

# European Committee on Antimicrobial Susceptibility Testing

## Routine and extended internal quality control for MIC determination and disk diffusion as recommended by EUCAST

Version 8.0, valid from 2018-01-01

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## Notes

1. In EUCAST quality control (QC) tables, both ranges and targets are listed. Repeat testing of EUCAST quality control strains should yield individual MIC and zone diameter values randomly distributed within the recommended ranges. If the number of tests is  $\geq 10$ , the mode MIC should be the target value and the mean zone diameter should be close to the target value.

2. Ranges in bold/italics are established by EUCAST. All targets are established by EUCAST.

3. For access to ISO standard documents, see [http://www.eucast.org/documents/external\\_documents/](http://www.eucast.org/documents/external_documents/).

4. EUCAST quality control strains for routine QC are used to monitor test performance. Control tests should be set up and checked daily, at least for antibiotic agents which are part of routine panels. For analysis of the QC test results, see [EUCAST Disk Diffusion Manual](#).

5. Specific  $\beta$ -lactamase-producing strains are recommended to check the inhibitor component of  $\beta$ -lactam- $\beta$ -lactamase inhibitor combinations. This should be part of the routine QC. The active component is checked with a susceptible QC strain.

6. EUCAST quality control strains for extended QC are complementary to the EUCAST routine QC strains. These strains are recommended for detection of specific resistance mechanisms (ESBL, MRSA, VRE, HLGR and PBP mutations) and are used to check that routine susceptibility testing will result in the correct S, I and R categorisation. Extended QC should be performed with any change in the susceptibility testing system (with each new batch of disks or medium) and/or monthly.

**Changes from previous version**

<b>Version 8.0</b> <b>2018-01-01</b>	<b>Changes</b> Cells containing a change or an addition from EUCAST QC Tables v. 7.0 are marked yellow.
General	<ul style="list-style-type: none"> <li>• New table with EUCAST recommended strains for routine QC based on organisms or groups of organisms in the EUCAST Breakpoint Tables.</li> <li>• Disk diffusion methodology removed (reference to the EUCAST Breakpoint Tables added).</li> </ul>
Notes	<ul style="list-style-type: none"> <li>• Note 2 new.</li> </ul>
ATCC 25922	<b>Revised comments</b> <ul style="list-style-type: none"> <li>• Comment 12 (CCUG and DSM numbers added for NCTC 13846)</li> </ul>
ATCC 27853	<b>Revised comments</b> <ul style="list-style-type: none"> <li>• Comment 8 (CCUG and DSM numbers added for NCTC 13846)</li> </ul>



## **Routine quality control**

## Recommended strains for routine quality control

Table 1 lists the recommended QC strains for each organism or groups of organisms in the EUCAST Breakpoint Tables. The recommendations are based on using a strain of the same (or a similar) species as the organism to be tested (*i.e.* principal QC), but sometimes other QC strains have to be added to cover all agents. Table 2 lists the EUCAST recommended QC strains for control of  $\beta$ -lactam inhibitor combinations.

**Table 1**

Recommendations for principal QC <sup>1</sup>		Recommendations for agents not covered by principal QC <sup>1</sup>	
Organism	QC strain	Agent	QC strain
Enterobacteriaceae (Enterobacterales <sup>2</sup> )	<i>E. coli</i> ATCC 25922	Colistin (MIC)	Add <i>E. coli</i> NCTC 13846
<i>Pseudomonas</i> spp.	<i>P. aeruginosa</i> ATCC 27853	Piperacillin (zone diameter)	<i>E. coli</i> ATCC 25922
		Ticarcillin (zone diameter)	<i>E. coli</i> ATCC 25922
		Colistin (MIC)	Add <i>E. coli</i> NCTC 13846
<i>Stenotrophomonas maltophilia</i>	<i>E. coli</i> ATCC 25922		
<i>Acinetobacter</i> spp.	<i>P. aeruginosa</i> ATCC 27853	Trimethoprim-sulfamethoxazole (MIC and zone diameter)	<i>E. coli</i> ATCC 25922
		Colistin (MIC)	Add <i>E. coli</i> NCTC 13846
<i>Staphylococcus</i> spp.	<i>S. aureus</i> ATCC 29213	Roxithromycin (MIC)	<i>H. influenzae</i> ATCC 49766
<i>Enterococcus</i> spp.	<i>E. faecalis</i> ATCC 29212	Ampicillin-sulbactam (MIC)	See table 2
		Amoxicillin (MIC)	<i>E. coli</i> ATCC 25922
		Amoxicillin-clavulanic acid (MIC)	See table 2
Streptococcus groups A, B, C and G	<i>S. pneumoniae</i> ATCC 49619	Teicoplanin (MIC)	<i>S. aureus</i> ATCC 29213
		Minocycline (MIC)	<i>S. aureus</i> ATCC 29213
		Trimethoprim (MIC)	<i>S. aureus</i> ATCC 29213
		Roxithromycin (MIC)	<i>H. influenzae</i> ATCC 49766
<i>Streptococcus pneumoniae</i>	<i>S. pneumoniae</i> ATCC 49619	Teicoplanin (MIC)	<i>S. aureus</i> ATCC 29213
		Minocycline (MIC)	<i>S. aureus</i> ATCC 29213
		Roxithromycin (MIC)	<i>H. influenzae</i> ATCC 49766
Viridans group streptococci	<i>S. pneumoniae</i> ATCC 49619	Teicoplanin (MIC)	<i>S. aureus</i> ATCC 29213
<i>Haemophilus influenzae</i>	<i>H. influenzae</i> ATCC 49766		
<i>Moraxella catarrhalis</i>	<i>H. influenzae</i> ATCC 49766		
<i>Listeria monocytogenes</i>	<i>S. pneumoniae</i> ATCC 49619		
<i>Pasteurella multocida</i>	<i>H. influenzae</i> ATCC 49766	Benzylpenicillin (MIC)	<i>S. pneumoniae</i> ATCC 49619
<i>Campylobacter jejuni</i> and <i>coli</i>	<i>C. jejuni</i> ATCC 33560	Ciprofloxacin (MIC)	<i>S. aureus</i> ATCC 29213
		Erythromycin (MIC)	<i>S. aureus</i> ATCC 29213
		Tetracycline (MIC)	<i>S. aureus</i> ATCC 29213
<i>Corynebacterium</i> spp.	<i>S. pneumoniae</i> ATCC 49619	Ciprofloxacin (MIC)	<i>S. aureus</i> ATCC 29213
		Gentamicin (MIC and zone diameter)	<i>S. aureus</i> ATCC 29213
<i>Aerococcus sanguinicola</i> and <i>urinae</i>	<i>S. pneumoniae</i> ATCC 49619	Ciprofloxacin (MIC)	<i>S. aureus</i> ATCC 29213
<i>Kingella kingae</i>	<i>H. influenzae</i> ATCC 49766	Benzylpenicillin (MIC)	<i>S. pneumoniae</i> ATCC 49619
<i>Aeromonas</i> spp.	<i>P. aeruginosa</i> ATCC 27853	Trimethoprim-sulfamethoxazole (MIC and zone diameter)	<i>E. coli</i> ATCC 25922

