9.5 *Content of the Data Matrix Code Symbol*

9.5.1 Each rectangular matrix code symbol shall contain between 46 message characters (for 16 rows × 36 columns) and 72 message characters (for 16 rows × 48 columns), encoded in accordance with AIM International Symbology Specification – Data Matrix.

9.5.2 The message characters may include any of those designated as "mostly upper case" Annex K of AIM International Symbology Specification – Data Matrix. 8-bit characters may also be encoded with reduced field capacity. The first 20 characters shall contain two elements:

a. a vendor-assigned 15-character mask identification code, followed by

b. a 1-character field concatenation symbol (+) and 2-character field ID (per ANSI MH 10.8)

9.5.3 The next 26 message characters shall contain two elements:

a. a customer-assigned 13-character part #, followed by

b. a 1-character field concatenation symbol (+) followed by a 2-character field ID and

c. a 12-character customer-assigned part revision number.

9.5.4 The remaining message characters, if any, shall contain information as agreed between the vendor and the user. This may require field identifiers and field concatenation.

9.5.4.1 Field identifiers listed in ANSI MH 10.8.2 include:

a. Customer part number revision: 2P

b. Customer specification number: 20P

c. Customer specification revision: 21P

d. Customer drawing number: 12P

e. Customer drawing number revision: 22P

9.5.5 *Location of the Data Matrix Code Symbol*

9.5.5.1 With the substrate positioned front surface up and with the orientation corner toward the operator and to the operator's left, the reference point of the data matrix code symbol shall be placed toward the orientation corner and

8 ± 1 mm from the substrate's y-edge; this provides clearance for corner cuts or other elements adjacent to the corner, and

3 ± 1 mm from the substrate's x-edge; this approximately centers the field between the x-edge and the FQA boundary.

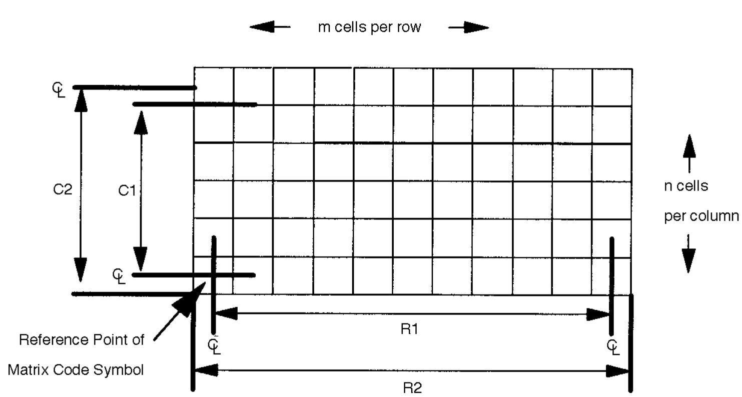

Figure 7
Data Matrix Field

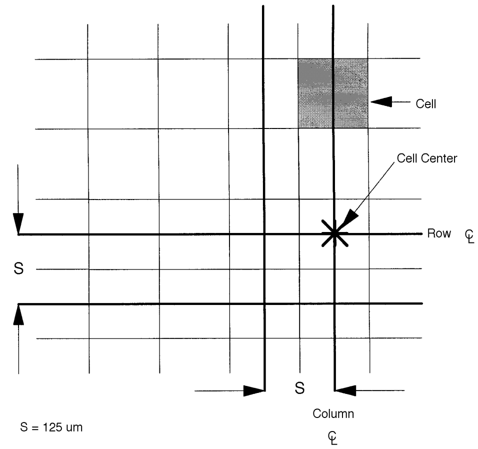

Figure 8
Data Matrix Cell Dimensions

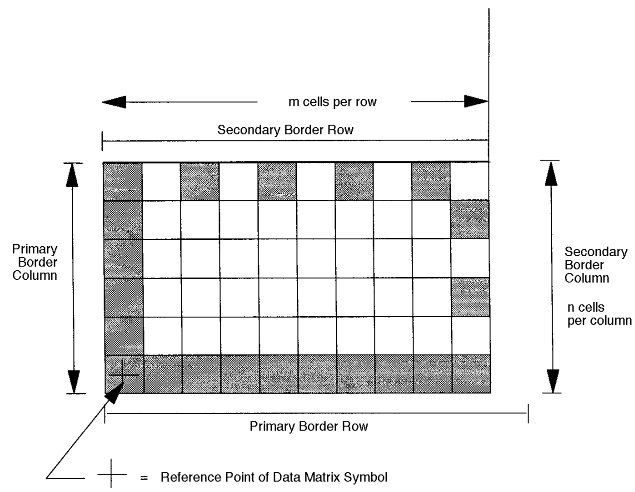

Figure 9
Border Rows and Columns

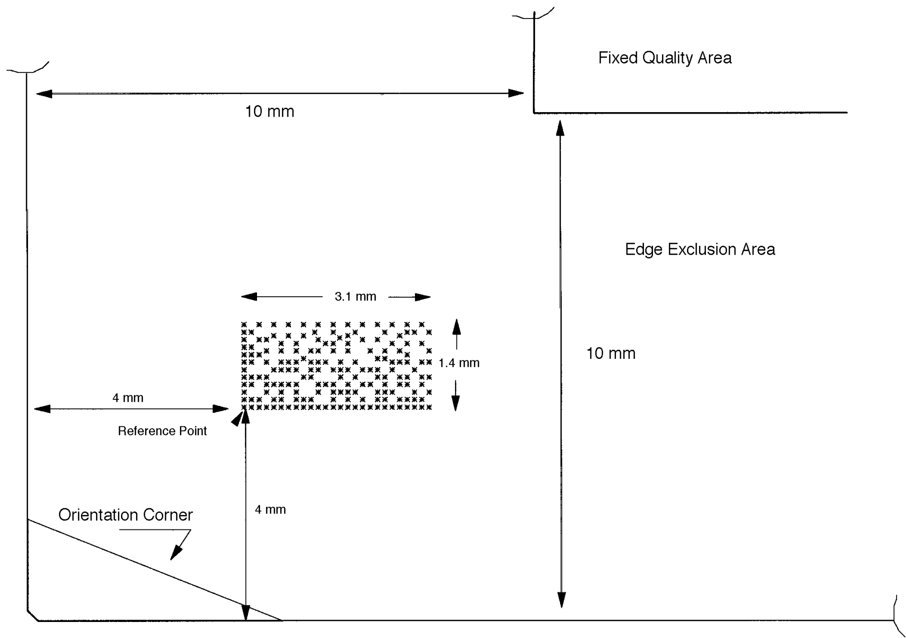

Figure 10
Data Matrix Code Field in Edge Exclusion Area

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 D27-1000
GUIDE FOR FLAT PANEL DISPLAY EQUIPMENT COMMUNICATION INTERFACES

This guide was technically approved by the Global Flat Panel Display Committee and is the direct responsibility of the North American Flat Panel Display Committee. Current edition approved by the North American Regional Standards Committee on August 28, 2000. Initially available at www.semi.org August 2000; to be published October 2000.

1 Purpose

1.1 This is a guide for implementing equipment communication features for successful integration and automation in a flat panel display manufacturing facility.

2 Scope

2.1 This guide includes references to other SEMI standards. It also includes definitions and explanations specific to FPD equipment automation.

2.2 The scope of this guide is limited to equipment communication features that interface with factory automation systems.

2.3 This guide does not reference physical or electrical interfaces, except to the extent necessary to implement the features described. For example, a serial data cable connector could be specified to have 9 pins or 25 pins.

2.4 This guide may not be applicable to all types of FPD equipment. It only applies to those for which a direct data communication interface will be implemented between the equipment and the factory automation systems.

2.5 This guide does not address all software standards that may be applicable, but addresses a subset that is necessary for effective integration and automation.

2.6 This standard does not purport to address safety issues, if any, 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.

3 Limitations

3.1 The other SEMI standards referred to in this document have been carefully reviewed for applicability to FPD manufacturing. However, when referring to other SEMI standards used in this specification, the reader should allow for some editorial exceptions in order to apply the specification to FPD equipment. For example, if another SEMI specification referenced here uses the term "wafer", the reader can assume that this also applies to FPD substrates, and likewise with "silicon" and glass or plastic. These minor differences in no way impact the interpretation or implementation of those standards in FPD manufacturing equipment and factory systems.

3.2 This guide is not an all-inclusive list of applicable standards, but is a starting point for defining requirements of these equipment automation functions, and a guideline for implementation.

4 Referenced Standards

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

4.1 *SEMI Standards*

SEMI E4 — SEMI Equipment Communications Standard 1 Message Transfer (SECS-I)

SEMI E5 — SEMI Equipment Communications Standard 2 Message Content (SECS-II)

SEMI E23 — Specification for Cassette Transfer Parallel I/O Interface

SEMI E30 — Generic Model for Communications and Control of SEMI Equipment (GEM)

SEMI E37 — High-Speed SECS Message Services (HSMS), Generic Services

SEMI E37.1 — High-Speed SECS Message Services, Single-Session Mode (HSMS-SS)

SEMI E84 — Specification for Enhanced Carrier Handoff Parallel I/O

5 Terminology

5.1 The following define some descriptive terms that can be used to refer to systems that meet the requirements of the standards referenced herein.

5.1.1 *SECS Compliant* — This term is often used to describe systems which comply completely with both the SEMI E4 (SECS-I) and SEMI E5 (SECS-II) standards. However, it is more appropriate to identify the system as "SECS-I Compliant" and/or "SECS-II" compliant. This distinction is important because SECS-II can be implemented independently from SECS-I. The term "SECS Compliant" is ambiguous, but commonly used. It is suggested that the following terms be used instead to describe the equipment and host communication interface.

5.1.2 *SECS-I Compliant* — This term is used to identify a system that complies completely with SEMI E4.

5.1.3 *SECS-II Compliant* — This term is used to identify a system that complies completely with SEMI E5.

5.1.4 *HSMS Compliant* — This term is used to describe systems which comply with SEMI E37 (HSMS) and either SEMI E37.1 (HSMS-SS) or SEMI E37.2 (HSMS-GS) or both. However, it is more appropriate to identify the system as either “HSMS-SS Compliant” or “HSMS-GS Compliant”, since they both imply compliance with SEMI E37, and the user must know exactly which of the two is supported. The term “HSMS Compliant” is ambiguous, but commonly used.

5.1.5 *HSMS-SS Compliant* — This term is used to identify a system that complies completely with SEMI E37 and SEMI E37.1. This protocol has been adopted for use in FPD.

5.1.6 *HSMS-GS Compliant* — This term is used to identify a system that complies completely with SEMI E37 and SEMI E37.2.

5.1.7 *GEM* — Generic Equipment Model as defined in SEMI E30.

5.1.8 *GEM Compliant* — This term is defined in SEMI E30.

5.1.9 *Fully GEM Capable* — This term is defined in SEMI E30.

5.1.10 *System* — Either manufacturing equipment or factory host.

6 Data Transfer

6.1 For optimum compatibility, systems supporting the automation capabilities described herein should support all requirements defined for at least one of the following SEMI protocol standards:

6.1.1 SEMI E4 (SECS-I)

6.1.2 SEMI E37.1 (HSMS-SS). Note that this requires implementation of SEMI E37.

6.1.2.1 HSMS-SS compliant interfaces are preferred for FPD manufacturing because of its performance and logistical advantages, and because it allows other protocols to operate on the same connection simultaneously.

6.1.2.2 However, SECS-I interfaces are acceptable in systems where the performance of a serial interface is sufficient. Since many off-the-shelf component software implementations support both protocols, it is relatively easy to design systems which can be configured to support either.

7 Data Format

7.1 The system should support all minimum requirements of SEMI E5 (SECS-II). Although more modern data communication specifications are available (e.g. HTML), SECS-II has unique aspects which are valuable in microelectronics manufacturing. Also, there are many available “off-the-shelf” software packages which provide the SECS-II feature set.

7.2 Furthermore, for maximum compatibility and reliability, the implementation of any optional SEMI E5 objects (data items, variable items, messages, etc.) on the system should meet the requirements of SEMI E5. For example, if an FPD system implements the S7,F3 message, it must do so in compliance with SEMI E5 to be considered “SECS-II Compliant”. It is possible to implement “user-defined” SECS-II messages, and it is allowed by SEMI E5.

7.3 However, it is usually unnecessary to use such custom SECS-II messages. Complicated scenarios such as production sequence control, inline production, consumable management, and material handling can all be implemented using standard SECS-II messages. Many SECS-II messages are designed to be very generic and very flexible such as the Remote Command message (S2F41 or S2F49) which can contain any number of parameters of any type in any format. Many of the basic SECS-II data items such as variables can also take on any type of value in any format.

7.4 User-defined data items and messages are more difficult to integrate into FPD factory automation systems and should be avoided.

8 GEM and SEM

8.1 *Generic Equipment Model (GEM)*

8.1.1 Any reference to the term “GEM” (Generic Equipment Model) with respect to FPD manufacturing equipment will be construed as a reference to SEMI E30. The system provider should ensure that this term is used only for those systems which rigidly adhere to SEMI E30. End-users will make certain assumptions about the capabilities of “GEM” systems based on the requirements of SEMI E30.

8.1.2 SEMI E30 is applicable to FPD manufacturing equipment. FPD equipment suppliers may choose to implement GEM. In order for FPD equipment to be “GEM Compliant” or “Fully GEM Capable”, it must meet the requirements of SEMI E30 without exception. However, it may not be necessary to implement certain optional GEM capabilities for effective FPD automation.

8.1.3 The implementation of SEMI E30, or lack thereof, is usually a point of much negotiation between equipment supplier and end-user. SEMI E30 provides a useful template for identifying which capabilities are to be provided and which are not. The "GEM Compliance Statement" document should be provided by the equipment supplier to describe the capabilities of the interface, whether or not the system is GEM Compliant.

8.1.4 GEM is not applicable to host systems, but host systems must implement a compatible set of features to work effectively with GEM equipment.

8.2 *Specific Equipment Model (SEM)*

8.2.1 The concept of a Specific Equipment Model, which requires compliance with SEMI E30 (GEM), could be applied to FPD equipment as well. This document does not address SEMs. The user may wish to review the published SEM standards and determine their applicability in an FPD implementation.

9 Interfaces to Material Transfer Systems

9.1 *Carrier Transfer Parallel I/O Interfaces*

9.1.1 Material handling systems are critical for many FPD manufacturing operations. But, not all equipment support the automated transfer of material to and from the equipment. This section only applies to systems, which support automated carrier transfer.

9.1.2 For compatibility with many automated material handling systems on the factory floor, FPD equipment should support all requirements for at least one of the following SEMI carrier transfer parallel I/O standards:

9.1.2.1 *SEMI E23 (Cassette Transfer Parallel I/O Interface)* — Note that the diagram in SEMI E23 showing placement of the photo-coupled I/O interface with respect to the carrier stage (CS) shows specific CS size measurements. However, this is just an example and not a requirement of SEMI E23. The requirement is that the photo sensor must be on the front edge of the CS and its center aligned with the center of the CS. This applies to a CS of any size.

9.1.2.2 *SEMI E84 (Enhanced Carrier Handoff Parallel I/O Interface)* — Note that SEMI E84 references SEMI E1.9, SEMI E15, SEMI E15.1, SEMI E47.1, and SEMI E64 which are semiconductor specific standards and not applicable to FPD. However, none of the requirements in these documents are prerequisites for implementing SEMI E84. SEMI E84 is applicable to FPD and can be implemented independently.

SEMI D28-1101
SPECIFICATION FOR MECHANICAL INTERFACE BETWEEN FLAT PANEL DISPLAY MATERIAL HANDLING EQUIPMENT AND TOOL PORT, USING AUTOMATED GUIDED VEHICLE (AGV), RAIL GUIDED VEHICLE (RGV), AND MANUAL GUIDED VEHICLE (MGV)

This specification was technically approved by the Global Flat Panel Display Material Handling Committee and is the direct responsibility of the Japanese Flat Panel Display Material Handling Committee. Current edition approved by the Japanese Regional Standards Committee on August 3, 2001. Initially available at www.semi.org September 2001; to be published November 2001.

1 Purpose

1.1 This specification defines a common set of feature requirements on and about tool ports of process tools used in manufacturing of flat panel displays. These standardized feature requirements are intended to facilitate the interfacing of AGV, RGV, and MGV equipment to the process tool. Such standards are intended to promote cost-effective interfacing while preserving freedom of choice in material handling equipment, using AGV, RGV, and MGV.

2 Scope

2.1 This specification defines mechanical features on or about the tool port, and in front of or on the tool face. Although these features are intended for specific functions of AGV, RGV, and MGV, the interface requirements are meant to avoid the promotion of any particular form of transport.

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

3 Limitations

3.1 Current display manufacturing utilizes several substrate sizes, many of them “non-standard.” This specification includes dimensions for the substrate sizes of 550 × 650 mm, 600 × 720 mm, 680 × 880 mm, 730 × 920 mm, and 800 × 950 mm and anticipates the establishment of standard dimensions in future substrate sizes.

4 Referenced Standards

4.1 None.

5 Ordering Information

5.1 Since this document is not a product specification but an interface specification, ordering information is not applicable.

6 Terminology

6.1 *Definitions*

6.1.1 *cassette loading position* — center point at under-surface of a cassette after loading by transport equipment.

6.1.2 *facial datum plane* — a plane that is parallel to the tool face and vertical to both vertical and horizontal datum planes at the cassette loading position.

6.1.3 *horizontal datum plane* — a plane that is parallel to the floor surface at the cassette loading position.

6.1.4 *vertical datum plane* — a plane that is vertical to both facial and horizontal datum planes at the cassette loading position.

6.2 *Dimensional Functions*

6.2.1 *X1* — width of the exclusion zone above the horizontal datum plane, which is needed by the transport equipment in loading cassettes.

