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Effect of Disinfectants on Aircraft Seating Materials

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Technical report

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16. Abstract

As a result of the coronavirus disease 2019 (COVID-19) public health emergency, aircraft owners and operators may find it necessary to increase the frequency with which they disinfect aircraft interiors and to include additional areas of the aircraft not previously disinfected. The effect of using liquid disinfectants was investigated and the results discussed. Current research focuses on evaluating the performance of aircraft seating materials when conditioned with liquid chemical disinfectants in a controlled manner.

Together with the SAE Seat Committee, the researchers identified five different types of materials used in aircraft seats for this study. In addition, five liquid disinfectants commonly used at the time of this research were chosen. All materials were evaluated for changes in flammability performance and the plastic and seat belt webbing materials were also evaluated for changes in mechanical strength.

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Acronyms

Acronym	Definition
ACES	Aviation Consulting and Engineering Solutions
ASTM	American Society for Testing and Materials
AVET	Advanced Virtual and Engineering Testing Laboratories
CFR	Code of Federal Regulations
CIE	International Commission on Illumination
CMH-17	Composite Materials Handbook-17
DIC	Digital Image Correlation
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
IPA	Isopropyl Alcohol
NIAR	National Institute for Aviation Research
SAE	Society for Automotive Engineers

Executive summary

As a result of the coronavirus disease 2019 (COVID-19) public health emergency, aircraft owners and operators may find it necessary to increase the frequency with which they disinfect aircraft interiors and to include additional areas of the aircraft not previously disinfected. Therefore, the effect of using disinfectants will be investigated. Current research focuses on evaluating the performance of aircraft seating materials when conditioned with liquid chemical disinfectants in a controlled manner.

Together with the Society for Automotive Engineers (SAE) Seat Committee, the researchers identified materials for study, which consisted of five types of material used in aircraft seats, together with five liquid disinfectants. All materials were evaluated for changes in flammability performance and the plastic and seat belt webbing materials were also evaluated for changes in mechanical strength.

The following common aircraft seating materials selected for study:

- Plastics (Kydex 6565, Boltaron 9815E, Lexan XHR, and Boltaron 9815N)
- Natural leather (Perrone Pewter BC. Perrone Feather Weight and Muirhead DF602)
- Synthetic leather (E-Leather CL820, Ultrafabrics 492-6579FR12, Tapisuede TSFRC0961and Ultraleather ULFRB971-1363)
- Wool/nylon blend (Lantal, Rohi Beach, Sheepskin, and Botany Fabric)
- Seatbelt webbing (SCHROTH and AmSafe)

Liquid disinfectants selected for study are as follows:

- 70% Isopropyl Alcohol (IPA)
- Calla 1452
- Sani-Cide EX3
- BactroKill+
- PREempt RTU

There were two conditioning methods followed in this study – Submersion and Wiping. Initially all the materials were conservatively conditioned with submersion method; however, some of the material types demonstrated reduced flammability performance. Thus, there was a need to reevaluate their flammability properties following a less conservative wiping conditioning method. For the submersion method, specimens were conditioned by fully immersing them in the liquid disinfectant for extended time periods. This conditioning approach simulated accelerated cycle testing and it was considered to be conservative. The wiping conditioning method was to

simulate the real world application of the liquid disinfectants in aircraft interior, which was achieved by wiping the test specimens by hand for 1,000 cycles.

Tension tests were conducted on the plastics following American Society for Testing and Materials (ASTM) D638. Statistical evaluation following Composite Materials Handbook-17 (CMH-17) guidelines showed that the tensile properties of Boltaron 9815E, when conservatively conditioned by submersion with liquid disinfectants, was not equivalent to the properties of unconditioned specimens. For the other three plastics (Kydex 6565, Boltaron 9815N, and Lexan XHR), there were no statistical effects on strength, as summarized in Table 1. Tension tests were also conducted on the seatbelt webbing. For SCHROTH webbings, no reduction in failure load was observed when the specimens were conditioned with Calla 1452, Sani-Cide EX3, BactroKill+ and PREempt. Reduction of less than 5% for failure load was observed when the specimens were conditioned with 70% IPA. For AmSafe webbings, no reduction in failure load was observed when the specimens were conditioned with 99% IPA, Sani-Cide EX3 and Calla 1452 for 24 hours.

Table 1. Mechanical properties results summary

Material Name	Disinfectant Type				
	70% IPA*	Calla 1452	Sani-Cide EX3	BactroKill+	PREempt RTU
Kydex 6565					
Boltaron 9815E					
Lexan XHR					
Boltaron 9815N					
SCHROTH Webbing					
Amsafe Webbing				-	-

*AmSafe Polyester webbing specimens were conditioned with 99% IPA

Material properties “equivalent” to unconditioned specimens

Material properties not “equivalent” to unconditioned specimens

Material properties “equivalent” to unconditioned specimens based on limited data

Reduction in failure load less than 5%

No Reduction in failure load

No Test Performed

Vertical Bunsen Burner Tests with a 60-second flame exposure were conducted per 14 CFR § 25.853 Appendix F to evaluate the effect of using liquid disinfectants on the flammability properties of the materials. Not all of the materials tested would be required to meet the 60-second test. However, the purpose of these tests was to compare the flammability performance of the material when conditioned with liquid disinfectants against unconditioned specimens, using a test method that would be likely to expose any differences Some of the required test methods, being less severe than the 60-second test, might not reveal differences due to the disinfection methods. The criteria used were based on the conservativeness of the conditioning method and was defined as outlined below:

- Flammability results for plastics, leather, synthetic leather, and Wool/Nylon fabric were considered not significantly different if the increase in average burn length of the conditioned specimens was less than or equal to approximately 50% of the average burn length obtained from the unconditioned specimens test data. We call these results "normally equivalent."
- Flammability results for plastics, leather, synthetic leather and Wool/Nylon fabric were considered significantly different, if the increase in average burn length of conditioned specimens was greater than approximately 50% of the average burn length obtained from the unconditioned specimens test data.
- Flammability results for seatbelt webbing were considered not significantly different, if the increase in average burn length of conditioned specimens was less than 6" when compared against unconditioned specimens and the webbing was self-extinguishable.

When conditioned following submersion method, all the plastic types and seatbelt webbing types had flammability results that were normally equivalent to the untreated materials. Other material types had a variable results based on the disinfectant type used. Results are summarized in Table 2.

Table 2. Flammability results summary – submersion method

Material Type	Material Name	Disinfectant Type				
		70% IPA*	Calla 1452	Sani-Cide EX3	BactroKill+	PREempt RTU
Plastic	Kydex 6565	Green	Green	Green	Green	Green
	Boltaron 9815E	Green	Green	Green	Green	Green
	Lexan XHR	Green	Green	Green	Green	Green
	Boltaron 9815N	Green	Green	Green	Green	Green
Synthetic Leather	E-Leather CL280	Red	Red	Red	Red	Red
	Ultrafabric 492-6579FR12	Green	Red	Red	Red	Red
	TapiSuede TSFRC0961	Green	Green	Green	Green	Green
	Ultraleather ULFRB971-1363	Green	Red	Red	Red	Red
Wool/Nylon Blend	Lantal	Green	Green	Red	Red	Green
	Rohi Beach	Green	Red	Red	Red	Red
	Sheepskin	Green	Green	Red	Red	Red
	Botany Fabric	Green	Green	Green	Red	Red
Leather	Pewter BC (Perrone)	Green	Green	Green	Green	Green
	Perrone Feather Weight	Green	Green	Red	Red	Red
Webbing	SCHROTH	Hatched	Hatched	Hatched	Hatched	Hatched
	AmSafe Polyester	Hatched	Hatched	Hatched	Hatched	Hatched

*AmSafe Polyester webbing specimens were conditioned with 99% IPA

(Green) Increase in average burn length is less than or equal to approximately 50 % of the average burn length obtained from the unconditioned specimens test data.

(Red) Increase in average burn length is greater than approximately 50% of the average burn length obtained from the unconditioned specimens test data.

(Hatched) Increase in average burn length is less than 6” when compared against unconditioned specimens and self-extinguishing

For the wiping condition method, flammability properties for all the selected combinations of synthetic leather and disinfectants were normally equivalent to the untreated materials. Natural leather and Nylon/wool blend had a variable flammability results based on the disinfectant type as shown in Table 3.

Table 3. Flammability results summary – wiping method

Material Type	Material Name	Disinfectant Type				
		70% IPA	Calla 1452	Sani-Cide EX3	BactroKill+	PREempt RTU
Synthetic Leather	E-Leather CL280					
	Ultrafabric 492-6579FR12					
	Ultraleather ULFRB971-1363					
Wool/Nylon Blend	Lantal					
	Rohi Beach					
	Sheepskin					
	Botany Fabric					
Leather	Muirhead DF602					
	Pewter BC (Perrone)					
	Perrone Feather Weight					

Increase in average burn length is less than or equal to approximately 50% of the average burn length obtained from the unconditioned specimens test data.

Increase in average burn length is greater than approximately 50% of the average burn length obtained from the unconditioned specimens test data.

Normally equivalent results obtained when conditioned using submersion method

Color appearance change was evaluated for materials conditioned using both submersion and wiping method. When conditioned using submersion method, change in the color was investigated both qualitatively and quantitatively. Qualitative comparison showed no color change for plastics and seat belt webbing, whereas color change was observed for one type of synthetic leather (TapiSuede TSFRC0961), three types of Nylon/Wool Fabric (Lantal, Sheepskin, and Rohi Beach), and two types of leather (Perrone Pewter BC and Perrone Feather Weight). Quantitative color measurements were taken for samples from all the material types using a color spectrometer. The color measurements of conditioned specimens were compared against baseline unconditioned specimens and reported according to International Commission on Illumination (CIE) L*a*b* Uniform Color Space. Results from this quantitative analysis show different color scale reading highlighting differences in lightness vs. darkness, redness vs. greenness, and yellowness vs. blueness of the material. When the materials were conditioned using wiping method, change in color was evaluated only qualitatively. No change in color was observed when the materials were conditioned with Calla 1452. However, change in color and/or texture was observed for all the selected materials when conditioned with Sani-Cide EX3, BactroKill+ and PREempt RTU.

1 Introduction

In December 2019, an outbreak of a new type of coronavirus was identified in the province of Hubei, China. Since that time, the outbreak has reached out to most of the countries worldwide (Panait, 2020). During air travel, the main source of infection for travelers is proximity to an infected person due to droplet-propagated infections. Once an infected person has left the scene, most of the risk from droplet exposure would have been reduced. Nevertheless, the scientific evidence (Kampf, 2020) (van Doremalen, et al., 2020) showed that the SARS-CoV-2 aerosol and fomite transmission is plausible, since the virus can remain viable and infectious in aerosols for hours and on surfaces up to days depending on the type of surface and the environmental conditions. In this context, the possibility that the virus can remain in the aircraft environment by contaminating common surfaces after the infected passenger has departed requires action in order to prevent further dissemination (Panait, 2020).

This resulted in the airline industry implementing meticulous and frequent interior disinfection procedures to allow the passengers confidence that they would not contract the virus while in an aircraft. However, the requirement for excessive use of disinfectants raised concerns on its potential negative impacts on materials performance, thus leading to the current research. Without the existence of proper guidance on methodologies to identify the potential impact of disinfectants on aircraft interiors, it became an urgent issue to determine what materials to test, what disinfectants to consider, how to prepare the test articles, and finally, how to perform the test. Using engineering judgement and airline background information assumptions, the collaborative research team rapidly put together a methodology.

1.1 Overview

The objective of this research was to identify and evaluate the effects of liquid disinfectants on mechanical and flammability properties of aircraft interiors. Current efforts were focused on the materials used in aircraft seats. Materials were selected in conjunction with the SAE Seat Committee. These materials include plastics and different types of fabrics, as presented in Figure 1. Test materials conditioned using liquid disinfectants were evaluated to quantify mechanical properties, resistance to flame using vertical burner tests, and qualitative and quantitative measurement of change in color. The materials performance was then compared and analyzed against unconditioned control specimens.

The report discusses the methods used to condition the test materials with various disinfectants followed by the detailed discussion on mechanical, flammability and color evaluation test results.

The results of this work may be used by the SAE Seat Committee, other standards organizations, design approval holders, operators, or regulators to create guidelines on the use of disinfectants and application procedures that would minimize the impact on the mechanical and flammability characteristics of aircraft interior components.

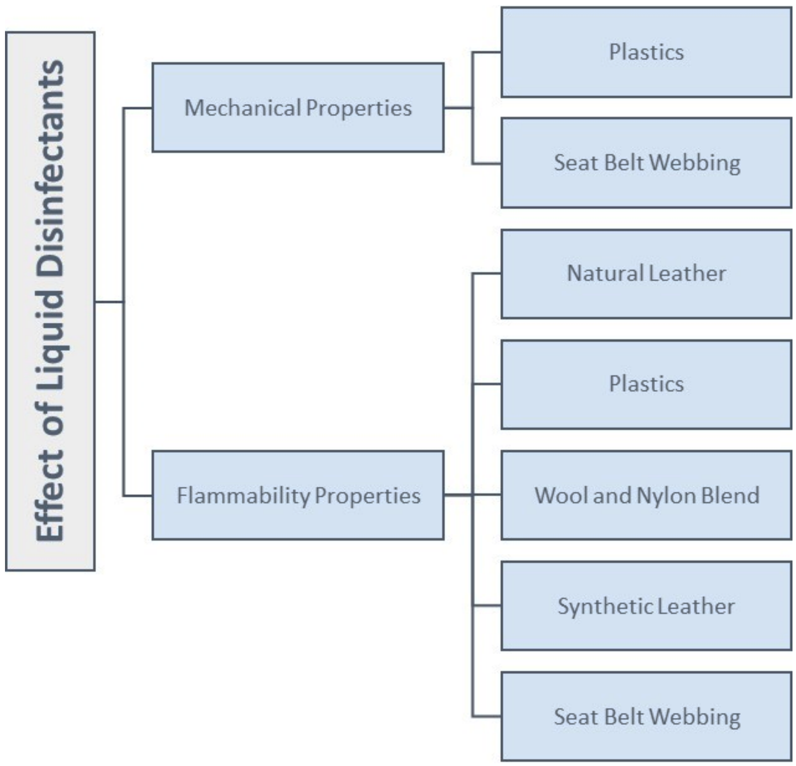


Figure 1. Flowchart outlining project overview

1.2 Selection of materials to test

The general plan developed was to create a list of a limited number of materials that could be evaluated rapidly, while at the same time covering the majority of materials utilized in seating products that could be exposed to disinfectants. The materials determined were:

- Plastics – Armrests and shrouds
- Dress Covers – For seat upholstery
- Seat Belts – For seat restraint systems
- Paint & Decorative Laminate – For seating trim
- Metallic – For seating structural components

The specific materials chosen for the above material categories was based on current seat manufacturer usage. The logic was to cover as much of the seating materials as possible in the limited time.

1.3 Selection of disinfectants to test

Due to the urgency of the need to return to flight, the airlines had already chosen some readily available disinfectants. Several disinfectants were already in use by the time that this effort was initiated. Therefore, the logic utilized was to determine a limited list of current in-use disinfectants to test to allow for rapid results. The disinfectants were determined as:

- No treatment – As a control test
- 70% Isopropyl Alcohol (IPA) – Currently listed in most seat manufacture's user manuals
- Calla 1452 – Currently in use
- Sani-Cide EX3 – Currently in use
- Bactrokill+ - Currently in use
- PREempt RTU – Currently in use

Future evaluation could be performed on the chemical composition of these disinfectants to determine applicability of the test results to other similar disinfectants.

1.4 Preparation of test articles

The basic application of disinfectants includes various forms of wiping on/off and various forms of spraying/fogging. The initial assumption was that aircraft interiors would be disinfected once per flight, which averaged out to 3000 disinfectant applications per year. Another assumption was that the effect, and possible damage, of the disinfectant on the seating materials would reach equilibrium at 4 months of application or 1000 applications. The various methods of spraying/fogging did not seem to lend itself in determining a suitable worst case to accommodate all of the methods. Therefore, it was judged that wiping the disinfectant would be considered to be worst on the seating materials due to the positive contact and abrasion associated with wiping. However, this approach consisted of performing a wiping cycle on the test material, allowing it to dry and then repeating the process through 1000 cycles, thus indicating a significant amount of time and effort. Therefore, an alternative procedure was conceived. This procedure would involve a worst case of submersion of the samples in disinfectant for a given period of time to reach equilibrium, and then allowing them to dry. So the two test methods were defined with the vision that the shorter time frame submersion method could be initially used then followed up with the more realistic method of wiping the test materials if the soaking results were significantly different.

Submersion – By evaluating various ASTM test procedures, it was determined that Plastics and Paint/Laminates would be soaked one week while dress covers and seat belts would be soaked twenty-hour hours.

Wiping – Based on the preliminary studies to determine the specifics for wiping procedure, it was determined to wipe the test material using disinfectant (either manually or automated) then either let it air dry (approximately 20 minutes) or use active drying, with no heating element, for each cycle.

In addition, it was determined that metals, paint, laminates, and rubbers could utilize DO-160, AMS 1452, and AMS 1453 as acceptable means of qualification as applicable.

1.5 Performing the testing

The concerns of the effects of disinfectants on seating materials were determined to be:

- Structural Integrity
- Flammability
- Corrosion
- Aesthetics

It is understood that the most significant immediate concerns are the evaluations of structural integrity and flammability, as their effect could have a near term impact on continued airworthiness of the seating certification. Corrosion concerns are mainly handled by DO-160 qualifications and aesthetic concerns are a by-product of the testing, and while not a concern for continued airworthiness, they aid in the selection of a disinfectant based on long-term replacement costs.

2 Material information

In this investigation, five different material types used for aircraft seating were selected in conjunction with the SAE seat committee. These materials included four plastics, two natural leather, four synthetic leather, four Wool/Nylon blend fabric and one seat belt webbing as shown in Figure 2. All the materials conditioned with liquid disinfectants were evaluated for flammability properties and change in color. Additionally, effect on tensile strength and failure load were investigated for plastics and seatbelt webbing, respectively. The current investigation evaluated only non-metallic materials as the components that are frequently exposed to liquid disinfectants comprise of limited metallic surfaces that are not a part of the primary load path. In addition, flammability properties of metal surfaces are not expected to be affected by disinfectants.

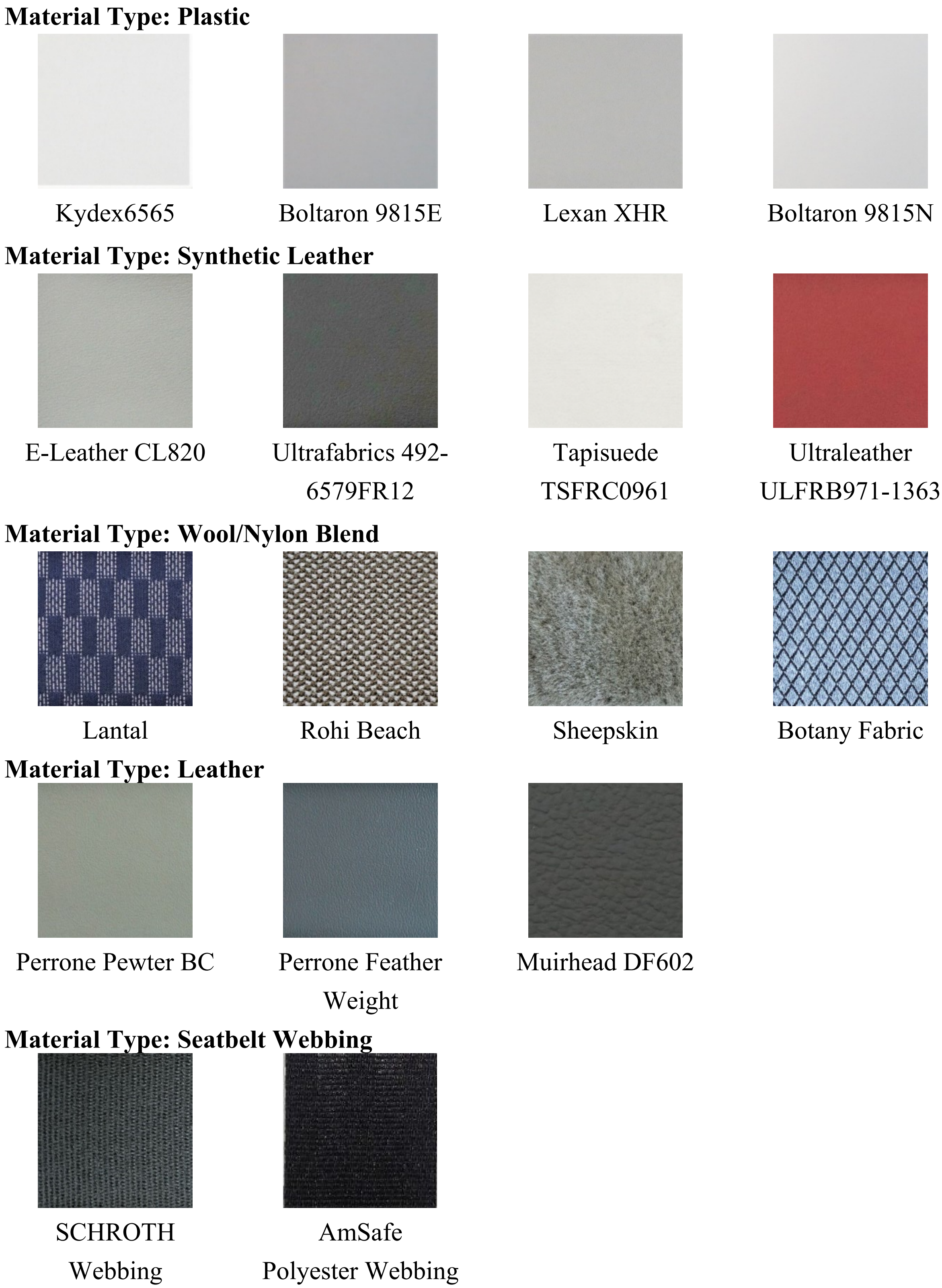


Figure 2. Materials used in the current investigation

3 Disinfectants information

In this investigation, five liquid disinfectants typically used for disinfecting aircraft interiors were selected in conjunction with the SAE seat committee. Table 4 shows the disinfectants used and their composition (Safety Data Sheet for Isopropyl Alcohol 70% in Water, 2010/2018) (Calla® 1452 Neutral Disinfectant Concentrated Cleaner, 2020) (Safety Data Sheet for Sani-Cide EX3, 2017) (Safety Data Sheet for BatroKill Plus®, 2017) (Safety Data Sheet for PREempt RTU, 2015).

Table 4. Liquid disinfectants used in the current investigation

Disinfectant	Composition		
	Active Ingredients	Weight (%)	Inert Ingredients (%)
70% IPA	Isopropyl alcohol	64.7	Water – 35.3
Calla 1452	Octyl decyl dimethyl ammonium chloride	0.814	97.287
	Dioctyl dimethyl ammonium chloride	0.407	
	Didecyl dimethyl ammonium chloride	0.407	
	Alkyl (50% C_{14}, 40% C_{12}, 10% C_{16}) dimethyl benzyl ammonium chloride	1.085	
Sani-Cide EX3	L-Lactic Acid	0.4	99.6
Bactrokill+	Chlorine Dioxide	0.2	Water - 99.59 Other ingredients – 0.04
	n-Alkyl Dimethyl benzyl ammonium chloride	0.085	
	n-Alkyl Ethylbenzyl ammonium chloride	0.085	
PREempt RTU	Hydrogen peroxide	0.5	99.5

4 Specimen conditioning

Test materials were conditioned using two different methods, submersion method and wiping method, details for which are explained in the consecutive sections below.

4.1 Submersion method

In this conditioning method, test materials were conditioned by submerging them in liquid disinfectants for extended time periods. Plastics were submerged for one week and all the other material types (webbing, natural leather, synthetic leather, Nylon/wool fabric) were submerged for 24 hours. After submersion, plastic specimens were allowed to dry for 24 hours and all the other material types were allowed to dry for 48 hours at room temperature and relative ambient humidity. This was followed by conditioning the specimens for a further 24 hours, as per 14 CFR

§ 25.853 - Compartment Interiors Appendix F. Weight was measured for each specimen before submersion and after conditioning.

This conditioning approach simulated accelerated cycle testing and it was considered to represent the worst-case scenario. All the materials were initially conditioned following this method, details for which are further explained in the flammability and strength evaluation test plans (Effect of Liquid Chemical Disinfectants in Aircraft Interior: Flammability Evaluation of Materials - R2, 2020) (Effect of Disinfectants in Aircraft Interior: Strength Characterization of Plastics - R1, 2020) (Effect of Disinfectants in Aircraft Interior: Strength Characterization of Seat Belt Webbings - IR, 2020). Figure 3 and Figure 4 shows plastic and leather specimens submerged in the liquid disinfectants, it was ensured that each specimen was entirely immersed in the disinfectant.

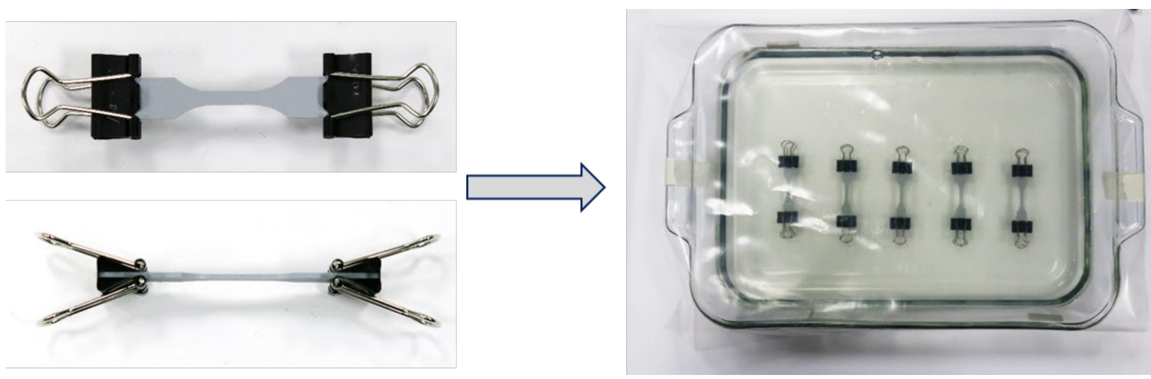


Figure 3. Specimen conditioning using submersion method for strength characterization

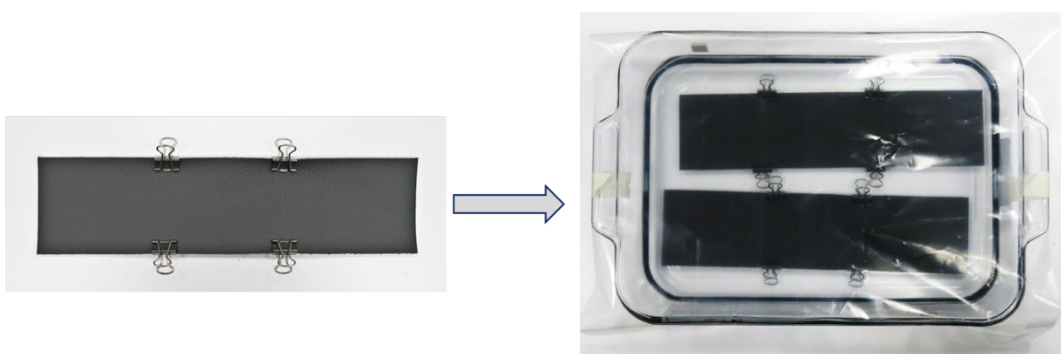


Figure 4. Specimen conditioning using submersion method for flammability testing

4.2 Wiping method

The objective of the wiping conditioning method was to simulate the real world application of the liquid disinfectants in aircraft interior. This was achieved by wiping the test specimens by hand for one thousand cycles. The test specimens were arranged on a flat surface and desk fans (without a heated element) were used to accelerate the drying of the specimens as shown in Figure 5. Specimens were wiped using a microfiber cloth that had been soaked in the required liquid disinfectants. The wiping process was repeated for 1000 cycles and the microfiber cloths were re-soaked in the disinfectants periodically to ensure that the cloth was always damp. Also, only the front face of the test specimens was exposed to the liquid disinfectants. Similar to the submersion method, each test specimen was weighed before and after conditioning.

Only a few selected materials were conditioned using the wiping methodology. The materials were selected based on the flammability results as explained further in the subsequent sections.

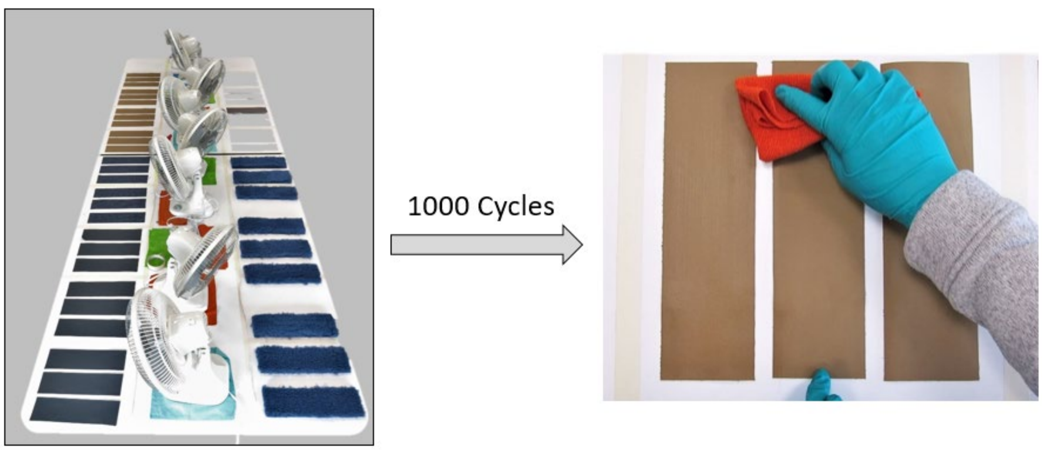


Figure 5. Specimen conditioning using wiping method for flammability testing

5 Mechanical properties

Uniaxial tensile experiments were conducted to understand the effects of liquid disinfectants on the tensile strength of plastics (Effect of Disinfectants in Aircraft Interior: Strength Characterization of Plastics - R1, 2020) and failure load of seatbelt webbing (Effect of Disinfectants in Aircraft Interior: Strength Characterization of Seat Belt Webbings - IR, 2020). The details of the test methods and experimental observations are discussed in this section. Both the plastic test specimen and seatbelt webbing specimens were only conditioned using the submersion method.

5.1 Plastics

5.1.1 Test matrix

Uniaxial tension tests were conducted for four different plastics types following ASTM D638 (Standard Test Method for Tensile Properties of Plastics, 2014). For each plastic type, five specimens were tested per disinfectant type as shown in Table 5.

Table 5. Test matrix for strength characterization of plastics

Plastic Type	**Test Standard**	**Liquid Disinfectant Type**					
		Pristine	70% IPA	Calla 1452 /Matrix 3	Sani-Cide EX3	BactroKill +	PREempt RTU
Kydex 6565	ASTM D638	x 5	x 5	x 5	x 5	x 5	x 5
Boltaron 9815E		x 5	x 5	x 5	x 5	x 5	x 5
Lexan XHR		x 5	x 5	x 5	x 5	x 5	x 5
Boltaron 9815N		x 5	x 5	x 5	x 5	x 5	x 5

5.1.2 Specimen dimensions and nomenclature

Specimens were manufactured from bulk plastic sheets in accordance with ASTM D638 (Standard Test Method for Tensile Properties of Plastics, 2014). Based on the thickness of the plastic sheets, specimen Type V was selected as shown in Figure 6. Nominal dimensions for the same are summarized in Table 6. Dimensions were measured for all the specimens and they have been summarized in Appendix A.

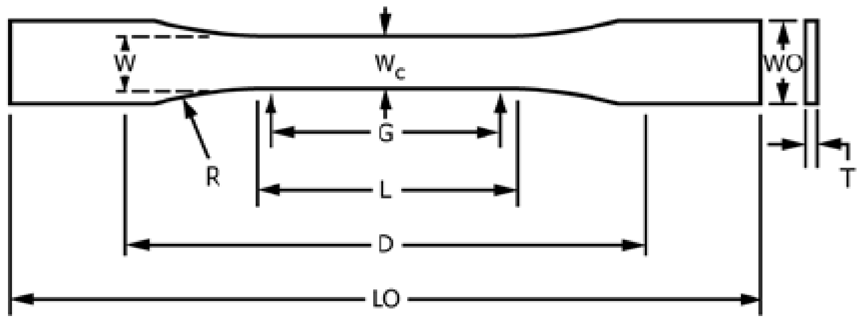


Figure 6. Plastic tension specimen geometry

Table 6. Plastic tension test specimen nominal dimensions, Type V

Length Overall [LO], in	2.500
Length of Narrow Section [L], in	0.375
Gage Length [G], in	0.300
Width Overall [WO], in	0.375
Width Narrow Section [W], in	0.125
Distance Between Grips [D], in	1.000
Radius of Fillet [R], in	0.500

In order to facilitate specimen identification and traceability, the following nomenclature was used [Client ID – Test Method ID – Plastic Type ID – Disinfectant ID – Specimen #]. Table 7 summarizes specimen identification nomenclature used for different materials.

Table 7. Specimen ID nomenclature for plastic strength characterization

Client ID	FAA	FAA
Test Method ID	ASTM D638 - Tension	T
Plastic Type	Kydex 6565	P1
	Boltaron 9815E	P2
	Lexan XHR	P3
	Boltaron 9815N	P4
Liquid Disinfectant	Pristine (No Disinfectant)	D0
	70% IPA	D1
	Calla 1452 /Matrix 3	D2
	Sani-Cide EX3	D3
	BactroKill +	D4
	PREempt RTU	D5
	4 Hours Exposure	D7
	24 Hours Exposure	D8

5.1.3 Test Setup

Tests were conducted at room temperature under displacement control at a nominal displacement rate of 0.05 in/min. Non-contact strain measurement technique, Digital Image correlation (DIC) was employed to measure longitudinal strains as shown in the test setup in Figure 7. All tests were conducted at room temperature until failure. The test apparatus used was a MTS Electrodynamic testing load frame with a static load capacity of 450 lbf.

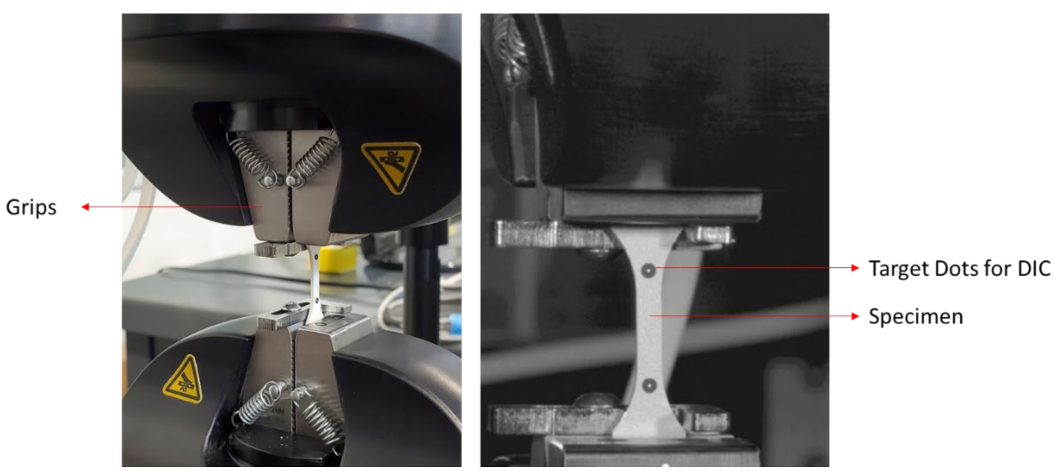


Figure 7. Test setup for tension test of plastics

5.1.4 Test Results

For each plastic type, specimens were tested until failure following the test matrix in Table 5. Post-test failure pictures of all the specimens can be found in Appendix B. Longitudinal stress-strain plots and comparison of yield stress, tensile strength and failure strain are shown for all plastics from Figure 8 to Figure 15.

For Kydex 6565, reduction in average yield stress, average tensile strength was less than 5% with the use of liquid disinfectants. No reduction in average failure strain was observed.

For Boltaron 9815E, no reduction in average failure strain was observed with use of liquid disinfectants. Reduction in average yield stress and average tensile strength was less than 5% when the specimens were conditioned with Call 1452 and Sani-Cide EX3. Reduction in average yield stress and average tensile strength was between 5% and 10% when the specimens were conditioned with 70% IPA, BactroKill+, and PREempt.

For Lexan XHR, no reduction in average yield stress, average tensile strength and average failure strain was observed with use of 70% IPA, Calla 1452, Sani-Cide EX3, and PREempt. Reduction in average yield stress and average tensile strength was less than 5% when conditioned with BactroKill+.

For Boltaron 9815N, no reduction in average yield stress and average tensile strength were observed with the use of liquid disinfectants. Reduction in average failure strain was between 15% and 30% when the specimens were conditioned with 70% IPA, Calla 1452, Sani-Cide EX3, and BactroKill+. This might not necessarily be due to disinfectant conditioning, but could be part of the natural variation of the material.

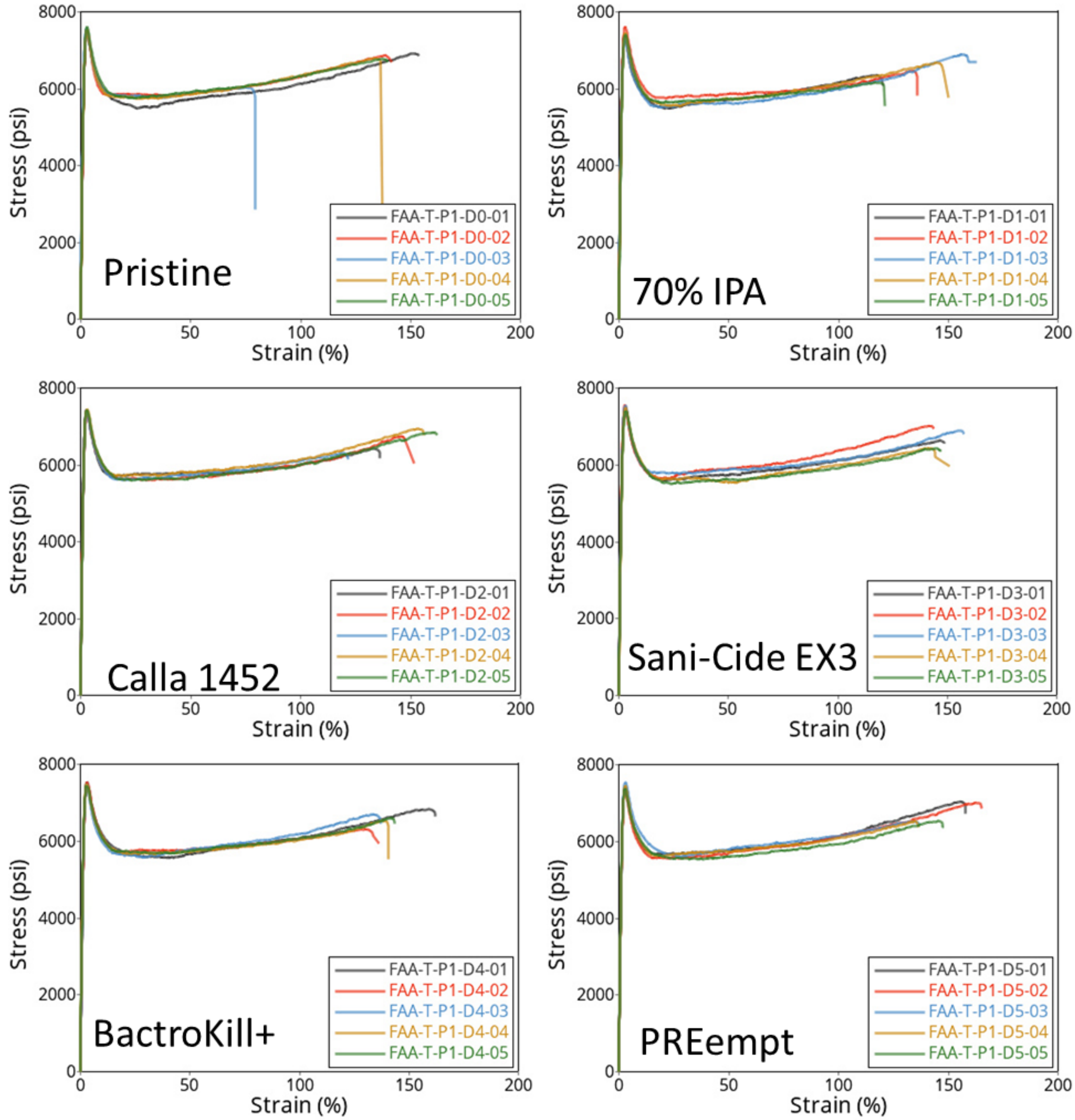


Figure 8. Longitudinal stress-strain response – Kydex 6565

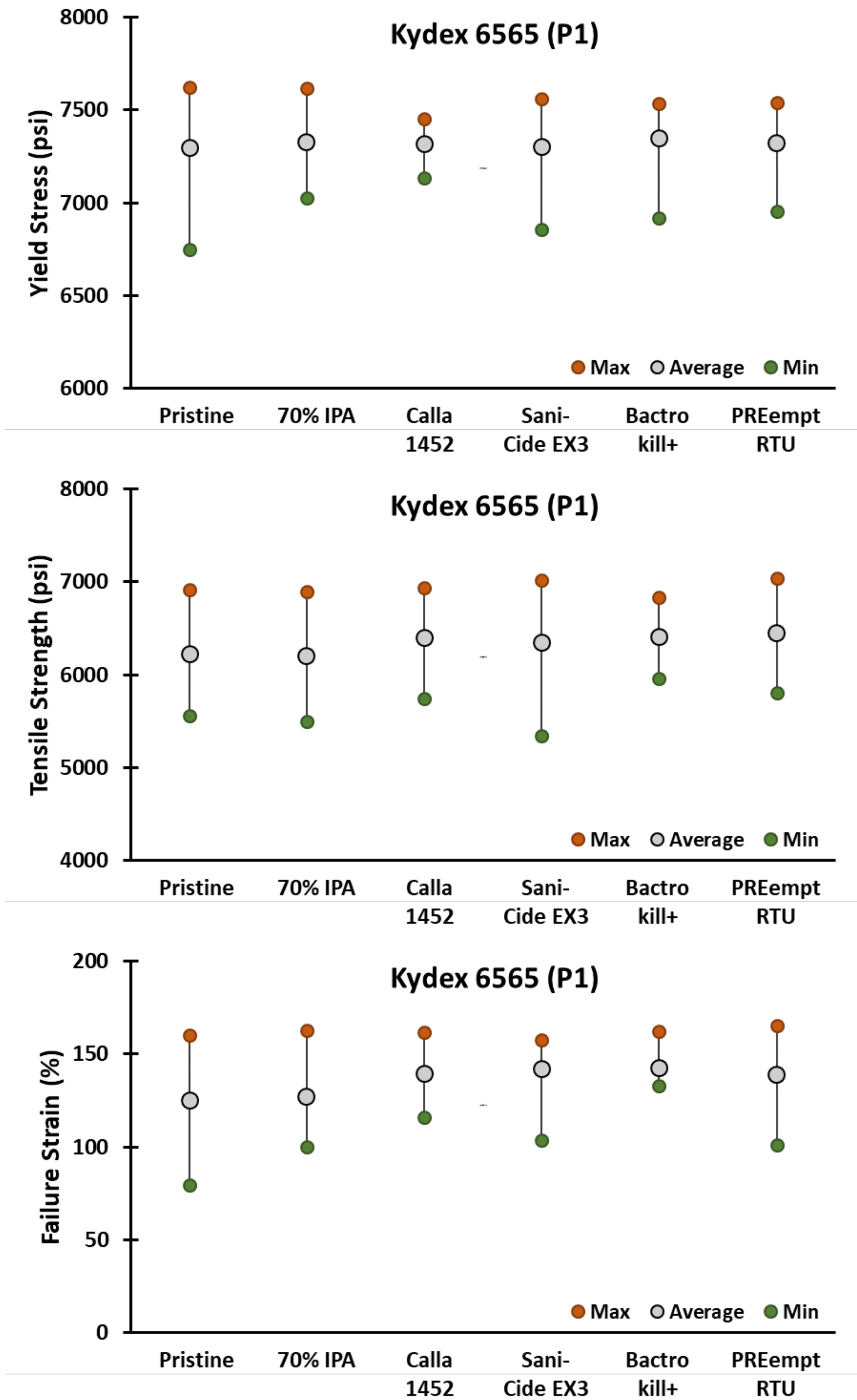


Figure 9. Yield stress, tensile strength and failure strain comparison – Kydex 6565

