

TECHNICAL APPENDIX

Supporting Documentation

Companion to:
Commercial Hand Dryer Performance: An Analysis of
Certification Claims, Empirical Evidence, and
Implications for Federal Agencies

January 2026

*This appendix provides comprehensive technical detail
supporting the findings summarized in the white paper.*

All underlying data is publicly available with permanent DOIs.

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Section A: The Certification Ecosystem

The certification system for commercial hand dryers operates as an interconnected network where each entity relies on the entity before it. This section documents the structure, participants, and relationships within that network.

A.1 Overview of the Network

Seven entities form the core of the certification ecosystem for commercial hand dryers in the United States:

Manufacturers:

Dyson, Inc. — Delaware corporation, principal place of business in Chicago, Illinois. Manufactures Airblade product line including Airblade V, Airblade dB, Airblade 9kJ, and Airblade Wash+Dry models. Products retail for \$949-\$1,949 per unit.

Excel Dryer, Inc. — Massachusetts corporation, principal place of business in East Longmeadow, Massachusetts. Manufactures XLERATOR and XLERATOReco product lines. Products retail for \$400-\$700 per unit.

Standards Bodies:

NSF International — Michigan nonprofit corporation, principal place of business at 789 North Dixboro Road, Ann Arbor, Michigan 48105. Created NSF Protocol P335 in April 2007. OSHA-recognized Nationally Recognized Testing Laboratory (NRTL) since December 10, 1998.

UL Solutions LLC — Delaware limited liability company, principal place of business at 333 Pfingsten Road, Northbrook, Illinois 60062. Created the Product Category Rules for Hand Dryers on July 13, 2016. OSHA-recognized NRTL, most recently renewed March 5, 2021.

Testing Organizations:

SGS North America, Inc. — Delaware corporation, principal place of business at 400 Broadacres Drive, Suite 200, Bloomfield, New Jersey 07003, with testing laboratory at 620 Old Peachtree Road NW, Suite 100, Suwanee, Georgia 30024. ISO/IEC 17025 accredited testing laboratory.

EPD Program Operators:

Smart EPD LLC — Virginia limited liability company, entity ID 11379451, registered office at 25320 Ripleys Field Dr, Chantilly, VA 20152 (a single-family residence). Mailing address at 585 Grove St., Ste. 145, PMB 966, Herndon, VA 20170 (a UPS Store

commercial mail receiving facility). Formed April 26, 2022 as "EPD USA LLC," renamed July 6, 2022.

Individual:

Anna Lasso — Individual residing in Virginia. From 2016 to 2022, employed by UL Environment as Product Manager of EPDs and PCR Project Manager. Founder and operator of Smart EPD LLC.

A.2 The Certification Chain

The certification system operates as a sequential chain where each step relies on the step before it:

Step	Entity	Action	Relies On	Independent Verification
1	Excel Dryer	Claims 8-second drying time	Internal assertion	None
2	SGS	Tests products, certifies results	Manufacturer-provided test parameters	None — tested at 12-15 sec, not 8
3	UL Environment	Issues EPD citing SGS data	SGS test report	None — certified 8 sec despite testing at 12-15
4	SmartEPD	Issues EPD citing same SGS data	11-year-old SGS report	None — Anna Lasso verifies herself
5	TrueNorth Collective	Conducts LCA	"Average test results provided by Excel"	None — manufacturer-supplied data
6	LEED / USGBC	Awards green building credits	EPD certifications	None — accepts certified values
7	Building Professionals	Input data into energy models	LEED guidance documents	None — use published specifications
8	Building Owners	Claim environmental benefits	LEED certifications	None — rely on professional certifications

Foundation: A drying time claim with no supporting public test data. Result: Every downstream calculation inherits the same unverified assumption.

A.3 The Closed Loop

The certification system exhibits circular characteristics:

Manufacturers who could not pass existing standards participated in creating new ones. The UL PCR committee that created the 0.25g standard consisted of 10 manufacturer representatives and 2 UL employees. Excel Dryer held 4 of 10 manufacturer seats. William Gagnon of Excel Dryer chaired the committee.

The people who created the standards were connected to the people who conducted the testing. SGS testing was commissioned by Denis Gagnon, Excel's President and a UL PCR committee member.

The people who conducted the testing are connected to those who issued the certifications. Thomas P. Gloria of Industrial Ecology Consultants verified both the 2017 UL EPD and the 2023 SmartEPD certificate for Excel products.

At no point in the Excel certification chain does an independent party verify that the 8-second claim is achievable. The 8-second value appears in marketing, flows through certifications, propagates into LEED calculations, and affects building energy accounting—without independent verification at any step.

Section B: The SGS Report Analysis

SGS Performance Test Report No. 2774929EFF-001, dated September 7, 2012, is the foundational document for Excel Dryer's performance claims. This section documents the report's contents, methodology, and the questions it raises.

B.1 Report Identification

Report Number: 2774929EFF-001

Date: September 7, 2012

Client: Excel Dryer, Inc.

Signed by: Martin Dodd, Project Engineer

Reviewed by: Jody Leber

Products tested: Five hand dryer models

B.2 The "Revised NSF Protocol P335" Issue

Page 4 of the SGS report states: "Each product was tested in accordance with a revised version of NSF Protocol P335 Hygienic Commercial Hand Dryers currently being developed and reviewed by NSF and its new technical panel for the 5 year protocol update."

This statement raises significant questions:

The phrase "revised version of NSF Protocol P335" implies NSF revised its protocol. However, documentation from subsequent litigation (Excel Dryer v. Dyson, Case 3:12-cv-30211-MAP) reveals that Excel had proposed amending NSF P335 to change the dryness threshold from 0.1 grams to 0.2 grams. NSF rejected this proposal.

Excel used the rejected standard for SGS testing while representing it as "a revised version of NSF Protocol P335." The SGS report does not disclose that NSF rejected the revision.

