Metformin Hydrochloride Extended-Release Tablets

Type of Posting                 Revision Bulletin
Posting Date                   27–Apr–2020
Official Date                  28–Apr–2020
Expert Committee               Chemical Medicines Monographs 3
Reason for Revision            Compliance

In accordance with the Rules and Procedures of the 2015–2020 Council of Experts, the Chemical Medicines Monographs 3 Expert Committee has revised the Metformin Hydrochloride Extended-Release Tablets monograph. The purpose for the revision is to add Dissolution Test 18 to accommodate FDA-approved drug products with different dissolution conditions and/or tolerances than the existing dissolution tests.

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 (C₆H₁₄N₃·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-heptanesulphonate 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: (L400 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 5 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 × 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 (C₆H₁₄N₃·HCl) in the portion of Tablets taken:

$$\text{Result} = \frac{(r_0/r_A) \times (C_l/C_0)}{100}$$

$r_0$ = peak response from the Sample solution
$r_A$ = peak response from the Standard solution
$C_l$ = concentration of USP Metformin Hydrochloride RS in the Standard solution (mg/mL)
$C_0$ = nominal concentration of metformin hydrochloride in the Sample solution

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 500 mg
Apparatus 2: 100 rpm for Tablets labeled to contain 750 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.

Calculate: The percentage of the labeled amount of metformin hydrochloride (C₆H₁₄N₃·HCl) released at each time point:

$$\text{Result} = \frac{[(A_{0} - A_{1}) \times C_l \times (V - V_1) + (C_{60} \times V_1) + (C_{180} \times V_2)] \times 100}{L}$$

$A_{0}$ = absorbance of the Sample solution
$A_{1}$ = absorbance of the Standard solution
$C_l$ = concentration of the Standard solution (mg/mL)
$V$ = initial volume of Medium in the vessel (mL)
$V_1$ = 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)
$L$ = label claim (mg/Table)

Tolerances: See 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>

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C236495-M871-CHM32015, rev. 00 20200427
2 Metformin

The percentages of the labeled amount of metformin hydrochloride (C₄H₁₁N₃·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 (C₄H₁₁N₃·HCl) (C₁) in Medium at each time point (t):

\[
\text{Result} = \frac{(A_t \times C_t \times D_t)}{A_s}
\]

\( A_t \) = absorbance of the Sample solution

\( C_t \) = concentration of metformin hydrochloride in the Standard solution (mg/mL)

\( D_t \) = dilution factor of the solution under test

\( A_s \) = absorbance of the Standard solution

Calculate the percentage of the labeled amount of metformin hydrochloride (C₄H₁₁N₃·HCl) dissolved at each time point by the following formulas:

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

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

\( C_1 \) = content of metformin hydrochloride in Medium at the first time interval (mg/mL)

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

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

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

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

\( C_2 \) = content of metformin hydrochloride in Medium at the second time interval (mg/mL)

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

\( SV \) = volume of the sample withdrawn at 1 h (mL)

\( C_1 \) = content of metformin hydrochloride in Medium at 1 h (mg/mL)

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

Percentage dissolved at the nth time point:

\[
\text{Result} = \frac{[(A_t \times A_s) \times C_t \times (V - (n-1)V_s) + (C_1 + C_2 + \ldots + C_{n-1}) \times V_s] \times (100/L)}{L}
\]

\( A_t \) = absorbance of the Sample solution

\( A_s \) = absorbance of the Standard solution

\( C_t \) = concentration of metformin hydrochloride in Medium determined at 1 h (mg/mL)

\( C_{n-1} \) = concentration of metformin hydrochloride in Medium determined at (n-1) h (mg/mL)

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

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

\( C_0 \) = 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)

\( C_{100} \) = concentration of metformin hydrochloride in Medium determined at 5 h (mg/mL)

\( C_{220} \) = concentration of metformin hydrochloride in Medium determined at 12 h (mg/mL)

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

Tolerances: See Table 2.