<sup>1</sup>  $\beta$ -lactam inhibitor combinations must be tested with both a susceptible QC strain and a  $\beta$ -lactamase-producing strain (see Table 2).

<sup>2</sup> Recent taxonomic studies have narrowed the definition of the family Enterobacteriaceae. Some previous members of this family are now included in other families within the Order Enterobacterales.

## Recommended strains for routine quality control

**Table 2**

<b>Control of <math>\beta</math>-lactam inhibitor combinations<sup>1</sup></b>		
<b>Organism</b>	<b>QC strain for active component</b>	<b>QC strain for inhibitor component</b>
Enterobacteriaceae (Enterobacterales <sup>2</sup> )	<i>E. coli</i> ATCC 25922	See page 16
<i>Pseudomonas</i> spp.	<i>P. aeruginosa</i> ATCC 27853	See page 16
<i>Enterococcus</i> spp.	<i>E. coli</i> ATCC 25922	See page 16
<i>Haemophilus influenzae</i>	<i>H. influenzae</i> ATCC 49766	See page 16
<i>Moraxella catarrhalis</i>	<i>H. influenzae</i> ATCC 49766	See page 16
<i>Pasteurella multocida</i>	<i>H. influenzae</i> ATCC 49766	See page 16

<sup>1</sup>  $\beta$ -lactam inhibitor combinations must be tested with both a susceptible QC strain and a  $\beta$ -lactamase-producing strain.

<sup>2</sup> Recent taxonomic studies have narrowed the definition of the family Enterobacteriaceae. Some previous members of this family are now included in other families within the Order Enterobacterales.

***Escherichia coli* ATCC 25922**

(NCTC 12241, CIP 76.24, DSM 1103, CCUG 17620, CECT 434)

See EUCAST Breakpoint Tables for short descriptions of MIC and disk diffusion methodology.

Antimicrobial agent	MIC (mg/L)		Disk content (µg)	Inhibition zone diameter (mm)	
	Target <sup>1</sup>	Range <sup>2</sup>		Target <sup>1</sup>	Range <sup>3</sup>
Amikacin	1-2	0.5-4	30	22-23	19-26
Amoxicillin	4	<b>2-8</b>	-	-	-
Amoxicillin-clavulanic acid <sup>4,5</sup>	4	2-8	20-10	21	18-24 <sup>6</sup>
Ampicillin	4	2-8	10	18-19	15-22 <sup>6</sup>
Ampicillin-sulbactam <sup>5,7</sup>	<b>2</b>	<b>1-4</b>	10-10	21-22	19-24 <sup>6</sup>
Aztreonam	0.125	0.06-0.25	30	32	28-36
Cefadroxil	-	-	30	<b>17</b>	<b>14-20</b>
Cefalexin	8	4-16	30	<b>18</b>	<b>15-21</b>
Cefepime	0.03-0.06	0.016-0.125	30	34	31-37
Cefixime	0.5	0.25-1	5	<b>23</b>	<b>20-26</b>
Cefotaxime	0.06	0.03-0.125	5	<b>28</b>	<b>25-31</b>
Cefoxitin	4	2-8	30	26	23-29
Cefpodoxime	0.5	0.25-1	10	25-26	23-28
Ceftaroline	0.06	0.03-0.125	5	<b>27</b>	<b>24-30</b>
Ceftazidime	0.125-0.25	0.06-0.5	10	<b>26</b>	<b>23-29</b>
Ceftazidime-avibactam <sup>8,9</sup>	0.125-0.25	0.06-0.5	10-4	<b>27</b>	<b>24-30</b>
Ceftibuten	0.25	0.125-0.5	30	31	27-35
Ceftobiprole	0.06	0.03-0.125	5	<b>28</b>	<b>25-31</b>
Ceftolozane-tazobactam <sup>10,11</sup>	0.25	0.125-0.5	30-10	28	24-32
Ceftriaxone	0.06	0.03-0.125	30	32	29-35
Cefuroxime	4	2-8	30	23	20-26
Chloramphenicol	4	2-8	30	24	21-27
Ciprofloxacin	0.008	0.004-0.016	5	<b>33</b>	<b>29-37</b>
Colistin <sup>12</sup>	0.5-1	0.25-2	-	-	-
Doripenem	0.03	0.016-0.06	10	31	27-35
Ertapenem	0.008	0.004-0.016	10	32-33	29-36
Fosfomycin <sup>13</sup>	1	0.5-2	200 <sup>14</sup>	<b>30</b>	<b>26-34</b> <sup>15</sup>
Gentamicin	0.5	0.25-1	10	22-23	19-26
Imipenem	0.125	0.06-0.25	10	29	26-32
Levofloxacin	0.016-0.03	0.008-0.06	5	33	29-37
Mecillinam <sup>16</sup>	0.06-0.125	0.03-0.25	10	27	24-30
Meropenem	0.016-0.03	0.008-0.06	10	31-32	28-35
Moxifloxacin	0.016-0.03	0.008-0.06	5	31-32	28-35
Nalidixic acid	2	1-4	30	25	22-28
Netilmicin	-	≤0.5-1	10	<b>21</b>	<b>18-24</b>
Nitrofurantoin	8	4-16	100	<b>20</b>	<b>17-23</b>
Nitroxoline	Note <sup>17</sup>	Note <sup>17</sup>	30	<b>21</b>	<b>18-24</b>
Norfloxacin	0.06	0.03-0.125	10	31-32	28-35
Ofloxacin	0.03-0.06	0.016-0.125	5	31	29-33
Pefloxacin	-	-	5	<b>29</b>	<b>26-32</b>
Piperacillin	2	1-4	30	<b>24</b>	<b>21-27</b>
Piperacillin-tazobactam <sup>10,11</sup>	2	1-4	30-6	<b>24</b>	<b>21-27</b>
Ticarcillin	8	4-16	75	27	24-30
Ticarcillin-clavulanic acid <sup>4,5</sup>	8	4-16	75-10	27	24-30
Tigecycline <sup>18</sup>	0.06-0.125	0.03-0.25	15	23-24	20-27
Tobramycin	0.5	0.25-1	10	22	18-26
Trimethoprim	1	0.5-2	5	24-25	21-28
Trimethoprim-sulfamethoxazole <sup>19</sup>	≤0.5 <sup>2</sup>	-	1.25-23.75	26	23-29