B.3 The Threshold Redefinition

Page 9 of Annex A states: "For the purposes of NSF Protocol P335, 'thoroughly dry' means that less than 0.1 grams of residual moisture per hand for a total of 0.2 grams or less is recovered when a user dries his or her hands on a paper towel after using the hand dryer."

This definition differs from NSF P335 Section 3.4, which defines dry hands as "less than 0.1 g residual moisture"—total, not per hand.

By redefining the threshold as "0.1 grams per hand for a total of 0.2 grams," the acceptable moisture level was doubled while preserving the appearance of the 0.1 gram figure.

B.4 Testing Times vs. Marketing Claims

SGS tested at 12 and 15 seconds. Excel markets 8 seconds.

The SGS report documented results at times longer than Excel's marketing claims. At 12 seconds, the SGS report found 0.186 grams residual moisture. Independent testing using NSF P335 methodology exactly as written documents 2.5 to 3.0 grams at the same interval—a discrepancy of 1,350 to 1,600 percent.

No public test data supports the 8-second claim. The 8-second value propagates through every downstream certification despite no independent verification that it is achievable.

B.5 Results Discrepancy

Source	Time	Residual Moisture	Notes
SGS Report (2012)	12 seconds	0.186g	Using "revised" protocol
SGS Report (2012)	15 seconds	Not specified in public excerpts	
Independent Testing (2023-2025)	12 seconds	2.5-3.0g	Using NSF P335 as written
Independent Testing (2023-2025)	15 seconds	2.77g average	451 trials

The SGS results cannot be independently replicated using the published NSF P335 methodology. The discrepancy of 1,350-1,600% exceeds any reasonable measurement variance.

B.6 Downstream Propagation

The SGS report became the foundation for every downstream certification and environmental claim:

The 2017 UL Environment EPD cited SGS testing.

The 2023 SmartEPD certificate states on page 13: "Tests were performed by SGS International on standard XLERATOR Hand Dryer with 0.8 inch nozzle to 0.25g or less of residual moisture, pursuant to the UL Environment Global Product Category Rules (PCR) for Hand Dryers."

Every lifecycle assessment, every LEED calculation, and every environmental marketing claim derives from this 2012 SGS report.

Section C: The Certification Transfer Timeline

This section documents the chronological sequence of events surrounding the transfer of Excel Dryer certification from UL Environment to Smart EPD LLC.

C.1 Timeline

July 25, 2017

UL Environment issues Environmental Product Declaration No. 4787137936.102.1 for Excel Dryer's XLERATOR hand dryer. Five-year validity period. Certificate specifies 8-second drying time and 3.68 Wh energy consumption.

April 1, 2022

UL Environment issues EPD No. 4787616201.106.1 for Hokwang Industries hand dryer. Certificate specifies 30-35 seconds drying time and 18 Wh energy consumption. Valid through April 2027.

April 26, 2022

Anna Lasso files articles of organization with Virginia for "EPD USA LLC," listing herself as registered agent and member or manager. At this time, Anna Lasso was either employed by UL Environment as Product Manager of EPDs and PCR Project Manager or had recently terminated employment.

July 6, 2022

Articles of amendment filed with Virginia changing company name from "EPD USA LLC" to "Smart EPD LLC."

July 2022

UL Environment EPD No. 4787137936.102.1 for Excel Dryer's XLERATOR expires. UL does not issue a renewal. UL continues to certify hand dryers for other manufacturers, including Hokwang.

June 23, 2023

Smart EPD LLC issues Environmental Product Declaration No. SmartEPD-2023-002-0006-01 for Excel Dryer's XLERATOR hand dryer. Certificate specifies identical specifications to the expired UL certificate: 8-second drying time and 3.68 Wh energy consumption. Thomas P. Gloria of Industrial Ecology Consultants verifies the lifecycle assessment—the same individual who verified the 2017 UL certificate.

C.2 The Certification Gap

Excel Dryer operated without EPD certification for approximately 11 months (July 2022 to June 2023). During this period:

UL would not renew Excel's certification at 8 seconds.

UL certified Hokwang at 30-35 seconds.

Anna Lasso formed Smart EPD LLC.

Smart EPD certified Excel at the specifications UL would not certify.

C.3 The Hokwang Comparison

UL's certification of Hokwang at 30-35 seconds provides a reference point:

Metric	Excel (SmartEPD)	Hokwang (UL)	Ratio
Drying time	8 seconds	30-35 seconds	3.75-4.4x difference
Energy consumption	3.68 Wh	18 Wh	4.9x difference
CO ₂ per use	~2g	14g	7x difference

Both certifications use the same UL PCR methodology. Both were verified by personnel connected to the same verification networks. The 4-7x difference in certified values for similar products raises questions about certification consistency.

C.4 Questions Raised

The timeline raises questions warranting further examination:

Why did UL decline to renew Excel's certification while actively certifying competitors at longer drying times?

What prompted Anna Lasso to form an EPD certification company 25 days after UL certified Hokwang at 30-35 seconds?

Why does SmartEPD certify 8 seconds when UL—using the same methodology—certifies 30-35 seconds?

What independent verification supports the 8-second claim that SmartEPD certified?

Section D: ISO 14025 Independence Analysis

ISO 14025:2006 establishes requirements for Environmental Product Declarations (EPDs), including specific independence requirements for verification. This section documents how SmartEPD certificates relate to these requirements.

D.1 ISO 14025 Requirements

Section 8.1.3

Requires that EPD verification be performed by an independent verifier "independent of the organization, the EPD, and any parties that have a commercial interest in the product."

Section 8.1.4

Specifies that the program operator "shall not act as verifier for EPDs within its own programme."

Section 6.2

States that verification "shall be conducted by an independent verifier."

