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Technical Data | July 2020

3M™ Foam Additive FA-188

Product Description

3M™ Foam Additive FA-188 is a clear, colorless, odorless and nonflammable fluid that is effective in reducing the thermal conductivity of polyurethane and other rigid foam formulations. The lower foam thermal conductivity provides manufacturers with a technology to help them meet the continually tightening energy efficiency targets. 3M Foam Additive FA-188, used in concentrations as low as 0.5% on the total foam weight, is effective at helping reduce the foam-cell size and thus the thermal conductivity of foam. The resulting foam displays thermal conductivities (lambda) that are typically 3% to 15% lower than those formulated without the additive. 3M foam additive FA-188 is approved on CEN 13165 “Thermal Insulation Products for Buildings”.

Foam Insulation Performance

3M™ Foam Additive FA-188 can significantly modify the morphology of the cured, rigid foam. This additive acts as a nucleating agent during the foam blowing process and reduces the average size of the foam cells. This reduced cell size results in a corresponding reduction in the thermal conductivity of the foam. The most significant reductions occur in foams blown with hydrocarbon blowing agents such as cyclopentane. This fluorinated additive displays a combination of physical properties that have proven to be effective at reducing the cell size of rigid polymeric foams.

Product Construction/Material Description

Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

3M™ Foam Additive FA-188 Property	Condition	Units	Value
Molecular Weight		g/mol	300
Boiling Point	101 kPa	°C	47
Freezing Point		°C	-80
Flash Point		°C	None
Liquid Density	at 20°C	g/ml	1.65
Viscosity	at 20°C	cSt	0.36
Vapor Pressure	at 20°C	kPa	34.7
Heat of Vaporization	at 48°C	kJ/kg	98
Specific Heat	at 25°C	kJ/kg.K	1.13
Surface Tension	at 25°C	mN/m	11.2

3M™ Foam Additive FA-188
Emulsion Technology

The key to realizing the benefits provided by 3M™ Foam Additive FA-188 is to emulsify the product into the foam resins prior to blowing the foam. 3M foam additive FA-188 has extremely low solubility in most polyols and isocyanates. Consequently, it is not possible to dissolve the additive into the resin as is common practice with other foam components such as surfactants, catalysts and blowing agents. The fluorinated additive must be emulsified into the resin. The fluorinated additive is the discontinuous phase and will be finely divided and distributed throughout the resin (the continuous phase). An emulsifier is required to create a fine, stable emulsion. The surfactants typically used for foam stabilization can also function as emulsifiers. The presence of the surfactant is critical during the emulsification step.

The emulsion can be created in one of two ways:

1) The 3M foam additive FA-188 can be blended with a hydrocarbon blowing agent prior to mixing into the resin. This technique requires good mixing when adding the blowing agent/additive mixture to the resin. High shear mixing is not required but is the preferred method for higher viscosity resins. High shear mixing can also improve emulsion stability. This method of addition can produce a consistent and potentially more stable emulsion.

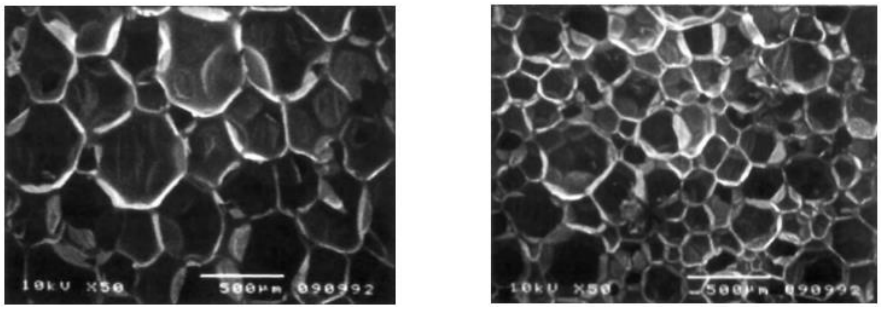
2) The 3M foam additive FA-188 can be dispersed into the resin under high shear. The typical emulsifying conditions are to mix at 2000 rpm or more using a high shear mixer, until the polyol turns from translucent to an even milky white emulsion. For hand mixed foams, it is advisable to limit mixing to 2 minutes or less to limit heat build-up in the emulsion. The evaporation rate of foam additive FA-188 will be significantly reduced once it is emulsified into the polyol. The loss of foam additive FA-188 should not be significant during formulation and foaming in a high-pressure foam injection machine. In this method, the other foam components such as the catalyst should also be added to the polyol prior to addition of the fluorinated additive. The blowing agent is typically added after the emulsion has been formed.

