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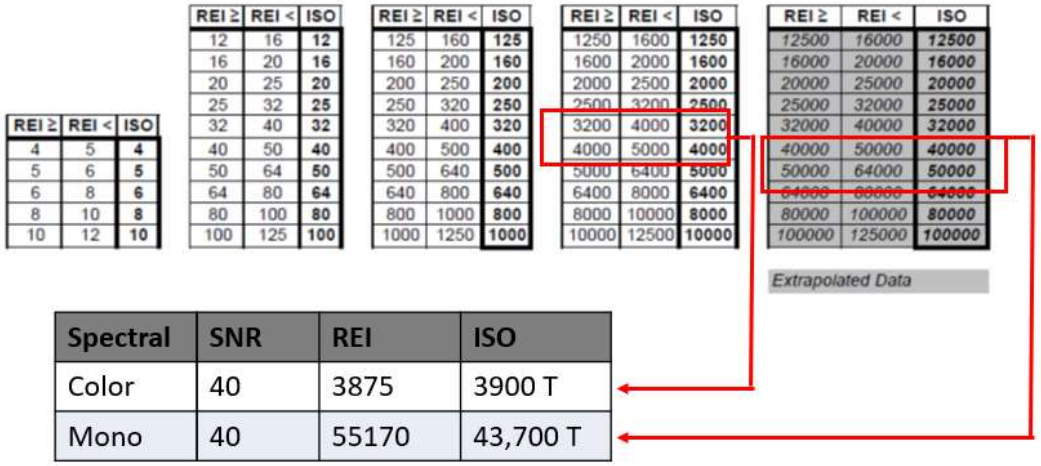
Understanding a Camera's ISO Rating



REI ≥	REI <	ISO
4	5	4
5	6	5
6	8	6
8	10	8
10	12	10

REI ≥	REI <	ISO
12	16	12
16	20	16
20	25	20
25	32	25
32	40	32
40	50	40
50	64	50
64	80	64
80	100	80
100	125	100

REI ≥	REI <	ISO
125	160	125
160	200	160
200	250	200
250	320	250
320	400	320
400	500	400
500	640	500
640	800	640
800	1000	800
1000	1250	1000

REI ≥	REI <	ISO
1250	1600	1250
1600	2000	1600
2000	2500	2000
2500	3200	2500
3200	4000	3200
4000	5000	4000
5000	6400	5000
6400	8000	6400
8000	10000	8000
10000	12500	10000

REI ≥	REI <	ISO
12500	*16000*	*12500*
16000	*20000*	*16000*
20000	*25000*	*20000*
25000	*32000*	*25000*
32000	*40000*	*32000*
40000	*50000*	*40000*
50000	*64000*	*50000*
64000	*80000*	*64000*
80000	*100000*	*80000*
100000	*125000*	*100000*

Extrapolated Data

Spectral	SNR	REI	ISO
Color	40	3875	3900 T
Mono	40	55170	43,700 T

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Understanding ISO 12232

- Objective is to give you the understanding about ISO
- I will explain a very simple method used EOI based on ISO 12232
- I will explain how VR may be reporting ISO

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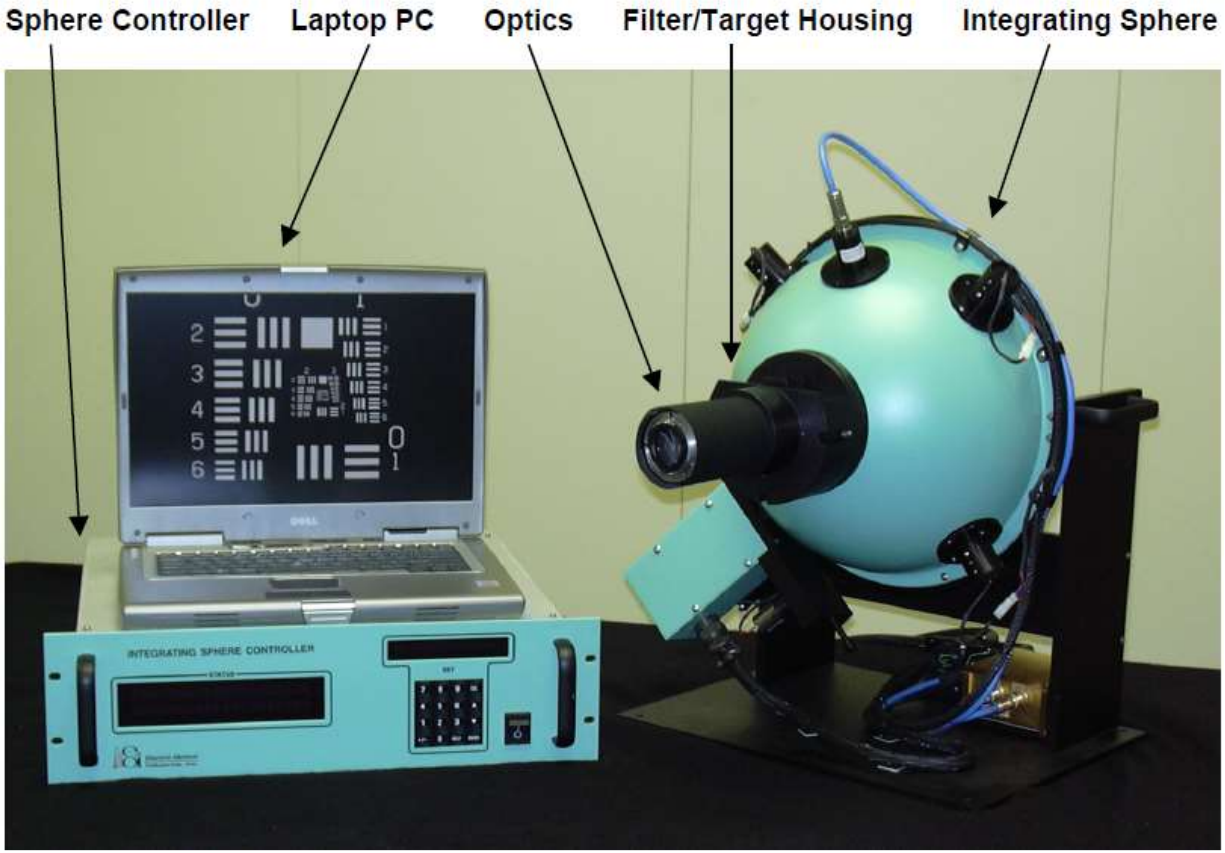
ISO-12232 Testing

