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VESA Standard: Display Specifications and Test Procedures

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Purpose:
To provide standard definitions and test conditions for computer display specifications, such that customers and users can compare specifications across different models and manufacturers in a meaningful way.

Summary:
In the past, many display specifications have not been clearly defined in the minds of the users, and the same specification − at least two items using the same *name* − from apparently comparable models from different suppliers were not directly comparable. The customer was unable to gain the information needed to compare the products solely from the published specifications. While VESA has no intention of mandating what specifications a manufacturer should or should not publish, and further does not intend to provide specified or recommended levels of performance, this standard has been developed to provide a "common language" for display specifications, so that such comparisons can be made and so that the user may have a common−sense understanding of the meaning of these parameters.

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Supplemental Standards

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1. General Information and Intent of Standard

The aim of this document is to provide the computer display industry with a set of standards for measuring and publishing display performance specifications and physical parameters, which achieves the following goals:

1.1. Provide a concise, easy–to–understand set of display specifications to the user, which are consistently measured and presented by all display manufacturers.

1.2. Provide a standard means for obtaining the values presented in these specifications, through the definition of test procedures, conditions, and preferred units.

1.3. Through this standardization, permit an objective comparison of different displays, in a manner which accurately reflects the user's expectations of a computer display device.

It is clearly beyond VESA's ability or intention to mandate the test procedures used by manufacturers in display production or by any user or customer in their standard evaluation procedures for displays. This standard is intended only to define a set of standard procedures which *may* be used if desired, and so provide a "common language" within the community of display producers and users.

Further, VESA has no intention, in establishing this standard, of mandating which specifications a manufacturer should or should not publish, nor to set recommended levels of performance per these specifications. This document is solely to establish a common meaning for those specifications which a manufacturer may elect to publish for a given model, such that the display user or customer is able to directly compare these specifications with similar figures published under this same standard for different products.

2. Definition of Terms

These definitions apply to the following terms as used in this standard.

2.1. APL, Applied Picture Level, – This refers to the level of the input video signal, expressed as a percentage of the reference white level of the video signal standard in use, relative to the BLACK level of that standard (which is considered 0% APL). Therefore, 100% APL refers to an input signal at the reference white level during the active image time. As mentioned above, 0% APL is taken to mean the black level of the signal standard, which is the lowest level of video input normally received by the display during the active video time, regardless of any difference ("setup") between this level and that used during the blanking intervals.

2.2. Active image – The "active image area" or "active image time" refers to that area of the displayed screen or image or that period in the video signal which corresponds to all portions of the video signal outside of the blanking times. For this definition only, "blanking time" is also taken to mean any "border" areas which are not a portion of the signal time or image area corresponding to the content of the host's frame buffer, if such a border is provided.

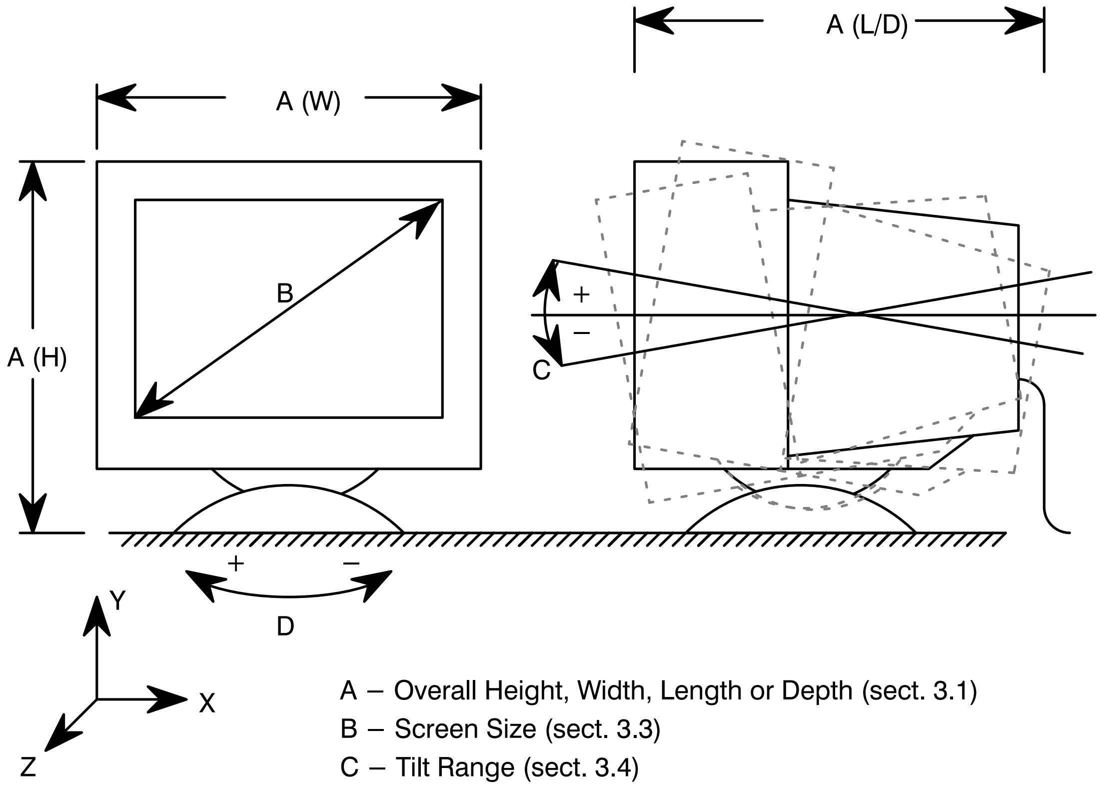
2.3. Raster – The area of the screen corresponding to the entire video signal time, including blanking/retrace; the total area scanned by the CRT's electron beam. "Background raster" is sometimes used to refer to those areas corresponding to the blanking times, which may be illuminated depending on the setting of the display brightness controls.

2.4. Specification – Any instance, including written communications, published specifications or other product information, advertising, etc., in which a display manufacturer, distributor, or customer conveys information relating to the intended or required performance, features, quality, or physical parameters of a display device.

2.5. "Shall be", "Should be", "Must be" – As used in this standard, these phrases are interchangeable, and both refer to a procedure, condition, parameter, or other aspect of a given specification standard or measurement/test procedure which is mandatory for compliance with this standard.

3. Display Physical Parameters

The following mechanical drawing is included to provide a guide to the references and measurements listed in this section



A – Overall Height, Width, Length or Depth (sect. 3.1)
B – Screen Size (sect. 3.3)
C – Tilt Range (sect. 3.4)
D – Swivel Range (sect. 3.4)

Note: Height, width, and depth measurements are to be made with the unit flat on the supporting surface, with no tilt or rotation with respect to this surface around the X or Z axes as defined above. See the relevant sections of this standard for details.

3.1. Overall Size (Height, Width, Length)

Description: Defines the overall physical size of the unit in question.

Specification std: The overall physical size of any display shall be given as overall height, width, and length (depth). These specifications shall be given in either centimeters or millimeters, although supplementary statement of these same dimensions in English units (feet, inches) is permissible; if English units are given, these should be presented in parentheses following the metric measurement. Example:

Overall width: 385 mm (15.2 in.)

The three dimensions given are defined as follows. The intention of these definitions is that the overall size specifications given accurately reflect the

product's size as it is normally configured and used:

Overall height: To be measured with the unit resting on a flat surface, with zero tilt (i.e., a vertical line tangent to the surface of the CRT at the center is normal to the plane on which the unit rests, unless the unit provides "fixed tilt" as described in 3.5). Any tilt/swivel assembly, etc., should be included in the overall height of the unit if it is attached to the unit as shipped, or if the unit cannot be operated normally without the attachment of such an assembly. If the use of a tilt/swivel assembly or other base is optional, two height specifications (one with the base on, and one with it off) should be given whether or not this base is attached to the unit as shipped.

Overall width: To be measured along a line parallel to both the surface on which the unit rests and a horizontal tangent to the surface of the CRT at its center, at the points of the maximum width of the unit.

Overall length (depth): To be measured along a line parallel to a line normal to the surface of the CRT at its center, at the point of maximum overall length or depth of the unit. This measurement should accurately reflect the depth required by the unit in normal operation; therefore, the following restrictions must be met:

In the case of a unit with integral or otherwise permanently attached video or other cabling on the rear surface of the unit, which would extend beyond the rear of the cabinet when said cables are bent with a radius of curvature of not less than three times the outside diameter of the cable or cable bundle, then the measurement is to be taken to the limit defined by the outer cable surface or the rearmost point of the unit's cabinet, whichever results in the greater measurement.

In the case where connectors are provided for video, AC power and/or other cables, the measurement is to be made to whichever of the following results in the greater overall measurement:

1. To the rearmost surface of a standard right−angle or "T" connector for the connector type used, when said connector is attached to the unit (for example, a standard BNC "T" if BNC video connectors are used), OR

2. The most rearward point of the recommended AC line cord, when installed in the AC input connector, and bent at a right angle as described above, OR

3. The rearmost point of the unit's cabinet.

3.2.Product Weight (packaged and unpackaged)

Description: Specifies the weight of the product both for shipping and as normally used.

Specification std: Packaged and unpackaged product weight is to be given in kilograms. English equivalents (pounds, ounces) may also be given, but only in parentheses following the metric specification. Example:

Unit weight: 22.5 kg. (50 lbs.)

Packaged weight must be explicitly identified as such; if no identification is given, the weight specification should be assumed to apply to the unpackaged product.

The packaged weight specification is to include the unit and all accessories, manuals, cables, assemblies, and other items normally shipped with the unit, plus the weight of the packaging material (carton, cushions, bags, etc.) itself. The packaging material used must be that which complies with the manufacturer's published specifications for transportation shock and vibration, etc..

The unpackaged product weight is to include only the weight of the unit itself, plus any assemblies (tilt/swivel assembly, etc.) which must be attached to the unit in normal operation, exclusive of detachable cables. Weights for optional equipment (for example, a detachable glare filter) should be listed separately.

3.3.Screen Size

Description: Defines the physical size of the exposed CRT screen.

Specification std: The physical size of the CRT screen is to be given in millimeters, and is defined as the height and width of the bezel opening or exposed CRT phosphor area, whichever is smaller. Providing an additional diagonal measurement for convenience is permissible; if this is done, this should be the diagonal measurement of the exposed CRT phosphor area (the "viewable" diagonal), rounded to the nearest centimeter. English−unit values (inches only) may also be provided in addition to the metric dimensions, but these should be given only in parentheses following the metric dimensions. In the case of the optional diagonal specification, the diagonal in inches should be given only to the nearest half inch. Example:

CRT Screen Size: 390 x 290 mm (15.4 x 11.4 inches)
(Diagonal: 49 cm (19"))

Note that if screen size information is given, it is recommended that image area information conforming to the VESA Image Area Definition (VIAD, latest revision) be given as well. Excerpts from this standard are given in section 5.3 of this document.

3.4.Tilt/Swivel Functionality; Height Adjustment Range

Description: Defines the range of motion for display tilt and swivel, and the range of adjustment for display height.

Specification std: Tilt and swivel range is specified for those monitor which include an integral tilt/swivel mechanism, or for which an optional tilt/swivel is available from the monitor manufacturer. If the tilt/swivel mechanism is optional, it must clearly be stated as such in this specification.

Tilt and swivel ranges are to be given separately, and in degrees, per the following conventions:

1. The zero degree reference for tilt is a plane parallel to the surface on which the unit rests in normal operation. This means that a display which does not include a tilt mechanism, but in which the CRT faceplate is tilted from vertical when the unit is in its normal operating position, should be specified as having a non−zero fixed tilt.

2. Tilt is specified as positive for those angles which are above the reference plane (i.e., a line normal to the CRT faceplate at its center would intersect the plane BEHIND the CRT faceplate) and negative for those angles below this plane.

3. The zero degree reference for swivel is that condition when a horizontal line tangent to the CRT faceplate at its center is parallel to the line defining the "front edge" of the tilt/swivel assembly as viewed by the user, or, in the case of a tilt/swivel assembly for which there is no well−defined "front" (as in the case of a circular base), the center of the range of tilt.

4. Swivel range is to be specified as degrees positive and negative from the zero reference, with clockwise rotation (as viewed from above) considered the positive direction. If a single number is given, with no explicit positive and negative (or "+/−" designation, that number shall be assumed to refer to the maximum swivel permitted in either of these directions, as opposed to the total range of swivel (which would be twice this value).

5. The maximum force required for the tilt and swivel adjustments shall also be specified; these shall be listed separately.

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6. The range of height adjustment shall also be specified if a height adjustment is provided. This range shall be stated by giving the minimum and maximum height of the display, as defined in 3.1.

3.5. Screen Reflectivity (Anti−Glare Performance)

Description: Reflectivity is a measure of the amount of light which will be reflected by a surface; as used to describe a CRT faceplate, this is an indication of the amount of glare that will be seen by the user. Reflectivity is normally given in terms of the percentage or fraction of the amount of light emitted from a standard source in a standard position that is reflected to a standard observer (usually a spot photometer).

Specification std: Reflectivity will be listed under this name. although the word "glare" may be included in parentheses if desired. The specification is to give the maximum expected value of reflectivity, as determined using the procedure given below, and given as a percentage to the nearest whole percentage point.

Example:

Reflectivity ("glare"): 35% maximum

Test Procedure: Equipment needed: A diffuse planar light source of not more than 50 mm (2") diameter, of color coordinates (x,y) = 0.313, 0.329. (Illuminant D, 6500° K), plus a spot photometer in photoptic filter mode with an acceptance angle of 0.2 degrees

or smaller. The photometer must have a spectral response matching the CIE Photoptic Curve.

