9.4.5.3 The locked sub state of Run and Stand-by may be used in order to force the FPU to maintain the current Run or Stand-by state until the lock is disabled. The reasons causing the lock are out of scope of this standard. In addition to the trigger to unlock, only critical failures can cause the FPU to leave the locked sub state. These critical failures are being defined on a case by case basis by the purchaser and supplier of the FPU and the system integrator.

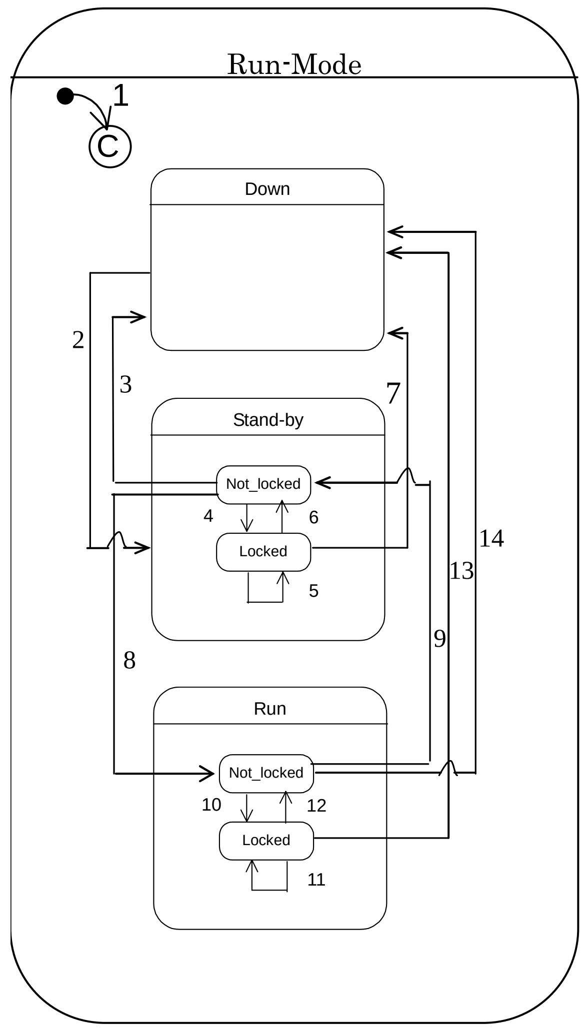


Figure 7
State Transition Diagram Run-Mode

Table 4 State Transition Table Run-Mode

Number	*Previous State*	*Trigger*	*New State*	*Actions*	*Remark*
1	(no state)	Start up of FPU.	Down or Stand by or Run	None.	Dependent on type of FPU; Normally when to Stand-by then to Stand by and not locked, but an automatic function may force FPU to Stand-by and locked; Normally when to Run then to Run and not locked, but an automatic function may force FPU to Run and locked.
2	Down	Trigger to activate the principal availability of the FPU (e.g. operator action or logical function).	Stand-by	FPU activates its stand-by functions including watchdog-toggle.	Normally to Stand-by and not locked, but an automatic function may force FPU to Stand-by and locked.
3	Stand-by and Not_Locked	Failure occurred.	Down	FPU deactivates its stand-by functions.	
4	Stand by and Not_Locked	Trigger to lock Stand by state.	Stand-by and Locked	FPU ignores trigger and any request to change state of Run-mode.	
5	Stand-by and Locked	Trigger to perform a scheduled down or non critical failure.	Stand-by and Locked	FPU ignores trigger and any request to change state of Run-mode.	
6	Stand-by and Locked	Trigger to unlock.	Stand by and Not_Locked	FPU releases pending triggers to change to other states.	
7	Stand-by and Locked	Critical failure occurred.	Down	FPU deactivates its stand by functions.	
8	Stand-by and Not_Locked	Trigger to activate Run (e.g. operator action or logical function).	Run and Not_Locked	FPU activates its running functions.	
9	Run and Not_Locked	Trigger to activate Stand-by (e.g. operator action or logical function).	Stand-by and Not_Locked	FPU deactivates its running functions.	
10	Run and Not_Locked	Trigger to lock Run.	Run and Locked	FPU ignores trigger and any request to change state of Run-mode.	
11	Run and Locked	Trigger to perform a scheduled down or non critical failure.	Run and Locked	FPU ignores trigger and any request to change state of Run-mode.	
12	Run and Locked	Trigger to release locked state of Run.	Run and Not_Locked	FPU releases pending triggers to change to other states.	
13	Run and Locked	Critical failure occurred.	Down	FPU stops its running functions.	
14	Run and Not_Locked	Trigger to perform a scheduled down or a critical failure.	Down	FPU deactivates its running functions.	

9.4.6 *Alarm-Mode*

9.4.6.1 Alarms are being defined on a case by case basis between the purchaser and the supplier of the FMCS and FPUs and the system integrator. Alarm-Mode specifies whether an alarm occurred:

- **No_Alarm**: No alarm present.
- **Alarm**: An alarm is present (at least one part of the FPU is in alarm condition).

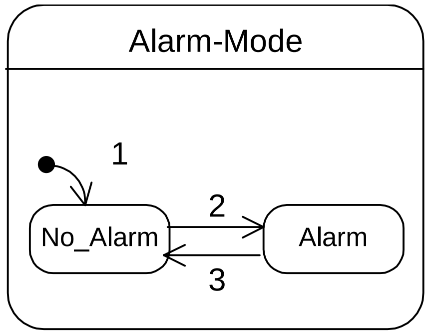


Figure 8
State Transition Diagram Alarm-Mode

Table 5 State Transition Table Alarm-Mode

Number	*Previous State*	*Trigger*	*New State*	*Actions*	*Remark*
1	(no state)	Start up of FPU.	No_Alarm	None.	
2	No_Alarm	Alarm event occurred.	Alarm	FPU may perform alarm routines.	
3	Alarm	Alarm condition disappeared.	No_Alarm	FPU releases alarm routines.	

9.4.7 *Warning-Mode*

9.4.7.1 Warnings are being defined on a case by case basis between the purchaser and supplier of the FMCS and FPUs and the system integrator. Warning-Mode specifies whether a warning occurred:

- **No_Warning**: No warning present
- **Warning**: Warning present.

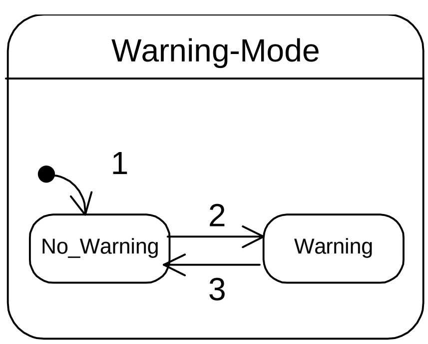


Figure 9
State Transition Diagram Warning-Mode

Table 6 State Transition Table Warning-Mode

Number	*Previous State*	*Trigger*	*New State*	*Actions*	*Remark*
1	(no state)	Start up of FPU.	No_Warning	None.	
2	No_Warning	Warning event occurred.	Warning	FPU may perform warning routines.	
3	Warning	Warning condition disappeared.	No_Warning	FPU releases warning routines.	

9.4.8 *Error-Mode*

9.4.8.1 Errors are being defined on a case by case basis by the purchaser and supplier of the FMCS and FPUs and the system integrator. Error-Mode specifies whether an error occurred:

- **No_Error**: No error present**.**
- **Error**: Error present.

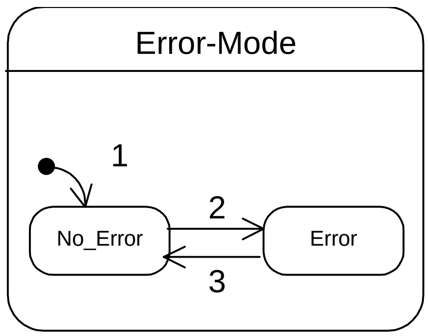


Figure 10
State Transition Diagram Error-Mode

Table 7 State Transition Table Error-Mode

Number	*Previous State*	*Trigger*	*New State*	*Actions*	*Remark*
1	(no state)	Start up of FPU.	No_Error	FPU may release error routines.	
2	No_Error	Error occurred.	Error	FPU may perform error routines.	
3	Error	Error condition disappeared.	No_Error	FPU may release error routines.	

9.4.9 *Maintenance-Mode*

9.4.9.1 Maintenance-Mode specifies whether maintenance is required or no maintenance is required:

- **No_Maintenance**: No maintenance required.
- **Maintenance**: Maintenance is required (at least one part of the FPU requires maintenance at the site of the FPU).

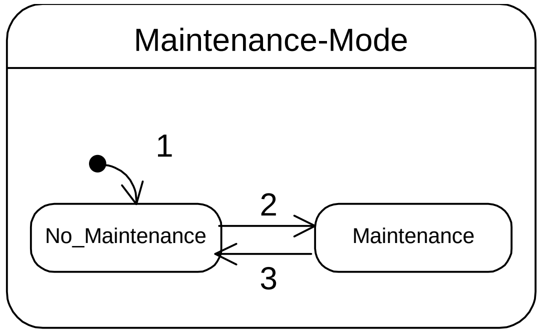


Figure 11
State Transition Diagram Maintenance-Mode

Table 8 State Transition Table Maintenance-Mode

Number	*Previous State*	*Trigger*	*New State*	*Actions*	*Remark*
1	(no state)	Start up of FPU.	No_Maintenance	None.	
2	No_Maintenance	Error or preventive maintenance event occurred.	Maintenance	FPU may request maintenance.	
3	Maintenance	Error condition or preventive maintenance condition disappeared.	No_Maintenance	None.	

9.4.10 *Simulation-Mode*

9.4.10.1 Simulation-Mode specifies whether the FPU or parts of the FPU are simulated:

- **No_Simulation**: FPU operates not in simulation mode (simulation turned off).
- **Simulation**: FPU or parts of the FPU are simulated. FPU functions are performed using simulated I/O signals.

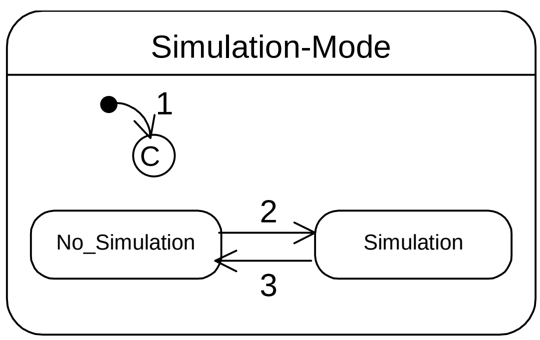


Figure 12
State Transition Diagram Simulation-Mode

Table 9 State Transition Table Simulation-Mode

Number	*Previous State*	*Trigger*	*New State*	*Actions*	*Remark*
1	(no state)	Start up of FPU.	No_Simulation or Simulation	None.	Dependent on local operator action.
2	No_Simulation	Local or remote operator action.	Simulation	FPU simulates parts of FPU or the entire FPU functions.	
3	Simulation	Local or remote operator action.	No_Simulation	FPU disables simulation of parts of the FPU or the entire FPU functions.	

9.5 *Operations Between FMCS and FPUs*

9.5.1 The Table below lists the operations between the FMCS and the FPU.

Table 10 Operation Definition

Operation	*Description*	*Mandatory/Optional*
Get Status	FMCS requests status data from FPU.	mandatory
Set Data	FMCS requests FPU to update data in the FPU.	optional
Get Data	FMCS requests to retrieve data from the FPU.	optional

9.5.2 *Get Status* — Is used by the FMCS to request the status of the FPU.

Table 11 Status Parameters

Parameter	*Description*	*Direction*	*Data Type*
Tag	Local identifier for the FMCS.	FMCS -> FPU	Out of scope.
Status value	Status field values of the FPU.	FPU -> FMCS	See Table 12 for details.

Table 12 Status Field Values

Field	*Bit*	*Meaning*	*Mandatory/optional*
Watchdog-Toggle	0	0/1	mandatory
OP-Mode	1	0: Manual 1: Automatic	mandatory
Control-Mode	2	0: Local (default, when not supported) 1: Remote (FMCS)	optional
Run-Mode	3-4	0: Down (unscheduled) 1: Down (scheduled) 2: Stand by 3: Run	mandatory
Alarm-Mode	5	0: No_Alarm (default, when not supported) 1: Alarm	optional
Warning-Mode	6	0: No_Warning (default, when not supported) 1: Warning	optional
Error-Mode	7	0: No_Error 1: Error	mandatory
Maintenance-Mode	8	0: No_Maintenance (default, when not supported) 1: Maintenance	optional
Simulation-Mode	9	0: No_Simulation (default, when not supported) 1: Simulation	optional
Lock-Mode	10	0: Not_Locked (default, when not supported) 1: Locked	optional
Reserved	11-15	none	optional

9.5.3 *Set Data* — Is used by the FMCS to set data in the FPU. Upon receiving this, the FPU shall update the data with the Set value.

Table 13 Set Data Parameter

Parameter	*Description*	*Direction*	*Data Type*
Tag	Local identifier for the FMCS.	FMCS -> FPU	Out of scope.
Set value	Value of the Set parameter field.	FMCS -> FPU	Must be agreed between suppliers and purchasers. See Related Information 2.

9.5.4 *Get Data* — Is used by the FMCS to get data from the FPU. Upon receiving this from the FPU, the FMCS shall update its data cache.

Table 14 Get Data Parameter

Parameter	*Description*	*Direction*	*Form*
Tag	Local identifier for the FMCS.	FMCS -> FPU	Out of scope.
Get Parameter value	Value of the Get parameter field.	FPU -> FMCS	Must be agreed between suppliers an purchasers. See Related Information 2.