EOI Test Station



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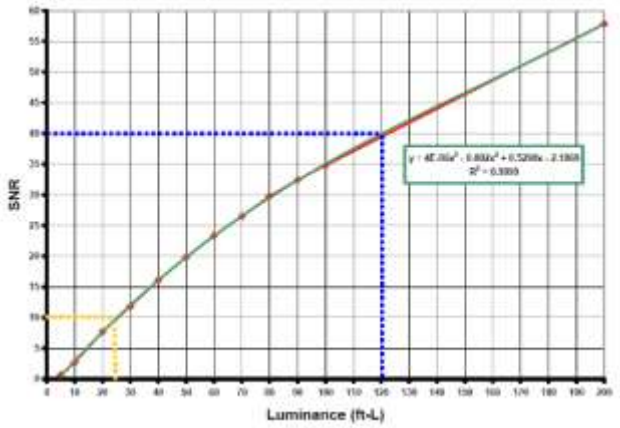
Half Moon Target

Measure SNR vs. Illumination



50 x 50 pixels

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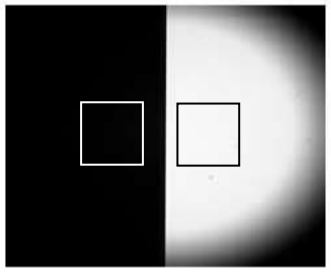
ISO 12232 Process

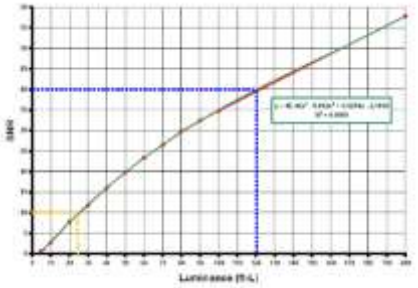


Camera

Light
(Ft-L)

Recommend Exposure Index

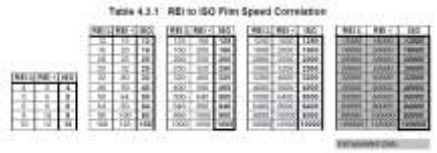
f#
Exposure Time



$$REI = 4.5\left[\frac{(f/\#)^2}{(L_{SNR(X)})(t)}\right]$$

ISO Rating

For a Given SNR
(40 dB or 10 dB)



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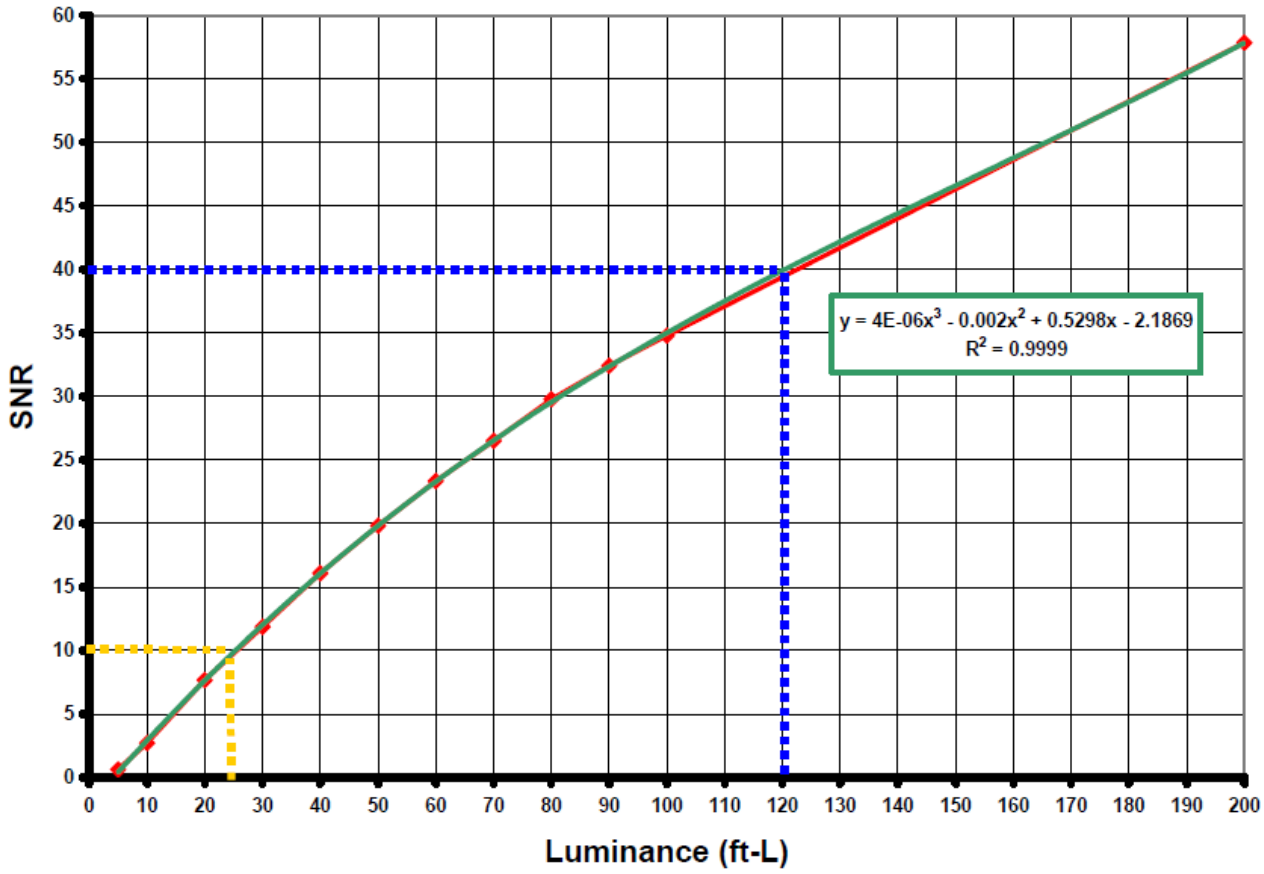
SNR vs Illumination



