

Thermal Death Points of Potential ThermaPureHeat® Target Organisms

The following list comprises a number of microorganisms, many of which are considered pathogens. These include bacteria, fungi, protozoa, helminthes and viruses. Most listed are human pathogens, but some are animal, avian or plant, or some combination. There are also pests and insects included in the list. The list provides the organism name and additional information including the references this information was originally cited. The resources include studies for food pasteurization, sewage sludge treatment, pest control, soil pasteurization, and compost and timber sterilization. In many of these studies a thermal death point or thermal death time of the pathogen was cited or evaluated. Oftentimes these results will vary from other sources because the medium in which the organism was cultured or treated varies or other conditions may vary. For example, *E. coli* will probably respond to temperature differently in a food product, such as milk, than in sewage sludge. Additionally, most of these results came from laboratory testing and therefore were not affected by field conditions such as the amount of biomass, RH, pH, etc.

The purpose of the table is to provide a level of information as to whether the organism is a potential ThermaPureHeat® target. The table information is not intended to provide absolute values, but rather ranges to use to set temperature and duration guidelines for specific targets. In the case of *E. coli* there is a consensus that 60°C/140°F is adequate to kill or inactivate the bacteria, but the durations range from 20 to 105 minutes at this temperature. To apply this information in a heat specification, it would be prudent to exceed both temperature and time determined from laboratory testing and to require a minimum of 66°C/150°F and duration of 3 hours to compensate for field conditions and requirements.

Pathogen/Organism	Group	Disease Affect	Thermal Death Point	Time Required	Reference/Source*
<i>Acinetobacter baumannii</i>	Bacteria	Human	63°C/145°F	15 minutes	Dumalisile, et al., 2005
<i>Aeromonas hydrophila</i>	Bacteria	Human	50°C/122°F	3 minutes**	Gerba, 1997; Gordon et al., 1992
<i>Bacillus anthracis</i>	Bacteria	Human	140°C/284°F	3 hours	Hampil, 1932; Koch, 1881
<i>Bacillus coli (E. coli)</i>	Bacteria	Human	60°C/140°F	10 minutes	Hampil, 1932; Loeffler, 1886
<i>Bacillus pestis (Yersinia)</i>	Bacteria	Human	60°C/140°F	2 minutes	Hampil, 1932; Gladin, 1898
<i>Bacillus typhosus (Salmonella)</i>	Bacteria	Human	56°C/133°F	10 minutes	Hampil, 1932; Sternburg, 1887
			63°C/145°F	4 minutes	Hampil, 1932; Orskov, 1926
<i>Bacterium tularensis</i>	Bacteria	Human	56°C/133°F	10 minutes	Hampil, 1932; McCoy, 1912
<i>Brucella abortus</i>	Bacteria	Human	61°C/142°F	3 minutes	Jones & Martin, 2003; Golueke, 1982
<i>Brucella abortus</i>	Bacteria	Human	55°C/130°F	60 minutes	Jones & Martin, 2003; Stern, 1974
			65°C/149°F	3 minutes	
<i>Brucella abortus</i> or <i>suis</i>	Bacteria	Human	55°C/130°F	60 minutes	Jones & Martin, 2003; Day & Shaw, 2000
			60°C/140°F	3 minutes	

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<i>Brucella melitensis</i>	Bacteria	Human Animal	55°C/130°F 60°C/140°F	30 minutes 15 minutes	Hampil, 1932; Zwick & Wedeman, 1913
<i>Burkholderia mallei</i>	Bacteria	Human Bio Warfare	55°C/130°F	10 minutes	Health Canada, 2007
<i>Campylobacter</i> spp.	Bacteria	Human	75°C/167°F	1 minute	Gerba, 1997; Bandres et al., 1988
<i>Chlamydia psittaci</i>	Bacteria	Human, Avian	56°C/133°F	5 minutes	TIP, 2000; Anderson et al., 1997
<i>Chryseobacterium meningosepticum</i>	Bacteria	Human	63°C/145°F	15 minutes	Dumalisile, et al., 2005
<i>Corynebacterium diphtheriae</i>	Bacteria	Human	55°C/130°F 70°C/158°F	45 minutes 4 minutes	Jones & Martin, 2003; Stern, 1974
Dysentery bacilli (<i>Shigella</i>)	Bacteria	Human	58-60°C/140°F	10 minutes	Hampil, 1932; Runge & O'Brien, 1924
<i>Enterococcus faecium</i>	Bacteria	Human	60°C/140°F 62.5°C/145°F 65°C/149°F	<45 minutes <20 minutes <10 minutes	Spelina et al., 2007
<i>Escherichia coli</i>	Bacteria	Human	45°C/113°F 60°C/140°F 65°C/149°F 70°C/158°F 75°C/167°F	24 hours 105 minutes 45 minutes 45 minutes 15 minutes	Abbott, 2011
<i>Escherichia coli</i>	Bacteria	Human	60°C/140°F	45 minutes	Padhye & Doyle, 1992
<i>Escherichia coli</i>	Bacteria	Human	65°C/149°F	1 minute	Gerba, 1997; Bandres et al., 1988
<i>Escherichia coli</i>	Bacteria	Human	60°C/140°F 70°C/158°F	60 minutes 5 minutes	Jones & Martin, 2003; Stern, 1974
<i>Escherichia coli</i>	Bacteria	Human	55°C/130°F 60°C/140°F	60 minutes 20 minutes	Jones & Martin, 2003; Day & Shaw, 2000
<i>Escherichia coli</i>	Bacteria	Human	55°C/130°F 60°C/140°F	60 minutes 20 minutes	Jones & Martin, 2003; Golueke, 1982
<i>Escherichia coli</i>	Bacteria	Human	63°C/145°F	25 minutes	Dumalisile, et al., 2005

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<i>Hemophilus influenzae</i>	Bacteria	Human	62°C/144°F	2 minutes	Hampil, 1932; Onorato, 1902
<i>Klebsiella pneumoniae</i>	Bacteria	Human	45°C/113°F 60°C/140°F 65°C/149°F 70°C/158°F	24 hours 105 minutes 45 minutes 45 minutes	Abbott, 2011
<i>Legionella</i>	Bacteria	Human	66°C/142°F	.45 minutes**	Gerba, 1997; Sarden et al., 1989
<i>Legionella pneumophila</i>	Bacteria	Human	60°C/140°F	30 minutes	Stout, et al., 1986
<i>Listeria monocytogenes</i>	Bacteria	Human	63°C/145°F	30+ minutes	Rowan and Anderson 1998
<i>Listeria monocytogenes</i>	Bacteria	Human	63°C/145°F	20 minutes	Dumalisile, et al., 2005
Meningococci	Bacteria	Human	60°C/140°F	1 minute	Hampil, 1932; Bettencourt and Franca, 1904
<i>Mycobacterium avium</i> sub. <i>paratuberculosis</i>	Bacteria	Human	62°C/144°F 71°C/160°F	23 minutes 73 seconds	Sung & Collins, 1998
<i>Mycobacterium diphtheriae</i>	Bacteria	Human	55°C/130°F 70°C/158°F	45 minutes 4 minutes	Jones & Martin, 2003; Stern, 1974
<i>Mycobacterium</i> spp. <i>M. avium</i>	Bacteria	Human	70°C/158°F	2 minutes 2.3 minutes**	Gerba, 1997; Robbecke and Buchhottz, 1992
<i>Mycobacterium avium</i> sub. <i>paratuberculosis</i>	Bacteria	Human	72°C/162°F	15 seconds	Pearce, 2001
<i>Mycobacterium tuberculosis</i>	Bacteria	Human	63°C/145°F	3 minutes	Hampil, 1932; North & Park, 1925
<i>Mycobacterium tuberculosis</i>	Bacteria	Human	70°C/158°F	20 minutes	Jones & Martin, 2003; Stern, 1974
<i>Mycobacterium tuberculosis</i>	Bacteria	Human	63°C/145°F 72°C/162°F	30 minutes 15 seconds	Connor, 2007
Paratyphoid bacilli	Bacteria	Human	60°C/140°F 63°C/145°F	20 minutes 3 minutes	Hampil, 1932; Krumwiede & Noble, 1921 Hampil, 1932; Orskov, 1926
<i>Pasteurella multocida</i>	Bacteria	Human and Avian	56°C/133°F 60°C/140°F	15 minutes 10 minutes	TIP, 2000; Rimler and Glisson, 1998
<i>Pasteurella</i> spp.	Bacteria	Human	55°C/131°F	15 minutes	Health Canada, 2007
Pneumococci	Bacteria	Human	60°C/140°F	30 minutes	Hampil, 1932; Baggar, 1926

