

COMMERCIAL HAND DRYER PERFORMANCE

**An Analysis of Certification Claims, Empirical Evidence,
and Implications for Federal Agencies**

A Technical White Paper

Prepared for:
United States Department of Agriculture (USDA)
Department of Health and Human Services / FDA
General Services Administration (GSA)

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*Based on independent research comprising 460+ drying trials,
221 contamination tests, and analysis of 127 facilities*

Executive Summary

The Observable Problem

The performance claims made for commercial hand dryers can be verified by anyone in minutes without specialized equipment. Visit any public restroom equipped with a hand dryer claiming compliance with NSF P335 or UL PCR standards. Wash hands. Place them in the dryer for 15 seconds—the least stringent drying time among manufacturer claims. Observe: (1) where the water goes as it leaves hands, (2) that hands remain visibly wet at 15 seconds, and (3) visible mold and water staining on walls near the dryer outlet.

A simple framework clarifies the analysis: remove the dryer from the room. Does the room improve or degrade by its presence?

Why This Matters

Commercial hand dryers are installed in approximately 1.3 to 1.6 million locations across the United States, used an estimated 55 billion times annually. Federal agencies rely on third-party certifications when specifying equipment for federal facilities. Building certification systems (LEED) incorporate certified energy data into environmental calculations. Institutional purchasers—including federal contractors and food service operations—depend on certification accuracy when making procurement decisions.

What Systems Are Implicated

The certification ecosystem includes NSF International (NSF P335 standard), UL Solutions (Product Category Rules for Hand Dryers), SGS North America (performance testing), and Environmental Product Declaration (EPD) program operators. These certifications establish drying time thresholds (0.1g to 0.25g residual moisture), energy consumption values, and hygiene claims that propagate into procurement specifications, building certifications, and environmental reporting.

What Evidence Exists

Independent testing comprising 451 drying time trials documented zero percent compliance with certified specifications at claimed drying times. Residual moisture averaged 2.77 grams—2,770% above the 0.1g NSF threshold. Testing of 136 hand dryer units documented bacterial amplification in 100% of samples, with median amplification of 49.6 to 110 times ambient air levels. Visual assessment of 127 facilities documented visible mold colonization in 100% of dispersal-type hand dryer installations. All research is published with permanent DOIs and raw data publicly available.

Questions Raised for Federal Agencies

These findings raise questions about: (1) whether current certification standards adequately measure intended performance; (2) whether federal procurement specifications should incorporate independent verification requirements; (3) whether facilities with food safety or public health mandates should reassess equipment choices; and (4) whether environmental calculations based on certified energy data require correction.

1. Background and Context

1.1 The Commercial Hand Dryer Industry

Commercial hand dryers are installed in public and commercial restrooms as an alternative to paper towels. The industry markets these devices on three primary claims: (1) hygiene—that they provide a sanitary method of drying hands; (2) speed—that they dry hands in 8 to 15 seconds; and (3) environmental benefit—that they reduce waste and carbon emissions compared to paper towels.

Major manufacturers include Dyson (Airblade product line, \$949-\$1,949 per unit) and Excel Dryer (XLERATOR product line, \$400-\$700 per unit). Both companies market their products to food service establishments, healthcare facilities, schools, and commercial buildings.

1.2 The Role of Third-Party Certification

Institutional purchasers rely on manufacturer performance representations and third-party certifications when making procurement decisions. A facility operator with hundreds of locations cannot independently test every product claim. The certification system exists precisely to make such verification unnecessary—purchasers rely on the apparent independence of the process.

The primary certification standards are NSF Protocol P335 ("Hygienic Commercial Hand Dryers") establishing a 0.1 gram residual moisture threshold, and the UL Product Category Rules for Hand Dryers establishing a 0.25 gram threshold. Environmental Product Declarations (EPDs) certify energy consumption and carbon footprint based on these underlying drying time assumptions.

1.3 The Scientific Foundation

Hand dryers exist because of 150 years of scientific consensus that wet hands spread disease. Washing hands exists to reduce microorganism count. Drying hands exists to reduce microorganism transfer. This is foundational: Semmelweis established the importance of hand hygiene in 1847; Patrick et al. established in 1997 that wet hands transfer up to 1,000 times more bacteria than dry hands.

Manufacturers cite this research in their own marketing. They use the science to justify the products. The same science that justifies the products also defines the standard against which performance must be measured: hands must leave the drying process measurably drier and no more contaminated than when they entered.

2. The Operational Test

All aspects of hand dryer performance can be understood through a simple operational test that requires no specialized equipment, no expert testimony, and no scientific training.

