EBU

OPERATING EUROVISION AND EURORADIO

Tech 3374

EOTF CHART FOR HDR CALIBRATION AND MONITORING

Geneva
December 2020

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Acknowledgement

The EBU gratefully acknowledges Pierre Routhier, Media Production Architect in the Canadian Broadcasting Corporation (CBC), whose work provided the basis for this specification.

EOTF Chart for HDR Calibration and Monitoring

EBU Committee	*First Issued*	*Revised*	*Re-issued*
TC	December 2020		

Keywords: EOTF, HDR, Calibration, Monitoring.

1. Introduction

This electronic chart was designed to rapidly validate some of the most common issues encountered when setting up an HDR monitoring system, namely:

- Validating that the monitoring system (from the input port to the displayed light) covers the specified dynamic range.
- Having a single solution to visually check all transfer functions independent of which EOTF (e.g. HLG [1], PQ [2], SLog3 [3], etc…) and bit depth (8, 10, 12 or 16-bit per colour) are used.
- Validating that all EOTFs deliver the same white point on the system.
- Troubleshooting the monitoring system for setup errors (e.g. incorrect settings on an SDI to HDMI converter, incorrect monitor configuration, etc).

NOTE: This test chart is not intended to accurately measure a display's Dynamic Range. It is intended as a visual check that code values (CV) are output as intended. Please see § 3 for appropriate usage.

2. Chart Description

The chart (Figure 1) has a centred, active zone, showing the range equivalent to SDI nominal range and file-based full range according to EBU R 103 [4]. A larger version of the chart is provided at the end of the document (Figure 7) for clarity.

In its reference format, the chart measures 3840 x 2160 pixels, at 16-bit per colour, in uncompressed RGB tiff format. At each luminance level, R = G = B value. A 10-bit uncompressed YUV 4:2:2 video version is available as well.

To avoid monitor over-range issues noticed when using full frame charts, the upper and lower parts of the chart are left black (0,0,0) on purpose, except for text, which is set at 50% of the code value range to avoid distraction and screen burn-in. The active zone in the middle is therefore 720 pixels high.

