Risk Analysis of Laundered Flat Mops for Cleanroom Use

Summary

A pharmaceutical manufacturing company located in the USA provided samples of blue microfiber flat pocket mops for evaluation. These mops are supplied and laundered by an institutional laundry company. The company provided ten mop each of 1) New mops that had been laundered one cycle, 2) mops that had been used and laundered repeatedly and 3) mops that had been used and laundered repeatedly, but had not been laundered since the last use. The mops were used to clean controlled environments within the manufacturing suites. Each mop was uniquely identified with a serial number and bar code, but it was not known how many use/laundry cycles each mop had experienced. Each of the mop sample types were analyzed for various aspects regarding the level of contamination and wear: Viable microorganisms, non-volatile residues, contaminants and wear using microscopy, contaminants released after extraction, and particle and fiber counts using a liquid particle counter.

- All mops appear to be in good condition and laundered mops were properly bagged and vacuum sealed.
- The new and used mops could be visually identified by discoloration of the white backing due to exposure to disinfectants or the laundry process.
- None of the mops had excessive or visible soiling. The used mops were received wet in a bag.
- Each mop was labeled with a serial number and bar code. Older mops (based on lower serial number) had more discoloration of the backing and showed more wear on the sewn mop edges.
- Two of each mop type were analyzed for microbial bioburden (aerobes, fungi) using standard microbiological techniques. No viable microorganisms were detected in any of the three sample types.
- Analysis of non-volatile residues on one section of each mop type was conducted by extracting the section in water and then boiling off all volatiles. Results of gravimetric analysis revealed very low levels of residue for all the samples.
- Examination of the used mops showed wear of the sewn edges of the mops and some visible threads.
- Examination of the used mops under a stereo microscope revealed the fiber bundles starting to fray and clumps of fibers forming, along with some debris that was entrapped in the mop.
- A simple water extraction/filtration test of the used laundered mops revealed high levels of white fibers (presumably shed from the mops or the laundry) that originated from use and/or cross-contamination during the laundry process. The images in the report show the substantial increase of fibers of the used laundered mop.
- Testing of the new and used laundered mop samples using a liquid particle counter showed that the number of particles nearly doubled, and the number of fibers counted using optical microscopy increased four times with laundered mops.
- These results indicate that re-use of microfiber mops and other textiles after laundering lead to an increasing level of contamination from the mops breaking down, the ability of microfiber to hold onto contaminants, and a laundering process that may not adequately remove all contaminants.
- It is recommended to consider single-use products as an alternative to alleviate these concerns. Single use microfiber mops provide known characteristics, no degradation of properties and consistency from mop to mop.

Contact us:
info@contecinc.com
contecinc.com

Contec, Inc.
Spartanburg, SC 29303 USA
tel: +1-864-503-8333

CONTEC® CLEANROOM

Background

Cleaning procedures for controlled environments traditionally have depended on using sorbent cellulose-based string mops and cleaning cloths. In the last few decades, most facilities have transitioned from cellulosed-based products, to cleaning with laundered or disposable synthetic flat mops and wipes. While several studies have shown the migration to these synthetic textiles has improved cleaning and disinfection techniques and effectiveness, recent studies conducted by Contec and others have raised serious concerns around cleaning with relaundered products, including:

- Degradation of the mops due to repeated use/laundry cycles.
- Increase in the amount of trapped particles and fibers as the mops are re-used and relaundered.
- Loss of cleaning capacity after repeated laundering due to damage to the textile fibers.
- Retention and accumulation of microbes, dirt and debris within the textiles through repeated use and inadequate laundering.
- Increased risk of cross-contamination and binding/neutralization of disinfectants from contamination during laundering, transport or storage.

Materials

This report summarizes the results of microbiological and residue analyses of flat blue polyester microfiber mops in the Fall of 2018. Three sets of samples (10 mop pads each) were provided, 10 each new mops, laundered; 10 used mops; and 10 used mops after laundering. Two mop pads of each type were evaluated. It is not known how many times the samples had been relaundered and re-used prior to testing.

