

*Contains Nonbinding Recommendations*  
**Draft Guidance on Tiotropium Bromide**

This draft guidance, when finalized, will represent the current thinking of the Food and Drug Administration (FDA, or the Agency) on this topic. It does not establish any rights for any person and is not binding on FDA or the public. You can use an alternative approach if it satisfies the requirements of the applicable statutes and regulations. To discuss an alternative approach, contact the Office of Generic Drugs.

**Active Ingredient:** Tiotropium bromide

**Dosage Form; Route:** Powder; inhalation

**Strength:** EQ 0.018 mg base/INH

**Recommended Studies:** In vitro and in vivo studies

FDA recommends the following in vitro and in vivo studies to establish bioequivalence (BE) of the test (T) and reference (R) dry powder inhalers (DPIs) containing tiotropium bromide.

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### **In Vitro Studies**

FDA recommends that applicants conduct the following in vitro studies for the T and R products. Use at least three batches each of T and R products, with no fewer than 10 units from each batch. The three batches of T product should be manufactured from, at minimum, three different batches of drug substance(s), excipient(s), and container/closure system.

1. Type of study: Single actuation content (SAC)

Design: The SAC test should be performed at the beginning (B), middle (M), and end (E) lifestages<sup>1</sup> of the product using flow rates of 20 L/min, 39 L/min and 60 L/min. U.S. Pharmacopeia (USP) <601> Apparatus B or another appropriate apparatus may be used to determine the SAC using a validated assay. The number of capsules used per determination should be one. The number of actuations per capsule should be two. The volume of air drawn through the delivery system per actuation should be 2 L.

**Equivalence based on:** Population bioequivalence (PBE) analysis of SAC. Please refer to the product-specific recommendation for Budesonide Inhalation Suspension for additional information regarding PBE.<sup>2</sup>

2. Type of study: Aerodynamic particle size distribution (APSD)

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<sup>1</sup> Based on the labeled number of actuations, the terms, B lifestage, M lifestage, and E lifestage represent the first actuation(s), the actuation(s) corresponding to 50 percent of the labeled number of actuations, and the actuation(s) corresponding to the labeled number of actuations, respectively.

<sup>2</sup> <http://www.fda.gov/downloads/Drugs/GuidanceComplianceRegulatoryInformation/Guidances/UCM319977.pdf>

**Design:** The APSD test should be performed at the B and E lifestages of the product using flow rates of 20 L/min, 39 L/min and 60 L/min. The USP <601> Apparatus 3, Apparatus 5, or another appropriate method may be used to determine APSD using a validated assay. The APSD determination of each unit should be performed with a minimum number of capsules justified by the sensitivity of the validated assay. The volume of air drawn through the delivery system should be 4 L.

**Additional comments:** Drug deposition on individual sites, including the mouthpiece adapter, the induction port, the pre-separator, and each stage of the cascade impactor (CI) and the filter, is requested. Mass balance accountability should be reported based on the sum of all deposition sites. For electronic submission of the individual CI data for the T and R products, provide a table using the format in the appendix, and send them as part of the abbreviated new drug application (ANDA) submission for BE evaluation.

**Equivalence based on:** PBE analysis of impactor-sized mass (ISM).<sup>3</sup> The CI profiles representing drug deposition on the individual stages of the CI along with the mass median aerodynamic diameter (MMAD), geometric standard deviation (GSD) and fine particle mass (FPM) should be submitted as supportive evidence for equivalent APSD.

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## Pharmacokinetic Study

FDA recommends that applicants conduct the following pharmacokinetic (PK) BE study for the T and R products.

3. **Type of study:** Fasting

**Design:** Single-dose, two-way crossover

**Dose:** Minimum number of inhalations that is sufficient to characterize a PK profile by using a sensitive analytical method

**Subjects:** Healthy males and non-pregnant females, general population

**Additional comments:** (1) Subjects enrolled for in vivo studies should be trained in the use of the inhalation powder in a standard fashion, prior to each treatment session, to assure a relatively consistent inspiratory flow rate and inspiratory duration. (2) Subjects should adhere to labeling as follows: “Must breathe in 2 times from the same capsule.” (3) A Bio-IND is required prior to conduct of the PK study if the dose exceeds the maximum labeled single dose.

**Analyte(s) to measure (in appropriate biological fluid):** Tiotropium in plasma

**Equivalence based on:** AUC and  $C_{max}$  for tiotropium. The 90% confidence intervals for the geometric mean T/R ratios of AUC and  $C_{max}$  should fall within the limits of 80.00 - 125.00%.

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<sup>3</sup> ISM is defined as a sum of the drug mass on all stages of the CI plus the terminal filter, but excluding the top CI stage because of its lack of a specified upper cut-off size limit.