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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>
<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 (C₄H₁₁N₃·HCl) dissolved at the times specified conform to 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 (C₄H₁₁N₃·HCl) released at each time point:

\[
\text{Result} = \frac{[(A_t \times A_s) \times C_t \times (V - (n-1)V_s) + (C_1 \times V_s) + (C_{120} \times V_s) + (C_{100} \times V_s) + (C_{220} \times V_s)] \times (100/L)}{L}
\]

\( A_t \) = absorbance of the Sample solution

\( A_s \) = absorbance of the Standard solution

\( C_t \) = 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)

\( C_{100} \) = concentration of metformin hydrochloride in Medium determined at 5 h (mg/mL)

\( C_{220} \) = concentration of metformin hydrochloride in Medium determined at 12 h (mg/mL)

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

Tolerances: See Tables 3 and 4.

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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>

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C236495-M871-CHM32015, rev. 00 20200427
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 (C₄H₁₀N₂ · 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-μm 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 (C₄H₁₀N₂ · HCl) (C), in Medium at each time point (t), by the formulas specified in Test 2.

Tolerances: See Table 5.

Table 5 (continued)

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<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 (C₄H₁₀N₂ · 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-μm 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 (C₄H₁₀N₂ · HCl) (C), 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

Figure 1
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>
<tr>
<td>16</td>
<td>NLT 90</td>
<td>NLT 90</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride (C6H11N6 · 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 (C6H11N6 · HCl) released at each time point.
6 Metformin

Result = \[\left(\frac{(A_s / A_r) \times C_s \times (V - V_s) + (C_{60} \times V_s) + (C_{120} \times V_s) + (C_{600} \times V_s)}{100}\right) / L\]

- \(A_r\) = 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 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>
<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 \((C_6H_11N_4 \cdot \text{HCl})\) 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 7; 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 \((C_6H_11N_4 \cdot \text{HCl})\) released at each time point:

Result = \[\left(\frac{(A_s / A_r) \times C_s \times (V - V_s) + (C_{60} \times V_s) + (C_{120} \times V_s) + (C_{600} \times V_s)}{100}\right) / L\]

- \(A_r\) = 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 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 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 \((C_6H_11N_4 \cdot \text{HCl})\) 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 \((C_6H_11N_4 \cdot \text{HCl})\) released at each time point:

Result = \[\left(\frac{(A_s / A_r) \times C_s \times (V - V_s) + (C_{60} \times V_s) + (C_{120} \times V_s) + (C_{600} \times V_s)}{100}\right) / L\]

- \(A_r\) = 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 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 9.
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 (C₅H₁₄N₂·HCl) released at each time point.

\[
\text{Result} = \left\{ \left( \frac{A_{10} - A_0}{A_{10}} \right) \times C_1 \times (V - V_i) + \left( C_i \times V_j \right) \right. \\
+ \left( C_i \times C_j \right) + \left( C_i \times V_j \right) \left[ \left( C_i \times (C_j + V_j) \right) \right] \times 100/\text{L}
\]

\[ A_0 = \text{absorbance of the Standard solution} \]
\[ A_{10} = \text{absorbance of the Standard solution} \]
\[ C_1 = \text{concentration of the Standard solution (mg/mL)} \]
\[ V = \text{initial volume of Medium in the vessel (mL)} \]
\[ V_i = \text{volume withdrawn from the vessel for previous samplings (mL)} \]
\[ C_i = \text{concentration of metformin hydrochloride in Medium determined at the first time point (mg/mL)} \]
\[ C_2 = \text{concentration of metformin hydrochloride in Medium determined at the second time point (mg/mL)} \]
\[ C_3 = \text{concentration of metformin hydrochloride in Medium determined at the third time point (mg/mL)} \]
\[ C_4 = \text{concentration of metformin hydrochloride in Medium determined at the fourth time point (mg/mL)} \]
\[ L = \text{label claim (mg/Tablet)} \]

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>20</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride (C₅H₁₄N₂·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) at each time point.