D.2 SmartEPD Certificate Structure

SmartEPD Certificate No. SmartEPD-2023-002-0006-01 for XLERATOR Hand Dryer lists the following on Page 2:

Function	Person Listed	Organization Listed
EPD Program Operator Contact	Anna Lasso	Smart EPD
Independent Critical Reviewer (ISO 14044, ISO 14071)	Anna Lasso	Smart EPD
Independent External Verifier (ISO 14025)	Anna Lasso	Smart EPD

One person occupies three roles that ISO 14025 requires to be independent: Program Operator, Independent Critical Reviewer, and Independent External Verifier.

D.3 The Independence Question

ISO 14025 requires independence between these functions for a structural reason: the program operator sets rules, the reviewer evaluates methodology, and the verifier

confirms compliance. When one person performs all three functions, the verification structure collapses into self-review.

Anna Lasso:

Worked at UL Environment from 2016 to 2022 as Product Manager of EPDs and PCR Project Manager.

Worked directly with William Gagnon as he chaired the UL PCR committee.

Her published article states: "The PCR development process was initiated by William Gagnon, Excel Dryer's vice president of marketing and sales... William was asked to serve as chairman of the PCR committee, working closely with me and other leading manufacturers."

Founded Smart EPD LLC in April 2022.

Now issues certifications under the standard she helped develop, for products made by companies she worked with while developing that standard.

D.4 The TrueNorth LCA Review

The TrueNorth Collective LCA underlying the SmartEPD certificate was also reviewed by Anna Lasso as panel chair. The review structure:

Anna Lasso chaired the LCA review panel.

Anna Lasso verified the EPD based on that LCA.

Anna Lasso operates the program that issued the EPD.

Three layers of required independence. One person.

D.5 Corporate Structure

Smart EPD LLC's corporate filings:

Registered office address: 25320 Ripleys Field Dr, Chantilly, VA 20152 — a single-family residence.

Mailing address: 585 Grove St., Ste. 145, PMB 966, Herndon, VA 20170 — a UPS Store commercial mail receiving facility.

Registered agent: Anna Lasso

Qualification: "Member or Manager of the Limited Liability Company"

The corporate structure indicates a single-member LLC operating from a residential address, raising questions about the organizational capacity to maintain the independence ISO 14025 requires.

Section E: The UL PCR Committee Structure

The UL Product Category Rules for Hand Dryers was published July 13, 2016. This section documents the committee composition and structure that created this standard.

E.1 Committee Composition

Category	Seats	Percentage	Representatives
Manufacturer Representatives	10	83%	Excel Dryer (4), World Dryer (3), Hokwang/FASTDRY (3)
UL Representatives	2	17%	UL Environment staff
Public Health Officials	0	0%	None
Consumer Representatives	0	0%	None
Independent Researchers	0	0%	None

E.2 Excel Dryer Representation

Excel Dryer held 4 of 10 manufacturer seats (40% of manufacturer representation, 33% of total committee).

William Gagnon, Excel's VP and COO, chaired the committee.

Denis Gagnon (William's father), Excel's President, participated as a committee member.

Denis Gagnon purchased Excel Dryer in 1996 and claims to have invented the first high-speed hand dryer.

E.3 The 0.25g Threshold

The UL PCR established a 0.25 gram residual moisture threshold—2.5 times weaker than NSF P335's 0.1 gram threshold.

The timeline suggests why this weaker standard emerged:

Excel proposed amending NSF P335 from 0.1 grams to 0.2 grams.

NSF rejected this proposal.

The UL PCR committee, with Excel holding 4 of 10 manufacturer seats and the chair position, established a 0.25 gram standard.

When Excel could not weaken one standard, it participated in creating a weaker one.

E.4 Scientific Justification

No scientific justification for the 0.25 gram threshold appears anywhere in the 35-page UL PCR document. The document does not explain:

Why 0.25 grams rather than 0.1 grams (NSF) or any other value.

What research supports this threshold as adequate for hygiene purposes.

How this threshold relates to the science of microbial transfer from wet hands.

E.5 UL PCR Figure 2

The UL PCR contains Figure 2, showing drying performance curves. This figure demonstrates that at 8 seconds, residual moisture is 0.456 grams—82% above the UL threshold of 0.25 grams and 356% above the NSF threshold of 0.1 grams.

The committee that approved this figure included Excel Dryer representatives. The data showing 8-second drying is impossible was published in the same document used to justify 8-second certification claims.

E.6 The Review Panel

The UL PCR Review Panel included:

Jon Dettling (Chair) — authored the 2009 Quantis LCA commissioned by Excel Dryer.

Jeremy Gregory — co-authored the 2011 MIT LCA.

Both reviewed a PCR that cited their own prior work as authority. They evaluated a standard built on research they themselves had produced.

Section F: Excel v. Dyson: The Historical Record

In December 2012, Excel Dryer sued Dyson in the United States District Court for the District of Massachusetts, Case 3:12-cv-30211-MAP. The litigation produced sworn testimony and documentary evidence relevant to understanding the certification ecosystem.

F.1 Case Overview

Case: Excel Dryer, Inc. v. Dyson, Inc.

Court: United States District Court, District of Massachusetts

Case Number: 3:12-cv-30211-MAP

Filed: December 2012

Disposition: Settled before discovery

F.2 Excel's Claims

Excel sought a preliminary injunction against Dyson's advertising, which claimed XLERATOR required 20 seconds to dry hands while Airblade required only 12 seconds.

Excel's motion relied on the SGS test purportedly showing the products' performance was "comparable" at 12 seconds.

F.3 Dyson's Response

Dyson's opposition memorandum revealed that Excel had represented to the court that its SGS testing used "a revised version of NSF Protocol P335 Hygienic Commercial Hand Dryers currently being developed and reviewed by NSF."

Dyson's attorneys stated: "The phrase 'revised NSF Protocol P335' unambiguously communicates that at some point, NSF revised its protocol P335 and that Excel's test was based on this revised protocol. That is absolutely untrue."

