

# Flash-Tunnel Light System

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## System Operations Guide



[www.clordisys.com](http://www.clordisys.com)

50 Tannery Road  
Suite 1  
Branchburg, NJ 08876  
EPA Est. #80802-NJ-1  
908-236-4100

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**ClorDiSys Solutions, Inc.**

**50 Tannery Road  
Suite 1  
Branchburg, NJ 08876  
EPA Est. #80802-NJ-1**

(1-908-236-4100)  
[www.clordisys.com](http://www.clordisys.com)  
[www.cleanhospital.com](http://www.cleanhospital.com)

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# Contents

Contents .....	3
<b>Chapter 1. Introduction</b> .....	<b>5</b>
About the Ultraviolet Disinfection System .....	5
• Benefits of the Flash-Tunnel UV-C Light System.....	6
Environmental Operating Conditions.....	7
Electrical Requirements .....	7
<b>Chapter 2. Safety</b> .....	<b>9</b>
Overview.....	10
Safety .....	10
• UV-C Light Exposure.....	10
• Safe Operation of the System.....	10
• Safe Handling of Lamps .....	11
• Safe Installation and Maintenance .....	12
• Use Only Approved Parts .....	15
Additional Information .....	15
<b>Chapter 3. Day-to-Day Operation</b> .....	<b>16</b>
Pre-cycle Checklist .....	17
• Placement of the Flash-Tunnel .....	17
Starting a Cycle.....	17
<b>Chapter 4. Troubleshooting &amp; Routine Maintenance</b> .....	<b>20</b>
Overview.....	21
Troubleshooting .....	21
Maintenance Schedule .....	22
• User Maintenance .....	22
• User Maintenance .....	22
• User Maintenance .....	23
<b>Appendix A. Antimicrobial Activity of UV-C Light</b> .....	<b>24</b>
Guidance on Development of Disinfection Processes.....	25
• Exposure Time/UV-C Concentration.....	25
<b>Appendix B. Warranties</b> .....	<b>29</b>
Service Warranty.....	30
Commercial Warranty.....	30



# Chapter 1. Introduction

*In this chapter . . .*

- *Overview*
- *About the system*

## About the Ultraviolet Disinfection System

The Flash-Tunnel UV-C disinfection conveyor is designed for use in any industrial, healthcare, pharmaceutical, manufacturing, laboratory, or research setting. It is used to provide a rapid and highly effective method to disinfect items travelling down conveyor in order to reduce the transfer of dangerous organisms. The Flash-Tunnel contains a belt conveyor to support the item(s) being disinfected. It simply plugs into any wall outlet. The disinfection conveyor produces an efficient UV-C output of approximately  $720 \mu\text{W}/\text{cm}^2$ . At a speed of 16 feet/minute, dosage is equivalent to about  $35\text{mj}/\text{cm}^2$ .

## Benefits of the Flash-Tunnel UV-C Light System

- UV-C is an effective antimicrobial agent.
- The Flash-Tunnel requires minimal power consumption and leaves no residues.
- The Flash-Tunnel contains 18 protected UV-C bulbs mounted on ceiling, walls, and underside of unit to provide increased disinfection coverage of items placed on conveyor.
- At the furthest point from the bulbs, the Flash-Tunnel provides approximately 750  $\mu\text{W}/\text{cm}^2$  of UV-C intensity. Physical Specifications

Flash-Tunnel Overall Dimensions	
Height	45"
Length	144"
Width	29"

  

Flash-Tunnel Usable Space	
Height	6"
Length	144"
Width	24"

# Environmental Operating Conditions

Flash-Tunnel	
Ambient Temperature	0 to 50 C (32 to 122 F)
Altitude	-100 to 3000 m above msl (-330 to 10,000 ft above msl)
Relative Humidity	10 to 85% RH, non-condensing
Surface	Flat, level surface
Indoor Use Only	

# Electrical Requirements

The following table shows the corresponding circuit capacity in amperes.

Flash-Tunnel	
115 VAC +/- 10%, 50/60 Hz	Conveyor 3.75 Amps, UV-C Fixtures 11.7 Amps





# Chapter 2.

# Safety

*In this chapter . . .*

- *Important safety information*

## Overview

Your safety is of primary concern. This section provides information on safely using the Flash-Tunnel. **You must read, understand and follow the information in this chapter before operating the unit.** The equipment must never be used in a manner not specified in this manual. Also, always pay attention to the warnings, cautions and notes throughout this guide. This information is for your safety and to ensure that you receive the greatest benefit from the safe operation of your UV-C System. Only trained, experienced technicians, who are fully acquainted with the unit, should repair or adjust the system.

## Safety

It is the system operator's responsibility to verify that the system is in a safe state when changing UV-C lamps. You must read, understand, and follow the procedures featured in the Routine Maintenance Chapter. These procedures detail safe handling of the electrical connections and replacement lamps.

