarify the substrate sizes that can be handled by this equipment. However, this standard does not deal with the equipment process performance. It takes the point of view that each panel manufacturer should evaluate each equipment's process performance, including yield, based on their own process requirements.

2.3 This standard does not purport to address all of the safety issues associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicablity of regulatory limitations prior to use.

3 Limitations

3.1 This standard does not attempt to include all elements necessary for equipment evaluation, and may be seen as incomplete from certain perspectives. However, it is believed that it will serve as the foundation for comparative evaluations.

4 Referenced Standards

None.

5 Terminology

5.1 Definitions for each of the items are listed in the following table.

6 CEO (Cost of Equipment Ownership) Table

6.1 Units in the document are for illustration only.

	Item	*Unit*	*Value*	*Definition & Formula*	*Notes*
A. Equipment Cost					
	(1) Base Cost	($)		Main Equipment Purchase Price	
	(2) Cost of Options	($)		Price of items which can be categorized as options separate from main equipment.	
	(3) Other Parts/Tools	($)		Price of tools and accessories (not included in main equipment or options price).	Enter maintenance-related consumables in D48 (Consumables).
	(4) Installation Cost	($)		Costs incurred in the installation of the equipment.	
	(5) Inspection Cost	($)		Costs incurred in inspection of the equipment.	
	(6) Shipping Cost	($)		Cost of shipping equipment to the installation location.	
	(7) Training Cost	($)		Cost of training in operation, maintenance, etc.	
	(8) Manual Cost	($)		Cost of manuals necessary for maintenance and operation.	
	(9) Other Costs	($)		Other necessary costs not included in above items.	
	(10) Subtotal	($)		Sum of (1) through (9).	If it is difficult to specify (1) through (9), it is possible to just enter (10).
	(11) Monthly Cost	($/month)		Monthly costs associated with equipment (10)/60 months.	Salvage value after 5 years is arbitrarily set here at 0. Adjust to real value as necessary.
B. Hook-Up Costs					
	(12) Materials (pipes, etc.)	($)		Costs for piping and other materials necessary to operate equipment.	
	(13) Power Connection	($)		Costs for connecting electricity, water, gas, air, etc. supplied by the factory to the equipment.	
	(14) Other	($)		Other installation costs not included in above items.	
	(15) Subtotal	($)		Sum of (12) through (14).	
	(16) Monthly Cost	($/month)		Monthly incidental installation costs (15)/60 months.	Salvage value after 5 years is arbitrarily set here at 0. Adjust to real value as necessary.
C. Clean Room Costs				For each area, if the shape is complex, use the square surface area.	Categorize clean area, gray area, and other dedicated areas according to the real situation of each factory.

	Item	*Unit*	*Value*	*Definition & Formula*	*Notes*
Clean Areas				Area for handling substrates and having the highest level of cleanliness.	
	(17) Main Equipment Dimensions (W*D)	(m^2)		Installed dimensions of the main equipment within the clean area.	
	(18) Accessory Dimensions (W*D)	(m^2)		Installed dimensions of pumps, power source, and other equipment outside of the main equipment within the clean area.	
	(19) Maintenance Area (W*D)	(m^2)		Dimensions of space in clean area necessary for maintenance of the equipment and accessories.	
	(20) Subtotal Area (W*D)	(m^2)		Subtotal of dimensions in clean area from above items (17) through (19).	
	(21) Floor Space (Unit Cost)	$\$/m^2 \bullet$ month		Monthly floor maintenance cost in clean area (by area unit).	
	(22) Monthly Dedicated Floor Cost	$/month		Monthly cost for clean area (20) $\times$ (21).	
Gray Area				Area with lower cleanliness level than above clean area.	
	(23) Main Equipment Dimensions (W*D)	(m^2)		Installed dimensions of the main equipment within the gray area.	
	(24) Accessory Dimensions (W*D)	(m^2)		Installed dimensions of pumps, power source, and other equipment outside of the main equipment within the gray area.	
	(25) Maintenance Area (W*D)	(m^2)		Dimensions of space in gray area necessary for maintenance of the equipment and accessories.	
	(26) Subtotal Area (W*D)	(m^2)		Subtotal of dimensions in gray area from above items (23) through (25).	
	(27) Floor Space (Unit Cost)	$\$/m^2 \bullet$ month		Monthly floor maintenance cost in gray area (by area unit).	
	(28) Monthly Dedicated Floor Cost	($/month)		Monthly costs for gray area (26) $\times$ (27).	
Other Dedicated Floor Area				Area with the lowest level of cleanliness (i.e., sub-floor, etc.).	
	(29) Dedicated Dimensions (W*D)	(m^2)		Installed dimensions of the main equipment in other dedicated floor area.	
	(30) Floor Space (Unit Cost)	$\$/m^2 \bullet$ month		Monthly floor maintenance cost in other dedicated floor area (by area unit).	
	(31) Monthly Dedicated Floor Cost	($/month)		Monthly costs for other dedicated floor area (29) $\times$ (30).	
D. Running Costs					

	Item	*Unit*	*Value*	*Definition & Formula*	*Notes*	
Power/ Utilities					Normal use and maximum use values entered by equipment manufacturer.	
					Normal Use [Unit]	Maximum Use [Unit]
	(32) Electricity	($/month)		Monthly cost of electricity necessary to operate equipment.	[ ]	[ ]
	(33) Cooling Water	($/month)		Monthly cost of cooling water necessary to operate equipment.	[ ]	[ ]
	(34) Air	($/month)		Monthly cost of air conditioning necessary to operate equipment.	[ ]	[ ]
	(35) Gas Exhaust Processing	($/month)		Monthly cost of gas exhaust processing necessary to operate equipment.	[ ]	[ ]
	(36) Liquid Waste Processing	($/month)		Monthly cost of liquid waste processing necessary to operate equipment.	[ ]	[ ]
	(37) Vacuum Line	($/month)		Monthly cost of vacuum volume necessary to operate equipment.	[ ]	[ ]
	(38) Nitrogen Gas	($/month)		Monthly cost of nitrogen gas necessary to operate equipment.	[ ]	[ ]
	(39) Dry Gas	($/month)		Monthly cost of dry gas necessary to operate equipment.	[ ]	[ ]
	(40) Other	($/month)		Other monthly power & utilities costs necessary to operate equipment.		
	(41) Power/Utilities Subtotal	($/month)		Subtotal of monthly power & utilities costs necessary to operate equipment; sum of (32) through (40).		
Process Materials Costs				Cost of materials necessary for processing.	Example: Resist, chemicals, process gases, cleaning gas, sputter target, etc. Enter by equipment in (42) to (46).	
	(42)	($/month)		Monthly cost	For the item name, enter each item necessary for the equipment.	
	(43)	($/month)		Monthly cost	For the item name, enter each item necessary for the equipment.	
	(44)	($/month)		Monthly cost	For the item name, enter each item necessary for the equipment.	
	(45)	($/month)		Monthly cost	For the item name, enter each item necessary for the equipment.	
	(46)	($/month)		Monthly cost	For the item name, enter each item necessary for the equipment.	
	(47) Process Materials Subtotal	($/month)		Subtotal of monthly costs for process materials; sum of (42) through (46).		

	Item	Unit	Value	Definition & Formula	Notes
Maintenance Costs				Expenditures (to external) for maintenance.	
	(48) Consumables	($/month)		Monthly cost for scheduled replacement parts.	
	(49) Scheduled Maintenance	($/month)		Monthly cost for scheduled maintenance.	Forecast maintenance
	(50) Other	($/month)		Monthly maintenance costs not included in above items.	
	(51) Maintenance Subtotal	($/month)		Subtotal of monthly expenditures (to external) for maintenance; sum of (48) through (50).	
	(52) Running Cost Subtotal	($/month)		Monthly running cost total: (41) + (47) + (51).	
E. Labor Costs				In-house labor costs	
	(53) Operator	($/month)		Equipment operator monthly labor cost	
	(54) In-house maintenance	($/month)		Equipment maintenance monthly labor cost	
	(55) Labor Cost Subtotal	($/month)		Subtotal of above costs (53) + (54).	Managers and engineers not included.
F. Cost Total					
	(56) Cost	($/month)		Total monthly costs necessary for operation of equipment: (11) + (16) + (22) + (28) + (31) + (52) + (55).	
G. Runtime					
	(57) Operating time	(hr/month)		Hours per month of factory operation	
	(58) 1-Item process time	(hr/ process)		Process recipe exchange time	
	(59) Number of processes/month	(process/ month)		Number of process recipe exchanges per month	
	(60) Process time	(hr/month)		Hour per month of process recipe exchange (58) $\times$ (59)	
	(61) Scheduled maintenance time	(hr/month)		Monthly scheduled maintenance time	
	(62) Start-up inspection time	(hr/month)		Time necessary, per month, for start-up.	
	(63) Down time (mc failure)	(hr/month)		Down time, per month, for machine failure.	
	(64) Other down time	(hr/month)		Down time, per month, not included in above items.	Product wait time not included.
	(65) Run time	(hr/month)		Monthly operation time (57) – [Σ (60) through (64)].	
H. Process Capacity					
	(66) Sheets/hour	(sheets/hr)		Number of sheets processed per hour	
	(67) Process capacity	(sheets/ month)		Number of sheets processed per month (65) $\times$ (66)	

	Item	Unit	Value	Definition & Formula	Notes
I. C.E.O. Cost of Equipment Ownership					
	(68) Cost per Substrate	($/sheet)		(56)/(67)	

7 Related Documents

7.1 *SEMI Standards*

SEMI E35 — Cost of Ownership for Semiconductor Manufacturing Equipment Metrics

SEMI E35.1 — Guide for Cost of Equipment Ownership Comparison Metric

7.2 *STEP '95 COO & RAM Textbook*

FPD Expo '95 Tutorial Seminar Textbook — a-Si TFT-LCD Front End Manufacturing Technology – Cost Reduction Seen from a Production Technology Viewpoint

NOTE 1: As listed or revised, all documents cited shall be the latest publications of adopted standards.

NOTICE: These standards do not purport to address safety issues, if any, associated with their use. It is the responsibility of the user of these standards to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. SEMI makes no warranties or representations as to the suitability of the standards set forth herein for any particular application. The determination of the suitability of the standard is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. These standards are subject to change without notice.

The user's attention is called to the possibility that compliance with this standard may require use of copyrighted material or of an invention covered by patent rights. By publication of this standard, SEMI takes no position respecting the validity of any patent rights or copyrights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of any such patent rights or copyrights, and the risk of infringement of such rights, are entirely their own responsibility.

SEMI D24-0200
SPECIFICATION FOR GLASS SUBSTRATES USED TO MANUFACTURE FLAT PANEL DISPLAYS

This specification was technically approved by the Global Flat Panel Display – Material and Components Committee and is the direct responsibility of the North American Flat Panel Display Committee. Current edition approved by the North American Regional Standards Committee on September 3, 1999. Initially available on SEMI OnLine November 1999; to be published February 2000.

1 Purpose

1.1 This standard specifies selected geometrical requirements of glass substrates used to manufacture flat panel displays.

2 Scope

2.1 This standard is intended to set levels of specification for glass substrates to insure repeatable manufacture of flat panel displays and uniformity of substrates from all vendors. This standard will also insure inter-changeability at all mechanical interfaces within process tools as well as with Transportation and Automation Cassettes.

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

3 Limitations

3.1 Substrate size (edge length and width) and thickness are **not** specified so as not to infringe on supplier/customer relationships. Wherever possible, tolerances are specified independent of substrate size. Additional documents will be developed to specify the standard method of measuring each dimension.

4 Referenced Standards

4.1 *SEMI Standards*

SEMI D3 — Quality Area Specification for Flat Panel Display Substrates

SEMI D4 — Method for Referencing Flat Panel Display Substrates

SEMI D5 — Standard Size for Flat Panel Display Substrates

SEMI D6 — Specification for Edge Length and Thickness for Flat Panel Display Mask Substrates

SEMI D7 — FPD Glass Substrate Surface Roughness Measurement Method

SEMI D9 — Definitions for Flat Panel Display Substrates

SEMI D12 — Specification for Edge Condition of Flat Panel Display (FPD) Substrates

SEMI D15 — FPD Glass Substrate Surface Waviness Measurement Method

4.2 *ISO Standard*[1]

ISO 1101 — Technical drawings — Geometrical Tolerances — Tolerances of Form, Orientation, Location and Run-Out — Generalities, definitions, symbols, indications on drawings

NOTE 1: As listed or revised, all documents cited shall be the latest publications of adopted standards.

5 Terminology

5.1 *FPD Waviness* W_{fpd} — surface profile calculated by a moving minimum zone method. It is expressed as the maximum value of a minimum zone method straightness of a certain sampling within an evaluation length. An approximation in Appendix 1 of SEMI D15 can be used as well.

NOTE 2: It is recommended that the computer approximation method described in Appendix 1 of SEMI D15 be used.

5.2 *minimum zone method straightness* — the smallest distance between two parallel straight lines between which all of objective profile is included (see ISO 1101, Section 3.1).

5.3 *reference edges* — the two edges adjacent to the orientation corner.

5.4 *squareness* — the total variation of the position of the short sides of a substrate relative to straight lines drawn between the ends of, and perpendicular to, the long reference edge of the substrate.

5.5 *warp* — the gap between a) the bottom surface of an FPD substrate and b) the reference plate on which the substrate rests.

NOTE 3: Warp in other applications has traditionally been the TIR, or peak-to-valley of a surface (top, or bottom or median surface) of a substrate, measured with respect to a reference plane.

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1 ISO Central Secretariat, C.P. 56, CH-1211 Geneve 20, Switzerland; available in the U.S. from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036

6 Test Methods

NOTE 4: The methods described below are approximations, except where they are followed by a reference such as SEMI D7. Formal test methods supporting the parameters in this document will be developed where needed; these will be published as separate documents. References to them will then be added to this document.

6.1 *Thickness* — Measure with differential (2-probe) gage using optical, non-contact, or contact sensors.

6.2 *Edge Squareness* — measure per Figure 2.

6.3 *Edge Conditions* — to be determined.

6.4 *Edge Straightness* — measure per Figure 2.

6.5 *Total Thickness Variation* — to be determined.

6.6 *Flatness, medium sheet* — to be determined.

6.7 *Roughness* — SEMI D7 roughness measurement method (contact stylus method, tip radium ≤ 2 μm).

6.8 *Warp* — Feeler gage with thickness equal to the specified maximum warp value, inserted between substrate bottom edge and surface plate, at any point or at specified points along the edges (formal test method/description to be developed).

6.9 *Waviness* — see SEMI D15.

7 Requirements

See Table 1.

8 Ordering Information

8.1 Purchase orders for substrates furnished to this specification shall include the following items:

8.1.1 Edge length

8.1.1.1 Long reference edge

8.1.1.2 Short reference edge

8.1.2 Orientation corner dimensions, from Table 1

8.1.3 Quality edge area exclusion

8.1.4 Thickness

8.1.4.1 Nominal

8.1.4.2 Tolerance

8.1.5 Warp

8.1.6 Straightness

NOTE 5: Table of Figures:

Figure 1 — Reference Items

Figure 2 — Squareness

Figure 3 — Warp

Figure 4 — Edge Condition

Figure 5 — Orientation and Corner Cuts

Figure 6 — Total Thickness Variation and Local Thickness Variation

Table 1 Specification for Gen III and Larger Active-Matrix LCD Substrates

Reference Information	*Range A*		*Range B*		*Reference Documents*
Edge Length Ranges	550 to 650 mm × 650 to 830 mm		750 to1000 mm × 900 to 1100 mm		
Edge Length Dimensions	600 × 720 mm, 650 × 830 mm, 550 × 650 mm		800 × 950 mm	900 × 1100 mm	
Edge Length Tolerance[1]	± 0.40 mm		± 0.40 mm	± 0.50 mm	SEMI D5 – Std. Sizes for FPD Substrates
Squareness[1]	± 0.83 mm		W = ± 0.80 mm L = ± 0.95 mm	± 1.0 mm	SEMI D4 – Referencing of FPD Substrates
Edge Condition[9]	Rounded[9] Bevel width = 0.1 mm – 0.6 mm, — extension onto top/bottom surfaces		Rounded[9] Bevel width = 0.1 mm – 0.6 mm		
Orientation Corner[2]	1 Corner, Symmetric C1x = 4.0 ± 1.0 mm C1y = 4.0 ± 1.0 mm	1 Corner, Asymmetric C1x = 5.0 ± 1.5 mm C1y = 2.0 ± 1.5 mm	1 Corner, Asymmetric C1x = 5.0 ± 1.5 mm C1y = 2.0 ± 1.5 mm		
Corner Cut	3 corners C2x & C2y = 1.5 ± 1.0 mm		3 corners C2x & C2y = 1.5 ± 1.0 mm		SEMI D12 – Edge Condition
Quality Area[3] Edge Exclusion	≤ 10 mm		≤ 20 mm[11]		SEMI D3 – Quality Area for FPD Substrates
Thickness	0.7 mm ± 0.07 mm		0.7 mm ± 0.07 mm		SEMI D5 – Std. Sizes for FPD Substrates
	1.1 mm ± 0.10 mm		1.1 mm ± 0.10 mm		
Total Thickness Variation[4]	60 µm		100 µm		
Local Thickness Variation[5]	≤ 20 µm for ≤ 130 mm		≤ 20 µm for ≤ 130 mm		
Waviness[6] [W_{fpd}]	≤ 0.1 µm, with λ_C = 0.8 mm, λ_L= 8 mm L_S = 20 mm		≤ 0.1 µm, with λ_C = 0.8 mm, λ_L= 8 mm L_S = 20 mm		SEMI D15 – Surface Waviness Measurement
Warp[7]	≤ 0.60 mm		≤ 1.0 mm		
Roughness, R_a	≤ 20 nm		≤ 20 nm		SEMI D7 – Roughness Measurement
Straightness[8]	± 0.4 mm		± 0.4 mm		

NOTES:

1 For dimensional tolerance and squareness the long edge typically has the maximum tolerance. See Figures 1 and 2.

2 An asymmetric orientation corner is specified for purposes of mechanical orientation and operator's visual confirmation of orientation within a cassette. Optical means of identifying orientation is under investigation. See Figure 5.

3 Quality Area is that area in which the specified criteria apply.

4 Total thickness variation is the peak to valley (TIR) of the entire substrate front surface relative to a reference plane when the substrate back surface is constrained against a vacuum chuck. This scale is typically important for some film deposition and lithography processes. See Figure 6.

5 Local thickness variation is the absolute value of the maximum deviation of the substrate from a plane constructed in any 100–130 mm square area, within the Quality Area, when the substrate back surface is constrained against a vacuum chuck. This scale is typically important for lithographic stepper processes.

6 Waviness is the rms (root mean square) surface profile, within the quality area, over 0.8–8 mm spatial wavelengths.

7 See Figure 3.

8 See Figure 2.

9 See Figure 4.

10 This table applies to the indicated edge length ranges and thicknesses.

11 Example: For an 800 × 950 mm substrate, the effective process area, which excludes portions not processable for physical reasons, would be ≥ 760 × ≥ 910 mm.

