

FREE TV AUSTRALIA OPERATIONAL PRACTICE OP-73

QUALITY SPECIFICATIONS FOR THE INTERNATIONAL AND NATIONAL EXCHANGE OF PROGRAMMES IN UHDTV FORMAT

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1. SCOPE

This document recommends the format and quality of the video and audio associated with ultra-high definition (UHDTV) formats for television programme material delivered to the Australian terrestrial television broadcast industry in ultra-high definition (UHDTV) format. Australian television broadcasters would perform the down conversion from UHDTV to HDTV if required for transmission. This document deals with the UHD-1 specification (3840 horizontal pixels x 2160 active lines), Standard and High Dynamic Range picture characteristics.

2. BACKGROUND

- 2.1 Australian terrestrial television broadcast have received programme material in SDTV and HDTV formats as specified in Free TV OP30 for many decades.
- 2.2 Programme content delivered in UHDTV formats is subject to a conversion process to a HD resolution level prior to commencement of UHDTV transmissions. In order to achieve optimum colour gamut and image quality in a conversion from UHDTV to HDTV, it is essential that the luminance and chrominance values are transferred accurately in accordance with the parameter values of Recommendations ITU-R BT.2020 and BT.709 for hue, lightness and chroma mapping.
- 2.3 UHDTV program content will be in the 25 / 50 progressive picture formats. Interlace picture formats are not acceptable.
- 2.4 It is necessary in the conversion to avoid any subjectively disturbing temporal artefacts, from both film and video originated program material.
- 2.5 UHDTV program material will be subject to MPEG, specifically High Efficiency Coding video compression at high compression ratios, as found in ISO / IEC 15444 aka ITU-T H.265. This places a significant demand on the quality of the program content with respect to video signal to noise ratio, image stability and freedom from artefacts which may waste data in the MPEG coding process.
- 2.6 Delivery of HDTV content in a High Dynamic Range image format should comply with the specifications for Hybrid Log Gamma found in Recommendation ITU-R BT.2100 *Image parameter values for high dynamic range television for use in production and international programme exchange*.
- 2.7 Down conversion from a UHDTV HDR image format found in Recommendation ITU-R BT.2100 to the HD image format ¹ Recommendation BT. 709-5 should be undertaken in accordance with ITU-R Report ITU-R BT.2446 *Methods for conversion of high dynamic range content to standard dynamic range content and vice-versa*.
- 2.8 Reference to UHDTV image formats should be undertaken in accordance

¹ Recommendation ITU-R BT.2100 specifies progressive image formats.

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with Recommendation ITU-R BT.2020 *Parameter values for ultra-high definition television systems for production and international programme exchange.*

- 2.7 Due to the continually advancing state of television technology, this documentation will evolve and will be added to and modified as required in the future.

3. ABBREVIATIONS

4k	4 096 pixels x 2 160 lines
HDR	High Dynamic Range
HFR	High frame rate
SDR	Standard dynamic range
UHD	Ultra high definition
UHD-1	3 840 pixels x 2 160 lines
WCG	Wide Colour Gamut

4. DEFINITIONS

4.1 Ultra High Definition Video

4.1.1 Ultra High Definition is a signal produced in accordance with the specifications of ITU-R Recommendation BT. 2020².

4.1.2 The Aspect Ratio of the image shall be 16:9.

4.1.3 The preferred video format for the exchange of programme material is:

UHD-1	3840 horizontal pixels
	2160 active lines
	25 or 50 frames per second
	25 / 50 progressive
	4:2:2 Asymmetric Chroma Resolution or
	4:2:0 Symmetrical Chroma Resolution

4.2. UHD Associated Audio

4.2.1 The associated audio signal should be 16 discrete PCM audio channels comprising *four* audio programmes, stereo & 5.1 Surround, plus the M+E versions of both. The 16 discrete channels representing – Stereo Full Mix / Stereo M+E / 5.1 Full Mix / 5.1 M+E (if available)³.