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<i>Pseudomonas aeruginosa</i>	Bacteria	Human	45°C/113°F 60°C/140°F 65°C/149°F 70°C/158°F	4 hours 75 minutes 45 minutes 45 minutes	Abbott, 2011
<i>Pseudomonas aeruginosa</i>	Bacteria	Human	60°C/140°F	<10 minutes	Spinks, et al., 2003
<i>Pseudomonas putida</i>	Bacteria	Human	63°C/145°F	20 minutes	Dumalisile, et al., 2005
<i>Salmonella</i>	Bacteria	Human	60°C/140°F	1 hour	Feachem, 1983
<i>Salmonella</i> sp.	Bacteria	Human	65°C/149°F	1 minute	Gerba, 1997; Bandres et al., 1988
<i>Salmonella newport</i>	Bacteria	Human	60°C/140°F 65°C/149°F	40 minutes 30 minutes	Wiley & Westerberg (1969)
<i>Salmonella typhi</i>	Bacteria	Human	60°C/140°F 70°C/158°F	30 minutes 4 minutes	Jones & Martin, 2003; Stern, 1974
<i>Shigella</i> sp.	Bacteria	Human	50°C/122°F	1 hour	Jones & Martin, 2003; Stern, 1974
<i>Shigella</i> sp.	Bacteria	Human	55°C/131°F	1 hour	Feachem, 1983
<i>Shigella</i> spp.	Bacteria	Human	65°C/149°F	1 minute	Gerba, 1997; Bandres et al., 1988
Staphylococci	Bacteria	Human	62°C/144°F	10 minutes	Hampil, 1932; Sternburg, 1887
<i>Staphylococcus aureus</i>	Bacteria	Human	45°C/113°F 50°C/122°F 60°C/140°F 65°C/149°F 70°C/158°F	96 hours 48 hours 105 minutes 45 minutes 45 minutes	Abbott, 2011
Methicillin Resistant <i>Staphylococcus aureus</i> (MRSA)	Bacteria	Human	50°C/122°F 65°C/149°F 70°C/158°F	24 hours 45 minutes 45 minutes	Abbott, 2011
<i>Staphylococcus aureus</i>	Bacteria	Human	50°C/122°F	10 minutes	Jones & Martin, 2003; Golueke, 1982
<i>Staphylococcus aureus</i>	Bacteria	Human	63°C/145°F	20 minutes	Dumalisile, et al., 2005
Streptococci	Bacteria	Human	60°C/140°F	30 minutes	Hampil, 1932; Ayers & Johnson, 1918
<i>Streptococcus pyogenes</i>	Bacteria	Human	54°C/129°F	10 minutes	Jones & Martin, 2003; Golueke, 1982
<i>Streptococcus pyogenes</i>	Bacteria	Human	55°C/131°F	10 minutes	Jones & Martin, 2003; Day & Shaw, 2000
<i>Vibrio cholera</i>	Bacteria	Human	55°C/131°F	1 minute**	Gerba, 1997; Roberts & Gilbert, 1979