### UV-C Light Exposure

- The system produces UV-C light. Care must be exercised when servicing and using the system.
- **ULTRAVIOLET LIGHT IS A FORM OF INVISIBLE RADIATION AND IS HAZARDOUS TO THE SKIN, EYES AND ANY LIVING TISSUE.** Exposure to ultraviolet light, even for short periods can be hazardous. Damage is dependent on the UV-C intensity, distance from lamps and the exposure time.
- **AVOID CONTACT WITH ANY MATERIALS (SOLID, LIQUID OR VAPOR) NOT COMPATIBLE WITH ULTRAVIOLET LIGHT.**

### Safe Operation of the System

- Before running a cycle, **ALWAYS VERIFY THAT THE CONVEYOR IS ON A FLAT LEVEL SURFACE.**
- **DO NOT SIT OR STAND ON CONVEYOR.**
- **DO NOT TOUCH CONVEYOR WHILE IN OPERATION.**
- **DO NOT OPERATE CONVEYOR WHILE DRIVE CHAIN GUARD COVER IS REMOVED.**
- **DO NOT SERVICE EQUIPMENT WHILE CONVEYOR IS MOVING OR ENERGIZED.**
- **DO NOT ATTEMPT TO REMOVE SIDE PANELS WHEN BULBS ARE ON. DO NOT LIFT SHIELDING CURTAINS WHILE UV-C BULBS ARE ON.**
  - The translucent side access panels of the unit do **NOT** allow UV-C rays to exit the unit.

- Warning labels are displayed on the UV-C System warning of potentially hazardous areas. These labels are shown below:



This label signifies that a potential electrical hazard exists in the area.



This label signifies that an ultraviolet light hazard exists.

## Safe Handling of Lamps

- WHEN HANDLING LAMPS, WEAR SAFETY GOGGLES AND GLOVES.**
- USE ONLY APPROVED UV-C LAMPS, WHICH HAVE BEEN SPECIALLY DESIGNED, TESTED AND APPROVED FOR USE IN THIS UV-C LIGHT SYSTEM.** Failure to do so invalidates the warranty. Non-approved lamps will impair equipment operation and result in costly repairs, could result in the non-disinfected target areas and could void the equipment warranty. Read the label for warnings and safety monitoring.
- BEFORE INSTALLING A LAMP, CHECK THE LAMP FOR DAMAGES DURING SHIPMENT.** If you can hear pieces moving around inside the lamp, then it is broken. Please contact ClorDiSys for instructions. Installation instructions are included in Chapter 6.
- DISPOSE OF UV-C LAMPS IN A SAFE MANNER.** Unbroken lamps have PASSED TCLP (Toxicity Characteristic Leaching Procedure) Testing and can be considered non-hazardous waste.
  - In 1990 the EPA develop the TCLP (Toxicity Characteristic Leaching Procedure) test to simulate the effect of disposing waste in conventional landfills under complex environmental conditions. The method is designed to determine the mobility of toxic material in liquid solid and multiphase waste. The EPA developed the Toxicity Characteristic Leaching Procedure to determine the toxicity of waste. The TCLP test does NOT measure the total mercury content but rather the potential of mercury to leach into groundwater if a waste is disposed of in a landfill. TCLP is designed to simulate the leaching a waste will undergo is it disposed in a sanitary landfill. This test includes mercury, lead, cadmium, and other hazardous materials. Passing this test for mercury for instance requires a yield of less than 0.2 milligrams per liter upon completion of the test. Lamps that PASS the TCLP are considered s non-hazardous waste by the EPA. We are proud to be among the first to offer the majority of our germicidal lamps as TCLP compliant. While lamps that pass TCLP may be classified as non-hazardous waste by the EPA, ClorDiSys Solutions and Clean Hospitals strongly encourage the recycling of spent germicidal lamps. Please contact our local environmental agency for assistance with lamp recycling or visit [www.lamprecycle.org](http://www.lamprecycle.org).
- DO NOT DISPOSE OF UV-C LAMPS IN LOCAL REFUSE OR WITH WASTE FOR INCINERATORS.**

- Check with local authorities to confirm appropriate UV-C Lamp storage requirements and quantities.
- **DO NOT USE NON-APPROVED UV-C LAMPS IN THIS UV-C SYSTEM. SUCH USE IS DANGEROUS AND CAN RESULT IN AN OPERATIONAL HAZARD** and will void system warranties.

## Safe Installation and Maintenance

- **CASTERS** If casters located on support legs require a hard, smooth surface, free from debris that could interfere with the movement of the wheels. Always lock brakes once Flash Tunnel is placed in final location. These casters are not intended for rapid movement or excessive force.
- **LIFTING OVEN** When lifting the Flash Tunnel, extreme caution must be exercised to prevent the forks on forklift from causing damage to the conveyor or any components at the ends and beneath the Flash Tunnel. Components such as: UV-C bulbs, conduit, and control panel need to be protected from damage due to forklift or other lifting apparatus. Be sure conveyor is balanced when lifting and supported from both ends if necessary. Forklift forks may be placed under the mid-section if IF raceways are also properly protected.