Sample Types:

Sample A: Company blue flat mop, new mop, laundered

Sample B: Company blue flat mop, used mop, not yet laundered

Sample C: Company blue flat mop, used mop, laundered

Sample A: Note the white backing of the new mop

Contact us:
info@contecinc.com
contecinc.com

Contec, Inc.
Spartanburg, SC 29303 USA
tel: +1-864-503-8333

Sample B: Note the nonuniform discoloration of backing

Sample C: Used mop that was laundered and packaged.

Methods

- The used mops were dried in a hood and bagged prior to testing.

Analysis 1 (Viable Microorganisms)

- Two mops of each type were sent to an outside laboratory for bioburden testing (total aerobes and total fungi) based on the standard method USP <61> “Microbiological Analysis of Non-sterile Products: Microbial Enumeration Tests”.
  - Briefly, the method involves extraction of samples in a buffer solution using a stomacher device, followed by pour plating of the extraction solution for total aerobes (Tryptic Soy Agar (TSA); incubated at 32°C for 3 days) or total fungi (Sabouraud Dextrose Agar (SDA); incubated at 25°C for 5 days).
  - After incubation, the numbers of Colony Forming Units (CFU) were counted unless the sample contained too many microbes to enumerate. In that case, the result was reported by the lab as Too Numerous to Count (TNTC). If no microbes were recovered from the extraction solution, the minimum count was reported as <80 CFU per total mop.

Contact us:
info@contecinc.com
contecinc.com

Contec, Inc.
Spartanburg, SC 29303 USA
tel: +1-864-503-8333

Analysis 2 (Non-volatile residues (NVR))

- One section from each mop type were examined using a simple method to measure non-volatile residues. Two samples of each type were tested. The sample was soaked and agitated in water, then the water was evaporated by boiling. The remaining residues were weighed on a balance. NVRs were tested in both IPA and DI water per IEST RP-CC004.2, Sec 6.1.2 test method.

Analysis 3 (Fiber and Particle Contamination using Microscopy)

- Samples of each mop type were examined using a stereo-microscope at magnifications ranging from 50-150x. Representative images were captured of wear found on the mops edges and debris found in the mop face.
- Each mop half was inserted in a stomacher bag with 500 ml of water and agitated. The extraction solution from each mop was filtered through a 0.45 µm filter. The filter was then inspected with a stereo microscope.

Analysis 4 (Contamination observed with Microscopy after Extraction and Filtration)

- Each mop half was inserted in a stomacher bag with 500 ml of water and agitated. The extraction solution from each mop was filtered through a 0.45 µm filter. The filter was then inspected with a stereo microscope.

Analysis 5 (Fiber and Particle Contamination using a Liquid Particle Counter)

- Using IEST method RP-CC004.3
- Samples are rinsed in solution and measured using the PMS Liquid Particle Counter
- The solution was filtered and fibers counted using optical microscopy

Results

Analysis 1 (Viable Microorganisms)

No fungi (more specifically, no growth on fungal ("SDA") agar) or Aerobes (all CFU on general purpose ("TSA") agar) were recovered from any of the four samples (<80 CFU/mop). The results are shown in table below.

Sample	Total Aerobes/mop (mostly bacteria)	Total Fungi/mop (yeast and mold)
A: New, laundered; #88848, #86707; (Rpt 171913)	<80 CFU	<80 CFU
B: Used; #65125, #91459; (Rpt 171915)	<80 CFU	<80 CFU
C: Used laundered; #66993, #57656, (Rpt 171914)	<80 CFU	<80 CFU

A recovery efficiency validation test to determine how well microbes can be extracted from mop was not conducted. Given the complexity of these terry cloth mops, recovery efficiency could be as low as 10-50%. Therefore, these results may underestimate the levels of contamination on the samples.

