A NEW PARADIGM FOR ANALYZING PWPB SYSTEMS LIKE THE COLUMBIA OUTDRY EX FEATHERWEIGHT

PROLOUGE

Good advice, received today as an email from a forum member, has been incorporated for this and subsequent versions:

Richard....For an individual like myself I found this source **https://www.rei.com/learn/expert-advice/rainwear-how-it-works.html** to be excellent in explaining and expanding my understanding concerning the subject matter and material covered in your current thread: A NEW PARADIGM FOR UNDERSTANDING PWPB FABRICS

As a retired educator from my past experiences with students K-12 thru college, I would say that there will be some when the discussion and postings come to an end would benefit with a conclusion OR summarizing remarks. (RN Epilogue added in this version)

Excellent presentation, write up and question answering by you, and once again, thank you from one who has learned much from your teaching and explanation on subjects I have little knowledge.

Ken

"Education is that which remains when one has forgotten everything learned in school."

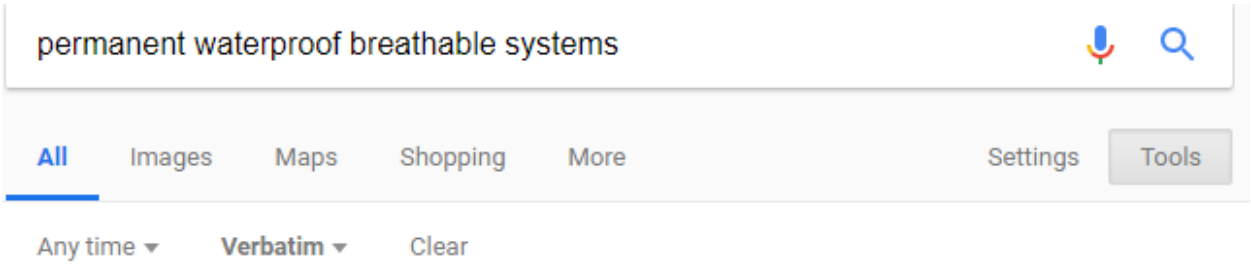
Albert Einstein

CONVERGENT TECHNOLOGIES RECENTLY PRECIPITATED PERMANENT WATERPROOF AND BREATHABLE (PWPB) SYSTEMS AND THIS IS A NEW PARADIGM TO ANALYZE

1) Up until about two years ago, a consumer's decision process regarding a WPB purchase was relatively easy. They all kept the rain off effectively. Although they used different underlying technologies to create breathability, the DWR was a constant; it was fluorocarbon c8. It repelled water and oil. It could be reactivated at home by just an occasional washing and drying. If it needed refurbishment, more DWR could be sprayed on. There was just one primary decision variable: *which alternative breathes adequately for my application?*
2) C8 was replaced with C6 about two years ago. C8 DWR was found to be PBT (Persistent, Bio-accumulative and Toxic), which is as problematic as it sounds and it was phased out worldwide. Fluorocarbon c6 was introduced as the primary alternative. It doesn't have the exact same properties as the original fluorocarbons, but the side products are way less persistent and bio-accumulative, meaner they're less harmful. The DWR maintenance procedure is identical. They all kept the rain off effectively. Although they used different underlying technology to create

breathability, the DWR was a constant; it was fluorocarbon c6 There was still just one primary decision variable: *which alternative breathes adequately for my application?*

3) C6 is less than ½ as long lasting at C8 but still yields environmental and human health risks. This provided a strong incentive to invent a new type of permanent durable water repellency (PDWR) which didn't have those downsides. Two PWPB alternatives were available when I originally wrote this report at the end of Feb '18 with a third alterative announced but, not available: Gore ShakeDry and Columbia Sportswear Outdry EX (includes Featherweight version) were the two available systems. Only one the two available options was warrantied to be used under a backpack and so this the one that was chosen for my first try at a PWPB analysis. Whereas previously, the DWR, although ephemeral, was a constant, the underlying breathability technology was a variable. With either of these two new PWBP alternatives, they are integrally coupled proprietary systems. The REI WPB overview, that Ken recommended, is a valuable prologue that preceded the advent of PWPB systems.



o results at the time I authored this report.

MOISTURE VAPOR TRANSMISSION RATE (MVTR IN G/M2/24 HRS) AKA BREATHABILITY

To a layman, a waterproof breathable (WPB) garment will keep them dry and comfortable in the rain. They correctly think the number listed for hydrostatic head (HH) will determine how much outside water force they are protected from. They incorrectly think that just a number listed for breathability will allow them to compare how much perspiration from the inside moves outside.

To an expert, they know that the HH number is rarely a performance limiting factor and so will not be focused on in this report format. They know that any MVTR number, without the test type specified is at best worthless and is more aptly described as dishonest. They know you need the same test type to compare numbers. Most importantly, they know that **none** of the standard test types measure how the garment will actually perform in the rain when active.

> I believe in evidence. I believe in observation, measurement, and reasoning, confirmed by independent observers. I'll believe anything, no matter how wild and ridiculous, if there is evidence for it. The wilder and more ridiculous something is, however, the firmer and more solid the evidence will have to be. Isaac Asimov, in *The roving mind (1April1983), p. 43*

MY REVIEW OF THE OUTDRY EX FEATHERWEIGHT FIT AND FEATURES

The Outdry EX Featherweight's weight (7.83 oz. for XL Carbon Blue) and feature set (supple fabric, two large vertical zipper pockets/ pit zips, internal pocket/stuff sack, and excellent cut make it an ideal UL backpacking option for environments where you will have frequent rain.

They have released that stealthy "Gravel" color for their Outdry EX Stretch jacket but not their Outdry EX Featherweight. It is a color I would have selected if it was available.

I have an athletic build and normally wear XL in any vendor's rain jacket. I feel no binding in the shoulder area when I rotate my elbows completely forward with this jacket. The other Columbia Outdry EX shells, of the same size using the 2x heavier material, bind on me. The one exception is their much heavier Outdry EX Stretch model.

The suppleness of the fabric makes the garment drape as a windshirt would as opposed to a stiff hard-shell. For me, that is a nicer look.

I have tried many of their other models on and on me, they looked like a boxy non-breathable rain jacket.

I have 35" arms but, the sleeves are long enough I can release the Velcro wrist tabs and pull them over my hands to protect them during rain. I can also open the Velcro and push the sleeves up to ventilate as if it were a short sleeve shirt. I won't go over any of my bicep, but it will go to just above my elbow. It is tighter than I would like in this mode but it is a doable ventilation feature.

The zippers are all waterproof so I don't have to worry about wind gusts sometimes blowing a zipper cover away from protection position as I do in some of my rain jackets.

The polyester hydrophilic liner feels like a conventional shirt against my skin. I could wear in that shirt mode if I really needed to minimize heat build-up.

The two pockets / vertical vents are about 7" wide and 14" tall. That large size is great for both torso ventilation, drying things out like oversized mitten shells, or carrying large maps.

The hood is minimalistic with only elastic to provide a vertical seal. The horizontal volume is adjustable via an elastic cord and friction retainer. I normally wear my sun visor under the hood to give it the additional rigidity it should inherently have.