10 Mapping to Various Communication Solutions

10.1 This standard does not make any assumptions about how the mapping to the communications protocols is made.

11 Test Methods and Compliance

11.1 *Overall Precondition* — The precondition for testing the FPU (and the FMCS) is the agreement between supplier and purchaser on a common set of issues which include:

- communication hardware and protocols to be used for the integration between FMCS and FPU,
- data formats and semantics to be transferred between FMCS and FPU,
- FMCS and FPU are initialized, the FPU reflects already a valid run state,
- FMCS shall be able to issue a Get Status, and
- FMCS shall be able to visualize the results of the tests.

11.1.1 See ordering information (§7) and Related Information 2 (§R2).

11.2 *Tests*

11.2.1 *Get Status Test*

11.2.1.1 *Preconditions:*

- FMCS and FPU are connected.
- FMCS is ready to issue a Get Status.

11.2.1.2 *Test Operations:*

- Operation 1: The FMCS shall issue a Get Status against the FPU.
- Operation 2: The FMCS shall issue a Get Status against the FPU. The FPU shall alternate the Watchdog-Toggle.
- Operation 3..n: The status of all status variables at the FPU is forced at least to change once; after each status change a new Get Status request shall be issued against the FPU.

11.2.1.3 *Post Conditions:*

- Post condition 1: The FPU shall respond with all requested parameters in the Status Response. The result shall be visualized by the FMCS and show the returned values of all supported status variables.
- Post condition 2: The FMCS shall visualize that the FPU is still alive or not alternating the Watchdog-Toggle within the specified time window.
- Post condition 3..n: The FPU shall respond with the changed status variable values. In each case the result of all supported status variables shall be visualized by the FMCS.

11.2.1.4 All status values of the Run-Mode shall be used at the FPU to show that state changes are correctly maintained and transmitted to the FMCS.

11.2.2 *Set Data Test* (if supported by FPU)

11.2.2.1 *Preconditions:*

- FMCS and FPU are connected.
- FMCS is ready to issue a Set Data.
- FMCS shall be able to enter the data to be transmitted by Set Data.

11.2.2.2 *Test Operations:*

- Operation 1..n: The FMCS shall issue a Set Data against the FPU.

11.2.2.3 *Post Conditions:*

- Post condition 1..n: The FPU shall reflect the new value of the variable set by the Set Data.

11.2.2.4 It is recommended that all parameters supported by Set Data are tested.

11.2.3 *Get Data Test* (if supported by FPU)

11.2.3.1 *Preconditions:*

- FMCS and FPU are connected.
- FMCS is ready to issue a Get Data.

11.2.3.2 *Test Operations:*

- Operation 1..n: A test person shall set the variable at the FPU to a particular value. The FMCS shall issue a Get Data against the FPU.

11.2.3.3 *Post Conditions:*

- Post condition 1..n: The FMCS shall visualize the new value of the variable.

11.2.3.4 It is recommended that all parameters supported by Get Data are tested.

11.3 *Compliance*

11.3.1 Table 15 provides a checklist for compliance with this standard.

Table 15 Compliance Checklist

	Section	*Implemented*	*Compliant*
Fundamental Requirements			
Watchdog-Toggle	9.4.2	☐Yes ☐ No	☐Yes ☐ No
OP-Mode	9.4.3	☐Yes ☐ No	☐Yes ☐ No
Run-Mode	9.4.5	☐Yes ☐ No	☐Yes ☐ No
Error-Mode	9.4.8	☐Yes ☐ No	☐Yes ☐ No
Get Status Operation	9.5.2	☐Yes ☐ No	☐Yes ☐ No
Optional Capabilities			
Control-Mode	9.4.4	☐Yes ☐ No	☐Yes ☐ No
Alarm-Mode	9.4.6	☐Yes ☐ No	☐Yes ☐ No
Warning-Mode	9.4.7	☐Yes ☐ No	☐Yes ☐ No
Maintenance-Mode	9.4.9	☐Yes ☐ No	☐Yes ☐ No
Simulation Mode	9.4.10	☐Yes ☐ No	☐Yes ☐ No
Lock-Mode	9.4.5.2	☐Yes ☐ No	☐Yes ☐ No
Set Data Operation	9.5.3	☐Yes ☐ No	☐Yes ☐ No
Get Data Operation	9.5.4	☐Yes ☐ No	☐Yes ☐ No

RELATED INFORMATION 1
APPLICATION EXAMPLES

NOTICE: This related information is not an official part of SEMI F97 and was derived from work of the originating task force. This related information was approved for publication by full letter ballot on November 10, 2004.

R1-1 Application Examples

R1-1.1 In order to help with understanding of FPU states specified in this standard, this Related Information provides examples of their use. Examples of simple and more complex FPUs are given. The status of the FPU retrieved by the FMCS is depicted in a table. In addition, a picture is given that might visualize the FPU status by the FMCS.

R1-2 Simple FPU – Pump

Table R1-1 Status Response of a Pump in Operation

Status Field Name	*Meaning*	*Value*
Watchdog-Toggle	Toggle value (not supported)	0
OP-Mode	Automatic	1
Control-Mode	Local	0
Run-Mode	Run	3
Alarm-Mode	No_Alarm	0
Warning-Mode	No_Warning	0
Error-Mode	No_Error	0
Maintenance-Mode	No_Maintenance	0
Simulation-Mode	No_Simulation	0
Lock-Mode	Not_Locked	0

FMCS- Visualization

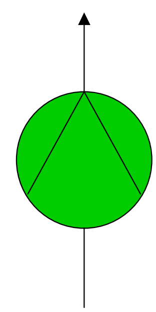
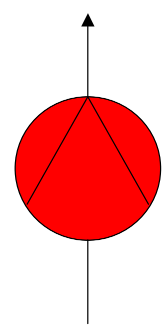


Table R1-2 Status Response of a Pump That is Not Operating Because of an Alarm, e.g. Motor-Overheat

Status Field Name	*Meaning*	*Value*
Watchdog-Toggle	Toggle value (not supported)	0
OP-Mode	Automatic	1
Control-Mode	Local	0
Run-Mode	Down (unscheduled)	0
Alarm-Mode	Alarm	1
Warning-Mode	No_Warning	0
Error-Mode	No_Error	0
Maintenance-Mode	No_Maintenance	0
Simulation-Mode	No_Simulation	0
Lock	Not_Locked	0

FMCS- Visualization



R1-2 Complex FPU – Makeup Air Unit (MAU)

Table R1-3 Status Response of a MAU in Run, Locked and Automatic Mode

Status Field Name	*Meaning*	*Bit-value*
Watchdog-Toggle	Toggle value	0/1
OP-Mode	Automatic	1
Control-Mode	Remote	1
Run-Mode	Run	3
Alarm-Mode	Alarm	0
Warning-Mode	No_Warning	0
Error-Mode	No_Error	0
Maintenance-Mode	No_Maintenance	0
Simulation-Mode	No_Simulation	0
Lock	Locked	1

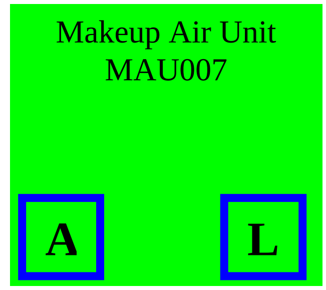
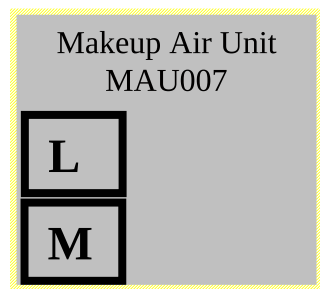


Table R1-4 Status Response of a MAU in Maintenance Mode

Status Field Name	*Meaning*	*Bit-value*
Watchdog-Toggle	Toggle value	0/1
OP-Mode	Automatic	1
Control-Mode	Local	0
Run-Mode	Stand-by	2
Alarm-Mode	Alarm	0
Warning-Mode	No_Warning	0
Error-Mode	No_Error	0
Maintenance-Mode	Maintenance	1
Simulation-Mode	No_Simulation	0
Lock	Not_Locked	0



RELATED INFORMATION 2
CHECKLIST FOR SUPPLIERS AND PURCHASERS

NOTICE: This related information is not an official part of SEMI F97 and was derived from work of the originating task force. This related information was approved for publication by full letter ballot on November 10, 2004.

R2-1 Checklist of Information Exchanged

R2-1.1 Table R2-1 lists the information that needs to be agreed upon by purchasers, system integrators and suppliers for a particular application within the focus of this standard.

Table R2-1 Template for the Information Exchanged Between FMCS and FPU

Project:	
FPU:	
Supplier FPU:	
FPU Model:	
Supplier FMCS:	
FMCS Model:	
Protocol FPU/FMCS:	

NOTE 1: Table R2-1 is comprised of three sections – General Information, Status Information, and Data Information

General Information

Status Information

Tag:				
Field	*Bit*	*Meaning*	*Issue*	*Comment/Value*
Watchdog-toggle	0	0/1	Supported? Yes / No Frequency?	
OP-Mode	1	0: Manual 1: Automatic	Variable supported? Yes / No Initial state when started? ☐Manual ☐Automatic State-Transitions supported? Yes / No Restrictions to switch between states?	
Control-Mode	2	0: Local 1: Remote	Variable supported? Yes / No Initial state when started? ☐Local ☐Remote State-Transitions supported? Yes / No	
Run-Mode	3-4	0: Down (unscheduled) 1: Down (scheduled) 2: Stand-by 3: Run	Variable supported? Yes / No Initial state when started? ☐Down (unscheduled) ☐Down (scheduled) ☐Stand-by ☐Run State-Transitions supported? Yes / No Restrictions to switch between states?	

Tag:				
Field	*Bit*	*Meaning*	*Issue*	*Comment/Value*
Alarm-Mode	5	0: No_Alarm 1: Alarm	Variable supported? Yes / No State-Transitions supported? Yes / No Type of acknowledgement?	
Warning-Mode	6	0: No_Warning 1: Warning	Variable supported? Yes / No State-Transitions supported? Yes / No	
Error-Mode	7	0: No_Error 1: Error	Variable supported? Yes / No State-Transitions supported? Yes / No	
Maintenance-Mode	8	0: No_Maintenance 1: Maintenance	Variable supported? Yes / No State-Transitions supported? Yes / No	
Simulation-Mode	9	0 : No_Simulation 1 : Simulation	Variable supported? Yes / No State-Transitions supported? Yes / No Initial state when started? ☐No_Simulation ☐Simulation Means provided to switch between states?	
Lock-Mode	10	0: Not_Locked 1: Locked	Variable supported? Yes / No List critical failures which cause FPU to leave locked state:	
Others (Describe)				

Data Information

FPU System Output Data									
Analog Data	*Set Data Possible (yes/no)*	*Tag*	*Data Type*	*Update Cycle Time*	*Value Range*	*Value Step*	*Polarity*	*Alarm Levels*	*Warning Levels*
Discrete Data	*Set Data Possible (yes/no)*	*Tag*	*Data Type*	*Update Cycle Time*	*Meaning*				
FPU Subcontrol Level Data									
Subsystem/Component:									
Analog Data	*Set Data Possible (yes/no)*	*Tag*	*Data Type*	*Update Cycle Time*	*Value Range*	*Value Step*	*Polarity*	*Alarm Levels*	*Warning Levels*
Discrete Data	*Set Data Possible (yes/no)*	*Tag*	*Data Type*	*Update Cycle Time*	*Meaning*				
Subsystem/Component:									
Analog Data	*Set Data Possible (yes/no)*	*Tag*	*Data Type*	*Update Cycle Time*	*Value Range*	*Value Step*	*Polarity*	*Alarm Levels*	*Warning Levels*
Discrete Data	*Set Data Possible (yes/no)*	*Tag*	*Data Type*	*Update Cycle Time*	*Meaning*				

R2-1.2 SEMI E6 recommends data to be supplied in the semiconductor equipment installation documentation including their units of measurement. It is recommended that FPUs and FMCS use the same units of measurement for the data to be exchanged between them.

R2-2 Example

R2-2.1 The tables below give examples of the template tables listed in R2-1.

