



Designation: D4660 – 23

# Standard Test Methods for Polyurethane Raw Materials: Determination of the Isomer Content of Toluenediisocyanate<sup>1</sup>

This standard is issued under the fixed designation D4660; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 1. Scope\*

1.1 These test methods measure the amount of toluene-2,6-diisocyanate (2,6-TDI) isomer or toluene-2,4-diisocyanate (2,4-TDI) isomer in mixtures of the 2,4- and 2,6-isomers of toluenediisocyanate (TDI). Two different test methods are provided to give accurate results over the broad range of isomer concentrations possible.

1.1.1 *Test Method A*—Applicable to TDI samples containing 5 to 95 % of 2,6-TDI isomer (5 to 95 % 2,4-TDI isomer).

1.1.2 *Test Method B*—Applicable to TDI samples containing 0 to 5 % of 2,6-TDI isomer (95 to 100 % 2,4-TDI isomer).

NOTE 1—These test methods are equivalent to ISO 15064.

1.2 The values stated in SI units are to be regarded as standard.

1.3 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards*:<sup>2</sup>

[D883 Terminology Relating to Plastics](#)

[E180 Practice for Determining the Precision of ASTM Methods for Analysis and Testing of Industrial and Spe-](#)

[cialty Chemicals \(Withdrawn 2009\)](#)<sup>3</sup>

[E456 Terminology Relating to Quality and Statistics](#)

[E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method](#)

[E2935 Practice for Evaluating Equivalence of Two Testing Processes](#)

2.2 *ISO Standard*:<sup>4</sup>

[ISO 15064 Plastics—Aromatic Isocyanates for Use in the Production of Polyurethanes—Determination of the Isomer Ratio in Toluenediisocyanate](#)

## 3. Terminology

3.1 Terms used in this standard are defined in accordance with Terminology [D883](#), unless otherwise specified. For terms relating to precision and bias and associated issues, the terms used in this standard are defined in accordance with Terminology [E456](#).

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *isomer*—a compound having the same molecular formula (percentage composition and molecular weight) as another compound but differs in chemical or physical properties.

3.2.2 *isomer content*—the amount of an isomer expressed as a percentage of total 2,4- and 2,6-TDI isomer amount.

## 4. Summary of Test Methods

4.1 Both test methods are based on the quantitative measurement of absorption bands arising from out-of-plane C-H deformation vibrations of the aromatic ring.

4.2 In Test Method A, the infrared spectrum of a cyclohexane solution of the sample is recorded in the 770 to 840-cm<sup>-1</sup> region. The absorbance ratio of the 805 cm<sup>-1</sup> to the 782 cm<sup>-1</sup> band is measured and converted to percent 2,6-TDI, or percent 2,4-TDI, or both, from a previously established calibration curve.

4.3 In Test Method B, the absorbance of the 782-cm<sup>-1</sup> band is measured from an infrared spectrum of an undiluted sample

<sup>1</sup> These test methods are under the jurisdiction of ASTM Committee [D20](#) on Plastics and are the direct responsibility of Subcommittee [D20.22](#) on Cellular Materials - Plastics and Elastomers.

Current edition approved March 15, 2023. Published March 2023. Originally approved in 1959. Last previous edition approved in 2018 as D4660 - 18. DOI: 10.1520/D4660-23.

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

<sup>4</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

\*A Summary of Changes section appears at the end of this standard

and then converted to percent 2,6-TDI from a previously established calibration curve.

## 5. Significance and Use

5.1 These test methods are suitable for research or for quality control to determine the isomer content of toluene diisocyanates.

5.2 The isomer content of a toluene diisocyanate relates to its reactivity.

## 6. Apparatus

6.1 *Spectrophotometer*—Any single- or double-beam recording infrared spectrophotometer accurate to 0.2 % transmission and capable of resolving the two peaks of the 2,4-TDI isomer doublet at 805-815  $\text{cm}^{-1}$  (see Fig. 1).

6.2 *Cells*, sealed sodium chloride (NaCl) liquid absorption cells with 0.2-mm (Test Method A) and 0.1-mm (Test Method B) path lengths. The actual thicknesses of the cells are to be known to  $\pm 0.002$  mm.

6.3 *Glassware*, 25-mL, glass-stoppered, volumetric flasks, 10-mL, glass-stoppered, flasks, 0.80-mL volumetric pipet, and an all-glass syringe.

## 7. Reagents and Materials

7.1 *Purity of Reagents*—Use reagent grade chemicals in all tests. Unless otherwise noted, all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society where such specifications are available.<sup>5</sup> Other grades are acceptable, provided it is ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 *Cyclohexane*, anhydrous, stored over molecular sieve.

