**Metformin Hydrochloride Extended-Release Tablets**

<table>
<thead>
<tr>
<th>Type of Posting</th>
<th>Revision Bulletin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posting Date</td>
<td>18-Dec-2020</td>
</tr>
<tr>
<td>Official Date</td>
<td>1-Jan-2021</td>
</tr>
<tr>
<td>Expert Committee</td>
<td>Small Molecules 3</td>
</tr>
</tbody>
</table>

In accordance with the Rules and Procedures of the Council of Experts, the Small Molecules 3 Expert Committee has revised the Metformin Hydrochloride Extended-Release Tablets monograph. The purpose for the revision is to add *Dissolution Test 23* to accommodate FDA-approved drug products with different dissolution conditions and/or tolerances than the existing dissolution tests.

*Dissolution Test 23* was validated using an Agilent Zorbax SB-C18 brand of 4.6-mm x 15-cm, 5-μm column with L1 packing. The typical retention time for metformin is about 2 min.

The Metformin Hydrochloride Extended-Release Tablets Revision Bulletin supersedes the currently official monograph.

Should you have any questions, please contact Andrea F. Carney, Scientific Liaison (301-816-8155 or afc@usp.org).
Metformin Hydrochloride Extended-Release Tablets

**DEFINITION**
Metformin Hydrochloride Extended-Release Tablets contain NLT 90.0% and NMT 110.0% of the labeled amount of metformin hydrochloride (C₄H₁₁N₅ · HCl).

**IDENTIFICATION**
- A. The retention time of the major peak from the *Sample solution* corresponds to that from the *Standard solution*, as obtained in the *Assay*.

**ASSAY**
- **Procedure**
  - *Buffer solution*: 0.5 g/L of *sodium 1-heptanesulfonate* and 0.5 g/L of *sodium chloride* in water. Before final dilution, adjust with 0.06 M *phosphoric acid* to a pH of 3.85.
  - *Mobile phase*: *Acetonitrile* and *Buffer solution* (1:9). [Note—To improve the separation, the composition of *acetonitrile* and *Buffer solution* may be changed to 1:19, if necessary.]
  - *Diluent*: 1.25% solution of *acetonitrile* in water
  - *Standard solution*: (L/4000) mg/mL of *USP Metformin Hydrochloride RS* in *Diluent*, where L is the labeled quantity, in mg, of metformin hydrochloride in each Tablet
  - *System suitability stock solution*: 12.5 μg/mL each of *USP Metformin Related Compound B RS* and *USP Metformin Related Compound C RS* in *Diluent*
  - *System suitability solution*: Dilute 0.5 mL of the *System suitability stock solution* with the *Standard solution* to 50 mL.
  - *Sample stock solution*: Finely powder NLT 10 Tablets. Transfer powder, equivalent to the average Tablet weight, to a homogenization vessel, and add 500 mL of a 10% *acetonitrile* solution. Alternately, homogenize and allow to soak until the sample is fully homogenized. [Note—A suggested homogenization sequence is as follows. Homogenize the sample using five pulses, each of 5 s, at about 20,000 rpm, and allow to soak for 2 min. Repeat these steps two additional times.]
  - *Sample solution*: Pass a portion of the *Sample stock solution* through a suitable filter of 0.45-μm pore size, discarding the first 3 mL of filtrate. Transfer 25 mL of the filtrate to a 200-mL volumetric flask, and dilute with water to volume.

**Chromatographic system**
(See *Chromatography (621), System Suitability.*)
- **Mode**: LC
- **Detector**: UV 218 nm
- **Column**: 3.9-mm x 30-cm; 10-μm packing *L1*
- **Column temperature**: 30°
- **Flow rate**: 1 mL/min
- **Injection volume**: 10 μL
- **Run time**: Until after the elution locus of metformin related compound C

**System suitability**
- **Sample**: *System suitability solution*
  - [Note—The relative retention times for metformin related compound B, metformin, and metformin related compound C are 0.86, 1.0, and 2.1-2.3, respectively. Metformin related compound C can have a variable retention time. The composition of the *Mobile phase* may be changed to 1:19, if it elutes at a relative retention time of less than 2.1.]
- **Suitability requirements**
  - **Resolution**: NLT 1.5 between the peaks due to metformin related compound B and metformin
  - **Tailing factor**: NLT 0.8 and NMT 2.0 for the metformin peak
  - **Relative standard deviation**: NMT 1.5% for the metformin peak and NMT 10% for each of the peaks due to metformin related compound B and metformin related compound C

**Analysis**
- **Samples**: *Standard solution and Sample solution*
  - Calculate the percentage of the labeled amount of metformin hydrochloride (C₄H₁₁N₅ · HCl) in the portion of Tablets taken:
    \[
    \text{Result} = \left( \frac{r_i}{r_S} \right) \times \left( C_D/C_I \right) \times 100
    \]
\[ \begin{align*}
    r_U & = \text{peak response from the Sample solution} \\
    r_S & = \text{peak response from the Standard solution} \\
    C_S & = \text{concentration of USP Metformin Hydrochloride RS in the Standard solution (mg/mL)} \\
    C_U & = \text{nominal concentration of metformin hydrochloride in the Sample solution}
\end{align*} \]

**Acceptance criteria:** 90.0%–110.0%

**PERFORMANCE TESTS**

**Change to read:**

- **Dissolution (711)**

  **Test 1**

  **Medium:** pH 6.8 phosphate buffer solution; 1000 mL

  **Apparatus 1:** 100 rpm for Tablets labeled to contain 750 mg

  **Apparatus 2:** 100 rpm for Tablets labeled to contain 500 mg

  **Times:** 1, 3, and 10 h

  **Detector:** UV 232 nm

  **Standard solution:** USP Metformin Hydrochloride RS in Medium

  **Sample solution:** Pass a portion of the solution under test through a suitable hydrophilic polyethylene filter of 0.45-μm pore size. Dilute, if necessary, with Medium to a concentration similar to that of the Standard solution.

