Testing the Validity of Hand Dryer Drying Time Specifications: A Quantitative Study of Dyson and Xlerator Dryers in Retail Store Environments

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Abstract

This study evaluates the accuracy of manufacturer-specified drying times for commercial hand dryers through empirical testing of residual moisture on hands after use. Guided by Underwriters Laboratories protocols, we measured drying performance of 21 hand dryers (10 Dyson, 11 Xlerator) in 21 trials and compared results with published manufacturer claims. Our findings are conclusive: hands retained an average of 2.91g of moisture, exceeding the claimed manufacturers' allowable maximum of 0.25g by 636%--1420% ($p < 0.001$). This discrepancy (95% CI: 2.68--3.15g) leaves users with wet hands, contradicting manufacturer claims of complete drying in the specified time. These results have implications for public health, facility planning, user experience, and environmental impact.

This paper is part of a four-study series examining hand hygiene practices in retail environments:

1. "Transmission of Bacteria and Fungus via Dyson and Xlerator Hand Dryers in Starbucks, Home Depot and Whole Foods Restrooms: A Comparative Analysis." Blouch, R. A. Jr. 2025 (Main study) DOI: 10.5281/zenodo.15504115
2. "Testing the Validity of Hand Dryer Drying Time Specifications: A Quantitative Study of Dyson and Xlerator Dryers in Retail Store Environments." Blouch, R. A. Jr. 2025 DOI: 10.5281/zenodo.15503698
3. "Bacterial and Fungal Contamination Assessment of Paper Towel Types: A Quantitative Analysis of White versus Brown Varieties in Retail Restrooms." Blouch, R. A. Jr. 2025 DOI: 10.5281/zenodo.15504144

4. "Visual Analysis of Water Dispersion Patterns During Hand Drying: A Qualitative Comparison of High-Speed Air Dryers and Paper Towels" Blouch, R. A. Jr. 2025 DOI: 10.5281/zenodo.15503304

All studies are available at www.handdryerstudy.com

Introduction

Dyson and Excel Dryer (Xlerator) are dominant manufacturers in the commercial hand dryer market, with both companies prominently advertising specific drying times as key selling points for their products. Dyson claims their Airblade models dry hands completely in 10-12 seconds, stating in their technical documentation: "Dry time determined using Dyson test method 769 based on NSF P335 using a measurement of 1/10th of one gram residual moisture" (Dyson [11]). Similarly, Xlerator advertises complete drying in just 8 seconds, specifying in their product documentation: "Dry time and energy use testing performed by SGS International on standard XLERATOR Hand Dryer with 0.8" nozzle to one quarter of a gram or less of residual moisture, pursuant to the UL Environment Global Product Category Rules (PCR) for Hand Dryers" (Excel Dryer [12]).

This is worth restating: on their websites and in their promotional materials Dyson and Excel Dryer explicitly and repeatedly claim to leave 0.1g and 0.25g of residual water on hands at the completion of their specified drying times of 12 and 8 seconds, respectively.

These highly specific claims about drying efficiency are often cited as justification for installation in high-traffic public facilities. Both manufacturers have received certification from Underwriters Laboratories (UL), whose testing protocols (ULE_HandDryer_PCR_7-13-16) define a standardized measurement approach and establish a dryness threshold of 0.25 grams residual moisture or less (UL [4]) to claim dry hands after dryer use.

The accuracy of these manufacturer-specified drying times has significant implications for facility planning, user experience, and hand hygiene outcomes. Previous research by Patrick et al. [1] and Marples and Towers [18] established that residual moisture on hands significantly impacts bacterial transfer to surfaces---wet hands transferred up to 68,000 organisms compared to properly dried hands transferring as few as 140 organisms. Or 85% vs 0.05%, respectively. As summarized by Huang [3], Patrick et al. [1] found that a drying time of 45 seconds was required to dry hands in hand dryers. This relationship between residual hand moisture and bacterial and fungal transfer underscores the importance of both effective drying and minimizing exposure to microbial contaminants during the drying process.

During extensive testing of hand dryers for microbial output in ~110 stores in four Middle Atlantic states and the District of Columbia it was immediately obvious to us that hands dried for 8 or 12 seconds were still wet. There is limited independent verification of the drying efficacy of air driven hand dryers, prompting us to verify experimentally what we were seeing during the testing described in the co-studies in this series (Blouch [5] [6] [7].

