1. SCOPE

This Operational Practice is recommended by Free TV Australia and refers to the 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. It is intended as an aid to avoiding the excessive loudness contrasts that can be annoying to consumers. The importance of matching and managing the loudness of soundtracks for television broadcasting is outlined in Appendix 3.

This document should be considered in conjunction with Free TV Australia's OP-48 *Audio Levels and Loudness*. Notwithstanding the guidelines in that OP, this document provides an extra perspective of loudness metering that can now be employed as an adjunct to the audio measuring regime in all stages of the production and broadcasting process. This OP is intended to supplement the sound engineer's ability to consistently measure and match loudness to a reference value where traditional level measurements with VU meters and PPMs have required extraordinary and subjective interpretation because segments that are ostensibly equal in electrical level can be different in perceived loudness.

2. MEASURING LOUDNESS AS WELL AS AUDIO LEVEL

The question that arises for many in the field of soundtrack production is "what is wrong with the VU meter and the PPM meter that you are familiar with, and which have been in service for many many years?"

The VU and PPM meters were both developed some 70 years ago. Simply put, these meters do not measure loudness. Today, more accurate measurement of audience perception of loudness can be achieved with an audio control regime based on loudness measurement and true peak level measurement.

Loudness is a human perception that can be difficult to quantify and thus to measure. The International Telecommunications Union (ITU) utilised very extensive human testing to devise an algorithm[1] which provides a good approximation to human loudness perception of programme audio i.e. television and radio audio. It is important to note this algorithm does not measure an acoustic signal but rather the electrical signal[2] as do VU meters and PPMs.

As a result of this development the broadcast and production industries have the ability to control the loudness of audio material by using loudness measurement techniques to supplement level measurements.

Meters conforming to the Recommendation ITU-R BS.1770 "Algorithms to measure audio programme loudness and true-peak audio level" indicate a unit-value for the loudness summed over an appropriate interval of time. This method provides a good facsimile of the processes involved in the human perception of loudness that cannot be directly reproduced by VU meters or PPMs.

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[1] Recommendation ITU-R BS.1770 "Algorithms to measure audio programme loudness and true-peak audio level"

[2] The algorithm in BS.1770 is defined in the digital domain but it can be applied with equal validity in the analogue domain.

Recommendation ITU-R BS.1770 has a companion Recommendation ITU-R BS.1771 "Requirements for loudness and true-peak indicating meters" giving operational, display and control requirements. The loudness instrument that has been specified in this Recommendation was conceived to be as simple and inexpensive as possible,. The configuration of loudness meters is outlined in Appendix 1.

While loudness is the main concern of the audience, broadcasters also need to know about headroom, so along with the loudness algorithm, a true peak algorithm was defined in BS.1770. Although the level meter may still be useful for preserving headroom in some broadcasting systems, only a true peak indicating meter is capable of representing the excursion of the wide dynamic range signals that occur in digital audio systems.

Loudness and level are two different things. If two different audio segments are aligned to equivalent loudness, their level measurements may not be equal. That may, at first be confusing for those who have been trained in VU or PPM meter operation.

The loudness meter compliant with BS.1770 is a long term integrating meter developed for measuring the finished product e.g. a 30 second commercial or a 90 minute movie. It is NOT a production tool to be used for mixing. Its purpose is to *normalise* the finished soundtrack to a standard loudness value and to that end such meters will be found in Post/Mastering, Distribution and Broadcasting. The architecture and workflow of each production or operation will be different and normalisation may occur at different points, including the "Ingest" or quality control point of a broadcast plant. As noted above, the BS.1770-compliant meter is not a production tool to be used for mixing. Production techniques will remain as present with VU/PPM or equivalent meters, using standard levelling techniques. The production process can now be completed by *normalising* the soundtrack using the BS.1770 loudness measuring method.

It is important for production sound engineers to realise that loudness normalisation does not in any way affect the nature or balance of the created mix; unlike existing transmission processing which will nearly always compromises the mix by the use of compression and / or equalisation. In a *loudness* controlled world this transmission processing can become largely redundant and the dynamic range of the soundtrack is not compromised.

3. LOUDNESS REFERENCE LEVEL

Loudness normalisation begs the question – *to what loudness target?* This has now been answered by the ITU. For the purpose of loudness measurement we are measuring the electrical (data) signal of the soundtrack in question. We are not concerned with acoustic levels. The answer to the question is, *-24LKFS*[3]. In other words the BS.1770 Loudness meter brings with it a new scale and measuring unit, the LKFS:

"L" for loudness,
"K" indicating the unique filtering of the meter algorithm, and
"FS" for full scale (digital).

[3] Refer ITU-R BS.1864 Operational practices for loudness in the international exchange of digital television programmes.

If a signal does not measure -24LKFS, the adopted *target loudness*, then correction (normalisation) to match that value is very simple.

EXAMPLE A: if a soundtrack measures -28LKFS, this means it is "softer" (further down the scale) than the target. This is simply corrected (normalised) by applying a 4dB gain increase – the steps between LKFS units are equal to 1dB intervals.