4.2.2 These audio signals shall be carried on the video storage medium as

² The companion signal interface document is being developed in ITU-R in a Preliminary draft new Recommendation ITU-R BT.2077 - Real-time serial digital interfaces for UHDTV signals

³ In an audio channel / 5.1 track order as specified in SMPTE 320M

discrete PCM channels, and clearly identified.

- 4.2.3 Bit depth should be 24bit.
- 4.2.4 Audio format should be AES3.
- 4.2.5 Audio sampling rate should be 48kHz
- 4.2.6 If a 5.1 surround audio mix is not available, then the preferred minimum audio requirement should be a stereo full mix, plus stereo M+E, optionally encoded with Dolby Surround (Pro Logic II), with the centre and surround information encoded into the Lt and Rt signals. Regular stereo (Lo and Ro) is also acceptable. The remaining audio channels shall be present but remain silent.

5. DELIVERY

While UHDTV production and post production may be applied for program origination Australian television broadcasters prefer to have the UHDTV standard dynamic range (BT.2020) and high dynamic range UHDTV and HDTV (BT.2100) content down converted to HDTV (BT.709) standard dynamic range content.

5.1 High Definition

- 5.1.1 For Ultra High Definition and High Dynamic Range programme content the program shall be supplied in 25p or 50p frame rate. The delivery system is to be mutually agreed upon between the program distributor and the television network.

5.2 Common Delivery Specifications

- 5.2.1 The audio content of the programme shall be a final mix in the English language and in correct synchronisation with the video content. However, if required by a broadcaster an alternative language may be supplied.
- 5.2.2 The supplied programme shall be free of extraneous material, such as closed caption and censorship classification indicators.
- 5.2.3 Alternatively, if textless material is supplied at the end of a programme, it shall start at 1 minute from the end of the programme and be identified on the programme identification board at the head of the programme.

6. VIDEO REQUIREMENTS

6.1 Common Video Requirements

- 6.1.1 The recorded image when displayed with the correct geometry has an aspect ratio of 16:9. Refer Annex A.

Distortion of the geometry of the original picture aspect ratio is not acceptable.

When the programme has been derived from an original of aspect ratio wider than 16:9 then a letterbox of the image is permitted in order to reveal additional width. This letterbox shall not be deeper

than 21:9.

- 6.1.2 Archival material may be accepted with a 4:3 aspect ratio, but this must be pillar boxed (i.e. side matted) within the 16:9 frame.
- 6.1.3 All titles and essential information must fall into the safe areas defined in Annex A. Recommended text height for low frame supers (56 lines) is illustrated in Annex B
- 6.1.4 Broadcasters seek to have signals encoded in such a way that whatever the combination of luminance and chrominance components the signal shall not produce an R.G.B. coded gamut error when measured by an appropriate instrument.

Programme black level shall not extend below blanking level.
- 6.1.5 Australian terrestrial television broadcast currently prefer programme content delivered as HDTV Standard Dynamic Range i.e. colour gamut and gamma corresponding to HDTV parameter values found in Recommendation ITU-R BT.709-6.
- 6.1.6 Wide Colour Gamut for UHDTV in accordance with Recommendation ITU-R BT.2020.
- 6.1.7 High Dynamic Range for HDTV and UHDTV in accordance with Recommendation ITU-R BT.2100.
- 6.1.8 Frame rates of 100 fps or higher are not currently accepted. If a production has been shot at 100 fps, it needs to be converted to 50 fps prior to delivery, preferably using a high quality vector motion compensated frame rate converter, which will add the correct amount of simulated motion blur to the resulting 50p signal. Simply deleting every second frame from a 100 fps signal to obtain 50 fps will result in possible motion artefacts such as 'shuttering' of the image due to the smaller amount of time the camera shutter was open during original capture.
- 6.1.9 The agreed UHD-1 video delivery format shall have a bit depth of 10 bits.