6.2.2 *X2* — width of the exclusion fork zone below the horizontal datum plane, which is needed by the transport equipment in loading cassettes.

6.2.3 *X3* — width of the exclusion zone required for MGV cart alignment equipment.

6.2.4 *Y1* — dimension between the facial datum plane and the front of the tool port.

6.2.5 *Y2* — dimension between the facial datum plane and the tool face, which is the exclusion zone needed by the transport equipment in loading cassettes.

6.2.6 *Y3* — depth of exclusion zone required for MGV cart alignment equipment.

6.2.7 *Z1* — height between the horizontal datum plane and the floor surface.

6.2.8 *Z2* — height of exclusion zone above the horizontal datum plane, which is needed by the transport equipment in loading cassettes.

6.2.9 *Z4* — height of exclusion zone required for MGV cart alignment equipment.

6.2.10 *Z5* — height of exclusion fork zone below the horizontal datum plane, which is needed by the transport equipment in loading cassettes.

7 Requirements

7.1 Dimensions and tolerances of the required characteristics are shown in Table 1 as well as Figures 1A and 1B.

7.2 The cassette is stored horizontally with the shorter side parallel to the tool face and horizontal datum plane.

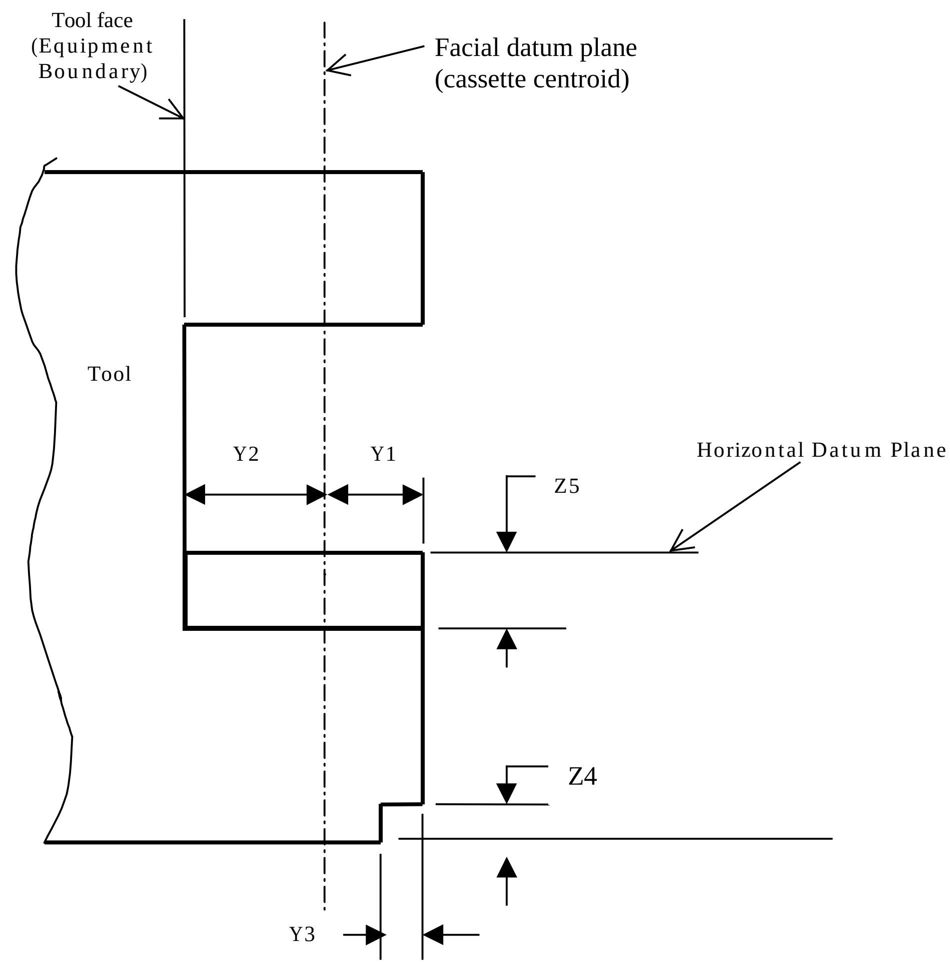

Figure 1A
(Arrow 'A' View)
Side View of Tool port

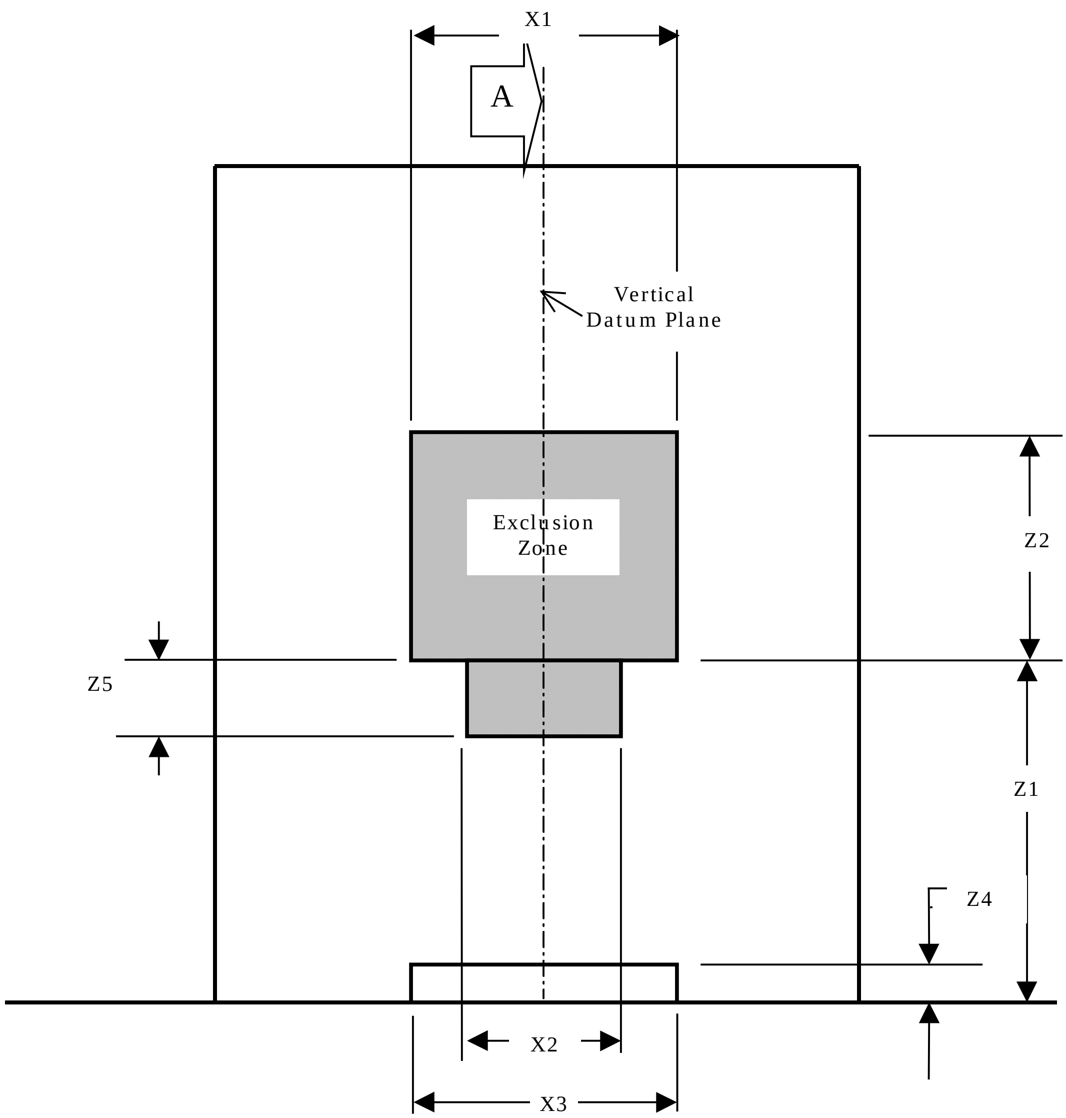

Figure 1B
Front View of Tool port

Table 1 Substrate Edge Length, Interface Dimensions, and Tolerances

Substrate Edge Length [mm]	*Interface Dimensions and Tolerances[mm]*									
	X1 max.	*X2 max.*	*X3 max.*	*Y1 max.*	*Y2 max.*	*Y3 max.*	*Z1 ± 2 mm*	*Z2 max.*	*Z4 max.*	*Z5 max.*
550 × 650	925	450	600	500	440	130	900, 950	1000	150	250
600 × 720	980	500	600	535	475	130	900, 1000	1000	150	250
680 × 880	1100	560	600	615	565	130	1000, 1100	1000	150	300
730 × 920	1150	600	600	630	590	130	1000, 1100	1000	150	300
800 × 950	1200	660	600	650	605	130	1000, 1100	1000	150	300

NOTE 1: Two values are specified for Z1, either value can be chosen.

8 Related Documents

8.1 *SEMI Standards*

SEMI D5 — Standard Size for Flat Panel Display Substrates

SEMI D11 — Specification for Flat Panel Display Glass Substrate Cassettes

SEMI D16 — Specification for Mechanical Interface Between Flat Panel Display Material Handling System and Tool Port

8.2 *Semiconductor Equipment Association of Japan (SEAJ)*

Semiconductor Equipment Association of Japan (SEAJ) Liquid Crystal Display Manufacturing Equipment Standardization Guideline – for Glass Substrate Size 800 × 950 (SEAJ/P-S3005-98, SEAJ/P-S3006-98), June 1998 [1]

8.3 *SEMI PCS-FPD*

SEMI PCS-FPD — Production Cost Saving (PCS) Forum – FPD Phase III Report, June 1999 [2]

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

2 SEMI PCS-FPD — Production Cost Saving (PCS) Forum – FPD Phase III Report, June 1999, Semiconductor Equipment and Materials International, 3081 Zanker Road , San Jose, CA 95134-2127 U.S.A.tel.+1-408-943-6900 fax:+1-408-428-9600 http://www.semi.org

RELATED INFORMATION 1
ASSUMED DIMENSIONS FOR SUBSTRATE EDGE AND CASSETTE SIZE

NOTE: This related information is not an official part of SEMI D28 and was derived from work of the originating committee. This related information was approved for publication by full letter ballot procedures on August 3, 2001.

Table R1-1 Cassette Size

Substrate Edge length [mm]	*Cassette size [mm] Width×Length×Height*
550×650	$591 \times 682 \times 524$
600×720	$642 \times 755 \times 695$
680×880	$736 \times 923 \times 706$
730×920	$792 \times 978 \times 770$
800×950	$870 \times 1010 \times 810$

NOTE 1: 550×650, 600×720, 680×880, and 730×920 are the sizes which are actually adopted at the manufacturing sites. As for 800×950, please refer to SEMI PCS-FPD-Phase III Report.
NOTE 2: Cassette sizes in Table R1-1 were used only hypothetically as assumption to prescribe dimensions in Table 1.

SEMI D29-1101
TEST METHOD FOR HEAT RESISTANCE IN FLAT PANEL DISPLAY (FPD) COLOR FILTERS

This test method was technically approved by the Global Flat Panel Display Materials and Components Committee and is the direct responsibility of the Japanese Flat Panel Display Materials and Components Committee. Current edition approved by the Japanese Regional Standards Committee on August 3, 2001. Initially available at www.semi.org September 2001; to be published November 2001.

1 Purpose

1.1 The purpose of this document is to standardize the method for measurement of heat resistance in color filters used for flat panel displays (FPD).

2 Scope

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

2.2 This method is used in general FPD production to test the resistance of color filters to heat.

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

3 Referenced Standards

3.1 *SEMI Standards*

SEMI D19 — Test Method for the Determination of Chemical Resistance of Flat Panel Display Color Filter

SEMI D22 — Test Method for the Determination of Color, Transmittance of Flat Panel Display Color Filter Assemblies

3.2 *ISO Standards*[1]

ISO 7724 [2,3] — Paints and varnishes -- Colorimetry

NOTE 1: Unless otherwise indicated, all documents cited shall be the latest published versions.

4 Terminology

4.1 *atomic force microscope (AFM)* — a device which precisely measures surface shape by gauging the reciprocal active force between atoms through use of a probe.

4.2 *clean oven* — a device that heats a specimen through circulation of heated air through an air filter.

4.3 *confocal scanning laser microscope* — a microscope which is able to create an image of just the focal point by concentrating light on a specimen using a confocal laser. This device can also measure surface shape by recording height information, which matches the focal point of each scans line image.

5 Summary of Method

5.1 Measure spectral transmittance, chromaticity, and surface shape of specimen.

5.2 Place specimen in heating device and leave at specified temperature for specified length of time.

5.3 Remove specimen from heating device and cool them.

5.4 Observe visually and by microscope to see if any exterior changes have occurred in the specimen.

5.5 Measure spectral transmittance, chromaticity, and surface shape of specimen.

6 Apparatus

6.1 *Heating Device and Holders*

6.1.1 *Heating Device* — Use a clean oven. The heating device being used must have the accuracy of temperature verified. Also, the device should have enough capacity to be able to heat the specimen evenly to the target temperature promptly. For example, there are devices where it is necessary to place a metal block inside to increase the heating capacity to the specimen.

6.1.2 *Holder* — First the holder should be raised to the specified temperature and then the specimen should be set in the holder.

1 International Organization for Standards(ISO), 1, rue de Varembe, Case, postale 56 CH-1211 Geneva 20, Switzerland. Tel: +41-22-749-01-11, E-mail: central@iso.ch, http://www.iso.ch

2 Available in Japanese as JIS Z8730 — Method for Specification of Color Differences for Opaque Material. Japanese Standards Association, 1-24, Akasaka 4 Chome, Minato-ku, Tokyo, 107-8440 Japan. Tel: +81-3-3583-8000, E-mail: webmaster@jsa.or.jp, http://www.jsa.or.jp

3 The expression method of its color differences is equal to the method defined in Publication of CIE No. 87 (1990) Parametric Effects in Color – Difference Evaluation. Commission Internationale de l'Eclairage, Kegelgasse 27, A-1030 Vienna, Austria. Tel: +43-1-714-31-87-0

6.2 *Measurement Devices*

6.2.1 *3-dimensional Profile Measurement Device* — Use a Stylus type surface roughness measurement device, AFM or laser microscope.

6.2.2 *Color Illuminator* — See SEMI D19.

6.2.3 *Floodlight* — See SEMI D19.

6.2.4 *Microscope* — See SEMI D19.

6.2.5 *Spectrophotometer* — Use a device in conformance with SEMI D22.

7 Test Conditions

7.1 As long as the test condition should be written in the test result, any combination of temperature and heating time can be acceptable in the conditions. The test conditions used should reflect actual conditions in the manufacturing process of flat panel displays. Table 1 contains a reference for test temperature, maintain time and atmosphere.

Table 1 Test Conditions

Item	*Device Condition*	*Test Temperature*	*Maintain time*
1	Room Air	180°C (± 2°C) 200°C (± 2°C) 230°C (± 2°C)	1 hour (± 5%)
2	Nitrogen Gas	180°C (± 2°C) 200°C (± 2°C) 230°C (± 2°C)	1 hour (± 5%)

8 Test Specimen

8.1 Use FPD color filters for specimens. In the test report, note the existence or non-existence of Transparent Conductive Film (ITO etc.).

9 Procedure

9.1 Adjust the temperature on the heating device and make sure of the furnace temperature.

9.2 Measure the spectral transmittance, chromaticity. Observe the surface of each color layer of the specimen. (The measurement method is described in Sections 9.6 and 9.7.)

9.3 Mount the specimen in the heating device.

9.4 After the temperature returns to the specified temperature, keep the specimen for the prescribed length of time.

9.5 Remove the specimen from the heating device and cool them to room temperature.

9.6 Inspect change of the outlook and the profile of the specimen according to the following procedures.

9.6.1 Observe the existence of peculiar changes in exterior appearance before and after each test (e.g. wrinkles, cracks, color "mura" etc.). It is possible for the users of this standard to use various appropriate methods of observation.

9.6.2 Visual observation by color illuminator from backside.

9.6.2.1 Visual observation by a floodlight from front side.

9.6.2.2 Microscope observation with transmitted illumination.

9.6.2.3 Microscope observation with reflected illumination.

9.6.2.4 Surface roughness measurement using a stylus-type surface roughness measurement device, AFM or laser microscope.

9.7 Measure the color changes according to the following procedures.

9.7.1 Measure the spectral transmittance and chromaticity of each color layer after heating using the method described in SEMI D22. (Measurements must be taken at the same location as before heating.)

9.7.2 Before and after the test, calculate the color difference ΔE^*ab or ΔE^*uv, in each color layer, according to ISO 7724, from the chromaticity of each color layer.

10 Reporting Results

10.1 Report the following items:

10.1.1 report date,

10.1.2 test date,

10.1.3 heating device type and conditions of use,

10.1.4 condition of specimen (with/without Transparent Conductive Film (ITO etc.), size, etc.),

10.1.5 conditions of test (temperature, length of time),

10.1.6 existence of change in outward appearance,

10.1.7 chromaticity, spectral transmittance of each color layer before and after thermal treatment (number of measuring points, position),

10.1.8 color difference of each color layer before and after thermal treatment, and

10.1.9 change in spectral transmittance at specified wavelength (e.g. back-light peak wavelength, etc.).

11 Related Documents

11.1 *SEMI Standards*

SEMI D13 — Terminology for FPD Color Filter Assemblies

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 D30-1101
TEST METHOD FOR LIGHT RESISTANCE IN FLAT PANEL DISPLAY (FPD) COLOR FILTERS

This test method was technically approved by the Global Flat Panel Display Materials and Components Committee and is the direct responsibility of the Japanese Flat Panel Display Materials and Components Committee. Current edition approved by the Japanese Regional Standards Committee on August 3, 2001. Initially available at www.semi.org September 2001; to be published November 2001.