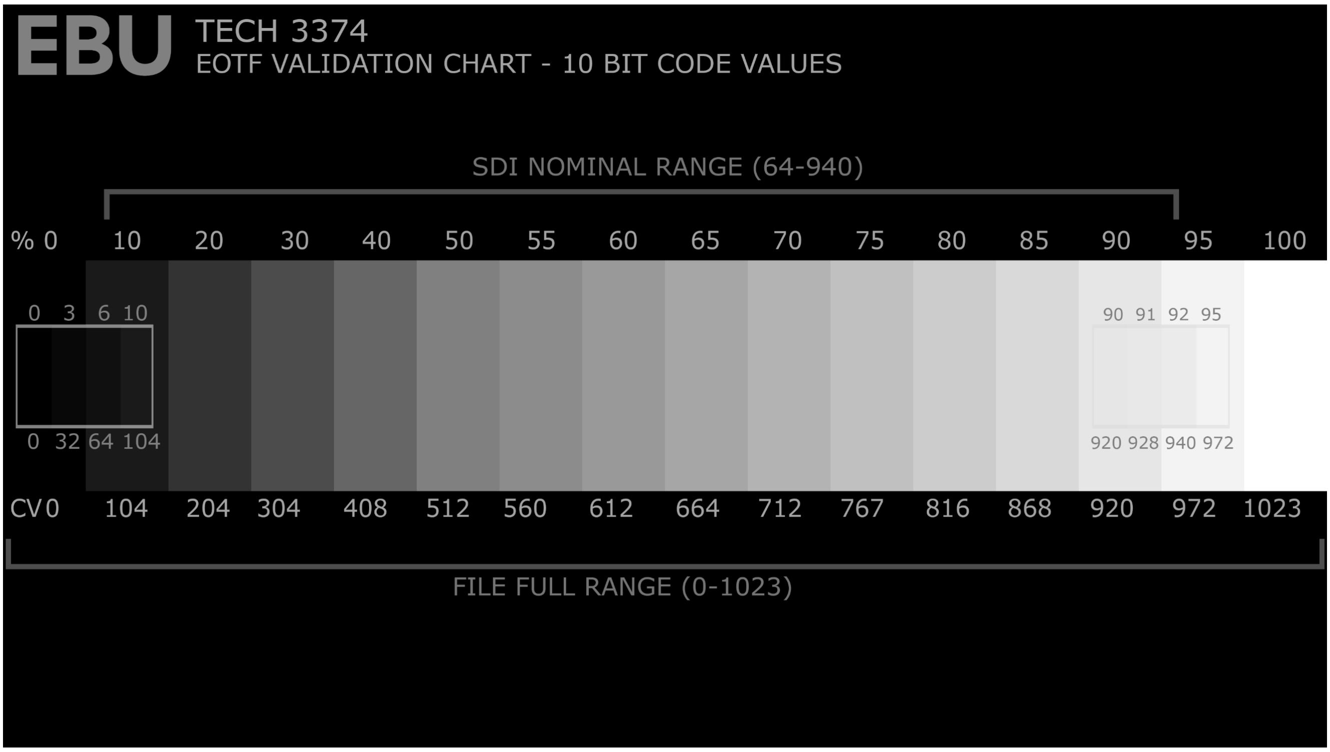

Figure 1: EOTF Calibration Chart

Non-linear EOTFs follow fully or partially logarithmic curves (output luminance versus code values) with slopes that increase significantly beyond 50% of the code range (HLG, PQ, etc...). Therefore, to plot the monitor EOTF close to the way the curves are designed, the chart is split into 10% increments of code values from 0 to 50%, then 5% increments from 50 to 100, enabling the detection of EOTF errors when measuring light levels for each column (Figure 2) while keeping the columns on the chart large enough for physical measurement if desired. Two boxes with more granular code value increments are provided on each side of the image, for validating that the displayed image is nominal or full range.