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<i>Vibrio cholerae</i>	Bacteria	Human	55°C/131°F	15 minutes	Hampil, 1932; Kitasato, 1889
<i>Yersinia enterocolitica</i>	Bacteria	Human	60°C/140°F	30 minutes	Gerba, 1997; Frazier and Westhoff, 1988
<i>Coxiella burnetii</i>	Bacteria Rickettsia	Human Q Fever	63°C/145°F	30 minutes	Connor, 2007
<i>Coxiella burnetii</i>	Bacteria Rickettsia	Human Q Fever	63°C/145°F	30 minutes	Health Canada, 2007
<i>Alternaria alternata</i>	Fungi	Human	63°C/145°F	25 minutes	Domsch, 1993; Page 37
<i>Aspergillus fumigatus</i>	Fungi	Human	65°C/149°F***	30 minutes	Bollen, 1969
<i>Aspergillus niger</i>	Fungi	Human	63°C/145°F	25 minutes	Domsch, 1993; Page 102
<i>Aspergillus ustus</i>	Fungi	Human	62°C/144°F	25 minutes	Domsch, 1993; Page 119
<i>Candida albicans</i>	Fungi/Yeast	Human	70°C/158°F	60 minutes	Wiley & Westerberg (1969)
<i>Candida lipolytica</i>	Fungi/Yeast	Human	63°C/145°F	15 minutes	Dumalisile, et al., 2005
<i>Chaetomium spp.</i> (Soft rot)	Fungi	Human	55°C/131°F	30 minutes	Bollen, 1969
<i>Chaetomium globosum</i>	Fungi	Human, Structure	57°C/135°F	10 minutes	Domsch, 1993
<i>Cladosporium herbarum</i>	Fungi	Human	50°C/122°F	10 minutes	Ridley and Crabtree, 2001
<i>Cladosporium herbarum</i>	Fungi	Human	60°C/140°F	30 minutes	Bollen, 1969
<i>Fusarium cincinnatum</i>	Fungi	Human, Plant	60°C/140°F	10 minutes	Ridley, G. unpublished data
<i>Fusarium oxysporum</i>	Fungi	Human	60°C/140°F	30 minutes	Bollen, 1969
<i>Fusarium redolens</i>	Fungi	Plant	60°C/140°F	30 minutes	Bollen, 1969
<i>Lasiodiplodia theobromae</i> formerly <i>Botryodiplodia theobromae</i>	Fungi	Plant, Human	60°C/140°F	10 minutes	Ridley and Crabtree, 2001
<i>Histoplasma capsulatum</i>	Dimorphic Fungi	Human			
<i>Myrothecium verrucaria</i>	Fungi	Plant	60°C/140°F	30 minutes	Bollen, 1969
Oömycetes	Fungi	Plant, Human	50°C/122°F	30 minutes	Bollen, 1969