6.2 Standards Conversion

- 6.2.1 Legacy 50Hz *native* interlaced content, either SD (576i) or HD (1080i), should be converted to 50p via a high quality motion compensated interlace to progressive converter, and then scaled to 2160/50p. This will help to 'fill in' the missing vertical picture information between the video fields.
- 6.2.2 Legacy 50Hz interlaced content, either SD (576i) or HD (1080i), which actually exists as 25 segmented frame (25PsF) can have the two interlaced fields simply weaved back together to effectively produce 25p, as each field is sourced from the same

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- point in time. This can then be scaled to 2160/25p or 2160/50p (with 2:2 cadence).
- 6.2.3 Native 24 frame material (& 23.976) should be speed changed to 25 frame before delivery. No repeated frames are allowed in the process of converting 24 frame to 25. No blended or interpolated frames are allowed. The simplest and best conversion method is 4% speed change.
- 6.2.4 Native 30p (& 29.97) material should be converted to 2160/25p (or 2160/50p with 2:2 cadence) via a high quality vector motion compensated standards converter prior to delivery.
- 6.2.5 Native 60p (& 59.94) material should be converted to 2160/50p via a high quality vector motion compensated standards converter prior to delivery.
- 6.2.6 If the 60p (59.94) material essentially contains an embedded 24fps programme via 3:2 pull-down, then that 24 frame product must be first extracted from the 60p master via 3:2 cadence detection & removal. Then the resulting 24fps programme can be speed changed to 25p in the normal required method.
- 6.2.7 Inherent motion blur as a result of low frame rate capture, like 23.976p, 25p or blurring as a rendered video effect, is not rejected. However, poor standards conversions which result in frame blending/interpolation and repeated frames will be rejected when detected by Australian commercial television broadcasters.
- 6.2.8 Australian TV networks currently transmit mostly in interlaced format whilst the monitoring often used in non-linear editing systems displays in progressive format.

Extra care needs to be taken to ensure that programmes delivered to Australian television broadcasters do not have artefacts or errors which may not have been evident in the progressive environment, but which are evident on the broadcast interlaced display.

As Australian television broadcasting transitions from interlace to progressive formats, It is essential that production, post production and standards conversion for picture content **MUST** be undertaken on interlace television picture monitors. Otherwise standards conversion artefacts or errors may not be detected on progressive displays.

- 6.2.9 Colour gamut conversion from Recommendation ITU-R BT.2020 to Recommendation ITU-R BT.709 should be in accordance with Report ITU-r BT.2407 *Colour gamut conversion from Recommendation ITU-R BT.2020 to Recommendation ITU-R BT.709*

6.2.10 Any HDTV to UHDTV conversion should recognize Recommendation ITU-R BT.2087 *Colour conversion from Recommendation ITU-R BT.709 to Recommendation ITU-R BT.2020*

7. SUBJECTIVE VIDEO QUALITY

7.1 Common Subjective Video Quality

- 7.1.1 Picture quality appreciation and production grading shall be made in a Review Room which meets SMPTE recommendations for that purpose including a D6500 illuminant monitor surround.
- 7.1.2 The picture black level shall appear to be subjectively correct with respect to content, free of any noticeable black crushing, compression or clipped dark areas.
- 7.1.3 Low key scenes shall have sufficient contrast and APL (average picture level) to appear acceptable under typical domestic viewing conditions.
- 7.1.4 Picture white areas where detail is required shall appear normal and free of noticeable highlight compression.
- 7.1.5 The transient (edge) response shall be crisp and clean - free of any noticeable horizontal or vertical pre-shoot, overshoot, ringing, smear/streak, echoes or telecine afterglow errors.
- 7.1.6 Moire and fixed pattern noise shall not be visible.
- 7.1.7 Any video noise shall be fine grained (i.e. high frequency) and not visible at normal viewing distances. However, the use of MPEG video data compression does require an image which is not only noise free but also free of artefacts such as film dirt or scratches or unwanted image movement.

Note: The excessive use of noise reduction will cause motion artefacts and a noticeable loss of resolution. The amount of noise reduction should only be sufficient to minimise noise.
- 7.1.8 The colour balance of the image shall be basically neutral when displayed on a monitor adjusted for 6500K.
- 7.1.9 Ultra high Definition images preferably shall be viewed on a correctly calibrated grade 1 display of at least 100cm diagonal and viewed at approximately 1.6 times picture height⁴ which complies to Recommendation ITU-R BT.2020. The light emitters of the calibrated display should be assessed in relation to the colorimetry specified in ITU-R Recommendation BT. 2020.
- 7.1.10 Assessment of HDR images are under consideration.

