REEDY CHEMICAL FOAM

Safoam™ CHEMICAL FOAMING AGENTS

CUSTOMER MANUAL FOR USING SAFOAM™ IN EXTRUSION APPLICATIONS

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The purpose of this manual is to provide insight into foaming polymers and to identify where Reedy CFAs can be used in extrusion processes. It is also intended for the customer to understand and identify the key considerations when foaming. If there are areas of the process not mentioned here feel free to discuss them with the technical experts at Reedy Chemical Foam.

WHAT IS FOAM?

A foam is a substance made by trapping air or gas bubbles inside a solid or liquid or a polymer.

WHY FOAM?

- Reduces density; provides lighter parts
- Reduces molded in stresses; may improve impact resistance
- Can be nailed or screwed without cracking - Important for synthetic wood
- Increases line speed
- Improves temperature insulation and sound insulation
- Improves dimensional stability
- Improves electrical properties in some exothermic applications

WHAT ARE SOME APPLICATIONS THAT ARE FOAMED?

- Sheet/board
- PP Ribbon
- Thermoformed items
- Pipe

- Twine or rope
- Wire and cable insulation for communication wire
- Art and advertising board
- Protective packaging
- Picture frames
- Moldings
- Floats
- Netting

FOAMING AGENTS USED IN THERMOPLASTIC

Physical Foaming Agents- Nitrogen, Carbon Dioxide, Pentane, Butane and Chlorofluorocarbons are examples of physical blowing agents. These foaming agents do not undergo a chemical reaction but change physical state to produce the gas and bubbles. e.g. liquid to gas, boiling etc.

When using physical foaming agents, special equipment is required to inject the foaming agent and to cool the polymer close to the polymer's glass transition temperature.

CHEMICAL FOAMING AGENTS (CFAS)

Chemical Foaming Agents are used in standard extrusion processes. These materials release either carbon dioxide or nitrogen when heated to a certain temperature. They are classified by the type of chemical reaction that occurs when they activate (release gas). They are then either endothermic or exothermic CFAs. **Reedy Chemical Foam** offers both kinds and they will help you choose the best CFA for your process.

TYPES OF CHEMICAL FOAMING AGENTS(CFAS)

Endothermic CFAs - These CFAs absorb heat when activated and therefore can reduce cooling times for the product being made. They usually release CO_2 and carbonate. When compared to exothermic CFAs, these endothermic foaming agents offer the following advantages.

Advantages of Endothermic CFAs

- Faster cycles/ Faster cooling
- Smaller cell size (better physical properties and appearance)
- Best for eliminating voids in extruded and molded parts
- De-gases within a few hours (important if painting)
- Meets most FDA requirements for food contact

Disadvantages of Endothermic CFAs

- Lower gas pressure and greater solubility from CO_2 can reduce weight reduction
- Can be affected by numerous ingredients such as water, acid
- Most endothermic CFAs release water so it may be a concern in moisture sensitive resins

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Exothermic CFAs - These CFAs release heat when activated and therefore can increase cooling times for the product being made. Azodicarbonamide is the most used exothermic CFA and releases nitrogen as the foaming gas. Its decomposition products include biurea, isocyanic acid, urarole, water and ammonia.

Advantages of Exothermic CFAs

- Produces higher gas pressure
- Wide operating temperature thru use of activators
- Can be used in cross linked polymers
- Usually gives the best weight reduction-higher gas pressure and non-solubility in resin
- Can be used in insulation of wire and cable used in communication applications

Disadvantages of Exothermic CFAs

- Azodicarbonamide (AZO) is the most used exothermic CFA and releases nitrogen as the foaming gas; decomposition by products include biurea, isocyanic acid, urazole, water, and ammonia
- Often leaves a slight yellow cast in foamed parts if the CFA is not completely activated
- Can produce larger cells than an endothermic if nucelating agents are not used
- Long de-gassing time of up to a week before parts can be painted
- Releases nitrogen after the processing causing "post-blow" where the part continues to expand after processing
- Usually longer cooling times
- Limited FDA for food contact

FOAM EXTRUSION USING REEDY SAFOAM ™

It is crucial to understand that the process is an important key for successful foaming. The CFA can be modified to accommodate the process conditions especially as it relates to activation temperature and cell size. Our sales representatives can make the best product recommendations after learning more about your application.

Void content is the amount of gas bubbles in the foamed polymer. It is a measure of the amount of polymer replaced by the foaming process. Depending on the process. void content can be as high as 60%, although less than 40% void content is common. In lbs/cu.ft the minimum achievable density is about 221bs/cu.ft. (.365g/cc) for a low density polyethylene with a density of 571bs.cu.ft (.918g/cc). Depending on the desired amount of foam, the dosage level for Safoam™ is approximately 0.5% - 3%.

Extrusion Equipment Recommendations

1. **An L:D ratio of 30:1 or longer:** It is ideal to have a long screw so that changes. especially temperature, are gradual. A shorter extruder can be used but will be more sensitive to changes in the extrusion profile.

