SMPTE ENGINEERING GUIDELINE

Safe Areas for Television

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Approved February 23, 2010

Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in Part XIII of its Administrative Practices.

SMPTE EG 2046-3 was prepared by Technology Committee 10E.

Intellectual Property

At the time of publication, no notice had been received by SMPTE claiming patent rights essential to the implementation of this Engineering Guideline. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

1 Scope

SMPTE has several Standards and Recommended Practices on safe areas for television. Among these are SMPTE ST 2046-1, SMPTE RP 2046-2, SMPTE RP 218, and SMPTE RP 27.3. It is the purpose of this Engineering Guideline to explain the use of these documents and the relationships among them and others, principally SMPTE ST 2016-1. A brief history of TV safe areas and their evolution is also given.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be defined in the future.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; followed by formal languages; then figures; and then any other language forms.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this recommended practice. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this recommended practice are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

None.

4 History of Television Safe Areas

From the early days of film and television, it has been recognized that not all of the information contained in the original image frame will necessarily be presented to the viewer. In television, the principal limitation has been the use of overscan in the viewer’s receiver.

In 1957, the SMPTE Journal included a paper entitled Television Receiver Picture Area Losses, in which the author, Charles Townsend, describes research conducted at NBC’s WRCA-TV in an effort to determine the extent of the broadcast image that was actually seen in viewers’ homes. The paper is reproduced in Annex B. Note that the safe area the author suggests is based on the assumption that all elements within the safe area will be viewable on at least 85% of receivers; no attempt is made to ensure viewability on 100% of receivers.

The safe area pattern recommended is 80% of image height and approximately 80% of image width, adjusted for the shape of the mask, which reflects the circular shape of the CRTs then in use.

Two letters to the editor of the Journal, published in May 1958, noted prior tests conducted in 1947 by Otis Freeman, then at DuMont, which had been published in the March 1948 issue of *Television* magazine. Mr. Freeman obtained very similar results. As a consequence, the following standard practice was included in the DuMont Television Network's *Engineering Standards Handbook*:

"All studio monitors shall be marked with lines to indicate full raster size and 10% margins on either side and at top and bottom. Engineering personnel will advise program personnel to keep important program material within these limits."

The 10% margins cited yield a safe area of 80% of picture width and 80% of picture height.

In 1961, SMPTE issued SMPTE RP 8, Safe Title Area for TV Transmission, which specified this 80% width, 80% height rectangle with rounded corners as the Safe Title Area. This was followed in 1963 by SMPTE RP 13, Safe Action Area for TV Transmission, which specified a 90% width, 90% height rectangle with rounded corners as the Safe Action Area. In 1968, the two RPs were combined into a revised SMPTE RP 8.

1972 saw the publication of SMPTE RP 27.3, Specifications for Safe Action and Safe Title Area Test Pattern for Television Systems, which specified a test pattern for 2 x 2 slides and 16mm and 35mm motion-picture film for television. This replaced SMPTE RP 8, maintaining the same dimensions and shapes of the safe areas. In 2002, SMPTE issued SMPTE RP 218, which brought the specification forward into the digital era by specifying safe areas in terms of pixel and line counts rather than linear dimensions. The rounded corners were also eliminated, as by that time consumer CRTs had square corners. Although superseded, SMPTE RP 27.3 was kept on the books for archival purposes.

All of these specifications and test patterns were based on the characteristics of CRT-based displays, including rounded corners (except in SMPTE RP 218) and safe-area margins large enough to compensate for centering and geometry errors and the overscan necessary to ensure that the CRT was completely filled with an image even when the receiver's components had aged or the line voltage sagged. These specifications – a safe action area 90% of the width and 90% of the height of the full image area and a safe title area 80% of the width and 80% of the height of the full image area – persisted until near the end of the first decade of the 21st century, despite significant improvements in CRT-based receiver technology.

By 2007-2008 it had become obvious that the CRT was rapidly being replaced by fixed-pixel-matrix (FPM) displays (plasma, LCD, DLP, etc.) While these technologies have significant differences among them, one characteristic they share is fixed image geometry. No longer is the consumer display subject to changing picture size due to conditions beyond the manufacturer's control. Moreover, since the early 2000s many broadcasters had been utilizing the space between the safe action area and the safe title area for news crawls and other title information, knowing that on modern CRT displays as well as FPM displays this information was virtually certain to be legible. Another complicating factor was the wide adoption of the 16:9 aspect ratio, making it necessary to create images that would be acceptable on both 4:3 and 16:9 displays.

