iNOEX

INSPIRE BEYOND MEASUREMENT

PVC
PROCESSING & AUTOMATION

Your guide to quality control, material efficiency and automation in PVC extrusion

- Critical quality parameters and process control in PVC extrusion
- Automated dosing and control for material and cost optimization

An Overview

Reliable processing and automation solutions that are tailored for the individual PVC extrusion application

CHALLENGES

- » Increasing and fluctuating raw material prices
- » Sustainability goals and challenges
- » Poorly flowable materials that are subject to bulk density variations
- » Shortage of skilled labour reduces process knowledge in production operations
- » Digitalisation of the production environment

In todays PVC extrusion, manufacturing companies are facing a variety of challenges which can be classified in global, material specific and process specific areas. Each PVC extrusion application, no matter if pipe, tube, profile or cable, requires a specific automation and processing solution which decides about the success and the competitiveness of a PVC extrusion company.

The fundamental requirement to provide solutions for these challenges requires a deep and long-term process know-how. With over 40 years experience in automation of extrusion processes, iNOEX can offer tailored solutions for the specific PVC application. By combining different technologies and solutions, like gravimetric and wall thickness measurement systems, the challenges of processing PVC can be reliably met and the production process can be optimized in terms of quality and material savings. In addition to the iNOEX portfolio of various automation solutions, strong partnerships with other PVC processing experts have been built to be the solution provider in the plastics industry.

This white paper deals with the challenges of processing PVC in different extrusion applications and provides an overview of suitable automation solutions. The following topics will be highlighted in detail:

- ***Which challenges occure when handling PVC in extrusion applications***
- ***At which points in the processing of PVC iNOEX solutions can help to optimize the process***
- ***For which PVC applications iNOEX solutions can be used***
- ***Which automation solution is most beneficial and suitable for each application***
- ***Examples where iNOEX solutions are already used successfully today***

Polyvinyl Chloride

The versatile raw material

Polyvinyl chloride (PVC) is a versatile and durable material which is used across numerous applications. In infrastructure, PVC pipes are widely used for drinking water transportation. Pipes made of PVC are also commonly used in sewer and drainage systems, where post-consumer PVC recyclate can be included in the middle layer of three-layer sewer pipes, contributing to a circular economy. Underground PVC pipes are well-known for their durability, as studies show a lifetime of buried PVC pipes exceeding 100 years. PVC pipes exhibit the lowest break rates compared to non-plastic materials, making them ideal for long-term installations with minimal maintenance. Additionally, PVC pipes offer the lowest total cost of ownership, making them an economical choice for both urban and rural infrastructure projects.

The rigidity, weather resistance and insulating properties make PVC ideal for efficient and long-lasting installations in construction profiles, such as window profiles and WPC applications (e.g. decking or wall panelling). PVC profiles contribute to energy-efficient building designs and require low-maintenance, making them a preferred choice for sustainable construction.

PVC's durability and flexibility makes it also suitable for electrical cable insulation. It protects cables from environmental factors, ensures safety, and has a high flame resistance.

Beyond the use of pipes, profiles and cables in industrial applications, PVC is also used in medical applications, where it is one of the most trusted materials for products like blood bags, tubing, catheters, oxygen masks and others.

A standout feature of PVC is its recyclability. PVC can be recycled several times without losing its core functional properties, which supports environmental goals and reduces waste. This recyclability is critical as it helps saving resources and aligns with sustainable production practices.

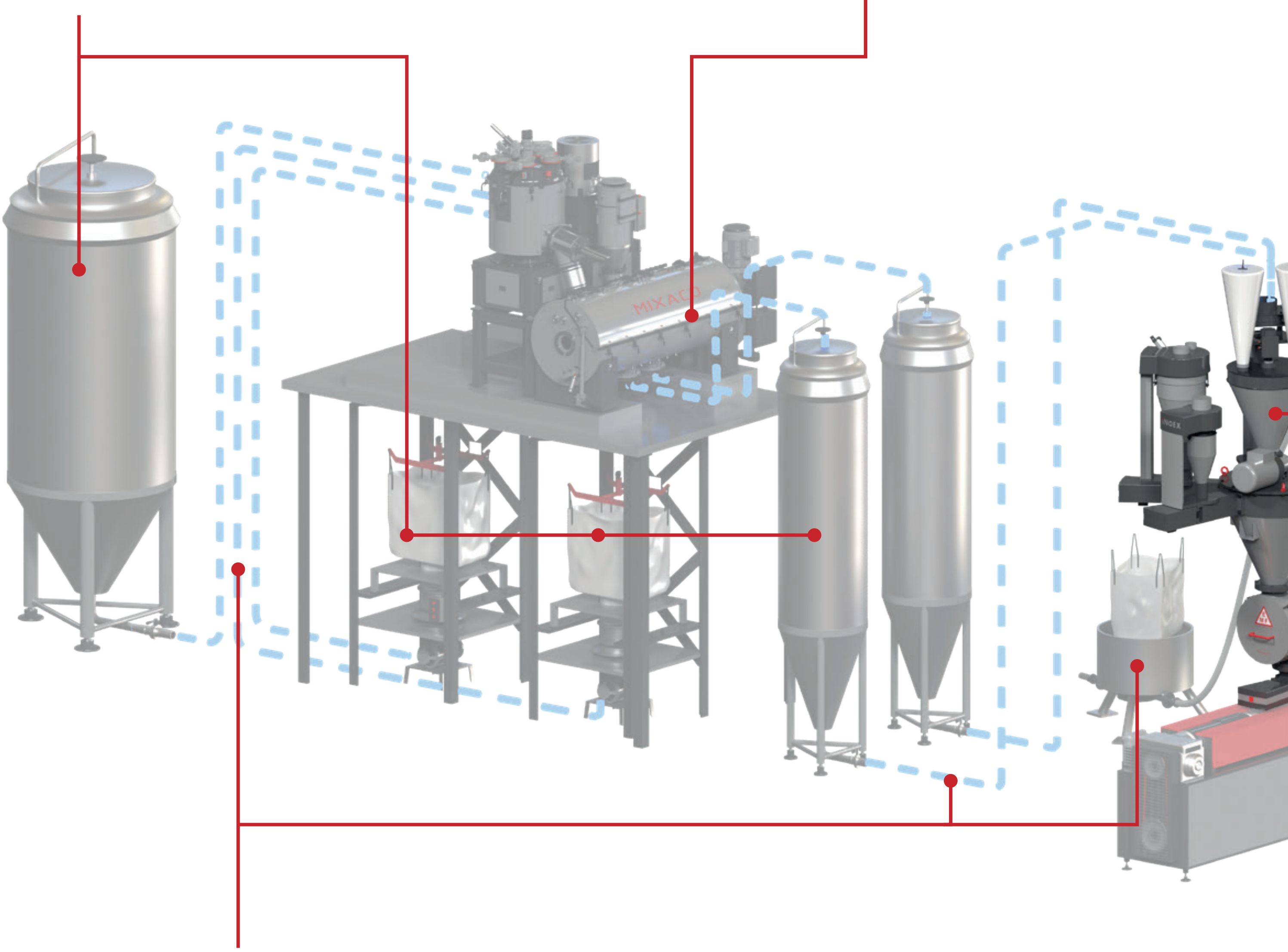
Another advantage is PVC's readiness for new energy applications, such as hydrogen distribution. Its chemical stability and durability makes it a promising material for future hydrogen distribution networks, supporting the transition to cleaner energy solutions.