1. Arrange the spot photometer and light source relative to the CRT faceplate to be tested per the geometry shown on the following page. The arrangement must be made such that the angle of incidence and the angle of reflection are accurate to within 0.5 degree, with the distances between the CRT faceplate and either the light source or photometer accurate to within 0.5 cm (or such that the light source has a diameter of 1 deg. +/− 0.05 deg. as measured from the surface of the screen). The image of the light source must entirely illuminate the circle of acceptance of the photometer. If the image of the source is visible to the photometer, and the angle of incidence was previously established, then the angle of reflection may be taken as correct and need not be measured separately. Except for the specified light source, there should be no light sources present (dark ambient) for this test, or the effect of such ambient must be compensated for in the final results.

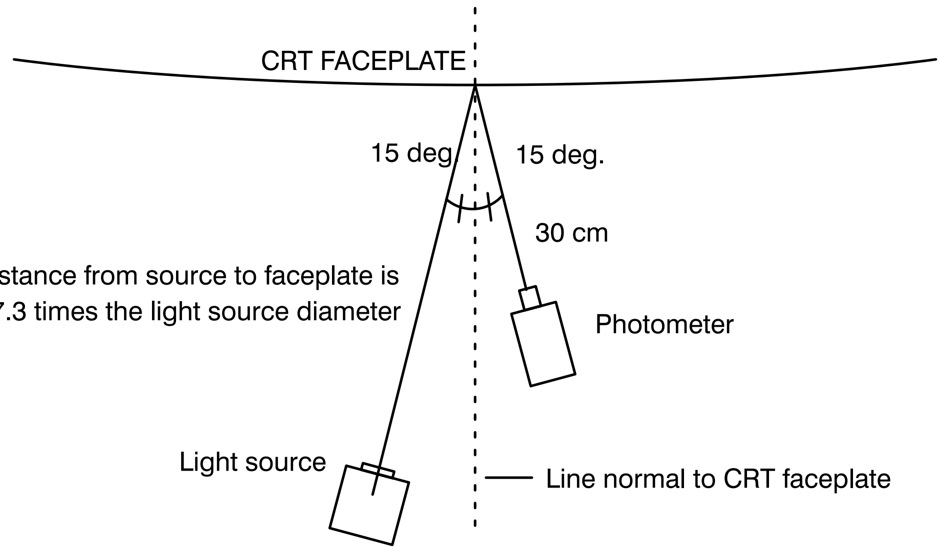


Fig. X – Geometry for reflectivity measurement

2. With this measurement geometry established, and the entire image of the source visible to the photometer and entirely included within the photometer's circle of acceptance, the total luminance of the reflected image should be measured (Y_t).

3. Rearrange the light source and photometer such that the distance between them is 1.00 meter, and the photometer is aimed directly at the source with the plane of the source perpendicular to the light path. Measure the luminance of the source (Y_s).

4. The reflectivity value may now be calculated as

$$\text{Reflectivity (\%)} = [\, Y_t / Y_s \,] \times 100\%$$

4. Signal Interface

4.1.Input Impedance or Termination Resistance; VSWR

Description: Defines the termination seen at the video input of the display.

Specification std: Input impedance or termination resistance is to be specified in ohms, and applies only to the video signal inputs.

If specified as "termination resistance," only the DC value need be given; this shall include a percentage tolerance.

If specified as "input impedance," the value and tolerance given must be valid over the range of frequencies from the lowest nominal refresh rate supported to the specified +/– 3 dB video bandwidth (per sect. 7.1), or several values may be given for various frequencies in this range. In either case, the specification must define the maximum and minimum values of input impedance over this full range.

For monitors specified as operating with timings above a 100 MHz pixel clock frequency, input impedance (as opposed to termination resistance) MUST be specified as defined above. A maximum value of Voltage Standing Wave Ratio (VSWR) over the same range of frequencies as specified for the input impedance, and assuming an ideal (matched to the nominal system impedance per the signal standard in use) source and line, must also be stated.

Unless explicitly given separately for the various inputs, the value given shall be assumed to apply to all video signal inputs.

If the unit provides switchable input terminations (for "loop–through" operation, etc.), the value specified should be that for the condition in which the unit in question is the sole termination of the video signal cable.

Input impedance, termination resistance, or some other means of specifying the load may also be provided for the sync and other inputs as desired.

5. Timing and Image Attributes

5.1.Supported Input Signal Timings/Formats; Factory–Preset Modes

Description: ”Supported timings” are those timings which the manufacturer lists in specifications, advertisements, manuals, and other related documents as being ”compatible” in relationship to the product in question. A ”factory preset mode” is any input timing format, within a specified frequency/timing tolerance, which corresponds to timing information and other parameters stored within the monitor which when used results in an image that the manufacturer guarantees will meet published specifications for all image and performance parameters.

Specification std: 1. When stating supported timings or factory presets which are VESA standard timings, reference to the VESA name for the timing is appropriate. If the timing is not a VESA standard timing, then it should be fully described, including the following parameters:

Timing name	Horizontal Total Time
Horizontal Pixels	Horizontal Addressable (active) Time
Vertical Pixels	Horizontal Blank Time
Horizontal Frequency	Horizontal Front Porch
Vertical Frequency	Horizontal Sync Width
Pixel (Dot) Clock	Horizontal Back Porch
	Vertical Total Time
Horiz. Addressable Line Length	Vertical Addressable (active) Time
Vert. Addressable Height	Vertical Blank Time
	Vertical Front Porch
Sync Polarity	Vertical Sync Width
Scan Type	Vertical Back Porch

(For the formal definitions of these parameters, please see other VESA standards such as the VDIF standard or the EDID section of the Display Data Channel standard.)

2. A timing should be considered as ”supported” only when the product will meet all specifications and operate normally (stable display, etc.) when presented signals at said timing, although meeting all specifications may require some user adjustment. A ”factory preset mode” refers to a timing or format for which the monitor will meet specifications and operate normally without user intervention, as long as the factory preset information remains intact within the unit in question.

5.2.Maximum Resolvable Addressability (Pixel Format)

Description: This is intended to give the customer some information regarding the resolvability of images presented on a given display using timings or formats which the display supports. Resolvability is considered separately from simple ”support” of a format, as it is clearly possible that a given display can operate (synchronize) at a given timing, and yet be unable to adequately resolve the addressability implied by that timing.

Specification Std: A manufacturer must state the minimum contrast ratio expected between alternate on–off pixels or lines at any point on the screen (as measured per section 6.3),

when the display is operated at the maximum pixel rate format claimed to be resolvable, and under the user control settings established under section 6.1. Formats with greater pixel counts or rates may be claimed as ”supported” per section 5.1, but it should be made clear that these are not claimed as ”resolvable” formats.

5.3. Image Area

Description: The image area defines the manufacturer's maximum recommended area for display of an image, measured in millimeters horizontally and vertically.

NOTE: A previous VESA standard, the VESA Image Area Definition, has been established to define this specification. The following standard is intended to comply with the VIAD definition; in case of any perceived conflict between the two, the VIAD definition is to be used until such time, if any, that the VIAD standard is formally removed by VESA.

Specification: The image area shall be stated in millimeters both horizontally and vertically. This is the largest rectangle in which the display is capable of presenting an image which meets all quality and performance specifications for that display, and which provides a direct representation of the contents of the video memory or frame buffer of the video display controller or graphics subsystem.

The following criteria define and shall be met in describing the image area:

1. The image area shall be an area which is wholly visible to the user. Therefore, this area cannot be larger than the bezel opening.

2. An image displayed within this area shall meet the quality specifications established by the manufacturer.

3. The image area specified does not include colored or non−colored border areas (those portions of a displayed image in which the pixel are not addressable).

The horizontal and vertical dimensions should be measured when a signal with the defined signal timing is applied, and with the display size, centering, etc., as set by the default factory adjustments. If the factory−adjusted dimensions vary or may be expected to vary by more than +/− 2%, the tolerance on the image area dimensions must be stated as ”+/− (tolerance in millimeters)”. The pattern to be used for this measurement shall be the standard brightness test pattern, as defined in section 9 of this standard, and the user brightness and contrast controls shall be set as in section 6.1.

If the manufacturer specifies more than one nominal signal timing, and if the image area varies depending on the signal timing, then the image area tolerances may be stated as ”+/− (tolerance in millimeters)”, as above, or the image area and tolerances may be specified separately for each individual timing.

If the display has user controls for the adjustment of the image area size, and if the User's Manual (or similar documentation) includes a detailed description of how

these controls should be used and adjusted, then the image area may be stated in terms of the dimensions obtained after adjustment of these controls. If the dimensions depend on user adjustments, then the specification should include text stating ”The actual dimensions depend on user adjustments.”

Examples:

The image area for a ”14 inch” CRT might be specified as any of the following:

Image area: 240 x 180 mm

Image area: 230 x 170 mm +/− 10 mm

Image area: 240 x 180 mm (actual dimensions depend on consumer adjustments)

Image area: 237 x 176 mm for MAC II
240 x 180 mm for VGA
235 x 178 mm for SVGA
239 x 180 mm for MCGA

5.4.White Point

Description: Defines the chromaticity of the nominal ”white” color displayed by the product.

Specification std: The display’s white point should be stated in x and y chromaticity coordinates, per the CIE 1931 Chromaticity Diagram. The ”color temperature” (the point on the ”black body” line corresponding to this white) may also be given if desired, in parentheses following these coordinates, and should be given in degrees Kelvin plus an integer number of Minimum Perceivable Color Difference units (MPCD) as needed.
A tolerance for the x and y values should be given along with any dependency on ambient conditions. The white point coordinates and tolerances must be provided for the flat−field 100% APL case described below; tolerances must also be explicitly stated for the 10% APL level (with the other test conditions remaining the same). Optionally, separate listings for both the white point chromaticity and tolerance at each of these levels may be provided.

Example:
White point: x = 0.283, y=0.298 per 1931 CIE Diagram (9300°K + 8 MPCD) (+/− 0.030 for both x and y, over a temp. range of 10 to 30 deg. C)

If the display can provide multiple user−selectable white points, the coordinates and tolerances should be specified separately for each, and the default white point explicitly identified.

Test procedure: White point is to be measured at the center of the screen, using a calibrated color analyzer or spectrophotomer. The user controls (brightness and contrast) should be set as in section 6.1. The signal levels at all video inputs shall be at the reference white level (100%).

If the white point is additionally tested or specified at points other than the screen center, then these locations must be described in terms of millimeters of offset vertically and horizontally from the physical center of the display.

The measurements for white points shall be made under dark ambient conditions, or the effects of ambient lighting subtracted out.

5.5. Phosphor Specifications

Description: Provides the basic information which specifies the appearance and flicker performance of the phosphors used in the display.

Specification std: Phosphor specifications should include at a minimum the phosphor decay time and the phosphor colorimetry. These specifications are to be given separately for each phosphor in a color display, and may be specified by either a single set of numbers or by a separate listing for each phosphor component in the case of a monochrome display; separate decay time listings for each component are preferred, but the chromaticity of the phosphor as a whole must be listed in addition to that of each component if the component specifications are given separately. Tolerances for each listing must also be provided.

The chromaticity values shall in all cases be stated in terms of the x and y coordinates from the 1931 CIE Chromaticity Diagram. These values are to be taken as the expected measurement at an ambient temperature of 25 deg. C, and at full illumination (100% video level) on all inputs, and user controls set as in section 6.1. The values given should be those expected with no external (ambient) illumination.

Phosphor decay times are to be given in milliseconds, and should specify the time required for the phosphor light output to decay from 100% of its initial luminance to 1/e times that value (approx. 36.8 %), starting at the time that excitation is removed. The conditions shall be the same as used for the chromaticity measurements above. The manufacturer may also provide the decay time to 10% of the initial luminance, but this information may only be provided in addition to the 1/e value.

5.6.Display Gamma

Description: Describes the exponent function of the nonlinear characteristic of the brightness of the display vs. the level of the video input signal, and is used for the purpose of correcting the system input/output transfer characteristics.

Specification std: The gamma function must be calculated based upon a minimum of 8 different brightness measurements. These measurements must be made at the center of the display, after a minimum of a 20 minute warm–up period. The measurements shall be made at equally–spaced intervals from 0% to 100% of the video signal level range on all inputs, using the standard brightness test pattern (see section 9) and the user control settings as established in section 6.1. The measurements should be performed in a dark environment, or the effects of ambient lighting subtracted from the measurements. Gamma, which is expressed as a dimensionless number to be used as the exponent of a power function, is then calculated from the curve thus obtained. The gamma number specified is to be

that which provides the best fit to the measured brightness data for the following function:

$$\text{Brightness} = (\text{input signal voltage})^{\wedge}\gamma$$

(Note: γ may be expected to be in the range of 2.2–2.7 for most CRT displays, with a value of approx. 2.5 being the most typical.) Gamma values may be listed separately for each channel of a color display if desired.

The table of values used to derive the gamma number may also be provided; in this case, the input signal level should be given in Vp–p (from the blanking level to the peak video level in each case) and the brightness values in cd/m^2.