⁴ Refer Recommendation ITU-R BT.2022 *General viewing conditions for subjective assessment of quality of SDTV and HDTV television pictures on flat panel displays*

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8. AUDIO REQUIREMENTS

8.1 Audio soundtracks should consist of 16 discrete PCM audio channels comprising *four* audio programmes: stereo & 5.1 Surround, plus M+E versions of both. The 16 discrete channel layout is listed below. Any associated XML file shall also flag the presence of a 5.1 mix

8.2 The audio track layout shall be as follows:

Track 1	L _t	(Full Stereo Mix)
Track 2	R _t	(Full Stereo Mix)
Track 3	L _t M+E	(Stereo M+E)
Track 4	R _t M+E	(Stereo M+E)
Track 5	Left Front	(5.1 Full mix)
Track 6	Right Front	(5.1 Full mix)
Track 7	Centre	(5.1 Full mix)
Track 8	LFE ⁵	(5.1 Full mix)
Track 9	Left Surround	(5.1 Full mix)
Track 10	Right Surround	(5.1 Full mix)
Track 11	Left Front	(5.1 M+E mix)
Track 12	Right Front	(5.1 M+E mix)
Track 13	Centre	(5.1 M+E mix)
Track 14	LFE ⁵	(5.1 M+E mix)
Track 15	Left Surround	(5.1 M+E mix)
Track 16	Right Surround	(5.1 M+E mix)

8.3 Alternatively, a programme mix may be completed for “immersive” audio, with the ‘base layer’ in a 7.1 format with the following track assignments;

Track 1	L _t	(Full Stereo Mix)
Track 2	R _t	(Full Stereo Mix)
Track 3	L _t M+E	(Stereo M+E)
Track 4	R _t M+E	(Stereo M+E)
Track 5	Left Front	(7.1 Full mix)
Track 6	Right Front	(7.1 Full mix)

⁵ Note on LFE use/misuse: The LFE channel should be used as intended; as an occasional low frequency special effects channel only, and not simply for bass that is filtered off from the main channels.

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Track 7	Centre	(7.1 Full mix)
Track 8	LFE ⁵	(7.1 Full mix)
Track 9	Left Surround	(7.1 Full mix)
Track 10	Right Surround	(7.1 Full mix)
Track 11	Left Rear	(7.1 Full mix)
Track 12	Right Rear	(7.1 Full mix)
Track 13	(MOS)	
Track 14	(MOS)	
Track 15	(MOS)	
Track 16	(MOS)	

- 8.4 If a 5.1 surround audio mix is not available, then the minimum shall be a stereo full mix on channels 1 & 2, M+E on channels 3 & 4, with the remaining audio channels being silent. This minimum audio requirement should be a Dolby Surround (Pro Logic II) encoded stereo pair (Lt & Rt). The average dialog level on the L_t and R_t shall have a loudness measuring -24LKFS across the duration of the programme.
- 8.5 If the measured audio loudness equals -24 LKFS as per OP59, then the DialNorm parameter will normally also be set to -24 by the Broadcaster for telecast.

9. SUBJECTIVE AUDIO QUALITY

- 9.1 The overall quality shall be pleasing and free of any audible noise or spurious signals (e.g. hum, buzz, distortion, wow, flutter or excessive sibilance) when monitored in a noise free environment on an essentially flat wide-band speaker system.
- 9.2 The tonal balance, bass to mid range to treble shall be pleasing and natural.
- 9.3 Stereo and multichannel programme material shall have the correct spatial relationships between audio and picture content (such as left-right or front-rear).
- 9.4 Programme audio shall be in synchronisation with the picture content.
- 9.5 Any supplied 5.1 or 7.1 audio shall be mixed in such a way that it will create an acceptable downmix to 2.0 stereo L_t and R_t if required, using downmix parameters and scaled coefficients as specified in Clause 7.8.2 of Recommendation ITU-R BS.1196.