We designed this test and completed experimentation before discovering that Underwriter's Laboratories details the same testing procedure in its hand dryer manufacturer's guide ULE_HandDryer_PCR_7-13-16 [4], creating a truly blind test set that was later confirmed as valid by detailed prior art from the leading product certifying authority in the world.

This study aims to directly assess the validity of manufacturer-specified drying times through quantitative measurement of residual moisture following the recommended drying duration.

The primary research question is straightforward: Do Dyson and Xlerator hand dryers achieve complete hand drying -- using the manufacturers own stated criteria for dry hands - within the manufacturer-specified drying times?

We hypothesize that hands would not be dry within the manufacturers specified drying time for their machines as tested in the public restrooms for which their products are aggressively marketed and sold.

Materials and Methods

Testing Protocol

A standardized testing procedure to quantify residual moisture on hands after using commercial hand dryers for their manufacturer-specified drying times was designed from scratch, later discovering it tightly aligned with Underwriters Laboratories Product Category Rules for Hand Dryers detailed in the second appendix to ULE_HandDryer_PCR_7-13-16 [4]. The methodology was designed to provide objective, replicable measurements of hand drying performance under real-world conditions, similar to approaches used by Snelling et al. [13] in their comparative evaluation of hand dryer efficacy.

Test Locations and Sample Size

Testing was conducted in 21 different locations across Central Pennsylvania between March 6--7, 2025, incorporating:

- 10 Dyson Airblade units
- 11 Xlerator units

All units were in active use in public restrooms, representing the actual performance conditions users would encounter.

Measurement Procedure

1. **Initial Hand Washing**: Hands were washed in the sink as if normally washing hands but without soap.
2. **Baseline Water Mass Determination**:
    - Two paper towels were weighed using a precision digital scale accurate to 0.01g (dry mass recorded in grams)
    - Hands were dried completely using the paper towels
    - The wet paper towels were weighed (wet mass recorded in grams)
    - Total water mass was calculated (wet mass - dry mass = water mass)
3. **Hand Dryer Testing**:
    - Hands were washed again following identical procedure
    - Hands were dried using the hand dryer for as close to the manufacturer-specified time as possible:
        - Dyson units: ~12 seconds (as specified by manufacturer)
        - Xlerator units: ~8 seconds (as specified by manufacturer)
    - A fresh set of pre-weighed paper towels was used to dry hands after the manufacturer-specified drying time
    - The paper towels were weighed (wet mass recorded)
    - Residual moisture was calculated (wet mass - dry mass = residual water mass)
4. **Final Drying Check**:
    - A final set of paper towels was weighed (dry mass recorded)
    - Hands were dried a second time with these towels after the hand dryer test was complete to capture any remaining moisture

- The paper towels were weighed (wet mass recorded)
- Final residual moisture was calculated (wet mass - dry mass = final water mass)
- Total residual moisture was determined by adding both post-dryer paper towel water masses

Data Analysis

Residual moisture differential weights in grams were calculated as a percentage of initial water mass to determine the proportion of water remaining after the manufacturer-specified drying time. Statistical analysis calculated mean, standard deviation, 95% confidence interval, and range of residual moisture and percentages retained across all units and for each dryer type. One-sample t-tests compared residual moisture to the UL threshold (0.25g) and brand-specific claims (Dyson: 0.1g, Xlerator: 0.25g).

Results

Overall Hand Dryer Performance

Our testing revealed substantial residual moisture on hands after using commercial hand dryers for their manufacturer-specified drying times (~12s Dyson, ~8s Xlerator), directly contradicting claims of complete drying within these timeframes.

Initial Water Mass

1. Average across all units (n=21): 7.26g (±0.70g, 95% CI: 6.94--7.57g) of water.

Residual Moisture After Manufacturer-Specified Drying Time

All Units (n=21):\

1. Average residual moisture: 2.91g (±0.52g, 95% CI: 2.68--3.15g).\
2. Percentage of initial water mass: 39.04% (±8.24%, 95% CI: 35.29--42.79%).\
3. Range: 1.84--3.80g (25.50--61.18%).