Example: Given a display which uses a ref. white level of 0.714 V, the following table might be provided:

Input signal level	Brightness
0.071 Vp–p	2.5 cd/m^2
0.142 Vp–p	8.2 cd/m^2
0.213 Vp–p	25.3 cd/m^2
..	..
..	..
..	..
0.7140 Vp–p	110.2 cd/m^2

6. Display Performance – Image Quality

6.1. LUMINANCE (BRIGHTNESS) / LUMINANCE (BRIGHTNESS) UNIFORMITY

Description: Specifies display luminance (brightness), confirms that luminance does not vary excessively over the entire image area. NOTE: What is measured by the typical photometer is ”luminance”; ”brightness”, strictly speaking, should only be used when talking about how a light source is *perceived* by normal human vision. However, these terms have come to be used interchangeably by the average user, and so this standard will permit the use of the term ”brightness” in display specifications. VESA does wish to express a preference for the use of ”luminance” in describing this aspect of display performance.

Specification Std: 1. Display luminance shall normally be stated in cd/m^2. If it is desired to list the luminance specification in other units, this shall be done in parentheses following the listing in nits. For example:

Luminance: 110 cd/m^2 max. (32 ft.–L.)

2. Luminance uniformity shall be expressed as a percentage of maximum, with this number giving the minimum luminance with respect to the max. which will be observed at any point within the active image area.

Test Proc. Std. Equipment needed: Video signal generator, calibrated photometer.

Test Pattern: VESA standard luminance test pattern. See section 9.

Procedure: Conditions for test: Standard measurement conditions as described in section 10; this includes a darkened ambient environment or some allowance for subtracting out the effects of ambient lighting. The user contrast control (video amplifier gain) may be set at the manufacturer’s discretion, with the understanding that the setting used to obtain the luminance measurement will be used for all other tests or specifications in this standard which reference the user control settings of this section. The user brightness (cut–off) control shall be set such that the ”blanked” portions of the image (the ”background raster”) is at the ”just extinguished” point (not more than 0.1 cd/m^2 luminance).

After a minimum 20 minute warm–up (unless some other warm–up period is specified by the manufacturer, but in any case not to exceed 45 minutes), measure and record the luminance of the display at the center and at each of the four corners. The corner measurements are to be taken at locations along the image diagonal, and 0.1 times the length of these diagonals IN from the corner of the image. To evaluate the luminance uniformity, divide each of the corner values by the center value, and express as a percentage. NOTE: While the corners are typically the dimmest areas of a CRT display, there may be cases where there are noticeable variations in luminance elsewhere on the screen. If this is the case, the uniformity measurement should be made at the dimmest point, as found through a search of the active image area with a full white raster.

6.2. LINE WIDTH

Description: Determine the line width produced by a CRT display; line width is a means whereby perceived display focus can be checked in a quantifiable manner.

Specification std:

1. Line width is to be listed in millimeters, as measured at the 50% luminance points of a displayed line.
2. Line width should be listed either in terms of the maximum width to be found over the entire screen, or as a two–part specification which includes the maximum line width to be found within a circle centered in the image area of a diameter equal to the nominal image height, plus the maximum line width to be found outside of this circle but within the nominal image area.
3. If the line width differs for horizontal or vertical lines, these may either be listed separately, or the larger of the two may be listed
4. If the ”shrinking raster” method is used to determine line width, the specification should clearly indicate this, and should list line widths as found at center of the screen and the worst case of either of the two sides.
5. Separate line width specifications for white lines and single–color lines may be l listed in the case of a color display.

Test Proc. Std. Equipment needed: Both methods require a video signal generator or equivalent signal source. (NOTE: The signal source used must provide a sufficiently source rise and fall time such that the source does not affect the width of vertical lines – i.e., that any rise/fall time effects on the horizontal spot size be solely due to video amplifier limitations.)

Direct measurement method: Spatial–luminance measuring system.

Shrinking raster method: Transparent scale.

Test Pattern: Direct measurement: Any test pattern which displays a grid of single–pixel–wide horizontal and vertical white lines on a black background. The geometry test pattern as defined in section 9 is recommended. (NOTE: In the case of color displays, it may be preferable to use additionally test using a test pattern of a single pure color – red, green, or blue – to avoid errors due to the misconvergence of a white spot or line. Each color should be checked, as the spot size may vary across the three guns.

Shrinking raster method: A pattern of alternating horizontal lines, white and black, each one pixel wide (i.e., one scan line on, one scan line off, alternating in this pattern for the full height of the active raster). Alternatively, a full white raster may be used, if the individual scan lines of the raster may be distinguished under magnification when the monitor is operating normally (at specified raster size, brightness, etc.).

Procedure: Both procedures: Set the monitor user controls as in 6.1. Display the appropriate test pattern and perform the measurement according to either of the following methods:

The direct measurement of line width by a spatial/photometric measuring system should be made according to the manufacturer’s recommended procedure for that

equipment. Measurement should be made in millimeters, at the 50% luminance points of the line.

Direct measurement is preferred, but if the needed equipment is not available, an alternate test – the ”shrinking raster” method – may be used. This test is performed as follows:

1. Display a pattern of alternating horizontal lines as described above. For best results, this pattern may use fewer lines than the normal timing for the display in question; set the programmable signal generator to produce such a pattern which uses the fewest possible scan lines but is still within the synchronization range of the monitor. Some experimentation may be needed to determine the best timing to use.

2. With this pattern displayed, adjust the monitor's vertical size control to reduce the height of the image until the lines just merge at the center of the screen (i.e., the individual lines cannot be distinguished, and the appearance at center is that of a flat white field). Measure the height of the raster at the center of the image. Divide this figure by the number of white lines (NOT the total number of lines in the frame) to obtain the 50% line width.

6.3. CONTRAST RATIO (AREA and DETAIL)

Description: Defines the relative luminance of "white" and "black" areas as displayed on the monitor in question. This is specified separately for large areas and for details such as parts of characters.

Specification std: Contrast is to be listed as a ratio, and as such is dimensionless (no units given). Contrast ratio specifications will therefore take the form of the following, listing area and detail contrast separately. Detail contrast ratios may be listed separately for all supported formats in the case of a multifrequency monitor.

Example:

CONTRAST: Area – 20:1
Detail – 5:1

Test Proc. std. Equipment needed: Video signal generator, photometer. The photometer must be capable of accurate measurements at both the maximum brightness produced by the display and down to at least 1/100 of this level, or 0.3 cd/m^2 (0.1 ft.–L.), whichever is less. For small–area contrast measurements, such as to indicate the contrast of a text or graphics image with full–range video excursions in the space of a few pixels, use of specialized spatial–luminance measuring equipment is required.

Test Pattern: Luminance test pattern (as described in section 6.1 and section 9). For small–area (detail) contrast measurements, use the "meme" pattern as described in section 9 for focus tests.

Procedure: After a minimum 20 minute warm–up (or other warm–up period as specified by the manufacturer, but in any case not to exceed 45 minutes), set the user brightness and contrast controls as described in section 6.1. Measurements must be made under the standard test conditions as described in section 10. Specifically, the tests should be made under ambient light conditions as specified by ISO Standard 9241, Part 3 (250 + 250 cos(A) lux).

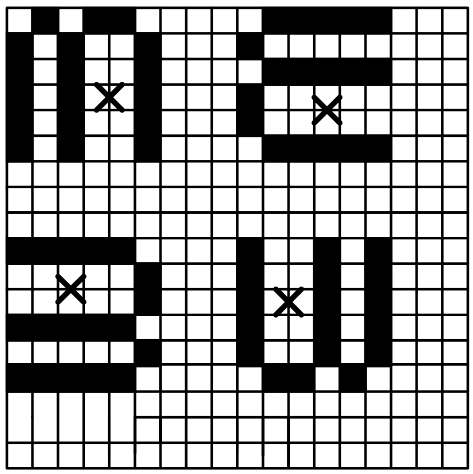
Area contrast: Measure and record the brightness of the five areas of the brightness test pattern, as used for the luminance test (6.1). Following this, measure and record the brightness of the adjacent black areas of this pattern. Contrast is expressed as the ratio of the two measurements taken in a given area (i.e., luminance of the white area divided by the luminance of the adjacent black area).

Contrast ratio = Lw/Lb, expressed as a ratio (i.e., "10:1")

where Lw is the luminance of the white area and Lb is the luminance of the black area in the same units.

The worst–case contrast found (lowest ratio of measurements of adjacent areas) should be the number listed as the result of this measurement.

Small–area or ”detail” contrast: To be measured directly by a spatial–luminance meas. system; follow the manufacturer’s procedure, measuring at the locations as indicated on the diagram below. The system used must be capable of providing accurate luminance measurements with a spatial resolution of not more than 0.1 times the nominal pixel size for the format in use. The worst case (smallest ratio) detail contrast found should be the number listed in the specification.



Luminance measurements to be made at the center of the white lines making up the characters, plus the centers of the inter–element black areas as indicated by the ”X” marks in this diagram. (Note: The ”X” marks are not a part of the image.)

These measurements are to be made in the four–character block of ”meme” characters

NOTE: This drawing is a NEGATIVE; the actual image should consist of WHITE (100% APL) characters on a BLACK background.

Comments: Note that for many types of displays, the ambient lighting will have a strong effect on the contrast of a display. The ISO 9241–3 standard specifies the ambient lighting to be used for contrast measurement as 250 lux plus 250 lux times the cosine of the angle formed by the axis along which the light measurements are to be made and a line tangent with the CRT faceplate center. This standard has been adopted as part of the standard test conditions under this VESA standard.

6.4. COLOR DISPLAY SPECIFICATIONS

Description: This section of the standard defines specifications and measurement procedures unique to color displays. The following requirements apply to all tests in this section.

Gen. Procedures: Each of the following is to be performed only after a 20 minute warm−up (or other warm−up period as specified by the manufacturer, but in any case not to exceed 45 minutes), and with the user contrast and brightness controls set for maximum luminance as in 6.1. The unit should be degaussed using a hand−held degaussing coil immediately prior to performing these tests, whether or not the display in question includes a built−in degauss coil. The color analyzer to be used should be calibrated using its internal cal. function immediately prior to use.

As color displays are very sensitive to external magnetic fields, it is important that these tests be performed with the unit under test in the specified orientation, and aware from any sources of either DC or AC magnetic fields (such as permanent magnets, motors, disc drives, etc.). If multiple units are being tested, make sure that the unit in test at the moment is not less than two feet from any other display, whether or not that display is powered up. If possible, these tests should be performed in the specified magnetic environment as provided by Helmholtz coils.

6.4.1:Misconvergence

Specification standard:
Misconvergence is to be specified in millimeters, and listed either as the maximum misconvergence to be found at any point within the nominal image area, or as two figures: one to be the maximum misconvergence to be found within a circle centered within the nominal image area and of a diameter equal to the nominal image height, plus a second number indicating the maximum misconvergence to be found outside this circle. If the latter specification is used, it must explicitly describe these two areas; simply listing the two misconvergence limits is not permissible (i.e., a listing of "Misconvergence: 0.3/0.5 mm").

In either case, the misconvergence specified should be either separate listings for the maximum allowable red and blue misconvergence (relative to the green), and so indicated, or the sum of these limits. Unless explicitly indicated in the specifications, the misconvergence limit given should be taken to be the sum of the maximum red and blue misconvergence figures (relative to green). Separate specifications may be provided for horizontal and vertical misconvergence, if clearly indicated as such; if a single figure is given, it shall be assumed to apply to both horizontal and vertical misconvergence.

Test pattern: VESA standard geometry test pattern (see section 9)

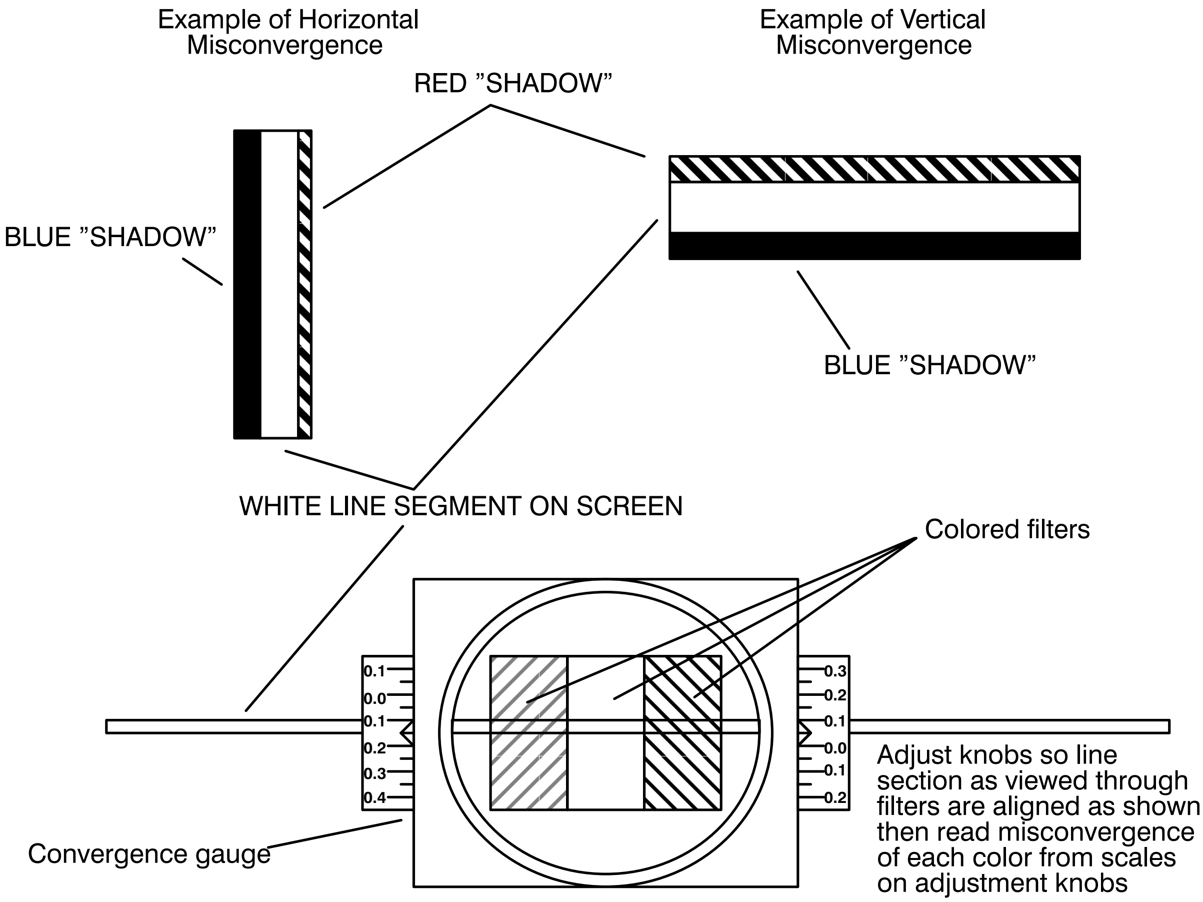
Test Procedure: Electronic devices are now available which measure misconvergence directly. The following procedure assumes use of the more typical optical "convergence gauge" (example: Klein CM–7). However, the equipment set–up should be the same as listed below in either case.