2. **One Stage Screw:** A one stage screw is best at minimizing pressure drops. Two stage screws have a decompression section at the end of the first stage which causes the foam to start expanding at the decompression section. The expanded foam will then collapse, with broken cells, as it makes it way into the second stage. The outcome is a rough surface large cells and voids.

Note: A two stage screw may be used if melt temperatures in the first stage stay below the activation temperature of the CFA. Use the second stage to increase heat and induce activaction of the CFA.

3. **Mixing Section or Static Mixer:** Thermal homogenization is one of the keys for making consistent foam. If temperatures across a processed part varies, the foam density will vary. Hot spots will cause collapse or large cells and cooler areas will have smaller cells. Adding mixing elements (for dispersive or distributive mixing) ensures consistent heating throughout the polymer matrix. The only exception is a barrier screw which is not recommended due to the pressure drop it creates.
4. **Die With a Short Land Length:** A land length ratio of 8:1 is preferred but not critical. A pressure drop occurs at the land and a long land length may cause pre-foaming and unacceptable foam. One can use an existing die and observe the results. Lowering the die temp is a way to increase the pressure at the Lind.
5. **Reliable Feeder:** The amount of CFA being used is critical and one should ensure that it is fed consistently (VERY IMPORTANT). Gravimetric feeders are the best option, but a volumetric feeder can be used if calibrated. Ribbon blenders, drum tumblers can be used as a last option.
6. **Use a screen:** at the breaker plate of no finer than a 60 mesh to minimize the pressure drop between the breaker plate and adaptor or die.

Extrusion Process Recommendations

Feed Hopper: Resin pellets and Reedy CFA (Safoam™) can be mixed together by means of a blender then add to the hopper or the Safoam™ can be fed via a gravimetric or volumetric feeder. Calibrating the gravimetric or volumetric feeder and determining the feed rate is important as the Safoam™ generally has a higher bulk density than resin.

Screw RPM: RPM should be set at 30 or more . Too slow RPM can cause pre-activation in the feed or transition zones.

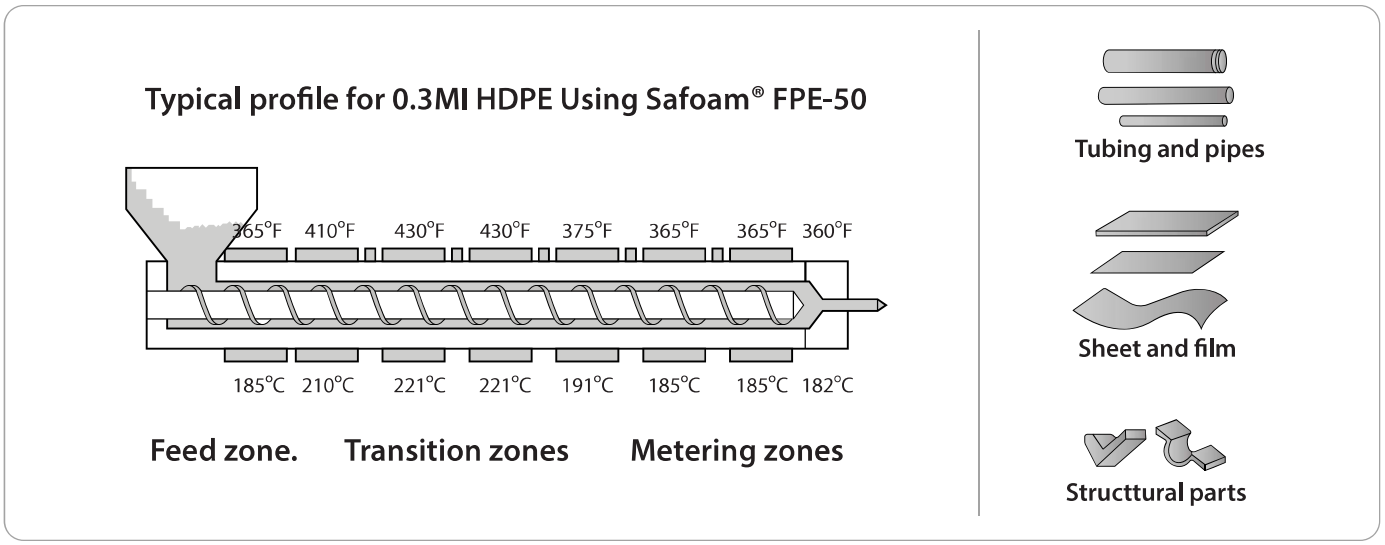

Figure 1

TEMPERATURE SETTINGS

Feed Zone: Set below the activation temperature but high enough to form a melt plug.

Transition Zone: Set it at 10°C to 15°C above the activation temperature. If the CFA is not activating raise temperatures about 2-3°C at a time.

Metering Zone: Set it cooler than the Transition zone by about 5°C or similar to or slightly lower than the feed zone.

Die: Set this below or close to the activation temperature to build pressure and to produce a smooth sheet.