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ISO 12232 Measurement

An SNR of 40 is defined as an "excellent" image and an SNR of 10 is defined as an "acceptable" image per ISO 12232*. The interpolated luminance at each of these points is read from the SNR plot and used to calculate the Recommended Exposure Index (REI), Equation 1 below, which was derived from ISO 12232.

$$REI = 4.5\left[\frac{(f/\#)^2}{(L_{SNR(X)})(t)}\right] \quad (1)$$

Where…

REI	=	*Recommended Exposure Index*
$f/\#$	=	*Effective f-number*
$L_{SNR(X)}$	=	*Luminance (ft-L) @ SNR = X*
t	=	*Sensor integration time (seconds)*

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ISO Table

Table 1 — ISO speed, ISO speed latitude, SOS and REI reported values

S_{sat} (from 6.2)	S_{noise} (from 6.3)	I_{SOS} and I_{REI}	Reported value
$8 < S_{sat} < 10$	$10 < S_{noise} < 12$	$8{,}909 < x < 11{,}22$	10
$10 < S_{sat} < 12$	$12 < S_{noise} < 16$	$11{,}22 < x < 14{,}14$	12
$12 < S_{sat} < 16$	$16 < S_{noise} < 20$	$14{,}14 < x < 17{,}82$	16
$16 < S_{sat} < 20$	$20 < S_{noise} < 25$	$17{,}82 < x < 22{,}45$	20
$20 < S_{sat} < 25$	$25 < S_{noise} < 32$	$22{,}45 < x < 28{,}28$	25
$25 < S_{sat} < 32$	$32 < S_{noise} < 40$	$28{,}28 < x < 35{,}64$	32
$32 < S_{sat} < 40$	$40 < S_{noise} < 50$	$35{,}64 < x < 44{,}90$	40
$40 < S_{sat} < 50$	$50 < S_{noise} < 64$	$44{,}90 < x < 56{,}57$	50
$50 < S_{sat} < 64$	$64 < S_{noise} < 80$	$56{,}57 < x < 71{,}27$	64
$64 < S_{sat} < 80$	$80 < S_{noise} < 100$	$71{,}27 < x < 89{,}09$	80
$80 < S_{sat} < 100$	$100 < S_{noise} < 125$	$89{,}09 < x < 112{,}2$	100
$100 < S_{sat} < 125$	$125 < S_{noise} < 160$	$112{,}2 < x < 141{,}4$	125
$125 < S_{sat} < 160$	$160 < S_{noise} < 200$	$141{,}4 < x < 178{,}2$	160
$160 < S_{sat} < 200$	$200 < S_{noise} < 250$	$178{,}2 < x < 224{,}5$	200
$200 < S_{sat} < 250$	$250 < S_{noise} < 320$	$224{,}5 < x < 282{,}8$	250
$250 < S_{sat} < 320$	$320 < S_{noise} < 400$	$282{,}8 < x < 356{,}4$	320
$320 < S_{sat} < 400$	$400 < S_{noise} < 500$	$356{,}4 < x < 449{,}0$	400
$400 < S_{sat} < 500$	$500 < S_{noise} < 640$	$449{,}0 < x < 565{,}7$	500
$500 < S_{sat} < 640$	$640 < S_{noise} < 800$	$565{,}7 < x < 712{,}7$	640
$640 < S_{sat} < 800$	$800 < S_{noise} < 1\,000$	$712{,}7 < x < 890{,}9$	800
$800 < S_{sat} < 1\,000$	$1\,000 < S_{noise} < 1\,250$	$890{,}9 < x < 1\,122$	1 000
$1\,000 < S_{sat} < 1\,250$	$1\,250 < S_{noise} < 1\,600$	$1\,122 < x < 1\,414$	1 250
$1\,250 < S_{sat} < 1\,600$	$1\,600 < S_{noise} < 2\,000$	$1\,414 < x < 1\,782$	1 600
$1\,600 < S_{sat} < 2\,000$	$2\,000 < S_{noise} < 2\,500$	$1\,782 < x < 2\,245$	2 000
$2\,000 < S_{sat} < 2\,500$	$2\,500 < S_{noise} < 3\,200$	$2\,245 < x < 2\,828$	2 500
$2\,500 < S_{sat} < 3\,200$	$3\,200 < S_{noise} < 4\,000$	$2\,828 < x < 3\,564$	3 200
$3\,200 < S_{sat} < 4\,000$	$4\,000 < S_{noise} < 5\,000$	$3\,564 < x < 4\,490$	4 000
$4\,000 < S_{sat} < 5\,000$	$5\,000 < S_{noise} < 6\,400$	$4\,490 < x < 5\,657$	5 000
$5\,000 < S_{sat} < 6\,400$	$6\,400 < S_{noise} < 8\,000$	$5\,657 < x < 7\,127$	6 400
$6\,400 < S_{sat} < 8\,000$	$8\,000 < S_{noise} < 10\,000$	$7\,127 < x < 8\,909$	8 000

