AFLAS® FLUOROELASTOMERS

AFLAS® technical bulletin

AFLAS® Processing Recommendations

DESCRIPTION

AFLAS® Fluoroelastomers are copolymers of tetrafluoroethylene and propylene. This combination gives AFLAS Fluoroelastomers unique properties over conventional FKM-type fluoroelastomers in demanding applications found in the oil & gas, chemical process, wire & cable, industrial equipment, food handling, pharmaceutical, heavy duty diesel and automotive industries.

PROCESSING METHODS

AFLAS is a unique elastomer with outstanding performance properties distinct from those of FKM-type fluoroelastomers. AFLAS has a slow curing speed and some resistance to mold-release, characteristics that require skillful processing. Use these recommendations to ensure optimal performance with AFLAS, which can be processed using the following common methods:

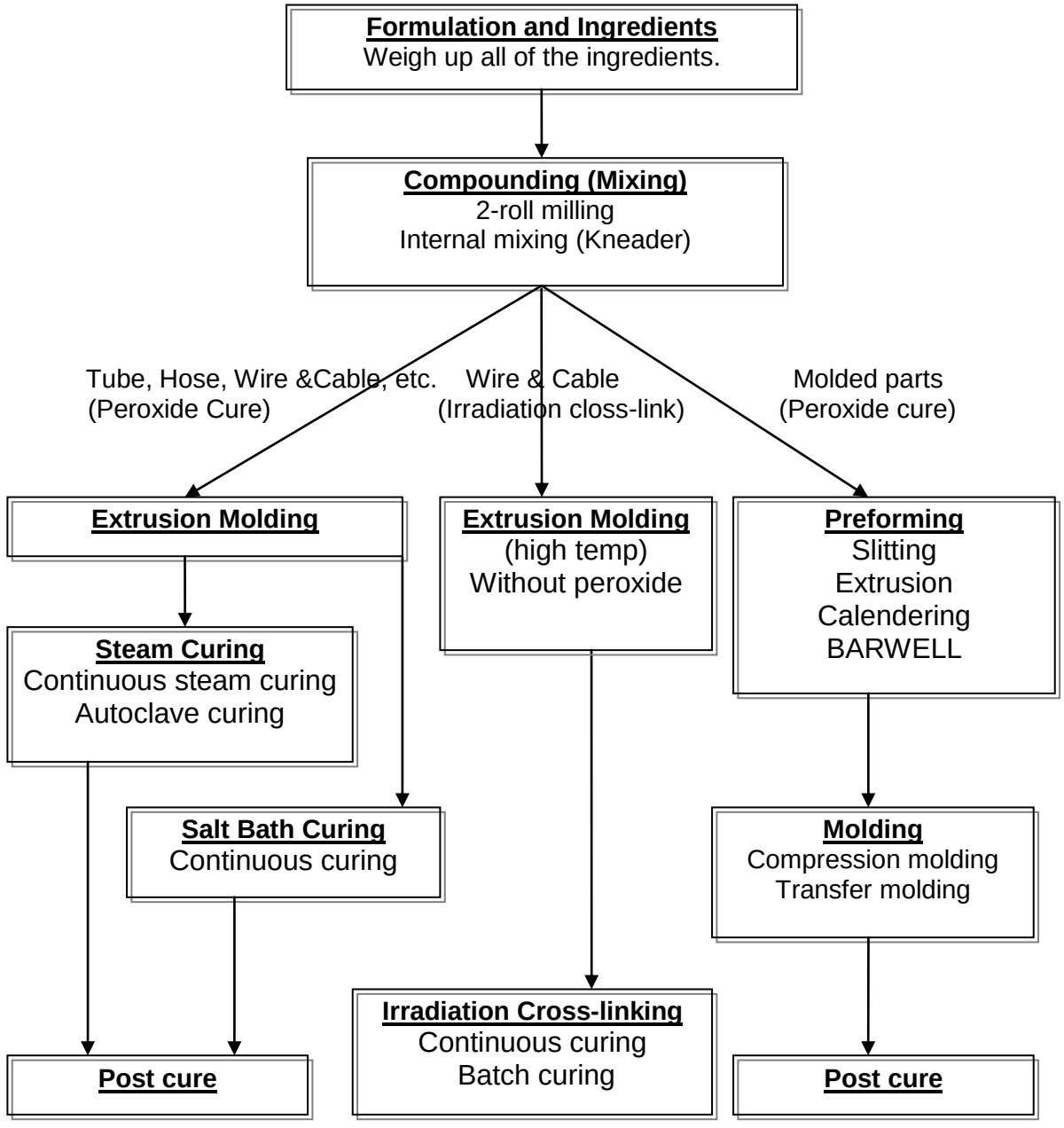
- Compression molding
- Transfer molding
- Extrusion molding