Extrudate: Since foam expansion occurs after exit from the die, look to make adjustments to accommodate the increase in volume. This usually involves increasing line speed and making adjustments to roll gap as well as die gap due to increase thickness when foam occurs.

Figure 1 shows an actual extrusion profile used to foam HDPE.

Try to keep pressures in the extrusion process above 1,400 PSI so that the foaming gas stays in solution. This will help to prevent pre-foaming in the extruder. For best foam quality, foam expansion should occur after exiting the die.

TROUBLESHOOTING

In most cases, use the trouble shooting recommendations from your resin supplier. The trouble shooting recommendations when foaming are as follows:

Not getting enough foam:

- Increase the amount of blowing agent 0.25% at a time. Generally, you should not need more than 3% total.
- Make sure your melt temperature is set high enough for full activation of the foaming agent. Increase heats in the transition section of the extruder.
- Check the roll gaps if making sheet. The foam cells can easily be crushed if the initial roll gaps are too narrow.

• The bead or bank at the first rolls should be minimized. The rolling of the bank can release the gas

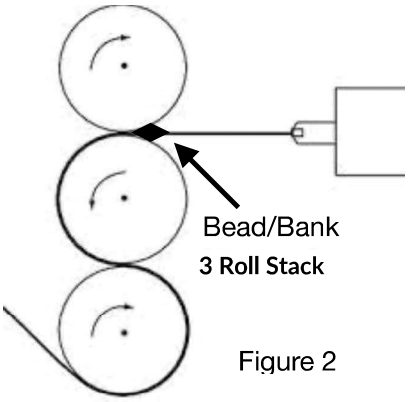

Figure 2

• Check for leaks in the extrusion system that can cause the gas to leak-out thus decreasing the amount of foaming. This also applies if there are any vents. They should be closed or capped exccpt when extruding PVC.

No foam occurring at the die:

• Increase heats 2-4°C (3.5-5°F) at the transition zone until foaming occurs, being sure that the transition zone is set above the CFA's activation temperature.

• Could be pre-activation of the CFA. Cool down the feed zone 2-4°C (3.5-5°F) at a time if it is suspected.

• Rough Surface and Uncontrollable Foaming. (Broken or open cells, rough surface, excessive shrinkage etc).

• Heats are too high at the die causing cell breakage on the surfae. lower die temperatures until a smooth surface is achieved. See figure 3.

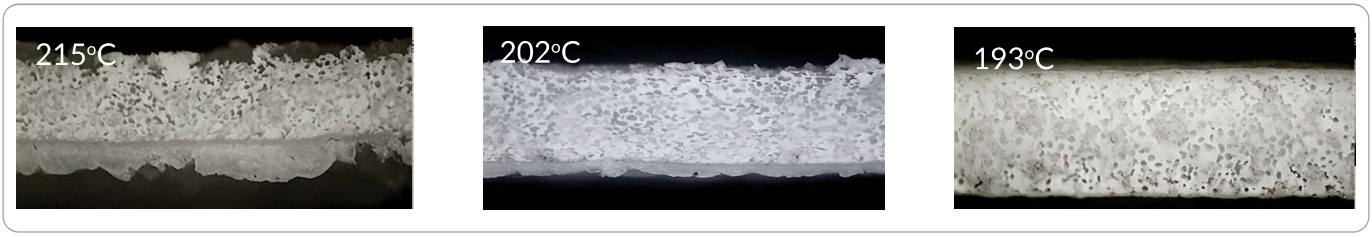

Figure 3

• If foaming comes-and-goes, it is likely caused by a temperature variance close to the activation temperature. Raise temperature in the transition zone to ensure full activation. The same can occur of there is varying temperature controller.

• To much foam. Cells are breaking at the surface. Decrease the amount of CFA by 0.25% at a time.
(I.e. 1% to .75%).

- Pre-activation is occurring and foam expansion is occurring in the extruder. Lower extruder temperatures especially at the feed and transition zones.
- Melt strength of the resin is poor. Change to a resin with higher melt strength.

OTHER CONSIDERATIONS

Resin selection: Choose resins that an highly branched and have good melt strength. For polyethylene and polypropylene. A melt index or melt flow below 5 appears to work the best.

Pigments: Most pigments work well in the foaming process. However, colors will look faded or "whiter" due to the foam. If a color concentrate is used, it must be dry as water can affect the decomposition of the CFA. Some black pigments can absorb CO_2 so one may need to increase the amount of CFA to compensate for the lost of gas. An additional 0.25% (i.e. From 1% to 1.25%) of Safoam™ is recommended.

Other additives: Additives with an acidic pH below 7 can sometimes he problematic as acids will activate most endothermic CFAs, lowering the activation temperature. Additive master batches that Contain high levels of Moisture can also effect decomposition temperature and cause larges cells.

Regrind: Regrind can be used, but nay require an adjustment to the amount of CFA being used. Usually you will have to decrease the amount of CFA if there is any residual or unactivated CFA in the regrind.

Inquiry Sheet: To ensure the best possible foam reccomendation is provided, fillout the attached inquiry sheet.

REEDY CONTACT INFORMATION

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- Notes: