WI 220804.09

T 1217

BALLOT NO. 02 SARG

DRAFT NO. 01

DATE 6/1/2023

WORKING GROUP
CHAIR To Be Determined

SUBJECT
CATEGORY Optical Properties

RELATED
METHODS See "Additional Information"

**CAUTION:**
This Test Method may include safety precautions which are believed to be appropriate at the time of publication of the method. The intent of these is to alert the user of the method to safety issues related to such use. The user is responsible for determining that the safety precautions are complete and are appropriate to their use of the method, and for ensuring that suitable safety practices have not changed since publication of the method. This method may require the use, disposal, or both, of chemicals which may present serious health hazards to humans. Procedures for the handling of such substances are set forth on Safety Data Sheets which must be developed by all manufacturers and importers of potentially hazardous chemicals and maintained by all distributors of potentially hazardous chemicals. Prior to the use of this method, the user must determine whether any of the chemicals to be used or disposed of are potentially hazardous and, if so, must follow strictly the procedures specified by both the manufacturer, as well as local, state, and federal authorities for safe use and disposal of these chemicals.

# Photometric linearity of optical properties instruments

*(Five-year review of Standard Practice T 1217 sp-18: Approval of T1217 Draft 1)*

## 1. Scope

1.1 This standard practice describes a test for linearity required by the following TAPPI optical methods:

| | |
|---|---|
| T 425 | Opacity |
| T 452, 525, 534, 646 | Brightness |
| T 480, 653 | Gloss |
| T 524, 527 | Color |
| T 560, 562 | Whiteness |

1.2 This standard practice is normally used by instrument manufacturers as the procedure for correction of photometric linearity errors.

## 2. Significance

This method is based on the rather simple principle that, if one can measure a radiant flux corresponding to *A* and another radiant flux corresponding to *B*, then when *A* and *B* are combined, one should have an indication corresponding to *A* + *B*. This is termed the *flux addition method* and implies that the current or voltage output of a photocell, or photocell plus electronic processor, should be strictly proportional to the flux upon the active surface of the cell. As an example, a linear optoelectronic system generating 1 μA output for a flux of 1 μW (a responsivity of 1 A/W) should produce exactly 2 μA if the flux is doubled to 2μW, 1.24 μA for 1.24μW, etc. More generally, *K*μW should generate *CK*μA (or volts), where *C* is an arbitrary constant.

## 3. Safety precautions

There are no specific safety precautions associated with this standard practice.

## 4. Description

A simple expression of this principle may be realized in the darkroom, using two small incandescent lamps each contained in a separate enclosure with exit aperture, blackened matte inside and out. A rectangular blackened cardboard mask is prepared so that either lamp may be shuttered from an external photoreceptor, either separately or simultaneously (see Figure 1). A 0.01% regulated variable DC supply may power both lamps, although two independent supplies provide greater flexibility. A concentrating lens system is recommended for each lamp. Each source must also contain a variable iris or spectrally non-selective graded-density neutral wedge, plus optical filtering to restrict energy falling upon the photoreceptor to the spectral range of interest. (If insensitive photodetectors are used, filtering must include a good infrared-blocking component for tests in the visual region.) To minimize error from multiple reflections between the sources and receptor assembly, the receptor should be separated from them by a minimum of 60 mm, and any specular interreflections avoided by slight tilting of components. The two sources should subtend an angle of not more than 6° at the active surface of a flat photodetector. (For strongly curved photodetector surfaces, such as those of many vacuum phototubes, it is necessary to eliminate shadowing by eliminating the angular difference between the two beams by means of a beam-combining pellicle or semi-transparent mirror.) Distribution of flux over the active surface should be as uniform as practicable. The receptor photocell should be shielded from stray light.

**NOTE 1:** This method is not suitable for use (without modification) where an integrating sphere, used in a substitution-type measurement mode, forms a part of the optical system.

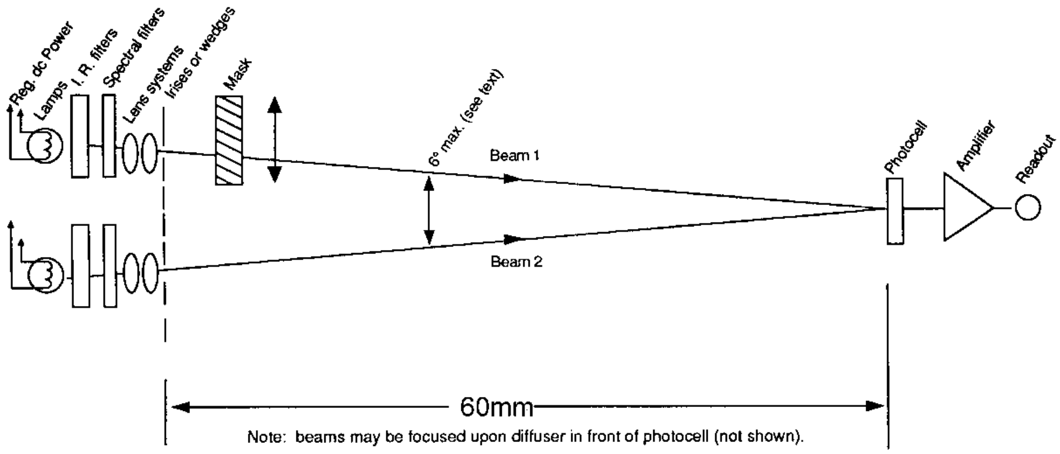


**Fig. 1.** The flux addition method for determining photometric linearity.

## 5. Procedure

5.1 Set each lamp to its rated voltage, or somewhat below this for increased life. Using the variable iris or neutral-density wedge in conjunction with the blackened mask, first set the readout to zero with both beams obscured; then set each beam to register 50.00. Recheck zero. When the mask is entirely removed, the readout should become 50.00 + 50.00 = 100.00. Any deviation from the arithmetic sum of the two beams may be taken as an indication of the nonlinearity of the system. Make several determinations and compute the average delta from 100.00.

5.2 Measurements at other irradiance levels (5X, 25X, $^1/_5$, $^1/_{25}$) may be performed for extended range linearity determinations. Alternatively, several intermediate linearity steps (such as 0, 20, 40, 60, 80, 100) are available by setting the first ("stepping") lamp to 20, shuttering it and matching the output with the second ("matching") lamp, exposing both lamps for a combined reading corresponding to 40, reshuttering the stepping lamp and adjusting the matching lamp to this reading, reexposing the stepping lamp, etc., until full-scale is achieved (*1*). In this case it is useful to normalize the result so that the average full-scale reading becomes 100.

## 6. Keywords

Optical properties, Optical instruments, Photometry, Linearity

## 7. Additional information

7.1 Effective date of issue: To Be Assigned

7.2 This standard practice formerly was TIP 0804-06 and was revised in 1998.

## Literature cited

1. Höfert H.J., and Loof, H., "Calibration of the Photometric Scale of a Reflectance Photometer," *Zeitschrift für Instrumentenkunde* **72**:139 (1964); communication in English, Carl Zeiss, Oberkochen.

*Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Standards Department.*

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