

Introduction:

Closed Cell Foam Insulation (CCF) has been used successfully in HVAC products as a thermal insulation. CCF offers many benefits over fiberglass insulation, which is the typical insulation used in HVAC products today. CCF insulating products are produced by using molten polymeric materials and non-CFC based blowing agents. When the blowing agent is introduced into the molten polymer, the closed cell air pockets are formed. CCF has a smooth, durable external surface that resists dirt and moisture accumulation, thus reducing the potential for fungal or biological pathogen growth. Because the surface is tough and resilient, it has a higher degree of puncture resistance when compared to fiberglass products. Even if the insulation surface is punctured, torn or otherwise damaged, the product still resists moisture absorption and microbial growth. CCF does not require an outer moisture vapor barrier or liner because the closed cell structure will not absorb moisture. The surface is easily cleaned if necessary to further resist microbial growth. CCF resists compression due to its rigidity and hence retains its thermal insulating capacity to a greater degree than fiberglass will under compressive forces. The cost of CCF is higher than that of fiberglass insulation and must be considered on price sensitive projects.

Physical Properties:

Closed Cell Foam insulation is a generic term used interchangeably for either Elastomeric or Polyethylene based insulation having a closed cell structure. These products are manufactured by several companies and are available in sheets, rolls, and tubing. Both products can be characterized as closed cell insulation designed to inhibit heat transfer and are routinely used in the HVAC and plumbing industry to prevent surface condensation. These products share some similar physical properties such as thermal conductivity, mold and mildew resistance, and air erosion resistance. However, one must be cognizant of other inherent differences in these two insulation materials prior to their specification or use in HVAC products.

Service Temperature:

One of the primary differences between the two CCF insulation materials is in the temperature limits of the insulation. Elastomeric materials are classified as thermoset. Thermoset materials have a gradual failure mode related to temperature rise and duration of exposure. As the temperature rises toward and above the service temperature limit of the material, the elastomeric materials slowly lose their elasticity and become brittle without noticeable dimensional change. Rapid temperature spikes for a short duration will not result in permanent or catastrophic failure. The elastomeric material will soften and lose its brittleness as temperatures return to normal.

Polyethylene based materials are classified as thermoplastic. This material begins to soften as the temperature approaches the service temperature limit. The temperature limit is based on the melting point of the polyethylene material used in the insulation. When the service temperature limit is reached, the product becomes plastic and catastrophically melts, shrinks, and slumps. Thermoplastic materials are very susceptible to temperature spikes even for a short period above their service limit. If the temperature is reduced, the material will not return to its previous shape because the cell walls collapse and hence will no longer perform as an insulator.

This photograph shows the effects of exceeding the service temperature limits for both types of insulation.



The sample on the left is a polyethylene-based material and the sample on the right is an elastomeric material. Each sample was exposed to a temperature corresponding with the upper service temperature limit for a period of 6-hours. Both samples were originally of the same size and thickness.

Polyethylene insulation has a lower temperature limit than elastomeric insulation. For service temperature limits see Physical Properties Comparison.

PHYSICAL PROPERTIES COMPARISON - CLOSED CELL FOAM INSULATION											
MFR.	Material Type	Characteristics	k @ 75°F. (BTU-in/hr-ft ² -deg F)	R (deg.F-ft ² -hr/BTU)				DENSITY (lb/ft ³)	TEMP RANGE (deg F)	MOISTURE PROPERTIES	
				3/8"	1/2"	3/4"	1"			ABSORP. (% VOL.)	VAPOR TRANS (perm-in)
Mfg. A	Elastomeric	Thermo-Set	0.277	1.35	1.81	2.71	3.61	6.0	-40 to 220	0.2	0.10
Mfg. B	Elastomeric	Thermo-Set	0.270	1.39	1.85	2.78	3.70	6.0	-70 to 220	0.5	0.10
Mfg. C	Elastomeric	Thermo-Set	0.250	1.50	2.00	3.00	4.00	6.0	-70 to 257	0.2	0.10
Mfg. D	Polyethylene	Thermo-Plastic	0.250	1.50	2.00	3.00	4.00	1.5	-160 to 200	0.1	0.05
Mfg. E	Polyethylene	Thermo-Plastic	0.250	1.50	2.00	3.00	4.00	1.5	-330 to 210	0.0	0.00

ACOUSTIC PROPERTY COMPARISON - CLOSED CELL FOAM INSULATION									
MFR.	Material Type	Characteristics	Sound Absorption Coefficients						
			ASTM C-423 (1" Insulation Thickness)						
			125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	NRC
Mfg. A	Elastomeric	Thermo-Set	0.16	0.15	0.45	0.36	0.20	0.29	0.30
Mfg. B	Elastomeric	Thermo-Set	0.17	0.07	0.16	0.69	0.18	0.28	0.30
Mfg. C	Elastomeric	Thermo-Set	NA	NA	NA	NA	NA	NA	NA
Mfg. D	Polyethylene	Thermo-Plastic	NA	NA	NA	NA	NA	NA	NA
Mfg. E	Polyethylene	Thermo-Plastic	NP	0.04	0.09	0.31	0.46	NP	0.25
	Fiberglass		0.10	0.32	0.64	0.84	0.98	1.01	0.7

NRC = Noise Reduction Coefficient
 NA = Not Available
 NP = Not provided

Acoustics:

Because CCF is generally more rigid and dense than fiberglass insulation, it does not absorb sound as well as fiberglass. This is especially true when one compares noise reduction coefficients and sound transmission classification between the materials. Laboratory tests performed in reverberant chambers confirm that discharge sound values are several decibels higher when using CCF than with fiberglass product. See Acoustic Property Comparison chart.

