xylem

Technical guide

Relative viscosity of polyamides (PA) according to ASTM D789

System configuration and practical considerations

Relative viscosity according to ASTM D789 remains a critical quality parameter in polyamide production. Because it correlates with molecular weight, it directly influences processing behavior, mechanical performance, and product quality.

In production laboratories, the challenge is not calculating relative viscosity. The real challenge is obtaining consistent, reproducible results while handling aggressive solvents and concentrated polymer solutions under daily QC conditions.

This technical guide focuses on practical implementation of ASTM D789 in polyamide laboratories, highlights key differences compared to ISO 307, and outlines system design considerations that improve safety, reproducibility, and operational reliability.

.

SI Analytics
xylem

ASTM D789 compared to ISO 307

Although both standards use capillary viscometry, their scope differs. ASTM D789 determines relative viscosity using concentrated polymer solutions, while ISO 307 measures viscosity number using dilute solutions. This difference alone affects the sample preparation, cleaning procedure, and solvent handling. Furthermore, the two standards diverge in solvent selection: ASTM D789 primarily uses 90% formic acid, with m-cresol specified for certain polymer grades. ISO 307, on the other hand, permits a broader range of solvents — including 96% sulfuric acid, 90% formic acid, and/or m-cresol — depending on the polyamide type being tested.

Both standards refer to Ubbelohde type viscometers as the preferred geometry, and specify a measuring temperature of 25 °C with a constant temperature bath. The 90% formic acid is a common solvent in both standards, even if some users of ISO 307 prefer sulfuric acid. Because ASTM D789 works with concentrated solutions, cleaning and residue control are more demanding than in ISO 307 applications.

Practical challenges in ASTM D789 in laboratories

In routine quality control, the main sources of issues or uncertainties are:

1. **Sample Preparation**
   The accuracy of concentration is critical for the final result. In many cases, poor comparability between different laboratories stems from differences in sample preparation.

2. **Cleaning and Residue Control**
   If formic acid evaporates, dissolved polyamide can precipitate and adhere to capillaries, funnels or tubing. Incomplete cleaning leads to carryover and poor reproducibility.

3. **Safe handling of formic acid**
   90% formic acid is volatile and corrosive and must be handled in a hood. Closed liquid handling and effective exhaust are required.

4. **System Reliability**
   Quality control environments require continuous operation. Downtime caused by blocked tubing, corroded components, or pump failure directly impacts production.

System configuration for reliable ASTM D789 testing with SI Analytics® brand viscosity systems

Xylem Analytics offers two automated glass capillary viscometry solutions perfect for reliable ASTM D789 testing, the AVS® 370 and the AVS® Pro III. These systems were developed specifically to address the critical requirements of polymer viscometry testing in production laboratories. Both systems contain a multi-position measuring controller for parallel measurements up to 4 positions, using optoelectronic flow time detection, transparent thermostat bath and cooler, and a waste and cleaning system.

The waste system can differ depending on individual needs. The difference between the two systems lies in sample handling: The AVS® 370 uses manual filling while the AVS® Pro III includes an autosampler for fully automated measurement sequences.

AVS® III - autosampling system

AVS® 370 - manual filling

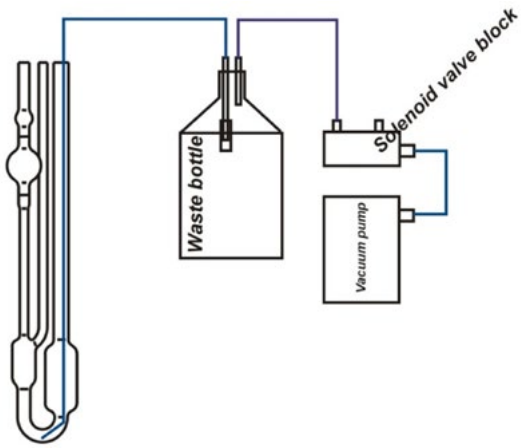


Figure (1). Waste system in AVS® systems

Controlled and safe liquid handling

When working with 90% formic acid and concentrated polyamide solutions, the liquid path must remain closed and always controlled. The system design should prevent solvents from escaping in the event of leakage.