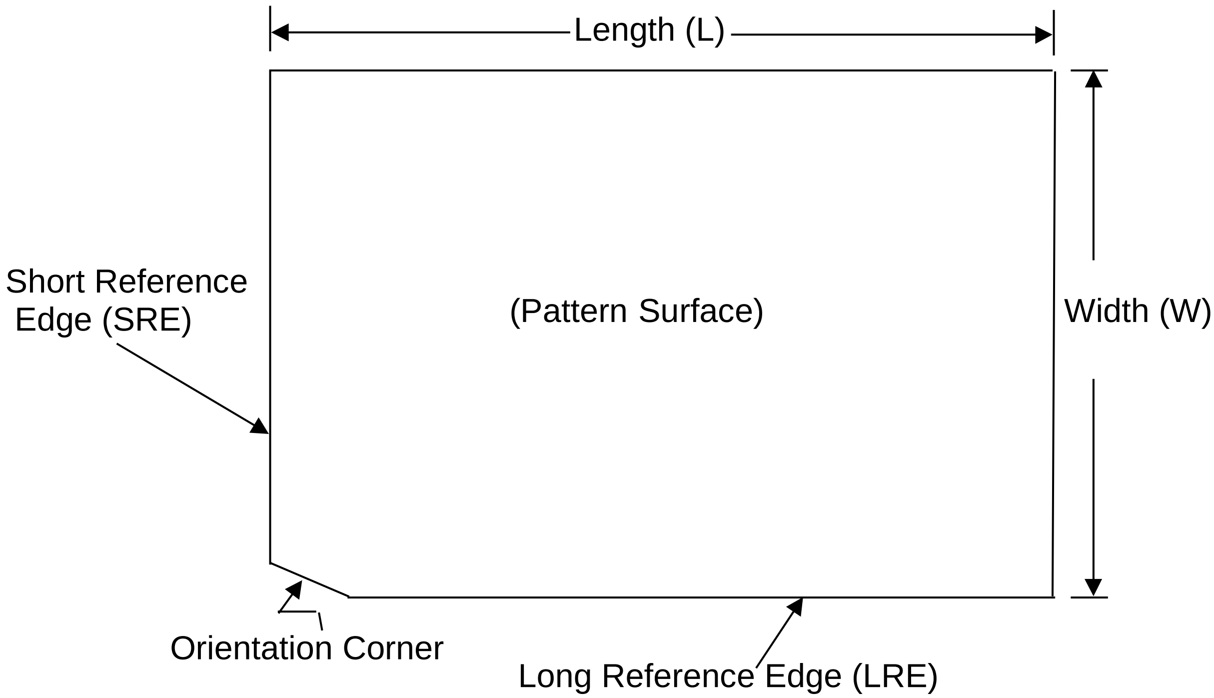
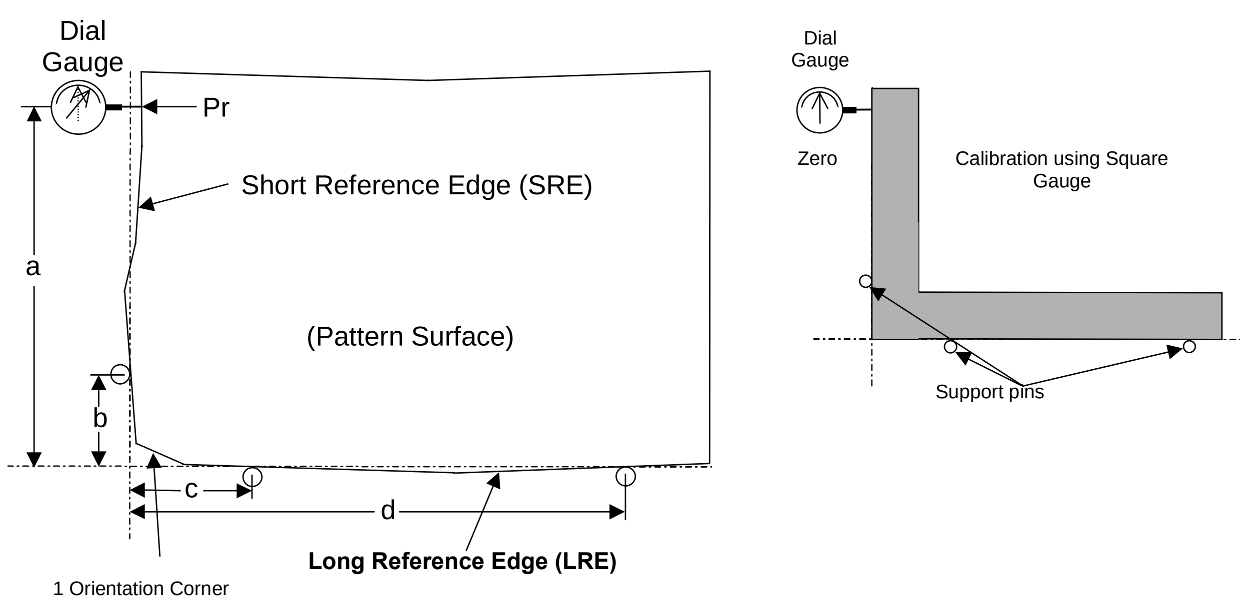


Figure 1
Reference Items



NOTE: a, b, c, and d are defined between supplier and customer.

Figure 2
Squareness

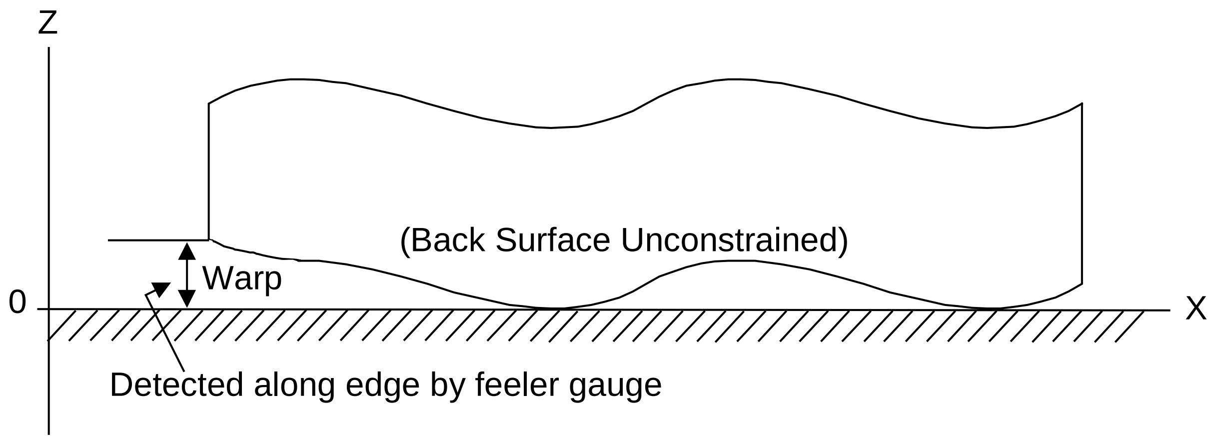


Figure 3
Warp

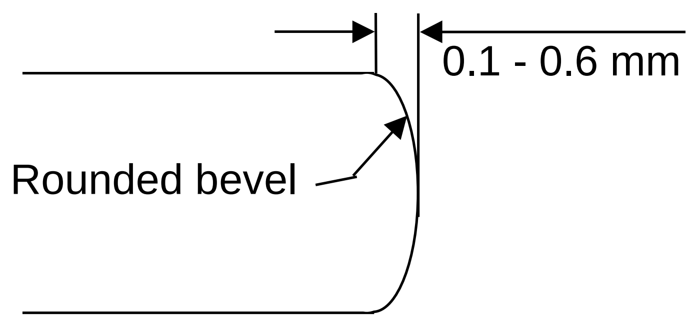


Figure 4
Edge Condition

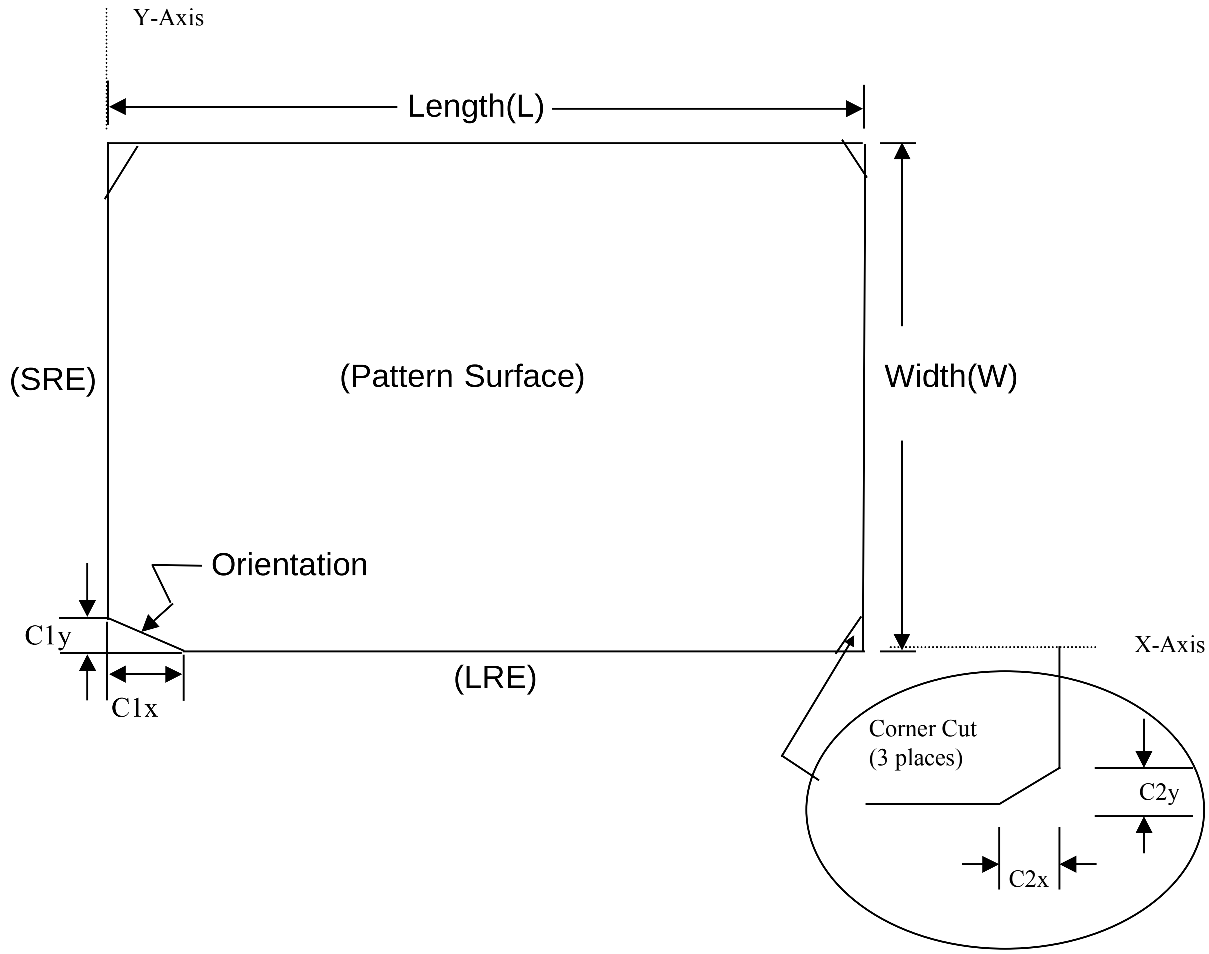


Figure 5
Orientation Corner and Corner Cuts

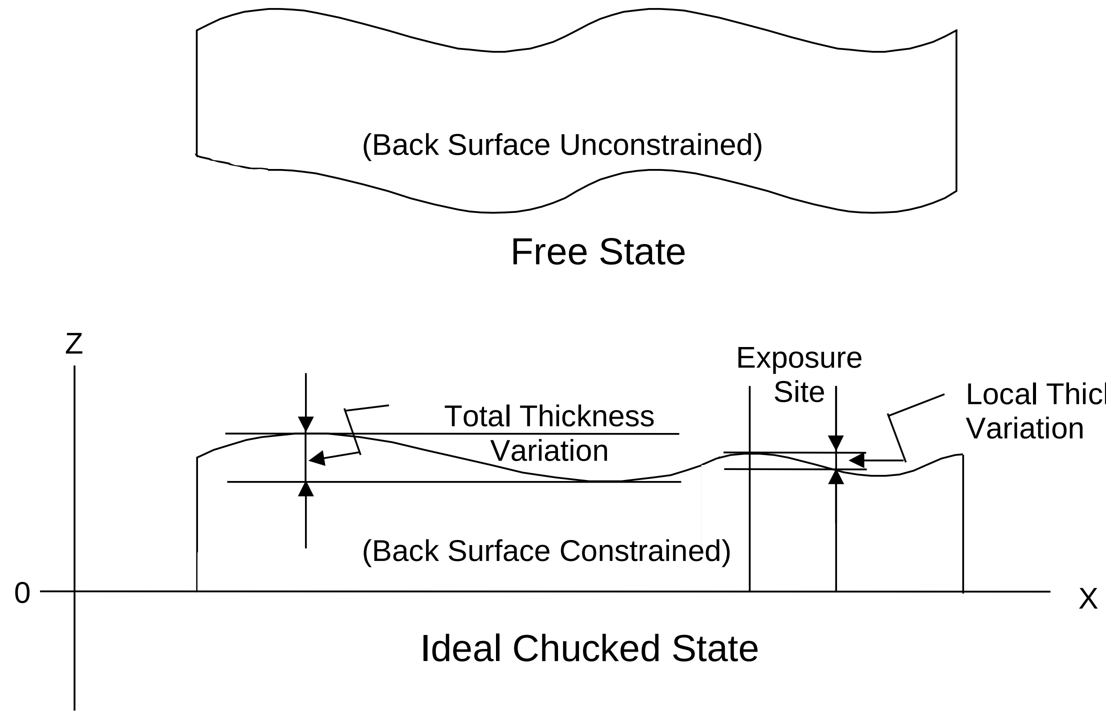


Figure 6
Total Thickness Variation and Local Thickness Variation

NOTICE: SEMI makes no warranties or representations as to the suitability of the standard set forth herein for any particular application. The determination of the suitability of the standard is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. These standards are subject to change without notice.

The user's attention is called to the possibility that compliance with this standard may require use of copyrighted material or of an invention covered by patent rights. By publication of this standard, SEMI takes no position respecting the validity of any patent rights or copyrights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of any such patent rights or copyrights, and the risk of infringement of such rights, are entirely their own responsibility.

SEMI D25-0600E
SPECIFICATION FOR FLAT PANEL DISPLAY SUBSTRATE SHIPPING CASE

This specification was technically approved by the Global Flat Panel Display Committee and is the direct responsibility of the Japanese Flat Panel Display Committee. Current edition approved by the Japanese Regional Standards Committee on April 21, 2000. Initially available on SEMI OnLine May 2000; to be published June 2000.

E This document was editorially modified in October 2003 to correct general editorial errors. Changes were made to Sections 3.2.2, 6.2.8.1, 6.2.9.1, and A3-1 (figure).

1 Purpose

1.1 This document provides the packing and shipping specifications and/or guides for FPD glass substrates, which are called fourth generation substrates (800 × 950 × 0.7 mm or 800 × 950 × 1.1 mm).

1.2 The objective of this document is to provide cost-effective packing and shipping in terms of packing materials, storage, and shipping, while making sure that packing meets the quality and automation requirements.

2 Scope

2.1 This document defines a specification for a full box type shipping case (see Figure 2) to be used for packing and shipping of 4th generation FPD glass substrates from the manufacturer of the glass substrate to the user.

2.2 The application of this packing specification is limited to the following four FPD glass substrates:

2.2.1 Bare glass substrates which can be used as array substrates, and do not have film deposition.

2.2.2 Bare glass substrates which can be used as facing substrates and color filter substrates, and do not have film deposition.

2.2.3 Array substrates which do have film deposition.

2.2.4 Facing substrates and color filter substrates which do have film deposition.

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

3 Prerequisites and Limitations

3.1 This specification does not apply to:

3.1.1 cassettes used for intra/inter bay transfer inside the user's plant;

3.1.2 the semi-separating type the contact type packi-ng method (see Figure 4) or the full corner supporter type and the double side supporter type (see Figure 3)

3.2 The premise for glass substrates for this packing specification is as follows.

3.2.1 *Size*

W (mm):	Short Edge
L (mm):	Long Edge
t (mm):	Thickness

W = 800 mm W tolerance: see SEMI D24
L = 950 mm L tolerance: see SEMI D24
t = 1.1 t tolerance = see SEMI D24
t = 0.7 t tolerance = see SEMI D24

3.2.2 *Squareness* — see SEMI D24

3.2.3 *Beveling* — R beveling

3.2.4 *Orientation Corner* — see SEMI D24

3.2.5 *Corner Cut* — see SEMI D24

3.2.6 *Edge Exclusion Area* — see SEMI D24

3.2.7 *Sag* — In the event of the glass substrate being placed horizontally on the support as shown in Figure 1, sag is defined by h2 (two sides supported), and h4 (four sides supported) (Unit = mm) (see Figure 1).

3.2.8 *Density* — Less than 2.8 g/cm^3

3.3 When the glass substrates are shipped, they shall be loaded vertically.

3.4 When the glass substrates are shipped, a standard sized pallet shall be used for efficient loading on the truck platform or the floor of the container (see Appendices 1 and 2). The standard size used here is less than 1,100 × 1,100 mm^2 or, at the outside, 1,100 × 1,200 mm^2.

3.5 When the glass substrates are shipped, the loading should be as efficient as possible utilizing the available space, in line with:

- The smallest height for truck platforms and containers is 2,300 mm (see Appendices 1 and 2).

- Taking into consideration the head clearance when loading and unloading by forklift, as well as the height of the shipping case, the maximum height of the load is approximately 2,000 mm. If more efficient loading can be achieved, multiple boxes can be stacked.

4 Referenced Documents

4.1 *SEMI Standards*

SEMI D9 — Definitions for Flat Panel Display Substrates

SEMI D11 — Specification for Flat Panel Display Glass Substrate Cassettes

SEMI D24 — Specification for Glass Substrates Used to Manufacture Flat Panel Displays

4.2 *JIS Documents*[1]

JIS D4002 — Internal Dimensions for Rear Body of Motor Trucks

JIS Z0604 — Wooden Flat Pallets

4.3 *ISO Documents*[2]

ISO 668 — Series 1, Freight Container – Classification, Dimensions and Ratings

NOTE 1: As listed or revised, all documents cited shall be the latest publications of adopted standards.

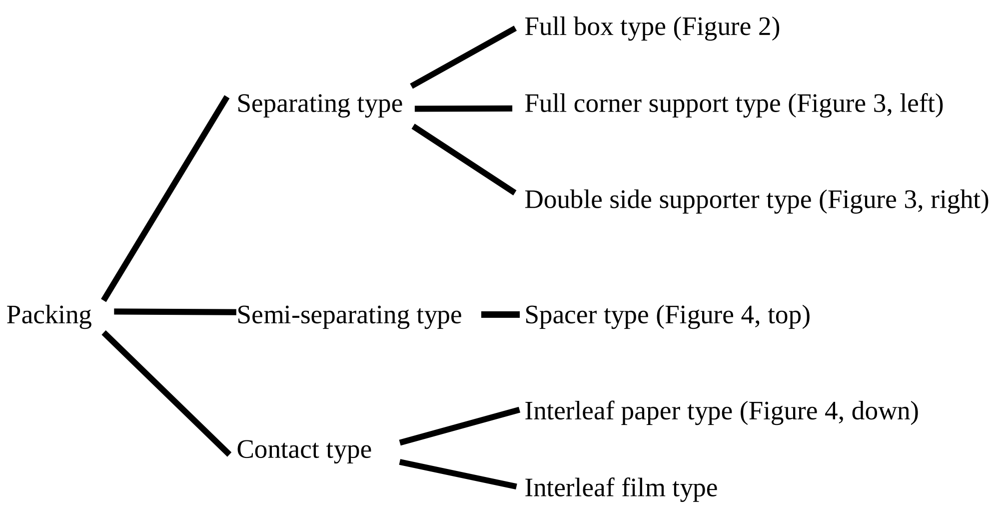
5 Terminology

5.1 *Size of exposed portion* — The length of the glass substrate exposed from the packing box (full box type) when the lid of the packing box is open.