Ends @ ISO 8000

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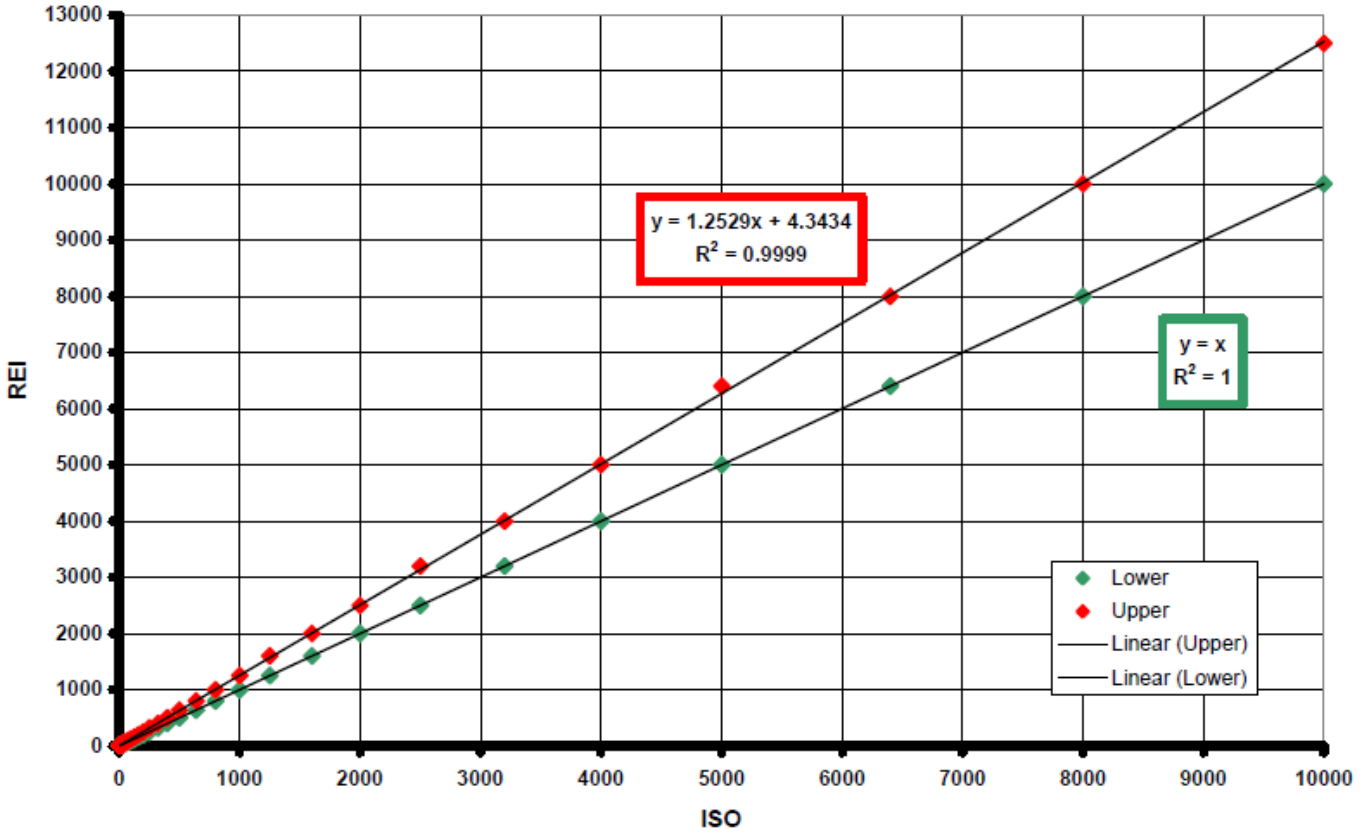
How did the ISO Gods create the ISO Table?

Upper and Lower Bounds for ISO Film Speed Latitude



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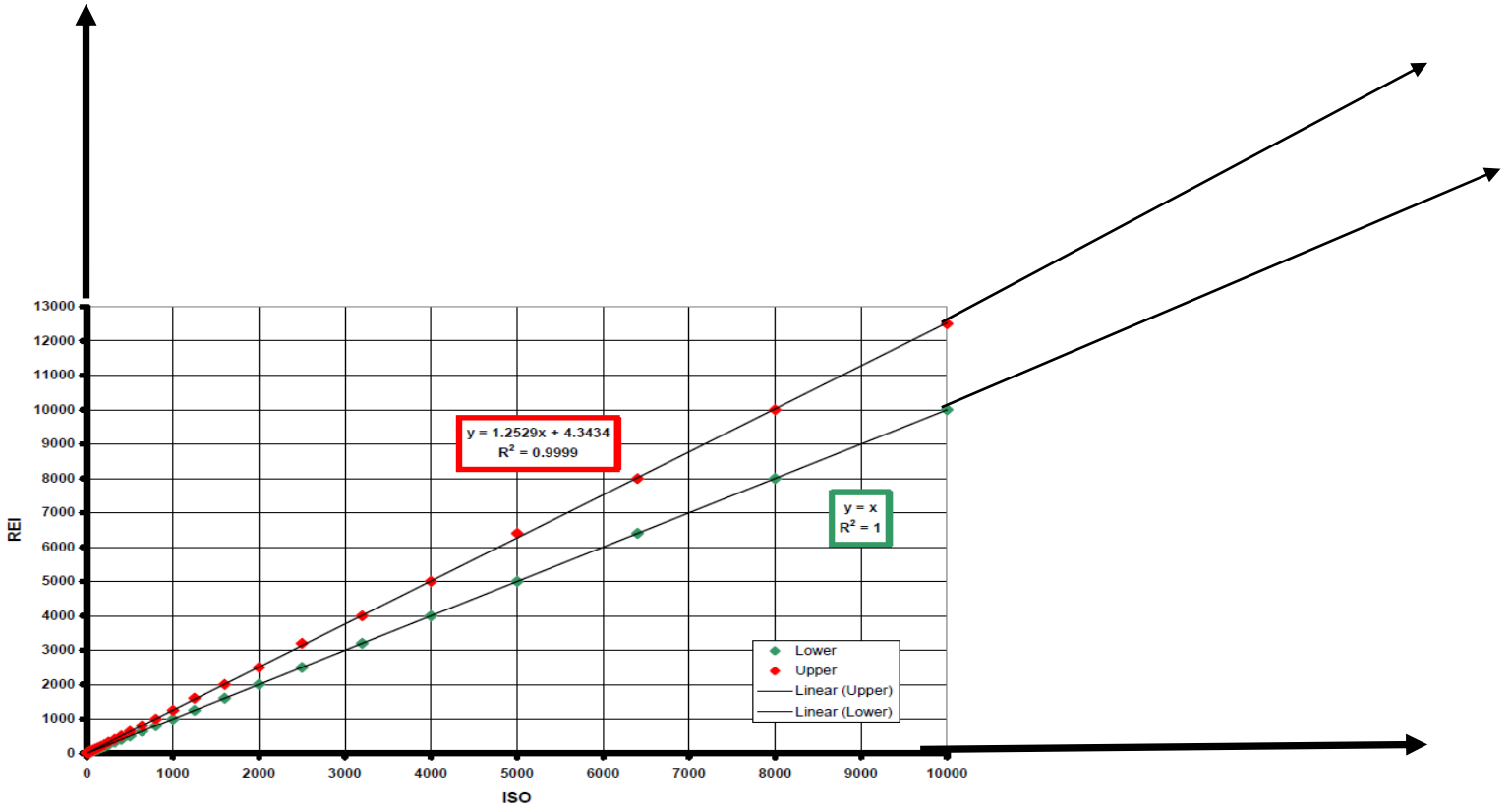
Extending the Range by Extrapolating