Overall, PVC is used in various applications from pipes, profiles, medical and cables to evolving uses in the energy sector. The unique combination of safety, longevity, recyclability, and cost-effectiveness makes PVC a valuable resource for present and future infrastructure and industrial needs.

Processing PVC in extrusion

Storage
PVC resin is stored in silos, while fillers are kept either in silos or big bags. Additives are stored in big bags or sacks. The resulting dry blends are held in intermediate or day silos until further processing.

Mixing
All ingredients are weighed and mixed into a dry blend in the heating/cooling mixer (e.g. MIXACO).



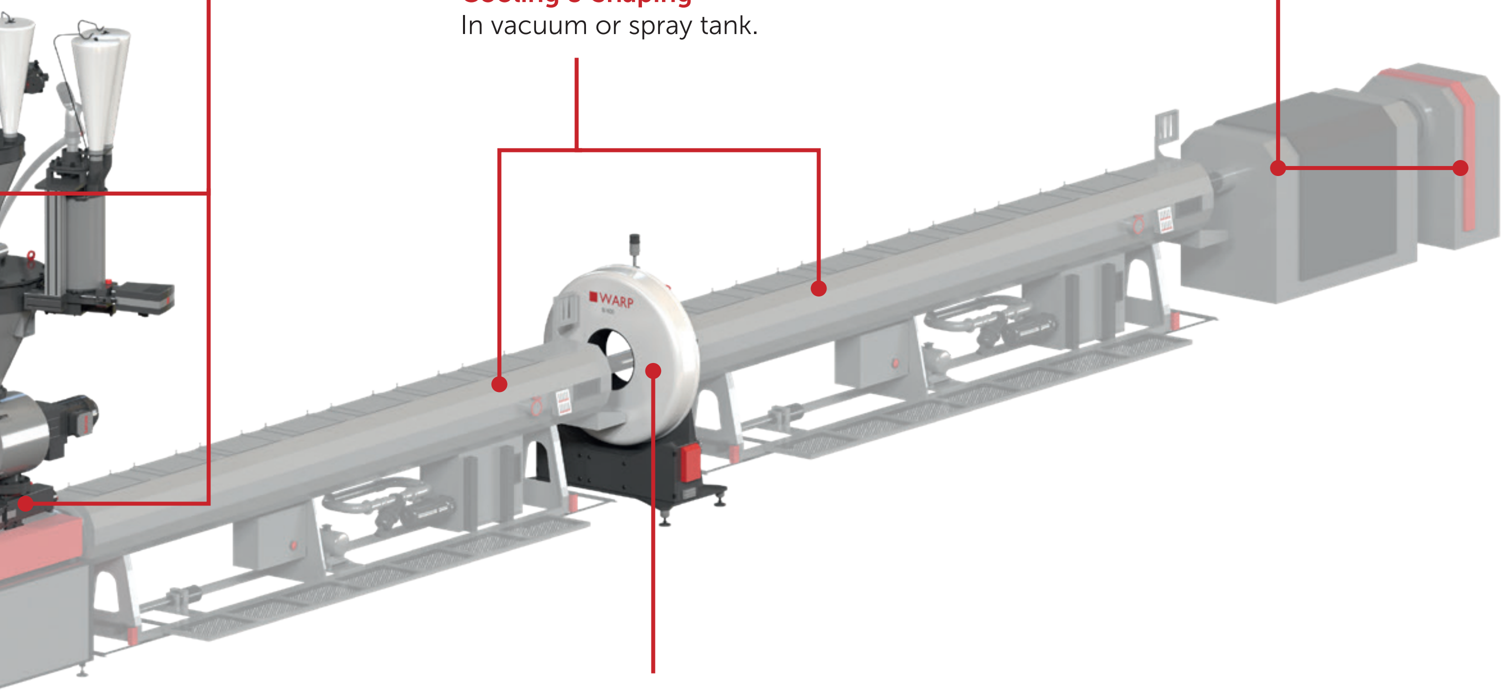
Conveying
All ingredients are first weighed and transferred to the heating/cooling mixer. The resulting dry blend is then conveyed to intermediate or day silos. From there, it is fed—along with all side components—pneumatically or via spiral feeders to the SAVEOMAT dosing station or mono weigher. In specific applications, such as 3-layer sewage pipes, additional filler can be added directly at the dosing station from big bags via spiral feeders.

The processing of PVC consists of several stages and may differ in small variations. The following scheme of a PVC pipe extrusion line with the prior processing of PVC and other raw materials contains the crucial components and should give a general overview of the main steps.

Dosing
All ingredients are dosed as defined in the recipe into the extruder throat. The recipe can be set individually and changed on the fly. The main component (central hopper) is the dedicated PVC Dry Blend hopper, the side components can be used for fillers, additives and recycled material. A mono weigher may also be used for single component applications. The final mixture is dosed with a constant throughput by a horizontal feeder (i.e. by twin screws) into the extruder.

Haul-Off & Saw

Cooling & Shaping
In vacuum or spray tank.



Measurement
Dimensional measurement by WARP, AUREX or iXRAY for further automation options and quality inspection in pipe/tube extrusion. The interplay of gravimetry, wall thickness measurement systems and control technology is key to increasing productivity, significantly reducing costs and at the same time ensure the highest quality.

Dynamic mixer kindly provided by EMF B.V.

Focus on key elements

Storage

The PVC resin, fillers and additives are usually delivered by trucks to the customer site. Whereas the PVC resin is stored in big silos, fillers and additives are usually handled in big bags or sacks due to the smaller required amount. When big amounts of fillers are processed, the fillers are optionally also stored in big silos. After the mixing of all components in the heating/cooling mixer, the Dry Blend is stored in intermediate silos to have a certain stock amount of ready Dry Blend. A stock amount for 1-2 days production may be available. In case different Dry Blend recipes are required for multiple applications, the Dry Blends can be stored in individual intermediate silos and be conveyed to the specific extrusion lines when needed.

Dry Blend mixing

To create a homogenous blend, all components are weighed and fed in the desired amount in the heating/cooling mixer. Industry leaders like Mixaco offer tailored solutions for the specific requirements of the producer. In the heating mixer the materials are heated up to temperatures of 110-120 °C so that the additives melt and stick together with the filler to the porous PVC resin particles. Afterwards the mixture falls by gravity into the cooling mixer, where it is cooled down to a temperature of ~40 °C to create a stable Dry Blend. During both stages, the materials are evenly mixed to get a homogenous blend.

The amount, number and type of additives and fillers in the Dry Blend depend on the specific application, the PVC type and the desired properties of the end product. In PVC extrusion, additives are mainly added for two reasons: To enable and improve the processing of PVC, i.e. stabilizers or lubricants, or to influence the mechanical and optical properties of the end product, i.g. plasticizers, fillers, flame retardants, blowing agents or pigments. Other reasons for adding fillers are related to reducing material costs and the overall CO_2 footprint.

When using high amounts of fillers in the heating/cooling mixer, it must be considered that high filler amounts can have a negative influence on the lifetime of the mixer. Therefore it is recommendable to mix the Dry Blend with a considerably small amount of filler and, if required, add further amounts of filler directly at the extrusion line with the SAVEOMAT system. This approach is not only beneficial for the lifetime of the heating/cooling mixer but gives the operator the flexibility to change the recipe and the amount of filler anytime on the fly.