Based on these facts, several broadcast organizations around the world determined it was time to widen the safe areas and asked SMPTE to investigate. SMPTE responded by establishing a Working Group on Safe Areas and under it an Ad Hoc Group on Television Safe Areas, reporting to Technology Committee 10E. The result was the development of a new Standard, SMPTE ST 2046-1, a new Recommended Practice, SMPTE RP 2046-2, and an amendment to SMPTE RP 218.

Many broadcasters had hoped that it would be possible to utilize the entire active picture area as the safe action area. However, for a variety of reasons, FPM-based consumer receivers, even if they are adjustable to show the entire image area, commonly default to a small amount of overscan to conceal image processing and compression edge artifacts. Moreover, although CRT-based receivers are no longer sold, large numbers of them remain in use. Based on research in the U. S., Europe and Japan, the specifications in SMPTE ST 2046-1 and SMPTE RP 2046-2 were adopted.

One aspect of the safe area specifications that has not changed, however, is that there is no ironclad guarantee that the entire safe action area or safe title area will be displayed on all television receivers. Given the advances in display technology since 1957, far more than 85% of consumer displays in the field are capable of doing so, but it is not possible to assert that all are.

5 The New Specifications

SMPTE ST 2046-1 defines the Safe Action Area as a rectangle that is 93% of the width and 93% of the height of the Production Aperture (or 720 x 480 in the case of 480-line formats) and concentric with it. The Safe Title Area is defined as a rectangle that is 90% of the width and 90% of the height of the Production Aperture (or 720 x 480 in the case of 480-line formats) and concentric with it. Annex C of the Standard provides informative tables giving the dimensions of these safe areas in terms of lines and pixels for the most commonly used image formats. Annex D provides example safe area graticules for both 4:3 and 16:9 aspect ratios, as well as a graticule for 4:3 images using the legacy safe area percentages.

SMPTE RP 2046-2 defines safe areas that should be used when composing 16:9 images that will be presented on both 4:3 and 16:9 displays. Two example graticules are defined, one for use when the 4:3 image is to be created by cropping the sides of the 16:9 image and the other for use when the full 16:9 image is to be presented in a letterbox on the 4:3 display. These are described in the context of the Active Format Description (AFD) specifications defined in SMPTE ST 2016-1. SMPTE RP 2046-2 defines only 90%, 90% safe areas.

Amendment 1 to SMPTE RP 218 deprecates its use except for formatting of closed captions as defined in CEA-708. The exception exists because all receivers deployed in countries that require the use of CEA-708 display captions in a window whose extents are defined by the old 80% width, 80% height safe title area defined in SMPTE RP 218. CEA-708 normatively references SMPTE RP 218. For all other applications, the amended RP directs users to SMPTE ST 2046-1 and SMPTE RP 2046-2.

6 A Use Case

As an example of how to use the new documents, let us suppose that we wish to create images for a broadcast. We will produce in 1920 x 1080 for broadcast in 1920 x 1080, but recognize that the broadcast will be viewed both on 16:9 HD displays and on legacy 4:3 displays via down-conversion.

ST 2046-1 gives us the safe action and safe title area percentages, as well as the line and pixel counts for 1920 x 1080 formats and an example graticule. However, we need to take account of the down-conversion for 4:3 displays, so we need to look at SMPTE RP 2046-2.

SMPTE RP 2046-2 tells us that we first need to determine whether the 4:3 images will be center-cut from the 16:9 images or whether they will be letterboxed. As the RP notes, this is dictated by both creative and business factors. Let us assume that these impel us to determine that the images will be center-cut, so we need to shoot to protect the 4:3 central area. These safe areas are defined in Section 4.1 of the RP; its Figure 1 gives us the graticule and its Table 1 gives us the dimensions in terms of lines and pixels. We find that the Safe Area is 972 lines high by 1296 pixels wide. This is the Safe Area for both titles and action, but not for captions.

On a 4:3 display, captions will be limited to 80% of the width and 80% of the height of the center-cut area. SMPTE RP 218 tells us the height directly; it is 864 lines. We need to calculate the width, which is 80% of the center cut width, given in SMPTE RP 2046-1 as 1440 pixels. 80% of this is 1152, so the area of the source image to which captions will be limited in 4:3 is 1152 x 864.