  **Analysis:** Calculate the percentage of the labeled amount of metformin hydrochloride (C<sub>4</sub>H<sub>11</sub>N<sub>5</sub>·HCl) released at each time point:

  \[
  \text{Result} = \left[ \left( \frac{A_U}{A_S} \right) \times C_S \times (V - V_S) + (C_{60} \times V_S) + (C_{180} \times V_S) \right] \times \left( \frac{100}{L} \right)
  \]

  \[\begin{align*}
    A_U & = \text{absorbance of the Sample solution} \\
    A_S & = \text{absorbance of the Standard solution} \\
    C_S & = \text{concentration of the Standard solution (mg/mL)} \\
    V & = \text{initial volume of Medium in the vessel (mL)} \\
    V_S & = \text{volume withdrawn from the vessel for previous samplings (mL)} \\
    C_{60} & = \text{concentration of metformin hydrochloride in Medium determined at 1 h (mg/mL)} \\
    C_{180} & = \text{concentration of metformin hydrochloride in Medium determined at 3 h (mg/mL)} \\
    L & = \text{label claim (mg/Tablet)}
  \end{align*}\]

  **Tolerances:** See Table 1.

**Table 1**

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Amount Dissolved, 500-mg Tablet (%)</th>
<th>Amount Dissolved, 750-mg Tablet (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20–40</td>
<td>22–42</td>
</tr>
<tr>
<td>3</td>
<td>45–65</td>
<td>49–69</td>
</tr>
<tr>
<td>10</td>
<td>NLT 85</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride (C<sub>4</sub>H<sub>11</sub>N<sub>5</sub>·HCl) dissolved at the times specified conform to Dissolution (711), Acceptance Table 2.

**Test 2:** If the product complies with this test, the labeling indicates that it meets USP Dissolution Test 2.

- **Medium:** Prepare as directed for Test 1; 1000 mL

  **Apparatus 2:** 100 rpm

  **Times:** 1, 2, 6, and 10 h
**Detector:** UV 232 nm  
**Standard solution:** USP Metformin Hydrochloride RS in Medium  
**Sample solution:** Pass a portion of the solution under test through a suitable polyethylene filter of 0.45-μm pore size. Dilute, if necessary, with Medium to a concentration that is similar to that of the Standard solution.  
**Analysis:** Calculate, in mg/mL, the content of metformin hydrochloride (C₄H₁₁N₅·HCl) (Cᵣ) in Medium at each time point (t):

\[
\text{Result} = \left( A_u \times C_s \times D_u \right)/A_s
\]

\[A_u = \text{absorbance of the Sample solution}\]
\[C_s = \text{concentration of metformin hydrochloride in the Standard solution (mg/mL)}\]
\[D_u = \text{dilution factor of the solution under test}\]
\[A_s = \text{absorbance of the Standard solution}\]

Calculate the percentage of the labeled amount of metformin hydrochloride (C₄H₁₁N₅·HCl) dissolved at each time point by the following formulas.

Percentage dissolved at the first time point (1 h):

\[
\text{Result} = (C_1 \times V \times 100)/L
\]

\[C_1 = \text{content of metformin hydrochloride in Medium at the first time interval (mg/mL)}\]
\[V = \text{volume of Medium, 1000 mL}\]
\[L = \text{label claim (mg/Tablet)}\]

Percentage dissolved at the second time point (2 h):

\[
\text{Result} = [C_2 \times (V - SV_1) + C_1 \times SV_1] \times (100/L)
\]

\[C_2 = \text{content of metformin hydrochloride in Medium at the second time interval (mg/mL)}\]
\[V = \text{volume of Medium, 1000 mL}\]
\[SV_1 = \text{volume of the sample withdrawn at 1 h (mL)}\]
\[C_1 = \text{content of metformin hydrochloride in Medium at 1 h (mg/mL)}\]
\[L = \text{label claim (mg/Tablet)}\]

Percentage dissolved at the nth time point:

\[
\text{Result} = \{C_n \times [V - (n - 1)V_S] + (C_1 + C_2 + ... + C_{n-1}) \times V_S\} \times (100/L)
\]

\[C_n = \text{content of metformin hydrochloride in Medium at the nth time interval (mg/mL)}\]
\[V = \text{volume of Medium, 1000 mL}\]
\[n = \text{time interval of interest}\]
\[V_S = \text{volume of sample withdrawn at each time interval (mL)}\]
\[C = \text{as } C_1, C_2, C_3, ..., C_{n-1}, \text{ the content of metformin hydrochloride in Medium at each time interval (mg/mL)}\]
\[L = \text{label claim (mg/Tablet)}\]

**Tolerances:** See Table 2.

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20–40</td>
</tr>
</tbody>
</table>

Table 2
<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>35–55</td>
</tr>
<tr>
<td>6</td>
<td>65–85</td>
</tr>
<tr>
<td>10</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride ($\text{C}_4\text{H}_{11}\text{N}_5\cdot\text{HCl}$) dissolved at the times specified conform to \textit{Dissolution (711), Acceptance Table 2}.

**Test 3:** If the product complies with this test, the labeling indicates that it meets USP Dissolution Test 3.

**Medium, Apparatus 1,** and **Apparatus 2:** Proceed as directed in Test 1.

**Times:** 1, 2, 5, and 12 h for Tablets labeled to contain 500 mg; and 1, 3, and 10 h for Tablets labeled to contain 750 mg

**Detector:** UV 232 nm

**Standard solution:** USP Metformin Hydrochloride RS in Medium

**Sample solution:** Pass a portion of the solution under test through a suitable hydrophilic polyethylene filter of 0.45-μm pore size. Dilute, if necessary, with Medium to a concentration similar to that of the Standard solution.

**Analysis:** Calculate the percentage of the labeled amount of metformin hydrochloride ($\text{C}_4\text{H}_{11}\text{N}_5\cdot\text{HCl}$) released at each time point:

$$
\text{Result} = \frac{\left( (A_U / A_S) \times C_S \times (V - V_S) \right) + (C_{60} \times V_S) + (C_{120} \times V_S) + (C_{300} \times V_S) + (C_{720} \times V_S) }{L} \times 100
$$

- $A_U$ = absorbance of the Sample solution
- $A_S$ = absorbance of the Standard solution
- $C_S$ = concentration of the Standard solution (mg/mL)
- $V$ = initial volume of Medium in the vessel (mL)
- $V_S$ = volume withdrawn from the vessel for previous samplings (mL)
- $C_{60}$ = concentration of metformin hydrochloride in Medium determined at 1 h (mg/mL)
- $C_{120}$ = concentration of metformin hydrochloride in Medium determined at 2 h (mg/mL)
- $C_{300}$ = concentration of metformin hydrochloride in Medium determined at 5 h (mg/mL)
- $C_{720}$ = concentration of metformin hydrochloride in Medium determined at 12 h (mg/mL)
- $L$ = label claim (mg/Tablet)

**Tolerances:** See **Tables 3 and 4**.

**Table 3. For Tablets Labeled to Contain 500 mg**

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20–40</td>
</tr>
<tr>
<td>2</td>
<td>35–55</td>
</tr>
<tr>
<td>5</td>
<td>60–80</td>
</tr>
<tr>
<td>12</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

**Table 4. For Tablets Labeled to Contain 750 mg**
<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22–42</td>
</tr>
<tr>
<td>3</td>
<td>49–69</td>
</tr>
<tr>
<td>10</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride (\(\text{C}_4\text{H}_{11}\text{N}_5\cdot\text{HCl}\)) dissolved at the times specified conform to Dissolution (711), Acceptance Table 2.