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10. SEQUENCE OF ALIGNMENT SIGNALS

10.1 Each programme or episode of a program shall have some form of identification, such as an associated XML file. Legibility of the identification is most important to Australian television broadcasters. This identification shall contain:

- Programme Title
- Episode
- Production Number
- Production House Name
- Date of Recording
- Audio Status incl. track assignment and content i.e. Mono, Lo/Ro, Lt/Rt, PCM 5.1 Audio on Tracks 5 through 10 or 7.1 on Tracks 5 to 12.
- Audio Status incl. track assignment and content i.e. Mono, Lo/Ro, Lt/Rt,
- Audio loudness level or Free TV Australia OP59 compliance (-24LKFS)
- Audio Meta-data values
- Aspect Ratio (16:9)
- Standards Conversion – type
- Closed Captions

11. CLOSED CAPTIONS – ULTRA HIGH DEFINITION

11.1 EBU Tech 3380 EBU TT-D Subtitling distribution format which currently can be mapped into ISO/IEC 14496-12 *Information technology - Coding of audio-visual objects - Part 12: ISO base media file format* is under consideration.

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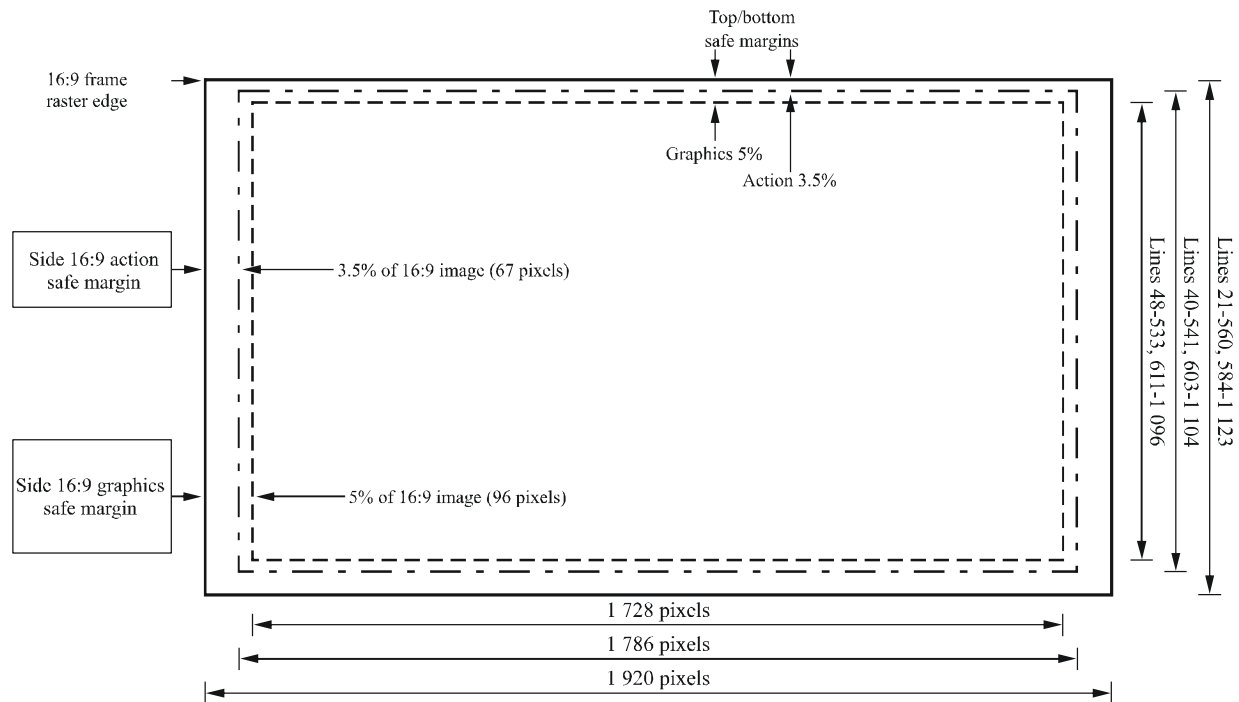
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Annex A

1. HDTV – SAFE ACTION AND SAFE GRAPHIC AREAS

- 1.1 The recommended HDTV 'Safe Action' and 'Safe Graphic' areas are defined by the following diagram.
- 1.2 Figure A.1 is the HD transmission situation, 16:9 Shoot to Protect 16:9, with a line length of 1920 pixels. The safe areas are calculated to this base.
- 1.3 The overscan of domestic displays is assumed to be 7% of overall picture width or height (i.e. 3.5% at each edge) but any one picture edge should not exceed 4% of total picture width or height.