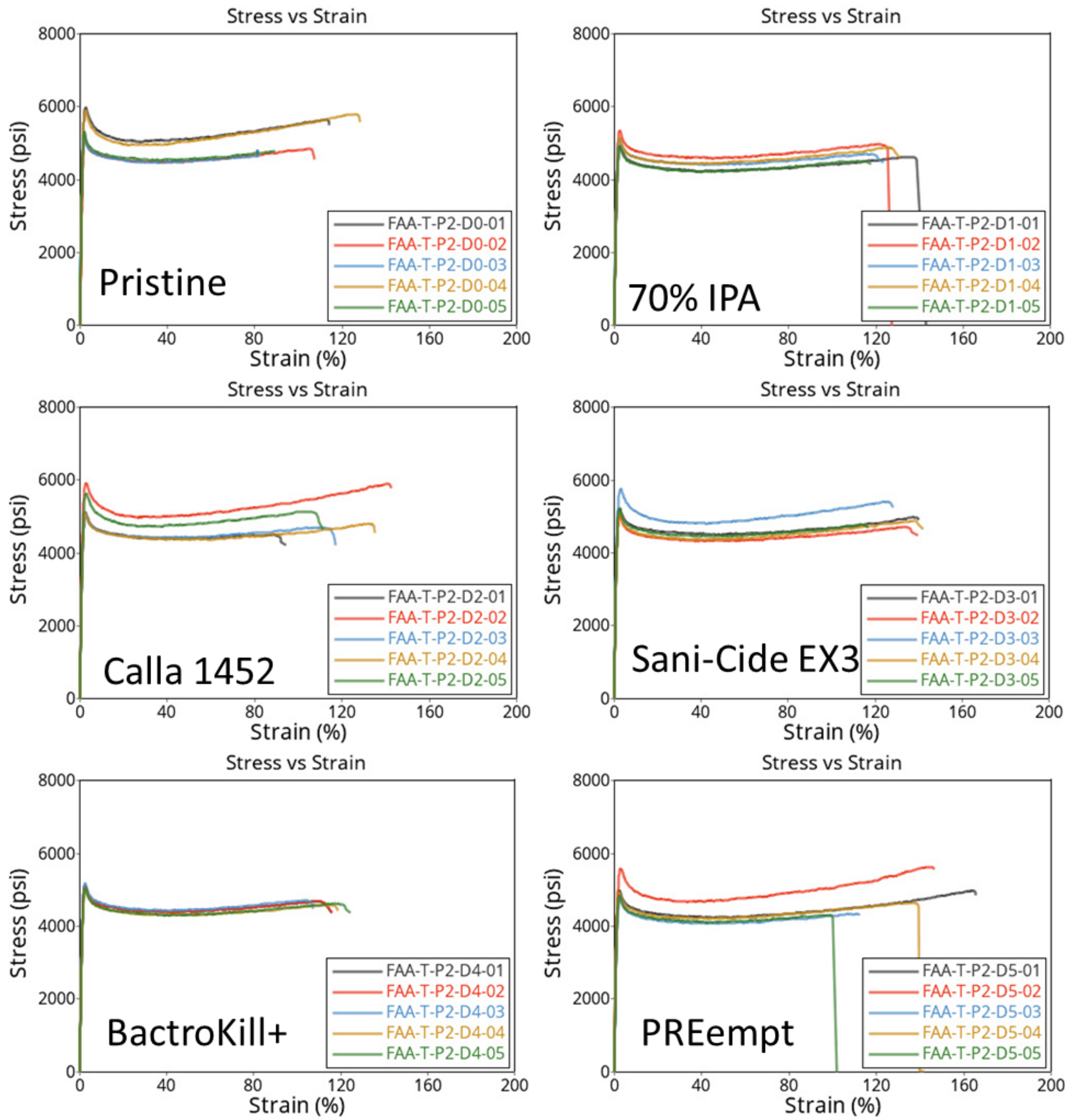


Figure 10. Longitudinal stress-strain response – Boltaron 9815E

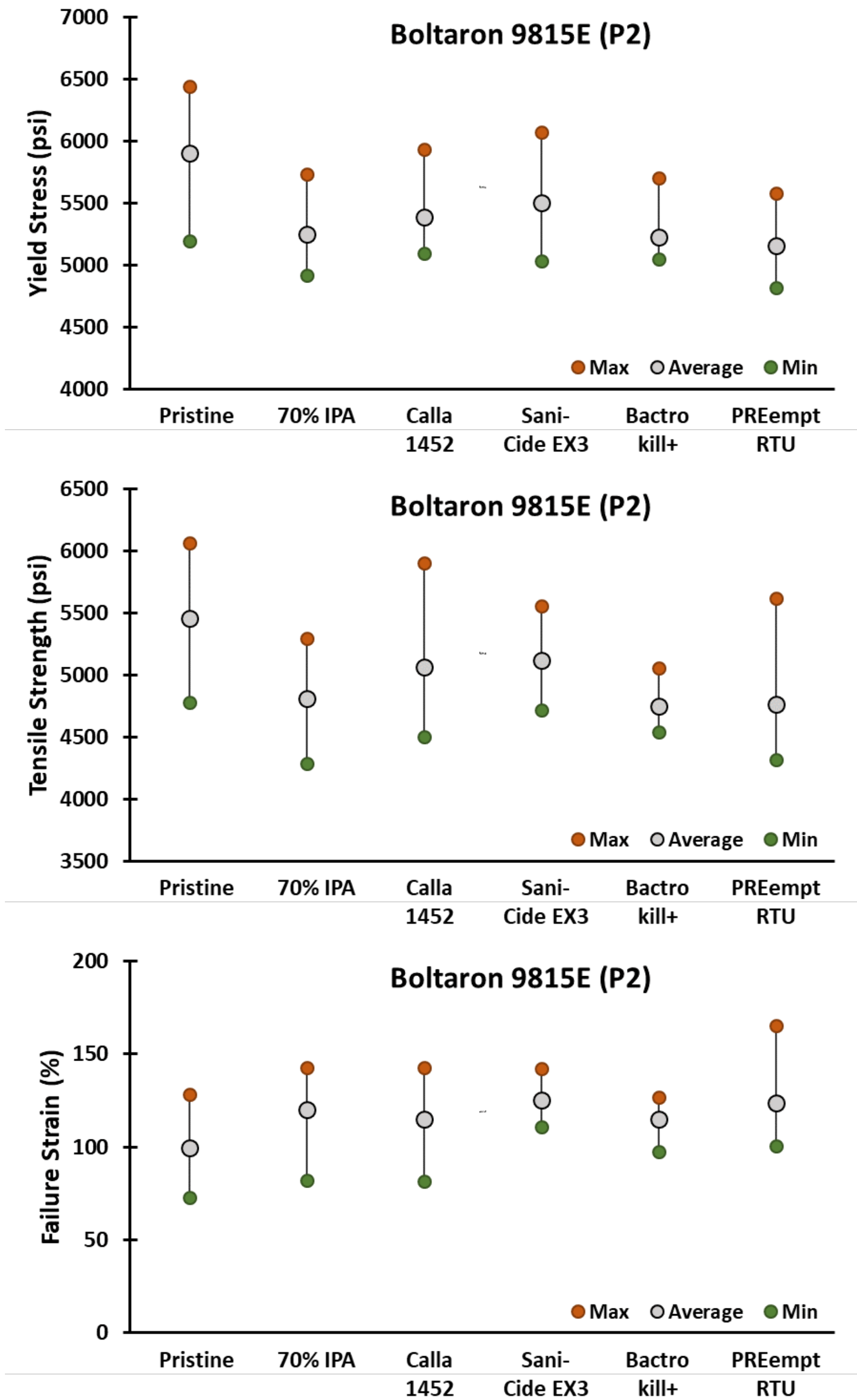


Figure 11. Yield stress, tensile strength and failure strain – Boltaron 9815E

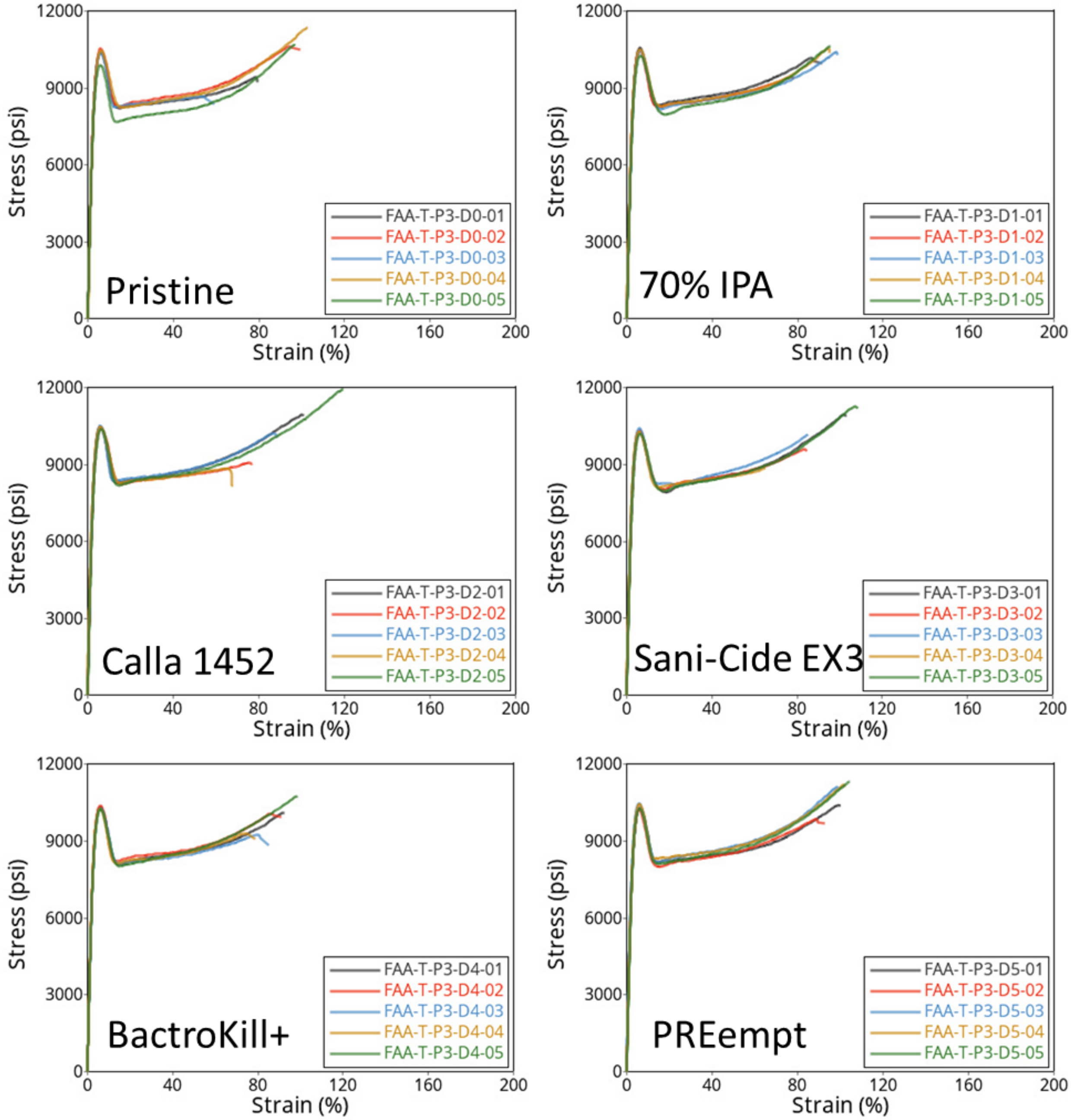


Figure 12. Longitudinal stress-strain response – Lexan XHR

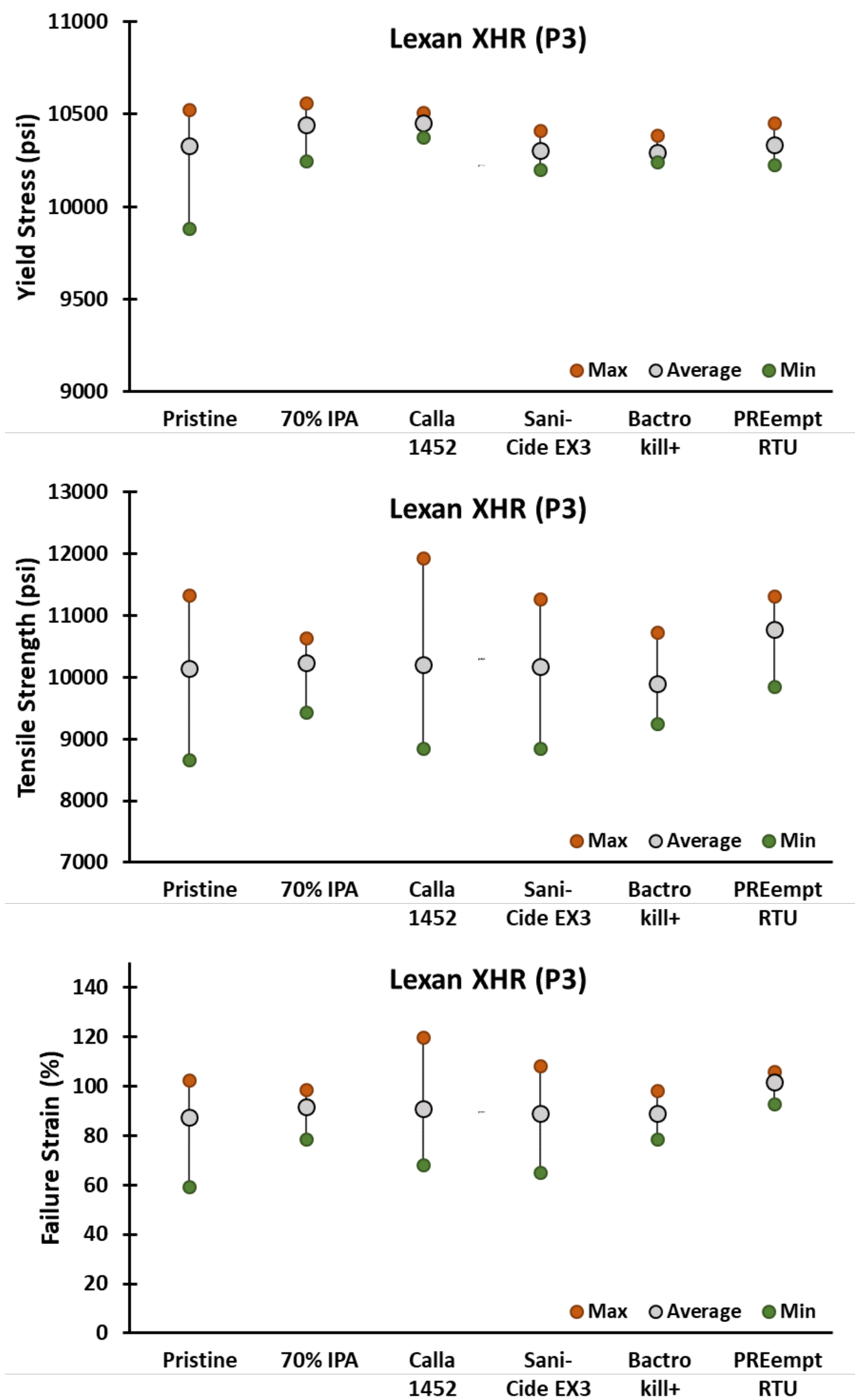


Figure 13. Yield stress, tensile strength and failure strain – Lexan XHR

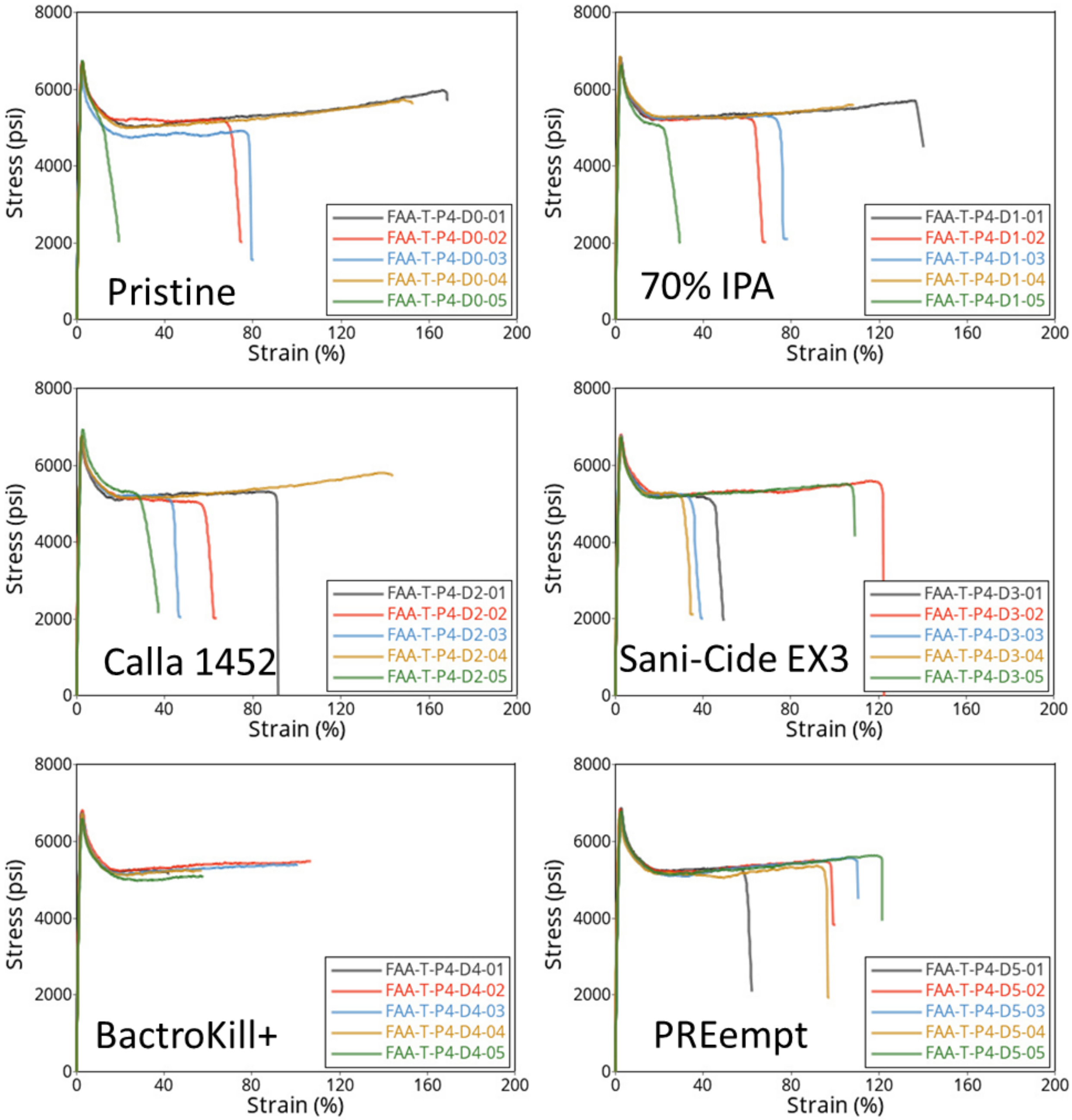


Figure 14. Longitudinal stress-strain response – Boltaron 9815N

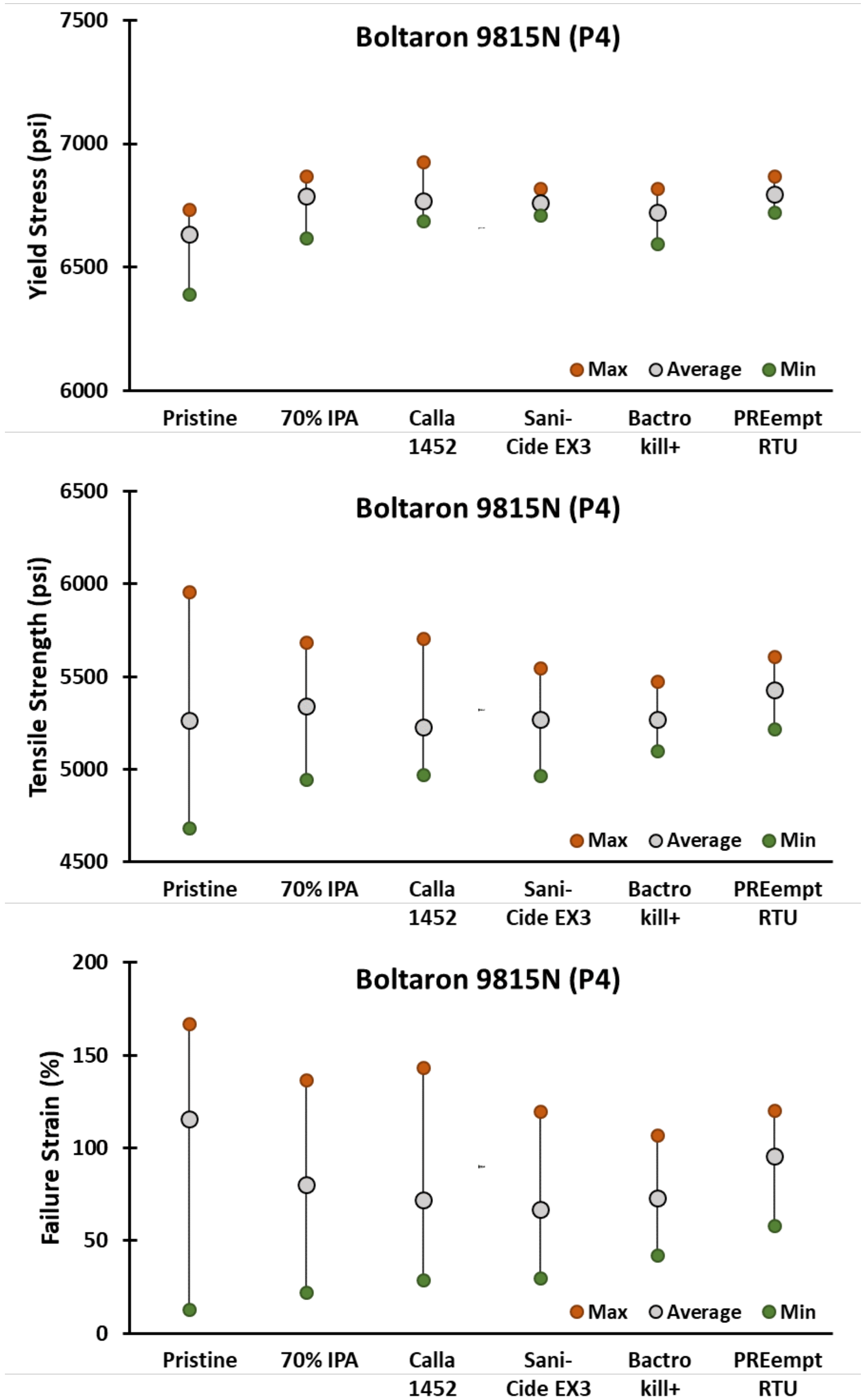


Figure 15. Yield stress, tensile strength and failure strain – Boltaron 9815N

5.1.5 Statistical Data Evaluation

To further investigate if the liquid disinfectants had any detrimental effect on the material properties of selected plastics, statistical analysis following guidelines in CMH-17 (Polymer Matrix Composites: Guidelines for Characterization of Structural Materials, 2012) was done. To have a larger data set for statistical evaluation, additional uniaxial tension tests were conducted for Kydex 6565 and Boltaron 9815E. For both the plastic types, thirteen more unconditioned specimens and three more conditioned specimens were tested as shown in Table 8. Longitudinal stress-strain curves for additional tests are summarized in Appendix I. Due to the limited amount of material available, additional tests were not conducted for Lexan XHR and Boltaron 9815N.

Table 8. Test matrix showing additional tests conducted for Plastics

Plastic Type	**Test Standard**	**Liquid Disinfectant Type**					
		Pristine	70% IPA	Calla 1452 /Matrix 3	Sani-Cide EX3	BactroKill +	PREempt RTU
Kydex 6565	ASTM D638	x 13	x 3	x 3	x 3	x 3	x 3
Boltaron 9815E		x 13	x 3	x 3	x 3	x 3	x 3

To have a baseline data set, basis value estimates of tensile strength of unconditioned specimens were calculated for all the plastic types as shown in Table 9. These are estimates only, since three different batches and 18 specimens are required for basis values per CMH-17. Even though there are 18 specimens tested for Kydex 6565 and Boltaron 9815E, the specimens are extracted from same batch or lot number. For Boltaron 9815N and Lexan XHR modified CV values were not reported because CV is over 8%, so the modified CV method does not apply.

Table 9. Tensile strength basis values for unconditioned Plastic specimens

Tensile Strength Basis Values and Statistics (psi)				
	KYDEX 6565	**Boltaron 9815E**	**Boltaron 9815N**	**Lexan XHR**
Mean	6233	5457	5264	10148
Stdev	403.9	392.7	545.5	1077
CV	6.479	7.196	10.36	10.61
Modified CV	8.000	8.000	10.36	10.61
Min	5625	4782	4683	8667
Max	6922	6069	5961	11333
No. Batches	1	1	1	1
No. Spec.	18	18	5	5
Basis Value Estimates				
B-Estimate	5436	4682	3399	6467
A-Estimate	4871	4132	2045	3794
Method	Normal	Normal	Normal	Normal
Modified CV Basis Value Estimates				
B-Estimate	5249	4595	NA	NA
A-Estimate	4553	3985		
Method	Normal	Normal		

For acceptance of the material properties from any batch, it must be shown that the properties obtained from the current batch are "equivalent" to the qualification batch; i.e., the batch data meets the material specification limits (Polymer Matrix Composites: Guidelines for Characterization of Structural Materials, 2012). In the current study, material properties obtained from unconditioned plastic specimens are treated as the qualification batch. Equivalency of the tensile strength and yield stress of all plastics conditioned with disinfectants is shown from Table 10 to Table 17.

For Kydex 6565, specimens treated with all the liquid disinfectants pass equivalency criteria for ultimate tensile strength and yield stress.

For Boltaron 9815E, specimens treated with all the liquid disinfectants fail equivalency criteria for ultimate tensile strength and yield stress.

For Lexan XHR, specimens treated with all the liquid disinfectants pass equivalency criteria for ultimate tensile strength and yield stress. However, it should be noted that due to material unavailability only five specimens per disinfectant type were tested, which is considered insufficient data.

For Boltaron 9815N, specimens treated with all the liquid disinfectants pass equivalency criteria for ultimate tensile strength and yield stress. However, it should be noted that due to material unavailability only five specimens per disinfectant type were tested, which is considered insufficient data.

Table 10. Equivalency of tensile strength of Kydex 6565

KYDEX 6565 Tensile Strength (psi)	D1		D2		D3		D4		D5	
	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.
Data as measured										
Mean Tensile Strength (psi)	6233	6205	6233	6394	6233	6352	6233	6408	6233	6449
Standard Deviation	403.9	495.2	403.9	431.6	403.9	546.8	403.9	309.9	403.9	444.9
Coefficient of Variation %	6.479	7.981	6.479	6.750	6.479	8.609	6.479	4.836	6.479	6.899
Minimum	5625	5495	5625	5742	5625	5345	5625	5959	5625	5803
Maximum	6922	6901	6922	6942	6922	7022	6922	6838	6922	7041
Number of Specimens	18	8	18	8	18	8	18	8	18	8
RESULTS	**PASS**		**PASS**		**PASS**		**PASS**		**PASS**	
Minimum Acceptable Equiv. Sample Mean	5959		5959		5959		5959		5959	
Minimum Acceptable Equiv. Sample Min	5143		5143		5143		5143		5143	
MOD CV RESULTS	**PASS with MOD**		**PASS with MOD**		**PASS with MOD**		**PASS with MOD**		**PASS with MOD**	
Modified CV%	7.240		7.240		7.240		7.240		7.240	
Minimum Acceptable Equiv. Sample Mean	5927		5927		5927		5927		5927	
Minimum Acceptable Equiv. Sample Min	5015		5015		5015		5015		5015	

Table 11. Equivalency of yield stress of Kydex 6565

KYDEX 6565 Yield Stress (psi)	D1		D2		D3		D4		D5	
	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.
Data as measured										
Mean Yield Stress (psi)	7301	7329	7301	7315	7301	7301	7301	7348	7301	7324
Standard Deviation	259.5	186.6	259.5	132.1	259.5	285.2	259.5	226.0	259.5	207.7
Coefficient of Variation %	3.554	2.547	3.554	1.806	3.554	3.906	3.554	3.075	3.554	2.836
Minimum	6751	7029	6751	7135	6751	6857	6751	6919	6751	6956
Maximum	7625	7617	7625	7454	7625	7562	7625	7537	7625	7539
Number of Specimens	18	8	18	8	18	8	18	8	18	8
RESULTS	**PASS**		**PASS**		**PASS**		**PASS**		**PASS**	
Minimum Acceptable Equiv. Sample Mean	7125		7125		7125		7125		7125	
Minimum Acceptable Equiv. Sample Min	6600		6600		6600		6600		6600	
MOD CV RESULTS	**PASS with MOD**		**PASS with MOD**		**PASS with MOD**		**PASS with MOD**		**PASS with MOD**	
Modified CV%	6.000		6.000		6.000		6.000		6.000	
Minimum Acceptable Equiv. Sample Mean	7003		7003		7003		7003		7003	
Minimum Acceptable Equiv. Sample Min	6118		6118		6118		6118		6118	

Table 12. Equivalency of tensile strength of Boltaron 9815E

Boltaron 9815E Tensile Strength (psi)	D1		D2		D3		D4		D5	
	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.
Data as measured										
Mean Tensile Strength (psi)	5457	4810	5457	5066	5457	5122	5457	4752	5457	4763
Standard Deviation	392.7	345.1	392.7	463.5	392.7	334.6	392.7	190.4	392.7	412.5
Coefficient of Variation %	7.196	7.174	7.196	9.150	7.196	6.532	7.196	4.006	7.196	8.661
Minimum	4782	4290	4782	4502	4782	4717	4782	4543	4782	4321
Maximum	6069	5299	6069	5903	6069	5555	6069	5061	6069	5624
Number of Specimens	18	8	18	8	18	8	18	8	18	8
RESULTS	**FAIL**		**FAIL**		**FAIL**		**FAIL**		**FAIL**	
Minimum Acceptable Equiv. Sample Mean	5190		5190		5190		5190		5190	
Minimum Acceptable Equiv. Sample Min	4397		4397		4397		4397		4397	
MOD CV RESULTS	**FAIL**		**FAIL**		**FAIL**		**FAIL**		**FAIL**	
Modified CV%	7.598		7.598		7.598		7.598		7.598	
Minimum Acceptable Equiv. Sample Mean	5175		5175		5175		5175		5175	
Minimum Acceptable Equiv. Sample Min	4337		4337		4337		4337		4337	

Table 13. Equivalency of yield stress of Boltaron 9815E

Boltaron 9815E Yield Stress (psi)	D1		D2		D3		D4		D5	
	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.
Data as measured										
Mean Yield Stress (psi)	5904	5253	5904	5386	5904	5507	5904	5229	5904	5152
Standard Deviation	397.0	327.3	397.0	366.6	397.0	409.2	397.0	256.3	397.0	285.1
Coefficient of Variation %	6.724	6.230	6.724	6.806	6.724	7.432	6.724	4.902	6.724	5.535
Minimum	5198	4917	5198	5094	5198	5031	5198	5050	5198	4822
Maximum	6448	5735	6448	5933	6448	6075	6448	5701	6448	5579
Number of Specimens	18	8	18	8	18	8	18	8	18	8
RESULTS	**FAIL**		**FAIL**		**FAIL**		**FAIL**		**FAIL**	
Minimum Acceptable Equiv. Sample Mean	5634		5634		5634		5634		5634	
Minimum Acceptable Equiv. Sample Min	4832		4832		4832		4832		4832	
MOD CV RESULTS	**FAIL**		**FAIL**		**FAIL**		**FAIL**		**FAIL**	
Modified CV%	7.362		7.362		7.362		7.362		7.362	
Minimum Acceptable Equiv. Sample Mean	5609		5609		5609		5609		5609	
Minimum Acceptable Equiv. Sample Min	4730		4730		4730		4730		4730	

Table 14. Equivalency of tensile strength of Lexan XHR

Lexan XHR Tensile Strength (psi)	**D1**		**D2**		**D3**		**D4**		**D5**	
	Qual.	**Equiv.**	**Qual.**	**Equiv.**	**Qual.**	**Equiv.**	**Qual.**	**Equiv.**	**Qual.**	**Equiv.**
Data as measured	**Insufficient Data**		**Insufficient Data**		**Insufficient Data**		**Insufficient Data**		**Insufficient Data**	
Mean Tensile Strength (psi)	10148	10231	10148	10203	10148	10167	10148	9893	10148	10767
Standard Deviation	1077	480.5	1077	1290	1077	984.0	1077	617.9	1077	626.7
Coefficient of Variation %	10.61	4.697	10.61	12.65	10.61	9.679	10.61	6.246	10.61	5.821
Minimum	8667	9428	8667	8844	8667	8849	8667	9248	8667	9842
Maximum	11333	10629	11333	11928	11333	11265	11333	10729	11333	11320
Number of Specimens	5	5	5	5	5	5	5	5	5	5
RESULTS	**PASS**		**PASS**		**PASS**		**PASS**		**PASS**	
Minimum Acceptable Equiv. Sample Mean	9230		9230		9230		9230		9230	
Minimum Acceptable Equiv. Sample Min	7425		7425		7425		7425		7425	

Table 15. Equivalency of yield stress of Lexan XHR

Lexan XHR Yield Stress (psi)	**D1**		**D2**		**D3**		**D4**		**D5**	
	Qual.	**Equiv.**	**Qual.**	**Equiv.**	**Qual.**	**Equiv.**	**Qual.**	**Equiv.**	**Qual.**	**Equiv.**
Data as measured	**Insufficient Data**		**Insufficient Data**		**Insufficient Data**		**Insufficient Data**		**Insufficient Data**	
Mean Yield Stress (psi)	10328	10442	10328	10456	10328	10305	10328	10293	10328	10335
Standard Deviation	254.3	118.9	254.3	51.14	254.3	79.51	254.3	59.57	254.3	106.7
Coefficient of Variation %	2.462	1.139	2.462	0.4891	2.462	0.7715	2.462	0.5788	2.462	1.032
Minimum	9884	10245	9884	10376	9884	10201	9884	10242	9884	10227
Maximum	10526	10560	10526	10511	10526	10415	10526	10386	10526	10455
Number of Specimens	5	5	5	5	5	5	5	5	5	5
RESULTS	**PASS**		**PASS**		**PASS**		**PASS**		**PASS**	
Minimum Acceptable Equiv. Sample Mean	10112		10112		10112		10112		10112	
Minimum Acceptable Equiv. Sample Min	9685		9685		9685		9685		9685	
MOD CV RESULTS	**PASS with MOD**		**PASS with MOD**		**PASS with MOD**		**PASS with MOD**		**PASS with MOD**	
Modified CV%	6.000		6.000		6.000		6.000		6.000	
Minimum Acceptable Equiv. Sample Mean	9800		9800		9800		9800		9800	
Minimum Acceptable Equiv. Sample Min	8761		8761		8761		8761		8761	

Table 16. Equivalency of tensile strength of Boltaron 9815N

Boltaron 9815N Tensile Strength	D1		D2		D3		D4		D5	
	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.
Data as measured	Insufficient Data		Insufficient Data		Insufficient Data		Insufficient Data		Insufficient Data	
Mean Tensile Strength (psi)	5264	5342	5264	5227	5264	5268	5264	5268	5264	5429
Standard Deviation	545.5	302.8	545.5	289.6	545.5	248.2	545.5	159.2	545.5	160.2
Coefficient of Variation %	10.36	5.669	10.36	5.541	10.36	4.711	10.36	3.023	10.36	2.951
Minimum	4683	4947	4683	4973	4683	4966	4683	5099	4683	5221
Maximum	5961	5687	5961	5708	5961	5548	5961	5475	5961	5608
Number of Specimens	5	5	5	5	5	5	5	5	5	5
RESULTS	**PASS**		**PASS**		**PASS**		**PASS**		**PASS**	
Minimum Acceptable Equiv. Sample Mean	4799		4799		4799		4799		4799	
Minimum Acceptable Equiv. Sample Min	3884		3884		3884		3884		3884	

Table 17. Equivalency of yield stress of Boltaron 9815N

Boltaron 9815N Yield Stress (psi)	D1		D2		D3		D4		D5	
	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.	Qual.	Equiv.
Data as measured	Insufficient Data		Insufficient Data		Insufficient Data		Insufficient Data		Insufficient Data	
Mean Yield Stress (psi)	6636	6789	6636	6770	6636	6761	6636	6724	6636	6796
Standard Deviation	140.4	98.26	140.4	92.32	140.4	40.69	140.4	82.53	140.4	60.03
Coefficient of Variation %	2.116	1.447	2.116	1.364	2.116	0.6018	2.116	1.227	2.116	0.8833
Minimum	6391	6618	6391	6689	6391	6712	6391	6594	6391	6721
Maximum	6735	6870	6735	6927	6735	6819	6735	6819	6735	6868
Number of Specimens	5	5	5	5	5	5	5	5	5	5
RESULTS	**PASS**		**PASS**		**PASS**		**PASS**		**PASS**	
Minimum Acceptable Equiv. Sample Mean	6517		6517		6517		6517		6517	
Minimum Acceptable Equiv. Sample Min	6281		6281		6281		6281		6281	
MOD CV RESULTS	**PASS with MOD**		**PASS with MOD**		**PASS with MOD**		**PASS with MOD**		**PASS with MOD**	
Modified CV%	6.000		6.000		6.000		6.000		6.000	
Minimum Acceptable Equiv. Sample Mean	6297		6297		6297		6297		6297	
Minimum Acceptable Equiv. Sample Min	5629		5629		5629		5629		5629	

5.2 Seat belt webbing

5.2.1 Seat belt webbing – SCHROTH

5.2.1.1 Test Matrix

Tension tests were conducted on seatbelt webbing until rupture (Effect of Disinfectants in Aircraft Interior: Strength Characterization of Seat Belt Webbings - IR, 2020). Three specimens were tested per disinfectant type as shown in Table 18.

Table 18. Test matrix for tensile test of seatbelt webbing

Webbing Type	**Test Reference**	**Liquid Disinfectant Type**					
		Pristine	70% IPA	Calla 1452 /Matrix 3	Sani-Cide EX3	BactroKill +	PreEmpt RTU
SCHROTH Polyester	DOT/FAA/TC-15/29	x 3	x 3	x 3	x 3	x 3	x 3

5.2.1.2 Specimen dimension and nomenclature

The test specimens were cut from an unmodified roll of seatbelt webbing. Test specimen width was kept as the original width of the roll. Specimen nominal geometry is shown in Figure 16.

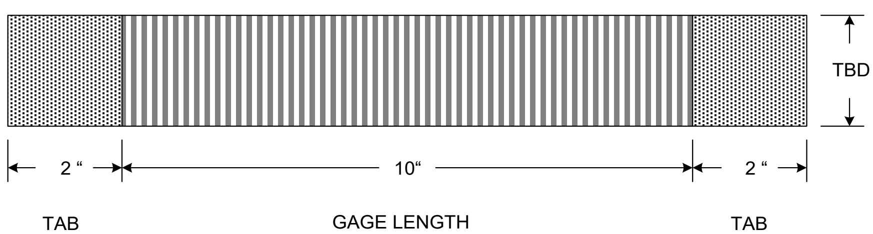


Figure 16. Seatbelt webbing nominal dimensions

In order to facilitate specimen identification and tracking the following nomenclature was used [Client ID – Test Method ID – Plastic Type ID – Disinfectant ID – Specimen #]. Table 19 summarizes specimen identification nomenclature to be used.

Table 19. Test matrix for tensile test of seatbelt webbing

Client ID	FAA	FAA
Test Method ID	Breaking Strength – Tension	T
Webbing Type	SCHROTH Polyester	W1
Liquid Chemical Disinfectant	Pristine (No Disinfectant)	D0
	70% IPA	D1
	Calla 1452 /Matrix 3	D2
	Sani-Cide EX3	D3
	BactroKill +	D4
	PREempt RTU	D5

5.2.1.3 Test setup

Tests were conducted at room temperature under displacement control at a nominal displacement rate of 3 in/min. All tests were conducted at room temperature until failure. The test apparatus used was a MTS Servo-Hydraulic testing load frame with a static load capacity of 55,000 lbf. Hydraulic self-aligning grips were used to grip the specimen as shown in Figure 17 and were at a gripping pressure of 3,000 psi.

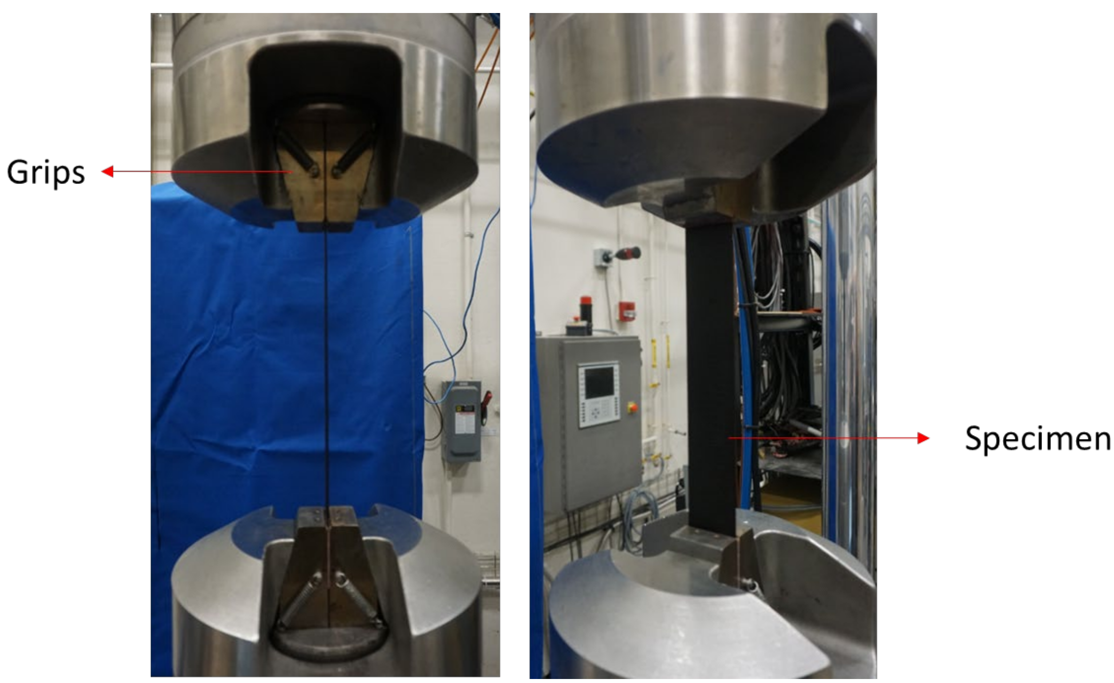


Figure 17. Seatbelt webbing test setup

5.2.1.4 Test results

Since the tests were not conducted according to SAE AS8043B with split drum grips, the position of failure in each specimen occurred near the grip tabs due to stress concentrations as shown in Appendix C. Thus, the failure load was below 5000 lbs. for all the specimens tested. However, the purpose of the tests was to investigate that if conditioning with liquid disinfectants resulted in reduction in failure load of seat belt webbing using a consistent test method.

Results shown in Figure 18 and Figure 19 indicate that there was no reduction in failure load or displacement for seatbelt webbings specimens when conditioned with Calla 1452, Sani-Cide EX3, BactroKill+, and PREempt. Reduction of less than 5% for both failure load and displacement was observed when the specimens were conditioned with 70% IPA.

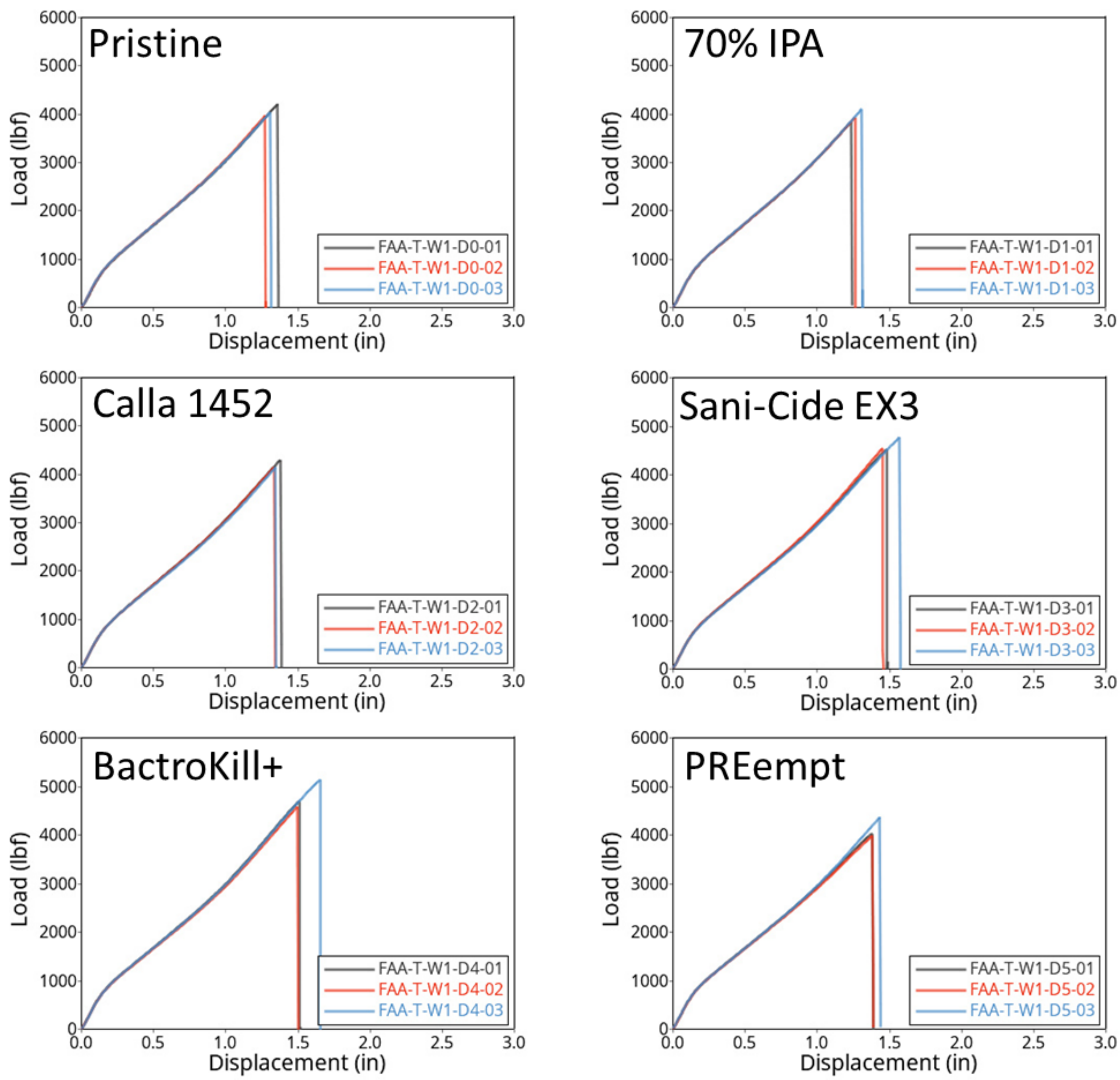


Figure 18. Load-Displacement response – SCHROTH webbing

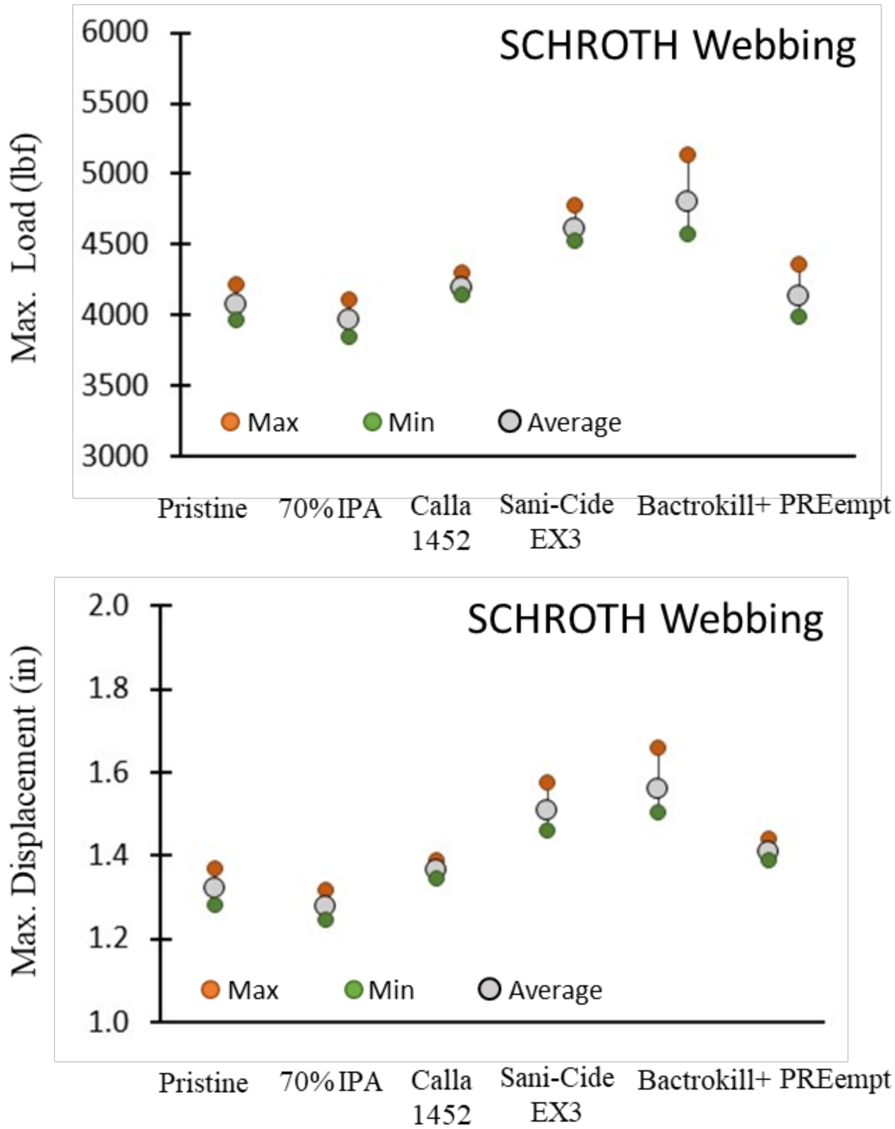


Figure 19. Peak load and displacement comparison – SCHROTH webbing

5.2.2 Seat belt webbing – AmSafe

5.2.2.1 Test matrix

AmSafe polyester webbing tension tests were conducted at the AmSafe testing facility. The specimens were tested following SAE AS8043B until rupture (Restraint Systems for Civil Aircraft, 1986/2008). In addition to conditioning the specimen for the required duration of one day, specimens were also conditioned for longer durations as shown in the Table 20. However, the test dataset was limited as only one specimen was tested per configuration. Furthermore, AmSafe included water in the test matrix and used 99% IPA instead of 70% IPA.