The waist bungee is so minimalistic as to be almost nonexistent. There is no adjustable elastic to form a tight seal. There is only a non-aggressive built in elastic along the back. Obviously, that isn't a problem if you are wearing pack belt. For environments when you want to use it for warmth when static, this is its biggest short-coming.

THERE ARE NO PIT ZIPS, BUT THE VERTICAL CHEST VENTS PROVIDE COMPARABLE FUNCTIONALITY

Contrary to their Web site description as of 2/27/18, there are no pit-zips.

The front vertical zip vents need not be partially or completely closed when in rain. First, the vertical WP chest vent zippers are relatively stiff which keep the vertical opening uniform. Second, there are 2 1/2-inch-wide WPB material strips on the inside of the vertical vents / pockets to insure no water ingress while ventilating during rain. Each internal mesh venting area is approximately 7 inches x 14 inches.

Figure 1: Two Large Vertical Vents vs Pit-zips

Figure 1A: Latest Version of the US Special Forces L6 (rain coat)

They use the same vertical vent positions and vent sizes. Natick Labs research relative to venting is extensive.

Figure 1C: Excellent wrist width adjustability for ventilation or protection

IS THE OUTDRY EX FEATHERWEIGHT MATERIAL A GAME CHANGER FOR THE INDUSTRY OR JUST ANOTHER OPTION?

Game changer for the industry… no, not for front-country use or just a weekend in the back-country.

Game changer for the industry… no, not for rainy weather back-country conditions longer than a weekend by low-information consumers.

Game changer for the industry… yes, but only for rainy weather back-country conditions longer than a weekend by high-information consumers (small fraction of the total market).

THE COLUMBIA OUTDRY EX FEATHERWEIGHT JACKET TEST IS THE FIRST WPB GARMENT TO BE MEASURED USING A NEW LAYMAN FRIENDLY PARADIGM

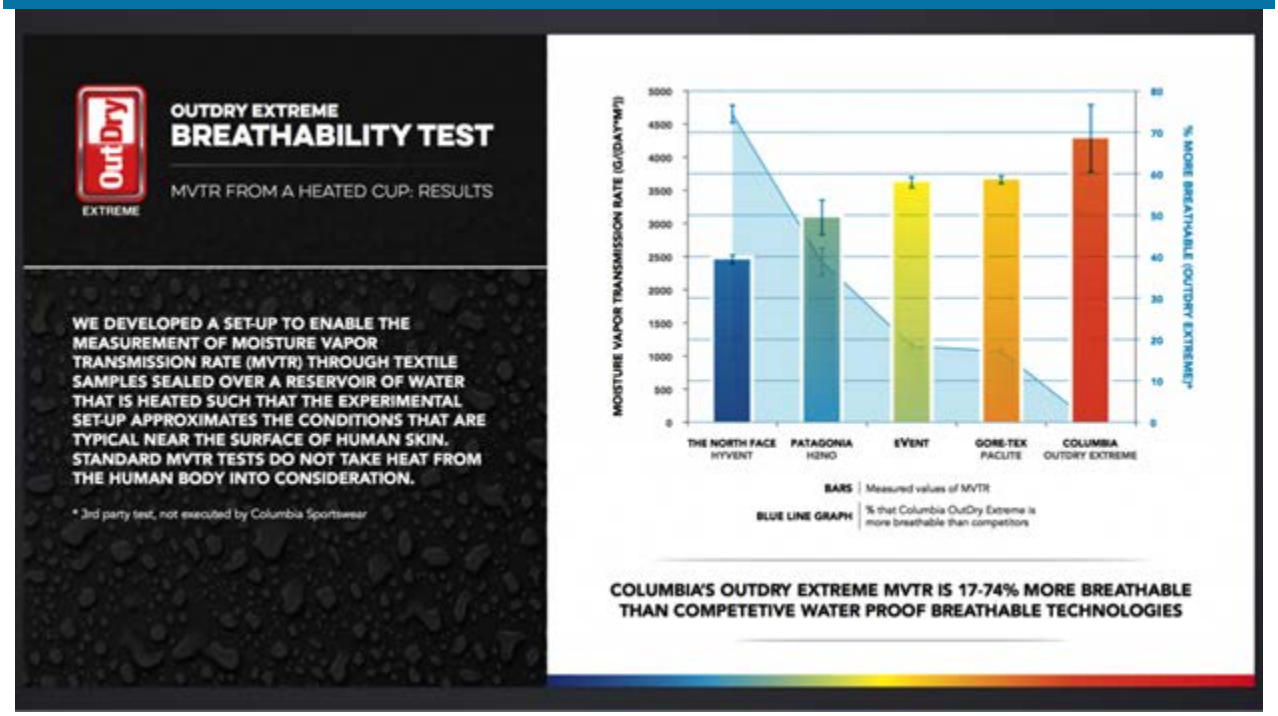


Figure 2: Columbia MVTR Claims: Source: https://blog.columbia.com/outdry-extreme-now-available/