**Test 4:** If the product complies with this test, the labeling indicates that it meets USP Dissolution Test 4.

**Medium:** Prepare as directed for Test 1; 1000 mL.

**Apparatus 2:** 100 rpm

**Times:** 1, 3, 6, and 10 h

**Detector:** UV 250 nm (shoulder)

**Standard solution:** USP Metformin Hydrochloride RS in Medium

**Sample solution:** Pass a portion of the solution under test through a suitable filter of 0.45-\(\mu\)m pore size. Dilute, if necessary, with Medium to a concentration similar to that of the Standard solution.

**Analysis:** Calculate, in mg/mL, the content of metformin hydrochloride (\(\text{C}_4\text{H}_{11}\text{N}_5\cdot\text{HCl}\)) (\(C_t\)) in Medium at each time point \((t)\), by the formulas specified in Test 2.

**Tolerances:** See Table 5.

### Table 5

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20–40</td>
</tr>
<tr>
<td>3</td>
<td>45–65</td>
</tr>
<tr>
<td>6</td>
<td>65–85</td>
</tr>
<tr>
<td>10</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride (\(\text{C}_4\text{H}_{11}\text{N}_5\cdot\text{HCl}\)) dissolved at the times specified conform to Dissolution (711), Acceptance Table 2.

**Test 5:** If the product complies with this test, the labeling indicates that it meets USP Dissolution Test 5.

**Medium:** pH 6.8 phosphate buffer solution; 900 mL, deaerated

**Apparatus 1:** 100 rpm, with the vertical holder described in Figure 1 and Figure 2

**Times:** 2, 8, and 16 h

**Detector:** UV 250 nm

**Standard solution:** USP Metformin Hydrochloride RS in Medium

**Sample solution:** Pass a portion of the solution under test through a suitable filter of 0.45-\(\mu\)m pore size. Dilute, if necessary, with Medium to a concentration similar to that of the Standard solution.

**Analysis:** Place a vertical sample holder into each basket (see Figures 1 and 2). Place 1 Tablet inside the sample holder, making sure that the Tablets are vertical at the bottom of the baskets. Calculate, in mg/mL, the content of metformin hydrochloride (\(\text{C}_4\text{H}_{11}\text{N}_5\cdot\text{HCl}\)) (\(C_t\)) in Medium at each time point \((t)\), by the formulas specified in Test 2.
NOTES:
1. MATERIAL: 316SS OR EQUIVALENT .017 WIRE VERTICAL MEAS SQUARE WEAVE WITH .039 SQUARE OPENINGS.
2. ALL DIMENSIONS ARE IN INCHES. TOLERANCES TO BE +/- .010
Tolerances: See Table 6.

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Amount Dissolved, 500-mg Tablet (%)</th>
<th>Amount Dissolved, 1000-mg Tablet (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>NMT 30</td>
<td>NMT 30</td>
</tr>
<tr>
<td>8</td>
<td>60–85</td>
<td>65–90</td>
</tr>
</tbody>
</table>
The percentages of the labeled amount of metformin hydrochloride (C₄H₁₁N₅·HCl) dissolved at the times specified conform to Dissolution (711), Acceptance Table 2.

**Test 6:** If the product complies with this test, the labeling indicates that it meets USP Dissolution Test 6.

**Medium:** pH 6.8 phosphate buffer solution; 1000 mL, deaerated

**Apparatus 2:** 100 rpm, with USP sinker, if necessary

**Detector:** UV 233 nm

**Standard solution:** USP Metformin Hydrochloride RS in Medium

**Sample solution:** Pass a portion of the solution under test through a suitable hydrophilic polyethylene filter of 0.45-μm pore size. Dilute, if necessary, with Medium to a concentration similar to that of the Standard solution.

**Analysis:** Calculate the percentage of the labeled amount of metformin hydrochloride (C₄H₁₁N₅·HCl) released at each time point:

\[
\text{Result} = \left( \frac{(A_U/A_S) \times C_S \times (V - V_S) + (C_{60} \times V_S) + (C_{180} \times V_S) + (C_{600} \times V_S)}{L} \right) \times 100
\]

- \(A_U\) = absorbance of the Sample solution
- \(A_S\) = absorbance of the Standard solution
- \(C_S\) = concentration of the Standard solution (mg/mL)\n- \(V\) = initial volume of Medium in the vessel (mL)
- \(V_S\) = volume withdrawn from the vessel for previous samplings (mL)
- \(C_{60}\) = concentration of metformin hydrochloride in Medium determined at 1 h (mg/mL)
- \(C_{180}\) = concentration of metformin hydrochloride in Medium determined at 3 h (mg/mL)
- \(C_{600}\) = concentration of metformin hydrochloride in Medium determined at 10 h (mg/mL)
- \(L\) = label claim (mg/Tablet)

**Tolerances:** See Table 7.

**Table 7**

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Amount Dissolved, 500-mg Tablet (%)</th>
<th>Amount Dissolved, 750-mg Tablet (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20–40</td>
<td>20–40</td>
</tr>
<tr>
<td>3</td>
<td>45–65</td>
<td>45–65</td>
</tr>
<tr>
<td>10</td>
<td>NLT 85</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride (C₄H₁₁N₅·HCl) dissolved at the times specified conform to Dissolution (711), Acceptance Table 2.

**Test 7:** If the product complies with this test, the labeling indicates that it meets USP Dissolution Test 7.

**Medium:** Prepare as directed in Test 1; 1000 mL.

**Apparatus 1:** 100 rpm for Tablets labeled to contain 750 mg

**Apparatus 2:** 50 rpm, with USP sinker, for Tablets labeled to contain 500 mg

**Times:** 1, 3, and 10 h

**Detector:** UV 232 nm

**Standard solution:** USP Metformin Hydrochloride RS in Medium
Sample solution: Pass a portion of the solution under test through a suitable filter of 0.45-μm pore size. Dilute, if necessary, with Medium to a concentration similar to that of the Standard solution.