Table 20. Test matrix for tensile test of AmSafe polyester seatbelt webbing

Disinfectants Type	Conditioning Duration (Days)										
	0	1	2	3	4	5	7	12	13	14	15
No Conditioning	x1	-	-	-	-	-	-	-	-	-	-
Water	-	x1	x1	x1	x1	x1	-	-	-	-	-
99% IPA	-	x1	x1	x1	x1	x1	-	-	-	-	-
Sani-Cide EX3	-	x1	x1	x1	x1	-	x1	-	-	-	-
Calla 1452	-	x1	-	-	-	-	-	x1	x1	x1	x1

5.2.2.2 Test setup

According to SAE AS8043B, the split drum grips are required for the webbing tests. The grip consists of eccentric cylinder to prevent the slipping during the test and avoid the failure at the grip location. Figure 20 illustrates the split drum grip with a webbing specimen inserted. After the specimen undergoes tensile load until failure, the breaking load and elongation were recorded.

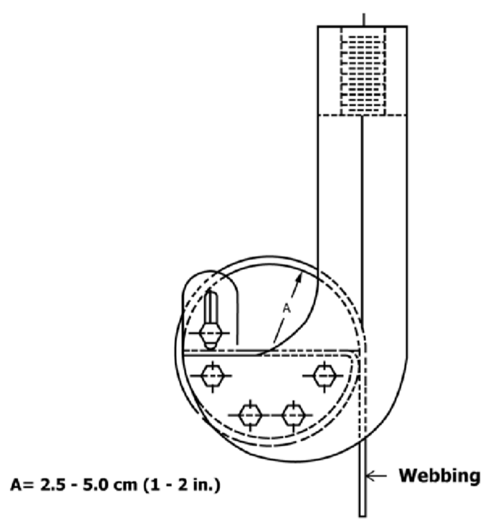


Figure 20. Split drum grip for strength and elongation test

5.2.2.3 Test results

Failure load and elongation test results for Amsafe polyester seatbelt webbing have been shown in Figure 21 and Figure 22, respectively. It should be noted that the test dataset was limited to only one specimen tested per configuration.

When the specimens were conditioned with 99% IPA, no reduction in the failure load was observed when compared against the control specimen. The elongation test data was only available for the specimen conditioned for 5 days, which showed a reduction of less than 5% in comparison to the control specimen.

When the specimens were conditioned with Sani-Cide EX3, no reduction in failure load was observed when compared against the control specimen for specimens conditioned for 1, 3, and 7 days. Reduction in failure load of less than 5% was observed when the specimens were conditioned with Sani-Cide EX3 for 2 and 4 days. No reduction in elongation was observed.

When the specimens were conditioned with Calla 1452, no reduction in failure load was observed for specimens conditioned for 1, 12, 12 and 14 days. Reduction in failure load of less than 5% was observed when the specimen was conditioned for 15 days. Reduction in elongation of less than 5% was observed for all the specimens conditioned for different time durations.

When the specimens were conditioned with water, no reduction in failure load was observed for specimens conditioned for 2 and 4 days. Reduction in failure load of less than 5% in comparison to the control specimen was observed when the specimens were conditioned with water for 1, 3, and 5 days. No reduction in elongation was observed for specimen conditioned for 1, 2, and 4 days; however, reduction of less than 5% was observed when the specimens were conditioned for 3 and 5 days.

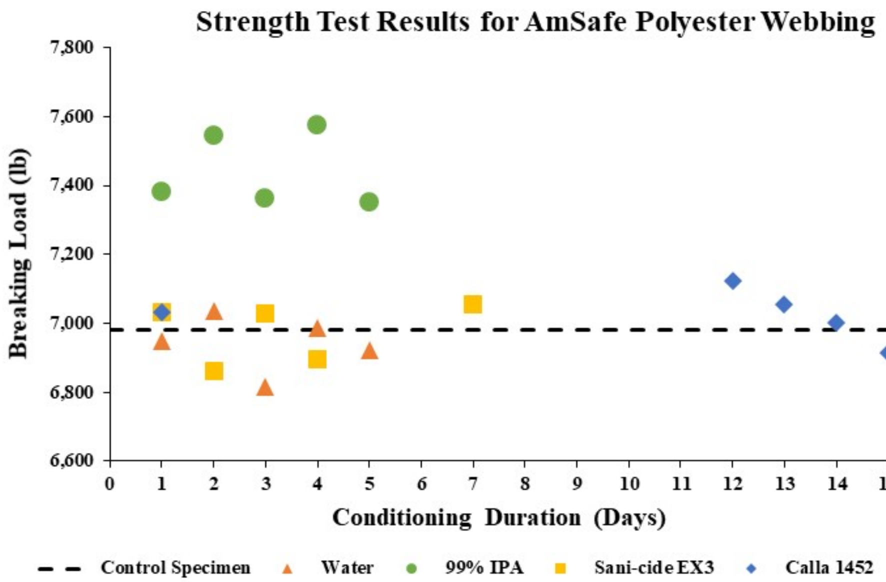


Figure 21. Peak load comparison – AmSafe polyester webbing

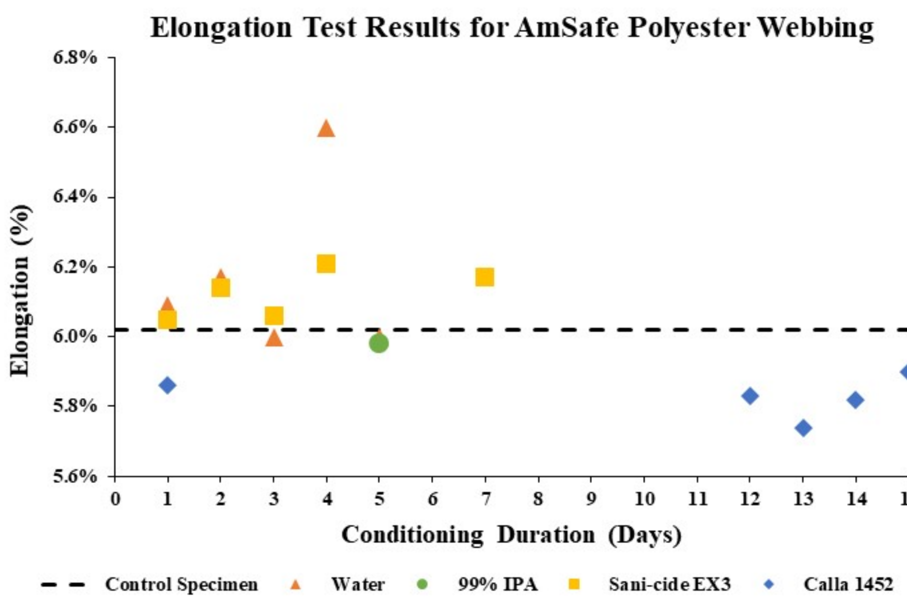


Figure 22. Elongation comparison – AmSafe polyester webbing

5.3 Summary of mechanical test results

To understand the effect of liquid disinfectants on the mechanical properties of plastics and seatbelt webbing, tensions tests were conducted on both the pristine and conditioned specimens.

For plastics, tests were conducted on a minimum of five specimens per disinfectant type following ASTM D638. Furthermore, additional specimens of Kydex 6565 and Boltaron 9815E were tested to have a larger data set for statistical evaluation. Statistical analysis following CMH-17 (Polymer Matrix Composites: Guidelines for Characterization of Structural Materials, 2012) showed that the material properties obtained from conditioned specimens were equivalent to the material properties obtained from unconditioned specimens for Kydex 6565, Lexan XHR and Boltaron 9815N, but were not equivalent for Boltaron 9815E, as shown in Table 21. It should be noted that additional tests were not conducted for Lexan XHR and Boltaron 9815N due to the limited material availability.

For SCHROTH seatbelt webbings, no reduction in failure load and displacement was observed when the specimens were conditioned with Calla 1452, Sani-Cide EX3, BactroKill+, and PREempt. Reduction of less than 5% for both failure load and displacement was observed when the specimens were conditioned with 70% IPA as shown in Table 21.

For Amsafe seatbelt webbings, no reduction in failure load was observed when the specimens were conditioned with 99% IPA, Sani-Cide EX3, and Calla 1452 for 24 hours as shown in Table 21. Additionally, Amsafe had also evaluated the effect of conditioning the specimens with liquid disinfectants for longer durations as summarized in Section 5.2.2. However, it should be noted that the test dataset was limited to only specimen tested per configuration.

Table 21. Mechanical properties results summary

Material Name	Disinfectant Type				
	70% IPA*	Calla 1452	Sani-Cide EX3	BactroKill+	PREempt RTU
Kydex 6565					
Boltaron 9815E					
Lexan XHR					
Boltaron 9815N					
SCHROTH Webbing					
Amsafe Webbing				-	-

**AmSafe Polyester webbing specimens were conditioned with 99% IPA*

Material properties “equivalent” to unconditioned specimens

Material properties not “equivalent” to unconditioned specimens

Material properties “equivalent” to unconditioned specimens based on limited data

Reduction in failure load less than 5%

No Reduction in failure load

6 Flammability Properties

This investigation evaluated the effect of liquid disinfectants on the flammability properties of all the materials. Tests were conducted according to the Vertical Bunsen Burner Tests specified in 14 CFR § 25.853 Appendix F (14 CFR § 25.853). All the flammability tests were conducted at Aviation Consulting and Engineering Solutions, Inc. (ACES) (KanUS).

6.1 Flammability performance criterion

The purpose of these tests was to compare the flammability performance of the material when conditioned with liquid disinfectants against unconditioned specimens. This data was not to be used for certification purposes. Hence, there was a need to define a criterion to measure the severity on flammability performance. The test method and conditioning environment was selected conservatively to be able to measure effects. In lieu of having a separate test method for each type of application, a generally accepted application was agreed upon. To cover as many types of disinfectants and application methods as possible, this generally accepted application is considered more conservative than what is being performed on current in-use seating products. The criterion is defined below:

- Flammability results for plastics, leather, synthetic leather, and Wool/Nylon fabric were considered not significantly different if the increase in average burn length of the conditioned specimens was less than or equal to approximately 50% of the average burn length obtained from the unconditioned specimens test data. We call these results “normally equivalent.”
- Flammability results for plastics, leather, synthetic leather, and Wool/Nylon fabric were considered significantly different, if the increase in average burn length of conditioned specimens was greater than approximately 50% of the average burn length obtained from the unconditioned specimens test data.
- Flammability results for seatbelt webbing were considered not significantly different, if the increase in average burn length of conditioned specimens was less than 6” when compared against unconditioned specimens and the webbing was self-extinguishable.

6.2 Vertical flammability – submersion method

Initially, all the materials being investigated for their flammability properties were only conditioned using the submersion methodology as described in section 4.1. This conditioning methodology was considered conservative and it required a shorter time frame for sample preparation. Three specimens were tested per disinfectant type for each material type following this conditioning methodology as shown in Table 22. Furthermore, for synthetic leather, natural leather, and Wool/Nylon fabrics control specimens were tested to determine the direction of weave corresponding to the most critical flammability conditions. Based on the control flammability test results, specimens cut along the critical direction were subjected to disinfectant conditioning.

Table 22. Test matrix for vertical flammability tests

Material Type	Material Name	Flammability Evaluation: Disinfectant Type					
		Pristine	70% IPA	Calla 1452	Sani-Cide EX3	BactroKill+	PREempt RTU
Plastic	Kydex 6565	x3	x3	x3	x3	x3	x3
	Boltaron 9815E	x3	x3	x3	x3	x3	x3
	Lexan XHR	x3	x3	x3	x3	x3	x3
	Boltaron 9815N	x3	x3	x3	x3	x3	x3
Webbing	SCHROTH	x3	x3	x3	x3	x3	x3
Synthetic Leather	E-Leather CL280	x3	x3	x3	x3	x3	x3
	Ultrafabric 492-6579FR12	x3	x3	x3	x3	x3	x3
	TapiSuede TSFRC0961	x3	x3	x3	x3	x3	x3
	Ultraleather ULFRB971-1363	x3	x3	x3	x3	x3	x3
Wool/Nylon Blend	Lantal	x3	x3	x3	x3	x3	x3
	Rohi Beach	x3	x3	x3	x3	x3	x3
	Sheepskin	x3	x3	x3	x3	x3	x3
	Botany Fabric	x3	x3	x3	x3	x3	x3
Leather	Murihead	x3	x3	x3	x3	x3	x3
	Pewter BC (Perrone)	x3	x3	x3	x3	x3	x3
	Perrone Feather Weight	x3	x3	x3	x3	x3	x3

6.2.1 Plastics

For plastics, test specimens of dimension 12” x 3” were manufactured from flat sheets and were submerged for a week in the liquid disinfectants. After conditioning, specimens were tested according to the 60-second Vertical Bunsen Burn Test.

As shown in results summarized in Table 23 to Table 26, the increase in the flammability properties of plastics when conditioned with liquid disinfectants was considered normally equivalent to the untreated material. Comparison of burn length is shown in Figure 23 to Figure 26.

Table 23. Flammability results for Kydex 6565 – submersion method

Vertical Flammability Test Results for Kydex 6565 (P1)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	2.90	2.50	3.60	0.00	0.00	0.00
70% IPA	0.00	0.00	0.00	3.40	3.20	2.90	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	3.30	3.60	3.80	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	3.20	3.30	3.30	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	3.60	3.50	3.10	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	3.30	3.60	3.70	0.00	0.00	0.00

Table 24. Flammability results for Boltaron 9815E – submersion method

Vertical Flammability Test Results for Boltaron 9815E (P2)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	3.70	3.00	3.10	0.00	0.00	0.00
70% IPA	0.00	0.00	0.00	3.50	3.90	3.60	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	3.70	3.90	3.90	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	3.40	3.80	3.60	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	3.80	3.20	3.70	0.00	0.00	0.00
PREempt RTU	0.00	0.00	4.79	3.70	4.00	3.40	0.00	0.00	0.00

Table 25. Flammability results for Lexan XHR – submersion method

Vertical Flammability Test Results for Lexan XHR (P3)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	2.50	2.30	2.70	0.00	0.00	0.00
70% IPA	2.46	0.00	0.00	2.80	2.70	2.90	0.00	0.00	0.00
Calla 1452	2.34	2.82	2.53	2.50	3.10	2.80	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	2.70	3.10	2.90	0.00	0.00	0.00
BactroKill+	2.36	1.67	0.00	2.80	2.70	2.60	0.00	0.00	0.00
PREempt RTU	0.00	0.00	6.76	2.90	2.80	2.70	0.00	0.00	0.00

Table 26. Flammability results for Boltaron 9815N – submersion method

Vertical Flammability Test Results for Boltaron 9815N (P4)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	2.40	2.90	3.70	0.00	0.00	0.00
70% IPA	8.50	8.60	0.00	2.70	2.60	3.50	0.00	0.00	0.00
Calla 1452	0.00	1.60	0.00	3.40	3.50	2.80	0.00	0.00	0.00
Sani-Cide EX3	11.50	0.00	3.50	2.60	2.70	3.10	0.00	0.00	0.00
BactroKill+	5.80	0.00	5.80	2.80	2.90	3.40	0.00	0.00	0.00
PREempt RTU	8.20	3.70	0.00	2.50	2.70	3.30	0.00	0.00	0.00

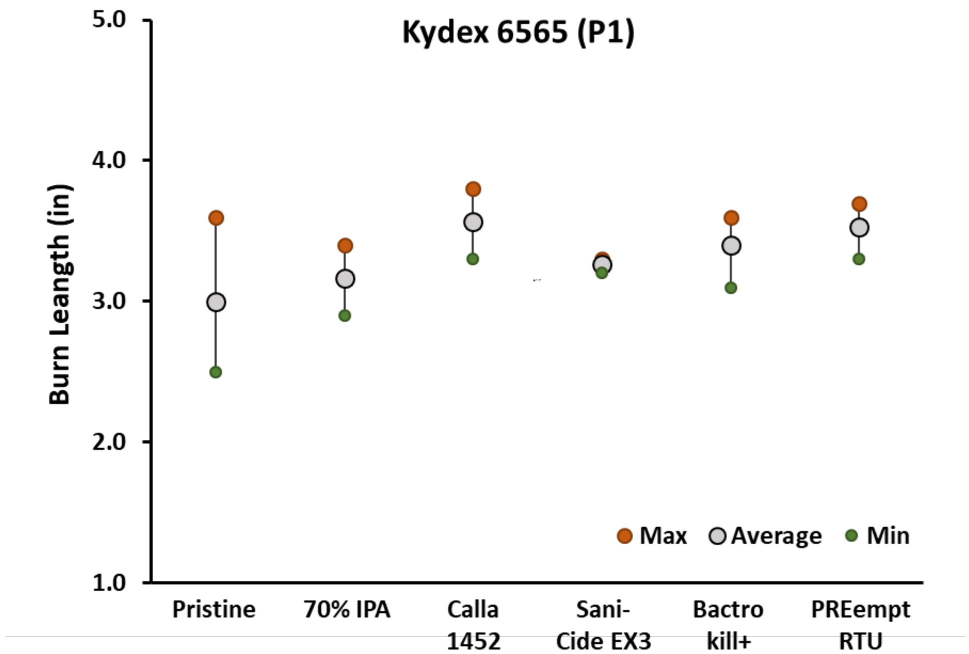


Figure 23. Burn length comparison for Kydex 6565 – submersion method

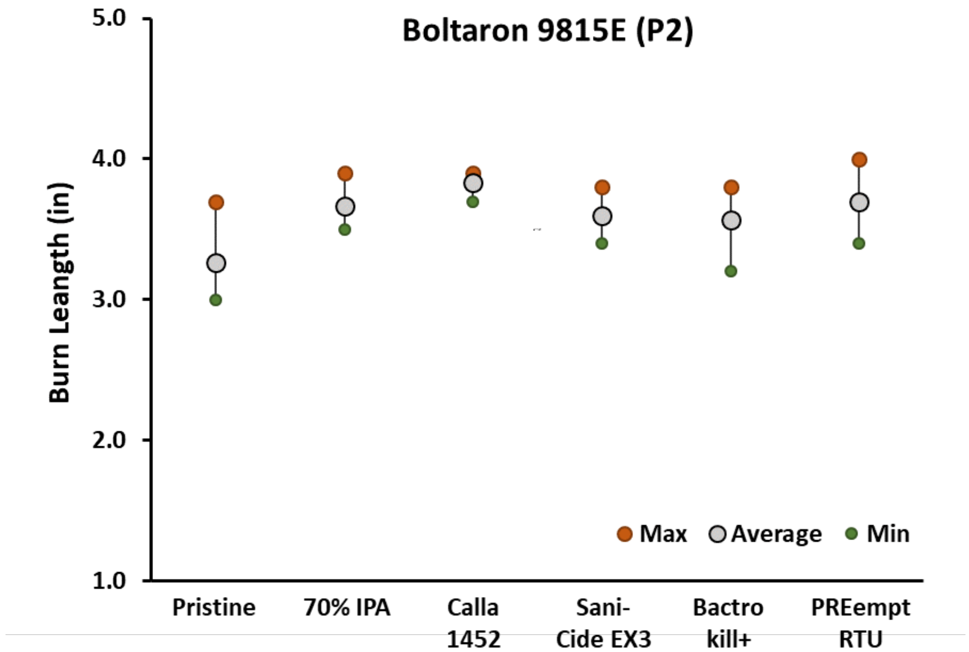


Figure 24. Burn length comparison for Boltaron 9815E – submersion method

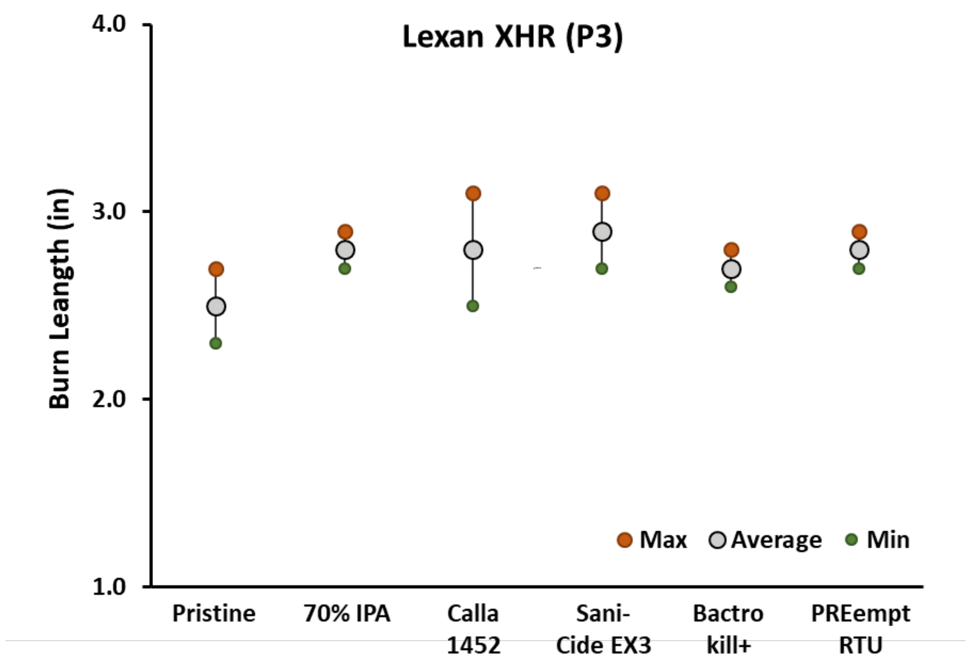


Figure 25. Burn length comparison for Lexan XHR – submersion method

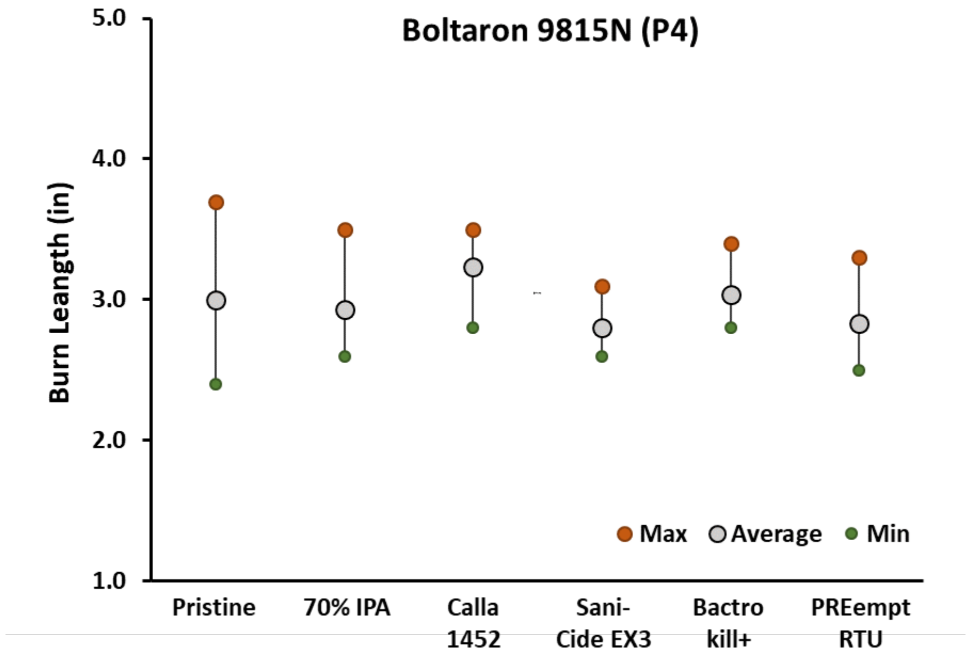


Figure 26. Burn length comparison for Boltaron 9815N – submersion method

6.2.2 Leather

Even though leather is an inherently variable natural material, control tests were still conducted to determine the direction critical to flammability conditions. These tests were conducted on unconditioned specimens cut along both the length and width of the roll. Results of control specimens are summarized in Table 27.

Table 27. Control flammability results for Leather – submersion method

Vertical Flammability Control Test Results for Leather							
Material Name	After Flame Time (s)		Burn Length (in)		Drip Flame Time (s)		Critical Direction
	Dir. A	Dir. B	Dir. A	Dir. B	Dir. A	Dir. B	
Perrone Pewter BC	0.00	0.00	1.20	1.50	0.00	0.00	B
Perrone Feather Weight (60s)	0.00	19.60	6.40	4.70	0.00	0.00	B
Perrone Feather Weight (12s)	N/A	2.23	N/A	0.50	N/A	0.00	

Based on the control flammability test results, test specimens of dimension 12” x 3” were cut ensuring that the critical direction was parallel to the longest dimension. Test specimens were then submerged in liquid disinfectants for 24 hours. After conditioning, specimens were tested according to the 60-second Vertical Bunsen Burn Test. Post-test pictures of specimens have been summarized in Appendix D.

For Perrone Pewter BC, the change in flammability properties was considered normally equivalent to the untreated material, as summarized in Table 28. A comparison of burn length is shown in Figure 27.

For Perrone Feather Weight, the change in flammability properties was considered normally equivalent when conditioned with 70% IPA and Calla 1452. However, the increase in average burn length was significantly different when conditioned with Sani-Cide EX3, BactroKill+, and PREempt RTU as shown in Figure 28. In addition, one of the test specimens conditioned with BactroKill+ had a burn length of 12”. This reflects that the sample was consumed during the test, and so the actual burn length, had the sample been longer, could have been longer.

Table 28. Flammability results for Perrone Pewter BC – submersion method

Vertical Flammability Test Results for Perrone Pewter BC (L2)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	3.30	3.00	3.60	0.00	0.00	0.00
70% IPA	0.00	0.00	0.00	3.20	2.90	2.70	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	4.20	3.80	3.90	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	4.90	4.80	4.30	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	5.50	4.20	4.50	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	4.70	3.80	4.10	0.00	0.00	0.00

Table 29. Flammability results for Perrone Feather Weight – submersion method

Vertical Flammability Test Results for Perrone Feather Weight (L3)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	4.80	4.90	5.00	0.00	0.00	0.00
70% IPA	0.00	0.00	0.00	4.20	4.20	4.30	0.00	0.00	0.00
Calla 1452	0.00	1.80	0.00	5.20	5.80	4.60	0.00	0.00	0.00
Sani-Cide EX3	0.00	4.30	2.30	6.20	7.30	7.60	0.00	0.00	0.00
BactroKill+	0.00	0.00	81.70	6.90	6.60	12.00	0.00	0.00	0.00
PREempt RTU	0.00	13.10	15.40	8.20	9.50	9.40	0.00	0.00	0.00

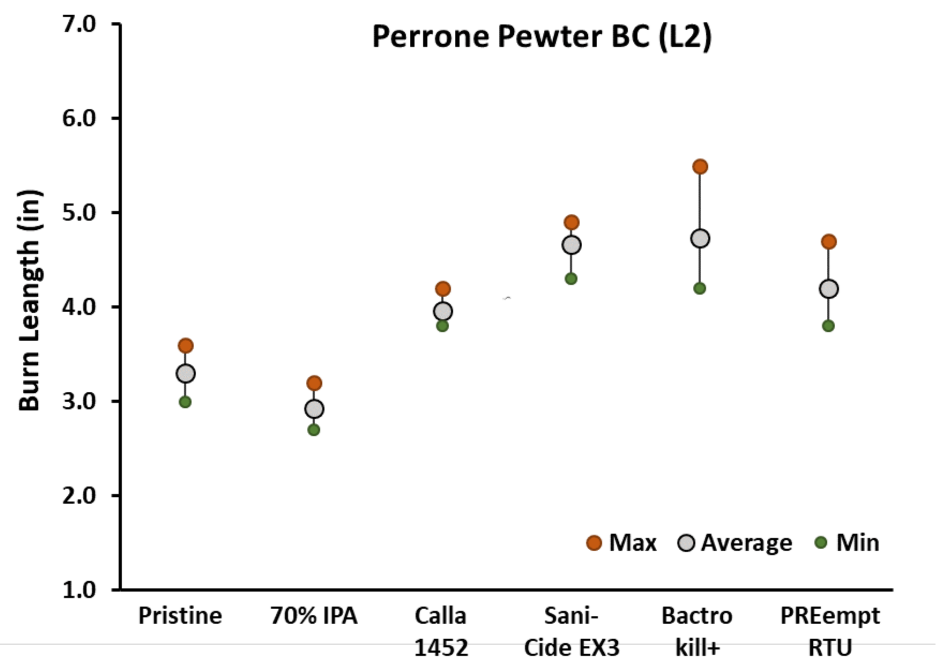


Figure 27. Burn length comparison for Perrone Pewter BC – submersion method

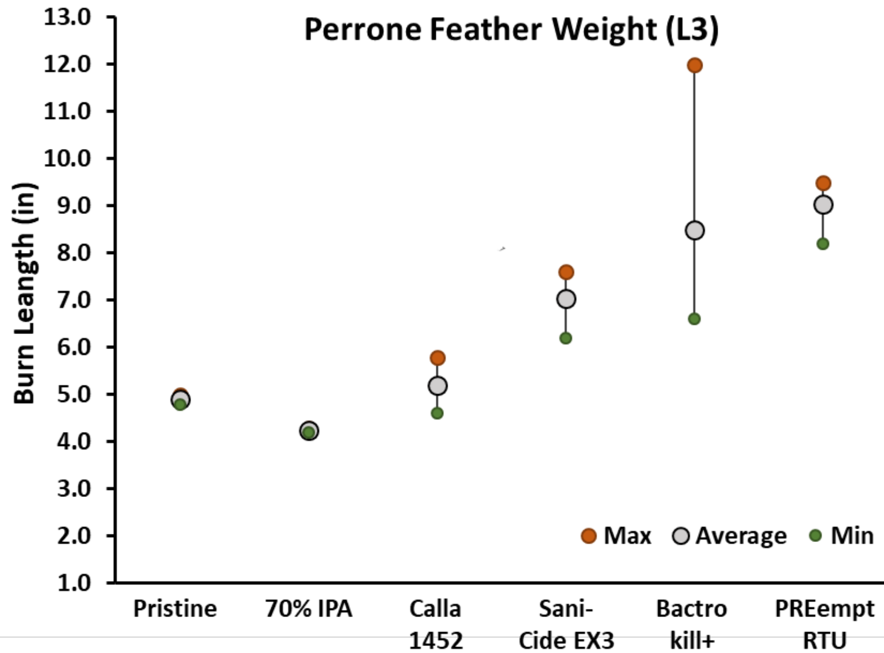


Figure 28. Burn length comparison for Perrone Feather Weight – submersion method

6.2.3 Synthetic leather

For synthetic leather, control tests were conducted to determine the direction critical to flammability conditions. These tests were conducted on pristine (unconditioned) specimens cut along both the length and the width of the roll. Results of the control specimens are summarized in Table 30. Based on the scope of project, only four synthetic leathers were selected for conditioning with disinfectants. The selected synthetic leathers were E-Leather CL820, TapiSuede TSFRC0961, Ultraleather ULFRB97-1363, and Ultrafabric 492-6579FR12.

After conducting control flammability tests, specimens of dimension 12” x 3” were cut, ensuring that the critical direction was parallel to the longest dimension. Test specimens were then submerged in liquid disinfectants for 24 hours. After conditioning, specimens were tested according to the 60-seconds Vertical Bunsen Burn Test. Post-test pictures of specimens have been provided in Appendix E.

For E-leather CL820, the change in flammability properties for all the conditioned specimens was significantly different in comparison to unconditioned specimens as summarized in Table 31. All the disinfectants resulted in burn length equivalent to specimen length as shown in Figure 29. This reflects that the sample was consumed during the test, and so the actual burn length, had the sample been longer, could have been longer. Additionally, tests showing a zero after time, while also showing full burn length, reflect that the entire burning period occurred during the 60-

second flame exposure time. Therefore, by the time the flame was withdrawn, the material had been consumed.

For Ultrafabric 492-6579FR12, change in flammability properties for specimens conditioned with Calla 1452, Sani-Cide EX3, BactroKill+, and PREempt RTU was significantly different as summarized in Table 32. Specimens treated with these four disinfectants resulted in burn length equivalent to specimen length as shown in Figure 30. This reflects that the sample was consumed during the test, and so the actual burn length, had the sample been longer, could have been longer. The change in flammability properties was considered normally equivalent when conditioned with 70% IPA.

For TapiSuede TSFRC0961, the change in flammability properties was considered normally equivalent to the untreated material when conditioned with disinfectants as summarized in Table 33.

For Ultraleather ULFRB97-1363, the change in flammability properties for specimens conditioned with Calla 1452, Sani-Cide EX3, BactroKill+, and PREempt RTU was significantly different as summarized in Table 34. Specimens treated with these four disinfectants resulted in large burn lengths as shown in Figure 32. The change in flammability properties was considered normally equivalent to the untreated material when conditioned with 70% IPA.

Table 30. Control flammability results for Synthetic leather – submersion method

Vertical Flammability Control Test Results for Synthetic Leather							
Material Name	After Flame Time (s)		Burn Length (in)		Drip Flame Time (s)		Critical Direction
	Dir. A	Dir. B	Dir. A	Dir. B	Dir. A	Dir. B	
E-Leather SL3UL	0.00	0.00	3.40	3.50	0.00	0.00	B
E-Leather CL820	0.00	0.00	5.20	5.00	0.00	0.00	A
UltraSuede USFRC5912	0.00	0.00	4.40	3.60	0.00	0.00	A
TapiSuede TSFRC0961	0.00	0.00	4.80	4.20	0.00	0.00	A
Ultraleather ULFRB971-1363	0.00	0.00	4.40	4.20	0.00	0.00	A
Ultrafabrics 291-5776FR12	0.00	0.00	3.20	3.70	0.00	0.00	B
Ultrafabrics 492-6579FR12	0.00	0.00	3.50	4.90	0.00	0.00	B
Ultrafabrics 554-1303FR12	0.00	0.00	4.10	4.20	0.00	0.00	B

Table 31. Flammability results for E-Leather CL820 – submersion method

Vertical Flammability Test Results for E-Leather CL820 (SL1)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	5.80	6.50	6.30	0.00	0.00	0.00
70% IPA	0.00	0.00	0.00	12.00	12.00	12.00	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	12.00	12.00	12.00	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	12.00	12.00	12.00	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	12.00	12.00	12.00	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	12.00	12.00	12.00	0.00	0.00	0.00

Table 32. Flammability results for Ultra Fabric 492-6579FR12 – submersion method

Vertical Flammability Test Results for Ultra Fabric 492-6579FR12 (SL2)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	4.20	4.10	3.80	0.00	0.00	0.00
70% IPA	0.00	0.00	0.00	4.70	5.10	4.80	0.00	0.00	0.00
Calla 1452	15.88	26.17	27.31	12.00	12.00	12.00	0.00	0.00	0.00
Sani-Cide EX3	13.88	13.28	15.48	12.00	12.00	12.00	0.00	0.00	0.00
BactroKill+	9.02	9.94	12.46	12.00	12.00	12.00	0.00	0.00	0.00
PREempt RTU	30.13	24.27	18.21	12.00	12.00	12.00	0.00	0.00	0.00

Table 33. Flammability results for TapiSuede TSFRC0961 – submersion method

Vertical Flammability Test Results for TapiSuede TSFRC0961 (SL3)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	5.70	5.80	5.90	0.00	0.00	0.00
70% IPA	0.00	0.00	0.00	5.30	4.40	6.00	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	5.70	5.80	5.45	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	5.40	5.65	5.20	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	5.90	4.60	5.50	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	5.40	5.40	5.00	0.00	0.00	0.00

Table 34. Flammability results for Ultra Leather ULFRB971-1363 – submersion method

Vertical Flammability Test Results for Ultra Leather ULFRB971-1363 (SL4)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	5.50	5.80	5.70	0.00	0.00	0.00
70% IPA	0.00	0.00	0.00	6.00	5.80	6.10	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	10.00	12.00	12.00	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	8.40	12.00	12.00	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	9.10	4.10	10.35	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	11.05	10.10	5.30	0.00	0.00	0.00

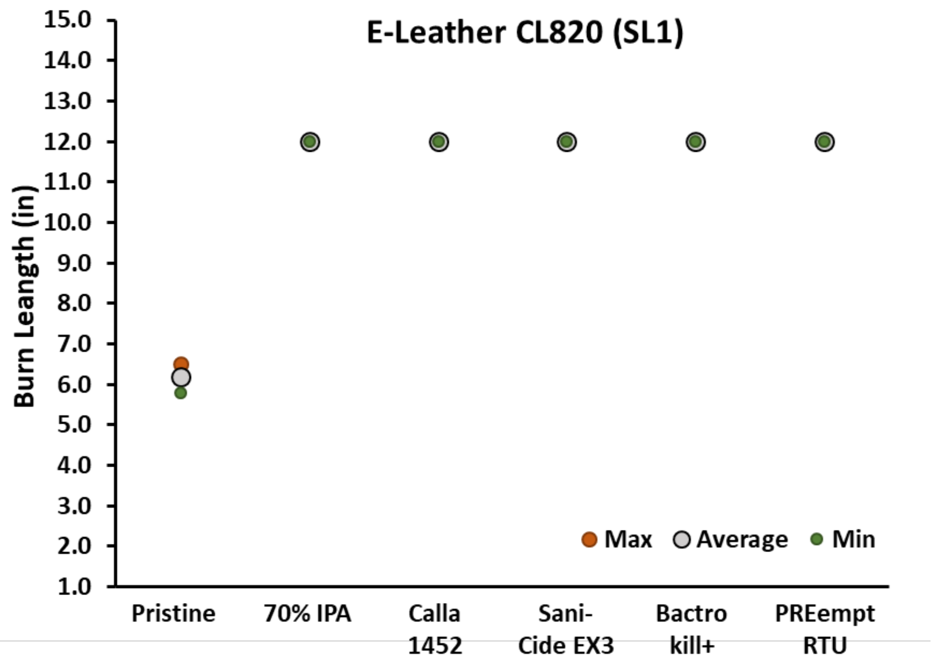


Figure 29. Burn length comparison for E-Leather CL820 – submersion method

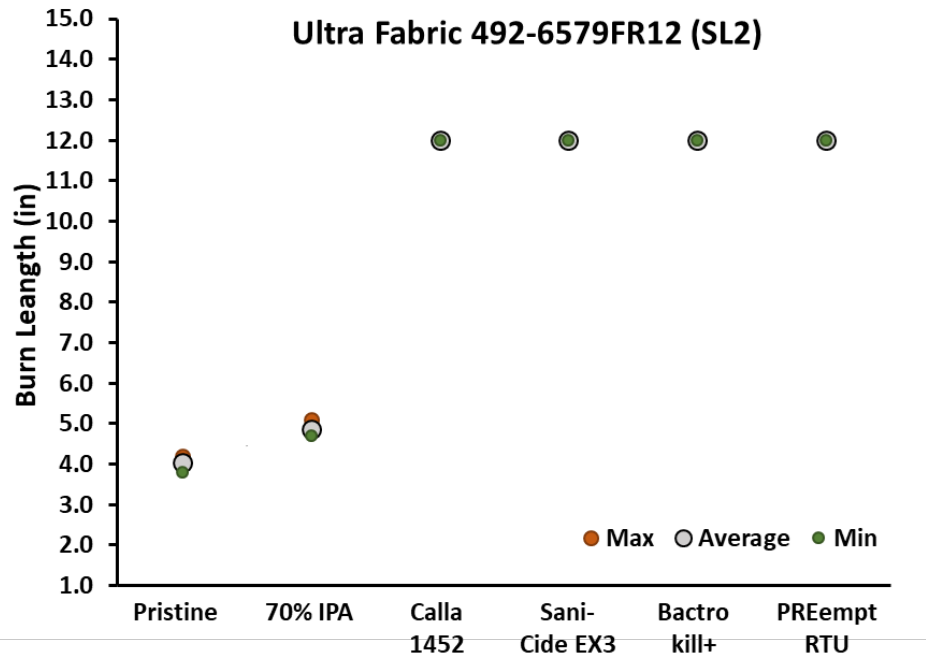


Figure 30. Burn length comparison for Ultra Fabric 492-6579FR12 – submersion method

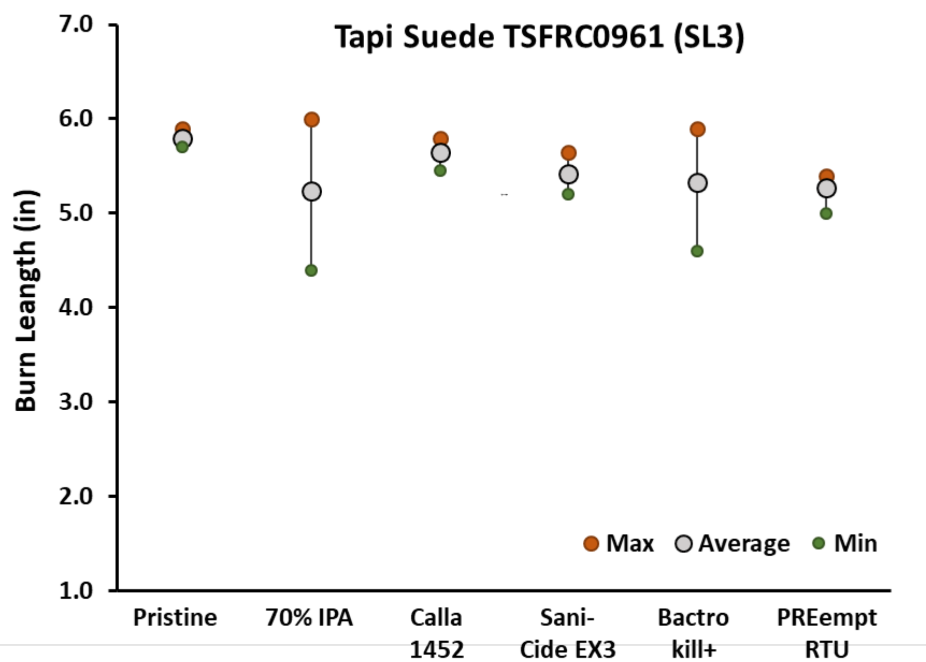


Figure 31. Burn length comparison for Tapi Suede TSFRC0961 – submersion method

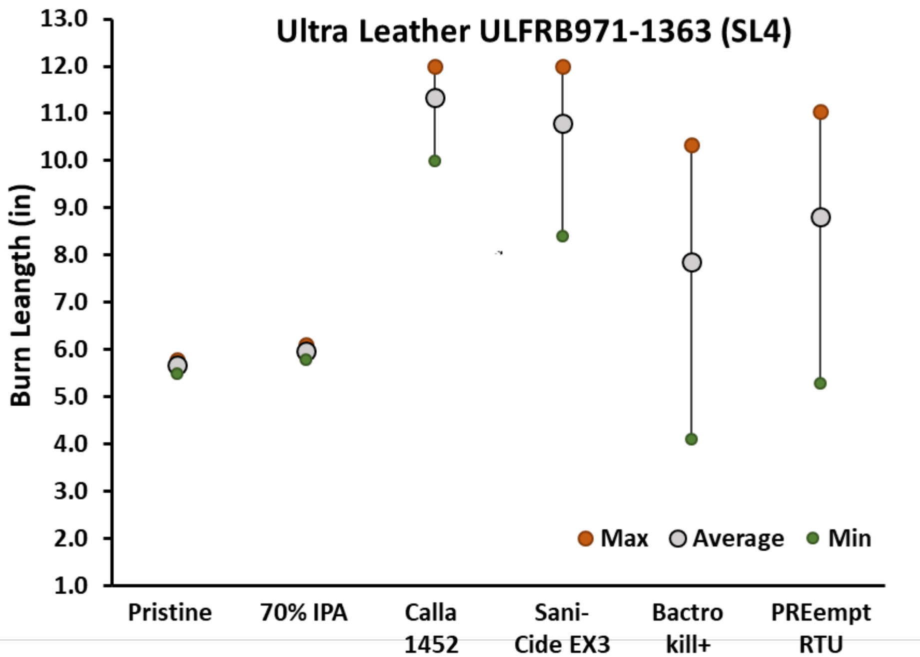


Figure 32. Burn length comparison for Ultra Leather ULFRB971-1363 – submersion method

6.2.4 Wool/Nylon blend

For Wool/Nylon blends, control tests were conducted to determine the direction critical to flammability conditions. These tests were conducted on pristine (unconditioned) specimens cut along both the length and the width of the roll. Results of the control specimens have been summarized in Table 35. Based on the scope of project, only four Wool/Nylon blends were selected for conditioning with disinfectants. The selected blends were Lantal, Rohi Beach, Botany Fabric (Batch IL131), and Sheepskin.

Table 35. Control flammability results for Wool/Nylon blend – submersion method

Vertical Flammability Control Test Results for Wool/Nylon Blend							
Material Name	After Flame Time (s)		Burn Length (in)		Drip Flame Time (s)		Critical Direction
	Dir. A	Dir. B	Dir. A	Dir. B	Dir. A	Dir. B	
Rohi	0.00	0.00	2.70	2.20	0.00	0.00	A
Lantal	0.00	0.00	3.30	3.20	0.00	0.00	A
Rohi Beach	0.00	0.00	3.35	3.50	0.00	0.00	B
Botany Fabric	0.00	0.00	3.20	3.35	0.00	0.00	B
Botany Fabric (Batch IL131)	0.00	0.00	3.10	3.50	0.00	0.00	B
Sheepskin	0.00	0.00	3.90	4.90	0.00	0.00	B

After conducting control flammability tests, specimens of dimension 12” x 3” were cut, ensuring that the critical direction was parallel to the longest dimension. Test specimens were then submerged in liquid disinfectants for 24 hours. After conditioning, specimens were tested according to the 60-seconds Vertical Bunsen Burn Test as shown in Appendix F.

For Lantal, the change in flammability properties for specimens conditioned with Sani-Cide EX3 and BactroKill+ was significantly different as summarized in Table 36. Specimens treated with these two disinfectants resulted in large burn lengths equivalent to the specimen length as shown in Figure 33. This reflects that the sample was consumed during the test, and so the actual burn length, had the sample been longer, could have been longer. Additionally, tests showing a zero after time, while also showing full burn length, reflect that the entire burning period occurred during the 60-second flame exposure time. Therefore, by the time the flame was withdrawn, the material had been consumed. The change in flammability properties was considered normally equivalent to the untreated materials when conditioned with 70% IPA, Calla 1452, and PREempt RTU.

For Rohi Beach, the change in flammability properties for specimens conditioned with Calla 1452, BactroKill+, Sani-Cide EX 3, and PREempt RTU was significantly different, as summarized in Table 37. Specimens treated with these three disinfectants resulted in large burn lengths in comparison to unconditioned specimens, as shown in Figure 34. The change in flammability properties was considered normally equivalent to the untreated material when conditioned with 70% IPA.