## Comparative Clinical Pharmacodynamic Study

FDA recommends that applicants conduct the following comparative clinical pharmacodynamic (PD) BE study for the T and R products.

4. Type of study: Comparative clinical PD BE study

Design: This study could be either of crossover or parallel-group design, taking into consideration the patient population and the current standard-of-care treatment for chronic obstructive pulmonary disease (COPD), and should include appropriate justification for the design chosen. The study should be randomized, single-dose, blinded (where possible) and placebo-controlled, at minimum consisting of a 2-week run-in period (to allow for washout of anticholinergic agents, as well as chronic long-acting beta-agonists and chronic inhaled corticosteroids) followed by a one-day treatment period of the placebo, T, or R product.

Strength: EQ 0.018 mg base/inh (tiotropium bromide inhalation powder)

Dose: 0.018 mg tiotropium, single-dose (2 inhalations from the same capsule)

Subjects: Males and non-pregnant females with COPD. The study may enroll all COPD patients who meet the inclusion and exclusion criteria, or may be enriched with patients who demonstrate  $\geq 15\%$  reversibility to bronchodilator therapy (appropriate justification should be included for the population chosen).

Inclusion and exclusion criteria:

Inclusion criteria should, at minimum, include:

- a. Adult ( $\geq 40$  y. o.) male or female subjects of non-child-bearing potential or of child-bearing potential but committed to consistent use of an acceptable method of birth control
- b. Diagnosis of COPD, as defined by American Thoracic Society (ATS) [GOLD criteria]
- c. Post-bronchodilator  $FEV_1 \leq 80\%$
- d. Post-bronchodilator  $FEV_1/FVC$  ratio  $\leq 0.70$
- e. Current or former smokers (e.g., with history of  $\geq 10$  pack-years)
- f. Willingness to give their written informed consent to participate in the study

Exclusion criteria should, at minimum, include:

- a. Known respiratory disorders other than COPD including, but not limited to the following: alpha-1 antitrypsin deficiency, cystic fibrosis, significant asthma, active bronchiectasis, sarcoidosis, lung fibrosis, pulmonary hypertension, pulmonary edema, or interstitial lung disease
- b. Evidence or history of other clinically significant disease or abnormality (such as congestive heart failure, uncontrolled hypertension, uncontrolled coronary artery disease, myocardial infarction, stroke, glaucoma, or cardiac dysrhythmia), which, in the opinion of the investigator, would put the patient at risk through study participation, or would affect the study analyses if the disease exacerbated during the study
- c. Known active tuberculosis
- d. History of paradoxical bronchospasm, narrow-angle glaucoma, prostatic hyperplasia, bladder neck obstruction, or any other condition, which, in the opinion of the investigator, would contraindicate the use of an anticholinergic agent

- e. History of allergy or hypersensitivity to anticholinergic/muscarinic receptor antagonist agents, beta-2 adrenergic agonists, lactose/milk proteins, or specific intolerance to aerosolized tiotropium-containing products or known hypersensitivity to any of the proposed ingredients or components of the delivery system
- f. Hospitalization for COPD or pneumonia within 12 weeks prior to the initiation of the study
- g. Treatment for COPD exacerbation within 12 weeks prior to study
- h. Inability to discontinue COPD medications during the run-in and treatment periods
- i. Acute (viral or bacterial) upper or lower respiratory tract infection, sinusitis, rhinitis, pharyngitis, urinary tract infection or illness within 6 weeks prior to the initiation of the study
- j. Abnormal and significant electrocardiogram (ECG) finding prior to the screening, during the run-in and treatment periods
- k. Lung volume reduction surgery within 12 months prior to the initiation of the study
- l. Chronic oxygen use for >12 hours/day

Additional comments:

- a. A clear list of permitted and restricted medications should be provided, including justification for use (or restriction) of certain classes of respiratory therapies, that considers the current standard-of-care for COPD.
- b. All spirometry should be conducted in accordance with ATS standards.
- c. The study protocol should list appropriate withholding times prior to spirometry for permitted concomitant medications (e.g., 4 hours for short-acting beta-agonists, 12 or 24 hours for long-acting beta-agonists).
- d. The study should begin with a placebo run-in period (at least 2 weeks in duration; appropriate justification should be included for the duration chosen) to washout any pre-study long-acting anticholinergic agents and to establish FEV<sub>1</sub> baseline values.
- e. To ensure adequate study sensitivity, the T and R products should both be statistically superior to placebo ( $p < 0.05$ ) with regard to the BE study primary endpoint.
- f. It is the sponsor's responsibility to enroll a sufficient number of subjects for the study to demonstrate BE of the T to the R product.
- g. All adverse events (AEs) should be reported, whether or not they are considered to be related to the treatment. The report of AEs should include date of onset, description of the AE, severity, relation to study medication, action taken, outcome and date of resolution.
- h. Appropriate pre-defined withdrawal criteria should be described for patients who may require withdrawal during washout period due to COPD exacerbation or inability to tolerate withdrawal of baseline therapy.
- i. Subjects who discontinued from the study early should be identified, and the protocol should clearly, prospectively state how missing data will be handled in the statistical analyses and provide appropriate justification for the method chosen. The protocol should also include subject retention strategies and other plans to minimize missing data. If there are missing data, adequate justification should be provided that the missing data do not lead to biased equivalence determination. Detailed information for all subjects who are discontinued from the study should be provided.

