

## **How Loud is a Movie? – a New Measurement Procedure**

**By Ioan Allen**

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Leq(m10)2.0

## How Loud is a Movie? – a New Measurement Procedure

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### Abstract:

A procedure is introduced to measure the subjective loudness of an entire movie and to develop a suitable metric.  $Leq(m)$  has been used for over 15 years to measure and then control the level of trailers and commercials, both in the US and overseas. The method to be described takes a ten-minute rolling average of  $Leq(m)$  throughout an entire movie, and then integrates the values above a given threshold. The procedure is not intended to constrain the levels of movies, simply to come up with a metric to describe the subjective loudness. A suggested descriptive is  $Leq(m10)$ .

### History:

As the sound quality of 35mm film improved over the years, from Academy mono, through Dolby Stereo, Dolby SR, and the digital sound on 35 mm film formats, so did the peak level achievable on each channel of a soundtrack.

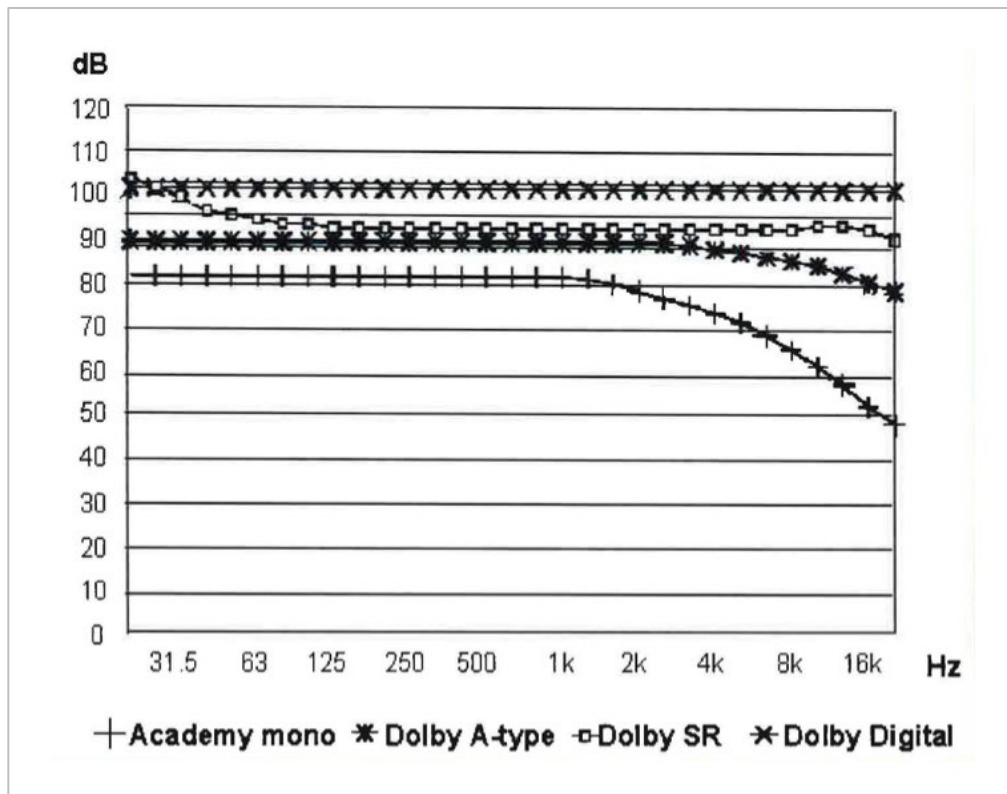


Figure 1. Peak Level Capability of Photographic Soundtrack Formats

And each development also increased the channel count, further raising the potential maximum sound pressure level in the cinema.

Now the movie business is unique in many ways! And one of these is the *potential* for control of image and sound quality throughout the chain from studio to exhibition. In contrast, the producer of a radio program or television show has no control whatsoever over the consumer's playback color adjustment, or the setting of the volume control. We used the word "potential" because the theatre operator can always over-ride the reference settings of sound and picture. A correctly aligned theatre playing a movie at fader 7 will reproduce the level heard by the director and mixer on the dubbing/mixing stage. Excessive use of the power capabilities of content technology, though, leads to many a theatre fader being lowered from reference 7 to 6, 5 or even  $4\frac{1}{2}$ , a reduction of as much as 10dB. Needless to say, such a lowering of level leads to severe dialog intelligibility problems.

Now, a film's director may have ultimate control of the film itself – but trailers are in part controlled by the studios' marketing department. Inevitably, the trailer designers feel that they are in competition with other trailers, and will pack every available highlight from the two-hour movie into the 90 second trailer. Naturally, the highlights more often than not will be the loudest elements.

Digital sound on 35 mm film was introduced in 1992 – and the loudness wars between trailers became so violent that there were many complaints from theatre owners and the general public, highlighted by trailers for films such as *Twister* (1996), *Star Wars* (1997 – re-release) and *Men in Black* (1997). As theatre chains employed fewer projectionists, and many cinemas were not equipped with automation control of fader settings, a lowered playback level of the trailers led to the same reduced level being applied to the feature. As a result, there were increased complaints of inaudible dialog levels on feature films – not surprising when the dialog levels had been lowered by as much as 10 dB below reference!

The studios realized that things were out of control, and a committee, later known as TASA, was formed by the (then) seven major studios to review the situation.

### **Leq(m):**

For years a process had been utilized to measure the average sound level of typically industrial noise over time, referred to as Leq. This averaging method commonly utilizes a "weighting" characteristic, which highlights certain frequencies depending on the application. See below, and Figure 2. Dolby Laboratories carried out some research work in 1996 to determine the ideal weighting characteristic for the measurement of trailers and commercials, both of which typically have a forceful upper mid-frequency dominance.

This led to their proposal for a measurement procedure called Leq(m), with "m" standing for "movies". (1)

## Hierarchy:

The intention of a loudness measurement system, not surprisingly, is to get a series of numbers which match the subjective loudness. In other words, if sample A is subjectively louder than sample B, and sample B louder than C, then the measurement system should also show that  $A > B > C$ . In this context, the scale  $A > B > C$  can be referred to as a “hierarchy.”

There are numerous weighting curves in use for different applications. Most common is probably A-weighting, typically used to measure the annoyance from industrial noise. It was found when evaluating a number of trailers and cinema specific commercials that the M-weighting curve, favoring the 2 kHz to 3 kHz regions, created a better “hierarchy” than C-weighting, A-weighting and no weighting at all. See Figure 2.

