SMPTE RECOMMENDED PRACTICE

Center, Aspect Ratio and Blanking of Video Images

1 Scope

Most video standards documents specify tolerances for individual picture blanking edges; center and aspect ratio are only implied by nominal blanking values, and vary as the blanking edges move within permitted tolerances. Modern techniques of post-production require compositing of images generated by multiple devices (and sometimes originated in different video standards). These techniques demand a degree of precision not afforded by the implied definitions of center and aspect ratio.

This practice defines picture center and aspect ratio for a number of existing video standards, and provides an extensible technique that may be used to define center and aspect ratio for future standards. Test charts and test patterns are described which permit image generation and display devices to be calibrated to the recommended geometry. Recommendations are made for blanking widths at various stages of the production/post-production process. Additionally, a definition is provided for a set of recommended screen units permitting simple cross reference between standards with aspect ratios of 4 × 3 and 16 × 9.

The practice is intended to be used for calibration of image generation and display devices. It is also intended as a reference for designers of such equipment (particularly graphics devices), and for designers of processing equipment such as image- manipulation devices.

2 Definitions

The following paragraphs define terms and concepts as used in this practice:

2.1 aspect ratio: Aspect ratio is the ratio of horizontal dimension to vertical dimension of an image area, when displayed according to the specifications of the video standard. Within this practice, the reference for an aspect ratio of 16 × 9 is the reference image lattice. The reference for an aspect ratio of 4 × 3 is any subset of the reference image lattice with 1440 pixels horizontally and 1080 pixels (lines) vertically.

2.2 clean aperture: An image lattice that is a subset of the production aperture of a video standard, fixed in size and position, and nominally cocentric with the production aperture. The clean aperture lies completely inside the picture area remaining after application of the widest blanking permitted for the standard. The dimensions of the clean aperture for a given video standard define the nominal aspect ratio for that standard. Where both composite and component versions of a standard exist, clean aperture is defined with respect to the image lattice specified for the component version.

2.3 edge processing region: The region of the production aperture that lies outside the clean aperture. Processing equipment should be designed so that all edge-related artifacts are confined to the edge processing region. Blanking transitions should occur completely within the edge processing region.

2.4 image lattice: A two-dimensional array of pixels.

2.5 production aperture: The image lattice that represents the maximum possible image extent in a given standard. The production aperture represents the desirable extent for image acquisition, generation, and processing prior to blanking. Where both composite and component versions of a standard exist, production aperture is defined with respect to the image lattice specified for the component version.

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2.6 reference image lattice (RIL): An image lattice of square pixels with 1920 pixels horizontally and 1080 pixels (lines) vertically.

2.7 square pixel: A picture element that represents an equal distance horizontally and vertically when the image is displayed at its defined aspect ratio.

3 Production and clean apertures

This practice recognizes that the video signal is operated on by many processing devices. Many of these operations (including most filters) produce edge-related artifacts. Blanking often is applied many times to the signal, and this usually results in distortion of the blanking edge or in an increase in blanking width. The result of this processing is that the useful image area is gradually reduced. It is, therefore, advantageous to acquire the maximum possible image area, and to define a region where artifacts are acceptable.

The production aperture, as defined above, is the maximum possible image area that can be supported by the video standard. The clean aperture is a slightly smaller image area, of similar aspect ratio to the production aperture, and contained within it. The part of the production aperture not included in the clean aperture is the edge processing region.

Ideally, a video source will capture or generate the full production aperture. This may not always be practical, but source blanking should be as close as possible to this ideal. When these conditions are met, a test chart of the correct aspect ratio may be imaged and superimposed on an electronic graticule representing the clean aperture, thus ensuring correct aspect ratio and centering.

Although underscanned monitors are used for technical monitoring, the ideal display for program viewing will display exactly the clean aperture. An electronic graticule representing the clean aperture may be used as a reference for display adjustment.

It should be noted that it is not the intent of this practice that information outside the clean aperture be discarded. Some or all of this information may be blanked (horizontally and/or vertically), depending upon the transmission standards and operational practice. Subject to these limitations, this information should be retained and, to the extent permitted by transmission blanking standards, it should be transmitted.

