ONEIDA RESEARCH SERVICES, INC.
INSPECTION • ANALYSIS • TESTING

ASTM E595 Outgassing Testing
Application Note 1:
Outgassing Analysis of Nylon 66 Materials

Introduction

Industries like aerospace, electronics, semiconductors and others relying on vacuum environments require rigorous material screening. The ASTM E595 test method offers a standardized way to assess a material's outgassing properties. For example, outgassing from plastic components (like Nylon 66) can compromise vacuum integrity and contaminate sensitive instruments. ASTM E595 test method can quantify:

- *Total Mass Loss (TML)* – Quantity of the total amount of material that evaporates or releases gasses during the outgassing
- *Collected Volatile Condensable Materials (CVCM)* – Measure of the specific volatile compounds (VOCs) that condense back on cooler surface (25°C).

Details of ASTM E595 Test Procedure

ASTM E595 test method requires a well-defined test procedure and apparatus to determine the volatile content of materials when exposed to a vacuum environment. The schematic for the test procedure is given in Fig. 1.

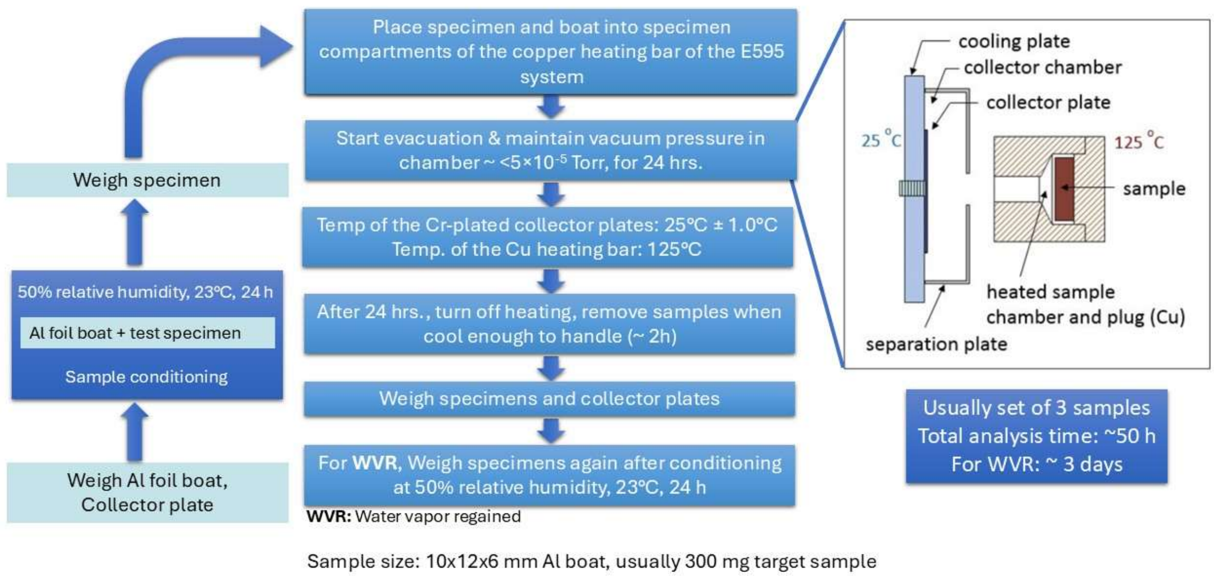


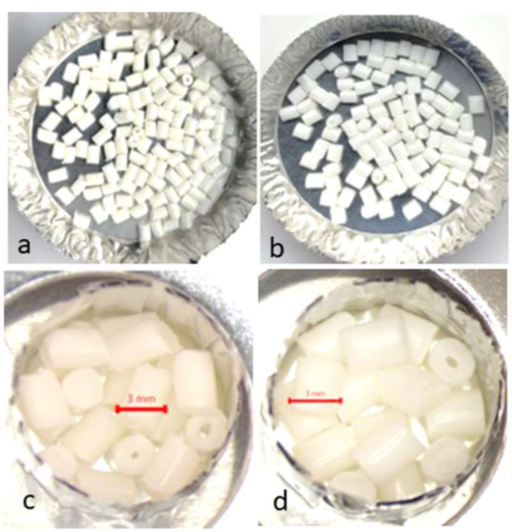
Fig. 1: Schematic providing major steps for performing ASTM E595 test

Case Study

Nylon 66—also written as Nylon 6,6 or PA66—is a high-performance engineering thermoplastic known for its strength, durability, and resistance to heat and chemicals. It's part of the polyamide family and is widely used in industries ranging from automotive to electronics to textiles due to their excellent properties. Nylon 66, while strong and versatile, contains small molecular species (plasticizers, lubricants, moisture) that can volatilize under vacuum and elevated temperatures. These volatiles can condense on optics, sensors, or surfaces—leading to performance degradation or contamination. Typically, Nylon materials are known for adsorbing moisture and has relatively higher TML, therefore so-called "low-outgassing" grades also needs verification. Different lots of Nylon 66- even from the same manufacturer-can have different outgassing properties due to additive packages, processing residues or aging. Testing of Nylon 66 by a standard outgassing method like ASTM E595 is therefore essential to validate low-outgassing performance. The test can support process improvement (such as preconditioning or bakeout steps) for the manufacturer.