For Sheepskin, the change in flammability properties for specimens conditioned with Sani-Cide EX3, BactroKill+, and PREempt RTU was significantly different, as summarized in Table 38. Specimens treated with these three disinfectants resulted in large burn lengths in comparison to unconditioned specimens, as shown in Figure 35. The change in flammability properties was considered normally equivalent to the untreated material when conditioned with 70% IPA and Calla 1452.

For Botany Fabric, the change in flammability properties for specimens conditioned with BactroKill+ and PREempt RTU was significantly different, as summarized in Table 39. Specimens treated with these two disinfectants resulted in large burn lengths in comparison to unconditioned specimens, as shown in Figure 36. The change in flammability properties was considered normally equivalent to the untreated material when conditioned with 70% IPA, Calla 1452, and Sani-Cide EX3.

Table 36. Flammability results for Lantal – submersion method

Vertical Flammability Test Results for Lantal (NW1)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	3.70	3.60	3.10	0.00	0.00	0.00
70% IPA	0.00	0.00	0.00	4.30	3.40	3.30	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	5.50	5.10	4.10	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	12.00	7.50	12.00	5.00	0.00	3.00
BactroKill+	0.00	1.60	0.00	12.00	12.00	12.00	3.00	2.00	3.00
PREempt RTU	0.00	0.00	0.00	5.50	5.10	4.20	0.00	0.00	0.00

Table 37. Flammability results for Rohi Beach – submersion method

Vertical Flammability Test Results for Rohi Beach (NW2)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	3.10	3.10	3.50	0.00	0.00	0.00
70% IPA	0.00	0.00	0.00	3.45	3.90	4.50	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	6.00	5.95	6.35	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	5.10	3.20	5.10	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	6.60	12.00	12.00	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	6.70	6.40	3.20	0.00	0.00	0.00

Table 38. Flammability results for Sheep Skin – submersion method

Vertical Flammability Test Results for Sheep Skin (NW3)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	4.60	3.90	3.80	0.00	0.00	0.00
70% IPA	0.00	0.00	0.00	5.30	4.00	4.50	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	4.00	3.90	5.10	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	8.10	8.30	6.00	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	6.30	7.50	4.90	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	11.10	10.70	9.50	0.00	0.00	0.00

Table 39. Flammability results for Botany fabric – submersion method

Vertical Flammability Test Results for Botany Fabric (NW4)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	3.80	3.20	2.80	0.00	0.00	0.00
70% IPA	0.00	0.00	0.00	3.00	2.80	4.00	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	3.80	3.80	3.30	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	4.75	4.20	4.40	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	6.50	6.70	6.00	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	5.50	3.80	6.70	0.00	0.00	0.00

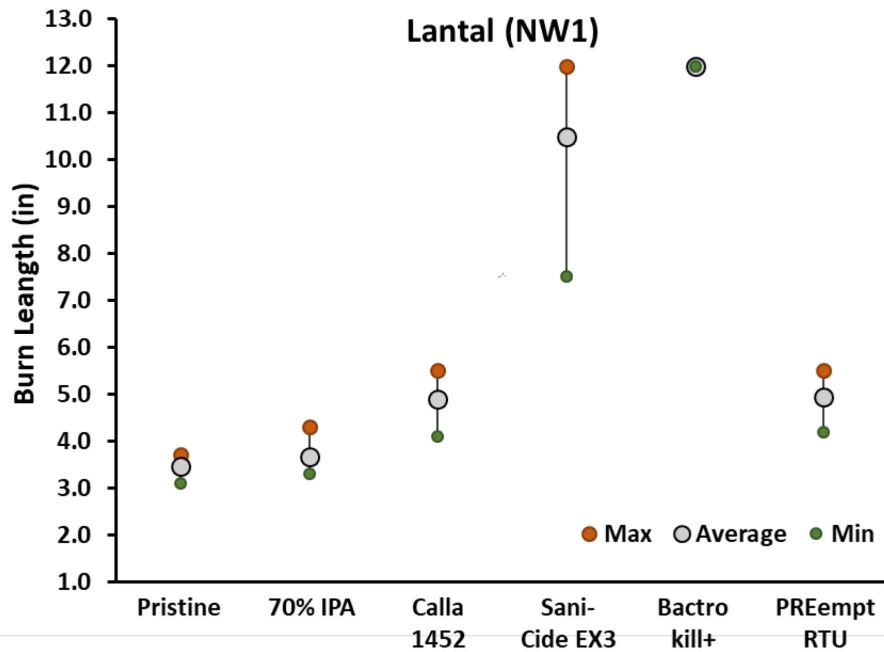


Figure 33. Burn length comparison for Lantal – submersion method

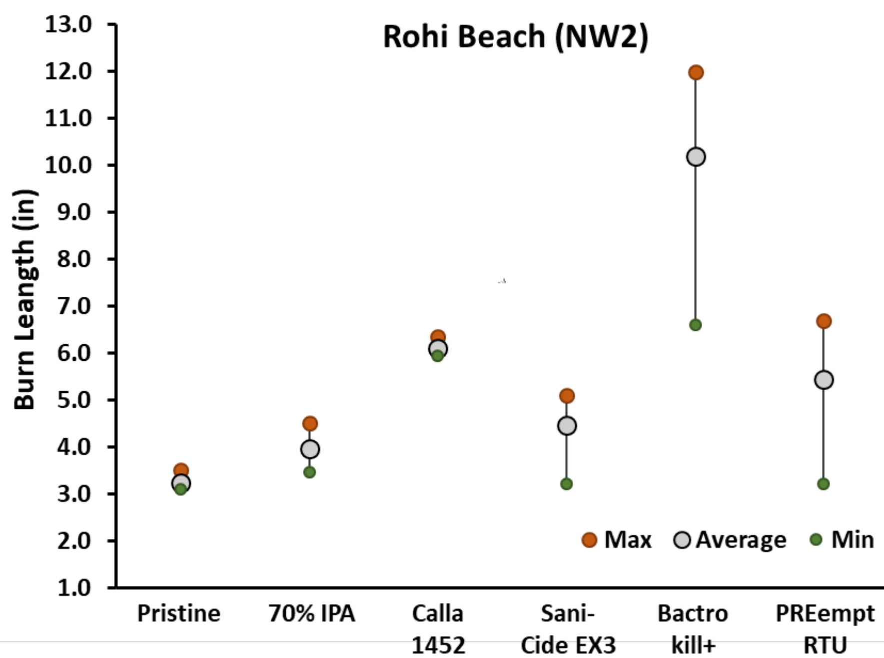


Figure 34. Burn length comparison for Rohi Beach – submersion method

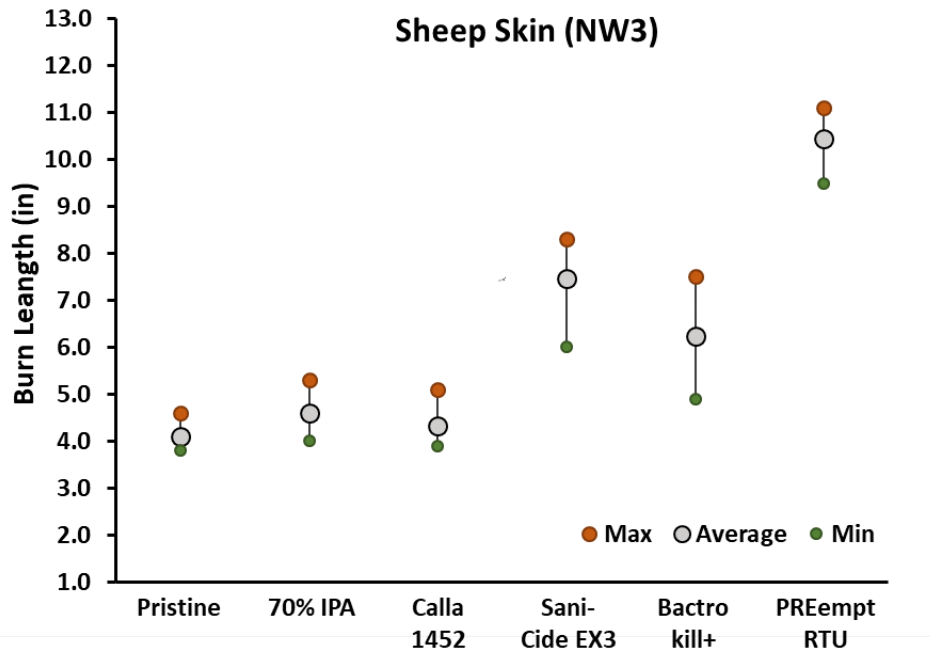


Figure 35. Burn length comparison for Sheep Skin – submersion method

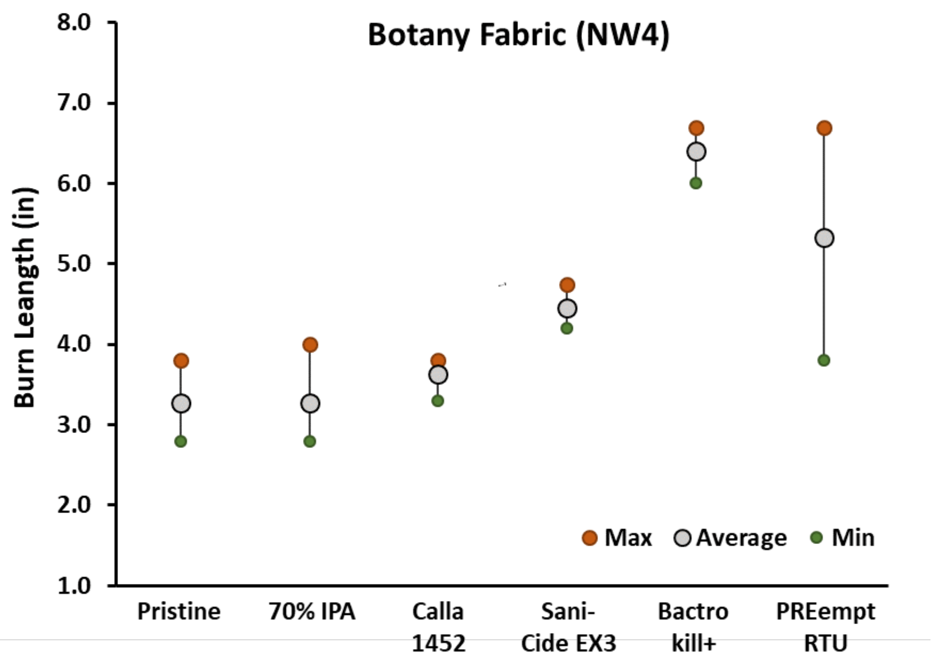


Figure 36. Burn length comparison for Botany fabric – submersion method

6.2.5 Seat webbing

6.2.5.1 Seat belt webbing – SCHROTH

For seatbelt webbing, control tests were conducted to determine the ignition time to be used for Vertical Bunsen Burn tests. Based on the results of the control test summarized in Table 40, it was decided that the 12-second ignition time would be used.

Table 40. Control flammability results for seatbelt webbing

Vertical Flammability Control Test Results for Seatbelt Webbing						
Material Name	After Flame Time (s)		Burn Length (in)		Drip Flame Time (s)	
	60s	12s	60s	12s	60s	12s
SCHROTH	57.39	0.00	3.30	3.60	8.00	2.00

After conducting control flammability tests, specimens of length 12" and width the same as the roll were cut and submerged in liquid disinfectants for 24 hours. After conditioning, specimens were tested according to the 12-seconds Vertical Bunsen Burn Test (14 CFR § 25.853). Results for the same have been summarized in Table 41. The change in the flammability properties for seatbelt webbings when conditioned with liquid disinfectants was considered normally equivalent to the untreated material.

Table 41. Flammability results for SCHROTH webbing (W1) – submersion method

Vertical Flammability Test Results for Schroth Webbing (W1)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	20.70	43.30	114.0	1.80	4.10	4.90	2.00	16.00	6.00
70% IPA	117.40	53.00	63.70	12.00	4.50	4.80	0.00	3.00	0.00
Calla 1452	64.40	41.10	97.90	4.20	3.80	4.80	0.00	2.00	11.00
Sani-Cide EX3	93.00	42.00	113.80	10.00	9.00	7.60	26.00	18.00	29.00
BactroKill+	89.00	49.00	43.00	8.20	4.60	3.40	31.00	9.00	11.00
PREempt RTU	43.40	40.00	36.00	3.20	3.10	3.30	3.00	6.00	5.00

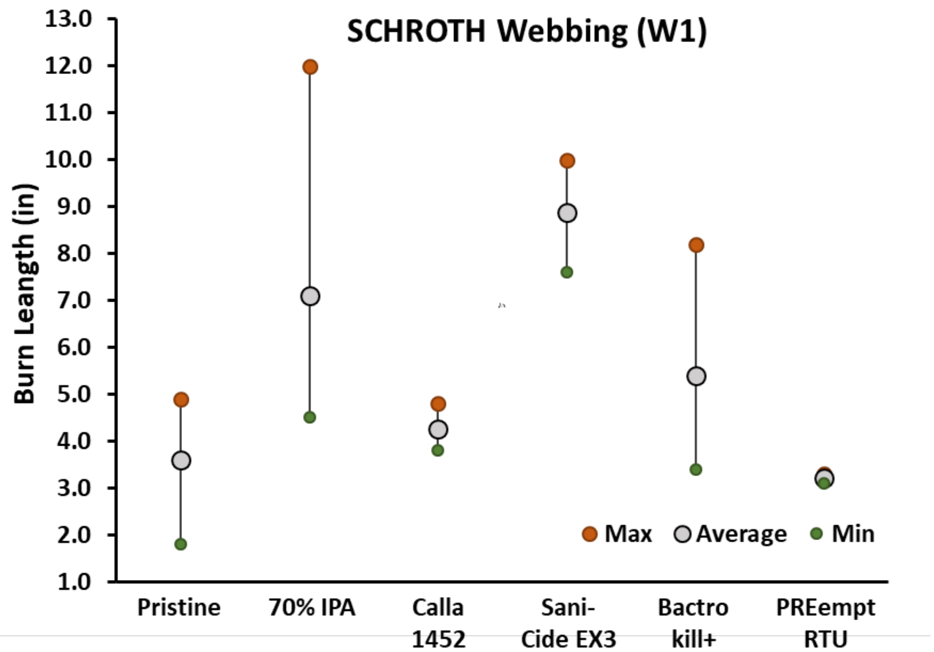


Figure 37. Burn length comparison for SCHROTH webbing

6.2.5.2 Seat belt webbing – AmSafe

Unlike other materials described in this section, the flammability tests for AmSafe polyester webbing were conducted by AmSafe. Furthermore, AmSafe included water in the test matrix and used 99% IPA instead of 70% IPA, as shown in Table 42.

Table 42. Test matrix for vertical flammability test of AmSafe seatbelt webbing

Material Name	Flammability Evaluation: Disinfectant Type						
	Pristine	Water	99% IPA	Calla 1452	Sani-Cide EX3	BactroKill+	PREempt RTU
AmSafe Polyester Webbing	x3	x3	x3	x3	x3	x3	x3

For AmSafe polyester webbing, the change in flammability properties was considered normally equivalent to the untreated material when conditioned with disinfectants, as summarized in Table 43 and Figure 38.

Table 43. Flammability results for AmSafe polyester webbing – submersion method

Vertical Flammability Test Results for AmSafe Polyester Webbing									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	73.00	90.00	125.00	5.00	6.50	5.50	33.00	88.00	98.00
Water	91.00	64.00	77.00	5.00	6.00	6.00	51.00	83.00	73.00
70% IPA	86.00	63.00	56.00	5.50	5.00	5.00	126.00	13.00	126.00
Calla 1452	63.00	61.00	95.00	6.00	4.50	5.00	45.00	29.00	53.00
Sani-Cide EX3	80.00	61.00	67.00	5.50	3.50	5.50	39.00	21.00	23.00
BactroKill+	164.00	76.00	130.00	8.50	7.50	8.00	84.00	95.00	42.00
PREempt RTU	69.00	223.00	86.00	5.00	11.00	5.00	73.00	184.00	38.00

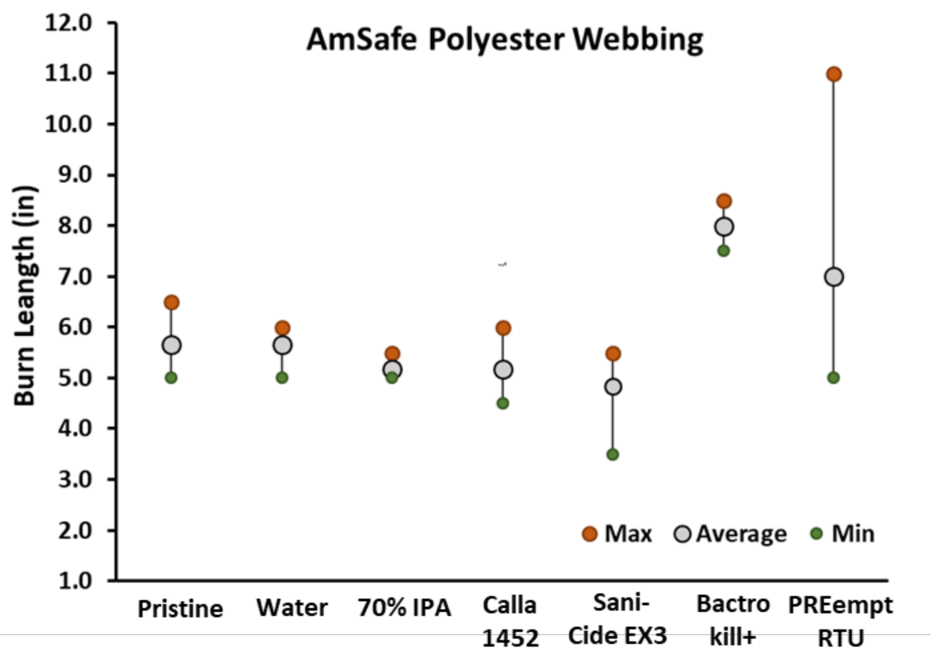


Figure 38. Burn length comparison for AmSafe polyester webbing – submersion method

6.2.6 Summary

Vertical Bunsen Burner Tests were conducted to evaluate the effect of using liquid disinfectants through soaking on the flammability properties of the materials. A criterion was defined in Section 6.1 to determine the performance of the flammability results. Results based on this criterion are summarized in Table 44.

Table 44. Flammability results summary – submersion method

Material Type	Material Name	Disinfectant Type				
		70% IPA*	Calla 1452	Sani-Cide EX3	BactroKill+	PREempt RTU
Plastic	Kydex 6565					
	Boltaron 9815E					
	Lexan XHR					
	Boltaron 9815N					
Synthetic Leather	E-Leather CL280					
	Ultrafabric 492-6579FR12					
	TapiSuede TSFRC0961					
	Ultraleather ULFRB971-1363					
Wool/Nylon Blend	Lantal					
	Rohi Beach					
	Sheepskin					
	Botany Fabric					
Leather	Pewter BC (Perrone)					
	Perrone Feather Weight					
Webbing	SCHROTH					
	AmSafe Polyester					

Increase in average burn length is less than or equal to approximately 50 % of the average burn length obtained from the unconditioned specimens test data.

Increase in average burn length is greater than approximately 50% of the average burn length obtained from the unconditioned specimens test data.

Increase in average burn length is less than 6” when compared against unconditioned specimens and self-extinguishing

*AmSafe Polyester webbing specimens were conditioned with 99% IPA.

6.3 Vertical flammability – wiping method

Materials for which the flammability results were significantly different when following the submersion process were revaluated by conditioning them following the wiping methodology. Wiping methodology was considered more realistic and is explained in section 4.2. For each material type, three specimens were tested as shown in Table 45.

Table 45. Test matrix for vertical flammability tests – wiping method

Material Type	Material Name	Flammability Evaluation: Disinfectant Type				
		70% IPA	Calla 1452	Sani-Cide EX3	BactroKill+	PREempt RTU
Synthetic Leather	E-Leather CL820	x3	x3	x3	x3	x3
	Ultrafabric 492-6579FR12	-	x3	x3	x3	x3
	Ultraleather ULFRB971-1363	-	x3	x3	x3	x3
Wool/Nylon Blend	Lantal	-	-	X3	x3	-
	Rohi Beach	-	X3	X3	x3	X3
	Sheepskin	-	-	X3	x3	X3
	Botany Fabric	-	-	-	x3	X3
Leather	Murihead DF602	x3	X3	X3	x3	x3
	Pewter BC (Perrone)	-	x3	x3	x3	x3
	Perrone Feather Weight	-	-	x3	x3	x3

6.3.1 Leather

For Muirhead DF602, the change in flammability properties was considered normally equivalent to the untreated material when conditioned with Calla 1452 and BactroKill. However, the increase in average burn length was significantly different when conditioned with 70% IPA, Sani-Cide EX3, and PREempt RTU, as shown in Figure 39. The flammability test results are summarized in Table 46.

For Perrone Pewter BC, the change in flammability properties was significantly different when conditioned with all the selected disinfectants, as summarized in Table 47 and Figure 40

For Perrone Feather Weight, the change in flammability properties was considered normally equivalent to the untreated material when conditioned with all the selected disinfectants, as summarized in Table 48 and Figure 41.

Table 46. Flammability results for Muirhead DF602 – wiping method

Vertical Flammability (Wiping Method) Test Results for Muirhead DF602 (L1)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	3.00	1.90	2.30	0.00	0.00	0.00
70% IPA	0.00	0.00	0.00	3.70	4.60	4.00	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	3.90	2.65	3.65	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	3.10	4.60	3.30	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	2.80	3.10	2.90	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	3.30	5.80	3.60	0.00	0.00	0.00

Table 47. Flammability results for Perrone Pewter BC – wiping method

Vertical Flammability (Wiping Method) Test Results for Perrone Pewter BC (L2)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	3.30	3.00	3.60	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	5.00	5.30	4.90	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	6.00	5.80	5.70	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	4.60	5.60	5.30	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	5.10	5.30	5.90	0.00	0.00	0.00

Table 48. Flammability results for Perrone Feather Weight – wiping method

Vertical Flammability (Wiping Method) Test Results for Perrone Feather Weight (L3)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	4.80	4.90	5.00	0.00	0.00	0.00
Sani-Cide EX3	96.00	0.00	0.00	12.00	2.80	4.00	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	6.70	4.60	5.00	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	5.60	7.30	7.90	0.00	0.00	0.00

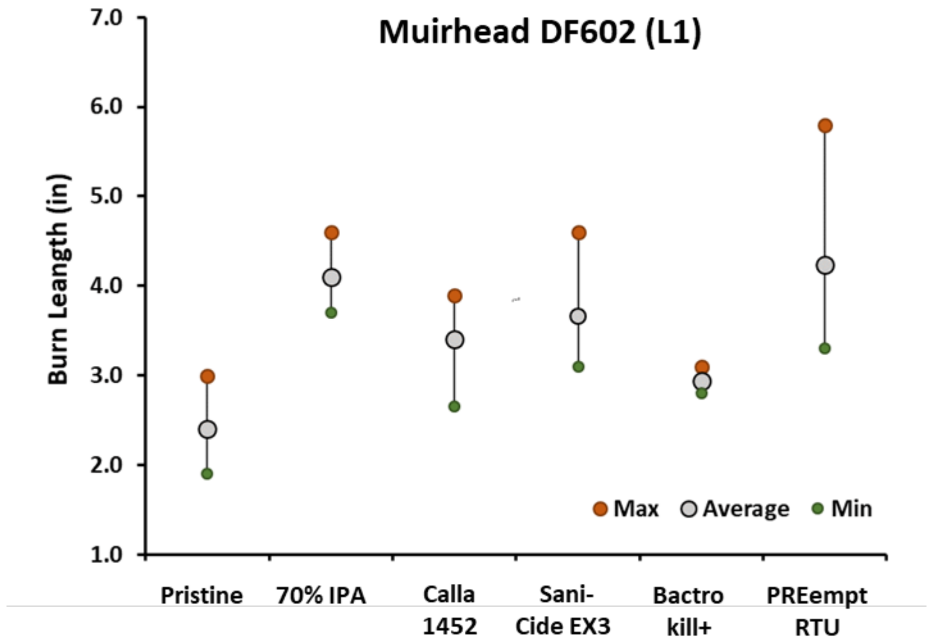


Figure 39. Burn length comparison for Muirhead DF602 – wiping method

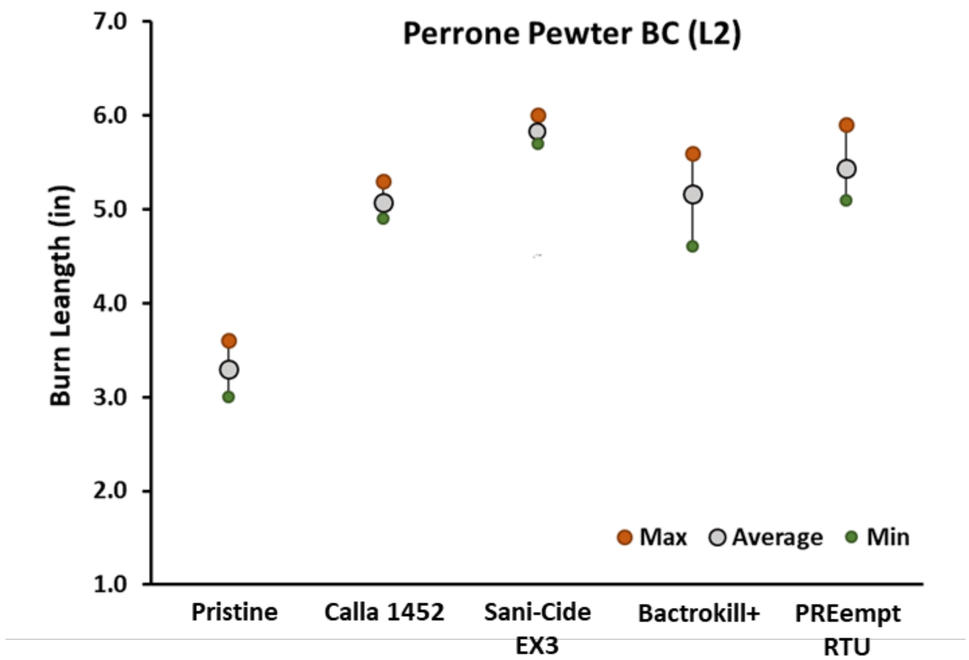


Figure 40. Burn length comparison for Perrone Pewter BC – wiping method

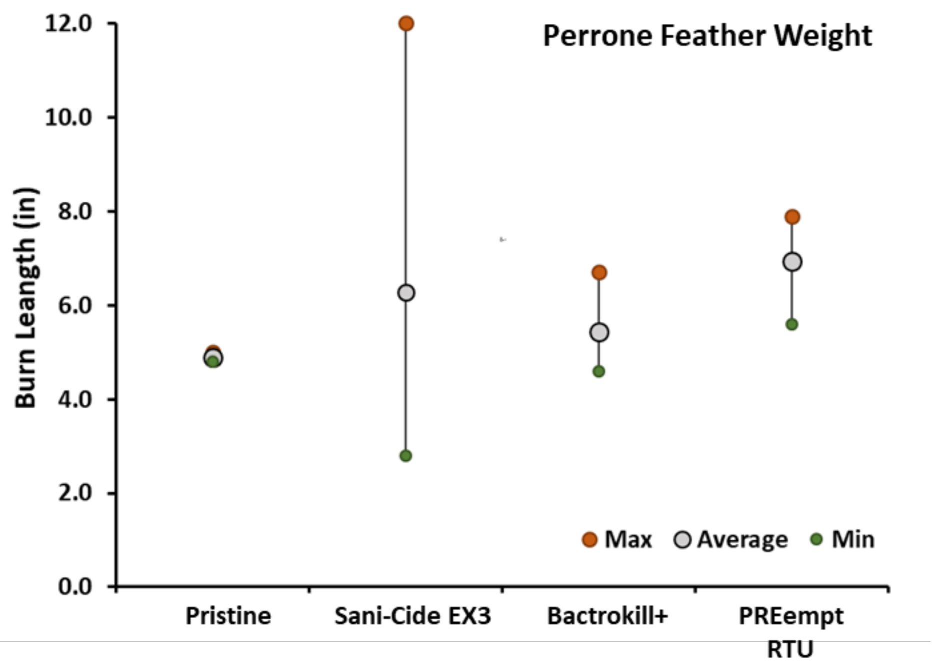


Figure 41. Burn length comparison for Perrone Feather Weight – wiping method

6.3.2 Synthetic leather

For E-Leather CL820, the change in flammability properties was considered normally equivalent to the untreated material when conditioned with the selected disinfectants, as summarized in Table 49 and Figure 42.

For Ultra Fabric 492-6579FR12, the change in flammability properties was considered normally equivalent to the untreated material when conditioned with the selected disinfectants, as summarized in Table 50 and Figure 43.

For Ultraleather ULFRB971-1363, the change in flammability properties was considered normally equivalent to the untreated material when conditioned with the selected disinfectants, as summarized in Table 51 and Figure 44.

Table 49. Flammability results for E-Leather CL820 – wiping method

Vertical Flammability (Wiping Method) Test Results for E-Leather CL820 (SL1)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
70% IPA	0.00	0.00	0.00	5.90	6.00	6.50	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	5.50	4.60	5.30	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	5.00	5.70	5.50	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	5.40	5.70	6.40	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	4.80	5.90	6.00	0.00	0.00	0.00

Table 50. Flammability results for Ultrafabric 492-6579FR12 – wiping method

Vertical Flammability (Wiping Method) Test Results for Synthetic Leather – Ultrafabric 492-6579FR12 (SL2)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	4.20	4.10	3.80	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	4.40	4.10	4.20	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	3.70	3.60	3.50	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	3.70	4.00	4.00	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	4.10	3.40	3.80	0.00	0.00	0.00

Table 51. Flammability results for Ultraleather ULFRB971-1363 – wiping method

Vertical Flammability (Wiping Method) Test Results for Synthetic Leather – Ultraleather ULFRB971-1363 (SL4)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	5.50	5.80	5.70	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	5.00	4.15	4.80	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	4.60	4.70	4.30	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	4.20	4.95	5.10	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	4.85	4.70	4.80	0.00	0.00	0.00

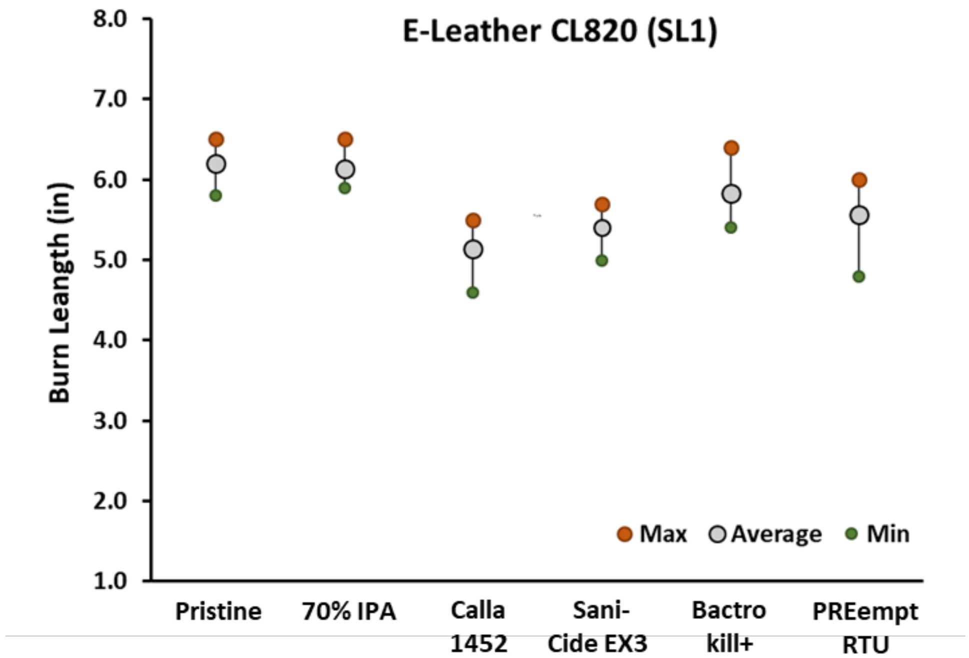


Figure 42. Burn length comparison for E-Leather CL820 – wiping method

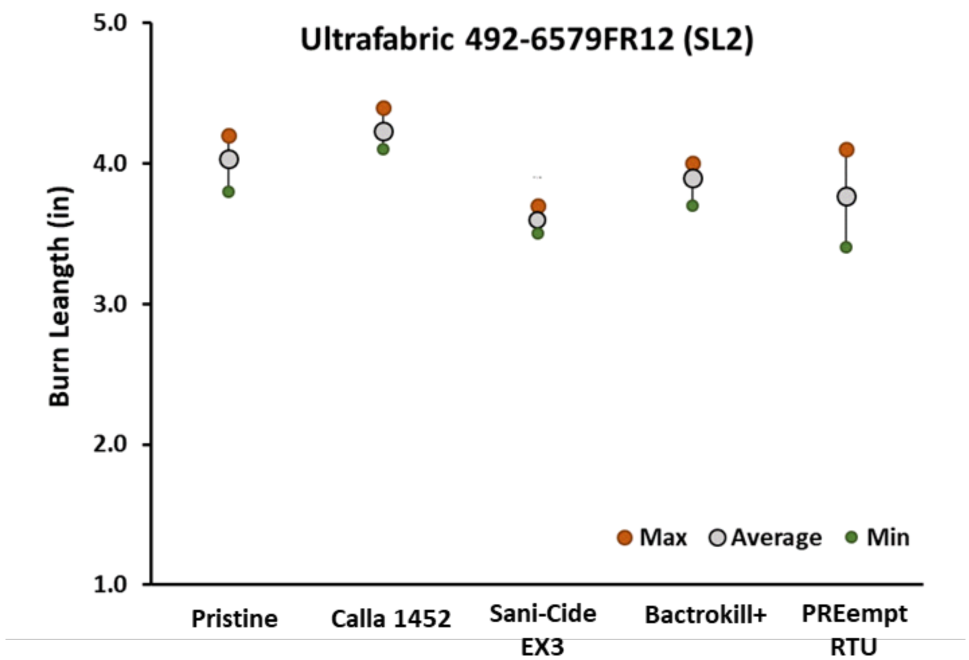


Figure 43. Burn length comparison for Ultrafabric 492-6579FR12 – wiping method

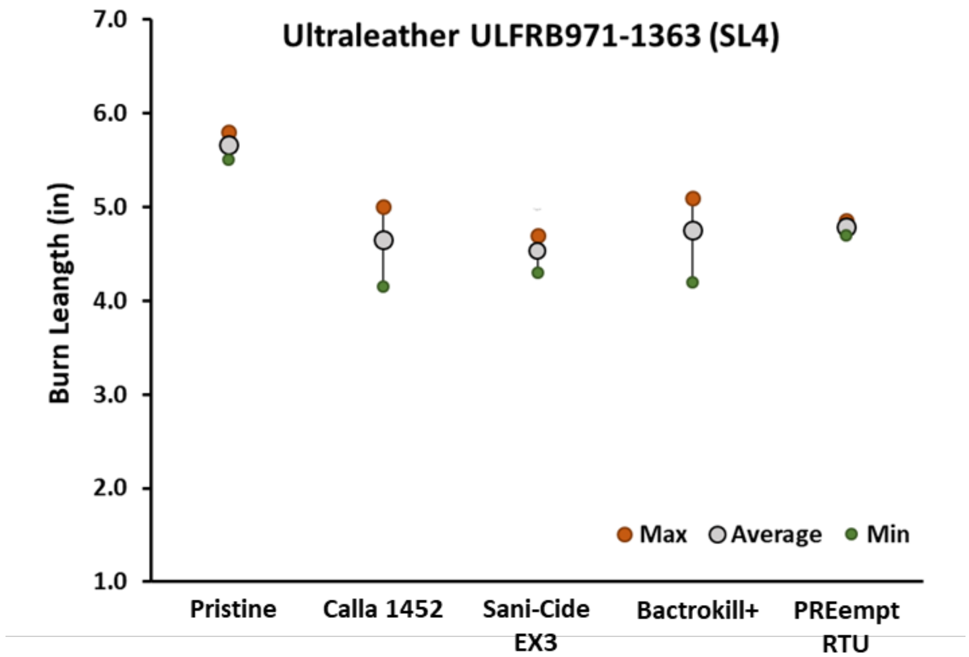


Figure 44. Burn length comparison for Ultraleather ULFRB971-1363 – wiping method

6.3.3 Wool/Nylon blend

For Lantal, the change in flammability properties was considered normally equivalent to the untreated material when conditioned with BactroKill+. However, the increase in average burn length was significantly different when conditioned with Sani-Cide EX3, as shown in Figure 45. The flammability test results are summarized in Table 52.

For Rohi Beach, the change in flammability properties was considered normally equivalent to the untreated material when conditioned with Calla 1452 and PREempt RTU. However, the increase in average burn length was considered significantly different when conditioned with Sani-Cide EX3 and BactroKill+, as shown in Figure 46. The flammability test results are summarized in Table 53.

For Sheepskin, the increase in average burn length was considered significantly different when conditioned with the selected disinfectants, as summarized in Table 54 and Figure 47.

For Botany Fabric, the increase in average burn length was considered significantly different when conditioned with the BactroKill+ and PREempt RTU, as summarized in Table 55 and Figure 48.

Table 52. Flammability results for Lantal – wiping method

Vertical Flammability (Wiping Method) Test Results for Nylon/Wool Blend – Lantal (NW1)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	3.70	3.60	3.10	0.00	0.00	0.00
Sani-Cide EX3	45.00	26.00	29.00	12.00	12.00	12.00	8.00	14.00	18.00
BactroKill+	0.00	0.00	0.00	4.80	4.40	5.10	0.00	0.00	0.00

Table 53. Flammability results for Rohi Beach – wiping method

Vertical Flammability (Wiping Method) Test Results for Nylon/Wool Blend – Rohi Beach (NW2)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	3.10	3.10	3.50	0.00	0.00	0.00
Calla 1452	0.00	0.00	0.00	4.55	4.00	3.80	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	6.00	5.30	5.00	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	4.80	4.85	5.40	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	4.40	4.75	3.70	0.00	0.00	0.00

Table 54. Flammability results for Sheepskin – wiping method

Vertical Flammability (Wiping Method) Test Results for Nylon/Wool Blend – Sheepskin (NW3)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	5.60	5.90	6.50	0.00	0.00	0.00
Sani-Cide EX3	0.00	0.00	0.00	12.00	12.00	12.00	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	10.90	10.40	10.70	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	8.90	10.10	9.70	0.00	0.00	0.00

Table 55. Flammability results for Botany fabric – wiping method

Vertical Flammability (Wiping Method) Test Results for Nylon/Wool Blend – Botany Fabric (NW4)									
Disinfectant Type	After Flame Time (s)			Burn Length (in)			Drip Flame Time (s)		
	#1	#2	#3	#1	#2	#3	#1	#2	#3
No Conditioning	0.00	0.00	0.00	3.80	3.20	2.80	0.00	0.00	0.00
BactroKill+	0.00	0.00	0.00	6.30	5.10	4.90	0.00	0.00	0.00
PREempt RTU	0.00	0.00	0.00	6.80	4.60	4.90	0.00	0.00	0.00

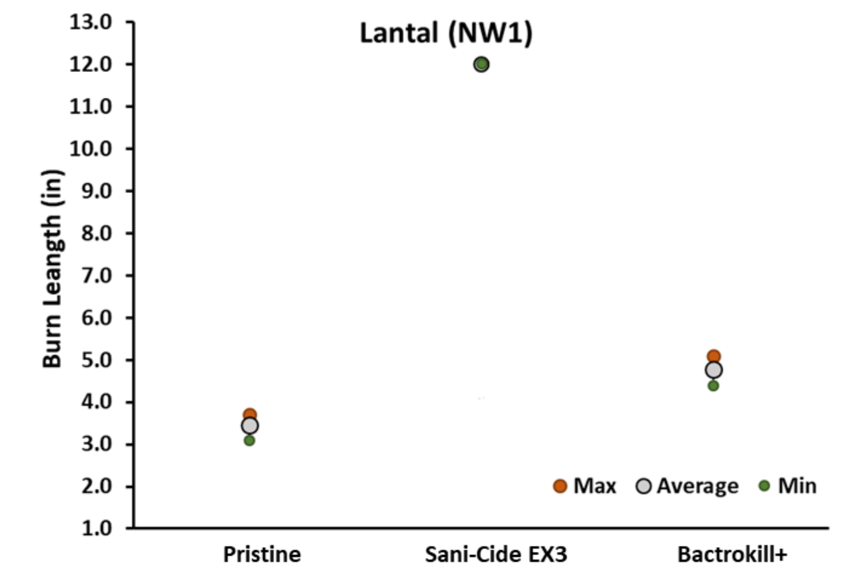


Figure 45. Burn length comparison for Lantal – wiping method

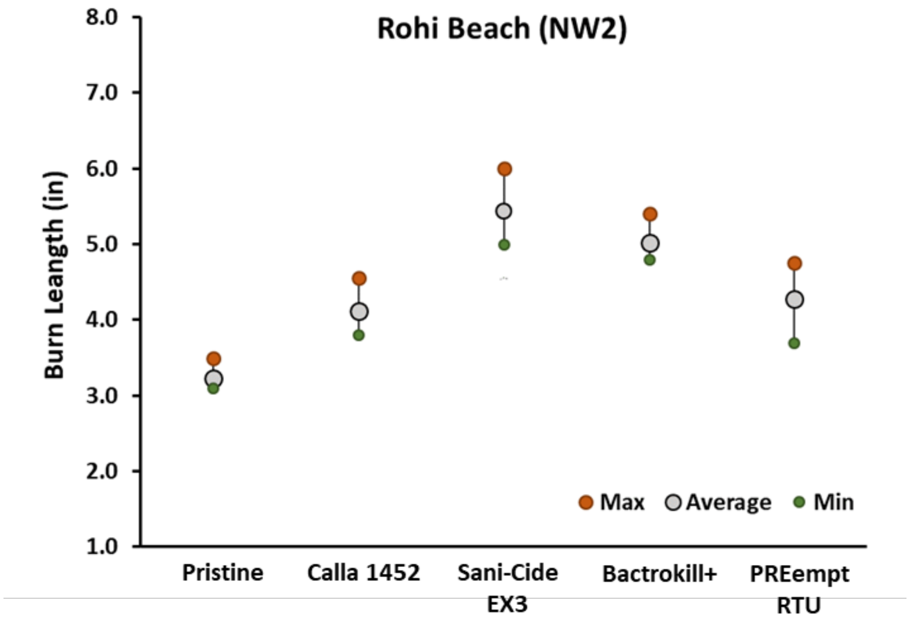


Figure 46. Burn length comparison for Rohi Beach – wiping method

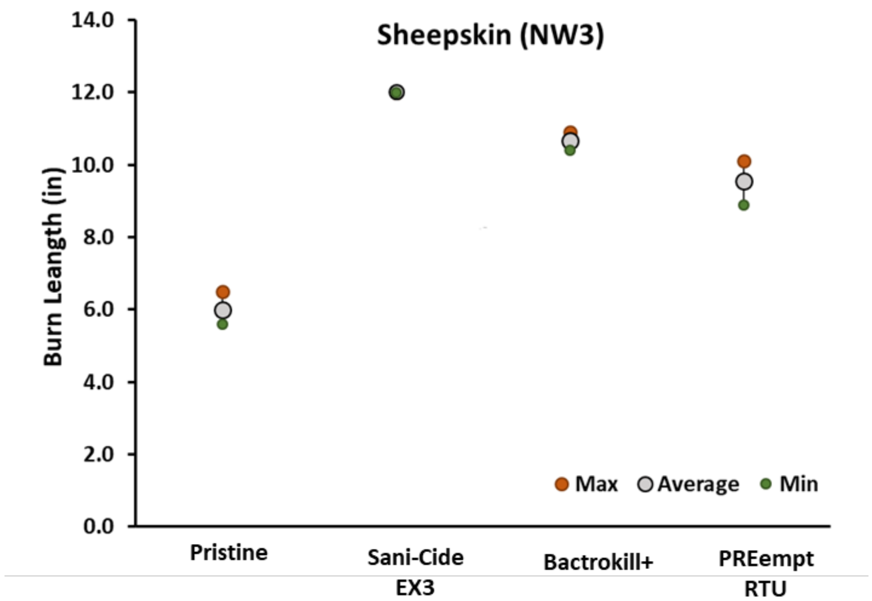


Figure 47. Burn length comparison for Sheepskin – wiping method

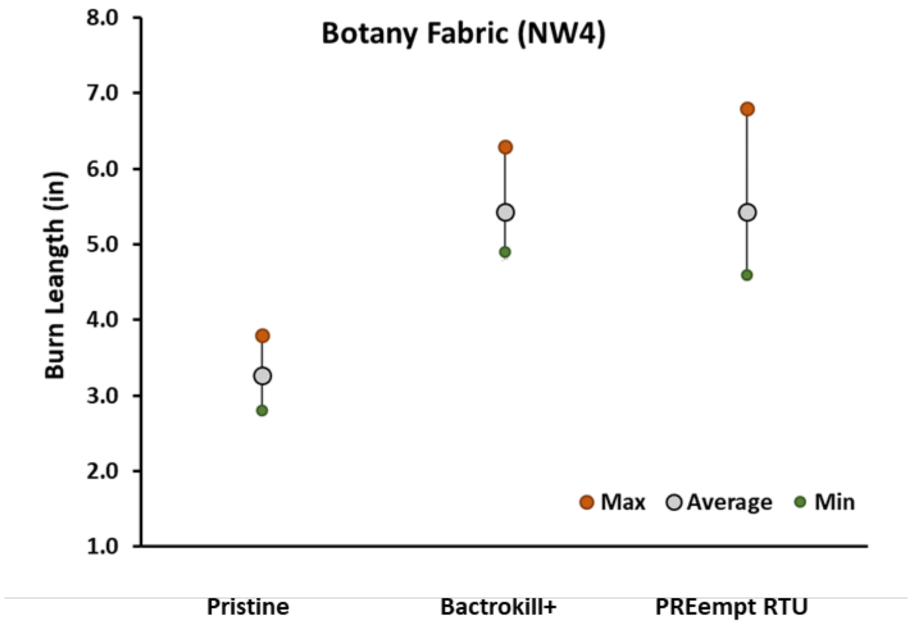


Figure 48. Burn length comparison for Botany fabric – wiping method

6.3.4 Summary

Vertical Bunsen Burner Tests were conducted to evaluate the effect of using liquid disinfectants on the flammability properties of selected materials using the wiping methodology. To determine the performance of the flammability results, criterion defined in Section 6.1 was used. Results based on this criterion are summarized in Table 56.

Table 56 Flammability results summary – wiping method

Material Type	**Material Name**	**Disinfectant Type**				
		70% IPA	**Calla 1452**	**Sani-Cide EX3**	**BactroKill+**	**PREempt RTU**
Synthetic Leather	E-Leather CL280	[green]	[green]	[green]	[green]	[green]
	Ultrafabric 492-6579FR12		[green]	[green]	[green]	[green]
	Ultraleather ULFRB971-1363		[green]	[green]	[green]	[green]
Wool/Nylon Blend	Lantal			[red]	[green]	
	Rohi Beach		[green]	[red]	[red]	[green]
	Sheepskin			[red]	[red]	[red]
	Botany Fabric				[red]	[red]
Leather	Muirhead DF602	[red]	[green]	[red]	[green]	[red]
	Pewter BC (Perrone)		[green]	[green]	[green]	[green]
	Perrone Feather Weight			[green]	[green]	[green]

[green] Increase in average burn length is less than or equal to approximately 50% of the average burn length obtained from the unconditioned specimens test data.

[red] Increase in average burn length is greater than approximately 50% of the average burn length obtained from the unconditioned specimens test data.

[white] Normally equivalent results obtained when conditioned using submersion method

7 Physical properties

In this investigation, the effect of liquid disinfectants was evaluated on the weight, color, and permeability of all the materials. The details of the test methods and observations are discussed in this section.

7.1 Weight change – submersion method

Weight was measured to an accuracy of 0.01g before submerging the specimens in liquid disinfectants and after letting them dry according to the conditioning methodology described in Section 4.1. The change in weight for the materials is summarized in Table 57 through Table 61. No significant weight increase was observed for any material type when conditioned with liquid disinfectants.

Table 57. Weight change comparison of Plastics – submersion method

Plastic Type	**Average Recorded Weight (g)**									
	70% IPA		Calla 1452		Sani-cide EX3		BactroKill +		PREempt RTU	
	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)
Kydex 6565	39.04	39.04	39.48	39.57	39.40	39.49	39.39	39.40	39.60	39.61
Boltaron 9815E	46.03	46.09	45.09	45.15	45.03	45.09	45.95	46.01	45.15	45.24
Lexan XHR	45.72	45.81	45.66	45.74	45.27	45.33	45.71	45.75	45.73	45.77
Boltaron 9815N	41.92	41.91	40.44	40.46	40.67	40.66	39.81	39.80	40.35	40.62

Table 58. Weight change comparison of Leather – submersion method

Leather Type	**Average Recorded Weight (g)**									
	70% IPA		Calla 1452		Sani-cide EX3		BactroKill +		PREempt RTU	
	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)
Perrone Pewter BC	24.88	22.95	24.68	23.09	24.93	25.15	25.13	23.39	25.19	25.23
Perrone Feather Weight	21.87	20.91	21.95	22.31	22.39	24.51	21.74	22.59	17.91	19.62

Table 59. Weight change comparison of Synthetic leather – submersion method

Synthetic Leather Type	Average Recorded Weight (g)									
	70% IPA		Calla 1452		Sani-cide EX3		BactroKill +		PREempt RTU	
	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)
E-Leather CL820	7.92	6.91	7.80	6.83	7.80	7.94	7.88	7.22	7.83	7.38
Ultrafabrics 492-6579FR12	13.18	12.31	13.17	11.29	13.15	12.03	13.10	11.31	13.19	11.55
TapiSuede TSFRC0961	13.19	12.83	13.58	13.60	12.89	13.21	12.64	13.04	13.48	13.53
Ultraleather ULFRB 971-1363	11.13	10.10	11.10	9.29	11.03	9.55	11.05	9.35	11.13	9.34

Table 60. Weight change comparison of Nylon/Wool blend – submersion method

Nylon/Wool Type	Average Recorded Weight (g)									
	70% IPA		Calla 1452		Sani-cide EX3		BactroKill +		PREempt RTU	
	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)
Lantal	8.90	8.91	8.92	8.99	8.89	10.53	9.03	9.49	8.90	10.29
Rohi Beach	11.26	11.42	11.29	11.60	11.24	12.97	11.23	12.02	11.32	13.03
Sheep Skin	45.64	44.78	46.04	58.95	49.08	54.45	47.06	49.83	36.26	44.67
Botany Fabric	12.14	12.24	12.11	12.53	11.96	13.18	11.91	12.51	12.03	13.82

Table 61. Weight change comparison of seatbelt webbing – submersion method

Webbing Type	Average Recorded Weight (g)									
	70% IPA		Calla 1452		Sani-cide EX3		BactroKill +		PREempt RTU	
	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)
Schroth Webbing	15.26	15.25	15.24	15.31	15.43	15.42	15.39	15.41	15.39	15.36

7.2 Weight change – wiping method

Weight was measured to an accuracy of 0.01g before and after conditioning the specimens with the wiping methodology, as described in Section 4.2. The change in weight for the materials is summarized in Table 62 through Table 64. No significant weight increase was observed for the selected materials.

Table 62. Weight change comparison of Leather – wiping method

Leather Type	Average Recorded Weight (g)									
	70% IPA		Calla 1452		Sani-cide EX3		BactroKill +		PREempt RTU	
	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)
Murihead DF602	18.28	18.05	18.39	18.17	18.12	18.58	18.63	18.48	18.48	18.65
Perrone Pewter BC			20.97	20.95	21.45	22.70	21.97	22.10	21.93	22.35
Perrone Feather Weight					19.82	21.96	21.52	21.92	20.71	21.46

Table 63. Weight change comparison of Synthetic leather – wiping method

Synthetic Leather Type	Average Recorded Weight (g)									
	70% IPA		Calla 1452		Sani-cide EX3		BactroKill +		PREempt RTU	
	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)
E-Leather CL820	7.70	7.72	7.72	7.78	7.76	8.46	7.70	7.82	7.88	8.21
Ultrafabrics 492-6579FR12			14.84	14.80	14.79	15.63	14.79	14.98	15.04	15.40
Ultraleather ULFRB 971-1363			11.02	11.01	11.04	12.29	11.02	11.34	11.22	11.73

Table 64. Weight change comparison of Nylon/Wool – wiping method

Nylon/Wool Type	Average Recorded Weight (g)							
	Calla 1452		Sani-cide EX3		BactroKill +		PREempt RTU	
	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)	Pre (g)	Post (g)
Lantal			10.54	15.66	10.60	12.78		
Rohi Beach	11.11	11.36	11.17	14.50	11.18	13.09	11.14	13.85
Sheepskin			34.16	36.12	34.03	33.85	33.79	33.31
Botany Fabric					12.09	15.31	12.14	15.53

7.3 Color change – submersion method

In this investigation, the effects of the liquid disinfectants on the material color was evaluated. A qualitative comparison was done by capturing images of test specimens before and after conditioning. Additionally, samples of size 3” x 3” were conditioned to do a quantitative color comparison using a color spectrometer.

7.3.1 Qualitative change

Table 65 summarizes qualitative color change due to conditioning of all the materials with liquid disinfectants following the submersion method. A comparison of the images before and after conditioning for all the materials is shown in Figure 50 through Figure 68.

For plastic specimens, paper clips corroded when conditioned with 70% IPA and Calla 1452 causing the edges to be stained. Besides the staining due to the paper clip, there was no qualitative color change observed for plastic specimens.

For synthetic leather, color changes were observed for TapiSuede when conditioned with Sani-Cide EX3. No significant changes in color were observed for the other synthetic leathers.

For Wool/Nylon blend, color changes were observed for Lantal, Rohi Beach, and Sheepskin. Color change was observed for all the three materials when conditioned with PREempt RTU. Additionally, Lantal, when treated with Sani-Cide EX 3, and Sheepskin, when treated with Calla 1452 and Bactrokill+, showed changes in color.

For Leather, both the materials, when conditioned with BactroKill+, had a sticky texture leading to qualitative color change. Additionally, Perrone Feather Weight, when conditioned with PREempt RTU, led to a similar color change.

Table 65. Qualitative color change summary – submersion method

Material Type	Material Name	Liquid Disinfectant Type				
		70% IPA	Calla 1452	Sani-Cide EX3	BactroKill+	PREempt RTU
Plastic	Kydex 6565	Staining of Material due to Paper Clips	Staining of Material due to Paper Clips	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture
	Boltaron 9815E	Staining of Material due to Paper Clips	Staining of Material due to Paper Clips	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture
	Lexan XHR	Staining of Material due to Paper Clips	Staining of Material due to Paper Clips	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture
	Boltaron 9815N	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture
Synthetic Leather	E-Leather CL280	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture
	Ultrafabric 492-6579FR12	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture
	TapiSuede TSFRC0961	No Change in Color or Texture	Change in Color Only	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture
	Ultraleather ULFRB971-1363	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture
Wool/Nylon Blend	Lantal	No Change in Color or Texture	No Change in Color or Texture	Change in Color Only	No Change in Color or Texture	Change in Color Only
	Rohi Beach	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture	Change in Color Only
	Sheepskin	No Change in Color or Texture	Change in Color Only	No Change in Color or Texture	Change in Color Only	Change in Color Only
	Botany Fabric	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture
Leather	Pweter BC	No Change in Color or Texture	Change in Color Only	No Change in Color or Texture	Change in Color and Texture	No Change in Color or Texture
	Perrone WA9374	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture	Change in Color and Texture	Change in Color and Texture
Webbing	SCHROTH	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture	No Change in Color or Texture

- No Change in Color or Texture
- Change in Color Only
- Change in Color and Texture
- Staining of Material due to Paper Clips

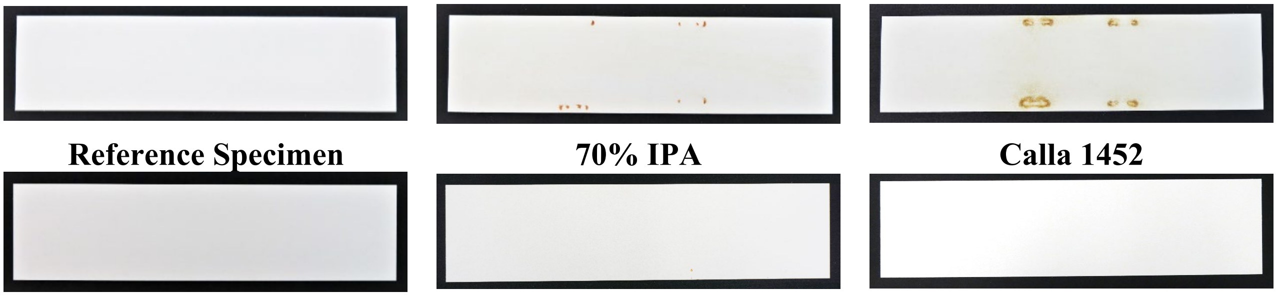


Figure 49. Color qualitative comparison with submersion method – Kydex6565

Figure 50. Color qualitative comparison with submersion method – Boltaron 9815E

Figure 51. Color qualitative comparison with submersion method – Lexan XHR shade 1

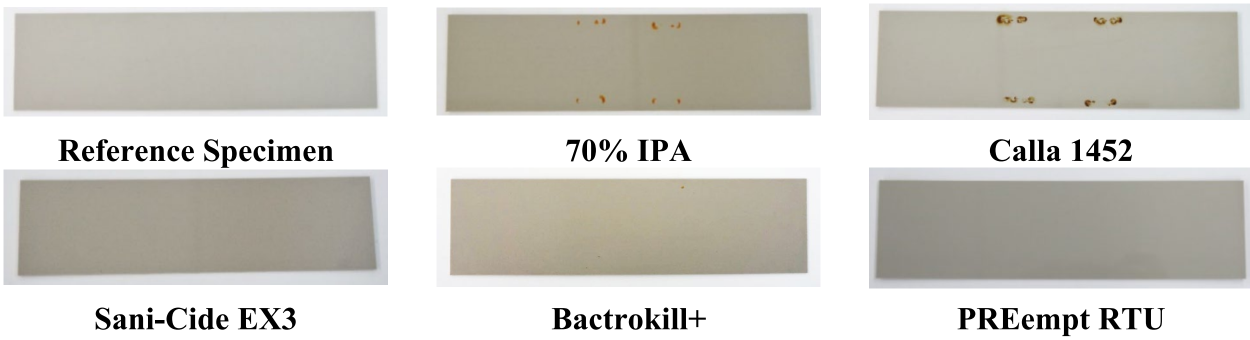


Figure 52. Color qualitative comparison with submersion method – Lexan XHR shade 2

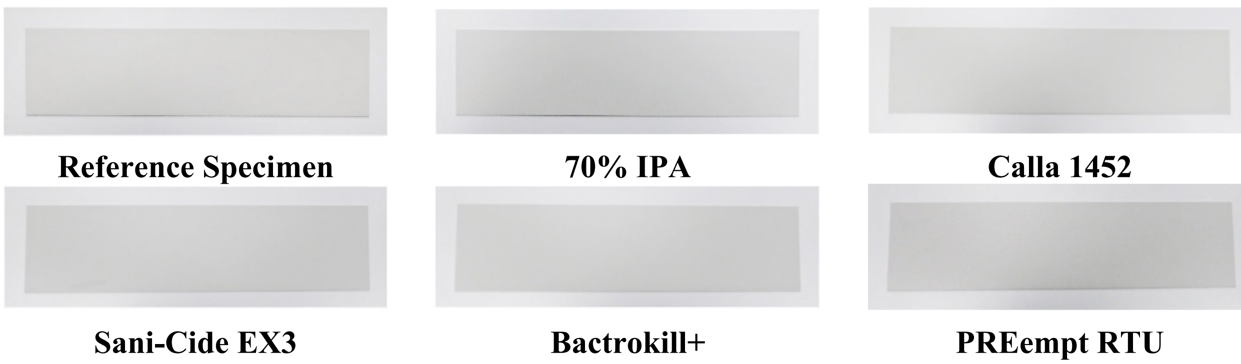


Figure 53. Color qualitative comparison with submersion method – Boltaron 9815N

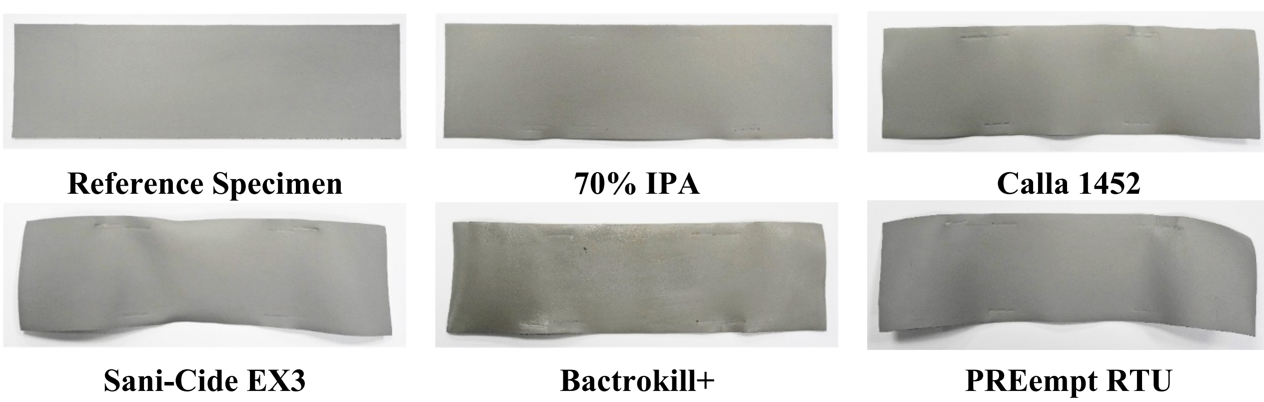


Figure 54. Color qualitative comparison with submersion method – Perrone Pewter BC

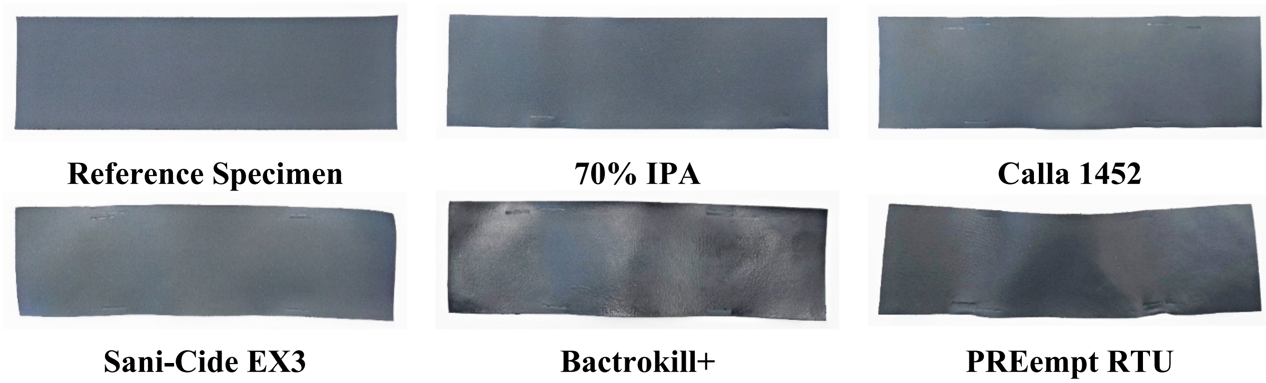


Figure 55. Color qualitative comparison with submersion method – Perrone Feather Weight

Figure 56. Color qualitative comparison with submersion method – E-Leather CL820 front face

Figure 57. Color qualitative comparison with submersion method – E-Leather CL820 back face

Reference Specimen | **70% IPA** | **Calla 1452**

Sani-Cide EX3 | **Bactrokill+** | **PREempt RTU**

Figure 58. Color qualitative comparison with submersion method – Ultrafabrics 492-6579FR12 front face

Reference Specimen | **70% IPA** | **Calla 1452**

Sani-Cide EX3 | **Bactrokill+** | **PREempt RTU**

Figure 59. Color qualitative comparison with submersion method – Ultrafabrics 492-6579FR12 back face

Reference Specimen | **70% IPA** | **Calla 1452**

Sani-Cide EX3 | **Bactrokill+** | **PREempt RTU**

Figure 60. Color qualitative comparison with submersion method – Tapisuede TSFRC0961 front face

Figure 61. Color qualitative comparison with submersion method – Tapisuede TSFRC0961 back face

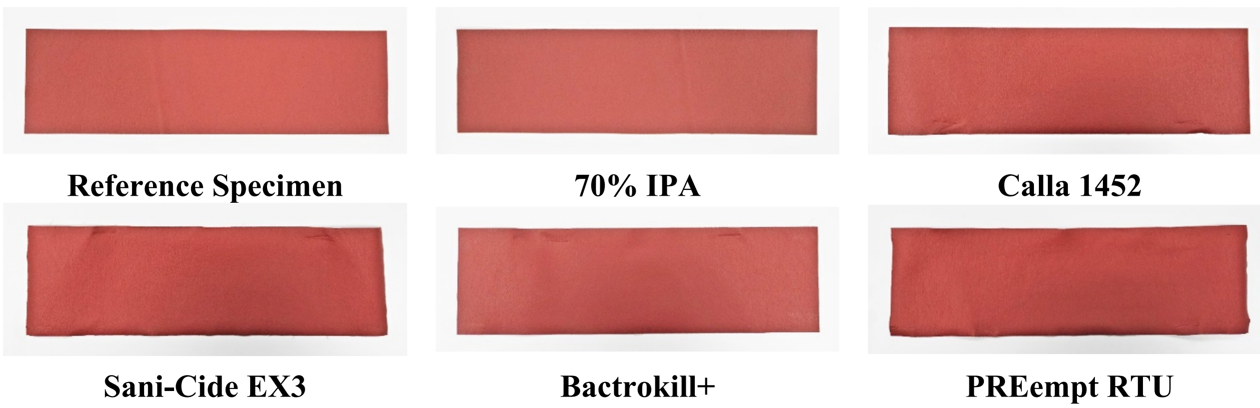


Figure 62. Color qualitative comparison with submersion method – Ultraleather ULFRB971-1363 front face

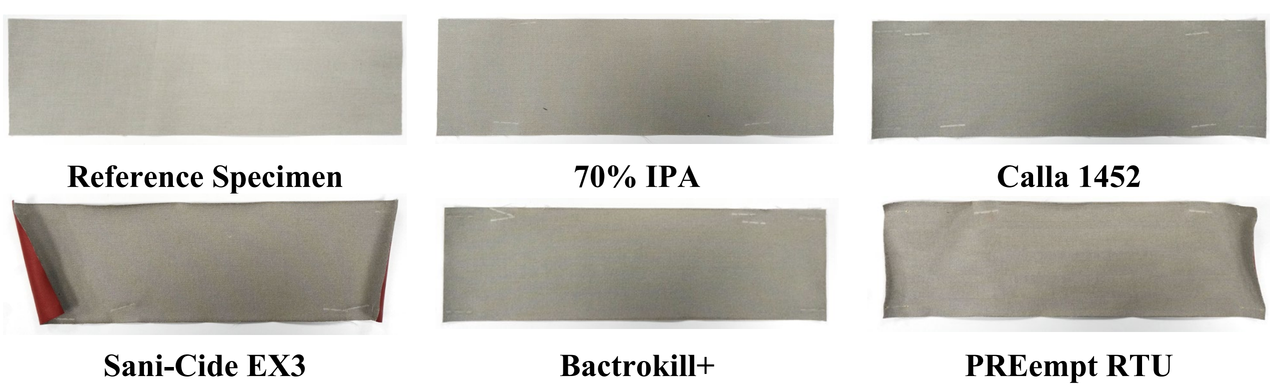


Figure 63. Color qualitative comparison with submersion method – Ultraleather ULFRB971-1363 back face

Figure 64. Color qualitative comparison with submersion method – Lantal

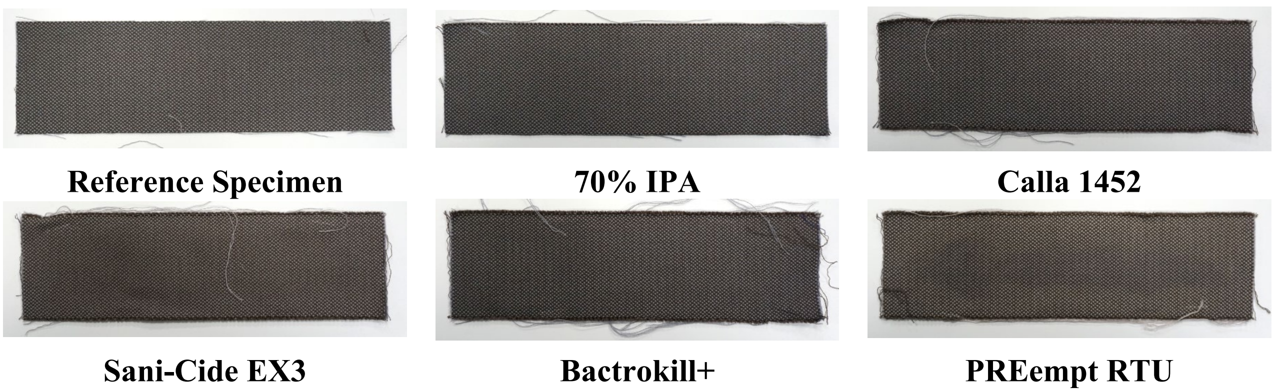


Figure 65. Color qualitative comparison with submersion method – Rohi Beach

Figure 66. Color qualitative comparison with submersion method – Sheepskin

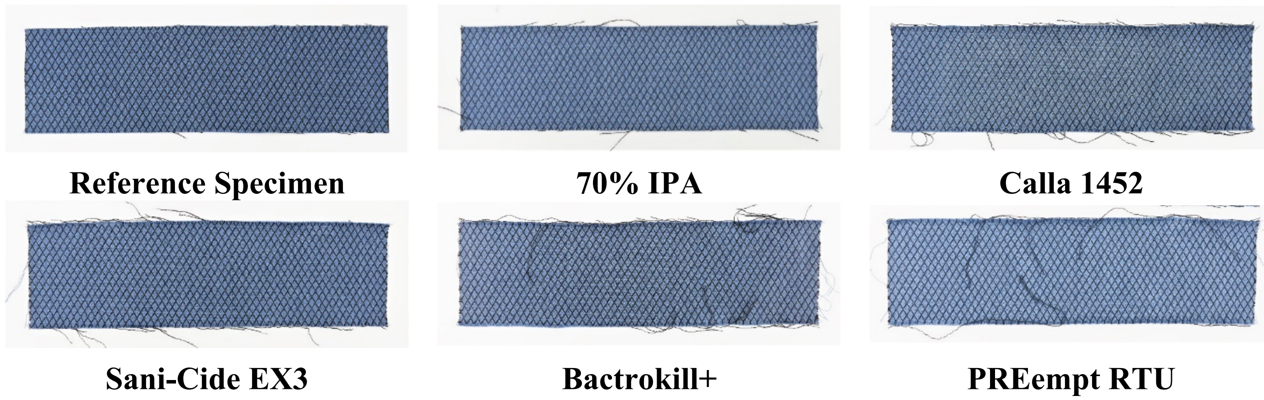


Figure 67. Color qualitative comparison with submersion method – Botany fabric

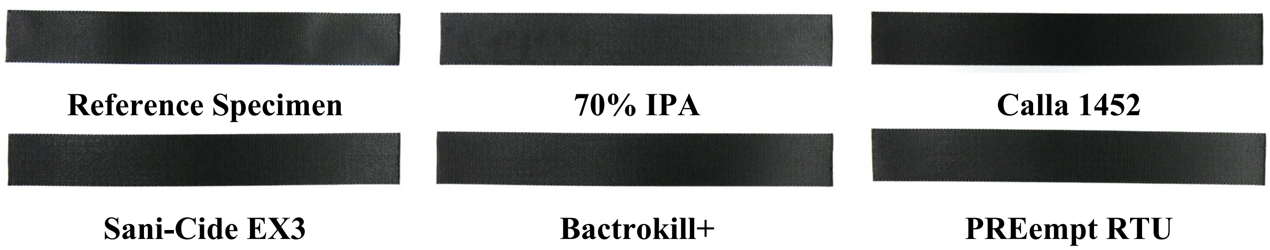


Figure 68. Color qualitative comparison with submersion method – SCHROTH webbing

7.3.2 Quantitative change

To further evaluate the effect of liquid disinfectants on the color, square tiles of side 3” were cut from all the material types and conditioned with liquid disinfectants, following the procedure detailed in Section 4. Post conditioning, color measurement of these samples was measured, using a color spectrometer, as shown in Figure 69, and compared against unconditioned baseline specimens.

Step 1 – Obtain 3 color measurements of baseline (unconditioned specimen)
Step 2 – Obtain 3 color measurements of conditioned specimens and compare against baseline
Figure 69. Color measurement using Spectrometer

The color measurements were then reported according to CIE L*a*b* Uniform Color Space, which is an approximately uniform color space based on nonlinear expansion of the tristimulus values, and taking differences to produce three opponent axes that approximate the percepts of lightness-darkness, redness-greenness, and yellowness-blueness (Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates, 2016). It is produced by plotting in rectangular coordinates the quantities L*, a*, b*, as shown in Figure 70.

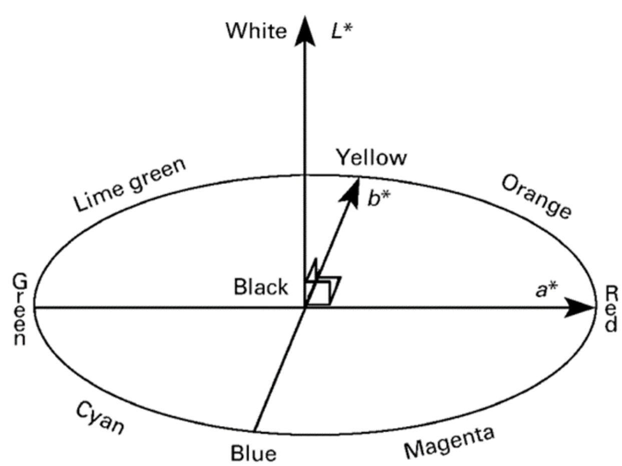
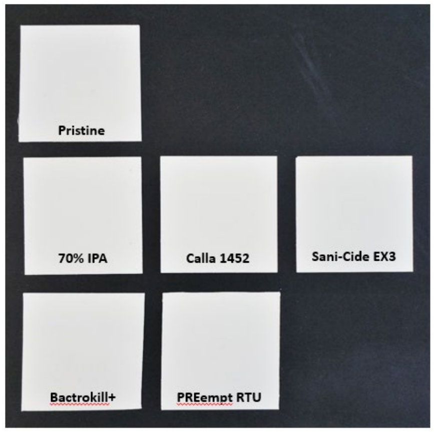


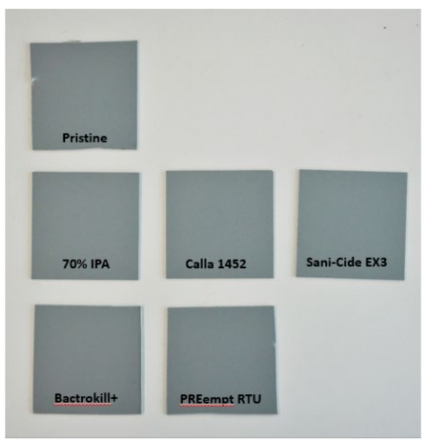
Figure 70. CIE L*a*b* color space (Gilchrist & Nobbs, 2000)

Color measurements results for all material types are summarized in Figure 71 through Figure 93.



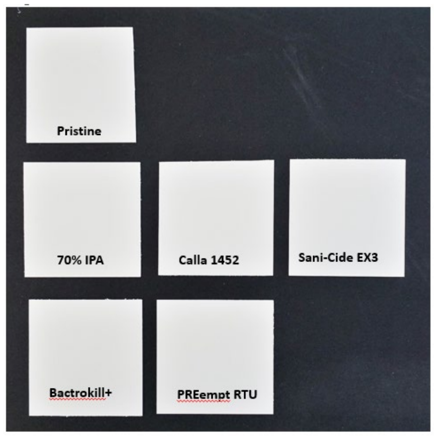
Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	88.48	88.40	88.35	88.36	88.38	88.55
a*	-0.94	-0.98	-0.87	-0.95	-0.91	-1.16
b*	1.31	2.06	2.06	2.34	2.22	2.16

Figure 71. Color measurement results – Kydex 6565



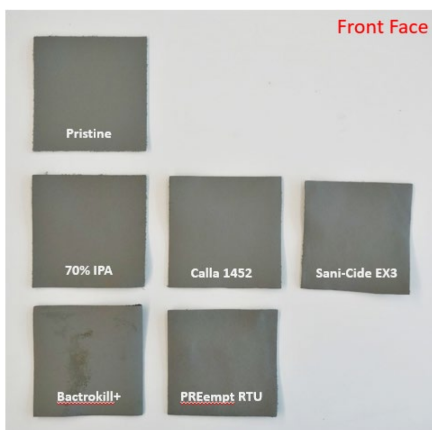
Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	67.56	67.63	67.37	67.58	67.59	67.75
a*	-1.42	-1.46	-1.50	-1.45	-1.47	-1.44
b*	-3.55	-3.54	-3.22	-3.45	-3.41	-3.48

Figure 72. Color measurement results – Boltaron 9815E



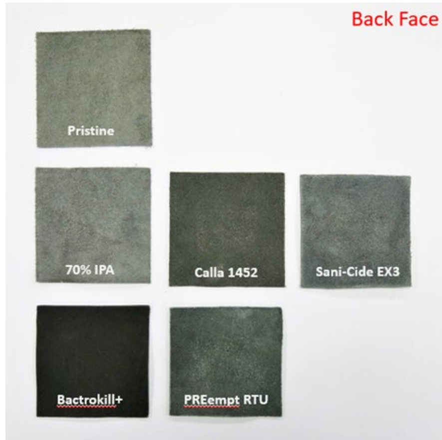
Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	84.04	84.10	83.90	83.88	83.93	84.00
a*	0.11	0.10	-0.15	-0.14	-0.09	-0.23
b*	1.25	1.28	1.03	1.02	1.10	1.44

Figure 73. Color measurement results – Boltaron 9815N



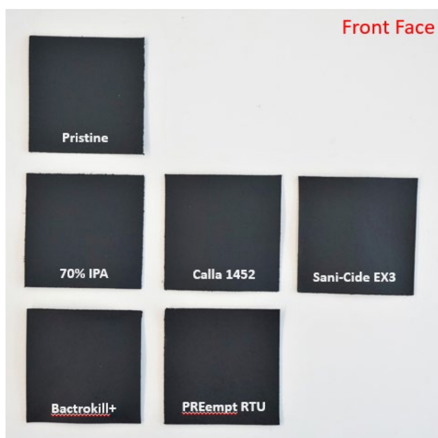
Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	67.56	67.63	67.37	67.58	67.59	67.75
a*	-1.42	-1.46	-1.50	-1.45	-1.47	-1.44
b*	-3.55	-3.54	-3.22	-3.45	-3.41	-3.48

Figure 74. Color measurement results – Perrone Pewter BC front face



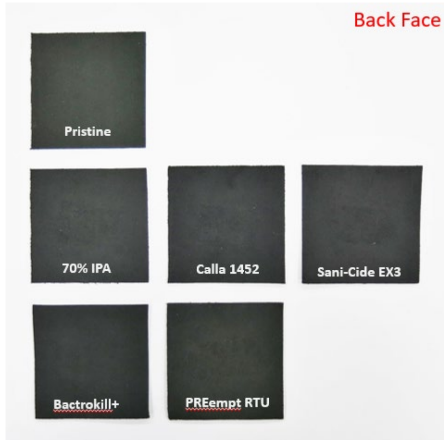
Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	67.56	67.63	67.37	67.58	67.59	67.75
a*	-1.42	-1.46	-1.50	-1.45	-1.47	-1.44
b*	-3.55	-3.54	-3.22	-3.45	-3.41	-3.48

Figure 75. Color measurement results – Perrone Pewter BC back face



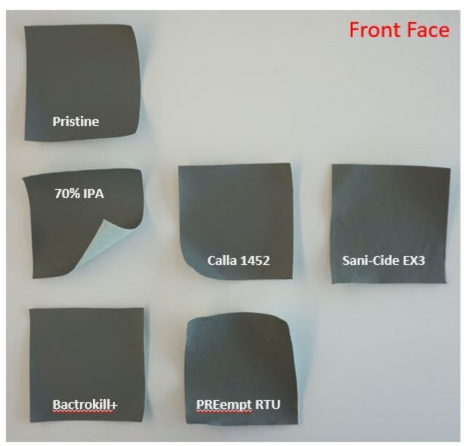
Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	67.56	67.63	67.37	67.58	67.59	67.75
a*	-1.42	-1.46	-1.50	-1.45	-1.47	-1.44
b*	-3.55	-3.54	-3.22	-3.45	-3.41	-3.48

Figure 76. Color measurement results – Perrone Feather Weight BC front face



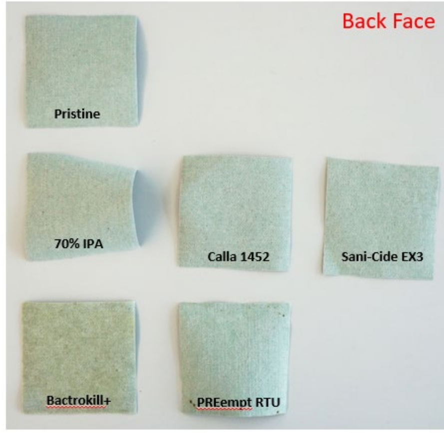
Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	67.56	67.63	67.37	67.58	67.59	67.75
a*	-1.42	-1.46	-1.50	-1.45	-1.47	-1.44
b*	-3.55	-3.54	-3.22	-3.45	-3.41	-3.48

Figure 77. Color measurement results – Perrone Feather Weight BC back face



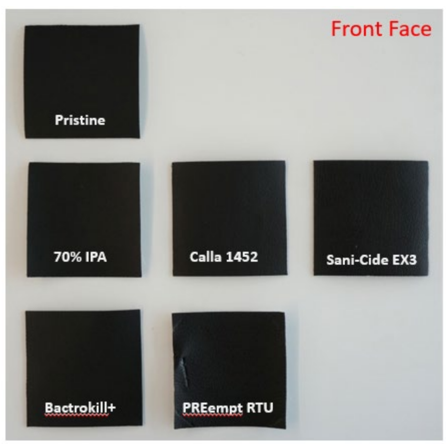
Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	53.74	53.72	53.79	53.84	53.68	53.61
a*	-0.60	-0.61	-0.62	-0.64	-0.60	-0.63
b*	0.22	0.16	0.19	0.22	0.24	0.27

Figure 78. Color measurement results – E-Leather CL820 front face



Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	79.32	78.84	77.42	78.60	76.18	78.71
a*	-5.94	-6.41	-6.24	-6.36	-5.94	-7.35
b*	3.67	2.99	4.65	4.61	11.50	4.16

Figure 79. Color measurement results – E-Leather CL820 back face

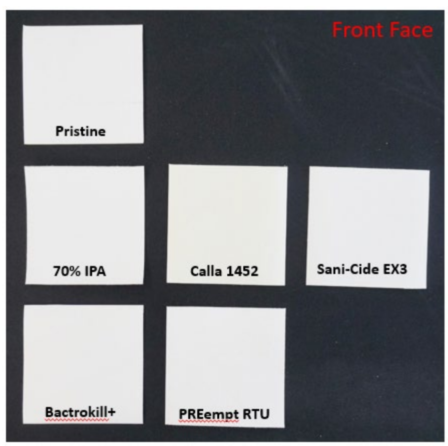


Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	24.62	24.60	24.52	24.21	24.62	24.06
a*	-0.15	-0.08	-0.15	-0.17	-0.15	-0.11
b*	-0.17	-0.14	-0.16	-0.17	-0.19	-0.31

Figure 80. Color measurement results – Ultrafabrics 492-6579FR12 front face

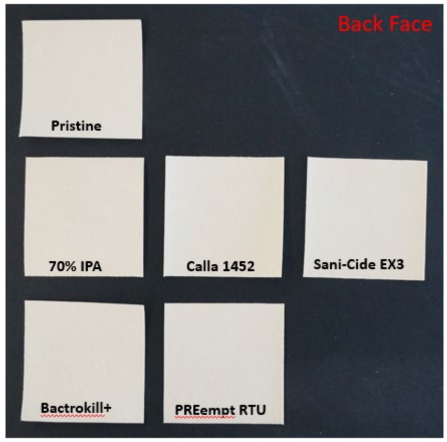
Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	69.32	69.45	68.97	68.89	70.18	69.08
a*	0.48	0.53	1.15	2.72	-0.02	1.60
b*	2.44	1.83	2.43	2.85	2.06	2.26

Figure 81. Color measurement results – Ultrafabrics 492-6579FR12 back face



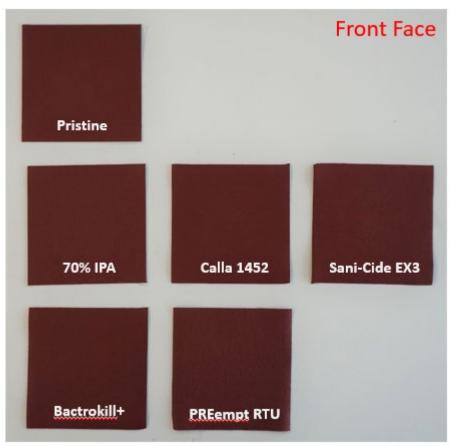
Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	91.47	91.19	89.11	91.68	91.35	91.19
a*	0.56	0.44	-1.62	0.47	0.61	0.56
b*	4.66	4.47	11.63	4.72	4.86	4.74

Figure 82. Color measurement results – Tapisuede TSFRC0961 front face



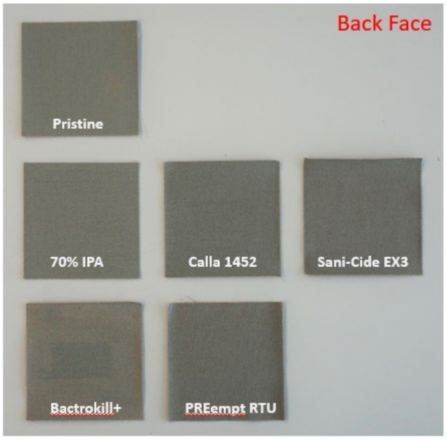
Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	76.39	76.02	76.04	76.63	76.57	76.41
a*	5.63	5.81	5.75	5.92	5.95	5.78
b*	11.63	11.77	11.77	11.54	11.64	11.22

Figure 83. Color measurement results – Tapisuede TSFRC0961 back face



Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	35.55	35.43	35.47	35.74	35.65	35.13
a*	24.36	24.32	24.40	25.21	24.39	24.64
b*	9.39	9.37	9.39	9.75	9.43	9.46

Figure 84. Color measurement results – Ultraleather ULFRB971-1363 front face



Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	62.84	62.54	59.27	59.30	60.14	59.80
a*	0.10	0.25	0.05	2.14	-0.42	1.43
b*	3.58	3.70	3.57	3.64	3.85	4.02

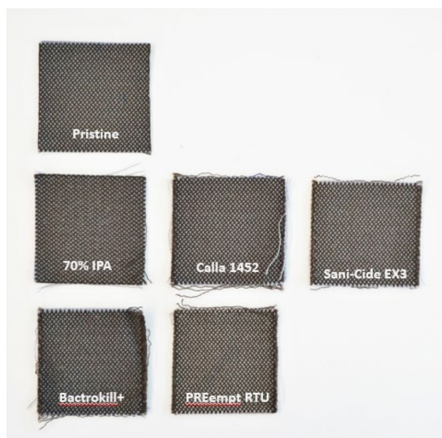
Figure 85. Color measurement results – Ultraleather ULFRB971-1363 back face

Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	24.63	30.83	28.44	27.54	31.13	31.60
a*	5.27	4.93	4.76	5.45	4.65	5.72
b*	-11.59	-9.21	-10.09	-12.78	-9.72	-10.50

Figure 86. Color measurement results – Lantal surface 1

Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	41.42	33.53	32.32	33.99	35.38	34.61
a*	3.74	4.13	3.82	4.11	3.70	4.17
b*	-4.49	-7.63	-8.90	-11.53	-8.13	-12.16

Figure 87. Color measurement results – Lantal surface 2



Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	40.02	40.86	37.63	38.74	40.51	38.70
a*	2.10	2.03	2.58	3.22	1.99	3.03
b*	0.34	0.10	1.03	2.10	1.04	1.92

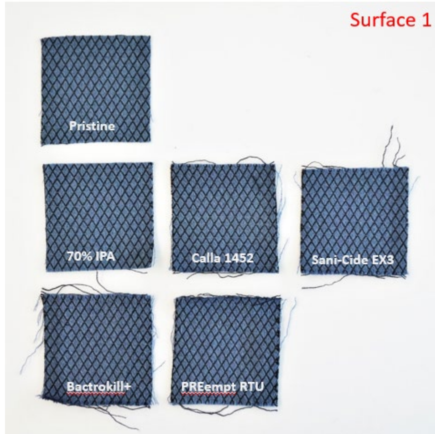
Figure 88. Color measurement results – Rohi Beach

Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	69.28	70.17	70.13	71.43	68.34	70.57
a*	0.58	0.47	-1.17	0.29	0.43	1.03
b*	0.95	0.99	4.84	2.28	3.02	0.76

Figure 89. Color measurement results – Sheepskin front face

Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	85.02	87.17	79.73	85.90	76.62	85.88
a*	0.88	1.62	-0.85	1.14	0.59	0.33
b*	5.08	7.39	10.99	6.76	7.81	3.97

Figure 90. Color measurement results – Sheepskin back face

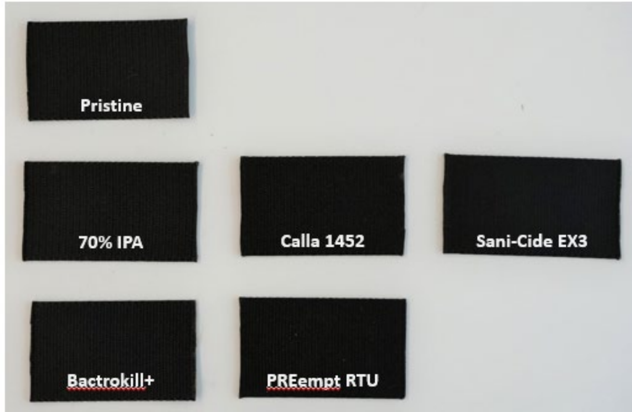


Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	36.41	37.78	38.33	37.42	35.83	37.92
a*	-0.99	-1.17	-1.37	-0.84	-0.59	-0.64
b*	-9.91	-10.36	-9.23	-10.79	-9.79	-10.64

Figure 91. Color measurement results – Botany fabric surface 1

Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	32.82	31.43	31.69	31.29	29.32	31.19
a*	-0.62	-0.40	-0.49	-0.08	-0.13	-0.02
b*	-8.37	-7.96	-7.83	-8.52	-7.68	-8.32

Figure 92. Color measurement results – Botany fabric surface 2



Parameter	Disinfectant Type					
	Pristine	70% IPA	Calla 1452	Sani-cide EX3	BactroKill +	PREempt RTU
L*	32.82	31.43	31.69	31.29	29.32	31.19
a*	-0.62	-0.40	-0.49	-0.08	-0.13	-0.02
b*	-8.37	-7.96	-7.83	-8.52	-7.68	-8.32

Figure 93. Color measurement results – SCHROTH webbing

The direction of the color difference is described by the magnitude and algebraic signs of the components ΔL*, Δa* and Δb*:

$$\Delta L^* = L_B^* - L_S^* \quad (1)$$

$$\Delta a^* = a_B^* - a_S^* \quad (2)$$

$$\Delta b^* = b_B^* - b_S^* \quad (3)$$

Where L^*_S, a^*_S, and b^*_S refer to the reference or standard which in this case would be the unconditioned specimen, and L^*_B, a^*_B, and b^*_B refer to the test specimens which would be conditioned specimens. These differences can be used to find if the material was lighter/darker, redder/greener, and yellower/bluer.

7.4 Color change – wiping method

In this investigation, the effects of the liquid disinfectants on the material color was evaluated. For the he wiping method, only a qualitative comparison was done by capturing images of test specimens before and after conditioning.

7.4.1 Qualitative change

Table 66 summarizes qualitative color change due to conditioning of selected materials with liquid disinfectants following the wiping method. A comparison of the images before and after conditioning for selected materials is shown in Figure 100 through Figure 106.

For synthetic leather, color changes were observed when conditioned with Sani-Cide EX3, BactroKill+, and PREempt RTU. No significant changes in color were observed for synthetic leathers conditioned with Calla 1452. Furthermore, due to the use of microfiber cloths during the process, change of color occurred on E-Leather CL820 while conditioning with 70% IPA. Materials conditioned with Sani-Cide EX3 also had a tacky residue on the surface. Materials conditioned with BactroKill+ had a white discoloration around most of the edges. Materials conditioned with PREempt RTU had a sheen-like residue.

For Wool/Nylon blends, color changes were observed when conditioned with Sani-Cide EX3, BactroKill+, and PREempt RTU. No color change was observed for Rohi Beach when conditioned with Calla 1452.

For Leather, color changes were observed when conditioned with Sani-Cide EX3, BactroKill+, and PREempt RTU. No change in color and texture was observed when conditioned with 70% IPA and Calla 1452. Materials conditioned with Sani-Cide EX3 had tacky residue on the surface. Materials conditioned with BactroKill+ had a white discoloration speckle on the surface. The surface of materials conditioned with PREempt RTU had a sheen like residue.