2.1 Test Protocol

Visit any public restroom equipped with an electric hand dryer claiming compliance with NSF P335 or UL PCR standards. Wash hands using standard technique. Place hands in the dryer for 15 seconds—the least stringent drying time standard among all manufacturer and certification claims.

Observe three things:

First, watch where the water goes as it leaves hands. High-velocity air (400-690 km/h in dispersal-type dryers) mechanically strips water from hands. That water must go somewhere. Observe walls, floors, user clothing, and airborne mist.

Second, remove hands at 15 seconds. They will be visibly and obviously wet. No instrumentation is required to verify this.

Third, examine walls and floor near the dryer's air outlet. Note visible mold, dirt accumulation, and water staining originating from that point.

2.2 The Interpretive Framework

A clarifying question: Does a dryer improve or degrade the room by being there?

Consider the room without the dryer. Water stays on hands or is absorbed by a towel. Mold does not grow on walls from drying equipment. No contamination zone forms. No impossible choice exists between leaving with wet hands or extended exposure to amplified microbial loads.

This framework applies to every finding in this analysis. Each documented condition can be evaluated by asking whether it would exist if the dryer were removed.

2.3 Reproducibility

This test can be performed by any person at any facility with installed hand dryers. The observations are not dependent on measurement precision, sampling technique, or statistical interpretation. The test produces the same observable results regardless of who performs it.

3. Empirical Findings

The findings summarized below are based on independent research conducted between 2023 and 2025. All methodology, data, and analysis are published in ten studies with Digital Object Identifiers on Zenodo and Harvard Dataverse. Raw data (1.3TB) is publicly hosted. The research is independently verifiable by any qualified party using documented methods.

3.1 Drying Time Performance

Performance testing comprised 451 drying time trials across three manufacturers (Dyson, Excel/XLERATOR, World Dryer). The methodology followed NSF P335 protocols with precision measurement of residual moisture.

Key Findings:

At manufacturer-claimed drying times (8-15 seconds), zero trials achieved any certification threshold. The most favorable single result was 1.67 grams residual moisture. Certifications specify 0.1 to 0.25 grams.

Average residual moisture at claimed times was 2.77 grams—2,770% above the NSF P335 threshold of 0.1 grams and 1,108% above the UL PCR threshold of 0.25 grams.

Actual time required to approach certification thresholds: 70-90 seconds. This represents a 500-1,000% deviation from claimed drying times.

Threshold	Standard	Compliance at Claimed Times
0.10g	NSF P335	0%
0.25g	UL PCR	0%

Cross-manufacturer correlation coefficients exceeded $r = 0.99$ ($p < 0.001$). All dryers—regardless of manufacturer, technology, air velocity, or price—converge on similar performance curves. Water removal follows bi-modal physics: rapid removal of loose surface water in the first 3-5 seconds, followed by slow evaporation of bound water requiring 70-90 seconds total.

3.2 Microbial Contamination

Contamination testing comprised 136 paired samples comparing ambient room air to hand dryer output air. The methodology used standard agar plate sampling at realistic drying times.

Key Findings:

100% of tested hand dryers amplified bacterial and fungal contamination compared to ambient air. Zero dryers reduced contamination.

Median amplification factor: 49.6x (LB agar, n=87) to 110x (TSA agar, n=49) compared to ambient room air sampled directly in front of the same machines.

The probability of 136 consecutive tests showing amplification under the null hypothesis (that dryers do not systematically amplify contamination) is approximately 10^{-41} .

Metric	Study 1 (n=87)	Study 9 (n=49)
Tests showing amplification	87 (100%)	49 (100%)
Tests showing reduction	0 (0%)	0 (0%)
Median ambient air CFU	1	2
Median dryer output CFU	73	200
Median amplification	49.6x	110x

HEPA filtration showed no statistically significant effect on output contamination ($p = 0.803$). HEPA filters address intake air while the primary contamination pathway is bacterial and fungal amplification from interior surfaces dispersed onto users.

3.3 Water Dispersal

Dispersal-type hand dryers (the dominant market design) operate at air velocities of 400-690 km/h. At these speeds, water is mechanically stripped from hands and dispersed into the room environment.

Key Findings:

Baseline water on freshly washed hands: 7.30 grams. Approximately 90% is removed by mechanical shear during the first drying phase, not by evaporation.

Water destinations documented via visual analysis include: adjacent walls and floor surfaces, user clothing (torso, forearms, thighs, shoes), user face and hair from upward dispersion, and airborne mist remaining visible for 3+ seconds.