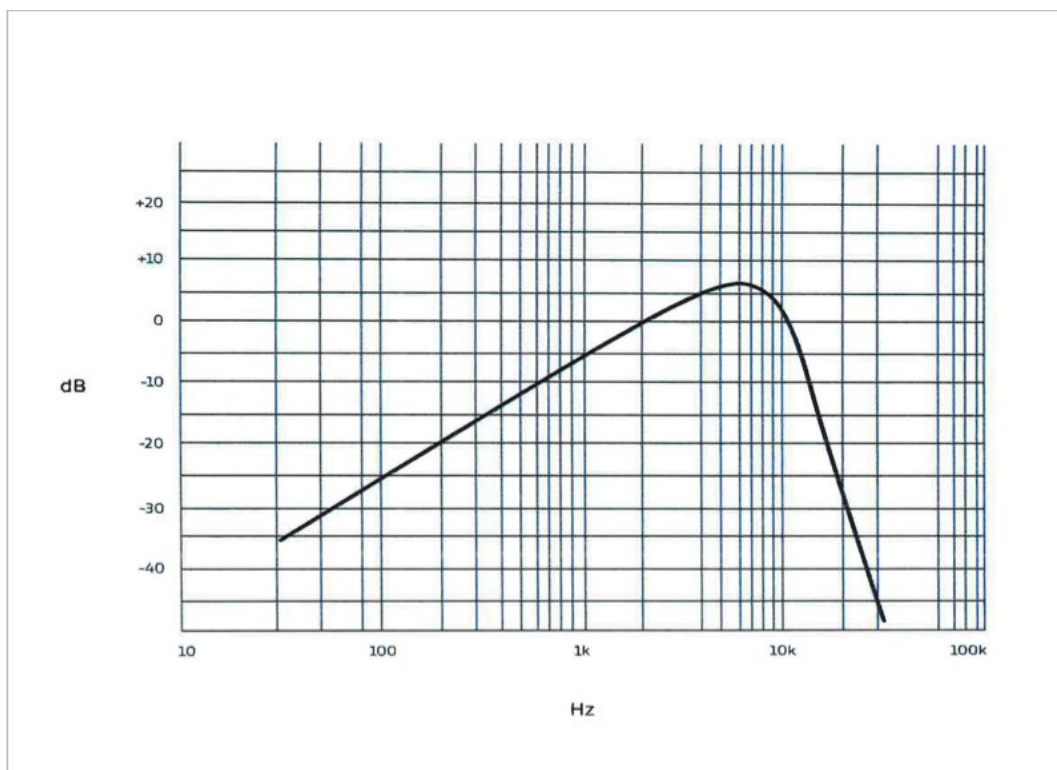


Figure 2: M-Weighting curve

## TASA:

TASA (the Trailer Audio Standards Association) had its first meeting in August 1997. The intention was to measure and control the level of trailers. The association adopted  $Leq(m)$  as the measurement procedure, and to formalize control procedure tied the TASA program with the ratings procedure of the MPAA. In June 1999 the MPAA administration formally began, and since that date no approval rating has been given to any trailer without TASA certification. An initial maximum level was 87 dB  $Leq(m)$ , and this was lowered in two steps to 85 dB  $Leq(m)$  in

2001, and remains there today for both film and digital cinema. Compare this with 1996 and 1997 when the loudest trailers measured 92 and 93 dB Leq(m). This means that the loudest trailers today are 8 dB quieter than before TASA was introduced. It also meant that the trailers better matched the level of the features.

Over 6000 trailers for US features have now (2015) passed through the TASA approval routine. The process has been adopted by several national standards bodies, and by the International Standards Organization. (2)

### **Potential legislation:**

“It’s the squeaky wheel that gets the oil.” Surveys and cinema exit polls suggest that most movie-goers are content with the volume levels of commercials, current trailers and the features. But the complaints that do arrive frequently get widely reported in the press – where the articles will rarely, if ever, point out that the movie-going experience is far quieter than the sustained loudness of a football game, or even a high-school basketball game.

From time-to-time politicians have reacted to these press articles by threatening legislation. But unfortunately some of the potential legislation has suggested constraining the peak level heard in the cinema. This would be wrong from two standpoints. First, it puts the onus on the theatre owner to check and control the levels – as mentioned previously, with a correctly aligned theatre, the levels are set by the film-maker. Secondly, control of peak levels could well constrain the artistic intent of the film-maker – a single gun-shot at peak level surprises, but 10 minutes of sustained machine-gun fire would prove extremely annoying!

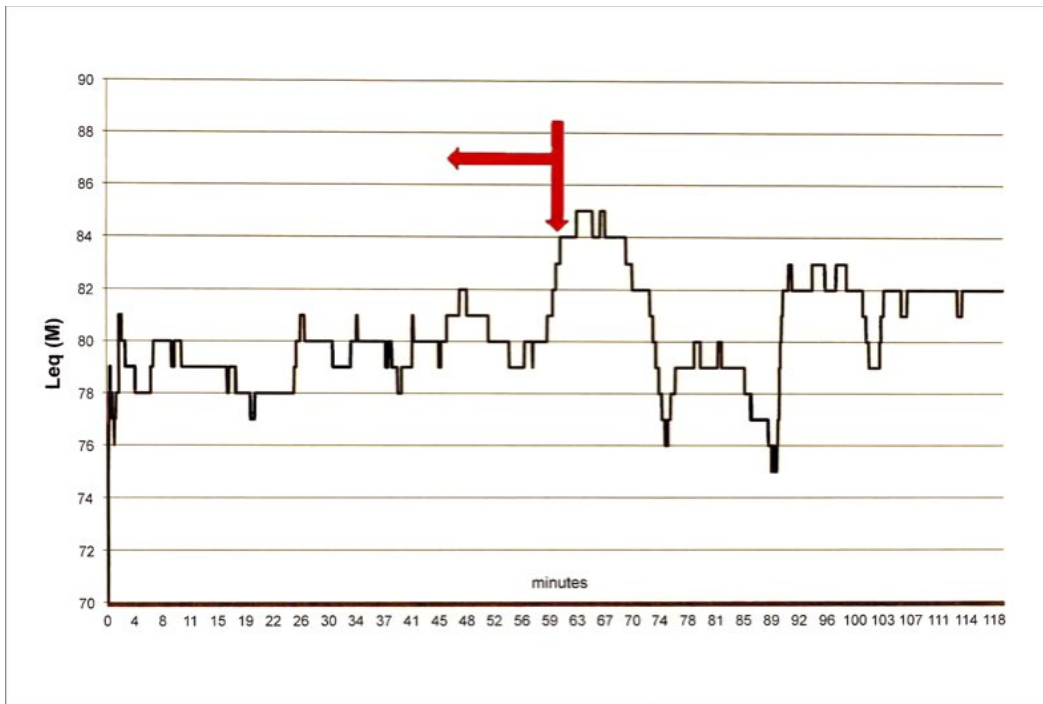
Luckily, at least in the US, no threatened legislation has so far been enacted.

### **What is the loudness of a feature film?**

The author is firmly against any constraint of levels of features films, believing that to be the domain of the film’s director and sound crew. If the film-makers are foolhardy enough to over-abuse the technology by piling up the loudness, that’s up to them.

But that said, there is one missing link – there is no established method of determining the subjective loudness of an entire feature film. It has been suggested that an Leq (long term average), such as Leq(m), could be used. This doesn’t work – think of a film having 6 twenty-minute reels. Imagine reels 1-5 being very quiet, but the whole of reel 6 being at 100% peak level. An Leq reading would come out quite low, but the audience would come out screaming at the end of reel 6. Twenty minutes at 100% is obviously too much sustained loudness.

So, at any one point in time, let’s consider the idea of measuring the Leq of the prior (let’s say) 10 minutes. (See Figure 3)



**Figure 3:** Not the current value, but an average of the previous ten minutes

This would be a useful starting tool – the Leq measurement would not be unduly influenced by a few sudden peaks, but would clearly show up prolonged use of 100% capability.