Analysis 2 (Non-volatile Residues (NVR))

Sample	NVR DI Water	NVR IPA
A: New, laundered; #90421, #86899; (ETR #4313)	0.02	0.06
B: Used; #78542, #78535; (ETR #4314)	1.85	0.34
C: Used laundered; #66504, 60540; (ETR #4315)	0.01	0.07

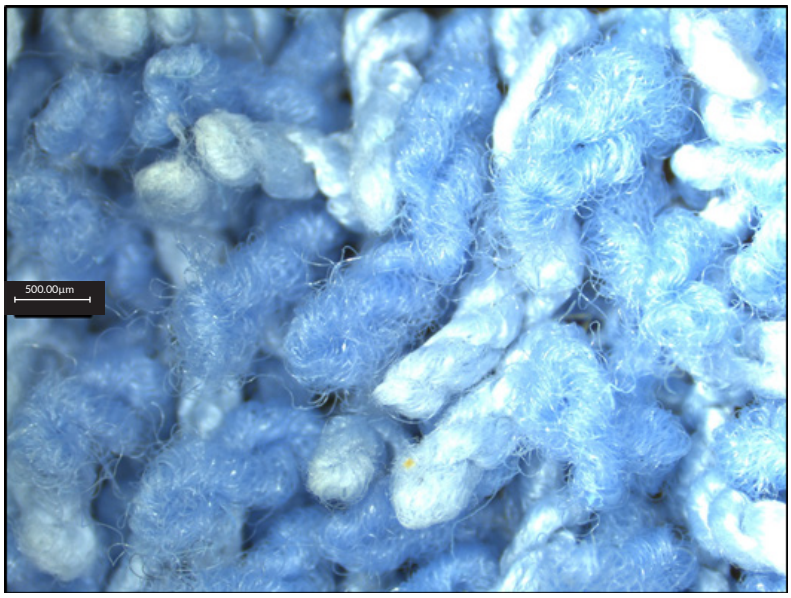
Results of gravimetric analysis revealed very low levels of residue for all the laundered samples. This was a reflection that most of the residue appeared to be fibers. The used samples had higher levels as expected due to residual cleaning chemicals.

Contact us:
info@contecinc.com
contecinc.com

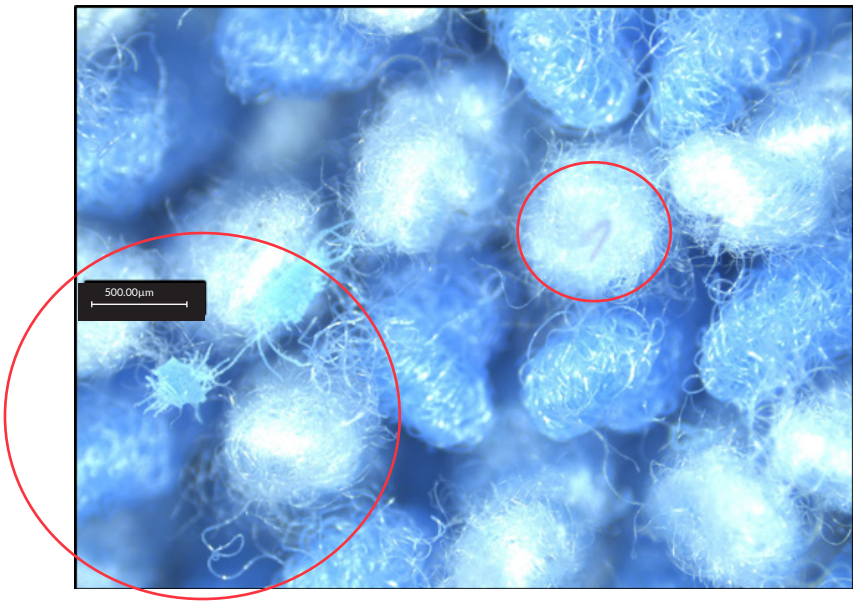
Contec, Inc.
Spartanburg, SC 29303 USA
tel: +1-864-503-8333

CONTEC® CLEANROOM

Analysis 3 (Fiber and Particle Contamination using Microscopy)



Sample showing two types of fiber bundles used in mop construction, light blue and dark blue

