

Draft Guidance on Epinephrine

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Active Ingredient:	Epinephrine
Dosage Form; Route:	Aerosol, metered; inhalation
Strengths:	0.125 mg/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) metered dose inhalers (MDIs) containing epinephrine.

In Vitro BE Studies

FDA recommends that prospective applicants conduct the following in vitro studies for the T and R products. Use at least three batches each of the T and R products, with no fewer than 10 units from each batch. FDA recommends that three primary stability batches be also used to demonstrate in vitro BE. The three batches of T product should be manufactured from, at minimum, three different batches of drug substance(s), excipient(s), and device components. The T product should consist of the final device constituent part and final drug constituent formulation intended to be marketed.

1. Type of study: Single actuation content (SAC)
Design: The SAC test should be performed at the beginning (B), middle (M), and end (E) lifestages¹ of the product, using a flow rate of 28.3 L/min. U.S. Pharmacopoeia (USP) <601> Apparatus A or other appropriate apparatus may be used to determine the SAC using a validated assay. The number of actuations per determination should be one.

Equivalence based on: Population bioequivalence (PBE) analysis of SAC. Refer to the product-specific guidance for *Budesonide Inhalation Suspension* for additional information regarding PBE analysis procedures.

2. Type of study: Aerodynamic Particle Size Distribution (APSD)

¹ Based on the labeled number of actuations, the terms B lifestage, M lifestage, and E lifestage represent the first actuation(s) following the labeled number of priming actuations, 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.

Design: The APSD test should be performed at the B and E lifestages of the product using a flow rate of 28.3 L/min or 30 L/min. The USP <601> Apparatus 1, Apparatus 6, or other 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 actuations justified by the sensitivity of the validated assay.

Additional comments: Drug deposition on individual sites, including the mouthpiece adapter, the induction port, each stage of the 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).² 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.

3. Type of study: Spray pattern

Design: The spray pattern test should be performed at the B lifestage of the product at two different distances from the actuator orifice. The selected distances should be at least 3 cm apart and based on the range of 3 to 7 cm from the R actuator mouthpiece.³

Impaction (thin-layer chromatography plate impaction), non-impaction (laser light sheet technology), or other suitable method may be used to determine the spray pattern.

Additional comments: The spray pattern test should be measured quantitatively in terms of ovality ratio and area within the parameter of the true shape (to include a high proportion, e.g., 95% of the total pattern) for the automated analysis or ovality ratio and D_{max} for the manual analysis. Ovality ratio is defined as the ratio of D_{max} to D_{min} . D_{max} and D_{min} are the longest and shortest diameters, respectively. The number of sprays per spray pattern would preferably be one.

Equivalence based on: At two selected distances, (i) qualitative comparison of spray shape, and (ii) PBE analysis of ovality ratio and area within the perimeter of the true shape or ovality ratio and D_{max} .

4. Type of study: Plume geometry

Design: The plume geometry test should be performed at the B lifestage of the product. The timed-sequence sound-triggered flash photography method, laser light sheet technology, or other suitable method may be used to determine the plume geometry at the appropriate post-actuation delay time.

² 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 cutoff size limit.

³ The distance between the actuator orifice and point of spray pattern measurement should be same for T and R.

Additional comments: Plume geometry measurements should be reported at a single delay time while the fully developed plume is still in contact with the actuator mouthpiece. Plume geometry should be measured quantitatively in terms of plume angle and width. The plume angle is based on the conical region of the plume extending from the vertex that occurs at or near the actuator mouthpiece. The plume width is measured at a distance equal to the greater of the two distances selected for characterization of the spray pattern.

Equivalence based on: Ratio of the geometric mean of the three batches of T to that of the three batches of R (based on log transformed data) for plume angle and width, which should fall within 90-111%.

5. Type of study: Priming and repriming

Design: The priming and repriming tests should take into consideration the emitted dose (ex-mouthpiece) of a single actuation immediately following the specified number of priming or repriming actuations specified in the R product labeling. The repriming test should be performed following storage for the specified period of non-use after initial use and/or other conditions (e.g., dropping), if the R product labeling provides such repriming information.