I TESTED BOTH AN OUTDRY EX GOLD AND A OUTDRY EX FEATHERWEIGHT

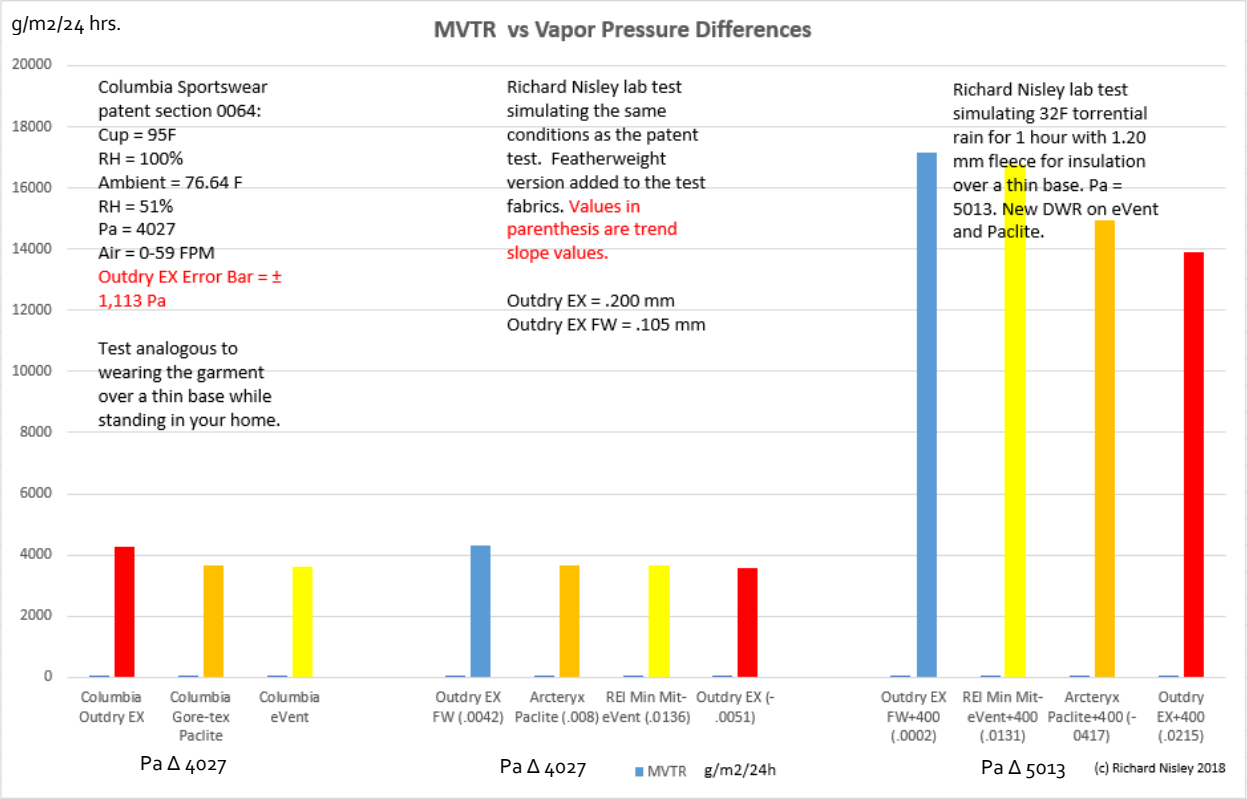


Figure 3: Richard Nisley MVTR Tests

The test conditions for the Columbia Sportswear Graphic are analogous to what would happen if you wore the garments over a thin base layer while standing in your home. The error bar on Columbia Sportwear Outdry EX graphic shows a ± 1,113 g/m2/24 hrs. tolerance. Since the Outdry EX Gold, that I tested had less MVTR than either the Gore-Tex Paclite or eVent fabrics their chart would have been incorrect except for the saving grace of their error bar.

The Outdry EX Featherweight, in contrast, tested with higher MVTR than the competitive products in the same environment as the Columbia graphic.

The 32F and torrential rain test condition on my chart used a fleece insulation layer that was only 1.2 mm thick (Polartec 150 g/m2). Had I chosen a thicker fleece for this test, the driving force would have been less as would the MVTR.

WHAT TYPE OF MEMBRANE IS OUTDRY EX & OUTDRY EX FEATHEARWEIGHT?

The Columbia Outdry blog states, "OutDry Extreme is ultra-breathable thanks to microscopic perforations in the membrane that allows moisture to escape while keeping rain at bay". I measured their membrane at 0 CFM and I can accurately detect down to .01 CFM. Assuming the Columbia information is at least partially correct, that infers that their membrane is bicomponent with a microporous PU layer inside, and an armored hydrophobic layer on the outside.

WHAT HAPPENS AFTER MORE THAN ONE HOUR OF RAIN?

The C6 DWR will stop functioning in a few hours of torrential rain on both the eVent and Paclite garments. At that point, if it is 70F and the RH is 50% between showers, the surface of a fabric outer WPB jacket will be at ~50.5 F or about 20 degrees colder than the Outdry EX FW. The breathability is reduced but, more importantly the garment's surface temperature drop may lead to hypothermia if you become inactive.

The fabrics I tested (an ePTFE, a bi-component ePTFE/hydrophilic, and 2 bi-component hydrophobic/microporous PU) maintain their initial breathability during **an hour** of heavy rain. Microporous PU, Hydrophilic PU, and PU coated fabrics reduce their breathability to about 1/4 their dry values during an hour of heavy rain.

During **continuous rain days**: The hydrophobic Outdry EX and EX FW exterior will not stop their breathability. Also, hydrophilic membranes will not stop their breathability as is also the case with non-Pro versions of Gore-Tex. PU coatings will keep their breathability for about 14 days. eVent and the Gore-Tex Pro versions will gradually reduce their breathability until it completely stops after about 7 days. Some versions of microporous PU will stop breathing 5 days and some will stop in one day.

Fick's Law states the net diffusion rate of a gas across a membrane is proportional to the difference in partial pressure, proportional to the area of the membrane and inversely proportional to the thickness of the membrane. The partial pressure value is shown in Pascals (Pa) on my chart as are the test conditions used to derive it. MVTR occurs at any rain temperature but will go down as the Pa goes down (outside temperature goes up).

WHAT HAPPENS WITH HIGH WATTS/MET RATES?

All of the materials I tested have adequate breathability for active walking on a level surface but are inadequate to pass the typical amounts of moisture that are generated while doing higher watt/MET activities. For a 180lb man with a body surface area of 2.4 m2, the average requirements are:

60 watts = .6 METS: Sleeping 2280 g/m2/day

100 watts = 1 MET: Sitting 3800 g/m2/day

200 watts = 2 MET: Gentle walking 7600 g/m2/day

300 watts = 3 MET: Active walking on a level surface = 11,500 g/m2/day

400 watts = 4 MET: Active walking on a level surface with a light pack = 15,200 g/m2/day

500 watts = 4.9 MET: Active walking on a level surface with a back pack =19,000 g/m2/day

600-800 watts or 5.9 - 7.9 MET: Active with a back pack in mountains = 22,800 - 38,400 g/m2/day (7 MET is the average backpacking MET rate)

1000-1200 or 9.9 - 11.9 MET Very heavy work 38,000 - 45,600 g/m2/day

The activities in red exceed adequate breathability for the best WPB fabrics during cold rain. Materials with less MVTR; warmer rain (lower Δ Pa); or degraded DWR; will result in a lower watts/METs level activity not being adequate.

HOW ARE THE WATTS AND METS NUMBERS DETERMINED AND ARE THEY ACCURATE?

Step 1 : I researched the watts numbers in the book "Intelligent Textiles and Clothing". I then verified their watt numbers by calculating the MET equivalents.
Step 2 : I converted their watts numbers to METs using these calculations:
A) Multiply Watts by 0.0143 to get kcal/min
B) Divide kcal/min by 5.05 to get liters of O2/min
C) Divide liters of O2/min by bodyweight in kg (pounds ÷ 2.2) to get mL/kg/min
D) Divide mL O2/kg/min by 3.5 to get METs

Step 3: I then verified my calculated backpacking MET value against The Compendium of Physical Activities Tracking Guide (gold standard for physiology research). It shows:

2000 compcode	METS	Heading	Description
15731	7	sports	wallyball, general
17010	7	walking	backpacking (Taylor Code 050)
17035	7	walking	climbing hills with 0 to 9 pound load

GIVEN THE FACT THAT I TESTED ONLY 4 JACKETS, GENERALIZING 7 MET LIMITATIONS TO ALL FABRICS IS A DARING CLAIM

https://www.thefreedictionary.com/daring

dar·ing (dâr'ĭng)

adj.

1. Willing to take or seek out risks; bold and venturesome. See Synonyms at adventurous.
2. Involving great risk or danger: *a daring rescue.*

n.

Audacious bravery; boldness.

Yes, my conclusion that "no WPB garment currently provides adequate MVTR for a 7 MET activity in >3 hr. heavy rain" statement involves "great risk or danger" to the Outdoor Industry and as a consequence

to myself. The manufacturers, retailers, advertisers, and the press that comprise the "Outdoor Industry" have invested large sums to convey conflicting messages to mine.

Their messages are simple ideas that a consumer can easily grasp and then believe it will provide an amazing result. If one or both of these are not possible, they can use marketing and advertising to obfuscate. They can take complex ideas or mediocre results and give them some spin with a few good phrases, convincing diagrams, and guarantees.