Analysis: Calculate the percentage of the labeled amount of metformin hydrochloride (C₄H₁₁N₅·HCl) released at each time point:

\[
\text{Result} = \left\{ \left[ \left( \frac{A_U}{A_S} \right) \times C_S \times (V - V_S) + (C_{60} \times V_S) + (C_{180} \times V_S) + (C_{600} \times V_S) \right] \times 100 \right\} / L
\]

\( A_U \) = absorbance of the Sample solution
\( A_S \) = absorbance of the Standard solution
\( C_S \) = concentration of the Standard solution (mg/mL)
\( V \) = initial volume of Medium in the vessel (mL)
\( V_S \) = volume withdrawn from the vessel for previous samplings (mL)
\( C_{60} \) = concentration of metformin hydrochloride in Medium determined at 1 h (mg/mL)
\( C_{180} \) = concentration of metformin hydrochloride in Medium determined at 3 h (mg/mL)
\( C_{600} \) = concentration of metformin hydrochloride in Medium determined at 10 h (mg/mL)
\( L \) = label claim (mg/Tablet)

Tolerances: See Table 8.

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Amount Dissolved, 500-mg Tablet (%)</th>
<th>Amount Dissolved, 750-mg Tablet (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20–40</td>
<td>20–40</td>
</tr>
<tr>
<td>3</td>
<td>45–65</td>
<td>40–60</td>
</tr>
<tr>
<td>10</td>
<td>NLT 85</td>
<td>NLT 80</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride (C₄H₁₁N₅·HCl) dissolved at the times specified conform to Dissolution (711), Acceptance Table 2.

Test 8: If the product complies with this test, the labeling indicates that it meets USP Dissolution Test 8.

Medium: Prepare as directed in Test 1; 1000 mL.

Apparatus 1: 100 rpm for Tablets labeled to contain 750 mg

Apparatus 2: 100 rpm, with sinker, for Tablets labeled to contain 500 mg

Times: 1, 2, 6, and 10 h

Detector: UV 232 nm

Standard solution: USP Metformin Hydrochloride RS in Medium

Sample solution: Pass a portion of the solution under test through a suitable filter of 0.45-μm pore size. Dilute, if necessary, with Medium to a concentration similar to that of the Standard solution.

Analysis: Calculate the percentage of the labeled amount of metformin hydrochloride (C₄H₁₁N₅·HCl) released at each time point:

\[
\text{Result} = \left\{ \left[ \left( \frac{A_U}{A_S} \right) \times C_S \times (V - V_S) + (C_{60} \times V_S) + (C_{120} \times V_S) + (C_{360} \times V_S) + (C_{600} \times V_S) \right] \times 100 \right\} / L
\]

\( A_U \) = absorbance of the Sample solution
\( A_S \) = absorbance of the Standard solution
\( C_S \) = concentration of the Standard solution (mg/mL)
\( V \) = initial volume of Medium in the vessel (mL)
\( V_S \) = volume withdrawn from the vessel for previous samplings (mL)
C<sub>60</sub> = concentration of metformin hydrochloride in Medium determined at 1 h (mg/mL)

C<sub>120</sub> = concentration of metformin hydrochloride in Medium determined at 2 h (mg/mL)

C<sub>360</sub> = concentration of metformin hydrochloride in Medium determined at 6 h (mg/mL)

C<sub>600</sub> = concentration of metformin hydrochloride in Medium determined at 10 h (mg/mL)

L = label claim (mg/Tablet)

**Tolerances:** See Table 9.

### Table 9

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Amount Dissolved, 500-mg Tablet (%)</th>
<th>Amount Dissolved, 750-mg Tablet (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20–40</td>
<td>20–40</td>
</tr>
<tr>
<td>2</td>
<td>30–50</td>
<td>35–55</td>
</tr>
<tr>
<td>6</td>
<td>65–85</td>
<td>75–95</td>
</tr>
<tr>
<td>10</td>
<td>NLT 85</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride (C<sub>4</sub>H<sub>11</sub>N<sub>5</sub>·HCl) dissolved at the times specified conform to Dissolution (711), Acceptance Table 2.

**Test 9:** If the product complies with this test, the labeling indicates that it meets USP Dissolution Test 9.

**Medium:** 0.05 M phosphate buffer, pH 6.8; 1000 mL

**Apparatus 1:** 100 rpm, for Tablets labeled to contain 750 mg

**Apparatus 2:** 100 rpm, for Tablets labeled to contain 500 mg

**Times:** 1, 5, 12, and 20 h for Tablets labeled to contain 500 mg; and 1, 4, 10, and 24 h for Tablets labeled to contain 750 mg

**Standard solution:** 0.5 mg/mL of USP Metformin Hydrochloride RS in Medium

**Sample solution:** Pass a portion of the solution under test through a suitable filter of 0.45-µm pore size.

**Detector:** UV 232 nm

**Path length:** 0.01 cm, flow cell

**Blank:** Medium

**Analysis:** Calculate the percentage of the labeled amount of metformin hydrochloride (C<sub>4</sub>H<sub>11</sub>N<sub>5</sub>·HCl) released at each time point:

\[
\text{Result} = \frac{\{([A_I/A_S] \times C_S \times (V - V_3) + (C_1 \times V_3) + (C_2 \times V_3) + (C_3 \times V_3) + (C_4 \times V_3)) \times 100\}}{L}
\]

\(A_I\) = absorbance of the Sample solution

\(A_S\) = absorbance of the Standard solution

\(C_S\) = concentration of the Standard solution (mg/mL)

\(V\) = initial volume of Medium in the vessel (mL)

\(V_3\) = volume withdrawn from the vessel for previous samplings (mL)

\(C_I\) = concentration of metformin hydrochloride in Medium determined at the first time point (mg/mL)

\(C_2\) = concentration of metformin hydrochloride in Medium determined at the second time point (mg/mL)

\(C_3\) = concentration of metformin hydrochloride in Medium determined at the third time point (mg/mL)

\(C_4\) = concentration of metformin hydrochloride in Medium determined at the fourth time point (mg/mL)

\(L\) = label claim (mg/Tablet)
Tolerances: See Tables 10 and 11.

Table 10. For Tablets Labeled to Contain 500 mg

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20–40</td>
</tr>
<tr>
<td>5</td>
<td>45–65</td>
</tr>
<tr>
<td>12</td>
<td>70–90</td>
</tr>
<tr>
<td>20</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

Table 11. For Tablets Labeled to Contain 750 mg

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20–45</td>
</tr>
<tr>
<td>4</td>
<td>45–70</td>
</tr>
<tr>
<td>10</td>
<td>70–95</td>
</tr>
<tr>
<td>24</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride \((\text{C}_4\text{H}_{11}\text{N}_5\cdot\text{HCl})\) dissolved at the times specified conform to Dissolution (711), Acceptance Table 2.

