

Antimicrobial Resistance Strains

Microbiologics offers a wide range of strains with characterized antimicrobial resistance mechanisms including:

- Extended-Spectrum β -lactamases (ESBL)
- Carbapenemases
- Vancomycin-Resistant Enterococci (VRE)
- Methicillin-Resistant *Staphylococcus aureus* (MRSA)

Several of the strains are used by the Clinical Laboratory Standards Institute (CLSI) and the European Committee on Antimicrobial Susceptibility Testing (EUCAST) for quality control of antimicrobial susceptibility tests. Microbiologics also offers several strains of *Clostridioides difficile*.

These strains come in convenient, ready-to-use formats which are used for the quality control of laboratory developed tests, antimicrobial resistance tests, and tests for toxinotypes. For more information visit microbiologics.com.

1. Penicillinase without Extended-Spectrum β -Lactamase Activity

Name	Catalog #	Characteristics
<i>Escherichia coli</i> derived from ATCC® 35218™*	0495	TEM-1 β -lactamase producer ^{1,2,3} CLSI and EUCAST control

2. Extended-Spectrum β -lactamases (ESBL)

2.1 TEM β -lactamases

Name	Catalog #	Characteristics
<i>Escherichia coli</i> derived from NCTC 13351	01085	TEM-3 ESBL ²

2.2 SHV β -lactamase

Name	Catalog #	Characteristics
<i>Klebsiella pneumoniae</i> subsp. <i>pneumoniae</i> derived from ATCC® 700603™*	0784	SHV-18 ESBL ⁴ OXA-2 ³ CLSI and EUCAST control

2.3 CTX-M β -lactamase

Name	Catalog #	Characteristics
<i>Enterobacter cloacae</i> derived from NCTC 13464	01105	CTX-M-15 ESBL <i>bla</i> _{CTX-M} group 9 gene ²
<i>Escherichia coli</i> derived from NCTC 13353	01265	CTX-M-15 ESBL ^{2,3} CLSI control

3. Carbapenemases

3.1 Class A Carbapenemases

Name	Catalog #	Characteristics
<i>Klebsiella pneumoniae</i> derived from NCTC 13438	01117	Carbapenemase KPC-3 positive ²
<i>Klebsiella pneumoniae</i> derived from ATCC® BAA-1705™*	01005	<i>bla</i> _{KPC} positive, <i>bla</i> _{NDM} negative ⁴ Carbapenemase KPC-2 positive ³ Carbapenem-resistant (imipenem and ertapenem) ⁴ SHV ³ TEM ³ CLSI control

Name	Catalog #	Characteristics
<i>Klebsiella pneumoniae</i> derived from ATCC® BAA-2814™*	01263	Carbapenemase KPC-3 positive ^{3,4}

3.2 Class B Carbapenemases - Metallo-β-lactamases

Name	Catalog #	Characteristics
<i>Escherichia coli</i> derived from ATCC® BAA-2469™*	01113	New Delhi metallo-β-lactamase (NDM-1) positive <i>bla</i> _{KPC} negative, <i>bla</i> _{NDM} positive Carbapenem-resistant (imipenem and ertapenem) ⁴
<i>Klebsiella pneumoniae</i> derived from CDC 1100192	01153	New Delhi metallo-beta-lactamase (NDM-1) positive <i>bla</i> _{NDM} positive ⁶
<i>Escherichia coli</i> derived from NCTC 13476	01136	IMP-type metallo-carbapenemase ²
<i>Klebsiella pneumoniae</i> derived from ATCC® BAA-2146™*	01060	New Delhi metallo-beta-lactamase (NDM-1) positive <i>bla</i> _{KPC} negative, <i>bla</i> _{NDM} positive ⁴
<i>Klebsiella pneumoniae</i> derived from NCTC 13439	01245	VIM-1 metallo-beta-carbapenemase positive Plasmid-mediated fluoroquinolone resistance ²
<i>Klebsiella pneumoniae</i> derived from NCTC 13440	01112	VIM-1 metallo-beta-carbapenemase positive
<i>Klebsiella pneumoniae</i> derived from NCTC 13443	01145	New Delhi metallo-carbapenemase (NDM-1) positive ²
<i>Escherichia coli</i> derived from ATCC® BAA-2452™*	01242	New Delhi metallo-β-lactamase (NDM-1) positive <i>bla</i> _{KPC} negative, <i>bla</i> _{NDM} positive Carbapenem-resistant (imipenem and ertapenem) ⁴