4 Center of image

The center of an image is defined as the point at the center of the clean aperture.

Horizontally, there will be an equal number of pixels within the clean aperture to the left and to the right of the center point. Vertically, there will be an equal number of pixels (lines) within the clean aperture above and below the center point.

The center position for each video standard is specified in the appropriate table of clause 11.

5 Horizontal blanking

5.1 Picture sources

As described above, it is desirable to capture the maximum possible extent of picture information. Some authorities believe the optimum position for horizontal blanking is where the midpoint of the blanking rise and fall are coincident with the first and last pixels of the production aperture. Others prefer that the blanking edges be contained (just) within the production aperture.

5.2 In-plant blanking

In-plant blanking should remain as narrow as possible, and should always be narrower than transmission blanking.

5.3 Narrow transmission blanking

This is the narrowest blanking permitted by a transmission standard and is provided for reference in appropriate tables of clause 11. This width of blanking may be very useful within a facility for signals that may be aired directly (without further blanking), but where it is desired to maintain as much information as possible for further processing. This figure may represent a useful operating practice for blanking of taped signals that may be aired directly or that may be used as inputs for further processing.

5.4 Wide transmission blanking

This figure, quoted in appropriate tables of clause 11, represents the widest blanking permitted by a transmission standard and is placed just outside the clean aperture. It should be noted that once this blanking has been applied, further processing or blanking will likely result in distortion of the blanking edge and/or loss of information from the clean aperture.

6 Vertical blanking

Vertical blanking is less frequently impacted by processing equipment than is horizontal blanking, but processes such as vertical filtering will result in distortion at the top and bottom of the image. In general, the full height of the production aperture should be captured or generated at the source. A transmission standard may specify an exact number of lines that should be transmitted.

Where processing requires wider vertical blanking than determined by the production aperture, such blanking should remain outside the clean aperture.

It should be noted that increasing the width of horizontal blanking but not of vertical blanking, as is common practice, results in an apparent change in aspect ratio. For this reason, both source and display aspect ratios should be set using an electronic graticule representing the clean aperture.

7 Screen units

Many items of equipment such as picture manipulation devices make use of a system of screen units as part of the operator interface. In equipment designed for systems with an aspect ratio of 4:3, it is common practice to define a grid 8 screen units horizontally by 6 screen units vertically. The nominal edges of the picture are then 4 units to the left and right of, and 3 units above and below, the center of the image.

For 16:9 systems, a similar approach is recommended. The grid should be 32 screen units horizontally by 18 screen units vertically. The nominal edges of the picture are then 16 units to the left and right of, and 9 units above and below, the center of the image.

The nominal edges of the picture referenced above should be the boundaries of the clean aperture. The clean aperture will be exactly 32×18 screen units in 16:9 systems. The 4:3 subset of a 16:9 image will measure 24×18 screen units, which is exactly three times the current practice (8×6) for 4:3 systems.

8 Conversion ratios

The tables in clause 11 contain horizontal and vertical conversion ratios to derive each scanning system from the reference image lattice. It is possible, therefore, to derive conversion ratios between any two scanning systems.

Ratios derived in this way should form the target ratios for standards converters. In practice, standards converters may use filters with a relatively small number of taps. An appropriate balance of cost and video quality may mean that some practical converters will not use the exact ratios calculated from the tables. The tables provide a reference for calculating the resulting image size and/or aspect ratio errors.

9 Test charts and signals

Figure 1 shows a pattern that may be used for both physical test charts and electronic graticules, for both 4:3 and 16:9 applications. The outer rectangles represent the clean apertures. (The markers represent 2.5%, 5%, 7.5%, and 10% overscan.)