<sup>5</sup> *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

7.3 *Diisocyanate Standards*—Pure samples of 2,4-TDI and 2,6-TDI are required for calibration. The following criteria can be used to judge purity:

Pure Isomer	Freezing point	Refractive Index @ 20C $n^{20}_D$	Density @ 20C/4C
2,4-TDI	22.0°C	1.56781	1.2186
2,6-TDI	18.2°C	1.57111	1.2270

## 8. Sampling

8.1 Since organic isocyanates react with atmospheric moisture, take special precautions in sampling. Usual sampling methods, even when conducted rapidly, can cause contamination of the sample with insoluble urea. Therefore, blanket the sample with dry air or nitrogen at all times. **Warning**—Diisocyanates are eye, skin and respiratory irritants at concentrations above the occupational exposure limit (TLV or PEL). Diisocyanates can cause skin and respiratory sensitization (asthma) in some people. Once sensitized, it is essential to limit further exposure to diisocyanates. Use a combination of engineering controls and personal protective equipment, including respiratory, skin and eye protection, to prevent over-exposure to diisocyanates. Consult the product suppliers' Safety Data Sheet (SDS) for more detailed information about potential health effects and other specific safety and handling instructions for the product.

## 9. Test Conditions

9.1 Since isocyanates react with moisture, keep laboratory humidity low, preferably around 50 % relative humidity.

### TEST METHOD A—SAMPLES CONTAINING 5 TO 95 % 2,6-TDI

## 10. Calibration

10.1 Weigh amounts of pure 2,4-TDI and 2,6-TDI into dry, 10-mL, glass-stoppered flasks (**Note 2**) to obtain the weight ratios given in 10.1.1 or 10.1.2. Carefully shake the mixtures. From the weights of pure 2,4-TDI and 2,6-TDI, calculate the weight ratios (2,4-TDI to 2,6-TDI), or the weight percent composition of the mixtures, or both, expressed to four significant figures.

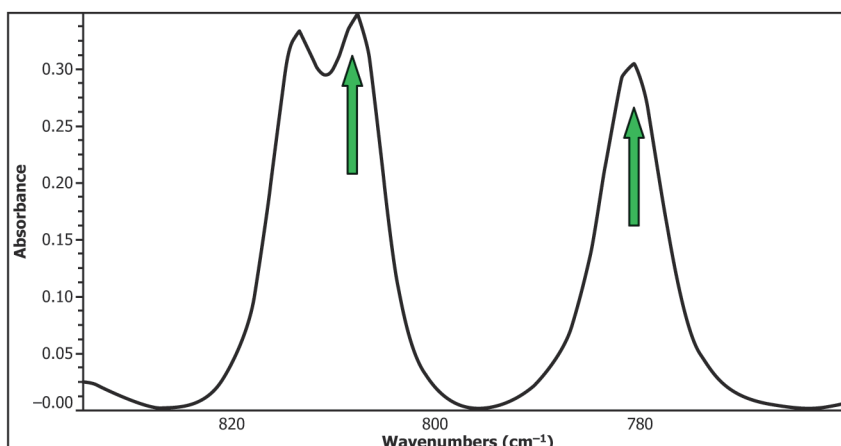


FIG. 1 IR Scan of TDI Showing 2,4-TDI Isomer Doublet at 810  $\text{cm}^{-1}$  and 2,6-TDI Isomer at 782  $\text{cm}^{-1}$

NOTE 2—Carefully dry all glassware since the diisocyanates react readily with moisture.

10.1.1 Approximate standard mixtures for wide-range calibration are given in Table 1 (5-95 % 2,6-TDI).

10.1.2 Approximate standard mixtures for narrow-range calibrations (see Note 3) are given in Table 2 (15-25 % 2,6-TDI) and Table 3 (30-40 % 2,6-TDI).

NOTE 3—Calibration over a narrow range covering the expected isomer ratio gives more accurate results than a wide-range calibration.

10.2 Preparation of Standard Solutions— Using a pipet, transfer 0.80 mL (0.98 g) of standard mixture into a dry, 25-mL glass-stoppered, volumetric flask. Dilute to volume with cyclohexane and mix thoroughly.

10.3 Fill two 0.2-mm sealed, liquid absorption cells (one for a single-beam instrument) with cyclohexane and record its spectrum from 770 to 840 cm<sup>-1</sup>. Refill the sample cell with a standard solution from 10.2 and record the spectrum superimposing it over the previously recorded solvent spectrum. The instrument controls must remain unchanged between the blank and the standards of a given series. Repeat the process for each standard solution from 10.2.