Sample Overview & Preparation

Two generic samples manufactured in separate batches Samples 1 and 2 were received cut/broken into pieces roughly 1-3 mm in size. For each sample, a portion of the pieces provided were randomly selected and placed in aluminum weigh boats. Roughly 100-300 mg of pieces were randomly selected for testing and were transferred into pre-weighed ultra-high vacuum aluminum test boats. Two empty boats were prepared as Blanks and one boat was prepared using a previously tested polyimide reference sample. The boats with samples were placed in a clean aluminum tray, which was then placed in a thermal humidity chamber to be pre-conditioned.



Pre-conditioning protocol:
- 23°C at 50% RH for 24 hours in a thermal humidity chamber
- Sample handling: Class 5 laminar flow cabinet with ULPA filter.

Test Conditions:
- Temperature: 125°C ± 1°C
- Vacuum: < 5×10^{-5} torr for 24 hours
- Collector Plates: Held at 25°C ± 1°C
- Test time: 24.0 hours

Fig. 2: Optical images of samples: (a): Sample 1 (b) Sample 2 (c) Sample 1 after precondition (d) Sample 2 after precondition

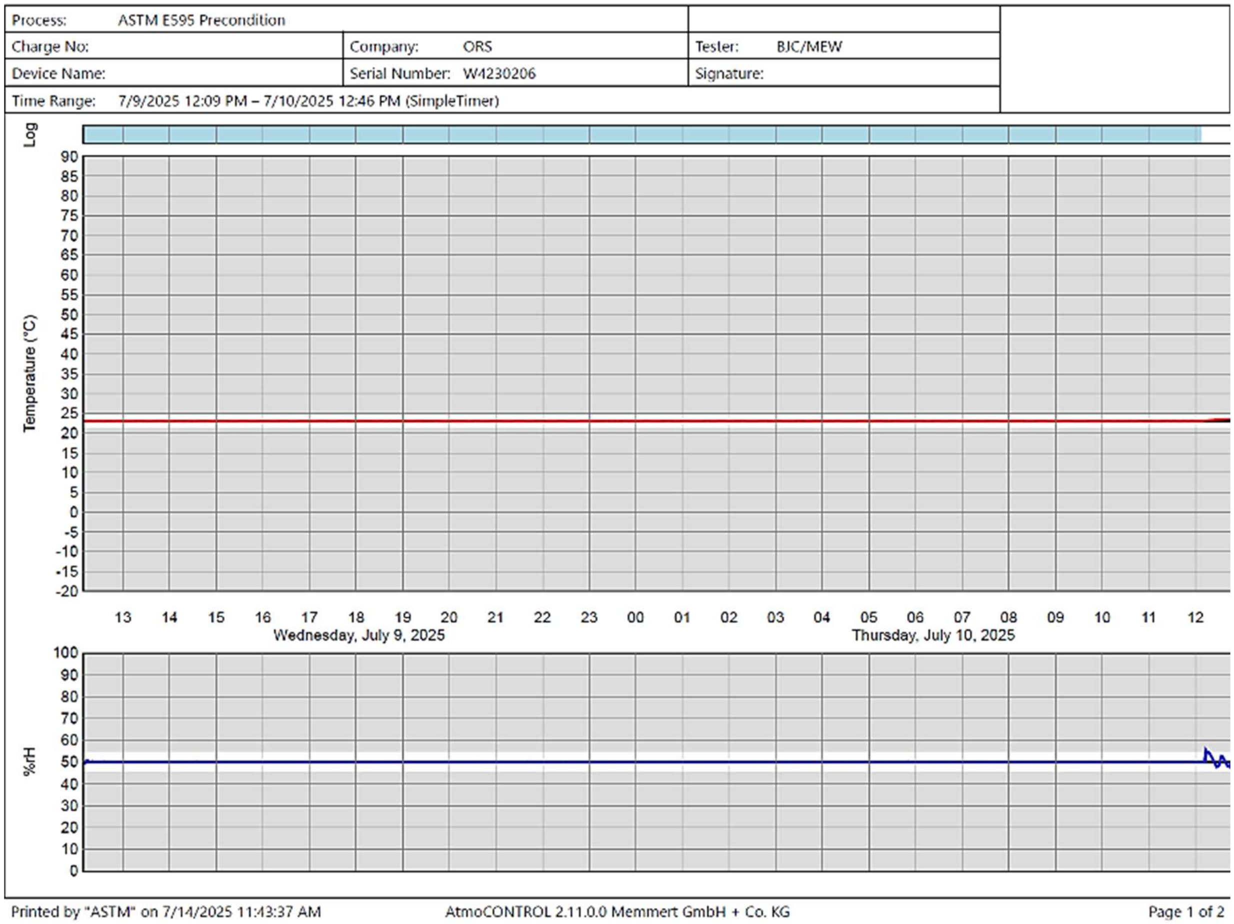


Fig. 3: Temperature and Humidity during preconditioning, indicating no anomalies.