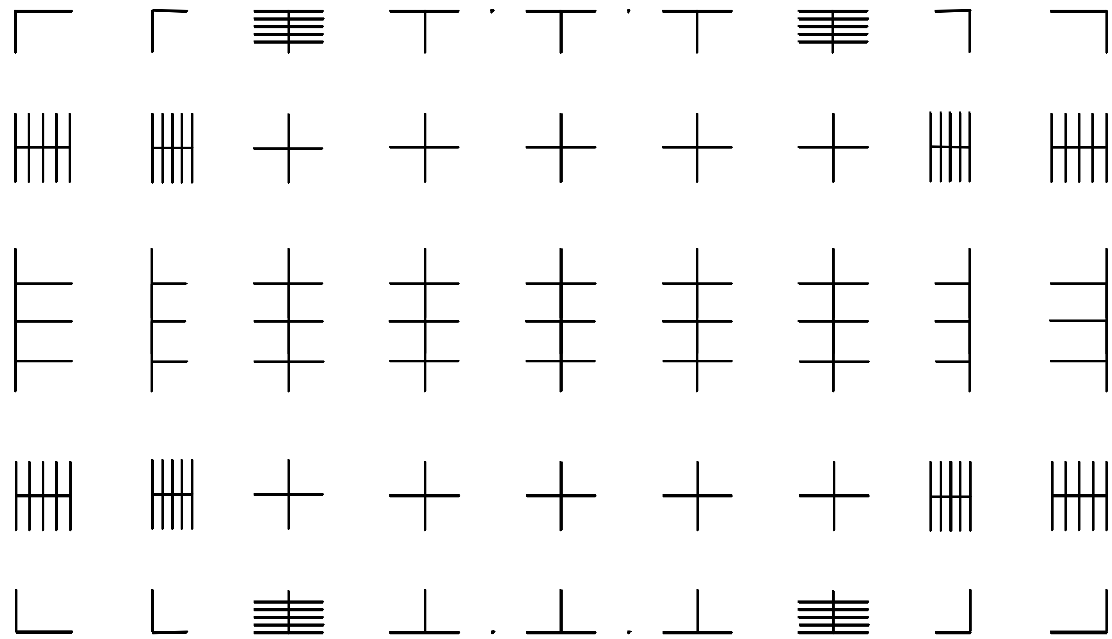
10 Safe action and safe title areas

Safe action and safe title areas are defined in other SMPTE Recommended Practices as subsets of the image area. The definition of the image area of a video picture used in deriving safe action and safe title areas should be the clean aperture for the appropriate video standard, as defined by this practice.

11 Tables of parameters

Tables 1–6 define parameters for a number of television standards. The information includes the extent of the production and clean apertures, the picture center, and where appropriate, values for horizontal blanking as discussed in clause 5.

All horizontal timings are expressed as fractions of the total line time τ_H.



NOTE -- Markers represent overscan in increments of 2% picture width/height.

Figure 1 – Test chart/graticule

Table 1 – Reference image lattice (RIL)

Production aperture	Size (pixels × lines)	1920 × 1080
	Horizontal extent (pixel # to pixel #, inclusive)	0 to 1919 (reference)
	Vertical extent (line # to line #, inclusive)	0 to 1079 (reference)
Clean aperture	Size (pixels × lines)	1888 × 1062
	Horizontal extent (pixel # to pixel #, inclusive)	16 to 1903
	Vertical extent (line # to line #, inclusive)	9 to 1070
	Aspect ratio	16:9
	Pixel aspect ratio (horizontal/vertical)	$\frac{1}{1}$
	Derivation from RIL -- Horizontal	n/a
	Derivation from RIL -- Vertical	n/a
Center of image	Horizontal (midway between pixel # and pixel #)	959 and 960
	Vertical (midway between line # and line #)	539 and 540
	Horizontal position with respect to 0_H	n/a

Table 2 – 525/59.94, 4:3 aspect ratio, 2:1 interlace (ANSI/SMPTE 125M)