EXAMPLE B: if a soundtrack measures -18LKFS, this means it is "louder" (further up the scale) than the -24LKFS target. This is corrected (normalised) by applying 6dB of attenuation (gain reduction). Remember that the BS.1770 compliant meter is indicating differences in perceived loudness. It is not indicating differences in electrical levels in the same fashion as VU meters and PPMs.

Taking the above actions will bring both signals to the standardised ITU loudness level of -24LKFS. The loudness of each soundtrack will then match and the listener will be provided with more consistent loudness if the two segments are presented sequentially.

4. RECOMMENDATIONS

The following principles are recommended for effective management of loudness in digital broadcasting:

1. All loudness measurements should be made using a meter complying with Recommendation ITU-R BS.1770 and indicating its loudness measurement with a numerical readout.

2. That for the exchange of digital television programmes not employing metadata to indicate loudness level, then the target loudness level value should be -24LKFS.

3. That for the exchange of soundtracks on digital television programmes that employ metadata to indicate a loudness level, then that metadata value should correspond to the measured loudness value as per BS.1770[4]. This value should be used for the "Dialnorm" metadata word in an AC-3[5] transmission encoder .

4. In both the cases of (2) and (3) it is possible to measure the loudness value in two ways.

   [a] By measuring the dialogue component only.

   [b] By measuring the full mix i.e. all components of the mix.

   Both methods have their place in the production of digital soundtracks for television depending on the nature of the programme content.

[4] The audio coding schemes used by Australian television broadcasters are outlined in Appendix 2
[5] Also know as Dolby Digital.

With most TV programme soundtracks which tends to be dialogue centric, method [a] is satisfactory – the dialogue to be measured is defined as "normal dialogue" i.e. normal spoken dialogue, not shouting and not whispering.

With music soundtracks or soundtracks where music or other material may be more significant, then method [b] is desirable.

Note for multi-channel audio measurements, at this time the LFE track has not been included in the BS.1770 algorithm.

5. Dialogue-only measurement presents a problem in that the dialogue has to be separated for measurement. In the case of multi-channel soundtracks this is easy as the centre channel (dialogue channel) is available for measurement. In the case of mono and stereo soundtracks, separating the dialogue for measurement is only possible using either a specialised metering system with dialogue recognition, or by manually reading a short-term meter. When the loudness meter does not provide a reliable method to separate dialogue, a measurement of the full mix should be made.

   Due to the increased difficulty in isolating dialogue in short form soundtracks particularly where other soundtrack elements are high in level in the mix, It is recommended that **all** short form soundtracks such as commercials, promotions and similar shall use the measurement method of **full mix** measured over the total duration of the soundtrack.

6. In the case of long form soundtracks the measurement method shall be as best defined by the nature of the programme genre as in [4] above. Because of time constraints, it will usually be necessary to measure a sample of the soundtrack. It is **vital** that the sample be of sufficient duration and **representative** of the total soundtrack, otherwise a false reading will occur, leading to incorrect normalisation.

7. Loudness differences can occur between programmes, between programmes and commercials/promotions, and between services. Thus the basic problem is one of **relative** levels between the above and this mandates that broadcasters must normalise both programme content on one hand and commercial/promotion content on the other.

8. Very wide loudness range soundtracks provide an additional problem to meaningful loudness measurement. Fortunately these soundtracks are in a minority. Further work is being done to standardise a method of measuring "Loudness Range" and defining what may or may not be a problem with respect to range. Prior to the availability of loudness measurement these soundtracks required a degree of compression to reduce the loudness range to an acceptable level and to provide a soundtrack which can be more reasonably matched to normalised programme listening. (Further information can be found in the AES Convention Paper 7948 – October '09 – Loudness Descriptors To Characterize Wide Loudness Range Material)

9. In the process of measurement the loudness value should be noted as an LKFS value and whether the measurement is referenced to dialogue or full mix should be

indicated. This information should be recorded in the metadata stored with the programme (or, as a minimum, written on the soundtrack labelling).

10. BS.1770 also specifies a “True Peak” meter (previous Peak meter devices have largely been inaccurate). The display of this True Peak meter may be configured as a moving bar-graph, or, as simply as a warning light flashing when a preset level is reached. If such a meter is used, it is necessary to ensure that the True Peak level does not exceed -2dBFS i.e. that the material as measured does not go to 0dBFS.

11. File-based operations will become more common in the future. The system architecture and work flow will be different, but the necessary corrections and normalisation are the same as for existing digital (or analogue) systems. It is possible that purpose-designed file based devices will become available for this necessary processing.

APPENDIX 1

LOUDNESS METER CONFIGURATIONS

Some implementations of loudness meters may provide a moving bar-graph as an additional display to the numerical readout. The scale on this bar-graph will most probably be calibrated in "LU" units (Loudness Units) with respect to 0LU which is the target loudness value (-24LKFS). Thus the scale is read as so many LU units above or below 0LU. The step between LU units, as with the step between LKFS units is equal to 1dB on all channels.