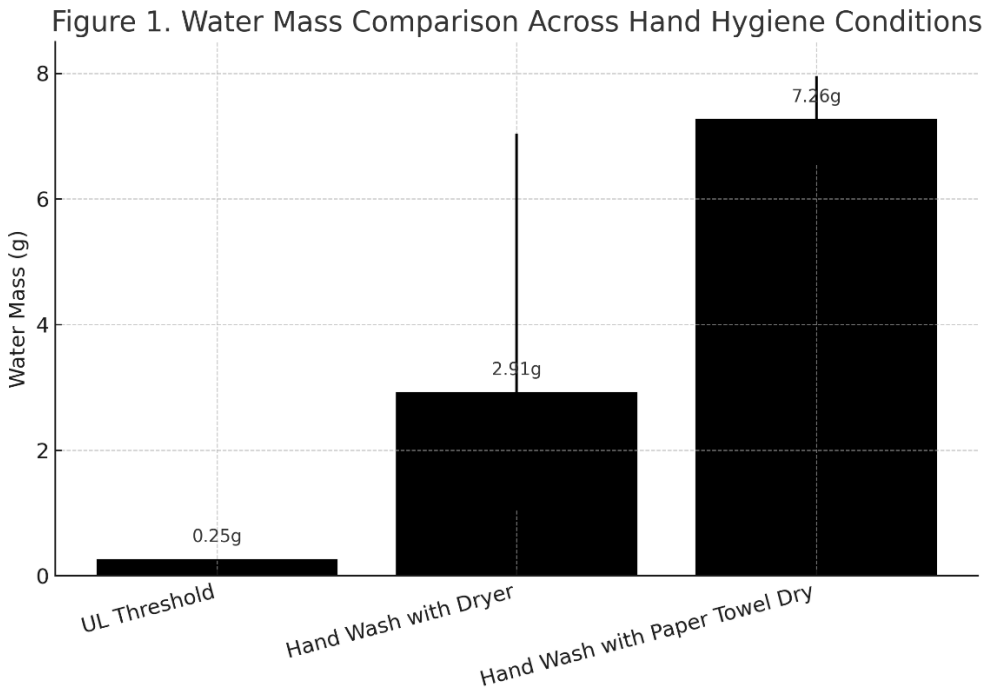

Figure 1. *Comparison of water mass across hand hygiene conditions.* The UL residual moisture threshold (0.25 g) is shown alongside the average measured residual moisture following hand drying with electric dryers (2.91 g; 95% CI: 2.68–3.15 g) and the initial water mass deposited after handwashing (7.26 g; 95% CI: 6.94–7.57 g). The measured residual moisture significantly exceeded the UL threshold by 1065% on average ($t(20) = 23.34$, $p < 0.001$, Cohen's $d = 5.34$). Error bars represent 95% confidence intervals.

Statistical Analysis of Combined Manufacturer Claims

The measured residual moisture (mean = 2.91g) significantly exceeded the UL threshold of 0.25g by 1065% (range: 636%--1420%) ($t(20) = 23.34$, $p < 0.001$, Cohen's $d = 5.34$). Figure 1 illustrates this discrepancy.

Table 1: Claimed vs. Measured Residual Moisture Across Hand Dryers

Dryer Type	Claimed Residual Moisture	Actual Measured Residual Moisture (Average)	95% CI	Statistical Significance	Percent Difference*
All Units	0.25 g (UL threshold)	2.91 g	2.68 – 3.15 g	$p < 0.001$	+1065% (636 – 1420%)