1 Purpose

1.1 The purpose of this document is to standardize the method for measurement of light resistance in color filters used for flat panel displays (FPD).

2 Scope

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

2.2 This method shall be used in general FPD production to test the resistance of color filters to light.

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

3 Referenced Standards

3.1 *SEMI Standards*

SEMI D19 — Test Method for Chemical Resistance of FPD Color Filter

SEMI D22 — Test Method for the Determination of Color, Transmittance of FPD Color Filter Assemblies

3.2 *JIS Standards (available in Japanese only)*[1]

JIS B7751 — Light-exposure and light-and-water-exposure apparatus (Enclosed carbon-arc type)

3.3 *ISO Standards*[2]

ISO 4892 — Methods of exposure to laboratory light sources

ISO 7724 [3,4] — Paints and varnishes -- Colorimetry

NOTE 1: Unless otherwise indicated, all documents cited shall be the latest published versions.

4 Terminology

4.1 *atomic force microscope (AFM)* — a device which precisely measures surface shape by gauging the reciprocal active force between atoms through use of a probe.

4.2 *fade meter* — a device which tests for the existence of external change or characteristics in materials by long term irradiation using fixed brilliance from a prescribed light source.

5 Summary of Method

5.1 Measure spectral transmittance, chromaticity, and surface shape of specimen.

5.2 Place specimen in light exposure apparatus and irradiate for specified length of time.

5.3 Remove specimen from light exposure apparatus.

5.4 Observe visually and by microscope to see if any exterior changes have occurred in the specimen.

5.5 Measure spectral transmittance, chromaticity, and surface shape of specimen.

6 Apparatus

6.1 *Light Exposure Apparatus* — Choose a test device to use from the following devices and specify which device was used in the report.

6.1.1 Carbon-arc Fade Meter

6.1.2 Sunshine Carbon-arc Fade Meter

6.1.3 Xenon-arc Fade Meter

1 Japanese Standards Association, 1-24, Akasaka 4 Chome, Minato-ku, Tokyo, 107-8440 Japan. Tel: +81-3-3583-8000, E-mail: webmaster@jsa.or.jp, http://www.jsa.or.jp

2 International Organization for Standards(ISO), 1, rue de Varembe, Case, postale 56 CH-1211 Geneva 20, Switzerland. Tel: +41-22-749-01-11, E-mail: central@iso.ch, http://www.iso.ch

3 Available in Japanese as JIS Z8730 — Method for Specification of Color Differences for Opaque Material.

4 The expression method of its colour differences is equal to the method defined in Publication of CIE No. 87 (1990) Parametric Effects in Color – Difference Evaluation. Commission Internationale de l'Eclairage, Kegelgasse 27, A-1030 Vienna, Austria. Tel: +43-1-714-31-87-0

6.2 *Measuring and Inspection Devices*

6.2.1 *Color Illuminator* — This light source shall have chromaticity, color rendering, luminance and intensity uniformity, diffusion, and a sufficient illumination area for observation of the specimen to be measured (See SEMI D19).

6.2.2 *Floodlight* — This light shall have luminance uniformity and an illumination area sufficient for the specimens to be measured (See SEMI D19).

6.2.3 *Microscope* — Use a microscope which has either transmitted illumination or reflected illumination, or both, and has a sufficient magnification ratio (See SEMI D19).

6.2.4 *Spectrophotometer* — The spectrophotometer shall be in conformance with SEMI D22.

6.2.5 *Surface Shape Measurement Device* — Use a Stylus-type surface roughness measurement (film thickness measurement) device, AFM or laser microscope.

7 Test Conditions

7.1 The principle test conditions are described in Table 1. In the case where tests are performed under conditions in addition to these, clearly state those conditions.

Table 1 Test Conditions

Item	*Device*	*Test Interval*	*Color Filter Condition*	*Evaluation Item*	*Reference Standard*
1	Carbon-arc Fade Meter	100 hrs. ± 5%	With/Without ITO Glass Surface Irradiation With UV-cut Filter	1. External Change 2. Color Difference ΔE*ab or ΔE*uv 3.Transmittance Change	JIS B7751 ISO 4892 ISO 7724
2	Sunshine Carbon-arc Fade Meter	100 hrs. ± 5%			
3	Xenon-arc Fade Meter	500 hrs. ± 5%			

8 Test Specimen

8.1 Use FPD color filters for specimens. In the test results, note the existence or non-existence of Transparent Conductive Film (ITO etc.). Specimen used in the test are cut to an appropriate size for the specified holder of the equipment above, and fastened at the specified distance from the light source. At this time, in order to test in conditions close to actual use, an UV-cut filter is attached to the glass surface, and light is radiated from UV-cut filter side.

9 Procedure

9.1 Turn on the light source of the light exposure apparatus and stabilize it.

9.2 Measure the spectral transmittance, chromaticity, and surface shape of each color layer of the specimen. (The measurement method is described in Sections 9.6 and 9.7.)

9.3 Mount the specimen in the light expose apparatus.

9.4 Radiate light on the specimen for the prescribed length of time. In order to keep the brilliance of the light source uniform over this period of time, control the light source according to the procedures accompanying your inspection device.

9.5 Remove the specimen from the light exposure device.

9.6 Inspect the change of the outlook and the profile of the specimen according to the following procedures.

9.6.1 Observe the existence of peculiar changes in exterior appearance before and after each test (e.g. wrinkles, cracks, color “mura” etc.).

9.6.1.1 Visual observation by a color illuminator from backside.

9.6.1.2 Visual observation by a floodlight from front side.

9.6.1.3 Microscope observation of color filter with transmitted illumination.

9.6.1.4 Microscope observation of color filter with reflected illumination.

9.6.1.5 Surface roughness measurement using a stylus-type surface roughness measurement device, AFM or laser microscope.

9.7 Measure the color changes according to the following procedures.

9.7.1 Measure the spectral transmittance and chromaticity of each color layer after the light resistance test using the method described in SEMI D22. (Measurements must be taken at the same location as before the test.)

9.7.2 Before and after the test, calculate the color difference ΔE*ab or ΔE*uv, in each color layer, according to ISO 7724, from the chromaticity of each color layer.

10 Reporting Results

10.1 Report the following items:

10.1.1 report date,

10.1.2 test date,

10.1.3 light exposure apparatus type and conditions of use,

10.1.4 condition of specimens (with/without Transparent Conductive Film (ITO etc.), size, etc.),

10.1.5 conditions of test (light source, brilliance, length of time, etc.),

10.1.6 existence of change in outward appearance,

10.1.7 chromaticity of each color layer before and after thermal treatment (number of measuring points),

10.1.8 color difference of each color layer before and after thermal treatment, and

10.1.9 change in spectral transmittance at specified wavelength (e.g. back-light peak wavelength, etc.).

11 Related Documents

11.1 *SEMI Standards*

SEMI D13 — Terminology for FPD Color Filter Assemblies

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SEMI D31-1102
DEFINITION OF MEASUREMENT INDEX (SEMU) FOR LUMINANCE MURA IN FPD IMAGE QUALITY INSPECTION

This definition was technically approved by the Global Flat Panel Display Committee and is the direct responsibility of the Japan Flat Panel Display Committee. Current edition approved by the Japan Regional Standards Committee on July 19, 2002. Initially available at www.semi.org October 2002; to be published November 2002.

1 Purpose

1.1 This standard will define the index of measurement for mura in FPD image quality inspection.

1.2 Conventionally, inspection of FPD image quality has been sensory, mainly conducted via the human eye, and among the items detected, there has been no common standard for mura and other associated defects. For this reason, when panel makers and their users who conduct business with a fixed quality level set a mura acceptance level, limit samples are used as necessary.

1.3 Operational problems with limit samples include:

- Level of mura cannot be determined without viewing the sample. Due to this, it is not possible to express the level via written documentation or telephone.
- The sample settings are subjectively decided by the setter, and lack objectivity.
- It is difficult to setup and maintain a consistent sample level at multiple locations.

1.4 *Etc.* — Above all, in a market complicated by multiple panel makers and multiple users, where presently there is no fixed standard for expressing mura level, we have to say that it is extremely difficult to ensure a fixed level for panel quality.

1.5 In this standard, using ergonomics approach, we will investigate the human eye's sensitivity regarding mura, and by expressing the relation between mura area and contrast, propose an index to express the level of mura.

2 Scope

2.1 This standard is applicable to FPD (Flat Panel Displays) excluding CRT and HMD (Head Mount Displays). The display sizes targeted are typically from Type 8 (8" (20.3 cm) diagonal) to Type 30 (30" (76.2 cm) diagonal).

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

3 Limitations

3.1 In the first edition of this standard, the target of measurement, mura, is limited as below.

3.1.1 Line defects narrower than 300 μm and pixel dot defects are not the subject of this standard.

3.1.2 Mura background display is limited to monochrome displays/intermediate gray scale level; RGB, etc. color background and L0/L63 background are not the subject of this standard.

4 Referenced Standards

None.

5 Terminology

5.1 *Definitions*

5.1.1 *Gray Scale* — Gray scale on image display. In this standard, indicates level 32 out of 64 level gray scale.

5.1.2 *L0 Display* — Gradation 0 out of 64. (Pitch Black)

5.1.3 *L63 Display* — Gradation 63 out of 64 (Completely white)

5.2 *Abbreviations and Acronyms*

5.2.1 *JND* — Abbreviation for Just Noticeable Difference. Used in the field of Psychophysics; for a certain stimulus, the smallest change in stimulus (luminance, for example) where a difference can be perceived. Specifically, it is often used to indicate a statistical value where the probability of the difference being "perceptible" is 50% and the probability of the difference "not being perceptible" is 50%. Also expressed using lower case letters, j.n.d.

5.2.2 *Semu* — Semi Mura, Measurement index for mura, defined in this standard.

6 Semu Definition

6.1 Under specific conditions, the below regressive relationship can be seen between area and contrast for Human Mura JND. (Refer to Related Information.)

$$Cjnd = F(Sjnd) = 1.97/Sjnd^{0.33} + 0.72$$

Cjnd: Contrast of mura at JND (Unit: % relative to background = 100%)

Sjnd: Area of mura at above contrast (Units: mm^2)

6.1.1 In the above equation, contrast at JND is inversely proportional to area raised to the 0.33 power. In short, it indicates that as mura area gets smaller, only darker muras can be sensed.

6.2 For the subject mura, the mura level, Semu, can be calculated using the below formula.

$$\begin{aligned} Semu &= |\ Cx| \ / \ Cjnd \\ &= |\ Cx| \ / \ F(Sx) \\ &= |\ Cx| \ /(1.97/Sx^{0.33} + 0.72) \end{aligned}$$

Cx: Average contrast of mura being measured (Unit: % relative to background = 100%)

Sx: Surface area of mura being measured (Units: mm^2)

7 Notation

7.1 Semu is a comparison ratio between contrast of the measurement target and contrast in a JND, and thus has no unit.

7.2 It is recommended that significant digits be displayed to one decimal place.

NOTE 1: Notation uses this following methodology.Notation Example 1: The level of JND mura in this study is Semu = 1.0. Notation Example 2: The level of this mura is Semu 2.5.

8 Test Methods

8.1 *Comparative Measurement and Direct Measurement* — The two methods for determining Semu levels on panels are comparative measurement and direct measurement.

8.1.1 *Comparative Measurement*

8.1.1.1 The comparative measurement method involves a panel and software which can simulate Semu level, to which a person compares a mura on an actual panel, making adjustments, until a level which appears similar is determined. This is a method that can be used in the actual production site easily using the Semu simulation panel as the variable level limit sample.

8.1.2 *Direct Measurement*

8.1.2.1 The direct measurement method captures the actual panel with a CCD camera, or the like, and is a method of measuring the Semu level of the mura section, making it possible to directly determine the Semu from the area and contrast of the mura section that is captured.

8.2 *Measurement Equipment*

8.2.1 Semu measurement consists of measurement of the area of mura on the display surface and contrast measurement, and needs to be appropriately calibrated.

8.3 *Measurement Environment*

8.3.1 Semu measurement will be conducted in a darkroom environment.

8.4 *Display Conditions*

8.4.1 Background luminance for Semu measurement shall be 50 ± 10 cd/m^2.

8.5 *Contrast Measurement*

8.5.1 The average contrast of the mura section shall be measured, and the contrast ratio of the mura section will expressed as a percentage, for when the background = 100%.

9 Related Documents

9.1 Experiment Overview for Calculation of Measurement Index for Mura in FPD Image Quality Inspection. R. Yositake IBM Japan, T.Tamura Tokyo Institute of Polytechnics Oct. 23/2001

RELATED INFORMATION 1
EXPERIMENT OUTLINE FOR CALCULATION OF MEASUREMENT INDEX FOR LUMINANCE MURA IN FPD IMAGE QUALITY INSPECTION

NOTE: This related information is not an official part of SEMI D31. This related information was approved for publication by full letter ballot procedures on July 19, 2002.

R1-1 Purpose

R1-1.1 It has been reported that under the range of certain conditions, a basic expression of FPD mura quality level can be made, using their size and contrast[1]. Here, recreating those experiments, we verified their reproducibility, conducting the experiment with a goal of calculating a measurement index for luminance mura for standardization.

R1-2 Experiment Method

R1-2.1 *Experiment Equipment*

R1-2.1.1 The experiment utilized a 14.1 inch, 1024 X 768 pixel backlit TFT/LCD. As there was a need to display low contrast luminance muras, it was reworked to display 256 gradations in a 43 cd/m^2 ~ 54 cd/m^2 range. A program capable of displaying rectangular and round muras as desired was created, and the muras were displayed in the center of the prepared LCD. The subjects could freely adjust the luminance of the displayed luminance muras using a handheld ten-key pad.

R1-2.2 *Experiment Conditions*

R1-2.2.1 21 types of muras were used. These were four round types (diameter:7, 25, 55, 305 pixels) and 17 rectangular types (31×1, 153×1, 240×1, 480×1, 31×2, 153×2, 240×2, 31×3, 153×3, 240×3, 31×16, 69×35, 140×17, 240×10, 1×31, 1×153, 1×240). Observation conditions were a viewing distance of 500 mm, and view angle normal to the center of the LCD. The experiment room was a darkroom, and the background luminance of the luminance mura was 48 cd/m^2.

R1-2.3 *Subjects/Experiment Procedure*

R1-2.3.1 The subjects for the experiment were 16 adults, with no eye disease and with **near vision strength** (50 cm) of 1.2 or greater for both eyes. Of the 16 subjects, there was an Expert group of 8 (7 male, 1 female, average age 40 years), consisting of engineers from LCD makers, who regularly conduct mura inspections and analysis. The remaining 8 subjects (6 males, 2 females, average age 21) were college students, a Novice group who were conducting luminance mura evaluation for the first time. Using the ten-key pad, the subjects adjusted the luminance of mura, to a point "where mura can just no longer be detected" (referred to as "jnd": just noticeable difference below) and to a "point where mura can clearly be detected" (referred to as "distinct" below), recording the contrasts at these times. Muras brighter than the background and lighter than the background were both targeted.

R1-3 Experiment Results

R1-3.1 The following matters became clear from the experiment.

- The larger the area of the mura, the smaller jnd contrast (*C jnd*) became. (Muras are more visible as area becomes larger)
- Muras with a width of one pixel, compared to other muras, require nearly 1.5 to 2 times the contrast. (Muras with a width of one pixel are difficult to detect)
- Comparing the distribution between the subjects, there was no difference between the Expert and Novice groups for jnd contrast (*C jnd*)
- Compared to the Expert group, the Novice group had a larger distribution for distinct contrast.

R1-3.2 The relation between mura area and jnd contrast showed the same trend as in past experience[1], and the quality of reproducibility was confirmed. Therefore at this point, for the sake of standardization, we examined the function for mura area, and tried linear regression for it with jnd contrast. Figure 1 shows the results. When the horizontal axis is $\frac{1}{S^{0.33}}$ (S is mura area in mm^2 units), and the vertical axis is at contrast, the bold line shows a strong correlation coefficient, understood through linear regression.

R1-3.3 This bold line shows the relation between mura area and contrast at the point where the mura becomes just not detectable (jnd), and if area is determined, then jnd contrast (C jnd) can be figured out. In Figure 1, ○ is a mura with a width of one pixel, and ● represents other muras (not one pixel wide) respectively representing the averages of the 16 subjects. As noted above in 2), a mura with a width of one pixel tends to be slightly different, which is why they were handled separately. Also considering past experiment results, when viewing distance is 500mm, the 0.3mm level seems to be the boundary. Here we propose Equation 1 which regressively analyzes the ● in Figure 1 as criteria for standardization.

$$Cjnd = 1.97\left(\frac{1}{S^{0.33}}\right) + 0.72 \quad \text{…. Equation 1}$$

R1-3.4 The criteria for standardization, *jnd*, is determined by the *C jnd* straight line, but we also propose, based on this criteria, quality levels for other visible muras. Figure 1 shows straight lines made up of 2.0 *jnd* and 3.0 *jnd*. × is distinct contrast for the Expert group, but in cases besides 1-pixel wide muras, it can be understood to be distributed slightly above the 2.0 jnd straight line.

R1-3.5 This indicates that the straight-line relationship of Figure 1 is not only *jnd* level, but also consists of visible contrast level. Accordingly, with the bold line *jnd* as a standard, mura quality level can be expressed by n in n x *jnd*. From the experiment results this time, from 3.0 being a level slightly above distinct, it can be thought that it is desirable to operate using a range of levels 1.0 to 3.0.