Code and Test Standard Conformance:

Insulation products are subjected to a series of nationally recognized standard tests to determine material physical properties and performance characteristics. Specific tests for conformance to fire and life safety, and building code compliance are denoted in the following table. Closed Cell Foam Insulation has been used successfully in HVAC products in lieu of fiberglass insulation however; one must be cognizant of claims to conformance to NFPA 90A and 90B when using polyethylene insulation. NFPA 90A and 90B require that duct-lining materials comply with test methods defined in ASTM C-411. This test standard is a witness test where visual observation of the material's propensity to resist warping, delamination, and its tendency to crack, smoke, glow, smolder, and deform is recorded. Since the test methods do not define specific amount of acceptable cracking, warping or delamination it is a subjective test. However, the basis for the test is to approve materials that do not deform, flame, smoke, glow, smolder, or crack. Since the minimum test temperature is 250°F., and polyethylene insulation catastrophically deforms at its service temperature limit, claims that passage of this test is impossible and hence compliance with NFPA 90A and 90B cannot be obtained.

PERFORMANCE TEST COMPLIANCE - CLOSED CELL FOAM INSULATION													
MFR.	Material Type	Characteristics	ASTM E-84		ASTM G-21	UL-181	UL-94	ASTM E-162	ASTM C-534	ASTM C-1427	ASTM C-411	NFPA 90A	NFPA 90B
			FSI	SDI								Conforms	Conforms
Mfg. A	Elastomeric	Thermo-Set	25	50	Pass	Pass	94-5V	25	Pass	NA	Pass	Yes	Yes
Mfg. B	Elastomeric	Thermo-Set	25	50	Pass	Pass	94-5V	25	Pass	NA	Pass	Yes	Yes
Mfg. C	Elastomeric	Thermo-Set	25	50	Pass	Pass	94-VO	25	Pass	NA	Pass	Yes	Yes
Mfg. D	Polyethylene	Thermo-Plastic	25	50	Pass	Pass	NP	25	NA	Pass	Fail	No	No
Mfg. E	Polyethylene	Thermo-Plastic	25	50	Pass	Pass	NP	25	NA	Pass	Fail	No*	No*
	Fiberglass		25	50	NA	Pass	NA	25	NA	NA	Pass	Yes	Yes
ASTM E-84 - Surface Burning Characteristics of Building Materials NFPA 255 and UL 723 are identical to this test standard FSI = Flame Spread Index SDI = Smoke Developed Index													
ASTM G-21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi													
UL-181 - Factory Made Air Duct materials and Air Duct Connectors Applicable sections: Mold Growth and Humidity Tests Air Erosion Tests													
UL-94 - Test for Flammability of Plastic Materials for Parts in Devices and Appliances													
ASTM E-162 - Surface Flammability of Materials Using a Radiant Heat Energy Source													
ASTM C-534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form													
ASTM C-1427 Standard Specification for Preformed Flexible Cellular Polyolefin Thermal Insulation in Sheet and Tubular Form													
ASTM C-411 - Standard Test Method for Hot Surface Performance of High Temperature Thermal Insulation													
NFPA 90A - Standard for the Installation of Air Conditioning and Ventilation Systems * Manufacturer E claims compliance, however to meet NFPA 90A compliance, ASTM C411 must be passed successfully. Since polyethylene insulation deforms at specified test temperatures in C411, a positive test cannot be achieved.													
NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems													
NP = No Data Provided NA = Not applicable													

Conclusion:

The use of Closed Cell Foam Insulation in HVAC appliances is a viable alternative to fiberglass insulation. CCF offers several advantages over fiberglass with regard to moisture absorption and its resistance against microbiological contamination. It is a superior product in its durability when compared to fiberglass. CCF however does not perform as well as fiberglass acoustically. If acoustics are not the primary concern on a project then CCF is an acceptable alternative. CCF costs more than fiberglass however, when one reviews the benefits of CCF as an inhibitor of microbial growth, first cost concerns are usually waived.

If CCF insulation is required, one must understand the inherent differences of the types of CCF insulation available today. Not all CCF insulation is manufactured of acceptable materials for use in HVAC products. One must specify elastomeric insulation in lieu of polyethylene insulation to prevent the potential for catastrophic failure if the insulation is exposed to service temperatures close to or in excess of its service temperature limits. All insulating materials used in HVAC products must meet the requirements of NFPA 90A. It is therefore essential that CCF products that have passed ASTM C-411 be specified. Polyethylene insulation does not meet the criteria of this standard regardless of the insulation Manufacturer's claims. Elastomeric based CCF insulation is the product of choice.