Polymer Type	Curing Method	Grades	Index of MW	Mooney Viscosity	Molding Method			Features
			G'	ML1+10,100℃	Compression Molding	Extrusion	Transfer	
100/150 series	Peroxide cure	100H	500	≧ 200	○			High hardness
		100S	340	160	○			High strength
		150P	240	90	○	○	○	General purpose
		150E	160	60		◎	○	Extrusion
		150L	80	30		○	○	Lining
	Electron beam cure	150C	490	≧ 200		○		High strength
		150CS	390	140		○		Extrusion
200 series SPL FKM	Peroxide cure	200P	220	90	○	○	○	Low-temperature flexibility

○: Applicable ◎: Most Suitable

AGC Chemicals Americas, Inc.
Business & Technical Center
55 E. Uwchlan Ave, Suite 201
Exton, PA 19341
Phone: 610.423.4300
Fax: 610.423.4301
http://www.agcchem.com

PROCESSING FLOWCHART



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FORMULATION AND INGREDIENTS

1. Formulation

AFLAS is peroxide curable. No curing promoters are incorporated in the product. The standard formulations are shown in Table 2. Use only suitable ingredients with AFLAS.

Table 2 Standard formulations (For 70 Shore-A Hardness, Black)

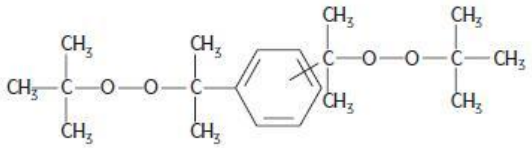
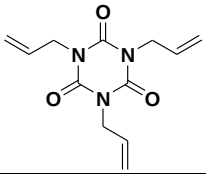
Components	100H	100S	150P	150E	200P
Polymer	100	100	100	100	100
MT-Carbon (N990)	30	30	30	30	25
TAIC	5	5	5	5	5
Peroxide *1 (as 100% active)	1	1	1	1	1
MgO					3
Sodium stearate (St-Na)	1	1	1	1	1

*1 1,3-di(t-buthylperoxy)-diisopropylbenzene (100% active)

2. Ingredients

Table 3 shows suitable ingredients for use with AFLAS.

Table 3 Suitable ingredients

Ingredients	
Curing agent (Peroxide) **Key point** Select the preferred peroxide and add it at a suitable level to ensure optimal AFLAS performance. You can also dilute these peroxides by adjusting the essential active levels using a carrier..	1,3-di(t-buthylperoxyisopropyl)benzene  Typical products Perkadox® 14 (100%) Luperox® F (100%) Vul-Cup® (100%) Perbutyl® P (100%)
Curing co-agent	TAIC (Triallylisocianurate) Typical products TAIC TAICROSS Saret® SR-533 

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Acid acceptor for AFLAS 200	MgO (Magnesium oxide) (High activity type)
Processing aid for AFLAS 100, 150, 200	St-Na (Sodium stearate) Typical product Nonsoul SN-1 (powder)
Other processing aids (at most 2 per hundred rubber - phr)	Typical product Struktol® WS-280, HT-290 ACPE AC-617A (for extrusion) Carnauba WAX
Reinforcing filler	Carbon Black N990 (MT-Carbon) Silica (White carbon)
Other Non-Black filler	BaSO4 CaCO3 Talc TiO2 Diatomite Etc.
Surface improver for extrusion	ACPE AC-617A

COMPOUNDING EQUIPMENT

Mix the raw gum and other ingredients in a conventional mixer for commercial elastomers, such as a 2-roll mill, kneader, Banbury® mixer, or extruder. A 2-roll mill is an open mixer, while the other types are internal mixers. A 2-roll mill and kneader are typically used for fluoroelastomers.