FIGURE A.1
16:9 shoot-to-protect the 16:9 full image, 1 080-line interlaced scan



Annex B

1. RECOMMENDED TEXT SIZE (lower frame supers)

Considering that it is desirable that text be readable under normal display and viewing conditions and that additionally in certain circumstances there may be a legal requirement for the text to be readable.

The following is recommended:

For high definition images, the minimum height of the text lower case elements should be 28 pixels / lines in 1080 displayed lines on a professional monitor's raster.



Figure B.12 Minimum height for text in a High Definition Television Commercial

More information is available on the Free TV website at -

http://www.freetv.com.au/content_common/pg-engineering-guides.seo

Annex D

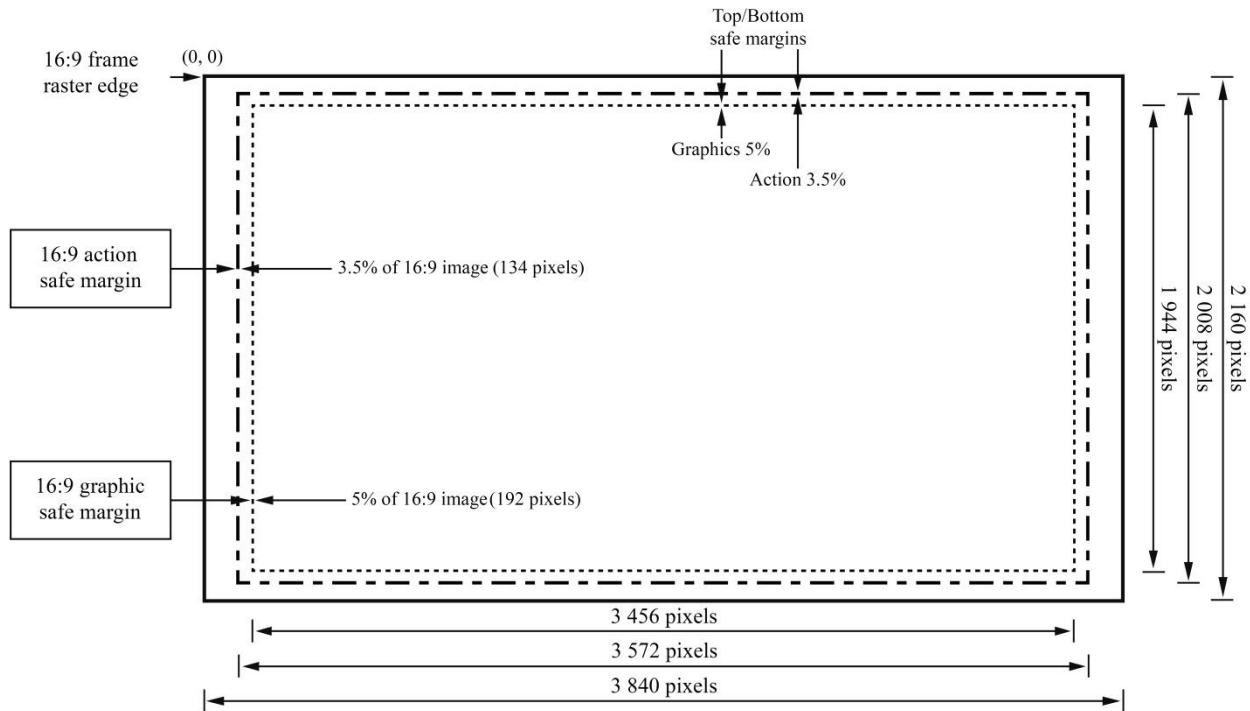
1. UHDTV – SAFE ACTION AND SAFE GRAPHIC AREAS

The recommended UHDTV 'Safe Action' and 'Safe Graphic' areas are defined by the following diagram in accordance with Recommendation ITU-R BT.1848 Safe areas of wide screen 16:9 aspect ratio digital productions.