Production aperture	Size (pixels × lines)	720 × 486
	Horizontal extent (pixel # to pixel #, inclusive)	0 to 719
	Vertical extent (line # to line #, inclusive)	283 (field II) to 263 (field I)
Clean aperture	Size (pixels × lines)	708 × 480
	Horizontal extent (pixel # to pixel #, inclusive)	6 to 713
	Vertical extent (line # to line #, inclusive)	22 (field I) to 524 (field II)
	Aspect ratio	4:3
	Pixel aspect ratio (horizontal/vertical)	$\frac{160}{177}$ (approx. 0.904)
	Derivation from RIL -- Horizontal	x $\frac{1}{2}$
	Derivation from RIL -- Vertical	x $\frac{160}{177}$ x $\frac{1}{2}$
Center of image	Horizontal (midway between pixel # and pixel #)	359 and 360
	Vertical (midway between line # and line #)	404 (field II) and 142 (field I)
	Horizontal position with respect to 0_H	$\frac{963}{1716} = \frac{321}{572}\tau_H$ approx. 35.667 µs
NTSC transmission blanking (50% points)	Narrow	pixel #717 to pixel #1 approximately 10.5 µs
	Nominal	pixel #716 to pixel #2 approximately 10.7 µs
	Wide	pixel #714 to pixel #5 approximately 11.0 µs

Table 3 – 525/59.94, 16:9 aspect ratio, 2:1 interlace, 13.5-MHz sampling (ANSI/SMPTE 267M)

Production aperture	Size (pixels × lines)	720 × 486
	Horizontal extent (pixel # to pixel #, inclusive)	0 to 719
	Vertical extent (line # to line #, inclusive)	283 (field II) to 263 (field I)
Clean aperture	Size (pixels × lines)	708 × 480
	Horizontal extent (pixel # to pixel #, inclusive)	6 to 713
	Vertical extent (line # to line #, inclusive)	22 (field I) to 524 (field II)
	Aspect ratio	16:9
	Pixel aspect ratio (horizontal/vertical)	$\frac{640}{531}$ (approx. 1.205)
	Derivation from RIL -- Horizontal	x $\frac{3}{4}$ x $\frac{1}{2}$
	Derivation from RIL -- Vertical	x $\frac{160}{177}$ x $\frac{1}{2}$
Center of image	Horizontal (midway between pixel # and pixel #)	359 and 360
	Vertical (midway between line # and line #)	404 (field II) and 142 (field I)
	Horizontal position with respect to 0_H	$\frac{963}{1716} = \frac{321}{572}\ \tau_H$ approx. 35.667 µs

Table 4 – 525/59.94, 16:9 aspect ratio, 2:1 interlace, 18-MHz sampling (ANSI/SMPTE 267M)

Production aperture	Size (pixels × lines)	960 × 486
	Horizontal extent (pixel # to pixel #, inclusive)	0 to 959
	Vertical extent (line # to line #, inclusive)	283 (field II<) to 263 (field I)
Clean aperture	Size (pixels × lines)	944 × 480
	Horizontal extent (pixel # to pixel #, inclusive)	8 to 951
	Vertical extent (line # to line #, inclusive)	22 (field I) to 524 (field II)
	Aspect ratio	16:9
	Pixel aspect ratio (horizontal/vertical)	$\frac{160}{177}$ (approx. 0.904)
	Derivation from RIL -- Horizontal	$x \frac{1}{2}$
	Derivation from RIL -- Vertical	$x \frac{160}{177} x \frac{1}{2}$
Center of image	Horizontal (midway between pixel # and pixel #)	479 and 480
	Vertical (midway between line # and line #)	404 (field II) and 142 (field I)
	Horizontal position with respect to 0_H	$\frac{1284}{2288} = \frac{321}{572} \tau_H$ approx. 35.667 µs

Table 5 – 1125/60, 16:9 aspect ratio, 2:1 interlace (SMPTE 240M)