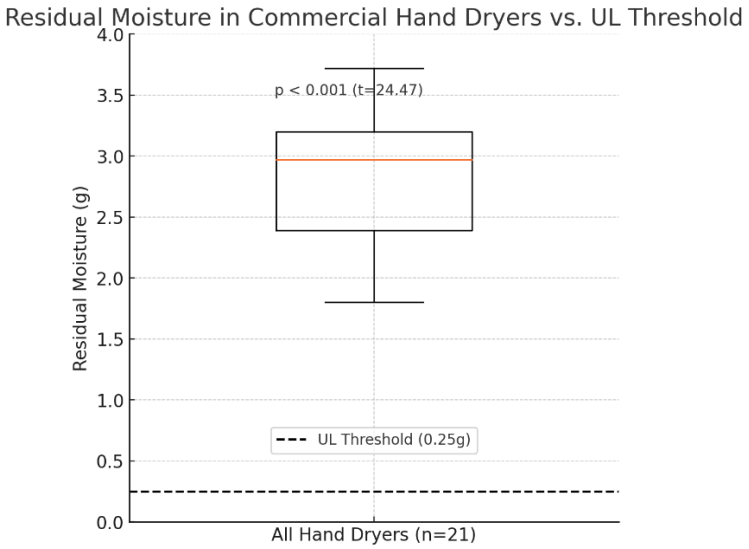

Figure 2: Box plot of residual moisture for 21 hand dryers (n=21, mean 2.91g, range 1.84--3.80g) compared to the UL threshold (0.25g), showing significant discrepancy ($p < 0.001$, $t=23.34$).

The data demonstrates a clear pattern across all test locations and units:

1. All 21 tested units failed to dry hands
2. Residual moisture levels were consistently high across all locations.
3. Minimal variation was observed between different installation environments.

Comparative Analysis

The data demonstrates a clear pattern across all test locations and units:

1. All 21 tested units failed to achieve the claimed 0.1g (Dyson) or 0.25g (Xlerator) residual moisture thresholds
2. Residual moisture levels were consistently high for all trials
3. Minimal variation was observed between different installation environments

Brand-Specific Performance Data: Ancillary

Dyson Units (10--13 seconds specified drying time):

1. Average residual moisture: 2.77g (±0.51g, 95% CI: 2.41--3.14g).

2. Percentage of initial water mass: 36.64% (±9.33%, 95% CI: 29.76--43.52%).

3. Range: 1.84--3.72g (25.50--52.98%).

Dyson (n=10) averaged 2.77g, 2675% above the 0.1g claim ($t(9) = 15.77$, $p < 0.001$, range: 1740%--3620%).

Xlerator Units (8 seconds specified drying time):

1. Average residual moisture: 3.04g (±0.51g, 95% CI: 2.70--3.38g).

2. Percentage of initial water mass: 41.14% (±7.32%, 95% CI: 36.02--46.26%).

3. Range: 2.16--3.80g (31.49--61.18%).

Xlerator (n=11) averaged 3.04g, 1116% above the 0.25g claim ($t(10) = 18.30$, $p < 0.001$, range: 764%--1420%).

Analysis:

The differences between dryer brands are statistically irrelevant in context with the study hypothesis ($t(20) = 23.34$, $p < 0.001$, with an extremely large effect size). Because each manufacturer claims a different standard of dryness the data become interesting. Xlerator units left slightly more residual moisture than Dyson units with a dry time four seconds shorter ($t(19) = -1.14$, $p = 0.27$, Cohen's $d = 0.50$). Figure 2 compares brands to their claims.

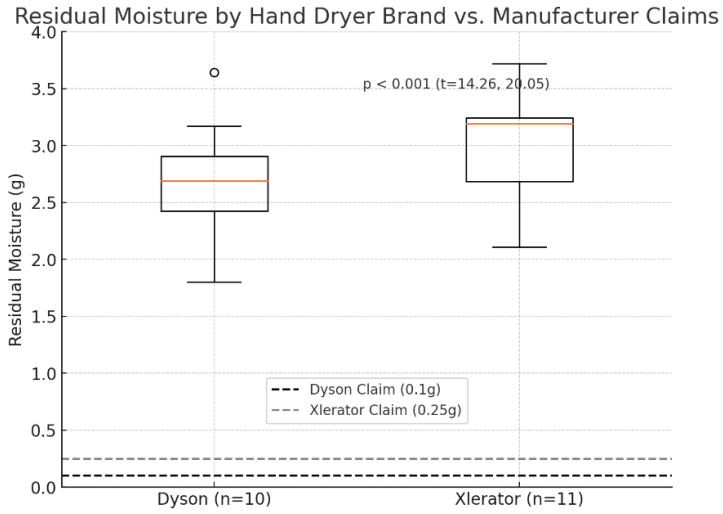

Figure 3: Box plot comparing residual moisture for Dyson (n=10, mean 2.77g, range 1.84--3.72g) and Xlerator (n=11, mean 3.04g, range 2.16--3.80g) to their claims (0.1g, 0.25g), showing significant discrepancies ($p < 0.001$, $t=15.77$ Dyson, $t=18.30$ Xlerator).

