Designation: E 958 – 93 (Reapproved 1999)

Standard Practice for Measuring Practical Spectral Bandwidth of Ultraviolet-Visible Spectrophotometers[1]

This standard is issued under the fixed designation E 958; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes a procedure for measuring the practical spectral bandwidth of a spectrophotometer in the wavelength region of 185 to 820 nm. Practical spectral bandwidth is the spectral bandwidth of an instrument operated at a given integration period and a given signal-to-noise ratio.

1.2 This practice is applicable to instruments that utilize servo-operated slits and maintain a constant period and a constant signal-to-noise ratio as the wavelength is automatically scanned. It is also applicable to instruments that utilize fixed slits and maintain a constant servo loop gain by automatically varying gain or dynode voltage. In this latter case, the signal-to-noise ratio varies with wavelength. It can also be used on instruments that utilize some combination of the two designs, as well as on those that vary the period during the scan. For digitized instruments, refer to the manufacturer's manual.

1.3 This practice does not cover the measurement of limiting spectral bandwidth, defined as the minimum spectral bandwidth achievable under optimum experimental conditions.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 131 Terminology Relating to Molecular Spectroscopy[2]

E 275 Practice for Describing and Measuring Performance of Ultraviolet, Visible, and Near Infrared Spectrophotometers[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *integration period*—the time, in seconds, required for the pen or other indicator to move 98.6 % of its maximum travel in response to a step function.

3.1.2 *practical spectral bandwidth*, designated by the symbol:

$$(\Delta\lambda)^{\pi}{}_{S/N} \qquad (1)$$

where:

$\Delta\lambda$ = spectral bandwidth,
π = integration period, and
S/N = signal-to-noise ratio measured at or near 100 % T.

3.1.3 *signal-to-noise ratio*—the ratio of the signal, *S*, to the noise, *N*, as indicated by the readout indicator. The recommended measure of noise is the maximum peak-to-peak excursion of the indicator averaged over a series of five successive intervals, each of duration ten times the integration period. (This measure of noise is about five times the root-mean-square noise.)

3.1.4 *spectral bandwidth*—the wavelength interval of radiation leaving the exit slit of a monochromator measured at half the peak detected radiant power. It is not synonymous with spectral slit width, which is the product of the mechanical slit width and the reciprocal linear dispersion of the spectrophotometer.

4. Summary of Practice

4.1 The pen period and signal-to-noise ratio are set at the desired values when the instrument is operated with its normal light source and adjusted to read close to 100 % *T*. The mechanical slit width, or the indicated spectral bandwidth, required to give the desired signal-to-noise ratio is recorded. The continuum source is replaced with a line emission source, such as a mercury lamp, and the apparent half-intensity bandwidth of an emission line occurring in the wavelength region of interest is measured using the same slit width, or indicated spectral bandwidth, as was used to establish the signal-to-noise ratio with the continuum source.

[1] This practice is under the jurisdiction of ASTM Committee E-13 on Molecular Spectroscopy and is the direct responsibility of Subcommittee E13.01on Ultraviolet and Visible Spectroscopy.

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[2] *Annual Book of ASTM Standards*, Vol 03.06.

5. Significance and Use

5.1 This practice should be used by a person who develops an analytical method to ensure that the spectral bandwidths cited in the practice are actually the ones used.

NOTE 1—The method developer should establish the spectral bandwidths that can be used to obtain satisfactory results.

5.2 This practice should be used to determine whether a spectral bandwidth specified in a method can be realized with a given spectrophotometer and thus whether the instrument is suitable for use in this application.

5.3 This practice allows the user of a spectrophotometer to determine the actual spectral bandwidth of the instrument under a given set of conditions and to compare the result to the spectral bandwidth calculated from data given in the manufacturer's literature or indicated by the instrument.

5.4 Instrument manufacturers can use this practice to measure and describe the practical spectral bandwidth of an instrument over its entire wavelength operating range. This practice is highly prefered to the general practice of stating the limiting or the theoretical spectral bandwidth at a single wavelength.