Test 10: If the product complies with this test, the labeling indicates that it meets USP Dissolution Test 10.

Medium: 0.05 M phosphate buffer (prepared by dissolving 6.8 g of monobasic potassium phosphate in 250 mL of water, adding 77 mL of 0.2 N sodium hydroxide and 500 mL of water, adjusting with 2 N sodium hydroxide or 2 N hydrochloric acid to pH 6.8, and diluting with water to 1000 mL)

Apparatus 1: 100 rpm for Tablets labeled to contain 750 mg

Apparatus 2: 100 rpm for Tablets labeled to contain 500 mg

Times: 1, 3, and 10 h

Standard solution: \((L/100,000)\) mg/mL of USP Metformin Hydrochloride RS in Medium, where \(L\) is the label claim, in mg/Tablet. This solution is stable for 72 h at room temperature.

Sample solution: At the times specified, withdraw 10 mL of the solution under test and replace with 10 mL of Medium previously equilibrated at 37.0 ± 0.5°. Centrifuge at 2500 rpm for 10 min. Dilute a portion of the supernatant with Medium to obtain a theoretical concentration of \((L/100,000)\) mg/mL, where \(L\) is the label claim, in mg/Tablet.

Detector: UV 233 nm

Path length: 1 cm

Blank: Medium

Analysis: Calculate the concentration, in mg/mL, of metformin hydrochloride \((C_s)\) at each time point:

\[
C_i = \left(\frac{A_U}{A_S}\right) \times C_S
\]

\(A_U\) = absorbance of the Sample solution

\(A_S\) = absorbance of the Standard solution

\(C_S\) = concentration of the Standard solution (mg/mL)

Calculate the cumulative percentage of the labeled amount of metformin hydrochloride \((\text{C}_4\text{H}_{11}\text{N}_5\cdot\text{HCl})\) dissolved \((Q_i)\) at each time point \((i)\):

At \(i = 1\):
\[ Q_i = (C_i \times V/L) \times 100 \]

At \( i = 3 \):

\[ Q_3 = [C_3(V - V_S) + (C_1 \times V_S)] \times 100/L \]

At \( i = 10 \):

\[ Q_{10} = [C_{10}(V - 2V_S) + (C_1 + C_3)V_S] \times 100/L \]

\( V \) = initial volume of Medium, 1000 mL

\( V_S \) = sampling volume, 10 mL

\( L \) = label claim (mg/Tablet)

**Tolerances:** See *Table 12.*

**Table 12**

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25-45</td>
</tr>
<tr>
<td>3</td>
<td>50-70</td>
</tr>
<tr>
<td>10</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride (\( \text{C}_4\text{H}_{11}\text{N}_5\cdot\text{HCl} \)) dissolved at the times specified conform to *Dissolution (711), Acceptance Table 2.*

**Test 11:** If the product complies with this test, the labeling indicates that it meets USP *Dissolution Test 11.*

**Medium:** pH 6.8 phosphate buffer solution; 1000 mL

**Apparatus 1:** 100 rpm for Tablets labeled to contain 750 mg

**Apparatus 2:** 100 rpm for Tablets labeled to contain 500 mg

**Times:** 1, 3, and 10 h

**Standard solution:** 7.5 \( \mu \)g/mL of *USP Metformin Hydrochloride RS* in Medium

**Sample solution:** At the times specified, withdraw 10 mL of the solution under test, and pass it through a suitable filter of 0.45-\( \mu \)m pore size, discarding the first 3 mL of filtrate. Dilute 3.0 mL of the filtrate with Medium to 200 mL. For Tablets labeled to contain 750 mg, dilute 2.0 mL of the filtrate with Medium to 200 mL. Replace the volume of Medium taken with the same volume of Medium preheated at 37.0 ± 0.5°.

**Detector:** UV 232 nm

**Path length:** 1 cm

**Blank:** Medium

**Analysis:** Calculate the percentage of the labeled amount of metformin hydrochloride (\( \text{C}_4\text{H}_{11}\text{N}_5\cdot\text{HCl} \)) dissolved at each time point:

\[ Q_i = (A_U/A_S) \times (C_S/L) \times V \times D \times 100 \]

At 1 h:

Result = \( Q_1 \)

At 3 h:

Result = \( Q_3 + [(Q_1 \times 10)/V] \)

At 10 h:

Result = \( Q_{10} + \{(Q_1 \times 10)/V] + [(Q_3 \times 10)/V]\} \)

\( A_U \) = absorbance of the *Sample solution*

\( A_S \) = absorbance of the *Standard solution*
\[ C_s \] = concentration of the Standard solution (mg/mL)
\[ L \] = label claim (mg/Tablet)
\[ V \] = volume of Medium, 1000 mL
\[ D \] = dilution factor of the Sample solution

Tolerances: See Table 13.

### Table 13

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25-45</td>
</tr>
<tr>
<td>3</td>
<td>50-70</td>
</tr>
<tr>
<td>10</td>
<td>NLT 80</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride \((C_{4H_{11}N_5}\cdot HCl)\) dissolved at the times specified conform to Dissolution (711), Acceptance Table 2.

**Test 12:** If the product complies with this test, the labeling indicates that it meets USP Dissolution Test 12.

**Medium:** pH 6.8 phosphate buffer solution; 1000 mL

**Apparatus 1:** 100 rpm

**Times:** 1, 4, and 12 h

**Standard stock solution:** 0.2 mg/mL of USP Metformin Hydrochloride RS in Medium

**Standard solution:** 0.01 mg/mL of USP Metformin Hydrochloride RS in water, from the Standard stock solution

**Sample solution:** At the times specified, withdraw 10 mL of the solution under test, and replace with 10 mL of Medium previously equilibrated at 37.0 ± 0.5\(^\circ\). Pass it through a suitable filter, discarding the first few mL of the filtrate.