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<i>Penicillium corylophilum</i>	Fungi	Plant	60°C/140°F***	30 minutes	Bollen, 1969
<i>Penicillium funiculosum</i>	Fungi	Human	70°C/158°F***	30 minutes	Bollen, 1969
<i>Peniophora spp.</i>	Fungi	Plant	54.4°C/130°F	15 minutes	Morrell, 1990
<i>Penicillium lapidosum</i>	Fungi	Plant	70°C/158°F***	30 minutes	Bollen, 1969
<i>Phialaphora mustea</i>	Fungi	Plant	60°C/140°F***	30 minutes	Bollen, 1969
<i>Phoma herbarum</i>	Fungi	Human	75°C/167°F***	30 minutes	Bollen, 1969
<i>Poria carbonica</i>	Fungi	Plant	60°C/140°F 70°C/158°F	3 hours 60 minutes	Morrell, 1987
<i>Poria placenta</i>	Fungi	Plant	60°C/140°F 65.5°C/150°F	6 hours 3 hours	Morrell, 1987
<i>Preussia fleischhაკii</i>	Fungi	Plant	60°C/140°F	30 minutes	Bollen, 1969
<i>Rhinocladiella mansonii</i>	Fungi	Plant	60°C/140°F	30 minutes	Bollen, 1969
<i>Serpula lacrymans</i> (Dry rot)	Fungi	Structure	45°C/113°F 50°C/122°F	3 hours 1 hour	Miric & Willeitner (1984)
<i>Sordaria carbonaria</i>	Fungi	Plant	65°C/149°F	30 minutes	Bollen, 1969
<i>Sordaria spp.</i>	Fungi	Plant	60°C/140°F	30 minutes	Bollen, 1969
<i>Sporormia aemulans</i>	Fungi	Plant	65°C/149°F	30 minutes	Bollen, 1969
<i>Stachybotrys atra</i> (<i>S. chartarum</i>)	Fungi	Human	60°C/140°F	30 minutes	Bollen, 1969
<i>Stachybotrys chartarum</i>	Fungi	Human	60°C/140°F	30 minutes	Domsch, 1993; Page 745
<i>Stereum sanguinolentum</i>	Fungi	Plant	54.4°C/130°F	15 minutes	Morrell, 1990
<i>Stemphyium botryosum</i>	Fungi	Plant	60°C/140°F***	30 minutes	Bollen, 1969
<i>Trichocladium piriformis</i>	Fungi	Plant	80°C/176°F***	30 minutes	Bollen, 1969
<i>Trichoderma lignorum</i>	Fungi	Plant, some Human	55°C/131°F	30 minutes	Bollen, 1969
<i>Zygorhynchus moelleri</i>	Fungi	Plant	55°C/131°F	30 minutes	Bollen, 1969
<i>Ascaris lumbricoides</i>	Helminths	Human	55°C/131°F	60 minutes	Feachem, 1983
<i>Ascaris lumbricoides</i> eggs	Helminths	Human	50°C/122°F 55°C/131°F	60 minutes 7 minutes	Jones & Martin, 2003; Stern, 1974

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<i>Necator americanus</i>	Helminths	Human	50°C/122°F	50 minutes	Jones & Martin, 2003; Stern, 1974
<i>Opisthorchis</i> spp.	Helminths	Human	56°C/133°F	30 minutes	Health Canada, 2007
Schistosoma eggs	Helminths	Human	50°C/122°F	60 minutes	Feachem, 1983
<i>Taenia saginata</i>	Helminths	Human	71°C/160°F	5 minutes	Jones & Martin, 2003; Golueke, 1982
<i>Taenia saginata</i>	Helminths	Human	71°C/160°F	5 minutes	Jones & Martin, 2003; Golueke, 1982
<i>Taenia saginata</i>	Helminths	Human	70°C/158°F	5 minutes	Jones & Martin, 2003; Stern, 1974
<i>Trichinella spiralis</i>	Helminths	Human	72°C/162°F	60 minutes	Jones & Martin, 2003; Golueke, 1982
<i>Agrilus planipennis</i> Emerald ash borer	Pests	Plant	71°C/160°F	75 minutes	APHIS Factsheet, 2009
<i>Anoplophora glabripennis</i> Asian longhorned beetle	Pests	Plant	71°C/160°F	75 minutes	APHIS Factsheet, 2009
<i>Blattella germanica</i> , German cockroach	Pests	Vector	54.4°C/130°F	7 minutes	Quarles, 2006; Forbes, Ebeling, 1987
<i>Cimex lectularius</i> , Bed Bug	Pests	Human	39-40°C/ 111-113°F		Getty, 2006; Usinger, 1966
<i>Cimex lectularius</i> , Bed Bug - Adults and nymphs	Pests	Human	>40°C/113°F	15 minutes	Getty, 2006; Gulmahamad, 2002
<i>Cimex lectularius</i> , Bed Bug Eggs	Pests	Human	>40°C/113°F	1 hour	Getty, 2006; Gulmahamad, 2002
<i>Cimex lectularius</i> , Bed Bug - Adults	Pests	Human	45°C/113°F 48°C/118°F 50°C/122°F	90 minutes 2 minutes 0 minutes	Hulasare, 2010
<i>Cimex lectularius</i> , Bed Bug Eggs	Pests	Human	45°C/113°F 48°C/118°F 50°C/122°F	8 hours 90 minutes 0 minutes	Hulasare, 2010
<i>Dermanyssus gallinae</i> , Chicken Mite or Poultry Red Mite	Pests	Vector Human Avian	45°C/113°F	2 hours	Nordenfors, 1999
<i>Dermatophagoides farinae</i> Am. Dust Mite	Pests	Human	60°C/140°F	60 minutes	Ogg, 1997