With the display user convergence and centering controls (if any) adjusted for optimum appearance, and all other user controls set as specified in 6.1, display the test pattern and note any areas in which the lines appear to have colored "shadows" or "fringes" (see drawing on following page). If any are found, measure the misconvergence using a convergence gauge as follows: place the gauge over the line in question, such that the line runs perpendicular to the adjustment knobs on either end of the gauge. While looking through the lens, adjust the knobs (which move the colored filters) such that the red, green, and blue line segments are aligned end–to–end. Read the misconvergence of the red and blue lines from the scales on the knobs for their respective filters, and record them separately.

6.4.2:Purity / Spot Landing

A direct measurement of beam mislanding is possible, but this requires very specialized equipment. For this reason, VESA does not recommend any direct specification of beam or spot landing. Instead, a specification of the limits of display colorimetry (given as the CIE 1931 chromaticity coordinates for white, red, green, and blue) at any point in the nominal image area may be made. This should conform to the standards and procedures given in section 5 of this document, with the limits on chromaticity variation given in thousandths for both x and y. Example:

Purity: Chromaticity coordinates to vary by not more than 0.01 in either x or y (per 1931 CIE chromaticity diagram) at any point on the screen.

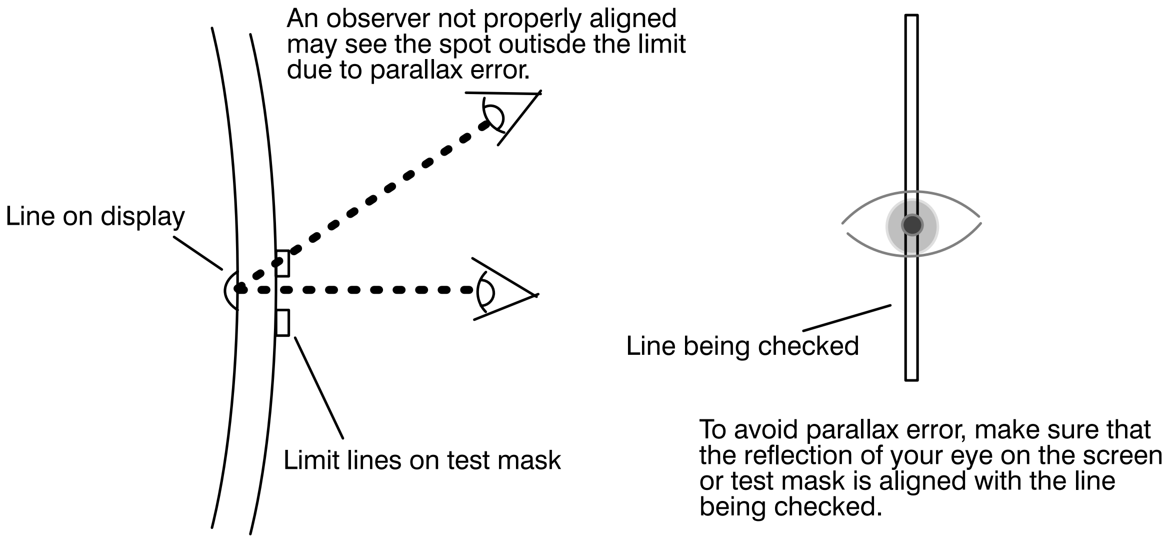

Example of Horizontal Misconvergence
Example of Vertical Misconvergence
RED ”SHADOW”
BLUE ”SHADOW”
BLUE ”SHADOW”
WHITE LINE SEGMENT ON SCREEN
Colored filters
0.1
0.0
0.1
0.2
0.3
0.4
0.3
0.2
0.1
0.0
0.1
0.2
Adjust knobs so line section as viewed through filters are aligned as shown, then read misconvergence of each color from scales on adjustment knobs
Convergence gauge

6.5. GEOMETRY SPECIFICATIONS

Description: The following series of specifications describe the display performance in terms of the accurate placement, shape, and size of geometric figures appearing on the display, and the proper position and shape of the displayed raster itself.

Test Pattern: For all of the following, the VESA standard general–purpose geometry test pattern as described in section 10. Each test may also specify the minimum acceptable pattern characteristics for that unique test.

Procedures: Display the indicated test pattern, or use the appropriate portion of the general–purpose geometry pattern. Perform the measurements as instructed for each test. In most cases, these will call for visual checks to be made, locating the lines of the test pattern vs. ruler graduations or limit lines on a test mask. Care must be taken to insure that visual parallax does not introduce errors into these tests; the inspector must be certain that his or her eye is located on a line perpendicular to the screen, as shown in the diagram below. To insure this, note the location of the reflection of your eye on the faceplate or the test mask; the pupil of the eye's reflection should be positioned on the line being tested. All checks and measurements are to be made to the center(s) of the line(s) in question.



NOTE: Unless otherwise noted, all positional measurement are made relative to (a) the edges of the cathode–ray tube itself, or (b) the front bezel of the monitor. In some cases, these two references may give different results, which will indicate mislocation of the bezel relative to the CRT.

6.5.1:Size

Specification standard: The specified size is to be that of the nominal image area, and is to be given in millimeters. Multiple size specifications must be given for all supported formats, unless the size specification is explicitly indicated as "maximum". In any event, the size specification given shall be that image size within which all other display performance specifications apply for the mode in question; if no mode for the size spec is explicitly given, the specifications may be taken as applying over the indicated area in all modes.

TEST PATTERN: Minimum required – Outline of active video area, including centerlines. The centerlines must be so designed so that the center of these lines falls on the exact center of the image; given that most display formats have an even number of pixels along both axes, this will require that these lines be doubled (2 pixels wide).

PROCEDURE: The display should be set for maximum brightness as described in 6.1. Using either a clear, flexible ruler, or a coordinate measuring system, measure the size of the test pattern along the center lines, to the center of the edge lines. If a measuring system is used, these measurements must be corrected for any tilt between the centerlines and the axes of the measuring system. In order to reduce errors introduced by geometric distortions, measurements of horizontal and vertical size along several lines parallel to the appropriate centerlines but between the centerlines and up to and including the raster edges should be made and averaged.

6.5.2:Miscentering

Specification standard: The miscentering of the image shall be specified as the maximum distance between the intersection of the centerlines of the displayed image, and the physical center of the bezel opening, in any direction. Maximum miscentering shall be stated in millimeters.

TEST PATTERN: Minimum required – Test pattern providing horizontal and vertical center lines, as described in 6.6.1.

PROCEDURE: Locate the center of the bezel front opening as the intersection of the diagonals drawn between opposite outside corners of the bezel.

Using either a clear, flexible ruler, or a coordinate measuring system, determine the distance from the physical center of the faceplate (as determined above) to the center of the image, as determined by the center of the intersection point of the test pattern center lines.

6.5.3:Linearity

Specification standard: Linearity is to be expressed as a percentage, and is determined by measuring the size of the squares in the standard geometry test pattern as described in section 9. Vertical and horizontal linearity are to be specified separately; if a single linearity figure is given, it shall be assumed to apply to both horizontal and vertical linearity. In any case, the linearity figure is obtained by performing measurement of all grid squares in the test pattern, determining the maximum and minimum grid square size (both vertically and horizontally), and applying the following formula separately to the vertical and horizontal maximum and minimum measurements:

$$\text{Lin. error (\%)} = 100\% \times (L_{max} - L_{min}) / [(L_{max} + L_{min})/2]$$

where L_{max} and L_{min} are the maximum and minimum grid sizes, respectively, measured along the axis in question.

6.5.4:Tilt (Rotation)

Specification standard: Tilt or rotation is to be specified in degrees, meaning the maximum expected deviation of the displayed horizontal and vertical centerlines from true horizontal and vertical, as determined by the rectangle made by the extreme corners of the front bezel opening. Only a single max. tilt value is to be given, and is to apply to both the horizontal and vertical centerlines. (Differences between observed tilt on the horizontal and vertical centerlines may be assumed to be due to poor yoke orthogonality or some other distortion; the tilt specification is intended to indicate only the true mounting of the deflection yoke on the CRT and the tube/yoke assembly within the display cabinet and front bezel.

PROCEDURE: Determine the center of the image (NOT, in this case, the center of the physical screen) from the test pattern centerlines. From this point, determine lines parallel to the true horizontal and vertical directions, relative to either the CRT/chassis assembly or the front bezel. Measure the deviation from true vertical or horizontal at the extreme ends of the test pattern vertical or horizontal centerlines. Note both the degree and direction of tilt. Also, check the degree of tilt as measured from the horizontal centerline at the same distance from center as the ends of the vertical centerlines; if this differs from the tilt measurement of the vertical line, at least some of the ”tilt” is very likely due to orthogonality problems; the tilt measurement must be corrected for the orthogonality distortion.

6.5.5:Trapezoidal distortion

TEST PATTERN: Minimum required – test pattern including top, bottom, and left/right edge lines, all one pixel wide, indicating the outer limit of the active raster, or at least ”corner marks” (chevrons) which indicate these limits.

Measure and record the length of the top, bottom, and left and right edges of the test pattern, measuring from the center of the corner spots. The trapezoidal error may be expressed as a percentage using the same formula as given in 6.5.3, where Lmax and Lmin are the lengths of the top and bottom or left and right edges, with the longer being Lmax in each case. Note that the measurement is to be made in a straight line from corner to corner, ignoring any deviation from a straight line by the edge in question.

6.5.6:Parallelogram distortion

Specification standard: Parallelogram distortion is to be specified as a maximum percentage, determined by comparing the lengths of opposite sides of the displayed raster, and applying the following formula:

$$\text{Parallelogram distortion (\%)} = 100\% \times (L_{max} - L_{min}) / [(L_{max} + L_{min})/2]$$

6.5.7:Orthogonality

Specification standard: Maximum orthogonality error is to be specified in degrees, and indicates the maximum allowable difference between the observed angle formed by the horizontal and vertical centerlines of the image, and 90 degrees. Note that this does NOT depend on the angle between either centerline and true horizontal and vertical; see section 6.5.4, ”Tilt.”

PROCEDURE: To check orthogonality using measurements, a coordinate measuring system with an appropriate magnifying eyepiece and viewing reticle is recommended. Set the zero reference for the system to the center point of the displayed image, and then measure the locations of the end points of the vertical and horizontal centerlines. The orthogonality of the raster may be determined as shown in section 6.5.10

6.5.8:Pincushion/Barrel

Specification standard: Maximum allowable pincushion (”pin”) and/or barrel distortion is to be given as a percentage, indicating the relative size of the positional error resulting from such distortion and the height or width of the displayed image, whichever is the smaller. An additional specification of incremental pincushion distortion may also be made; this shall be in the form of maximum deviation permissible over a specified distance, said distance not to be less than 10% of the length of the shortest side of the displayed raster.

TEST PATTERN: Minimum required – a pattern supplying both the centerlines as required by 6.5.1, plus the raster edge lines as described in 6.5.5.