Production aperture	Size (pixels × lines)	1920 × 1035
	Horizontal extent (pixel # to pixel #, inclusive)	0 to 1919
	Vertical extent (line # to line #, inclusive)	603 (field II) to 1120 (field I)
Clean aperture	Size (pixels × lines)	1888 × 1018
	Horizontal extent (pixel # to pixel #, inclusive)	16 to 1903
	Vertical extent (line # to line #, inclusive)	607 (field II) to 553 (field I)
	Aspect ratio	16:9
	Pixel aspect ratio (horizontal/vertical)	$\frac{1018}{1062}$ (0.9586)
	Derivation from RIL -- Horizontal	x $\frac{1}{1}$
	Derivation from RIL -- Vertical	x $\frac{1018}{1062}$
Center of image	Horizontal (midway between pixel # and pixel #)	959 and 960
	Vertical (midway between line # and line #)	line 861 (field II) and line 299 (field I)
	Horizontal position with respect to 0_H	$\frac{2303}{4400}\,\tau_H$ (approx. 15.508 µs)

Table 6 – 625/50, 4:3 aspect ratio, 2:1 interlace (EBU 3267)

Production aperture	Size (pixels × lines)	720 × 576
	Horizontal extent (pixel # to pixel #, inclusive)	0 to 719
	Vertical extent (line # to line #, inclusive)	23 (field I) to 623 (field II)
Clean aperture	Size (pixels × lines)	690 × 566
	Horizontal extent (pixel # to pixel #, inclusive)	15 to 704
	Vertical extent (line # to line #, inclusive	338 (field II) to 308 (field I)
	Aspect ratio	4:3
	Pixel aspect ratio (horizontal/vertical)	$\frac{1132}{1035}$ (approx. 1.094)
	Derivation from RIL -- Horizontal	$\times \frac{115}{118} \times \frac{1}{2}$
	Derivation from RIL -- Vertical	$\times \frac{283}{531}$
Center of image	Horizontal (midway between pixel # and pixel #)	359 and 360
	Vertical (midway between line # and line #)	479 (field II) and 167 (field I)
	Horizontal position with respect to 0_H	$\frac{983}{1728} \tau_H$ approx. 36.407 µs
PAL transmission blanking (50% points)	Narrow	pixel #711 to pixel #6 approximately 11.78 µs
	Nominal	pixel #710 to pixel #8 approximately 12.00 µs
	Wide	pixel #706 to pixel #12 approximately 12.59 µs

Annex A (informative)
Applications information

A.1 Cameras

Camera blanking should be set to be as narrow as possible, consistent with the size of the production aperture and with in-plant blanking practice. For maximum image extent, the 50% points of blanking should be coincident with the edge pixels of the production aperture.

A test chart of the appropriate aspect ratio (4:3 or 16:9) should be imaged and superimposed on the clean aperture of an electronic graticule.

A.2 Telecine and film recording

Although the terminology is different, the concept of multiple apertures is standard in film work. The camera taking aperture is generally larger than the intended projection aperture.

The most critical requirements for image position, size, and aspect ratio occur when film is transferred to video, processed, and then re-recorded on film for intercutting with the original. It is imperative that sufficient clean image be available to fill the projection aperture.

To achieve this end, the video clean aperture should be coincident with the intended projection aperture for both telecine and film recording. In both cases, blanking width should be minimized to transfer as much additional image as possible.

A.3 Electronically generated images

(These notes also apply to matte generators, etc., incorporated in video processing equipment.)

Where the signal will be blanked by associated processing equipment, signals generated electronically should occupy the full production aperture. Otherwise, all electronically generated signals should include provision for adjustable blanking, and this should be set to conform to the facility’s standards for in-plant blanking.

A.4 Computer generated images

Although computer-generated images are electronically generated, some considerations are different from dedicated electronic image generation hardware.

Virtually, all modern computer systems utilize square pixel formats. Many television formats do not employ square pixels. Use of computer-generated imagery for such video formats will, therefore, require resampling in at least one dimension.

A particular problem arises when using a 640×480 format to produce images for 525-line 4:3 video. The 480 pixels vertically can map exactly to the 480 lines of the 525 clean aperture. Horizontally, this requires that 640 pixels be mapped to the required 708 pixels of the clean aperture. Resampling horizontally in the ratio of 11:10 (with appropriate interpolation/filtering) will yield 704 pixels. It is recommended that edge pixel replication be employed to extend the image to 720 pixels, followed by appropriate production blanking.