Conveying

The different raw materials and also the Dry Blend are usually pneumatically conveyed throughout the processing. Optionally spiral feeders are used. For the conveying it is recommendable to keep the amount of fillers as low as possible in the Dry Blend and add further filler amounts with the SAVEOMAT system directly at the extrusion line. For this the filler is fed by a spiral feeder from a big back or intermediate hopper standing close to the extrusion line into the SAVEOMAT system.

Similar like for the heating/cooling mixer, high filler amounts can cause higher wear to the parts of the conveying system. Another important effect is segregation. During the conveying of the Dry Blend, high filler amounts can lead to segregation between the PVC and filler particles. The starting point of segregation is depending on various factors and can vary to a certain degree but can be considerably noted with filler amounts >20 PHR. Segregation can have a negative effect on the extrusion process and thus the end product's mechanical and optical properties and must therefore be prevented.

SAVEOMAT – The robust and hig

Raw materials for extrusion applications are available in different types and shapes, such as: granules, powder, regrind, chips, grist, flakes and others. All plastic raw materials have in common, that they are subject to bulk density variations which can lead to an unstable production process and a varying product quality.

Depending on the material type, the conformity of the particle shape and the flow behavior, the degree of bulk density variations can vary from material to material. The bulk density variations of virgin granules are usually smaller compared to recycled material, which can have a highly varying particle shape and size. When it comes to PVC extrusion applications, mostly powder or pulverized materials are processed in twin screw extruders. An exception is the extrusion of PVC cables, where raw materials including the PVC resin are granulated first and then processed in single screw extruders. The single raw materials and the Dry-Blend mixture often show a quite poor flowability. This challenge can not only be encountered in the processing of the raw materials during storage, transport and the mixing of the raw materials to form a Dry Blend, but also during the dosing of the materials into the extruder. Especially at the dosing of the materials the poor flowability and the bulk density variations can lead to negative effects on the production quality during the extrusion process.

Considering the different flow behaviors of the mentioned raw materials, different designs of weighing hoppers, neck pieces and dosing units are required to ensure a steady flow of all materials. Additionally environmental factors like temperature or humidity can have a negative influence on the processability of the raw materials.

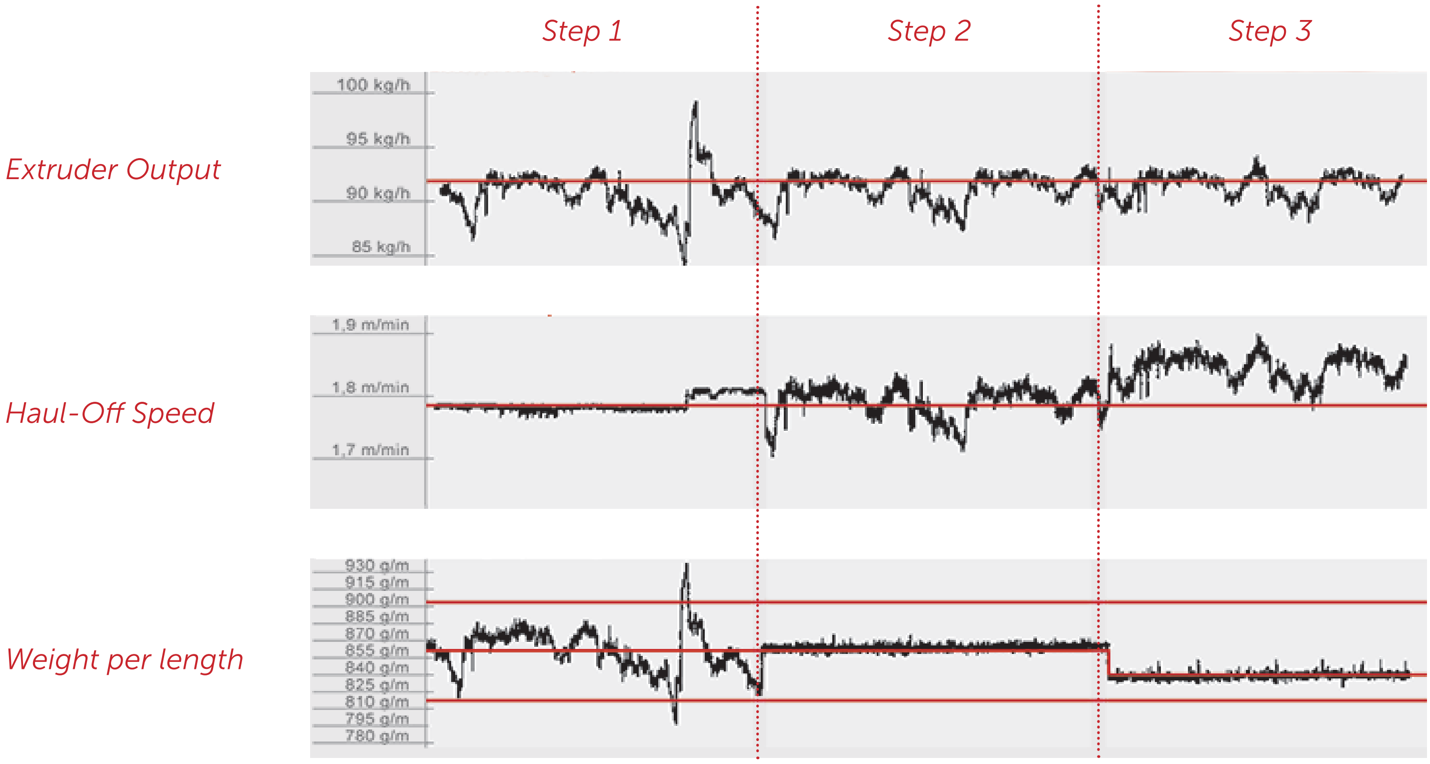
The solution for the described challenges is iNOEX gravimetric system SAVEOMAT.

The material dosed by each component is weighed individually using high-resolution load cells before it is dosed into the extruder. In that way bulk density variations are recorded and compensated by automatic controls of the dosing screw, the extruder or the haul-off, so that a constant mass throughput and/or weight per meter can be set. This can be achieved for mono layer products just like for co-extruded products with a high number of different components and layers. Special hopper geometries ensures an even flow of the materials. Agitators inside the neck piece and the hoppers can be used for components with a very poor flowability, like pure $CaCO_3$ or high filler Dry Blends.

GRAVIMETRIC EXPLANATORY VIDEO

ROBUST AND HIGH-END DOSING SOLUTION

High-end gravimetric dosing solution



The working principle of the SAVEOMAT can be underlined by the following case study, which was performed on a PVC profile extrusion line with a SAVEOMAT mono weigher for PVC Dry Blend.

In *step 1* of the study, the production line was operated manually while the SAVEOMAT system was recording the extruder output, haul-off speed and weight per meter. The haul-off speed was kept constant, while it could already be seen that due to the bulk density variations of the material, the uncontrolled process was subject to a varying mass throughput and varying weight per meter. At the second part of stage 1, the operator noted a decreasing weight per meter and therefore corrected the haul-off speed. Unfortunately the line speed was increased by the operator, so that the weight per meter was reduced even more and thus violating the minimum tolerance. When the operator noted this error, he increased the extruder RPM, so that the mass throughput and the weight per meter increased above the upper tolerance. These recordings illustrate, how incorrect operator adjustments can have a negative influence on the process quality.