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<i>Dermatophagoides farinae</i> Am. Dust Mite	Pests	Human	45°C/113°F 50°C/122°F 60 °C/140°F 70 °C/158°F	200 minutes 30 minutes 8 minutes 4 minutes	Chang, 1998
<i>Dermatophagoides pteronyssinus</i> Eur. Dust Mite	Pests	Human	60°C/140°F 50°C/122°F	60 minutes 30 minutes	Ogg, 1997 Mahakittikun, 2001
<i>Incisitermes minor</i> , Western Drywood Termite	Pests	Damage - Structural	54.4°C/130°F	6 minutes	Quarles, 2006; Forbes, Ebeling, 1987
<i>Lepisma saccharina</i> Silverfish - Nymphs	Pests	Damage – Books	40°C/104°F	“A few hours”	Sweetman, 1939
<i>Lepisma saccharina</i> Silverfish - Adults	Pests	Damage – Books	>32°C/90°F	“A few hours”	Sweetman, 1939
<i>Lithepuhema humile</i> , Argentine Ant	Pests	Damage - Structural	54.4°C/130°F	1 minute	Quarles, 2006; Forbes, Ebeling, 1987
<i>Lyctus</i> Powder Post Beetle All Forms	Pests	Damage - Structural	54.4°C/130°F	2 1/2 hours	Parkin, 1937; Fisher, 1928
<i>Lyctus</i> Powder Post Beetle Larvae	Pests	Damage - Structural	52°C/125°F	2-4 hours	Parkin, 1937
<i>Pediculus humanus</i> , Human Body Louse	Pests	Vector	46.6°C/116°F	1 hour	Mellanby, 1932
<i>Tetropium fuscum</i> Brown Spruce Longhorn Beetle Larvae	Pests	Damage- Structural	50°C/122°F 55°C/131°F	30 minutes 15 minutes	Mushrow, 2004
<i>Thermobia domestica</i> Firebrat	Pests	Damage – Books	55°C/131°F	5 minutes	Sweetman, 1938
<i>Tineola bisselliella</i> Webbing Clothes Moth	Pests	Damage- Textiles	48.9°C/120°F	30 minutes	Rust, 2000

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<i>Tineola bisselliella</i> (All Stages) Webbing Clothes Moth	Pests	Damage-Textiles	41°C/106°F	4 hours	Rawle, 1951
<i>Tinibrio molitor</i> Yellow Mealworm	Pests	Damage - Food	42.8°C/109°F	1 hour	Mellanby, 1932
<i>Triboltum confusum</i> , Adult Flour Beetle	Pests	Damage - Food	54.4°C/130°F	4 minutes	Quarles, 2006; Forbes, Ebeling, 1987
<i>Xenopsylla cheopis</i> , Rat Flea Larvae	Pests	Vector	39.4°C/103°F	1 hour	Mellanby, 1932
<i>Xenopsylla cheopis</i> , Rat Flea Adult	Pests	Vector	40.6°C/105°F	1 hour	Mellanby, 1932
<i>Cryptosporidium parva</i>	Protozoa	Human	72.4°C/ 162.3°F	1 minute	Gerba, 1997; Fayer, 1994
<i>Entamoeba histolytica</i>	Protozoa	Human	60°C/140°F	1 minute	Feachem, 1983
<i>Entamoeba histolytica</i>	Protozoa	Human	60°C/140°F	1 minute	Gerba, 1997; Chang, 1943
<i>Entamoeba histolytica</i> cysts	Protozoa	Human	50°C/122°F	5 minutes	Jones & Martin, 2003; Stern, 1974
<i>Giardia lamblia</i>	Protozoa	Human	60°C/140°F	2-3 minutes	Univ of Utah, 2005
<i>Giardia Lamblia</i>	Protozoa	Human	50°C/122°F	1 minute**	Gerba, 1997; Cerva, 1955
<i>Toxoplasma gondii</i> Oocysts	Protozoa	Human	>66°C/151°F	10 minutes	Health Canada, 2007
<i>Trypanosoma cruzi</i>	Protozoa	Human, Avian	45°C/113°F	60 minutes	Von Brand, 1946
Adenovirus	Virus	Human	60°C/140°F	20 minutes	Gerba, 1997; Mahnel, 1977
Avian pneumovirus	Virus	Avian	56°C/133°F	30 minutes	TIP, 2000; Collins, 1986
Cercopithecine Herpes Virus 1	Virus	Human Animal	60°C/140°F	30 minutes	Health Canada, 2007
Coronavirus	Virus	Human	55°C/131°F	2 minutes	Gerba, 1997; Laude, 1981
Coxsackievirus	Virus	Human	60°C/140°F	30 minutes	Health Canada, 2007
Cytomegalovirus	Virus	Human	60°C/140°F	30 minutes	Health Canada, 2007
Ebola virus	Virus	Human	60°C/140°F	60 minutes	Health Canada, 2007