**Possible Lifting Techniques:**





- **REPAIRS AND ADJUSTMENT TO THIS EQUIPMENT SHOULD BE MADE ONLY BY TRAINED SERVICE PERSONNEL.** Non-routine maintenance performed by unqualified personnel or installation of unauthorized parts could cause personal injury, invalidate the warranty, or result in costly damage. CONTACT YOUR SERVICE REPRESENTATIVE REGARDING SERVICE OPTIONS.
- **USE NONABRASIVE CLEANERS WHEN CLEANING THE EXTERIOR OF THE UNIT** Abrasive cleaners can damage the surfaces. Follow directions on the container and rub in a back-and-forth motion (in the same direction as the surface grain). Cleaner rubbed in a circular motion or applied with a wire brush or steel wool can damage the surfaces.
- **LOADING / UNLOADING** Have trained personnel load or unload equipment. The conveyor must be properly handled when transferring from the unloading area to final site location to prevent damage.
- **GUARDS / GUARDING** Interfacing of Equipment. When two or more pieces of equipment are interfaced, special attention shall be given to the interfaced area to ensure the presence of

adequate guarding and safety devices. Guarding Exceptions. Wherever conditions prevail that would require guarding under this standard but such guarding would render the conveyor unusable, seek guidance from your safety professional.

- **ANCHORING DO NOT** operate conveyor unless it is properly anchored. Serious injury or death may result.
- **SAFETY WARNING** Install all safety devices, guards and guarding prior to equipment start-up.

### **Use Only Approved Parts**

- **USE OF UNAUTHORIZED PARTS MAY BE DANGEROUS AND WILL VOID THE WARRANTY.** Use of unauthorized parts for maintenance or repair could cause personal injury and result in costly damage or unit malfunction.

## **Additional Information**

The information in this chapter is repeated where appropriate throughout this guide for your safety and use. This information is subsequently labeled: **WARNINGS**, **Cautions** or **Notes** as appropriate.

- **WARNINGS** are shown in the text in all bold upper-case letters. They indicate events or conditions that can result in serious injury or death. All safety precautions must be strictly followed.
- **Cautions** are shown in the text in bold letters, and they indicate events or conditions that can result in damage to equipment.





# Chapter 3.

# Day-to-Day

# Operation

*In this chapter . . .*

- *Initial operation caution*
- *Security*
- *Running a Cycle*

## Pre-cycle Checklist

Before operation of the Flash-Tunnel, please go over the following Pre-Cycle Checklist to ensure safe and proper usage.

- Items should be cleaned of soils and debris before running a UV-C cycle. UV-C should not be trusted to be effective within soiled loads.
- Ensure that the UV-C bulbs are in place and connected.
- Ensure that the Flash-Tunnel and the UV-C bulbs are clean and free of dust.

*Note: If the UV-C lamps are estimated to be at the end of their life cycle, be sure to change the lamps prior to starting a new exposure.*

- Ensure conveyor belt is square to frame.
- System maintenance is complete.

## Placement of the Flash-Tunnel

The Flash-Tunnel UV-C system is to be placed on a flat level surface. The side access panels block all UV-C light from passing through allowing the unit to be located near personnel working in the same room. Curtains prohibit most UV-C light exposure, however personnel should not stare through curtains while UV-C lamps are illuminated without proper PPE (i.e. safety glasses, face shield, etc.).

## Starting a Cycle

1. Conveyor belt is started via turn knob. Speed can be adjusted via dial adjuster. Access key is needed in order to get inside access panel.
2. UV-C lights can be illuminated via “Start” green push button. To turn off UV-C bulbs, press “Stop” red push button.
3. Before placing item(s) inside of Flash-Tunnel, ensure all visible dirt/grime has been removed from the surfaces of each item. Place the item(s) to be disinfected on belt surface of the Flash-Tunnel in an orientation such that no items overlap one another and prohibit light exposure on surfaces.
4. Items will travel down conveyor via specified speed. Positioned at “20” will result in travel time of 45 seconds and deliver approximate dose of 35mj/cm<sup>2</sup>.



5. Inspect to see that all bulbs are lit by looking through side access panels.
6. Upon cycle completion, turn off UV-C lights as well as conveyor.
7. If needed, Emergency Stop button can be pushed in to stop unit if stop button malfunctions or other hazard occurs. To reset Emergency Stop, pull button out.