***Escherichia coli* ATCC 25922****(NCTC 12241, CIP 76.24, DSM 1103, CCUG 17620, CECT 434)**

<sup>1</sup> Calculated by EUCAST.

<sup>2</sup> From International Standards Organisation, ISO 20776-1: 2006 (with updates as in the latest CLSI M100 document), except ranges in bold/italics established by EUCAST. All ranges have been validated by EUCAST.

<sup>3</sup> From Clinical and Laboratory Standards Institute, M100-S27, 2017, except ranges in bold/italics established by EUCAST. All ranges have been validated by EUCAST.

<sup>4</sup> For MIC testing, the concentration of clavulanic acid is fixed at 2 mg/L.

<sup>5</sup> *E. coli* ATCC 35218 is used to check the inhibitor component (see Routine quality control for  $\beta$ -lactam- $\beta$ -lactamase inhibitor combinations).

<sup>6</sup> Ignore growth that may appear as a thin inner zone on some batches of Mueller-Hinton agar.

<sup>7</sup> For MIC testing, the concentration of sulbactam is fixed at 4 mg/L.

<sup>8</sup> For MIC testing, the concentration of avibactam is fixed at 4 mg/L.

<sup>9</sup> *K. pneumoniae* ATCC 700603 is used to check the inhibitor component (see Routine quality control for  $\beta$ -lactam- $\beta$ -lactamase inhibitor combinations).

<sup>10</sup> For MIC testing, the concentration of tazobactam is fixed at 4 mg/L.

<sup>11</sup> Either *E. coli* ATCC 35218 or *K. pneumoniae* ATCC 700603 can be used to check the inhibitor component (see Routine quality control for  $\beta$ -lactam- $\beta$ -lactamase inhibitor combinations).

<sup>12</sup> Quality control of colistin must be performed with both a susceptible QC strain (*E. coli* ATCC 25922 or *P. aeruginosa* ATCC 27853) and the colistin resistant *E. coli* NCTC 13846 (*mcr-1* positive). For *E. coli* NCTC 13846 (CCUG 70662, DSM 105182), the colistin MIC target value is 4 mg/L and should only on occasion be 2 or 8 mg/L.

<sup>13</sup> Agar dilution is the reference method for fosfomycin. Fosfomycin MICs must be determined in the presence of glucose-6-phosphate (25 mg/L in the medium). Follow the manufacturer's instructions for commercial systems.

<sup>14</sup> Fosfomycin 200 g disks must contain 50  $\mu$ g glucose-6-phosphate.

<sup>15</sup> Ignore isolated colonies within the inhibition zone and read the outer zone edge (for reading examples see the EUCAST Reading Guide or Breakpoint Tables).

<sup>16</sup> Agar dilution is the reference method for mecillinam MIC determination.

<sup>17</sup> There is currently no MIC range for *E. coli* ATCC 25922 and nitroxoline.

<sup>18</sup> For tigecycline broth microdilution MIC determination, the medium must be prepared fresh on the day of use.

<sup>19</sup> Trimethoprim:sulfamethoxazole in the ratio 1:19. MIC values are expressed as the trimethoprim concentration.



***Pseudomonas aeruginosa* ATCC 27853**

(NCTC 12903, CIP 76.110, DSM 1117, CCUG 17619, CECT 108)

See EUCAST Breakpoint Tables for short descriptions of MIC and disk diffusion methodology.