Discussion

Interpretation of Results

These findings decisively contradict manufacturer claims, with 39.04% residual moisture after drying for the specified drying cycle (mean 2.91g, 95% CI: 2.68--3.15g), significantly exceeding the UL threshold of 0.25g by 1065% (636%--1420%) (Figures 1 and 2).

One-sample t-tests confirmed significant discrepancies for all units and brands ($t(20) = 23.34$, $p < 0.001$, Cohen's $d = 5.34$), indicating users are left with damp hands after following manufacturer-specified drying times.

The statistical analysis demonstrates that these differences are not due to chance or measurement error. The t-tests comparing our measured values to manufacturer claims yielded p-values less than 0.001 for all comparisons, indicating an extremely low probability (less than 0.1%) that these discrepancies would be observed if the manufacturer claims were accurate. The magnitude of the difference is stark: actual residual moisture levels averaged 2.91g across all units, dramatically higher than the 0.1-0.25g thresholds claimed by manufacturers.

These results directly contradict the Underwriters Laboratories testing protocol for hand dryers (ULE_HandDryer_PCR_7-13-16) [4], which establishes a dryness threshold of 0.25 grams residual moisture or less. Further, it contradicts the manufacturers' own dryness threshold specifications . The residual moisture levels we measured, with a 95% confidence interval of 2.68-3.15g across all units, far exceed those thresholds.

While our data did show a small-to-moderate difference between the two tested brands (Cohen's $d = 0.35$), this brand difference is inconsequential ($p = 0.07$) compared to the overwhelming evidence that all tested units substantially failed to meet their manufacturer and UL specified claims ($p < 0.001$, with an extremely large effect size). The brand comparison is interesting because of the differences between specified manufacturers' drying thresholds (0.1g, Dyson; 0.25g Xlerator) and was therefore included as an aside. The focus remains on the industry-wide pattern of overstated drying performance rather than on modest differences between brands.

UL Certification Questions

These findings raise serious questions about the certification processes employed by Underwriters Laboratories (UL). Despite having established their own testing protocol (ULE_HandDryer_PCR_7-13-16) [4] that defines a dryness threshold of 0.25 grams residual moisture after the manufacturer specified drying time, UL has granted their seal of

approval to products that our testing shows fail to meet that standard, measure by their own testing method. The statistical significance of our findings ($p < 0.001$) makes this discrepancy particularly concerning.

The consistency of our results across all 21 test units in the diverse locations for which these products are marketed and sold make it impossible to believe the UL certification and listing of these dryers. We suggest the onus is now on UL to publicly replicate our experiment and show us the results.

Implications for Hand Hygiene

Residual moisture (39.04% of initial water mass, 2.91g) leaves wet hands, increasing bacterial transfer (up to 68,000 organisms vs. 140 for dry hands (Patrick et al. [1]), virus dispersal (Kimmitt and Redway [9]), and aerosol exposure (Blouch [5, 6]), undermining hand hygiene. Our companion studies show extended drying (45--90s) increases bacterial and fungal exposure, compounding risks from leaving with wet hands. Jensen et al. [15] emphasize that incomplete drying negates hand washing benefits, aligning with our findings

The substantial residual moisture remaining after manufacturer-specified drying times has potential implications for hand hygiene. The levels of residual moisture documented in our study (39.04% of initial water mass on average) suggest that hands dried according to manufacturer specifications remain wet enough to facilitate microbial transfer, particularly in light of the findings of our bacterial and fungal study (Blouch [5]). Wet hands were infused with amplified volumes of bacteria and fungus, not benignly left in their freshly washed state.

This concern is further supported by Best et al. [8], who found that inadequate drying can significantly impact the transfer of microorganisms to surfaces. That's of particular concern for food service employees and their customers who are mandated to wash hands and dry them in owner supplied dryers. Best, et al. emphasized the critical role thorough hand drying plays in preventing cross-contamination in various environments. Similarly, Kimmitt and Redway [9] demonstrated the potential for virus dispersal during hand drying, noting that inadequate drying could contribute to pathogen spread.