**WARNING!**

***BE SURE TO READ THE SAFETY PRECAUTIONS IN “CHAPTER 2. FOR YOUR SAFETY.” THIS SYSTEM PRODUCES UV-C RAYS THAT CAN DAMAGE YOUR EYES, CAUSE TISSUE DAMAGE AND OTHER HEALTH RISKS. USE CARE WHEN OPERATING THE UNIT.***

# Chapter 4. Troubleshooting & Routine Maintenance

*In this chapter . . .*

- *Power issues*
- *Maintenance schedule*
- *User maintenance*
- *Yearly maintenance*
- *Changing UV-C Bulbs*

## Overview

The chapter provides information on troubleshooting and maintenance of the Flash-Tunnel. Scheduling your maintenance on a routine basis is useful for preventing serious equipment failure resulting from undetected or preventable problems. Perform the maintenance procedures shown below at the designated intervals. A summary of the procedures is shown the following table.

## Troubleshooting

### Troubleshooting for UV-C Components:

Problem	Action
The unit is not turning on	<ul style="list-style-type: none"> <li>• If the power cord is connected but the unit is still not on, check your outlets to see if a circuit breaker tripped.</li> <li>• Ensure UV-C lamps do not appear broken.</li> <li>• Check to see the switch is not powering up.</li> <li>• Check that an Emergency Stop button was not pushed in.</li> <li>• Call us at 1-908-236-4100 if still not working properly</li> </ul>
Other Problems	Call us at 1-908-236-4100 for troubleshooting

**Troubleshooting for Conveyor:**

## Maintenance Schedule

UV-C Components Procedure	Yearly	As Needed
Review equipment operation with your department personnel.	X	X
Check the unit for unusual sources of noise.		X
Replace UV-C lamps if necessary	X	X
Clean unit so that it is free of dust and dirt.		X

### User Maintenance

#### -UV-C

These procedures are to be performed as needed:

- Replace UV-C lamps.
- Check the unit for unusual sources of noise.
- Ensure UV-C lamps are not broken or cracked.
- Clean UV-C lamps so that they are free of dust and dirt using alcohol wipes.

*Note: Awareness of the system operation and unusual system activity should not be confined just to routine maintenance.*

### User Maintenance

The consumables consist of removable UV-C lamps; the following procedure details the replacement of these consumables. Lamps should always be changed with the power plug unplugged. It is the system operator's responsibility to verify that the system is in a safe state when consumables are being changed. You must read, understand and follow the procedures below. Replacement bulbs should only be purchased directly through ClorDiSys, otherwise the warranty will be voided.

The UV-C Lamps on average should last for 13,000 hours of on time and be replaced on an as needed basis.

**WARNING! READ THE “FOR YOUR SAFETY” CHAPTER PRIOR TO CHANGING ANY CONSUMABLES. THERE IS A POTENTIAL FOR UV-C EXPOSURE.**

## **To Remove:**

1. Remove Side Access Panel(s)
2. Each of the bulbs can be carefully slid out of the connectors.
3. The bulb should be pressed into the spring-loaded connector and then pulled away from the other connector. The bulb can then be slid out of spring-loaded connector.

## **To Install:**

1. Each bulb should be pressed into the spring-loaded connector and then positioned in front of the other connector until the pin aligns with the hole.
2. The bulb can then be pushed into the non-spring-loaded connector by reducing force pushing it into the spring-loaded connector
3. Reattach Side Access Panel(s)

## **User Maintenance**

### **-Conveyor**

- Keep all surfaces clean and clear of debris. When conveyor is off, wipe down periodically with a damp cloth. For dirt or stains dampen your rag with a small amount of mild soap and water. On more stubborn stains Mineral Spirits can be used. On non-painted surfaces such as Galvanized, Aluminized or Stainless Steel, paint thinner can be used.
- Once a month, check grease/oil levels in all gear drives and bearings. Use semi-fluid grease for gear oil.

# Appendix A. Antimicrobial Activity of UV-C Light

*In this appendix . . .*

- *Guidance and development of UV-C processes*
- *Exposure time/dosage*



# Guidance on Development of Disinfection Processes

This appendix provides guidance on UV-C contact time for different organisms.

## Exposure Time/UV-C Concentration

ClorDiSys' UV-C Flash-Tunnel System outputs 14 mJ/cm<sup>2</sup> UV-C dosage during a four-second exposure (time if travelling 60 feet per second).

The table below shows the required dosage required for the organisms listed.