Table 66. Qualitative color change summary – wiping method

Material Type	Material Name	Liquid Disinfectant Type				
		70% IPA	Calla 1452	Sani-Cide EX3	BactroKill +	PREempt RTU
Synthetic Leather	E-Leather CL820					
	Ultrafabric 492-6579FR12					
	Ultraleather ULFRB971-1363					
Wool/Nylon Blend	Lantal					
	Rohi Beach					
	Sheepskin					
	Botany Fabric					
Leather	Murihead DF602					
	Perrone Pewter BC					
	Perrone Feather Weight					

No Change in Color or Texture

Change in Color Only

Change in Color and Texture

Change in Color due to the Microfiber Cloth

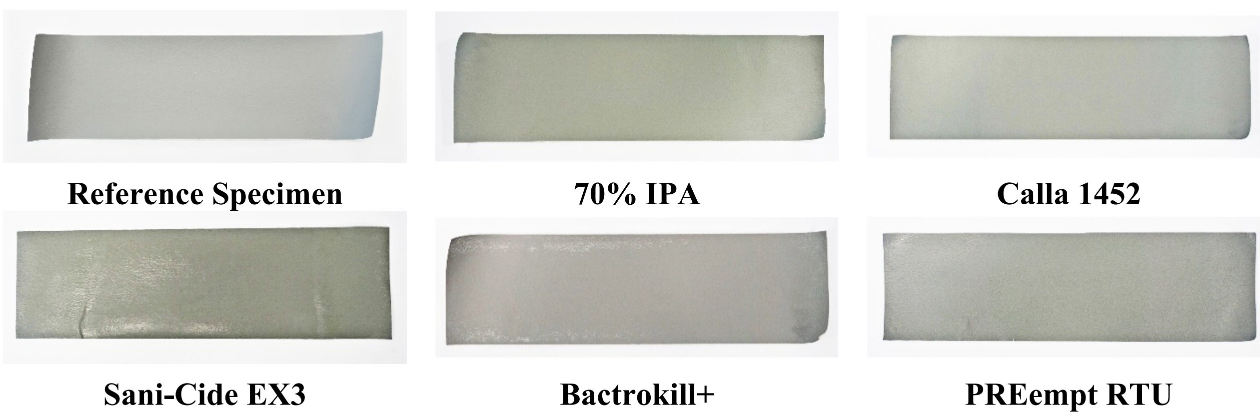


Figure 94. Color qualitative comparison with wiping method – E-Leather CL820 front face

Figure 95. Color qualitative comparison with wiping method – E-Leather CL820 back face

Figure 96. Color qualitative comparison with wiping method – Ultrafabrics 492-6579FR12 front face

Figure 97. Color qualitative comparison with wiping method – Ultrafabrics 492-6579FR12 back face



Reference Specimen **Calla 1452** **Sani-Cide EX3**


Bactrokill+ **PREempt RTU**

Figure 98. Color qualitative comparison with wiping method – Ultraleather ULFRB971-1363 front face



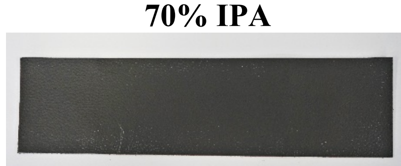
Reference Specimen **Calla 1452** **Sani-Cide EX3**


Bactrokill+ **PREempt RTU**

Figure 99. Color qualitative comparison with wiping method – Ultraleather ULFRB971-1363 back face



Reference Specimen **70% IPA** **Calla 1452**

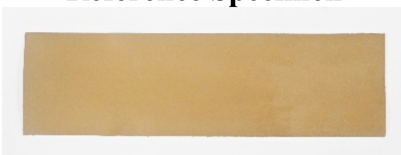

Sani-Cide EX3 **Bactrokill+** **PREempt RTU**

Figure 100. Color qualitative comparison with wiping method – Muirhead DF602

Reference Specimen

Calla 1452

Sani-Cide EX3



Bactrokill+

PREempt RTU

Figure 101. Color qualitative comparison with wiping method – Perrone Pewter BC

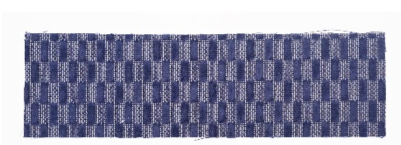
Reference Specimen

Sani-Cide EX3

Bactrokill+

PREempt RTU

Figure 102. Color qualitative comparison with wiping method – Perrone Feather Weight



Reference Specimen

Sani-Cide EX3

Bactrokill+

Figure 103. Color qualitative comparison with wiping method – Lantal



Reference Specimen **Calla 1452** **Sani-Cide EX3**


Bactrokill+ **PREempt RTU**

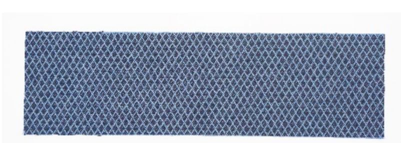
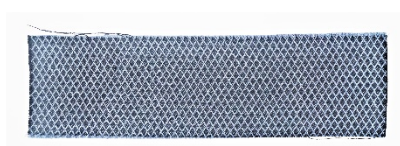
Figure 104. Color qualitative comparison with wiping method – Rohi Beach



Reference Specimen **Sani-Cide EX3** **Bactrokill+**

PREempt RTU

Figure 105. Color qualitative comparison with wiping method – Sheepskin


Reference Specimen **Bactrokill+** **PREempt RTU**

Figure 106. Color qualitative comparison with wiping method – Botany fabric

7.5 Permeability evaluation

In this investigation, a rapid evaluation of permeability of synthetic leather, wool/nylon blend, and leather was conducted. This was done to establish if the liquid disinfectants would permeate the selected materials.

7.5.1 Test matrix

For each material, three specimens were tested as summarized in Table 67. Distilled water was used to conduct the permeability tests. Due to the material availability, both Muirhead DF602 (leather) and sheepskin (nylon/wool) were not evaluated.

Table 67. Test matrix for permeability evaluation tests

Material Type	Material Name	Permeability Evaluation: Fluid Type
		Distilled Water
Synthetic Leather	E-Leather CL820	x3
	Ultrafabrics 492-6579FR12	x3
	TapiSuede TSFRC0961	x3
	UltraLeather ULFRB971-1363	x3
Wool/Nylon Blend	Lantal	x3
	Rohi Beach	x3
	Botany Fabric	x3
Leather	Pewter BC	x3
	Perrone Feather Weight	x3

7.5.2 Test setup

The permeability test fixture consisted of a base plate, four rods to hold all the plates together, a support and a clamp plate to secure the specimen in place, and a center plate to insert a syringe on top, as shown in Figure 107. Tests were conducted by gradually injecting 10ml of distilled water at the center of test specimens and waiting for a duration of 15 minutes. Water indicating tape was attached to the back face of each specimen, which when in contact with a liquid changes the color to red.

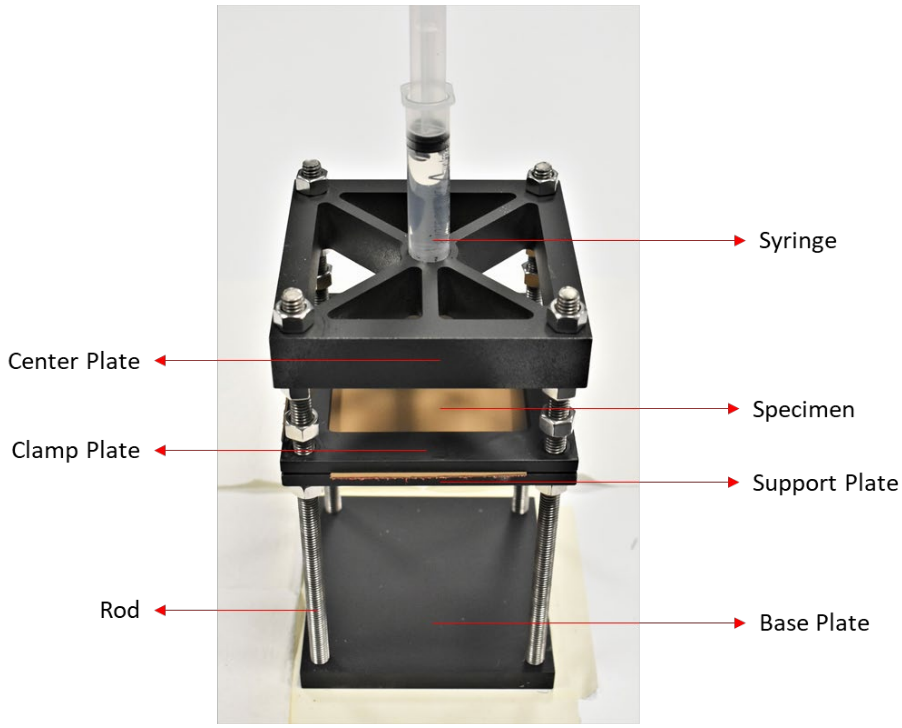


Figure 107. Test setup for permeability evaluation

7.5.3 Test results

Besides using the water indicating tape, the weight of the specimens was recorded as well. The permeability evaluation results are summarized in Table 68 through Table 76.

For synthetic leather materials, permeability was not observed for E-Leather CL820, Ultrafabrics 492-6579FR12, and TapiSuede TSFRC0961. However, two test specimens of UltraLeather ULFRB971-1363 were permeated with the distilled water.

For Wool/Nylon blend, the fluid permeated for all the test specimens.

For leather material, permeability was not observed for any of the specimens.

Table 68. Permeability evaluation results for E-Leather CL820

Permeability Evaluation Test Results for E-Leather CL820 (SL1)			
Specimen	**Weight Change**	**Test Time (s)**	**Permeation**
#1	0.0%	900	No
#2	1.5%	900	No
#3	1.4%	900	No

Table 69. Permeability evaluation results for Ultrafabrics 492-6579FR12

Permeability Evaluation Test Results for Ultrafabrics 492-6579FR12 (SL2)			
Specimen	**Weight Change**	**Test Time (s)**	**Permeation**
#1	0.4%	900	No
#2	0.3%	900	No
#3	0.3%	900	No

Table 70. Permeability evaluation results for TapiSuede TSFRC0961

Permeability Evaluation Test Results for TapiSuede TSFRC0961 (SL3)			
Specimen	**Weight Change**	**Test Time (s)**	**Permeation**
#1	1.0%	900	No
#2	1.0%	900	No
#3	0.0%	900	No

Table 71. Permeability evaluation results for UltraLeather ULFRB971-1363

Permeability Evaluation Test Results for UltraLeather ULFRB971-1363 (SL4)			
Specimen	**Weight Change**	**Test Time (s)**	**Permeation**
#1	18.4%	900	No
#2	26.7%	650	Yes
#3	6.8%	169	Yes

Table 72. Permeability evaluation results for Lantal

Permeability Evaluation Test Results for Lantal (NW1)			
Specimen	**Weight Change**	**Test Time (s)**	**Permeation**
#1	5.3%	4	Yes
#2	13.4%	5	Yes
#3	4.4%	7	Yes

Table 73. Permeability evaluation results for Rohi Beach

Permeability Evaluation Test Results for Rohi Beach (NW2)			
Specimen	**Weight Change**	**Test Time (s)**	**Permeation**
#1	0.8%	7	Yes
#2	1.5%	4	Yes
#3	0.8%	6	Yes

Table 74. Permeability evaluation results for Botany fabric

Permeability Evaluation Test Results for Botany Fabric (NW4)			
Specimen	**Weight Change**	**Test Time (s)**	**Permeation**
#1	1.2%	4	Yes
#2	2.4%	5	Yes
#3	0.0%	3	Yes

Table 75. Permeability evaluation results for Pewter BC

Permeability Evaluation Test Results for Pewter BC (L2)			
Specimen	**Weight Change**	**Test Time (s)**	**Permeation**
#1	0.9%	900	No
#2	0.5%	900	No
#3	1.0%	900	No

Table 76. Permeability evaluation results for Perrone Feather Weight

Permeability Evaluation Test Results for Perrone Feather Weight (L3)			
Specimen	**Weight Change**	**Test Time (s)**	**Permeation**
#1	0.1%	900	No
#2	0.0%	900	No
#3	0.6%	900	No

8 Conclusions

The effect of liquid chemical disinfectants was evaluated on the flammability, mechanical, and physical properties of materials used in aircraft seats. Materials and disinfectants used in this study were selected in conjunction with the SAE seat committee. Materials were conditioned with liquid disinfectants following two different methods – submersion and wiping. Initially, all the materials were conditioned by submerging them in liquid disinfectants for a fixed duration of time. This conditioning approach simulated accelerated cycle testing and it was considered to represent the worst-case scenario. Based on the flammability performance criteria, a few selected materials were also conditioned using the wiping methodology to reevaluate their flammability properties. The objective of the wiping conditioning method was to simulate the real world application of the liquid disinfectants in aircraft interior. This was achieved by wiping the test specimens by hand for one thousand cycles.

Tension tests, following ASTM D638, were conducted on four different type of plastics, which were Kydex 6565, Boltaron 9815E, Lexan XHR, and Boltaron 9815N. Statistical evaluation following CMH-17 guidelines showed that the properties of conditioned Boltaron 9815E specimens were not equivalent to the properties of unconditioned specimens. For the other three plastics, equivalency between conditioned and unconditioned tensile properties was observed, as shown in Table 77. However, due to the limited material availability, the test data set for Lexan XHR and Boltaron 9815N was limited to five specimens per disinfectant type.

Tension tests were also conducted on seatbelt webbing until rupture. For SCHROTH webbings, no reduction in failure load was observed when the specimens were conditioned with Calla 1452, Sani-Cide EX3, BactroKill+, and PREempt. Reduction of less than 5% for both failure load was observed when the specimens were conditioned with 70% IPA, as shown in Table 77. For Amsafe webbings, no reduction in failure load was observed when the specimens were conditioned with 99% IPA, Sani-Cide EX3, and Calla 1452 for 24 hours.

Table 77. Mechanical properties results summary

Material Name	Disinfectant Type				
	70% IPA*	Calla 1452	Sani-Cide EX3	BactroKill+	PREempt RTU
Kydex 6565					
Boltaron 9815E					
Lexan XHR					
Boltaron 9815N					
SCHROTH Webbing					
Amsafe Webbing				-	-

* AmSafe Polyester webbing specimens were conditioned with 99% IPA

Material properties “equivalent” to unconditioned specimens

Material properties not “equivalent” to unconditioned specimens

Material properties “equivalent” to unconditioned specimens based on limited data

Reduction in failure load less than 5%

No Reduction in failure load

Vertical Bunsen Burner Tests, as per 14 CFR § 25.853 Appendix F, were conducted to evaluate the effect of using liquid disinfectants on the flammability properties. The purpose of these tests was to compare the flammability performance of the material when conditioned with liquid disinfectants against unconditioned specimens. Based on the criterion defined, the change in flammability properties were considered either significantly different or normally equivalent to the untreated material. At first, all the materials were conditioned using submersion method. For this conditioning method, only plastics and seatbelt webbing flammability results were normally equivalent when conditioned with all the liquid disinfectants. Other material types had a combination of both variable flammability results based on the disinfectant type as shown in Table 78.

Table 78. Flammability results summary – submersion method

Material Type	Material Name	Disinfectant Type				
		70% IPA*	Calla 1452	Sani-Cide EX3	BactroKill+	PREempt RTU
Plastic	Kydex 6565					
	Boltaron 9815E					
	Lexan XHR					
	Boltaron 9815N					
Synthetic Leather	E-Leather CL280					
	Ultrafabric 492-6579FR12					
	TapiSuede TSFRC0961					
	Ultraleather ULFRB971-1363					
Wool/Nylon Blend	Lantal					
	Rohi Beach					
	Sheepskin					
	Botany Fabric					
Leather	Pewter BC (Perrone)					
	Perrone Feather Weight					
Webbing	SCHROTH					
	AmSafe Polyester					

* AmSafe Polyester webbing specimens were conditioned with 99% IPA

Increase in average burn length is less than or equal to approximately 50 % of the average burn length obtained from the unconditioned specimens test data.

Increase in average burn length is greater than approximately 50% of the average burn length obtained from the unconditioned specimens test data.

Increase in average burn length is less than 6" when compared against unconditioned specimens and self-extinguishing

Materials and disinfectant combinations for which flammability properties were significantly different when conditioned following submersion method were revaluated by conditioning them following the wiping method. For this conditioning method, flammability properties for all the selected combinations of synthetic leather and disinfectants were normally equivalent to the untreated material. Other material types had a combination of both variable flammability results based on the disinfectant type, as shown in Table 79.

Table 79. Flammability results summary – wiping method

Material Type	Material Name	Disinfectant Type				
		70% IPA	Calla 1452	Sani-Cide EX3	BactroKill+	PREempt RTU
Synthetic Leather	E-Leather CL280					
	Ultrafabric 492-6579FR12					
	Ultraleather ULFRB971-1363					
Wool/Nylon Blend	Lantal					
	Rohi Beach					
	Sheepskin					
	Botany Fabric					
Leather	Muirhead DF602					
	Pewter BC (Perrone)					
	Perrone Feather Weight					

Increase in average burn length is less than or equal to approximately 50% of the average burn length obtained from the unconditioned specimens test data.

Increase in average burn length is greater than approximately 50% of the average burn length obtained from the unconditioned specimens test data.

Normally equivalent results obtained when conditioned using submersion method

Color appearance change was evaluated for materials conditioned using both submersion and wiping method. When conditioned using submersion method, change in the color was investigated both qualitatively and quantitatively. Qualitative comparison showed no color change for plastics and seat belt webbing, whereas color change was observed for one type of synthetic leather (TapiSuede TSFRC0961), three types of Nylon/Wool Fabric (Lantal, Sheepskin, and Rohi Beach), and two types of leather (Perrone Pewter BC and Perrone Feather Weight). Quantitative color measurements were taken for samples from all the material types using a color spectrometer. The color measurements of conditioned specimens were compared against baseline unconditioned specimens and reported according to CIE L*a*b* Uniform Color Space. Results from this quantitative analysis show different color scale readings, highlighting differences in lightness vs. darkness, redness vs. greenness, and yellowness vs. blueness of the material. When the materials were conditioned using wiping method, change in color was evaluated only qualitatively. No change in color was observed when the materials were conditioned with Calla 1452. However, change in color and/or texture was observed for all the selected materials when conditioned with Sani-Cide EX3, BactroKill+, and PREempt RTU.

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A Plastic strength specimen dimensions

Table 80. Specimen dimensions for Kydex 6565

Specimen	LO	WO	W1	W2	W3	Wavg	T1	T2	T3	Tavg
FAA-T-P1-D0-01	2.5065	0.3750	0.1250	0.1245	0.1250	0.1248	0.0465	0.0465	0.0465	0.0465
FAA-T-P1-D0-02	2.5065	0.3750	0.1250	0.1250	0.1250	0.1250	0.0455	0.0455	0.0450	0.0453
FAA-T-P1-D0-03	2.5100	0.3750	0.1250	0.1245	0.1250	0.1248	0.0465	0.0460	0.0470	0.0465
FAA-T-P1-D0-04	2.5060	0.3750	0.1250	0.1250	0.1255	0.1252	0.0460	0.0460	0.0460	0.0460
FAA-T-P1-D0-05	2.5070	0.3755	0.1250	0.1255	0.1250	0.1252	0.0460	0.0475	0.0460	0.0465
FAA-T-P1-D1-01	2.5060	0.3750	0.1250	0.1255	0.1250	0.1252	0.0465	0.0470	0.0460	0.0465
FAA-T-P1-D1-02	2.5040	0.3750	0.1255	0.1250	0.1250	0.1252	0.0460	0.0465	0.0460	0.0462
FAA-T-P1-D1-03	2.5070	0.3750	0.1255	0.1260	0.1255	0.1257	0.0465	0.0465	0.0460	0.0463
FAA-T-P1-D1-04	2.5030	0.3750	0.1255	0.1250	0.1250	0.1252	0.0460	0.0460	0.0465	0.0462
FAA-T-P1-D1-05	2.5050	0.3770	0.1255	0.1250	0.1260	0.1255	0.0470	0.0465	0.0470	0.0468
FAA-T-P1-D2-01	2.5050	0.3755	0.1255	0.1250	0.1260	0.1255	0.0465	0.0460	0.0465	0.0463
FAA-T-P1-D2-02	2.5080	0.3763	0.1270	0.1250	0.1250	0.1257	0.0470	0.0470	0.0470	0.0470
FAA-T-P1-D2-03	2.5085	0.3760	0.1245	0.1250	0.1250	0.1248	0.0465	0.0465	0.0465	0.0465
FAA-T-P1-D2-04	2.5065	0.3765	0.1250	0.1250	0.1250	0.1250	0.0460	0.0465	0.0465	0.0463
FAA-T-P1-D2-05	2.5100	0.3760	0.1250	0.1250	0.1250	0.1250	0.0455	0.0460	0.0455	0.0457
FAA-T-P1-D3-01	2.5065	0.3765	0.1255	0.1250	0.1250	0.1252	0.0470	0.0465	0.0470	0.0468
FAA-T-P1-D3-02	2.5080	0.3755	0.1255	0.1250	0.1250	0.1252	0.0465	0.0465	0.0470	0.0467
FAA-T-P1-D3-03	2.5080	0.3765	0.1250	0.1250	0.1255	0.1252	0.0460	0.0460	0.0465	0.0462
FAA-T-P1-D3-04	2.5075	0.3770	0.1255	0.1250	0.1250	0.1252	0.0455	0.0455	0.0455	0.0455
FAA-T-P1-D3-05	2.5065	0.3760	0.1250	0.1250	0.1260	0.1253	0.0460	0.0460	0.0465	0.0462
FAA-T-P1-D4-01	2.5070	0.3770	0.1260	0.1250	0.1250	0.1253	0.0455	0.0455	0.0460	0.0457
FAA-T-P1-D4-02	2.5065	0.3765	0.1250	0.1250	0.1250	0.1250	0.0465	0.0465	0.0465	0.0465
FAA-T-P1-D4-03	2.5080	0.3765	0.1250	0.1250	0.1250	0.1250	0.0470	0.0470	0.0470	0.0470
FAA-T-P1-D4-04	2.5075	0.3765	0.1250	0.1250	0.1250	0.1250	0.0460	0.0465	0.0465	0.0463
FAA-T-P1-D4-05	2.5065	0.3765	0.1250	0.1250	0.1255	0.1252	0.0465	0.0465	0.0470	0.0467
FAA-T-P1-D5-01	2.5075	0.3760	0.1250	0.1250	0.1250	0.1250	0.0455	0.0455	0.0455	0.0455
FAA-T-P1-D5-02	2.5075	0.3765	0.1250	0.1250	0.1250	0.1250	0.0465	0.0470	0.0470	0.0468
FAA-T-P1-D5-03	2.5075	0.3770	0.1250	0.1250	0.1255	0.1252	0.0465	0.0465	0.0465	0.0465
FAA-T-P1-D5-04	2.5085	0.3760	0.1250	0.1245	0.1250	0.1248	0.0460	0.0455	0.0460	0.0458
FAA-T-P1-D5-05	2.5065	0.3760	0.1250	0.1250	0.1255	0.1252	0.0455	0.0455	0.0455	0.0455

Table 81. Specimen dimensions for Boltaron 9815E

Specimen	LO	WO	W1	W2	W3	Wavg	T1	T2	T3	Tavg
FAA-T-P2-D0-01	2.5040	0.3750	0.1250	0.1250	0.1250	0.1250	0.0485	0.0480	0.0480	0.0482
FAA-T-P2-D0-02	2.5060	0.3765	0.1250	0.1250	0.1255	0.1252	0.0475	0.0470	0.0470	0.0472
FAA-T-P2-D0-03	2.5020	0.3755	0.1250	0.1260	0.1255	0.1255	0.0495	0.0490	0.0490	0.0492
FAA-T-P2-D0-04	2.5080	0.3750	0.1255	0.1250	0.1250	0.1252	0.0495	0.0500	0.0495	0.0497
FAA-T-P2-D0-05	2.5060	0.3760	0.1250	0.1255	0.1250	0.1252	0.0520	0.0525	0.0520	0.0522
FAA-T-P2-D1-01	2.5070	0.3760	0.1250	0.1245	0.1250	0.1248	0.0525	0.0520	0.0525	0.0523
FAA-T-P2-D1-02	2.5035	0.3765	0.1255	0.1250	0.1260	0.1255	0.0495	0.0495	0.0495	0.0495
FAA-T-P2-D1-03	2.5005	0.3760	0.1245	0.1255	0.1245	0.1248	0.0480	0.0480	0.0480	0.0480
FAA-T-P2-D1-04	2.5005	0.3755	0.1255	0.1250	0.1245	0.1250	0.0515	0.0500	0.0520	0.0512
FAA-T-P2-D1-05	2.5006	0.3755	0.1245	0.1250	0.1255	0.1250	0.0495	0.0485	0.0495	0.0492
FAA-T-P2-D2-01	2.5004	0.3755	0.1255	0.1260	0.1260	0.1258	0.0495	0.0490	0.0495	0.0493
FAA-T-P2-D2-02	2.5060	0.3755	0.1255	0.1250	0.1255	0.1253	0.0495	0.0500	0.0500	0.0498
FAA-T-P2-D2-03	2.5050	0.3750	0.1255	0.1260	0.1250	0.1255	0.0485	0.0480	0.0485	0.0483
FAA-T-P2-D2-04	2.5060	0.3750	0.1245	0.1250	0.1255	0.1250	0.0525	0.0515	0.0520	0.0520
FAA-T-P2-D2-05	2.5030	0.3760	0.1250	0.1250	0.1250	0.1250	0.0500	0.0510	0.0510	0.0507
FAA-T-P2-D3-01	2.5045	0.3765	0.1250	0.1245	0.1250	0.1248	0.0480	0.0475	0.0470	0.0475
FAA-T-P2-D3-02	2.5065	0.3765	0.1245	0.1250	0.1255	0.1250	0.0495	0.0485	0.0490	0.0490
FAA-T-P2-D3-03	2.5080	0.3755	0.1250	0.1255	0.1255	0.1253	0.0510	0.0500	0.0495	0.0502
FAA-T-P2-D3-04	2.5010	0.3760	0.1250	0.1255	0.1245	0.1250	0.0500	0.0495	0.0500	0.0498
FAA-T-P2-D3-05	2.5000	0.3760	0.1245	0.1250	0.1245	0.1247	0.0515	0.0525	0.0520	0.0520
FAA-T-P2-D4-01	2.5060	0.3755	0.1250	0.1250	0.1250	0.1250	0.0490	0.0490	0.0490	0.0490
FAA-T-P2-D4-02	2.5055	0.3765	0.1250	0.1250	0.1250	0.1250	0.0485	0.0485	0.0485	0.0485
FAA-T-P2-D4-03	2.5070	0.3755	0.1250	0.1250	0.1250	0.1250	0.0490	0.0490	0.0490	0.0490
FAA-T-P2-D4-04	2.5085	0.3775	0.1270	0.1270	0.1270	0.1270	0.0510	0.0510	0.0510	0.0510
FAA-T-P2-D4-05	2.5060	0.3760	0.1265	0.1265	0.1265	0.1265	0.0510	0.0510	0.0510	0.0510
FAA-T-P2-D5-01	2.5065	0.3785	0.1250	0.1250	0.1250	0.1250	0.0490	0.0490	0.0490	0.0490
FAA-T-P2-D5-02	2.5065	0.3765	0.1250	0.1250	0.1250	0.1250	0.0500	0.0500	0.0500	0.0500
FAA-T-P2-D5-03	2.5065	0.3790	0.1250	0.1250	0.1250	0.1250	0.0525	0.0525	0.0525	0.0525
FAA-T-P2-D5-04	2.5085	0.3765	0.1250	0.1250	0.1250	0.1250	0.0490	0.0490	0.0490	0.0490
FAA-T-P2-D5-05	2.5065	0.3760	0.1250	0.1250	0.1250	0.1250	0.0490	0.0490	0.0490	0.0490

Table 82. Specimen dimensions for Lexan XHR

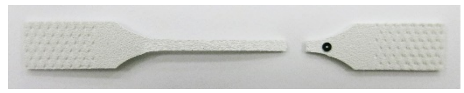
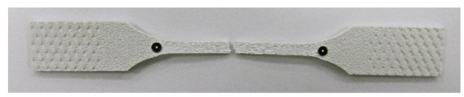
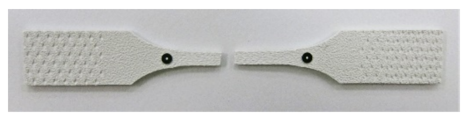
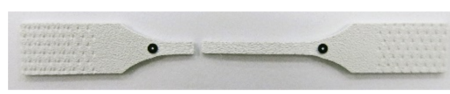
Specimen	LO	WO	W1	W2	W3	Wavg	T1	T2	T3	Tavg
FAA-T-P3-D0-01	2.5070	0.3760	0.1255	0.1250	0.1255	0.1253	0.0620	0.0620	0.0620	0.0620
FAA-T-P3-D0-02	2.5055	0.3760	0.1250	0.1240	0.1250	0.1247	0.0620	0.0620	0.0620	0.0620
FAA-T-P3-D0-03	2.5055	0.3760	0.1255	0.1250	0.1255	0.1253	0.0620	0.0620	0.0620	0.0620
FAA-T-P3-D0-04	2.5055	0.3755	0.1260	0.1265	0.1265	0.1263	0.0610	0.0610	0.0615	0.0612
FAA-T-P3-D0-05	2.5065	0.3755	0.1265	0.1260	0.1265	0.1263	0.0615	0.0615	0.0615	0.0615
FAA-T-P3-D1-01	2.5070	0.3760	0.1245	0.1250	0.1250	0.1248	0.0620	0.0620	0.0620	0.0620
FAA-T-P3-D1-02	2.5055	0.3760	0.1250	0.1250	0.1250	0.1250	0.0620	0.0620	0.0620	0.0620
FAA-T-P3-D1-03	2.5055	0.3765	0.1250	0.1245	0.1245	0.1247	0.0620	0.0620	0.0620	0.0620
FAA-T-P3-D1-04	2.5055	0.3765	0.1265	0.1260	0.1265	0.1263	0.0620	0.0620	0.0620	0.0620
FAA-T-P3-D1-05	2.5050	0.3765	0.1265	0.1265	0.1260	0.1263	0.0610	0.0610	0.0610	0.0610
FAA-T-P3-D2-01	2.5065	0.3770	0.1265	0.1265	0.1270	0.1267	0.0620	0.0620	0.0620	0.0620
FAA-T-P3-D2-02	2.5080	0.3765	0.1250	0.1250	0.1255	0.1252	0.0620	0.0620	0.0620	0.0620
FAA-T-P3-D2-03	2.5055	0.3760	0.1250	0.1250	0.1250	0.1250	0.0620	0.0620	0.0620	0.0620
FAA-T-P3-D2-04	2.5010	0.3760	0.1250	0.1245	0.1245	0.1247	0.0620	0.0620	0.0615	0.0618
FAA-T-P3-D2-05	2.5060	0.3760	0.1240	0.1245	0.1250	0.1245	0.0610	0.0610	0.0610	0.0610
FAA-T-P3-D3-01	2.5070	0.3765	0.1270	0.1270	0.1270	0.1270	0.0625	0.0625	0.0625	0.0625
FAA-T-P3-D3-02	2.5065	0.3770	0.1265	0.1265	0.1265	0.1265	0.0625	0.0625	0.0625	0.0625
FAA-T-P3-D3-03	2.5080	0.3765	0.1265	0.1265	0.1265	0.1265	0.0625	0.0625	0.0625	0.0625
FAA-T-P3-D3-04	2.5085	0.3760	0.1265	0.1265	0.1265	0.1265	0.0630	0.0630	0.0630	0.0630
FAA-T-P3-D3-05	2.5050	0.3755	0.1270	0.1270	0.1270	0.1270	0.0630	0.0630	0.0630	0.0630
FAA-T-P3-D4-01	2.5060	0.3765	0.1250	0.1250	0.1250	0.1250	0.0620	0.0620	0.0620	0.0620
FAA-T-P3-D4-02	2.5050	0.3770	0.1250	0.1250	0.1250	0.1250	0.0625	0.0625	0.0625	0.0625
FAA-T-P3-D4-03	2.5065	0.3765	0.1260	0.1260	0.1260	0.1260	0.0625	0.0625	0.0625	0.0625
FAA-T-P3-D4-04	2.5050	0.3770	0.1265	0.1265	0.1265	0.1265	0.0625	0.0625	0.0625	0.0625
FAA-T-P3-D4-05	2.5055	0.3760	0.1270	0.1270	0.1270	0.1270	0.0620	0.0620	0.0620	0.0620
FAA-T-P3-D5-01	2.5065	0.3760	0.1250	0.1250	0.1250	0.1250	0.0620	0.0620	0.0620	0.0620
FAA-T-P3-D5-02	2.5030	0.3760	0.1270	0.1270	0.1270	0.1270	0.0625	0.0625	0.0625	0.0625
FAA-T-P3-D5-03	2.5050	0.3755	0.1250	0.1250	0.1250	0.1250	0.0620	0.0620	0.0620	0.0620
FAA-T-P3-D5-04	2.5030	0.3765	0.1250	0.1250	0.1250	0.1250	0.0620	0.0620	0.0620	0.0620
FAA-T-P3-D5-05	2.5060	0.3760	0.1250	0.1250	0.1250	0.1250	0.0615	0.0615	0.0615	0.0615

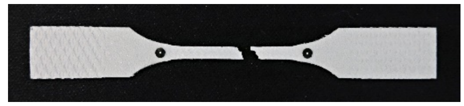
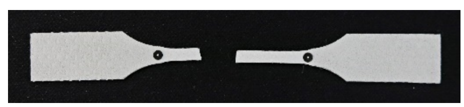
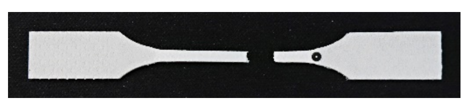
Table 83. Specimen dimensions for Boltaron 9815N

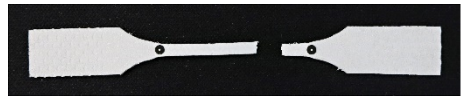
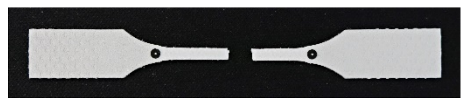
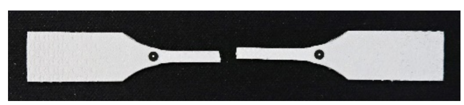
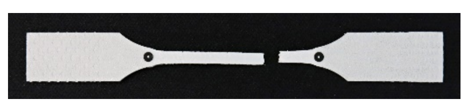
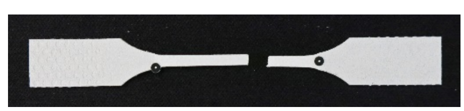
Specimen	LO	WO	W1	W2	W3	Wavg	T1	T2	T3	Tavg
FAA-T-P4-D0-01	2.4785	0.3755	0.1250	0.1250	0.1250	0.1250	0.0490	0.0485	0.0485	0.0487
FAA-T-P4-D0-02	2.4760	0.3760	0.1230	0.1230	0.1230	0.1230	0.0490	0.0495	0.0490	0.0492
FAA-T-P4-D0-03	2.4780	0.3740	0.1225	0.1220	0.1215	0.1220	0.0490	0.0490	0.0490	0.0490
FAA-T-P4-D0-04	2.4780	0.3755	0.1230	0.1240	0.1230	0.1233	0.0490	0.0490	0.0485	0.0488
FAA-T-P4-D0-05	2.5260	0.3740	0.1235	0.1225	0.1220	0.1227	0.0495	0.0490	0.0490	0.0492
FAA-T-P4-D1-01	2.5175	0.3760	0.1220	0.1230	0.1240	0.1230	0.0490	0.0490	0.0490	0.0490
FAA-T-P4-D1-02	2.5400	0.3760	0.1240	0.1245	0.1240	0.1242	0.0490	0.0485	0.0485	0.0487
FAA-T-P4-D1-03	2.4850	0.3770	0.1235	0.1230	0.1230	0.1232	0.0480	0.0480	0.0485	0.0482
FAA-T-P4-D1-04	2.5380	0.3755	0.1275	0.1270	0.1270	0.1272	0.0485	0.0490	0.0490	0.0488
FAA-T-P4-D1-05	2.5065	0.3765	0.1230	0.1230	0.1240	0.1233	0.0500	0.0500	0.0495	0.0498
FAA-T-P4-D2-01	2.4765	0.3755	0.1210	0.1215	0.1215	0.1213	0.0490	0.0495	0.0490	0.0492
FAA-T-P4-D2-02	2.5420	0.3775	0.1220	0.1220	0.1230	0.1223	0.0490	0.0490	0.0495	0.0492
FAA-T-P4-D2-03	2.5130	0.3760	0.1240	0.1240	0.1245	0.1242	0.0495	0.0500	0.0500	0.0498
FAA-T-P4-D2-04	2.4835	0.3760	0.1240	0.1240	0.1245	0.1242	0.0485	0.0480	0.0480	0.0482
FAA-T-P4-D2-05	2.4770	0.3760	0.1215	0.1220	0.1225	0.1220	0.0490	0.0490	0.0490	0.0490
FAA-T-P4-D3-01	2.4870	0.3765	0.1230	0.1230	0.1225	0.1228	0.0485	0.0485	0.0485	0.0485
FAA-T-P4-D3-02	2.4805	0.3765	0.1240	0.1235	0.1240	0.1238	0.0485	0.0480	0.0480	0.0482
FAA-T-P4-D3-03	2.4990	0.3780	0.1220	0.1225	0.1230	0.1225	0.0490	0.0495	0.0495	0.0493
FAA-T-P4-D3-04	2.4780	0.3770	0.1225	0.1230	0.1235	0.1230	0.0490	0.0490	0.0490	0.0490
FAA-T-P4-D3-05	2.4775	0.3735	0.1220	0.1220	0.1215	0.1218	0.0490	0.0485	0.0485	0.0487
FAA-T-P4-D4-01	2.4815	0.3760	0.1220	0.1225	0.1240	0.1228	0.0495	0.0495	0.0495	0.0495
FAA-T-P4-D4-02	2.4780	0.3770	0.1220	0.1225	0.1230	0.1225	0.0490	0.0485	0.0490	0.0488
FAA-T-P4-D4-03	2.4770	0.3740	0.1235	0.1230	0.1230	0.1232	0.0490	0.0485	0.0480	0.0485
FAA-T-P4-D4-04	2.5270	0.3750	0.1255	0.1255	0.1250	0.1253	0.0490	0.0490	0.0490	0.0490
FAA-T-P4-D4-05	2.4795	0.3750	0.1230	0.1225	0.1225	0.1227	0.0490	0.0490	0.0485	0.0488
FAA-T-P4-D5-01	2.5285	0.3770	0.1230	0.1230	0.1235	0.1232	0.0490	0.0490	0.0490	0.0490
FAA-T-P4-D5-02	2.4810	0.3755	0.1240	0.1240	0.1245	0.1242	0.0485	0.0485	0.0490	0.0487
FAA-T-P4-D5-03	2.4785	0.3750	0.1235	0.1230	0.1225	0.1230	0.0490	0.0485	0.0490	0.0488
FAA-T-P4-D5-04	2.4785	0.3765	0.1220	0.1225	0.1230	0.1225	0.0490	0.0490	0.0485	0.0488
FAA-T-P4-D5-05	2.4770	0.3760	0.1255	0.1255	0.1250	0.1253	0.0490	0.0490	0.0490	0.0490

B Plastic strength test pictures

Table 84. Test photographs for FAA-T-P1-D0-0X (Kydex 6565)

	Pre-Test	**Post-Test**
FAA-T-P1-D0-01		
FAA-T-P1-D0-02		
FAA-T-P1-D0-03		
FAA-T-P1-D0-04		
FAA-T-P1-D0-05		

	Pre-Test	Post-Test
FAA-T-P1-D0-06		
FAA-T-P1-D0-07		
FAA-T-P1-D0-08		
FAA-T-P1-D0-09		
FAA-T-P1-D0-10		
FAA-T-P1-D0-11		

	Pre-Test	Post-Test
FAA-T-P1-D0-12		
FAA-T-P1-D0-13		
FAA-T-P1-D0-14		
FAA-T-P1-D0-15		
FAA-T-P1-D0-16		
FAA-T-P1-D0-17		

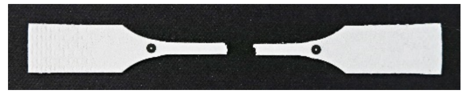
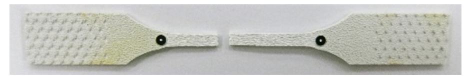
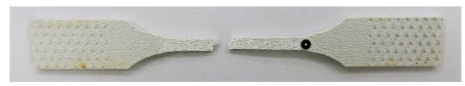
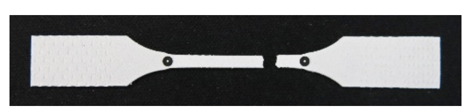
	Pre-Test	Post-Test
FAA-T-P1-D0-18		

Table 85. Test photographs for FAA-T-P1-D1-0X (Kydex 6565)

	Pre-Conditioning	**Post-Conditioning/ Pre-Test**	**Post-Test**
FAA-T-P1-D1-01			
FAA-T-P1-D1-02			
FAA-T-P1-D1-03			
FAA-T-P1-D1-04			
FAA-T-P1-D1-05			
FAA-T-P1-D1-06			

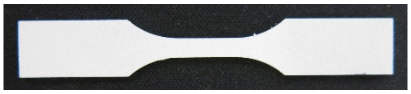
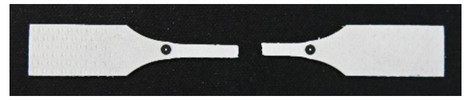
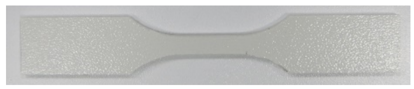
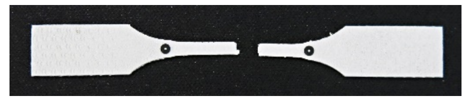
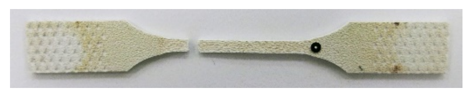
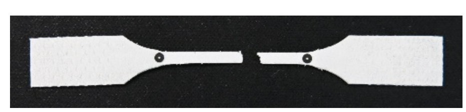
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P1-D1-07			
FAA-T-P1-D1-08			

Table 86. Test photographs for FAA-T-P1-D2-0X (Kydex 6565)

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P1-D2-01			
FAA-T-P1-D2-02			
FAA-T-P1-D2-03			
FAA-T-P1-D2-04			
FAA-T-P1-D2-05			
FAA-T-P1-D2-06			

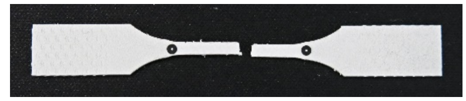
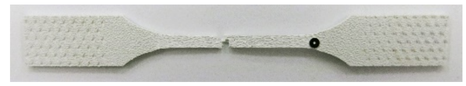
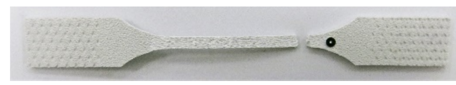
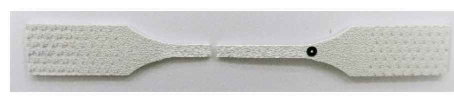
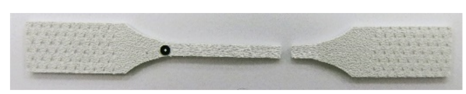
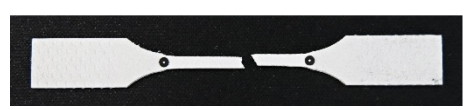
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P1-D2-07			
FAA-T-P1-D2-08			

Table 87. Test photographs for FAA-T-P1-D3-0X (Kydex 6565)

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P1-D3-01			
FAA-T-P1-D3-02			
FAA-T-P1-D3-03			
FAA-T-P1-D3-04			
FAA-T-P1-D3-05			
FAA-T-P1-D3-06			

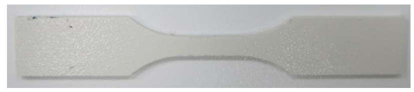
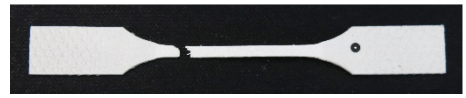
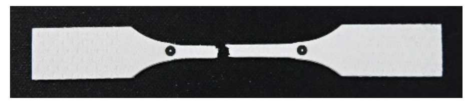
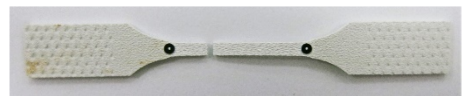
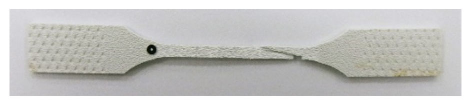
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P1-D3-06			
FAA-T-P1-D3-08			

Table 88. Test photographs for FAA-T-P1-D4-0X (Kydex 6565)

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P1-D4-01			
FAA-T-P1-D4-02			
FAA-T-P1-D4-03			
FAA-T-P1-D4-04			
FAA-T-P1-D4-05			
FAA-T-P1-D4-06			

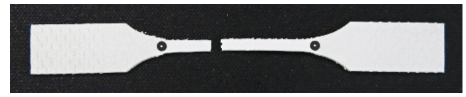
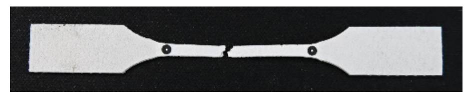
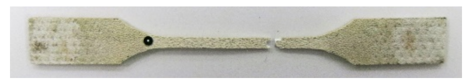
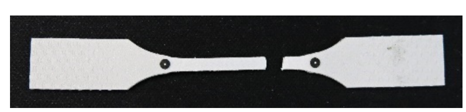
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P1-D4-07			
FAA-T-P1-D4-08			

Table 89. Test photographs for FAA-T-P1-D5-0X (Kydex 6565)

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P1-D5-01			
FAA-T-P1-D5-02			
FAA-T-P1-D5-03			
FAA-T-P1-D5-04			
FAA-T-P1-D5-05			
FAA-T-P1-D5-06			

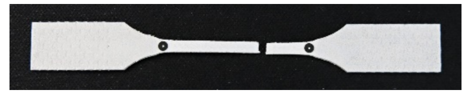
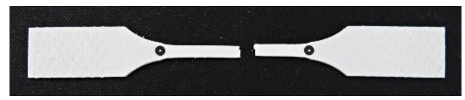
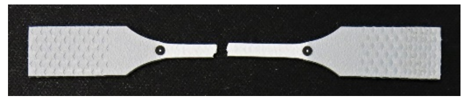
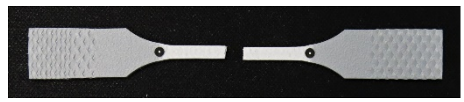
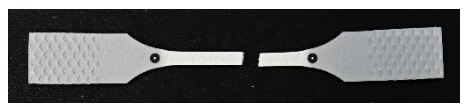
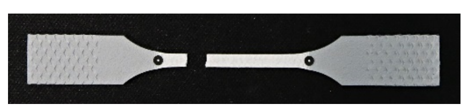
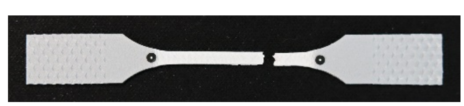
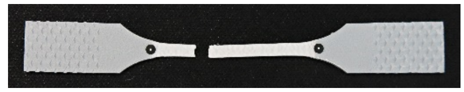
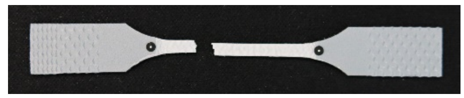
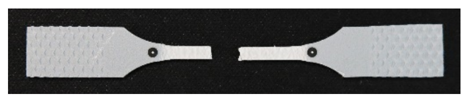
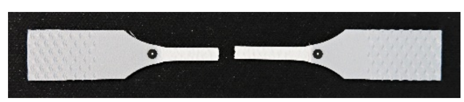
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P1-D5-07			
FAA-T-P1-D5-08			

Table 90. Test photographs for FAA-T-P2-D0-0X (Boltaron 9815E)

	Pre-Test	**Post-Test**
FAA-T-P2-D0-01		
FAA-T-P2-D0-02		
FAA-T-P2-D0-03		
FAA-T-P2-D0-04		
FAA-T-P2-D0-05		
FAA-T-P2-D0-06		

	Pre-Test	Post-Test
FAA-T-P2-D0-07		
FAA-T-P2-D0-08		
FAA-T-P2-D0-09		
FAA-T-P2-D0-10		
FAA-T-P2-D0-11		
FAA-T-P2-D0-12		