Dyson revealed that Excel had proposed amending NSF P335 to change the dryness threshold from 0.1 grams to 0.2 grams, that NSF rejected this proposal, and that Excel used the rejected standard anyway while representing it as "the revised NSF Protocol P335" without disclosing NSF's rejection.

F.4 NSF Certification Status

Dyson's memorandum stated explicitly: "The Xlerator is not NSF Certified, meaning NSF has not independently verified that it passes NSF P335 and dries hands within 15 seconds."

This remains accurate. Excel has never achieved NSF P335 certification. Dyson is marketed as "the only hand dryer certified by NSF International Protocol P335."

F.5 Dyson's Sworn Counterclaims

On February 22, 2013, Dyson filed its Answer, Statement of Defenses, and Counterclaims. In sworn counterclaims, Dyson stated:

"The claim that the Xlerator dries hands completely in 10-15 seconds is literally false. According to testing performed by Dyson in accordance with NSF P335, the Xlerator takes approximately 20 seconds."

Dyson further stated under oath that "the Airblade achieves hygienic dryness in less than 12 seconds."

F.6 Independent Verification

Both companies' sworn claims can now be evaluated against independent testing. 451 residual moisture trials demonstrate:

Neither product achieves threshold dryness until 70-90 seconds.

At 12 seconds, both products show residual moisture of 2.5-3.0 grams.

Dyson was correct that Excel cannot achieve 10-15 second drying.

Excel was implicitly correct that Dyson cannot achieve superior performance.

Both companies made sworn claims about their own products that independent testing does not support.

F.7 Settlement

The case settled before discovery. The settlement preserved the status quo: both companies continue marketing drying times that independent testing shows neither can achieve.

Discovery would have required both companies to produce:

Internal testing data and methodology.

Communications regarding the discrepancy between test times and marketing claims.

Documentation of what each company knew about actual product performance.

The settlement avoided this examination.

Section G: Full Empirical Results: Drying Performance

This section provides complete documentation of drying performance testing conducted between 2023 and 2025. All methodology, data, and analysis are published with permanent DOIs.

G.1 Methodology Overview

Protocol

Testing followed NSF P335 methodology with precision measurement of residual moisture. Hands were washed using standard technique, placed in dryer for specified duration, and residual moisture captured via paper towel absorption and precision scale measurement (0.01g resolution).

Sample Size

451 total drying time trials across three manufacturers (Dyson, Excel/XLERATOR, World Dryer). This exceeds the NSF P335 requirement of 20 trials by more than 22 times.

Products Tested

Dyson Airblade V, Airblade dB, Airblade 9kJ

Excel XLERATOR (multiple variants)

World Dryer VerdeDri

G.2 Results at Claimed Drying Times

At manufacturer-claimed drying times (8-15 seconds), testing documented:

Metric	Result
Trials at claimed times	31
Trials achieving 0.1g (NSF threshold)	0 (0%)
Trials achieving 0.25g (UL threshold)	0 (0%)
Most favorable single result	1.67g
Average residual moisture	2.77g
Deviation from NSF threshold	2,770%
Deviation from UL threshold	1,108%

G.3 Compliance Rates

Threshold	Standard	Compliance at Claimed Times	Ever Achieved (429 extended trials)
0.10g	NSF P335	0%	3.5% (15 trials)
0.20g	Excel rejected proposal	0%	14.9%
0.25g	UL PCR	0%	16.8%

NSF P335 Section 6.3 requires 95% compliance across 20 trials. Actual compliance at claimed times: 0%. The deviation is not marginal variation—it is categorical failure.

G.4 Actual Time to Threshold

Extended drying trials documented the actual time required to approach certification thresholds:

Threshold	Time Required	Deviation from 8-Second Claim
0.25g (UL)	40-60 seconds	400-650%
0.10g (NSF)	70-90 seconds	775-1,025%

G.5 Bi-Modal Physics

Testing revealed that water removal follows a bi-modal decay pattern:

Phase 1: Mechanical Removal (0-5 seconds)

Loose surface water is mechanically stripped from hands by high-velocity air. Approximately 75% of total water removal occurs in this phase. The water is not evaporated—it is blown off hands and dispersed into the environment.

Phase 2: Evaporative Removal (5-90 seconds)

Bound water must be evaporated. This process follows exponential decay physics and cannot be accelerated beyond physical limits. All dryers converge on similar performance curves regardless of air velocity, technology, or price.

Model fit: $R^2 = 0.9998$ across all trials. Near-perfect fit to bi-modal decay model.

G.6 Cross-Manufacturer Correlation

Testing across three manufacturers documented convergent performance:

Comparison	Correlation Coefficient	Significance
Dyson vs. Excel	$r > 0.99$	$p < 0.001$
Dyson vs. World Dryer	$r > 0.99$	$p < 0.001$
Excel vs. World Dryer	$r > 0.99$	$p < 0.001$

The joint probability of three independent manufacturers producing correlation coefficients all exceeding $r = 0.99$ under the null hypothesis (that performance varies by manufacturer) is less than one in one billion.

This convergence indicates that the limitation is physical, not engineering. No manufacturer has solved the bi-modal physics problem because the physics cannot be circumvented.

G.7 Predictive Validation

On December 4, 2025, prior to testing World Dryer products for the first time, a formal prediction was documented: World Dryer products would fail identically to Dyson and Excel because this is a physics issue, not an engineering problem.

On December 5, 2025, World Dryer VerdeDri units were tested at three locations. The prediction was confirmed. World Dryer achieved first compliance with its claimed standard of 0.25 grams at 40 seconds—233% longer than the manufacturer's 12-second claim.

G.8 Excel's Own Research

Excel's own researchers had identified bi-modal drying. In an undated preprint filed as Exhibit H in Case 3:12-cv-30211-MAP, Excel's consultants Sol Aisenberg and G. Freedman documented:

"Two sequential phases of drying are used. Phase 1 is the blowing off of loose water droplets, accounting for about 75 percent of total water removal in the first 3 seconds, and Phase 2, the evaporation phase."

Their Figure 4 shows residual moisture of 1.25 grams at 4 seconds, declining to 0.2 grams at 13.5 seconds—using Excel's self-invented 0.2 gram threshold, not NSF's 0.1 gram standard.

They concluded: "preliminary experimental data... indicate that we can realistically expect this number to be reduced to the 10 to 12 second range in the near future."

Excel now markets 8 seconds to UL's 0.25g. Independent testing found 80-90 seconds to approach 0.1g.

G.9 Statistical Summary

Metric	Value
Total trials	451
Compliance at claimed times	0%
Average residual moisture at claimed times	2.77g
Time to 0.1g threshold	70-90 seconds
Cross-manufacturer correlation	$r > 0.99$
Model fit (bi-modal decay)	$R^2 = 0.9998$
Statistical significance	$p < 0.001$

Section H: Full Empirical Results: Contamination

This section documents microbial contamination testing comparing ambient room air to hand dryer output air.

H.1 Methodology

Protocol

Standard agar plate sampling at realistic drying times. Ambient air sampled directly in front of dryer (control). Dryer output air sampled at same location during operation (treatment). Colony-forming units (CFU) counted after incubation.

Sample Size

136 paired samples across 87 locations (Study 1, LB agar) and 49 locations (Study 9, TSA agar).

Media

LB (Luria-Bertani) agar for general bacterial growth.

TSA (Tryptic Soy Agar) for broader microbial detection.

H.2 Results

Metric	Study 1 (LB Agar, n=87)	Study 9 (TSA Agar, n=49)	Combined (n=136)
Tests showing amplification	87 (100%)	49 (100%)	136 (100%)
Tests showing reduction	0 (0%)	0 (0%)	0 (0%)
Median ambient air CFU	1	2	—
Median dryer output CFU	73	200	—
Median amplification factor	49.6x	110x	—
Probability under null hypothesis	—	—	$p \approx 10^{-41}$

H.3 Statistical Interpretation

136 consecutive tests showed amplification. Zero tests showed reduction.

Under the null hypothesis that hand dryers do not systematically affect microbial levels (50% chance of amplification, 50% chance of reduction), the probability of 136 consecutive amplifications is:

$$P = (0.5)^{136} \approx 10^{-41}$$

This probability is so small as to be functionally impossible. The result conclusively rejects the null hypothesis.

H.4 HEPA Filtration Effect

Some manufacturers claim HEPA filtration provides hygiene benefits. Testing compared HEPA-filtered and non-HEPA-filtered units:

Comparison	Result
HEPA vs. non-HEPA amplification difference	Not statistically significant
p-value	0.803
Interpretation	HEPA filtration does not reduce output contamination

HEPA filters address intake air. The primary contamination pathway is bacterial and fungal amplification from interior surfaces, downstream of the filter, dispersed onto users via the output air stream.

H.5 Contamination Mechanism

The interior environment of a hand dryer provides ideal conditions for microbial colonization:

Warm: Heating elements maintain elevated temperatures.

Moist: Water from users' hands accumulates inside the unit.

Dark: Interior surfaces are not exposed to UV light.

Nutrient-rich: Organic matter from hands deposits on interior surfaces.

Microorganisms colonize these interior surfaces. Each use cycle draws air across colonized surfaces and disperses the amplified microbial load onto the user and into the room.

H.6 Dual-Intervention Tests

Study 9 conducted dual-intervention tests: both hand dryer and paper towels tested in the same restroom on the same day under identical ambient conditions.

Hand dryers produced 138-407x more contamination than white paper towels in matched comparisons. The difference is the device, not the environment.

H.7 The Fundamental Test

Remove the dryer from the room. Measure ambient air contamination. Install the dryer. Measure output air contamination. The difference is the dryer's contribution.

In 136 tests, that contribution was always positive (amplification). Products certified as "hygienic" amplify contamination by 50-110 times compared to the baseline condition.

Section I: Full Empirical Results: Water Dispersal

This section documents where water goes during the hand drying process and the implications for sanitation.

I.1 Dryer Types

Dispersal-Type Dryers

The dominant market design. High-velocity air (400-690 km/h) mechanically strips water from hands and disperses it into the room environment. No mechanism for capturing or containing the dispersed water. Includes Dyson Airblade and Excel XLERATOR product lines.

Capture-Type Dryers

Older design, now rare. Water is collected in receptacles for disposal. NSF P335 Section 6.5 imposes detailed disinfection requirements on capture-type dryers.

I.2 Baseline Water Measurement

Water mass on freshly washed hands: 7.30 grams (documented in Baseline Water Mass study).

During dispersal-type drying:

Phase 1 (0-5 seconds): Approximately 90% of water (6.57g) is mechanically stripped from hands.

Phase 2 (5-90 seconds): Remaining water evaporates slowly.

The water removed in Phase 1 is not evaporated. It is blown off hands at hurricane-force velocity and must go somewhere.

I.3 Water Destinations

Visual analysis documented water destinations during dispersal-type drying:

Adjacent surfaces

Walls directly below and beside the dryer outlet.

Floor surfaces in a spreading pattern from the outlet.

Fixtures (sinks, toilets, counters) within spray radius.

User

Torso and forearms from direct spray.

Thighs and shoes from downward dispersal.

Face and hair from upward dispersal (particularly with slot-type dryers like Airblade V).

Airborne

Visible mist remaining suspended for 3+ seconds after drying.

Aerosol droplets small enough to be inhaled.

I.4 Standards Gap

Neither NSF P335 nor the UL PCR contains any standard, test, measurement, or specification for water dispersal.

The primary output of the drying process—where the water goes—is completely unaddressed in all known certification frameworks.

NSF P335 Section 6.5 imposes detailed, strict disinfection requirements on capture-type dryers: 99.9999% bacterial kill in collected water. NSF P335 imposes zero requirements on dispersal-type dryers that spray water throughout the room.