R1-4 Summary

R1-4.1 A proposal was made regarding the quantization of FPD luminance mura. The quality level of a mura can be expressed as a function between mura area and contrast, using the contrast at the jnd point as criteria. By using this method, even if mura area, shape, or contrast is different, we can now calculate similar quality level jnd.

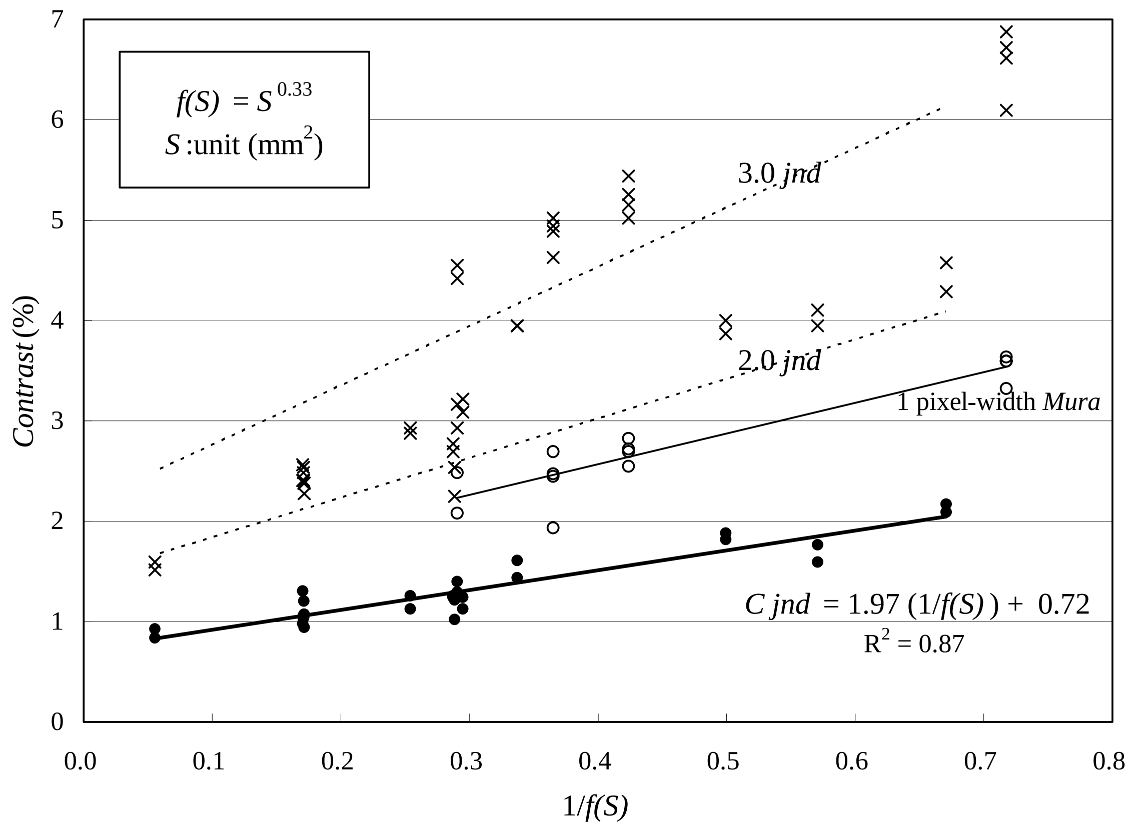

Figure R1-1
Relation between luminance mura area and jnd contrast (C jnd)

(●: jnd contrast of mura not 1 pixel wide, ○:jnd contrast of mura 1 pixel wide,
×: Distinct contrast of all muras (Average of Expert group only))

Prepared by R. Yoshitake and T. Tamura

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SEMI D32-0303
SPECIFICATION FOR IMPROVED INFORMATION MANAGEMENT FOR GLASS FPD SUBSTRATES THROUGH ORIENTATION CORNER UNIFICATION

This specification was technically approved by the Global 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.

1 Purpose

1.1 This specification provides the location, dimensions, and message size of the marking symbol that consists of a two-dimensional code symbol and related alpha numeric characters (capable of being read visually through the reader camera and display) and is located outside of the quality area of glass flat panel display (FPD) substrate.

1.2 The marking symbol in this specification allows the inclusion of identification information for each individual substrate together with the additional information previously provided by various orientation corner (OC) cut shapes.

1.3 Thus, this specification allows suppliers of glass substrates for FPDs to simplify substrate information management by marking such information in one location around the OC on the substrate, before shipping. In addition, use of this marking symbol will facilitate the future elimination of the numerous types of OC cut shapes presently in use.

1.4 The marking symbol covered by this specification is intended for use by suppliers and purchasers of glass substrates for FPDs.

2 Scope

2.1 This specification provides for a standardized OC location in support of future unification of the OC cut shape as well as location. When this is done, the provisional nature of the specification can be removed.

2.2 This specification covers the content, dimensions, and surface positioning of the marking symbol located outside of the quality area of glass substrates for FPD use.

2.2.1 This marking symbol is marked in a manner and location to avoid affecting the user patterning process.

2.2.2 Although this specification does not specify the marking technique to be employed when complying with its requirements, it is assumed that the marking symbol will be obtained by laser marking individual dots.

2.3 Marking symbols are applicable across all stages of FPD processing, from virgin substrates to fully patterned substrates. The format and algorithm for the Data Matrix code is based on two-dimensional symbology specified in ISO/IEC 16022.

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 Since the symbol is marked in a region of the substrate outside of the quality area, it is not available for use after this area is cut off.

3.2 Since only a single symbol is marked on each substrate, the marking symbol is not directly applicable for management of individual panels in multi-panel displays.

4 Referenced Standards

4.1 *ISO/IEC Standard*[1]

ISO/IEC 16022 — International Symbology Specification – Data Matrix

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

5 Terminology

5.1 Terms relating to the Data Matrix code symbol characteristics are defined in ISO/IEC 16022.

5.2 Definitions of terms relating to alphanumeric characters are as follows:

5.2.1 *character separation* — the horizontal distance between the adjacent boundaries of any two adjacent characters.

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: http://www.iso.ch

5.2.2 *character separation, vertical* — the vertical distance between the adjacent boundaries of any two adjacent characters.

5.2.3 *character spacing* — the horizontal distance between the character centerlines of two adjacent characters.

5.3 Definitions of terms relating to the marking area are as follows:

5.3.1 *mark area* — a rectangular area containing the mark field(s) and the surrounding quiet zone.

5.3.2 *mark field* — an area within which all mark dots occur.

5.3.3 *quiet zone* — an unpatterned, unmarked area that surrounds a mark field.

5.3.4 *TIR* — total indicator reading, the difference between the maximum and minimum distances of a line from a reference line.

6 Ordering Information

6.1 Content information of mark, as agreed to between purchaser and supplier

6.2 Number of message characters (up to a maximum of 20, see Section 7.7.1), as agreed to between purchaser and supplier.

7 Requirements

7.1 *Orientation Corner* — The OC location shall be the lower left corner of the substrate with the pattern surface up and the long edge at the bottom. Since the necessary information is encoded in the identification marks, it is not necessary to distinguish the shapes of the other corners of the substrate. OC cut shape is not specified at this time, but it is expected that in the future a single shape will be established for the next generation of substrates.

7.2 *Shape, Size, and Location of Marking Symbols*

7.2.1 The location of the mark field relative to the orientation corner and the adjacent edges of the sub-strate shall be as shown in Figure 1. The reference point of the two-dimensional code symbol, together with a parallelism requirement, locates the entire mark field.

7.2.2 The mark field dimensions and the symbols within the mark field shall be as shown in Figure 2.

7.2.3 Overall mark area dimensions shall be as shown in Figure 3.

7.2.4 The values of the dimensions shall be as defined in Tables 1 and 2.

7.3 *Data Matrix Code Symbol Dimensions*

7.3.1 Each rectangular Data Matrix code symbol shall be composed of an array of 18 rows and 18 columns, as shown schematically in Figure 4.

7.3.2 Cell spacing shall be 80 μ m, center to center.

7.3.3 The Data Matrix code symbol shall be constructed such that it can be read in accordance with ISO/IEC 16022.

7.4 *Alphanumeric Symbol Dimensions*

7.4.1 Use of the modified SEMI OCR Character Set as defined in Table 3 is recommended.

7.4.2 Characters shall be marked in a dot matrix format, contained within a character window 0.72 mm high × 0.40 mm high.

7.4.3 Character window separation shall be 0.24 mm horizontally and 0.16 mm vertically.

7.5 *Reference Point* for all symbols shall be the center point of the cell common to the primary border row and primary border column of the Data Matrix code symbol.

7.6 *Mark Field Dimensions* shall be in accordance with the dimensions *D* and *F* given in Table 2. Parallelism (*T*) of the top of the mark field within dimension *L*, relative to the nearest edge, shall be ≤ 1.0 mm TIR.

7.7 *Message Characters*

7.7.1 Up to 20 alphanumeric characters in the character set listed in Table 3 shall be encoded in the two-dimensional code symbol, and alphanumeric characters with the same content shall be placed symmetrically around the two-dimensional code symbol as shown in Figure 2. The message content is not defined, but it does not include any check sum characters. It may include information provided by the glass substrate supplier, and the remainder of the message characters, if any, can be used to insert information agreed on between supplier and purchaser. If the message contains less than 20 characters, a dash (–) may be inserted for the unused characters, at the supplier's discretion.

7.7.2 The Data Matrix code symbol shall be encoded with error checking and correcting characters in accordance with ECC 200 in accordance with ISO/IEC 16022.

7.7.3 Alphanumeric characters shall:

7.7.3.1 Be positioned such that their lower part faces toward the nearest edge of the glass substrate.

7.7.3.2 Contain message characters identical to those encoded in the Data Matrix code field.

7.7.3.3 Consist of two sets of two-line strings as shown in Figure 2.

7.7.4 The order of the alphanumeric characters shall be as agreed upon between supplier and user.

NOTE 1: A typical sequence could be: The message begins at the upper leftmost window, progresses horizontally to the upper rightmost window, continues at the lower leftmost window and ends at the lower rightmost window.

7.8 *Quiet Zones*

7.8.1 The space between the Data Matrix code symbol and adjacent alphanumeric symbols shall be 0.48 mm.

7.8.2 A 0.50 mm wide quiet zone surrounds the entire mark field.

Table 1 Mark Location Dimensions (see Figure 1)

Letter Symbol	*Name of Dimension*	*Nominal Value, mm*	*Tolerance, mm*
A	Edge to Mark Reference Point	15.0	± 0.5
B	Nearest Edge to Mark Reference Point	2.5	± 0.5
E	Edge to Quality Area	5.0	Reference (See Note 1.)
– S –	Reference Line parallel with substrate edge	Reference (See Note 2.)	
T	Top of Mark Field to Reference Line Parallelism across Mark Area Width (L) (see Table 2 and Figure 3)		≤1.0 TIR

NOTE 1: This is a reference dimension.

NOTE 2: This line is a virtual reference line.

Table 2 Mark Field Dimensions (see Figures 2 and 3)

Letter Symbol	*Name of Dimension*	*Nominal Value, mm*	*Tolerance, mm (See Note 1.)*
C_2	Data Matrix Field Width	1.44	
D	Mark Field Width	8.32	
F	Mark Field Height	1.60	
G	Bottom of Mark to Mark Reference Point	0.20	
H	Alphanumeric Character Window Height	0.72	
I	Alphanumeric Character Window Width	0.40	
J	Alphanumeric Character Window Horizontal Separation	0.24	
K	Alphanumeric Character Window Vertical Separation	0.16	
L	Mark Area Width	9.32	
M	Mark Area Height	2.60	
Q_1	Data Matrix Quiet Zone, Horizontal	0.48	
Q_2	Mark Area Quiet Zone, Width and Height	0.50	
R_2	Data Matrix Field Height	1.44	

NOTE 1: The laser marker can control these field dimensions to much tighter tolerances than it can control the field location. For that reason it is not necessary to apply tolerances to these values and it is appropriate to define these dimensions with two decimal places.

Table 3 Modified SEMI OCR Character Set

A	B	C	D	E	F	G	H	I	J	K	L	M
N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	1	2	3	4	5	6	7	8	9	0	–	