Table R2-2 Example of the Use of the Tables R2-1 for One Particular FPU

General Information

Project:	Fab XXX, Purchaser Name, Location
FPU:	UPW (Ultra Pure Water)
FPU Model:	YYY-ZZZ
Supplier:	Supplier Name
Protocol FPU/FMCS:	PROFIBUS-DP

Status Information

Tag:	CUB_UPW_STATUS			
Field	*Bit*	*Meaning*	*Issue*	*Comment/Value*
Watchdog-Toggle	0	0/1	Supported? **Yes** / No Frequency?	 **60 seconds**
OP-Mode	1	0: Manual 1: Automatic	Supported? **Yes** / No Initial state when started? ☒**Manual** ☐Automatic Restrictions to switch between states?	 **None**
Control-Mode	2	0: Local 1: Remote	Supported? **Yes** / No Initial state when started? ☒**Local** ☐Remote	
Run-Mode	3-4	0: Down (unscheduled) 1: Down (scheduled) 2: Stand-by 3: Run	Supported? **Yes** / No Initial state when started? ☐Down (unscheduled) ☐Down (scheduled) ☒**Stand-by** ☐Run	
Alarm-Mode	5	0: No_Alarm 1: Alarm	Supported? **Yes** / No Type of acknowledgement?	 **Operator must acknowledge at FPU**
Warning-Mode	6	0: No_Warning 1: Warning	Supported? **Yes** / No	
Error-Mode	7	0: No_Error 1: Error	Supported? **Yes** / No	
Maintenance-Mode	8	0: No_Maintenance 1: Maintenance	Supported? **Yes** / No	

Tag:	CUB_UPW_STATUS			
Field	*Bit*	*Meaning*	*Issue*	*Comment/Value*
Simulation-Mode	9	0 : No_Simulation 1 : Simulation	Supported? **<u>Yes</u>** / No Initial state when started? ☒**No_Simulation** ☐Simulatiom Means to switch between states?	**Manual switch at control panel of FPU**
Lock-Mode	10	0: Not_Locked 1: Locked	Supported? **<u>Yes</u>** / No Critical failures which cause FPU to leave locked state?	**see functional design specification xxxx**
Others (Describe)				

Data Information

FPU System Output Data									
Analog Data	*Set Data Possible (yes/no)*	*Tag*	*Data Type*	*Update Cycle Time*	*Value Range*	*Value Step*	*Polarity*	*Alarm Levels*	*Warning Levels*
Temperature (°C)	Yes	CUB_UPW_ TIC_401	Real 32	2 s	20–100	0.1	Unipolar	Low: 22 High: 40	Low: 25 High: 30
Resistivity (MegaOhm-cm)	No	CUB_UPW_ RES_402	Real 32	2 s	10–100	0.1	Unipolar	Low: 16	Low: 17
Operation time (hours)	No	CUB_UPW_ TIME_403	Real 32	6 min	0–100,000	0.1	Unipolar		
FPU Subcontrol Level Data									
Subsystem/Component:		Reverse Osmosis							
Analog Data	*Set Data Possible (yes/no)*	*Tag*	*Data Type*	*Update Cycle Time*	*Value Range*	*Value Step*	*Polarity*	*Alarm Levels*	*Warning Levels*
Capacity (%)	No	CUB_UPW_ ROS_CAP	Integer 16	5 s	0–100	1	Unipolar	High: 95	High: 90
Discrete Data	*Set Data Possible (yes/no)*	*Tag*	*Data Type*	*Update Cycle Time*	*Meaning*				
Cartridge RO-1 (on/off)	No	CUB_UPW_ RO1_STATUS	Unsigned8	2 s	0: Off 1: On				
Cartridge RO-2 (on/off)	No	CUB_UPW_ RO2_STATUS	Unsigned8	2 s	0: Off 1: On				

Subsystem/Component:		Pumps				
Discrete Data	*Set Data Possible (yes/no)*	*Tag*	*Data Type*	*Update Cycle Time*	*Meaning*	
Pump 1 (on/off)	No	CUB_UPW_ PUMP1_STATUS	Unsigned8	5 s	0: Off 1: On	
Pump 2 (on/off)	No	CUB_UPW_ PUMP2_STATUS	Unsigned8	5 s	0: Off 1: On	

SEMI F98-0305
GUIDE FOR TREATMENT OF REUSE WATER IN SEMICONDUCTOR PROCESSING

This guide was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on December 10, 2004. Initially available at www.semi.org February 2005; to be published March 2005.

1 Purpose

1.1 This guide establishes definitional requirements for industrial water systems that reuse water in a semiconductor manufacturing facility. It is intended to establish a common basis for developing detailed specifications in subsequent documents concerning design, performance, optimization, and monitoring of such systems.

1.2 This document may be used by users and suppliers as a basis for developing site-specific specifications and performance criteria.

2 Scope

2.1 This guide applies to water systems designed for reuse of water including reclaim and recycle, used in semiconductor manufacturing facilities, supplying water to a variety of uses. Such uses include directing waters to the front end of a UPW system, to cooling systems, scrubbers, thermal processes, and to irrigation systems, depending on the quality of the water.

2.2 This guide can be used to understand the design elements and functionality of water systems that support reuse of water. Although such systems can be retrofitted into existing manufacturing factories, there is a broader range of opportunities available in new facilities that can be designed with water saving applications in mind.

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 Limitations

3.1 This guide does not define the actual specifications generally negotiated between the user and the manufacturer of the reclaim or recycle system.

3.2 This guide does not address the methodology for optimizing the reuse of spent rinse waters.

3.3 This guide does not address the frequency or scope of ongoing maintenance for reuse water systems including change-out of resin beds and replacement of filters.

3.4 This guide does not describe the broad range of possible reuse opportunities and the associated water quality required for each.

3.5 This guide does not intend to cover any of the important safety considerations that relate to the proper installation, operation, or maintenance of a reuse water system.

4 Referenced Standards

4.1 *SEMI Standards*

SEMI E49 — Guide for High Purity and Ultrahigh Purity Piping Performance, Subassemblies, and Final Assemblies

SEMI F63 — Guide for Ultrapure Water System Used in Semiconductor Processing

SEMI S2 — Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment

4.2 *Other Standards*

"Strategies for Water Reuse Reduction in Semiconductor Manufacturing", Technology Transfer 97013232A-ENG[1]

2004 International Technology Roadmap for Semiconductors[1]

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

5 Terminology

5.1 *Acronyms and Abbreviations*

5.1.1 *UPW* — Ultrapure Water

5.2 *Definitions*

5.2.1 *spent water* — any discharge water that is consumed or processed and is ready to be discharged to drain.

5.2.2 *UPW reclaim* — the reuse of spent water as feed water for a process different from the one that discharged it, e.g. RO reject fed into cooling towers.

5.2.3 *UPW recycle* — the reuse of spent water as feed water for the same process that discharged it (Point-of-Discharge (POD) recycling), or the plant UPW system.

5.2.4 *UPW reuse* — the secondary use of spent water.

6 Design Components and Elements

6.1 *Collection of Waste Streams* — The most common collection system includes fab-wide gravity collection piping using PVC or PVDF transfer piping and associated pipe racks and tunnels to the collection tanks. Proper venting is also critical to correct operation. The system may also include a reclaim pit, pumps, tanks, and controls. Separate holding tanks are used for each grade of water or type of waste stream so that routing of waste and types of treatment can be matched to specific needs (see Figure 1).

6.1.1 A key consideration for the design of a water reuse system is the ability to separate different grades of water and collect each type of effluent. Typical types of segregation include: segregation of clean rinse water from acid waste; separation of waste streams that contain organics, (e.g. from IPA drying); and isolation of waste streams that require specific treatment such as for hydrofluoric acid, CMP processing, copper solutions, or phosphoric acid.

6.1.2 A recent initiative by semiconductor fabs encourages tool manufacturers to include multiple drain lines within the tool so that waste streams can be easily segregated. Diverter valves can be used to segregate chemicals and are also useful when organics exceed recommended levels. Tool manufacturers can also incorporate plumbing and treatment modules for returning spent water discharged from a tool as feed water for that tool (Point of Discharge [POD] recycling). Purchasing tools with recycle hardware already built-in eliminates the need for users to design and install customized water reuse systems unique to their site.

6.2 *Treatment of Waste Streams* — In addition to choosing the most effective and technically sound design choices, other considerations for treatment choices include easy access to all major components for operations and maintenance, availability of consumables and spare parts, and a high level of automation and reliability. There are several choices related to treatment choices:

6.2.1 TOC (total oxidizable carbon) destruction by UV is commonly used for removal of organics found in reclaim waters and is sometimes combined with ozone or hydrogen peroxide.

6.2.2 Activated Carbon or other adsorbents (e.g. GAC) are used for removal of organics and decomposed hydrogen peroxide, and is a common type of treatment in recycle water systems.

6.2.3 Electrodeionization (EDI) enables ion exchange reactions to be carried out continuously, without off-line regeneration, by introducing a dc electric field across the resin bed. This electric filed is oriented transverse to the direction of water flow through the ion exchange column. Under the influence of the applied electric field, impurity ions, chemically captured by the ion exchange reactions, drift from resin bead to neighboring resin bead and

1 International SEMATECH, 2706 Montopolis Drive, Austin, TX 78741, USA, Website: www.sematech.org

ultimately through a semipermeable membrane that isolates the feed water channel from adjacent circulating water flows (“concentrate channels”) that sweep away the impurities entering through the semipermeable membranes. This continuous regeneration action eliminates the need to take ion exchange columns off-line for resin regeneration and also eliminates the need for storing regeneration chemicals on site.

6.2.4 Reverse Osmosis Membrane Treatment provides extremely high rejection of dissolved ions (charged atoms and molecules), organic (carbon containing) compounds, silica (silicon containing) compounds, and virtually complete rejection of suspended contaminants, but will not reject dissolved gases and volatile organic compounds as well. For reclaim systems, special types of high rejection or low fouling RO membranes may be selected.

6.2.5 Often RO Systems are combined with ion exchange processes either with the purpose of increasing the recovery rate of the RO or by combining the high efficiency of a membrane process with the lower fouling potential of ion exchange resins, e.g. Weakly Acidic Cation Resin (WAC) is designed to remove Ca and Mg ions in the water. The system design should reflect that most of the contaminants of rinse waters are anionic in nature and may foul RO membranes, but recycling water may be mixed with other water qualities and may therefore contain hardness, which can react with the Fluoride of the recycling water.

6.2.6 Biological processes are used to treat water with higher organic contents. They can be either fixed bed systems or fluidized bed systems. These processes typically require both upstream and downstream processes, such as neutralization, and maintaining a stable feed concentration for the biological process upstream and removal of bacteria downstream. The operation of such systems is quite sensitive, but most of the organics used in semiconductor manufacturing can be treated by such systems, including TMAH and chemicals used for lithography and stripping.

6.2.7 *Other Treatment* — Includes microfiltration, ultrafiltration, and other types of water treatment typically used to protect RO Membranes. Pretreatment equipment may include media filtration (bulk suspended solids removal), 1–5 micron cartridge filtration (polishing step for suspended solids removal), sodium-cycle cation exchange (softening, to remove scale-forming cations), acid injection (to minimize cellulose acetate membrane damage and/or to control carbonate scales), scale inhibitor injection (to control scaling), and sulfite ion injection (to remove oxidizing agents).

6.3 *Monitoring* — TOC, pH, conductivity, and temperature are typical parameters that can be monitored on-line and tracked over time to optimize performance. The set points and level of monitoring depends on the chemistries being used and what the ionic and organic loads are in each waste stream after the application and the treatment. To ensure the accuracy of certain on-line measurements, a minimum residence time and volume of sample is required and can be provided through the use of a buffer station and separate sample tanks. Other parameters such as fluoride levels, specific organics, and oxidants from undeveloped ammonia must be measured in the laboratory.

7 Grades of Water Effluent

7.1 *Rinse Water* — The second and third rinses from wafer cleaning processes are sufficiently high quality to be reused without further treatment either for make-up water in a UPW system, or directly for use in a lower grade application such as CMP cleaning.

7.2 *Non-treated Reclaim Water* — Is a lower grade of water with possible applications including fab air pollution abatement scrubbers, fab point-of-use hazardous gas burn boxes, and drain flushing for CMP drains.

8 Special Issues

8.1 *Difficulty of Identifying and Treating Organics* — It is difficult to evaluate rinse waters after solvent use. Real time, on-line instruments are not available to easily quantify and identify the complete composition of the organic molecules for proper segregation. In addition, treatment of waste water containing organics is more difficult in some cases, depending on the organic molecules being removed or converted.

8.2 *Managing Excursions* — Excursions in reuse water quality can occur due to various reasons such as human error in operating non-automated manufacturing equipment.

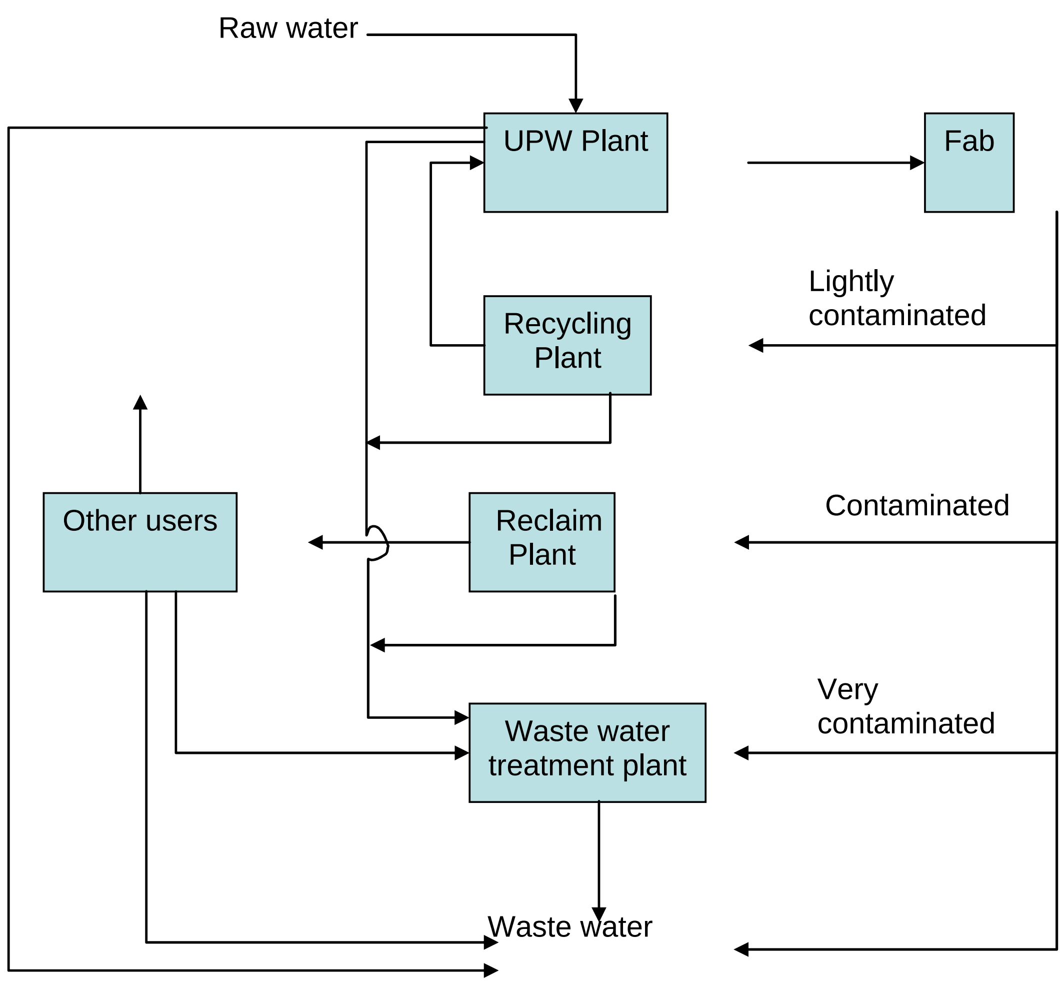
8.2.1 It is important to detect and redirect such water before it can contaminate the system for which it directed for reuse or possibly even damage the treatment equipment. Excursions from organics are particularly difficult because they cannot be detected in real time. Two methods have been used to compensate for this delay: locate the analyzers at a sufficient distance upstream of the central diverter point, or provide a sufficient buffer/quarantine volume.