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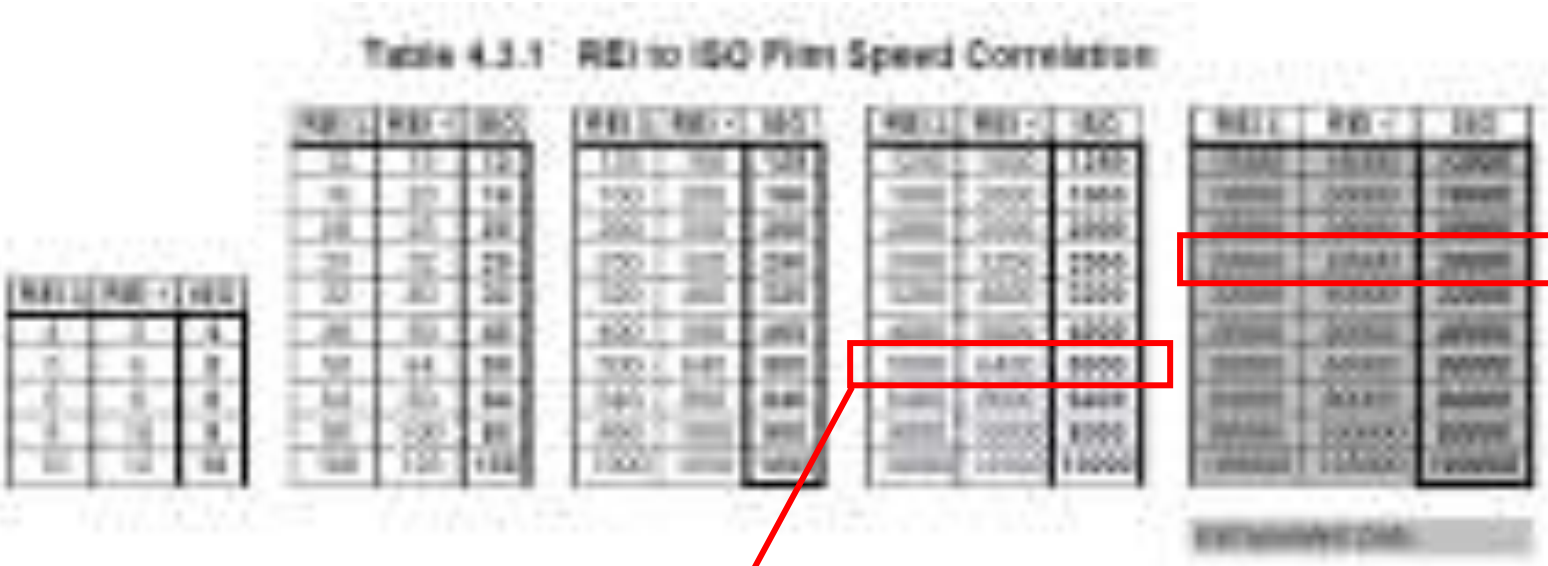
Extrapolating the ISO Table



SNR	REI	ISO
40	6233	**5000**
10	30125	**25000**

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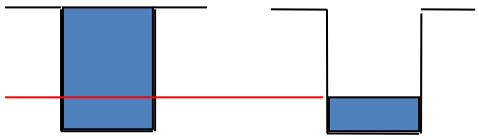
Noise vs. Saturation Based Reporting

The maximum exposure level is the exposure level where an image will have parts saturated. The pixel has the maximum signal that can be read.

The minimum exposure level depends on the amount of noise that can be tolerated in the image.

These situations lead to two different types of speed values, saturation signal-based values and noise-based values.

Using noise based method is the preferred test but most companies are using Saturation Based because the ISO #s are larger.



Saturated Noise

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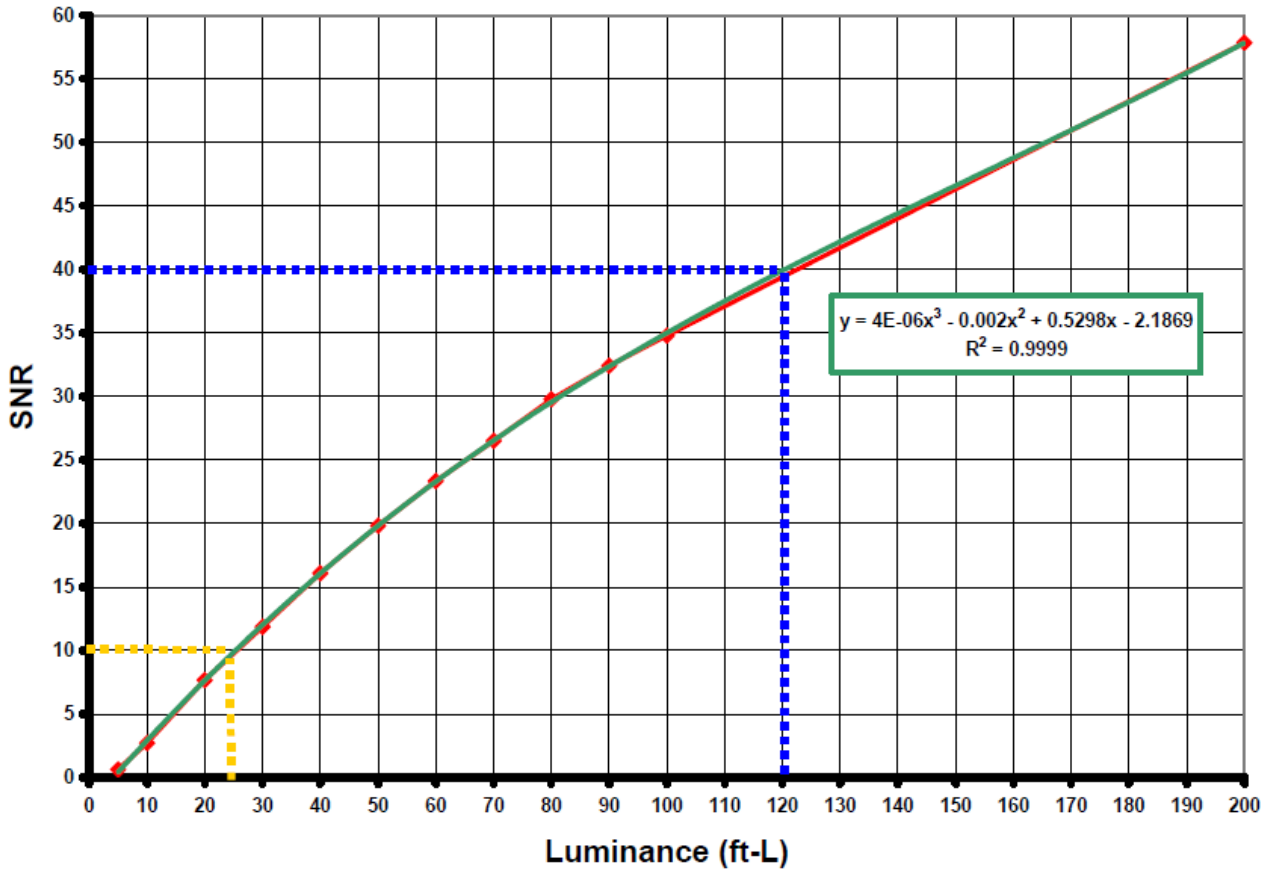
An Example: SNR vs Illumination