UV-C Dose (Fluence) (mJ/cm <sup>2</sup> ) for a given Log Reduction without photo-reactivation									
	Lamp Type	1	2	3	4	5	6	7	Reference
<b>Spore</b>									
Bacillus anthracis spores - Anthrax spores	N/A	24.32	46.2						Light Sources Inc. 2014
Bacillus magaterium sp. (spores)	N/A	2.73	5.2						Light Sources Inc. 2014
Bacillus subtilis ATCC6633	N/A	36	48.6	61	78				Chang et al. 1985
Bacillus subtilis ATCC6633	LP	24	35	47	79				Mamane-Gravetz and Linden 2004
Bacillus subtilis ATCC6633	LP	22	38	>50					Sommer et al. 1998
Bacillus subtilis ATCC6633	LP	20	39	60	81				Sommer et al. 1999
Bacillus subtilis WN626	LP	0.4	0.9	1.3	2				Marshall et al., 2003
Bacillus subtilis spores	N/A	11.6	22.0						Light Sources Inc. 2014
<b>Bacterium</b>									
Aeromonas salmonicida	LP	1.5	2.7	3.1	5.9				Liltved and Landfald 1996
Aeromonas hydrophila ATCC7966	LP	1.1	2.6	3.9	5	6.7	8.6		Wilson et al. 1992
Bacillus anthracis - Anthrax	N/A	4.52	8.7						Light Sources Inc. 2014
Bacillus magaterium sp. (veg.)	N/A	1.3	2.5						Light Sources Inc. 2014
Bacillus paratyphus	N/A	3.2	6.1						Light Sources Inc. 2014
Bacillus subtilis	N/A	5.8	11.0						Light Sources Inc. 2014
Campylobacter jejuni ATCC 43429	LP	1.6	3.4	4	4.6	5.9			Wilson et al. 1992
Citrobacter diversus	LP	5	7	9	11.5	13			Giese and Darby 2000
Citrobacter freundii	LP	5	9	13					Giese and Darby 2000
Clostridium tetani	N/A	13.0	22.0						Light Sources Inc. 2014
Corynebacterium diphtheriae	N/A	3.37	6.51						Light Sources Inc. 2014
Ebertelia typhosa	N/A	2.14	4.1						Light Sources Inc. 2014V
Escherichia coli O157:H7 CCUG 29193	LP	3.5	4.7	5.5	7				Sommer et al. 2000
Escherichia coli O157:H7 CCUG 29197	LP	2.5	3	4.6	5	5.5			Sommer et al. 2000
Escherichia coli O157:H7 CCUG 29199	LP	0.4	0.7	1	1.1	1.3	1.4		Sommer et al. 2000
Escherichia coli O157:H7 ATCC 43894	LP	1.5	2.8	4.1	5.6	6.8			Wilson et al. 1992
Escherichia coli	N/A	3.0	6.6						Light Sources Inc. 2014
Escherichia coli ATCC 11229	N/A	2.5	3	3.5	5	10	15		Harris et al. 1987
Escherichia coli ATCC 11229	N/A	3	4.8	6.7	8.4	10.5			Chang et al. 1985