8.3 *Temperature* — Hot water effluent from rinse tanks on wet benches can provide a challenge in recycling treatment systems, as temperature can be an important variable to water recycling system performance and can cause an increase in bacteria growth. This issue is influenced by seasonal variations in ambient temperature. Heat exchangers for process waters can be added to a recycle system in order to keep the system at a steady state.

8.4 *Discharge Permits* — One aspect of water reuse that can have significant economic impact relates to site effluent and local discharge permits. As water reuse increases, contaminant concentrations in the site effluent will also increase due to the reduced volume of the wastewater. If site water reuse is great enough, these higher concentrations may approach the limits of the local wastewater discharge permits and need to be closely monitored.

9 Economic Considerations

9.1 *General* — Potential cost savings are available from the introduction of reuse water systems. One type of savings can be measured from the actual cost of the water being replaced. The cost savings depends on the grade of water being replaced and the original cost of producing that grade of water at that location. Additional savings can often be realized in maintenance costs (e.g. membrane cleaning) given that the reclaim water is generally of better quality than incoming water. Models for evaluating the economics of a reclaim or recycle water application have been developed in the industry.



NOTE: Courtesy of German UPW standard VDI 2083 Part 13

Figure 1

Schematic of Basic Reclaim Water System

SEMI F99-0705
DIMENSIONAL SPECIFICATION OF A DIAPHRAGM VALVE FOR A METRIC PFA TUBE

This specification was technically approved by the Global Liquid Chemicals Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on March 11, 2005. It was available at www.semi.org in June 2005 and on CD-ROM in July 2005.

1 Purpose

1.1 This document specifies the outside dimensions of diaphragm valves used with metric PFA tubes in liquid chemical distribution facilities and process equipment for semiconductor and flat panel display manufacturing.

2 Scope

2.1 This specification addresses dimensions of diaphragm valves used with metric PFA tubes except for face-to-face dimensions. Since there are many seizes of fittings being applied to valves, this document doesn't specify face-to-face dimensions.

2.2 These diaphragm valves are limited to pneumatic valves. Specification for manual valves should be separately provided as needed.

2.3 These diaphragm valves are used in chemical distribution systems for semiconductor and flat panel display manufacturing.

2.4 The valves are made from materials such as PTFE or PFA, which have high corrosion resistance and low contamination contribution to the fluid.

2.5 The valves withstand up to 0.2 megapascals (MPa) [29 pounds per square inch (psi)] back pressure.

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 F65 — Dimensional Specification for Mounting Bases of Diaphragm Valves Used with Metric PFA Tubes

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

4 Terminology

4.1 *Abbreviations and Acronyms*

4.1.1 *PFA* — Tetrafluoroethylene Perfluoroalkylvinylether

4.1.2 *PTFE* — Tetrafluoroethylene

4.2 *Definitions*

4.2.1 *back pressure* — a maximum allowable pressure applied to outlet of a diaphragm valve.

4.2.2 *liquid chemicals* — acid, alkali, organic solvent, and pure water used for wet stations; resists and developers used for truck system; and other chemicals used for process or maintenance (such as slurry of CMP) of equipment or facilities.

5 Dimensional Specifications

5.1 *Overall Height Dimensions* — The height (B) and (C) indicated in Figure 1 and the values for different tube sizes are specified in Table 1.

5.2 *Port Height Dimensions* — The height (A) indicated in Figure 1 and the values for different tube sizes are specified in Table 1.

5.3 *Body Dimensions* — The length (D) and width (E) of the body indicated in Figure 1 and the values for different tube sizes are specified in Table 1.

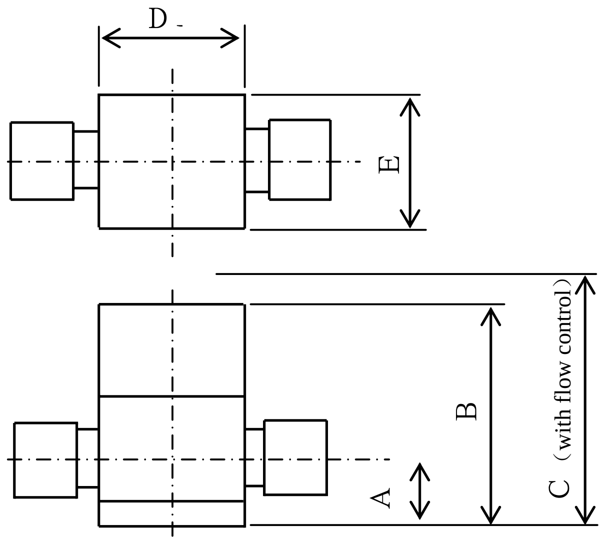


Figure 1
Top View of A Typical Diaphragm Valve

Table 1 Dimensional Specifications

*Tube Size (mm) (OD / ID)**	*A (mm)*	*B (mm)*	*C (mm)*	*D (mm)*	*E (mm)*
25/22	35–40	MAX 145	MAX 175	MAX 62	MAX 62
19/16	25–30	MAX 120	MAX 150	MAX 60	MAX 60
12/10	20–30	MAX 95	MAX 115	MAX 36	MAX 40
10/8	20–25	MAX 95	MAX 115	MAX 36	MAX 40
6/4	15–25	MAX 80	MAX 100	MAX 35	MAX 35

[#1] OD and ID are the outside diameter and inside diameter of the tube respectively.

[#2] As seen above, dimensions of A are specified by the range, and dimensions from B to E are specified as maximum dimensions that are to be considered as targets.

6 Measurements

6.1 The mounting base must be conditioned for a minimum of one hour in an air environment of 23 ± 3ºC (73.4 ±5.4ºF) prior to measuring the dimensions.

SEMI F100-0705
COMPLIANCE TEST METHOD FOR MINIMUM FLOW COEFFICIENT OF DIAPHRAGM VALVE FOR METRIC PFA TUBE

This test method was technically approved by the Global Liquid Chemicals Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on March 11, 2005. It was available at www.semi.org in June 2005 and on CD-ROM in July 2005.

1 Purpose

1.1 This compliance test method presents that the verification of the compatibility of each diaphragm valves for Metric PFA tube simply.

1.2 This document specifies the relative orifice that gives the minimum flow coefficient for diaphragm valve for Metric PFA tube.

1.3 This compliance test method describes how to verify the flow coefficient of the diaphragm valve by comparing with the relative orifice.

2 Scope

2.1 This Specification addresses a capacity of diaphragm valves used with metric PFA tubes.

2.2 These diaphragm valves are used in chemical distribution systems for semiconductor and flat panel display manufacturing.

2.3 The valves are made from materials such as PTFE or PFA, which have high corrosion resistance and low contamination contribution to the fluid.

2.4 The valves withstand up to 0.2 megapascals (MPa) [29 pounds per square inch (psi)] backpressure.

2.5 Fully open to fully shut switch over is the objective of the shut-off valve.

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 Terminology

3.1 *Abbreviations and Acronyms*

3.1.1 *PFA* — Perfluroalkoxy

3.1.2 *PTFE* — Polytetrafluoroethylene

3.1.3 *P1* — Gauge pressure at upstream pressure tap, kPa

3.1.4 *Q* — Volumetric flow rate

3.2 *Definitions*

3.2.1 *back pressure* — a maximum allowable pressure applied to outlet of a diaphragm valve.

3.2.2 *liquid chemicals* — acid, alkali, organic solvent, and pure water used for wet stations; resists and developers used for track system; and other chemicals used for process or maintenance (such as slurry of CMP) of equipment or facilities.

4 Test Fluids

4.1 *Incompressible (Liquid) Fluid* — Water is standard liquid test fluid.

5 Test Setup

5.1 *Standard Orifice*

5.1.1 *Orifice Diameter (A)*

On the basis of 50% of the inner diameter of PFA tube connection. See Figure 1.

- φ2.0[mm] orifice (φ6-4[mm] tube)
- φ4.0[mm] orifice (φ10-8[mm] tube)
- φ5.0[mm] orifice (φ12-10[mm] tube)
- φ8.0[mm] orifice (φ19-16[mm] tube)
- φ11.0[mm] orifice (φ25-22[mm] tube)

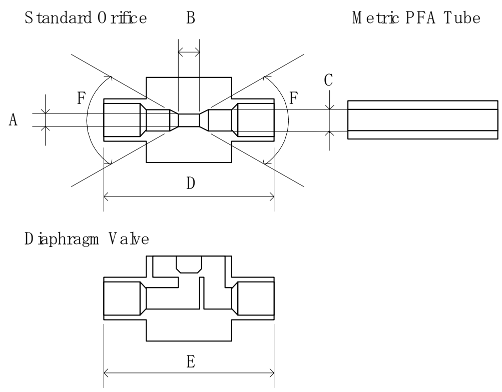


Figure 1
Inside View of Standard Orifice

5.1.2 *Orifice Diameter Tolerance*

Tolerance: +0.2, −0 [mm]

5.1.3 Orifice Length (B) should be less than inner tube diameter, i.e., B ≤ A.

5.1.4 Dimensions (D) should be determined in accordance with the test valve port connection, i.e., D ≤ E.

5.1.5 Dimension (F) should be equal to or less than a 90 degree angle.

5.2 *Test Circuit*

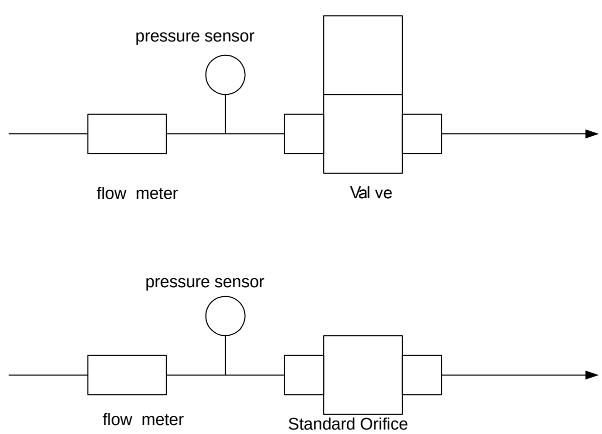


Figure 2
Test Circuit

5.2.1 The valve and orifice tests must be applied with identical pressure sensors/flow meters.

5.2.2 Reproducibility and repeatability of measuring devices must rate 2 % or less of R.S.

5.2.3 Both the test valve and test orifice must have identical port connections.

5.3 *Test Method/Procedure*

5.3.1 In accordance to the test circuit of ¶5.2, flow rate is compared under the same pressure condition. Volume and weight of accumulative flow can be compared without the use of a flow meter.

5.3.2 P1 is set 50kPa or more.

5.4 *Qualification of Standard*

5.4.1 The standard of diaphragm valves used with metric PFA tubes is determined by the flow rate Q1 of the tested valve being greater than the flow rate Q2 of the standard orifice tested of ¶5.1. (Q1 > Q2 / Q1 < Q2).

SEMI INTERNATIONAL STANDARDS

FLAT PANEL DISPLAY

Semiconductor Equipment and Materials International

SEMI D3-91 (Reapproved 0703)
QUALITY AREA SPECIFICATION FOR FLAT PANEL DISPLAY SUBSTRATES

This specification was technically reapproved by the Global Flat Panel Display Committee and is the direct responsibility of the Japanese FPD Materials and Components Committee. Current edition approved by the Japanese Regional Standards Committee on April 28, 2003. Initially available at www.semi.org June 2003; to be published July 2003. Originally published in 1991.

1 Purpose

1.1 This document defines various areas on the pattern surface of a flat panel display substrate and describes their relationship. It assumes the existence of terminology and a banking convention described in other SEMI flat panel display documents.

2 Scope

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 D9 — Terminology for FPD Substrates

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

4 Significance

4.1 The patterns placed on a flat panel display substrate are expected to occur only in a specified, central area, and certain requirements are applied in that area to both the substrate and pattern quality. The substrate peripheral area(s) outside this zone have different specified properties. Defining the terms to apply and the geometric relationship in these various areas will assist the suppliers and users of substrates and processing/inspection equipment.