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COMPOUNDING PROCEDURES

1. Procedure of 2-roll milling
   a. Weigh up all of the ingredients

☆Note

When mixing AFLAS, there is no need to feed the ingredients into the roll separately. Weigh all of the ingredients together. TAIC is prone to slipping on roll mills and should be absorbed by other fillers in advance. This shortens the processing time.

b. Polymer milling

☆Note

Feed 100H or 100S gradually into the 2-roll mill (because of its extremely high Mooney viscosity). Use your preferred internal cooling system to cool off any heat generated by the 2-roll shear.

c. Mixing

☆Note

Use your preferred internal cooling system to cool the heat generated by the shear stress during mixing. Keep the roll temperature below 80˚C. Mix all of the ingredients into the rubber gradually.

d. Final mixing

☆Note

Narrow the distance between the two rolls to obtain a high enough shear stress to obtain good dispersion. Mix the ingredients well until no lumps are seen in the compound.

e. Preforming full compound

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2. Kneading procedure (internal mixer):
   a. Make sure the mixer is completely clean by running a cleanout batch using raw gum of EPDM or other with no cure additives or fillers prior to mixing.
   b. Premix all ingredients except the peroxide.
   c. Use full cooling water on all rotors and chamber. Rotor speed should be between 30 and 40 rpm and the ram pressure generally between 60 and 80 psi. Add the AFLAS to the chamber and lower the ram. Breakup the polymer for about 1 minute. The temperature should reach approximately 120° to 130°F (49° to 54°C).
   d. Add ½ the premixed ingredients. Lower the ram and continue mixing until the temperature reaches between 150° and 180°F (66° to 82°C). Add the remaining additives (except the peroxide) and mix until temperature reaches 200° to 220°F (93° to 105°C). Raise the ram and sweep. Lower ram and continue until a temperature of 220° to 250°F (105° to 121°C) is reached.
   e. Dump the batch onto a mill (which should also use full water cooling). Adjust mill gap to get a uniform bank rolling. Add the peroxide and make cuts and folds until the peroxide is fully dispersed.
   f. Alternatively, if you want to add the peroxide into the mixer it should be done on a second pass, i.e., remove the first mix and allow to cool. Once cool, add back to mixer and mix 1 minute to once again breakup and then add the peroxide. Continue to mix until the temperature has reached 190° to 220°F (88° to 105°C). Remove the batch and use mill to get a uniform sheet. Allow to cool.

☆Note

When mixing high molecular weight AFLAS grades, such as 100H or 100S, it is recommended to pre-heat the raw gum overnight in a “hot room”, between 150° to 160°F (65° to 71°C) prior to chopping up and feeding the mixer. Feeding the mixer with warm AFLAS helps to overcome the initial high energy required to mix these grades by reducing the raw gum viscosity.

3. Check dispersion level of processing aid:
   One of the best processing aids for AFLAS is St-Na (Sodium Stearate). If the St-Na disperses poorly, this will require additional mixing to improve dispersion.

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STORING FULL COMPOUND

Store the full compound at room temperature in a dry environment.

1. AFLAS full compound tends to stick together when stacked. To avoid sticking, apply a powder filler like Talc to the surface.
2. When storing AFLAS full compound for long durations, the TAIC tends to bleed out (see the picture below). If bleeding appears, re-mill the AFLAS full compound.