3.3 Class D Carbapenemases - OXA Carbapenemases

Name	Catalog #	Characteristics
<i>Acinetobacter baumannii</i> derived from NCTC 13304	01266	OXA-27 carbapenemase ²
<i>Klebsiella pneumoniae</i> derived from NCTC 13442	01148	OXA-48 carbapenemase ²
<i>Klebsiella pneumoniae</i> derived from CDC AR-0039	01241	OXA-181 carbapenemase ⁶
<i>Klebsiella pneumoniae</i> derived from CDC AR-0066	01240	OXA-232 carbapenemase ⁶
<i>Klebsiella pneumoniae</i> subsp. <i>pneumoniae</i> derived from ATCC® 700603™*	0784	OXA-2 carbapenemase SHV-18 ESBL ³ CLSI and EUCAST control

4. AmpC β-lactamases

Name	Catalog #	Characteristics
<i>Enterobacter cloacae</i> derived from ATCC BAA-1143	01018	Control strain for the AmpC disk test High level producer of chromosomal AmpC β-lactamase
<i>Enterobacter cloacae</i> derived from NCTC 13406	01111	Control for AmpC detection tests ²
<i>Pseudomonas aeruginosa</i> derived from ATCC® 27853™*	0353	Contains inducible AmpC β-lactamase ³

5. Plasmid-mediated Fluoroquinolone Resistance

Name	Catalog #	Characteristics
<i>Klebsiella pneumoniae</i> derived from NCTC 13439	01245	VIM-1 metallo-beta-carbapenemase positive Plasmid-mediated fluoroquinolone resistance ²

6. Colistin Resistance

Name	Catalog #	Characteristics
<i>Escherichia coli</i> derived from CDC AR-0346	01259	Colistin resistant Contains mcr-1 gene ESBL positive ⁶
<i>Escherichia coli</i> derived from NCTC 13846	01244	Colistin resistant Contains mcr-1 gene Extended-spectrum beta-lactamase (ESBL) positive TEM1 CTX-M-27 ²

7. Vancomycin Resistant Enterococci (VRE)

Name	Catalog #	Characteristics
<i>Enterococcus faecalis</i> derived from ATCC® 51299™*	0959	<i>vanB</i> positive ant(6)-I aac(6') aph(2'') Low-level vancomycin resistant Sensitive to teicoplanin ⁴ Resistant to high level aminoglycosides ^{3,4} High level gentamicin and streptomycin resistant ¹
<i>Enterococcus faecalis</i> derived from ATCC® 51575™*	01089	<i>vanB</i> positive Resistant to gentamicin, streptomycin and vancomycin Sensitive to teichoplanin ⁴
<i>Enterococcus faecium</i> derived from ATCC® 700221™*	01000	<i>vanA</i> positive <i>IS16</i> and <i>esp</i> positive Resistant to vancomycin and teicoplanin ⁴
<i>Enterococcus faecium</i> derived from NCTC 12204	01143	<i>vanA</i> -type glycopeptide resistance Vancomycin resistant ²

8. Methicillin-Resistant *Staphylococcus aureus* (MRSA)

Name	Catalog #	Characteristics
<i>Staphylococcus aureus</i> subsp. <i>aureus</i> derived from ATCC® 33591™*	0496	Methicillin resistant SCCmec: Type III ⁴
<i>Staphylococcus aureus</i> subsp. <i>aureus</i> derived from ATCC® 33592™*	0889	Methicillin and gentamicin resistant SCCmec: Type III ⁴
<i>Staphylococcus aureus</i> subsp. <i>aureus</i> derived from ATCC® 43300™*	0852	<i>mecA</i> positive ³ Methicillin and oxacillin resistant ⁴ SCCmec: Type II ⁴ CLSI control
<i>Staphylococcus aureus</i> subsp. <i>aureus</i> derived from ATCC® 700698™*	01022	Methicillin resistant Heterogeneous susceptibility to vancomycin SCCmec: Type II ⁴