In *step 2* of the case study, the SAVEOMAT automatic mode was activated. For this extrusion line a weight per meter control was used by adjusting the haul-off speed. The SAVEOMAT was recording the mass throughput variations, which were caused by bulk density variations of the raw material. By adjusting the haul-off speed accordingly to the variations, the weight per meter could now be kept constant within the set product specifications.

Now that the process was running stable, a lower weight per meter was set in the recipe so that the haul-off speed was increased even more by the SAVEOMAT, resulting in a further decrease of the weight per meter while maintaining the product specifications (*step 3*). At the end a stable process with material savings could be seen.

New SAVEOMAT P+ hopper

The solution for dosing PVC Dry Blends

Looking at the various applications in which PVC is used, it becomes clear that individual Dry-Blend recipes are required to ensure that all requirements can be met by the end product. The Dry Blends can differ in the type and amount of additives to ensure a proper function or processing of the material, but also in the amount of fillers. This variety of different recipes requires a flexible and robust dosing solution, which can be adapted to the individual customer requirements. To meet these challenges and ensure a reliable dosing, iNOEX has developed a new hopper series especially dedicated for PVC Dry Blends: **The new P+ hopper.**

The SAVEOMAT P+ scale adapts to the diverse requirements of different recipes and can be used for dosing a wide variety of dry mix compositions:

- Standard version with a large hopper and high-angle hopper sides, with a large inlet of 150 mm diameter and a 120 mm outlet for dry mixes with good to medium flow (i.e., with smaller fill volumes)
- The option of expanding the hopper with a dynamic agitator for dosing poorly flowing dry mixes with high fill volumes.

The P+ hopper without the dynamic agitator is especially suitable for low filler Dry-Blends, such as used for PVC pressure pipes. For all other applications with poorly flowable Dry Blends, the hopper can be equipped with a dynamic agitator which keeps the material in motion inside the hopper and ensures a steady flow. A dynamic adaptation of the agitator RPM to the current mass throughput supports the prevention of bridging inside the hopper. To stay flexible for future changes in PVC Dry-Blend formulations, the agitator can also be retrofitted at a later stage easily, since the hopper has been designed for maximum flexibility.

Since the weighing cells are positioned below the hopper, the hopper is completely dust-proof sealed without the need of filter cloths. Two hopper sizes for mass throughputs of up to 1,000 kg/h or 1,600 kg/h are available. As all other iNOEX hopper types, the P+ hopper can be used in different setups: as a mono weigher on a horizontal dosing unit for mono component applications or as a main or side component in a dosing station when dosing multiple material components.

With the new P+ hopper iNOEX is strengthening its PVC product portfolio and makes sure, that customers have a reliable and flexible dosing solution which can be adapted to changing PVC Dry-Blend recipes when needed.

SAVEOMAT G AND P

SAVEOMAT G and P

*Dosing of additives
and recycled material*

Apart from dosing the PVC Dry-Blend, a recipe may also require additional dosing units for the exact and precise dosing of additional components in granule or powder type. If recycled material should be re-fed into the process, this inhomogeneous material may also be dosed as a side component in a dosing station.

In PVC extrusion, the following additives or side components may be dosed additionally:

- Recycled/reworked material
- Stabilizers
- Lubricants
- Foaming agents
- Color masterbatch
- Fillers like $CaCO_3$
  (dosed with HF hopper, see pg. 12)
- Plasticizers
- Processing aids
- Modifiers

Being suitable for all different kinds of granules, the **SAVEOMAT G** hopper has the optimal geometry for a perfect flow behavior of granule raw material. The hopper has a transparent weigher outlet for a visual flow control and is designed to ensure a dead zone free filling and accurate weighing of the material. The hopper size can be selected according to the required mass throughput range.

For pourable powder components, materials which tend to create a lot of dust or also recycled material, the **SAVEOMAT P** hopper can be used. This hopper type has filter cloths to ensure that material dust is not polluting the environment. Additional special features, like a separating plate inside the hopper, supports an improved flow of the material throughout the hopper. Especially for the rising demand of dosing recycled material, a precise and steady dosing becomes crucial. Recycled material tends to have high bulk density variations since the particle size distribution is quite uneven compared to virgin raw material. This can lead to a fluctuating throughput when such variations are not measured and compensated. A fluctuating throughput is directly linked to an unstable production process and thus also to an unstable product quality. To master the rising demand of introducing recycled material, the use of a SAVEOMAT system is a must-have to maintain the highest product quality. In many PVC applications, bigger recycled material amounts are especially fed into the middle layers of co-extruded products, i.e. in the middle layers of window profiles or sewage pipes.

For this big variety of possible side components, iNOEX can select from a variety of different dosing units like dosing screws, spirals or also twin screws and thus select the most suitable dosing unit for the specific material type.

SAVEOMAT HF hopper

Dosing of pure calcium carbonate

For the direct dosing of 100 % $CaCO_3$, a special design of the dosing hopper is required to ensure a consistent material flow. The **SAVEOMAT HF** hopper combines several special design elements to face the very poor flowability and the special material fluctuations of $CaCO_3$. The hopper is executed as a cylinder, which minimizes the risk of laying material deposits on the hopper surface. To prevent material blockages, an agitator inside the hopper is constantly keeping the material in motion and routing the material into the filling entry of the dosing unit. The dosing unit is equipped with a twin screw.

A further highlight of the HF hopper is the special measuring and control software, which is especially developed for the characteristics of $CaCO_3$. Since the hopper is executed as a cylinder and the material has a high bulk density, the weight of the material inside the hopper is causing a fluctuating infeed behavior of the material into the dosing unit. A higher material level inside the hopper causes a higher pressure, so that the material feed rate increases. When the material level inside the hopper decreases, the pressure of the material column also decreases so that the feed rate is decreasing. To compensate this effect, the HF hopper has a very dynamic measurement and control algorithm, which ensures a constant throughput even for materials like $CaCO_3$.

The HF hopper is prepared for a filling via a supply hopper by using a valve or also for a direct feeding of the hopper (i.e. with a spiral feeder). Since most of the $CaCO_3$ types have a quite poor flowability, the hopper is usually filled directly without a valve or supply hopper. In this setup the HF hopper is actuating the spiral feeder whenever the re-filling process should be started and also stopping the process when the hopper is sufficiently filled.

Maximizing flexibility

SAVEOMAT PVC
dosing station

Dosing pure $CaCO_3$ directly above the extruder with the SAVEOMAT can have several advantages. High filler amounts in the Dry Blend can have a negative influence on the wear of the heating/cooling mixer and the conveying system. By adding pure $CaCO_3$ on each extrusion line, the producer can mix a basic PVC Dry Blend in the heating/cooling mixer with a relatively low filler amount, which can be used for all extrusion lines. Depending on the end product application, the producer can addition-ally dose further amounts of required additives, recycled material but also fillers like $CaCO_3$ with the SAVEOMAT PVC dosing station directly at the extrusion line. In that way the highest degree of flexibility can be achieved. The increase of the filler amount for cost reduction may also be an important advantage when considering a dosing of pure $CaCO_3$.

The iNOEX PVC dosing station consists of different components out of the iNOEX portfolio. For those components, which are not available in the iNOEX portfolio, strong partnerships with other PVC experts have been established to ensure a full solution with all required components.

