
**Plastics — Aromatic isocyanates for
use in the production of polyurethanes
— Determination of the isomer ratio
in toluenediisocyanate (TDI)**

*Plastiques — Isocyanates aromatiques pour utilisation dans la
production de polyuréthanes — Détermination du rapport des
isomères dans le diisocyanate de toluène (TDI)*

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ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 12, *Thermosetting materials*.

This third edition cancels and replaces the second edition (ISO 15064:2010), which has been technically revised.

The main changes compared to the previous edition are as follows:

- a NOTE has been added to [6.2](#);
- the testing temperature has been added in [Clause 8](#).

Plastics — Aromatic isocyanates for use in the production of polyurethanes — Determination of the isomer ratio in toluenediisocyanate (TDI)

WARNING — Persons using this document should be familiar with normal laboratory practice. This document does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practices and to ensure compliance with any national regulatory conditions prior to use.

1 Scope

This document specifies methods for the measurement of toluene-2,6-diisocyanate in mixtures of the 2,4- and 2,6-isomers. Two methods based on infrared spectroscopy are used to give accurate results over a broad range of isomer concentrations. Method A is applicable to toluenediisocyanate (TDI) samples containing between 5 % and 95 % of the 2,6-isomer. Method B is applicable to TDI samples containing 0 % to 5 % of the 2,6-isomer. Both methods are based on the quantitative measurement of absorption bands arising from out-of-plane C–H deformation vibrations of the aromatic ring at 810 cm^{-1} and 782 cm^{-1} ($12,3\text{ }\mu\text{m}$ and $13,8\text{ }\mu\text{m}$).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 648, *Laboratory glassware — Single-volume pipettes*

ISO 4787, *Laboratory glassware — Volumetric instruments — Methods for testing of capacity and for use*

ISO 6353-2, *Reagents for chemical analysis — Part 2: Specifications — First series*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at <http://www.electropedia.org/>

— ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

isomer

compound having the same percentage composition and molecular mass as another compound, but differing in chemical structure and properties

3.2

isomer content

amount of an *isomer* (3.1) expressed as a mass percentage of the total isomer amount

3.3

polyurethane

polymer prepared by the reaction of an organic di- or polyisocyanate with compounds containing two or more hydroxyl groups

4 Sampling

Since organic isocyanates react with atmospheric moisture, take special precautions in sampling. Usual sampling methods (for example, sampling an open drum with a thief), even when conducted rapidly, can cause contamination of the sample with insoluble ureas; therefore, blanket the sample with a dry inert gas (e.g. nitrogen, argon or dried air) at all times.

WARNING — Organic isocyanates are hazardous when absorbed through the skin or when the vapours are breathed in. Provide adequate ventilation and wear protective gloves and eyeglasses.

5 Principle

5.1 Method A

In method A (between 5 % and 95 % 2,6-isomer), the infrared spectrum of a cyclohexane solution of the sample is recorded in the 770 cm⁻¹ to 840 cm⁻¹ (12 μm to 13 μm) region. The absorbance ratio of the 810 cm⁻¹ and 782 cm⁻¹ bands is measured and converted to % toluene-2,6-diisocyanate from a previously established calibration curve.

5.2 Method B

In method B (0 % to 5 % 2,6-isomer), the absorbance of the 782 cm⁻¹ band is measured from an infrared spectrum of an undiluted sample and then converted to % 2,6-isomer from a previously established calibration curve.

6 Reagents

Reagent-grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that the reagents shall conform to the specifications of ISO 6353-2. Other grades may be used, provided that it is first determined that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

6.1 Cyclohexane, distilled and stored over silica gel to remove traces of moisture.

6.2 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:

for 2,4-TDI: freezing point = 22,0 °C; $n_D^{20} = 1,567\ 81$; $\rho_4^{20} = 1,218\ 6$;

for 2,6-TDI: freezing point = 18,2 °C; $n_D^{20} = 1,571\ 11$; $\rho_4^{20} = 1,227\ 0$.

The diisocyanates can be prepared by phosgenating the corresponding pure amines and vacuum-distilling the products. Since these diisocyanates will react with moisture and can discolour in the presence of air, store them under dry nitrogen.

NOTE Gas chromatography (GC) has also been used to establish purity. Isomers determined to be greater than 99,5 % pure by GC with either thermal conductivity (TCD) or flame ionization (FID) detection have been found suitable to be standards.