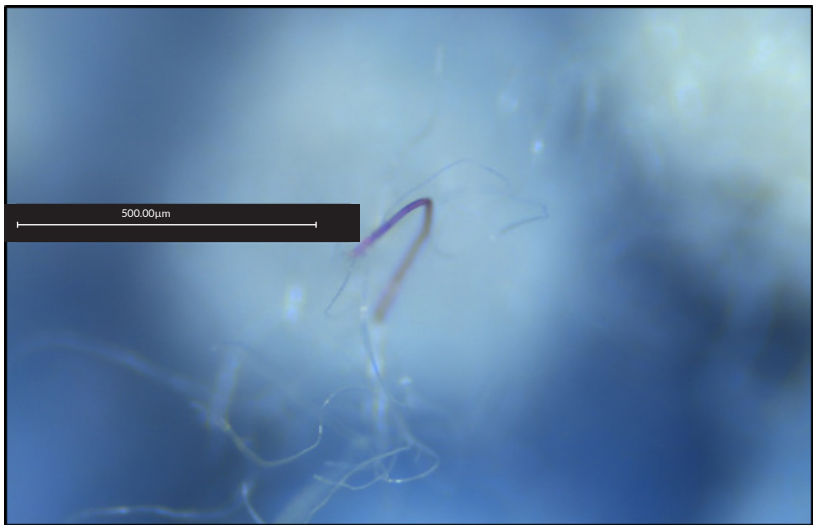


Laundered used mop show fraying of the fibers in the tufts and fiber clumps forming.

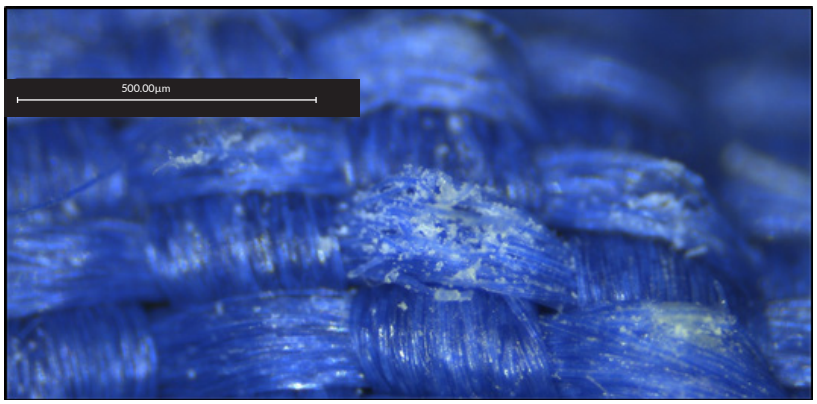
Contact us:
info@contecinc.com
contecinc.com