Additional comments: For BE evaluation, the priming and repriming tests should be based on products stored in the upright position, with the exception of MDIs for which the R labeling recommends storage in the valve down position. The priming data can be based on the SAC data at the B lifestage.

Equivalence based on: PBE analysis of the emitted dose of a single actuation immediately following the specified number of priming or repriming actuations specified in the R product labeling.

Pharmacokinetic (PK) BE Study

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

6. 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: Adult males and non-pregnant females, general population

Analyte to measure: Epinephrine in plasma

Additional comments: (1) Since epinephrine is an endogenous substance, the plasma concentrations of epinephrine should be corrected for baseline endogenous levels by subtracting the mean pre-dose baseline value (average of at least three pre-dose values, e.g., -1, -0.5, and 0 hours). Any negative values obtained from baseline correction at time

0 hour should be designated as zero (0) and any subject with pre-dose concentration more than 5% of their C_{max} should be excluded from BE statistical analysis and the 90% confidence intervals based on the remaining subjects. Both baseline corrected and baseline uncorrected data should be submitted in the application. (2) Subjects enrolled for in vivo studies should be trained in the use of the inhalation aerosols in a standard fashion, prior to each treatment session, to assure a relatively consistent inspiratory flow rate and inspiratory duration. (3) A Bio-IND is required prior to conduct of the PK study if the dose exceeds the maximum labeled single dose.

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

Comparative Clinical Pharmacodynamic (PD) Study

7. Type of study: Comparative clinical PD 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 asthma, 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: 0.125 mg/Inh

Dose: 0.125 mg, single dose (i.e., one inhalation from 0.125 mg/Inh epinephrine metered inhalation aerosol)

Inclusion and exclusion criteria should, at a minimum, include:

- a. Adult male or female subjects of non-childbearing or of childbearing potential committing to consistent and correct use of an acceptable method of birth control.
- b. Diagnosis of asthma as defined by the National Asthma Education and Prevention Program⁴ at least 12 months prior to screening.
- c. Pre-bronchodilator FEV₁ of ≥ 50.0 and ≤ 85.0 % of predicted normal value during the screening visit and on the first day of treatment.
- d. Reversible airway obstruction as demonstrated by an improvement of 15 % or more in FEV₁ 30 minutes after two inhalations (2 x 0.125 mg) of R inhalation aerosol, metered.

⁴ Guidelines for the Diagnosis and Management of Asthma: Expert Panel Report 3. National Education and Prevention Program; National Institute of Health; National Heart, Lung, and Blood Institute. 2007, Publication No. 07-4051

- e. Patients should be stable on their chronic asthma treatment regimen for at least 4 weeks prior to enrollment.
- f. Currently non-smoking; had not used tobacco products (i.e., cigarettes, cigars, pipe tobacco) within the past year, and having had ≤ 10 pack-years of historical use.
- g. Ability to replace current short-acting β agonist (SABAs) with salbutamol/albuterol inhaler for use as needed for the duration of the study. Subjects should be able to withhold all inhaled SABAs for at least 6 hours prior to lung function assessments on study visits.
- h. Ability to discontinue their asthma medications (e.g., inhaled corticosteroids and long-acting β agonists) during the run-in period and for remainder of the study.
- i. Willingness to give their written informed consent to participate in the study.