In AVS® systems, waste transport is based on vacuum rather than pressure.

Figure 1 shows the principle. A vacuum pump creates low pressure inside the waste bottle. This pressure difference draws liquid from the viscometer into the waste container.

This design offers two practical advantages:

1. **Leak safety**
   If a tube connection between the viscometer and the waste bottle becomes loose or damaged, air enters the system instead of liquid escaping. Since the waste line operates under reduced pressure, solvent cannot be pushed out of the system.

2. **No solvent-contacting waste pump or valve**
   Formic acid is corrosive, and concentrated polymer solutions can precipitate if solvent evaporates. In pressure-driven systems, pumps and valves in contact with the liquid are exposed to chemical attack and blockage.

   In the AVS® configuration, the solenoid valve does not come into contact with the sample liquid, only with vapor. This reduces the risk of corrosion, clogging, and maintenance-related downtime.

   This vacuum-based concept improves operational safety and long-term reliability when working with aggressive solvents and concentrated polymer solutions.

Precision and reproducibility: The importance of cleaning

In ASTM D789 testing, the viscometry measurement itself is highly stable. Modern temperature control systems provide consistent bath conditions at 25.0 °C, and optoelectronic flow time detection ensures precise timing.

Therefore, in routine practice, the relative viscosity measurement itself is very robust and accurate. The largest contributions to the total measurement uncertainty come from:

- Sample preparation
- Incomplete cleaning between samples

In this guide, we focus on the cleaning to keep it concise. Since ASTM D789 uses **concentrated** polymer solutions in 90% formic acid, cleaning is particularly critical. If solvent evaporates, dissolved polyamide can precipitate and adhere to capillaries, funnels, or tubing. Even small residues can affect reproducibility.

Cleaning Approaches

Two basic strategies are used:

Solvent rinsing
The system is rinsed with a suitable solvent to remove any residues. If the solvent is not sufficiently volatile, a second, more volatile solvent should be used to ensure complete drying. Any remaining traces may affect subsequent measurements. Before refilling, the viscometer and filling system must be completely clean and dry.

Rinsing with the next sample
This method is faster and avoids drying steps. However, it is only suitable when consecutive samples are similar in chemistry and viscosity. With concentrated PA solutions, this method alone is often not sufficient.

Recommended practice for ASTM D789
Because concentrated polyamide solutions can precipitate quickly, solvent rinsing is typically required.

AVS® 370 (manual filling)
A two-step solvent rinse is recommended:

1. Formic acid to dissolve polymer residues
2. Acetone to displace formic acid and allow rapid drying

This approach is particularly important in open filling systems where evaporation can occur.

AVS® Pro III (automatic filling)
In closed dosing systems, complete solvent drying increases cycle time. For this reason, a combined strategy is preferred: Formic acid rinse, followed by sample rinsing steps. This balances both cleaning effectiveness and sample through-put.

System Advantage

AVS® systems allow flexible configuration of rinsing and drying procedures depending on workflow requirements. The design minimizes residue risk, e.g. in connection hoses, while maintaining reproducibility and efficient cycle times.

System robustness

ASTM D789 testing is typically performed in production laboratories where reliability is critical. Systems must operate continuously while handling corrosive solvents and concentrated polymer solutions.
AVS® systems are designed to meet these operational demands.

Chemically Resistant Construction

All components exposed to solvent or sample are selected for long-term chemical resistance.

- Borosilicate glass viscometers
- PTFE and FEP tubing for wetted parts
- PPS screw connections
- Stainless steel or Hastelloy in critical metal components
- Chemically resistant structural materials such as PVDF and PPA

This material selection reduces corrosion risk and extends service life when working with 90% formic acid and concentrated polyamide solutions.