Name	Catalog #	Characteristics
<i>Staphylococcus aureus</i> subsp. <i>aureus</i> derived from ATCC® 700699™*	0158	Methicillin and oxacillin resistant Reduced vancomycin susceptibility SCC <i>mec</i> : Type II Absence of <i>pvl</i> gene Strain designation Mu50 ⁴ Propagate on BHI with 4 µg/l vancomycin in order to retain reduced susceptibility
<i>Staphylococcus aureus</i> subsp. <i>aureus</i> derived from ATCC® BAA-44™*	01055	Methicillin resistant Multi-drug resistant strain Resistant to ampicillin, amoxicillin/clavulanic acid, ciprofloxacin, cephalothin, doxycycline, gentamicin, erythromycin, imipenem, methicillin, penicillin, tetracycline, oxacillin, azithromycin, clindamycin, ceftriaxone, rifampin, amikacin and tobramycin SCC <i>mec</i> : Type I ⁴
<i>Staphylococcus aureus</i> derived from ATCC® BAA-1708™*	01007	Methicillin resistant SCC <i>mec</i> : Type II ⁴ <i>mupA</i> -mediated high-level mupirocin resistance ³ CLSI control
<i>Staphylococcus aureus</i> derived from ATCC® BAA-2312™*	01122	Methicillin resistant <i>mecC</i> positive SCC <i>mec</i> : Type XI positive ⁴
<i>Staphylococcus aureus</i> derived from NCTC 12493	01065	Methicillin resistant <i>mecA</i> positive EUCAST control ¹

9. Macrolide-Resistant *Staphylococcus aureus*

Name	Catalog #	Characteristics
<i>Staphylococcus aureus</i> subsp. <i>aureus</i> derived from ATCC® BAA-976™*	0146	<i>msrA</i> -mediated macrolide-only resistance ³ Negative control for inducible clindamycin resistance ⁴ D-zone test negative ⁴ CLSI control

10. Inducible Clindamycin Resistant *Staphylococcus aureus*

Name	Catalog #	Characteristics
<i>Staphylococcus aureus</i> subsp. <i>aureus</i> derived from ATCC® BAA-977™*	0147	Inducible <i>ermA</i> -mediated macrolide resistance ³ Positive control for inducible clindamycin resistance ⁴ D-zone test positive ⁴ CLSI control

11. *Neisseria gonorrhoeae* Resistant Strains

Name	Catalog #	Characteristics
<i>Neisseria gonorrhoeae</i> derived from CDC F-28	01217	According to the CDC document "Neisseria gonorrhoeae Reference Strains for Susceptibility Testing" this strain is resistant to spectinomycin (<i>SpcR</i>). ⁵
<i>Neisseria gonorrhoeae</i> derived from CDC SPL-4	01218	According to the CDC document "Neisseria gonorrhoeae Reference Strains for Susceptibility Testing" this strain exhibits decreased sensitivity to cefixime (<i>CfxDS</i>). ⁵
<i>Neisseria gonorrhoeae</i> derived from CDC SPJ-15	01219	According to the CDC document "Neisseria gonorrhoeae Reference Strains for Susceptibility Testing" this is an isolate with a critical MIC greater than or equal to 1.0 µg/ml of azithromycin (<i>AznC</i>). ⁵

Name	Catalog #	Characteristics
<i>Neisseria gonorrhoeae</i> derived from CDC 10329	01222	According to the CDC document "Neisseria gonorrhoeae Reference Strains for Susceptibility Testing" this strain is resistant to ciprofloxacin (<i>CipR</i>). ⁵
<i>Neisseria gonorrhoeae</i> derived from CDC 10328	01239	According to the CDC document "Neisseria gonorrhoeae Reference Strains for Susceptibility Testing" this strain is intermediate to ciprofloxacin (<i>CipI</i>). ⁵