5 Summary

5.1 A substrate edge length is defined in two dimensions, L_X and L_Y, with nominal and tolerance values for each.

5.2 A quality area is defined by two dimensions, QA_X and QA_Y, with nominal and tolerance values for each.

5.3 A fixed edge exclusion area is defined for the substrate edges to be placed against reference (also called “banking”) pins.

5.4 Two variable edge exclusion areas result from combining the above three dimension sets.

6 Procedure

6.1 Locate the properties in Sections 6.2–6.4 relative to the substrate origin, using the nominal values assigned by the substrate specification.

6.2 Let L_X = the substrate edge length in the x-direction, and

L_Y = the substrate edge length in the y-direction. (See Figure 1.)

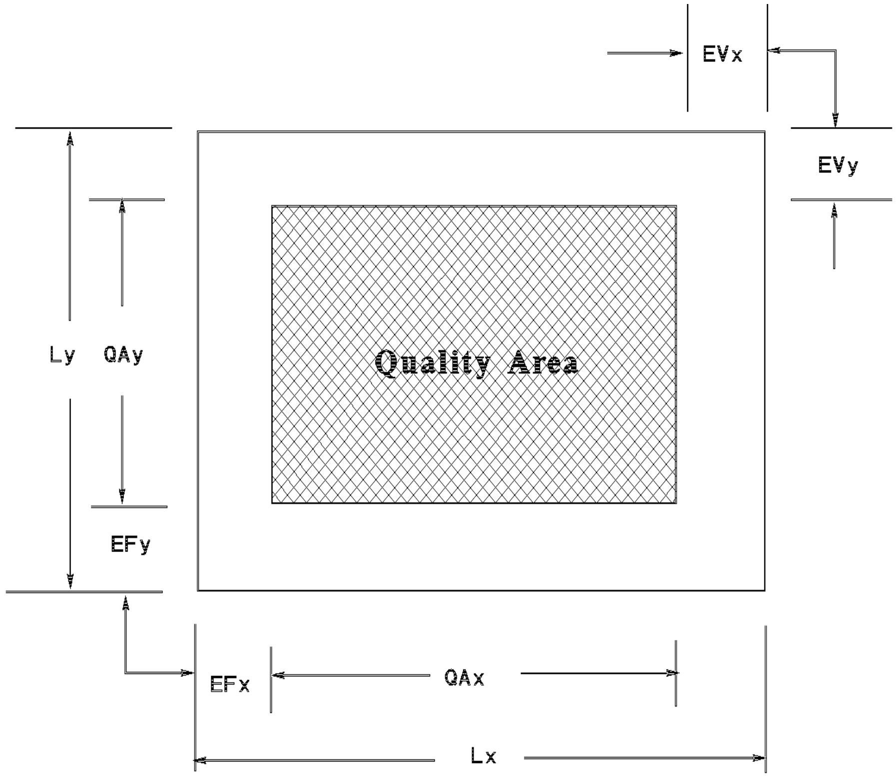
6.3 Let EF_X = the fixed edge exclusion area along the substrate’s lower edge, and

EF_Y = the fixed edge exclusion area along the substrate’s left edge.

6.4 Let QA_X = the quality area’s edge length in the x direction, and

QA_Y = the quality area’s edge length in the y direction.

6.5 Then EV_X and EV_Y, the variable edge exclusions, are not specified. They result from the interaction of substrate tolerance variations from nominal with the fixed location origin.



L_X, L_Y

QA_X, QA_Y are specified, nominal dimensions

EF_X, EF_Y

EV_X, EV_Y are not specified, but result from tolerance effects.

Figure 1
Substrate Area Relationships

SEMI

SEMI D5-94 (Reapproved 0703)
STANDARD SIZE FOR FLAT PANEL DISPLAY SUBSTRATES

This standard was technically reapproved by the Global Flat Panel Display Committee and is the direct responsibility of the Japanese FPD Materials and Components Committee. Current edition approved by the Japanese Regional Standards Committee on April 28, 2003. Initially available at www.semi.org June 2003; to be published July 2003. Originally published in 1993; previously published in 1994.

1 Purpose

1.1 This standard covers the specification of nominal edge length and thickness and related tolerances of a flat panel display substrate.

2 Scope

2.1 These dimensions apply to substrates that are principally used in fabricating AMLCD displays. These dimensions may also be applicable to substrates for other display types. The edge lengths specified range from 300 × 300 mm to 500 × 500 mm. A single thickness, 1.1 mm, applied to all substrates.

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 D3 — Quality Area Specification for Flat Panel Display Substrates

SEMI D4 — Method for Referencing Flat Panel Display Substrates

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

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

4 Dimensions

4.1 *Edge Length*

Table 1 Standard (Arithmetical Progression) Edge Length (mm)

300 × 300	300 × 350	300 × 400	300 × 450	300 × 500
	350 × 350	350 × 400	350 × 450	350 × 500
		400 × 400	400 × 450	400 × 500
			450 × 450	450 × 500
				500 × 500

NOTE 1: For substrates larger than 500 mm × 500 mm, it is recommended that the edge lengths be increased in increments of 50 mm.

Table 2 Standard Edge Length (mm)

320 mm × 300 mm
320 mm × 400 mm
360 mm × 465 mm

Table 3 Edge Length Tolerance

Nominal	*Tolerance*
< 400 mm	± 0.2 mm
≥ 400 mm	± 0.3 mm

4.2 *Thickness* — 1.1 ± 0.1 mm

NOTE 1: Nominal values and tolerances for thickness < 1.1 mm, and > 1.1 mm are under discussion.

NOTICE: 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 D6-0305
SPECIFICATION FOR LIQUID CRYSTAL DISPLAY (LCD) MASK SUBSTRATES

This specification was technically approved by the Global Flat Panel Display Mask Committee and is the direct responsibility of the Japanese Flat Panel Display Materials and Mask. Current edition approved by the Japanese Regional Standards Committee on January 11, 2005. Initially available at www.semi.org January 2005; to be published March 2005. Originally published in 1992; previously published November 2001.

1 Purpose

1.1 This specification defines standard for substrates used to fabricate liquid crystal display masks.

2 Scope

2.1 This specification applies to photomasks that are principally used in fabricating liquid crystal displays. The edge lengths specified range from 202.8 × 202.8 mm to 700 × 800 mm.

2.2 Substrates with an edge length less than 200 mm follow the specifications for a semiconductor mask (see SEMI P1).

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 Standard*

SEMI P1 — Specification for Hard Surface Photomask Substrates

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

4 Terminology

4.1 None.

5 Ordering Information

5.1 Ordering information shall be discussed between suppliers and users.

6 Edge Length and Thickness Specification

6.1 *Edge Length* — Units are in mm. See Tables 1 and 2, 3 and 4, 5 and 6, and 7 and 8 for a combination of materials, edge length, and thickness.

6.2 *Edge Length Tolerance* — ± 0.4 mm. Applies to all groups.

6.3 *Thickness, Tolerance*

6.3.1 Thickness of substrates shall be specified by the edge length group and materials as shown in Tables 2, 4, and 6.

6.3.2 *Tolerance* — For Groups A and B: –0.4 ~ + 0.2 mm. For Group C: See Table 6. For Group D: See Table 8.

6.4 *Material* — See §7.

Table 1 Edge Length (Group A) in mm

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

Table 2 Plate Thickness and Materials (Group A) in mm

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

Table 3 Edge Length (Group B) in mm

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

Table 4 Plate Thickness and Materials (Group B) in mm

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

Table 5 Edge Length (Group C) in mm

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

Table 6 Plate Thickness and Materials (Group C) in mm

Material		
ULTE	*Thickness (mm)*	Tolerance (mm)
+	5.0	± 0.2

Table 6 Plate Thickness and Materials (Group C) in mm

+	8.0	-0.4 ~+ 0.2

Table 7 Edge Length (Group D) in mm

390 × 610

Table 8 Plate Thickness and Materials (Group D) in mm

Material		
ULTE	*Thickness (mm)*	*Tolerance (mm)*
+	6.0	± 0.2

7 Material Specification

7.1 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; of MTE materials are borosilicate and aluminosilicate glasses; of LTE materials are aluminosilicate glasses; and of ULTE materials are synthetic quartz glasses.

7.2 Substrate materials shall conform to thermal expansion and optical transmittance characteristics specified in SEMI P1.

7.3 Selected physical properties of HTE, MTE, LTE, and ULTE materials are provided for information in SEMI P1, Appendix 1.

8 Related Document

8.1 *SEMI Standards*

SEMI D21 — Terminology for Flat Panel Display Masks

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SEMI D7-94 (Reapproved 0703)
FPD GLASS SUBSTRATE SURFACE ROUGHNESS MEASUREMENT METHOD

This standard was technically reapproved by the Global Flat Panel Display Committee and is the direct responsibility of the Japanese FPD Materials and Components Committee. Current edition approved by the Japanese Regional Standards Committee on April 28, 2003. Initially available at www.semi.org June 2003; to be published July 2003. Originally published in 1994.

1 Purpose

1.1 This document defines the method of FPD glass substrate surface roughness measurement by stylus method surface roughness measurement instrument.

2 Scope

2.1 This specification shall be used by vendors and/or buyers of glass substrates for flat panel display and is effective for all glass substrates used.

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 *ISO Standards* [1]

ISO486-1982 — Surface Roughness — Parameters, Their Values and General Rules for Specifying Requirements

ISO3274-1975 — Instruments for the Measurement of Surface Roughness by the Profile Method — Contact (Stylus) Instruments of Consecutive Profile Transformation

ISO4287/1-1984 — Surface Roughness — Terminology — Part 1: Surface and its Parameters

3.2 *JIS Standard* [2]

JIS B0601-1982 — Definitions and Designation of Surface Roughness

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

4 Terminology

4.1 *Definitions*

4.1.1 *long wavelength cutoff* — wavelength that the attenuation ratio of its amplitude becomes 75% when the traced profile is passed through the high-pass wavelength filter which eliminates waviness element.

4.1.2 *short wavelengh cutoff* — wavelength that the attenuation ratio of its amplitude becomes 75% when the traced profile is passed through the low-pass wavelength filter which eliminates noise element.

4.1.3 *stylus method surface roughness measuring instrument* — instrument that traces on a section of a surface by a stylus, records irregularity on the surface in a enlarged form, and indicates its amplitude as roughness parameters.

4.1.3.1 The type of instrument in this standard is specified to an instrument which is sometimes called as a profiler for very thin films and steps.

5 Measurement Instrument

5.1 *Method* — Stylus method surface roughness measuring instrument defined in Sections 3.1 or 3.2, or an instrument which meets those conditions.

5.2 *Stylus*

Material — diamond

Shape — circular cone or rectangular cone

Tip Radius — 2 µm or less

5.3 *Measuring Force* — 0.1 mN (0.01 gf) or above, 0.7 mN (0.07 gf) or less.

5.4 *Sampling Interval* — 1 µm or less.

5.5 Vertical noise amplitude p-p value: 3 nm (= 30 Å) or less.

6 Measurement Conditions

6.1 Long Wavelength Cutoff, λc — 0.08 mm or close.

6.1.1 Short Wavelength Cutoff, λs — 0.0025 mm or less.

6.1.2 Evaluation length, Le — 0.4 mm.

1 International Organization for Standardization, ISO Central Secretariat, 1, rue de Varembé, Case postale 56, CH-1211 Geneva 20, Switzerland. Telephone: 41.22.749.01.11; Fax: 41.22.733.34.30, Website: www.iso.ch

2 Japanese Industrial Standards, Available through the Japanese Standards Association, 1-24, Akasaka 4-Chome, Minato-ku, Tokyo 107-8440, Japan. Telephone: 81.3.3583.8005; Fax: 81.3.3586.2014, Website: www.jsa.or.jp

6.1.3 *Surface Roughness Parameter* — Maximum height of the profile Ry5(ISO4287/1-1984)(=Rz (DIN4768-1990)) or 10 point height of irregularities which is close to Ry5, Rz (JIS B0601-1982).

7 Test Specimen

7.1 A clean FPD glass substrate. No stains or oils should be seen by the naked eye.

8 Measurement Procedure

8.1 Contact the specimen on the stage of the instrument and leave for five minutes to condition the specimen to room temperature.

8.2 Put the stylus on the specimen, measure roughness by tracing the surface, and calculate the defined roughness parameter.

8.3 Change the measurement location to the location near the previous location and measure again.

8.4 Change the measurement location to the location defined in Section 9 and repeat the above measurement.

9 Measurement Location

9.1 Describe the measurement location on the report, for example, measure the following two locations:

a. The center of the specimen.
b. The point which is 20 mm inside from both edges of the orientation corner.

10 Calculations or Interpretation of Results

10.1 Show the measurement results in nm (nanometers) and round fractions of 0.5 and over to the next highest whole numbers.

Table 1 Example: Measurement Results

Maximum Height: Ry5	n1	n2
The Center	**nm	**nm
The Corner	**nm	**nm

Measurement Conditions

Surface — The pattern surface

Instrument — (type of instrument and name of maker)

Stylus tip radius — 2 μm

Tracing speed — ** μm/sec

Measuring force — 0.* mN

Cutoff λc — 0.08 mm

SEMI D9-0303
TERMINOLOGY FOR FPD SUBSTRATES

This terminology was technically approved by the FPD Materials and Components Committee and is the direct responsibility of the Japanese FPD Materials and Components Committee. Current edition approved by the Japanese Regional Standards Committee on January 10, 2003. Initially available at www.semi.org January 2003; to be published March 2003. This document was originally published in 1994; previously published November 2001.