If anyone can provide an independent test result that shows any currently commercially available WPB garment (2/28/18), that is warrantied to be worn under a backpack, has sufficient MVTR for a 7 MET activity, in heavy rain (>3 mm drop size) longer than 3 hours, I will amend my original conclusion and credit both the forum poster and the product in my report.

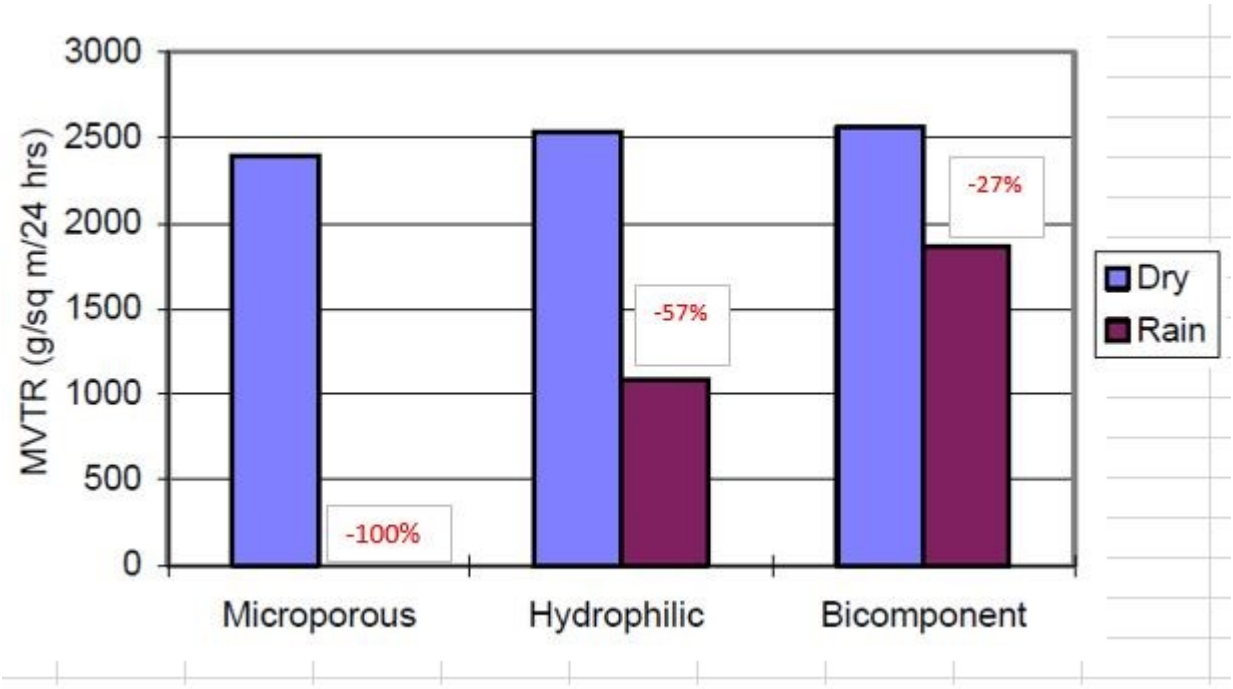
EVEN THE WPB WITH THE HIGHEST JIS L 1099-B1 APPEARS TO HAVE THE SAME MET LIMIT

Companies make 50,000 to 60,000 JIS L 1099-B1 g/m2/24hr MVTR claims for multiple products (ZPacks Ventrice, Kuiu, Bergans, ect). They are using Torray's Dermizax NX hydrophilic membrane which, in its present form, has been available since 2010. Hydrophilic membranes only reduce their MVTR ~ 57% after 3 hours of hard rain. Although I didn't physically test this product, I did approximate its rain performance to contrast with the Outdry EX and Outdry EX FW membranes.

I first calculated the ratio between the eVent MVTR number for the Columbia hard rain test vs its JIS L 1099-B1 test result. A JIS 1099-B1 tests gives approximately 2x the MVTR value as the Columbia hard rain test. I then used that ratio to calculate what the Dermizax NX MVTR value would have been for the Columbia hard rain test. I then reduced this estimated dry value to a wet value using the historical reduction value for hydrophilic membranes during hard rain to contrast it with the Columbia hydrophobic outer technology MVTR which doesn't appear to decrease appreciably in rain.

It appears that it will meet its MVTR limit at approximately the same sub 7 MET point as the Columbia Outdry EX and EX FW membranes previously reviewed. As a plus, it would breathe better than Columbia alternatives if you used it as wind shirt. As a neutral, its MVTR limit in rain is about the same as the Columbia products tested. As a negative, you would face the big temperature drop from wet out that you wouldn't with the Columbia products.

Fabric	JIS L 1099 -B1	Columbia Test @ 32F & Rain	Ratio	Adjustment for Rain	Results
eVent	27826	16728	1.66		
Dermizax NX	56000	33666		57%	19189
Red numbers are calculated					



Rain Test Conditions (3 hr):		
Inside	91.4	F
	100	% RH
Outside	41	F
	100	% RH

OPTIONS TO ADDRESS THE HIGH WATTS/METS MVTR LIMITATION OF WPB GARMENTS

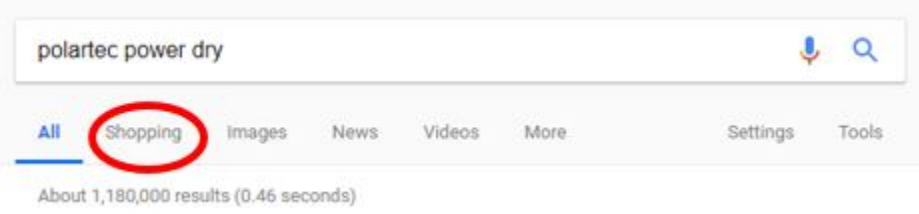
When it is raining, the removal of perspiration through venting becomes less effective for two reasons. First, the ambient air, which usually mixes with and dilutes the air within the clothing microclimate has itself got a very highwater-vapor concentration. Second, the garment apertures through which venting occurs, are usually closed to prevent rain ingress. This means that the removal of water vapor through the fabrics themselves becomes more critical when it is raining

Adjustable venting is a benefit to WPB garments but are not the optimal solution. They are a better solution than fixed ventilation in WPB garments. Let's look at an example of the lighter Columbia Outdry EX Colorado rain jacket as an example of fixed venting. Consider a case with internal environment of 73.16F with 50% RH and an outside rain environment of 68F with 100% RH. The vapor pressure gradient would be -944 PA, which would push moisture from the outside of the jacket to the inside.

Natick laboratories scientists train US Special Forces what to wear in different conditions without explaining the underlying physiology or physics. They simply say, "if it is raining and you are active, wear L1 or L2 base layer(s) in combination with either a level 5 softshell (5 CFM and >300 mm HH) or a Level 4 windshirt (25 CFM and >300 mm HH)". You will be more comfortable and efficient than with any WPB. "If you are static, wear a WPB shell." My aforementioned list of watts or METs, for different activities, provides more refined guidance as to "static" not being a point but a range.