No certification standard addresses water dispersal destination. The primary output of the drying process—where the water goes—is completely unaddressed in NSF P335, UL PCR, and all known certification frameworks.

3.4 Environmental Mold Colonization

Visual assessment of 127 public restrooms documented contamination patterns beneath hand drying equipment using NIOSH and FDA standard mold assessment techniques.

Key Findings:

Intervention Type	n	Visible Mold	Rate
Dispersal-type hand dryers	50	50	100%
White paper towel dispensers	39	5	13%
Brown paper towel dispensers	30	12	40%

Every dispersal-type hand dryer installation exhibited visible wall mold (100%). The contamination pattern radiates outward from the device, originating narrow at the unit and fanning toward the floor.

Independent laboratory analysis (Hayes Microbial Consulting, EPA Laboratory ID: VA01419) confirmed fungal presence including *Aspergillus*/*Penicillium*, *Alternaria*, *Cladosporium*, and *Chaetomium*—organisms documented by CDC and Institute of Medicine to cause allergic reactions and hypersensitivity pneumonitis.

3.5 Paper Towel Comparison

Paper towel testing produced a novel finding: prior research had not sorted by towel type.

Key Findings:

White paper towels are statistically equivalent to ambient room air in microbial content. In testing (n=29), 55.6% of white towels were completely sterile (0 CFU). Mean contamination: 0.56 CFU. Wilcoxon signed-rank test against ambient air: $p = 0.23$ (no significant difference).

Brown paper towels showed contamination in 100% of samples (6-186 CFU), intrinsic to the manufacturing process.

The distributions do not overlap. The 75th percentile of white towels (1 CFU) falls below the 25th percentile of brown towels (11 CFU). Cohen's $h = 1.671$.

Paper towels dry hands in 20-30 seconds to 0.1g residual moisture, contain water safely during drying, produce no dispersal or aerosol, and show 13% mold rates versus 100% for dispersal dryers.

4. Standards and Certification Framework

4.1 Relevant Standards

NSF Protocol P335: Hygienic Commercial Hand Dryers

Created by NSF International in April 2007. Establishes 0.1 gram residual moisture threshold with 95% compliance across 20 trials. Section 6.3 specifies performance at manufacturer-claimed times or 15 seconds, whichever is shorter. NSF certifies Dyson products under this standard.

UL Product Category Rules for Hand Dryers

Created by UL Solutions in July 2016. Establishes 0.25 gram threshold—2.5 times weaker than NSF P335. The PCR committee 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. Zero public health officials, consumer representatives, or independent researchers participated.

Environmental Product Declarations (EPDs)

EPDs certify lifecycle environmental impact based on underlying drying time and energy consumption assumptions. Energy consumption calculations use the formula: power (watts) × time (seconds) ÷ 3600 = watt-hours per use. All environmental claims are mathematically derived from drying time assumptions.

4.2 What Standards Measure

Current standards address: residual moisture at specified times, electrical safety, noise levels, and (for EPDs) energy consumption and carbon footprint calculations based on claimed operating parameters.

4.3 What Standards Do Not Measure

Current standards do not address: microbial content of output air, water dispersal destination, environmental contamination from continuous operation, real-world compliance rates, or whether claimed drying times are achievable under actual use conditions.

NSF P335 mentions hygiene in its title and acknowledges that wet hands spread contamination, but provides no testing protocol for output air contamination. The UL PCR mentions hygiene once in 35 pages and provides no testing requirements. No standard addresses the 100% mold colonization rate documented at dispersal-type installations.

4.4 The Standard Indivisibility Problem

A drying standard for a product whose sole purpose is reducing microbe transmission is inherently a hygiene standard. These cannot be separated. Hands must leave the device as clean or cleaner than when they entered.

Current standards address one part of the product cycle while ignoring the rest. NSF P335 Section 6.2 requires HEPA filtration to prevent contaminated air intake—while ignoring that contamination occurs downstream of the filter. NSF P335 Section 6.5 requires 99.9999% bacterial kill for water in capture-type dryers—while requiring nothing for dispersal-type dryers that spray water throughout the room.

5. Points of Divergence Between Certification and Reality

5.1 Drying Time Divergence

Claim Source	Claimed Time	Actual Time to Threshold	Divergence
Excel XLERATOR	8 seconds	70-90 seconds	775-1,025%
Dyson Airblade	10-12 seconds	70-90 seconds	500-800%
UL PCR Figure 2	8 sec = 0.456g	Threshold: 0.25g	82% over threshold

The UL PCR itself contains data proving the divergence. Figure 2 shows 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. This figure was approved by a committee that included Excel Dryer representatives. The data showing 8-second drying is impossible was published in the same document used to certify 8-second claims.