1 Purpose

1.1 This document provides terms and definitions of materials and defects within and on the surface of flat panel display (FPD) substrates and of dimensional, thermal, chemical, optical and mechanical properties of FPD substrates.

2 Scope

2.1 These terms and definitions are applicable to both front and back substrates used in FPD fabrication.

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 D3 — Quality Area Specification for Flat Panel Display Substrates

SEMI D5 — Standard Size for Flat Panel Display Substrates

SEMI D7 — FPD Glass Substrate Surface Roughness Measurement Method

SEMI D11 — Specification for Flat Panel Display Glass Substrate Cassettes

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

SEMI D15 — FPD Glass Substrate Surface Waviness Measurement Method

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

3.2 *ASTM Standards*[1]

ASTM C336 — Standard Test Method for Annealing Point and Strain Point of Glass by Fiber Elongation Test Method (Elongation of Glass Fibers)

ASTM C338 — Standard Test Method for Softening Point of Glass

ASTM C598 — Standards Test method for Annealing Point and Strain Point by Beam Bending

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

4 Terminology

NOTE 1: SEAJ Liquid Crystal Display Manufacturing Equipment Dictionay is referred as to every term in Section 4.

4.1 *Internal Defects*

4.1.1 *bubble* — a gaseous inclusion.

4.1.2 *open bubble* — a gaseous inclusion which is so close to the surface that it is obviously open and/or one so close to the surface that it may be broken open with the point of a soft lead pencil.

4.1.3 *inclusion* — opaque or partially melted particle of refractory or batch material embedded in glass. Its size is usually determined by the size of the distorted area.

4.1.4 *devitrification* — a crystalline area within the glass.

4.1.5 *knot* — an embedded glassy, transparent, lump having an irregular or tangled appearance. Its size is usually determined by the size of the distorted area.

4.2 *Material on the Surface*

4.2.1 *cullet* — small transparent glass particles that are adhered or fused to the glass substrate surface.

4.2.2 *particle* — a micron-size piece of foreign material on the glass surface.

1 American Society for Testing and Materials, 100 Barr Harbor Drive West Conshohocken, Pennsylvania, USA 19428-2959. Tel: 610-832-9585, Fax: 610-832-9555, http://www.astm.org

4.2.3 *stain* — organic or inorganic material on the surface.

4.2.4 *blur* — any erosion of the surface; generally cloudy in appearance, it sometimes exhibits an apparent color.

4.3 *Surface Defects*

4.3.1 *scratch* — a surface fissure generally caused during handling.

4.3.2 *sleek* — a very shallow type of scratch on the polished surface that is sometimes invisible when the viewing angle is changed.

4.3.3 *latent scratch* — a scratch which is usually invisible but when subjected to an etching action by dipping into a detergent or a corrosive solution, such as an acid, the previously invisible scratch becomes visible due to the minor removal of surface glass.

4.3.4 *chip* — a region of material missing from the edge of the glass substrate, which is sometimes caused by processing or handling.

4.3.5 *pit/dig* — small indentation on the glass substrate surface.

4.3.6 *bump* — a small protuberance on the glass substrate.

4.3.7 *crack* — a fissure located at the sheet edge area or central area.

4.3.8 *streak* — a defect with a very small undulation on the glass substrate surface.

4.4 *Dimensional Properties*

4.4.1 *outsize dimension* — vertical and horizontal dimensions of the glass substrate.

4.4.2 *thickness* — the distance between the front surface and the back surface of a glass substrate at same single point.

4.4.3 *thickness variation* — any differences between maximum and minimum values within the thickness of a glass substrate.

4.4.4 *warp* — defined as the maximum distance from a reference plane to the guaranteed surface; this includes twists, partial rises or declines in the glass compared with the reference plane. Warp expression a condition of the whole glass (substrate).

4.4.5 *waviness* — the residual unevenness after the long wavelength component (warp) and the short wavelength component (surface roughness) have been eliminated. This is also called "FPD Waviness" when referring specifically to FPD substrates, as in SEMI D15.

4.4.6 *surface roughness* — the criterion for the smoothness of the sheet surface. Usually the randomly selected areas on the sheet surface are measured by a surface analyzer. Details are defined in SEMI D7.

4.4.7 *beveling* — grinding out or shaping substrate edges by lapping or grinding.

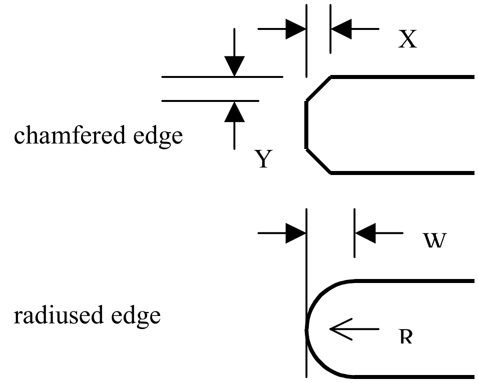

Figure 1
Beveling

4.4.7.1 *chamfered edge* — a beveled angle of approximately 45° in respect to the surface and cut edge surface. One characteristic is that part of the cut edge surface remains. For this reason, R-beveled edges have come to be used in conjunction with chamfered edges in liquid crystal applications. Chamfered edges with particularly small widths are also referred to as "string bevels". (See Figure 1.)

4.4.7.2 *R beveled edge* — a beveled shape of an arc in respect to the surface and cut edge surface. One characteristic is that the complete cut edge surface is ground with a wheel and processed into a frosted glass state. Generally, in TFT liquid crystals, R-beveled edges are used more often. (See Figure 1.)

4.4.8 *orientation corner* — the corner of a substrate which identifies the pattern surface and the rotational orientation. It is defined by the X and Y dimensions in the following figure. It is also commonly known as "orientation flat" or "orifra".

4.4.9 *corner cut* — removal of the corners of the substrate by either lapping or grinding. As with the orientation corner, this is defined by the X and Y dimensions, but generally, most corner cuts have a X and Y of the same length.

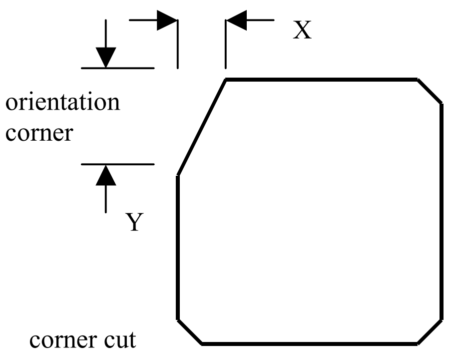

Figure 2
Orientation Corner and Corner Cut

4.4.10 *squareness* — deviation of the outline of the substrate from a true square or rectangle. Using the drawing below, it is defined as PS or PL, but must be recorded with a or b dimensions. Dimensions a and b can be decided voluntarily, but generally, most applications use a = S and b = L. (See Figure 3.)

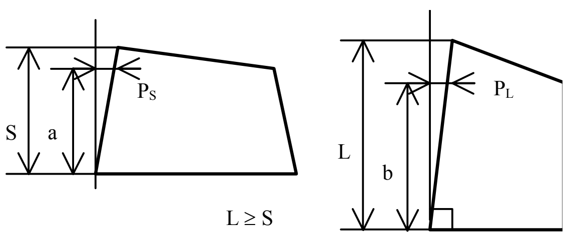

Figure 3
Squareness

4.5 *Thermal Properties*

4.5.1 *coefficient of thermal expansion* — expansion is the change in length per initial length caused by a thermal change. Concretely, it is shown as ΔL/L0, where ΔL = L2 – L1 and L0, L1, and L2 are the lengths of the material at the temperature T0, T1, T2 respectively. Usually, the coefficient of expansion (A), means the average coefficient of expansion over the temperature range T1 to T2. This is shown in the following equation.

$$\alpha = (\Delta L/\Delta T)/L_0 = [(L_2 - L_1)/(T_2 - T_1)]/L_0$$

4.5.2 *thermal shrinkage* — when the substrate is heat treated along a specific thermal profile, the relaxation of thermal stress and the structure change occur in material, and create the shrinkage of the substrate. Usually it is described with ΔL/L0, where, ΔL is the amount of change and shown as ΔL = L0 – L. L0 is the length of material before heat treatment, and L is after heat treatment.

4.5.3 *strain point* — temperature of the glass when its viscosity is approximately $10^{14..5}$ dPa·s. Strain point is defined by two methods in ASTM: Test Method C336 (Elongation of Glass Fibers) and Test Method C598 (Bending in Glass Beams). In practice, the strain point of glass is the maximum temperature at which glass can be processed without triggering unnecessary strain. Internal strain can be relieved by keeping (the glass) at this temperature for 4 hours.

4.5.4 *annealing point* — temperature of the glass when its viscosity is approximately 10^{13} dPa·s. The annealing point is the temperature at which internal strain can be relieved in 15 minutes.

4.5.5 *softening point* — temperature of the glass when its viscosity is approximately $10^{7.6}$ dPa·s. Softening point is defined in ASTM C338.

4.6 *Chemical Properties*

4.6.1 *chemical durability* — a measure of corrosion or attack of a glass surface when subjected to a specific reagent, such as acid, base, or water at a specific concentration for a specific time and temperature.

4.7 *Optical Properties*

4.7.1 *transmittance* — percentage of incident light which permeates the glass. It is defined as I/Io, where Io is the strength of the incident light, and I is strength of the permeated light. Transmittance is effected by material composition, temperature, thickness and light wavelength.

4.7.2 *refractive index* — ratio of the speed of light in the material and in a vacuum at a specific wavelength. The refractive index of substrate glass is between approximately 1.50 and 1.53.

4.8 *Mechanical Properties*

4.8.1 *density* — mass per unit volume. Decided by the mass of the material's atomic composition and the volume (comparative capacity, mol capacity) which it occupies.

4.8.2 *Young's modulus* — a type of elasticity ratio, which shows the stretch (or compression) elasticity. When stretch (or compression) deformation stress σ and the strain ε resulting from the stress are proportionate, the proportionate constant E = σ/ ε is called Young's modulus, a material characteristic.

4.8.3 *shear modulus* — a type of elasticity ratio which shows divergence elasticity. When divergent deformation stress τ and the strain Φ resulting from the stress are proportionate, the proportionate constant G = τ/Φ is called Shear Modulus, a material characteristic.

4.8.4 *Poisson's ratio* — the ratio between Young's modulus and shear modulus.

4.8.5 *Vickers hardness* — a type of pressure test. A diamond pyramid indentator with a face angle of 136° is pressed into the glass surface to find the degree of hardness by measuring trace indentation on the overall squareness.

4.9 *Electrical Properties*

4.9.1 *dielectric constant* — the proportionate dielectric constant which is the ratio between a vacuum dielectric constant and the material dielectric constant.

4.9.2 *dielectric loss* — the phenomenon, or volume, of (electricity) loss through heat when a dielectric is introduced to an alternating current.

4.9.3 *resistivity* — the reciprocal of electric conductivity.

4.10 *pattern surface* — the main area where device patterns can be formed, determined by the orientation corner, etc.

4.11 *quality area* — the center area to the substrate where specified substrate quality criteria (primarily internal defects, surface contamination, surface defects, waviness, and surface roughness) are applicable.

5 Referenced Documents

SEAJ(Semiconductor Equipment Association of Japan) Liquid Crystal Display Manufacturing Equipment Dictionary[2]

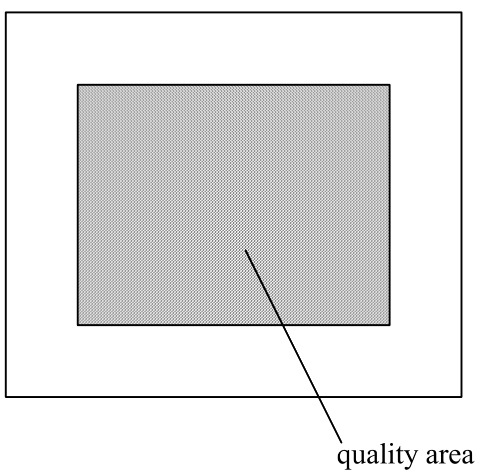

Figure 4
Quality Area

2 Semiconductor Equipment Association of Japan, 7-10 Shinjuku 1-chome, Shinjuku-ku, Tokyo, 160-0022 Japan. Tel:+81-3-3353-7589, fax:+81-3-3353-7970, http://www.seaj.or.jp

SEMI D10-95 (Reapproved 0703)
TEST METHOD FOR CHEMICAL DURABILITY OF FLAT PANEL DISPLAY GLASS SUBSTRATES

This test method was technically reapproved by the Global Flat Panel Display Committee and is the direct responsibility of the Japanese FPD Materials and Components Committee. Current edition approved by the Japanese Regional Standards Committee on April 28, 2003. Initially available at www.semi.org June 2003; to be published July 2003. Originally published in 1995.

1 Purpose

1.1 This test procedure evaluates quantitatively the durability of flat panel display (FPD) glass substrates using reagents employed in FPD production processes.

2 Scope

2.1 This standard may be used by vendors and/or buyers of glass substrates for FPD.

2.2 This standard defines three methods for testing chemical durability of various flat panel display substrates: (Method A) Weight Loss, (Method B) Step Measurement Using Profilometry, and (Method C) Surface Haze. Each method provides a measure of the amount of material that is removed from a substrate during a controlled chemical reaction sequence. This sequence is nominally identical for each method.