No Solvent-Contacting Pumps

As described earlier, AVS® systems avoid pumps and valves in direct contact with hazardous liquids wherever possible. Waste transport is vacuum-based, and dosing is performed using chemically resistant burette systems.

This reduces:

- Mechanical wear from aggressive solvents
- Risk of pump blockage due to polymer precipitation
- Maintenance requirements

Modular Service Concept

Downtime in quality control impacts production. For that reason, AVS® systems follow a modular design. Key components, such as the ViscoPump controller or measuring stands, can be exchanged individually. If a spare or loan unit is available, the system can remain operational while the defective module is serviced.
This approach minimizes interruption and supports continuous QC operation.

Conclusions

ASTM D789 testing of polyamides requires more than accurate flow time measurement. The method uses concentrated polymer solutions in aggressive solvents, making system design critical to reproducibility, safety, and long-term reliability. Critical success factors include:

- Stable temperature control
- Accurate and reproducible sample concentration
- Effective and consistent cleaning procedures
- Controlled handling of 90% formic acid
- Chemically resistant components
- Minimal downtime in QC environments

Automated AVS® systems are engineered to address these practical requirements. The combination of vacuum-based waste handling, solvent-resistant materials, flexible rinsing strategies, and modular serviceability supports reliable ASTM D789 operation in demanding production laboratories.

For polyamide manufacturers, this translates into reproducible results, safe solvent handling, and stable long-term performance in daily quality control.

This content was created together with:
Xylem Analytics Germany Sales GmbH & Co. KG, SI Analytics
TechInfo.XAGS@xylem.com
Erich-Dombrowski-Straße 4
D-55127 Mainz
Germany

For more information: xylemanalytics.com/en/products/viscometry

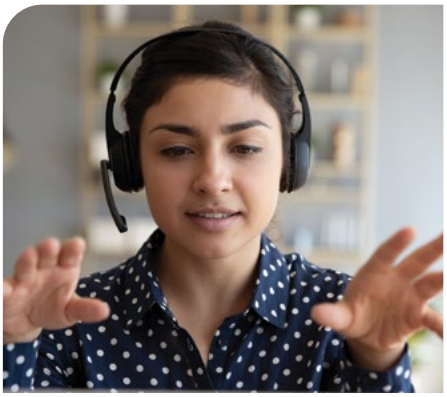
Xylem |'zīləm|

1) the tissue in plants that brings water and nutrients upward from the roots.
2) a leading provider of unique solutions for your lab.

Xylem Lab Solutions' global brands have been leaders in the laboratory instrumentation market for decades, and are relied upon every day across more than 150 countries. Working in true partnership with our clients, we listen, learn and adapt to individual needs, offering deep application expertise built upon our long history of innovation in instruments and services. Our solutions for analysis, measurement and monitoring help enable many of today's modern laboratories and industrial processes, and provide our customers the trusted and high performing solutions they need to succeed.

Our support goes beyond instrumentation

We have all the consumables and supplies and we also offer in-house and in-field technical support to keep you up and running. Reach out to your local sales person to see what products are available in your region.



Technical support

We are here to get your products up and running. It may be a phone call to our tech support team or an on-site visit for installation and familiarization.

Consumable & spares

We offer a full compliment of operating supplies and spares. A well-maintained instrument will deliver the best results. Our eCommerce is set up to help you get what you need quickly.

Calibration & Service

Now that your unit is up and running and generating superior data, we are here to help you keep it that way. We offer certified calibration services and repair support globally.

SI Analytics
xylem

Xylem Analytics Germany Sales GmbH & Co.
Am Achalaich 11
82362 Weilheim
Germany

Phone: +49 881 183-0
Fax: +49 881 183-420
Info.XAGS@xylem.com
www.xylemanalytics.com

xylem