TEKNOR APEX

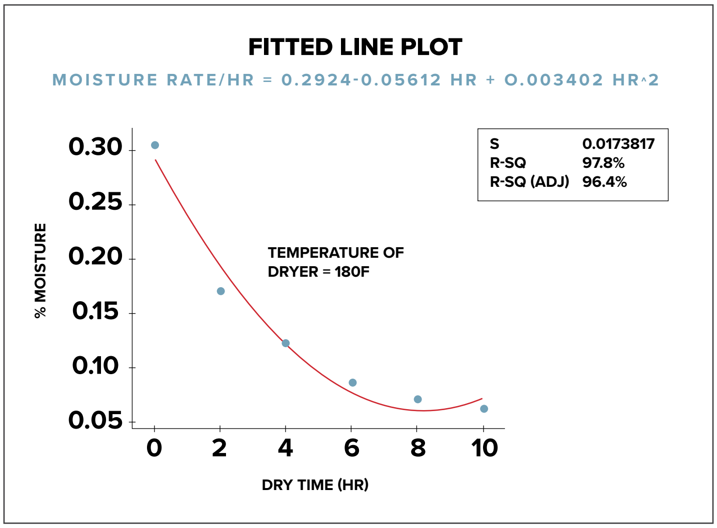
NYLON MOISTURE GUIDE

One of the leading causes of nylon processing issues and part defects is moisture — and it's often the most overlooked.

THE INTERRELATIONSHIP OF NYLON AND MOISTURE

Unlike most other polymers, nylon is extremely sensitive to moisture. Some moisture is needed, but too much is harmful. **EVERY NYLON MATERIAL HAS A UNIQUE RANGE OF MOISTURE LEVELS THAT ALLOWS FOR BEST PERFORMANCE. THIS "MOISTURE WINDOW" IS THE KEY TO OPTIMUM PROCESSING.**

Appropriate nylon moisture and dry time can be assessed in two ways. The first way is by creating a simple moisture graph, as illustrated to the right.



The second method is performing a Moisture Study Design of Experiments (DOE) to determine optimum dryer time and target moisture. More comprehensive and data driven than a moisture graph, the Moisture Study DOE is ideal for moisture management in nylon applications, especially when you work with an experienced custom compounder like Teknor Apex to leverage the DOE benefits.

We compiled this Nylon Moisture Guide to help you develop a deeper understanding of nylon moisture management and what tools and processes are best suited for obtaining consistent outcomes.

MOISTURE ANALYZERS: GRAVIMETRIC VS. MOISTURE SPECIFIC

THERE ARE TWO TYPES OF MOISTURE ANALYZERS AVAILABLE FOR DETERMINING THE AMOUNT OF MOISTURE PRESENT IN NYLON. To invest in the one that best serves your needs, it's important to understand the differences in the equipment:

GRAVIMETRIC MOISTURE ANALYZERS

- Measure the total change in weight of the material when a sample is heated at a specific temperature (loss by weight)
- Focus on moisture burn-off to calculate moisture presence, but do not take into account volatiles that burn off along with moisture
- May overestimate moisture values in a nylon resin, which could lead to over-drying

MOISTURE SPECIFIC ANALYZERS

(e.g., Karl Fischer and CompuTrac®)

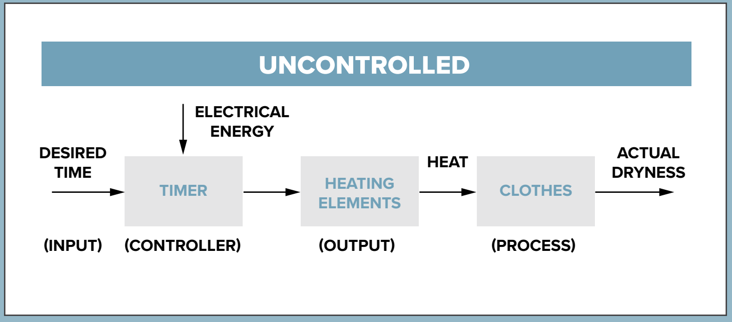
- Use a chemical process to specifically detect moisture levels, for highly accurate results that are not impacted by volatile burn-off
- Closely control testing temperatures and other variables to ensure precise calculations
- Align with ASTM D7191 compliance requirements