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 Limitations

3.1 These tests are not applicable to calculating variations in chemical durability in local areas within a substrate.

3.2 The calculations assume that all edges are nominally straight. They do not include adjustments for corner cuts.

3.3 The chemicals used in these practices are potentially harmful and should be handled in a fume hood with the utmost care at all times. **Warning** - Hydro- fluoric acid solutions are particularly hazardous. **Precaution:** They should not be used by anyone who is not familiar with the specific preventive measures and first aid treatments given in the appropriate Material Safety Data Sheet.

4 Referenced Standards

4.1 *SEMI Standard*

SEMI D5 — Standard Size for Flat Panel Display Substrates

4.2 *ASTM Document*[1]

C729 — Test Method for Density of Glass by Sink Float Comparator

4.3 *ISO Document*[2]

ISO 3274 — Instruments for the Measurement of Surface Roughness by the Profile Method Contact (Stylus) Instruments of Consecutive Profile Transformation Contact Profile Meters, System M

4.4 *JIS Documents*[3]

JIS B0651 — Instruments for the Measurement of Surface Roughness by the Stylus Method

JIS B7507 — Vernier, Dial, and Digital Callipers

JIS B7601 — Trip Balances

JIS K7105 — Testing Methods for Optical Properties of Plastics

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

5 Terminology

5.1 *Definitions*

5.1.1 *haze* — a method to measure the degree of haze created on the FPD glass substrate surface by a chemical etch sequence.

1 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

2 International Organization for Standardization, ISO Central Secretariat, 1, rue de Varembé, Case postale 56, CH-1211 Geneva 20, Switzerland. Telephone: 41.22.749.01.11; Fax: 41.22.733.34.30, Website: www.iso.ch

3 Japanese Industrial Standards, Available through the Japanese Standards Association, 1-24, Akasaka 4-Chome, Minato-ku, Tokyo 107-8440, Japan. Telephone: 81.3.3583.8005; Fax: 81.3.3586.2014, Website: www.jsa.or.jp

5.1.2 *step measurement using profilometry* — a method to measure depths of etching by comparing the differences in heights between etched and non-etched parts of a specimen measured by profilometry or an equivalent method.

5.1.3 *weight loss method* — a method to calculate depths of etching by comparing differences in specimen weights before and after the etch sequence.

6 Apparatus

6.1 For all chemical reactions, the following apparatus shall be used.

6.1.1 *Reaction Vessel*

6.1.1.1 *Material* — Teflon or other suitably etch-resistant material.

6.1.1.2 *Shape and Capacity* — Cylindrical wide-mouthed sealable vessel, suitable for the size and quantity of samples to be tested.

6.1.2 *Thermostatically Controlled Shaker Bath or Equipment*

6.1.2.1 *Shaking Stroke* — 10 to 60 mm.

6.1.2.2 *Shaking Frequency* — 30–90/min., controllable to ± 10/min.

6.1.2.3 *Operating Temperature Range* — 20 to 150° C, controllable to ± 1° C.

6.1.3 *Oven* — Controllable to ± 10° over an operating range of 50 to 200° C.

6.1.4 *Desiccator* — Room temperature, with sufficient capacity and size for all samples to be tested.

6.1.5 *Caliper* — Per JIS B7507, or equivalent.

6.2 For the measurements, one of the following shall be used.

6.2.1 *Method A* — Balance per JIS B7601, or equivalent.

6.2.2 *Method B* — Profilometer per ISO 3274, JIS B0651, or equivalent.

6.2.3 *Method C* — Haze measurement equipment with integrating sphere per JIS K7105, or equivalent.

NOTE 1: It is ideal to use haze measurement equipment which automatically measures total transmittance, diffuse transmittance, and haze values.

7 Reagents and Materials

7.1 No specific requirement is defined for the reagents and materials. As long as the test conditions are reported with the result, any combination of chemical reagents with any concentration can be used for the test. The test conditions should reflect actual process conditions which are specific for the Flat Panel Display manufacturers. Some reagents suggested for the test are provided in Related Information 1 as a reference.

7.2 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

8 Sample Preparation

8.1 Prepare at least a specimen from a lot of the substrates to be tested. The specimen is a rectangular plate about 25 × 50 mm edge length for Methods A and B, or 40 × 40 mm edge length for Method C.

8.1.1 If they are not already chamfered, specimen edges and corners should be chamfered slightly to remove chips and prevent cracking. If repeated tests are expected, prepare an appropriate quantity of test specimens.

8.2 Measure edge lengths of the test specimens, and calculate total surface area, A:

$$A = (L \times W \times 2) + \{ L + W) \times T \times 2)\} \qquad (1)$$

where

L = one edge length of test specimen in cm,

W = adjacent edge length of test specimen in cm,

T = thickness of test specimen in cm, and

A = total surface area of test specimen in cm^2.

8.3 Clean all test specimens by a method appropriate for the history of the material. The cleaning method should not cause any corrosion. Clean the specimens by an appropriate neutral or alkali detergent for approximately 10 minutes using an ultrasonic bath.

8.3.1 Rinse them continuously in a stream of deionized water, having a conductivity of less than 1 µ S/cm, for 1 minute using the ultrasonic bath. Finally, dry them.

8.4 Place all specimens on a clean heat resistant sample holder. Dry the specimens at 140 ± 10° C for 30 minutes.

8.5 Place all specimens in a desiccator containing silica gel or calcium sulfate and cool them, for a minimum of 1 hour, to room temperature.

8.6 If Method A will be used, weigh the test specimen to 0.1 mg or 0.01 mg as required using the balance.

8.7 If Method B will be used, coat about a half portion of each test specimen by an appropriate coating material durable to the test media and conditions. (Wax, varnish, epoxy resins, adhesive tape, etc., may be used.)

9 Procedure

9.1 *Test Specimen Processing*

9.1.1 Prepare cylindrical wide-mouthed sealable vessels, sample holders, etc., made of materials which do not react with the test medium under the test conditions. Use a reaction vessel in which the test specimen, while on the sample holder, is sufficiently immersed in the required volume of test reagent.

9.1.2 Place the test specimen on the sample holder with spacing of 1 to 2 cm between the test specimen and bottom of the empty vessel. When a part of the specimen is coated by protective material, position the sample so that its coated portion faces down. The test specimen may be leaned against the vessel wall if the test is to be done in relatively brief or slightly corrosive conditions, or in concentrated, extremely corrosive media.

9.1.3 Pour the test reagents into the reaction vessel. Volume of the test medium shall be 5 to 10 ml per cm^2 of specimen surface area. Preheat the test medium to the specified test temperature.

9.1.4 Place the reaction vessel in the preheated shaker bath with specified shaking stroke and frequency. Close the reaction vessel loosely, and expose the specimen at specified temperature for specified time.

9.1.5 At the completion of specified test time, immediately remove the reaction vessel from the shaker bath. Remove the test specimens from the reaction vessel using soft forceps, and rinse the specimens immediately by deionized water at appropriate temperature. When the specimen temperature is high following this process, rinse the specimens completely with water of gradually decreasing temperature. Finish it by deionized water at room temperature. Less caution is required when the reaction temperature is low. A synthetic rubber or plastic glove may be used instead of forceps if sufficient care is taken. In all cases, the surface of the test specimen shall not be scrubbed. Never dry the test specimen during this operation. Generation of cracks or chips due to thermal or mechanical shocks should be avoided.

9.1.6 For Method B samples, remove coating by appropriate non-corrosive method, and clean samples again. In this case, residue from the coating material should not contaminate the overall test specimen.

9.1.7 Place the test specimens on a clean heat-resistant sample holder, and dry them at 140 ± 10° C for 30 minutes.

9.1.8 Place the specimens in the desiccator and allow them to cool to room temperature.

9.2 *Measurement Method*

9.2.1 *Method A (Weight Change)*

9.2.1.1 Weigh the test specimen to 0.1 mg or 0.01 mg as required, using the balance.

9.2.1.2 Calculate the areal weight change with the following equation.

$$W_A = \frac{W_2 - W_1}{A} \qquad (2)$$

where

W_1 = the initial weight of the test specimen in mg,

W_2 = weight of the test specimen in mg after the test,

A = is surface area of test specimen in cm^2, as calculated in 8.2, and

W_A = the areal weight change, in $mg \bullet cm^{-2}$.

NOTE 2: A negative result indicates a real weight loss, and a positive result indicates a real weight gain.

9.2.1.3 Calculate penetration depth of corrosion, P, of the test sample by the following equation.

$$P = \frac{10 W_A}{D} \qquad (3)$$

where

W_A = the areal weight change in $mg \bullet cm^{-2}$

D = the density of the substrate material in $mg \bullet cm^{-3}$ (see 9.2.1.4) and

P = penetration depth in μm

NOTE 3: A negative result indicates loss of material, and a positive result indicates material gain.

9.2.1.4 When density of the materials is unknown, use the value measured by the method described in ASTM C729.

9.2.2 *Method B (Profilometry)*

9.2.2.1 Measure the height, H, in μm, of the step between the unetched (coated) section and the etched (uncoated) section by a calibrated surface profilometer. Trace length shall be between 2 and 4 mm, with the boundary between the two sections located near the center of the trace.

Repeat this measurement at least 3 times.

9.2.2.2 Calculate the average penetration depth P:

$$P = \frac{H_1 + H_2 + \bullet \bullet \bullet \bullet \bullet + H_N}{N} \qquad (4)$$

NOTE 4: A negative result indicates loss of material, and positive result indicates material gain.

9.2.3 *Method C (Surface Haze)*

9.2.3.1 Measure total transmittance, Tt, and diffuse transmittance, Td, and calculate the haze value from the following expression:

$$H = \frac{Td}{Tt} \times 100 \qquad (5)$$

where

Tt = total transmittance,

Td = diffuse transmittance, and

H = haze value in %.

10 Reporting Results

10.1 Report date and time of test, ambient temperature, test operator, test conditions (reagent and concentration, volume of the test medium, test temperature, test time, stroke length, and frequency of shaking), specimen size and total surface area, specimen cleaning method, and the following:

10.1.1 *Method A* — The areal weight change (W_A), the initial weight of the specimen (W_1), the density of the substrate material (D), and calculated depth of corrosion (P).

10.1.1.1 *Method B* — Penetration depth (P).

10.1.1.2 *Method C* — The average, maximum and minimum value of total transmittance (Tt), diffuse transmittance (Td), and haze value (H).

10.2 *Remarks* — In a typical test, one specimen is immersed in an unused medium of specified volume in a reaction vessel during a specified time. However, as long as various conditions are described in the report, even irregular methods may be allowed. Repetitive usage of a medium may not markedly affect the result when the test is done in relatively brief or slightly corrosive conditions, or in concentrated, extremely corrosive media.

11 Precision and Accuracy

11.1 Interlaboratory evaluation of these test methods is planned to verify their suitability and reliability. Until the results are established, use of this test method for commercial transactions is not recommended unless the parties to the test establish the degree of correlation that can be obtained.

11.2 No standards exist against which any bias of this test method can be evaluated.

RELATED INFORMATION 1

NOTICE: This related information is not an official part of SEMI D10 and is not intended to modify or supercede the official standard. Publication was authorized by full letter ballot procedures. Determination of the suitability of the material is solely the responsibility of the user.

NOTICE: This related information does not purport to address all of the safety issues associated with its use. It is the responsibility of the user of this related information to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

R1-1.1 The following chemicals and test conditions are recommended when this test is applied to flat panel display glass substrates:

Buffered hydrofluoric acid (1:5) 49% HF, 49% NH_4F, at 40° C for 10 minutes.

Hydrofluoric acid nitric acid (1:5) 49% HF, 70% HNO_3, at 40° C for 10 minutes.

Hydrochloric acid (diluted) (1:1) 36% HCl, H_2O, at 50° C for 20 minutes.

Sodium hydroxide solution (10%) at 50° C for 20 minutes.

NOTICE: 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 D11-95 (Reaproved 0703)
SPECIFICATION FOR FLAT PANEL DISPLAY GLASS SUBSTRATE CASSETTES

This specification was technically approved by the Global Flat Panel Display Committee and is the direct responsibility of the Japanese FPD Materials and Components Committee. Current edition approved by the Japanese Regional Standards Committee on April 28, 2003. Initially available at www.semi.org June 2003; to be published July 2003. Originally published in 1995.

1 Purpose

1.1 This document describes cassettes that are used with glass substrates in the fabrication and processing of subassemblies and masks for flat panel displays (FPD).

2 Scope

2.1 This document applies to cassettes that hold a quantity of rectangular FPD substrates. Selected terms and definitions and summary specifications are included. The specifications for single-substrate cassettes will be developed in other documents.

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 D3 — Quality Area Specification for Flat Panel Display Substrates

SEMI D5 — Standard Size for Flat Panel Display Substrates

SEMI D6 — Specification for Edge Length and Thickness for Liquid Crystal Display (LCD) Mask Substrates

SEMI D9 —Terminology for FPD Substrates

SEMI D21 — Definitions for Flat Panel Display Masks

SEMI E1 — Specification for 3 inch, 100 mm, 125 mm, and 150 mm Plastic and Metal Wafer Carriers

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

4 Terminology

4.1 The following descriptions assume that the cassette orientation places the substrates in a horizontal plane.

4.2 *Definitions*

4.2.1 *cassette bottom plate* — the bottom plate of the cassette. It is parallel to the substrate plane. It is physically different from the cassette top plate for purposes of machine interface and for mechanical positioning by operators.