I.5 Contamination Vector

The dispersed water cannot be sterile. Microbial testing documented 50-110x bacterial amplification in dryer output air. The contamination measured on petri dishes arrived via the air stream. The air stream contains water droplets. Those droplets originated from users' hands. The water is the carrier medium for the measured contamination.

I.6 User Compliance Compound Effect

CDC and WHO guidelines require soap and 20 seconds of washing for effective hand hygiene. Compliance studies estimate proper handwashing rates at 5-30% in public restrooms.

The dryer does not verify compliance. The dryer disperses whatever is present on hands—properly washed or not—into the shared environment.

Consider three users:

Compliant user (soap, 20 seconds, proper technique)

Disperses water contaminated by dryer amplification of 50-110x.

Average user (quick rinse, minimal soap)

Disperses significantly more contaminated water from inadequately washed hands, plus dryer amplification.

Non-compliant user (10-second wet, no soap)

Disperses fecal bacteria, pathogens, and whatever was touched directly into the room—amplified by the dryer—for the next person to encounter.

Every user's output becomes every other user's input. The least hygienic user contaminates the air for everyone who follows.

I.7 Population Scale

At 150 million daily dispersal-type dryer uses in the United States:

Timeframe	Water Dispersed
Daily	2.8-4.6 million cups
Annually	1-1.7 billion cups
Per dryer per day	~3 cups

That is not incidental moisture. It is systematic environmental contamination at industrial scale.

I.8 Paper Towel Comparison

Paper towels show a single water destination: absorption into the towel material, followed by disposal. Minimal environmental dispersal.

Water removed by paper towels: contained and disposed.

Water removed by dispersal dryers: broadcast into shared environment.

I.9 The Interpretive Question

Remove the dryer from the room. Where does the water go?

With paper towels: into the towel, then into the trash.

With dispersal dryer: onto walls, floors, fixtures, users, and into the air.

The dryer creates the dispersal. The dryer is the dispersal.

Section J: Full Empirical Results: Environmental Mold

This section documents visible mold colonization patterns in restrooms with different drying interventions.

J.1 Methodology

Sample

127 public restrooms randomly selected across multiple geographic regions and facility types.

Assessment Protocol

Visual examination using NIOSH and FDA standard mold assessment techniques, supplemented with a detailed proprietary criteria set. All drying interventions assessed as found, with no criteria for exclusion.

Documentation

Photographic evidence of contamination patterns. Location and extent recorded for each installation.

J.2 Results by Intervention Type

Intervention Type	n	Wall Plume Present	Visible Mold	Mold Rate
Dispersal-type hand dryers	50	50 (100%)	50	100%
Capture-type hand dryers	3	0 (0%)	—	—
Brown paper towel dispensers	30	—	12	40%
White paper towel dispensers	39	—	5	13%

J.3 Statistical Analysis

Comparison: Dispersal dryers (100%) vs. white paper towels (13%)

$$\chi^2 = 72.0$$

$$p < 0.001$$

Ratio: Dispersal dryers show 8x higher mold rates than white paper towel installations.

J.4 The Plume Pattern

Every dispersal-type hand dryer installation exhibited a characteristic contamination pattern:

Origin: Narrow band directly at the dryer outlet.

Spread: Fanning outward and downward toward the floor.

Shape: Plume-like, widening with distance from source.

Content: Visible mold, mineral deposits, dirt accumulation.

The pattern is physically consistent with continuous water deposition from a directed air stream.

J.5 Laboratory Confirmation

Independent laboratory analysis by Hayes Microbial Consulting (EPA Laboratory ID: VA01419) confirmed fungal presence in wall contamination samples.

Species identified:

Aspergillus/Penicillium

Alternaria

Cladosporium

Chaetomium

These organisms are documented by CDC and Institute of Medicine to cause allergic reactions, hypersensitivity pneumonitis, and mycotoxin production.

J.6 Correlation with Microbial Findings

The visible mold correlates with the airborne contamination findings:

Dryer output air contains 50-110x amplified microbial loads.

That air carries water droplets stripped from users' hands.

The water deposits on walls and floors.

Continuous deposition provides moisture for mold growth.

Visible mold appears in 100% of installations.

The plume is the visible signature of the contamination process.

J.7 Universal Finding

The 100% mold rate in dispersal-type installations is notable. Even facilities with excellent cleaning practices showed at least trace mold, particularly directly under the dryer where air turbulence is maximum.

The mold is not a maintenance failure. It is a design consequence. Continuous water deposition creates conditions for mold growth regardless of cleaning frequency.

J.8 Exposure Beyond Users

The contamination affects everyone who enters the restroom, not just dryer users:

A person who uses paper towels (if provided).

A person who uses the sink but not the dryer.

A person who simply walks through.

All are exposed to amplified microbial loads and environmental mold created by the dryer. The exposure extends beyond users to everyone in the space.

J.9 The Interpretive Question

Remove the dryer. Does the mold grow?

Paper towel installations show 13% mold rates. Dispersal dryer installations show 100%.

The difference is the dryer.

Section K: Energy and Environmental Analysis

This section documents the relationship between drying time claims and energy/environmental calculations.

K.1 The Fundamental Calculation

Energy consumption is power multiplied by time:

$$\text{Energy (Wh)} = \text{Power (W)} \times \text{Time (seconds)} \div 3600$$

When drying time claims are false, every calculation built on those claims is mathematically invalid.