EXAMPLES OF UL COMMERCIAL PRODUCTS THAT ARE ROUGHLY EQIVALENT TO WHAT THE MILITARY USES ABOVE THE MVTR UPPER LIMIT

Military L2 bi-component wicking base layers: UL commercial equivalents Web Search



Military L4 or L5 equivalent UL commercial equivalents:

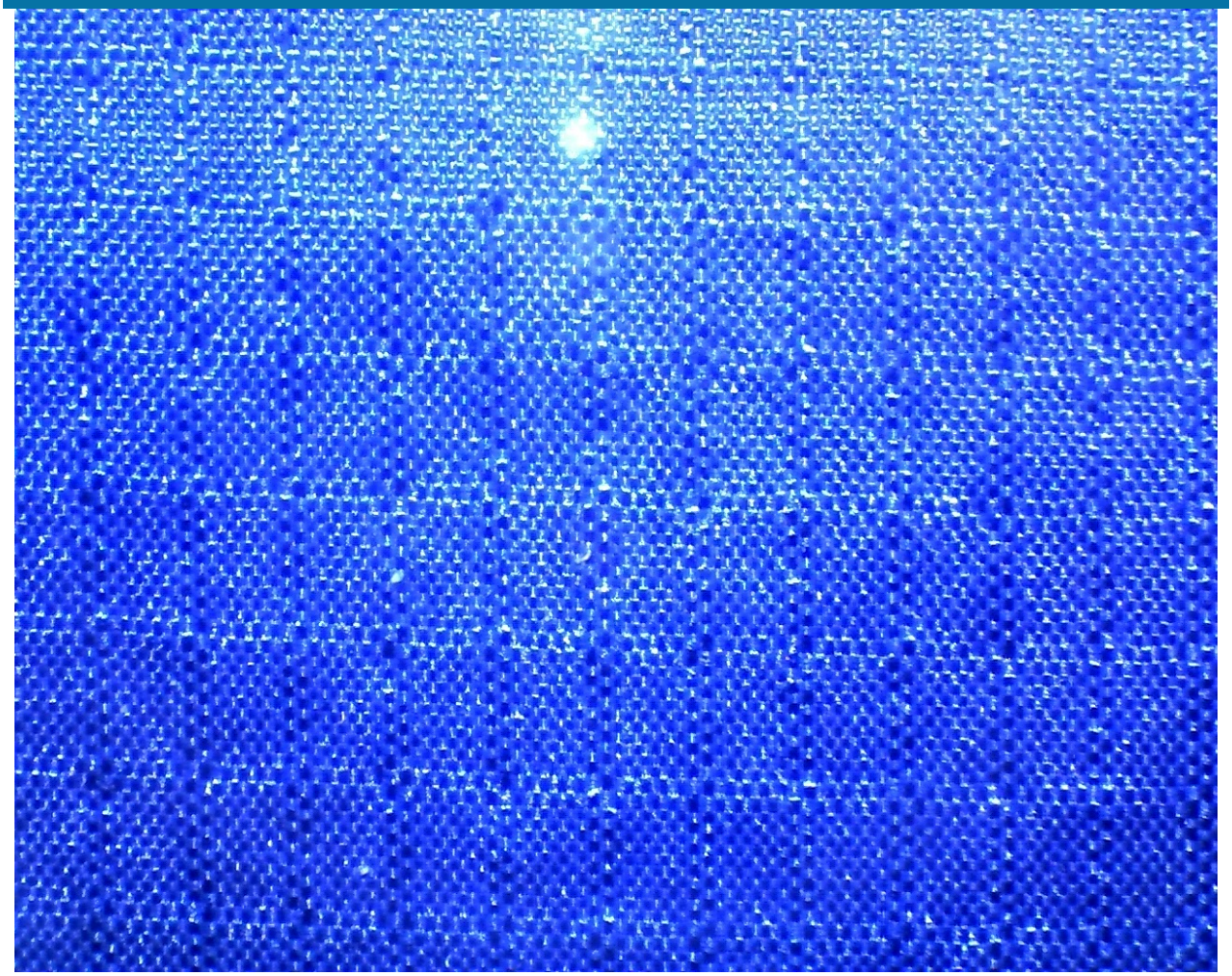
Similar to L4 CFM and HH specs: Montbell UL Stretch Wind Parka, XL = 4.6 oz, HH = 482, CFM = 17.6 (normally a March/April restock)

Similar to L5 CFM and HH specs: Patagonia Houdini, XL = 4.1 oz, HH = 387, CFM = 3.7

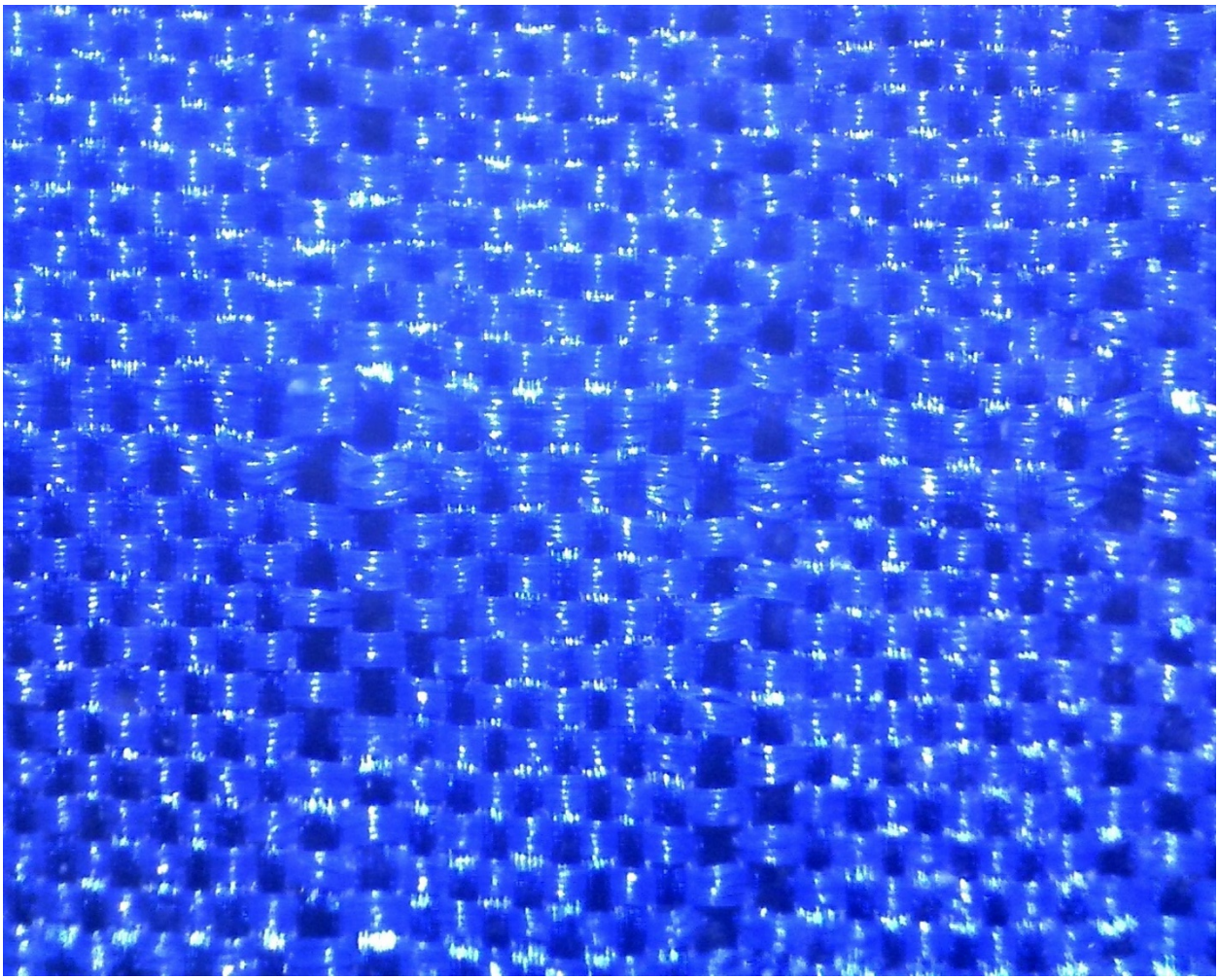
Note that although both of these commercial items have adequate HH performance, their DWR is C6 versus Epic for the military versions. They will have a colder surface temperature after the DWR wears off but, the bellows action from hiking will keep the larger, than WPB, pores open for breathability.