6 Packing

6.1 *Classification*

6.1.1 Classification of packing is as follows:



1 Japan Standards Association, 4-2-24, Minato-ku, Tokyo 107, Japan

2 ISO Central Secretariat, C.P. 56, CH-1211 Geneve 20, Switzerland

6.2 *Packing Box Dimensions* — Figure 5 shows the key dimensions and tolerances of the packing box for the full box type.

6.2.1 *Packing Box Loading and Unloading*

6.2.1.1 Vertical loading shall be used to load and unload the glass substrates to and from the packing box (see Figure 6).

6.2.1.2 Vertical loading requires a tall loader/unloader because of the height of the loading direction. The ceiling height of the room where the loading equipment is installed has to be designed accordingly.

6.2.1.3 A suggested method for loading/unloading substrates from the shipping case with an automatic vertical loader/unloader is to tilt the box as shown in Figure 7. Align the substrates on one side of the clearance of the mizo and proceed with loading/unloading.

6.2.1.4 An alternative method for loading/unloading would be to rotate the packing box 90°, as shown in Figure 8.

6.2.1.5 Loading and unloading the substrates also can be done manually without using an automatic loader/unloader.

6.2.2 *Packing Box Size*

6.2.2.1 The shorter side of the substrate (side W, or the 800 mm side) as the vertical direction (direction z in Figure 5) during shipping. This way, the size of the substrate determines the inside measurements of the packing box, H: 800 mm (direction z), W: 950 mm (direction x).

6.2.2.2 The outside measurements of the packing box shall be H: 980 mm × W: 1,200 mm × L: $\leq$ 1100mm (Figure 5). It is important to note that the height of 980 mm indicates that it is possible to stack up the packing boxes, i.e. 980 mm × 2 = 1,960 mm, and still be less than the possible maximum height (2,000 mm) of the truck load.

6.2.2.3 The length of the packing box is determined by the calculated product of the pitch size between the substrates times the number of substrates stored in the box. the length (L in Figure 5) of the packing box cannot exceed 1,100 mm

6.2.3 *Packing Box Lid*

6.2.3.1 The packing box must prevent the substrates from getting contaminated as well as to give pressure to the substrates for securing them from both top and bottom. The lid must securely seal and be able to latch closed to the packing box by a lock. The latching mechanism must allow easy automatic lock and unlock as well.

6.2.3.2 The lid shall also have automatic and manual opening/closing capability. The inside of the lid is covered with a shock absorber that functions to secure the glass substrates by pressing them from the top and bottom.

6.2.4 *Mizo Pitch and Capacity of Packing Boxes*

6.2.4.1 The sag, h4 = 20 mm will be for the substrates of the size 800 × 950 × 0.7 mm as shown in Appendix 3, when a sudden turn, acceleration, or braking during shipping forces a 1G acceleration against the substrates. From this point of view, the pitch required here is a little bit larger than 20 mm. However, since all the substrates in the box are affected by the acceleration at the same time and in the same direction, the distance between the substrates will remain constant which means the substrates should not touch each other.

6.2.4.2 The mizo pitch, must be standardized by each shipping case supplier, but must range from a minimum of 9 mm to a maximum of 22 mm ± 0.2 mm. Table 1 shows possible number of substrates per shipping case at a given pitch.

Table 1 Pitch and Number of Substrates

Pitch (mm)	*Number of Substrates (pc)*
22	40
18	50
15	60
11	80
9	100

6.2.4.3 The first mizo clearance (see Figure 9) is to be more than 40.0 mm at the center of the groove. The distance from the reference plane to the first mizo is the sum of the first mizo clearance and the thickness of the side of the box which is the reference plane, and its allowance is ± 1.0 mm. The allowance of cumulative pitch distance is less than ± 2.0 mm, and that of each pitch is less than ± 1.0 mm.

6.2.4.4 Mizo clearance shall be designed to store the glass substrate of a thickness ranging from 0.7 mm to 1.1 mm.

6.2.5 *Size of Exposed Portion*

6.2.5.1 In this document, the size of f1 in Figure 10 is called "the size of the exposed portion" which is set as f1 = 100 mm. Size h in Figure 10 is the shorter side of the substrate at 800 mm. The size of f2 is 700 mm which means one eighth of the whole substrate is exposed.

6.2.6 *Reference Plane*

6.2.6.1 The reference plane needs to be determined as follows from three directions, x, y, and z in Figure 5 for automatic transferring:

x: Both sides or center position
y: Both sides or center position
z: Bottom surface of the box (not the bottom of the skid described later)

6.2.6.2 Specifically use the small area as a reference surface in Figure 11. The detail of the position and size of the reference surfaces shall be standardized to use a compatible reference for two different design boxes. Also the center line of substrate is automatically defined by symmetrical location between substrate and reference plane of case.

6.2.7 *Transfer and Lift Method for Packing Boxes*

6.2.7.1 It is expected that not only boxes containing glass substrates but also empty boxes are fairly heavy. At least, they probably cannot be carried by hand. Therefore, it is assumed that whether the box contains glass substrates or not and whether the box is in a regular room or a clean room, it shall be lifted by a forklift and transferred mechanically. To accommodate a mechanical transfer and lift, skids must be installed at the bottom of the box so that the forklift can insert its tongues underneath the box (see Figure 5). The height of the skids shall be standardized for each shipping case supplier, but not exceed 150 mm.

6.2.7.2 Assuming lifting of the box and short distance, transfer is done using a balancer; the packing box is required to have handles, as shown in Figure 12, on the sides of the box. The structure of the handles shall be designed in such a way that it does not hinder the reference plane.

6.2.8 *Packing Box Strength*

6.2.8.1 The weight of the contents of the box, with the prescribed number of substrates, can be calculated from the density of substrates. The packing box has to be strong enough to bear that weight. Moreover, it has to be strong enough to hold another full box on top of itself.

6.2.8.2 Stacking three boxes with glass substrates is prohibited. Therefore there is no need for the packing box strength to hold two boxes on top of one box. However, empty boxes may be stacked three high, but the box has to be designed to bear the weight of two empty boxes.

6.2.8.3 The handles shall be strong enough to hold the weight when the box is filled with glass substrates as well as a full box on top or two empty boxes on top.

6.2.9 *Packing Box Material*

6.2.9.1 Packing box material is not covered in this document. Neither carcinogen nor de-gasification is covered. For the purpose of cleaning, cleanliness, and particle reduction, the material of the box has to be washable and solvent-resistant. The addition of draining holes is acceptable. Material must meet cleanliness, mechanical strength, and durability in line with specifications of this document.

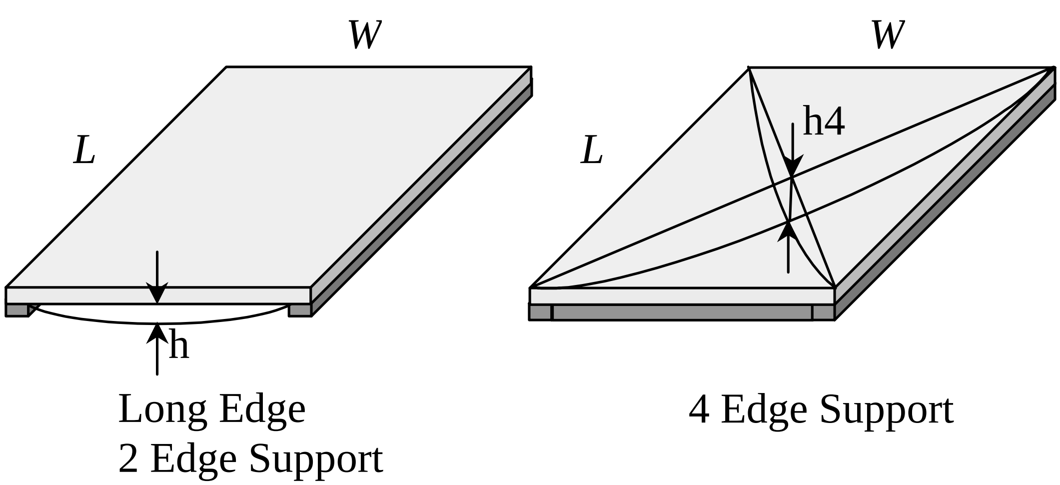


Figure 1
Sag

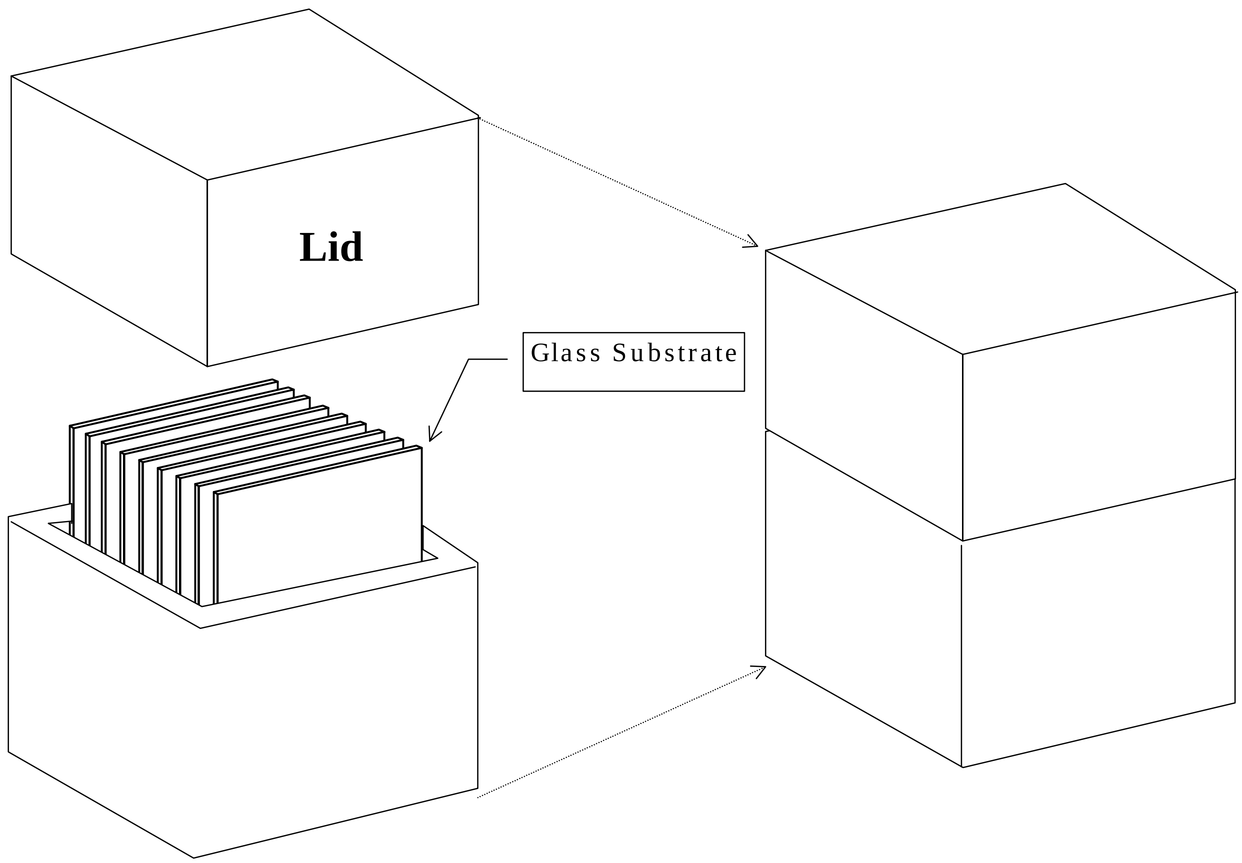
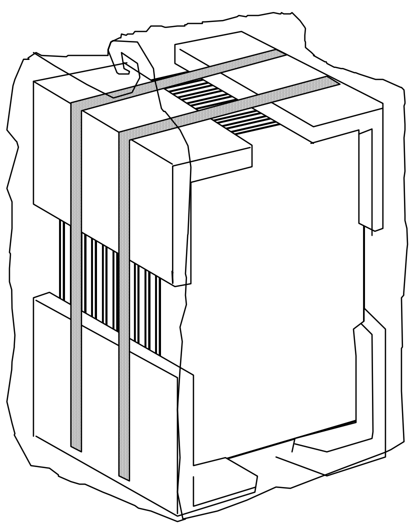
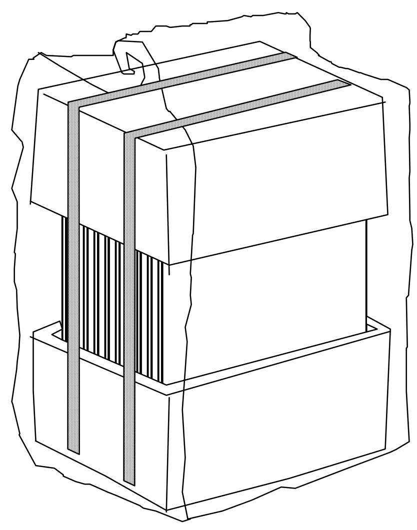