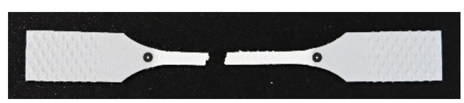
	Pre-Test	Post-Test
FAA-T-P2-D0-13		
FAA-T-P2-D0-14		
FAA-T-P2-D0-15		
FAA-T-P2-D0-16		
FAA-T-P2-D0-17		
FAA-T-P2-D0-18		

Table 91. Test photographs for FAA-T-P2-D1-0X (Boltaron 9815E)

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P2-D1-01			
FAA-T-P2-D1-02			
FAA-T-P2-D1-03			
FAA-T-P2-D1-04			
FAA-T-P2-D1-05			
FAA-T-P2-D1-06			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P2-D1-07			
FAA-T-P2-D1-08			

Table 92. Test photographs for FAA-T-P2-D2-0X (Boltaron 9815E)

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P2-D2-01			
FAA-T-P2-D2-02			
FAA-T-P2-D2-03			
FAA-T-P2-D2-04			
FAA-T-P2-D2-05			
FAA-T-P2-D2-06			

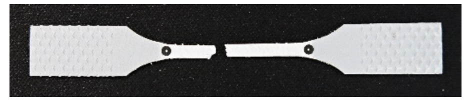
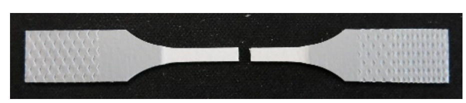
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P2-D2-07			
FAA-T-P2-D2-08			

Table 93. Test photographs for FAA-T-P2-D3-0X (Boltaron 9815E)

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P2-D3-01			
FAA-T-P2-D3-02			
FAA-T-P2-D3-03			
FAA-T-P2-D3-04			
FAA-T-P2-D3-05			
FAA-T-P2-D3-06			

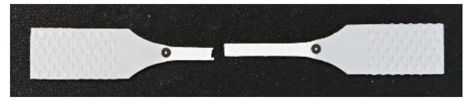
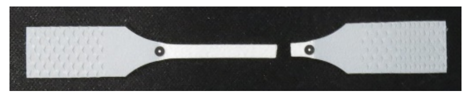
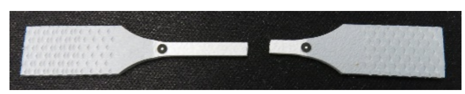
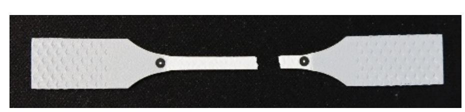
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P2-D3-07			
FAA-T-P2-D3-08			

Table 94. Test photographs for FAA-T-P2-D4-0X (Boltaron 9815E)

1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P2-D4-01			
FAA-T-P2-D4-02			
FAA-T-P2-D4-03			
FAA-T-P2-D4-04			
FAA-T-P2-D4-05			
FAA-T-P2-D4-06			

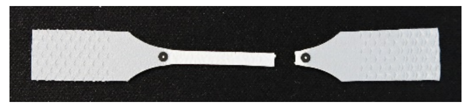
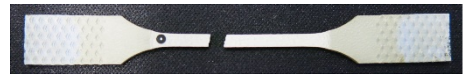
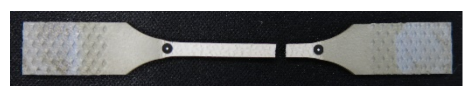
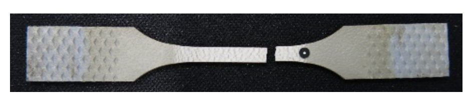
1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P2-D4-07			
FAA-T-P2-D4-08			

Table 95. Test photographs for FAA-T-P2-D5-0X (Boltaron 9815E)

	Pre-Conditioning	**Post-Conditioning/ Pre-Test**	**Post-Test**
FAA-T-P2-D5-01			
FAA-T-P2-D5-02			
FAA-T-P2-D5-03			
FAA-T-P2-D5-04			
FAA-T-P2-D5-05			
FAA-T-P2-D5-06			

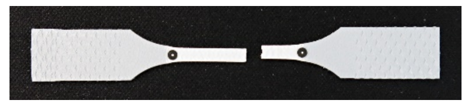
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P2-D5-07			
FAA-T-P2-D5-08			

Table 96. Test photographs for FAA-T-P3-D0-0X (Lexan XHR)

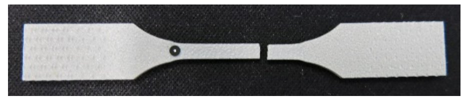
	Pre-Test	Post-Test
FAA-T-P3-D0-01		
FAA-T-P3-D0-02		
FAA-T-P3-D0-03		
FAA-T-P3-D0-04		
FAA-T-P3-D0-05		

Table 97. Test photographs for FAA-T-P3-D1-0X (Lexan XHR)

1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P3-D1-01			
FAA-T-P3-D1-02			
FAA-T-P3-D1-03			
FAA-T-P3-D1-04			
FAA-T-P3-D1-05			

Table 98. Test photographs for FAA-T-P3-D2-0X (Lexan XHR)

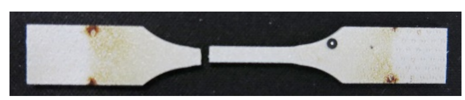
	Pre-Conditioning	**Post-Conditioning/ Pre-Test**	**Post-Test**
FAA-T-P3-D2-01			
FAA-T-P3-D2-02			
FAA-T-P3-D2-03			
FAA-T-P3-D2-04			
FAA-T-P3-D2-05			

Table 99. Test photographs for FAA-T-P3-D3-0X (Lexan XHR)

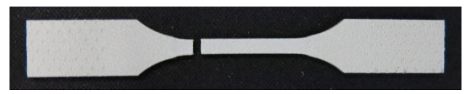
1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P3-D3-01			
FAA-T-P3-D3-02			
FAA-T-P3-D3-03			
FAA-T-P3-D3-04			
FAA-T-P3-D3-05			

Table 100. Test photographs for FAA-T-P3-D4-0X (Lexan XHR)

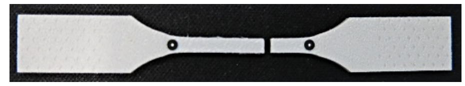
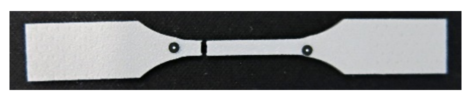
	Pre-Conditioning	**Post-Conditioning/ Pre-Test**	**Post-Test**
FAA-T-P3-D4-01			
FAA-T-P3-D4-02			
FAA-T-P3-D4-03			
FAA-T-P3-D4-04			
FAA-T-P3-D4-05			

Table 101. Test photographs for FAA-T-P3-D5-0X (Lexan XHR)

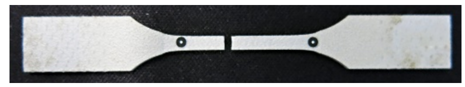
1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P3-D5-01			
FAA-T-P3-D5-02			
FAA-T-P3-D5-03			
FAA-T-P3-D5-04			
FAA-T-P3-D5-05			

Table 102. Test photographs for FAA-T-P4-D0-0X (Boltaron 9815N)

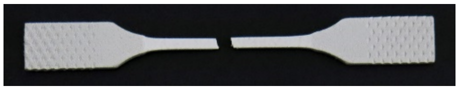
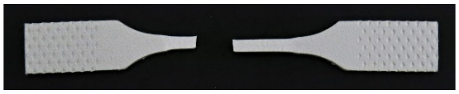
	Pre-Test	Post-Test
FAA-T-P4-D0-01		
FAA-T-P4-D0-02		
FAA-T-P4-D0-03		
FAA-T-P4-D0-04		
FAA-T-P4-D0-05		

Table 103. Test photographs for FAA-T-P4-D1-0X (Boltaron 9815N)

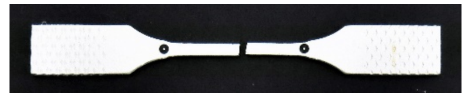
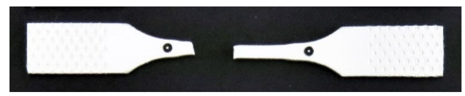
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P4-D1-01			
FAA-T-P4-D1-02			
FAA-T-P4-D1-03			
FAA-T-P4-D1-04			
FAA-T-P4-D1-05			

Table 104. Test photographs for FAA-T-P4-D2-0X (Boltaron 9815N)

1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P4-D2-01			
FAA-T-P4-D2-02			
FAA-T-P4-D2-03			
FAA-T-P4-D2-04			
FAA-T-P4-D2-05			

Table 105. Test photographs for FAA-T-P4-D3-0X (Boltaron 9815N)

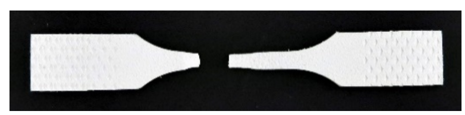
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P4-D3-01			
FAA-T-P4-D3-02			
FAA-T-P4-D3-03			
FAA-T-P4-D3-04			
FAA-T-P4-D3-05			

Table 106. Test photographs for FAA-T-P4-D4-0X (Boltaron 9815N)

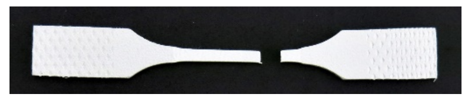
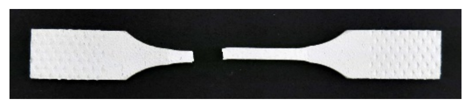
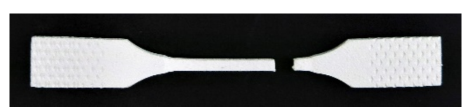
	Pre-Conditioning	**Post-Conditioning/ Pre-Test**	**Post-Test**
FAA-T-P4-D4-01			
FAA-T-P4-D4-02			
FAA-T-P4-D4-03			
FAA-T-P4-D4-04			
FAA-T-P4-D4-05			

Table 107. Test photographs for FAA-T-P4-D5-0X (Boltaron 9815N)

1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-T-P4-D5-01			
FAA-T-P4-D5-02			
FAA-T-P4-D5-03			
FAA-T-P4-D5-04			
FAA-T-P4-D5-05			

C Seatbelt webbing strength test pictures

Table 108. Test photographs for FAA-T-W-DX-0X (SCHROTH webbing)

	Pre-Test	Post-Test
FAA-T-W-D0-01		
FAA-T-W-D0-02		
FAA-T-W-D0-03		
FAA-T-W-D1-01		
FAA-T-W-D1-02		
FAA-T-W-D1-03		

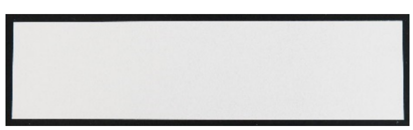
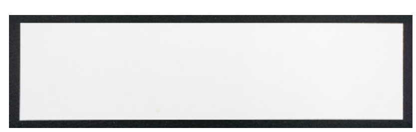
	Pre-Test	Post-Test
FAA-T-W-D2-01		
FAA-T-W-D2-02		
FAA-T-W-D2-03		
FAA-T-W-D3-01		
FAA-T-W-D3-02		
FAA-T-W-D3-03		
FAA-T-W-D4-01		

	Pre-Test	Post-Test
FAA-T-W-D4-02		
FAA-T-W-D4-03		
FAA-T-W-D5-01		
FAA-T-W-D5-02		
FAA-T-W-D5-03		

D Plastic flammability pictures

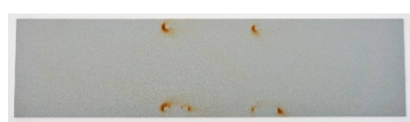
Table 109. Test photographs for FAA-VF-P1-DX-0X (Kydex 6565)

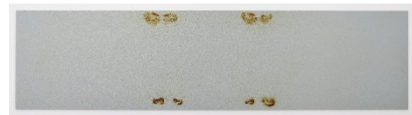
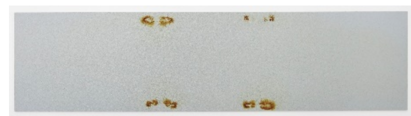
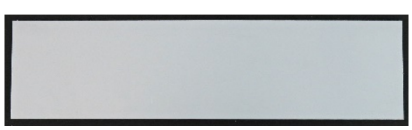
1	Pre-Conditioning	Post-Conditioning/ Pre-Test
FAA-VF-P1-D0-01		
FAA-VF-P1-D0-02		
FAA-VF-P1-D0-03		
FAA-VF-P1-D1-01		
FAA-VF-P1-D1-02		
FAA-VF-P1-D1-03		

1	Pre-Conditioning	Post-Conditioning/ Pre-Test
FAA-VF-P1-D2-01		
FAA-VF-P1-D2-02		
FAA-VF-P1-D2-03		
FAA-VF-P1-D3-01		
FAA-VF-P1-D3-02		
FAA-VF-P1-D3-03		
FAA-VF-P1-D4-01		

1	Pre-Conditioning	Post-Conditioning/ Pre-Test
FAA-VF-P1-D4-02		
FAA-VF-P1-D4-03		
FAA-VF-P1-D5-01		
FAA-VF-P1-D5-02		
FAA-VF-P1-D5-03		

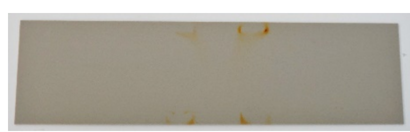
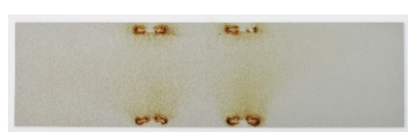
Table 110. Test photographs for FAA-VF-P2-DX-0X (Boltaron 9815E)

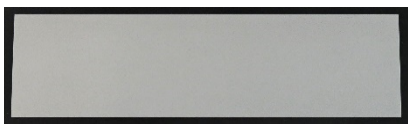
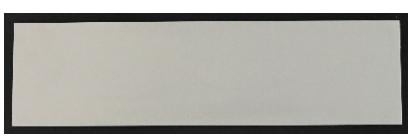
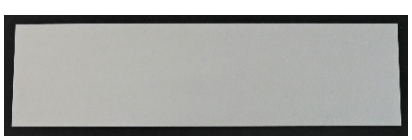
1	Pre-Conditioning	Post-Conditioning/ Pre-Test
FAA-VF-P2-D0-01		
FAA-VF-P2-D0-02		
FAA-VF-P2-D0-03		
FAA-VF-P2-D1-01		
FAA-VF-P2-D1-02		
FAA-VF-P2-D1-03		
FAA-VF-P2-D2-01		

1	Pre-Conditioning	Post-Conditioning/ Pre-Test
FAA-VF-P2-D2-02		
FAA-VF-P2-D2-03		
FAA-VF-P2-D3-01		
FAA-VF-P2-D3-02		
FAA-VF-P2-D3-03		
FAA-VF-P2-D4-01		
FAA-VF-P2-D4-02		

1	Pre-Conditioning	Post-Conditioning/ Pre-Test
FAA-VF-P2-D4-03		
FAA-VF-P2-D5-01		
FAA-VF-P2-D5-02		
FAA-VF-P2-D5-03		

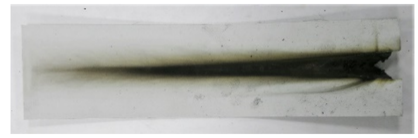
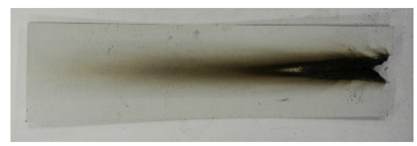
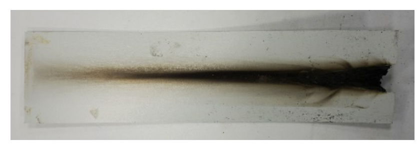
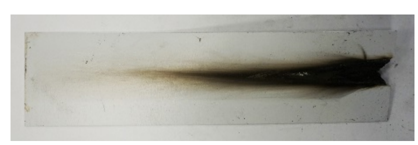
Table 111. Test photographs for FAA-VF-P3-DX-0X (Lexan XHR)

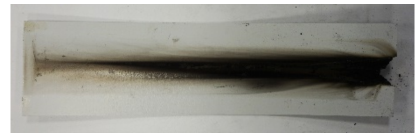
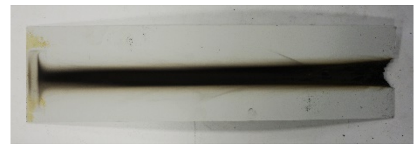
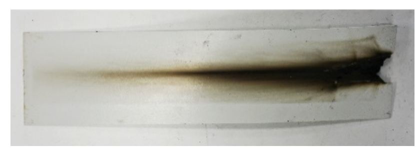
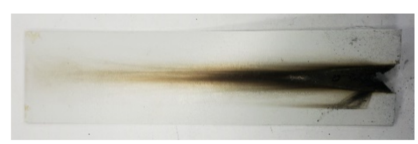
1	Pre-Conditioning	Post-Conditioning/ Pre-Test
FAA-VF-P3-D0-01		
FAA-VF-P3-D0-02		
FAA-VF-P3-D0-03		
FAA-VF-P3-D1-01		
FAA-VF-P3-D1-02		
FAA-VF-P3-D1-03		
FAA-VF-P3-D2-01		

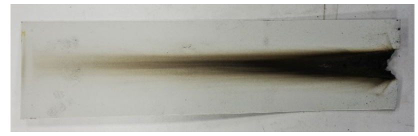
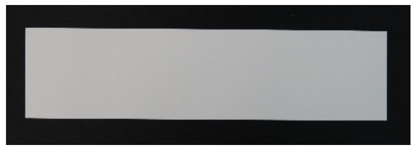
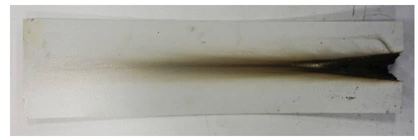
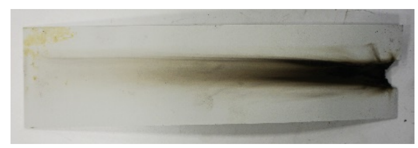
1	Pre-Conditioning	Post-Conditioning/ Pre-Test
FAA-VF-P3-D2-02		
FAA-VF-P3-D2-03		
FAA-VF-P3-D3-01		
FAA-VF-P3-D3-02		
FAA-VF-P3-D3-03		
FAA-VF-P3-D4-01		
FAA-VF-P3-D4-02		

1	Pre-Conditioning	Post-Conditioning/ Pre-Test
FAA-VF-P3-D4-03		
FAA-VF-P3-D5-01		
FAA-VF-P3-D5-02		
FAA-VF-P3-D5-03		

Table 112. Test photographs for FAA-VF-P4-DX-0X (Boltaron 9815N)

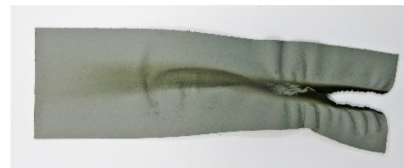
	Pre-Conditioning	**Post-Conditioning/ Pre-Test**	**Post-Test**
FAA-VF-P4-D0-01			
FAA-VF-P4-D0-02			
FAA-VF-P4-D0-03			
FAA-VF-P4-D1-01			
FAA-VF-P4-D1-02			
FAA-VF-P4-D1-03			

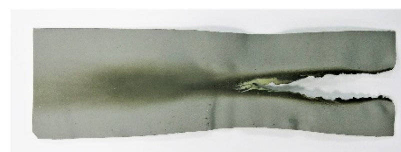
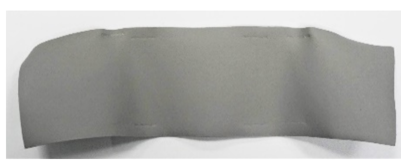
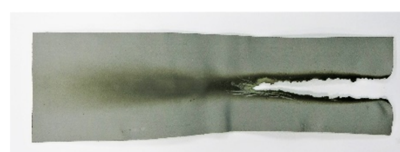
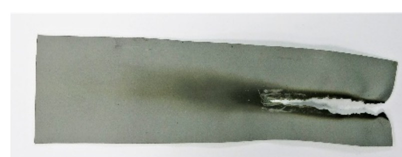
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-P4-D2-01			
FAA-VF-P4-D2-02			
FAA-VF-P4-D2-03			
FAA-VF-P4-D3-01			
FAA-VF-P4-D3-02			
FAA-VF-P4-D3-03			
FAA-VF-P4-D4-01			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-P4-D4-02			
FAA-VF-P4-D4-03			
FAA-VF-P4-D5-01			
FAA-VF-P4-D5-02			
FAA-VF-P4-D5-03			

E Leather flammability pictures

Table 113. Test photographs for Perrone Pewter BC

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-L1-D0-01			
FAA-VF-L1-D0-02			
FAA-VF-L1-D0-03			
FAA-VF-L1-D1-01			
FAA-VF-L1-D1-02			
FAA-VF-L1-D1-03			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-L1-D2-01			
FAA-VF-L1-D2-02			
FAA-VF-L1-D2-03			
FAA-VF-L1-D3-01			
FAA-VF-L1-D3-02			
FAA-VF-L1-D3-03			
FAA-VF-L1-D4-01			

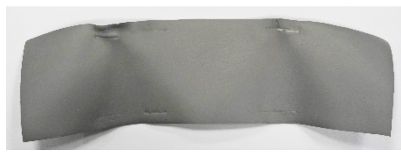
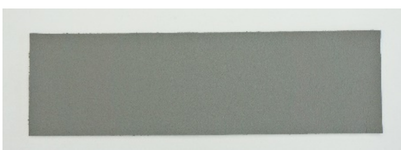
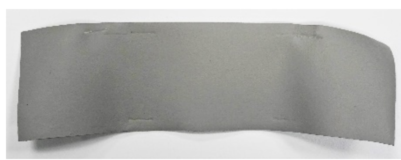
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-L1-D4-02			
FAA-VF-L1-D4-03			
FAA-VF-L1-D5-01			
FAA-VF-L1-D5-02			
FAA-VF-L1-D5-03			

Table 114. Test photographs for Perrone Feather Weight

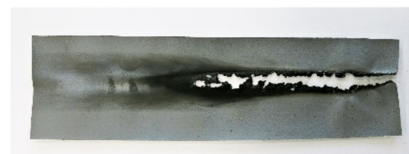
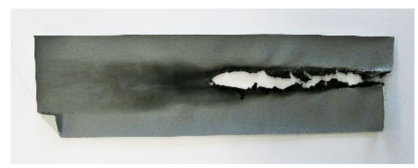
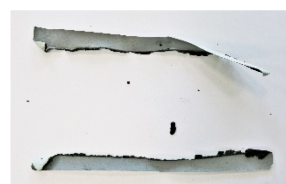
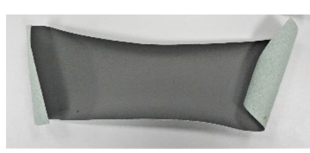
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-L3-D0-01			
FAA-VF-L3-D0-02			
FAA-VF-L3-D0-03			
FAA-VF-L3-D1-01			
FAA-VF-L3-D1-02			
FAA-VF-L3-D1-03			

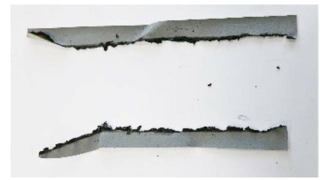
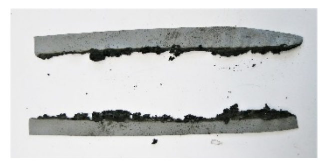
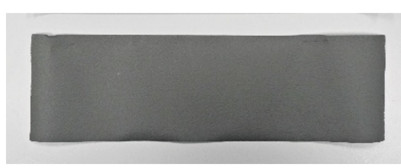
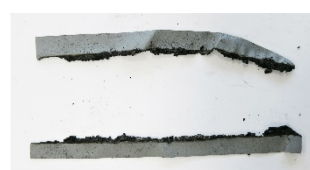
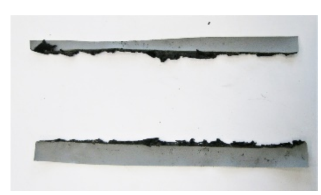
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-L3-D2-01			
FAA-VF-L3-D2-02			
FAA-VF-L3-D2-03			
FAA-VF-L3-D3-01			
FAA-VF-L3-D3-02			
FAA-VF-L3-D3-03			
FAA-VF-L3-D4-01			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-L3-D4-02			
FAA-VF-L3-D4-03			
FAA-VF-L3-D5-01			
FAA-VF-L3-D5-02			
FAA-VF-L3-D5-03			

F Synthetic leather flammability pictures

Table 115. Test photographs for E-Leather CL820

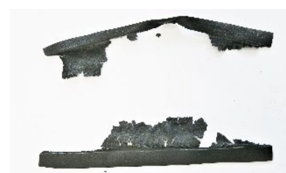
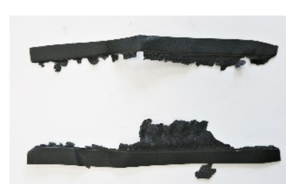
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL1-D0-01			
FAA-VF-SL1-D0-02			
FAA-VF-SL1-D0-03			
FAA-VF-SL1-D1-01			
FAA-VF-SL1-D1-02			
FAA-VF-SL1-D1-03			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL1-D2-01			
FAA-VF-SL1-D2-02			
FAA-VF-SL1-D2-03			
FAA-VF-SL1-D3-01			
FAA-VF-SL1-D3-02			
FAA-VF-SL1-D3-03			
FAA-VF-SL1-D4-01			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL1-D4-02			
FAA-VF-SL1-D4-03			
FAA-VF-SL1-D5-01			
FAA-VF-SL1-D5-02			
FAA-VF-SL1-D5-03			

Table 116. Test photographs for Ultrafabric 492-6579FR12

1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL2-D0-01			
FAA-VF-SL2-D0-02			
FAA-VF-SL2-D0-03			
FAA-VF-SL2-D1-01			
FAA-VF-SL2-D1-02			
FAA-VF-SL2-D1-03			

1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL2-D2-01			
FAA-VF-SL2-D2-02			
FAA-VF-SL2-D2-03			
FAA-VF-SL2-D3-01			
FAA-VF-SL2-D3-02			
FAA-VF-SL2-D3-03			
FAA-VF-SL2-D4-01			

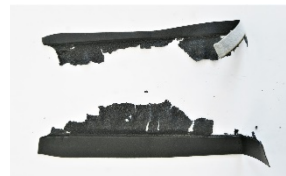
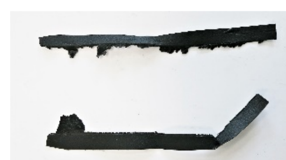
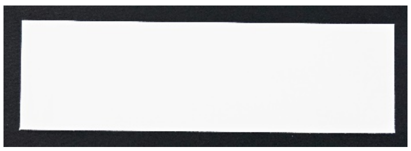
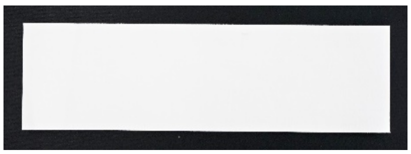
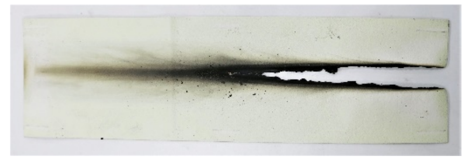
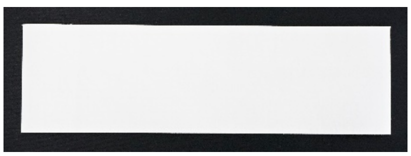
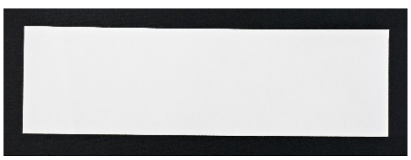
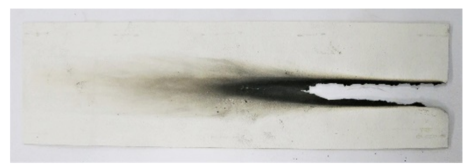
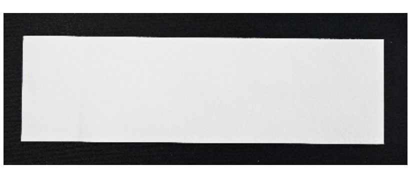
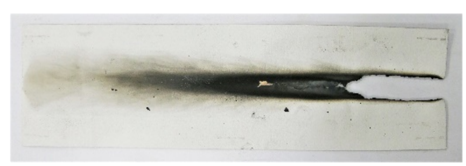
1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL2-D4-02			
FAA-VF-SL2-D4-03			
FAA-VF-SL2-D5-01			
FAA-VF-SL2-D5-02			
FAA-VF-SL2-D5-03			

Table 117. Test photographs for TapiSuede TSFRC0961

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL3-D0-01			
FAA-VF-SL3-D0-02			
FAA-VF-SL3-D0-03			
FAA-VF-SL3-D1-01			
FAA-VF-SL3-D1-02			
FAA-VF-SL3-D1-03			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL3-D2-01			
FAA-VF-SL3-D2-02			
FAA-VF-SL3-D2-03			
FAA-VF-SL3-D3-01			
FAA-VF-SL3-D3-02			
FAA-VF-SL3-D3-03			
FAA-VF-SL3-D4-01			

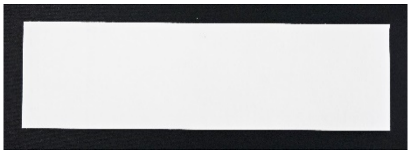
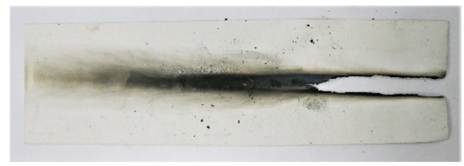
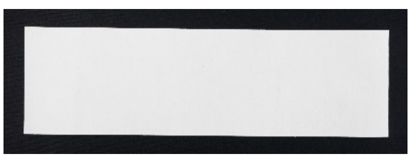
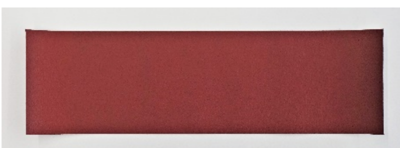
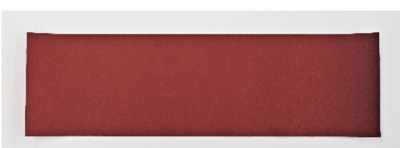
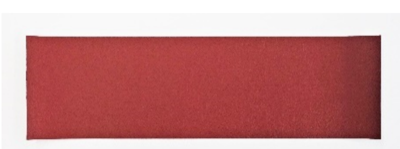
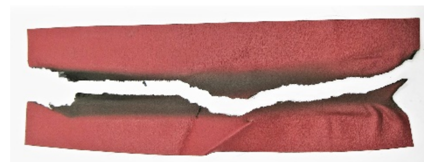
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL3-D4-02			
FAA-VF-SL3-D4-03			
FAA-VF-SL3-D5-01			
FAA-VF-SL3-D5-02			
FAA-VF-SL3-D5-03			

Table 118. Test photographs for Ultraleather ULFRB971-1363

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL4-D0-01			
FAA-VF-SL4-D0-02			
FAA-VF-SL4-D0-03			
FAA-VF-SL4-D1-01			
FAA-VF-SL4-D1-02			
FAA-VF-SL4-D1-03			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL4-D2-01			
FAA-VF-SL4-D2-02			
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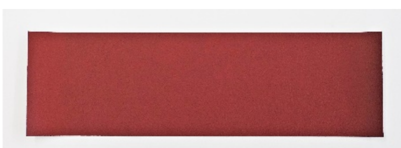
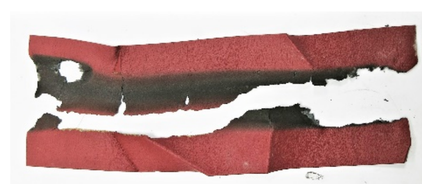
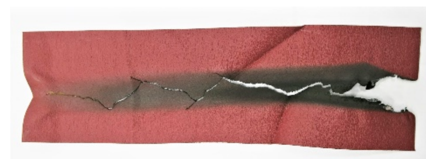
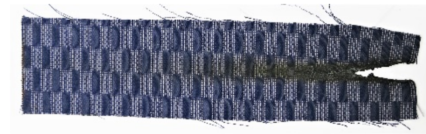
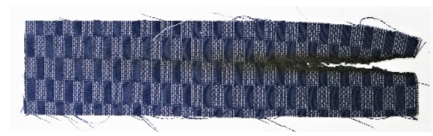
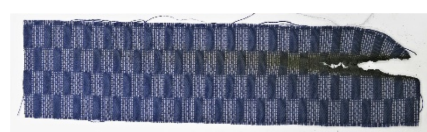
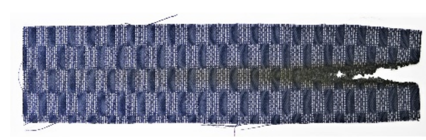
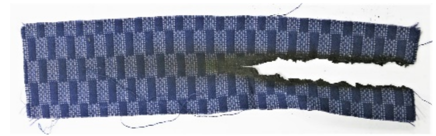
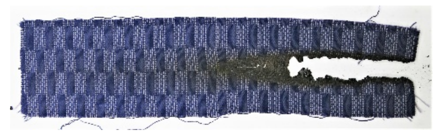
FAA-VF-SL4-D3-01			
FAA-VF-SL4-D3-02			
FAA-VF-SL4-D3-03			
FAA-VF-SL4-D4-01			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL4-D4-02			
FAA-VF-SL4-D4-03			
FAA-VF-SL4-D5-01			
FAA-VF-SL4-D5-02			
FAA-VF-SL4-D5-03			

G Nylon/wool flammability pictures

Table 119. Test photographs for Lantal

1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW1-D0-01			
FAA-VF-NW1-D0-02			
FAA-VF-NW1-D0-03			
FAA-VF-NW1-D1-01			
FAA-VF-NW1-D1-02			
FAA-VF-NW1-D1-03			

1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW1-D2-01			
FAA-VF-NW1-D2-02			
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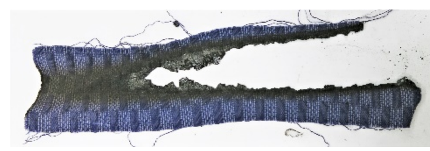
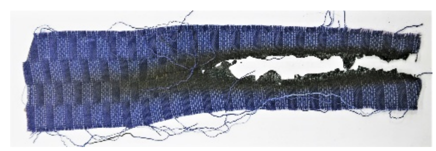
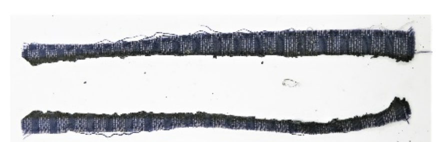
FAA-VF-NW1-D3-01			
FAA-VF-NW1-D3-02			
FAA-VF-NW1-D3-03			
FAA-VF-NW1-D4-01			

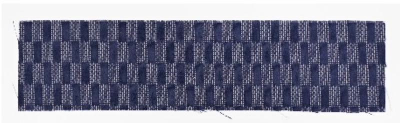
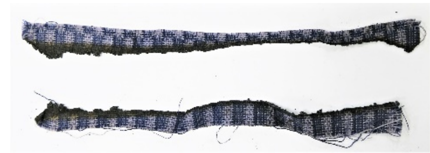
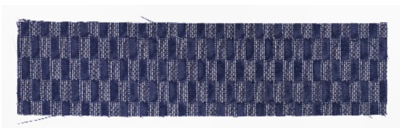
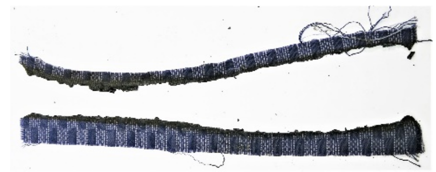
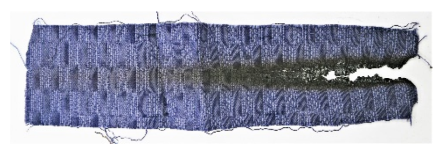
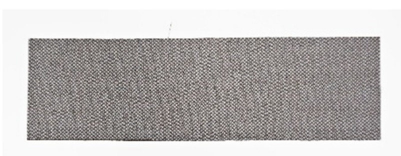
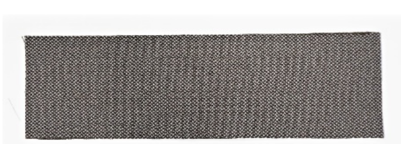
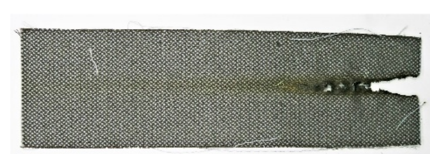
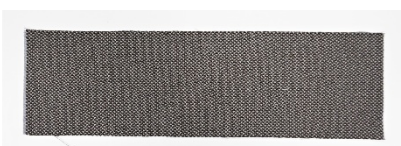
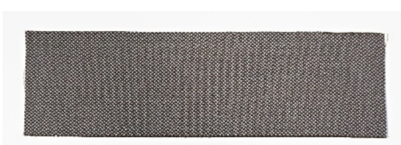
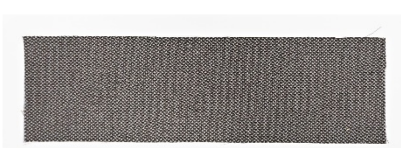
1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW1-D4-02			
FAA-VF-NW1-D4-03			
FAA-VF-NW1-D5-01			
FAA-VF-NW1-D5-02			
FAA-VF-NW1-D5-03			

Table 120. Test photographs for Rohi Beach

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW2-D0-01			
FAA-VF-NW2-D0-02			
FAA-VF-NW2-D0-03			
FAA-VF-NW2-D1-01			
FAA-VF-NW2-D1-02			
FAA-VF-NW2-D1-03			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW2-D2-01			
FAA-VF-NW2-D2-02			
FAA-VF-NW2-D2-03			
FAA-VF-NW2-D3-01			
FAA-VF-NW2-D3-02			
FAA-VF-NW2-D3-03			
FAA-VF-NW2-D4-01			

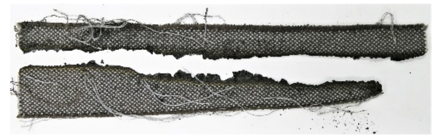
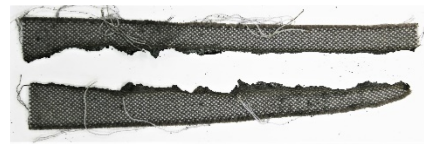
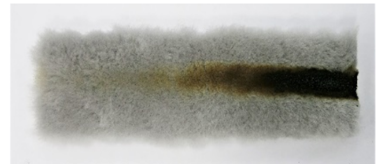
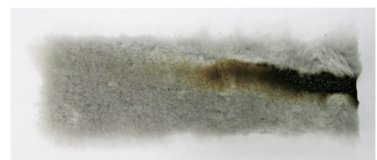
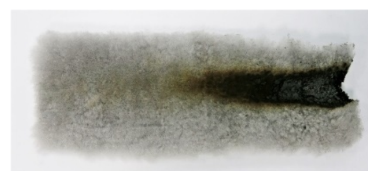
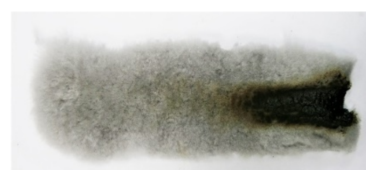
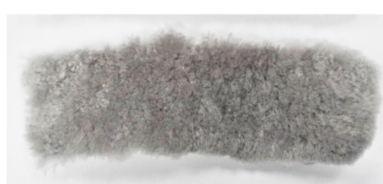
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW2-D4-02			
FAA-VF-NW2-D4-03			
FAA-VF-NW2-D5-01			
FAA-VF-NW2-D5-02			
FAA-VF-NW2-D5-03			

Table 121. Test photographs for Sheepskin

<table>
<tr><th></th><th>Pre-Conditioning</th><th>Post-Conditioning/ Pre-Test</th><th>Post-Test</th></tr>
<tr><td>FAA-VF-NW3-D0-01</td><td></td><td></td><td></td></tr>
<tr><td>FAA-VF-NW3-D0-02</td><td></td><td></td><td></td></tr>
<tr><td>FAA-VF-NW3-D0-03</td><td></td><td></td><td></td></tr>
<tr><td>FAA-VF-NW3-D1-01</td><td></td><td></td><td></td></tr>
<tr><td>FAA-VF-NW3-D1-02</td><td></td><td></td><td></td></tr>
<tr><td>FAA-VF-NW3-D1-03</td><td></td><td></td><td></td></tr>
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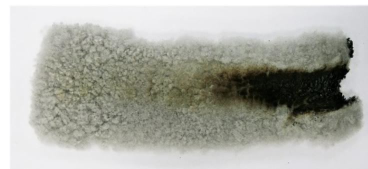
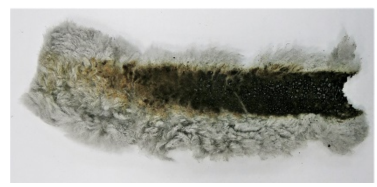
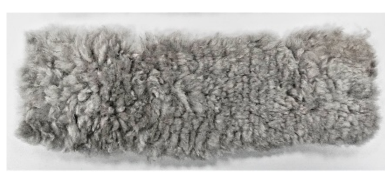
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW3-D2-01			
FAA-VF-NW3-D2-02			
FAA-VF-NW3-D2-03			
FAA-VF-NW3-D3-01			
FAA-VF-NW3-D3-02			
FAA-VF-NW3-D3-03			
FAA-VF-NW3-D4-01			

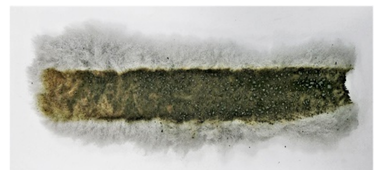
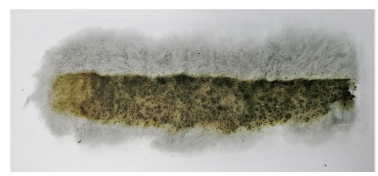
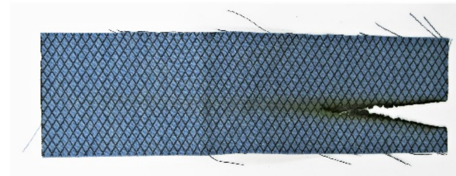
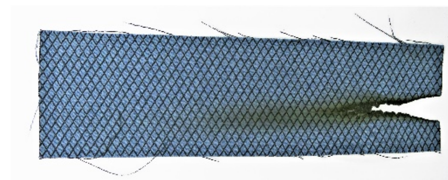
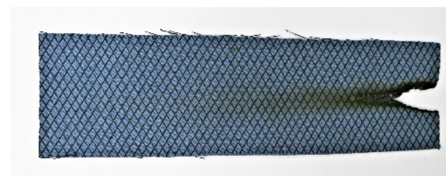
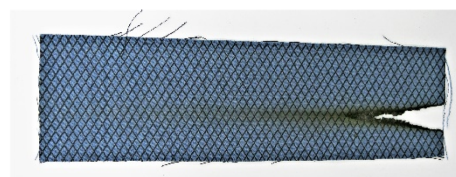
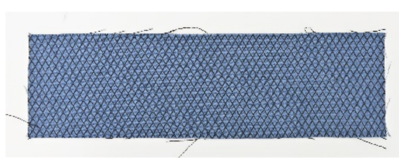
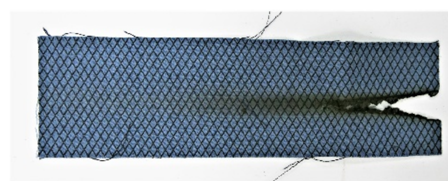
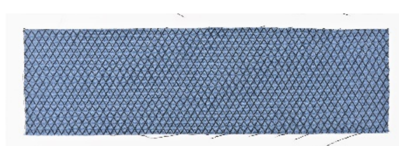
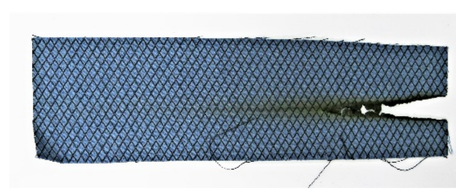
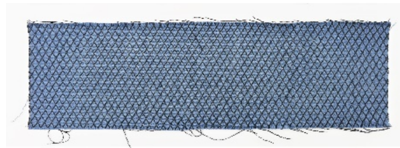
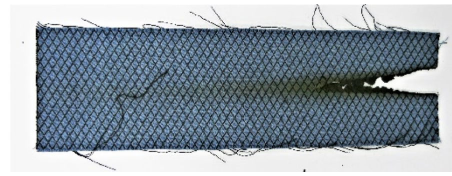
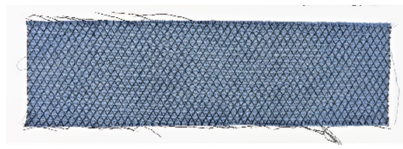
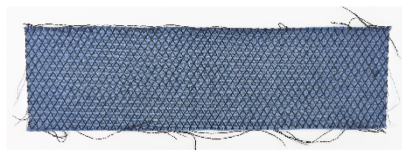
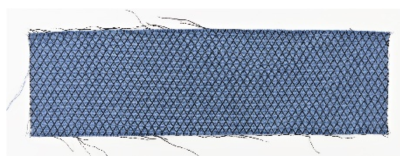
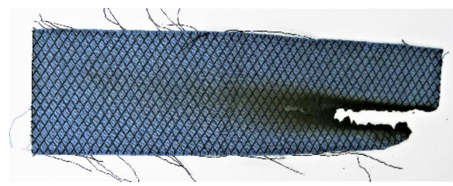
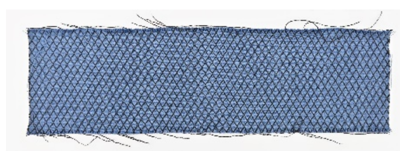
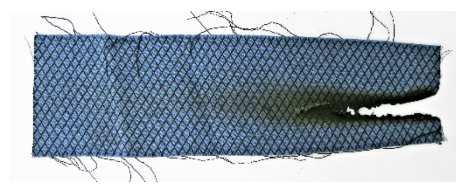
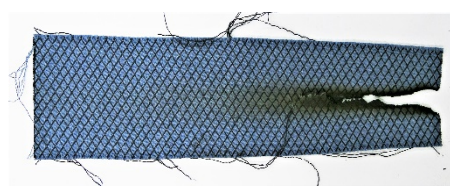
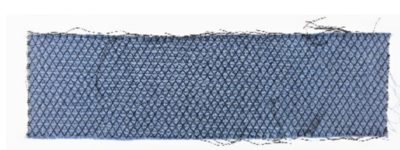
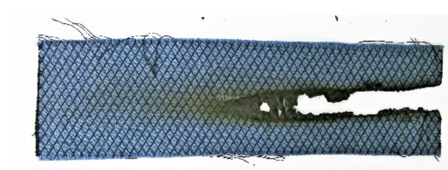
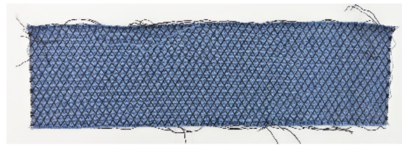
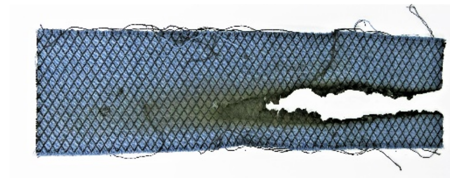
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW3-D4-02			
FAA-VF-NW3-D4-03			
FAA-VF-NW3-D5-01			
FAA-VF-NW3-D5-02			
FAA-VF-NW3-D5-03			