\[
C_i = \left( \frac{A_{i0}}{A_{i0}} \right) \times C_1
\]

\[ A_{i0} = \text{absorbance of the Sample solution} \]
\[ A_{i0} = \text{absorbance of the Standard solution} \]
\[ C_1 = \text{concentration of the Standard solution (mg/mL)} \]

Calculate the cumulative percentage of the labeled amount of metformin hydrochloride (C₅H₁₄N₂·HCl) dissolved (Q) at each time point (i):
At \( i = 1 \):
\[
Q_1 = \left( C_i \times V/L \right) \times 100
\]

At \( i = 3 \):
\[
Q_3 = \left[ C_i(V_3 - V_i) + C_i V_j \right] \times 100/L
\]

At \( i = 10 \):
\[
Q_{10} = \left[ C_i(V_3 - 2V_i) + C_i(C_1 + C_2) \right] \times 100/L
\]

\[ V = \text{initial volume of Medium, 1000 mL} \]
\[ V_i = \text{sampling volume, 10 mL} \]
\[ C = \text{label claim (mg/Tablet)} \]

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>5</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

© 2020 The United States Pharmacopeial Convention All Rights Reserved.
The percentages of the labeled amount of metformin hydrochloride (C_{6}H_{11}N_{4}·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 μg/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-μm 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 °C.

Detector: UV 232 nm

Path length: 1 cm

Blank: Medium

Analysis: Calculate the percentage of the labeled amount of metformin hydrochloride (C_{6}H_{11}N_{4}·HCl) dissolved at each time point:

\[ Q = \left( \frac{A_o}{A_i} \right) \times \left( \frac{C_s}{L} \right) \times V \times D \times 100 \]

At 1 h:

Result = \( Q_1 \)

At 3 h:

Result = \( Q_1 + \left( \frac{(Q_1 \times 10)}{V} \right) \)

At 10 h:

Result = \( Q_{10} + \left[ \left( \frac{(Q_1 \times 10)}{V} \right) + \left( \frac{(Q_1 \times 10)}{V} \right) \right] \)

\( A_o \) = absorbance of the Sample solution

\( A_i \) = 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>
<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_{6}H_{11}N_{4}·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, 6, and 14 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 °C. 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_{6}H_{11}N_{4}·HCl) in the sample withdrawn at each time point (i):

\[ C_i = \left( \frac{A_o}{A_i} \right) \times C_s \times \frac{V}{L} \]

\( A_o \) = absorbance of the Sample solution

\( A_i \) = 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_{6}H_{11}N_{4}·HCl) dissolved (Q) at each time point (i):

\[ Q_i = \left[ \left( \frac{C_s}{L} \right) \times \left( \frac{V}{L} \right) \right] \times D \times 100 \]

\( C_i \) = 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 (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NMT 15</td>
</tr>
<tr>
<td>2</td>
<td>35-65</td>
</tr>
<tr>
<td>3</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride (C_{6}H_{11}N_{4}·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

**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°C. 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 ($C_s$) in mg/mL of metformin hydrochloride ($C_{H_2}N_3 \cdot HCl$) in the sample withdrawn from the vessel at each time point ($t$):

$$\text{Result}_s = (A_s / A_d) \times C_s \times D$$

where
- $A_s$ = absorbance of the Sample solution
- $A_d$ = 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 ($C_{H_2}N_3 \cdot HCl$) dissolved at each time point ($t$):

$$\text{Result}_t = C_s \times V \times (1/L) \times 100$$

where
- $C_t$ = 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 15.

<table>
<thead>
<tr>
<th>Time Point ($t$)</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 ($C_{H_2}N_3 \cdot HCl$) dissolved at the times specified conform to **Dissolution** (711), Acceptance Table 2.

**Test 14:** If the product complies with this test, the labeling indicates that it meets USP **Dissolution Test 14.**

**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 μg/mL of USP Metformin Hydrochloride RS in Medium

**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-μm pore size. Pass a portion of the filtered solution through a suitable filter of 0.45-μm pore size, discarding the first few milliliters. Dilute with Medium to a concentration similar to that of the Standard solution.