The additional steps in foam mixing and handling remain the same. Incorporation of the isocyanate is not altered – i.e. mixing of parts A and B can be done in the usual manner. On a machine, it may also be advantageous to introduce the foam additive FA-188 as a third stream in the mixing head with the polyol and isocyanate. The reaction profile for these foams is similar to standard foam formulations.

Reduced Cell Size and Thermal Conductivity

The presence of the emulsified 3M foam additive FA-188 during the blowing process provides numerous sites for the initiation of cell formation. These nucleation sites produce a more uniform distribution of smaller cells as compared to conventional foams. Examples of this effect are shown in Figure 1.

Figure 1

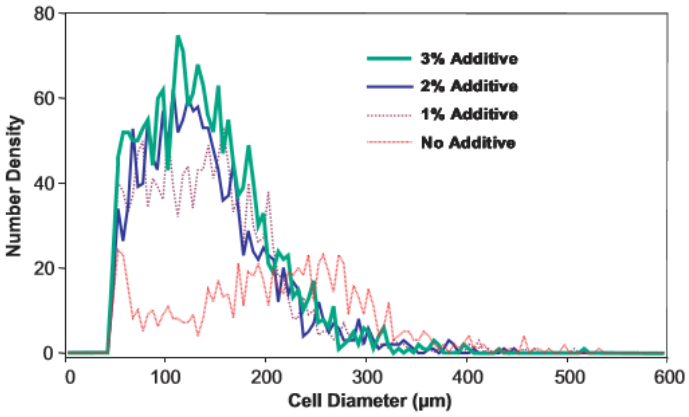


Without Additive | With Additive

3M™ Foam Additive FA-188
Emulsion Technology (continued)

Concentrations of 3M™ Foam Additive FA-188 as low as 0.5% of the total foam weight can have a measurable impact on the cell size and thermal conductivity of the foam. The additive concentration can be varied until an optimum cost to performance ratio is obtained. Results with 1 to 3 percent of additive in the foam resin are shown in Figure 2 below compared to the same formulation with no additive.

Figure 2



Test specimens of the same base formulation were prepared with different additive amount and at different foam thickness. Key foam properties were measured for each test specimen and shown in Table 1.

The cyclopentane blown foam displayed reductions up to 8% and 11% in the initial and aged thermal conductivity, respectively. Similar effects have been observed in other foam formulations with thermal conductivity reductions ranging from 3 to 15%.

Table 1 Foams Blown with Cyclopentane*

Additive Amount FA-188 (%)	Nominal Thickness (mm)	Density (kg/m³)	Initial Lambda, k (mW/mK)	Aged for 175 days at 70 °C (mW/mK)	Δk (mW/mK)	Initial Lambda Reduction (%)	Aged Lambda Reduction (%)
0	60	30.1	20.9	25.4	4.5		
2		29.7	19.8	24.1	4.3	5	5
4		29.8	19.3	23.2	3.9	8	9
0	80	31.7	20.8	24.1	3.3		
2		34.2	20.1	22.7	2.6	3	6
4		33.6	19.1	22.3	3.2	8	8
0	120	32.8	19.1	21.6	2.5		
2		33.0	17.7	19.8	2.1	7	8
4		33.2	17.6	19.3	1.7	8	11

*FIW Munich Test Report, October 2014

3M™ Foam Additive FA-188
Environment

Environmental considerations have been the principal forces driving changes in foam formulations for many years. The initial changes in foam formulations addressed the concerns with the use of ozone-depleting substances used as blowing agents. Additional changes have been occurring to manage the potential climate impact of the foam technology. Conversions to non-ozone depleting blowing agents have resulted in tradeoffs between HFC and hydrocarbon blowing agents. The HFC blowing agents provide the lowest thermal conductivity foam but the HFC compounds possess a significant global warming potential. Hydrocarbon blowing agents have very low global warming potentials (GWP) but typically produce less effective, more thermally conductive, foams.

Environmental regulations have also played a role in the switch from HFC to HC blowing agents. The main driver in the EU is the F gas regulation, where HFCs are currently in a phase down.