5.2 Energy and Environmental Divergence

Energy calculations are mathematically dependent on drying time: $\text{Energy (Wh)} = \text{Power (W)} \times \text{Time (s)} \div 3600$.

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 actual drying times, energy consumption is 7-10 times higher than certified. The claimed 85-90% CO₂ advantage over paper towels disappears entirely. Products marketed as environmentally superior produce emissions equivalent to or exceeding paper towels under conservative analysis.

UL Solutions issued EPD No. 4787616201.106.1 for Hokwang hand dryers at 30-35 seconds drying time. This UL-certified data validates the empirical methodology while demonstrating the impossibility of 8-second certifications. If 30 seconds produces 14g CO₂, then 8 seconds cannot produce 2g. The math does not work.

5.3 Hygiene Divergence

Products certified as "hygienic" amplify bacterial contamination by 50-110 times compared to ambient air. This is not marginal underperformance—it is the opposite of the certified claim.

5.4 The Logical 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 operational consequences, then certifications of products that exceed thresholds by 1,000-2,770% expose users to conditions the standards were designed to prevent.

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

Both positions raise questions warranting review.

6. Federal Relevance and Reliance Pathways

6.1 Procurement Reliance

Federal agencies specify equipment based on third-party certifications. When GSA schedules include products with certified specifications, downstream purchasers rely on those specifications without independent verification. The certification system exists to make such verification unnecessary.

If certified specifications do not reflect actual performance, federal procurement decisions are based on inaccurate data. The cost of independent verification—approximately \$60,000 and 2.5 years per product line based on the research underlying this analysis—exceeds what any individual purchaser can reasonably bear.

6.2 Facility Operation Reliance

Federal facilities with food service operations, healthcare functions, or public health mandates rely on equipment certifications when selecting restroom fixtures. A USDA-inspected facility, an FDA-regulated environment, or a federal healthcare facility assumes that "certified hygienic" equipment performs as certified.

At any given moment during business hours, approximately 125,000 Americans are simultaneously using certified hand dryers. The exposure occurs at population scale.

6.3 Data Reuse in Downstream Systems

Certified energy data propagates into building certification calculations. Excel Dryer's LEED v4.1 guidance instructs building professionals to "input 3.68 Wh per 8 second cycle use... for energy modelling purposes." This data flows into LEED software, affects credit calculations, and becomes part of building certification records.

An estimated 500,000 hand dryers operate in LEED-certified buildings. If certified energy values are 7-10 times lower than actual consumption, an estimated 560 GWh of annual energy consumption is missing from LEED environmental accounting—enough to power approximately 50,000 American homes.

6.4 The Verification Gap

The certification system is designed so that purchasers need not independently verify every claim. When certifications are inaccurate, the entire system fails. Purchasers have no practical mechanism to detect divergence between certified and actual performance without conducting the research described in this analysis.

7. Implications by Agency Domain

7.1 Food Safety Environments (USDA)

Food service facilities present heightened relevance because the journey from restroom to food contact is measured in seconds. Employees wash hands before preparing food at deli counters, hot bars, and food preparation areas. When hand drying equipment leaves hands wet with amplified bacterial loads—and disperses contaminated water throughout the restroom environment—the contamination infrastructure sits adjacent to food service.

Specific considerations:

USDA-inspected facilities rely on hygiene certifications when selecting equipment. Products certified as "hygienic" that amplify contamination by 50-110 times may not align with food safety requirements.

Cross-contamination pathways from restroom to food preparation merit evaluation when the drying intervention increases rather than decreases microbial load.

The 100% mold colonization rate at dispersal-type installations raises questions about facility sanitation in food-adjacent environments.

7.2 Public Health Environments (HHS/FDA)

Healthcare facilities and public health environments serve vulnerable populations where infection control is paramount. The assumption that "certified hygienic" equipment reduces contamination risk is foundational to facility design.

Specific considerations:

Bacterial and fungal amplification of 50-110 times ambient levels in healthcare-adjacent restrooms may affect infection control assumptions.

The contamination documented in this analysis affects everyone who enters the restroom, not just dryer users. A person who uses paper towels, uses only the sink, or simply walks through is exposed to amplified microbial loads and environmental mold.

Current certification standards do not address output air contamination, creating a gap between certification and public health relevance.