Left : Full-compound with TAIC bleeding
Right : Re-milled

3. If TAIC starts to bleed out, the loss of TAIC will reduce the curability of the full compound.
4. If TAIC is bleeding out, be sure to re-mill the full compound before molding. Molding without re-milling may result in mold fouling and poor mold release.

MOLD RELEASE RECOMMENDATIONS

1. Processing Aids
   It is strongly recommended to use processing aids to improve not only mixing but also mold release. 1 phr of St-Na is recommended for AFLAS 100, 150, 200. Additionally, 1 to 2 phr of Struktol WS-280 or HT-290 is also effective.

2. Mold-release Agents
   It is strongly recommended to apply a mold-release agent onto the mold when processing AFLAS by compression molding. A silicone-type mold-release agent is generally effective for AFLAS. A mold-release agent such as TraSys® 9825 by DuPont is recommended. If it is needed to be silicone free, a mold-release agent such as TraSys 818 by DuPont is recommended. Select a suitable compression temperature and time. AFLAS cures more slowly than other synthetic rubber. Insufficient curing can have a negative effect on mold release.

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MOLDING PROCEDURES

1. Compression molding

   Chrome-plated molds are recommended. Clean the mold and use a mold-release agent before molding. The recommended molding temperature is from 170° to 180° C. Adjust the molding time by mold size and design. AFLAS cures more slowly than other synthetic rubber. Compression molding takes somewhat longer to finish. For the compression molding of small parts like O-rings, we recommend a molding temperature of 170° to 180° C and molding time of 10 to 20 minutes.

   Figure 1 shows the cure rates for a standard AFLAS formulation at different curing temperatures. Use this graph to decide the curing condition for compression molding.

2. Extrusion molding

   AFLAS 150E was designed for extrusion moldings such as wire insulators, tubes, tapes, etc.. The low viscosity of AFLAS 150E results in faster extrusion and smoother surfaces in extrusion molding. Keep the compound temperature in the extruder below 100° C to prevent premature curing. The top of the extruded and shaped compound is connected to the winding roll through the curing equipment. Many different types of curing equipment can be used, including steam autoclaves, liquidized lithium salt baths, oil baths, or electron beam radiation devices.

   If the extruded compound is wound up before curing, the shaped compound may easily deform. The length of the curing equipment and winding speed controls the curing time. The curing temperature is higher than 200° C. The curing time is usually kept within a few minutes to ensure productivity. Use your own mold shapes and equipment to control the curing temperature and curing time.

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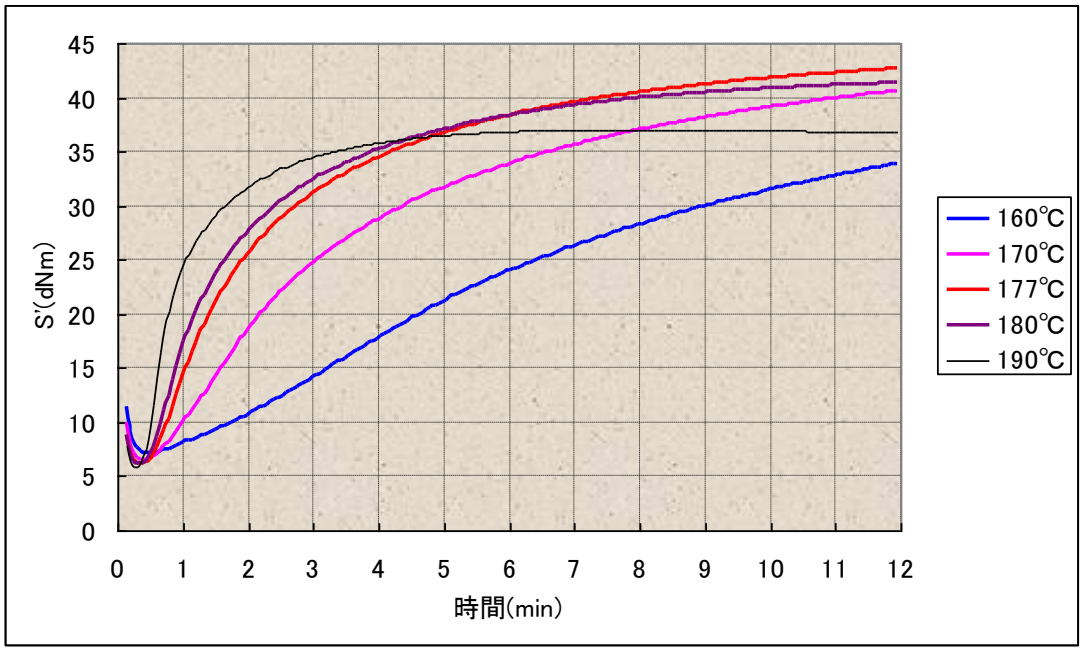
Figure 1: The cure rates for AFLAS depend on temperature.