10.4 Using the solvent spectrum as the baseline, measure the absorbance of each standard solution sample at 805 cm<sup>-1</sup> (2,4-TDI) and 782 cm<sup>-1</sup> (2,6-TDI) and calculate the 805/782-cm<sup>-1</sup> absorbance ratio. Construct a calibration curve (see Fig. 2) by plotting absorbance ratio (ordinate) versus weight ratio of 2,4-TDI to 2,6-TDI (abscissa).

10.5 For convenience in short-range calibrations, the absorbance ratio is plotted against the concentration, expressed in weight percent, of each isomer (see Figs. 3 and 2). This allows direct determination of composition without equations, however, the relationship is not linear and the shape of the calibration curve must be carefully determined.

## 11. Procedure

11.1 Using a dry pipet, transfer 0.8 mL (0.98 g) of sample into a dry, 25-mL, glass-stoppered, volumetric flask. Dilute to volume with anhydrous cyclohexane and mix thoroughly. Fill the 0.2-mm cell with the cyclohexane and record the blank solvent spectrum from 770 to 840 cm<sup>-1</sup>. Without changing instrument settings, refill the sample cell with the sample solution and record its spectrum superimposed on the blank solvent spectrum.

TABLE 1 Approximate Standard Mixtures for Wide-Range Calibration, 5–95 % 2,6-TDI

Weight Ratio		
%, 2,4-TDI	%, 2,6-TDI	2,4-/2,6-TDI
5.0	95.0	0.05
10.0	90.0	0.11
20.0	80.0	0.25
30.0	70.0	0.43
40.0	60.0	0.67
50.0	50.0	1.00
60.0	40.0	1.50
70.0	30.0	2.33
80.0	20.0	4.00
90.0	10.0	9.00
95.0	5.0	19.00

TABLE 2 Approximate Standard Mixtures for Narrow-Range Calibration, 15–25 % 2,6-TDI

Weight Ratio		
%, 2,4-TDI	%, 2,6-TDI	2,4-/2,6-TDI
75.0	25.0	3.00
78.5	21.5	3.65
79.0	21.0	3.76
79.5	20.5	3.88
80.0	20.0	4.00
80.5	19.5	4.13
81.0	19.0	4.26
81.5	18.5	4.40
85.0	15.0	5.67

TABLE 3 Approximate Standard Mixtures for Narrow-Range Calibration, 30–40 % 2,6-TDI

Weight Ratio		
%, 2,4-TDI	%, 2,6-TDI	2,4-/2,6-TDI
60.0	40.0	1.50
63.5	36.5	1.74
64.0	36.0	1.77
64.5	35.5	1.82
65.0	35.0	1.86
65.5	34.5	1.90
66.0	34.0	1.94
66.5	33.5	1.98
70.0	30.0	2.33

NOTE 4—All scans of the solvent, standards, and samples are to be ratioed against an open beam background.

## 12. Calculation

12.1 Using the solvent spectrum as the baseline, measure the absorbance of the sample at 805 cm<sup>-1</sup> (2,4-TDI) and 782 cm<sup>-1</sup> (2,6-TDI) and calculate the 805/782-cm<sup>-1</sup> absorbance ratio. From the appropriate standard curve, obtain the percentage composition (Figs. 3 and 2), or isomer weight ratio (*R*), (Fig. 4), or both, that corresponds to the measured absorbance ratio.

12.2 When using the isomer weight ratio, (*R*), calculate the percentage of each isomer as follows:

$$\text{Percent 2,6 - TDI} = \frac{100}{(R + 1)} \quad (1)$$

and

$$\text{Percent 2,4 - TDI} = 100 - \text{percent 2,6 - TDI} \quad (2)$$

12.3 Express the result to one decimal place.

## 13. Precision and Bias

13.1 Precision—Table 4 is based on a round robin conducted in 1994 in accordance with Practice E180 involving two samples tested by eight laboratories. For each material, all the samples were prepared at one source, but the individual specimens were prepared at the laboratories that tested them. Each laboratory obtained ten test results for each material on a given day. Narrow-range calibrations were used.