**For Tablets labeled to contain 500 mg:** Dilute 2.0 mL of the filtrate with water to 100 mL.

**For Tablets labeled to contain 1000 mg:** Dilute 1.0 mL of the filtrate with water to 100 mL.

**Detector:** UV 232 nm

**Blank:** Dilute 1 mL of Medium with water to 100 mL.

**Analysis:** Calculate the concentration \((C_i)\), in mg/mL, of metformin hydrochloride \((C_{4H_{11}N_5}\cdot HCl)\) in the sample withdrawn at each time point \((i)\):

\[
Result_i = \left(\frac{A_U}{A_S}\right) \times C_s \times D
\]

\[ A_U \] = absorbance of the Sample solution
\[ A_S \] = absorbance of the Standard solution
\[ C_s \] = concentration of the Standard solution (mg/mL)
\[ D \] = dilution factor of the Sample solution

Calculate the percentage of the labeled amount of metformin hydrochloride \((C_{4H_{11}N_5}\cdot HCl)\) dissolved \((Q_i)\) at each time point \((i)\):

\[
Result_1 = C_i \times V \times (1/L) \times 100
\]

\[
Result_2 = \left\{ [C_2 \times V] + [C_1 \times V_S] \right\} \times (1/L) \times 100
\]

\[
Result_3 = \left\{ [C_3 \times V] + [(C_2 + C_1) \times V_S] \right\} \times (1/L) \times 100
\]

\[ C_i \] = concentration of metformin hydrochloride in the portion of sample withdrawn at time point \(i\) (mg/mL)
\[ V \] = initial volume of Medium, 1000 mL
\[ L \] = label claim (mg/Tablet)
\( V_S \) = volume of the Sample solution withdrawn, 10 mL

**Tolerances:** See Table 14.

<table>
<thead>
<tr>
<th>Time Point (i)</th>
<th>Time (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>NMT 15</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>35-65</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride \((C_4H_{11}N_5 \cdot HCl)\) dissolved at the times specified conform to *Dissolution* (711), *Acceptance Table 2.*

**Test 13:** If the product complies with this test, the labeling indicates that it meets USP *Dissolution Test 13.*

**Medium:** pH 6.8 phosphate buffer solution; 1000 mL

**Apparatus 1:** 100 rpm

**Times:** 1, 4, 6, and 14 h

**Standard stock solution:** 0.2 mg/mL of USP Metformin Hydrochloride RS prepared as follows. Transfer a suitable amount of USP Metformin Hydrochloride RS into an appropriate volumetric flask. Dissolve by adding Medium to fill 50% of the flask volume and dilute with Medium to volume.

**Standard solution:** 0.01 mg/mL of USP Metformin Hydrochloride RS from Standard stock solution in water

**Sample stock solution:** At the times specified, withdraw 10 mL of the solution under test, and replace with the same volume of Medium preheated at 37.0 ± 0.5°. Pass a portion of the solution under test through a suitable filter of 0.45-μm pore size, discard the first few mL, and use the filtrate.

**Sample solution**

*For Tablets labeled to contain 500 mg:* Dilute 2 mL of Sample stock solution with water to 100 mL.

*For Tablets labeled to contain 1000 mg:* Dilute 1 mL of Sample stock solution with water to 100 mL.

**Instrumental conditions**

(See *Ultraviolet-Visible Spectroscopy (857).*)

**Mode:** UV

**Analytical wavelength:** 232 nm

**Blank**

*For Tablets labeled to contain 500 mg:* Dilute 2 mL of Medium with water to 100 mL.

*For Tablets labeled to contain 1000 mg:* Dilute 1 mL of Medium with water to 100 mL.

**System suitability**

**Sample:** Standard solution

**Suitability requirements**

**Relative standard deviation:** NMT 2.0%

**Analysis**

**Samples:** Standard solution, Sample solution, and Blank

Calculate the concentration \((C_i)\), in mg/mL, of metformin hydrochloride \((C_4H_{11}N_5 \cdot HCl)\) in the sample withdrawn from the vessel at each time point \((i)\):

\[
\text{Result}_i = \left( \frac{A_U}{A_S} \right) \times C_S \times D
\]

\( A_U \) = absorbance of the Sample solution

\( A_S \) = absorbance of the Standard solution

\( C_S \) = concentration of the Standard solution (mg/mL)

\( D \) = dilution factor of the Sample solution

Calculate the percentage of the labeled amount of metformin hydrochloride \((C_4H_{11}N_5 \cdot HCl)\) dissolved at each time point \((i)\):
Result_1 = C_i \times V \times (1/L) \times 100

Result_2 = [(C_2 \times V) + (C_1 \times V_S)] \times (1/L) \times 100

Result_3 = \{(C_3 \times V) + [(C_2 + C_1) \times V_S)] \times (1/L) \times 100

Result_4 = \{(C_4 \times V) + [(C_3 + C_2 + C_1) \times V_S]\} \times (1/L) \times 100

C_i = \text{concentration of metformin hydrochloride in the portion of sample withdrawn at the specified time point (mg/mL)}

V = \text{volume of Medium, 1000 mL}

L = \text{label claim (mg/Tablet)}

V_S = \text{volume of the Sample solution withdrawn at each time point and replaced with Medium (mL)}

\textbf{Tolerances:} \textbf{See Table 15.}

\textbf{Table 15}

<table>
<thead>
<tr>
<th>Time Point (i)</th>
<th>Time (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>NMT 20</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>45–65</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>65–85</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride (C_4H_{11}N_5 \cdot HCl) dissolved at the times specified conform to \textit{Dissolution (711), Acceptance Table 2.}

\textbf{Test 14:} If the product complies with this test, the labeling indicates that it meets USP \textit{Dissolution Test 14.}

\textbf{Medium:} pH 6.8 phosphate buffer solution; 1000 mL

\textbf{Apparatus 1:} 100 rpm for Tablets labeled to contain 750 mg

\textbf{Apparatus 2:} 100 rpm for Tablets labeled to contain 500 mg

\textbf{Times:} 1, 3, and 10 h

\textbf{Standard solution:} 7.5 \, \mu g/mL of \textit{USP Metformin Hydrochloride RS} in Medium

\textbf{Sample solution:} At the times specified, withdraw 10 mL of the solution under test and replace with the same volume of Medium. Pass the solution under test through a suitable filter of 10-\mu m pore size. Pass a portion of the filtered solution through a suitable filter of 0.45-\mu m pore size, discarding the first few milliliters. Dilute with Medium to a concentration similar to that of the Standard solution.

