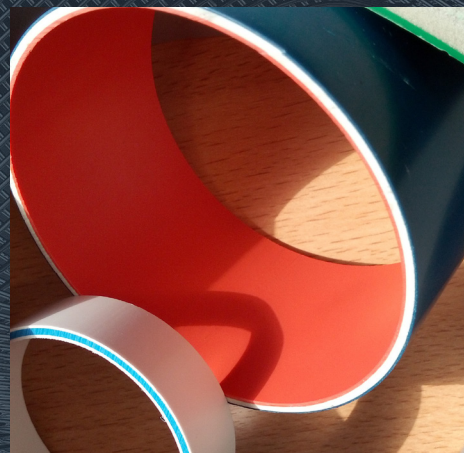
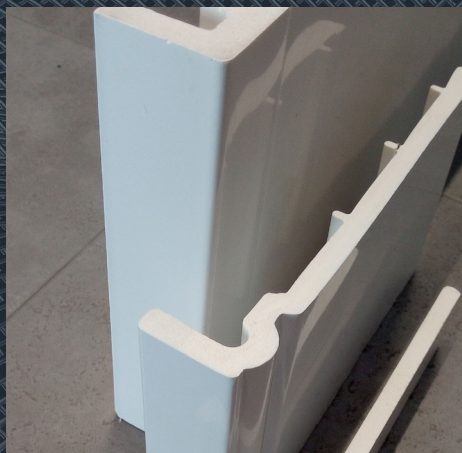


Acrylic Additives for PVC Foam Technology



PVC Foam Applications

Cost optimization and weight reduction have been key market priorities for end-use products in recent years and they have led to developments across the value chain from raw material suppliers to converters and consumers. Consequently, we have seen the development of many new foam solutions.

The main technologies used to produce foamed PVC end-use products are: Free Foam extrusion, Celuka extrusion and Co-extrusion.

PVC Foam Technologies

Free Foam Extrusion: Expansion occurs between the die exit and the temperature-controlled metal rollers of the down-stream equipment. Foaming is the result of the combination of elastic recovery and the formation of gas cells. The down-stream equipment enhances surface smoothness. Sheet products exhibit regular cell-structure across the entire section of the extrudate.

Free Foam extrusion is used to produce Free Foam Sheets which are ideally suited to the design of end-use products with outstanding printability, typical of printed display panels and point of sale displays. In the Building and Construction market, Free Foam Sheets are widely used for applications including ceiling panels, door panels and trim boards. Automotive applications include wall linings for van interiors.

Inward Foaming Extrusion (Celuka Type): Expansion occurs inside the calibrator filling the space/volume of the die mandrel. The calibrator is located several millimeters from the die exit, inhibiting foaming at the surface whilst the melt foams inwardly. Celuka type products tend to display a gradient of cell sizes from the surface to the center of the cross section.

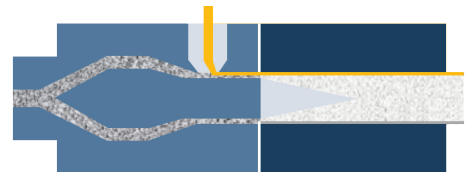
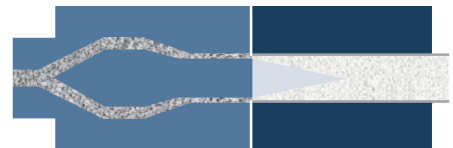
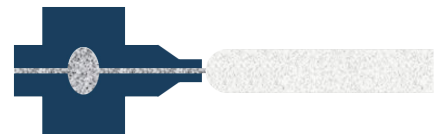
Celuka extrusion allows production of sheets with harder, more durable surfaces, when compared to Free Foam Sheets, as well as PVC foam profiles.

Celuka foam sheets and foam profiles are suitable for a wide range of applications in different markets including: Automotive, Commercial Transportation and Building & Construction, for purposes including insulation, noise reduction, partition walls, interior and exterior window trim profiles, fascia and soffit for example.

Co-Extrusion: The combination of two or more layers of compact and foamed PVC provides products which display comparable surface properties to rigid PVC combined with the attributes of PVC foam.