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Calculating REI: Photron's SA1.1

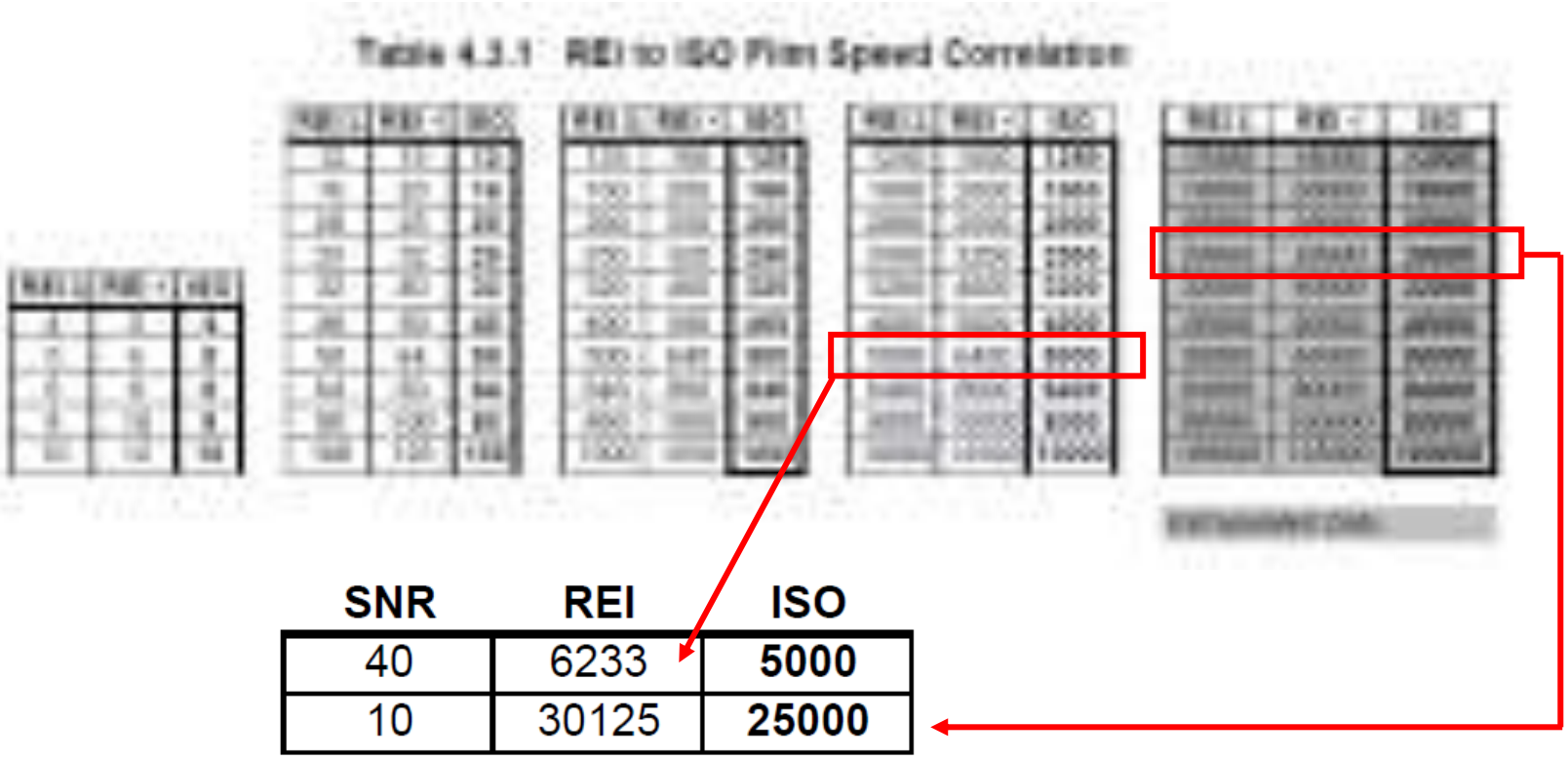
An SNR of 40 is defined as an "excellent" image and an SNR of 10 is defined as an "acceptable" image per ISO 12232. The interpolated luminance at each of these points is read from the sensitivity plot, Figure 5.3.2, and used to calculate the Recommended Exposure Index (REI), Equation 2.

$$REI = 4.5\left[\frac{(f/\#)^2}{(L_{SNR(X)})(t)}\right] = 6239.6$$

Where…

REI	=	*Recommended Exposure Index*
$f/\#$	=	*5.6*
$L_{SNR(X)}$	=	*25.296 (ft-L) @ SNR:10*
		122.254 (ft-L) @ SNR:40
t	=	*0.000185 (seconds)*

ISO for Photron's SA1.1



SNR	REI	ISO
40	6233	**5000**
10	30125	**25000**

Note: REI is 2.6% under ISO 6400

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VR Phantom v1610

- **1280 x 800 resolution**
- **28 micron pixel size, 12-bit depth**
- **1 µs shutter or 500 ns shutter with FAST option**
- **Color ISO 3,900 T**
- **Monochrome ISO 43,700 T (ISO 12232 SAT method)**