Also note that their CFM values are lower than the equivalent military versions.

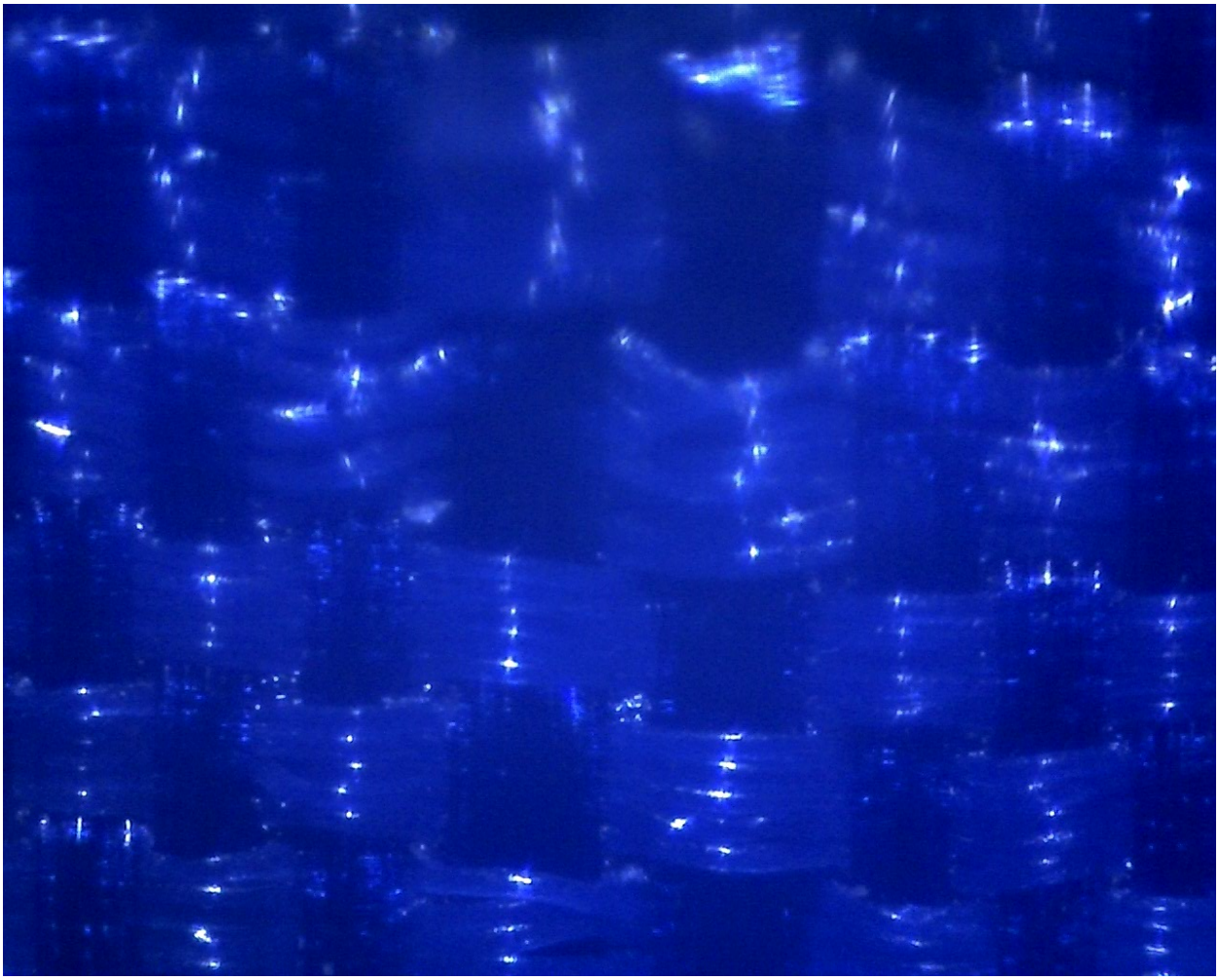
OUTDRY EX FEATHERWEIGHT MICROGRAPHS



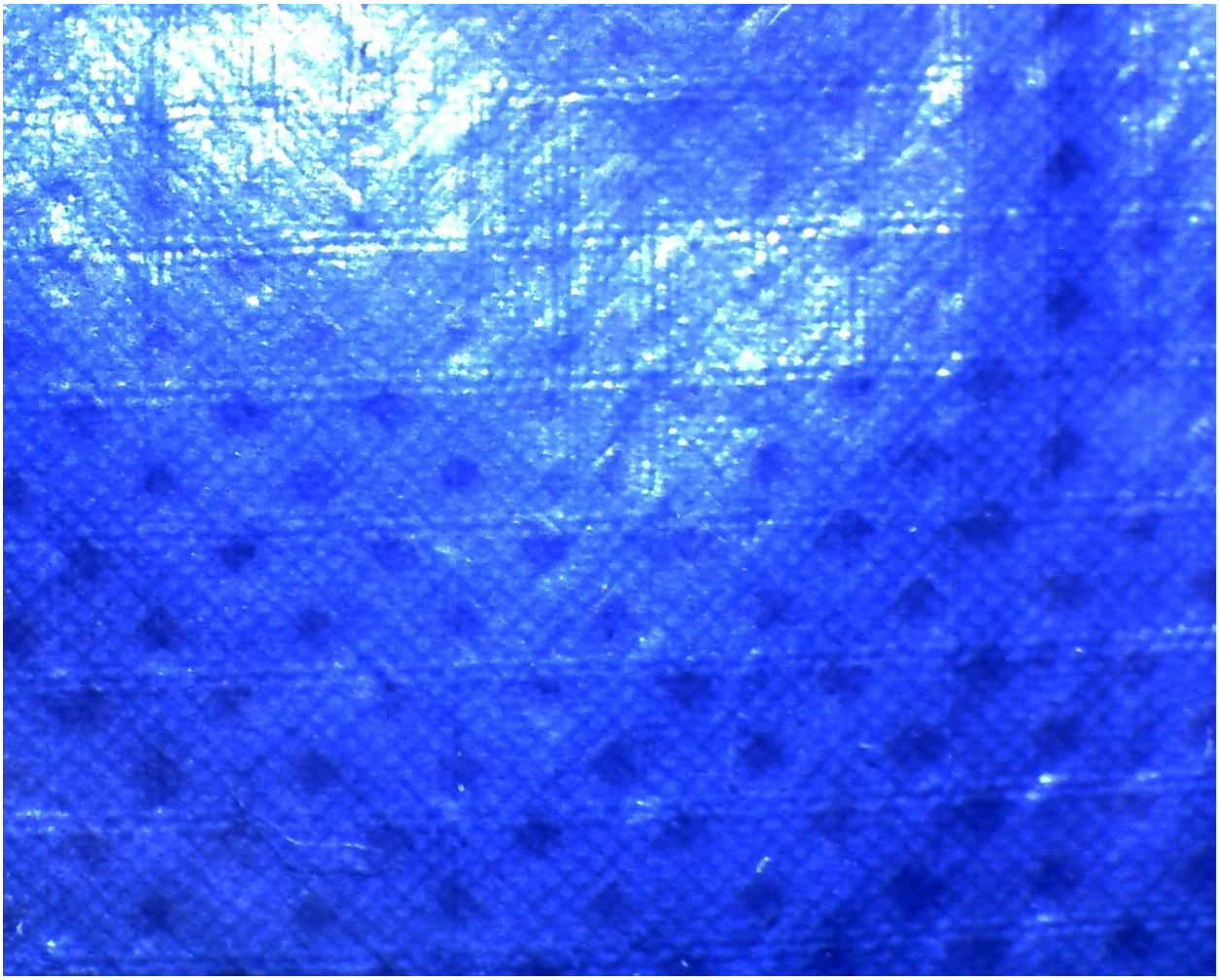
20 mm FOV - Outdry EX Featherweight Polyester Lining