Figure 2
Full Box Type

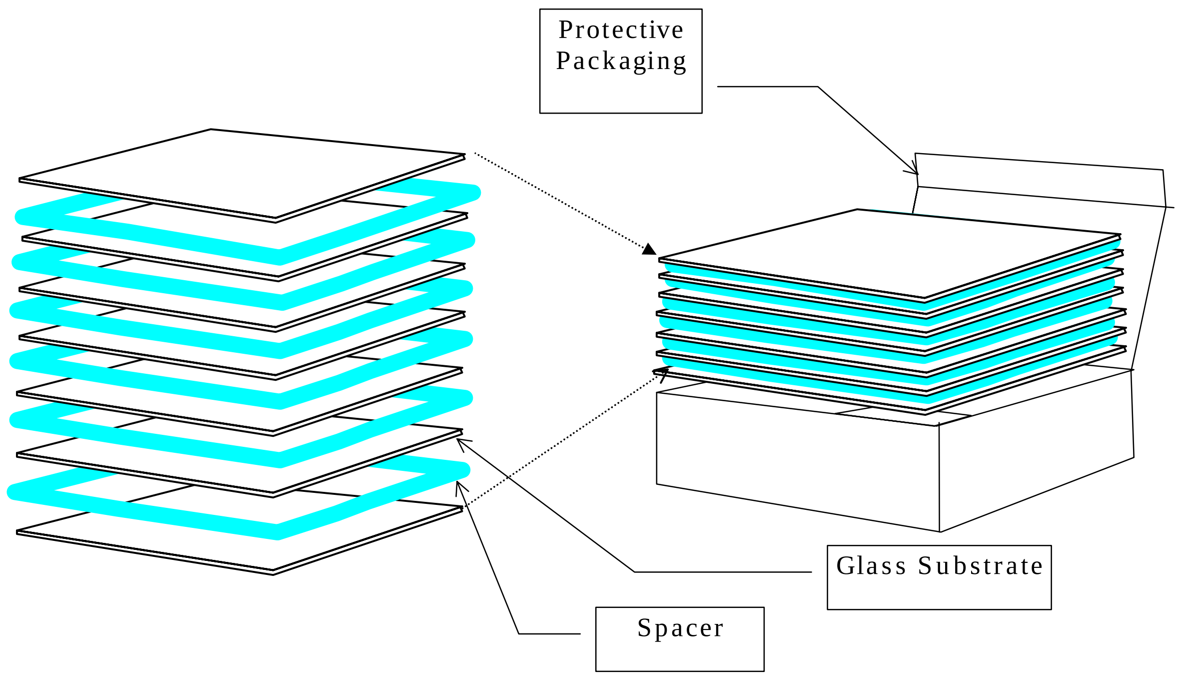


4 Corner Supporter Type

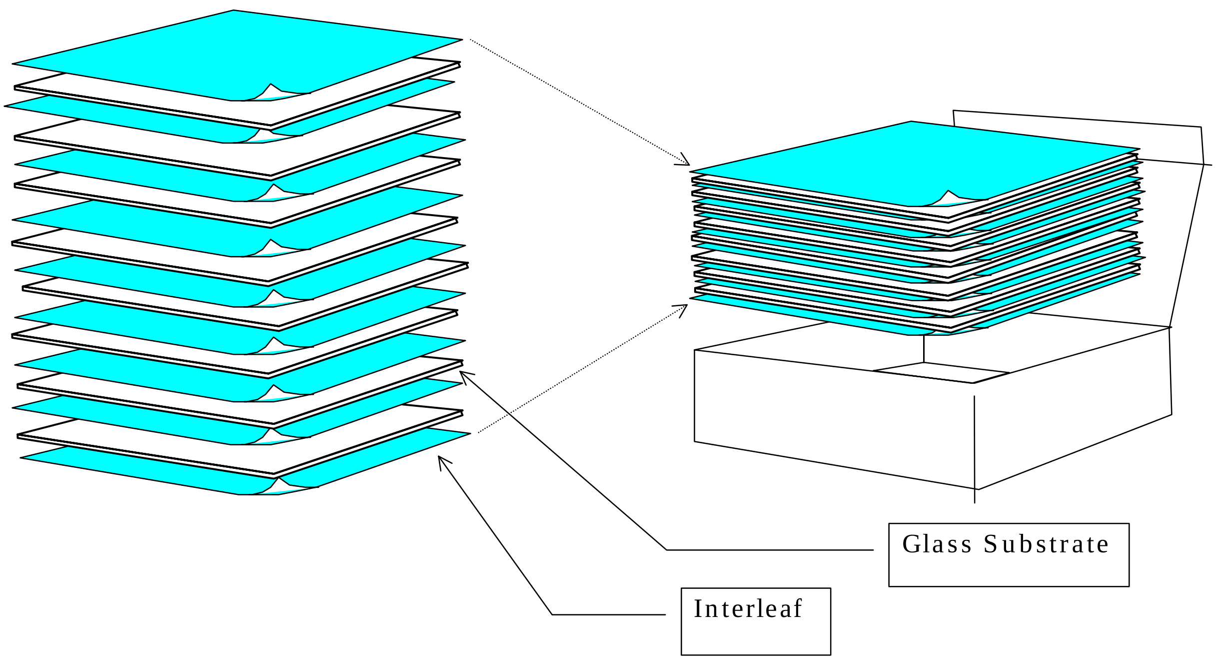


2 Edge Supporter Type

Figure 3
Partial Box Type



Spacer Type



Interleaf Type

Figure 4
Separator Contact Types

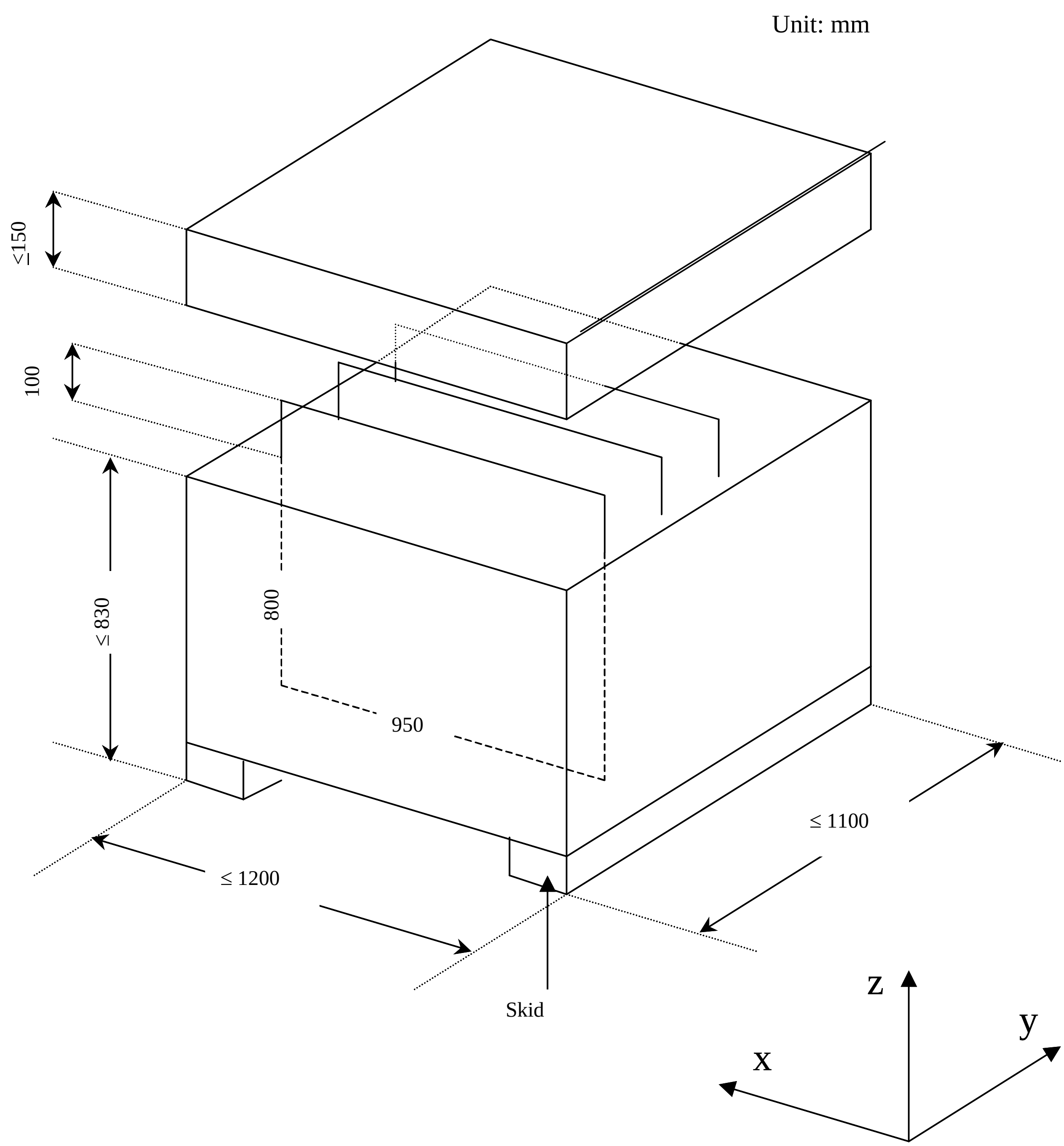


Figure 5
Packing Box Concept

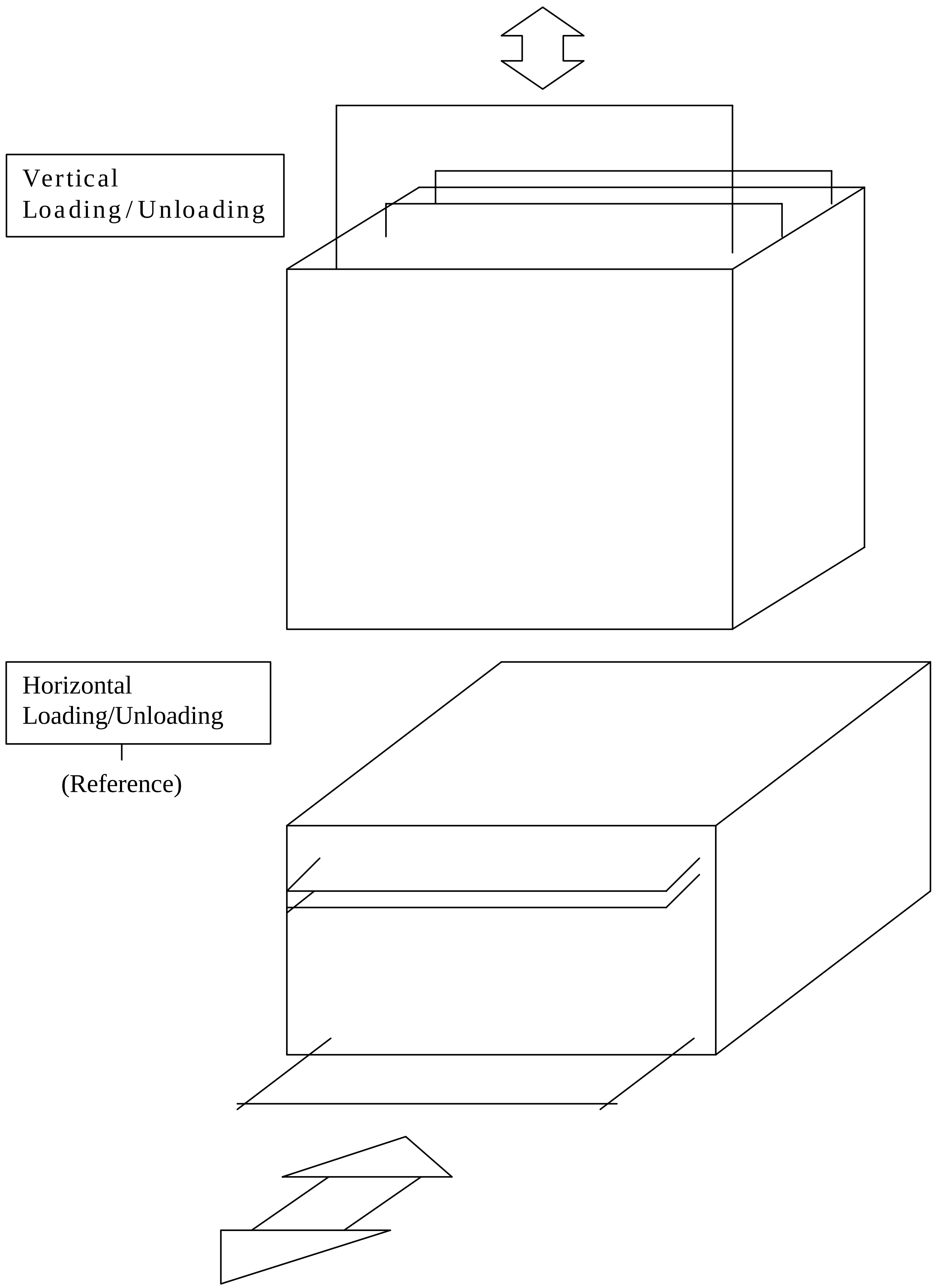


Figure 6
Loading/Unloading Method

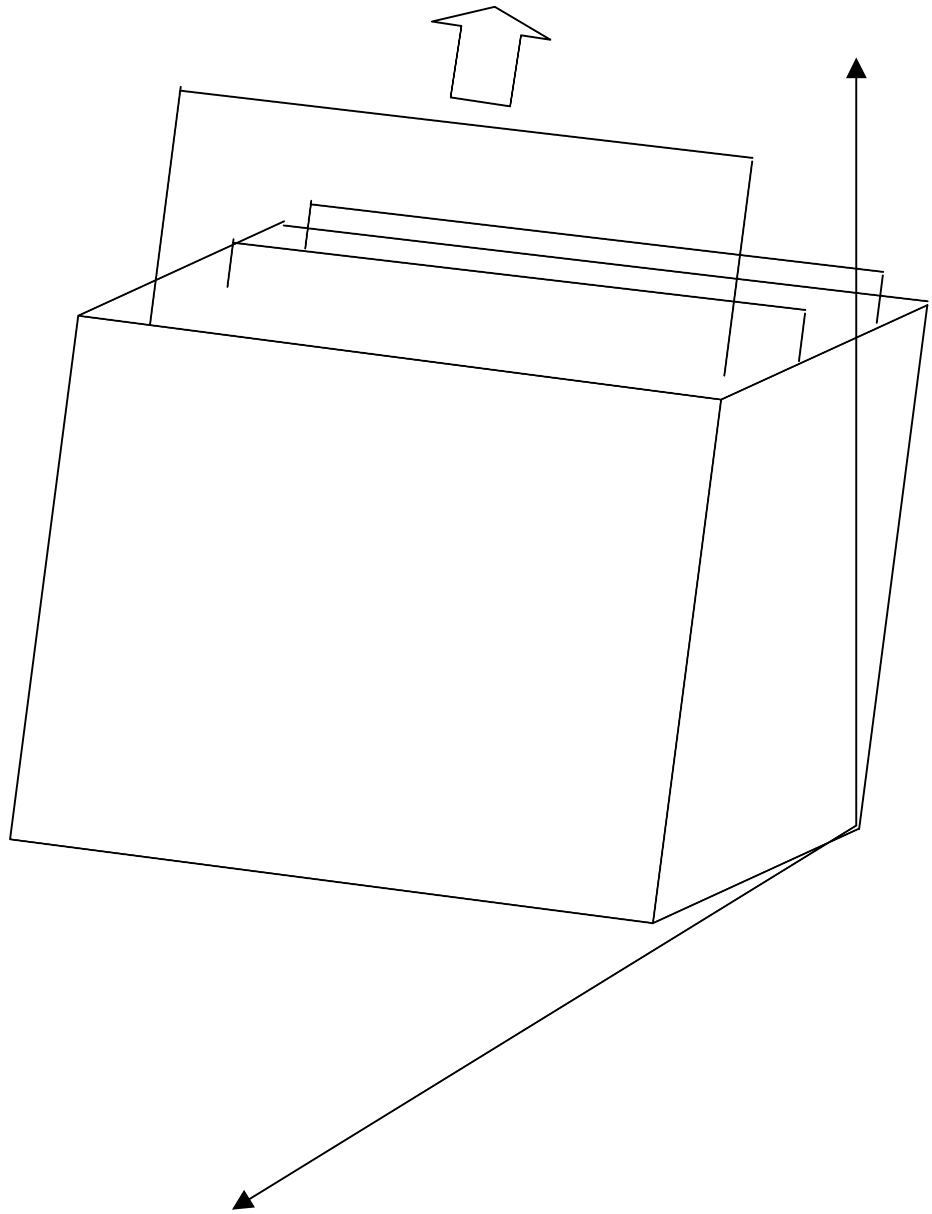


Figure 7
Leaning Vertical Unloading

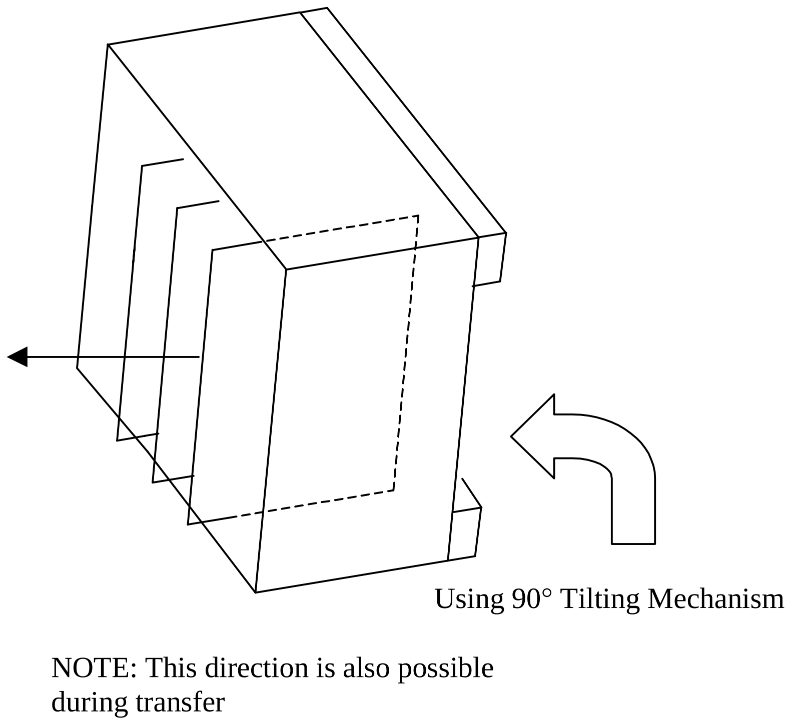


Figure 8
Removing Glass with a 90° Tilting Mechanism

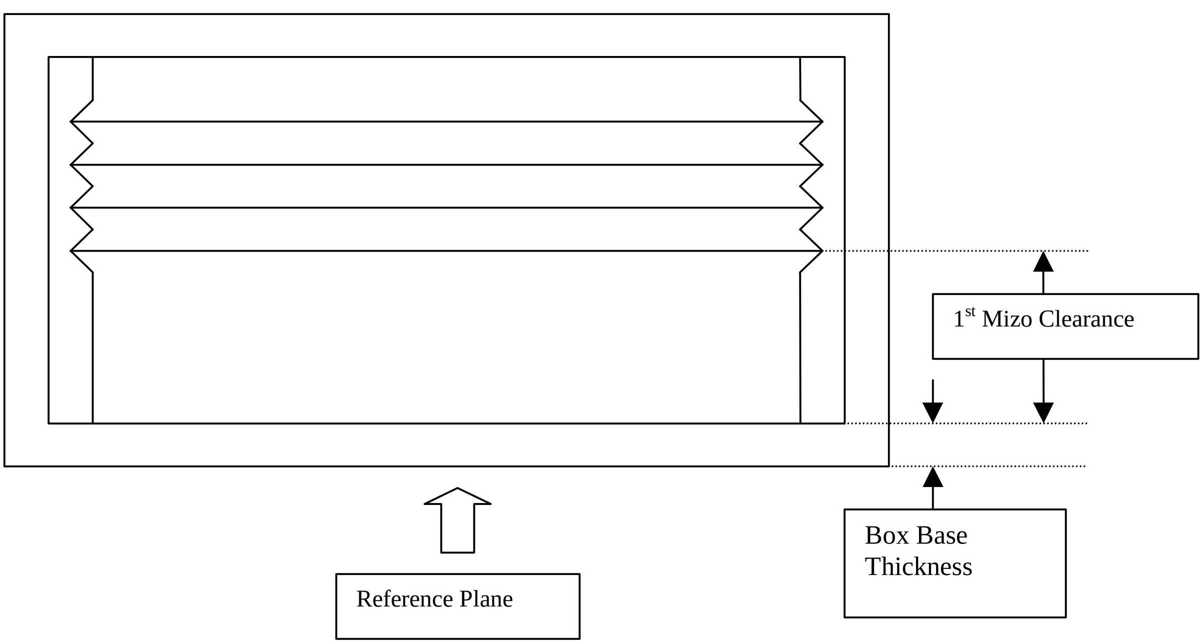


Figure 9
Mizo Definition

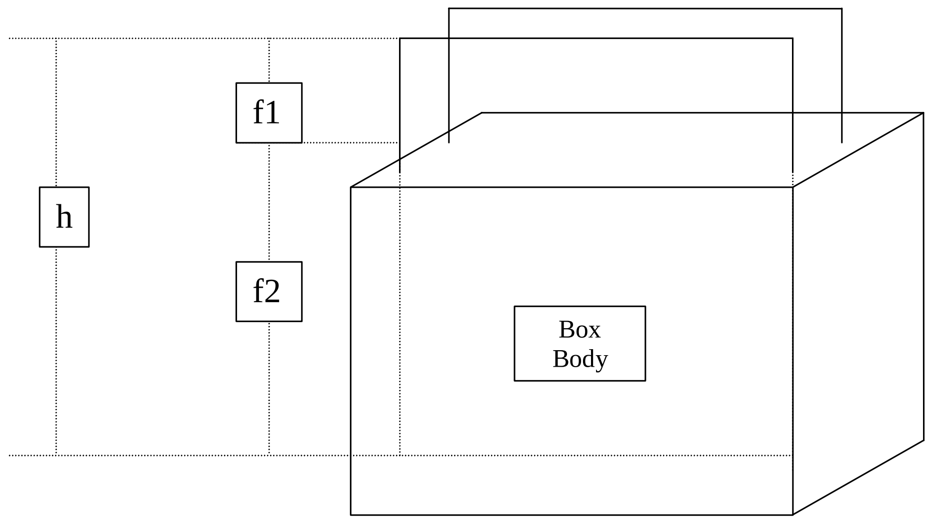


Figure 10
Size of Exposed Portion

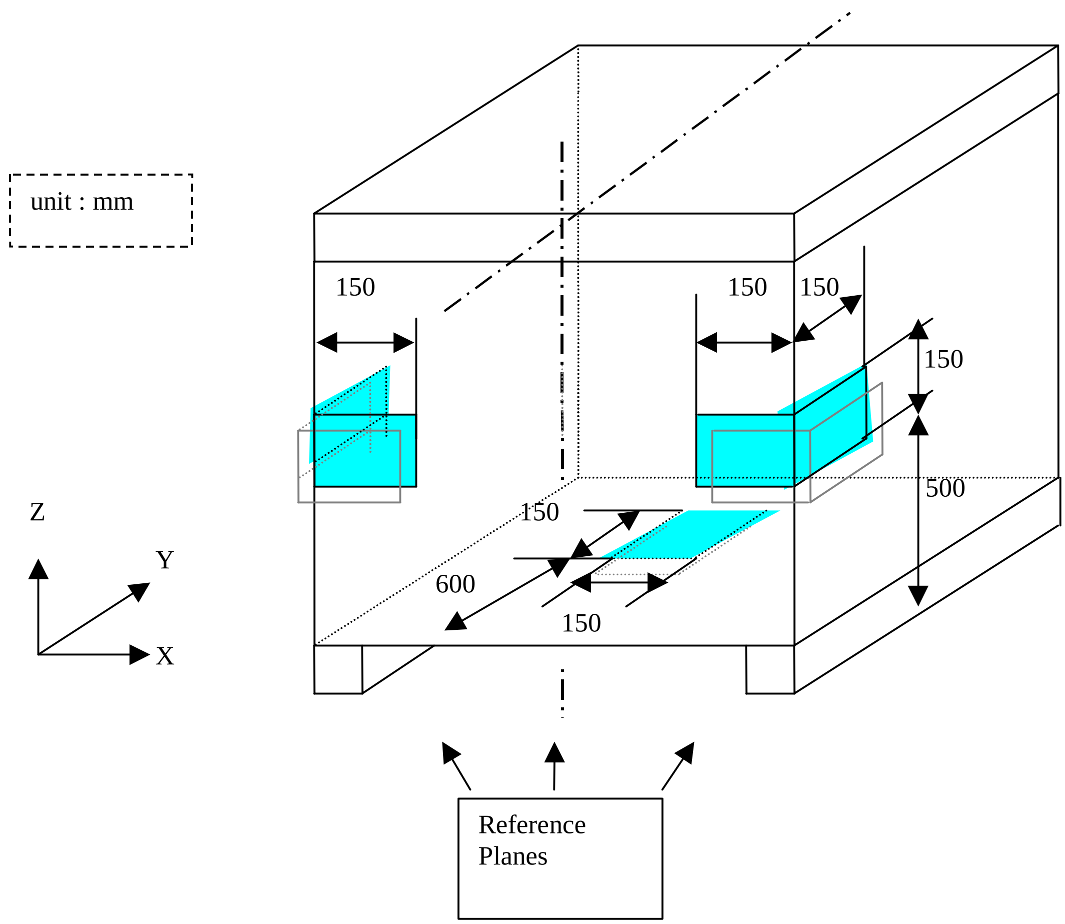


Figure 11
Polishing Reference Planes

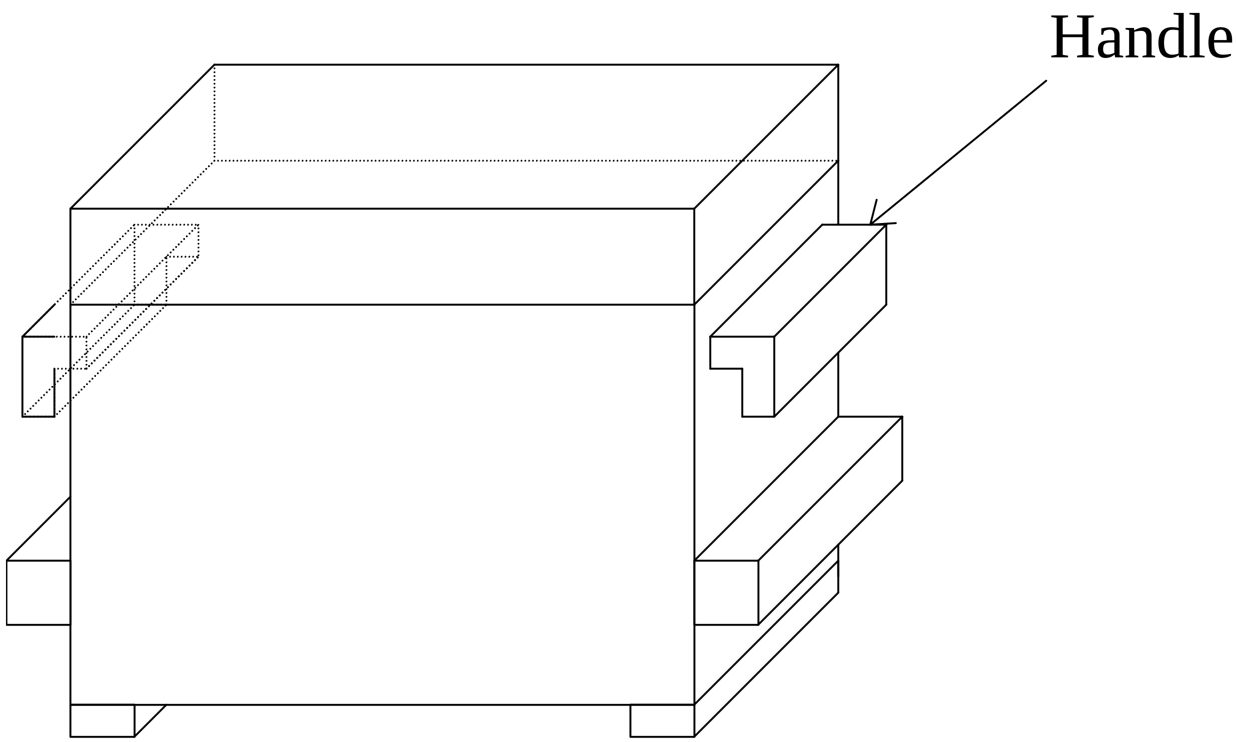


Figure 12
Packaging Handles

APPENDIX 1

NOTE: The material in this appendix is an official part of SEMI D25 and was approved by full letter ballot procedures on April 21, 2000 by the Japanese Regional Standards Committee.

A1-1 Truck Platform Dimensions

NOTE: This data only applies in Japan.

Reference: JIS D4002 Internal Dimensions for Rear Body of Motor Trucks

A1-1.1 *Dimensions* — The platform inner dimensions are categorized by width and length and listed in the table below. These dimensions shall be selected on the basis of their feasibility with regard to the functions of the chassis and the shape, use and special equipment of the platform. The dimensions represent the minimum dimensions for each category.

Table A1-1 Platform Inner Dimensions (mm)

Width Category	Symbol	A	B
	Ordinary Platform	2340	2120
	Van Body	2370	2150
Length Category		9600	
		9000	
		8400	
		7800	
		7200	7200
		6600	6600
		6000	6000
		5400	5400
		4800	4800
		4200	4200
Note		5-12 tons	4 ton wide 5-6 ton narrow

A1-1.2 *Dimension Naming* — Naming of the inner dimensions of the platform is accomplished by using the type (either Ordinary Platform or Van Body), the symbol for the width category and the length category in meters. Example:

Ordinary A – 8. 4

Van B - 6. 6

Length Category

Width Category

Van Body

At present, it seems that generally 10 ton-class trucks use A, and 4 ton trucks use B. The following information was gathered from one transport company:

10 Ton – W=2330	L=9560	H=2280
4 Ton – W=2100	L=6700	H=2300

(Unit = mm)

Measurements may differ depending on the manufacturer and model.

A1-2 Shipping Model

A1-2.1 The shipping model (Figure A1-15) shows the storing of fourth generation flat panel display glass substrates in the packing box as described in this specification, a glass substrate manufacturer transporting substrates to a user, and the user returning the box.

A1-2.2 For covering the outside of the packing box, a plastic bag over the top is recommended. If the contamination of the bottom part of the box is a concern, prevention is not limited. In any case, the goal of this shipping model is to make it as simple as possible and to reduce the cost and investment.

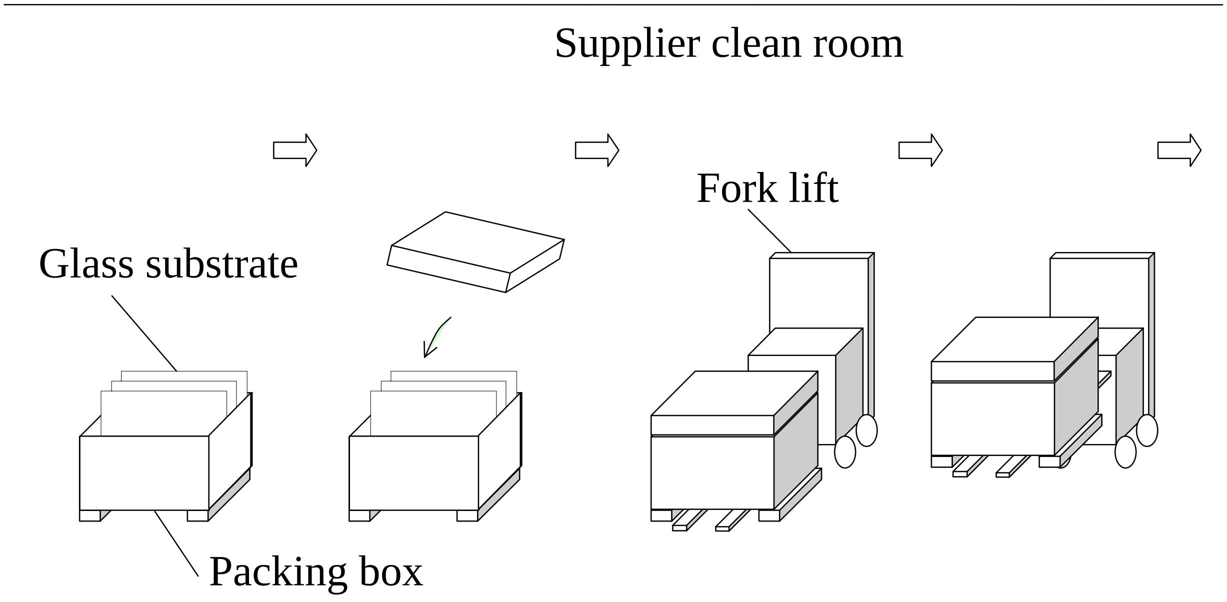


Figure A1-1
Supplier Clean Room

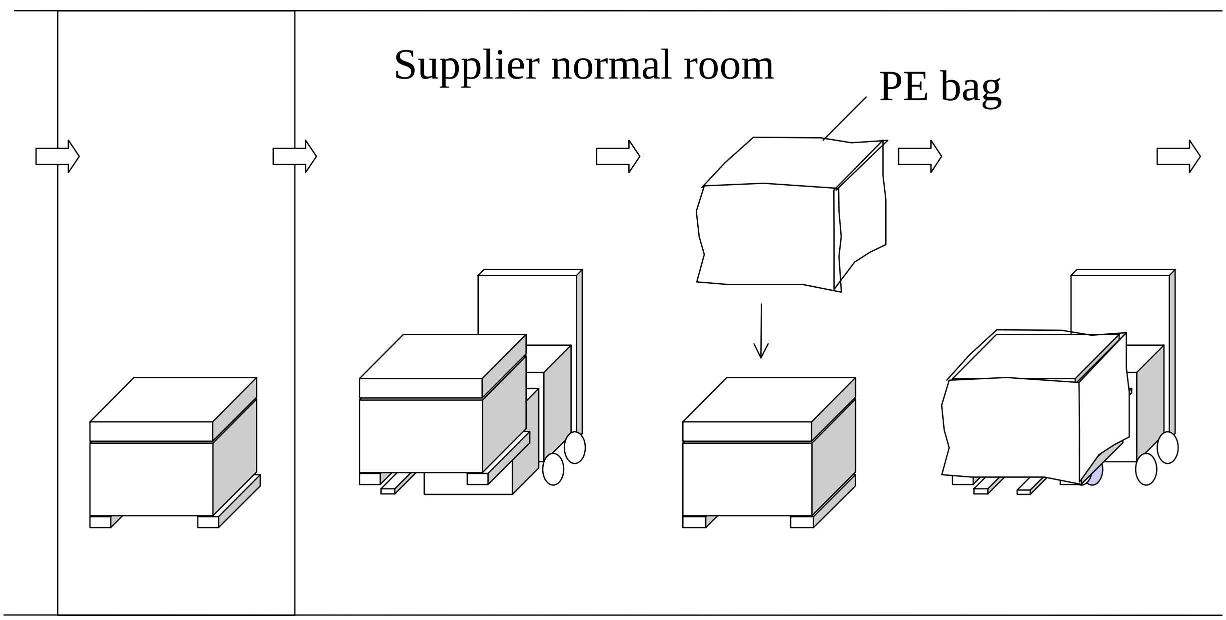


Figure A1-2
Supplier Normal Room (1)

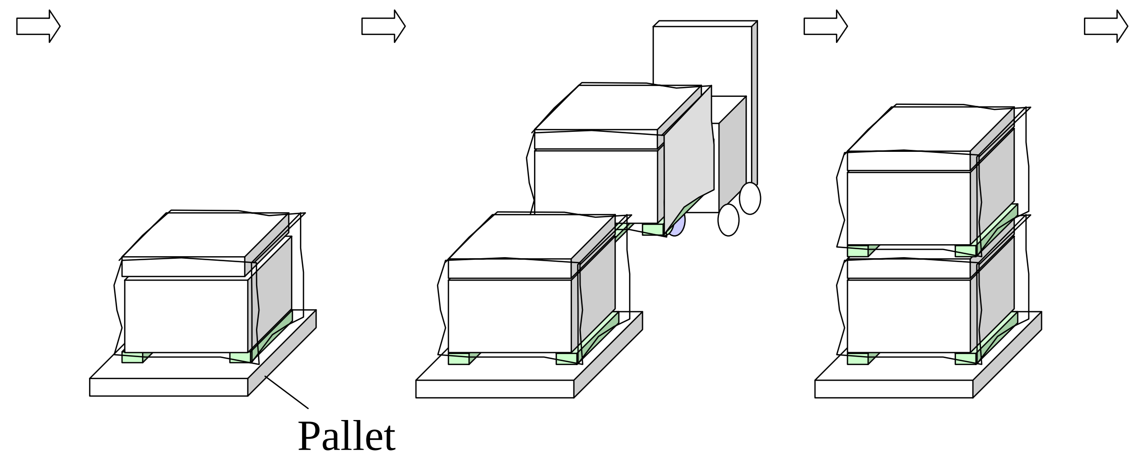


Figure A1-3
Supplier Normal Room (2)

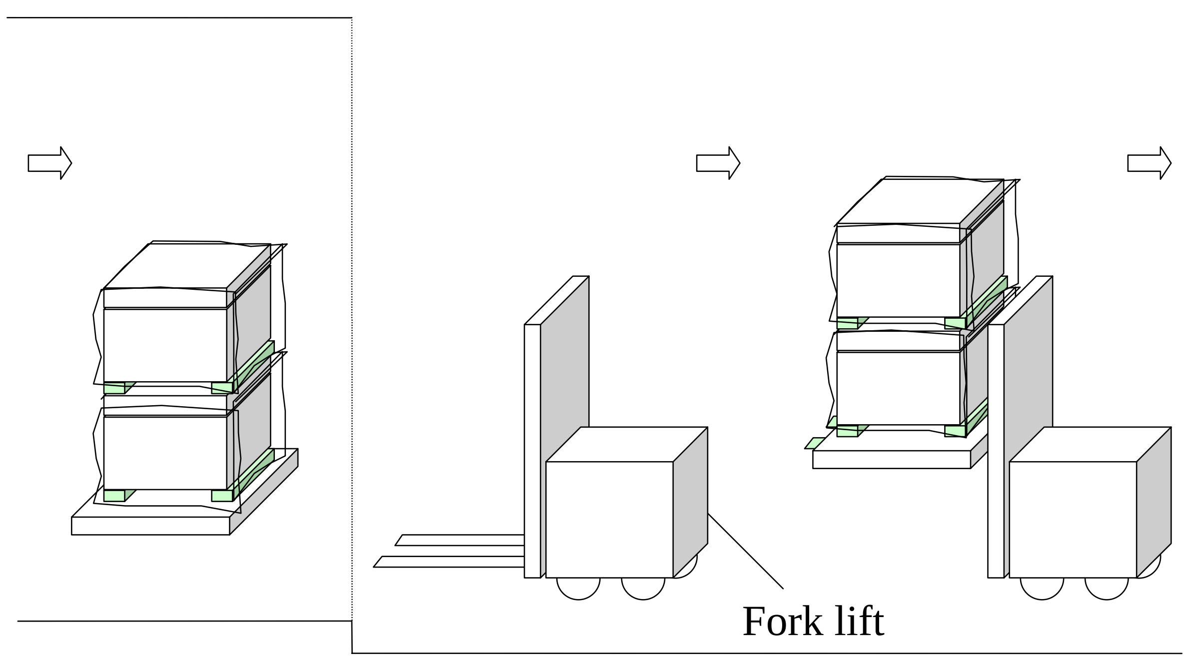


Figure A1-4
Supplier Normal Room (3)