12. *Clostridioides difficile* Strains

Name	Catalog #	Characteristics
<i>Clostridioides difficile</i> derived from ATCC® 43255™*	01206	Genotype: <i>tcdA</i> positive, <i>tcdB</i> positive Toxinotype 0 Ribotype 087 ⁴
<i>Clostridioides difficile</i> derived from ATCC® 43593™*	0833	Genotype: <i>tcdA</i> negative, <i>tcdB</i> negative Binary toxin gene <i>cdtB</i> not amplified by PCR Ribotype 060 Serogroup B ⁴
<i>Clostridioides difficile</i> derived from ATCC® 9689™*	0329	Genotype: <i>tcdA</i> positive, <i>tcdB</i> positive Binary toxin gene <i>cdtB</i> not amplified by PCR Toxinotype 0 Ribotype 001 Produces cytotoxin ⁴
<i>Clostridioides difficile</i> derived from ATCC® 700057™*	0527	Genotype: <i>tcdA</i> negative, <i>tcdB</i> negative Binary toxin gene <i>cdtB</i> not amplified by PCR Ribotype 038 Nontoxigenic ⁴
<i>Clostridioides difficile</i> derived from ATCC® BAA-1870™*	01048	Genotype: <i>tcdA</i> positive, <i>tcdB</i> positive Binary toxin gene <i>cdtB</i> was amplified by PCR Toxinotype IIIb; Ribotype 027 PFGE Type NAP1 REA type BI 8 Binary Toxin positive ⁴
<i>Clostridioides difficile</i> derived from CDC 20110736	01161	Genotype: <i>tcdA</i> negative, <i>tcdB</i> negative <i>tcdC</i> _deletion negative <i>cdtA</i> negative, <i>cdtB</i> negative ⁶
<i>Clostridioides difficile</i> derived from CDC 20110995	01162	Genotype: <i>tcdA</i> positive, <i>tcdB</i> positive <i>tcdC</i> _deletion 0 bp <i>cdtA</i> negative, <i>cdtB</i> negative PFGE Type NAP11 ⁶
<i>Clostridioides difficile</i> derived from CDC 20120296	01163	Genotype: <i>tcdA</i> positive, <i>tcdB</i> positive <i>tcdC</i> _deletion 39 bp <i>cdtA</i> positive, <i>cdtB</i> positive PFGE Type NAP8 ⁶
<i>Clostridioides difficile</i> derived from CDC 20120905	01164	Genotype: <i>tcdA</i> positive, <i>tcdB</i> positive <i>tcdC</i> _deletion 0 bp <i>cdtA</i> negative, <i>cdtB</i> negative PFGE Type NAP4 ⁶

Name	Catalog #	Characteristics
<i>Clostridioides difficile</i> derived from CDC 20121308	01165	Genotype: <i>tcdA</i> positive, <i>tcdB</i> positive <i>tcdC</i> _deletion 18 bp <i>cdtA</i> positive, <i>cdtB</i> positive PFGE Type NAP1 ⁶
<i>Clostridioides difficile</i> derived from CDC 20131122	01166	Genotype: <i>tcdA</i> positive, <i>tcdB</i> positive <i>tcdC</i> _deletion 39 bp <i>cdtA</i> positive, <i>cdtB</i> positive PFGE Type NAP7 ⁶

References

¹European Committee on Antimicrobial Susceptibility Testing (EUCAST). *Extended quality control as recommended by EUCAST*; Version 6.0, valid from 2019-01-01. www.eucast.org. European Society of Clinical Microbiology and Infectious Diseases (ESCMID). Basel, Switzerland.

²The National Collection of Type Cultures (NCTC): *Antimicrobial Resistance Reference Strains* Available from NCTC, Website; www.phe-culturecollections.org.uk. Public Health England. Salisbury, U.K.

³Clinical Laboratory Standards Institute (CLSI®) *M100S Performance Standards for Antimicrobial Susceptibility Testing*. 26th Edition. January 2018. Wayne, PA, United States

⁴American Type Culture Collection (ATCC®) Website; www.atcc.org. Manassas, VA, United States.

⁵Center for Disease Control (CDC): *Neisseria gonorrhoeae Reference Strains for Antimicrobial Susceptibility Testing*. 2005. Atlanta, GA, United States

⁶Center for Disease Control (CDC). Atlanta, GA, United States.

⁷American Type Culture Collection (ATCC®) ATCC Multidrug-Resistant Testing Reference Strains, Website; www.atcc.org. Manassas, VA, United States.



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