The other thing SMPTE RP 2046-2 tells us is that images shot in 16:9 to protect a 4:3 central area should have an AFD of ‘1111’. For a detailed explanation of what this means and how AFD works, see SMPTE ST 2016-1.

Annex A (Informative)
Bibliography

SMPTE 2016-1:2008, Format for Active Format Description and Bar Data

SMPTE ST 2046-1:2009, Specifications for Safe Action and Safe Title Areas for Television

SMPTE RP 8-1968, Safe Title Area for TV Transmission (Withdrawn)

SMPTE RP 13-1963, Safe Action Area for TV Transmission (Withdrawn)

SMPTE RP 27.3-1989, Specifications for Safe Action and Safe Title Area Test Pattern for Television Systems

SMPTE RP 218:2009, Specifications for Safe Action and Safe Title Areas for Television Systems

SMPTE RP 2046-2:2009, Television — Safe Areas for Protection of Alternate Aspect Ratios

CEA-708-D (August 2008), Digital Television (DTV) Closed Captioning

Chipp, Rodney D., Letter to the Editor, JSMPTE, Volume 67, Page 343, May 1958

Freeman, Otis, Letter to the Editor, JSMPTE, Volume 67, Page 343, May 1958

Townsend, Charles L., Television Receiver Picture Area Losses, JSMPTE, Volume 66, Pages 758-759, December 1957 (reprinted as Annex B below)

Annex B *Television Receiver Picture Area Losses*[1]

Television Receiver Picture-Area Losses

By CHARLES L. TOWNSEND

The problem of determining how much of the picture telecast by a standardized TV station is received on the home receiver is one of vital importance to station employees as well as to program sponsors. A test conducted with the cooperation of WRCA-TV provided data which were used to define "Safe Areas" in telecasting.

JUST HOW MUCH of the picture radiated by a standardized TV station is seen on the home receiver? This question has been asked at frequent intervals ever since television first entered the world of commerce and acquired sponsors for its programs. Complaints that "No one called because the telephone number across the bottom of the picture was cut off," or that a shampoo advertisement was ineffective because "The model's hair was cut off at home," are no novelty.

Probably every worker in the field has had reason to consider the problem of "Safe Area" and many of them have offered drawings and masks to illustrate their ideas on the subject. Some are based upon real and perhaps bitter experience, and reasonably good results are often achieved. But the nagging thought remains that little, if any, concrete evidence exists to support these proposed solutions.

A recent problem in shooting film for television brought about a decision to eliminate as much guesswork as possible from the study of this problem. A widespread test of home receivers was not possible since commercial air time is rarely contributed on a no-pay, no-charge basis. It seemed, however, that a significant sample might be obtained from a one-station test. WRCA-TV broadcast the basic chart (Figs. 1 and 2) for fifteen minutes just before regular program time in the morning. The chart shown at that time did not, of course, include the dotted lines. A recorded announcement was played, giving the audience directions for participating in the experiment.

A contribution received on October 15, 1957, from Charles L. Townsend, Film and Kinescope Operations, National Broadcasting Co., RCA Bldg., Radio City, New York 20.

The chart shows a central circle for judging linearity, and radial lines marked off in numbered segments. Each segment is equal to 5% of the picture height. Each viewer was asked to jot down a series of letters defining specific lines and numbers indicating how far along that line he could see. That series, such as A3, B5, C5, etc., would fully define the aperture of his receiver as it was established by his local scanning and the receiver mask.

About seventy-five replies were received. A small sample, surely, but there is little reason to believe it unrepresentative. The results were carefully tabulated and analyzed according to several concepts of practical usefulness. The numbers obtained did not directly produce a useful "Safe Area" shape. A certain amount of practical adjustment was necessary to get a symmetrical, balanced design. The final result of that work is the Safe Area defined by the dashed lines in Fig. 1. *Picture material within those lines will be reproduced on at least* 85% *of all receivers in the sample.*

The curved sides of the Safe Area of Fig. 1, as well as the actual values used for the radials, are believed to be a practical outgrowth of the preliminary designs shown in the charts. The figure has been made symmetrical without excessive loss of area, and the sides are portions of a simple circle centered at the pattern center. The minimum border values on all four sides are equal at 10% of picture height. Thus the shape is easily defined and reproduced.