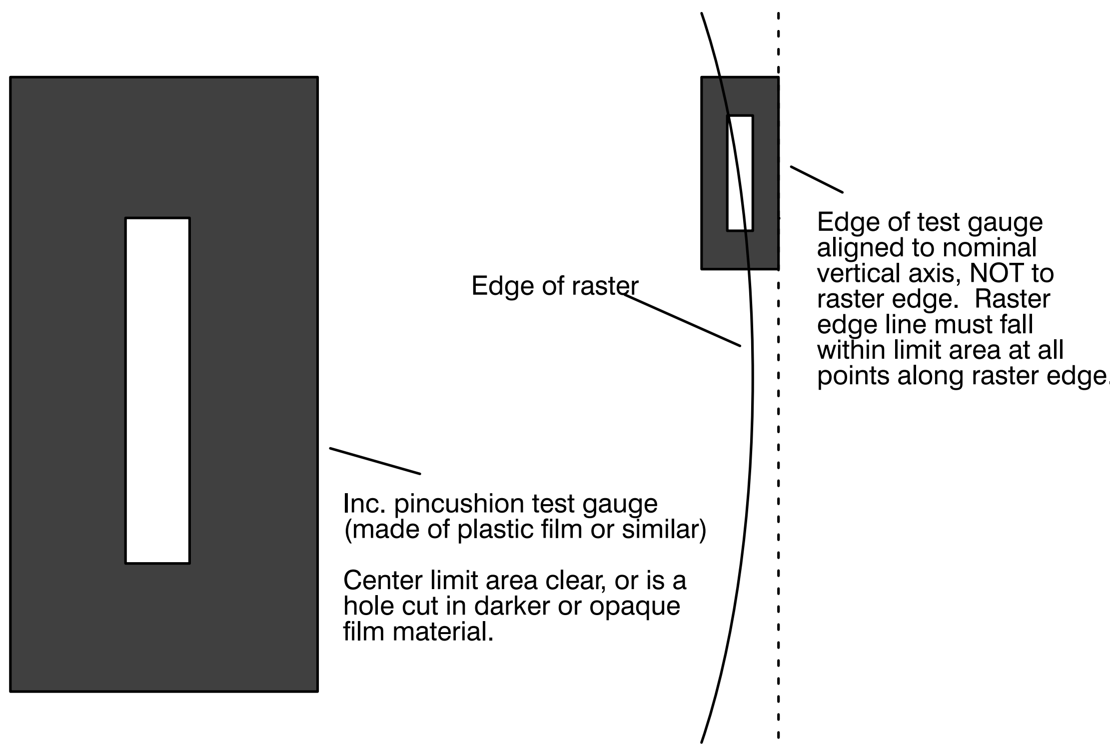
PROCEDURE: Measure the maximum deviation of the raster edges from the lines on the test mask, or from a flexible straightedge placed on the end of the centerline and perpendicular to it. In the case of the corners, the deviation from both nominal edge lines should be recorded separately, rather than measuring the distance of the corner from its nominal location.

If a coordinate measuring device is used to determine the degree of pin/barrel distortion, the following procedure should be used. First, check the tilt of the image centerlines (both axes) using the tilt test procedure. If the tilt can be adjusted to zero, do so before proceeding with the pin/barrel check. If not, all measurements must be adjusted for the tilt–induced deviation of the image edge from the measuring system’s axis. Measure the deviation of the image edge lines from the nominal edge as determined by a line perpendicular to, and touching the end of, the appropriate centerline.

NOTE: ”Pincushion” distortion is present when the image width and height at the corners exceeds that as measured along the centerlines; ”barrel” distortion exists when the largest measurement of width and height is along the centerlines. These

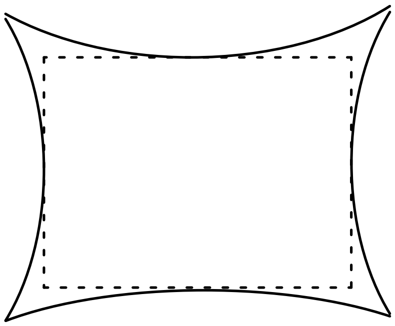
terms may be used in recording the deviation from the nominal edge line, as in "max. left edge pin of 1.5 mm located 1/3 down from UL corner." To avoid confusion, it may be better to record these measurements using the convention of labelling deviations toward the nearest bezel edge as positive (+), and those toward the image center as negative (−).

Incremental pin/barrel distortion: In addition to specifying overall pin/barrel distortion, many display specifications will also limit the amount of deviation allowed in a given distance along the edge. This is best checked using a test gauge as shown below, where the width of the limit area is the maximum allowable change and the length is that distance over which this incremental change is specified. To use this gauge, the long axis of the test window should be placed parallel to the nominal horizontal or vertical axis, depending on the edge being tested, and a visual check is made to insure that the edge of the raster falls within the limit area at all points along that edge.

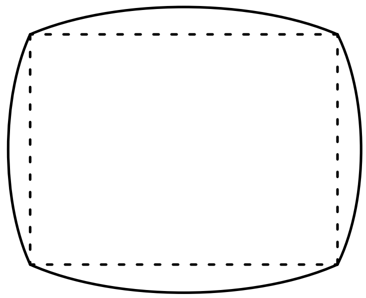


6.5.9:Comments

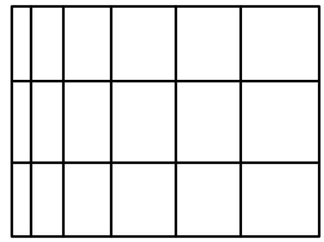
The following drawings are intended to provide the user with a better idea of the distinctions between the various types of raster distortion. A short list of some of the possible causes of each is given following the drawings.



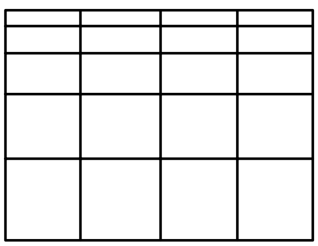
1. Pincushion distortion



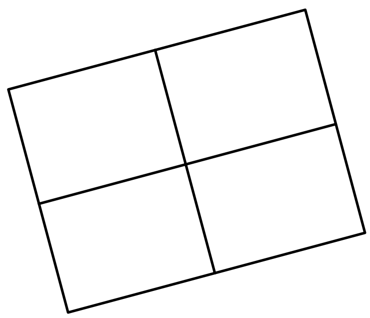
2. Barrel distortion



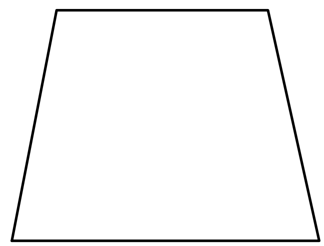
3. H. linearity error



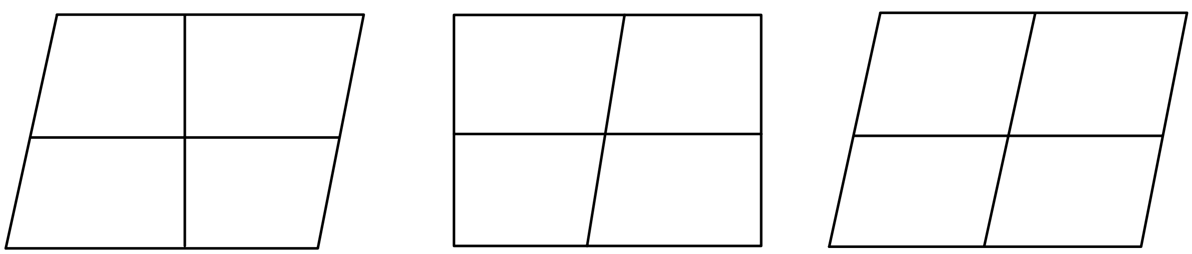
4. V. linearity error



5. Tilt



6. Trapezoidal distortion



7−9. Parallelogram, orthogonality, and both combined.

1&2 − *Pincushion* and *barrel* distortions are both caused by either the yoke itself, missing or excessive pin correction magnets, or misadjusted or malfunctioning pin correction circuits. Note that, due to the differences between the tube faceplate radius of curvature and the distance from the screen to the ”point of deflection” at the yoke, the normal raster with no correction applied will show pincushion distortion. Pin correction may come from changes in the yoke design, addition of permanent magnets, correction waveforms impressed on the deflection waveform, or a combination of these. Overcorrection of pin may lead to barrel distortion.

3&4 − *Linearity* problems may result from incorrect yoke assembly, or misadjusted or malfunctioning linearity correction components in the deflection circuits.

5 – *Tilt,* without other distortion (note difference between tilt and parallelogram/orthogonality distortions), indicates that the deflection yoke is improperly aligned (rotated) on the tube neck.

6 – *Trapezoidal distortion* indicates that yoke is misaligned on the tube neck (tilted relative to the CRT centerline – imagine an overhead projector with a tilted screen), the electron gun within the CRT is misaligned, or a combination of these. In displays with electronic pin correction circuits, or independent control of top and bottom width, it may also indicate misadjusted or malfunction of these circuits.

7–9: If the deflection yoke is not constructed with the horizontal and vertical deflection coils exactly 90 degrees apart, and no other correction is applied, the raster will be distorted in a manner similar to drawing #9. However, if subsequent geometry correction is applied to restore the corners to "squareness" the resulting image may appear more like drawing #8. Conversely, errors in geometry correction may result in a "*parallelogram*" distortion as shown in #7, even if the yoke is correct (*orthogonal).* To distinguish these, distortion as shown in #7 will be referred to as *parallelogram* distortion, and that as in #8 will be considered *orthogonality* problems, regardless of the actual or supposed source. In other words, be aware that the parallelogram test is concerned only with the outer edges of the images, while the orthogonality check is performed only on the center lines. Images as in drawing #9 would be considered as having both orthogonality and parallelogram problems, reported separately, even though the root cause of both *may* simply be improper yoke orthogonality.

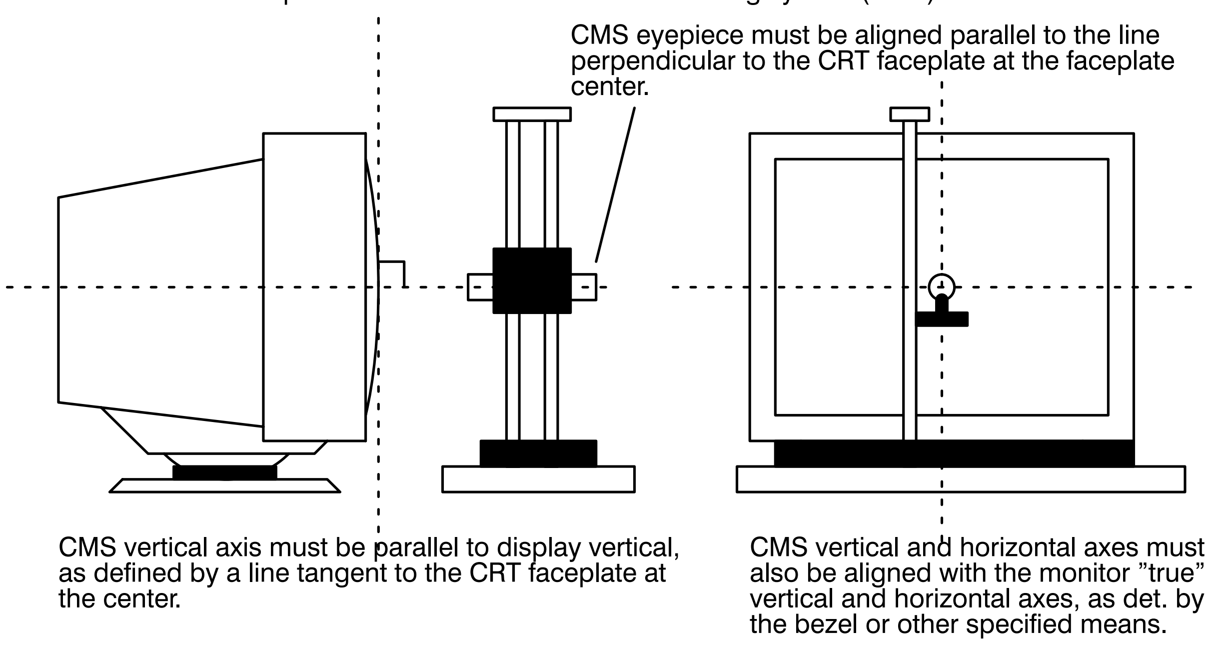
6.5.10:**ALTERNATE METHOD FOR GEOMETRIC DISTORTION MEASUREMENTS**

This section describes a method whereby the important geometric distortion measurements for a display may be derived from information provided by a single set of measurements, taken using a coordinate measuring system.

Equipment Needed: Coordinate measuring system set up as shown, with resettable X and Y distance indicators and capable of measuring accurately to at least 0.05 mm. The eyepiece should include a magnifier of min. 10X power, with an appropriate reticle for locating the center point of the image. Any lines or other markings on this reticle must be of narrow enough width such that they appear to be not more than 50% of the nominal line width on the display to be measured, when viewed through the eyepiece.

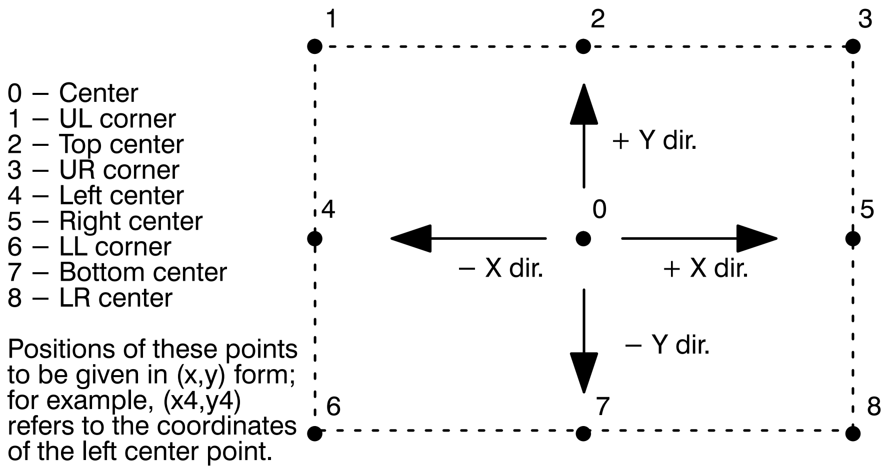
Test Pattern: The general−purpose geometric distortion pattern described in section 10 may be used, or any pattern which provides clearly identifiable centerlines and corner indications. At a minimum, this shall consist of a pattern of nine dots as follows: four single−pixel dots at the extreme corners of the active image area of the raster, a 2x2 dot located at the center, 2 pixels horizontally at the top and bottom of the vertical centerline, and 2 pixels vertically at the left and right ends of the horizontal centerline. Note that the 2−pixel dots are required for a display in which the horizontal and vertical dimensions are an even number of pixels (as is normally the case), to accurately locate the center between the 2 pixels. In the event that a display is to be tested which uses an odd number of pixels on either axis, the dots at the ends of the centerline perpendicular to that axis should be single pixels, and the ”center” dot should have 3 pixels arranged parallel to that axis.