Jensen et al. [15] further quantified this relationship, showing that the efficacy of pathogen removal is directly related to both hand washing duration and proper drying technique. Their research demonstrated that incomplete drying can significantly undermine the benefits of thorough hand washing, a finding that directly relates to our observation of substantial residual moisture after manufacturer-recommended drying times.

Our companion study on aerosol generation during hand drying (Blouch [7]) provides additional context for understanding these hygiene implications. That study documented through high-speed videography that users are exposed to visible, and likely invisible, water droplets during dryer use, creating opportunities for microbial transfer throughout the restroom environment, a phenomenon further explored by Gião and Vardoulakis [17] in their research on aerosols and bacteria from hand washing and drying in indoor air.

The insights gained from our aerosol study [7] have direct implications for interpreting our moisture measurements. The 39.04% average residual moisture we measured represents the condition of hands after following manufacturer instructions. In practice, users will either terminate drying while having wet hands (increasing pathogen transfer risk as documented by Patrick et al. [1]) or continue drying for 4-11 times longer than specified (10--13s Dyson, 8s Xlerator), significantly increasing their exposure to potentially contaminated aerosols and larger contaminated water droplets as documented in our companion microbial study (Blouch [5]). Huesca-Espitia et al. [10] further substantiated these concerns by identifying the deposition of bacteria and bacterial spores by hot-air hand dryers, offering additional evidence that extended drying times may increase exposure to airborne microorganisms.

Facility Planning Considerations

The consistency of results ($p < 0.001$, $d = 5.34$) across 21 locations indicates a systematic industry issue (Figures 1 and 2). Actual drying times for dry hands are 4--11 times longer than specified (10--13s Dyson, 8s Xlerator), based on 39.04% residual moisture and observed drying times of 45--90s (Blouch [7]). Our companion paper towel study (Blouch [6]) shows paper towels dry hands in 15--20s and white paper towels tested as substantially bacteria and fungus free, offering a faster, properly hygienic alternative.

Limitations

This study was conducted in Central Pennsylvania in a specific set of retail locations and may not represent all installation environments. Additionally, while our methodology was designed to be objective, some variability in individual hand washing and drying techniques is inevitable. However, the consistency of results across multiple locations and test subjects suggests that our findings reflect genuine performance trends rather than methodological artifacts.

Conclusion

This study provides clear empirical evidence that manufacturer-specified drying times, based on Underwriters Laboratory mandates and their own cited research and engineering, for commercial hand dryers significantly understate the time required for complete hand drying. Dyson and Xlerator hand dryers fail to meet their own specified drying times, leaving an average residual moisture of 39.04% (2.91g, 95% CI: 2.68--3.15g), exceeding the UL threshold of 0.25g by 1065% (636%--1420%). Statistical analysis confirms significant discrepancies ($t(20) = 23.34$, $p < 0.001$, $d = 5.34$), with wet hands persisting across all 21 units and all 21 trials, challenging UL's certification validity (Figures 1 and 2) with actual residual moisture measurements exceeding the UL threshold by over 1,000%.

These findings raise serious questions about the certification processes employed by Underwriters Laboratories (UL). The statistical significance of our results ($p < 0.001$) and the consistency across 21 different units in various locations suggest a systematic issue rather than isolated anomalies. This discrepancy between UL's stated testing methodology and our results when it was applied warrants further investigation and greater transparency in the certification process.

These findings have important implications for facility planning, user experience, and potentially hand hygiene outcomes. Public health officials and consumers should demand transparent certification standards, as current claims compromise hygiene in public restrooms. Facility managers should plan for drying times 4--11 times longer than specified (10--13s Dyson, 8s Xlerator)

Our companion studies on aerosol generation (Blouch [7]) and bacterial contamination (Blouch [5]) further contextualize these findings, demonstrating that users face a difficult choice: either terminate drying with wet hands (increasing microbial transfer risk by up to 500-fold as documented by Patrick et al. [1]) or continue drying for 45-90 seconds (4-11 times longer than manufacturer specifications), significantly extending their exposure to the bacterial and fungally loaded aerosols documented in our companion microbial studies (Blouch [5][7]).