K.2 Claimed vs. Actual Energy Consumption

Excel XLERATOR

Claimed: $1,450\text{W} \times 8\text{s} \div 3600 = 3.22 \text{ Wh per use}$

Actual: $1,450\text{W} \times 70\text{s} \div 3600 = 28.2 \text{ Wh per use}$

Ratio: 8.75x higher than claimed

Dyson Airblade

Claimed: $1,000\text{W} \times 12\text{s} \div 3600 = 3.33 \text{ Wh per use}$

Actual: $1,000\text{W} \times 90\text{s} \div 3600 = 25.0 \text{ Wh per use}$

Ratio: 7.5x higher than claimed

K.3 CO₂ Emissions

Use-phase electricity constitutes 87-92% of total hand dryer lifecycle impact. CO₂ emissions scale with energy consumption.

Source	Time	Energy (Wh)	CO ₂ (g)
Certified (SmartEPD)	8 sec	3-4	~2
UL Hokwang EPD	30-35 sec	18	14
Empirical testing	70-90 sec	25-28	12-18

At claimed times: ~2g CO₂ per use

At actual times: 12-18g CO₂ per use (conservative)

Ratio: 6-9x higher than claimed

K.4 The Paper Towel Comparison

Paper towel lifecycle emissions for two towels (~4g total): 12-20g CO₂ per use depending on recycled content and methodology.

Metric	Paper Towels (4g)	Dryer (Claimed)	Dryer (Actual)
CO ₂ - Conservative (g)	17-19.5	~2	12-18
CO ₂ - Expansive (g)	12-20	4-10	30-50

At claimed drying times: Hand dryers produce 50-70% less CO₂ than paper towels.

At actual drying times: Hand dryers produce emissions equivalent to paper towels (conservative) or 2-3x worse (expansive).

The claimed 85-90% CO₂ advantage does not exist.

K.5 The Hokwang Validation

UL Environment EPD No. 4787616201.106.1 for Hokwang hand dryers provides independent validation:

UL certified Hokwang at 30-35 seconds drying time.

UL certified 18 Wh energy consumption and 14g CO₂.

This EPD was issued April 1, 2022—25 days before Anna Lasso formed EPD USA LLC.

Excel's UL certification expired in July 2022 without renewal.

UL's methodology, applied to Hokwang, produces values consistent with empirical testing. The same methodology, applied to Excel by SmartEPD, produces values 7x lower.

If 30 seconds produces 14g CO₂, then 8 seconds cannot produce 2g. The math does not work.

K.6 LEED Propagation

False energy data propagates into building certification systems.

Excel's LEED v4.1 Credit Contribution document instructs building professionals: "Project teams may input 3.68 Wh per 8 second cycle use... for energy modelling purposes."

The instruction explicitly cites: "Product-Specific Type III Environmental Product Declaration (EPD) certified by UL Environment."

The cascade:

SGS tests at 12-15 seconds.

UL Environment certifies EPD stating 8.355 seconds and 3.680 Wh.

SmartEPD issues replacement certification with identical specifications.

Excel cites these certifications in LEED guidance.

Building professionals enter values into LEED software.

LEED awards credits based on false underlying data.

At no point does any party verify that the 8-second claim is achievable.

K.7 Scale of LEED Impact

Approximately 500,000 hand dryers operate in LEED-certified buildings in the United States.

If certified energy values are 7-10 times lower than actual consumption:

Missing energy: ~560 GWh annually

Equivalent homes powered: ~50,000

This energy consumption is absent from LEED environmental accounting.

K.8 Global Scale

Based on market analysis: 1.5-15 million units in the United States, 55-550 billion annual uses domestically.

Annual impact of the gap between claimed and actual performance:

Metric	Conservative	Expansive
Excess energy	5.8 TWh	45 TWh
Excess CO ₂	2.85 million metric tons	20 million metric tons

Equivalent homes powered	550,000	4.3 million
Equivalent national CO ₂ output	Iceland	Mongolia

This excess occurs annually, in perpetuity, based on claims that independent testing shows cannot be achieved.

K.9 AI Verification

Three independent AI systems (Claude, ChatGPT, Grok) verified these calculations using manufacturer-published lifecycle assessment data, working from primary sources without access to each other's outputs. All three converged on the same conclusion.

Section L: The Certification Mark as Public Undertaking

This section documents the role of certification marks in the commercial hand dryer market and the questions raised by divergence between certification and performance.

L.1 The Function of Certification Marks

Certification marks serve a specific commercial function: they allow purchasers to rely on third-party verification rather than conducting independent testing.

UL has spent 130 years building one of the most recognized consumer safety brands in the world. The UL mark appears on 22 billion products annually. It is designed to be seen by purchasers at the point of purchase and users at the point of use.

NSF markets itself as "protecting public health" and promises "assurance that the product has been rigorously tested."

These marks are not incidental. They are the product the certification bodies sell.

L.2 The Reliance Structure

The certification ecosystem depends on purchaser reliance:

Manufacturers pay certification fees because certification increases sales.

Certification increases sales because purchasers trust the marks.

Purchasers trust the marks because they cannot independently verify every claim.

The value of certification derives entirely from this reliance.

L.3 NRTL Status

Both UL and NSF hold special status as Nationally Recognized Testing Laboratories (NRTLs) under 29 CFR § 1910.7.

UL: OSHA-recognized NRTL, most recently renewed March 5, 2021 (86 FR 12710).

NSF: Recognized December 10, 1998 (63 FR 68296).

OSHA permits employers to rely on NRTL certification to satisfy federal workplace safety requirements. The marks carry regulatory weight.

L.4 The Divergence Problem

When certification marks diverge from actual performance, the reliance structure fails:

Purchasers made decisions based on certified specifications.

Certified specifications do not reflect actual performance.

Purchasers have no practical mechanism to detect the divergence.

The cost of independent verification exceeds what individual purchasers can bear.

L.5 The Hanberry Framework

Hanberry v. Hearst Corp., 276 Cal. App. 2d 680 (1969), addressed analogous issues with the Good Housekeeping Seal. The court held that one who endorses products for economic gain owes a duty of care to consumers who rely on that endorsement:

"Having voluntarily involved itself into the marketing process, having in effect loaned its reputation to promote and induce the sale of a given product... public policy imposes upon it the duty to use ordinary care in the issuance of its seal and certification of quality so that members of the consuming public who rely on its endorsement are not unreasonably exposed to the risk of harm."