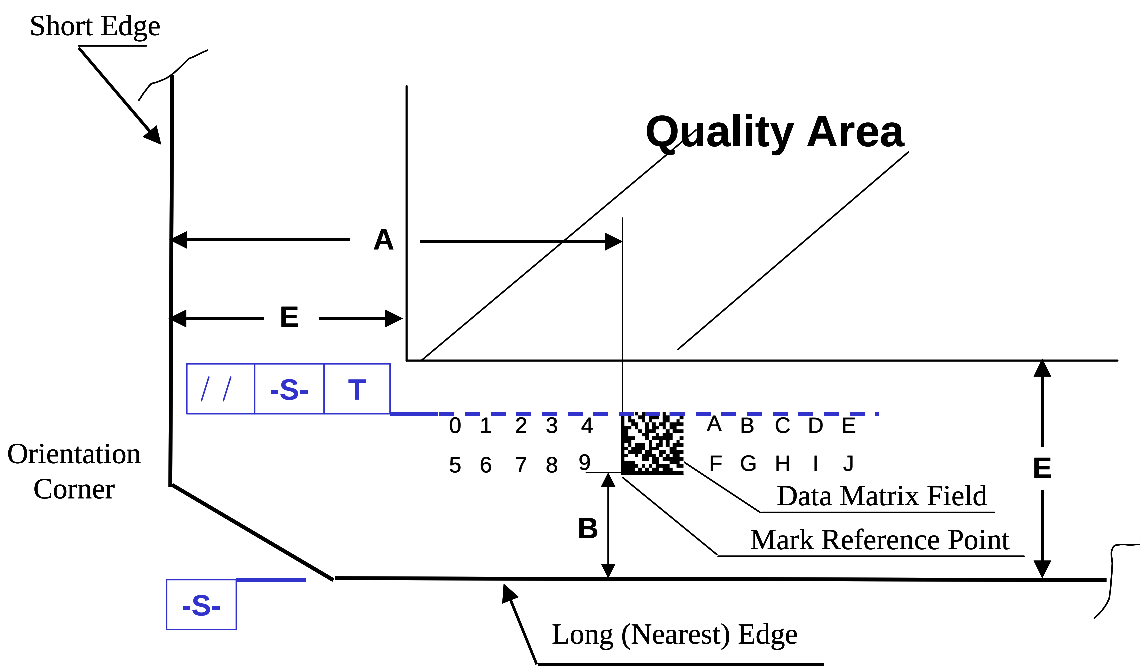

Figure 1
Data Matrix Field Location

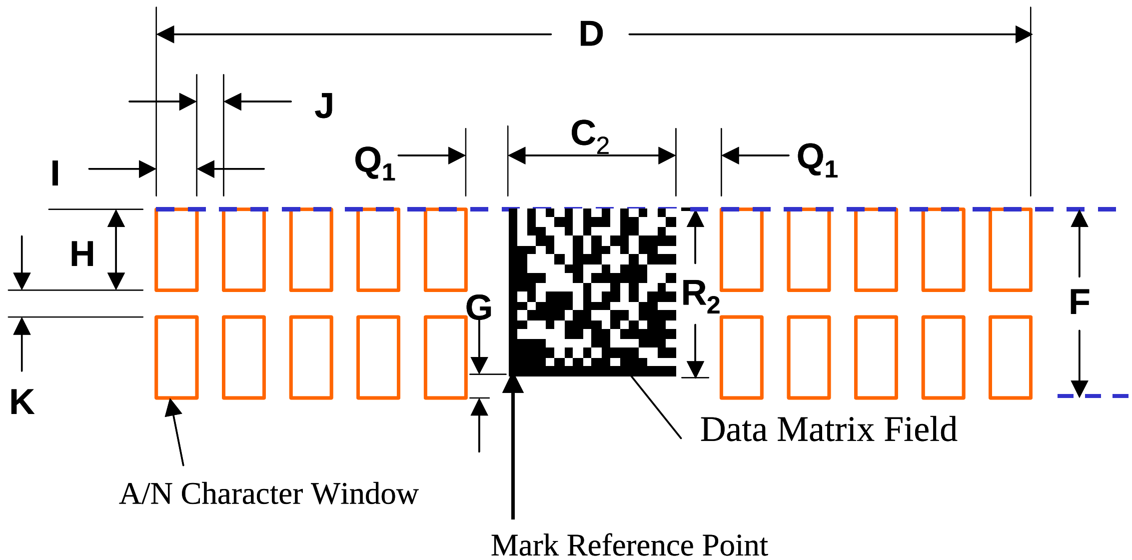

Figure 2
Mark Field Dimensions

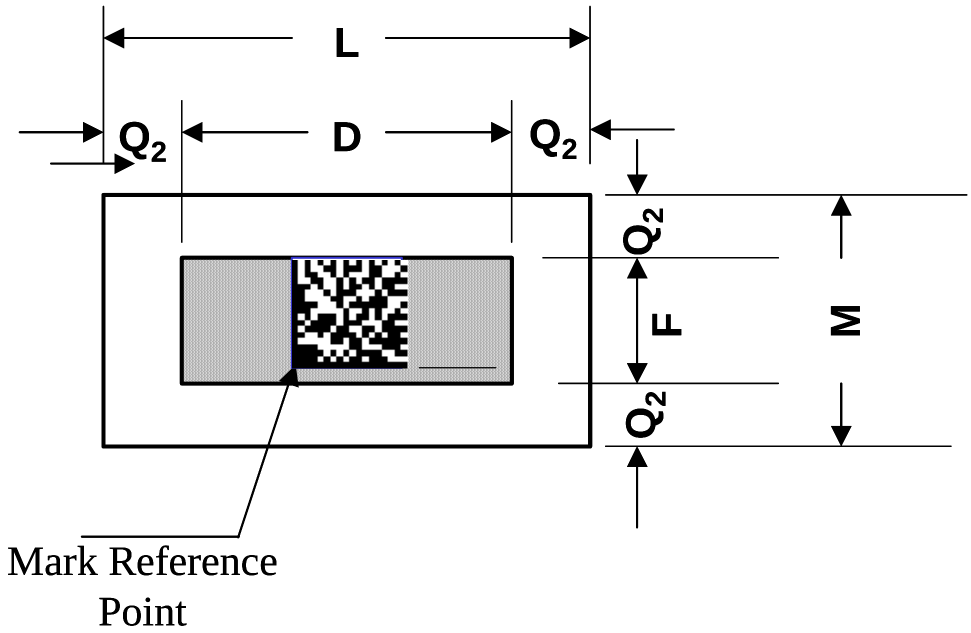

Figure 3
Mark Area Dimensions

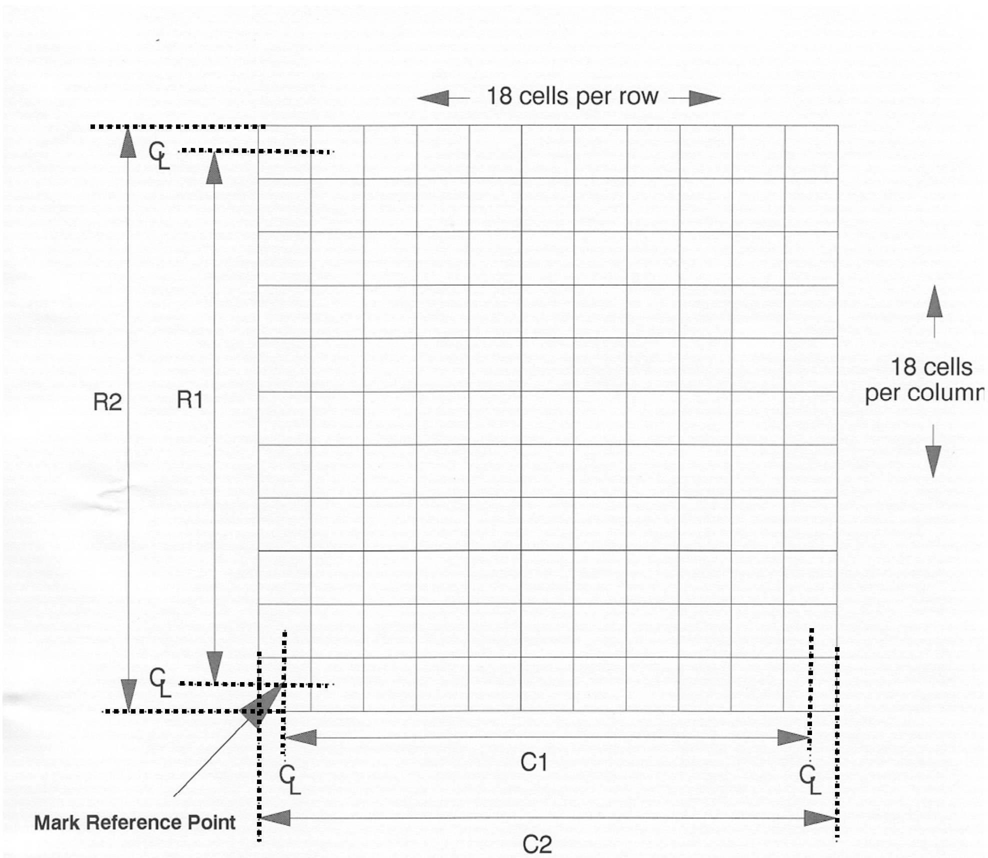

Figure 4
Data Matrix Field

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SEMI D33-0703
MEASURING METHOD OF OPTICAL CHARACTERISTICS FOR BACKLIGHT UNIT

This method 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 May 2003; to be published July 2003.

1 Purpose

1.1 The electro optical characteristics of backlight unit (BLU) have a great influence on the characteristics of LCD like uniformity, luminance and chromaticity etc. There are many measurement methods for BLU of electro optical characteristics. It is so different that the measurement method for BLU in each company (e.g.: the testing position, test condition, equipment concept etc.). Therefore, this standard will present the general measurement method.

2 Scope

2.1 This standard is applicable to BLU for Liquid Crystal Display (LCD) and the measurement includes only the optical area. The other areas (Electric characteristics, Reliability, and so forth) are dealt with by other SEMI standards.

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 standard does not include the test of each BLU component such as: light guide panel, optical film, Cold Cathode Fluorescent Lamp (CCFL), film characteristics, and etc.

4 Referenced Standards

4.1 *Other Standards*

Flat Panel Display Measurement Standard, VESA FPDM 2.0, June 2001.

Commission Internationale de l'Eclairage (CIE), "Colorimetry of Self-Luminous Displays-A Bibliography," CIE Publication No. 87, 1990.

Commission Internationale de l'Eclairage (CIE), "Colorimetry," CIE Publication No. 15.2, 1986.

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

5 Terminology

None.

6 The Optical Measurement Method

6.1 The test result of BLU can vary because of the environment and measurement conditions. Therefore, the measurement environment and conditions need to be determined.

6.2 *Measurement Setup*

6.2.1 Environment conditions:

- Temperature: 25 ± 2°C
- Humidity: 65 ± 20% RH
- Illumination of surrounding: dark room below 10 lux
- Air flow: no wind

6.2.2 *Measurement Conditions*

6.2.2.1 The measuring distance is suitable for 500 ± 50 mm at field aperture 1° and the viewing direction of all tests are 90° ± 1°. This distance is applied for all measurements in this standard.

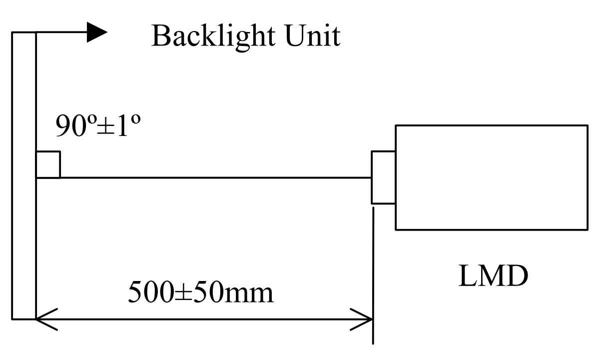

Figure 1
The Measuring Configuration for Measuring Optical Characteristics of BLU

6.2.2.2 Electrical conditions for driving are the typical lamp current and typical operating frequency. A nonconductor for jig of BLU is needed and it must be ground treated to reduce each noise signal.

6.2.3 *Measuring Equipment*

6.2.3.1 *Instrument for Driving of BLU*

6.2.3.1.1 In this standard a DC power supply is needed and an inverter for BLU driving of electro-optical test. It is required that the DC-power supply has the range of the output voltage between 0 to 30V and has the range of the output current between 0 to 8A.

6.2.3.2 *Instrument For Optical Measurement*

6.2.3.2.1 In this standard, spectroradiometer is needed for optical test. Spectroradiometer is more adequate than a filter photometer for BLU color measurement and it can use filter photometer and spectroradiometer for luminance measurement.

6.2.4 *Warm-Up Time*

6.2.4.1 Warm-up time is the period from power-on to saturation of the light intensity. The optical measurement needs 15 to 30 minutes for a more accurate measurement in case of luminance and luminance uniformity.

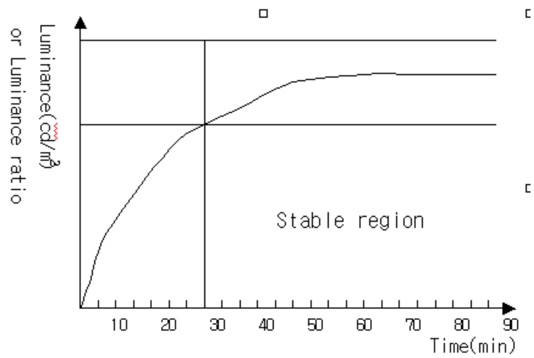

Figure 2
The Warm-Up Time of BLU

6.2.5 *Others*

6.2.5.1 It is recommended that the user record the environment and condition such as: temperature, humidity, illumination of surrounding, testing distance, warm-up time, lamp current, etc.

6.3 *Measurement Items*

6.3.1 The following measurement items are recommended for BLU, but these items depend on user requirements if they are specified.

6.3.2 *Luminance*

6.3.2.1 It is the surface luminance that is detected in all test areas. Luminance should be expressed in a unit such as candelas per meter squared [cd/m^2]. This luminance is the value measured at one center point or average value at several testing points. Generally, the lamp current of BLU should be set to typical lamp current. If the lamp current value has fluctuation state, the user should wait by stable state. The measurements are performed in the dark room under standard measuring conditions and design viewing direction.

6.3.3 *Luminance Uniformity*

6.3.3.1 Luminance uniformity is a measure of how well the luminance remains constant over the surface of the active area and it is a closely related measurement to luminance itself. Backlights are particularly liable to have the non-uniformity characteristics. The measuring method is similar to the luminance measuring method. In this measurement, it is important to determine the testing position. The determination of the testing position occur some different testing result. In this standard, we calculate the uniformity with the ratio of max luminance and min luminance level. The simple formulas are below. There are two formulas for uniformity. These formulas explain the non-uniformity concept, but they very popular with related industry.

Measuring position in luminance uniformity formula:

$$Uniformity(\%) = (\frac{L_{\max} - L_{\min}}{L_{\max}}) \times 100$$

$$Uniformity(ratio) = \frac{L_{\max}}{L_{\min}}$$

NOTE 1: For example, if the maximum luminance is 100 cd/m^2 and the minimum luminance is 80 cd/m^2 the Uniformity (%) is 20%. And the uniformity (ratio) is 1.25.

Comparison		*Case A*	*Case B*	*Case C*
Luminance	Max.	200	200	200
	Min.	140	160	180
Uniformity (%)		30%	20%	10%
Uniformity (ratio)		1.43	1.25	1.11

6.3.3.2 For this calculation, there are some positioning methods and the each user can select the test point option (the testing number is 5/9/13/25 point).

6.3.3.3 Figures 3a to 3d show each test position and test number.

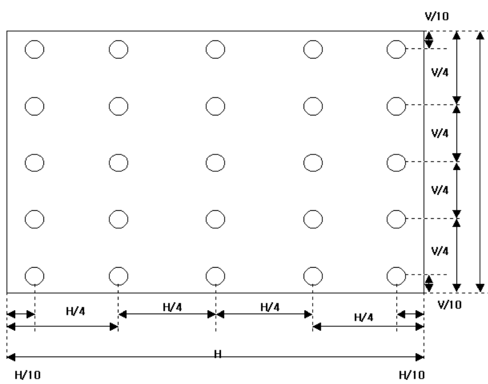

Figure 3a
25 measuring points

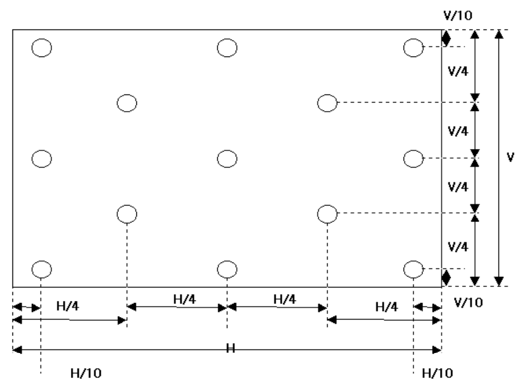

Figure 3b
13 measuring points

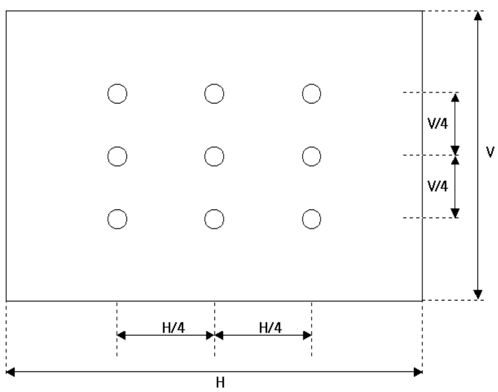

Figure 3c
9 measuring points

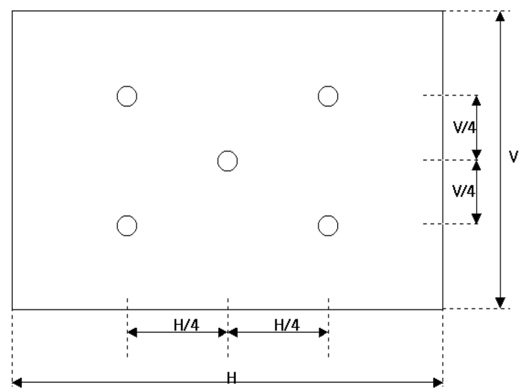

Figure 3d
5 measuring points

6.3.4 *Color*

6.3.4.1 In this standard, color coordinate systems are the 1931 or 1976 CIE systems. CIE1931 use the 'x' and 'y' coordination and CIE1976 use u' and v' coordination. The relation between CIE1931 to CIE1976 is below:

$$u' = \frac{4X}{X + 15Y + 3Z} = \frac{4x}{-2x + 12y + 3}$$

$$v' = \frac{9Y}{X + 15Y + 3Z} = \frac{9y}{-2x + 12y + 3}$$

$$x = \frac{27u'}{18u' - 48v' + 36}$$

$$y = \frac{12v'}{18u' - 48v' + 36}$$

6.3.4.2 Generally, because the light source of BLU is a discontinue wavelength, color should be measured by spectroradiometer. It is more accurate than filter colorimeter for color measuring. In this standard, the measuring distance and viewing direction are the same with the luminance testing method.

6.3.5 *Color Uniformity*

6.3.5.1 Color Uniformity is a same meaning with the Color difference in this standard. It means how the displays have the consistent chromaticity. In case of the color uniformity, we use the u' and v' coordinates from CIE1976. The reference point is center position. It is referenced the Δu'v' formula.

The formula is below:

$$\Delta u'v' = \sqrt{(u_1' - u_2')^2 + (v_1' - v_2')^2}$$

6.3.5.2 There are some positioning methods for color uniformity test. It is the same point with luminance uniformity, but in this standard, five point color uniformity is recommended. (Confer with Figure 3d.)

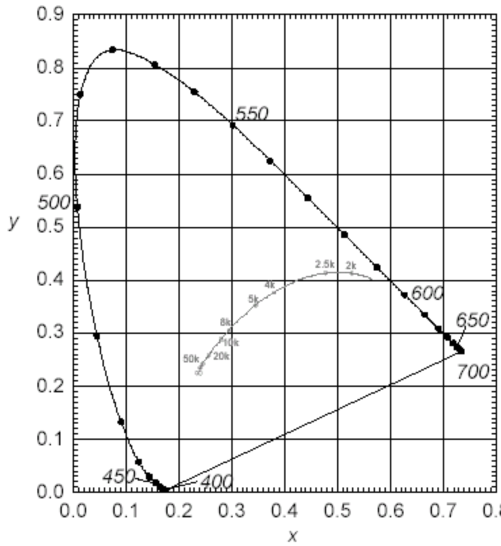

Figure 4
The 1931 CIE Coordinates (x,y)

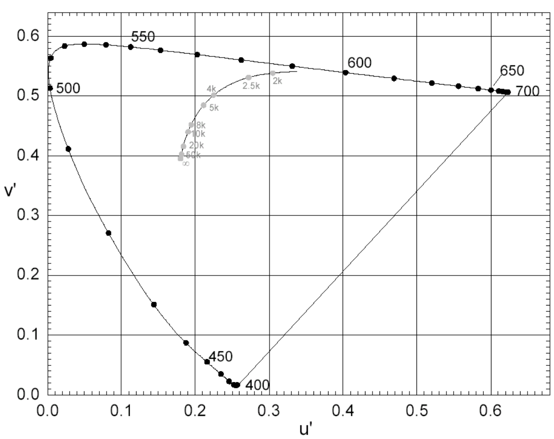

Figure 5
The 1976 CIE Coordinates (u',v')

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SEMI D34-0703
TEST METHOD FOR MEASUREMENT OF FPD POLARIZING FILMS

This test method 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 May 2003; to be published July 2003.

1 Purpose

1.1 This standard establishes implementation guidelines for the measurement of visual appearance, thickness, and optical characteristics of FPD Polarizing Films. These methods can be applied in manufacturing, quality control, and research and development.

2 Scope

2.1 This document specifies measurement methods.

2.2 Specifies measurement methods for visual appearance (dot defects, line defects, visual exclusion area), thickness, optical characteristics (single transmittance, parallel transmittance, cross transmittance, UV cut performance, polarization efficiency, hue a, b and hue a*, b* and haze) of polarizing films.

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 *Japan Industry Standards (JIS)*[1]

JIS K7105[2] — Testing methods for optical characteristics of plastics

JIS Z8701[3] — Colour specification -- The CIE 1931 standard colorimetric system and the CIE 1964 supplementary standard colorimetric system

JIS Z8720[4] — Standard Illuminants and sources for colorimetry

JIS Z8723[5] — Methods for visual comparison of surface colours

JIS Z8729[6] — Colour specification -- CIE LAB and CIE LUV colour spaces

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

4 Terminology

None.

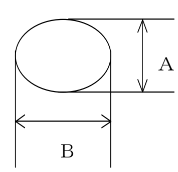
5 Definitions of Measured Object and Summary of Measurement Methods

5.1 *Visual Appearance of Polarizing Film (Dot Defects)*

5.1.1 *Definition of Defect Size*

5.1.1.1 *Non-White Spot* — Points that can be verified visually during reflection inspection and transmission inspection. Size is defined by measuring the long side and short side of the core section and taking their mean value (Φ).

5.1.1.2 *White Spot* — Points that can be verified visually during Cross-Nicol transmission inspection. Size is defined by measuring the long side and short side of the core section and taking their mean value (Φ).



$\phi = (A+B)/2$

Figure 1
Definition of Defect Size (Dot Defect)

1 Japan Standards Association(JSA) 4-1-24 Akasaka, Minato-ku, Tokyo, 107-8440 Japan. Tel: +81-3-3583-8000, E-mail: webmaster@jsa.or.jp, http://www.jsa.or.jp

2 English version available.

3 Related International Standards: CIE 15.2, ISO/CIE 10526: CIE standard colorimetric illuminants, ISO/CIE 10527: CIE standard colorimetric observers; Commission Internationale de l'Eclairage, Kegelgasse 27, A-1030 Vienna, Austria. Tel: +43-1-714-31-87-0; International Organization for Standards(ISO), 1, rue de Varembe, Case, postale 56 CH-1211 Geneva 20, Switzerland. Tel: +41-22-749-01-11, E-mail: central@iso.ch, http://www.iso.ch

4 Related International Standards: ISO/CIE 10526: CIE standard colorimetric illuminants

5 Related International Standards: ISO/DIS 3668: Paints and varnishes – Visual comparison of the colour of paints

6 Related International Standards: Not Applicable; English version not available.

5.1.2 *Defect Measurement (Inspection) Method* — Observe defects under fluorescent light (600–1600 lux), using either reflection, transmission, or Cross-Nicol transmission inspection, or a combination of the above, at approximately 30 cm from the sample.

5.1.2.1 Reflection Inspection: Conduct on a blackboard, using fluorescent light.

5.1.2.2 Transmission Inspection: Conduct on a backlight

5.1.2.3 Cross-Nicol: Place a reference polarizing film on a backlight, and conduct transmission inspection in transmission inspection Cross-Nicol state.

5.2 *Polarizing Film Visual Appearance (Line Defects)*

5.2.1 *Defect Size Definition*

5.2.1.1 Line defects visually detected during reflection, transmission, or Cross-Nicol inspection. Size is defined by measuring the length of the long side and short side.

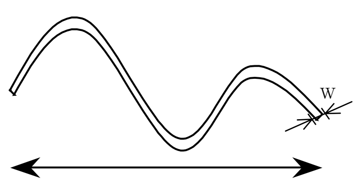


Figure 2
Definition of Defect Size (Line Defect)

5.2.2 *Defect Measurement (Inspection) Method* — Observe defects under fluorescent light, using either reflection, transmission, or Cross-Nicol transmission inspection, or a combination of the above, at approximately 30 cm from the sample.

5.2.2.1 Reflection Inspection: Conduct on a blackboard, using fluorescent light.

5.2.2.2 Transmission Inspection: Conduct on a backlight

5.2.2.3 Cross-Nicol: Place a reference polarizing film on a backlight, and conduct transmission inspection in transmission inspection Cross-Nicol state.

5.3 *Polarizing Film Visual Appearance (Visual Exclusion Area)*

5.3.1 *Definition*

5.3.1.1 L of the Visual Exclusion Area is the measurement of the distance from each side of the polarizing film.

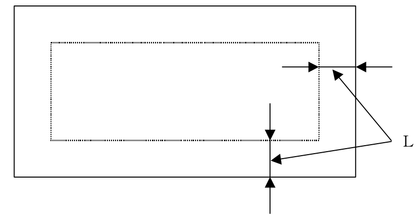


Figure 3
Definition of Visual Exclusion Area

5.4 *Polarizing Film Thickness*

5.4.1 *Thickness Definition*

5.4.1.1 Thickness, excluding the thickness of protective film and separate film.

5.4.2 *Thickness Measurement Method*

5.4.2.1 Measured using a thickness gauge that can measure to 0.001 mm.

5.5 *Polarizing Film Optical Characteristics*

5.5.1 *Definition of Single Transmittance (Ty) and Measurement Method*

5.5.1.1 Value of Transmittance of 1 polarizing film, visibility corrected (JIS Z8701) by supplementary standard illuminant C (JIS Z8720)[7], 2° range of view.

5.5.1.2 *Measurement Conditions*

5.5.1.2.1 Equipment: Spectrophotometer

5.5.1.2.2 Measurement Wavelength: 400–700 nm (10 nm intervals)

5.5.2 *Definition and Measurement Method of Parallel Transmittance ($T_{//}$)*

5.5.2.1 Value of Transmittance of 2 polarizing films placed parallel Nicol, visibility corrected (JIS Z8701) by supplementary standard illuminant C (JIS Z8720), 2° range of view.

5.5.2.2 *Measurement Conditions*

5.5.2.2.1 Equipment: Spectrophotometer

5.5.2.2.2 Measurement Wavelength: 400–700 nm (10 nm intervals)

5.5.3 *Definition and Measurement Method for Cross Transmittance ($T_{\perp}$)*

5.5.3.1 Value of Transmittance of 2 polarizing films placed crossed Nicol, visually corrected (JIS Z8701) by supplementary standard illuminant C (JIS Z8720), 2° range of view.

7 Commonly known as “Light Source C”. Abbreviated to “Ill.C”.

5.5.3.2 *Measurement Conditions*

5.5.3.2.1 Equipment: Spectrophotometer

5.5.3.2.2 Measurement Wavelength: 400–700 nm (10 nm intervals)

5.5.4 *Definition and Measurement Method for Transmittance of each Wavelength*

5.5.4.1 Measured value of 1 polarizing film at specific wavelengths (440 nm, 550 nm, 610 nm)

5.5.4.2 *Measurement Conditions*

5.5.4.2.1 Equipment: Spectrophotometer

5.5.4.2.2 Measurement Wavelength: 440 nm, 550 nm, 610 nm

5.5.5 *Definition and Measurement Method of UV Cut Performance*

5.5.5.1 Transmittance of 1 polarizing film, measured at 380 nm, is defined as UV cut performance.

5.5.5.2 *Measurement Conditions*

5.5.5.2.1 Equipment: Spectrophotometer

5.5.5.2.2 Measurement Wavelength: 380 nm

5.5.6 *Definition and Measurement Method of Polarization Efficiency (Py)*

5.5.6.1 Expressed using the following formula, where T_A is transmittance (visibility corrected) on the absorption axis, and T_B is transmittance (visibility corrected) on the transmittance axis.

$$Py = \frac{T_B - T_A}{T_B + T_A} \times 100\ (\%)$$

5.5.6.2 The same value from the above equation can also be calculated using the below equation, where $T_{//}$ is parallel transmittance and $T_{\perp}$ is cross transmittance.

$$Py = \sqrt{\frac{T_{//} - T_{\perp}}{T_{//} + T_{\perp}}} \times 100\ (\%)$$

5.5.6.3 *Measurement Conditions*

5.5.6.3.1 Equipment: Spectrophotometer

5.5.6.3.2 Measurement Wavelength: 400–700 nm (10 nm intervals)

5.5.7 *Definition and Measurement Method for Hue a*, b**

5.5.7.1 Polarizing film transmittance value calculated in accordance with JIS Z8729.

5.5.7.2 *Measurement Conditions*

5.5.7.2.1 Equipment: Spectrophotometer

5.5.7.2.2 Measurement Wavelength: 400~700 nm (10 nm intervals)

5.5.8 *Definition and Measurement Method for Hue a, b*

5.5.8.1 Visibility corrected (JIS Z8701) value by supplementary standard illuminant C (JIS Z8720), 2° range of view, calculated using the tristimulus values (X, Y, Z) from the below formula.

$$a = \frac{17.5(1.02X - Y)}{\sqrt{Y}}$$

$$b = \frac{7.0(Y - 0.847Z)}{\sqrt{Y}}$$

5.5.8.2 *Measurement Conditions*

5.5.8.2.1 Equipment: Spectrophotometer

5.5.8.2.2 Measurement Wavelength: 400–700 nm (10 nm intervals)

5.5.9 *Definition and Measurement Method for Haze*

5.5.9.1 Scattered transmittance and all line transmittance, measured using integrated sphere light transmittance measurement equipment, expressed as a ratio.

$$H = \frac{T_d}{T_t} \times 100\ (\%)$$

T_d: Scattered Transmittance （%）

T_t: All line transmittance （%）

To be measured in accordance with JIS K7105.

6 Equipment

6.1 Spectrophotometer with the below performance shall be used.

6.1.1 Optical Wavelength: Sub 10 nm analysis capability, adjustable between 380–780 mm.

7 Equipment Calibration

7.1 Equipment shall be calibrated in accordance with the manufacturer's manual.

7.2 When, due to calibration, there is a change in the equipment's performance, for example, linearity, phase deviation, etc., a record shall be kept.

8 Related Document

8.1 Measurement Method for Optical Characteristics of Polarizing Films Using Crystal Rotation Method

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RELATED INFORMATION 1
MEASUREMENT METHOD FOR OPTICAL CHARACTERISTICS OF POLARIZING FILMS USING CRYSTAL ROTATION METHOD

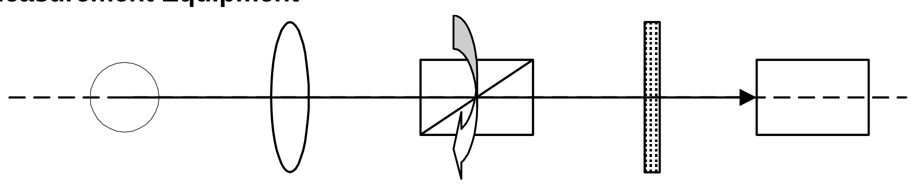
NOTICE: This related information is not an official part of SEMI D34 and was derived from Otsuka Electronics Co., Ltd. This related information was approved for publication by full letter ballot procedures.

R1-1 Outline

R1-1.1 This method is not to use two polarizing film in normal, but to use polarizing prism and one polarizing film, which can be used for measurement of Single transmittance (Ty), Parallel transmittance ($T_{//}$), Cross transmittance ($T_{\perp}$), Transmittance of each wavelength, UV cut performance, Polarizing Efficiency (Py) and Hue a, b.

R1-1.2 Equipments are shown below. Measurement condition is same as standard method.

R1-2 Measurement Equipment



R1-3 Formula

R1-3.1 $K_A(\lambda)$ is measured on condition of polarizing prism and polarizing film placed perpendicularly and $K_B(\lambda)$ is measured on condition of polarizing prism and polarizing film placed parallel, where $K_A(\lambda)$ is transmittance light on the absorption axis and $K_B(\lambda)$ is transmittance light on the transmittance axis.

$$K_A(\lambda) = S_{//}(\lambda) / R_{//}(\lambda)$$
$$K_B(\lambda) = S_{\perp}(\lambda) / R_{\perp}(\lambda)$$

$S_{//}(\lambda)$: Light intensity of transmittance on condition of polarizing film and polarizing prism placed parallel with polarizing film.
$R_{//}(\lambda)$: Light intensity of transmittance without polarizing film on same condition of $S_{//}(\lambda)$.
$S_{\perp}(\lambda)$: Light intensity of transmittance on condition of polarizing film and polarizing prism placed perpendicularly with polarizing film.
$R_{\perp}(\lambda)$: Light intensity of transmittance without polarizing film on same condition of $S_{\perp}(\lambda)$.

R1-3.2 *Definition for Single Transmittance (Ty)*

Single transmittance light $Ts(\lambda)$:
Single transmittance Ty: Value of $Ts(\lambda)$ visibility corrected (JIS Z8701).

$$Ts(\lambda) = \frac{K_A(\lambda) + K_B(\lambda)}{2}$$

R1-3.3 *Definition for Parallel Transmittance ($T_{//}$)*

Parallel transmittance light Tp (λ):

$$Tp(\lambda) = \frac{K_A{}^2(\lambda) + K_B{}^2(\lambda)}{2}$$

Parallel transmittance $T_{//}$: Value of Tp (λ) visibility corrected (JIS Z8701).

R1-3.4 *Definition of Cross Transmittance ($T_{\perp}$)*

Cross transmittance light Tc (λ): Tc (λ) = K_A (λ) × K_B (λ)

Cross transmittance $T_{\perp}$: Value of Tc (λ) visibility corrected (JIS Z8701).

R1-3.5 *Definition for Transmittance of Each Wavelength*

Value of Single Transmittance Ts (λ) at the wavelength of 440 nm, 550 nm and 610 nm.

R1-3.6 *UV Cut Performance*

Value of Single Transmittance Ts (λ) at the wavelength of 380 nm.

R1-3.7 *Definition for Polarizing Efficiency (Py)*

R1-3.7.1 Value calculated from following formula same as standard method, where the value of transmittance light $K_A(\lambda)$ (visibility corrected) on the absorption axis is transmittance T_A on the absorption axis, and transmittance light $K_B(\lambda)$ (visibility corrected) on the transmittance axis is transmittance T_B on the transmittance axis.

$$Py = \frac{T_B - T_A}{T_B + T_A} \times 100 \quad (\%)$$

R1-3.7.2 Same as the standard method, Py is calculated from the Parallel transmittance ($T_{//}$) and Cross transmittance ($T_{\perp}$) using the latter formula which is equivalent with the former formula.

$$Py = \sqrt{\frac{T_{//} - T_{\perp}}{T_{//} + T_{\perp}}} \times 100 \quad (\%)$$

R1-3.8 *Definition for Hue a. b.*

R1-3.8.1 Value calculated from below formulas same as standard method using the tristimulus values (X, Y, Z) obtained from Single spectra-transmittance Ts (λ) visibility corrected (JIS Z8701) by light source C at 2° range of view.

$$a = \frac{17.5(1.02X - Y)}{\sqrt{Y}}$$

$$b = \frac{7.0(Y - 0.847Z)}{\sqrt{Y}}$$

R1-4 Related Documents

The Kogyo Zairyo Vol. 28 –7 P.37~P.45

SEMI D35-1103[E]
TEST METHOD FOR MEASUREMENT OF COLD CATHODE FLUORESCENT LAMP (CCFL) CHARACTERISTICS

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

[E] This standard was editorially modified in November 2004 to correct editorial errors. Changes were made to multiple sections, figures, and tables.

1 Purpose

1.1 The purpose of this document is to standardize the method for measurement of electrical and optical characteristics of cold cathode fluorescent lamp (CCFL).

2 Scope

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

2.2 This method shall be used in general for CCFL to measure the initial characteristics of CCFL (single item) and its reliability after tests, and to carry out quality inspection for incoming and outgoing CCFLs.

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 *JIS Standards*[1]

JIS Z 8113 — Lighting vocabulary

3.2 *IEC Standards*[2]

IEC 60050 (845) — Lighting, Section 1: Radiation, Quantities and Units, 3: Colorimetry

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

4 Terminology

4.1 *Abbreviations and Acronyms*

4.1.1 *CCFL* — Cold Cathode Fluorescent Lamp

4.2 *Definitions*

4.2.1 *effective emission area* — an area (length) in which a certain percentage of luminance against the luminance of a central part is maintained with almost even luminance distribution (LE[mm]).

4.2.2 *lamp current* — effective current inside the lamp (IL[mArms]). (The GND side shall be measured.)

4.2.3 *lamp voltage* — effective voltage across both ends (between two electrodes) of a lamp at rated lamp current (VL[Vrms]).

4.2.4 *lamp wattage* — a product of the lamp current, lamp voltage and a power factor. A reference value (W[Wrms]).

4.2.5 *luminance stabilization time* — the time to reach a certain percentage of the luminance of a central part (Ts[min.]).

4.2.6 *stable discharge voltage* — effective voltage at lamp ends (between two electrodes) when a main discharge starts (Es[Vrms]).

5 Summary of Method

5.1 Warm up the measuring equipment for a specified period of time to stabilize (according to the instruction manual of measuring equipment).

5.2 Keep the lamp wall temperature of a CCFL and the ambient temperature in equilibrium. The ambient temperature shall be stable.

5.3 Set the CCFL on the measuring equipment.

5.4 Adjust the point of measurement (viewing angle), focus and distance.

5.5 Measure the stable discharge voltage.

5.6 Turn on the CCFL by applying a rated current and measure the lamp current when it is stable.

1 Japanese Standards Association, 1-24, Akasaka 4 Chome, Minato-Ku, Tokyo, 107-8840 Japan. Tel: +81-3-3583-8000, E-mail: webmaster@jsa.or.jp, http://www.jsa.or.jp

2 International Electrotechnical Commision(IEC), 3, rue de Varembé , P.O. Box131 CH-1211 Geneva 20, Switzerland. Tel: +41-22-919-02-11, E-mail: iec@iec.ch, http://www.iec.ch

5.7 Measure the lamp voltage when the rated lamp current is stable.

5.8 Measure the luminance and chromaticity when the rated lamp current is stable.

5.9 Turn off the CCFL and remove it from the measuring equipment.

5.10 Refer to Sections 9.3 and 9.4 regarding the measurement of the effective emission area and luminance stabilization time.

6 Apparatus

6.1 *Electrical Apparatus* — Choose measuring equipment to use from the following devices and specify which devices were used, and also specify a measuring circuit, lighting frequency, rating of electrical wire and its length in the report. The electrical (and optical) characteristics of CCFL depend on the frequency of the lighting circuit.

6.1.1 *Power Supply* — For the lighting of CCFL, use a power supply unit that provides the substantial sinusoidal waveform and frequency of 50–60 kHz. Also, use the combination of a Stabilized DC power supply unit and an inverter, or a power supply unit designed specially as an integrated type (special purpose). The output voltage of either of them is variable but the variability shall not affect the measurement.

6.1.2 *Meter* — Use a meter that indicates true AC voltage values for measurement. The meter built in a special purpose power supply unit shall indicate true values as well.