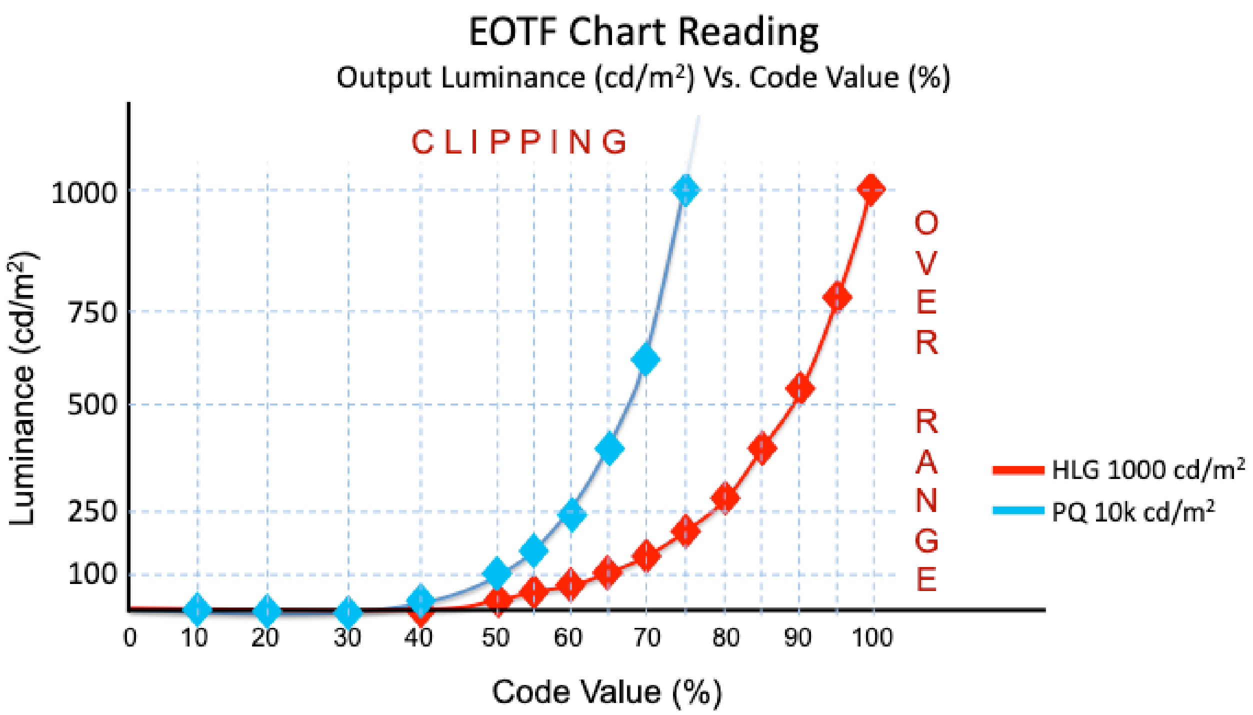

Figure 2: Plotting points (diamonds) relative to EOTF (curves) for a 1000 cd/m² monitor

From left to right, the middle section of the chart (Figure 1) is split into 16 columns, each measuring 240 pixels wide by 720 pixels high.

Below each column, its code value is indicated. Above each column, the relative code value (0 to 100%) is indicated. Figure 1 shows the code values for a 10-bit chart.

3. Chart Applications and Operating Procedures

Here are covered the applications for which the chart was designed and a brief procedure on how to use it for each case.

3.1 Quick EOTF Check

To visually validate the EOTF of a viewing system, the chart is sent from the source input through to the monitoring device. The image path may take several forms, from direct HDMI, SDI to HDMI conversion, HDMI to SDI conversion, etc. (Figure 3).[1]

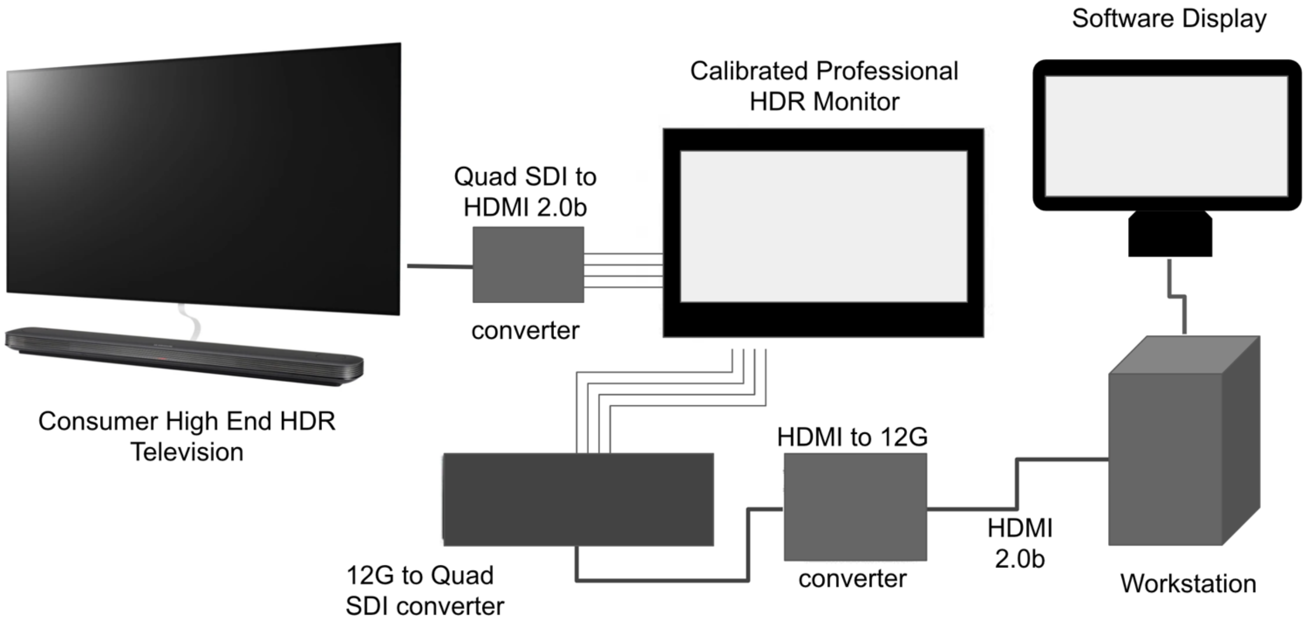

Figure 3: Example of a complex viewing system (manufacturers and models vary)

If there is no dynamic range compression through the system, each of the chart's columns will display a clearly different luminance level from the one preceding and/or following it (Figure 1), which will match the theoretical curve when measured.