**BE study primary endpoint:** Area under the serial FEV<sub>1</sub>-time curve calculated from time zero to 24 hours (AUC<sub>0-24h</sub>) following the treatment.

The above BE study endpoint should be baseline-adjusted (change from baseline). FEV<sub>1</sub> measurements should be performed and interpreted in accordance with ATS guidelines.

Serial spirometry (FEV<sub>1</sub>) should be measured at 0, 5 and 30 min, 1, 2, 4, 6, 8, 10, 12, 23 and 24 hours post-dose.

For each treatment group, time to peak bronchodilator response (T<sub>max</sub>) and FEV<sub>1</sub> values at all measurement times within each evaluation period should be included in the final study report.

**Equivalence based on:** T/R ratio for the primary endpoint. The 90% confidence intervals for the T/R ratios for the BE study endpoint should fall within 80.00 - 125.00%.

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## Additional Information

### Formulation:

FDA recommends that the T product be qualitatively (Q<sub>1</sub>)<sup>4</sup> and quantitatively (Q<sub>2</sub>)<sup>5</sup> the same as the R product.

If a sponsor seeks approval of a formulation that is not Q<sub>2</sub> the same as the R product, the sponsor should explain the reason(s) for not using a T formulation that is Q<sub>2</sub> the same as the R formulation. In addition, the sponsor should provide pharmaceutical development data involving in vitro testing of multiple drug-to-excipient ratios that encompass combinations below and above the ratios used in the T and R products.

### Device:

Sponsors should refer to FDA's Guidance for Industry entitled, *Comparative Analyses and Related Comparative Use Human Factors Studies for a Drug-Device Combination Product Submitted in an ANDA* (January 2017)<sup>6</sup>, which, when finalized, will provide the Agency's current thinking on the identification and assessment of any differences in the design of the user interface for a proposed generic drug- device combination product when compared to its RLD.

FDA recommends that applicants consider the following characteristics of the R product when designing the T product:

- Passive (breath-actuated) device
- Pre-metered single-unit dose capsule-based format

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<sup>4</sup> Q<sub>1</sub> (qualitative sameness) means that the test product uses the same inactive ingredient(s) as the reference product.

<sup>5</sup> Q<sub>2</sub> (quantitative sameness) means that concentrations of the inactive ingredient(s) used in the test product are within ± 5% of those used in the reference product.

<sup>6</sup> <https://www.fda.gov/ucm/groups/fdagov-public/@fdagov-drugs-gen/documents/document/ucm536959.pdf>

- Number of doses of the R product
- External operating principles and external critical design attributes of the R product
- Size and shape of the R product
- Device resistance of the R product

In addition, in vitro and in use studies should be conducted to support the functionality, accuracy and robustness of the proposed T product.

## APPENDIX

Variable Name	Variable Type	Content	Notes
Product Name	Character	TEST or REF	Identifier for product
LOT Number	Alphanumeric/Numeric	Alphanumeric/Numeric	Identifier for product lot
UNIT Number	Numeric	Numeric values	Identifier for unit must be unique for each product (e.g. #1-30 for test and #31-60 for ref).
Stage 1	Numeric	Numeric Values	S1
Stage 2	Numeric	Numeric Values	S2
Stage 3	Numeric	Numeric Values	S3
Stage 4	Numeric	Numeric Values	S4
Stage 5	Numeric	Numeric Values	S5
Stage 6	Numeric	Numeric Values	S6
Stage 7	Numeric	Numeric Values	S7
Stage 8 or Filter	Numeric	Numeric Values	S8
ISM	Numeric	Numeric Values	ISM
MMAD	Numeric	Numeric Values	MMAD
GSD	Numeric	Numeric Values	GSD
FPM	Numeric	Numeric Values	FRM

Example

PRODUCT	LOT	Unit	S1	S2	S3	S4	S5	S6	S7	S8 or Filter	ISM	MMAD	GSD	FPM
TEST	1234	1												
		2												
		3												
		4												
		5												
		6												
		7												
		8												
		9												
		10												