7 Apparatus

7.1 Spectrophotometer. Any single- or double-beam recording infrared spectrophotometer, or FTIR spectrophotometer, accurate to 0,2 % transmission and capable of resolving the two peaks of the 2,4-isomer doublet at 810 cm^{-1} .

7.2 Sealed sodium chloride (NaCl) liquid absorption cells, with 0,2 mm (method A) and 0,1 mm (method B) path lengths. The actual path lengths of the cells shall be known to $\pm 0,002\text{ mm}$.

7.3 Glassware, 25 ml glass-stoppered volumetric flasks, 0,80 ml pipette and an all-glass syringe conforming to ISO 648 or ISO 4787.

7.4 Laboratory balance, capable of weighing to $\pm 0,1\text{ mg}$.

8 Test conditions

Since isocyanates react with moisture, keep laboratory humidity low, preferably under 50 % relative humidity. Thoroughly dry all laboratory ware. Store cells (7.2) in a dessicator and use thin rubber or plastic gloves while handling. Testing is done at room temperature (typically $18\text{ }^{\circ}\text{C}$ to $27\text{ }^{\circ}\text{C}$).

9 Method A — Samples containing between 5 % and 95 % of 2,6-TDI

9.1 Calibration

9.1.1 Weigh the amounts of pure 2,4- and 2,6-TDI given in [Table 1](#), [2](#) or [3](#) as appropriate for the calibration range desired. Calibration over a narrow range gives more accurate results than a wide-range calibration.

9.1.2 Prepare standard solutions and calibration curves as follows.

9.1.2.1 Using a pipette, transfer 0,80 ml (0,98 g) of each standard isomer mixture into dry, 25 ml glass-stoppered volumetric flasks ([7.3](#)). Dilute each to volume with cyclohexane ([6.1](#)) and mix thoroughly.

9.1.2.2 Fill two 0,2 mm sealed, liquid absorption cells (one for a single-beam instrument) with cyclohexane and record the spectrum from 770 cm^{-1} to 840 cm^{-1} ($12\text{ }\mu\text{m}$ to $13\text{ }\mu\text{m}$). Refill the sample cell with a solution from [9.1.2.1](#) and record the spectrum, superimposing it over the previously recorded solvent spectrum. Repeat the process for each solution in [9.1.2.1](#).

9.1.2.3 Using the solvent spectrum as the baseline, measure the absorbance of each standard solution at 810 cm^{-1} (2,4-TDI) and 782 cm^{-1} (2,6-TDI) and calculate the $810/782\text{ cm}^{-1}$ absorbance ratio. See [Figure A.4](#) for an illustrative spectrum. Construct a calibration curve (see [Figure A.1](#)) by plotting absorbance ratio (ordinate) versus mass ratio of 2,4- to 2,6-TDI (abscissa).

9.1.2.4 For convenience in narrow-range calibrations, the absorbance ratio may be plotted against the concentration (expressed in mass %) of each isomer (see [Figure A.2](#) and [Figure A.3](#)). This allows direct

determination of composition without equations. However, the relationship is not linear and the shape of the calibration curve shall be carefully determined.

Table 1 — Approximate standard mixtures for wide-range 2,4-/2,6-TDI calibration

Mass 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 80 % 2,4-/20 % 2,6-TDI samples

Mass 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 65 % 2,4-/35 % 2,6-TDI samples

Mass 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

9.2 Procedure

Using a pipette (7.3), transfer 0,80 ml (0,98 g) of sample into a dry, glass-stoppered volumetric flask (7.3). Dilute to volume with cyclohexane (6.1) and mix thoroughly. Fill a 0,2 mm cell with the solution and record the spectrum from 770 cm^{-1} to 840 cm^{-1} (12 μm to 13 μm) and, without changing the instrument settings, refill the sample cell with pure solvent and record its spectrum superimposed on the sample spectrum.

9.3 Expression of results

9.3.1 Using the solvent spectrum as the baseline, measure the absorbance of the sample at 810 cm^{-1} (2,4-TDI) and 782 cm^{-1} (2,6-TDI) and calculate the 810/782 cm^{-1} absorbance ratio. Read from the appropriate calibration curve the isomer mass ratio (Figure A.1) or percentage composition (Figures A.2 and A.3) that corresponds to the measured absorbance ratio.

9.3.2 When using the isomer mass ratio, calculate the percentage of each isomer using Formula (1) and Formula (2):

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

and

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

where R is the isomer mass ratio from Figure A.1.