APPENDIX 2

AUDIO CODING SCHEMES SPECIFIED IN AUSTRALIAN TELEVISION BROADCASTING

In Australia two quite different audio coding schemes for digital television services are applied.

- MPEG 1 Layer II (commonly just called MPEG).

This coding scheme codes two audio channels (Stereo). It is most commonly associated with the Standard Definition digital television service. From the point of view of this document, its important characteristic is that it does **NOT** have an inbuilt level control mechanism i.e. metadata.

- Dolby Digital, otherwise known as AC3.

This coding scheme codes from one to six audio channels – and is thus used for multi-channel 5·1 transmission. It is most commonly associated with the High Definition digital television service. Dolby Digital does incorporate an inbuilt level control mechanism using control information called "Metadata". This Metadata (control information) is inserted by the television broadcaster and travels with the soundtrack bit stream to the DTV receiver. This Metadata has many components, but the part we are concerned with, in the context of loudness, is the Metadata word "Dialnorm" (dialogue normalisation). This Dialnorm data word controls the gain (actually attenuation) of the audio signal in the Dolby Digital decoder in the DTV receiver. The decoder output is specified to be at a constant level (-31dBFS).

The "value" of this Dialnorm word which is inserted during the transmission process is in fact a variable which can have any value between 1 and 31.

For any given programme or soundtrack, the key to understanding the value of Dialnorm inserted at transmission is that it is the LKFS Loudness number measured for that programme or item with the BS.1770 meter.

When the Dolby Digital decoder in the DTV receiver reads the Dialnom value, it does some internal sums and applies the correct value of attenuation to the signal to give an output of -31LKFS. Thus it does this process for each programme or item – producing a constant -31LKFS loudness output, **but only if the original Dialnorm words have been correctly measured using the BS.1770 meter.**

If the Dialnorm words are not appropriate then the loudness output will not be consistent and the listening experience will be compromised.

Thus the key to successful soundtrack production is that every programme or soundtrack must be read by a BS.1770 meter, and that information the Dialnorm number, then be transmitted with that programme or soundtrack as part of its unique Metadata.

Australian television broadcasters encourage the accurate authoring of the Metadata supplied with programmes soundtracks i.e. the Dialnorm number being valid and not just set at the Dolby Digital default value. If this is not the case the broadcaster will find it necessary and wise to measure the Dialnorm value and make appropriate corrections.

APPENDIX 3

THE IMPORTANCE OF MATCHING LOUDNESS

As a result of the findings of an Australian government inquiry in 2001/2002[6], Australian free to air broadcasters have given an undertaking to the Australian Communications and Media Authority that they will manage the loudness of advertisements relative to adjacent programming, within the terms of the broadcasting industry's voluntary Code of Practice. This approach relies on co-operation between advertisers, producers and broadcasters. It differs from some other countries wherein regulations for loudness management are mandatory and there are penalties in place for broadcasters and advertisers who fail to comply with those regulations.

In Australia some basic loudness management techniques have been implemented in the form of Free TV Operational Practice OP 48[7] which advises producers to be conservative in their use of techniques such as compression, limiting and spectral manipulation (equalization) that can increase the perceived loudness of audio material.

It is well understood that television viewers are not happy or satisfied with a sequence of audio segments which vary in loudness, especially when there is excessive contrast between programme and commercial soundtracks. This is not a new issue and has been the subject of many complaints over the years. However, it is true that the advent of digital audio transmission with its possible wider loudness range has made the problem more difficult to manage.

This problem is worldwide, not just local, and as a result the International Telecommunications Union (ITU)[8] has been working on this problem for some years and has recently finalised the initial Recommendations that are necessary to create standardised worldwide loudness measurement and control. These are;

Recommendation ITU-R BS.1770 defines the measuring algorithm – the instrument or measuring tool, and also defines a means of measuring true peak levels.
Recommendation ITU-RBS.[LOUD] defines how to use the measuring instrument to achieve consistent loudness in the exchange of digital soundtracks accompanying television programs.

A number of administrations have now in place recommended practices with advice implementing the BS.1770 method to achieve consistent loudness in broadcasting operations e.g. ATSC *A/85 (2009) Techniques for Establishing and Maintaining Audio Loudness for Digital* is one such recommendation and has been referenced in this OP.

It should be noted that the ITU has also published Recommendation ITU-R BS.1771 which describes notional physical attributes for an instrument for measuring loudness. Although some current instruments may be labelled *BS.1771-Compliant*, the human-interface of

[6] Refer http://www.acma.gov.au/WEB/STANDARD/pc=PC_91342
[7] Refer http://www.freetv.com.au/Content_Common/pg-Engineering-Guides.seo
[8] Australia and Australian television broadcasters participate in the development of international standards in the ITU – refer http://www.itu.int/ITU-R/index.asp?category=study-groups&rlink=rsg6&lang=en.

current loudness meters is more sophisticated than that described in BS.1771, and a single number display (e.g. ***-24***) is now the preferred presentation for the loudness of the material being measured.