- 1.2 Figure A.1 shows 16:9 "shoot and protect" limits for a UHD 16:9 picture with a displayed picture size of 3840 pixels horizontally by 2160 lines vertically. The safe areas are calculated to this base.
- 1.3 The overscan of displays is assumed to be up to 7% of overall picture width or height (i.e. 3.5% at each edge) but any one picture edge should not exceed 4% of total picture width or height.

FIGURE D.1

16:9 shoot-to-protect the 16:9 full image, 2 160-line progressive scan



Annex E.

1. Recommended Text Size (lower frame supers).

Considering that it is desirable that text be readable under normal display and viewing conditions. The following is recommended:

For ultra high definition images, the minimum height of the text lower case elements should be 56 pixels / lines in 2160 displayed lines on a professional monitor's raster.

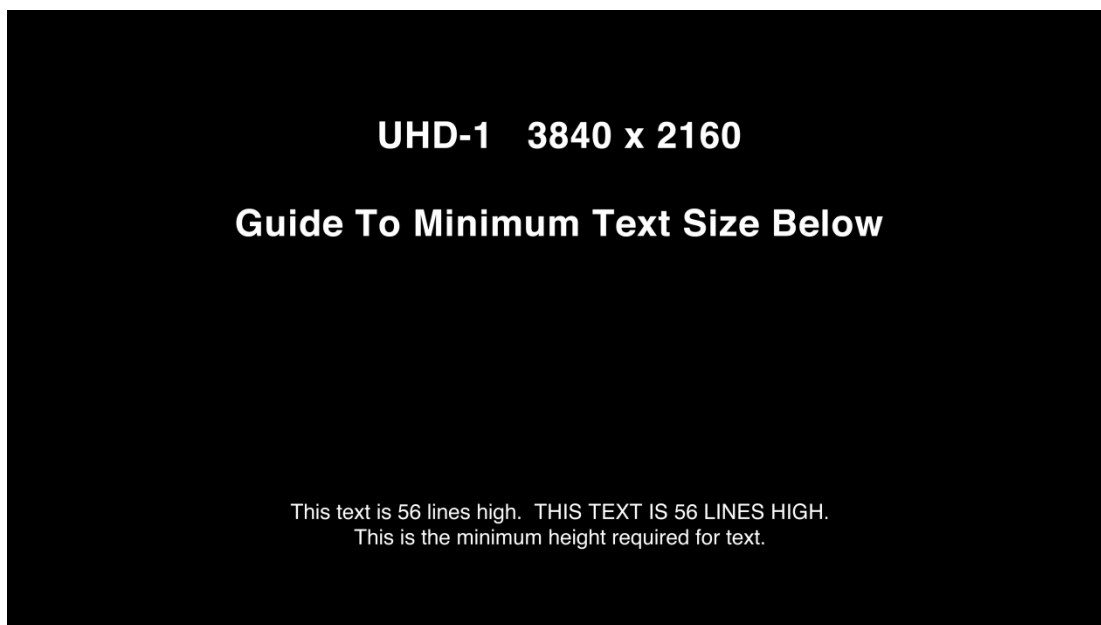


Figure E.1: Recommended height for text in a Ultra High Definition Television lower frame text

Annex F.

1. Audio Levels and Loudness.

This annex provides advice on the relationship of this OP and Free TV Australia OP59 Measurement and Management of Loudness in Soundtracks for Television Broadcasting which provides guidance on measurement of audio loudness as distinct from audio level. It sets out guidelines for measuring and matching the loudness of programmes, promotional spots and commercial advertisements that are presented contiguously in digital television broadcasting on Australian television services.