\textbf{Instrumental conditions}

\textbf{Mode:} UV

\textbf{Analytical wavelength:} 232 nm

\textbf{Blank:} Medium

\textbf{Analysis}

\textbf{Samples:} Standard solution, Sample solution, and Blank

Calculate the concentration (C_i), in mg/mL, of metformin hydrochloride (C_4H_{11}N_5 \cdot HCl) in the sample withdrawn from the vessel at each time point (i):

\[ \text{Result}_i = (A_U / A_S) \times C_S \times D \]

\begin{align*}
A_U & = \text{absorbance of the Sample solution} \\
A_S & = \text{absorbance of the Standard solution} \\
C_S & = \text{concentration of the Standard solution (\mu g/mL)} \\
D & = \text{dilution factor of the Sample solution}
\end{align*}
Calculate the percentage of the labeled amount of metformin hydrochloride \((C_{4}H_{11}N_{5} \cdot \text{HCl})\) dissolved at each time point \((i)\):

\[
\text{Result}_1 = C_1 \times V \times (1/L) \times 100
\]

\[
\text{Result}_2 = [(C_2 \times V) + (C_1 \times V_S)] \times (1/L) \times 100
\]

\[
\text{Result}_3 = \{(C_3 \times V) + [(C_2 + C_1) \times V_S]\} \times (1/L) \times 100
\]

\[
\text{Result}_4 = \{(C_4 \times V) + [(C_3 + C_2 + C_1) \times V_S]\} \times (1/L) \times 100
\]

\(C_i\) = concentration of metformin hydrochloride in the portion of sample withdrawn at the specified time point (mg/mL)

\(V\) = volume of Medium, 1000 mL

\(L\) = label claim (mg/Tablet)

\(V_S\) = volume of the Sample solution withdrawn at each time point and replaced with Medium (mL)

**Tolerances:** See Table 16.

### Table 16

<table>
<thead>
<tr>
<th>Time Point ((i))</th>
<th>Time (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>500 mg Tablets</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>30–50</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>55–75</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride \((C_{4}H_{11}N_{5} \cdot \text{HCl})\) dissolved at the times specified conform to **Dissolution (711)**, **Acceptance Table 2**.

**Test 16:** If the product complies with this test, the labeling indicates that it meets USP **Dissolution Test 16**.

**Medium:** **pH 6.8 phosphate buffer solution**; 1000 mL

**Apparatus 1:** 100 rpm

**Times:** 1, 3, and 10 h

**Standard solution:** 0.015 mg/mL of USP Metformin Hydrochloride RS in Medium. Sonicate as needed.

**Sample stock solution:** At the times specified, withdraw 10 mL of the solution under test and pass it through a suitable filter.

**Sample solution**

- **For Tablets labeled to contain 500 mg:** Dilute 3 mL of the Sample stock solution with Medium to 100 mL.
- **For Tablets labeled to contain 750 mg:** Dilute 2 mL of the Sample stock solution with Medium to 100 mL.

**Instrumental conditions**

(See **Ultraviolet-Visible Spectroscopy (857).**)

**Mode:** UV-Vis

**Analytical wavelength:** UV 232 nm

**Path length:** 1 cm

**Blank:** Medium

**System suitability**

- **Sample:** Standard solution

**Suitability requirements**

- **Relative standard deviation:** NMT 2.0%

**Analysis**

**Samples:** Standard solution and Sample solution

Calculate the concentration \((C_i)\) of metformin hydrochloride \((C_{4}H_{11}N_{5} \cdot \text{HCl})\) in the sample withdrawn from the vessel at each time point \((i)\):
Result = \( \frac{A_U}{A_S} \times C_S \times D \)

\( A_U \) = absorbance of the **Sample solution**
\( A_S \) = absorbance of the **Standard solution**
\( C_S \) = concentration of the **Standard solution** (mg/mL)
\( D \) = dilution factor for the **Sample solution**

Calculate the percentage of the labeled amount of metformin hydrochloride \( \text{(C}_4\text{H}_{11}\text{N}_5\cdot\text{HCl)} \) dissolved at the specified time point:

\[ \text{Result}_1 = C_1 \times V \times (1/L) \times 100 \]

\[ \text{Result}_2 = \{(C_2 \times (V - V_S)) + (C_1 \times V_S)\} \times (1/L) \times 100 \]

\[ \text{Result}_3 = \{(C_3 \times (V - (2 \times V_S))) + [(C_2 + C_1) \times V_S]\} \times (1/L) \times 100 \]

\( C_i \) = concentration of metformin hydrochloride in the portion of sample withdrawn at the specified time point (mg/mL)
\( V \) = volume of **Medium**, 1000 mL
\( L \) = label claim (mg/Tablet)
\( V_S \) = volume of the **Sample solution** withdrawn at each time point (mL)

**Tolerances:** See *Table 17.*

<table>
<thead>
<tr>
<th>Time Point ((i))</th>
<th>Time ((h))</th>
<th>Amount Dissolved ((%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>25–45</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>50–70</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>NLT 80</td>
</tr>
</tbody>
</table>

**Note:** The percentages of the labeled amount of metformin hydrochloride \( \text{(C}_4\text{H}_{11}\text{N}_5\cdot\text{HCl)} \) dissolved at the times specified conform to *Dissolution (711), Acceptance Table 2.*

**Test 18:** If the product complies with this test, the labeling indicates that it meets USP **Dissolution Test 18**.

**Medium:** pH 6.8 **phosphate buffer solution**; 900 mL, deaerated

**Apparatus 1:** 100 rpm, with vertical holder described in *Figure 1*

**Times:** 1, 4, and 10 h

**Standard solution:** 0.044 mg/mL of **USP Metformin Hydrochloride RS** in Medium. Sonicate as needed.

**Sample stock solution:** At the times specified, withdraw a suitable amount of solution under test and replace with a suitable amount of Medium. Pass the solution under test through a suitable filter and discard the first few milliliters.

**Sample solution**
- For Tablets labeled to contain **500 mg**: Dilute 2 mL of the **Sample stock solution** with **Medium** to 25 mL.
- For Tablets labeled to contain **1000 mg**: Dilute 2 mL of the **Sample stock solution** with **Medium** to 50 mL.

**Instrumental conditions**
(See *Ultraviolet-Visible Spectroscopy (857).*)

**Mode:** UV-Vis

**Analytical wavelength:** UV 250 nm

**Path length:** 1 cm

**Blank:** Medium

**System suitability**
- **Sample:** Standard solution
- **Suitability requirements**
**Relative standard deviation:** NMT 2.0%

**Analysis**

**Samples:** Standard solution and Sample solution

Place a vertical sample holder into each basket (see Figure 1). Place 1 Tablet inside the sample holder, making sure that the Tablets are vertical at the bottom of the baskets.