Test Method: Set up the monitor and coordinate measuring system (CMS) as shown below:



Note that the alignment of the CMS axes with the proper axes of the display is critical; if this cannot be achieved, the measurements taken must be corrected before computation of the geometric parameters of the display.

Measure and record the distances from the left, right, top, and bottom inner edges of the bezel to the center of the center spot of the test pattern. These will be used to calculate the miscentering of the display. Then set the CMS origin to the center of the center spot of the test pattern, and determine the locations (x,y) of the other eight spots (four corners of the pattern, four edge centers) relative to the center. Note that all measurements should be made to the center of the dot or line. The following convention in numbering these points should be used:



With the locations of these points recorded, the geometric specifications may be checked as follows:

CENTERING: Using the measurements from bezel edges to center spot, calculate miscentering as follows:

HORIZ. MISCENTER = [(left bezel to center spot) – (right bezel to center spot)]/2
VERT. MISCENTER = [(bottom bez. to center spot) – (top bez. to center spot)]/2
TOTAL MISCENTER = SQRT[(H. MISCENTER)^2 + (V. MISCENTER)^2]

RASTER SIZE: Calculate the lengths of lines 1–3, 4–5, 6–8, and 1–6, 2–7, and 3–8 as follows (example given is for top edge, 1–3):

Length = SQRT[$(x3-x1)^2 + (y3-y1)^2$]

The raster height and width are then found by averaging the three lengths in each direction (here, the notation "L13" means the length of line 1–3):

HEIGHT = (L16 + L27 + L38)/3 WIDTH = (L13 + L45 + L68)/3

PARALLELOGRAM DISTORTION: Calculate the lengths of the diagonals 1–8 and 3–6 as shown below (example for 1–8):

Length = SQRT[$(x8 - x1)^2 + (y8 - y1)^2$]

The percent parallelogram distortion is then calculated as in the earlier section:

Parallelogram dist. (%) = 100% x $(L_{max} - L_{min}) / [(L_{max} + L_{min})/2]$

TRAPEZOIDAL DISTORTION: Using the edge lengths found above, trapezoidal distortion may be calculated using the same formula as presented earlier:

Trapezoid dist. (%) = 100% x $(L_{max} - L_{min}) / [(L_{max} + L_{min})/2]$

where Lmax and Lmin now refers to the lengths of opposite parallel edges (such as top and bottom edges).

TILT: Assuming that the CMS was, in fact, properly aligned with the monitor's reference horizontal and vertical axes, raster tilt may be checked by checking the tilt of the four half–centerlines and averaging this figure. Note that difference in "tilt" among these four indicates some distortion in the raster. To determine the tilt of each of these line segments (2–0, 4–0, 5–0, and 7–0), perform the following calculations:

Example – Tilt of upper vertical half–centerline (line segment 2–0)

Determine length of line segment 2–0 as before.
Tilt is then:

Tilt (deg.) = arcsin [(x2 – x0)/L20]

Note that this calculation will give tilt as positive if tilted clockwise from the true vertical, and negative if tilted counterclockwise. Tilt calculations for the remaining line segments should be performed so as to maintain this convention. Averaging the four tilt figures so obtained gives the tilt of the raster:

Tilt = (tilt20 + tilt 40 + tilt 50 + tilt 70)/4

ORTHOGONALITY: Using the tilt figures for the four segments as determined above, raster orthogonality may now be determined by finding the average tilt of the horizontal and vertical centerlines and comparing them:

V. CENTERLINE TILT = (tilt 20 + tilt 70)/2
H. CENTERLINE TILT = (tilt 40 + tilt 50)/2

ORTHOGONALITY (deg.) = V. TILT – H. TILT

PINCUSHION/BARREL: A measurement of this nature is NOT sufficient to determine the pin or barrel distortion of the display well enough to check it against specifications; however, a rough estimate of the pin or barrel distortion may be made by comparing the lengths of various segments of the centerlines and edges to the average raster height or width previously found:

Example: Top edge distortion check.

Determine the lengths (y1 – y0), (y2 – y0), and (y3 – y0).

Compare each of these to half of the average height as previously determined.

If the lengths (y1 − y0) and (y3 − y0) are GREATER than half the average height, and length (y2 − y0) is LESS, this edge has PINCUSHION DISTORTION.

If (y1 − y0) and (y3 − y0) are LESS than half the height and (y2 − y0) is GREATER, this edge has BARREL DISTORTION.

The degree of pin or barrel distortion for each edge may be expressed as a percentage using the formula given in earlier sections.

6.6. Resolution/Addressability Ratio (RAR)

Description: Resolution/Addressability Ratio (RAR) is an indication of a display's ability to resolve the pixels or lines which make up the displayed image. This specification gives a simple, easy–to–understand indication of the suitability of a display device for a given format or resolution in a manner which has been shown to correspond to the perceived image quality.

Specification Std.: Resolution/Addressability Ratio shall be given as two numbers, expressed at least to one decimal place of accuracy, which represents the maximum and minimum values of this specification which are to be found at any location within the active image area for a given format, as calculated using the following formula:

RAR = Line width/Pixel spacing

The line width used should be either the maximum or minimum value for a white line (as measured per section 6.2 of this standard), depending on whether the maximum or minimum RAR value is being calculated. The pixel spacing is determined by dividing the specified nominal raster size in either axis (expressed in the same units as the line width value) by the total number of pixels in the format in question, counted along that axis. If the pixel spacing is different horizontally and vertically by more than 5% of the nominal line width (i.e., the format produces "non–square" pixels), the RAR shall be stated separately for the horizontal and vertical case. RAR must be listed separately for all supported timings listed in the monitor specification, or, if no timings are explicitly listed, must be listed at least for the case of the supported timing with the smallest pixel spacing. The specification may also provide RAR maximum and minimum values for specified areas of the screen, but this information is to be provided in addition to the overall maximum and minimum specification as required above.

Example: At a 640 x 480 format, a given display has a nominal image size of 240 x 180 mm, a maximum line width at any location of 0.49 mm, and a minimum line width of 0.25 mm. The maximum and minimum RAR values are:

Pixel spacing = 240 mm/640 = 0.375 mm

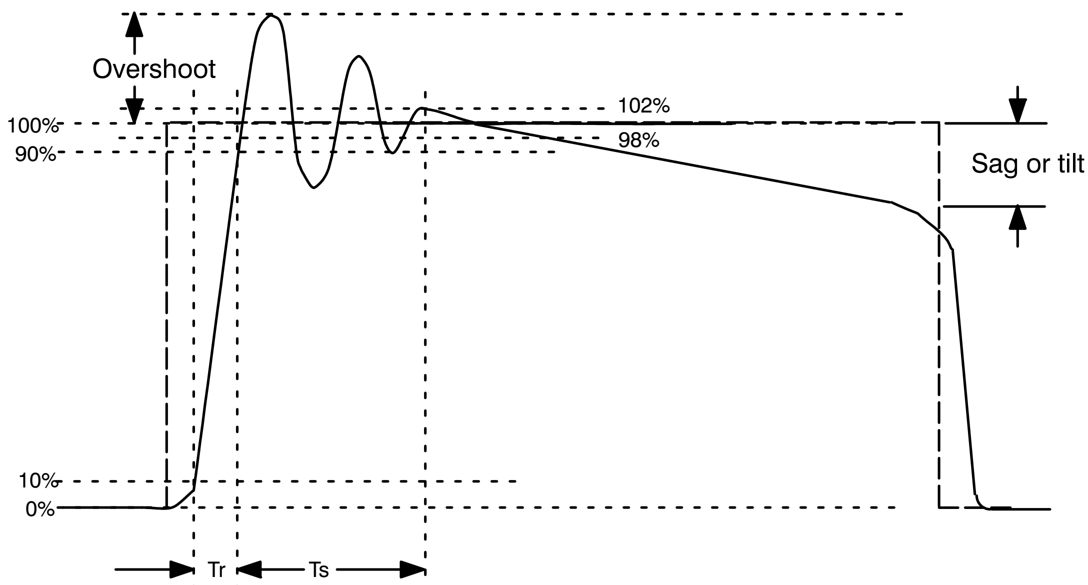
RAR (max.) = 0.49/0.375 = 1.31 (may be listed as 1.3)
RAR (min.) = 0.25/0.375 = 0.67 (may be listed as 0.7)

Comments: Limits on minimally acceptable RAR values are generally believed to be approximately 0.5 (min.) and 2.0–2.5 (max.), with an optimum value of approximately 1.5. At 0.5 and below, the displayed spots do not overlap or even make visible contact, resulting in a very coarse and "grainy" image; the individual spots making up characters and other displayed elements are clearly visible to a degree which is unacceptable to most users. At an RAR of 2.0 or above, the displayed spots overlap to such a degree that single–pixel elements (such as a single–pixel black line or spot between two white pixels) cannot be resolved, and characters with such elements are unreadable. An RAR of approx. 1.5 results in a displayed image which is not so grainy so as to be unacceptable, but which still has a smooth, continuous appearance to lines and characters.

7. Display Performance – Video Amplifier Specifications

The performance of the video amplifier circuit is determined by how accurately this circuit can amplify the input video signal without introducing distortion. Distortion of the video signal waveform can be characterized in a number of different ways. The principle ways in which the signal may be distorted, and which may manifest themselves as visible problems in the displayed image, are the rise and fall time, overshoot and undershoot, ringing, and tilt and sag. One additional parameter not shown by the diagram below which relates to the video amplifier performance (bandwidth) is also covered by this section of the standard.

Ideally, the output of the video amplifier (as measured at the CRT, typically at the cathode) will track the input signal exactly. The diagram below is intended to help in defining the various forms of distortion, showing a hypothetical output (cathode) waveform vs. an ideal "square" signal (i.e., one which is simply a higher amplitude version of an ideal square input).



Tr = Rise time

Ts = Settling time

7.0 General requirements: The following specification and procedural requirements are applicable to all of the parameters covered in this section.

7.0.1 Definition of video circuit: The video circuit to which these specifications apply shall consist of the entire signal path of the unit as supplied by the manufacturer, up to the CRT connection, but with the standard CRT for the unit in question connected and operating normally. This shall include the video amplifier, all normally–supplied internal cabling and connectors, the input signal connectors, and/or the video cable if this is supplied with the unit.

7.0.2 Multiple inputs or signal paths: In the case of a monitor which provides multiple input systems, connectors, or paths, separate specifications should be given for each input, or the worst–case specification for any of these shall be listed.

7.0.3 Test equipment and procedures: The equipment used to evaluate the performance of monitor video circuits in general consists of an input signal source, a connection to the equipment under test (such as a probe), and an output analysis or display device (such as an oscilloscope or network analyzer). The following requirements shall apply to this equipment and the procedures used in these measurements:

1. The signal source shall be connected to the unit under test using the connectors and cabling recommended or supplied for use with this product. An impedance−matching transformer or pad may be inserted if required.

2. The source shall be capable of covering a range of frequencies from 10 Hz to not less than 150% of the expected bandwidth of the unit under test with no significant degradation in signal characteristics when connected to a standard load impedance of the nominal value stated for the monitor inputs. Further, the rise and fall time of the source shall be not greater than 10% of that expected for the video amplifier; if this is not possible, the rise/fall time measurement must be corrected as given in that section.

3. The probe used to connect to the CRT cathode or grid shall be of a type which places negligible additional load on the video amplifier (<10% change from the unloaded case). If this cannot be achieved, the measured parameters should be corrected for probe loading effects as described in the individual specification and measurement definitions.

4. The user ”brightness” and ”contrast” controls must be set as given in section 6.1 (Luminance); that is, the user contrast control shall be at its maximum (max. luminance) position, and then the user brightness control set such that the background raster (those portions of the image which correspond to the blanking times of the input signal) is just extinguished.

7.1.Video Bandwidth

Definition: The bandwidth of the video amplifier is that range of frequencies over which the amplifier's response changes by less than 3 dB from its nominal (mid−frequency) performance.

Specification Std.: Video amplifier bandwidth shall be stated as a range of frequencies in Hertz (Hz) to Megahertz (MHz) over which the amplifier's gain remains within +/− 3dB of the mid−frequency value. If desired, an additional bandwidth specification may be given using limits other than the +/− 3 dB frequencies; if this is done, the limits for the additional specification must be explicitly stated, and this additional bandwidth specification shall not be presented in such a manner so as to take precedence over the standard 3 dB specification. Example:

Video bandwidth: 50 Hz to 100 MHz +/− 3 dB (BNC inputs)
50 Hz to 80 MHz +/− 3 dB (15 p. D sub input)
(60 Hz to 75 MHz, +/− 1 dB, either input)

Test proc. std.: The input signal used shall be a sine wave whose peak−to−peak amplitude is one−half the maximum peak−to−peak amplitude of the video signal specified for the unit or inputs in use. The DC offset of the signal shall be set and other input signals (synchronization, etc.) provided as needed such that no part of the input signal is cut off or altered by any clamping, sync stripping, etc., action of the video amplifier's input circuit. The frequency of the input signal shall be swept from 5 Hz to at least 150% of the maximum pixel clock specified for the supported input timings/formats of the monitor. The output (at the CRT cathode or grid) shall be observed, and the frequencies at which the output amplitude drops 3 dB under that at observed at mid−frequencies noted. NOTE: In the absence of any other

appropriate specification, the ”mid–frequency” point may be taken to be an input frequency equal to the maximum horizontal sweep rate supported by the unit in question. In the case of color displays, the bandwidth for the individual channels (i.e., red, green, and blue) shall be determined independently, and the lowest bandwidth found among these shall be used for the overall bandwidth.