Analytical Conditions

After pre-conditioning, samples with boats were weighed on a microbalance accurate to 1 µg and then placed in a vacuum environment at < 5×10^{-5} torr, and heated to 125°C (+/-1) for 24 hours. Samples were positioned opposite collector plates held at 25°C (+/-1). Analysis time began once all three variable setpoints had been reached. Test time was set for 24.0 hours. Charting and data recording features of the instrumentation and software indicated no significant anomalies during testing (Fig. 4).

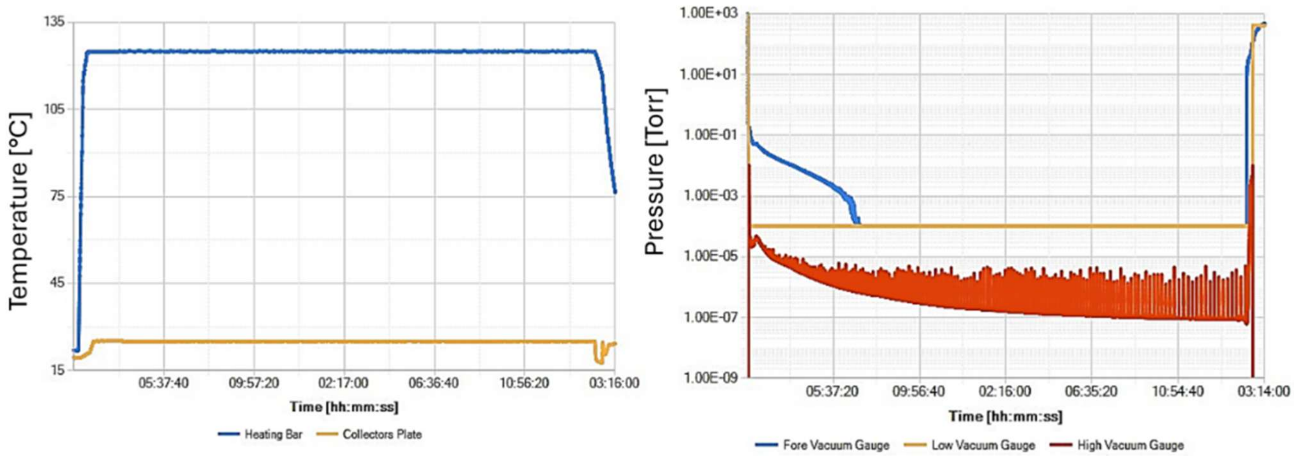


Fig. 4: Temperature and vacuum charts for sample heating bar and collector plates(left) and vacuum gauges (right) during testing. Intermittent spikes on high vacuum chart are electronic noise, all $<5\times10^{-5}$ torr.

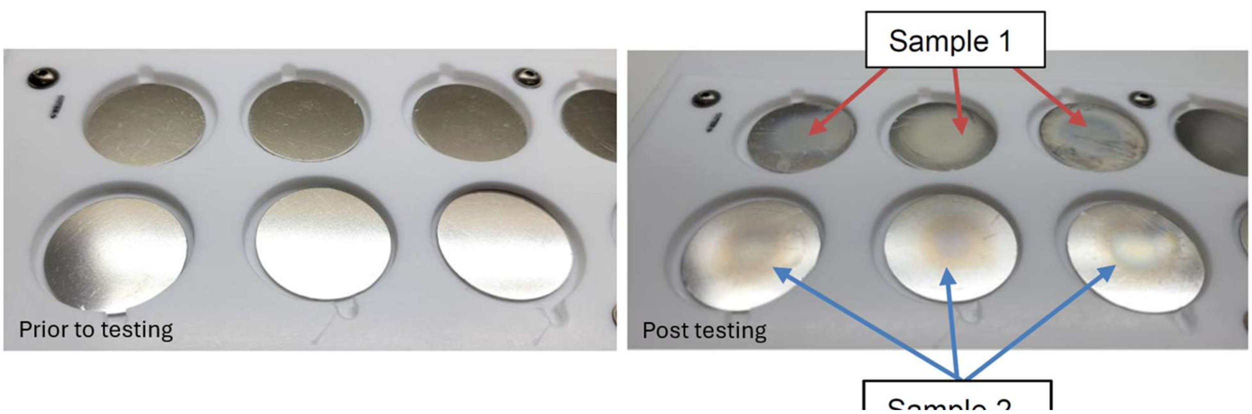


Fig. 5: Optical images of collector plates prior to and post testing. The deposition on the collector plates provides visual proof of outgassing occurred during the testing.