<b>UV-C Dose (Fluence) (mJ/cm<sup>2</sup>) for a given Log Reduction without photo-reactivation</b>									
	Lamp Type	1	2	3	4	5	6	7	Reference
<i>Escherichia coli</i> ATCC 11229	LP	<5	5.5	6.5	7.7	10			Zimmer et al. 2002
<i>Escherichia coli</i> ATCC 11229	MP	<3	<3	<3	<3	8			Zimmer et al. 2002
<i>Escherichia coli</i> ATCC 11229	LP	7	8	9	11	12			Hoyer 1998
<i>Escherichia coli</i> ATCC 11229	LP	3.5	4.7	5.5	6.5	7.5	9.6		Sommer et al. 2000
<i>Escherichia coli</i> ATCC 11229	LP	Gff6	6.5	7	8	9	10		Sommer et al. 1998
<i>Escherichia coli</i> ATCC 11303	LP	4	6	9	10	13	15	19	Wu et al. 2005
<i>Escherichia coli</i> ATCC 25922	LP	6	6.5	7	8	9	10		Sommer et al. 1998
<i>Escherichia coli</i> C	LP	2	3	4	5.6	6.5	8	10.7	Otaki et al. 2003
<i>Escherichia coli</i> K-12 IFO3301	LP & MP	2	4	6	7	8.5			Oguma et al. 2002
<i>Escherichia coli</i> K-12 IFO3301	LP & MP	2.2	4.4	6.7	8.9	11.0			Oguma et al. 2004
<i>Escherichia coli</i> K-12 IFO3301	LP	1.5	2	3.5	4.2	5.5	6.2		Otaki et al. 2003
<i>Escherichia coli</i> O157:H7	LP	1.5	3	4.5	6				Tosa and Hirata 1999
<i>Escherichia coli</i> O157:H7	LP	<2	<2	2.5	4	8	17		Yaun et al. 2003
<i>Escherichia coli</i> O25:K98:NM	LP	5	7.5	9	10	11.5			Sommer et al. 2000
<i>Escherichia coli</i> O26	LP	5.4	8	10.5	12.8				Tosa and Hirata 1999
<i>Escherichia coli</i> O50:H7	LP	2.5	3	3.5	4.5	5	6		Sommer et al. 2000
<i>Escherichia coli</i> O78:H11	LP	4	5	5.5	6	7			Sommer et al. 2000
<i>Escherichia coli</i> Wild type	LP	4.4	6.2	7.3	8.1	9.2			Sommer et al. 1998
<i>Halobacterium elongate</i> ATCC33173	LP	0.4	0.7	1					Martin et al. 2000
<i>Halobacterium salinarum</i> ATCC43214	LP	12	15	17.5	20				Martin et al. 2000
<i>Klebsiella pneumoniae</i>	LP	12	15	17.5	20				Giese and Darby 2000
<i>Klebsiella terrigena</i> ATCC33257	LP	4.6	6.7	8.9	11				Wilson et al. 1992
<i>Legionella pneumophila</i> ATCC33152	MP	1.9	3.8	5.8	7.7	9.6			Oguma et al. 2004
<i>Legionella pneumophila</i> ATCC 43660	LP	3.1	5	6.9	9.4				Wilson et al. 1992
<i>Legionella pneumophila</i> ATCC33152	LP	1.6	3.2	4.8	6.4	8.0			Oguma et al. 2004
<i>Leptospiracanicola</i> - infectious Jaundice	N/A	3.15	6.0						Light Sources Inc. 2014
<i>Micrococcus candidus</i>	N/A	6.05	12.3						Light Sources Inc. 2014
<i>Micrococcus sphaeroides</i>	N/A	1.0	15.4						Light Sources Inc. 2014
<i>Mycobacterium tuberculosis</i>	N/A	6.2	10.0						Light Sources Inc. 2014
<i>Neisseria catarrhalis</i>	N/A	4.4	8.5						Light Sources Inc. 2014
<i>Phytomonas tumefaciens</i>	N/A	4.4	8.0						Light Sources Inc. 2014
<i>Proteus vulgaris</i>	N/A	3.0	6.6						Light Sources Inc. 2014
<i>Pseudomonas stutzeri</i>	UV-CB	100	150	195	230				Joux et al. 1999
<i>Pseudomonas aeruginosa</i>	N/A	5.5	10.5						Light Sources Inc. 2014
<i>Pseudomonas fluorescens</i>	N/A	3.5	6.6						Light Sources Inc. 2014
RB2256	UV-CB	175	>300						Joux et al. 1999
<i>Salmonella paratyphi</i> - Enteric fever	N/A	3.2	6.1						Light Sources Inc. 2014
<i>Salmonella anatum</i> (from human feces)	N/A	7.5	12	15					Tosa and Hirata 1998
<i>Salmonella derby</i> (from human feces)	N/A	3.5	7.5						Tosa and Hirata 1998
<i>Salmonella enteritidis</i> (from human feces)	N/A	5	7	9	10				Tosa and Hirata 1998
<i>Salmonella infantis</i> (from human feces)	N/A	2	4	6					Tosa and Hirata 1998
<i>Salmonella spp.</i>	LP	<2	2	3.5	7	14	29		Yaun et al. 2003
<i>Salmonella typhi</i> ATCC 19430	LP	1.8	4.8	6.4	8.2				Wilson et al. 1992
<i>Salmonella typhi</i> ATCC 6539	N/A	2.7	4.1	5.5	7.1	8.5			Chang et al. 1985
<i>Salmonella typhimurium</i> (from human feces)	N/A	2	3.5	5	9				Tosa and Hirata 1998
<i>Salmonella typhimurium</i>	UV-CB	50	100	175	210	250			Joux et al. 1999