If there is dynamic range clipping in the highlights, columns will show the same luminance level beyond a certain level. For example, if a monitor is set for a SMPTE 2084 EOTF but has a maximum luminance level of 1000 cd/m² (which in SMPTE 2084 corresponds to approx. 75% CV), the columns on the screen should be identical (and should be at the screen's maximum luminance of 1000 cd/m²) between 75 and 100 % (Figure 4).

[1] Note: Users should be aware that 10-bit code values below 4 and above 1019 in SDI are used for signalling and thus will not be visible (see EBU R 103).

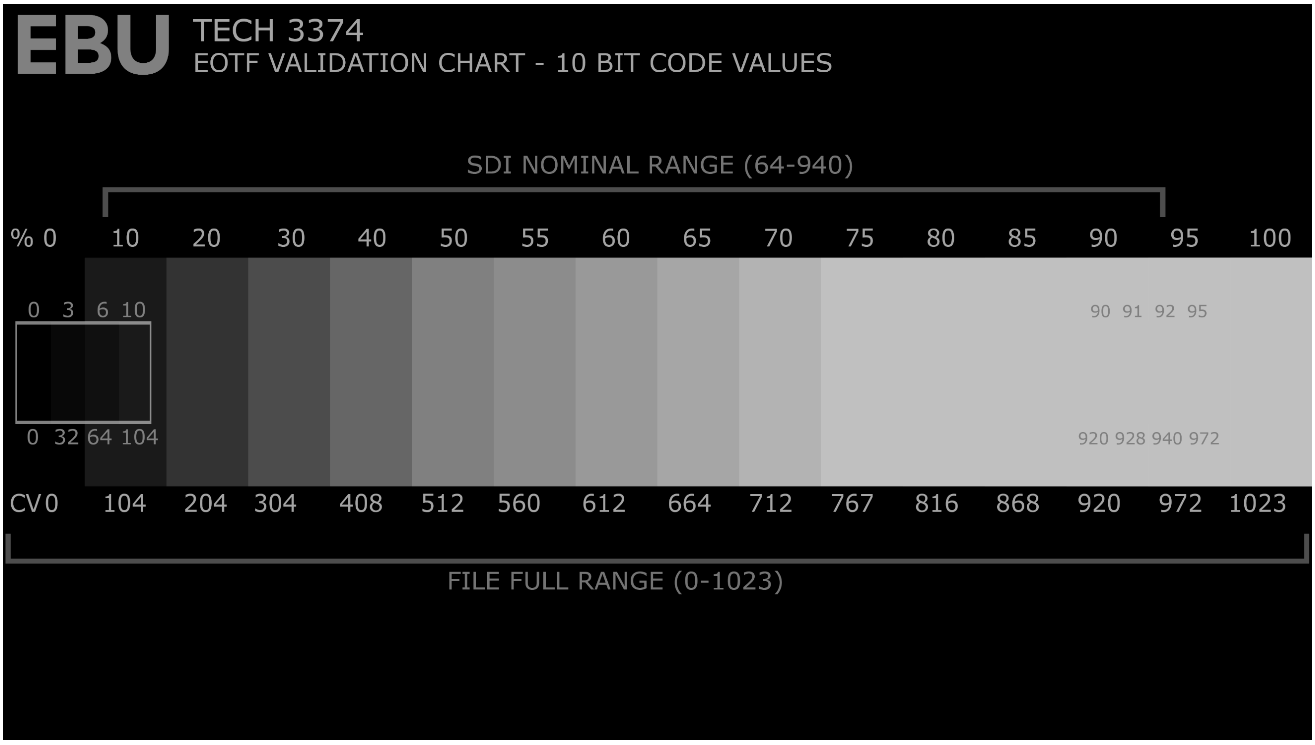

Figure 4: Example of highlight compression (true SMPTE 2084 on a 1000 cd/m² monitor)

If there is dynamic range clipping due to code value conversion errors, then two or more columns on the left and/or right-hand sides of the chart may show identical luminance values.