Cure rate for AFLAS150P standard formulation. (Same tendency for every grade.)
Torque number (S') measured by a Rubber Process Analyzer (RPA2000).



Temperature	MH (dNm)	ML (dNm)	MH-ML	T10 (min)	T90 (min)
160 ℃	33.9	7.2	26.7	1.7	9.8
170 ℃	40.6	6.6	34.0	1.0	8.2
177 ℃	42.7	6.2	36.5	0.8	6.5
180 ℃	41.4	6.2	35.2	0.7	5.6
190 ℃	37.0	5.8	31.2	0.5	2.8

MH-ML stands for curability.
T10 stands for the time recommended from compound placement to start of compression.
T90 stands for the minimum required curing time.

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POST CURE

The post cure is a form of heat treatment for the press-cured article. The post cure enhances the physical properties, including the tensile strength and modulus. It also improves the compression set and decreases elongation.

An air-circulating gear or convection oven is recommended as the post cure equipment. In a peroxide cure, the peroxide decomposition generates low-molecular weight residual volatiles. The post cure eliminates these residual volatiles. The conditions for the post cure should therefore be mild: usually at 200 to 230° C for 4 to 24 hours (for cured articles of average size). When a cured article is rather thick, set the temperature low at the beginning of the post cure and raise it gradually to the final temperature, either continuously or stepwise, over a long period of time. When post-curing a small article, the stress inside the article sometimes generates cracks. The stress in smaller articles should be released gradually.

Recommended post-cure condition for AFLAS grades

AFLAS 100/150 series	200° C × 4 hours
AFLAS 200P SPL FKM	230° C × 24 hours

TROUBLE SHOOTING

Trouble	Action
Mold-release problem (Sticks to mold)	1) Like most fluoroelastomers, AFLAS starts out as a sticky material. Use St-Na to avoid mold-release problems. 2) Use a mold-release agent when processing AFLAS by compression molding. A silicone-type mold-release agent is generally effective for AFLAS. Use an agent such as TraSys 9825 from DuPont. 3) Select a suitable compression temperature and time. AFLAS cures more slowly than other synthetic rubber. Insufficient curing can have a negative effect on mold release. 4) Chrome-plated molds are recommended.
Bubbles in the molded parts	Poor St-Na dispersion may lead to bubbling in the molded and cured product. For good dispersion, a powder-type St-Na is recommended.
Lower properties	1) Select a recommended peroxide at a suitable level to achieve the best AFLAS performance. You can also dilute one of these peroxides by adjusting the essential active level. 2) This may reduce the curability. A longer curing time and appropriate post cure are required.

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NOTE: The data listed here represents typical values for the stated grades of AFLAS® fluoroelastomers. This information should be used as a guide only and not to establish specification limits or design criteria. AGC Chemicals Americas assumes no obligation or liability for any advice furnished by us or for results obtained with respect to this product. All such advice is provided free of charge and the buyer assumes sole responsibility for results obtained in reliance thereon.

For more information and samples contact

AGC Chemicals Americas, Inc.
55 E. Uwchlan Avenue, Suite 201
Exton, PA 19341
Phone: (800) 424- 7833
Fax: (610) 423-4301

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