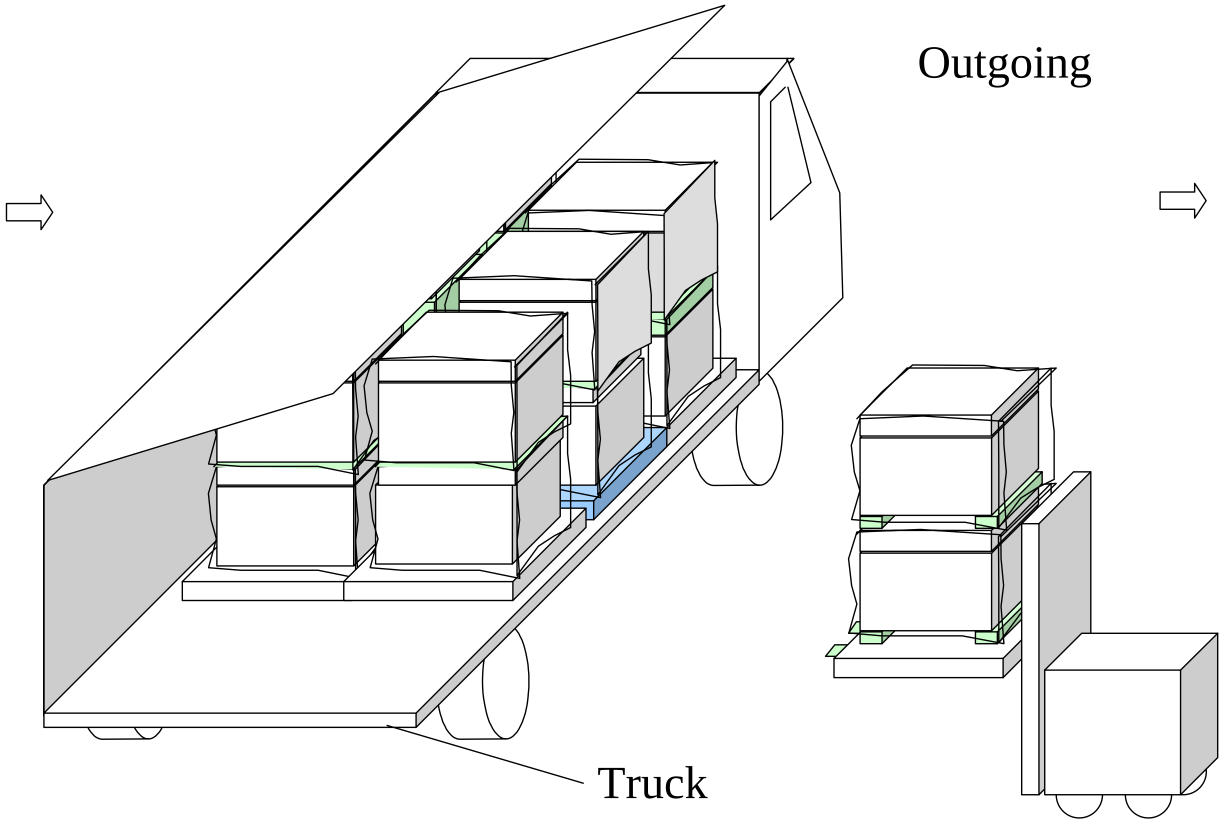


Figure A1-5
Outgoing

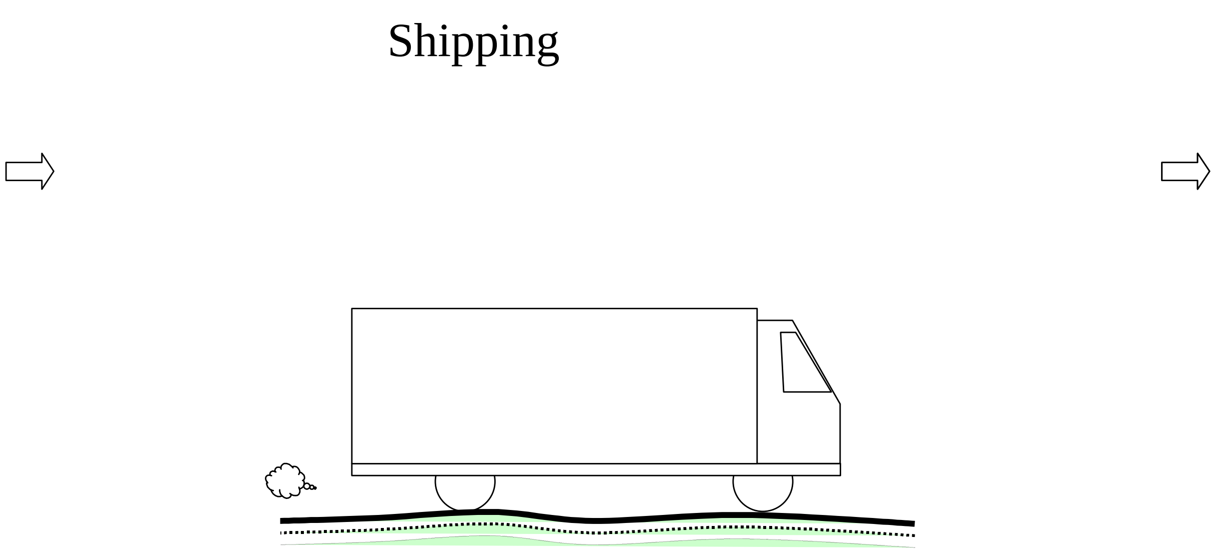


Figure A1-6
Shipping

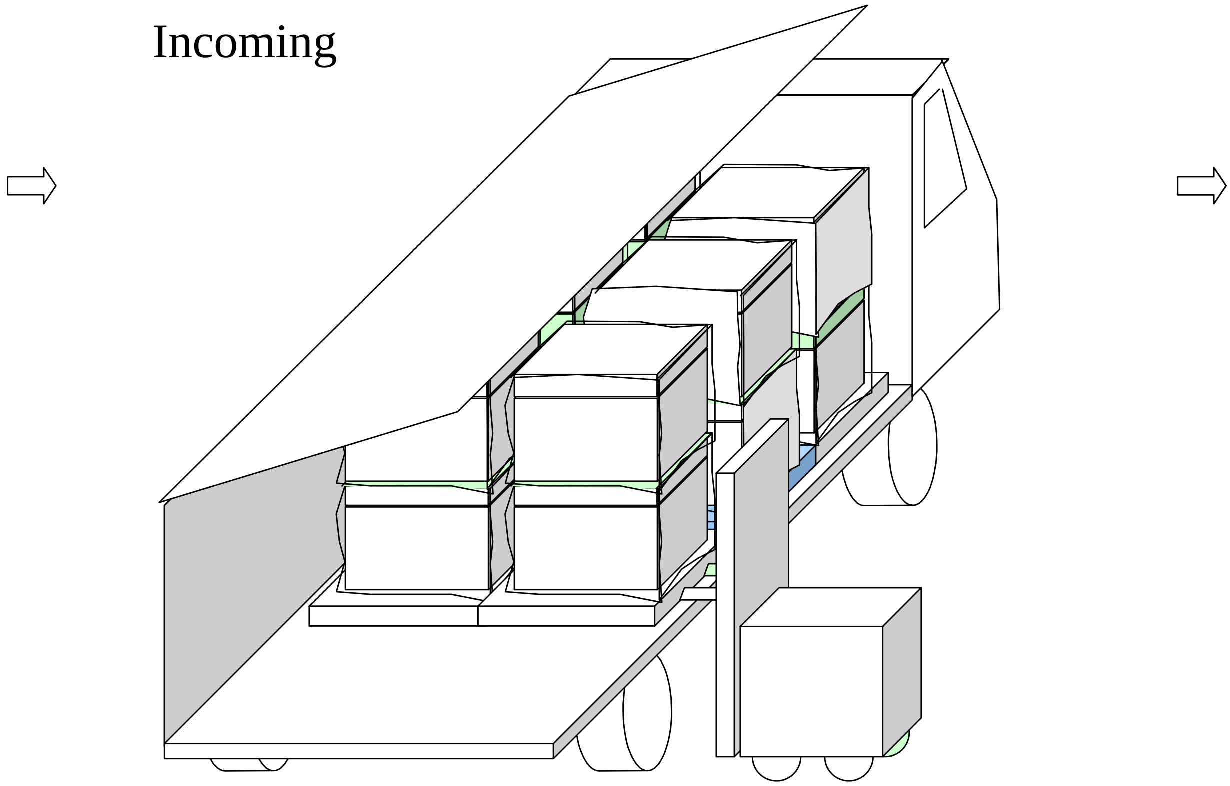


Figure A1-7
Incoming

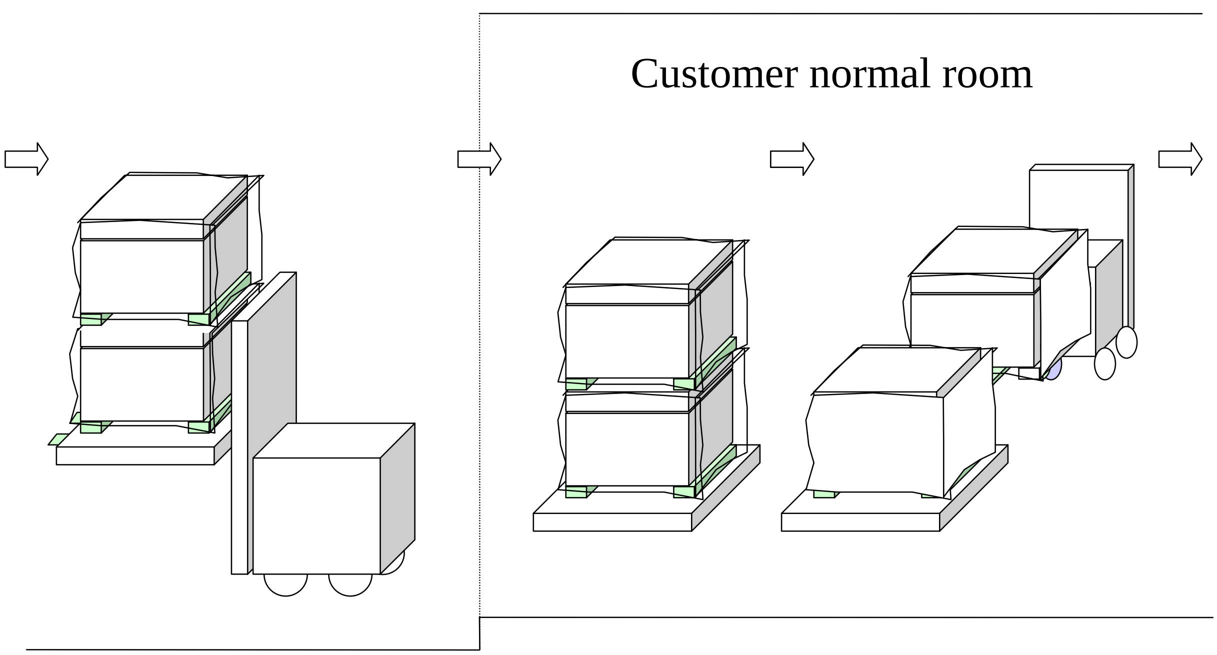


Figure A1-8
Customer Normal Room

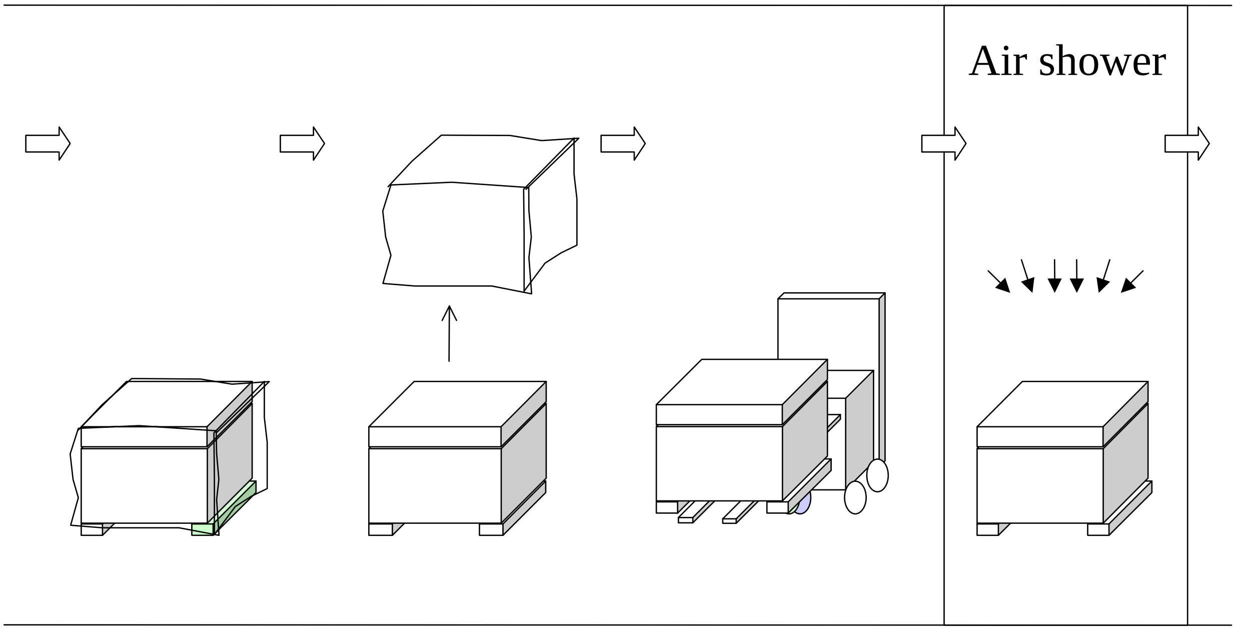


Figure A1-9
Customer Normal Room to Air Shower

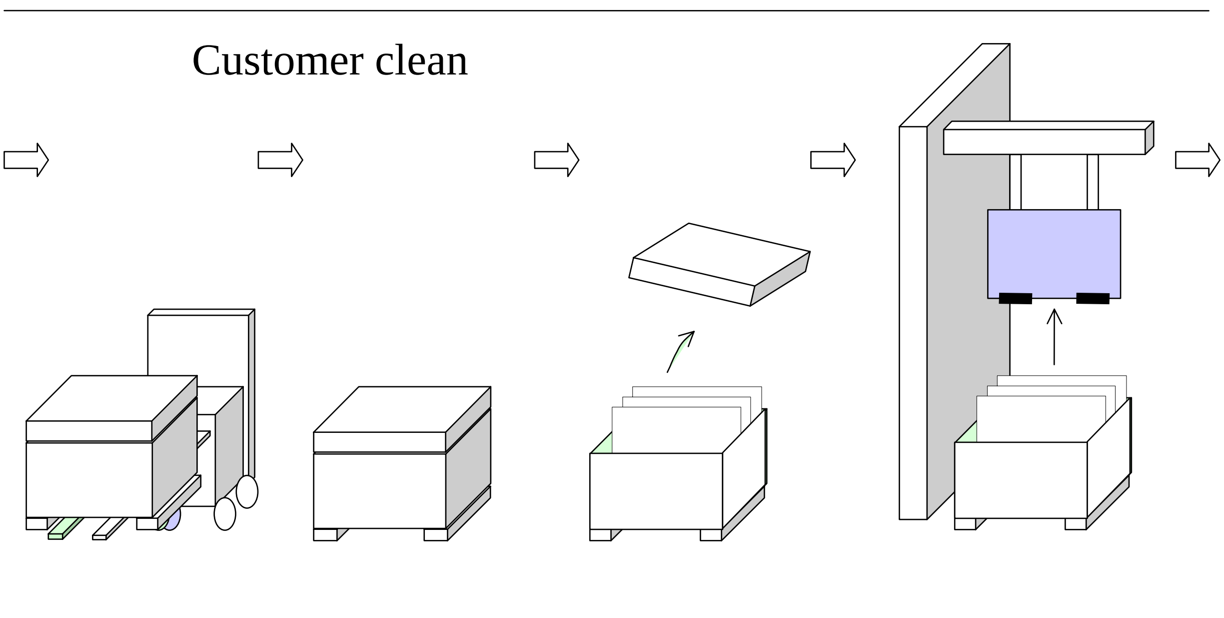


Figure A1-10
Customer Clean Room

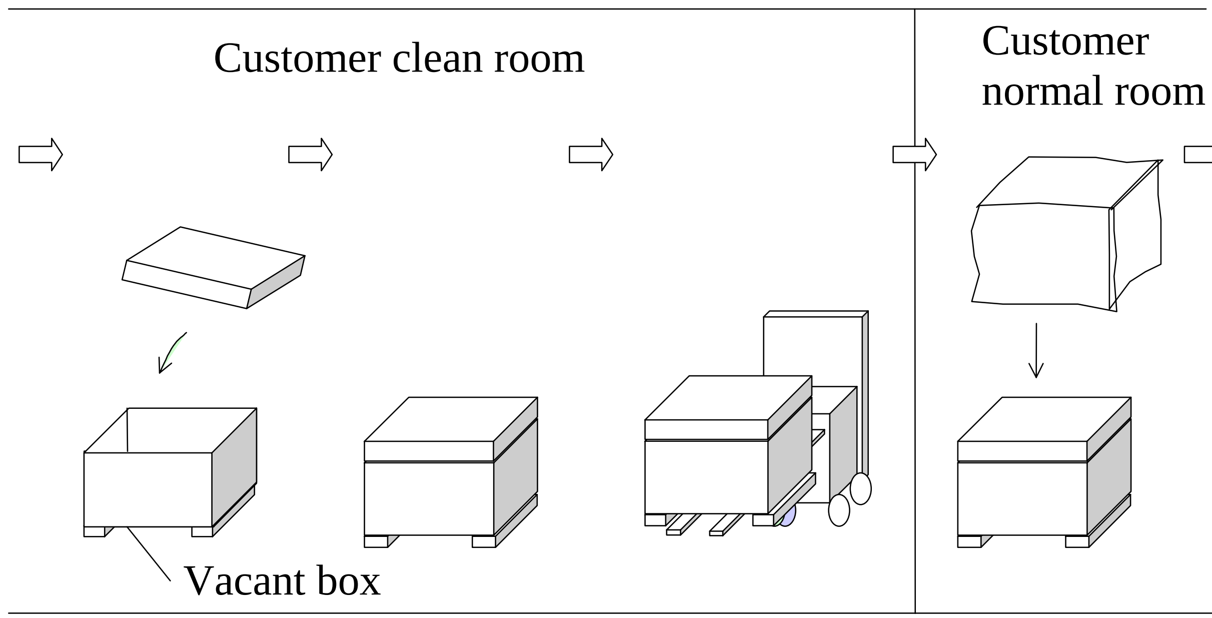


Figure A1-11
Vacant box, from Customer Clean Room to Customer Normal Room

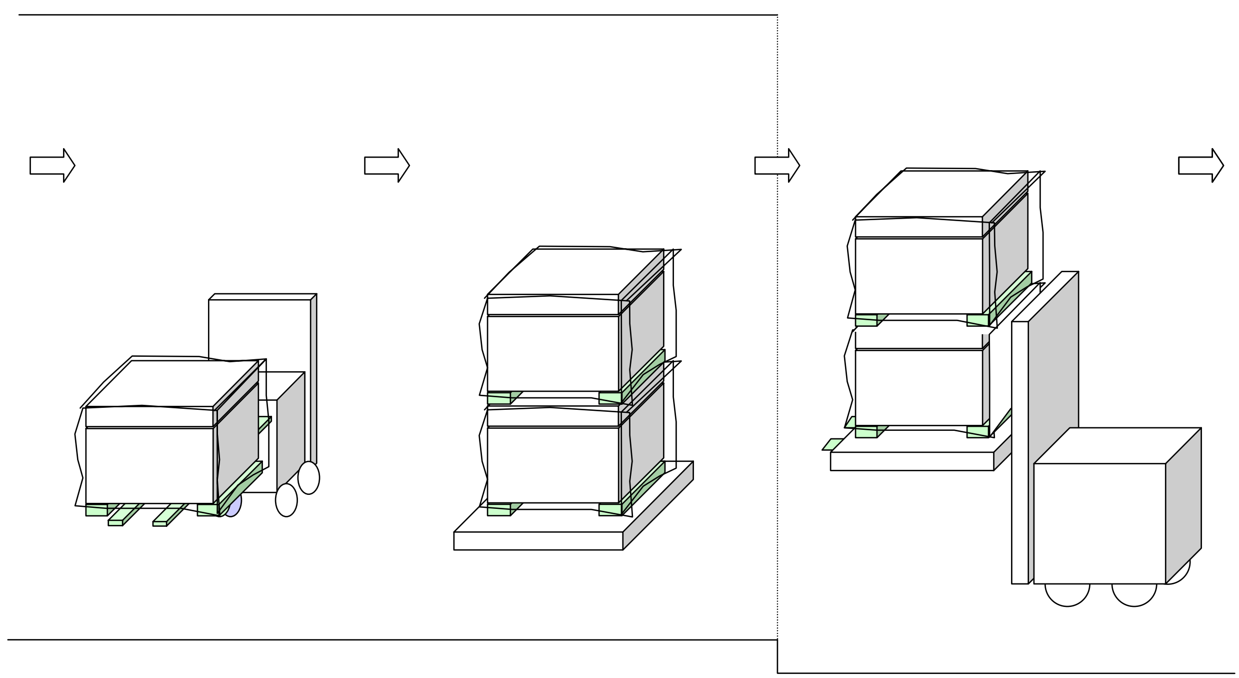


Figure A1-12
Vacant Box, Customer Normal Room

Vacant box returned

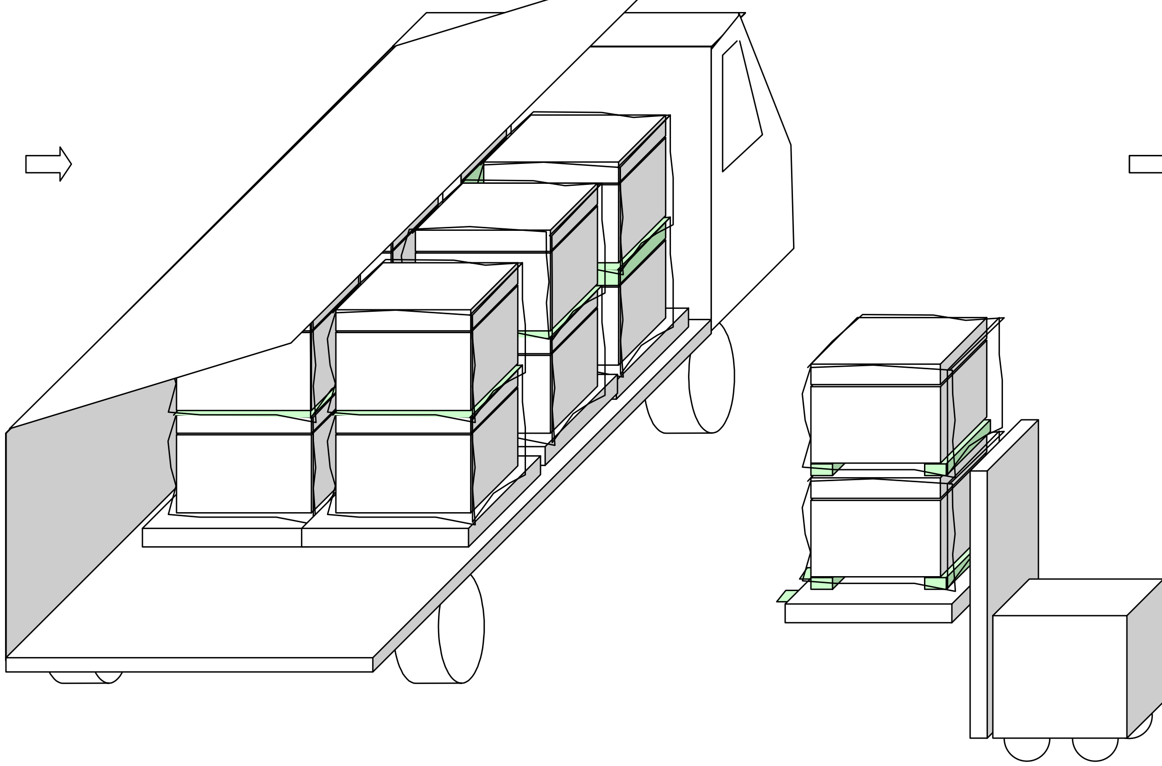


Figure A1-13
Vacant Box Returned

Shipping

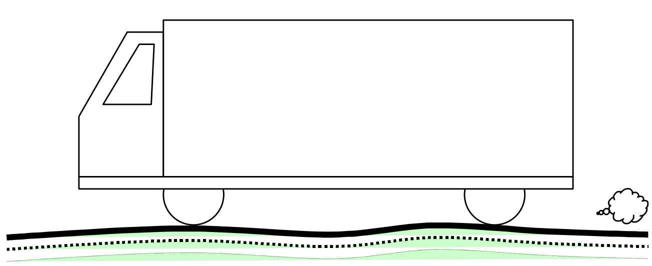


Figure A1-14
Shipping

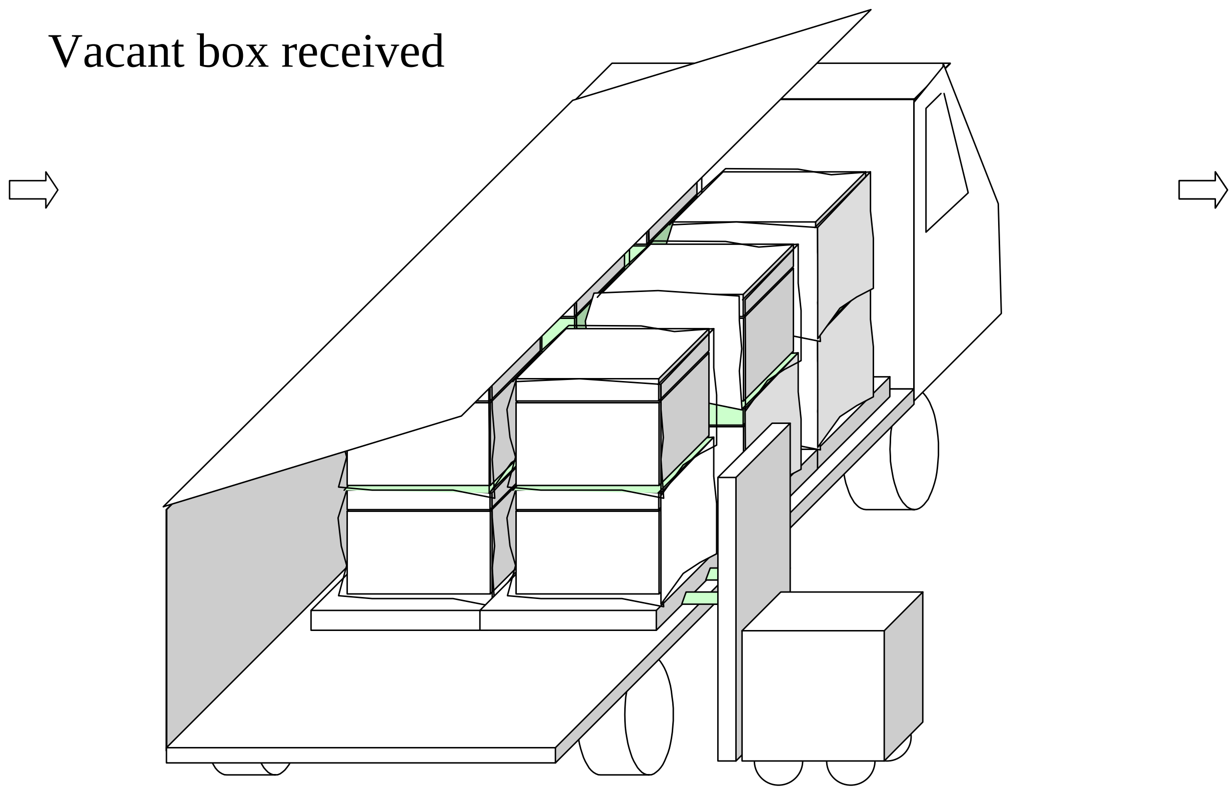


Figure A1-15
Vacant Box Received

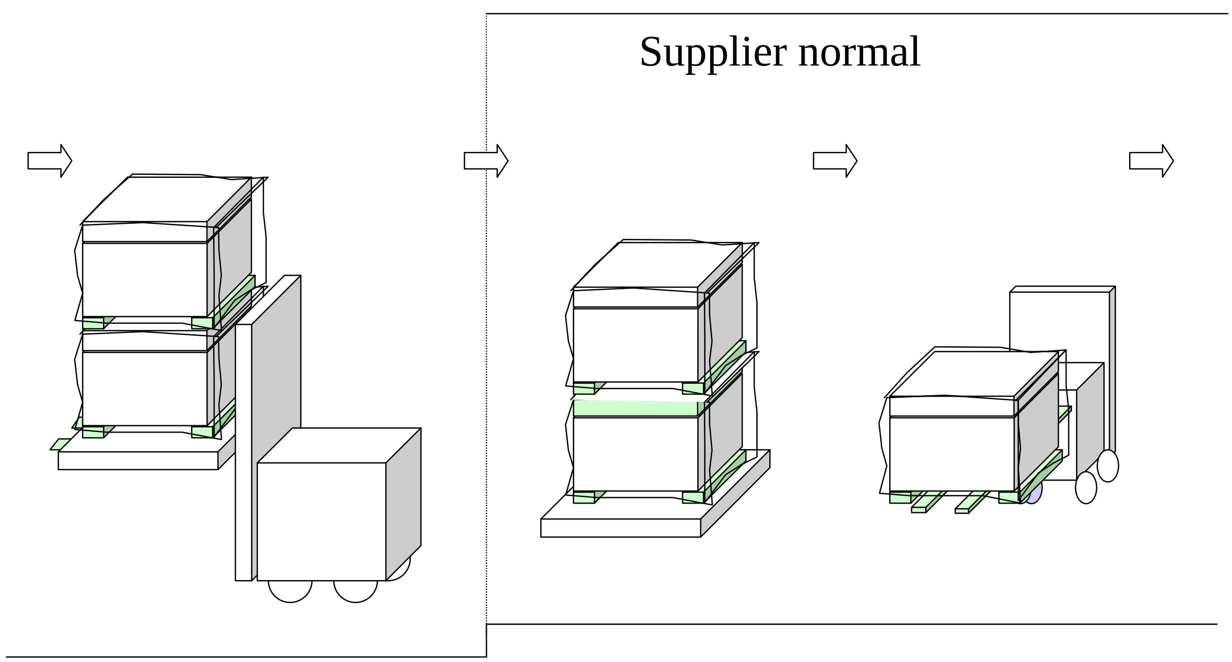


Figure A1-16
Vacant Box, Supplier Normal Room

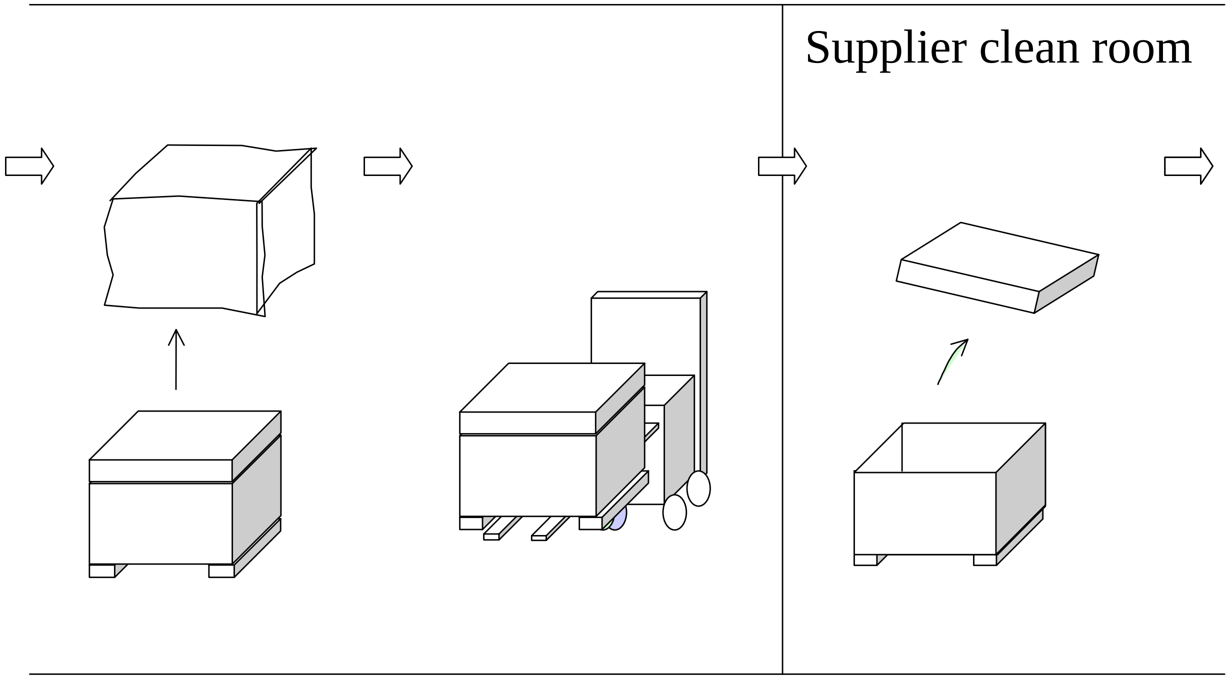


Figure A1-17
Vacant Box, Supplier Clean Room

APPENDIX 2

NOTE: The material in this appendix is an official part of SEMI D25 and was approved by full letter ballot procedures on April 21, 2000 by the Japanese Regional Standards Committee.

A2-1 40 Foot Container Size

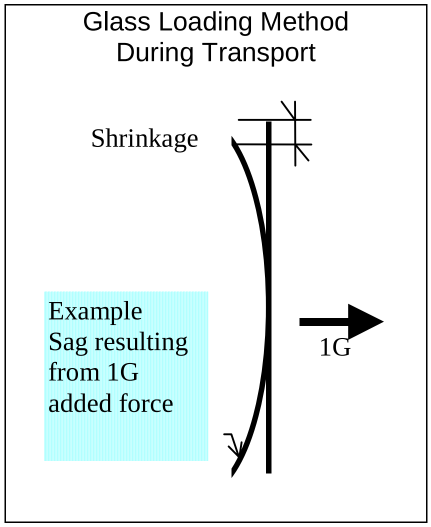
Reference: ISO 668, Series 1 Freight Container – Classification, Dimensions and Ratings

W=2350   L=12060   H=2390 (Unit = mm)

APPENDIX 3

NOTE: The material in this appendix is an official part of SEMI D25 and was approved by full letter ballot procedures on April 21, 2000 by the Japanese Regional Standards Committee.

A3-1 Sag Caused by Acceleration



Unit = mm

Substrate Size	*G Value*	*Support Method*	*Span*	*Sag*	*Curved Shrinkage*	*Substrate Dimensions*		*Memo*
						Long Edge	*Short Edge*	
800 × 950 × 0.7	**1**	**4**	**--**	**20**	**1.4**	**950**	**800**	Sag is for substrates
		2	800	52	9.0	950	800	supported in
			950	103	30.2	950	800	horizontal.

NOTE: Calculated by Asahi Glass Company

SEMI D26-1000
PROVISIONAL SPECIFICATION FOR LARGE AREA MASKS FOR FLAT PANEL DISPLAYS (NORTH AMERICA)

This specification was technically approved by the Global Flat Panel Display Committee and is the direct responsibility of the North American Flat Panel Display Committee. Current edition approved by the North American Regional Standards Committee on July 14, 2000. Initially available on SEMI OnLine August 2000; to be published October 2000.

1 Purpose

1.1 This specification establishes a set of standards to assist in specifying and ordering large area masks for the Flat Panel Display industry. A major objective is to improve the cycle time, order process efficiency and reduce the overall cost of manufacturing for both the mask maker and the customer.

1.2 This specification is intended for use in North America as an emerging market. However, the applicability of this specification is not restricted or limited to this region alone. This standard was developed to address a North American need for a common set of requirements for specifying, manufacturing, and ordering large area masks.

2 Scope

2.1 The following areas are covered by this document:

2.1.1 Registration and Accuracy

2.1.2 Critical Dimensions

2.1.3 Centrality

2.1.4 Pellicles

2.1.5 Edge Length and Thickness

2.1.6 Symbology

2.1.7 Data Formats

2.1.8 Auto Inspection Artifacts

2.1.9 Product Labeling

2.2 This specification is being issued so that the industry may evaluate the concept covered before its adoption as a full standard. It is expected that initial application will occur mostly in North America, however, nothing in this standard limits its use to this market region.

2.3 This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the user of these standards to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3 Limitations

3.1 The document does not seek to be comprehensive. Instead, the areas listed are meant to help move the current industry towards an agreed upon set of standards that are useful in reducing the overall cost of supplying masks for use by FPD manufacturers. The document only describes 1X full field masks up to 620 × 720 mm for all display types except for Plasma, TN and STN LCD technologies.

4 Referenced Standards

NOTE: As listed or revised, all documents cited shall be the latest publications of adopted standards.

4.1 *SEMI Standards*

SEMI D6 — Specification for Edge Length and Thickness for Flat Panel Display Mask Substrates

SEMI P1 — Specification for Hard Surface Photomask Substrates

SEMI P5 — Specification for Pellicles

SEMI P6 — Specification for Registration Marks for Photomasks

SEMI T8 — Specification for Marking of Glass Flat Panel Display Substrates with a Two-Dimensional Matrix Code Symbol

4.2 *AIM International Technical Specifications*[1]

AIM International Symbology Specification – Data Matrix

5 Terminology

Each section of the document defines the terms used in that section, with the exception of:

5.1 *alignment bar, of a data matrix symbol* — A solid line of contiguous filled cells abutting a line of alternatively filled and empty cells (AIM International Symbology Specification Data Matrix)

1 AIM International Inc., 11860 Sunrise Valley Drive, Suite 100, Reston, VA 20191, tel y703.391.7621, fax 703.391.7624

5.2 *border column* — The outermost column of a data matrix code symbol. This column is a portion of the finder pattern.

5.3 *border row* — The outermost row of a data matrix code symbol. This row is a portion of the finder pattern.

5.4 *cell, of a data matrix code symbol* — The area within which a dot may be placed to indicate a binary value.

6 Ordering Information

6.1 Purchase orders for substrates furnished to this specification shall include the following items:

Checklist:

6.2 Edge length

6.3 Long reference edge

6.4 Short reference edge

6.5 Orientation corner dimensions

6.6 Quality edge area exclusion

6.7 Thickness

6.8 Tolerance for all specified dimensions

6.9 Warp

6.10 Marking

6.10.1 Marking message characters

6.10.1.1 Quantity (46 to *mm*, where mm = 72)

6.10.1.2 Content of message characters related to Customer Specification Number, and message characters 47 and up, if present.

6.10.1.3 Location of mark, if different from Section 9.5.5

7 Requirements

7.1 *Materials Specification* — Substrate material shall be specified as high thermal expansion (HTE), medium thermal expansion (MTE), low thermal expansion (LTE), or ultra low thermal expansion (ULTE). Examples of HTE materials are soda lime glasses; examples of ULTE materials are synthetic quartz glasses. Substrate materials shall conform to thermal expansion and optical transmittance characteristics specified in SEMI P1. Selected physical properties of HTE, MTE, LTE, and ULTE materials are provided for information in SEMI P1.

7.2 *Overlay* — Overlay refers to alignment of the printed pattern of one mask to another of the same set. Overlay error shall not exceed ± 6.0 µm for soda lime plates and ± 2.0 µm for quartz plates when plate temperature is maintained within ± 1°C. Alignment or registration marks per SEMI P6 may be used to facilitate measurements.

7.3 *Positional Accuracy* — Relation between actual and desired locations of a printed feature on a glass substrate. This is a tolerance to be agreed upon by the end user and mask designer. The following guidelines should be used, with measurements being taken in a temperature and humidity controlled environment:

- ± 0.0157 µm/mm/ °C for soda lime masks
- ± 0.00394 µm/mm/ °C for quartz masks

Dimensioning from a central reference point shall be used.

7.4 *Critical Dimensions (CD)* — The gauging or measurement process is fundamental to manufacturing of masks. The purpose of this section is to define standard CD patterns to provide consistent evaluation and testing of micropatterning equipment, metrology instruments and processes used in large area mask photomask manufacturing.

7.4.1 Figures 1 and 2 are intended to illustrate the proper layout of each pattern cell and to define appropriate design elements used within each basic cell. The user will determine all appropriate dimensions for the feature as they apply to specific processing/ equipment situations.

7.4.2 *L-bar cell (see Figure 1)* — The L-bar cell is designed to be a measurement site for isolated features as well as line and space groups in orthogonal axes. The basic cell consists of one or more groups of nested L-shaped lines at a specific pitch. The pitch is defined as twice the nominal feature width. The center L-bar of each group shall extend beyond the ends of the other L-bars by at least 10µm. This implies that the number of bars is odd.

7.4.3 *Contact array cell (see Figure 2)* — The contact array cell is designed to provide resolution and proximity effect information over a wide range of contact sizes. The design elements will consist of a 5 × 5 contact array and an isolated contact. The 5 × 5 array will produce the maximal proximity for the center contact.

7.4.4 A label to indicate the nominal feature width must be placed near each basic cell. The labels must be of a clearly printable size. The details of the pattern cells, such as the orientation, magnitude, range of line widths and polarity of tone (clearfield vs. darkfield) shall be defined by the user.

7.4.4.1 The target CD should closely represent the size of the most critical feature in the end user's process, not necessarily the minimum feature. A reasonable tolerance is ± 10% of the target CD.

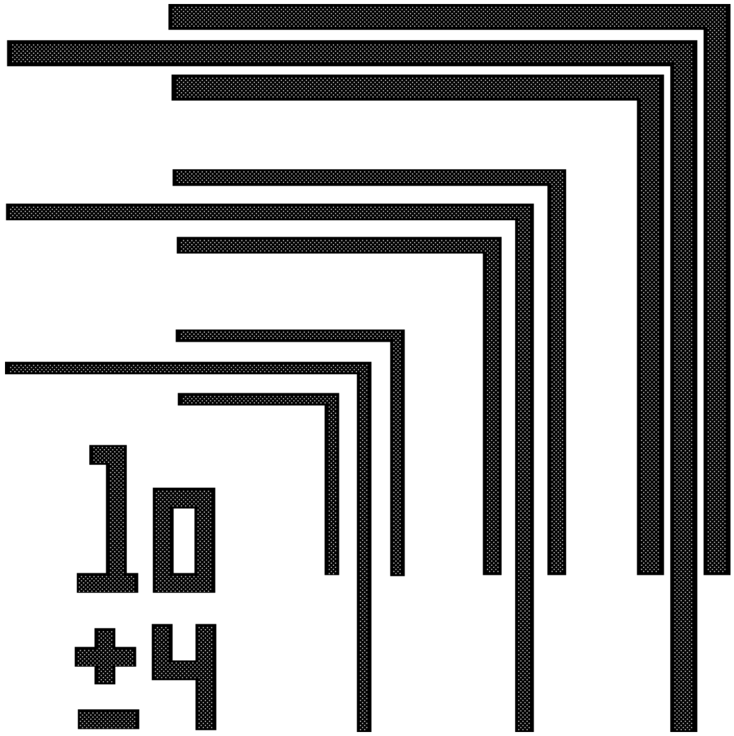


Figure 1
L-Bar Cell

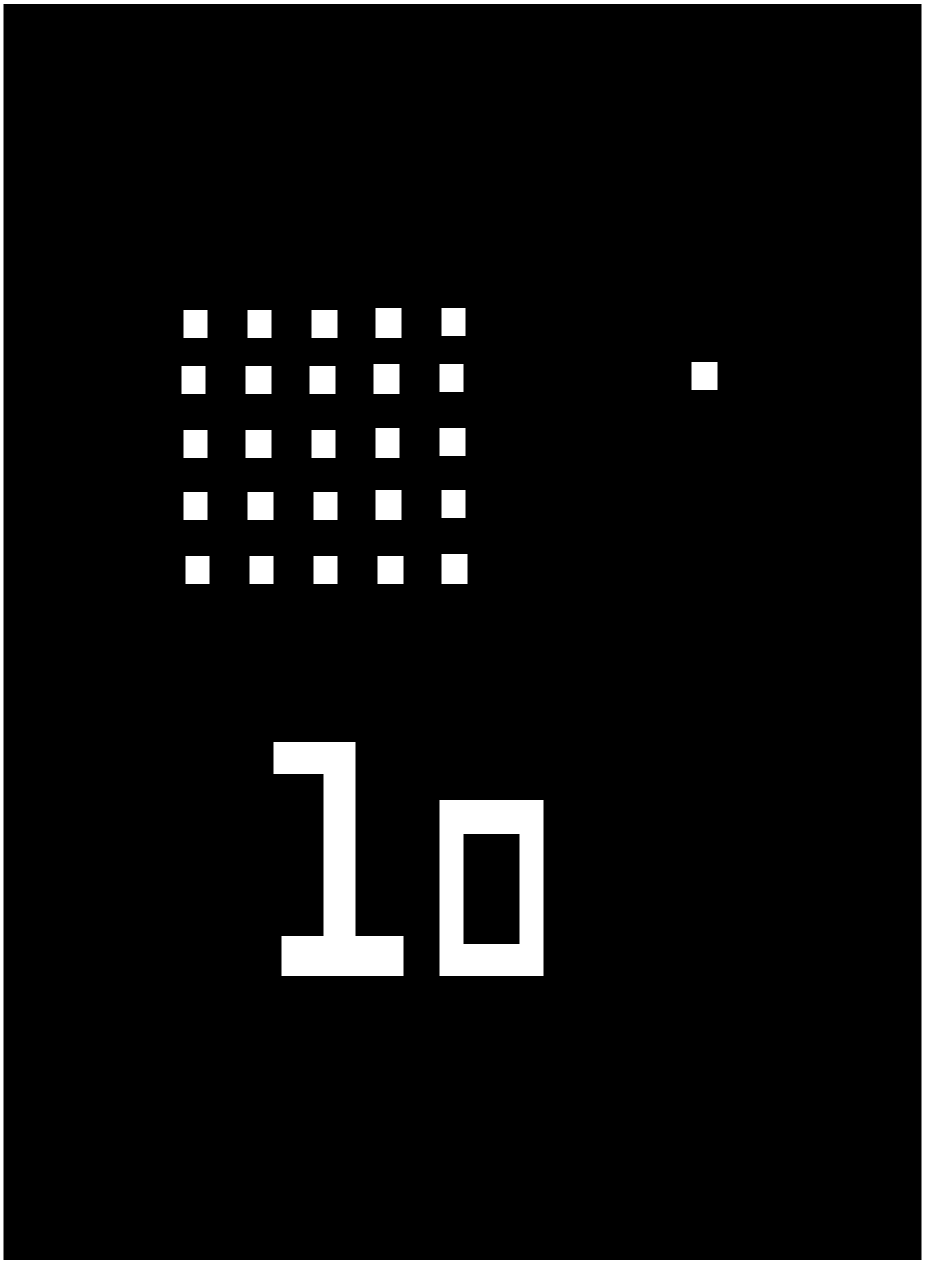


Figure 2
Contact Array Cell

7.5 *Centrality* — This section defines the placement of a patterned photo image onto a Mask Substrate relative to known reference points. It is defined as the physical (datum) position of a specific point on a photo pattern relative to a separate point on the substrate designated to be the photomask center.