This can happen when the signal is processed by components that reduce bit depth in a non-linear fashion or limit range, for example (Figure 5).

Figure 5: Example of compressed dynamic range in low-lights and high-lights

3.2 Monitor Tone Mapping (not adhering to standards)

Another issue the chart helps detect is the case where range-limited monitors tone-map the input (i.e. re-plot tones to avoid clipping, given the monitor's brightness limitations). A good example is a 320 cd/m^2 peak brightness monitor set in SMPTE 2084. Following the standard, any code value beyond 60% should be clipped at 320 cd/m^2 on the screen. However, some monitors will remap the SMPTE 2084 code values to avoid clipping. The effect is a non-conforming image, which does not meet the creative intent. In this case, depending on the mapping setting, some, or all zones beyond 60% will be visible on the screen.

3.3 White point variation between different EOTFs

For this application, the chart is sent uncompressed from the source input through to the monitoring device.

On a professional HDR monitor, the operator toggles between different EOTF modes. Alternatively, if the device is a consumer-grade display, the operator can use a third-party converter to force the output signal to be recognized by the display for a specific EOTF through the HDMI port.

Independent of the selected EOTF, the white point should remain identical. However, in some instances, it has been noticed that some consumer-grade devices manage colour differently in different modes and consequently display different white points for different EOTFs (Figure 6).

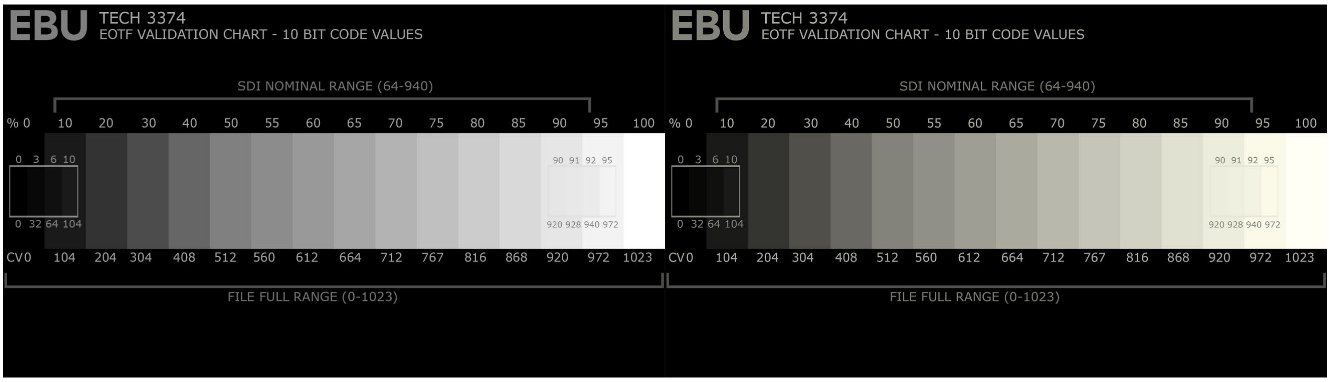

Figure 6: Example (exaggerated for illustrative purposes) of hue shift between different EOTFs

4. Bibliography

[1] HLG (Hybrid Log Gamma) ITU-R Recommendation BT.2100 '*Image parameter values for high dynamic range television for use in production and international programme exchange*' https://www.itu.int/rec/R-REC-BT.2100

[2] PQ (Perceptual Quantizer) SMPTE ST :2014 '*High Dynamic Range Electro-Optical Transfer Function of Mastering Reference Displays*'. Also specified in ITU-R BT.2100 (see above).