6. Test Materials and Apparatus

6.1 Table 1 lists reference emission lines that may be used for measuring the spectral bandwidth of ultraviolet/visible instruments at the levels of resolution encountered in most commercial instruments. All of the lines listed have widths less than 0.02 nm, suitable for measuring spectral bandwidths of greater than 0.2 nm. The wavelengths of these lines in nanometres are listed in the first column. Values refer to measurements in standard air (760 nm, 15°C) except for the two lines below 200 nm. The wavelength for these lines refer to a nitrogen atmosphere at 760 nm and 15°C.

6.1.1 The second column in Table 1 lists the emitter gas of six sources. Only sources operating at low pressure should be used, as line broadening can introduce errors. The hydrogen, deuterium, and mercury lamps used to obtain these data were Beckman lamps operated on Beckman spectrophotometer power supplies. The other lamps are all of the "pencil-lamp" type.[3] A mercury vapor Pen-Ray lamp[4] was used to obtain the data shown in Fig. 1. In many applications the mercury and hydrogen (or deuterium) lines suffice.

[3] Suitable lamps are available from laboratory supply houses as well as manufacturers, which include UVP, Inc., 5100 Walnut Grove Ave., P.O. Box 1501, San Gabriel, CA 91778-1501; Spectronics Corp., 956 Brush Hollow Rd., P.O. Box 483, Westbury, NY 11590-0483; Jelight Co., Inc., 23052 Alcalde, Unit E, P.O. Box 2632, Laguna Hills, CA 92653-2632; and BHK, Inc., 2885 Metropolitan Place, Pomona, CA 91767.

[4] Available from UVP, Inc.

TABLE 1 Emission Lines Useful for Measuring Spectral Bandwidth

Reference Line, nm	Emitter	Intensity	Nearest Neighbor, nm	Separation, nm	$I_{Neighbor}/I_{Reference}$	Weak Neighbor, nm
184.91	Hg	8	194.17	9.26	0.13	
194.17	Hg	8	184.91	9.26	0.13	197.33
205.29	Hg	4	202.70	2.59	0.08	
226.22	Hg	5	237.83	11.61	0.06	226.03
253.65	Hg	10	...	...	...	253.48
275.28	Hg	5	280.35	5.07	0.08	
289.36	Hg	6	296.73	7.37	0.42	
296.73	Hg	8	302.15	5.42	0.04	
318.77	He	5	294.51	24.26	0.06	
334.15	Hg	7	313.18	20.97	0.70	
341.79	Ne	5	344.77	2.98	0.20	
359.35	Ne	5	352.05	7.30	0.14	360.02
388.87	He	7	447.15	58.28	0.04	
404.66	Hg	8	407.78	3.12	0.04	
427.40	Kr	5	431.96	4.56	0.28	428.30
435.95	Hg	9	407.78	28.17	0.02	435.75
447.15	He	5	471.31	24.16	0.04	
471.31	He	4	492.19	20.88	0.25	
486.0	D_2	...	...	...	...	
486.13	H_2	6	492.87	6.74	0.03	485.66
501.57	He	5	492.19	9.38	0.06	
546.07	Hg	8	577.12	31.05	0.04	
557.03	Kr	3	587.09	30.06	0.30	556.22
587.56	He	7	706.52	118.96	0.03	667.82
603.00	Ne	5	607.43	4.43	0.54	
614.31	Ne	7	616.36	2.05	0.04	
626.65	Ne	6	630.48	3.83	0.07	
640.23	Ne	7	638.30	1.93	0.11	
656.1	D_2	...	...	...	...	
656.28	H_2	7	...	...	...	656.99
667.82	He	5	706.52	38.70	0.50	
692.95	Ne	6	703.24	10.29	0.45	
703.24	Ne	7	692.95	10.29	0.06	702.41
724.52	Ne	5	703.24	21.28	0.02	717.39
743.89	Ne	4	724.52	19.37	1.4	748.89
785.48	Kr	3	769.45	16.03	0.7	
819.01	Kr	2	811.29	7.72	3.1	