A.5 Picture manipulation devices

These devices should process the maximum possible image extent. This may be the production aperture, or may be adjustable to reflect in-plant blanking standards. Care must be taken to ensure that filters requiring edge replication do not replicate blanked pixels.

Output blanking should be adjustable to conform to in-plant blanking standards.

Manipulations that use the nominal picture width or height (“push effects,” geometric solids, etc.) should use the width or height of the clean aperture. For example, in a “push” effect, the two images should be displaced by the width of the clean aperture, and the 50% mix point between the two signals should be the edge pixel of the clean aperture.

A.6 Standards converters

Standards converters should process the full extent of the production aperture. Target parameters for conversion should be those that exactly translate the source standard clean aperture into the clean aperture of the destination standard. Where practical design considerations preclude exact conversion, the resulting errors in image extent, position, and aspect ratio should be stated.

It should be noted that the necessary deviations from ideal conversion ratios often mean that the clean aperture of the source standard is converted to less than the clean aperture of the destination standard. Under these conditions, generation of the full clean aperture in the destination standard requires that video outside the clean aperture is present in the source signal. This is another reasosn to minimize blanking widths in production and post-production.

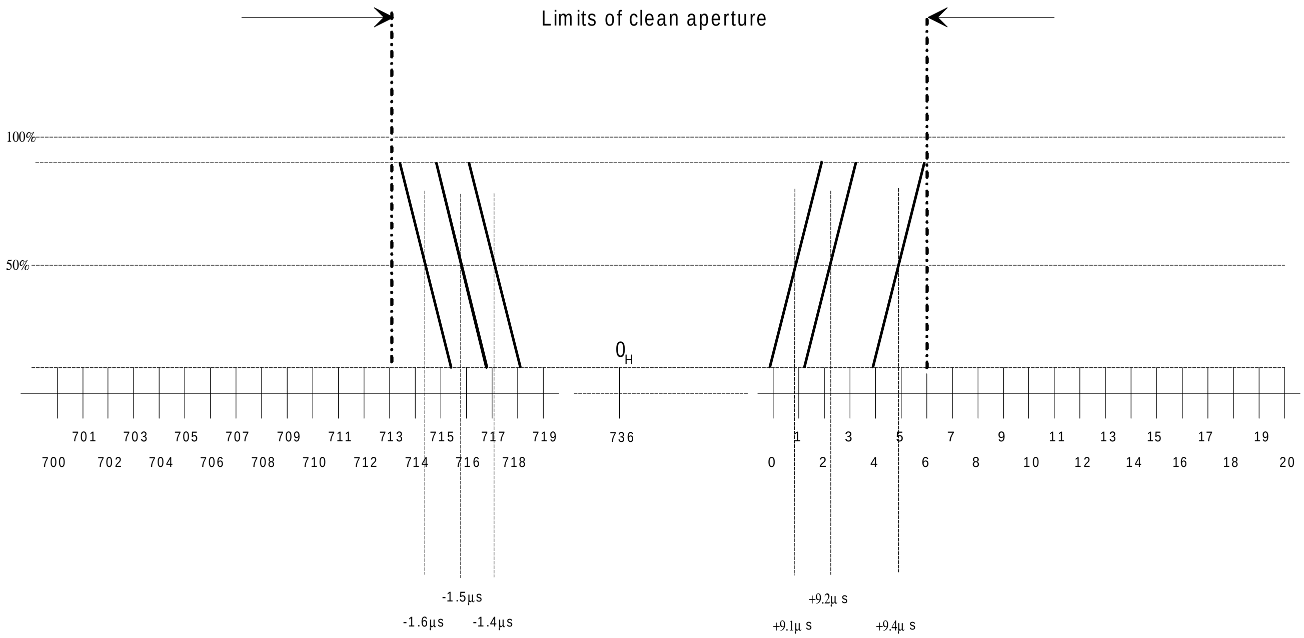
A.7 Test signal generators

Electronic graticules as described herein have been implemented on programmable generators. Best results are obtained when vertical lines are produced by raised sine pulses of 2-pixel HAD (half-amplitude duration). The exact positions of vertical lines should be represented by appropriate interpolation (not nearest pixel).