Contec, Inc.
Spartanburg, SC 29303 USA
tel: +1-864-503-8333

Analysis 3 (Fiber and Particle Contamination using Microscopy) *continued*



Laundered mop sample - Close up of foreign fiber contamination

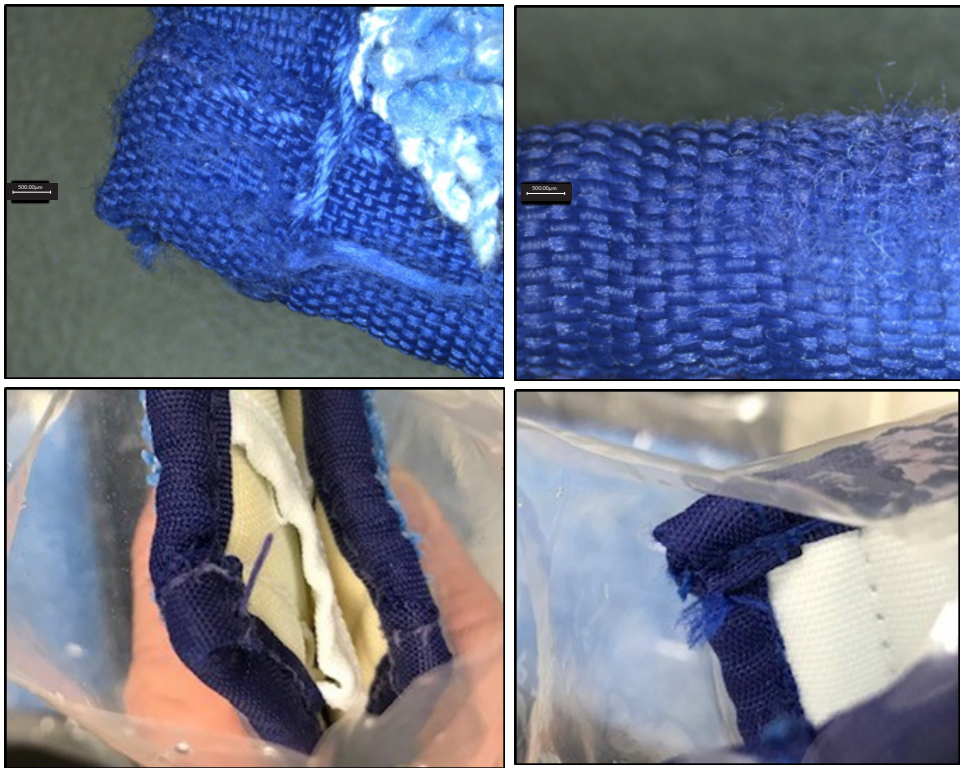


Used mop showing what appear to be bleach residues

Contact us:
info@contecinc.com
contecinc.com

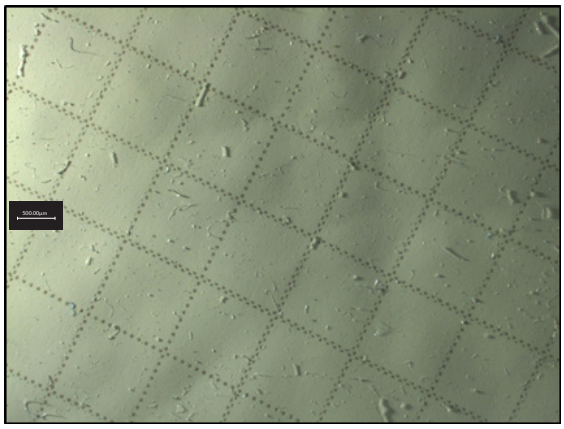
Contec, Inc.
Spartanburg, SC 29303 USA
tel: +1-864-503-8333

Analysis 3 (Fiber and Particle Contamination using Microscopy) *continued*

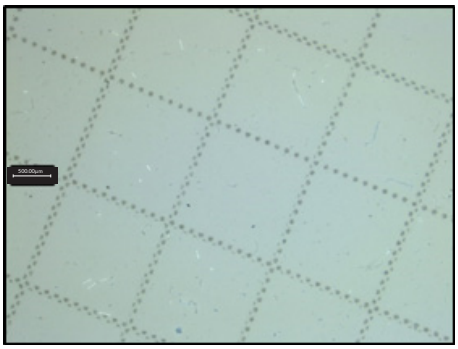


Used and laundered mop samples showing loose fibers and abraded edges

Analysis 4 (Contamination Observed with Microscopy after Extraction and Filtration)



Lighting from Side



Sample A – New laundered mops

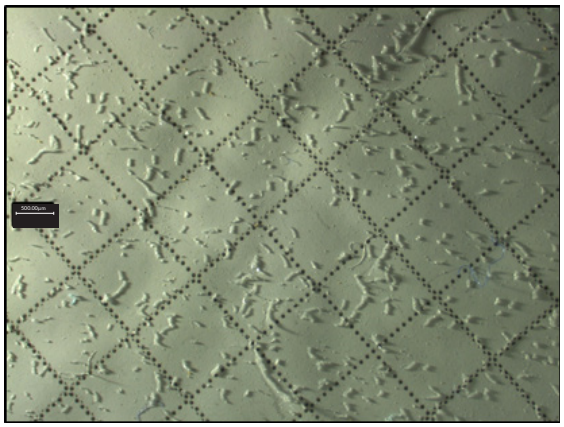
Lighting from Above

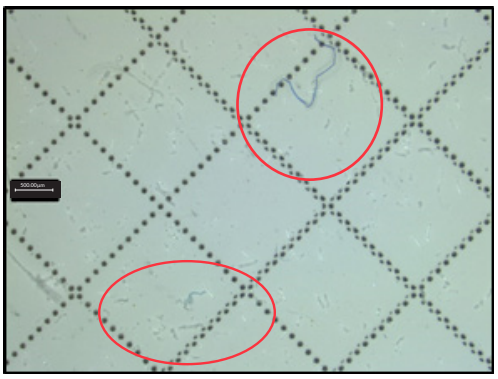
Numerous fibers and small pieces of fibers from the mop. The above lighting pictures show that all fibers are white colored.