And because we’re trying to assess typical film program material here, applying the same M-weighting as is being used for the subjective measurement of trailers, this ten-minute average

would be weighted in the same way – let's call it  $Leq(m10)$ . Here are a few examples

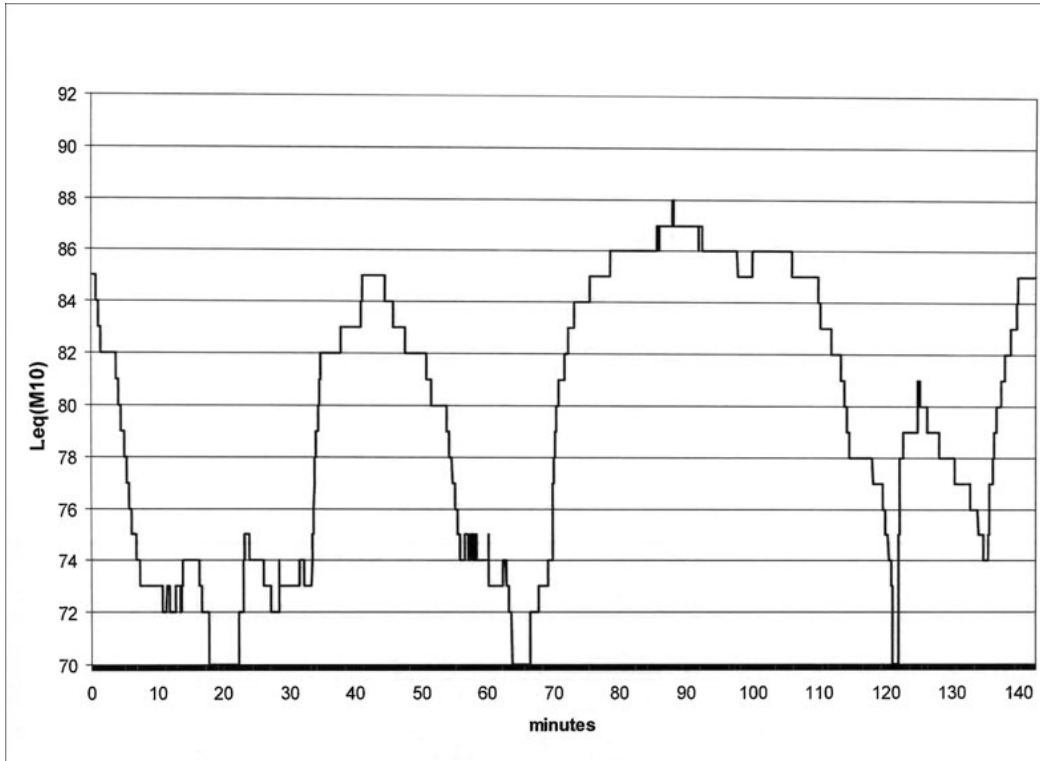


Figure 4: Star Wars Episode II

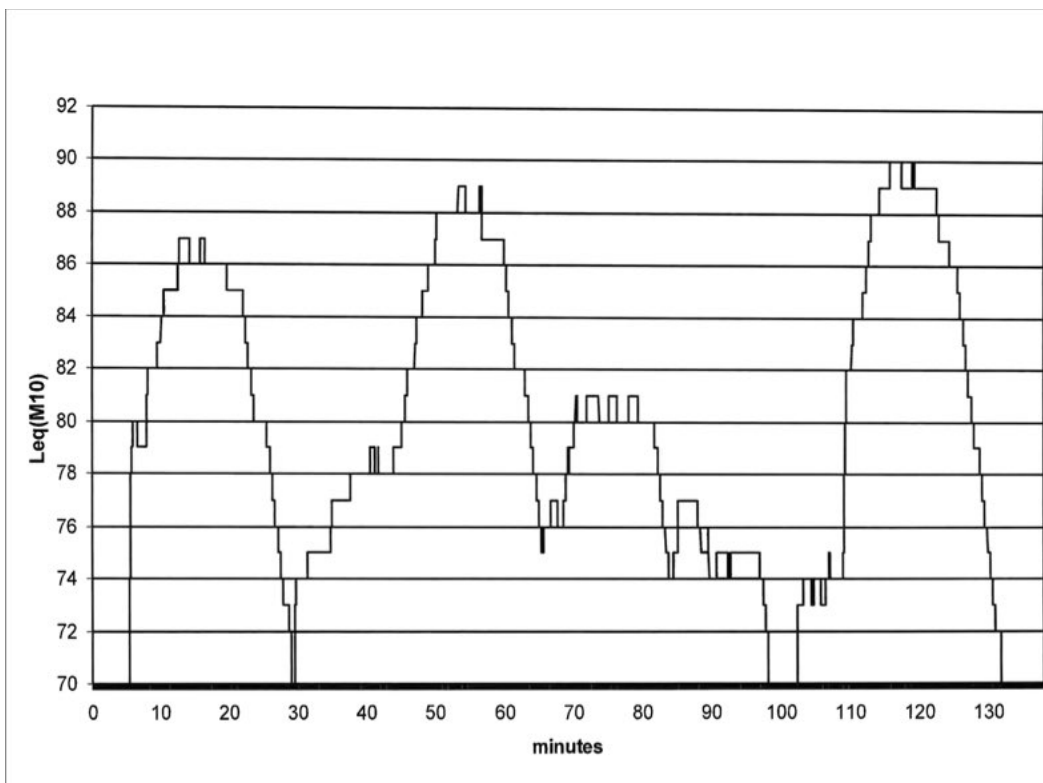


Figure 5: Master and Commander

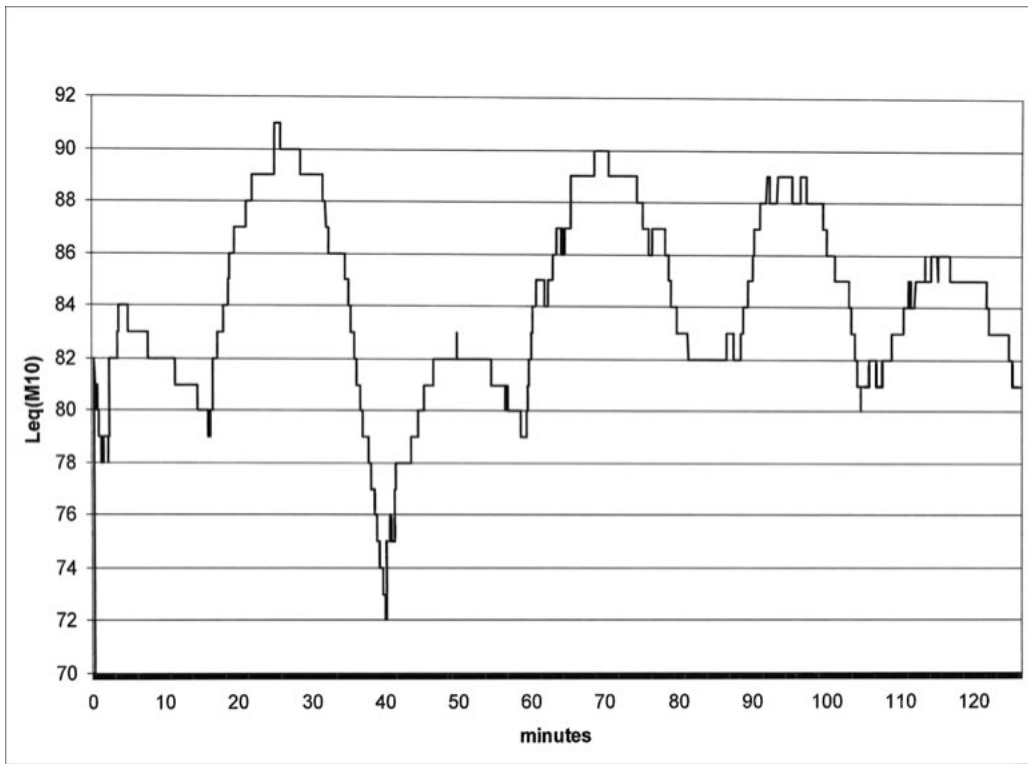


Figure 6: Mission Impossible 3

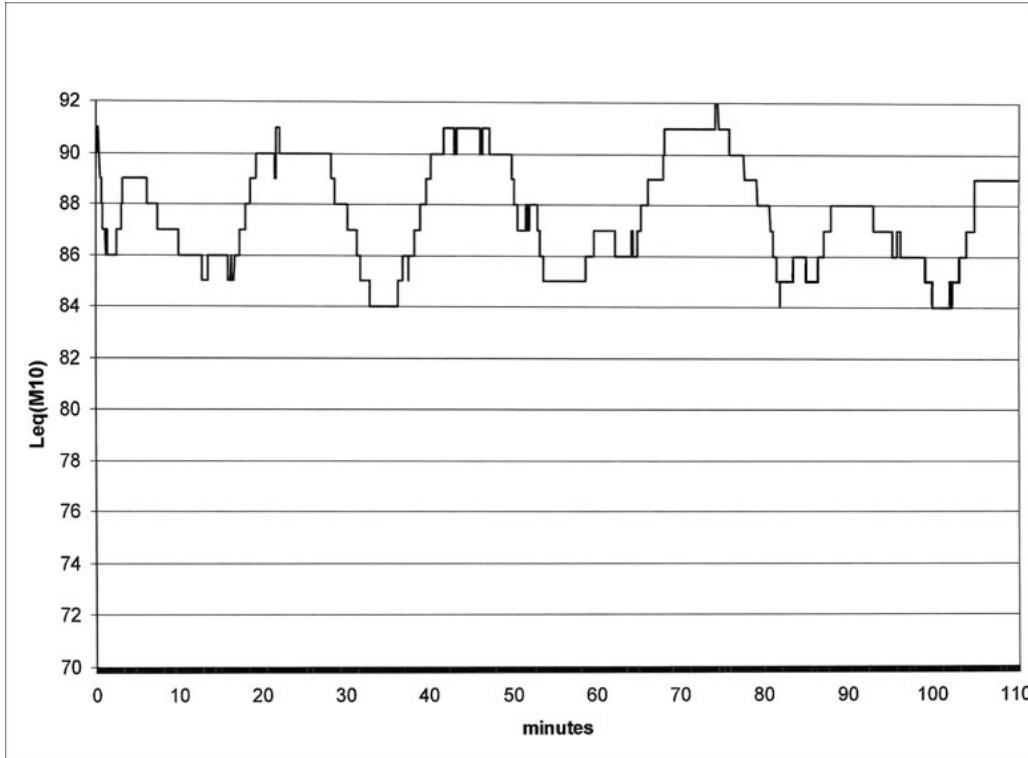


Figure 7: Veer Zara



## **A metric:**

But this in itself is not very useful. It's not very helpful, for example, just to say that at 23 minutes into the film, the  $Leq(m10)$  for the previous ten minutes was 85 dB, or to state it more correctly, 85 dB  $Leq(m10)$ .

So, let's try adding together all the  $Leq(m10)$  readings at some given constant clock frequency (sample rate), and then dividing by the duration of the film.

For the first ten minutes of the movie, the data will show a conventional  $Leq$  reading. At the ten-minute point, the pre-ten minute samples will be dropped off. The last reading will be taken at LFOA.

To make a further improvement, we don't want to have the result influenced in any way by sustained low-level material. As an example, the difference between quiet dialog and quiet atmospheres should have minimal effect. Our interest is only in sustained material above a certain level. So, let's set a threshold point.

Our starting parameters were:

1. Window duration – currently 10 minutes
2. Threshold – initially 85 dB  $Leq(m10)$ , but changed later (see below)
3. Sample rate – currently 750 mS -not a time constant, but the point at which a sample is taken.
4. Film duration units – minutes (why not?)

A bunch of films were measured using these parameters, creating a single metric, and a hierarchy close to subjective analysis was revealed.