DRYER SYSTEMS: UNCONTROLLED VS. CONTROLLED

Dryers are instrumental in proper nylon moisture management and molding within correct moisture ranges. **THERE ARE TWO TYPES OF DRYER SYSTEMS, UNCONTROLLED AND CONTROLLED.**

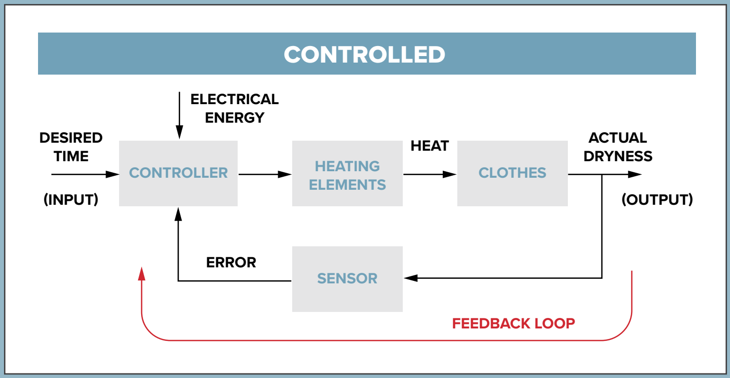
Understanding which system you have and working within its parameters influences nylon moldability.

UNCONTROLLED DRYER SYSTEMS (prior to 2006)



- Airflow, temperature, and time are all fixed
- No deviation in runs, and no allowance for input-output communication (i.e., old clothes dryer)
- Moisture study DOEs are required to create contour plots to follow prior to and during production, which could lead to inconsistencies and nylon over-drying

CONTROLLED DRYER SYSTEMS (circa 2006 and newer)



- Additive control systems automatically adjust airflow and temperature to achieve ideal drying temperatures
- Time is not fixed
- Continuous input-output feedback loop provides data before and during production to monitor moisture ranges for optimum nylon drying and moldability

CALCULATING DRYER/HOPPER SIZE

Determining proper dryer/hopper size is the first step in launching an application that uses nylon material. For accurate calculation and to achieve the ideal 4-5 hour residence time, three factors are needed:

- Part weight (runners and parts)/total shot weight
- Cycle time
- Bulk density conversion of dryer to materials, as follows:

$$\frac{\text{MATERIAL BULK DENSITY}}{\text{HOPPER BULK DENSITY}}$$

Formulaically, the data is used in this equation to calculate material throughput per hour:

$$\frac{\text{MATERIAL BULK DENSITY}}{\text{HOPPER BULK DENSITY}} \times \frac{\text{3600 SEC}}{\text{1 HOUR}} = \text{MATERIAL PROCESSING LBS/HR}$$

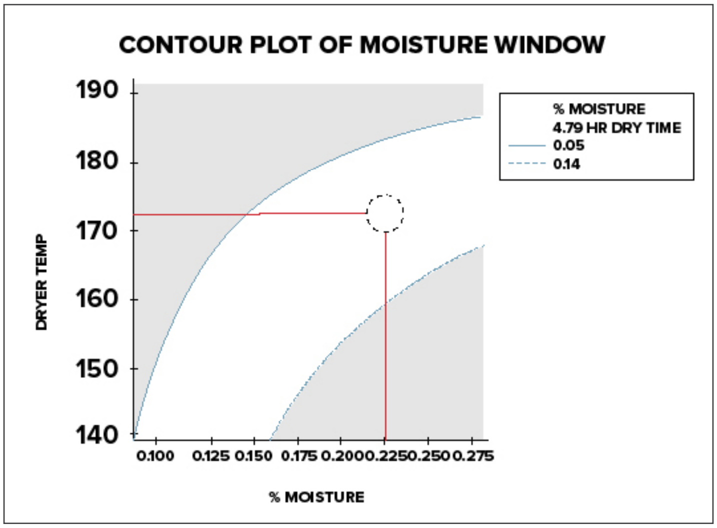
Once bulk density is converted and hourly throughput is found, dryer capacity is determined as follows:

(TARGET DRYING TIME) X (MATERIAL THROUGHPUT PER HOUR) X (BULK DENSITY CONVERSION)

This comprehensive information is insightful, but doesn't fully answer the questions of optimum dryer temperature and target moisture. To glean those values for certain uncontrolled dryer systems, a Moisture Study DOE is necessary.

MOISTURE STUDY DOE: DETERMINING OPTIMUM DRYER TEMPERATURE AND TARGET MOISTURE

For plants with uncontrolled dryer systems without over-dry protection or moisture manager, a Moisture Study DOE is invaluable. With it you can generate a contour plot of the moisture window to identify the ideal intersection of dryer temperature and moisture percentage, as illustrated to the right.



PREPARING FOR THE MOISTURE STUDY DOE

1. Verify use of correct dryer size and residence time for your application
2. Find actual dry time, meaning the amount of time it takes for the pellets to pass through the hopper (hopper size ÷ bulk density conversion ÷ material throughput/hour)
3. Identify the number of dryers for study to determine the number of required test repetitions (best dryer size for study 50-200 lb):

    1 dryer = 3 repetitions

    2 dryers = 2 repetitions

    3 dryers = 1 repetition

    4 dryers = 0 repetitions

4. Prepare samples, with size dependent on dryer size:

    2 samples around 0.3% moisture

    2 samples around .05% moisture

5. Prepare moisture analyzer. If using a loss by weight analyzer*, characterize nylon material prior to the study

*Loss by weight moisture analyzers are not recommended for this study

PERFORMING THE MOISTURE STUDY DOE

To perform the Moisture Study DOE, you will need:

- 1 to 4 dryers
- 4 material samples: 2 dry samples (around 0.08%) and 2 wet samples (around 0.28%)
- Verification of 2 specific dryer temperature set points: 140°F and 190°F

DOE FOR OPTIMAL DRYER TEMPS

STD ORDER	RUN ORDER	CENTER PT	BLOCKS	DRYER TEMP	MATERIAL MOISTURE
1	1	1	1	140	0.08
2	2	1	1	190	0.08
3	3	1	1	140	0.28
4	4	1	1	190	0.28

TIPS FOR MOLDING WITHIN THE MOISTURE WINDOW

UNCONTROLLED DRYER SYSTEMS

1. Perform Moisture Study DOE to create contour plots
2. Check moisture of nylon material 4-5 hours before start of production
3. Dry nylon material if needed (temperature depends on moisture contour plot)
4. Verify moisture of nylon material is within the mixture window before starting production
5. Use run data to detect increased moisture levels, and monitor peak injection pressure for any changes due to viscosity

CONTROLLED DRYER SYSTEMS

1. Check moisture of nylon material 4-5 hours before start of production
2. Dry material if needed at 180°F
3. Verify moisture of nylon material is within the moisture window before starting production
4. Check moisture every 2-4 hours during production to ensure moisture is within the moisture window
5. Use run data to detect increased moisture levels, and monitor peak injection pressure for any changes due to viscosity

WE ARE HERE TO HELP

Nylon is an extremely versatile material, but it can also present complications where moisture is concerned. An experienced custom compounder like Teknor Apex can help you leverage the benefits of nylon while avoiding hydrolysis and other moisture-related pitfalls.

CONSULT WITH OUR EXPERTS FOR GUIDANCE ON OPTIMIZING NYLON PROCESSING AND PERFORMANCE.

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