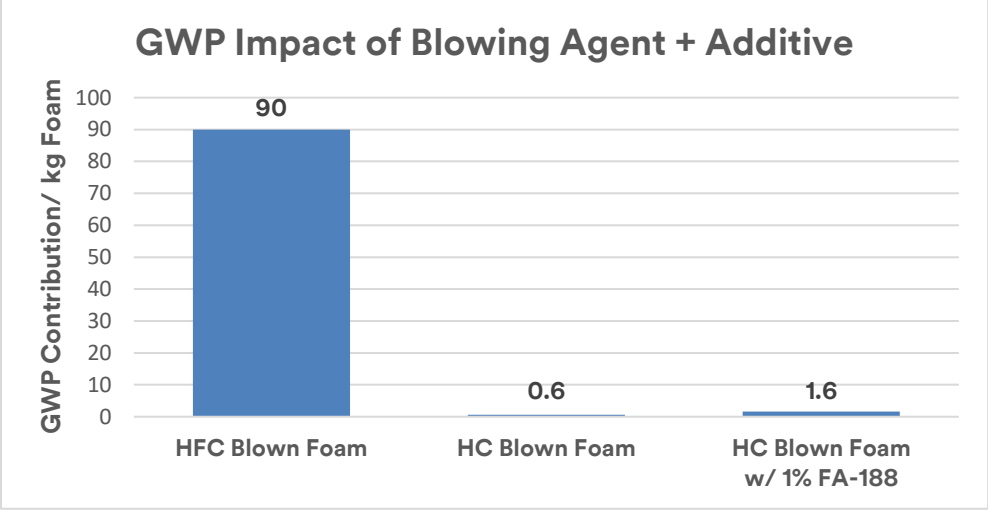
3M™ Foam Additive FA-188 has an excellent combination of environmental properties as shown in Table 2.

Table 2: Environmental Properties of 3M™ Foam Additive FA-188

Atmospheric Lifetime	1 year
Ozone Depletion Potential	0
Global Warming Potential (100 yr ITH)	80

The use of 3M foam additive FA-188 in hydrocarbon blown foam provides an improved thermal conductivity without any measurable increase in the global warming potential of the components. Figure 3 below compares the GWP contribution of a cyclopentane blown foam containing foam additive FA-188 to a foam blown without an additive, as well as to an HFC blown foam.

Figure 3: Comparison of GWP Contribution of Foam Formulations
Improved Climate Footprint of Foam Compared to Hydrocarbon Blown Counterpart



HFC blowing agents such as HFC-365mfc and HFC-245fa have nominal GWP of 900 and are used at approximately 10% of the foam formulation. A hydrocarbon such as cyclopentane has GWP of approximately 10 and is used at approximately 6% of the foam formulation. 3M™ Foam Additive FA-188 has GWP of 80 and is used at approximately 1% of the foam formulation

3M™ Foam Additive FA-188

Safety/Health

3M™ Foam Additive FA-188 is a fluoroalkene that has been investigated through a variety of toxicological tests. A workplace exposure guideline of 6 ppm by volume in air (8-hour time weighted average) has been established for this material. 3M foam additive FA-188 is relatively volatile with a vapor pressure at room temperature of 34.7kPa. When emulsified into the foam formulation, 3M foam additive FA-188 becomes encapsulated in the resin and its rate of evaporation is significantly reduced. As a result, potential exposure to 3M foam additive FA-188 is expected to be highest during its initial incorporation into the polyol resin.

Good industrial hygiene practices must be followed in order to maintain ambient air concentrations below the exposure guideline. 3M foam additive FA-188 is nonflammable and is highly resistant to thermal breakdown and hydrolysis in storage and during use. Recommended handling procedures are provided in the Safety Data Sheet. **Before using this product, contact your 3M sales or technical service representative regarding training on proper use of the product. Read the current product Safety Data Sheet (available online or through your 3M sales or technical service representative) and the Recommendations for Storage, Handling and Use.**

Summary

3M™ Foam Additive FA-188 offers a chemical solution to improve foam insulation with favorable environmental properties. Low levels of this fluorinated additive can have a significant effect on foam morphology producing a smaller, more uniform distribution of cells. This reduction in cell size produces lower thermal conductivity foam. Use of 3M foam additive FA-188 in combination with hydrocarbon blowing agents can produce a cost-effective foam technology with improved climate impact because of its low global warming potential and zero ozone depleting potential.

Shelf Life

The shelf life of 3M™ FA-188 is 36 months from the date of manufacture when stored in the original packaging materials and stored at 21°C (70°F) and 50% relative humidity.

Certificate of Analysis (COA)

The 3M Certificate of Analysis (COA) for this product is established when the product is manufactured and deemed commercially available from 3M. The COA contains the 3M specifications, test methods and test results for the products performance attributes that the product will be supplied against. Contact your local 3M representative for this product's COA.

Final product specifications and testing methods will be outlined in the products Certificate of Analysis (COA) that is shipped with the commercialized product.

3M™ Foam Additive FA-188

Safety Data Sheet: Consult Safety Data Sheet before use.

Regulatory: For regulatory information about this product, contact your 3M representative.

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