7.2.Rise and Fall Times

Definition: Rise and fall times for a video amplifier give the time required for the amplifier output to transition from the ”white” to ”black” levels (or vice–versa). Note that since this is generally the largest signal amplitude the system is designed to handle, rise and fall times are typically NOT directly related to the video amplifier bandwidth as previously defined, due to slew–rate limits.

Specification std.: The rise and fall time specifications shall be given as maximum times, expressed in nanoseconds (ns). Unless these are explicitly given and identified separately, a single figure may be given which shall be assumed to be the maximum time expected for either case. If the rise or fall times are expected to be limited by the rise or fall times of the expected signal source, this should be clearly stated and the rise/fall time of the source which results in the specifications given should also be listed. Example:

Rise/fall time: 8.5 ns max. (assuming max source rise/fall time of 3 ns)

The rise and fall times stated shall be the maximum time required for the video amplifier output to transition from 10% to 90% of its nominal peak value (exclusive of overshoot and ringing) or 90% to 10% of this value (for rise and fall, respectively). NOTE: The video amplifiers used in CRT displays typically produce an output signal which is inverted with respect to the input; that is, the most positive point of the output signal corresponds to the black level as displayed. As defined here, the rise time is normally a measure of the time to transition from **white to black** (between the 10% and 90% points), while the fall time covers the **black to white** transition. In other words, these specifications are always made taking a positive–going transition at the CRT as the ”rise”, regardless of the effect of this transition on the image.

Test procedure std.: Rise and fall times may be measured using an input signal which changes from the black level to the full white level and back, such transitions to occur no closer together than 20 times the period of the highest supported pixel clock. If the signal source used is not capable of supplying an input signal whose rise and fall times are less than 10% of those expected of the video amplifier under test, the measured rise and fall times may be corrected using the following formula:

$$T_r \text{ (corrected)} = \text{SQRT}(T_{rm}^2 - T_{gen}^2)$$

where T_{rm} is the measured rise time, and T_{gen} is the rise time of the signal source used (substitute fall times as appropriate for the fall time correction formula). However, the source used should be representative of the expected sources which might be employed by the user at the highest pixel clock (maximum X x Y pixels and maximum refresh rate) supported by the display.

7.3.Overshoot and Undershoot

Definition: Overshoot or undershoot refers to that distortion in a wave front characterized by a rise above the final value in a positive–going transition, or a fall below the final value in a negative–going transition, followed in either case by a return to the final value (which may exhibit further oscillations before attaining the final value; see 7.4, "Ringing and Settling Time").

Specification std.: Overshoot and undershoot shall be specified as a percentage rise above or fall below the final value of the output video pulse as measured at the CRT. The following formula (or the corresponding version for the undershoot case) should be used:

Overshoot(%) = [(Peak level) – (Nominal level)]/(Nominal level) x 100%

In either case, the maximum or minimum level achieved between the signal transition and the settling time (as defined in 7.4 below) shall be the value used to determine the degree of overshoot or undershoot. The specification shall list the maximum overshoot and/or undershoot expected using the same signal source as indicated for the rise/fall time specification. If only a single number is given, it shall be assumed to apply to both the overshoot and undershoot cases. Examples:

Overshoot: 10% max.
Undershoot: 12% max.

or

Over/undershoot: 10% max.

In the case of a color display, the overshoot or undershoot characteristics of all channels must be specified separately, or the worst–case (highest percentage) expected over all channels must be the value specified.

Test procedure std.: The test set–up employed should be the same as used for the rise/fall time (7.2) and ringing/settling time (7.4) tests defined here. An input signal as specified for the rise/fall time test should also be used.

7.4.Ringing & Settling Time

Definition: Ringing refers to a distortion in the video amplifier output signal which appears in the form of a superimposed damped oscillatory waveform which, when present, usually follows a major transition of the output signal. When ringing is present, "jitter" or the appearance of "bars" can often be observed in the displayed image. NOTE: This is a separate concern from "ringing" as the term is applied in the case of deflection yoke operation, although yoke ringing can also result in the appearance of "bars" in the displayed image, occurring in the first moments of active video following a retrace (i.e., near the top or left edges of an image, if the deflection system uses a conventional raster–scan format).

Settling time refers to the time from the maximum or minimum of the initial pulse

(overshoot or undershoot) required for the oscillatory distortion to damp out to such that the signal is within 2% of its final value.

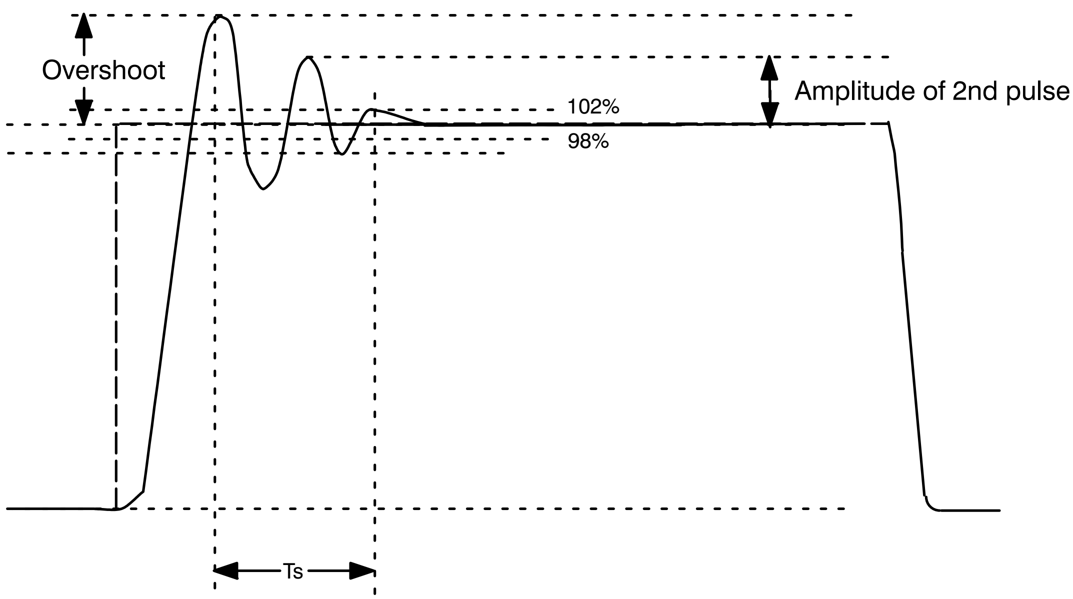
Specification std.: Ringing shall be specified as a ratio of the amplitude initial pulse (relative to the final level of the signal) to that of the second pulse of the superimposed oscillation. (See figure below.) As a large ratio is desirable (showing that ringing, if present, is rapidly damped out), the value specified should be the minimum ratio expected.

Settling time is to be specified in nanoseconds (ns), and should give the maximum time expected between the maximum or minimum immediately following the initial transition and that time after which the signal remains within 2% of its final value. (See figure below.)

In the case of a color display, the ringing and settling time specifications should refer to the minimum ringing ratio and maximum settling time expected across all channels.

Example:

Video pulse ringing:	> 8:1, all channels
Settling time:	< 10 ns, all channels



Ts = Settling time

Test procedure std.: The test set–up employed should be the same as used for the rise/fall time (7.2) and overshoot/undershoot (7.3) tests defined here. An input signal as specified for the rise/fall time test should also be used.

7.5.Tilt and Sag

Definition: ”Tilt” or ”sag” refers to a slope or change in what is intended to be a constant signal level, as observed at the output of a video amplifier at the CRT, due to the inability of the video amplifier to maintain the proper reference level or due to poor low–frequency response. As specified under this standard, either term refers

specifically to the amount of change observed at the output, for a constant–level input, over one active line time at the lowest support horizontal timing (i.e., lowest supported horizontal sweep rate and longest horizontal active time supported at that rate). The direction or "polarity" of this change (the sign of the slope resulting from tilt or sag) is irrelevant; the specification will given the maximum change expected in either direction.

Specification std.: Tilt or sag is to be expressed as a percentage, taken to mean the change in output level expressed as a percentage of the peak level. The value specified shall be the maximum expected tilt or sag as measured using the following procedure.

Test procedure std.: The test set–up shall be as previously used. However, the input signal timing in this case shall be set to use the lowest horizontal sweep rate, and minimum horizontal blanking time, as specified as supported by the display in question. The test signal shall consist of either a single horizontal black (0%) line on a white (100%) field, or a white (100%) line on a black (0%) field, whichever results in the worse tilt or sag performance for the video amplifier in question. The amount of tilt or sag is measured as the change in video amplifier output signal level (as measured at the CRT cathode or grid) between the nominal full–white or full–black level, depending on which pattern is in use, and the final level as measured no more than 10 pixel times prior to the end of the active line. The value for the "nominal full–white or full–black level" shall be taken to be that level measured at not more than 3 times the specified settling time from the beginning of the active line. Both measurements shall be made with respect to blanking level, as measured in the nearest blanking period to the level in question, excluding the effect of any active blanking pulse produced by the display (i.e., the reference point should be that level of the output signal corresponding to the blanking time of the input signal, as linearly amplified by the action of the video amplifier, WITHOUT any additional superimposed blanking pulse generated by the display circuits). The tilt or sag percentage is then calculated as follows:

$$\text{Tilt (\%)} = [\ |(\text{nominal level} - \text{final level})| / \text{final level}\ ] \times 100\%$$

8. AC Power, Reliability, and Environmental Specifications

8.1.AC Power Specifications

8.1.1: AC line voltage and frequency ranges

Description: Defines the AC power line conditions over which the unit is expected to operate.

Specification std: AC power specifications must provide, at a minimum, the range or ranges of RMS voltage and frequency over which the unit is expected to operated normally and to meet all other specifications, at whatever conditions of signal level, user control settings, etc. result in maximum power supply load. If the unit is available with optional accessories which use power from the same supply as the basic display, then these specifications should either be stated for the condition of all such accessories being present and in use, or should explicitly state that they apply to the basic unit only. The specifications are to be given in terms of a range or range or numbers (i.e., "47–63 Hz"), as opposed to a percentage tolerance (i.e., 60 Hz +/− 10%) or other form of specification.

The acceptable range of AC input voltage is to be specified in volts RMS.

The acceptable range of AC input frequency is to be given in Hertz.

8.1.2: Power Management

Description: Power management is that display feature which allows the display, after some period of inactivity, to enter into conditions which provide power savings and/or power off. This is done to extend CRT and display life, and to reduce energy consumption.

Specification std.: If power management is specified as a feature or available option on the display, the power management states, the purpose of each state, conditions for initiation of each state, conditions for recovery from each state, and the level of power reduction (either as a percentage of maximum power or in terms of the maximum real power in watts consumed during operation in each state) must be described. If the monitor provides power management capability which complies with a VESA power management standard (I.e., the VESA Display Power Management Signalling, or "DPMS" , standard), then only the levels of power reduction need to be provided in addition to reference to the DPMS standard. Example:

Power management:	Complies with VESA DPMS Rev. 1.0	
	Normal operation:	110 W max.
	Standby:	70 W max.
	Suspend:	25 W max.
	Off (w/auto–recovery):	3 W max.

8.1.3: Power Consumption, Power Factor, and AC line current.

Description: These specifications provide information on the power required by the display in all supported states of power management, as defined in 8.1.2 above. Power factor information is also an important part of the data needed to fully understand how a

display handles AC power, how much line current will be required, and what impact the display might have on the overall load of a given installation.

Specification std: Power is to be listed in true watts (RMS), to a minimum of two significant figures, and explicitly stated as either a guaranteed maximum under the test conditions listed below or as separate typical and maximum values expected under these conditions, for each of the power–management states provided by the display as specified under the standards of 8.1.2 above.

The maximum value listed for each state should in no case be less than the value determined by measuring the true power of not less than 5 randomly–chosen units which are representative of the production design and assembly process, under the specified test conditions, determining the expected distribution for each state based on the measurement of these samples, and using the projected power consumption at the upper three–sigma point of this distribution as the specified maximum.

If typical values are given, they should be the mean of the distributions determined in this manner, again for a sample size of not less than 5 units. Power may be listed separately for each input voltage or voltage range supported, and must be so listed if there is more than a 10% difference in the expected maximum power consumption between any two such ranges. If a single power specification is given, it should be the value obtained at whichever test condition results in the highest power consumption.

Power factor information shall also be given whenever power consumption is specified. The power factor should be specified as the expected minimum value under the standard test conditions, and explicitly listed as either ”leading” or ”lagging”, as defined by the relative phase of the current waveform with respect to the voltage waveform. Again, separate specifications may be listed for the various input voltage/frequency ranges supported by the product.

In addition to the power consumption in watts, the manufacturer may also specify the maximum and typical line current required for each input voltage range; however, this information cannot be stated in the absence of the power information. The maximum and typical values for AC line current should be determined using the same sample lot as was used to determine the power values, and using the same method. In addition to these values, the maximum inrush current value for each voltage range should be specified. All current specifications are to be given in Amperes (RMS), to a minimum of two significant figures.