It is believed that the Safe Area shown in Fig. 1 is a practical design which can be used with good expectation of commercially satisfactory results.

The information received from the viewing public was compiled in the form of a list of related numbers. Of several possible methods of handling that list, the graphical system of Fig. 3 seemed the most suitable, although it is not by any means the only practical approach.

The bar graphs indicate that there are several bases for mask design, depending upon the limits deemed reasonable. Two approaches to the problem and the methods used are given here.

Design for Dominant Group

The Safe Area limits were designed on the basis of the specifications for the dominant group of receivers. In the tabulation of replies one group of figures was found to have significantly more entries than any other group — that group is:

A4	B4	C6	D3
E3	F3	G6	H4

A series of straight lines drawn through those figures on the chart will not produce a realizable area shape. However, if the B, D, F, and H numbers are used as radii, a normal looking mask shape is produced, as shown in Fig. 2 as the larger area enclosed by dashed lines.

Having drawn the outer dashed lines of Fig. 2, the next question is "What part of the TV audience will be served by it?" The answer is a little complex.

"A" Direction, Value 4: 56% of receivers will show the stated line length; 34% will cut off 5 percentiles more; and 10% of receivers will cut off 10 percentiles, that is, down to numeral 2.

"B" Direction, Value 4: 50% of receivers will show the stated line length; 32% will cut off an additional 5 percentiles; and 18% will cut off 10 percentiles, which is at numeral 2.

"C" Direction, Value 6: 51% of receivers will reproduce the stated line length; 37% will cut off 5 percentiles more; and 12% of receivers will cut off 10 percentiles, which is down to numeral 4.

"D" Direction, Value 3: 78% of receivers will reproduce the stated line length; the remaining 22% will cut off 5 percentiles.

"E" Direction, Value 3: 85% of receivers will reproduce the stated line length; 15% will cut off 5 percentiles more.

[1] Originally published in SMPTE's Motion Imaging Journal, Volume 66, December, 1957.

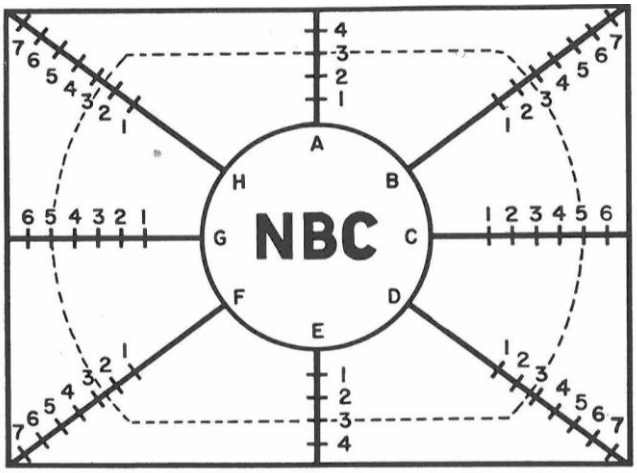

Fig. 1. Material within the dashed lines will be reproduced by at least 85% of receivers in the test.

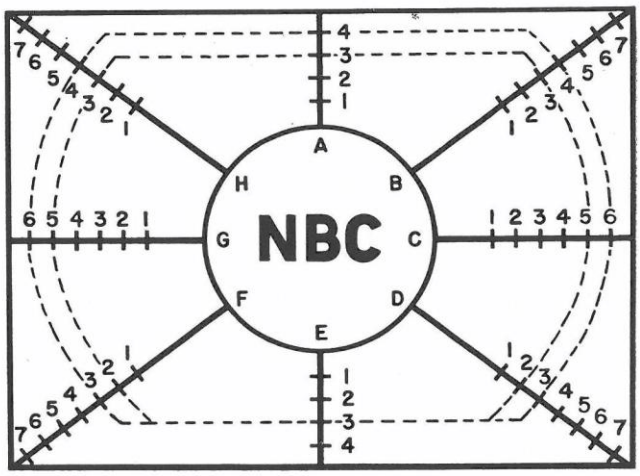

Fig. 2. Outer dashed lines define results of design for the dominant group; inner dashed lines, design for shape and symmetry.

Note that the difference between the values for the A and E lines indicates that the picture has been centered downward; that is, the center of the mask is about 2½ percentiles above the center of the chart.