Antimicrobial agent	MIC (mg/L)		Disk content (µg)	Inhibition zone diameter (mm)	
	Target <sup>1</sup>	Range <sup>2</sup>		Target <sup>1</sup>	Range <sup>3</sup>
Amikacin	2	1-4	30	22	18-26
Aztreonam	4	2-8	30	26	23-29
Cefepime	1-2	0.5-4	30	28	25-31
Ceftazidime	2	1-4	10	<b>24</b>	<b>21-27</b>
Ceftazidime-avibactam <sup>4,5</sup>	1-2	0.5-4	<b>10-4</b>	<b>24</b>	<b>21-27</b>
Ceftolozane-tazobactam <sup>6,7</sup>	0.5	0.25-1	30-10	28	25-31
Ciprofloxacin	0.5	0.25-1	5	29	25-33
Colistin <sup>8</sup>	1-2	0.5-4	-	-	-
Doripenem	0.25	0.125-0.5	10	31-32	28-35
Fosfomycin <sup>9</sup>	4	2-8	-	-	-
Gentamicin	1	0.5-2	10	20	17-23
Imipenem	2	1-4	10	24	20-28
Levofloxacin	1-2	0.5-4	5	22-23	19-26
Meropenem	0.5	0.25-1	10	30	27-33
Netilmicin	2	0.5-8	10	<b>18</b>	<b>15-21</b>
Piperacillin	2-4	1-8	-	-	-
Piperacillin-tazobactam <sup>6,7</sup>	2-4	1-8	30-6	<b>26</b>	<b>23-29</b>
Ticarcillin	16	8-32	-	-	-
Ticarcillin-clavulanic acid <sup>10,11</sup>	16	8-32	75-10	24	20-28
Tobramycin	0.5	0.25-1	10	23	20-26

<sup>1</sup> Calculated by EUCAST.<sup>2</sup> From International Standards Organisation, ISO 20776-1: 2006 (with updates as in the latest CLSI M100 document). All ranges have been validated by EUCAST.<sup>3</sup> From Clinical and Laboratory Standards Institute, M100-S27, 2017, except ranges in bold/italics established by EUCAST. All ranges have been validated by EUCAST.<sup>4</sup> For MIC testing, the concentration of avibactam is fixed at 4 mg/L.<sup>5</sup> *K. pneumoniae* ATCC 700603 is used to check the inhibitor component (see Routine quality control for β-lactam-β-lactamase inhibitor combinations).<sup>6</sup> For MIC testing, the concentration of tazobactam is fixed at 4 mg/L.<sup>7</sup> Either *E. coli* ATCC 35218 or *K. pneumoniae* ATCC 700603 can be used to check the inhibitor component (see Routine quality control for β-lactam-β-lactamase inhibitor combinations).<sup>8</sup> Quality control of colistin must be performed with both a susceptible QC strain (*E. coli* ATCC 25922 or *P. aeruginosa* ATCC 27853) and the colistin resistant *E. coli* NCTC 13846 (*mcr-1* positive). For *E. coli* NCTC 13846 (CCUG 70662, DSM 105182), the colistin MIC target value is 4 mg/L and should only on occasion be 2 or 8 mg/L.<sup>9</sup> Agar dilution is the reference method for fosfomycin. Fosfomycin MICs must be determined in the presence of glucose-6-phosphate (25 mg/L in the medium). Follow the manufacturer's instructions for commercial systems.<sup>10</sup> *E. coli* ATCC 35218 is used to check the inhibitor component (see Routine quality control for β-lactam-β-lactamase inhibitor combinations).<sup>11</sup> For MIC testing, the concentration of clavulanic acid is fixed at 2 mg/L.

***Staphylococcus aureus* ATCC 29213**

(NCTC 12973, CIP 103429, DSM 2569, CCUG 15915, CECT 794)

 $\beta$ -lactamase-producing strain (weak)

See EUCAST Breakpoint Tables for short descriptions of MIC and disk diffusion methodology.

Antimicrobial agent	MIC (mg/L)		Disk content ( $\mu$ g)	Inhibition zone diameter (mm)	
	Target <sup>1</sup>	Range <sup>2</sup>		Target <sup>1</sup>	Range <sup>3</sup>
Amikacin	2	1-4	30	21	18-24
Ampicillin	-	-	2	18	15-21
Azithromycin	1	0.5-2	-	-	-
Benzylpenicillin	0.5-1	0.25-2	1 unit	15	12-18
Cefoxitin	2	1-4	30	27	24-30
Ceftaroline	0.25	0.125-0.5	5	27	24-30
Ceftobiprole	0.25-0.5	0.125-1	5	25	22-28
Chloramphenicol	4-8	2-16	30	24	20-28
Ciprofloxacin	0.25	0.125-0.5	5	24	21-27
Clarithromycin	0.25	0.125-0.5	-	-	-
Clindamycin	0.125	0.06-0.25	2	26	23-29
Dalbavancin <sup>4</sup>	0.06	0.03-0.125	-	-	-
Daptomycin <sup>5</sup>	0.25-0.5	0.125-1	-	-	-
Doxycycline	0.25	0.125-0.5	-	-	-
Erythromycin	0.5	0.25-1	15	26	23-29
Fosfomycin <sup>6</sup>	1-2	0.5-4	-	-	-
Fusidic acid	0.125	0.06-0.25	10	29	26-32
Gentamicin	0.25-0.5	0.125-1	10	22	19-25
Levofloxacin	0.125-0.25	0.06-0.5	5	26	23-29
Linezolid	2	1-4	10	24	21-27
Minocycline	0.125-0.25	0.06-0.5	30	26	23-29
Moxifloxacin	0.03-0.06	0.016-0.125	5	28	25-31
Mupirocin	0.125	0.06-0.25	200	34	31-37
Netilmicin	$\leq 0.25^2$	-	10	23	20-26
Nitrofurantoin	16	8-32	100	20	17-23
Norfloxacin	1	0.5-2	10	21	18-24
Ofloxacin	0.25-0.5	0.125-1	5	24	21-27
Oritavancin <sup>4</sup>	0.03-0.06	0.016-0.125	-	-	-
Quinupristin-dalfopristin	0.5	0.25-1	15	24	21-27
Rifampicin	0.008	0.004-0.016	5	33	30-36
Tedizolid	0.5	0.25-1	-	-	-
Teicoplanin	0.5	0.25-1	-	-	-
Telavancin <sup>4</sup>	0.06	0.03-0.125	-	-	-
Telithromycin	0.125	0.06-0.25	15	IP	IP
Tetracycline	0.25-0.5	0.125-1	30	27	23-31
Tigecycline <sup>7</sup>	0.06-0.125	0.03-0.25	15	22	19-25
Tobramycin	0.25-0.5	0.125-1	10	23	20-26
Trimethoprim	2	1-4	5	25	22-28
Trimethoprim-sulfamethoxazole <sup>8</sup>	$\leq 0.5^2$	-	1.25-23.75	29	26-32
Vancomycin	1	0.5-2	-	-	-