Contact us:
info@contecinc.com
contecinc.com

Contec, Inc.
Spartanburg, SC 29303 USA
tel: +1-864-503-8333

Analysis 3 (Contamination Observed with Microscopy after Extraction and Filtration) *continued*

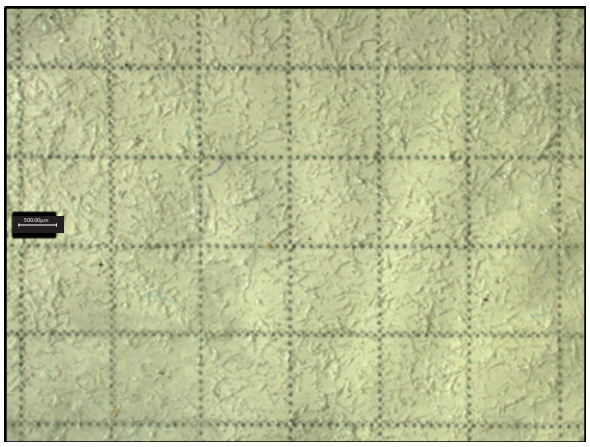




Sample C: Laundered used mop

Lighting from Side Lighting from Above

Substantial increase in fibers in used and laundered mop. The above lighted picture shows almost all contamination is of white color, a few blue.



Sample B: Used Mop

Lighting from Side

Used mops had very high levels of particulates and fibers - presumably from the cleaning solution, entrapped particles and fibers from the mop pad itself. The filter became fouled/plugged after filtering 1/3 of the target extraction solution (so filter was still wet). All contaminants appear to be white or translucent.

Contact us:
info@contecinc.com
contecinc.com

Contec, Inc.
Spartanburg, SC 29303 USA
tel: +1-864-503-8333

CONTEC CLEANROOM

Analysis 5 (Fiber and Particle Contamination using a Liquid Particle Counter)

Sample	Particles, Po	Fibers
A: New, laundered; #90070, #78610; (ETR #4318)	4.37 x 10^6/mop	0.17 x 10^3/mop
C: Used laundered; #78375, #62803; (ETR #4317)	8.09 x 10^6/mop	0.70 x 10^3/mop
Increase from New to Used laundered mops	1.85X	4.12X

Key to note here are that the number of nearly doubles while more problematic is the 4-fold increase in fibers. This observation can be visually seen on the micrographs of the new and used laundered mops on page 8.

Conclusion

Results of this study indicate that re-use of microfiber mop pads after laundering can lead to an increasing level of contamination from the mops breaking down, the ability of microfiber to hold onto contaminants, and a laundering process that may not adequately remove all contaminants. Detailed findings were:

- Visual wear of the mop edges and loose threads
- Optical microscopy showed fraying of the fiber bundles and fiber clumps forming
- Optical microscopy showed significant increase in the residual contamination after laundry. The majority of which appears to be fibers. The source of the fibers is most likely degradation and breakage of the microfibers that the mop is made of. The degradation along with the affinity of the microfiber to hold onto contamination mean that the amount of contamination will continue to build in the mop, resulting in decreasing mop performance over time.
- Counting of the fibers quantified the increase from the new to used laundered mops as four-fold. This is expected to continue to climb with each mop re-use, resulting in increasing contamination from the mop over time.
- In addition to adding to the total amount of contamination, the degradation of the terry cloth mop structure will affect the ability of the mop to sorb solution and remove contaminants from the mopped surfaces.

It is recommended that single-use products be considered as an alternative to alleviate these concerns. Single use microfiber mops provide known characteristics, are consistent from mop to mop and provide consistent performance properties while in use.

Testing and report by Pier de Jong, Technical Service Manager and Mark Wiencek, Ph.D., Lead Microbiologist, Contec, Inc.

Contact us:
info@contecinc.com
contecinc.com

Contec, Inc.
Spartanburg, SC 29303 USA
tel: +1-864-503-8333

CONTEC® CLEANROOM