Material that has been compressed will sound louder, even though there is no increase in volume. This is because compression of a sound track raises the energy content of the sound by reducing the dynamic range (i.e. the difference between the loudest and softest levels of the sound) thereby making it more dense.

Many modern processors are not calibrated in dB, have constantly varying compression ratios and are likely to be multi-band devices which apply different amounts of compression in different frequency bands. This makes it difficult for sound track producers to accurately measure and quantify how much compression is applied to a soundtrack. However, prior to the final mix it is recommended that every effort should be made to ensure that the nature of any compression or equalisation used is such that the end result does not produce a sound track with a loudness characteristic which is incompatible with program material.

Broadcasters provide the following advice and recommendations for definition of a compression profile related to any processing applied AFTER the final mix.

In all cases the loudness of the final mix should be measured using a ITU-R BS-1770-4⁶ compliant loudness meter to ensure conformance to the -24LKFs loudness level.

If any further peak limiting were to be necessary, it would be provided automatically by the transmission processor.

It is undesirable and not creatively responsible to simply use aggressive compression on the final mix to reach -24LKFS compliance. A degree of dynamic contrast in the soundtrack is encouraged and professional mixing techniques should be employed to achieve -24LKFS compliance.

⁶Loudness measurements made on BS.1770-2 and BS.1770-4 meters are identical.

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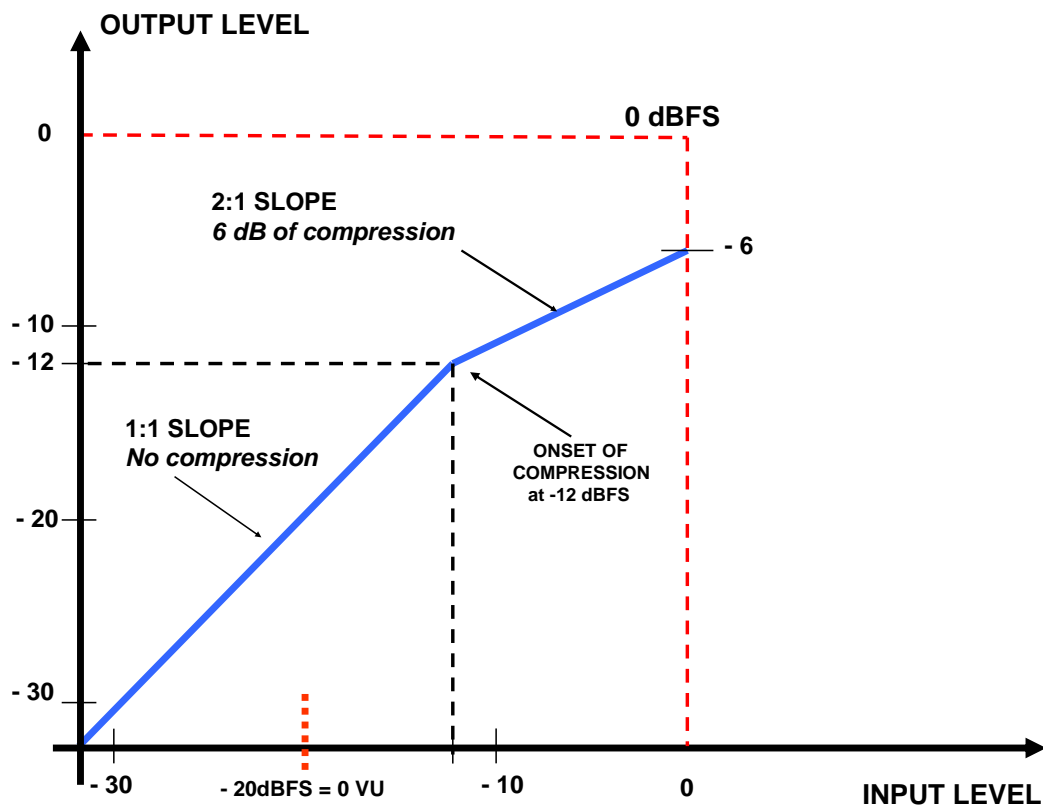


Figure 1