13.1.1 The following explanations of *r* and *R* (13.1.2 – 13.1.4) are only intended to present a meaningful way of considering the approximate precision of this test method. The data in Table 4 are not to be rigorously applied to the

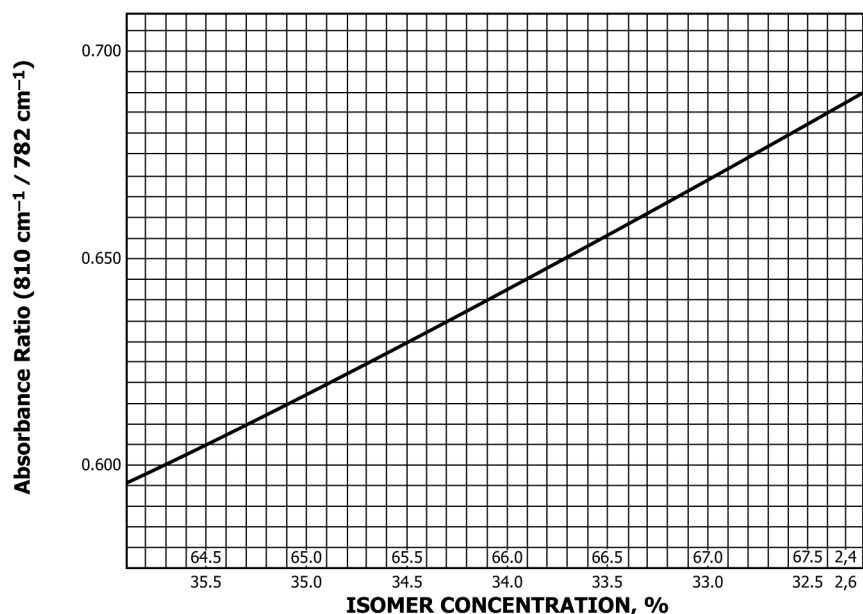


FIG. 2 Calibration Curve Toluene Diisocyanate 65:35 (2,4-TDI : 2,6-TDI)

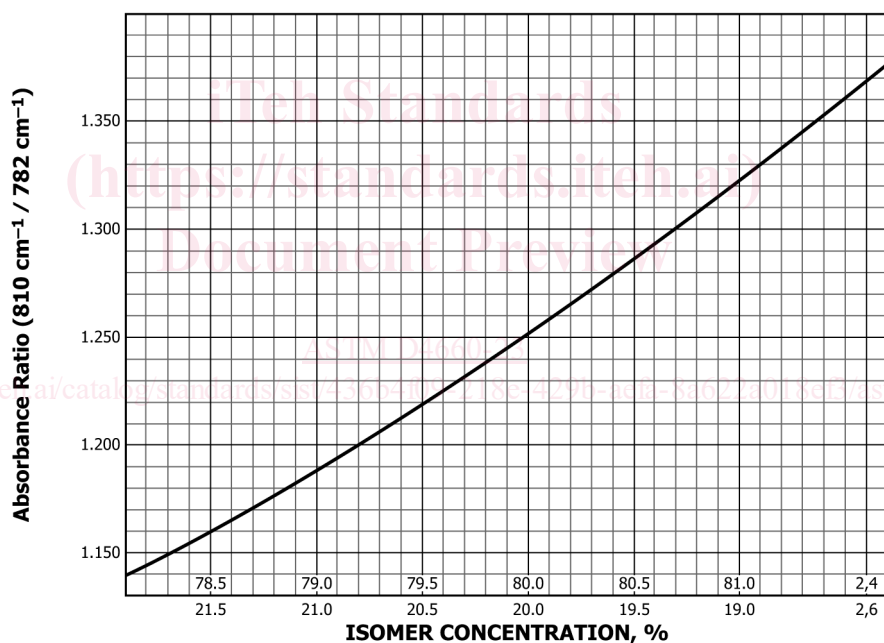


FIG. 3 Calibration Curve Toluene Diisocyanate 80:20 (2,4-TDI : 2,6-TDI)

acceptance or rejection of material, as these data apply only to the materials tested in the round robin and are unlikely to be rigorously representative of other lots, conditions, materials and laboratories. Users of this test method should apply the principles outlined in Practice E180 to generate data specific to their laboratory and materials, or between specific laboratories. The principles of 13.1.2 and 13.1.3 would then be valid for such data.

13.1.2 *Repeatability*—For the data generated above, the maximum expected difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory due solely to the method is 0.21 % for TD-80 and 0.26 % for TD-65.

13.1.3 *Reproducibility*—For the data generated above, the maximum expected difference between two test results for the same material, obtained by different operators using different equipment in different laboratories due solely to the method is 0.45 % for TD-80 and 0.31 % for TD65.

13.1.4 Any judgement in accordance with the repeatability and reproducibility statements shown above would have an approximate 95 % (0.95) probability of being correct.

13.2 *Bias*—There are no recognized standards by which to estimate the bias of this test method.

13.3 For information on equivalence, refer to Practice E2935.