6.1.3 *Circuit* — The circuit to measure electrical characteristics shall conform to Figure 1 or Figure 2.

6.1.4 Specify the ratings and lengths of electrical wires that connect each meter and lamp. Since the wires produce leakage current due to stray capacitance and the amount differs according to the lengths, set the wires as short as possible and do not bundle them.

6.2 *Optical Measuring Equipment* — Choose a measuring equipment to use from the following devices and specify which devices were used, and also specify the measuring distance, viewing angle, and ambient temperature in the report. The optical (and electrical) characteristics of CCFL depend on the ambient (lamp wall) temperature.

6.2.1 *Black Box for Measurement* — The black box used to measure shall be so designed that the lamp surface may not be affected by wind. The delustered black paint shall be applied on the inside of the box so that it may not be affected by the background color or reflected light when the luminance is measured. In addition, in order not to be affected by stray capacitance, non-conductive materials shall be used. For the installation of a CCFL in the box, a fixing method shall be employed for avoiding the impact to the lamp wall temperature distribution at lighting.

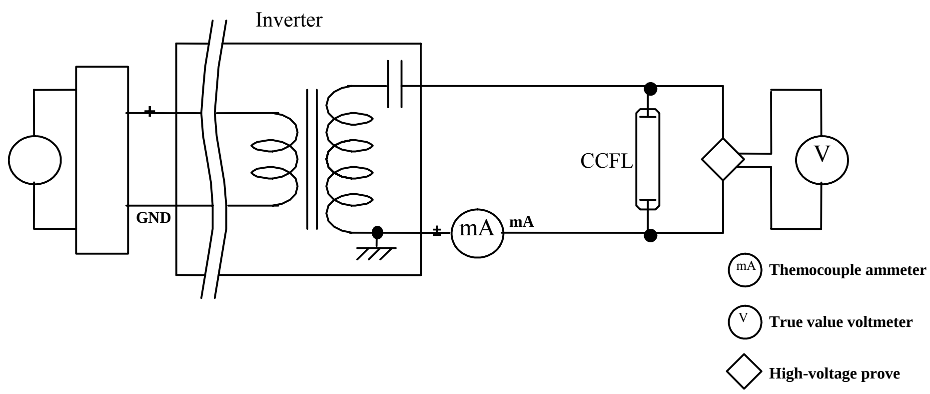


Figure 1
Combination of Stabilized DC Power Source and Inverter

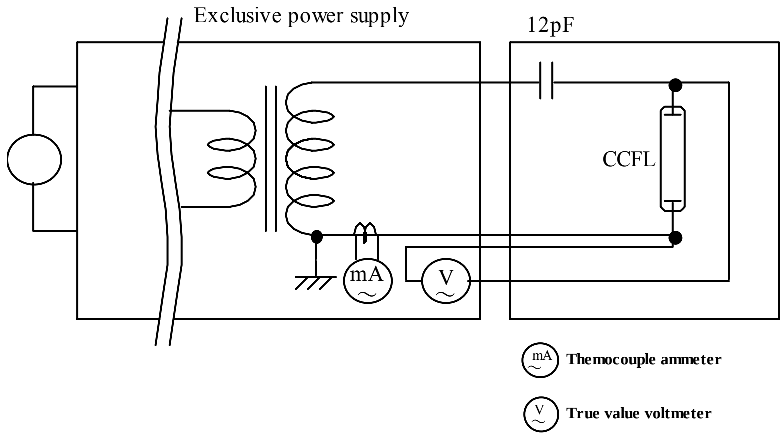


Figure 2
Exclusive Power Supply

6.2.2 *Meter* — Use a spectroradiometer or colorimeter to measure the luminance and chromaticity. Keep the spectroradiometer under control of calibration system with the meter of national standard and traceability. Calibrate the colorimeter in such a way that it can reproduce the luminance value of a master CCFL obtained by a calibrated spectroradiometer. Since each colorimeter has the instrumental error and changes with the passage of time, the calibration is necessary for daily use. For the calibration, a master CCFL, which has the emission spectrum value close to that of a CCFL to be measured, shall be used.

6.2.3 *Diagram for Measurement* — The diagram for optical measurement shall conform to Figure 3.

7 Measurement Conditions

7.1 The place for measurement shall be kept at 25 ± 2°C for ambient temperature and 30–85%RH. The temperature fluctuation shall be within 1°C and if the temperature is specified, the measurement shall be carried out at such temperature. There shall be no wind or vibration that may affect the measurement.

7.2 For the measurement of luminance and chromaticity, arrange the situation where ambient reflected light may not affect it or such can be ignored.

7.3 For the measurement of voltage, points to be measured shall be specified in circuit diagrams. Measured values may vary by the impact of ballast capacitor or probe based upon whether the points measured are located at an inverter transformer side or a lamp side (or located at front or rear side of ballast capacitor).

7.4 The electrostatic capacity of a high voltage probe used to measure a voltage shall be so small that the impact to the probe by leakage current may be less and it shall be specified.

8 Test Specimen

8.1 Use a CCFL in which the wall temperature and ambient temperature are kept in equilibrium before lighting. Especially when measuring the stable discharge voltage again after the first measurement, carry out after the lamp has been in equilibrium on both temperatures, the lamp wall temperature and ambient temperature.

8.2 Fix a CCFL horizontally along its long side on the jig of the above-mentioned equipment and this method shall not affect the temperature distribution on the wall. The measured point shall be measured in the air.

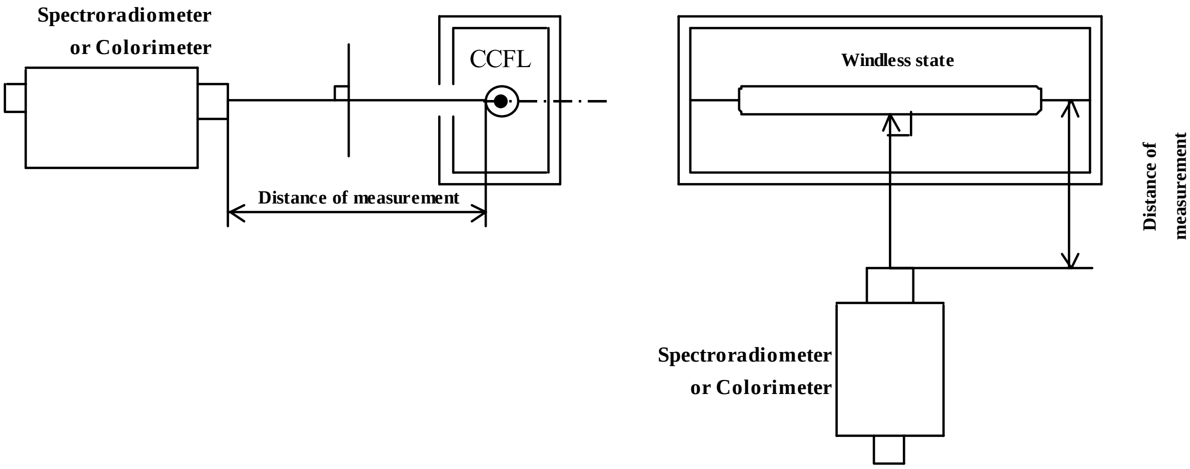


Figure 3
Optical Characteristics Measurement

9 Procedure

9.1 *Measurement of Electrical Characteristics*

9.1.1 *Measurement of Stable Discharge Voltage* — Apply zero or very low voltage to the both ends of a lamp (between two electrodes) and increase the voltage gradually (slide-up). The lamp starts to discharge after the voltage reaches a certain value. Furthermore, increase the voltage gradually (slide-up) and measure the potential difference between the lamp ends (electrodes) as a stable discharge voltage when a main discharge starts.

9.1.2 *Measurement of Lamp Current* — Adjust the output voltage of power supply unit to gain a specified lamp current. Measure the lamp current at GND terminal when it becomes stable at a specified value. Record the preset voltage of the power supply as well. (Refer to Figure 1 or Figure 2.)

9.1.3 *Measurement of Lamp Voltage* — Measure the potential difference between both ends (electrodes) of a lamp as a lamp voltage when the lamp current becomes stable at a specified lamp current. If the lamp current is affected when a probe is connected, adjust the lamp current to make it a specified lamp current. Measure the lamp current after it becomes stable.

9.1.4 *Lamp Wattage* — It is defined as a product of lamp current, lamp voltage and power factor ($W = VL \times IL \times \cos\theta$) and expressed as a reference value. When the phase difference between the lamp current and lamp voltage can be ignored and if such situation is specified, the product of the lamp current and lamp voltage ($W = VL \times IL$) may be expressed as a reference value.

9.2 *Measurement of Optical Characteristics*

9.2.1 *Point of Measurement* — The point is the side surface of a lamp, which is within the range of viewing angle (black circle) of a measuring instrument. The area of measurement is the central part of the lamp. The point of measurement shall be so small relatively to the inner diameter of the lamp that the dislocation of the point may not vary the luminance and chromaticity. The point of measurement is a cylindrical surface but it could be regarded as a plain surface due to the smallness. (See Figure 5.) The dispersion due to dislocation of a point of measurement is smaller within the range that is less than or equal to 50% of the inner diameter. The luminance decreases in the other range.

9.2.2 *Distance of Measurement* — The distance shall be from a lamp surface to be measured to a light-receiving lens surface of a measuring instrument. The size of viewing angle varies according to adjustment by luminance meter and the distance of measurement, set the distance to match the inner diameter mentioned above. When measuring, the inner surface of the lamp and the focal point shall be well matched (Figure 5). (If the focal point of the luminance meter is displaced, the luminance and chromaticity values will not be indicated correctly.)

9.2.3 *Timing of Measurement* — Measure after the luminance seems stable at a specified lamp current (where the luminance fluctuation difference is within ± 3% of the stable luminance, for example). (See Figure 4.)

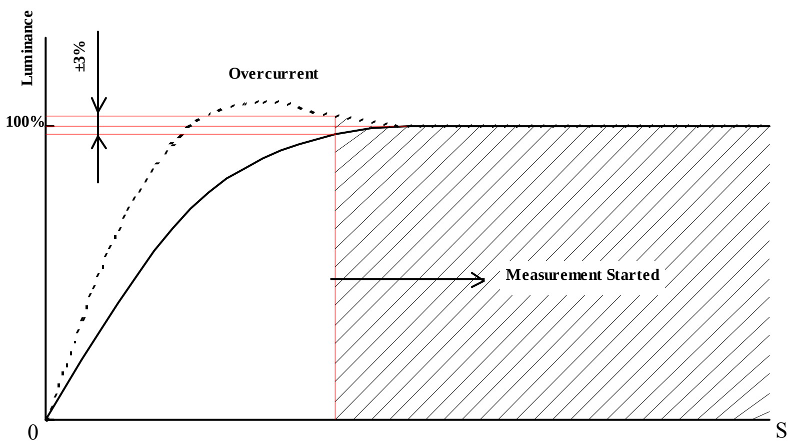


Figure 4
Measuring Time of Optical Characteristics

Commentary on Figure 4: The CCFL luminance has a special rising property. The highest luminance and stable luminance vary by the combination of ambient temperature and lamp current and the transitions vary as well. This is based upon the fact that the CCFL luminance depends on temperature and the generated heat by lighting affects it. For this reason, the luminance varies until the lamp wall temperature becomes stable. Before the measurement, grasp the special rising property of luminance and set the timing of measurement of the stable luminance.

9.2.4 *Measurement of Luminance* — Set a spectroradiometer or a colorimeter vertical to a side to be measured and measure according to the above-mentioned instruction of measurement. Avoid shades of mercury particles in the lamp. (See Figure 5.)

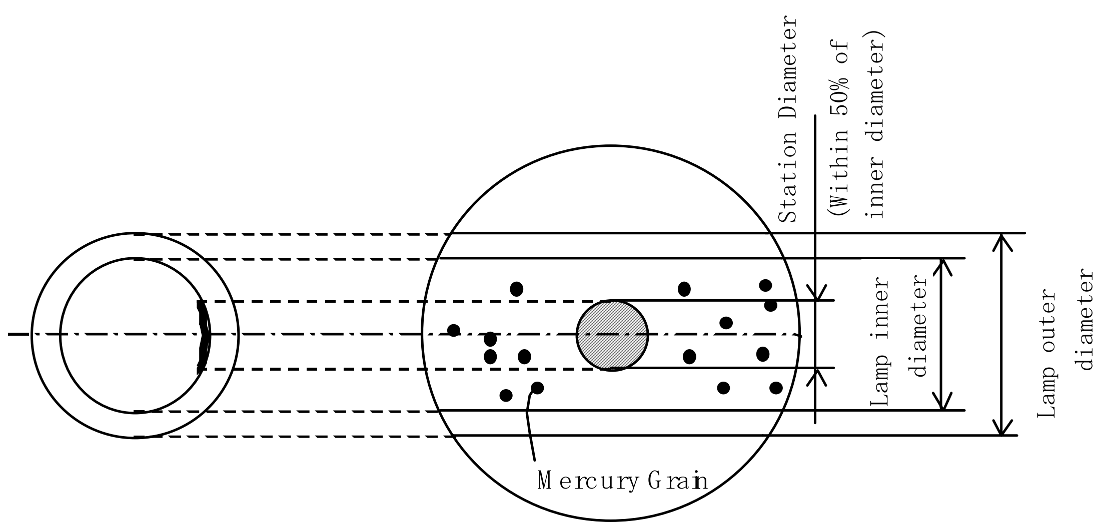


Figure 5
Measuring Spot (Diameter) for Optical Characteristics

9.2.5 *Measurement of Chromaticity* — Measure in the same manner and at the same time of the measurement of luminance.

9.3 *Measurement of Effective Length of Luminous Part* — Measure when the luminance is fully stable at a specified lamp current according to the measuring conditions mentioned above. The luminance varies greatly around electrodes since the temperature variation is big among points of measurement due to high temperature of a lamp wall. Sufficient aging shall be performed before measurement to avoid impacts of the change of passage of time to each point to be measured. Fix the lamp and move the spectroradiometer or the colorimeter for better measurement since the lamp wall temperature does not vary and so the luminance becomes stable in this way. (See Figure 6.)

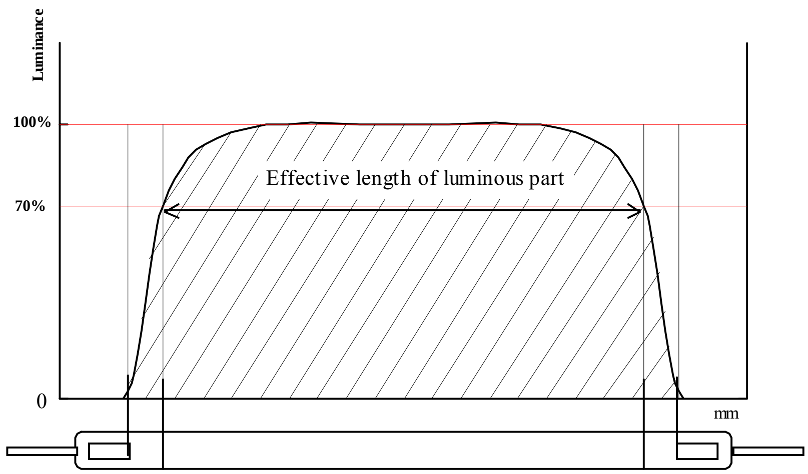


Figure 6
Measurement of Effective Length of Luminous Part

9.4 *Measurement of Luminance Stabilization Time* — Use a CCFL in which the wall temperature and ambient temperature are kept in equilibrium before lighting. From just after a CCFL is turned on by specified lamp current, measure the luminance changes until it seems stable (where the luminance fluctuation difference is within ± 3% of the stable luminance, for example).

10 Reporting Results

10.1 Report the following items:

10.1.1 report date,

10.1.2 test date,

10.1.3 measuring equipment types, and conditions of use (lighting frequency, rated length of connecting wire, distance of measurement, viewing angle, etc.),

10.1.4 conditions of test specimen (size, other specifications, etc.),

10.1.5 to specify item names and necessary entries for the CCFL outer and inner diameters, lamp length and necessary specifications,

10.1.6 conditions of measurement (ambient temperature, aging time, etc.),

10.1.7 measurement results (electrical and optical characteristics), and

10.1.8 remarks (other notes).

11 Related Documents

Related Information 1: documents regarding main discharge,

Related Information 2: dark characteristics, and

Related Information 3: precautions for measuring method (leakage current, lamp wall temperature, temperature slide-up speed for master CCFL, etc.).

RELATED INFORMATION 1
STARTING VOLTAGE OF COLD CATHODE FLUORESCENT LAMP (CCFL)

NOTICE: This related information is not an official part of SEMI D35 and was derived from Japan Backlight TF.

R1-1 Phenomenon of CCFL Discharge Starting

R1-1.1 Although the phenomenon of CCFL discharge starting shows the similarity to that of low gas pressure discharge starting, a high frequency lighting circuit (inverter) with approximately 30–100 kHz is mostly used to discharge and so it is affected by stray capacitance.

R1-1.2 When the secondary voltage of inverter is stepping up from a sufficiently low voltage gradually, an emission area appears near the electrode connected to higher voltage side. (See Figure R1-1 1st Phase). This means that the discharge starts between the electrode and ground level of discharge circuit through the stray capacitance, and a spark after dark current takes place in the discharge space in the tube. In the discharge, the other electrode is the tube wall (glass or fluorescent substance); the formation of dielectric barrier discharge and the existence of the secondary electron supply system to the discharge space can be considered and thus the discharge seems sustainable. Therefore, the emission around the electrode is judged to be the emission mainly by negative glow of glow discharge.