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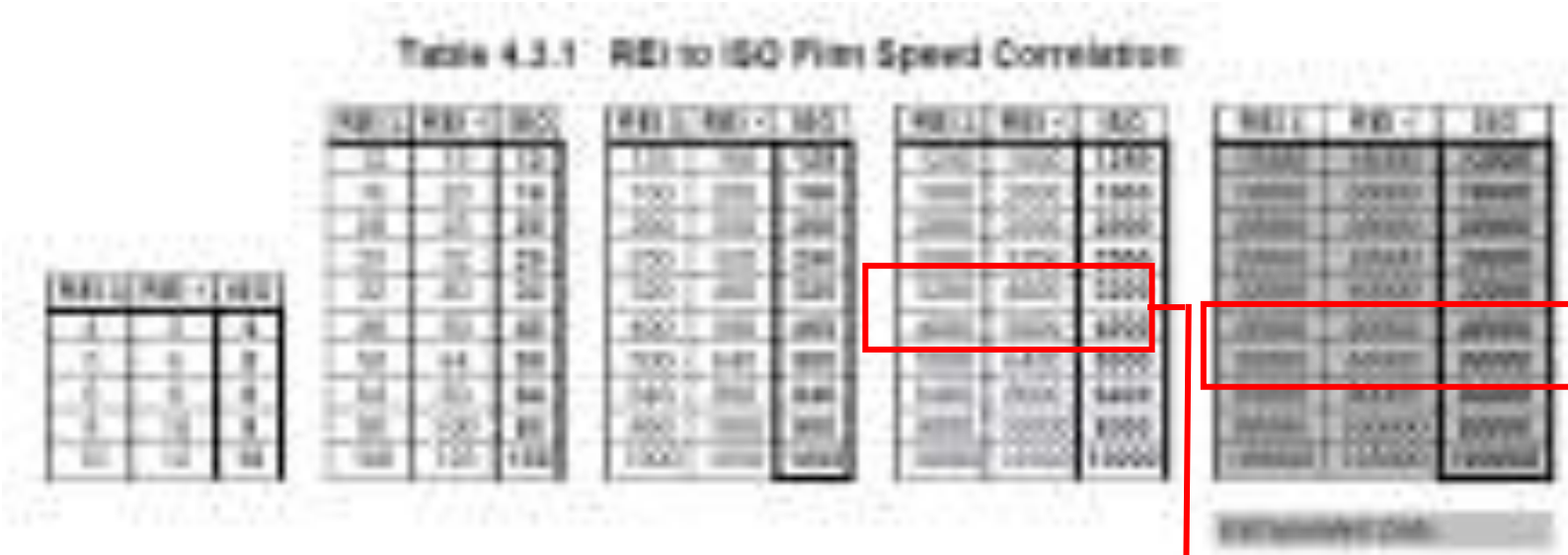
ISO for a high speed v1610, is it “REAL”



Spectral	SNR	REI	ISO
Color	?	?	3900 T
Mono	?	?	43,700 T

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First Thoughts

Use to be that a color vs. mono camera was about 1-2 f-stops. Why is the monochrome so much greater than the color?

- Was the ISO reported not SNR_{40} but SNR_{10} ?
- Was Vision Research Phantom v1610 EDR function used?
- Was the use or non use of an IR Block filter an issue?
- Is there a significant change in technology?

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First Thoughts

Use to be that a color vs. mono camera was about 1-2 f-stops.
Why is the monochrome so much greater than the color?

Was the ISO reported not SNR_{40} but SNR_{10} ?

Possible but Standard requires defining

Was Vision Research EDR function used?

Possible but Standard does not allow

Was the use or non use of an IR Block filter an issue?

Only if VR uses a IR filter on a mono camera

Is there a significant change in technology?

This is the answer.

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High Speed Cameras ISO Compared

Photron	Nac	Vision Res
APX-RS color …….. 200/1,000	HX6 ……2,500/10,000	v1210/1610 color/mono 3,900/43,700
APX-RS mono …….5,000/25,000	HX5…….…2,500/10,000	Miro 3 …… 1,200/4,800
SA1 mono ……4,000/20,000	HX4…….. 10,000/40,000	Miro 310 ……1,800/11,100
SA1.1 mono …….5,000/25,000	HX3 …..... 10,000/40,000	Ir300 …… 4,800 (mono)
MC2 mono ……1,000/4,000	HX1 ----.----2,500/10,000	
SA5 color …….. 10,000	GX1 …..…..5,000/20,000	v640 color ……....1,000
SA8 color ……...5,000	GX-ir ……...20,000	v640 mono ……..4,000
SA-X2 color ……...20,000	K5 color ….. 5,000	
	K5 mono …. 32.000	v12.1 color …….. 1,600
		v12.1 mono ……6,400
		v10/9.1 color ……… 600
		v10/9.1 mono ……. 2,400
		v7.3 color …… 1,200
		v7.3 mono …….. 48,00
		v5.2 color …….. 600
		v5.2 mono ……... 2,400