***Staphylococcus aureus* ATCC 29213****(NCTC 12973, CIP 103429, DSM 2569, CCUG 15915, CECT 794)**

β-lactamase-producing strain (weak)

<sup>1</sup> Calculated by EUCAST.<sup>2</sup> From International Standards Organisation, ISO 20776-1: 2006 (with updates as in the latest CLSI M100 document). All ranges have been validated by EUCAST.<sup>3</sup> Established and validated by EUCAST.<sup>4</sup> MICs must be determined in the presence of polysorbate-80 (0.002% in the medium for broth dilution methods; agar dilution methods have not been validated). Follow the manufacturer's instructions for commercial systems.<sup>5</sup> Daptomycin MICs must be determined in the presence of Ca<sup>2+</sup> (50 mg/L in the medium for broth dilution methods; agar dilution methods have not been validated). Follow the manufacturer's instructions for commercial systems.<sup>6</sup> Agar dilution is the reference method for fosfomycin. Fosfomycin MICs must be determined in the presence of glucose-6-phosphate (25 mg/L in the medium). Follow the manufacturer's instructions for commercial systems.<sup>7</sup> For tigecycline broth microdilution MIC determination, the medium must be prepared fresh on the day of use.<sup>8</sup> Trimethoprim:sulfamethoxazole in the ratio 1:19. MIC values are expressed as the trimethoprim concentration.

IP = In Preparation

***Enterococcus faecalis* ATCC 29212**

(NCTC 12697, CIP 103214, DSM 2570, CCUG 9997, CECT 795)

See EUCAST Breakpoint Tables for short descriptions of MIC and disk diffusion methodology.

Antimicrobial agent	MIC (mg/L)		Disk content (µg)	Inhibition zone diameter (mm)	
	Target <sup>1</sup>	Range <sup>2</sup>		Target <sup>1</sup>	Range <sup>3</sup>
Ampicillin	1	0.5-2	2	<b>18</b>	<b>15-21</b>
Ciprofloxacin	0.5-1	0.25-2	5	<b>22</b>	<b>19-25</b>
Gentamicin	8	4-16	30 <sup>4</sup>	<b>15</b>	<b>12-18</b>
Imipenem	1	0.5-2	10	<b>27</b>	<b>24-30</b>
Levofloxacin	0.5-1	0.25-2	5	<b>22</b>	<b>19-25</b>
Linezolid	2	1-4	10	<b>22</b>	<b>19-25</b>
Nitrofurantoin	8	4-16	100	<b>21</b>	<b>18-24</b>
Norfloxacin	4	2-8	10	<b>19</b>	<b>16-22</b>
Quinupristin-dalfopristin	4	2-8	15	<b>14</b>	<b>11-17</b>
Streptomycin	Note <sup>5</sup>	Note <sup>5</sup>	300 <sup>6</sup>	17	14-20 <sup>7</sup>
Teicoplanin	0.5	0.25-1	30	<b>18</b>	<b>15-21</b>
Tigecycline <sup>8</sup>	0.06	0.03-0.125	15	<b>23</b>	<b>20-26</b>
Trimethoprim	0.25	0.125-0.5	5	<b>28</b>	<b>24-32</b>
Trimethoprim-sulfamethoxazole <sup>9</sup>	≤0.5 <sup>2</sup>	-	1.25-23.75	<b>30</b>	<b>26-34</b>
Vancomycin	2	1-4	5	<b>13</b>	<b>10-16</b>

<sup>1</sup> Calculated by EUCAST.<sup>2</sup> From International Standards Organisation, ISO 20776-1: 2006 (with updates as in the latest CLSI M100 document). All ranges have been validated by EUCAST.<sup>3</sup> Established and validated by EUCAST.<sup>4</sup> Screening disk for high-level aminoglycoside-resistance in enterococci.<sup>5</sup> There is currently no MIC range for *E. faecalis* ATCC 29212 and streptomycin.<sup>6</sup> Screening disk for high-level streptomycin-resistance in enterococci.<sup>7</sup> From Clinical and Laboratory Standards Institute, M100-S27, 2017.<sup>8</sup> For tigecycline broth microdilution MIC determination, the medium must be prepared fresh on the day of use.<sup>9</sup> Trimethoprim:sulfamethoxazole in the ratio 1:19. MIC values are expressed as the trimethoprim concentration.

***Streptococcus pneumoniae* ATCC 49619\***

(NCTC 12977, CIP 104340, DSM 11967, CCUG 33638)

Strain with reduced susceptibility to benzylpenicillin

\* Zone edges for *S. pneumoniae* on MH-F are often accompanied by  $\alpha$ -haemolysis. Read inhibition of growth and not inhibition of haemolysis. Tilt the plate to easier differentiate between haemolysis and growth. There is usually growth in the whole area of  $\alpha$ -haemolysis but on some MH-F media, there is additional  $\alpha$ -haemolysis without growth.