Table 122. Test photographs for Botany fabric

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW4-D0-01			
FAA-VF-NW4-D0-02			
FAA-VF-NW4-D0-03			
FAA-VF-NW4-D1-01			
FAA-VF-NW4-D1-02			
FAA-VF-NW4-D1-03			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW4-D2-01			
FAA-VF-NW4-D2-02			
FAA-VF-NW4-D2-03			
FAA-VF-NW4-D3-01			
FAA-VF-NW4-D3-02			
FAA-VF-NW4-D3-03			
FAA-VF-NW4-D4-01			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW4-D4-02			
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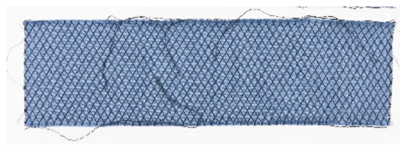
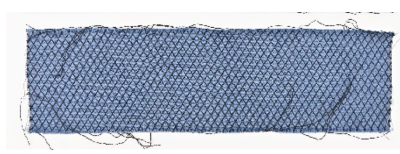
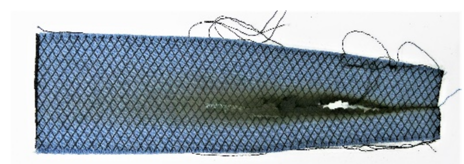
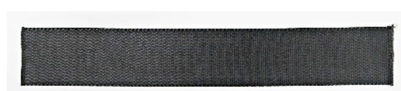
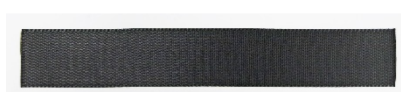
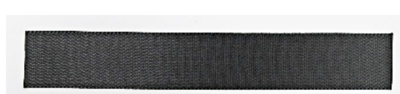
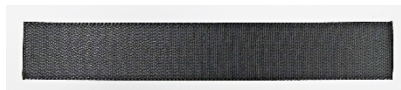
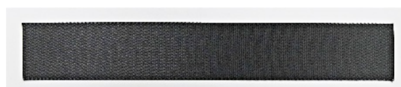
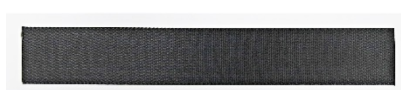
FAA-VF-NW4-D5-01			
FAA-VF-NW4-D5-02			
FAA-VF-NW4-D5-03			

H Webbing flammability pictures

Table 123. Test photographs for SCHROTH webbing

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-W-D0-01			
FAA-VF-W-D0-02			
FAA-VF-W-D0-03			
FAA-VF-W-D1-01			
FAA-VF-W-D1-02			
FAA-VF-W-D1-03			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-W-D2-01			
FAA-VF-W-D2-02			
FAA-VF-W-D2-03			
FAA-VF-W-D3-01			
FAA-VF-W-D3-02			
FAA-VF-W-D3-03			
FAA-VF-W-D4-01			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-W-D4-02			
FAA-VF-W-D4-03			
FAA-VF-W-D5-01			
FAA-VF-W-D5-02			
FAA-VF-W-D5-03			

I Additional plastic strength tests

Table 124. Longitudinal stress-strain response of Kydex6565

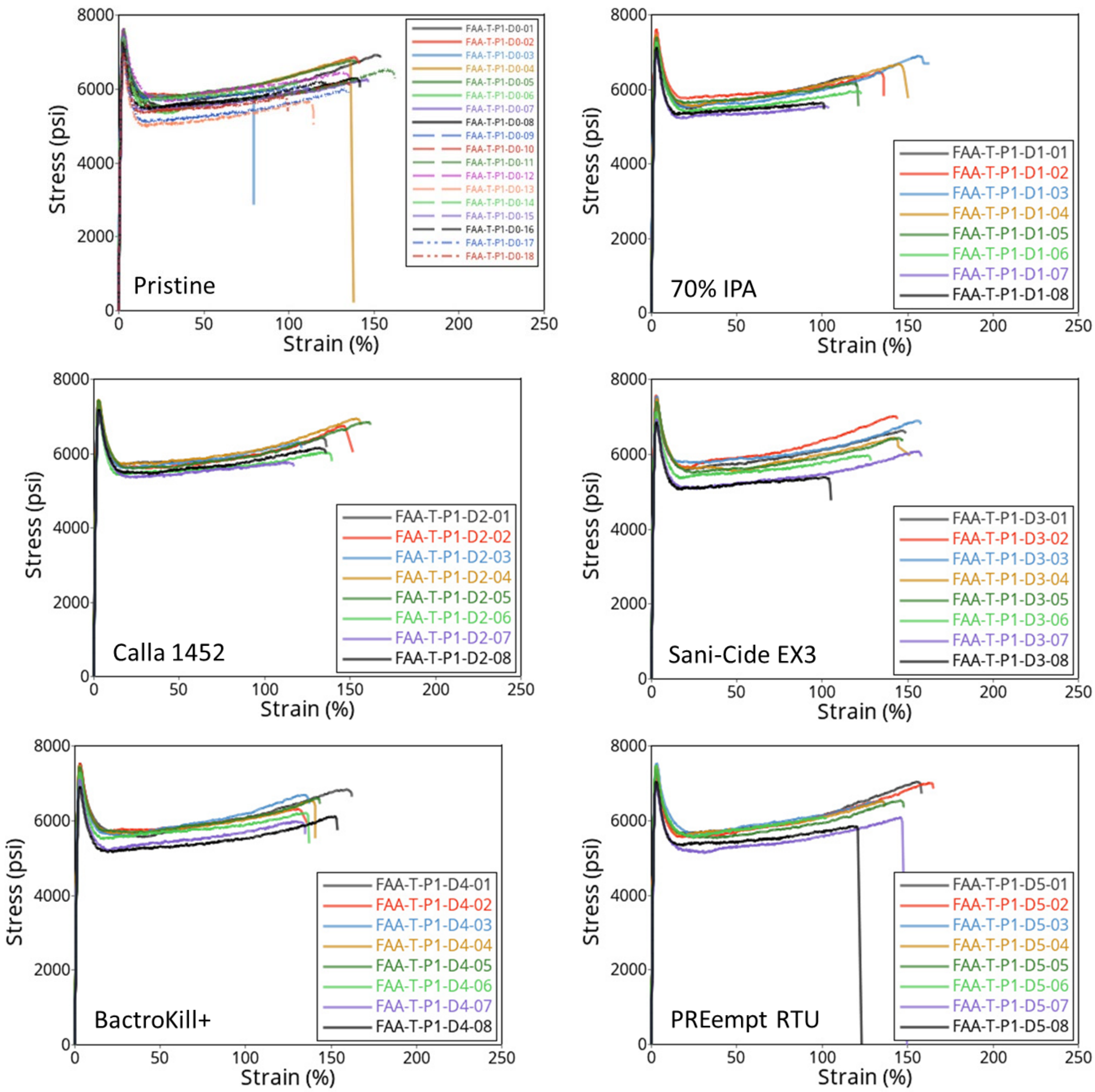
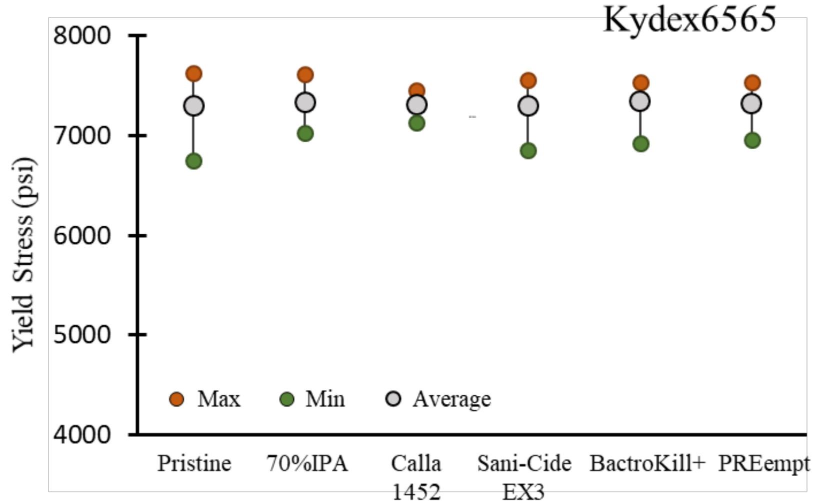
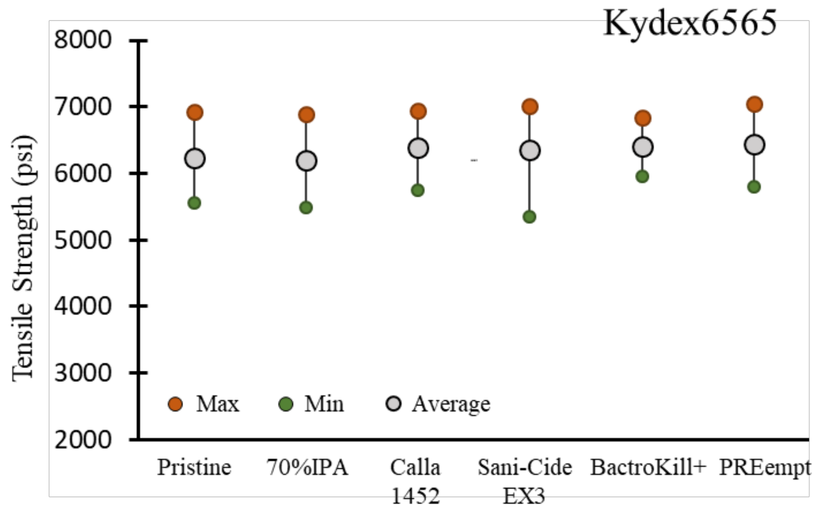


Table 125. Yield Stress, tensile strength, and failure strain comparison of Kydex 6565





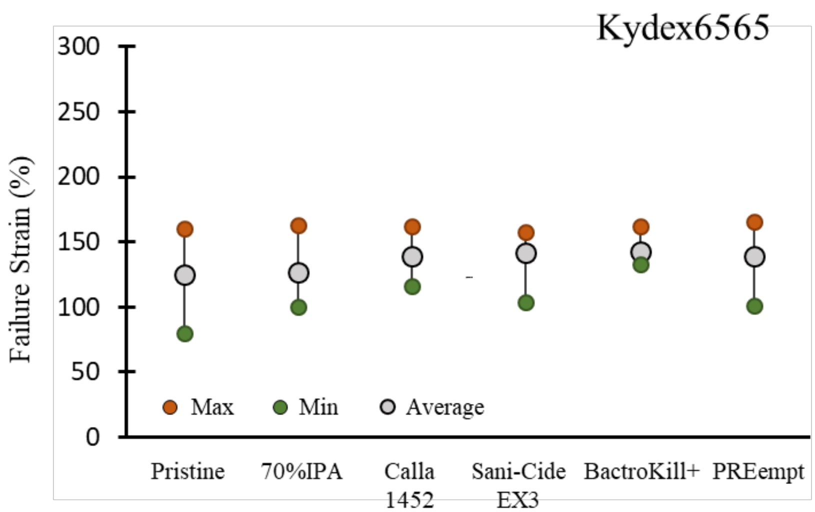


Table 126. Longitudinal stress-strain response of Boltaron 9815E

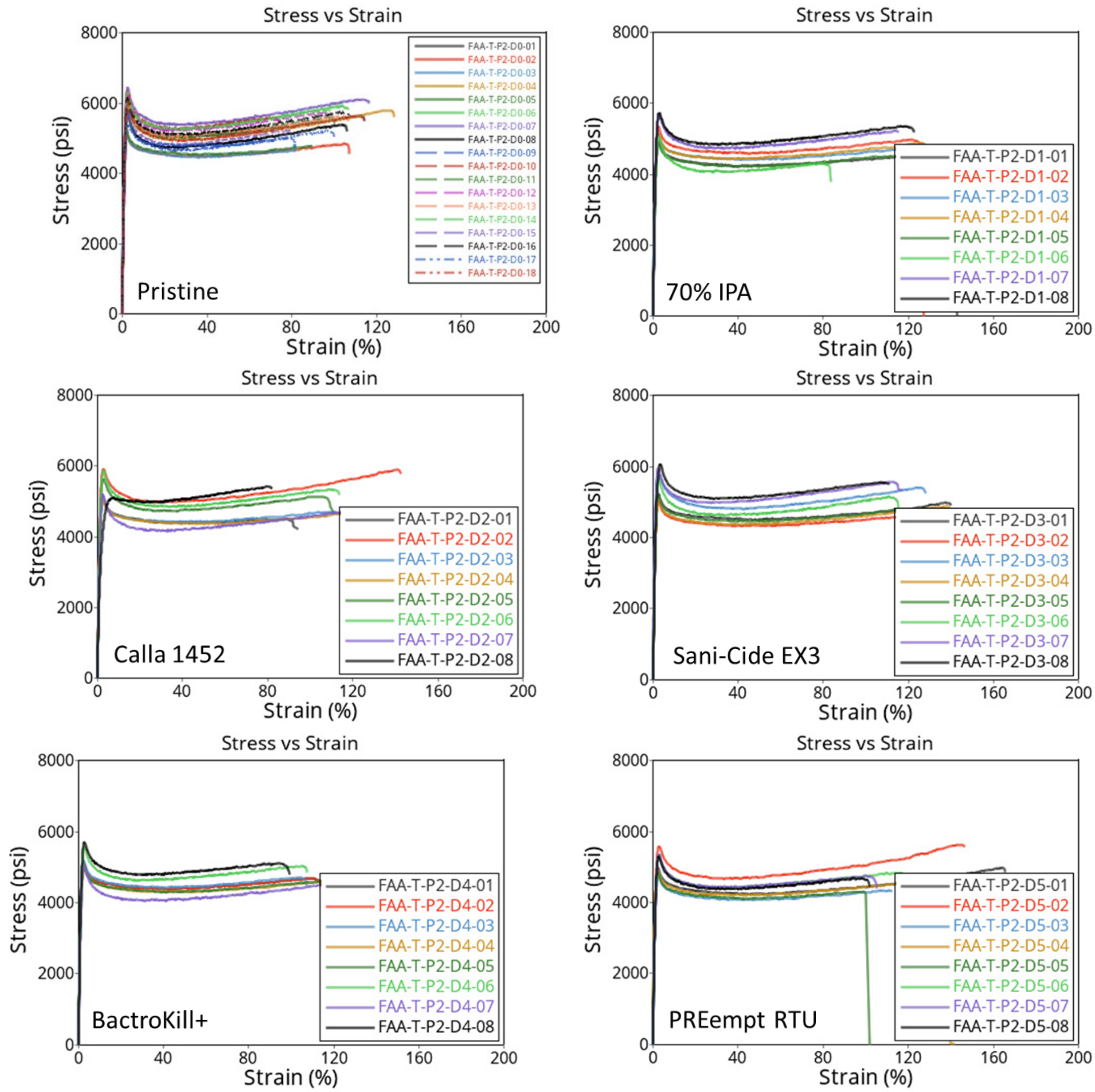
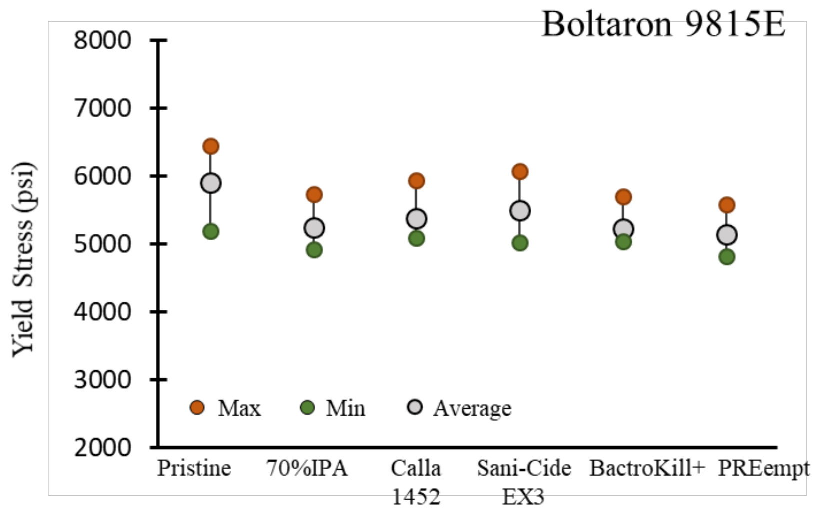
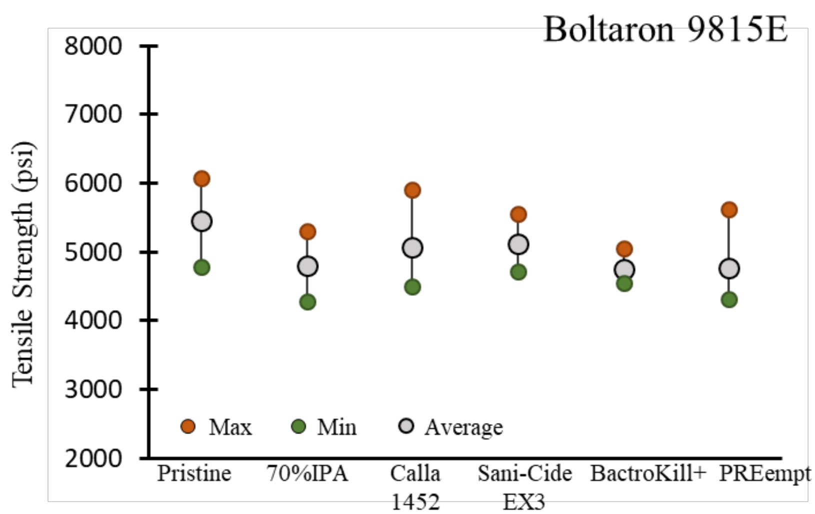
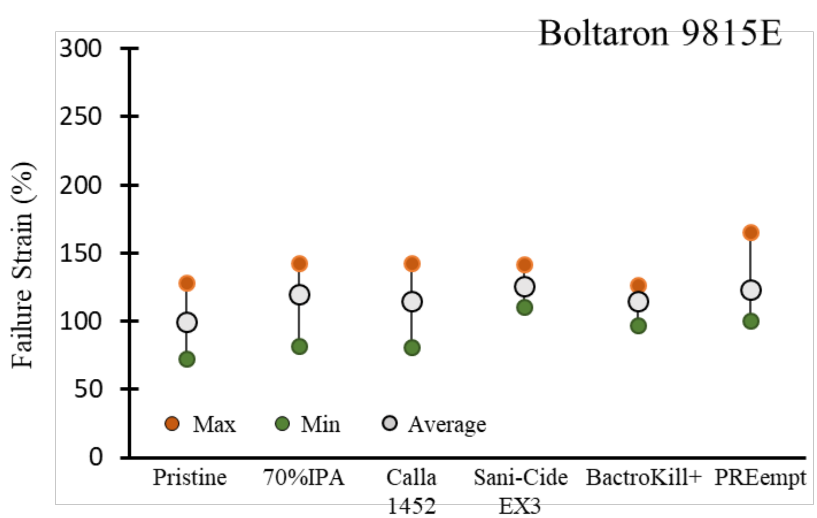


Table 127. Yield Stress, tensile strength, and failure strain comparison of Boltaron 9815E







J Leather flammability wiping method pictures

Table 128. Test photographs for Muirhead DF602 – wiping method

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-L1-D1-01			
FAA-VF-L1-D1-02			
FAA-VF-L1-D1-03			
FAA-VF-L1-D2-01			
FAA-VF-L1-D2-02			
FAA-VF-L1-D2-03			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-L1-D3-01			
FAA-VF-L1-D3-02			
FAA-VF-L1-D3-03			
FAA-VF-L1-D4-01			
FAA-VF-L1-D4-02			
FAA-VF-L1-D4-03			
FAA-VF-L1-D5-01			

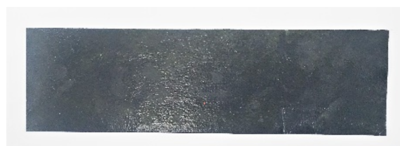
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-L1-D5-02			
FAA-VF-L1-D5-03			

Table 129. Test photographs for Perrone Pewter BC – wiping method

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-L2-D2-01			
FAA-VF-L2-D2-02			
FAA-VF-L2-D2-03			
FAA-VF-L2-D3-01			
FAA-VF-L2-D3-02			
FAA-VF-L2-D3-03			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-L2-D4-01			
FAA-VF-L2-D4-02			
FAA-VF-L2-D4-03			
FAA-VF-L2-D5-01			
FAA-VF-L2-D5-02			
FAA-VF-L2-D5-03			

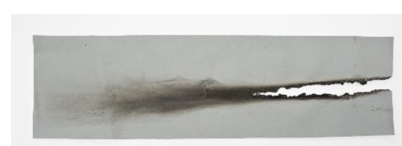
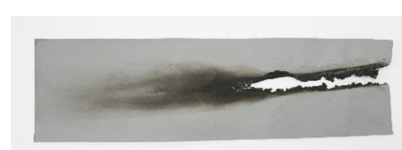
Table 130. Test photographs for Perrone Feather Weight – wiping method

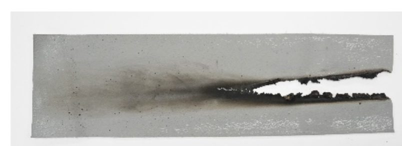
	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-L3-D3-01			
FAA-VF-L3-D3-02			
FAA-VF-L3-D3-03			
AA-VF-L3-D4-01			
FAA-VF-L3-D4-02			
FAA-VF-L3-D4-03			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-L3-D5-01			
FAA-VF-L3-D5-02			
FAA-VF-L3-D5-03			

K Synthetic leather flammability wiping method pictures

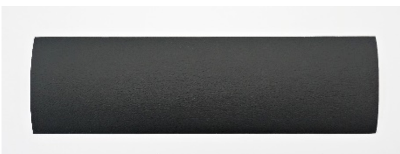
Table 131. Test photographs for E-Leather CL820 – wiping method

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL1-D1-01			
FAA-VF-SL1-D1-02			
FAA-VF-SL1-D1-03			
FAA-VF-SL1-D2-01			
FAA-VF-SL1-D2-02			
FAA-VF-SL1-D2-03			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL1-D3-01			
FAA-VF-SL1-D3-02			
FAA-VF-SL1-D3-03			
FAA-VF-SL1-D4-01			
FAA-VF-SL1-D4-02			
FAA-VF-SL1-D4-03			
FAA-VF-SL1-D5-01			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL1-D5-02			
FAA-VF-SL1-D5-03			

Table 132. Test photographs for Ultrafabric 492-6579FR12 – wiping method

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL2-D2-01			
FAA-VF-SL2-D2-02			
FAA-VF-SL2-D2-03			
FAA-VF-SL2-D3-01			
FAA-VF-SL2-D3-02			
FAA-VF-SL2-D3-03			

	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL2-D4-01			
FAA-VF-SL2-D4-02			
FAA-VF-SL2-D4-03			
FAA-VF-SL2-D5-01			
FAA-VF-SL2-D5-02			
FAA-VF-SL2-D5-03			

Table 133. Test photographs for Ultraleather ULFRB971-1363 – wiping method

1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL4-D2-01			
FAA-VF-SL4-D2-02			
FAA-VF-SL4-D2-03			
FAA-VF-SL4-D3-01			
FAA-VF-SL4-D3-02			
FAA-VF-SL4-D3-03			

1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-SL4-D4-01			
FAA-VF-SL4-D4-02			
FAA-VF-SL4-D4-03			
FAA-VF-SL4-D5-01			
FAA-VF-SL4-D5-02			
FAA-VF-SL4-D5-03			

L Nylon/wool flammability wiping method pictures

Table 134. Test photographs for Lantal – wiping method

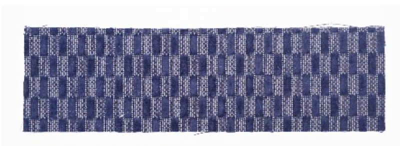
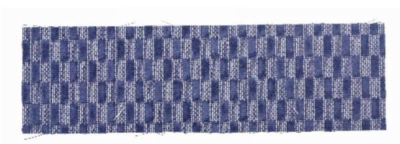
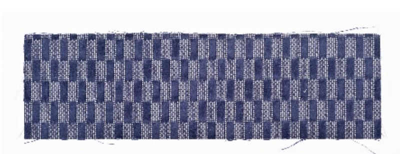
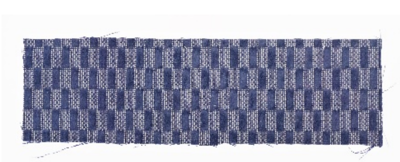
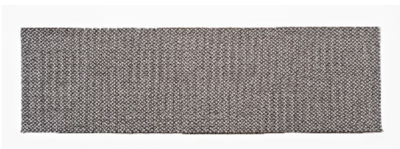
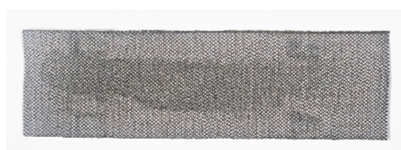
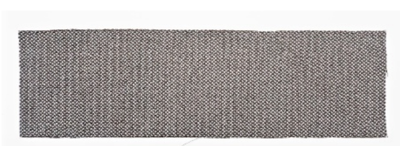
1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW1-D3-01			
FAA-VF-NW1-D3-02			
FAA-VF-NW1-D3-03			
FAA-VF-NW1-D4-01			
FAA-VF-NW1-D4-02			
FAA-VF-NW1-D4-03			

Table 135. Test photographs for Rohi Beach – wiping method

1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW2-D2-01			
FAA-VF-NW2-D2-02			
FAA-VF-NW2-D2-03			
FAA-VF-NW2-D3-01			
FAA-VF-NW2-D3-02			
FAA-VF-NW2-D3-03			

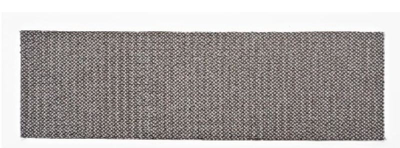
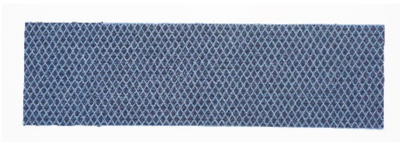
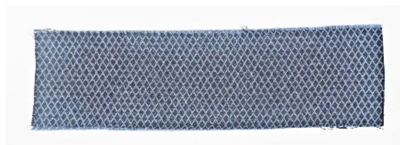
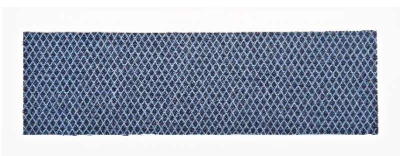
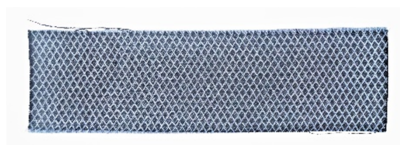
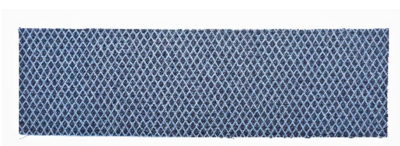
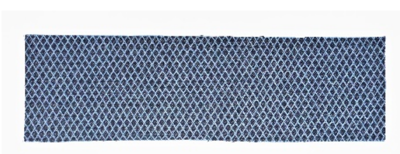
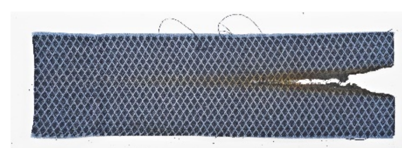
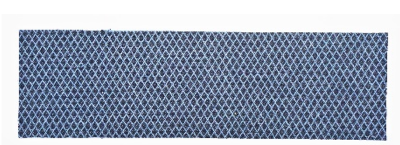
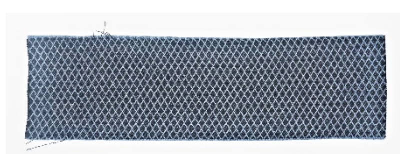
1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW2-D4-01			
FAA-VF-NW2-D4-02			
FAA-VF-NW2-D4-03			
FAA-VF-NW2-D5-01			
FAA-VF-NW2-D5-02			
FAA-VF-NW2-D5-03			

Table 136. Test photographs for Sheepskin – wiping method

1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW3-D0-01			
FAA-VF-NW3-D0-02			
FAA-VF-NW3-D0-03			
FAA-VF-NW3-D3-01			
FAA-VF-NW3-D3-02			
FAA-VF-NW3-D3-03			

1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW3-D4-01			
FAA-VF-NW3-D4-02			
FAA-VF-NW3-D4-03			
FAA-VF-NW3-D5-01			
FAA-VF-NW3-D5-02			
FAA-VF-NW3-D5-03			

Table 137. Test photographs for Botany fabric – wiping method

1	Pre-Conditioning	Post-Conditioning/ Pre-Test	Post-Test
FAA-VF-NW4-D4-01			
FAA-VF-NW4-D4-02			
FAA-VF-NW4-D4-03			
FAA-VF-NW4-D5-01			
FAA-VF-NW4-D5-02			
FAA-VF-NW4-D5-03			

M Leather permeability pictures

Table 138. Test photographs for Perrone Pewter BC

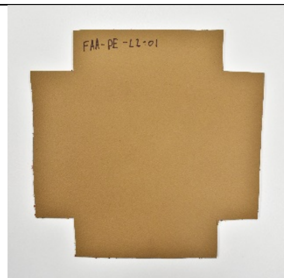
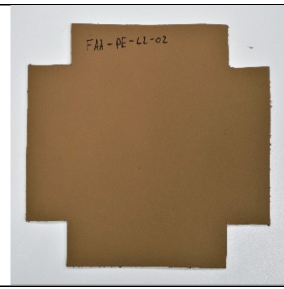
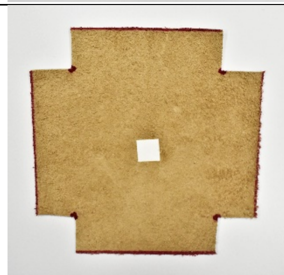
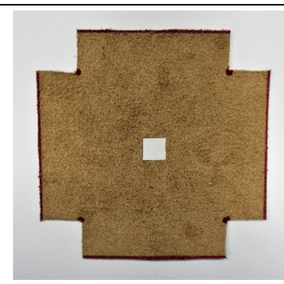
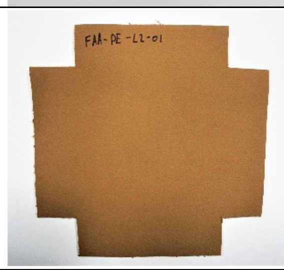
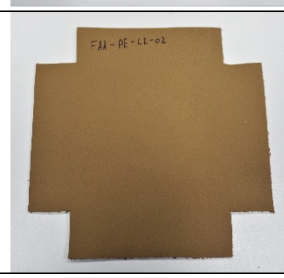
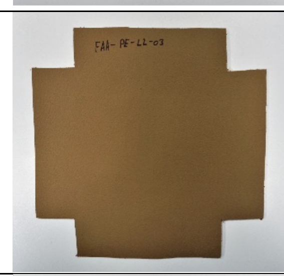
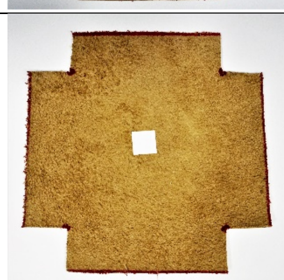
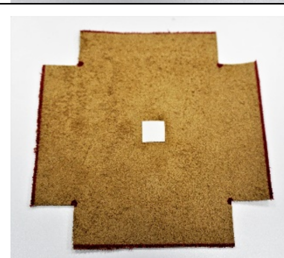
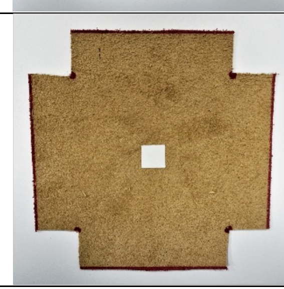
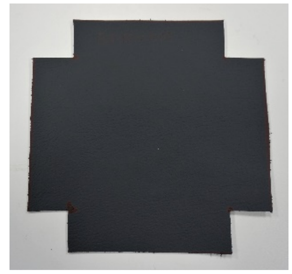
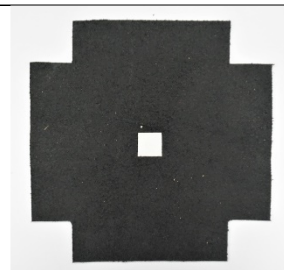
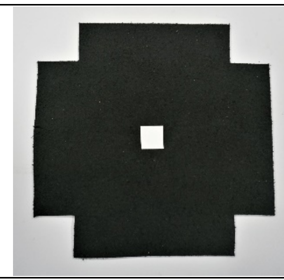
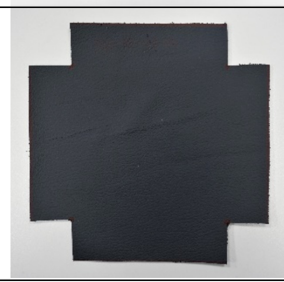
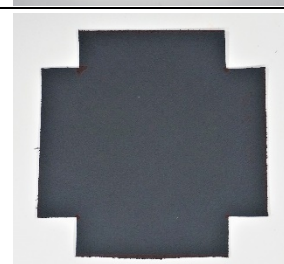
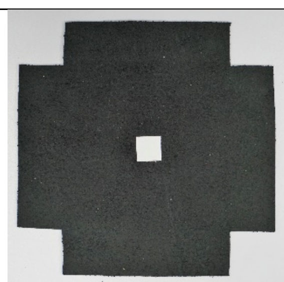
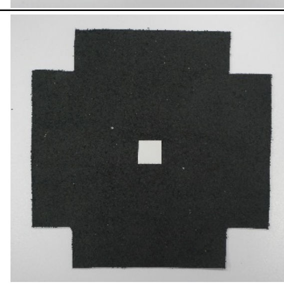
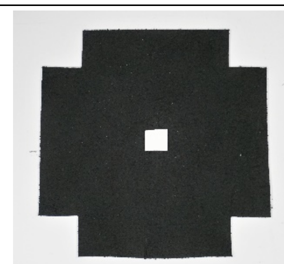
1	FAA-PE-L2-01	FAA-PE-L2-02	FAA-PE-L2-03
Pre-Test Front Side			
Pre-Test Back Side			
Post-Test Front			
Post-Test Back Side			

Table 139. Test photographs for Perrone Feather Weight

1	FAA-PE-L3-01	FAA-PE-L3-02	FAA-PE-L3-03
Pre-Test Front Side			
Pre-Test Back Side			
Post-Test Front Side			
Post-Test Back Side			

N Synthetic leather permeability pictures

Table 140. Test photographs for E-Leather CL820

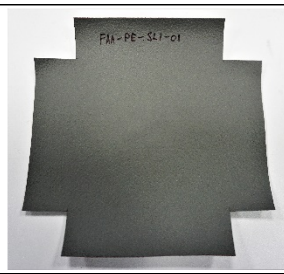
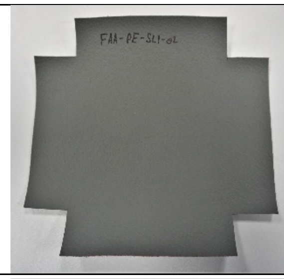
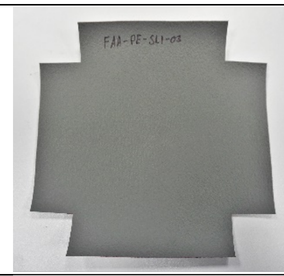
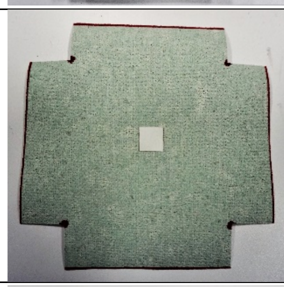
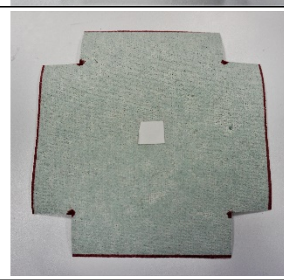
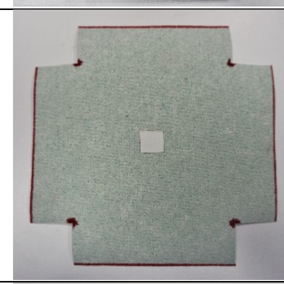
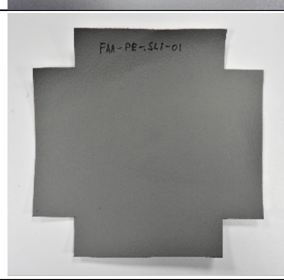
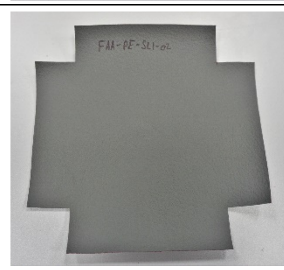
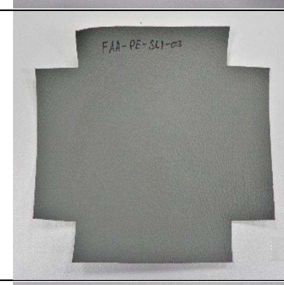
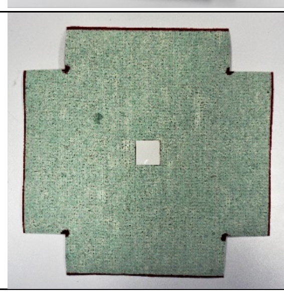
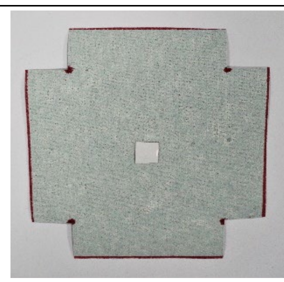
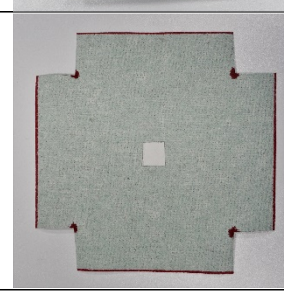
1	FAA-PE-SL1-01	FAA-PE-SL1-02	FAA-PE-SL1-03
Pre-Test Front Side			
Pre-Test Back Side			
Post-Test Front Side			
Post-Test Back Side			

Table 141. Test photographs for Ultrafabric 492-6579FR12

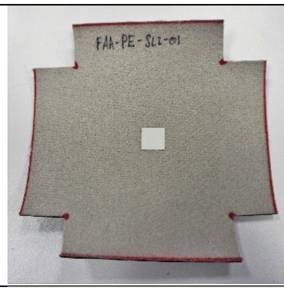
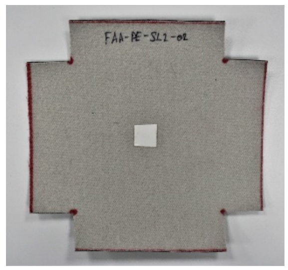
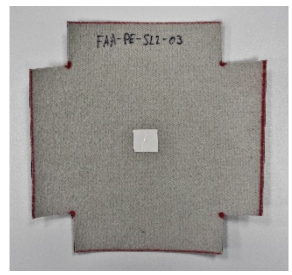
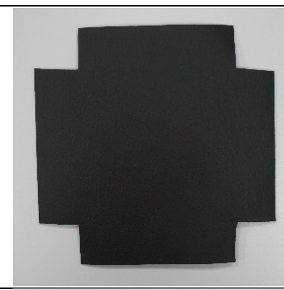
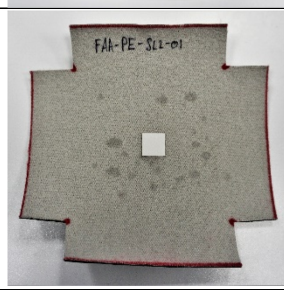
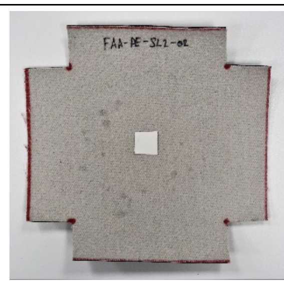
1	FAA-PE-SL2-01	FAA-PE-SL2-02	FAA-PE-SL2-03
Pre-Test Front Side			
Pre-Test Back Side			
Post-Test Front Side			
Post-Test Back Side			

Table 142. Test photographs for TapiSuede TSFRC0961

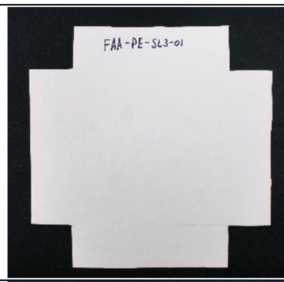
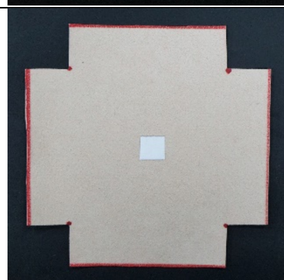
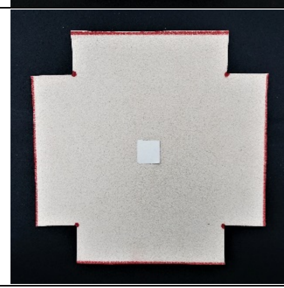
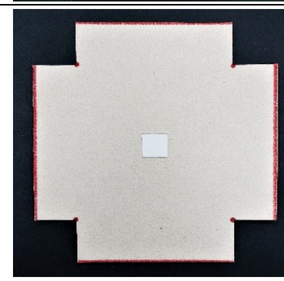
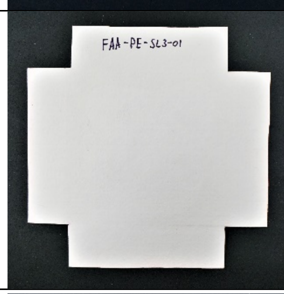
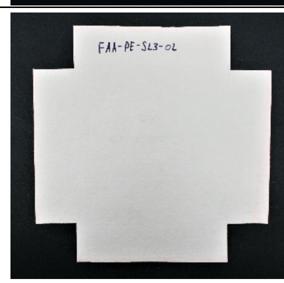
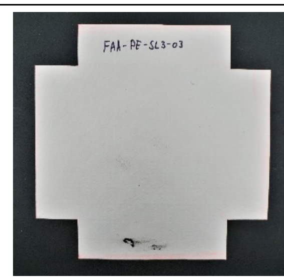
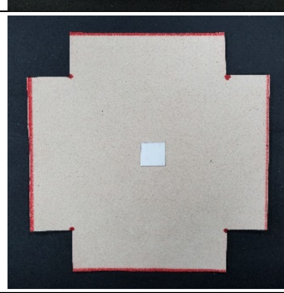
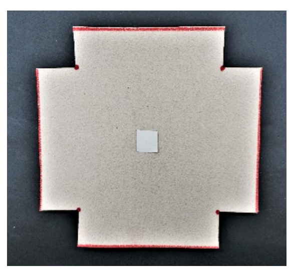
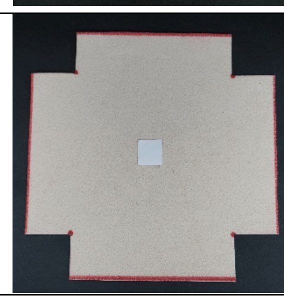
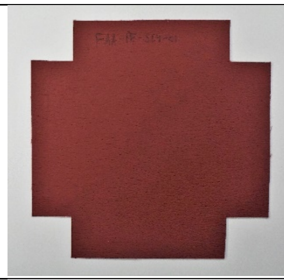
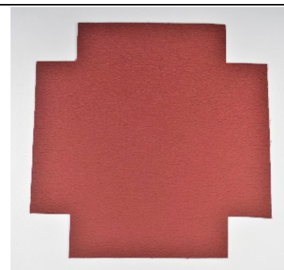
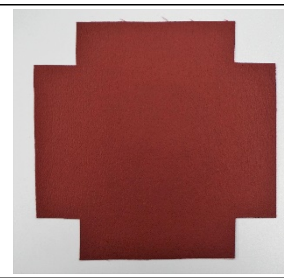
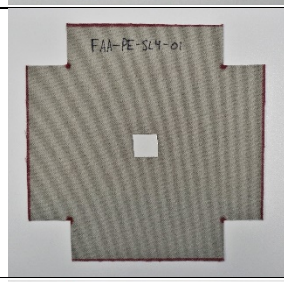
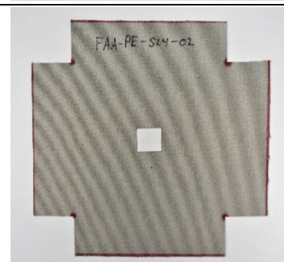
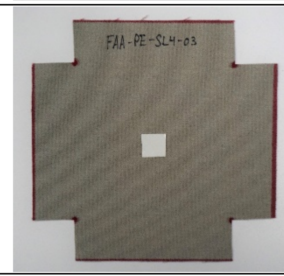
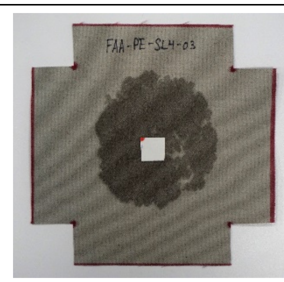
1	**FAA-PE-SL3-01**	**FAA-PE-SL3-02**	**FAA-PE-SL3-03**
Pre-Test Front Side			
Pre-Test Back Side			
Post-Test Front Side			
Post-Test Back Side			

Table 143. Test photographs for Ultraleather ULFRB971-1363

1	FAA-PE-SL4-01	FAA-PE-SL4-02	FAA-PE-SL4-03
Pre-Test Front Side			
Pre-Test Back Side			
Post-Test Front Side			
Post-Test Back Side			

O Nylon/wool permeability pictures

Table 144. Test photographs for Lantal

1	**FAA-PE-NW1-01**	**FAA-PE-NW1-02**	**FAA-PE-NW1-03**
Pre-Test Front Side			
Pre-Test Back Side			
Post-Test Front Side			
Post-Test Back Side			

Table 145. Test photographs for Rohi Beach

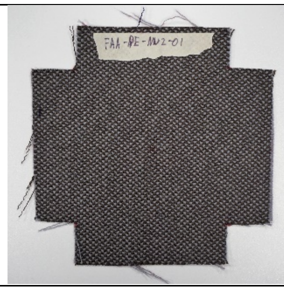
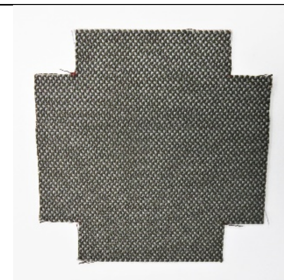
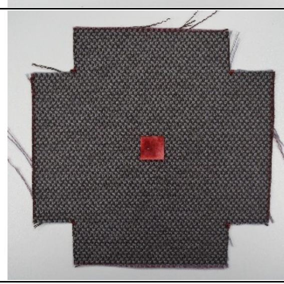
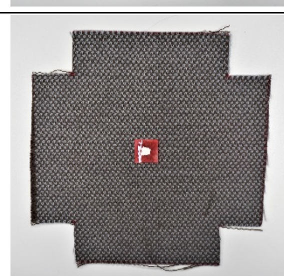
1	FAA-PE-NW2-01	FAA-PE-NW2-02	FAA-PE-NW2-03
Pre-Test Front Side			
Pre-Test Back Side			
Post-Test Front Side			
Post-Test Back Side			

Table 146. Test photographs for Botany fabric

1	FAA-PE-NW4-01	FAA-PE-NW4-02	FAA-PE-NW4-03
Pre-Test Front Side			
Pre-Test Back Side			
Post-Test Front Side			
Post-Test Back Side