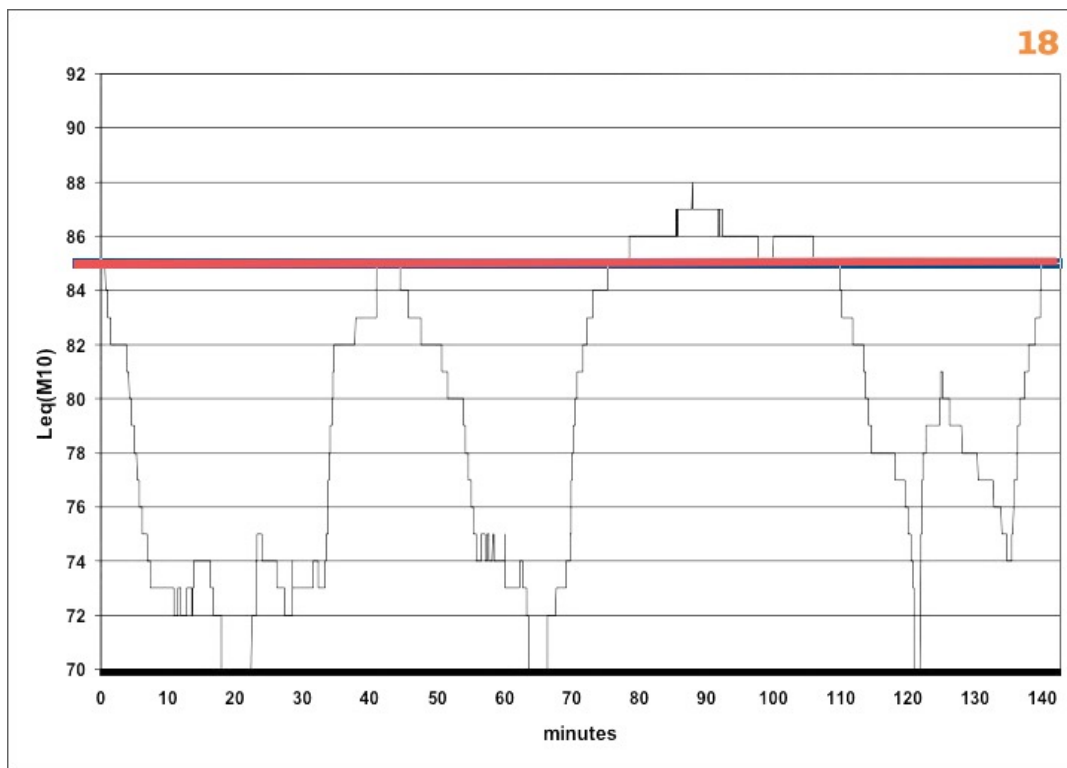


Figure 8: Star wars Episode II – with 85 dB threshold and showing single metric

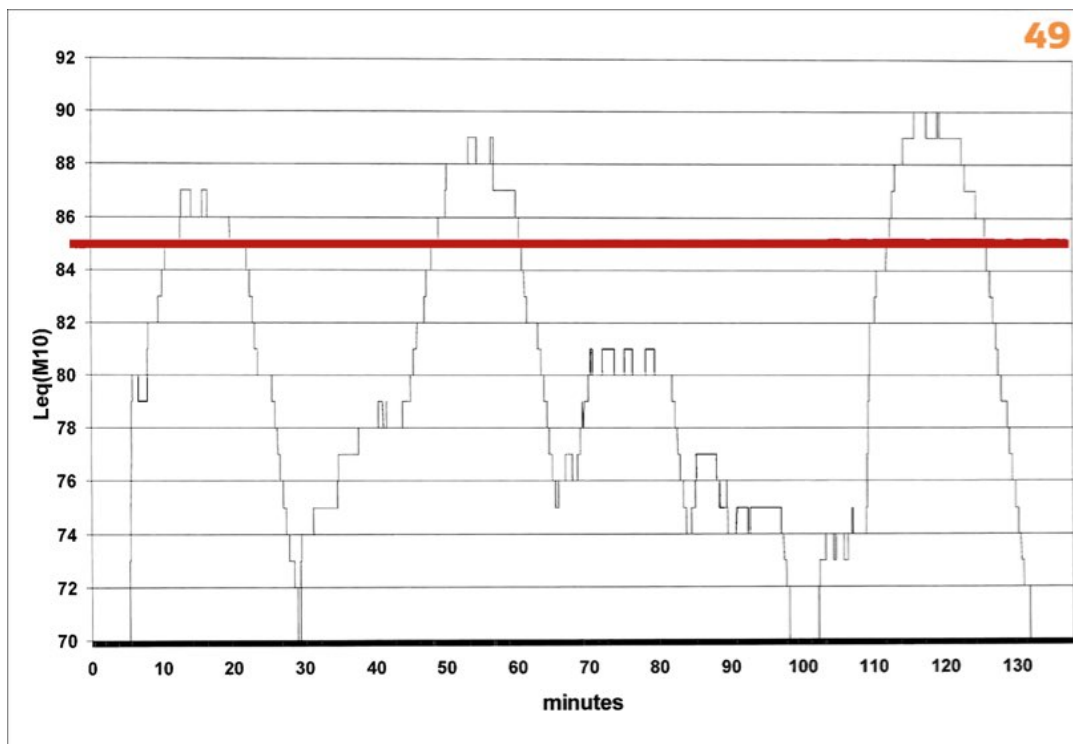


Figure 9: Master and Commander

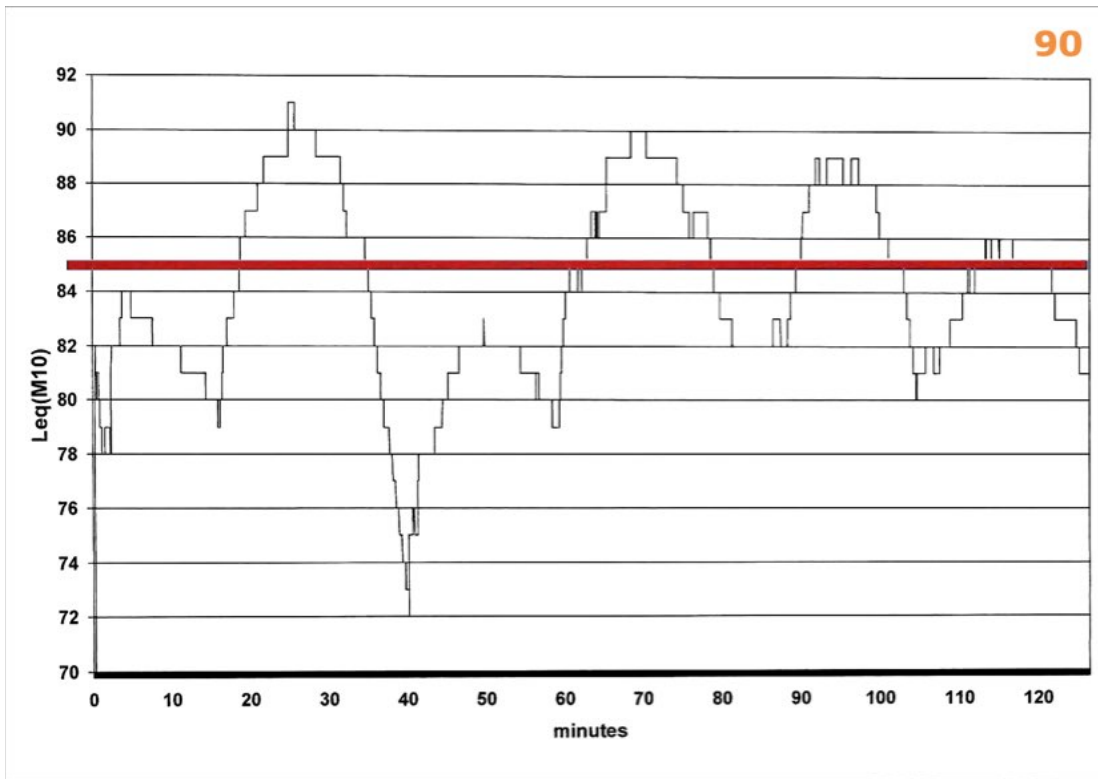


Figure 10: Mission Impossible 3

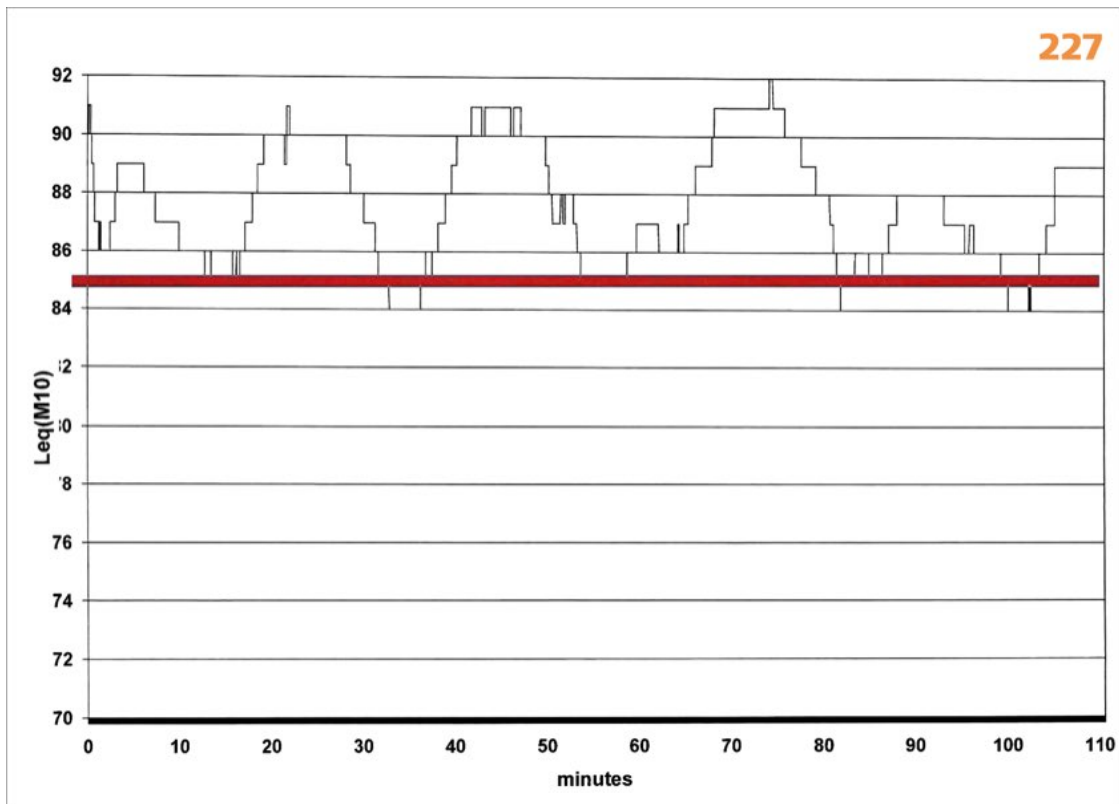


Figure 11: Veer Zara

But a couple of films seem to come out with too low a number when compared with the subjective level. Noticeable was *Slumdog Millionaire*, where a lot of energy was concentrated in the region between 80 dB Leq(m) and 85 dB Leq(m).

### Threshold Selection:

We took some selected titles, and compared an 85 dB threshold with a 70 dB threshold, and the results are shown in Figure 12.