9.3.3 Use of Figure A.2 or A.3 gives mass % of 2,4-TDI directly from the calibration curve. The 2,6-TDI content is calculated using Formula (3):

$$\% \text{ 2,6-TDI by mass} = 100 - \% \text{ 2,4-TDI} \quad (3)$$

9.3.4 Record the results to one decimal place.

9.4 Precision and bias

9.4.1 Precision

Use the following criteria to judge the acceptability of results. Values were obtained in an interlaboratory test involving two samples (80:20 and 65:35 TDI) tested by eight laboratories. Each laboratory obtained 10 test results for each material on a given day.

Repeatability: Duplicate results obtained by the same analyst using the same equipment on the same day shall only be considered suspect if they differ by more than $\pm 0,23$ % of isomer (narrow-range calibration).

Reproducibility (multilaboratory): Results, each the mean of duplicates, obtained on identical material in separate laboratories shall only be considered different if they differ by more than $\pm 0,39$ % of isomer (narrow-range calibration).

9.4.2 Bias

Bias is the difference between the expectation of the test results and an accepted reference value. The bias for this test method has not been determined.

9.5 Test report

The test report shall include the following information:

- a reference to this document, i.e. ISO 15064;
- all details necessary to identify the product analysed (such as manufacturer, product type, lot or notebook numbers, date of manufacture, as required);
- the results obtained, expressed as % isomer to the nearest 0,1 %;
- the date of the analysis;
- any incident or detail not stipulated in this document which might have influenced the result.

10 Method B — Samples containing 0 % to 5 % of 2,6-TDI

10.1 Calibration

10.1.1 Using pure isomers, prepare the series of calibration mixtures given in [Table 4](#).

Table 4 — Approximate standard mixtures for 2,4-TDI samples

Mass of 2,4-TDI g	Mass of 2,6-TDI g	2,6-TDI %
5,000	0,000	0,00
4,975	0,025	0,50
4,950	0,050	1,00
4,900	0,100	2,00
4,850	0,150	3,00
4,800	0,200	4,00
4,750	0,250	5,00

10.1.2 Using a 0,1 mm sealed liquid absorption cell ([7.2](#)), record the spectrum of each of the above seven mixtures from 770 cm^{-1} to 840 cm^{-1} .

10.1.3 For each of the calibration samples, measure the absorbance of the 2,6-isomer band at 782 cm^{-1} from a baseline-drawn tangent to the band shoulders. Draw a calibration curve by plotting absorbance versus concentration of the 2,6-isomer.

10.2 Procedure

10.2.1 Fill a 0,1 mm cell ([7.2](#)) with the sample and obtain the spectrum from 770 cm^{-1} to 840 cm^{-1} .

10.2.2 Measure the absorbance of the 2,6-isomer band at 782 cm^{-1} and read the % 2,6-isomer content from the calibration curve.

10.3 Expression of results

10.3.1 The 2,6-isomer content, expressed as mass % 2,6-TDI, is read directly from the calibration curve and reported to the nearest 0,1 % 2,6-TDI.

10.3.2 The 2,4-TDI isomer content can be calculated using [Formula \(4\)](#):

$$\% \text{ 2,4-TDI by mass} = 100 - \% \text{ 2,6-TDI} \quad (4)$$

where

% 2,6-TDI is the 2,6-isomer content (defined in [10.3.1](#)).

10.4 Precision and bias

10.4.1 Precision

Use the following criteria to judge the acceptability of results.

Repeatability: Duplicate results obtained by the same analyst using the same equipment on the same day shall only be considered suspect if they differ by more than $\pm 0,15\%$ 2,6-TDI (narrow-range calibration).

Reproducibility (multilaboratory): Results, each the mean of duplicates, obtained on identical material in separate laboratories shall only be considered different if they differ by more than $\pm 0,25\%$ 2,6-TDI (narrow-range calibration).

10.4.2 Bias

Bias is the difference between the expectation of the test results and an accepted reference value. The bias for this test method has not been determined.

10.5 Test report

The test report shall include the following information:

- a) a reference to this document, i.e. ISO 15064;
- b) all details necessary to identify the product analysed (such as manufacturer, product type, lot or notebook numbers, date of manufacture, as required);
- c) the results obtained, expressed as % isomer to the nearest 0,1 %;
- d) the date of the analysis;
- e) any incident or detail not stipulated in this document which might have influenced the result.

Annex A
(normative)

Calibration curves



Key

X mass ratio (2,4-TDI/2,6-TDI)

Y absorbance ratio (810 cm⁻¹/782 cm⁻¹)

Figure A.1 — Calibration curve for 80:20 toluenediisocyanate