**See EUCAST Breakpoint Tables for short descriptions of MIC and disk diffusion methodology.**

Antimicrobial agent	MIC (mg/L)		Disk content ( $\mu$ g)	Inhibition zone diameter (mm)	
	Target <sup>1</sup>	Range <sup>2</sup>		Target <sup>1</sup>	Range <sup>3</sup>
Amoxicillin	0.06	0.03-0.125	-	-	-
Ampicillin	0.125	0.06-0.25	2	28	25-31
Azithromycin	0.125	0.06-0.25	-	-	-
Benzylpenicillin	0.5	0.25-1	1 unit	19	16-22
Cefaclor	2	1-4	30	28	25-31
Cefepime	0.06-0.125	0.03-0.25	30	34	31-37
Cefotaxime	0.06	0.03-0.125	5	31	28-34
Cefpodoxime	0.06	0.03-0.125	10	32	29-35
Ceftaroline	0.016	0.008-0.03	-	-	-
Ceftobiprole	0.008-0.016	0.004-0.03	-	-	-
Ceftriaxone	0.06	0.03-0.125	30	35	32-38
Cefuroxime	0.5	0.25-1	30	31	28-34
Chloramphenicol	4	2-8	30	27	24-30
Ciprofloxacin	-	-	5	25	22-28
Clarithromycin	0.06	0.03-0.125	-	-	-
Clindamycin	0.06	0.03-0.125	2	25	22-28
Dalbavancin <sup>4</sup>	0.016	0.008-0.03	-	-	-
Daptomycin <sup>5</sup>	0.125-0.25	0.06-0.5	-	-	-
Doripenem	0.06	0.03-0.125	10	34	31-37
Doxycycline	0.03-0.06	0.016-0.125	-	-	-
Ertapenem	0.06-0.125	0.03-0.25	10	31	28-34
Erythromycin	0.06	0.03-0.125	15	29	26-32
Imipenem	0.06	0.03-0.125	10	38	34-42
Levofloxacin	1	0.5-2	5	24	21-27
Linezolid	0.5-1	0.25-2	10	26	23-29
Meropenem	0.125	0.06-0.25	10	34	30-38
Minocycline	-	-	30	28	25-31
Moxifloxacin	0.125	0.06-0.25	5	27	24-30
Nitrofurantoin	8	4-16	100	28	25-31
Norfloxacin	4	2-8	10	21	18-24
Ofloxacin	2	1-4	5	21	18-24
Oritavancin <sup>4</sup>	0.002	0.001-0.004	-	-	-
Oxacillin <sup>6</sup>	-	-	1	11	8-14 <sup>6</sup>
Rifampicin	0.03	0.016-0.06	5	29	26-32
Tedizolid	0.25	0.125-0.5	-	-	-
Teicoplanin	-	-	30	21	18-24
Telithromycin	0.008-0.016	0.004-0.03	15	30	27-33
Tetracycline	0.125-0.25	0.06-0.5	30	31	28-34
Tigecycline <sup>7</sup>	0.03-0.06	0.016-0.125	15	27	24-30
Trimethoprim-sulfamethoxazole <sup>8</sup>	0.25-0.5	0.125-1	1.25-23.75	22	18-26
Vancomycin	0.25	0.125-0.5	5	20	17-23

***Streptococcus pneumoniae* ATCC 49619\*****(NCTC 12977, CIP 104340, DSM 11967, CCUG 33638)**

Strain with reduced susceptibility to benzylpenicillin

<sup>1</sup> Calculated by EUCAST.<sup>2</sup> From International Standards Organisation, ISO 20776-1: 2006 (with updates as in the latest CLSI M100 document). All ranges have been validated by EUCAST.<sup>3</sup> Established and validated by EUCAST.<sup>4</sup> MICs must be determined in the presence of polysorbate-80 (0.002% in the medium for broth dilution methods; agar dilution methods have not been validated). Follow the manufacturer's instructions for commercial systems.<sup>5</sup> Daptomycin MICs must be determined in the presence of Ca<sup>2+</sup> (50 mg/L in the medium for broth dilution methods; agar dilution methods have not been validated). Follow the manufacturer's instructions for commercial systems.<sup>6</sup> *S. aureus* ATCC 29213 can be used for quality control of oxacillin 1 µg with target 22 mm and range 19-25 mm (according to disk diffusion methodology for *S. aureus*).<sup>7</sup> For tigecycline broth microdilution MIC determination, the medium must be prepared fresh on the day of use.<sup>8</sup> Trimethoprim:sulfamethoxazole in the ratio 1:19. MIC values are expressed as the trimethoprim concentration.

***Haemophilus influenzae* ATCC 49766**  
(NCTC 12975, CIP 103570, DSM 11970, CCUG 29539)

See EUCAST Breakpoint Tables for short descriptions of MIC and disk diffusion methodology.