7.3 Federal Procurement (GSA)

GSA schedules and federal procurement specifications incorporate certified values for performance, energy consumption, and environmental impact. Downstream purchasers rely on these specifications.

Specific considerations:

Specification accuracy: If certified drying times are 500-1,000% shorter than actual performance, specifications based on those certifications may not reflect operational reality.

Energy calculations: If certified energy consumption is 7-10 times lower than actual consumption, energy specifications and environmental calculations require correction.

Verification requirements: Current procurement processes assume certification accuracy. Independent verification mechanisms may warrant consideration for product categories where certification divergence has been documented.

8. Questions Raised for Review

The findings documented in this analysis raise questions that existing frameworks may not adequately address:

8.1 Standards Adequacy

Are current certification standards sufficient to measure intended performance in real-world operating conditions?

Should certification standards for hygiene-related products include testing of actual hygiene outcomes (output air contamination, environmental effects)?

Is the gap between NSF P335 (0.1g) and UL PCR (0.25g) thresholds scientifically justified?

8.2 Certification Integrity

How should certification systems respond when empirical testing demonstrates systematic divergence from certified specifications?

Should certification renewals require independent verification of continued compliance?

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

8.3 Procurement Implications

Should federal procurement specifications incorporate independent verification requirements for product categories where certification divergence has been documented?

How should downstream data systems (LEED, energy modeling) be corrected when source certifications prove inaccurate?

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

8.4 Facility Operations

Should facilities with food safety or public health mandates reassess equipment choices when certification claims diverge from documented performance?

How should facility operators evaluate the trade-off between certified but non-performing equipment and alternatives (white paper towels) that achieve documented hygiene outcomes?

9. Conclusion

This analysis documents systematic divergence between certified specifications and observed performance for commercial hand dryers. The findings are based on 451 drying time trials, 136 contamination tests, and assessment of 127 facilities. All methodology, data, and analysis are publicly available with permanent DOIs.

The findings are observable and reproducible. Any facility can verify drying time performance using only a stopwatch and paper towels. Any facility can observe water dispersal patterns, residual moisture at claimed times, and environmental contamination beneath drying equipment.

The divergence between certification and reality is not marginal. Drying times exceed claims by 500-1,000%. Contamination amplification is 50-110 times ambient levels. Mold colonization occurs in 100% of dispersal-type installations. Energy consumption is 7-10 times higher than certified.

The analysis does not prescribe action. It documents conditions that existing frameworks may not adequately address and raises questions for agency review. The operational test is available to any party seeking independent verification.

Remove the dryer from the room. Does the room improve or degrade? The answer to that question determines whether current approaches serve their intended purpose.

Appendix A: Research Publications

All research is published with permanent Digital Object Identifiers (DOIs) on Zenodo and Harvard Dataverse. Raw data (1.3TB) is publicly hosted at Cloudflare and Backblaze.

Published Studies

1. Transmission of Bacteria and Fungus via Dyson and Xlerator Hand Dryers (DOI: 10.5281/zenodo.15504115)
2. Testing the Validity of Hand Dryer Drying Time Specifications (DOI: 10.5281/zenodo.15503698)
3. Visual Analysis of Water Dispersion Patterns (DOI: 10.5281/zenodo.15503304)
4. Bacterial and Fungal Contamination Assessment of Paper Towel Types (DOI: 10.5281/zenodo.15504144)
5. Systematic Performance Failure in Commercial Hand Dryers (DOI: 10.5281/zenodo.17858443)
6. Baseline Water Mass on Freshly Washed Hands (DOI: 10.5281/zenodo.17858834)
7. An Empirical Refutation of Green Energy Claims (DOI: 10.5281/zenodo.17859198)
8. Catastrophic Time-To-Dry Failures via Bi-Modal Mechanism (DOI: 10.5281/zenodo.17869567)
9. Validation of Hand Dryer Microbial Amplification (DOI: 10.5281/zenodo.17859894)
10. The Wandering Plume of Filth (DOI: 10.5281/zenodo.17860971)
11. Performance Failures in Commercial Hand Dryers: Historical Synthesis (DOI: 10.5281/zenodo.18322481)

Laboratory Verification

Hayes Microbial Consulting (EPA Laboratory ID: VA01419) — fungal species identification in environmental samples.

Appendix B: Standards Documents Referenced

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

Appendix C: Contact Information

Questions regarding this analysis, requests for underlying data, or inquiries about replication methodology may be directed to the research author.

All raw data, methodology documentation, and analysis scripts are publicly available for independent verification.