The NSF P335 mark and UL mark function identically to the Good Housekeeping Seal. They are endorsement marks designed to induce reliance.

L.6 The Contract Analysis

Classical contract elements are present in the certification relationship:

Offer

The mark communicates a specific promise: this product has been tested and meets published standards. The mark is designed for visibility at point of purchase. It is a representation intended to induce reliance.

Acceptance

Purchase of a product bearing the mark constitutes acceptance. The mark influenced the decision. The transaction completed.

Consideration

Certification fees are embedded in product pricing. Purchasers pay those fees with every purchase. Certifiers receive payment through manufacturers as conduits.

Mutual Assent

130 years of deliberate, consumer-facing brand development manifests intent to create a relationship with those who rely on the marks.

L.7 The Defective Standard Problem

Traditional certifier protection applies when products fail due to manufacturing defects. If a certified product malfunctions due to assembly error or component failure, the manufacturer is liable. The certifier tested a sample; it cannot guarantee every unit.

This case presents a different question: what happens when the standard itself is defective?

The UL PCR was written by a committee composed 83% of manufacturer representatives.

The standard established a 0.25g threshold with no scientific justification.

The standard's own Figure 2 shows 8-second drying is impossible.

The standard does not address output air contamination, water dispersal, or mold.

When products "pass" certification but harm users, and the certification process itself enabled the harm, the certification is the defect.

L.8 The Binary Position

Certification bodies established residual moisture thresholds as performance standards. These thresholds exist because exceeding them was determined to create risk.

If exceeding thresholds causes harm, then certification of products that exceed thresholds by 1,000-2,770% exposes users to conditions the standards were designed to prevent.

If exceeding thresholds does not cause harm, then the standards are arbitrary and certification fees were collected for compliance with standards that protect nothing.

Both positions raise questions about the certification system's function.

L.9 Questions Raised

The documentation in this appendix raises questions about certification marks and their function:

What verification supports certified specifications that independent testing cannot replicate?

What mechanisms exist to update certifications when underlying performance data proves inconsistent?

What responsibility accompanies the commercial benefits of purchaser reliance?

What recourse exists for purchasers who relied on certifications that do not reflect actual performance?

Section M: Research Publications and Data Access

All research underlying this appendix is published with permanent Digital Object Identifiers (DOIs) and raw data publicly available.

M.1 Published Studies

Study 1: Transmission of Bacteria and Fungus via Dyson and Xlerator Hand Dryers

DOI: 10.5281/zenodo.15504115

Content: Initial microbial contamination study (n=87)

Study 2: Testing the Validity of Hand Dryer Drying Time Specifications

DOI: 10.5281/zenodo.15503698

Content: Drying performance methodology and initial results

Study 3: Visual Analysis of Water Dispersion Patterns

DOI: 10.5281/zenodo.15503304

Content: Water destination documentation

Study 4: Bacterial and Fungal Contamination Assessment of Paper Towel Types

DOI: 10.5281/zenodo.15504144

Content: Paper towel comparison study

Study 5: Systematic Performance Failure in Commercial Hand Dryers

DOI: 10.5281/zenodo.17858443

Content: Comprehensive performance analysis

Study 6: Baseline Water Mass on Freshly Washed Hands

DOI: 10.5281/zenodo.17858834

Content: Baseline water measurement

Study 7: An Empirical Refutation of Green Energy Claims

DOI: 10.5281/zenodo.17859198

Content: Energy and environmental analysis

Study 8: Catastrophic Time-To-Dry Failures via Bi-Modal Mechanism

DOI: 10.5281/zenodo.17869567

Content: Bi-modal physics documentation

Study 9: Validation of Hand Dryer Microbial Amplification

DOI: 10.5281/zenodo.17859894

Content: Expanded contamination study (n=49)

Study 10: The Wandering Plume of Filth

DOI: 10.5281/zenodo.17860971

Content: Environmental mold documentation (n=127)

Study 11: Performance Failures in Commercial Hand Dryers: Historical Synthesis

DOI: 10.5281/zenodo.18322481

Content: Comprehensive synthesis and summary

M.2 Raw Data

Total data volume: 1.3TB

Hosting: Cloudflare and Backblaze

Availability: Publicly accessible

Preservation: 50 hard drives distributed to 50 trusted individuals

M.3 Laboratory Verification

Hayes Microbial Consulting

EPA Laboratory ID: VA01419

Content: Fungal species identification in environmental samples

M.4 Standards Documents

NSF Protocol P335: Hygienic Commercial Hand Dryers (April 2007)

UL Product Category Rules for Hand Dryers (July 13, 2016)

ISO 14025: Environmental Labels and Declarations

ISO 14044: Life Cycle Assessment Requirements and Guidelines

M.5 Certifications Referenced

Smart EPD Certificate SmartEPD-2023-002-0006-01 (XLERATOR)

SGS Performance Test Report No. 2774929EFF-001 (September 7, 2012)

UL Environment EPD No. 4787137936.102.1 (XLERATOR, July 2017)

UL Environment EPD No. 4787616201.106.1 (Hokwang, April 2022)

NSF P335 Dyson Certified Listing

M.6 Litigation Documents

Excel Dryer, Inc. v. Dyson, Inc.

Case 3:12-cv-30211-MAP (D. Mass.)

Documents: Original Complaint, Denis Gagnon Affidavit, Toby Saville Affidavit, Dyson Answer and Counterclaims, Opposition Memorandum

M.7 Replication

All methodology is documented in sufficient detail for independent replication. The operational test described in the white paper can be performed by any person at any facility without specialized equipment. The empirical methodology can be replicated by any qualified laboratory using documented protocols.

Inquiries regarding methodology, data access, or replication may be directed to the research author.