7.5.1 *Requirements* — Pattern Placement Tolerance ± 400µm in x and y relative to coordinates on the photomask designated as center when referenced to the 0.000, 0.000 datum (see Figure 3).

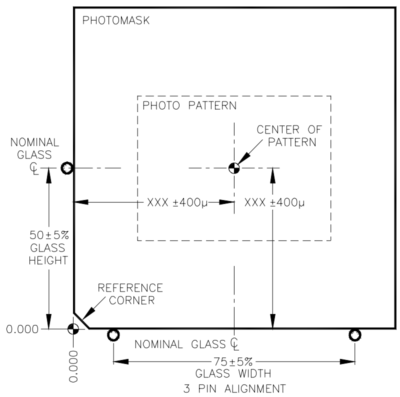


Figure 3
Pattern Placement Tolerance

7.5.2 *Reference 0.000, 0.000* — A datum identified as a point on the extension of a line drawn between the mask contact points on the bottom 2 pins, which is directly below the mask contact point on the third pin (see Figure 4).

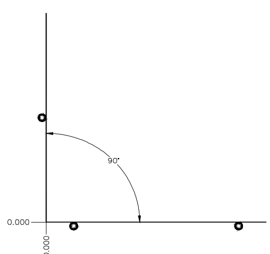


Figure 4
Reference Datum

7.6 *Pellicles (see SEMI P5)*

7.6.1 For Polychromatic exposure systems: Shape, Size, and Standoff of Pellicle

7.6.1.1 *Shape* — This is determined by agreement between the user and supplier.

7.6.1.2 *Size* — This is determined by agreement between the user and supplier, but expression of tolerance is as follows:

7.6.1.3 Outer diameter tolerance — + 0, -x

7.6.1.4 Inner diameter tolerance — + x, -0

7.6.1.5 *Standoff* — This is determined by agreement between the user and supplier. But expression of tolerance is as follows:

7.6.1.6 *Tolerance* — + 0, -x

Film Characteristics Polymer Films — Type - AR-coated or non AR-coated (see Table 1)

7.6.1.7 *Exposure Range* — 360 nm - 440 nm.

7.6.1.8 *Optical Transmission Rate* — There are the following two types depending on optical transmission rate at an incident angle of 90° from surface of pellicle.

Table 1 Film Characteristics Polymer Films

Type	*Average*	*Minimum*
AR-Coated	≥ 94%	88%
Non-AR-Coated	≥ 91%	82%

7.6.1.9 *Thickness* — This is determined by agreement between the user and supplier.

7.6.1.10 *Thickness Conformity* — This is determined by agreement between the user and supplier.

7.6.1.11 *Thickness Uniformity* — This is determined by agreement between the user and supplier.

7.6.1.12 *Film Thickness* — This is determined by agreement between the user and supplier

7.6.1.13 *Mechanical Strength* — The requirements for air blow are determined within ranges shown below:

- The air blow gun should be used; air pressure: ≤ 2.1 kgf/cm^2 (at input of the air blow gun);
- Nozzle diameter of the air blow gun: ≤ 2 mm. Distance between the nozzle tip and the film: ≥ 25 mm

7.6.2 *Defect Limits* — Maximum defect limits based on the pellicle standoff and the numerical aperture of the given type of exposure system are given in Table 1. Any departure from these defect limits shall be agreed to between supplier and user. Maximum defect limits are given in Table 2.

7.6.2.1 *Adhesives*

7.6.2.1.1 *Film Adhesive* — Film must be sealed on the entire top of the frame, with a minimum of 50% of the frame width at any location.

7.6.2.1.2 *Frame Adhesive* — Frame adhesive must be continuous and allow no gaps between pellicle frame and adhesive and between adhesive and photomask after attachment. No part of the frame adhesive may extend beyond the frame wall, and its edges must be free of visually detectable stringers (and particles). Adhesive should form a complete seal between the frame and the mask over a minimum of 40% of the width of the frame.

7.6.2.2 *Frame* — Pellicle frame must have no visually detectable machining burrs, discontinuities in anodization, or particles.

7.6.2.3 *Light Resistance* — This is expressed by total exposure energy value (mJ/cm^2 or J/cm^2) on pellicle film resulting in a 1% loss of transmission at any wavelength in the range 360 nm–440 nm. Also the test conditions (special characteristics of exposure wave-length, exposure energy between 360 nm–440 nm, exposure conditions, and others) must be clearly stated.

Table 2 Maximum Defect Limits

Characteristics	*Max. # Allowable*	*Size counted for Max. # Allowable*
Non-removable		
Particles	None	$\geq$ 50 µm
Pinholes	None	> limit of detection
Scratches	None	Width $\geq$ 50 µm
Dirt	None	> limit of detection

7.6.3 *Pellicles for g, h and i Exposure Systems* — This specification includes the characteristics of pellicles for use in "g" (436 nm), "h" (405 nm), and "i" (365 nm) line exposure systems.

7.6.3.1 *Shape, Size, and Standoff of Pellicle*

7.6.3.1.1 *Shape* — This is determined by agreement between the user and supplier.

7.6.3.1.2 *Size* — This is determined by agreement between the user and supplier, but expression of tolerance is as follows:

- Outer diameter tolerance: +0, -x
- Inner diameter tolerance: +x, -0

7.6.3.1.3 *Standoff* — 6.3 mm and 4.0 mm should be standard.

7.6.3.1.3.1 Tolerance — + 0, -x

7.6.3.2 *Film Characteristics Polymer Films* — Type: AR-coated or non AR-coated.

7.6.3.3 *Exposure Wavelength* — "g", "h", and/or "i" lines.

7.6.3.4 *Optical Transmission Rate* — There are the following two types depending on optical transmission rate at incident angle of 90° from surface of pellicle at the specified wavelength(s).

Table 3 Film Characteristics Polymer Films

Type	*Minimum*
AR Coated	99 %
Non AR Coated	98 %

7.6.3.5 *Thickness* — This is determined by agreement between the user and supplier.

7.6.3.6 *Thickness Conformity* — This is determined by agreement between the user and supplier.

7.6.3.7 *Thickness Uniformity* — This is determined by agreement between the user and supplier.

7.6.3.8 *Film Thickness* — This is determined by agreement between the user and supplier.

7.6.3.9 *Mechanical Strength* — The requirements for air blow are determined within ranges shown below:

7.6.3.9.1 The air blow gun should be used. Air pressure: ≤ 2.1 kgf/cm^2 (at input of the air blow gun). Nozzle diameter of the air blow gun: ≤ 2 mm.

7.6.3.9.2 Distance between the nozzle tip and the film: ≥ 25 mm.

7.6.3.10 *Defect Limits* — Maximum defect limits based on the pellicle standoff and the numerical aperture of the given type of exposure system are given in Table 4. Any departure from these defect limits shall be agreed to between the user and supplier.

7.6.3.11 *Frame* — Pellicle frame must have no visually detectable machining burrs, discontinuities in anodization, or particles.

7.6.3.12 *Light Resistance* — This is expressed by total exposure energy value (mJ/cm^2 or J/cm^2) of specified wavelength on pellicle film resulting in a 0.5% loss of transmission at any wavelength in the range 360–440 nm. Also, the test conditions (half bandwidth of exposure specified wavelength, energy of exposure specified wavelength, exposure conditions, and others) must be clearly specified.

Table 4 Maximum Defect Limits

Characteristics	*Max. No. Allowable*	*Size Counted for Max. No. Allowable*
Non-removable		
Particles	None	> 20 µm
Pinholes	None	> limit of detection
Scratches	None	Width > 20 µm
Dirt	None	> limit of detection

7.7 *Edge Length and Thickness* — These dimensions apply to photomasks that are principally used in fabricating flat panel display. The edge lengths specified range from 202.8 mm × 202.8 mm to 620 mm × 720 mm. Substrates with an edge length less than 200 mm follow the specification for a semiconductor mask (see SEMI P1and SEMI D6).

7.7.1 *Edge Length and Tolerance* — Units are in mm. See Table A1 and A2 and Table B1 and B2 and Table C1 and C2 for a combination of materials, edge length, and thickness.

7.7.1.1 *Edge Length Tolerance* — + 0.4 mm. Applies to all groups.

7.7.2 *Thickness Center Point* — Thickness of substrates at center point shall be specified by the edge length group and materials as shown in Tables A2, B2 and C2.

7.7.2.1 *Tolerance* — ≤ 5 mm ± 0.2 mm, 8 mm + 0.2 mm, - 0.4 mm.

Table A-1 Edge Length (mm) (Group A)

202.8 × 202.8				
200 × 250	250 × 250			
	250 × 300	300 × 300		
		300 × 350	350 × 350	
			350 × 400	400 × 400

Table B-1 Plate Thickness and Materials (Group A)

MATERIAL			
HTE	*MTE/LTE*	*ULTE*	*Thickness (mm)*
+	+	+	3.0
+			4.8
	+	+	5.0

Table A-2 Edge Length (mm) (Group B)

330 × 450			
	400 × 500		
		450 ×550	
			500 × 600

Table B-2 Plate Thickness and Materials (Group B)

MATERIAL			
HTE	*MTE/LTE*	*ULTE*	*Thickness (mm)*
+			4.8
+	+	+	5.0

Table C-1 Edge Length (Group C)

620 × 720 mm
650 × 750 mm
650 × 800 mm
700 × 800 mm

Table C-2 Plate Thickness and Materials (Group C)

MATERIAL	
ULTE	*Thickness (mm)*
+	5.0
+	8.0

7.7.2.2 The active area is defined as area within the plate that is within 20 mm from the edge of the plate (See Figure 5).

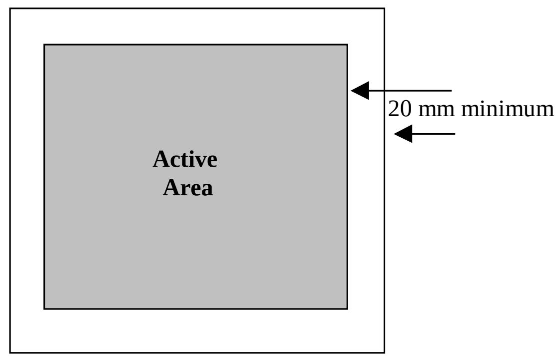


Figure 5
Defined Active Area

7.8 *Data Formats*

7.8.1 *Data Transfer Standards* — CAD data for mask generation can be designed with and delivered to the vendor in several different standardized data transfer formats. Among these are DXF, Gerber and its variants (274-D, 274-X, F9XXX, and BARCO DPF), GDSII, EDIF, IGES, and IPC-D-350.

7.8.2 *Non-Recommended Practices* — The following is a summary of some design practices and CAD entities that *should be avoided* when using DXF and Gerber data formats, since their use can have at best unintended results.

7.8.2.1 *DXF*

- Commands regarding 3D CAD.
- Parameters which control the view only, such as 3DFACE, VIEWPORT, STYLE, VIEW, DIMSTYLE, UCS, APPID, ATTRIB, ATTDEF, and POINT
- HATCH

- Outlines constructed with ARC and LINE that do not match exactly at the corners
- Duplicated entities
- Self-intersecting poly-lines
- VERTEX flags options
- TAPERED POLYLINE entities (different start and end width), straight or arced
- SHAPE entities
- ELLIPSE entities
- "Stretched” BLOCK entities – blocks with different X- and Y-scale factor
- Rotated BLOCK entities
- POINT entities
- Any of the "Curve-fitted" POLYLINE entities, such as "SPLINE" shapes
- “Paint & Scratch” LAYER entities without a specific identification of which layers should be opaque and which should be clear, and in which order.
- TEXT entities without the appropriate font files.
- TEXT entities with special attributes (mirror, rotate, slant, etc.).
- XREF BLOCK entities.
- Non-decimal linear and angular coordinates.
- Radian angular units.

7.8.2.2 *Gerber*

- Self-intersecting entities (line draws, outlines, “butterfly targets”, etc.).
- Arrayed arrays (nested).
- Drawn apertures using shapes other than round (square apertures may be used only if drawn parallel to either axis).

7.8.3 *Recommended Practices* — The following is a summary of some recommended design practices DXF and Gerber data formats.

7.8.3.1 *DXF*

- SOLID entities
- TRACE entities
- CIRCLE entities
- BLOCKS, with a minimum level of nesting as required by the design
- Closed, zero width POLYLINE or LWPOLYLINE entities to describe complex CAD feature outlines
- TEXT objects that are exploded and exported as POLYLINE entities, either as closed zero width, or POLYLINE entities with width
- Decimal units for inches, mils, millimeters, microns, or degrees.

7.8.4 *Gerber*

- Subfigure or SR codes.
- POEX/POIN or G36/G37 codes.
- Complex apertures and aperture macros.
- Embedded apertures and parameters.

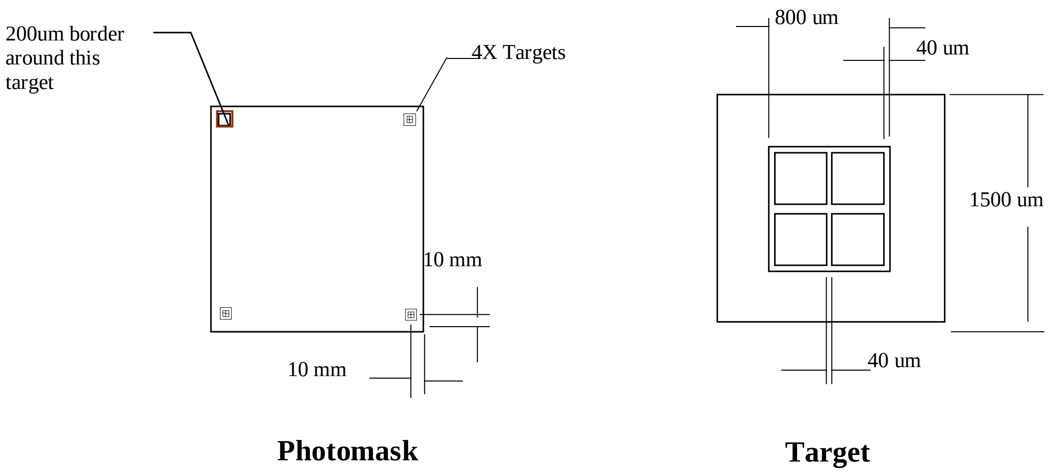


Figure 6
Location and Pattern

7.8.5 *Design Rules* — A comprehensive and well-presented set of design rules is an invaluable communication tool between the customer and supplier. For the manufacture of large area precision glass and quartz substrate photomasks having geometry's in the low to sub-micron range, design rules are an essential component of any successful program designed to minimize the risks of introducing errors and delays into the process.

7.8.5.1 The best match occurs when there is a commonality between the customer's design capabilities and vendor's requirements.

7.8.5.2 Design rule documents are usually unique to each Large Area Mask supplier, and the details depend mainly upon the vendor's software repertoire and their ability to process certain types of data.

7.8.5.3 The type of Computer Aided Design software package used by the customer to design their product must be capable of either exporting data in a format that the vendor can readily use, or the vendor must be capable of using data in the native format of the customer's design package.

8 Test Methods

8.1 *Auto Inspection Artifacts* — To perform any automated inspection of a photomask, the inspection equipment and photomask pattern must be precisely located. This is done with four alignment targets on the photomask. The alignment targets are part of the photomask pattern and are located near each corner of the photomask. The target in the upper left corner will also have a 200 micron border around it with a 10 micron space between the target and the border. When appropriate, this additional border will also be used as a closure test by exposing the targets first and then the border at the end of the plate exposure.

8.1.1 4 Alignment targets provide optimum alignment accuracy.

8.1.2 Greater distance between the targets provides greater alignment accuracy.

8.1.3 The target locations near the edge of the glass provide the maximum product image area.

8.1.4 The target pattern can be easily located visually on the photomask.

8.1.5 The target can be clear on dark or dark on clear.

9 Product Labeling

9.1 *General* — Large Area Masks used in FPD manufacturing are valuable, fragile and prone to contamination prior to use. The content of a LAM is difficult to discern unless each unit contains a unique ID that can be read by various tools. To simplify AMHS and process/metrology tool operations, this ID needs to be consistently readable on the bare mask, with and without resist coating; ideally it would be readable through the plastic container in which the mask is shipped. See Figures 7–10.

9.2 *Summary* — The labeling specified herein consists of a rectangular two-dimensional (2-D), machine-readable, binary Data Matrix symbology located on the pattern surface of LAMs, within the edge region and near the orientation corner. The specification defines a 46-character default message that is included in all mark fields, and option for up to 26 additional characters, for a total of 72 message characters (see SEMI T8).

9.3 *Field Construction* — While this specification does not specify the marking techniques that may be employed when complying with its requirements, it is assumed the symbol may be obtained through lithographic techniques, for instance during the mask exposure sequence.

9.4 *Shape and Size of the Data Matrix Code Symbol*

9.4.1 *Data Matrix Code Symbol Dimensions*

9.4.1.1 Each rectangular matrix code symbol shall be composed of an array of 16 rows and 36 or 48 columns as defined in AIM International Symbology Specification – Data Matrix. It may contain an alignment bar.

9.4.1.2 Cell spacing shall be 25 μm, center to center.

9.4.1.3 Matrix code symbol nominal dimensions are:

a. 4 × 9 mm, for a 16 row × 36 column field, or
b. 4 × 12 mm, for a 16 row × 48 column field.

9.4.2 *Dot Size* — The nominal shape of the dot produced in the matrix may be circular or square. Its diameter or edge length shall be 250 ± 10 μm.

9.4.3 *Border Rows and Columns (see Figure 9)*

9.4.3.1 One border row and one border column shall contain a dot in each cell. There are identified as the primary border row and the primary border column. These are used by the code reader to determine the orientation of the matrix.

9.4.3.2 The opposing (secondary) border row and column shall contain dots in alternating cells.

9.4.3.3 For these rectangular matrix code symbols, the reference point of the symbol shall be the physical center point of the cell common to the primary border row and the primary border column.