Exclusion criteria should, at minimum, include:

- a. Life-threatening asthma, defined as a history of asthma episodes(s) requiring intubation, and/or associated with hypercapnia, respiratory arrest, or hypoxic seizures, asthma related syncopal episode(s), or hospitalizations within the past year prior to the screening or during the run-in period.
- b. Significant respiratory disease other than asthma (e.g., COPD, interstitial lung disease, cystic fibrosis, bronchiectasis, tuberculosis, chronic bronchitis, and emphysema).
- c. Evidence of respiratory tract infection within six weeks prior to the study.
- d. Evidence or history of clinically significant disease or abnormality including: congestive heart failure, uncontrolled hypertension, uncontrolled coronary artery disease, myocardial infarction, or cardiac dysrhythmia. In addition, historical or current evidence of significant hematologic, hepatic, neurologic, psychiatric, renal, or other diseases that, in the opinion of the investigator, would put the patient at risk through study participation, or would affect the study analyses if the disease exacerbates during the study.
- e. Asthma exacerbations that required emergency care or hospitalized treatment within 4 weeks prior to screening.
- f. Patients receiving β_2 -blockers, anti-arrhythmics, anti-depressants, and/or monoamine oxidase inhibitors within 4 weeks prior to the screening.

- g. Hypersensitivity to any sympathomimetic drug (e.g., albuterol) or any of the excipients in the study drugs or rescue medication formulation.
- h. Patients receiving systemic, oral, parenteral, or depot corticosteroids, or other immunosuppressive medications within 4 weeks prior to screening and during the study.

Additional comments:

- The study may enroll all asthma patients who meet the inclusion and exclusion criteria or may be enriched by using a subpopulation of patients predicted to respond well to the study treatment (appropriate justification should be included for the population chosen for study).
- Subjects who discontinue 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.
- All spirometry should be conducted in accordance with American Thoracic Society Standards.
- The study should begin with a placebo run-in period at least two weeks in duration, to wash out any pre-study corticosteroids/long-acting bronchodilators and to establish FEV1 baseline values.
- The study protocol should include pre-specified definitions of asthma exacerbation, as well as pre-specified and appropriate escape criteria with consideration to patient safety.
- The study protocol should provide a definition of compliant subjects (e.g., used at least 75% and no more than 125% of study drug doses) and specify how compliance will be verified (e.g., by the use of subject diaries).
- To ensure study sensitivity, the T and R products should both be statistically superior to placebo ($p < 0.05$) with regard to the BE study endpoint.
- It is the prospective applicant's responsibility to enroll a sufficient number of subjects for the study to demonstrate BE of the T to the R product.

- A clear list of permitted and restricted medications should be provided, including justification for use (or restriction) of certain classes of respiratory therapies, considering the current standard of care for asthma.
- The start and stop date of concomitant medication use during the study should be provided in the data set in addition to the reason for the medication use. The prospective applicant should clearly explain whether the medication was used prior to baseline visit, during the study or both.
- All adverse events (AEs) should be reported, whether or not they are considered to be related to the treatment. The report of each AE should include the date of onset, description of AE, severity, relation to study medication, action taken, outcome, and date of resolution. The information will assist FDA in determining whether the incidence and severity of adverse reactions is different between the T and R products.

BE study endpoint: Area under the serial FEV₁-time curve calculated from time zero to 4 hours (AUC_{0-4h}) following the treatment.

The above BE study endpoint should be baseline-adjusted (change from baseline). FEV₁ measurements should be performed and interpreted in accordance with ATS guidelines.

Serial spirometry (FEV₁) should be measured at 0, 10, 15, 30, 60, 90, and 120 minutes, and 3 and 4 hours post-dose.

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

Additional information

Formulation:

- FDA recommends that the T formulation be qualitatively (Q1)⁵ and quantitatively (Q2)⁶ the same as the R formulation.

Device:

- Prospective applicants should refer to FDA's guidance for industry *Comparative Analyses and Related Comparative Use Human Factors Studies for a Drug-Device Combination Product Submitted in an ANDA* (January 2017), which, when

⁵ Q1 (qualitative sameness) means that the test formulation uses the same inactive ingredient(s) as the reference formulation.

⁶ Q2 (quantitative sameness) means that the concentrations of the inactive ingredient(s) used in the test formulation are within ±5% of those used in the reference formulation.

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 prospective applicants consider the following characteristics of the R product when designing the T product:

- Size and shape of the R product
- Number of doses in the R product
- External operating principles and external critical design attributes of the R product
- Dose indicator/counter

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												