UV-C Dose (Fluence) (mJ/cm <sup>2</sup> ) for a given Log Reduction without photo-reactivation									
	Lamp Type	1	2	3	4	5	6	7	Reference
<i>Salmonella typhimurium</i> (in act. sludge)	LP	3	11.5	22	50				Maya et al. 2003
<i>Salmonella enteritidis</i>	N/A	4.0	7.6						Light Sources Inc. 2014
<i>Salmonella typhimurium</i>	N/A	8.0	15.2						Light Sources Inc. 2014
<i>Salmonella typhosa</i> - Typhoid fever	N/A	2.15	4.1						Light Sources Inc. 2014
<i>Sarcina lutea</i>	N/A	19.7	26.4						Light Sources Inc. 2014
<i>Serratia marcescens</i>	N/A	2.42	6.16						Light Sources Inc. 2014
<i>Shigella dysenteriae</i> ATCC29027	LP	0.5	1.2	2	3	4	5.1		Wilson et al. 1992
<i>Shigella dysenteriae</i> - Dysentery	N/A	2.2	4.2						Light Sources Inc. 2014
<i>Shigella flexneri</i> - Dysentery	N/A	1.7	3.4						Light Sources Inc. 2014
<i>Shigella paradysenteriae</i>	N/A	1.68	3.4						Light Sources Inc. 2014
<i>Shigella sonnei</i> ATCC9290	N/A	3.2	4.9	6.5	8.2				Chang et al. 1985
<i>Spirillum rubrum</i>	N/A	4.4	6.16						Light Sources Inc. 2014
<i>Staphylococcus aureus</i> ATCC25923	N/A	3.9	5.4	6.5	10.4				Chang et al. 1985
<i>Staphylococcus albus</i>	N/A	1.84	5.72						Light Sources Inc. 2014
<i>Staphylococcus aureus</i>	N/A	2.6	6.6						Light Sources Inc. 2014
<i>Staphylococcus hemolyticus</i>	N/A	2.16	5.5						Light Sources Inc. 2014
<i>Staphylococcus lactis</i>	N/A	6.15	8.8						Light Sources Inc. 2014
<i>Streptococcus faecalis</i> (secondary effluent)	N/A	5.5	6.5	8	9	12			Harris et al. 1987
<i>Streptococcus faecalis</i> ATCC29212	N/A	6.6	8.8	9.9	11.2				Chang et al. 1985
<i>Streptococcus viridans</i>	N/A	2.0	3.8						Light Sources Inc. 2014
<i>Vibrio anguillarum</i>	LP	0.5	1.2	1.5	2				Liltved and Landfald 1996
<i>Vibrio cholerae</i> ATCC25872	LP	0.8	1.4	2.2	2.9	3.6	4.3		Wilson et al. 1992
<i>Vibrio comma</i> - Cholera	N/A	3.375	6.5						Light Sources Inc. 2014
<i>Vibrio natriegens</i>	UV-CB	37.5	75	100	130	150			Joux et al. 1999
<i>Yersinia enterocolitica</i> ATCC27729	LP	1.7	2.8	3.7	4.6				Wilson et al. 1992
<i>Yersinia ruckeri</i>	LP	1	2	3	5				Liltved and Landfald 1996
<b>Yeasts</b>									
Brewers yeast	N/A	3.3	6.6						Light Sources Inc. 2014
Common yeast cake	N/A	6.0	13.2						Light Sources Inc. 2014
<i>Saccharomyces carevisiae</i>	N/A	6.0	13.2						Light Sources Inc. 2014
<i>Saccharomyces ellipsoideus</i>	N/A	6.0	13.2						Light Sources Inc. 2014
<i>Saccharomyces</i> spores	N/A	8.0	17.6						Light Sources Inc. 2014
<b>Molds</b>									
<i>Aspergillus flavus</i>	N/A	60.0	99.0						Light Sources Inc. 2014
<i>Aspergillus glaucus</i>	N/A	44.0	88.0						Light Sources Inc. 2014
<i>Aspergillus niger</i>	N/A	132.0	330.0						Light Sources Inc. 2014
<i>Mucor racemosus</i> A	N/A	17.0	35.2						Light Sources Inc. 2014
<i>Mucor racemosus</i> B	N/A	17.0	35.2						Light Sources Inc. 2014
<i>Oospora lactis</i>	N/A	5.0	11.0						Light Sources Inc. 2014
<i>Penicillium digitatum</i>	N/A	44.0	88.0						Light Sources Inc. 2014
<i>Penicillium expansum</i>	N/A	13.0	22.0						Light Sources Inc. 2014
<i>Penicillium roqueforti</i>	N/A	13.0	26.4						Light Sources Inc. 2014
<i>Rhizopus nigricans</i>	N/A	111.0	220.0						Light Sources Inc. 2014
<b>Protozoan</b>									
<i>Chlorella Vulgaris</i>	N/A	13.0	22.0						Light Sources Inc. 2014
<i>Cryptosporidium hominis</i>	LP & MP	3	5.8						Johnson et al. 2005
<i>Cryptosporidium parvum</i>	LP & MP	2.4	<5	5.2	9.5				Craik et al. 2001
<i>Cryptosporidium parvum</i>	MP	<5	<5	<5	~6				Amoah et al. 2005
<i>Cryptosporidium parvum</i>	MP	<10	<10	<10					Belosevic et al. 2001