[3] SLog3 '*What is S-Log?*' - A Sony Help Guide For Creators https://helpguide.sony.net/di/pp/v1/en/contents/TP0000909108.html

[4] EBU R 103 '*Video Signal Tolerance in Digital Television Systems*' https://tech.ebu.ch/publications/r103

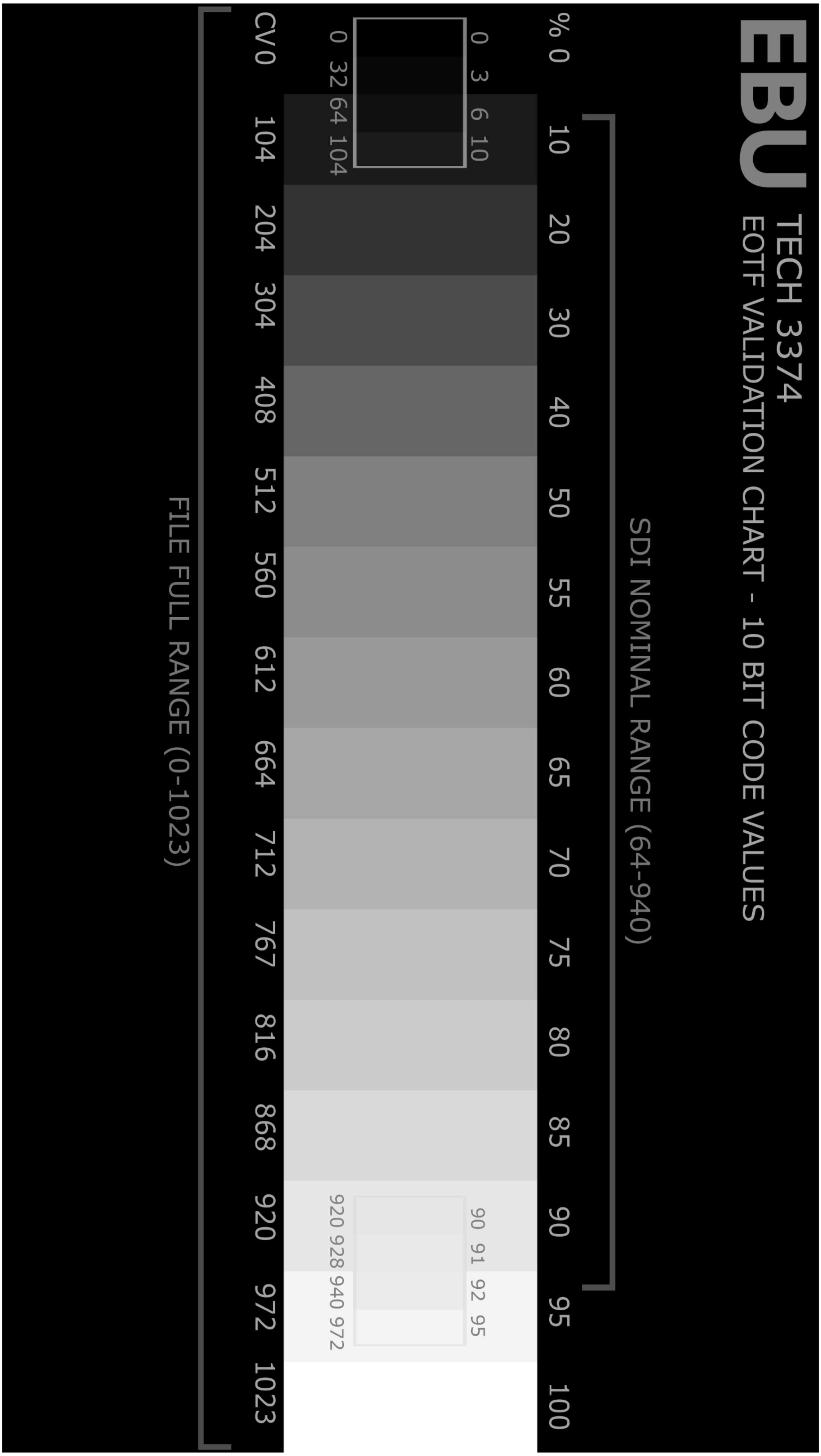

Figure 7: EOTF Chart for HDR Calibration and Monitoring