Companies Not Using ISO 12232

PCO (Cooke)	Photosonics
IDT	Fastec
AOS	Olympus

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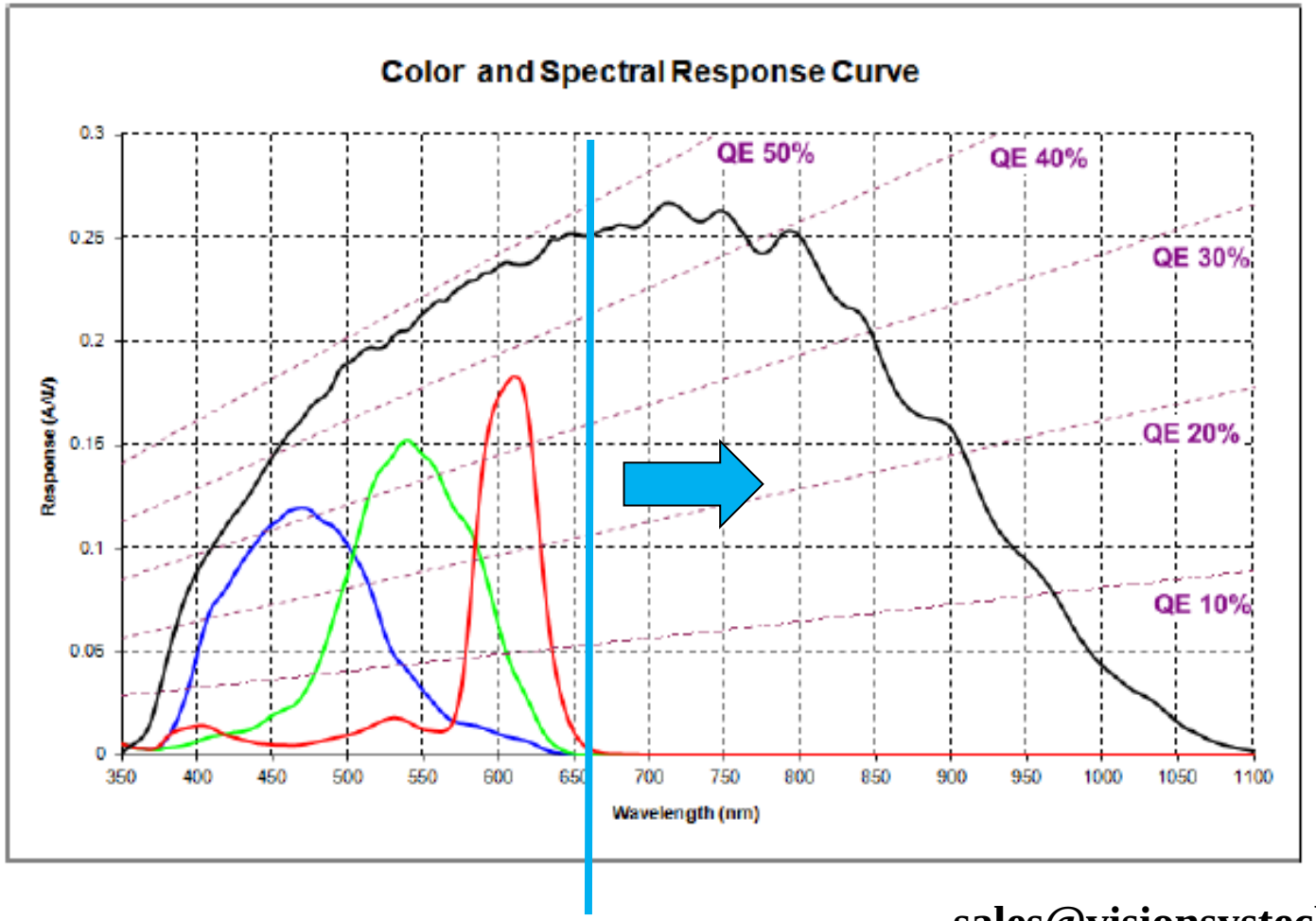
Spectral Curve

PHANTOM V1610/V1210



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Spectral Curve – v1610 & ir300

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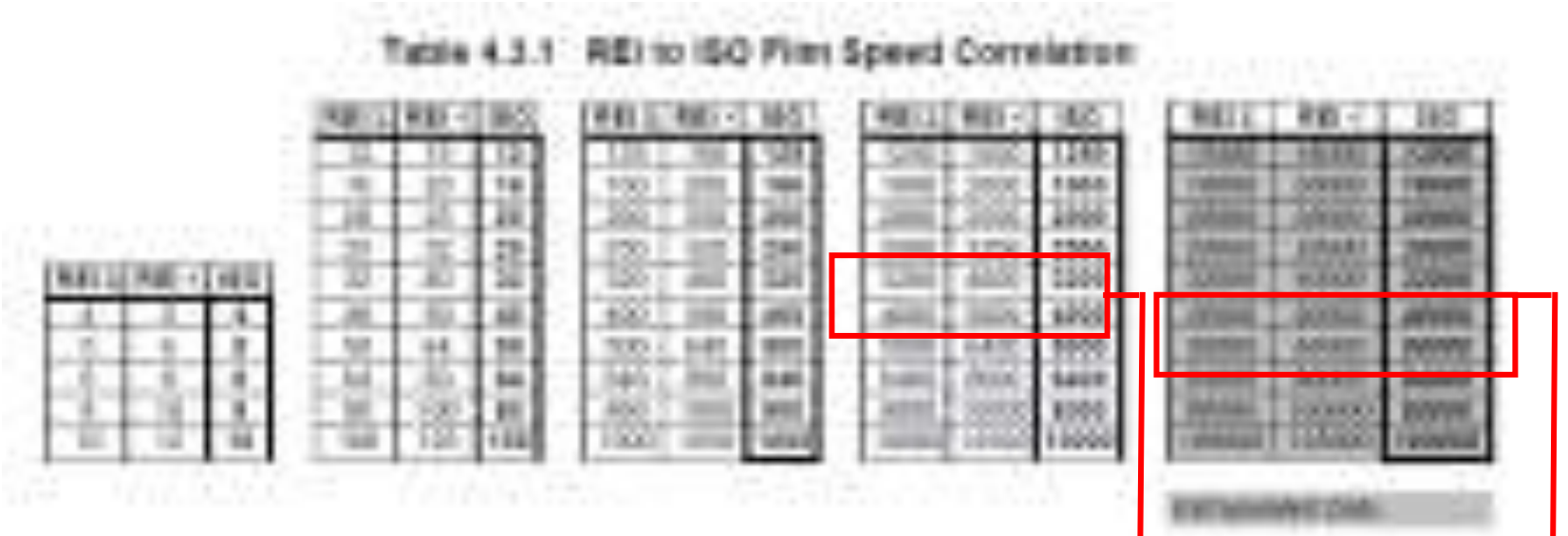
ISO for v1610, is it “REAL”



Spectral	SNR	REI	ISO
Color	40	3875	3900 T
Mono	40	55170	43,700 T

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Some Things to know

1) Using the Standard, ask for Noise Based ISO measurement unless Saturation Based ISO has a higher value.

2) If required by manufacture (color), an IR Blocking filter should be used.

3) Using Dual Slope or EDR is not accepted by the standard since the response is no linear

4) Type of lighting should be reported in the ISO number: D for daylight, T for Tungsten

5) Highest ISO # in the ISO 12232 is 8000. Anything above is extrapolated.

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