UV-C Dose (Fluence) (mJ/cm <sup>2</sup> ) for a given Log Reduction without photo-reactivation									
	Lamp Type	1	2	3	4	5	6	7	Reference
<i>Cryptosporidium parvum</i>	LP	1	2	<5					Shin et al. 2001
<i>Cryptosporidium parvum</i>	MP	1	2	2.9	4				Bukhari et al. 2004
<i>Cryptosporidium parvum</i>	LP	<2	<2	<2	<4	<10			Clancy et al. 2004
<i>Cryptosporidium parvum</i>	MP	<3	<3	3-9	<11				Clancy et al. 2000
<i>Cryptosporidium parvum</i>	LP	<3	<3	3-6	<16				Clancy et al. 2000
<i>Cryptosporidium parvum</i>	LP	0.5	1	1.4	2.2				Morita et al. 2002
<i>Cryptosporidium parvum</i>	LP	2	<3	<3					Zimmer et al. 2003
<i>Cryptosporidium parvum</i>	MP	<1	<1	<1					Zimmer et al. 2003
<i>Cryptosporidium parvum</i> , oocysts, tissue culture assay	N/A	1.3	2.3	3.2					Shin et al. 2000
<i>Encephalitozoon cuniculi</i> , microsporidia	LP	4	9	13					Marshall et al. 2003
<i>Encephalitozoon hellem</i> , microsporidia	LP	8	12	18					Marshall et al. 2003
<i>Encephalitozoon intestinalis</i> , microsporidia	LP & MP	<3	3	<6	6				Huffman et al. 2002
<i>Encephalitozoon intestinalis</i> , microsporidia	LP	3	5	6					Marshall et al. 2003
<i>G. muris</i> , cysts	MP	<5	<5	5					Amoah et al. 2005
<i>G. muris</i> , cysts, mouse infectivity assay	N/A	<2	<6	10 + tailing					Craik et al. 2000
<i>Giardia lamblia</i>	LP	<10	~10	<20					Campbell et al. 2002
<i>Giardia lamblia</i>	LP	<2	<2	<4					Mofidi et al. 2002
<i>Giardia lamblia</i> , gerbil infectivity assay	LP	<0.5	<0.5	<0.5	<1				Linden et al. 2002b
<i>Giardia lamblia</i> , excystation assay	N/A	40	180						Karanis et al. 1992
<i>Giardia lamblia</i> , excystation assay	N/A	> 63							Rice and Hoff 1981
<i>Giardia muris</i>	MP	1	4.5	28 + tailing					Craik et al. 2000
<i>Giardia muris</i>	MP	<10	<10	<25	~60				Belosevic et al. 2001
<i>Giardia muris</i>	LP	<1.9	<1.9	~2	~2.3				Hayes et al. 2003
<i>Giardia muris</i>	LP	<2	<2	<4					Mofidi et al. 2002
<i>Giardia muris</i> , excystation assay	N/A	77	110						Carlson et al. 1985
Nematode Eggs	N/A	45.0	92.0						Light Sources Inc. 2014
<i>Paramecium</i>	N/A	11.0	20.0						Light Sources Inc. 2014

# Appendix B. Warranties

*In this appendix . . .*

- *Service warranty*
- *Commercial warranty*

## Service Warranty

Service repairs are warranted to be free from defects in materials and workmanship for a period of 90 days after the date of repair when serviced by a Representative or authorized dealer.

This warranty is null and void if service is performed by persons who are not authorized to do so by ClorDiSys Solutions, Inc. If, after examination by a Service Representative, the previously repaired portion of the unit is found to be defective within the period specified above, and Service is satisfied that the failure was due to defective materials and/or workmanship, Service will, at its option, repair or replace the defective parts without charge. This warranty is not valid for repair or replacement for defects due to external factors including, but not limited to, defective electrical installation or electrical/atmospheric disturbances. Service reserves the right to make the necessary repair in its own factory, at any authorized repair station, or at the facilities of the purchaser of the instrument.

Replacement items can be either new or remanufactured. Defective parts replaced under warranty shall become the property of CSI.

THE EXPRESS WARRANTY ABOVE IS THE SOLE WARRANTY OBLIGATION OF CLORDISYS SOLUTIONS, INC., AND THE REMEDY PROVIDED ABOVE IS IN LIEU OF ANY AND ALL OTHER REMEDIES. THERE ARE NO OTHER AGREEMENTS, GUARANTEES OR WARRANTIES -- ORAL OR WRITTEN -- EXPRESSED OR IMPLIED, INCLUDING WITHOUT LIMITATION WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. CLORDISYS SOLUTIONS, INC. SHALL HAVE NO LIABILITY WHATSOEVER FOR ANY IMPROPER USE OR UNAUTHORIZED SERVICE OR REPAIR.

## Commercial Warranty

The Flash-Tunnel System and reusable accessories supplied by ClorDiSys Solutions, Inc. (CSI) are warranted to be free from defects in materials and workmanship for a period of one [1] year from the date of installation, when properly installed, maintained and used for their intended purpose. This warranty applies only to the original purchaser of the equipment and only if the equipment is used in the country to which it was originally shipped by ClorDiSys Solutions, Inc.

This warranty is null and void if service is attempted or performed by persons who are not authorized to do so by CSI. If, after examination by a Service Representative, any portion of the unit is found to be defective within the period specified above, and Service is satisfied that the failure was due to defective materials and/or workmanship, Service will, at its option, repair or replace the defective parts without charge. This warranty is not valid for repair or replacement for defects due to external factors including, but not limited to, defective electrical installation or electrical/atmospheric disturbances or physical breakage of any parts due to improper or rough handling. Service reserves the right to make the necessary repair/replacement in its own factory, at any authorized repair station, or at the facilities of the purchaser of the instrument. Replacement items can be either new or remanufactured. Defective parts replaced under warranty shall become the property of Service. This warranty does not cover the UV-C lamps.