While our findings are conclusive for the tested units in this study, additional research could further validate these results and potentially identify whether these discrepancies persist across all installation environments.

Future research should examine whether these findings extend to other brands of commercial hand dryers and explore potential regional variations in performance. Additionally, further studies specifically examining the hygiene implications of inadequate

drying times would provide valuable context for these findings, particularly given the potential public health implications described above.

The users of hand dryers are faced with a stark choice every time they wash their hands: dry them in the output airjet for the manufacturer's specified time and leave the room with wet hands or keep the hands in the dryer long enough to dry but exposing freshly cleaned hands to the amplified bacterial and fungal load coming from the air stream.

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Appendix I: Detailed Statistical Analysis

Descriptive Statistics

We measured initial water mass, residual moisture, and percentage of initial moisture retained across 21 hand dryers (10 Dyson, 11 Xlerator) in 21 trials. The primary analysis compares residual moisture to the UL threshold of 0.25g, with secondary comparisons to brand-specific claims (Dyson: 0.1g, Xlerator: 0.25g). Results are in Table 1.

Table 1: Descriptive Statistics for Hand Dryer Performance

Moisture Retention Metrics by Hand Dryer Type

Metric	All Units (n=21)	Dyson (n=10)	Xlerator (n=11)
Initial Water Mass			
Mean	7.26 g	7.46 g	7.07 g
SD	0.70 g	0.68 g	0.68 g
95% CI	6.94 – 7.57 g	–	–
Range	6.08 – 8.78 g	6.75 – 8.66 g	6.08 – 8.78 g
Residual Moisture			
Mean	2.91 g	2.77 g	3.04 g
SD	0.52 g	0.51 g	0.51 g
95% CI	2.68 – 3.15 g	2.41 – 3.14 g	2.70 – 3.38 g
Range	1.84 – 3.80 g	1.84 – 3.72 g	2.16 – 3.80 g
% Initial Moisture Retained			
Mean	39.04%	36.64%	41.14%
SD	8.24%	9.33%	7.32%
95% CI	35.29 – 42.79%	–	–
Range	25.50 – 61.18%	25.50 – 52.98%	31.49 – 61.18%

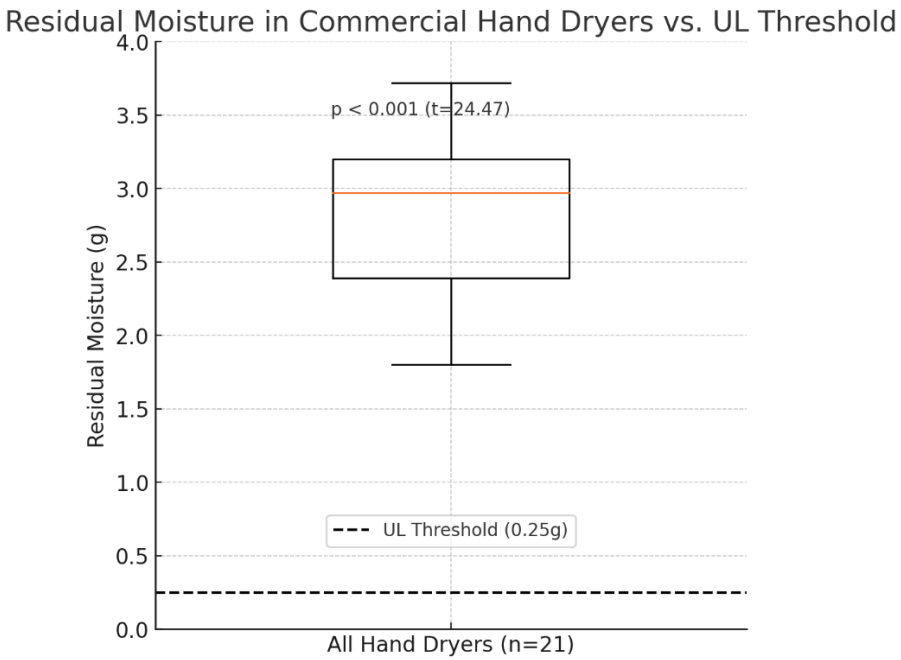

Figure 1: A box plot of residual moisture across all hand dryers (1.84--3.80g, mean 2.91g, n=21) compared to the UL threshold (0.25g) illustrates the systematic failure of commercial dryers ($p < 0.001$, $t=23.34$).