Calculate the concentration \((C_i)\) of metformin hydrochloride \((C_4H_{11}N_5 \cdot HCl)\) in the sample withdrawn from the vessel at each time point \((t)\):

\[
\text{Result} = (A_U / A_S) \times C_S \times D
\]

- \(A_U\) = absorbance of the Sample solution
- \(A_S\) = absorbance of the Standard solution
- \(C_S\) = concentration of the Standard solution (mg/mL)
- \(D\) = dilution factor of the Sample solution

Calculate the percentage of the labeled amount of metformin hydrochloride \((C_4H_{11}N_5 \cdot HCl)\) dissolved at each time point \((t)\):

\[
\text{Result}_1 = C_i \times V \times (1/L) \times 100
\]

\[
\text{Result}_2 = [(C_x \times V) + (C_i \times V_s)] \times (1/L) \times 100
\]

\[
\text{Result}_3 = [(C_x \times V) + (C_x + C_i) \times V_s] \times (1/L) \times 100
\]

- \(C_i\) = concentration of metformin hydrochloride in the portion of sample withdrawn at the specified time point (mg/mL)
- \(V\) = volume of Medium, 900 mL
- \(L\) = label claim (mg/Tablet)
- \(V_s\) = volume of the Sample solution withdrawn at each time point and replaced with Medium (mL)

**Tolerances:** See Table 18.

<table>
<thead>
<tr>
<th>Time Point ((i))</th>
<th>Time ((h))</th>
<th>Amount Dissolved ((%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>NMT 30</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>45–70</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride \((C_4H_{11}N_5 \cdot HCl)\) dissolved at the times specified conform to Dissolution (711), Acceptance Table 2.

**Test 23:** If the product complies with this test, the labeling indicates that it meets USP Dissolution Test 23.

**Medium:** pH 6.8 phosphate buffer; 900 mL, deaerated

**Apparatus 1:** 100 rpm

**Times:** 1, 4, and 10 h

**Buffer:** 2.8 g/L of sodium phosphate, monobasic, 2.0 g/L of sodium 1-heptanesulfonate, and 2 mL/L of triethylamine prepared as follows. Dissolve 2.8 g of sodium phosphate, monobasic and 2.0 g of sodium 1-heptanesulfonate in 800 mL of water. Add 2 mL of triethylamine, and dilute with water to volume. Adjust with phosphoric acid to a pH of 3.5.

**Mobile phase:** Methanol and Buffer (40:60)

**Standard solution:** \((L/900)\) mg/mL of USP Metformin Hydrochloride RS in Medium, where \(L\) is the label claim in mg/Tablet. Sonicate to dissolve, if necessary.
**Sample solution:** At the times specified, withdraw a suitable amount of solution under test. Pass the solution under test through a suitable filter, and discard the first 3 mL.

**Chromatographic system**
(See Chromatography (621), System Suitability.)

**Mode:** LC

**Detector:** UV 260 nm

**Column:** 4.6-mm × 15-cm; 5-µm packing L1

**Column temperature:** 35°C

**Flow rate:** 1 mL/min

**Injection volume:** 10 µL

**Run time:** NLT 2 times the retention time of metformin

**System suitability**

**Sample:** Standard solution

**Suitability requirements**

**Tailing factor:** NMT 2.5

**Relative standard deviation:** NMT 3.0%

**Analysis**

**Samples:** Standard solution and Sample solution

Calculate the concentration \( (C_i) \) of metformin hydrochloride \( (\text{C}_4\text{H}_{11}\text{N}_5 \cdot \text{HCl}) \) in the sample withdrawn from the vessel at each time point \((i)\):

\[
\text{Result} = \left( \frac{r_U}{r_S} \right) \times C_S
\]

\(r_U\) = peak response of metformin from the Sample solution

\(r_S\) = peak response of metformin from the Standard solution

\(C_S\) = concentration of USP Metformin Hydrochloride RS in the Standard solution (mg/mL)

Calculate the percentage of the labeled amount of metformin hydrochloride \( (\text{C}_4\text{H}_{11}\text{N}_5 \cdot \text{HCl}) \) dissolved at the specified time point \((i)\):

\[
\text{Result}_1 = C_i \times V \times (1/L) \times 100
\]

\[
\text{Result}_2 = \left( [C_2 \times (V - V_S)] + (C_1 \times V_S) \right) \times (1/L) \times 100
\]

\[
\text{Result}_3 = \left( [C_3 \times (V - (2 \times V_S))] + [(C_2 + C_1) \times V_S] \right) \times (1/L) \times 100
\]

\(C_i\) = concentration of metformin hydrochloride in the portion of sample withdrawn at the specified time point (mg/mL)

\(V\) = volume of the Medium, 900 mL

\(L\) = label claim (mg/Tablet)

\(V_S\) = volume of the Sample solution withdrawn at each time point (mL)

**Tolerances:** See Table 19.

### Table 19

<table>
<thead>
<tr>
<th>Time Point ((i))</th>
<th>Time ((h))</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>10–30</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>50–70</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride \( (\text{C}_4\text{H}_{11}\text{N}_5 \cdot \text{HCl}) \) dissolved at the times specified conform to Dissolution (711), Acceptance Table 2. (RB 1-Jan-2021)
• **Uniformity of Dosage Units (905):** Meet the requirements

**IMPURITIES**

• **Organic Impurities**

  Mobile phase, Sample solution, and Chromatographic system: Proceed as directed in the Assay.

  Analysis: From the chromatogram of the Sample solution obtained in the Assay, calculate the percentage of each impurity in the portion of Tablets taken:

  \[ \text{Result} = \left( \frac{r_i}{r_T} \right) \times 100 \]

  \( r_i \) = peak response for each impurity

  \( r_T \) = sum of all the peak responses

  **Acceptance criteria**

  Individual impurities: NMT 0.1%

  Total impurities: NMT 0.6%

  [Note—Disregard any peak less than 0.05%, and disregard any peak observed in the blank.]

**ADDITIONAL REQUIREMENTS**

• **Packaging and Storage:** Preserve in well-closed, light-resistant containers, and store at controlled room temperature.

• **Labeling:** When more than one dissolution test is given, the labeling states the Dissolution test used only if Test 1 is not used.

• **USP Reference Standards (11)**
  - USP Metformin Hydrochloride RS
  - USP Metformin Related Compound B RS
  - 1-Methylbiguanide hydrochloride. 
    \( \text{C}_3\text{H}_7\text{N}_2\text{HCl} \) 151.60
  - USP Metformin Related Compound C RS
  - \( N,N\)-Dimethyl-[1,3,5]triazine-2,4,6-triamine.
    \( \text{C}_5\text{H}_{10}\text{N}_6 \) 154.17

---

**Page Information:**

Not Applicable

**DocID:** "© 2020 The United States Pharmacopeial Convention All Rights Reserved."