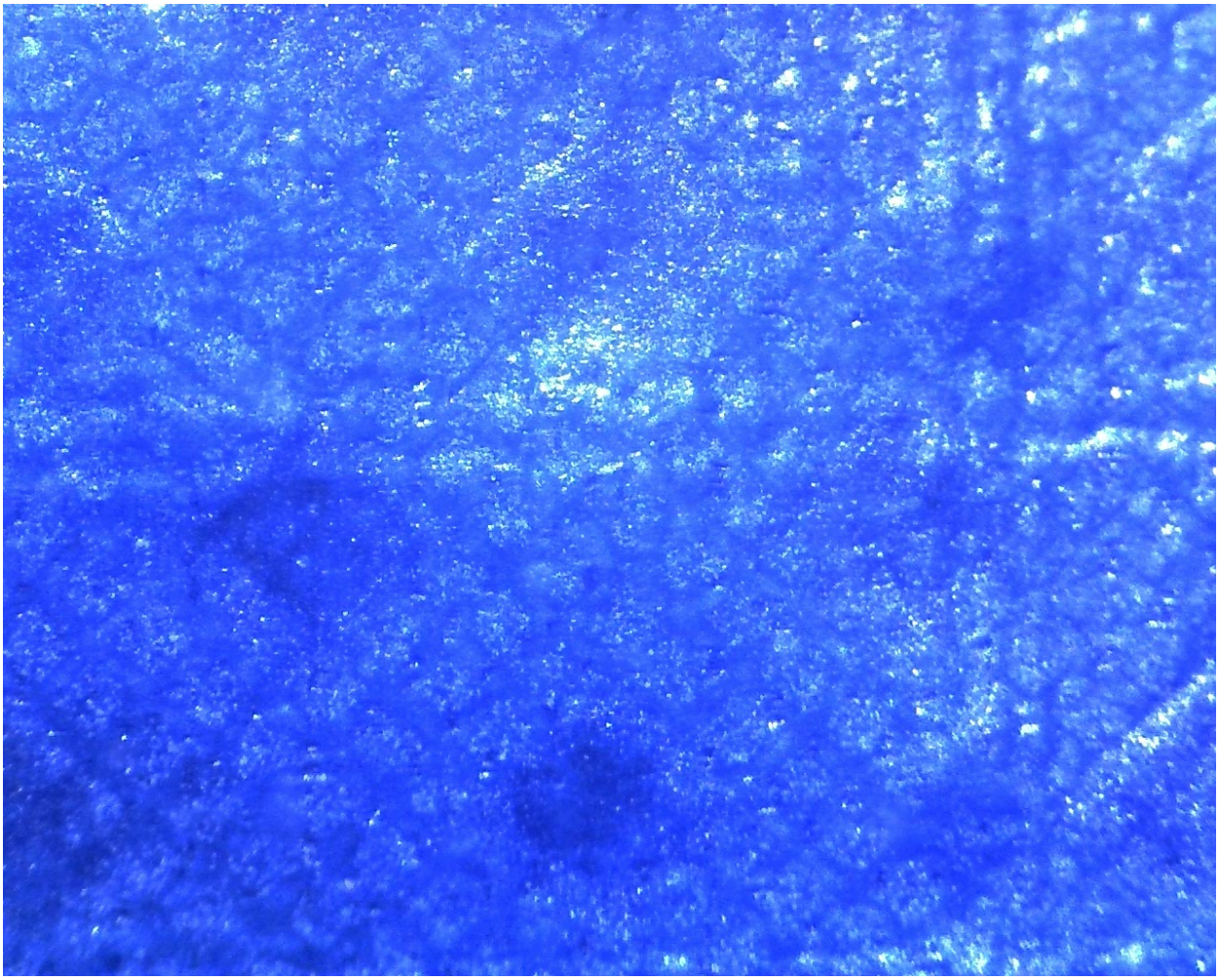
5 mm FOV - Outdry EX Featherweight Polyester Lining