4.2.2 *cassette front* — the area between top and bottom cassette plates through which substrates pass during loading and unloading.

4.2.3 *cassette plate opening* — an opening in the cassette top and bottom plate that provides access to the glass substrates for external roller driver mechanisms to move substrates into/from the cassette.

4.2.4 *cassette rear* — the area between top and bottom cassette plates opposite the cassette front.

4.2.5 *cassette top plate* — the upper plate of the cassette. It is parallel to the substrate plane. It is physically different from the cassette bottom plate for the purpose of machine interface and for mechanical positioning by operators.

4.2.6 *first mizo clearance* — the distance between the inside surface of the bottom plate and the centerline of the nearest mizo.

4.2.7 *first mizo dimension* — the distance between the outside surface of the bottom plate and the centerline of the nearest mizo.

4.2.8 *glass substrate cassette* — a container for holding glass substrates for processing, storage, and transportation during the fabrication of FPD.

4.2.9 *inner height* — the shortest distance between the inside surface of the bottom plate and the inside surface of the top plate.

4.2.10 *mizo* — a term (plural form = mizo) describing a family of rails that support the substrates. They may be smooth-sided, toothed symmetrically, or toothed non-symmetrically. Precise mizo contours are not described in this document.

4.2.11 *mizo base* — the innermost portion of a mizo.

4.2.12 *mizo centerline* — 1/2 the mizo clearance.

4.2.13 *mizo clearance* — the minimum dimensions between two adjacent mizo teeth, into which a substrate can be placed.

4.2.14 *mizo depth* — the distance between the base of the mizo and the top of the tooth. It is also called 'tooth height.'

4.2.15 *mizo flat* — the distance along the mizo base between two adjacent mizo teeth.

4.2.16 *mizo opening width* — the distance between the extreme ends of two adjacent mizo teeth.

4.2.17 *mizo pitch* — the distance between adjacent mizo centerlines.

4.2.18 *mizo plate* — a plate that contains mizo for supporting glass substrates.

4.2.19 *mizo plate space* — the distance between adjacent mizo plates. It is used in the alignment of substrates after loading.

4.2.20 *mizo size* — the distance between opposite mizo bases.

4.2.21 *substrate clearance* — the difference between the substrate width and the mizo size.

4.2.22 *substrate load depth* — the shortest distance between the front surface of the cassette and the front surface of the substrate stops.

4.2.23 *substrate stop* — a portion of the cassette, located at the cassette rear, that provides a mechanical stop for substrates during their insertion.

4.2.24 *tooth* — the protrusion, on the inner surface of the mizo-pocket plate, that contains the mizo shape.

4.2.25 *tooth height* — see "mizo depth."

5 Cassette Specification

5.1 An FPD substrate cassette contains the following items:

5.1.1 One cassette bottom plate.

5.1.2 One cassette top plate.

5.1.3 One or more substate stops. A mizo plate may be used as a substrate stop.

5.1.4 Three or more mizo plates.

5.2 *Capacity* — Two or more substrates.

5.3 *Dimensions and Tolerances* — To be agreed upon between supplier and user. The following table and figures explain application of the above definitions and located related dimensions.

5.4 *Material* — To be agreed upon between supplier and user. Construction may be of one or more molded or machined parts.

Table 1 Cassette Designations

Symbol	*Description*
A1	Outer height
A2	Outer width
A3	Outer length
B1	Mizo per plate
B2	Mizo pitch
B3	The distance between the first mizo centerline and the last mizo centerline
B4	Substrate load depth
B5	The distance between the cassette rear and the inside surface of the substrate stop
B6	The distance between the cassette front and the front edge of the substrate
C1	Mizo opening width
C2	Mizo depth
C3	Mizo clearance
C4	Mizo size
C5	Tooth size
C6	Substrate clearance
D1	First mizo dimension
D2	First mizo clearance
D3	Thickness of the cassette bottom plate
D4	Thickness of the cassette top plate
D5	Inner height
D6	Width of mizo plate space

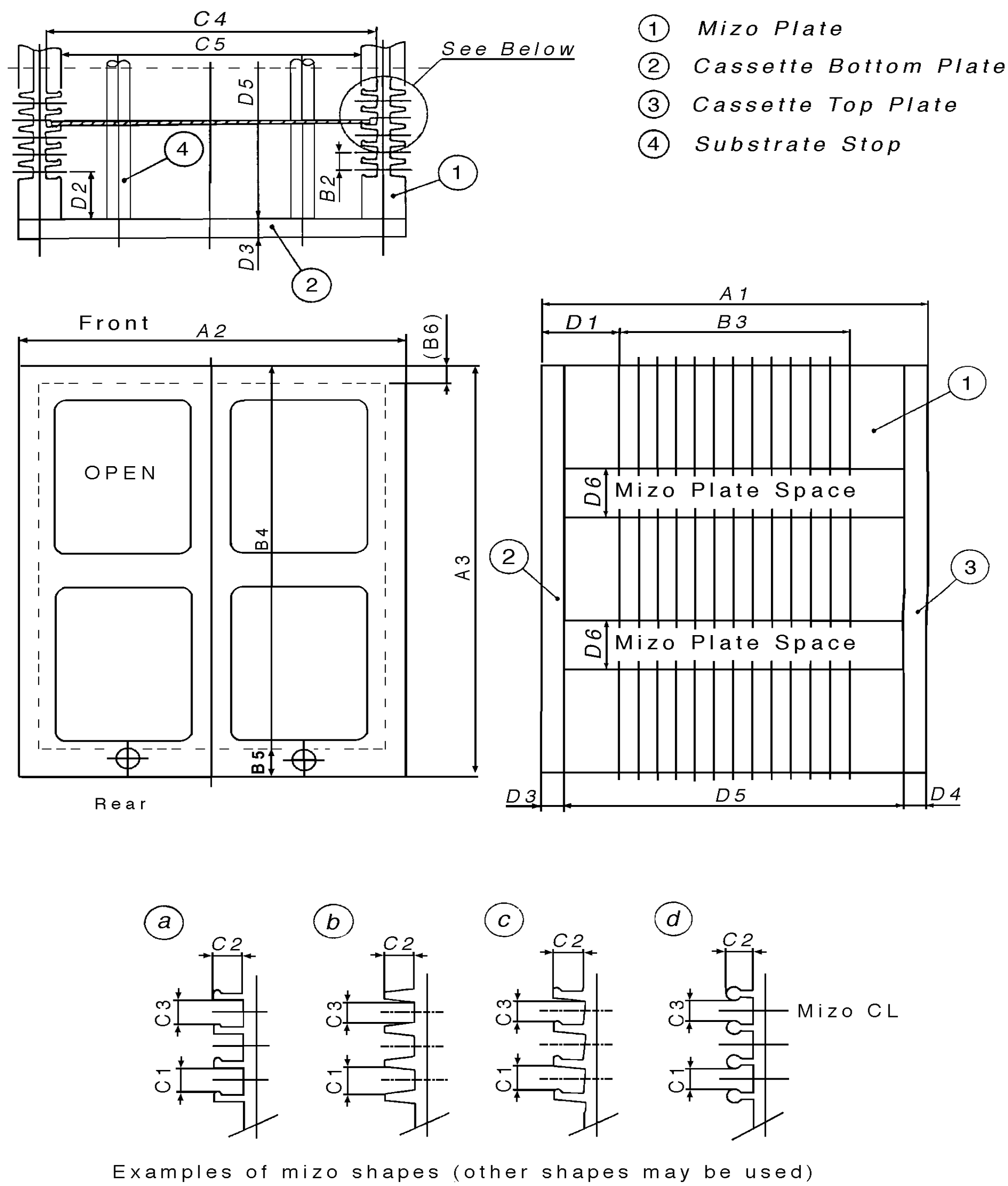

Figure 1
FPD Substrate Cassette (Detail View)

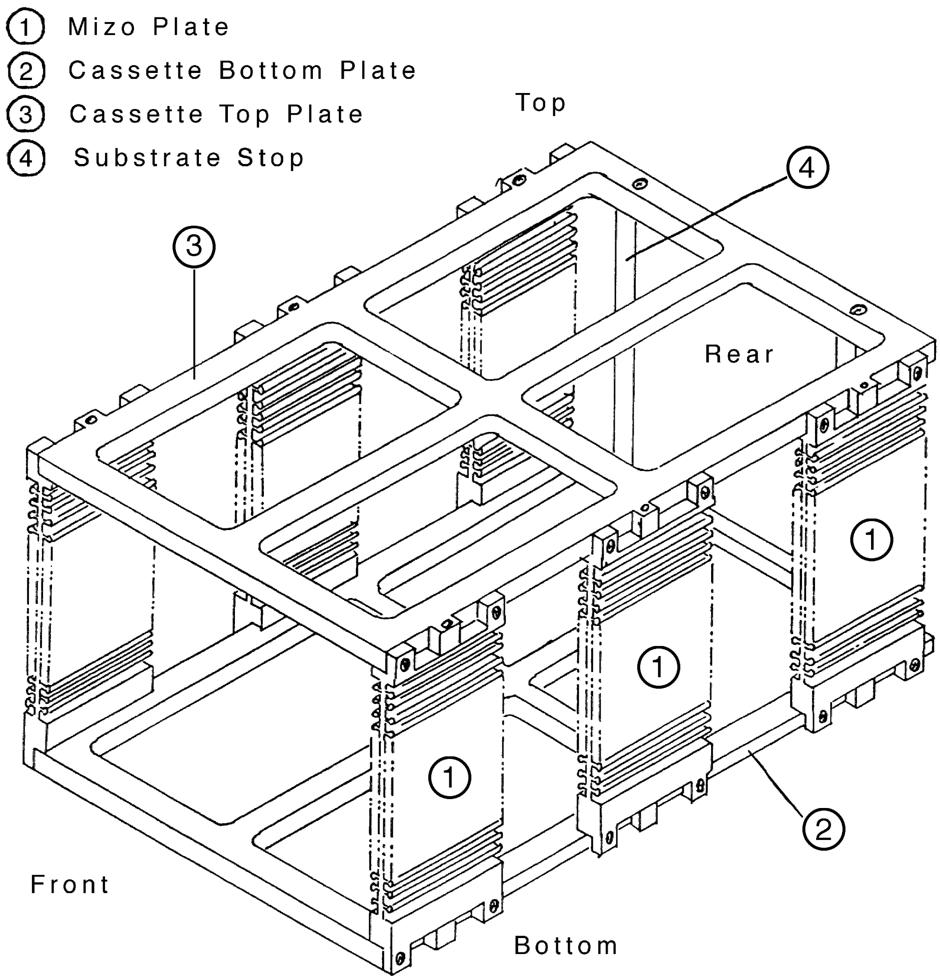

Figure 2

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SEMI D12-95 (Reapproved 0703)
SPECIFICATION FOR EDGE CONDITION OF FLAT PANEL DISPLAY (FPD) SUBSTRATES

This specification was technically approved by the Global Flat Panel Display Committee and is the direct responsibility of the Japanese FPD Materials and Components Committee. Current edition approved by the Japanese Regional Standards Committee on April 28, 2003. Initially available at www.semi.org June 2003 to be published July 2003. Originally published in 1995.

1 Purpose

1.1 This document defines various aspects of the edges of a flat panel display substrate and describes their relationships. It assumes the existence of terminology described in other SEMI flat panel display documents. It applies to substrates whose nominal thickness specification is 1.1 mm.

2 Scope

2.1 *Significance* — The edges of a flat panel display substrate are important in both the specifications for and uses of the material. They effect the means for producing, handling, storing, and processing substrates. Defining the terminology and the geometric properties of these edges will assist both the producers and users of substrates and processing/inspection equipment.

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 D3 — Quality Area Specification for Flat Panel Display Substrates

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

4 Terminology

4.1 *Definitions*

4.1.1 *corner* — of a substrate, any corner other than the orientation corner.

4.1.2 *edge length* — of a substrate, the nominal length of an edge, including that portion at the edge corner(s) from which material may have been removed for finishing purposes. It is "…defined by two dimensions X and Y, with nominal and tolerance values for each."

4.1.3 *orientation convention* — a means for denoting the rotational orientation of a substrate.

4.1.4 *orientation corner* — the corner of a substrate which identifies the pattern surface and rotational orientation.

5 Edge Condition

5.1 All edges shall be treated for purposes of operator safety and to minimize particulate generation. Edges shall be chamfered per Figure 1; other edge treatments are being developed as outlined in Related Information 1.

5.2 Other edge-related parameters shall be per Table 1.

6 Corner Condition

6.1 The orientation corner is asymmetrical for all substrates, with dimensions per Figure 2.

6.2 The edge condition within all corner areas shall meet the criteria of Section 5.

Table 1

Parameter	*Nominal*	*Tolerance*
Length	< 400 mm ≥ 400 mm	± 0.2 mm ± 0.3 mm
Squareness	≤ ± 1/1000 of longer edge for chamfered edge	

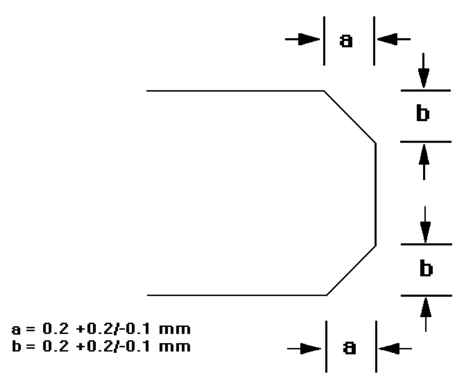

Figure 1
Chamfered Edge