Antimicrobial agent	MIC (mg/L)		Disk content (µg)	Inhibition zone diameter (mm)	
	Target <sup>1</sup>	Range <sup>2</sup>		Target <sup>1</sup>	Range <sup>2</sup>
Amoxicillin-clavulanic acid <sup>3,4</sup>	<b>0.25</b>	<b>0.125-0.5</b>	2-1	<b>20</b>	<b>17-23</b>
Amoxicillin	<b>0.25</b>	<b>0.125-0.5</b>	-	-	-
Ampicillin	<b>0.125</b>	<b>0.06-0.25</b>	2	<b>22</b>	<b>19-25</b>
Ampicillin-sulbactam <sup>5</sup>	<b>0.125</b>	<b>0.06-0.25</b>	-	-	-
Azithromycin	<b>1</b>	<b>0.5-2</b>	-	-	-
Benzylpenicillin	-	-	1 unit	<b>18</b>	<b>15-21</b>
Cefepime	<b>0.06</b>	<b>0.03-0.125</b>	30	<b>33</b>	<b>30-36</b>
Cefixime	<b>0.03</b>	<b>0.016-0.06</b>	5	<b>32</b>	<b>29-35</b>
Cefotaxime	<b>0.008</b>	<b>0.004-0.016</b>	5	<b>33</b>	<b>29-37</b>
Cefpodoxime	<b>0.06</b>	<b>0.03-0.125</b>	10	<b>33</b>	<b>30-36</b>
Ceftaroline	<b>0.008</b>	<b>0.004-0.016</b>	-	-	-
Ceftibuten	<b>0.03</b>	<b>0.016-0.06</b>	30	<b>34</b>	<b>31-37</b>
Ceftriaxone	<b>0.004</b>	<b>0.002-0.008</b>	30	<b>38</b>	<b>34-42</b>
Cefuroxime	0.5	0.25-1 <sup>6</sup>	30	<b>30</b>	<b>26-34</b>
Chloramphenicol	<b>0.5</b>	<b>0.25-1</b>	30	<b>34</b>	<b>31-37</b>
Ciprofloxacin	<b>0.008</b>	<b>0.004-0.016</b>	5	<b>36</b>	<b>32-40</b>
Clarithromycin	<b>8</b>	<b>4-16</b>	-	-	-
Doripenem	0.125	0.06-0.25 <sup>6</sup>	10	<b>29</b>	<b>26-32</b>
Doxycycline	<b>0.5</b>	<b>0.25-1</b>	-	-	-
Ertapenem	0.03	0.016-0.06 <sup>6</sup>	10	<b>30</b>	<b>27-33</b>
Erythromycin	<b>4</b>	<b>2-8</b>	15	<b>13</b>	<b>10-16</b>
Imipenem	0.5	0.25-1 <sup>6</sup>	10	<b>27</b>	<b>24-30</b>
Levofloxacin	<b>0.016</b>	<b>0.008-0.03</b>	5	<b>35</b>	<b>31-39</b>
Meropenem	0.06	0.03-0.125 <sup>6</sup>	10	<b>31</b>	<b>27-35</b>
Minocycline	<b>0.25</b>	<b>0.125-0.5</b>	30	<b>29</b>	<b>26-32</b>
Moxifloxacin	<b>0.016</b>	<b>0.008-0.03</b>	5	<b>33</b>	<b>30-36</b>
Nalidixic acid	-	-	30	<b>30</b>	<b>27-33</b>
Ofloxacin	<b>0.03</b>	<b>0.016-0.06</b>	5	<b>34</b>	<b>31-37</b>
Rifampicin	<b>0.5</b>	<b>0.25-1</b>	5	<b>24</b>	<b>21-27</b>
Roxithromycin	<b>8</b>	<b>4-16</b>	-	-	-
Telithromycin	<b>2</b>	<b>1-4</b>	15	<b>17</b>	<b>14-20</b>
Tetracycline	<b>0.5</b>	<b>0.25-1</b>	30	<b>31</b>	<b>28-34</b>
Trimethoprim-sulfamethoxazole <sup>7</sup>	<b>0.03</b>	<b>0.016-0.06</b>	1.25-23.75	<b>31</b>	<b>27-35</b>

<sup>1</sup> Calculated by EUCAST.

<sup>2</sup> Established and validated by EUCAST.

<sup>3</sup> For MIC testing, the concentration of clavulanic acid is fixed at 2 mg/L.

<sup>4</sup> *E. coli* ATCC 35218 (MIC) and *S. aureus* ATCC 29213 (disk diffusion) are used to check the inhibitor component (see Routine quality control for β-lactam-β-lactamase inhibitor combinations).

<sup>5</sup> For MIC testing, the concentration of sulbactam is fixed at 4 mg/L.

<sup>6</sup> From Clinical and Laboratory Standards Institute, M100-S27, 2017, and validated by EUCAST.

<sup>7</sup> Trimethoprim:sulfamethoxazole in the ratio 1:19. MIC values are expressed as the trimethoprim concentration.

***Campylobacter jejuni* ATCC 33560**

(NCTC 11351, CIP 702, DSM 4688, CCUG 11284)

See EUCAST Breakpoint Tables for short descriptions of MIC and disk diffusion methodology.

Antimicrobial agent	MIC (mg/L)		Disk content (µg)	Inhibition zone diameter (mm)	
	Target	Range		Target <sup>1</sup>	Range <sup>2</sup>
Ciprofloxacin	IP	IP	5	<b>38</b>	<b>34-42</b>
Erythromycin	IP	IP	15	<b>31</b>	<b>27-35</b>
Tetracycline	IP	IP	30	<b>34</b>	<b>30-38</b>

<sup>1</sup> Calculated by EUCAST.<sup>2</sup> Established and validated by EUCAST.

IP = In Preparation



## Control of the inhibitor component of $\beta$ -lactam- $\beta$ -lactamase inhibitor combinations

See EUCAST Breakpoint Tables for short descriptions of MIC and disk diffusion methodology.

### *Escherichia coli* ATCC 35218

(NCTC 11954, CIP 102181, DSM 5923, CCUG 30600, CECT 943)

TEM-1  $\beta$ -lactamase-producing strain (non-ESBL)

Antimicrobial agent	MIC (mg/L)		Disk content ( $\mu$ g)	Inhibition zone diameter (mm)	
	Target <sup>1</sup>	Range <sup>2</sup>		Target <sup>1</sup>	Range <sup>2</sup>
Amoxicillin-clavulanic acid <sup>3</sup>	<b>8-16</b>	<b>4-32</b>	20-10	19-20	17-22 <sup>4</sup>
Ampicillin-sulbactam <sup>5</sup>	<b>32-64</b>	<b>16-128</b>	10-10	16	13-19 <sup>4</sup>
Ceftolozane-tazobactam <sup>6,7</sup>	0.125	0.06-0.25	30-10	28	25-31
Piperacillin-tazobactam <sup>6,7</sup>	1	0.5-2	30-6	<b>24</b>	<b>21-27</b>
Ticarcillin-clavulanic acid <sup>3</sup>	16	8-32	75-10	23	21-25

### *Klebsiella pneumoniae* ATCC 700603

(NCTC 13368, CCUG 45421, CECT 7787)

SHV-18 ESBL producer

Antimicrobial agent	MIC (mg/L)		Disk content ( $\mu$ g)	Inhibition zone diameter (mm)	
	Target <sup>1</sup>	Range <sup>2</sup>		Target <sup>1</sup>	Range <sup>2</sup>
Ceftazidime-avibactam <sup>8</sup>	0.5-1	0.25-2	10-4	<b>21</b>	<b>18-24</b>
Ceftolozane-tazobactam <sup>6,7</sup>	1	0.5-2	30-10	21	17-25
Piperacillin-tazobactam <sup>6,7</sup>	16	8-32	30-6	<b>17</b>	<b>14-20</b>

### *Staphylococcus aureus* ATCC 29213

(NCTC 12973, CIP 103429, DSM 2569, CCUG 15915, CECT 794)

$\beta$ -lactamase-producing strain (weak)

Antimicrobial agent	MIC (mg/L)		Disk content ( $\mu$ g)	Inhibition zone diameter (mm)	
	Target <sup>1</sup>	Range <sup>2</sup>		Target <sup>1</sup>	Range <sup>2</sup>
Amoxicillin-clavulanic acid <sup>3</sup>	Note <sup>9</sup>	Note <sup>9</sup>	2-1	<b>22</b>	<b>19-25</b>

<sup>1</sup> Calculated by EUCAST.