R1-2 From Discharge Starting to Stable Lighting Mode

R1-2.1 After the discharge takes place near the electrode and the secondary voltage of the inverter increases gradually, the emission area near the electrode grows longer accordingly. (See Figure R1-2.) This means that a positive column is generated by applied voltage to have such the length as corresponds to the value of resistance based on the applied voltage. When the voltage is applied furthermore, the emission area (i.e. positive column) between two electrodes is generated finally. (See Figure R1-3 2nd Phase.) However, if the tube is thin and long and the stray capacitance is relatively greater to the discharge circuit, the ratio of current that flows through the stray capacitance is still large at this phase. With the increase of the inverter secondary voltage, the ratio of current that flows in the tube also increases and most of the current flows in the tube because the impedance of discharge path decreases on the contrary due to negative characteristics of discharge. (See Figure R1-4 3rd Phase.)

R1-2.2 Each voltage applied at these three phases may be called starting voltage at the first phase, or stable discharge voltage or tube current at the third phase, for example. Sometimes it could be hard to distinguish the second phase from the third phase. In addition, since the second phase is hardly observed by the tube designs (for the tube length, outer and inner diameters of tube, pressure and composition of filler gas, and peripheral members of tube), it looks as if the first phase shifted to the third phase suddenly. This is because the stray capacitance is so big that the current cannot flow into the tube, the discharge surges immediately after the current flows into the tube, the impedance of the discharge path decreases due to the negative characteristics and a large amount of current flows in the tube all of a sudden.

R1-2.3 From the viewpoint of discharge phenomenon, the voltages applied to the tube at the first and third phases are important. Especially the voltage applied at the third phase should be noted practically. (The voltage applied at the second phase may be noted also.)

R1-3 Cautions at Discharge Starting

R1-3.1 At the discharge starting, α coefficient of discharge gas and γ coefficient of electrode are involved. These coefficients contain the pressure of discharge gas (particle density) as a parameter. Especially when the mercury is filled in, the control of ambient temperature becomes very important because the mercury vapor (particle density) pressure changes sensitively to the ambient temperature.

R1-3.2 In addition, the lighting circuit is usually built for AC, the reduction of unnecessary stray capacitance base on frequency shall be required. As the impact of stray capacitance becomes greater especially when the tube is thin and long, sufficient consideration shall be given.

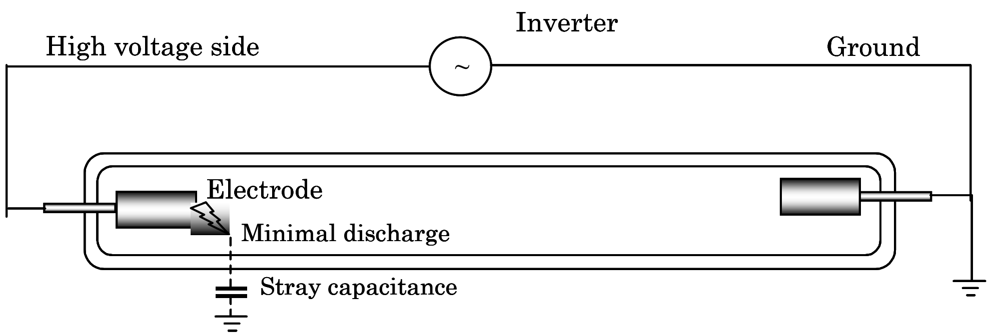


Figure R1-1
1st Phase of CCFL Discharge Starting

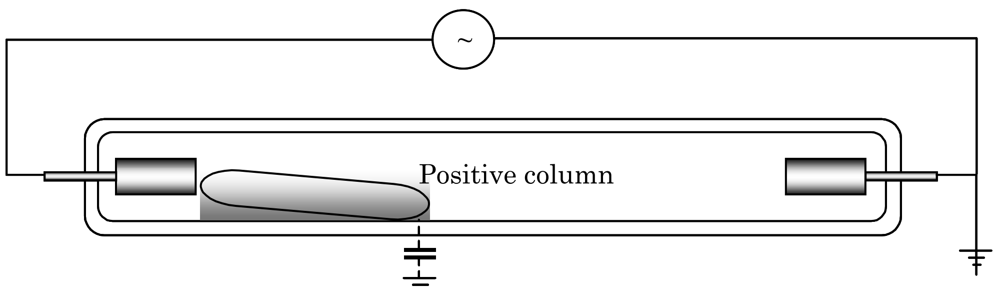


Figure R1-2
From 1st Phase to 2nd Phase of CCFL Discharge Starting

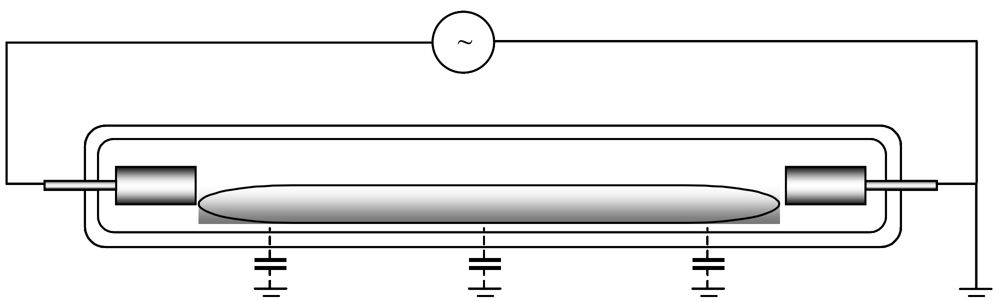


Figure R1-3
2nd Phase of CCFL Discharge Starting

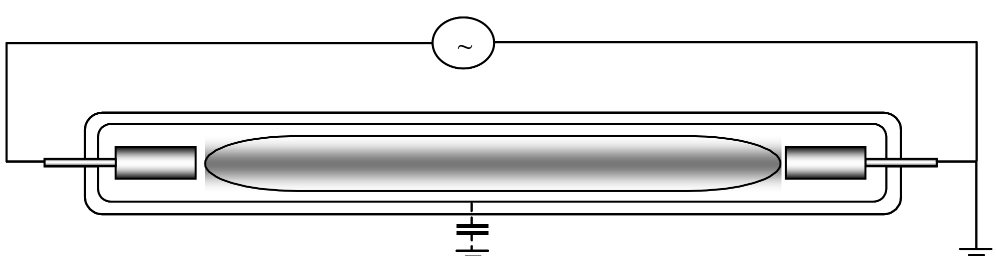


Figure R1-4
3rd Phase of CCFL Discharge Starting

RELATED INFORMATION 2
DARK CHARACTERISTICS OF DISCHARGE LAMP

NOTICE: This related information is not an official part of SEMI D35 and was derived from Japan Backlight TF.

R2-1 Start of Discharge Lamp

R2-1.1 When a discharge lamp is activated, there must be electrons (initial electrons) in the discharge space generally. In order to start up, it is necessary to apply an electric field, accelerate the initial electrons, excite and ionize gaseous particles, and establish discharges (keep up discharges) in the discharge space. At that moment, the initial electrons are said to have relation to the continuity of discharges at random, and the combinations of the status of a lamp when manufactured, history of on/off of lighting, various factors of a discharge lamp, and lighting circuits are involved.

R2-1.2 For these reasons, in terms of the start-up of a discharge lamp, initial electrons are required and there are probability factors to be considered, and so the discharge start-up time delay should be observed statistically.

R2-2 Dark Characteristics of Discharge Lamp and Remedy

R2-2.1 A discharge lamp usually starts up in a bright place even when the initial electron source is not provided especially. It is considered that this is because the external light gives energy to materials (gas, electrode, etc.) inside the discharge space to emit electrons (photoelectrons) as an initial electron. However, in order to activate the discharge lamp in a dark place, the photoelectron cannot be used. There are electron sources such as natural radiation as the other initial electrons (cosmic rays and radian from the earth) but these are not enough to get initial electrons at present.

R2-2.1.1 Since the initial electrons in the discharge space in the darkness decrease greatly, the discharge start-up time delay, which is from the voltage-applied time to the start-up time, tends to be salient. This is defined as dark characteristics.

R2-2.2 In order to start up a discharge lamp within a limited time, the method to supply positively initial electrons in a discharge space is needed. For example, regarding a fluorescent lamp for ordinary lighting purpose, its negative electrode is preheated before the start-up. As a result, thermoelectrons, which are emitted from the emitter applied to the negative electrode, are used as an initial electron. For a glow starter, bremesstrahlung electrons by radioisotope (RI) built in the electrodes are employed. In addition, there are other methods such as applying high-voltage to supply electrons from the electrodes (field emission) and supplying photoelectrons by turning on another light source (light bulb) located nearby a discharge lamp before its start-up.

R2-2.3 In terms of a discharge lamp used as an LCD backlight, the conventional remedies have not been utilized because it must have compact cathode electrodes, the RI is hardly used from the environmental view point, the output voltage for an inverter of high-frequency lighting circuit is limited, and the space is too small to built another light source in it. Thus, unique methods have been studied. Nowadays, the followings, such as exposing a metal oxide that emits exoelectrons[*1] in the discharge space, forming spattering layers[*2] on the wall near cathode electrodes by lighting a discharge lamp for a certain time, and making a compound of materials with low work function[*3] into electrodes or placing it near electrodes, are performed.

R2-3 Theory on Discharge Start-up Time Delay

R2-3.1 The equation on the discharge start-up time delay is as follows.

$\tau = 1/(P \cdot Q)$ ----------------------------- (1)

where
τ: average discharge start-up time delay (sec)
P: percentage of one electron that discharges (/particle)
Q: number of initial electrons (particle/sec)

R2-3.2 In Q factors mentioned before, such as the photoelectrons[*4], thermoelectrons by external light, electrons emitted by field emission, electrons by natural radiation, electrons by RI, and exoelectrons, and in P factors, such as the voltage applied to a discharge lamp, filler gas pressure, kind of gases, electrode materials, impact of residual impure gases and concessionary shape of electrode, are involved.

R2-3.3 Here, if a maximum value “1” is set to P by adjusting a discharge lamp and lighting circuit and if at least one particle of electron per second exists in a discharge space, τ will be 1 second. Usually P is considered to be the order of 10^{-3}. If τ becomes approximately 1 second, the initial electrons with order of 10^3 particles per second will be required, and for 0.1

second, approximately initial electrons with the order of 10^4 particles per second will be required.

R2-3.4 Measuring τ under various conditions helps us to understand the dark characteristics and improve the remedies.

*1: When a material emits electrons, the energy greater than work function must be given to electrons in the material but here the electrons are such energies emitted as low heat and light. The alpha alumina is said to emit exoelectrons and it is actually used as an initial electron source for a cold cathode lamp. However, the details are still unknown.

*2: The mercury seems to interact with the spattering layer to create the exoelectrons source.

*3: The cesium (Cs) and the like with low work function applied to an electrode is used as compound.

*4: The question still remains if photoelectrons can be supplied when energy more than work function is given to a discharge lamp material by external light (visible light). The electron by external light may be also considered as an exoelectron.

RELATED INFORMATION 3
PRECAUTIONS AGAINST MEASURING METHOD OF COLD FLUORESCENT LAMP

NOTICE: This related information is not an official part of SEMI D35 and was derived from Japan Backlight TF.

R3-1 Introduction

R3-1.1 The cold fluorescent lamp (CCFL) is turned on usually by using a compact DC/AC convertible power supply called inverter. The CCFL has been developed with top priorities such as a narrow diameter, space-saving shape and high brightness for its application and so the inverter has been requested to have a low profile space-saving shape with high efficiency as well.

R3-1.2 Understanding these requirements are satisfied and the characteristics such as high voltage, high frequency and micro current are compassable as trade-off in the CCFL, we should handle it with care.

R3-2 Stray Capacitance and Leakage Current

R3-2.1 *Stray Capacitance*

R3-2.1.1 The stray capacitance is defined as a characteristic that behaves as if it had the electrostatic capacity that system does not provide and its volume is too unstable to be measured quantitatively (unintentional electrostatic capacity element). If a formula for electrostatic capacity between two parallel copper wires is put into an equation, it will be nearly expressed as follows;

$$C = Q/V = (\pi\varepsilon 0)/(\log((d-a)/a) \text{ ------ } (1)$$

where
C: electrostatic capacity (stray capacitance)
d: distance between wires
a: diameter of wire

R3-2.1.2 According to the above-mentioned equation (1), it is understood that the stray capacitance does not affect the frequency but is inversely proportional to logarithm of the distance between wires. (This means that the closer the distance between high potentials becomes, the more the stray capacitance increases, and the longer the wire becomes, the stray capacitance increases as well.)

R3-2.2 *Leakage Current*

R3-2.2.1 The leakage current is the inverter secondary current that flows to the above-mentioned stray capacitance. (It equal to the inverter secondary current except for that of CCFL.) Suppose "C" is the stray capacitance around CCFL and "I" is the current that flows to "C" and sinusoidal AC voltage is applied, the bellow-equation is obtained.

$$I = \omega \cdot C \cdot V = 2\pi f \cdot C \cdot V \text{ ------ } (2)$$

where
I: leakage current (true AC current)
f: AC frequency
C: stray capacitance (electrostatic capacity)
V: tube voltage (true AC voltage)

R3-2.2.2 According to the above-mentioned equation (2), the leakage current increases proportionally to the increase of the frequency, stray capacitance, or potential difference.

R3-2.2.3 Since the stray capacitance and leakage current increase or decrease by each parameter such as the length of high voltage wire, distance between the wire and the conductor of ground, lighting frequency and potential difference, it is recommended that measuring conditions should be specified and standardized as much as possible.

R3-3 Temperature Characteristics

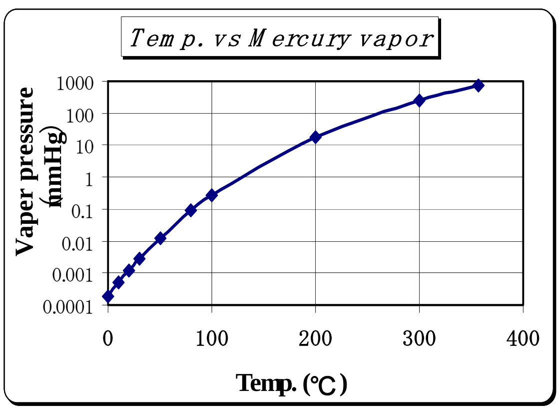
R3-3.1 The CCFL is quite sensitive to mercury temperature characteristics because its fluorescent substance emits light receiving ultraviolet rays from mercury particles as activation energy.

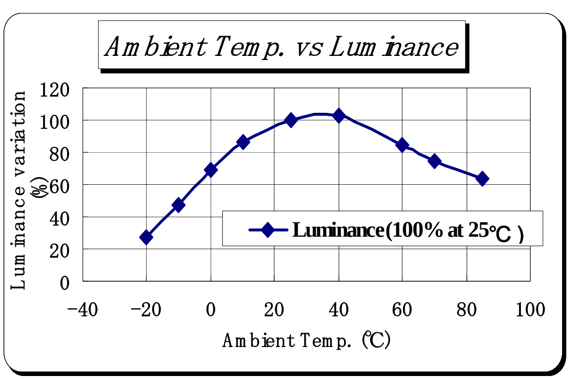
R3-3.2 If the temperature of mercury particles is regarded as the same as the CCFL wall temperature when lighting, and suppose the tube temperature is 25°C at 0°C of ambient temperature against wall temperature at 50°C, approximately 1/10 of saturated steam pressure difference will take place and actual luminance of the tube will be approximately 1/2. On the contrary for the high temperature side, suppose the wall temperature is 100°C against the ambient temperature 70°C the steam pressure difference which is greater by 20 times will take place and the actual tube luminance is approximately 2/3.

R3-3.3 In this manner, the temperature and tube luminance have peak characteristics within a certain temperature range because the partial pressures of Ar, Ne and Hg have the optimum density against the lighting tube current. When the temperature is low, the luminance decreases due to the lack of absolute amount of ultraviolet rays caused by insufficient mercury molecules.

R3-3.4 On the other hand, when the temperature is high, the mercury molecule density goes up dramatically, reabsorption of ultraviolet rays by mercury itself takes place, the amount of ultraviolet rays that reach the fluorescent substance decreases and so the luminance decreases accordingly. The further attention necessary is that the mass (thickness) of glass tube is made as thin as possible because the CCFL has been developed with such top priority as to have the narrow diameter, space-saving shape and high luminance. For this reason, the heat capacity is very small, which means the inside mercury molecule temperature will be affected greatly by heat transfer caused by interference with surrounding members and cooling effect of convective wind to the glass.

R3-3.5 Since the luminance varies due to the impact to the glass temperature by each parameter such as the interference of surrounding members, contact of other materials and cooling effect of convective wind, it is recommended that measuring conditions should be specified and standardized as much as possible.





R3-4 Slide-up Speed

R3-4.1 The status where a main discharge starts is measured for the measurement of stable discharge voltage sliding gradually the voltage up from the sufficiently low value. Since the starting point of main discharge may vary by the slide-up speed, a special attention should be paid.

R3-4.2 When the slide-up speed is so slow that the ratio of partial pressure of Ar, Ne and Hg shifts to the condition where lighting is easily performed because the mercury vapor pressure increases by the heat generation caused by half-lighting, the main discharge may begin easily compared to the condition at low CCFL temperature.

R3-4.3 Therefore, when measuring the CCFL, these conditions should be specified and standardized as much as possible.

R3-5 Use of Master CCFL

R3-5.1 When interrelating the spectroradiometer and colorimeter, an actual CCFL is used often as a master CCFL.

Precautions for such cases are

1) the registration date, production history, lighting history and expiring date of the master CCFL should be specified and attached to it, and
2) the master CCFL should be kept such that there shall be no impact to reproduction of measurement.

R3-5.2 Since this document is positioned as a related document to standardized documents, the contents are treated as "just for information".