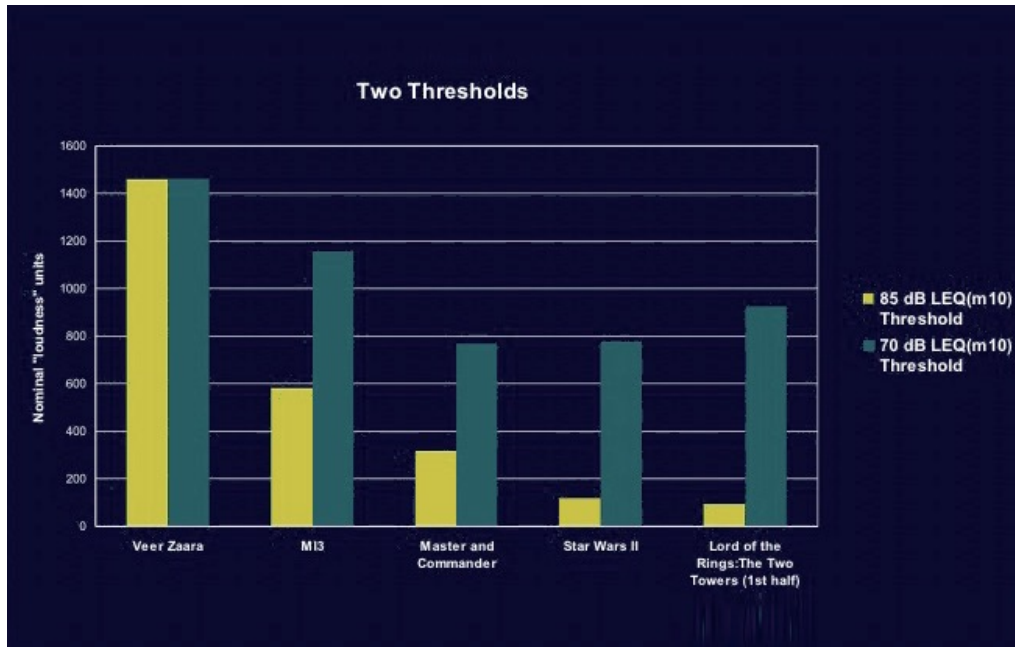
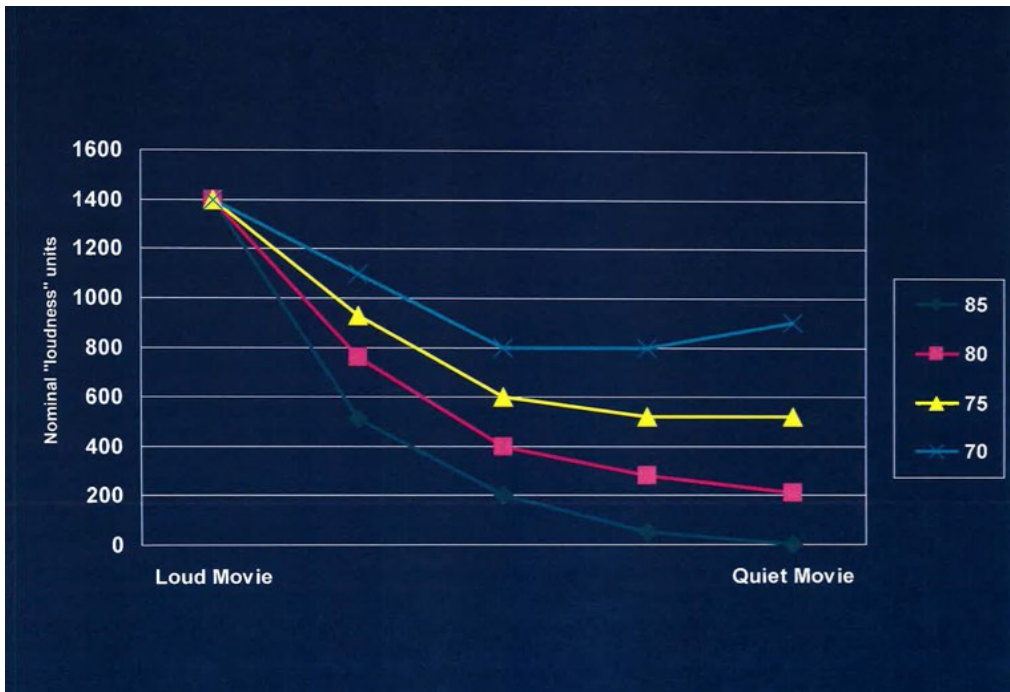


Figure 12 : Comparison of 85 dB and 70 dB thresholds

Next, we made an analysis of “loud” movies versus “quiet” movies at different thresholds, as shown in Figure 13.



**Figure 13** : Comparison of “loud” and “quiet” movies at different thresholds

The final conclusion was that an 80 dB threshold gave the best hierarchy, and a comparison of 85 dB and 80 dB can be seen in Figure 14. Not only a good hierarchy, but more evenly spread.

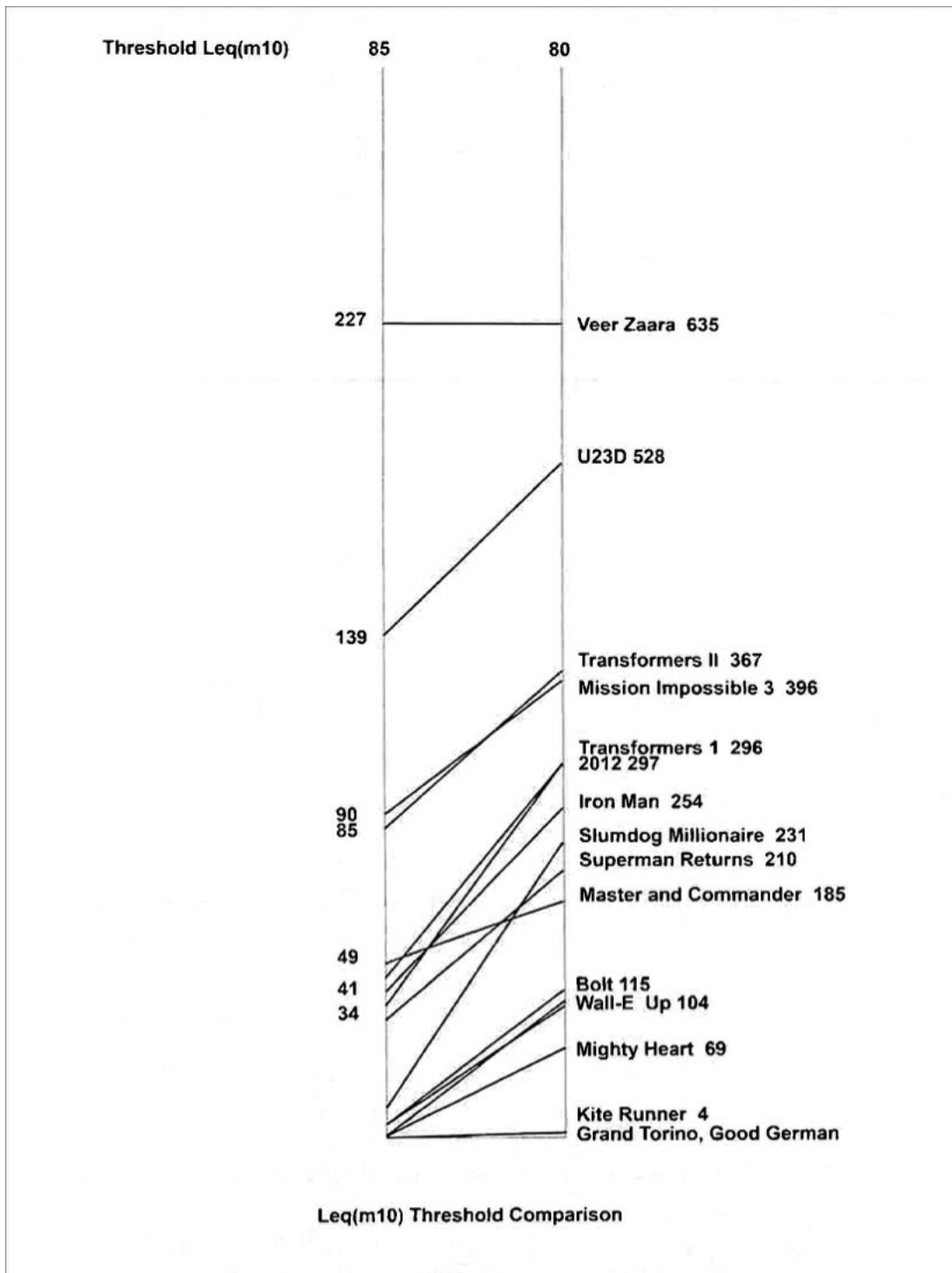


Figure 14 : Effect of changing threshold from 85 dB to 80 dB – normalized to *Veer Zara*, the loudest movie measured to date

**Window duration:**

As stated earlier, too short a window and peak levels would be restricted. Too long a window could allow abuse. 10 minutes seems about right. This was a subjective call, but minor revisions would probably not cause major changes in the hierarchy.