<sup>2</sup> From Clinical and Laboratory Standards Institute, M100-S27, 2017, except ranges in bold/italics established by EUCAST. All ranges have been validated by EUCAST.

<sup>3</sup> For MIC testing, the concentration of clavulanic acid is fixed at 2 mg/L.

<sup>4</sup> Ignore growth that may appear as a thin inner zone on some batches of Mueller-Hinton agar.

<sup>5</sup> For MIC testing, the concentration of sulbactam is fixed at 4 mg/L.

<sup>6</sup> For MIC testing, the concentration of tazobactam is fixed at 4 mg/L.

<sup>7</sup> Either *E. coli* ATCC 35218 or *K. pneumoniae* ATCC 700603 can be used to check the inhibitor component.

<sup>8</sup> For MIC testing, the concentration of avibactam is fixed at 4 mg/L.

<sup>9</sup> For MIC testing, *E. coli* ATCC 35218 is used to check the inhibitor component.



## **Extended quality control for detection of resistance mechanisms with disk diffusion**

## Quality control strains for detection of resistance mechanisms with disk diffusion on Mueller-Hinton agar

See EUCAST Breakpoint Tables for short descriptions of MIC and disk diffusion methodology.

### ESBL production in Enterobacteriaceae

#### *Klebsiella pneumoniae* ATCC 700603

(NCTC 13368, CCUG 45421, CECT 7787)

SHV-18 ESBL-producer

Antimicrobial agent	Disk content (µg)	Target susceptibility <sup>1</sup>	Range <sup>2</sup> (mm)	Comments
Aztreonam	30	R	9-17	
Cefotaxime	5	I or R	<b>12-18</b>	
Cefpodoxime	10	R	9-16	
Ceftazidime	10	I or R	<b>6-12</b>	
Ceftriaxone	30	I or R	<b>16-22</b>	

### Methicillin resistance in *Staphylococcus aureus*

#### *Staphylococcus aureus* NCTC 12493

(CCUG 67181)

Methicillin resistant (MRSA), *mecA* positive

Antimicrobial agent	Disk content (µg)	Target susceptibility <sup>1</sup>	Range <sup>2</sup> (mm)	Comments
Cefoxitin	30	R	<b>14-20</b>	

### *vanB*-mediated glycopeptide resistance in enterococci

#### *Enterococcus faecalis* ATCC 51299

(NCTC 13379 ,CIP 104676, DSM 12956, CCUG 34289)

*vanB*-positive strain

Antimicrobial agent	Disk content (µg)	Target susceptibility <sup>1</sup>	Range <sup>2</sup> (mm)	Comments
Teicoplanin	30	S	<b>16-20</b>	
Vancomycin	5	R	<b>6-12</b>	Examine zone edge with transmitted light (plate held up to light). Inhibition zones with fuzzy zone edges are interpreted as resistant, even if the zone diameter is above the susceptible breakpoint (for reading examples see the EUCAST Reading Guide or Breakpoint Tables).

### High-level aminoglycoside resistance in enterococci

#### *Enterococcus faecalis* ATCC 51299

(NCTC 13379 ,CIP 104676, DSM 12956, CCUG 34289)

High-level gentamicin and streptomycin resistant

Antimicrobial agent	Disk content (µg)	Target susceptibility <sup>1</sup>	Range <sup>2</sup> (mm)	Comments
Gentamicin	30	R	<b>6</b>	
Streptomycin	300	R	<b>6</b>	

<sup>1</sup> Targets comply with EUCAST clinical breakpoints and are set to ensure that resistance mechanisms are correctly detected. Interpretation according to EUCAST clinical breakpoints: S=Susceptible, I=Intermediate, R=Resistant.

<sup>2</sup> From Clinical and Laboratory Standards Institute, M100-S27, 2017, except ranges in bold/italics established by EUCAST. All ranges have been validated by EUCAST.

## Quality control strains for detection of resistance mechanisms with disk diffusion on Mueller-Hinton fastidious (MH-F) agar

See EUCAST Breakpoint Tables for short descriptions of MIC and disk diffusion methodology.

### Reduced susceptibility to $\beta$ -lactam agents due to PBP mutations in *Haemophilus influenzae*

*Haemophilus influenzae* ATCC 49247

(NCTC 12699, CIP 104604, DSM 9999, CCUG 26214)

Antimicrobial agent	Disk content ( $\mu$ g)	Target susceptibility <sup>1</sup>	Range <sup>2</sup> (mm)	Comments
				Inhibition zone diameters are particularly affected by variation in medium, inoculum and incubation conditions. Inhibition zones with growth of small colonies up to the disk are interpreted as no zone.
Ampicillin	2	R	<b>6-12</b>	
Benzylopenicillin	1 unit	R	<b>6-9</b>	

<sup>1</sup> Targets comply with EUCAST clinical breakpoints and are set to ensure that resistance mechanisms are correctly detected. Interpretation according to EUCAST clinical breakpoints: S=Susceptible, I=Intermediate, R=Resistant.

<sup>2</sup> Established and validated by repeated testing by EUCAST.