**Instrumental conditions**
- **Mode:** UV
- **Analytical wavelength:** 232 nm

**Blank:** Medium

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

Calculate the concentration ($C_s$), in mg/mL, of metformin hydrochloride ($C_{H_2}N_3 \cdot HCl$) in the sample withdrawn from the vessel at each time point ($t$):

$$\text{Result}_s = (A_s / A_d) \times C_s \times D$$

where
- $A_s$ = absorbance of the Sample solution
- $A_d$ = absorbance of the Standard solution
- $C_s$ = concentration of the Standard solution (μg/mL)
- $D$ = dilution factor of the Sample solution

Calculate the percentage of the labeled amount of metformin hydrochloride ($C_{H_2}N_3 \cdot HCl$) dissolved at each time point ($t$):

$$\text{Result}_t = C_t \times V \times (1/L) \times 100$$

where
- $C_t$ = 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 ($t$)</th>
<th>Time (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 mg Tablets</td>
<td>750 mg Tablets</td>
<td></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>
10 Metformin

The percentages of the labeled amount of metformin hydrochloride (C₆H₁₃N₇ · 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) of metformin hydrochloride (C₆H₁₃N₇ · HCl) in the sample withdrawn from the vessel at each time point (t):

\[
\text{Result} = (A_s/A_f) \times C \times D
\]

\[A_s\] = absorbance of the Sample solution
\[A_f\] = absorbance of the Standard solution
\[C\] = concentration of the Standard solution (mg/mL)
\[D\] = dilution factor for the Sample solution

Calculate the percentage of the labeled amount of metformin hydrochloride (C₆H₁₃N₇ · HCl) dissolved at the specified time point:

\[
\text{Result}_1 = C \times V \times (1/L) \times 100
\]
\[
\text{Result}_2 = \left[\frac{(C \times V) + (C_s \times V_s)}{2} \right] \times (1/L) \times 100
\]
\[
\text{Result}_3 = \left[\frac{(C \times V) + (C_s \times V_s)}{2} \right] \times (1/L) \times 100
\]

\[C_s\] = 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 (h)</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>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride (C₆H₁₃N₇ · 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) of metformin hydrochloride (C₆H₁₃N₇ · HCl) in the sample withdrawn from the vessel at each time point (t):

\[
\text{Result} = (A_s/A_f) \times C \times D
\]

\[A_s\] = absorbance of the Sample solution
\[A_f\] = absorbance of the Standard solution
\[C\] = concentration of the Standard solution (mg/mL)
\[D\] = dilution factor for the Sample solution

Calculate the percentage of the labeled amount of metformin hydrochloride (C₆H₁₃N₇ · HCl) dissolved at each time point (t):

\[
\text{Result}_1 = C_s \times V \times (1/L) \times 100
\]
\[
\text{Result}_2 = \left[\frac{(C \times V) + (C_s \times V_s)}{2} \right] \times (1/L) \times 100
\]
\[
\text{Result}_3 = \left[\frac{(C \times V) + (C_s \times V_s)}{2} \right] \times (1/L) \times 100
\]

\[C_s\] = 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 (h)</th>
<th>Amount Dissolved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NMT 30</td>
</tr>
<tr>
<td>2</td>
<td>45–70</td>
</tr>
<tr>
<td>3</td>
<td>NLT 85</td>
</tr>
</tbody>
</table>

The percentages of the labeled amount of metformin hydrochloride (\( C_{6}H_{14}N_{3} \cdot HCl \)) dissolved at the times specified conform to Dissolution (711), Acceptance Table 2. (FR 2B 28-Apr-2020)

- **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. \( C_{6}H_{14}N_{3} \cdot HCl \) 151.60
- USP Metformin Related Compound C RS
- \( N,N \)-Dimethyl-[1,3,5]triazine-2,4,6-triamine. \( C_{6}H_{14}N_{2} \) 154.17