The main hopper of the dosing station, which can be found in the center of the station, is executed with the new SAVEOMAT P+ hopper and takes care of dosing the PVC Dry Blend. With the option to equip the hopper with an agitator, also high filled Dry Blend formulations can be dosed. Other side components like additives or recycled material are fed into the neck piece with standard SAVEOMAT G and P hoppers. For the dosing of pure $CaCO_3$, one of the side components is executed with the SAVEOMAT HF hopper with a twin screw dosing unit. The neck piece has an integrated agitator which makes sure that all dosed components are continuously flowing out of the neck piece. In the next stage the final mixing of all components is done by a dynamic mixing unit (e.g. EMF). This is especially required for those applications, where high filler amounts or foaming agents are dosed and an even distribution of all ingredients is crucial. After the mixing, the material mixture is dosed by a horizontal dosing unit into the neck piece of the extruder. In most cases the feeder is equipped with a twin screw, as an option a spiral feeder may also be used for certain material mixtures.

By adjusting the RPM of the horizontal feeder, the SAVEOMAT ensures a steady and precise dosing of the material mixture, maintaining a constant mass throughput into the extruder. As an option the feeder RPM can also be synchronized with the extruder RPM, so that all adjustments are done simultaneously and the ratio between the feeder and extruder RPM can be set individually at any time. For certain applications, like i.e. PVC pipe production, the mass throughput control can additionally be combined with a weight per meter control with the haul-off speed, so that a full line control is possible.

Dynamic mixer kindly provided by EMF B.V.

Measuring systems overview

Maximizing efficiency and quality.

TODAY'S CHALLENGES

- Long-term competitiveness
- High standards for product quality
- Increasingly complex requirements for process and product data documentation
- Shortage of skilled labor resulting in a loss of manufacturing process knowledge
- Rising material costs and strict sustainability targets
- Production environment digitization

In addition to global supply chain issues and the overall economic climate, the challenges mentioned above are particularly relevant to much of the plastics processing industry today and therefore also to the production of pipes, tubes, and cables.

Finding solutions to these challenges requires the ability to react quickly to changes in the market and, at the same time, meet the highest standards when it comes to product quality, accuracy, and documentation. This requires precise wall/layer thickness distribution data, compliance with standard values for ovality and eccentricity, the ability to easily adjust varying product parameters, and robust and durable system components.

The demand for high-quality products yet the shortage of skilled workers has created a major challenge for many branches of industry. In combination with our gravimetric systems, our measuring systems offer various control options to ensure consistently high product quality. The data collected for process improvement and quality control create the data pool used for automation.

> ***Improving efficiency** and achieving the highest level of accuracy is not possible without **systematic process automation**.*

This holistic approach makes us a solution provider for the plastics industry. Manufacturers benefit from increased material savings of up to 5% and drastically lower quality assurance and documentation costs, resulting in a quick return on investment. At a time when there is a growing shortage of skilled labor, plant managers are no longer solely dependent on specific plant operators with many years of experience.

AUREX ultrasonic measuring system

Our intelligent AUREX ultrasonic systems not only reliably measure pipe diameter, wall thickness, ovality, and eccentricity with precision. Defect detection is also available as an option. The result are higher quality single- and multi-layer pipes and cables. When combined with our SAVEOMAT gravimetric systems, the entire process can be completely automated.

WARP radar-based measuring system

Developed using our own sensor technology, WARP radar measuring systems provide precise, non-contact measurement with automatic centering and (optional) 100% pipe coverage. Our inline system is specifically designed to measure smooth walled and corrugated pipes to give you maximum flexibility. Thanks to advanced chip technology, our WARP systems are reliably accurate and efficient.

iXRAY X-ray measuring system

Our non-contact iXRAY X-ray technology measures the diameter and wall thickness of single and multi-layer pipes and hoses with precision. The advanced 3-axis technology measures more points in comparison points to a 2-axis system, resulting in improved ovality detection. Our systems are versatile and perfectly suited for aluminum multilayer pipes, fabric-reinforced pressure hoses, pipes, and cables.

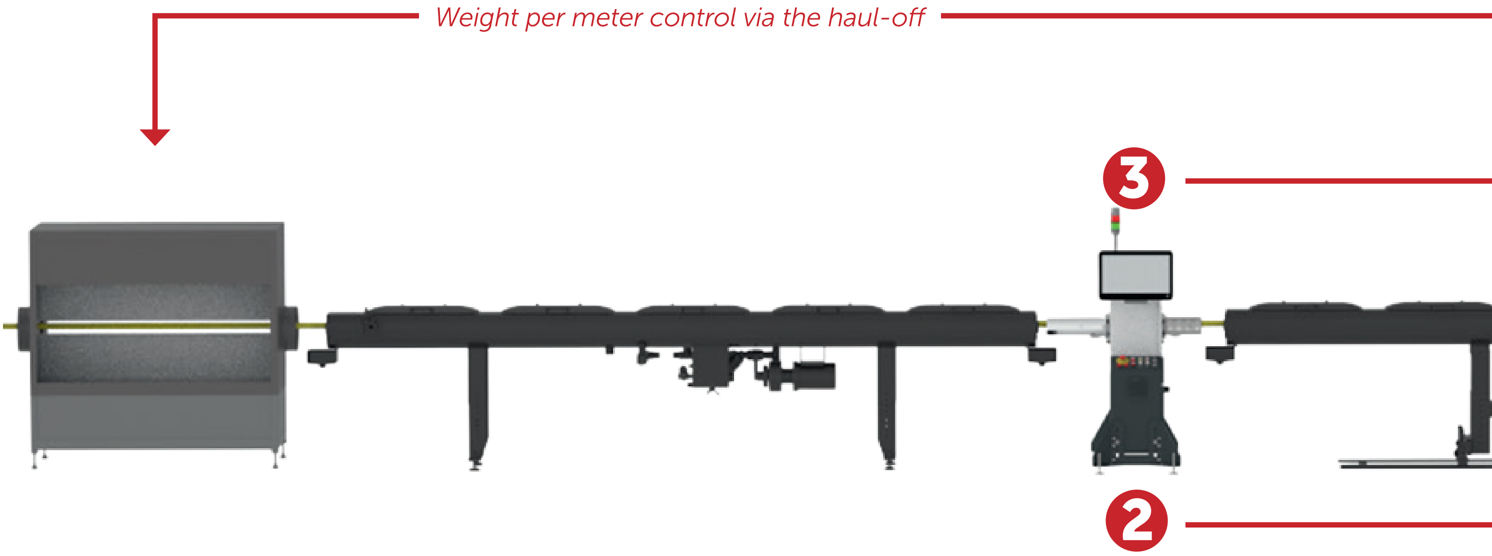
TURN YOUR MEASURING SYSTEM INTO AN **INSTRUMENT FOR CONTROL**

One of the main challenges many manufacturers face today is fulfilling increasingly complex product and quality control requirements while at the same time experiencing a shortage of labor. **Improving efficiency and achieving the highest level of accuracy is not possible without systematic process automation.**

As a solution provider for pipe extrusion, automation is therefore our guiding principle.

Combining gravimetry with a measuring system and control technology is key to increasing productivity, significantly reducing costs, and at the same time ensuring the highest level of quality possible.

Furthermore, when raw materials are used efficiently, you move closer to achieving your sustainability goals and securing your competitive advantage for the future.



1 THE ROLE OF GRAVIMETRY

Every raw material is subject to fluctuations in bulk density. Gravimetric weighing allows fluctuations in mass throughput to be recorded and automatically balanced out. In principle, gravimetry offers two control options: mass throughput control and meter weight control.

Mass throughput control: The extruder speed is adjusted to the material feed into the extruder.

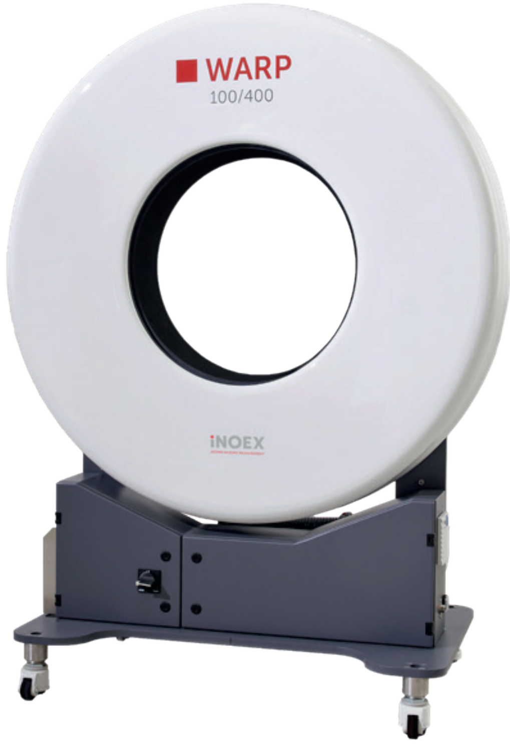
Weight per meter control: The haul-off speed is controlled based on the amount of material fed into the extruder. This keeps the weight per meter constant and eliminates fluctuations in wall thickness in the direction of extrusion. The smaller fluctuations also reduce the target wall thickness, saving material.

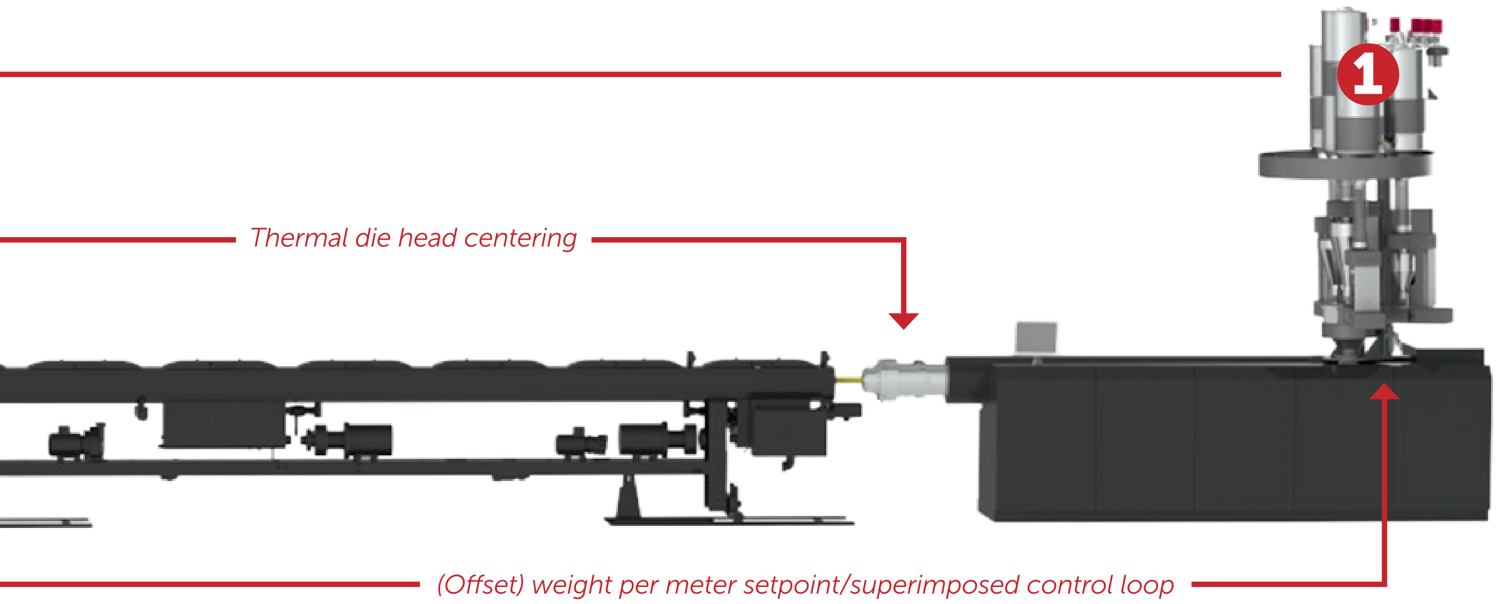
2 THE ROLE OF THE MEASURING SYSTEM

The wall thickness measuring system is integrated into the production line and offers additional control options during the extrusion process. The system measures important parameters such as diameter, wall thickness, ovality, and eccentricity.

Thin point control: This is where the pipe or tube is first measured. The thinnest point defines the control section. The control system then calculates the new target value for the weight per meter and adjusts the haul-off speed, which also changes the wall thickness.

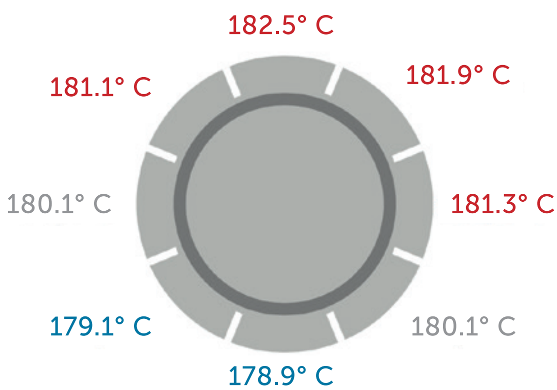
As a result, the system records fluctuations in mass throughput and wall thickness so adjustments can be made. This ensures a further reduction in weight per meter. Wall thicknesses are significantly reduced while the minimum wall thickness is maintained.





3 FURTHER CONTROL OPTIONS

Thermal die head centering: Thermal die head centering for PVC pipes helps save material. The measurement data from the measuring system can be used as a starting point for manual pipe centering. The wall thickness distribution and pipe geometry are recorded by the measuring system and temperature adjustments are then made according to the optimum wall thickness and pipe geometry. New target values are defined and set for the temperature zones. The resulting change in melting speed in the heating zone reduces eccentricity. This leads to a uniform wall thickness distribution over the pipe circumference and optimal end products.



PVC multi strand lines

For certain PVC applications, the PVC end product is not always produced in a single strand extrusion line but can also be produced in a multi strand line. In this setup one extruder plasticizes the material before it is formed by the die into multiple strands.

This concept can be applied to both PVC pipes and PVC profiles. Advantages of multistrand lines are space and investment cost savings compared to the same number of single strand lines. Multistrand pipe extrusion lines are used for small diameter pipes, mainly with diameter sizes of up to 4 inches.

Because the melt is split into multiple strands, which are not divided entirely in the same ratio and which can slightly shift during the production, a special control concept by the SAVEOMAT and iNOEX wall thickness measurement system must be applied. The SAVEOMAT ensures a constant mass throughput by controlling the horizontal feeder RPM. This control concept can be used for both pipe as well as profile extrusion lines. For multistrand pipe extrusion lines, iNOEX wall thickness measurement systems can be added. Each strand is equipped with a wall thickness measurement system which controls the strand individually. By measuring the wall thickness of the respective strand, the system determines the actual minimum wall thickness. The measured value is compared to the set value in the recipe and the haul-off speed of the strand is adjusted accordingly to produce close to the minimum allowed wall thickness while maintaining the set tolerances.