Co-extrusion is mainly applied to the Celuka type process for profiles and to the production of foam core pipes. Significant weight reduction is obtained for profiles with weatherable surfaces in profiles used in demanding exterior applications. Good surface durability and high crush resistance ratings are achieved in foam core pipe applications for underground use, as well as noise reduction benefits for apartment down pipes.

Technology Variants: Across the EMEA region, a myriad of other applications and technology variants exist such as extruded foam picture frames, profiles and free foam pipes produced from recycled PVC. Some companies produce co-extruded free foam products such as highly filled substrates for Luxury Vinyl Tiles and foam window profiles. Thus, in addition to the best known applications, a wide range of opportunities exist for innovation with PARALOID™ and SURECEL™ Processing Aids.



Additives for PVC Foam Formulation

The extrusion technologies previously described (Free Foam extrusion, Celuka extrusion and Co-extrusion) can be used to produce a wide range of end-use foamed PVC products, such as PVC foam sheets, PVC foam profiles, and PVC foam core pipes, designed for many different applications and markets.

PVC formulation variables affect the foaming of rigid PVC formulations. One of the most important formulation variables is

undoubtedly the Acrylic Processing Aid. Molecular weight (Mw) greatly influences melt rheology and hence the foam process. The molecular weight of processing aids affects the melt strength, melt elasticity, cell growth and cell density.

PARALOID™ and SURECEL™ are the two complementary trademarks for Dow's Acrylic Processing Aids and Polymeric Lubricants that we recommend for PVC foam applications.

Acrylic Processing Aids		
Product name	Mw range	Applications
PARALOID™ 435 PARALOID™ 435G	Very high Mw	Foamed core pipes
SURECEL™ 445	Very high Mw	Free Foam Sheets, with lower thickness (<19mm)
SURECEL™ 466 ER	Ultra high Mw	Free Foam Sheets and Celuka foamed sheets, with higher thickness (>19 mm) Foamed profiles (Celuka extrusion, Co-extrusion for foamed core profiles)
SURECEL™ 4280	Very high Mw	Free Foam Sheets, Celuka foamed sheets, Co-extruded sheets Designed for wide sheet-dies
Polymeric Lubricants		
Product name	Typical function	Applications
PARALOID™ K-175 ER	Excellent hot metal release	All
PARALOID™ K-185 ER	Outstanding hot metal release	Extruded or Co-extruded foamed sheets

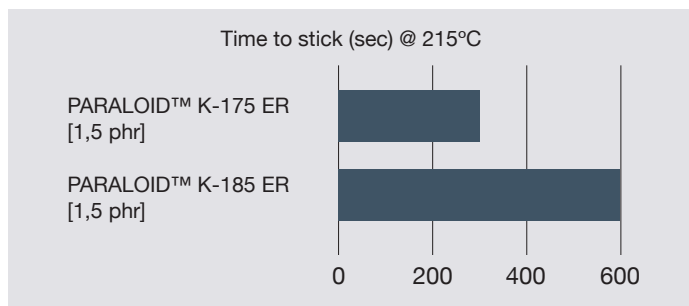
The combination of PARALOID™ and SURECEL™ Processing Aids, with PARALOID™ Polymeric Lubricants, allows Dow to meet all the needs of PVC foam end-use products, such as sheets, foam core pipes and foam profiles.

Efficiency: Up to 30% more efficient
Optimized formulations based on cost and performance

Anti-stick performance @ 190°C		
Polymeric Lubricants for PVC formulation	0 seconds	900 seconds
PARALOID™ K-175 ER [0,6 phr]	✓	✓
PARALOID™ K-185 ER [0,4 phr]	✓	✓

The data provided are typical values and should not be construed as specifications

Effectiveness: Up to twice as effective
Facilitates processing at high temperature



PVC Foam Sheets

An extensive range of sheets can be produced in various widths and thicknesses via Free Foam extrusion, Celuka extrusion and Co-extrusion.

Dow produces three grades of Processing Aids: SURECEL™ 445, SURECEL™ 466 ER and SURECEL™ 4280 for PVC foam sheet applications. The additive type and dosage depends on the extrusion technology, the thickness and the width of the sheets.

SURECEL™ 4280 Processing Aid is designed with a tailored molecular weight distribution, to reach optimized melt flow whilst maintaining a high efficiency of foaming.

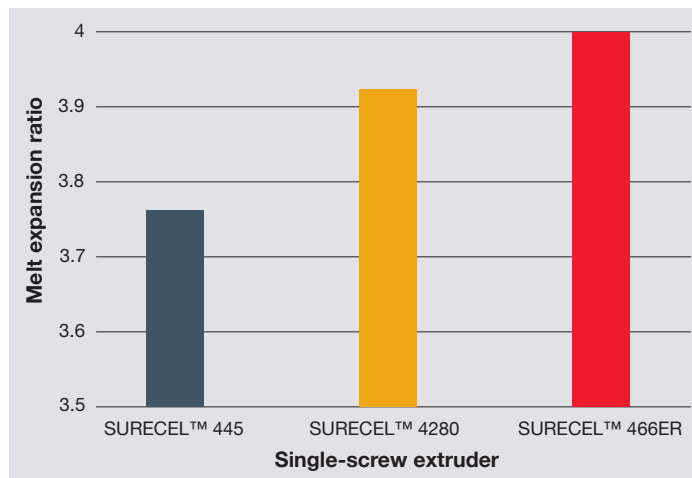
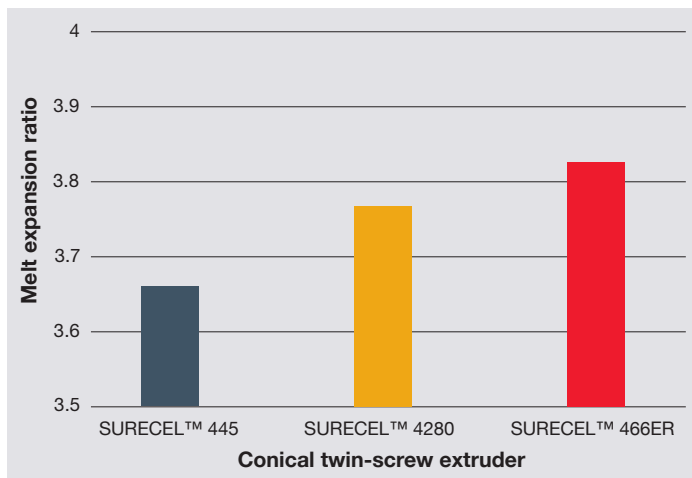
SURECEL™ 4280 Processing Aid contributes to a stable structure for PVC foam sheets with high cell density and small cell size. The thickness of the final product is well controlled and a low density can be reached whilst maintaining a high quality surface.

PARALOID™ K-175 ER and PARALOID™ K-185 ER Polymeric Lubricants are key to efficient production of free foam sheets.

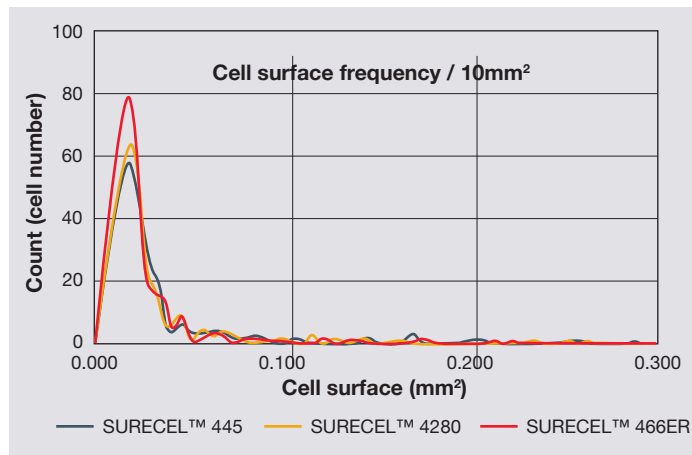
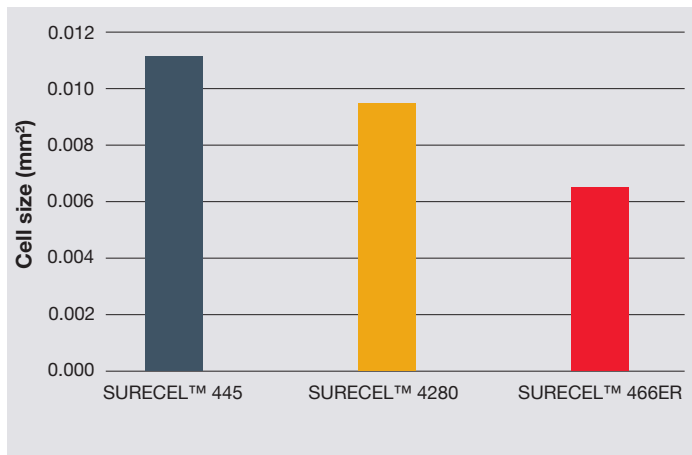
PARALOID™ K-175 ER and PARALOID™ K-185 ER Polymeric Lubricants prevent sticking at the high temperature edges of wide sheet dies, without the disadvantages of traditional lubricants.

The data below highlights the foaming performance of the different grades of SURECEL™ Processing Aids. This comparison was conducted on a tin stabilized PVC foam formulation.

Melt expansion ratio data under different processing conditions



Cell structure



The data provided are typical values and should not be construed as specifications

PVC Foam Profiles

Lightweight Profiles

Co-extruded PVC foam profiles are mainly used in architecture, as cladding, siding, soffit and fascia for example. This type of profile provides a significant weight reduction with a highly weatherable surface.

SURECEL™ 466 ER Processing Aid is designed and produced with an ultra-high molecular weight. SURECEL™ 466 ER Processing Aid is ideally suited to the production of PVC foam profiles with thick walls whilst providing excellent cell structure, cell size distribution, and hence enhanced physical properties.

Foam Core PVC Pipes

Production of Large Diameter Pipes

Specific applications, such as PVC-U drain, waste and vent pipes of up to 600 mm diameter, use foam cores to achieve weight reduction whilst maintaining the desired levels of crush resistance for buried applications, and noise reduction in apartment building down pipes.

PARALOID™ K-435 and PARALOID™ K-435G Processing Aids have a very high molecular weight and are used to produce foam core PVC pipes by co-extrusion technology.

PARALOID™ K-435 and PARALOID™ K-435G Processing Aids facilitate optimum cell structure whether the material is recycled or a virgin formulation. PARALOID™ K-435 and PARALOID™ K-435G Processing Aids contribute to an improved foaming process in small diameter pipes at high line speeds but also in large diameters running at far lower line speeds.

PARALOID™ K-435				
Dosage (phr)	5		7	
Screw speed (rpm)	20	40	20	40
Density (g/cm3)	0.45	0.33	0.42	0.33

The data provided are typical values and should not be construed as specifications

The data in the table are based on a CaZn stabilized formulation for foamed core PVC pipes containing an exothermic blowing agent.

Dow offers additives for all foaming extrusion technologies and applications, which provide excellent performance during processing and in the end-use product.

About Dow

Dow (NYSE: DOW) combines one of the broadest technology sets in the industry with asset integration, focused innovation and global scale to achieve profitable growth and become the most innovative, customer centric, inclusive and sustainable materials science company. Dow's portfolio of performance materials, industrial intermediates and plastics businesses delivers a broad range of differentiated science-based products and solutions for our customers in high-growth segments, such as packaging, infrastructure and consumer care. Dow operates 113 manufacturing sites in 31 countries and employs approximately 37,000 people. Dow delivered pro forma sales of approximately \$50 billion in 2018. References to Dow or the Company mean Dow Inc. and its subsidiaries. For more information, please visit www.dow.com or follow [@DowNewsroom](https://twitter.com/DowNewsroom) on Twitter.

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Handling precautions

Before using any product mentioned herein, consult the product's Material Safety Data Sheet (MSDS)/Safety Data Sheet (SDS) for details on product hazards, recommended handling precautions and product storage.

Product stewardship

Dow has a fundamental concern for all who make, distribute, and use its products, and for the environment in which we live. This concern is the basis for our product stewardship philosophy by which we assess the safety, health, and environmental information on our products and then take appropriate steps to protect employee and public health and our environment. The success of our product stewardship program rests with each and every individual involved with Dow products - from the initial concept and research, to manufacture, use, sale, disposal, and recycle of each product.

Dow strongly encourages its customers to review both their manufacturing processes and their applications of Dow products from the standpoint of human health and environmental quality to ensure that Dow products are not used in ways for which they are not intended or tested. Dow personnel are available to answer your questions and to provide reasonable technical support. Dow product literature, including safety data sheets, should be consulted prior to use of Dow products. Current safety data sheets are available from Dow.

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