Test pattern: All parameters covered by this section of the specification shall be measured while the display in question is displaying either a pattern of alternating single–pixel wide vertical or horizontal lines (alternating between full white and full black), or a full white raster, whichever of these results in the highest power consumption, and displayed at the format which results in the highest supported resolution or any other format which has been determined to result in higher power consumption. This applies in the case of the ”active” mode only; for all other power management states, the input video/sync signals should provide the proper sync signals for that state, but the video should be at the blank level throughout.

Test procedure: Power consumption, power factor, and AC line current values should be measured on each sample using a calibrated true RMS power meter and/or true RMS current and voltage meters connected between an AC source of variable voltage and frequency and the display's normal AC line connector. With the display provided the specified video signal, and with the user contrast and brightness controls set as described in section 6.1 of this document, true RMS power and/or current and voltage should be monitored as the AC source voltage and frequency are set to each of the following standard test conditions:

1. 100 VAC (RMS) at 50 Hz.
2. 117 VAC (RMS) at 60 Hz
3. 230 VAC (RMS) at 50 Hz.

The maximum inrush current should be determined over the same range of test conditions, but using the following procedure. For each unit tested, and prior to each measurement, the unit must be disconnected from AC power, but connected to earth ground via the normal ground connection, for a minimum of 30 minutes. AC power should then be applied and the unit switched on, while the line current is monitored via a current–measuring device capable of capturing the current waveform for a minimum of 5 seconds following the time at which AC power is applied and power to the unit is turned on, to a resolution of 1 ms, or capable of accurately determining the peak value of the current over this same period to the same resolution. The maximum inrush current observed over the range of possible test conditions should be recorded for each unit, and used to determine the distribution and specified maximum value for this parameter as described above.

8.1.4: Power Factor

Description: Power factor is an indication of the portion of a load which is reactive. It is the ratio of the real power (in watts) to the vector sum of real and reactive power (in volt–amps). A value of 1.0 indicates a purely resistive load (input voltage and current in phase), while a value between 0 and 1 indicates the relative level of reactive power.

Specification std: Power factor is specified as a dimensionless number, and should indicate the minimum power factor expected for the display under conditions of maximum load on the display power supply, and under whatever conditions of AC line voltage and frequency (within the specified ranges) results in minimum power factor. If power factor correction is available either optionally or as a standard feature which may be defeated by the user, the power factor specification should be stated both with and without such correction.

8.2.Magnetic Susceptibility

Description: Indicates the level of immunity to external magnetic fields.

Background: The CRT's electron beam is influenced by external magnetic fields just as it is by the display's own deflection yoke. There are many sources of interfering magnetic fields: the Earth's own field, the distortion of the Earth's field by such things as steel furniture and building structures; steel furniture, etc., which is itself magnetized (for example, through spot welding); and time–varying magnetic fields

produced by electric motors, transformers, and other inductive components.

Depending on the nature of these fields, their effects may be manifested as either positional (spatial) errors in the scanned image, or in errors in the angular incidence of the electron beam, resulting in a purity error. In the case of AC fields producing these effects, the result is usually viewed as jitter or a type of flicker of the displayed image. [QUESTION: Do we cover just DC fields here, or DC and AC both? We have no other jitter spec that is clearly external–fields–only.]

Specification Std.: The magnetic susceptibility specification shall state the maximum ambient (external) field strength, or range of field strengths, over which compliance to the purity, convergence, centering, and geometry specifications will be maintained. (Adjustment of the user controls to maintain compliance is permitted.) The field strength shall be given in Gauss or milliGauss, and stated separately for the horizontal and vertical components as measured relative to the monitor in its normal operating position. The specification shall apply to any tilt position available through the monitor's normal or optional tilt mechanism, and with the monitor facing in any compass direction.

8.3.Reliability

8.3.1: MTBF (Excluding CRT)

Description: MTBF (Mean Time Between Failures) is an indication of the reliability of a given product.

Specification std: MTBF is to be specified in operational hours, to at least the nearest 10,000 hours. MTBF may be either calculated or demonstrated, with the latter preferred. If the MTBF provided is a calculated figure, this must be explicitly stated, along with an identification of the method used for this calculation. The method used in determining calculated MTBF must be a recognized standard (e.g., MIL–HNDBK–217F).

If a demonstrated MTBF is given, explicit description of the reliability testing used to determine this figure need not be given, but said test must be designed to provide at least 90% confidence in the MTBF figure given for normal operation at 25 deg. C under the following test conditions: user controls set as in section 6.1, displaying the standard luminance test pattern at the maximum supported timing, and with at least one hour of power off per every 24 hours (the off time not to be counted in the total operational time). If the MTBF expected at the worst–case conditions within the specified operating environmental range is significantly less that this number (i.e., less than 90% of the standard MTBF), then derating for those conditions must be explicitly given. Accelerated life testing is acceptable to demonstrate MTBF, but the conditions of the test much be established such that the MTBF value so obtained is no greater than that expected under the standard conditions listed above. In particular, the test must include power cycling including sufficient off time for the unit to stabilize thermally such that thermal cycling equivalent to that achieved in the standard conditions is performed.

Both calculated and demonstrated MTBF figures need not include the CRT; if these figures do not include the expected CRT life, this should be explicitly stated and the

CRT life expectancy given separately. Example

MTBF: min. 55,000 hours (demonstrated, excluding CRT)
CRT life: 15,000 hours (median time to failure or half−bright, demonstrated)

8.3.2: CRT Median Time to Failure or Half−bright

Description: Defines the expected useful lifetime of the CRT itself, exclusive of the display electronics, in normal operation. A **median** lifetime (as opposed to a **mean)** is used, as a CRT's useful life is determined by a gradual loss of brightness as opposed to a "hard" mid−life failure.

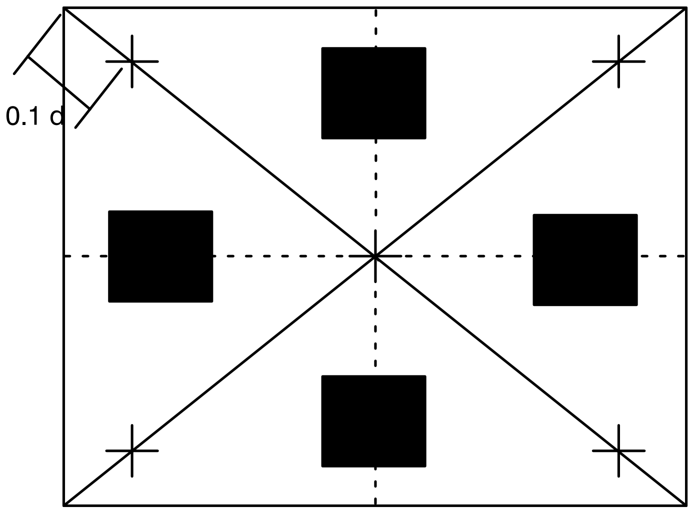
Specification std: CRT reliability shall be given in terms of the median time to half−bright or failure, and shall be stated in hours to at least the nearest 2,500 hours. If specified, CRT life must be given only as a demonstrated number.

The test used to determine CRT lifetime must be designed so as to provide a value which is the true CRT MTTF, to 90% confidence, under normal operating conditions and with the display area illuminated to full brightness at least 50% of the time. A failure in the test must be defined as either a "hard" failure of the CRT itself (i.e., a failure of the CRT resulting in its inability to operate normally), or a reduction in brightness (as measured per this standard) to 50% of the initial brightness for that unit, for whatever reason. Non−CRT failures resulting in the failure of the unit (such that the unit in question cannot continue the test) may either be corrected and the test of the CRT continued, or the unit may be removed from the test and shall not contribute in any way to the test results. The test shall continue until at least 50% of the initial population under test have been recorded as CRT failures under these criteria.

9. Standard Test Patterns

9.1.Standard luminance test pattern

The standard test pattern used for luminance and similar tests should be a flat white field, with all video inputs at 100% APL, with four 0% APL (black) areas occupying a total of 20% of the image area and located as shown. The standard measurement locations are as shown below.



Overall size:
Full active image area.

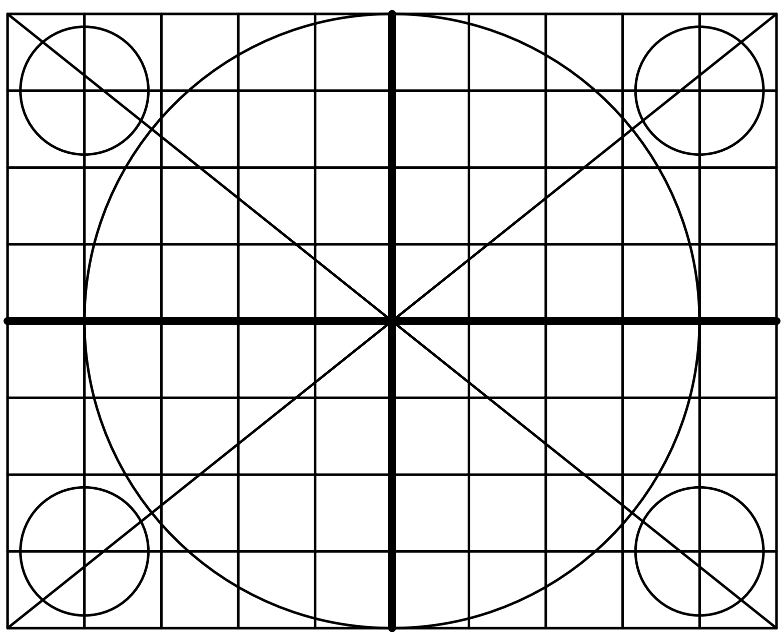
Measurements to be made at the five locations indicated by the "+" marks on this diagram.

These are the center, plus four corner locations whose centers are located in from their respective corners a distance of 0.1 times the length of the diagonal of the active image area, and on that diagonal.

The four 0% APL areas are to be located along the H and V centerlines as shown, and sized such that each area occupies 5% of the total image area (total black area of 20%), and as close as possible to square in shape.

Note: The lines and "+" marks shown are for reference only, and are not to appear in the actual test pattern.

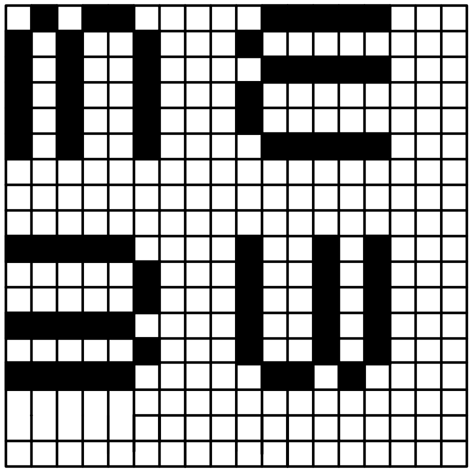
9.2.Standard geometry/linearity test pattern



1. Image to cover full active video area.
2. This pattern shown reversed; to be displayed as 100% APL white lines on 0% APL back– ground.
3. All lines to be 1 pixel wide, except for centerlines. Centerlines should be double wide or triple wide, so that they may be readily idenitifed and so the center of the line is truly at the center of the image width or height.
3. Diagonals must run corner to corner, passing through center point.
4. Large circle to be centered in pattern, diameter = image height.
5. Small circles centered on grid intersections as shown, diameter to be approx. 1.5–2 x grid size.

Note: the number and size of squares is to be selected such that the squares are truly square for the format in use, and such that there is a minimum of 8 squares along the shortest side of the imge. The maximum number of squares is optional, but should be selected so that the sqaures are not less than 25 mm on a side, unless acheiving this size would require fewer than 8 squares along the shortest side.

9.3.Standard focus test pattern ("meme")



Pattern to fill screen; maintain 3 pixel inter−character and inter−line spacing throughout

Each box = 1 pixel

Black = pixel ON

"Reversed" 2nd line is optional; not all generators will be capable of this pattern.

10. Standard Test Conditions

This section is provided as a summary of the standard test conditions presented in this standard, and a cross–reference to those tests using these conditions.

User Control Settings

As noted in section 6.1 (Luminance), the setting of the user brightness and contrast controls for the purpose of the luminance specification is left to the manufacturer's discretion. However, the same settings of these controls as are used for the luminance specification must be used for all other specifications involving image performance, such as contrast ratio, convergence, etc.. The sections of this standard to which this restriction applies includes the following:

5.4 White Point
5.5 Phosphor Specifications
5.6 Display Gamma
6.1 Luminance
6.2 Line Width
6.3 Contrast Ratio
6.4 Color Display Specifications (all)
6.5 Geometry Specifications (all)

Ambient Conditions

Lighting: The standard ambient for most tests involving photometric or chromaticity measurements shall be a dark environment, or else the effects of ambient lighting must be compensated for in the results. The sections of this standard to which these conditions apply includes the following:

3.6 CRT Faceplate Reflectivity (Anti–Glare Performance)
5.4 White Point
5.5 Phosphor Specifications
5.6 Display Gamma
6.1 Luminance
6.2 Line Width
6.4 Color Display Specifications (all)

For test involving contrast measurements and others concerned with the appearance of the display in a normally–lit environment, the standard test conditions of ISO Standard 9241, Part 3, shall apply. This standard specifies a diffuse ambient lighting of 250 lux, plus 250 lux times the cosine of the angle formed by the axis along which the light measurements are to be made, and a line tangent to the center of the faceplate of the CRT. The sections of this standard to which these conditions apply includes the following:

6.3 Contrast Ratio

Other ambient conditions: Unless otherwise explicitly stated, it is the intent of this standard that display specifications apply to the operation of the display in question under conditions approximating a normal office environment (i.e., 25 deg. C ambient temperature, ~50% relative humidity, etc.).