Depending on the center distance between the strands, a special positioning of the iNOEX wall thickness measurement systems can be found, especially when having very short center distances between the strands. WARP systems can be placed with an offset to each other so that the systems are not colliding with each other. When using AUREX systems, especially for very small pipe diameters, the center distance between the strands can be that small, that the water tanks of the ultrasonic system would collide with the adjacent strand. In such extrusion lines two AUREX measuring chambers are installed in a common water tank and positioned with an offset to each other, so that collisions are prevented. This concept can be also used for 4-strand lines, for which two water chambers are used which are both equipped with two measuring chambers, so that each of the four strands has its own wall thickness measurement system.

PVC applications

The following segments describe different applications of PVC extruded products and possible iNOEX automation solutions. Since PVC offers a very wide range of applications, a discussion of all areas of application would go beyond the scope of this document. However also for other, not described PVC applications the iNOEX automation solutions may fit as well.

PVC Pipes for Drinking Water

PVC pipes are one of the preferred choices for drinking water applications. The first installations of PVC pipes for transporting drinking water have been done in the 1930s in Germany and are mostly still in use today. Due to ful-filling hygienic requirements, their corrosion resistance and long-evity, PVC pipes are being preferably used for drinking water applications and are increasingly repla-cing concrete pipes. The smooth surface of PVC pipes is especially important in pressure applications, as fric-tion losses are considerably small and pressure losses are therefore reduced. PVC drinking water pipes are available in many different sizes and can range from small to large diameter pipes.

Since the PVC pipes must withstand higher internal pressure levels when being used for the transportation of drinking water, the amount of used filler is considerably lower compared to other PVC applications. Higher filler amounts reduce the long-term creep resistance and make the pipe more brittle, which can lead to cracks or failures under pressure. Filler contents below 10 PHR are therefore common.

SUITABLE SAVEOMAT SYSTEMS AND CONTROL OPTIONS

- ***SAVEOMAT P+*** for mono component applications
- ***SAVEOMAT DOS*** for dosing PVC Dry Blend and further side components (i.e. masterbatch)
- ***WARP or AUREX***

- ***Mass throughput control*** by horizontal feeder RPM (optionally synchronized with extruder RPM)
- ***Weight per meter control*** by haul-off speed
- ***Thin point control*** (only in combination with AUREX or WARP)
- ***Thermal die centering*** (only in combination with AUREX or WARP)

PVC applications

PVC Pipes for Sewage and Drainage

Apart from drinking water, PVC pipes are also widely used for transporting waste or drain water inside and outside of buildings. For this application PVC has its strengths due to its corrosion resistance and the smooth inner surface, which prevents deposits on the inner pipe surface.

Underground PVC pipes show a life expectance of more than 100 years, making them the ideal choice for long lasting wastewater applications.

Since waste and drain water is transported pressureless just by gravity, such pipes do not need to be designed to withstand high internal pressure levels. Therefore, the possible amount of fillers and recycling material is quite high compared to other PVC pipe applications. Sewage and drainage pipes are produced as 1-layer compact pipes as well as 3-layer co-extruded pipes. In 3-layer pipes, the high amounts of fillers and recycled material are especially used in the middle layer, whereas the outer and inner layer show less parts of fillers and recycling material. In addition, the middle layer can be foamed to reduce the overall weight of the pipe and save material costs. Another benefit of the foamed layer is a better sound absorption.

SUITABLE SAVEOMAT SYSTEMS AND CONTROL OPTIONS

- ***SAVEOMAT P+*** with integrated agitator for mono component applications
- ***SAVEOMAT PVC dosing station*** for dosing PVC Dry Blend and further side components like pure $CaCO_3$
- ***WARP or AUREX***

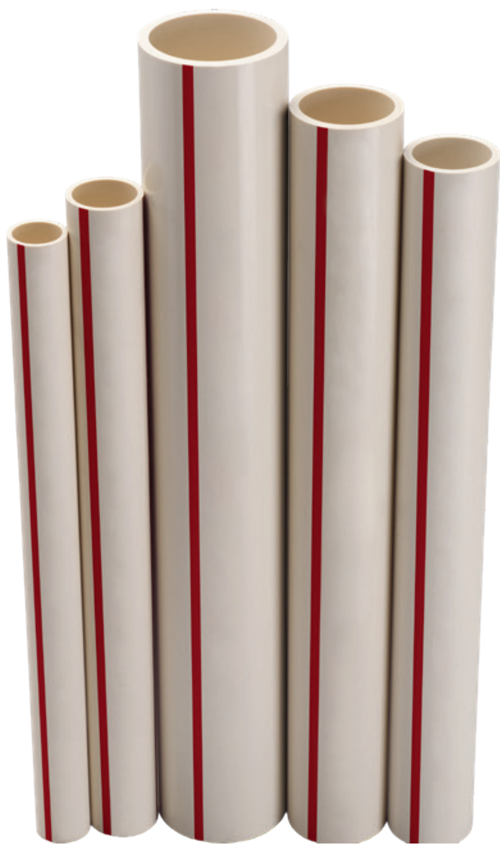
- ***Mass throughput control*** by horizontal feeder RPM (optionally synchronized with extruder RPM)
- ***Weight per meter control*** by haul-off speed
- ***Thin point control*** (only in combination with AUREX or WARP)
- ***Thermal die centering*** (only in combination with AUREX or WARP)

PVC applications

C-PVC pipes for High Temperature Applications

Chlorinated PVC is used for applications, which demand a higher heat and chemical resistance. Such applications are e.g. the transport of hot and cold water in water distribution systems or also the transport of chemical liquids or gases. Compared to unplasticized PVC, c-PVC can withstand temperatures which are approx. 30 °C higher. The available diameter sizes usually range from 16 to 160 mm. c-PVC pipes are widely used in the North American region as well in Asia and Middle East.

To fulfill the high technical requirements, especially when used for industrial applications, c-PVC pipes are produced without fillers to guarantee maximum performance. For this application the iNOEX SAVEOMAT P+ weigher without an integrated agitator should be the preferred choice, used as a mono weigher or as a main component in a dosing station. For regions with high humidity and materials with a poor flowability, the P+ hopper may be equipped with an agitator to make sure that a consistent material flow can be ensured. c-PVC pipes are often produced in dual strand lines, which require a special control philosophy of the iNOEX gravimetric system SAVEOMAT and the iNOEX wall thickness measurement systems WARP or AUREX.



SUITABLE SAVEOMAT SYSTEMS AND CONTROL OPTIONS

- ***SAVEOMAT P+*** for mono component applications
- ***SAVEOMAT dosing station with P+ hopper*** and further side components
- ***WARP or AUREX***

- ***Mass throughput control*** by horizontal feeder RPM (optionally synchronized with extruder RPM)
- ***s-min control*** by haul-off speed (for multi strand lines)
- ***thin point control*** (for single strand lines)
- ***Weight per meter control*** by haul-off (for single strand lines)

PVC applications

PVC-O Pipes for High Pressure Applications

Oriented PVC pipes are the result of unplasticized PVC pipes, which have been running through an orientation process to change the molecular structure and achieving even better mechanical properties. PVC-O pipes show an improved tensile strength and impact resistance, while being more flexible and lighter compared to unplasticized PVC pipes. Having these superior advantages, PVC-O pipes are used for high pressure applications as well as buried applications such as sewer and irrigation. Another promising application is the transport of hydrogen, as newest studies confirm.