Horizontal lines should be represented by line pairs, one above and one below the intended position (one line in each field for interlaced standards).

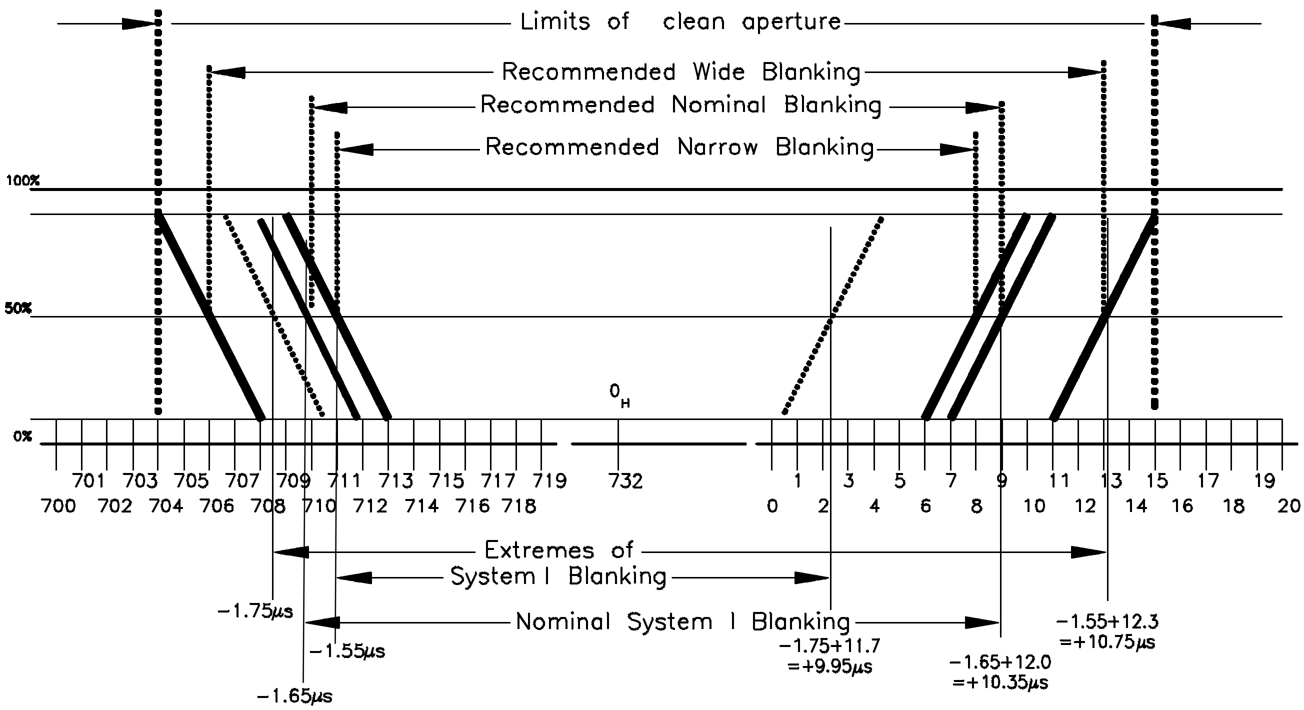
Annex B (informative)
Transmission blanking

Figures B.1 and B.2 indicate the relationship between clean aperture and various values of horizontal blanking.



NOTES
1 Front porch = 1.5 µs ± 0.1 µs.
2 Back porch = 9.2 µs + 0.2 µs – 0.1 µs.
3 Blanking edges are drawn with rise time of 2T (148 ns) 10% – 90%.

Figure B.1 – 525/60 clean aperture vs NTSC blanking



NOTES
1 System "I" values are shown (from ITU-R BT.470).
2 Front porch = 1.65 µs ± 0.1 µs.
3 Blanking = 12.0 µs ± 0.3 µs.
4 Blanking edges are drawn with rise time of 4T (296 ns) 10% – 90%.

Figure B.2 – 625/50 clean aperture vs PAL

Annex C (informative)
Bibliography

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