Results

Sample ID	Avg. TML (%)	TML Status	Avg. CVCM (%)	CVCM Status
Sample 1	1.76	❌ Fail	0.02	✅ Pass
Sample 2	1.43	❌ Fail	0.01	✅ Pass

ASTM E595 compliance thresholds: TML ≤ 1.0%, CVCM ≤ 0.1%

- CVCM results passed for both samples, indicating minimal condensation risks. However, as shown in Fig. 5, the condensation is clearly visible on the collector plates, which could cause problems on sensitive surfaces like lenses or optics.
- TML values exceeded the limit in both cases, signaling unacceptable bulk mass loss under thermal stress.
- Sample 1 showed slightly higher TML variability than Sample 2.

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ASTM E595 Job #(s) Case study

Tested By: BJC/MEW

Precondition Date/Time In: 7/9/25 @ 1209 Out: 7/10/25 @ 1210 Test Date/Time Start: 7/10/25 @ 1412 End: 7/11/25 @ 1415

Balance auto-cal Precond MEW Balance auto-cal Init MEW Chiller H2O check MEW Balance auto-cal Final MEW

Sample Cup	Sample ID	Collector Mass (i)	Collector Mass (f)	Cup Mass	Sample + Cup	Sample Mass	Final Mass (sample + Cup)	Δ Mass Sample	Δ Mass Collector
1	Sample 1-1	5.866790	5.866849	0.062456	0.348906	0.286450	0.343882	0.005024	0.000059
2	Sample 1-2	5.830589	5.830628	0.062172	0.355687	0.293515	0.350579	0.005108	0.000039
3	Sample 1-3	5.848152	5.848246	0.062758	0.359000	0.296242	0.353729	0.005271	0.000094
4	blank	5.836423	5.836415	0.062518	0.062521	0.000003	0.062519	0.000002	-0.000008
5	ref 6502	5.756956	5.757289	0.062119	0.346602	0.284483	0.345142	0.001460	0.000333
6	blank	5.780336	5.780330	0.062120	0.062124	0.000004	0.062123	0.000001	-0.000006
7	Sample 2-1	5.768387	5.768399	0.062203	0.347763	0.285560	0.343688	0.004075	0.000012
8	Sample 2-2	5.815883	5.815900	0.061664	0.350559	0.288895	0.346440	0.004119	0.000017
9	Sample 2-3	5.816346	5.816374	0.062129	0.344226	0.282097	0.340161	0.004065	0.000028

Sample Cup	Sample ID	TML (%)	AVG TML	CVCM (%)	AVG CVCM	TV (TML)	% Rec TML	TV(CVCM)	% Rec CVCM
1	Sample 1-1	1.75	1.76	0.02	0.02				
2	Sample 1-2	1.74		0.01					
3	Sample 1-3	1.78		0.03					
4	blank	<20 ug		<20 ug					
5	ref 6502	0.51		0.12		0.60	85.54%	0.15	78.04%
6	blank	<20 ug		<20 ug					
7	Sample 2-1	1.43	1.43	0.00	0.01				
8	Sample 2-2	1.43		0.01					
9	Sample 2-3	1.44		0.01					

Fig. 6: ASTM E595 test results for Sample 1 and Sample 2.

Conclusion

- Excess TML suggests risk of physical degradation or release of non-condensable volatiles.
- Applications like space-bound connectors or vacuum instrumentation may require alternative formulations.
- Consider Nylon variants or blends with lower TML profiles.
- Implement batch-specific qualification protocols for critical applications.
- Utilize the E595 test as part of design validation and risk mitigation.
- Optionally, explore materials with proven compliance such as polyimides or specialized thermoplastics.
- While the tested Nylon 66 materials show low condensable emissions (CVCM), their mass loss rates are not suitable for environments requiring full ASTM E595 compliance.

- Future development could include formulation modifications, additional bake-out steps, or material substitution.
- ORS reports include high resolution images of samples as received, after preconditioning, and after testing so clients can observe potential physical changes in their samples, and their associated collector plates, as well as whether samples meet standard “Pass/Fail” criteria.
- This is also a situation where additional “WVR” may be worthwhile, in order to determine how much of the TML was due to moisture, as many space applications already have a means to control moisture, which could lead to an end user determining that the “high” TML is acceptable for their needs.

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