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Echovirus	Virus	Human	50°C/122°F	2 hours	Health Canada, 2007
Enterovirus 70	Virus	Human	60°C/140°F	30 minutes	Health Canada, 2007
Enteroviruses, Reoviruses and Adenoviruses (All)	Virus	Human	60°C/140°F	2 hours	Feachem, 1983
Epstein-Barr Virus	Virus	Human	60°C/140°F	30 minutes	Health Canada, 2007
Hantavirus Pulmonary Syndrome (HPS)	Virus	Human	60°C/140°F	30 minutes	Health Canada, 2007
Hepatitis A	Virus	Human	70°C/158°F	10 minutes	Gerba, 1997; Siegl et al., 1984
Hepatitis A	Virus	Human	70°C/158°F	4 minutes	Health Canada, 2007
Highly Pathogenic Avian Influenza (HPAI)	Virus	Human, Avian	56°C/133°F	15 minutes	TIP, 2000; Blaha, 1989
Infectious bronchitis	Virus	Human, Avian	56°C/133°F	15 minutes	Otsaki, 1979
Newcastle Disease Virus (NDV)	Virus	Human, Avian	60°C/140°F 70°C/158°F	1 hour 50 seconds	TIP, 2000; Foster & Thompson, 1957
Norwalk virus	Virus	Human	>60°C/140°F	>30 minutes	Health Canada, 2007
Parvoviruses	Virus	Human, Avian	60°C/140°F	30 minutes	TIP, 2000; Gough et al., 1981
Poliovirus	Virus	Human	60°C/140°F	25 minutes	Gerba, 1997; Larkin and Fasolitis, 1979
Poliovirus 1	Virus	Human	55°C/131°F 60°C/140°F	30 minutes 5 minutes	Feachem, 1983, p163; Wiley & Westerberg, 1969
Poxviruses	Virus	Human, Avian	60°C/140°F	8 minutes	TIP, 2000; Tripathy, 1993
Reovirus	Virus	Human	60°C/140°F	20 minutes	Gerba, 1997; Mahnel, 1977
Rotavirus	Virus	Human	63°C/145°F	30 minutes	Feachem, 1983, p188; G.N. Woode
Rotavirus	Virus	Human	50°C/122°F	30 minutes	Gerba, 1997 ; Estes, et al., 1979
Viruses (Most)	Virus	Human	70°C/158°F	20 minutes	Jones & Martin, 2003; Day & Shaw, 2000
Viruses (Most)	Virus	Human	70°C/158°F	25 minutes	Jones & Martin, 2003; Stern, 1974

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* Lists the reference cited in this document and the original reference cited in the referenced document. For example, the Gerba document lists numerous primary sources.

** Time for 90% inactivation of microorganism.

*** Maximum Temperature “Heat Tolerant” Species Survived (Thermal death point not reached)

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