The other lines of the chart show similar variations, but are not detailed because of the need for vertical symmetry in practical Safe Area design.

Design for Shape and Symmetry

To design the Safe Area limits for reasonable shape and symmetry and for approximately 85% of receivers to see all of it, these numbers are chosen:

A3	B3	C5	D2
E3	F2	G5	H3

The Safe Area shown by the inner dashed lines of Fig. 2 results from these numbers. Again, the center of edge radius is about 2½ percentiles above the chart center. *Note that it would be quite difficult to assign straight sides to these values and still arrive at a practical area shape.*

The results of this shape are as follows:

"A" Direction, Value 3: 90% of receivers will reproduce this line; 10% will cut off an additional 5 percentiles.

"B" Direction, Value 3: 81 % of receivers will reproduce the entire line; 19% will cut off an additional 5 percentiles.

"C" Direction, Value 5: 88% of receivers will reproduce the en tire line; 12% will cut off 5 percentiles more.

"D" Direction, Value 2: All receivers will reproduce the entire line.

"E" Direction, Value 3: 85% of receivers will reproduce all the line; 13% of receivers will cut off 5 percentiles more; and 2% will cut off 10 percentiles more.

To construct a commercially useful Safe Area design requires some adjustment of the results given above. It seems doubtful, for instance, that the narrower response to the lower diagonals shown in Fig. 2, as against the upper diagonals of that figure, is anything more than an accident. When the lower diagonal numbers are increased to equal the upper value of 3, a symmetrical mask area is obtained. Also, the receiver distribution charts show that if fractional number responses had been requested, the higher values for lines D and F would be fairly well founded. The resulting Safe Area is shown in Fig. 1.

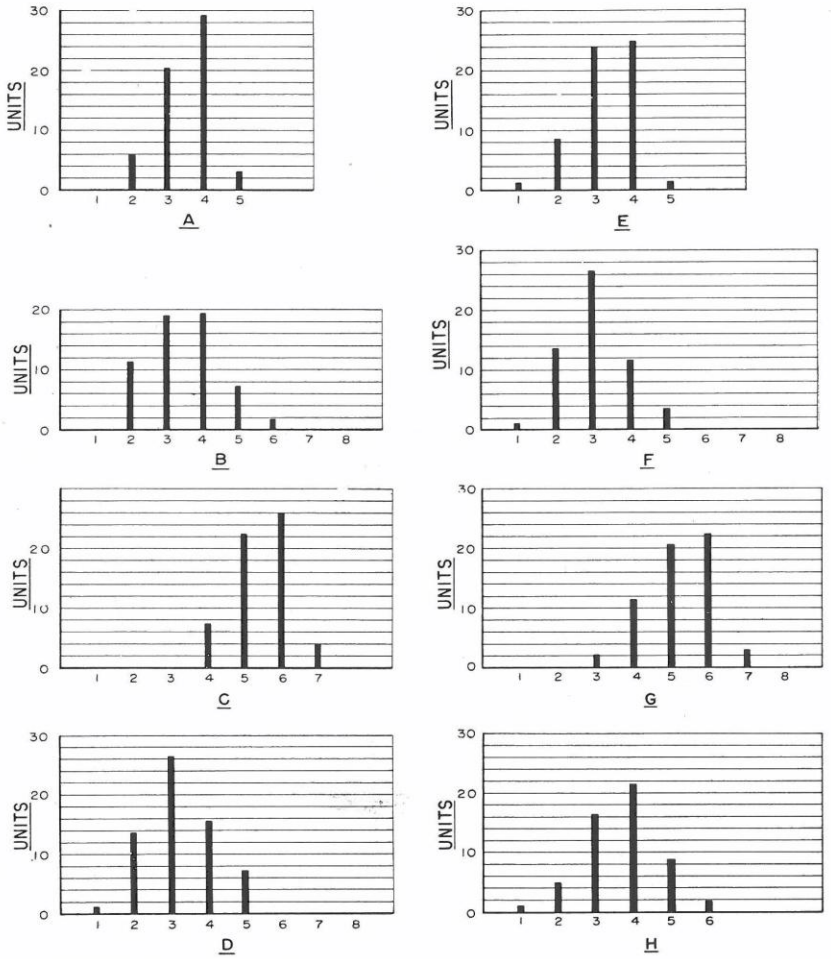

Fig. 3. Compilation of viewer replies.