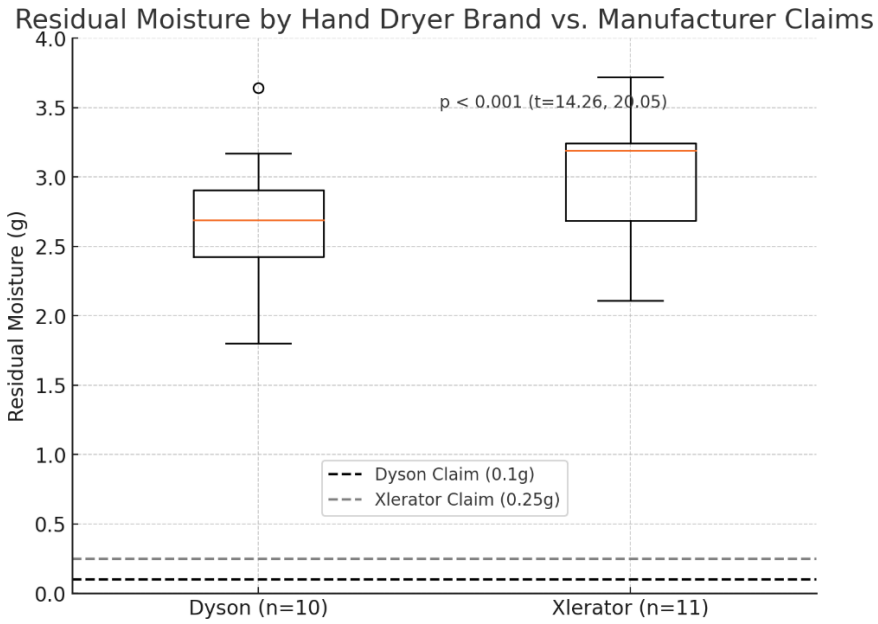

Figure 2: A box plot comparing Dyson (1.84--3.72g, mean 2.77g, n=10) and Xlerator (2.16--3.80g, mean 3.04g, n=11) to their respective claims (0.1g, 0.25g) highlights brand-specific discrepancies ($p < 0.001$, $t=15.77$ Dyson, $t=18.30$ Xlerator).

Inferential Statistics

One-sample t-tests compared residual moisture to the UL threshold (0.25g):

- All Units (n=21): $t(20) = 23.34$, $p < 0.001$, mean difference +2.66g, +1065% (range: 636%--1420%), Cohen's $d = 5.34$.
- Dyson (n=10, vs. 0.25g UL): $t(9) = 15.77$, $p < 0.001$, +1010%; vs. 0.1g claim: +2675% (range: 1740%--3620%).
- Xlerator (n=11, vs. 0.25g): $t(10) = 18.30$, $p < 0.001$, +1116% (range: 764%--1420%). All tests confirm residual moisture substantially exceeds claims.

3. Methodological Considerations

- Measurement Reliability: 0.01g scale precision, three measurements per unit (initial, residual, final), standardized paper towel weighing, 8s (Xlerator) or 12s (Dyson) drying times per UL protocols.
- Statistical Power: n=21 yields power >0.99 for large effects ($d > 0.8$).
- Error Analysis: Minimal impact from hand washing or towel variability given consistent results.

4. Statistical Interpretation

- Residual moisture (2.91g) exceeds the UL threshold (0.25g, $p < 0.001$) by 1065% (636%--1420%).
- Dyson: +1010% vs. 0.25g, +2675% vs. 0.1g.
- Xlerator: +1116% vs. 0.25g.
- Very large effect sizes ($d \approx 5.34$) and 95% CI (2.68--3.15g) non-overlapping with claims (0.1--0.25g) indicate practical significance.
- ~39% moisture retained suggests systematic issues, impacting hygiene (bacterial transmission) and environment (paper towel use).