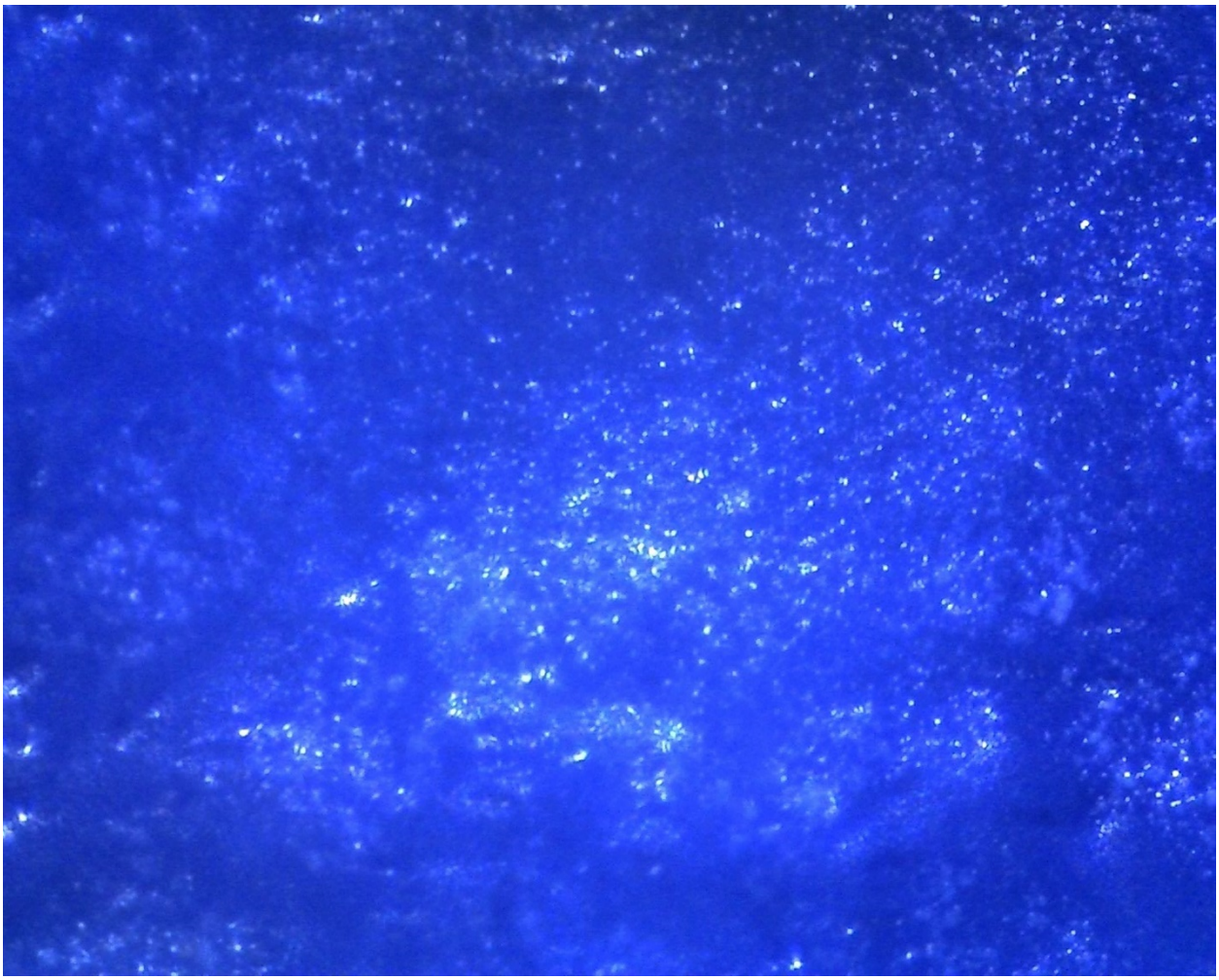
1.4 mm FOV - Outdry EX Featherweight Polyester Lining



20mm FOV – Outside of Armored Hydrophobic Coating



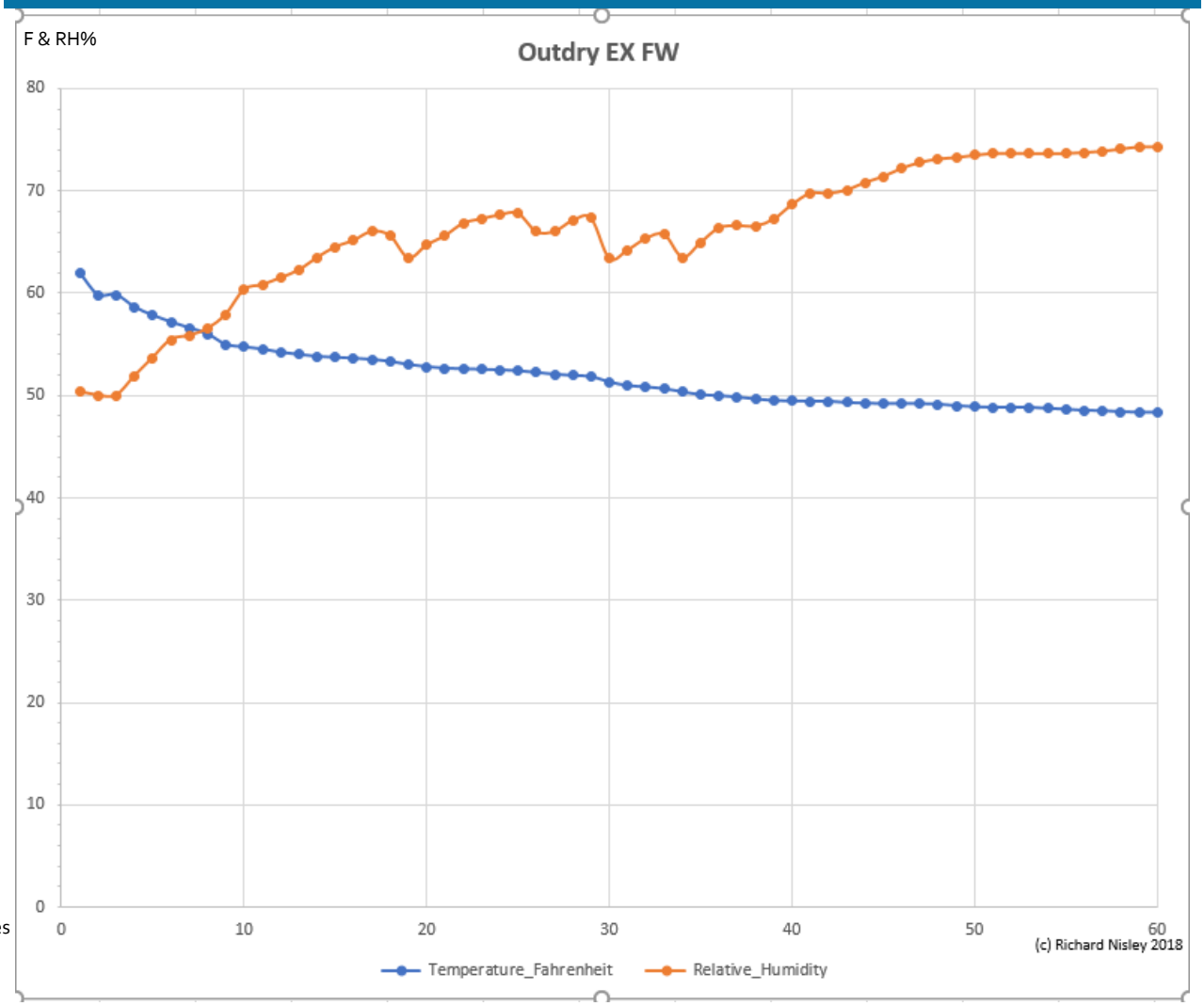
5 mm FOV - Outside of Armored Hydrophobic Coating



1.4mm FOV - Outside of Armored Hydrophobic Coating

OUTDRY EX FEATHERWEIGHT F AND RH AT THE GRADIENT POINT BETWEEN THE FLEECE, AND WPB INNER

OUTDRY EX FEATHERWEIGHT F AND RH AT THE GRADIENT POINT BETWEEN THE SKIN THE FLEECE INSULATION



EPILOGUE

The Columbia Outerwear Outdry EX Featherweight, has a weight, feature set, and is PWPB to maximize safety for backcountry travelers. As the end of Feb 2018, when this report was originally offered it was the only PWPB alternative on the market, that was warranted for wear with a backpack. I recommend it highly.

Since I wrote this report Marmot announced EVODry, their new PWPB solution. Each new PWPB solution will have relevant information released by their manufactures that will help us to better understand this type of product. They will also be reviewed by other individuals than myself, using different test criteria and reporting formats optimized for their unique target audiences. Hopefully my work in addition to those of others will be of benefit to those who have interest in PWPB solutions.

https://backpackinglight.com/forums/topic/a-new-paradigm-for-understanding-wpb-fabrics/#comments