Oriented PVC pipes can be produced in two different methods. In the 2-step process, an unplasticized PVC pipe is produced in a standard PVC pipe extrusion line. In an additional step, the pipe piece gets heated up again and mechanically stretched for orienting the pipe. A fast cooling of the pipe locks the oriented molecules. In modern production the orientation can also be done in an one step process. In this method the pipe is not entirely cooled after being produced but transferred to an orientation chamber inline. While still having a sufficiently high temperature, the pipe is then stretched by using a mandrel with pressurized air or a mechanical tooling. The one step process has multiple advantages compared to the classic method, as time and energy costs can be reduced.

PVC-O pipes are produced without filler contents to fulfill the highest requirements. Therefore the P+ hopper without the agitator may be the preferred choice as a mono weigher or main component in a dosing station. To maintain a constant weight per meter but not influence the orientation process, the control method should typically be a weight per meter control by the extruder RPM. In that way the weight per meter is kept constant, while the haul-off speed can be regulated by the extruder OEM control.

SUITABLE SAVEOMAT SYSTEMS AND CONTROL OPTIONS

- » ***SAVEOMAT P+*** for mono component applications
- » ***SAVEOMAT dosing station with P+ hopper*** and further side components
- » ***WARP or AUREX***

- » ***Mass throughput control or weight per meter control*** by horizontal feeder RPM (optionally synchronized with extruder RPM)

PVC applications

PVC Profiles

Profiles are nowadays used for a variety of different applications. Depending on the technical requirement for the specific application, profiles must have a high weather resistance, durability and be cost efficient. A low weight, high-quality surface and soundproofing may also be important for certain purposes. All of these requirements are fulfilled by profiles made of PVC.

In the building sector, PVC profiles are used as window and door frames, claddings and gutters. Especially window frames are produced with a high amount of recycled material. These profiles are produced as 3-layer profiles, whereas the core (or middle) layer is produced with a big amount of recycled material. The inner and outer layers are produced with virgin material or smaller amounts of recycled content. Another possible combination is to produce the middle layer as a foamed layer. By doing this the profile has a higher soundproof and is also lighter. Another application in the building sector are profiles made of WPC, where the plastic material, PVC or sometimes HDPE, is mixed with wood flour. Such profiles are used for fences or also decking boards.

WPC profiles are also used in the second big application field of PVC, the furniture sector (floorings in buildings, decorative strips or as edge bandings). PVC profiles are also widely used as electrical conduits which protect cables. The automotive sector is another applications field of PVC profiles, where they are used for interior paneling's, sealings and covers for different purposes. Especially in the automotive sector PVC profiles have the advantage of a relatively low weight, which has a major impact on saving costs.

The Dry Blend used for profile extrusion can also include a decent amount of fillers which are reducing the overall costs and which can influence the mechanical and optical properties of the end product. Because of this the Dry Blend may show a poor flowability.

SUITABLE SAVEOMAT SYSTEMS AND CONTROL OPTIONS

» ***SAVEOMAT P+*** with integrated agitator for mono component applications

» ***SAVEOMAT dosing station with P+ hopper*** and further side components

» » ***Mass throughput control or weight per meter control***
by horizontal feeder RPM (optionally synchronized with extruder RPM)

» ***Weight per meter control*** by haul-off for certain profiles

PVC applications

PVC Cables

For cables PVC is a widely used material for the insulation and sheathing of the inner cable parts. PVC cables have a high flame resistance, high flexibility, resistance against moisture and chemicals as well as a high electrical dielectrical strength. Due to the possibility to form different formulations, PVC cables can be used in a variety of different applications, such as in building and installation applications, for industry purposes , as telecommunication and data cables or in automotive cables. PVC cables are also widely used for low and medium voltage cables.

In contrast to PVC pipes and profiles, PVC cables are produced with single screw extruders, as the PVC Dry Blend is granulated first and then dosed along with other components (i.e. recycled material, masterbatch and others). Therefore SAVEOMAT G hoppers can be used for most of the materials, whether as a mono component or in a dosing station for multiple components. For special processes, where it is important to prevent a contamination inside the hoppers, dust and damp-proof filter cloths are available, which prevents contamination and moisture entering the hopper.

The recommended control type in cable extrusion processes is a weight per meter control by the extruder RPM. Since in cable extrusion the haul-off speed is adjusted by the line control quite dynamically when changing the coil, the SAVEOMAT is only measuring the line speed and controlling the extruder RPM to maintain a constant weight per meter and an exact recipe.

SUITABLE SAVEOMAT SYSTEMS AND CONTROL OPTIONS

- ***SAVEOMAT G*** for mono component applications
- ***SAVEOMAT dosing station with G and P hoppers*** for further side components
- ***AUREX or iXRAY***

- ***Weight per meter control*** by extruder RPM or reference throughput control
- ***Extruder control variables***: The secondary components follow the main component

PVC applications

PVC Conduits

Another widely used application for PVC pipes is the protection of electrical cables and communication installations. PVC cable protection pipes and hoses offer a mechanical protection and have a high durability. Due to the high fire resistance, impact resistance and UV stability, cable protection systems made of PVC are used for a variety of different cables in the building, industry and infrastructure sector. Rigid or flexible pipes and hoses may be used for the respective application. Another big advantage of PVC, especially when used for cable protection systems, is its cost-efficiency. Apart from relatively low costs for PVC resin, cable protection pipes are produced with a relatively high amount of fillers and recycled content. Since the pipes do not need to withstand high internal pressures, the used filler and recycled content is higher compared to other PVC applications.

Also for PVC cable protection systems a dosing of the PVC Dry Blend may be done by the SAVEOMAT P+ as a mono component or as a main component in the SAVEOMAT PVC dosing station. Additional calcium carbonate amounts can be dosed with the SAVEOMAT HF hopper, while the recycled content may be dosed by a standard SAVEOMAT P hopper. Especially for the rising trend of introducing higher amounts of recycled material, a gravimetric solution is key to maintain highest production quality when using such materials with very high bulk density variations. A mass throughput control via the horizontal feeder RPM can be combined with a weight per meter control by the haul-off speed. With an iNOEX wall thickness system, further control options like the thin point control or thermal die centering may be possible.

SUITABLE SAVEOMAT SYSTEMS AND CONTROL OPTIONS

- ***SAVEOMAT P+*** with integrated agitator for mono component applications
- ***SAVEOMAT dosing station with P+ hopper and HF scale***
- ***Mass throughput control or weight per meter control***
  by horizontal feeder RPM (optionally synchronized with extruder RPM)
- ***Weight per meter control*** by haul-off for certain profiles

LEARN MORE ABOUT OUR **PVC AUTOMATION SOLUTIONS**

1984-2024 YEARS OF MEASUREMENT EXCELLENCE

Our cooperation is characterized by a clear mission statement and a focus on customer needs. This is based on our values and principles. Every day, we work with enthusiasm and passion on our claim to "inspire beyond measurement".

Vision

We are the most innovative solution provider for measurement technology in the plastics industry. Today and in the future.

Mission

As both pioneers and experts we offer our customers added value in the pipe, hose, film, cable, blow molding and profile extrusion industries.

Our high quality products are user-friendly, intelligent and innovative solutions that are key factors for sustainable success.

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