**Source Content:**

All the material cited in this paper came from DCP packages, with the exception of Figure 19 which for historical reference shows the Leq(m10) of the 35 mm Dolby Digital version of *Apocalypse Now*.

We have carried on measuring selected features and a few of these are shown in Figures 15, 16, 17, 18.

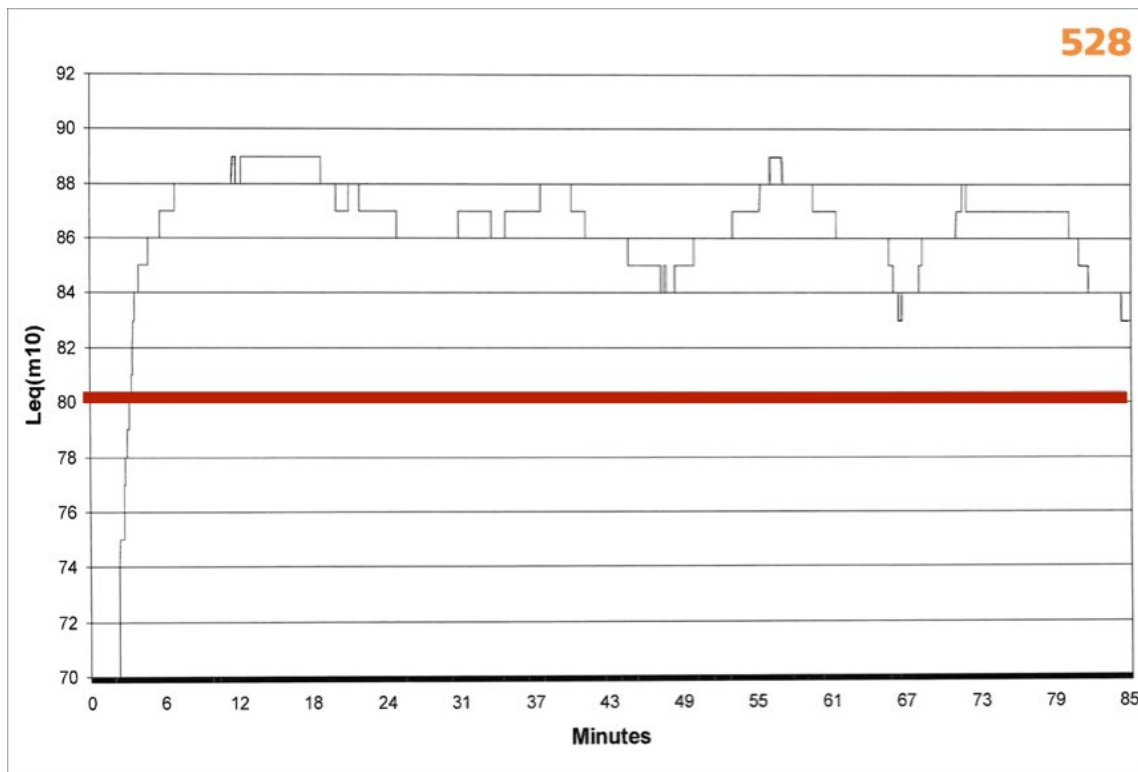


Figure 15: U2 3D -- 80 dB threshold

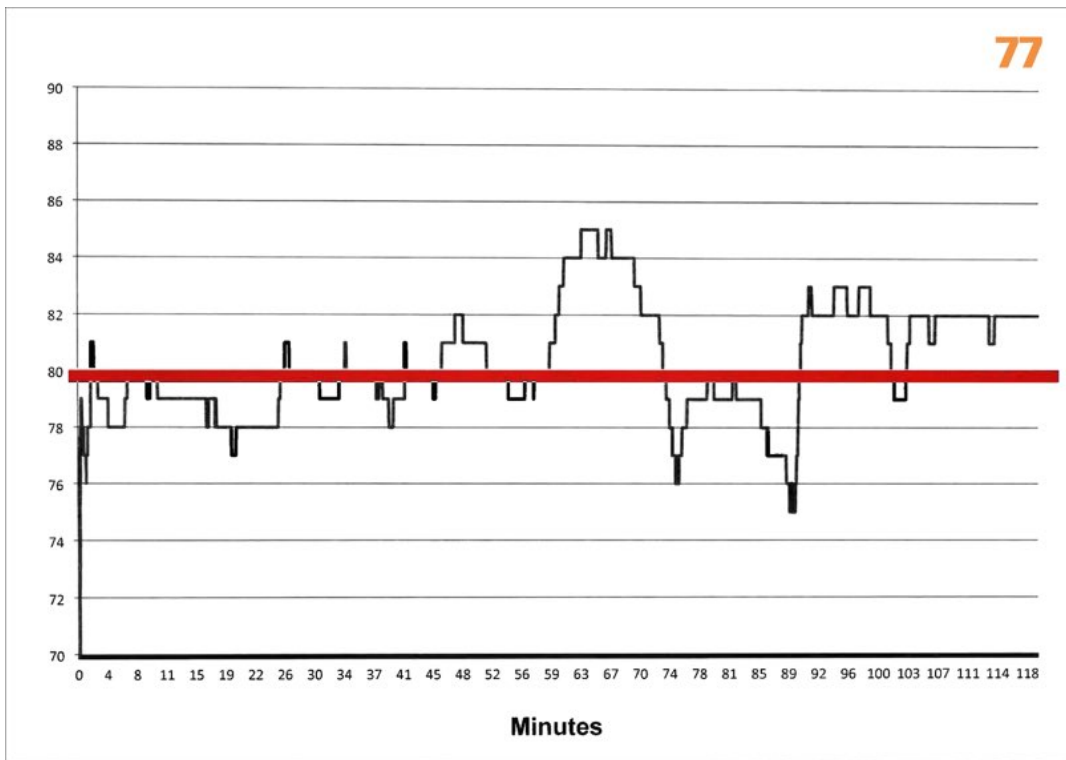


Figure 16 : Birdman

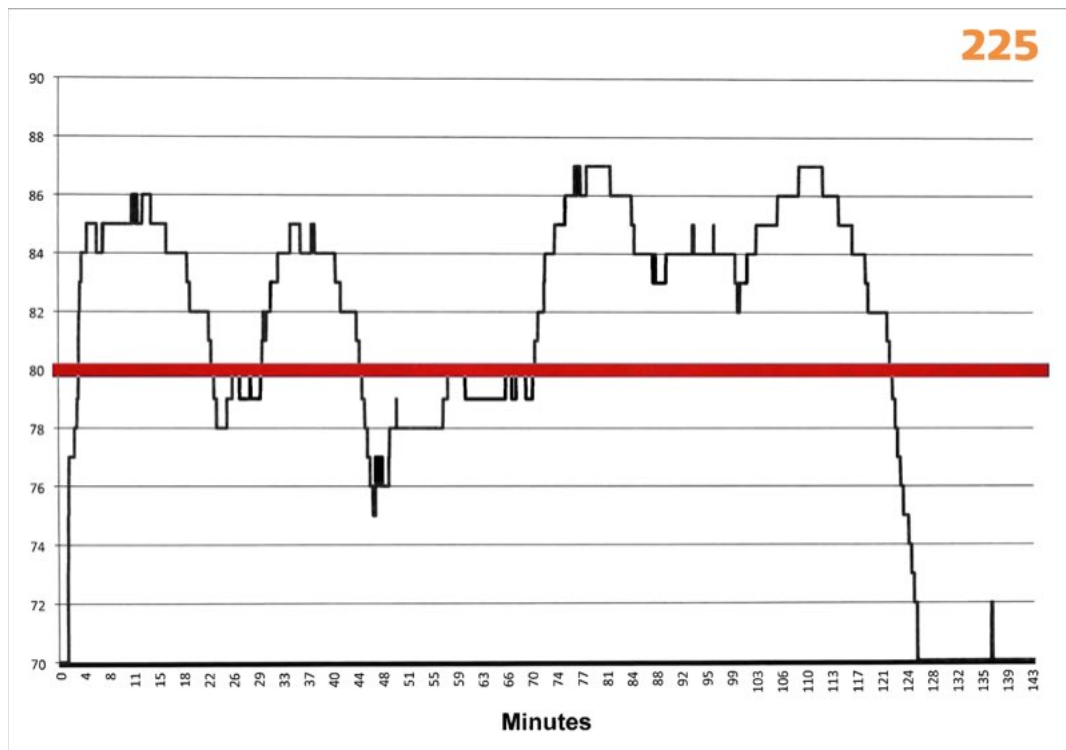


Figure 17 : Hobbit 3



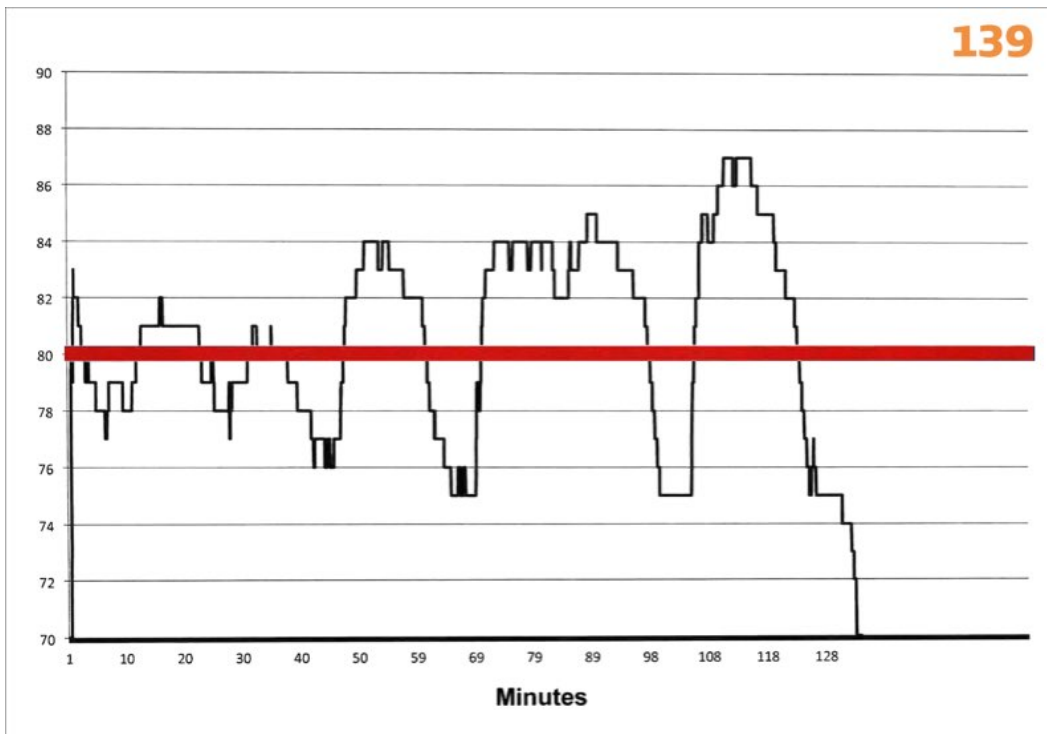


Figure 18 : American Sniper

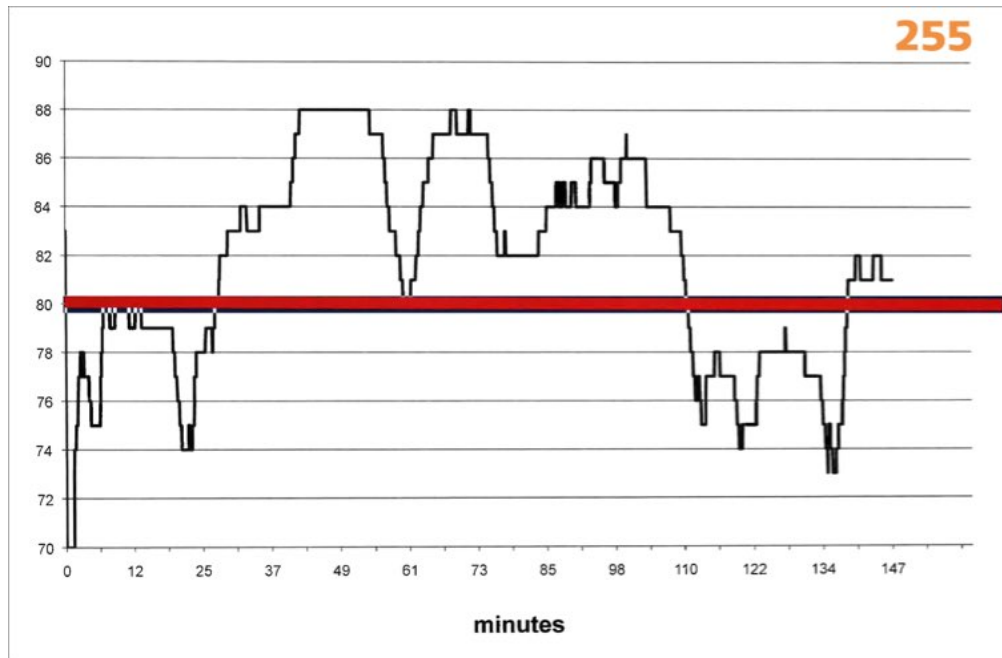


Figure 19 : Apocalypse Now – 35 mm Dolby Digital

Some selected films are shown in order of  $Leq(m10)$  in the table:

• U2 3D	528
• Mad Max: Fury Road	422
• Transformers III	360
• Mission Impossible III	356
• Star Wars: The Force Awakens	317
• Apocalypse Now	255
• Tron: Legacy	240
• Slumdog Millionaire	231
• Hobbit 3	225
• Skyfall	170
• American Sniper	139
• Moonrise Kingdom	86
• Birdman	77
• Grand Torino	0

### Conclusion:

Once again, we are *in no way* suggesting that feature films should be regulated. The procedure described is primarily being offered as a much better method of deriving a number which reports the subjective loudness of a movie – far better than measuring the peak levels reached. And it should be pointed out that the metric described has no absolute value – its value is purely relative, revealing which films are subjectively louder than others.

### Reference:

1. “Are movies too loud?” SMPTE Journal, vol. 107, pg30, 1998
2. ISO 21727, “Method of Measurement of Perceived Loudness of Short Duration Motion-picture Audio Material.”

### Notes:

1. Some of the material contained in this paper is updated content from presentations made to the SMPTE October 2007 and The Hollywood Post Alliance, February 2009.
2. This paper is copyright by the SMPTE, and has been approved for publication in the SMPTE Motion Imaging Journal.