



One-pass Sponge Weatherstrip Processing Guide

NORDEL™ 6555 OE EPDM

Product Description

NORDEL™ 6555 OE EPDM is an amorphous grade of ethylene propylene diene terpolymer (EPDM) designed for extruded foam applications. It is ideally suited for extruded sponge profiles requiring fast curing conditions. The combination of high viscosity and low crystallinity allows for good balance of processability, extensibility, low temperature properties, and performance. The NORDEL™ 6555 OE EPDM product features improved mixing and extrusion characteristics, suitable for class A surface manufacturing, with improved shape stability of the green compound.

Main characteristics:

- Amorphous
- High diene
- High molecular weight
- Good low temperature properties
- Complies with U.S. FDA 21 CFR 175.105 (consult regulations for complete details)

Table 1: ASTM & ISO Properties⁽¹⁾

Property	Nominal Value	Units	Test Method
Specific Gravity	0.862	g/cc	ASTM D297
Mooney Viscosity (ML 1+4 at 125°C)	55	MU	ASTM D1646
Ethylene Content	53.0	wt%	ASTM D3900
Ethylidene Norbornene (ENB) Content	8.5	wt%	ASTM D6047
Ash Content	< 0.1	wt%	ASTM D296
Molecular Weight Distribution	Medium		Dow Method
Propylene Content	38.5	wt%	ASTM D3900
Oil Content	20-23	phr	Dow Method
Residual Transition Metal	< 10	ppm	Dow Method
Volatile Matter	< 0.40	wt%	Dow Method

⁽¹⁾ Data per tests conducted by Dow. Additional information available upon request. Properties shown are typical, not to be construed as specifications. Users should confirm results by their own tests.

Applications:

- Extruded profiles (dense or sponge)
- Coolant hoses

Model Formulation

NORDEL™ 6555 OE EPDM Rubber was utilized to successfully produce closed cell sponge weatherstrip profiles via a one-pass process to enable flexibility in processing and meet customer needs.

A rubber internal mixer with a net volume of 135 L equipped with an intermeshing rotor design and hydraulic ram control was used in this evaluation. However, other rubber mixing equipment can be utilized with appropriate mixing procedures and mixing conditions. See list below:

- Rubber internal mixer: intermeshing rotor design
- Rubber internal mixer: tangential rotor design
- Rubber kneader
- Two-roll mill

Table 2: One-pass Formulation (EPDM & other small chemicals)

Material	Formulation (phr)
NORDEL™ 6555 OE	120.0
Sunpar 2280	70.0
Calcium Carbonate	50.0
N-550 Carbon Black	90.0
PEG 4000	2.0
Stearic Acid	2.0
Zinc Oxide	5.0
Curatives	
Azodicarbonamide (ADC)	4.50
Tellurium Diethyldithiocarbamate (TDEC) 80%	0.16
Calcium Oxide (80% dispersion)	2.00
Sulphur (80% dispersion)	1.88
2-2'-Dithiobis(benzothiazole) (MBTS) 70%	0.36
Mercaptobenzothiazole (MBT) (80%)	1.88
Zinc Dibutyldithiocarbamate (ZDBC) 80%	3.90
Tetramethylthiuram Disulfide (TMTD) 75%	0.95
Zinc Dibutyldithiophosphate (ZnBPD) 50%	2.00
Total Parts	356.63

One-pass Mixing Procedure

The following mixer settings and mixing procedure were utilized for one-pass mixing:

- Fill factor = 0.73
- Bath size = 114.6 Kg

For detailed steps, see Table 3.

Table 3: One-pass Mixing Procedure

Step	Command	Logic	Time (s)	Temp. (°F [°C])	Rotor RPM
1	Raise Ram	None	–	–	45
2	Charge Black/White/Oil	None	–	–	45
3	Auto Charge EPDM	None	20	–	45
4	Close Hopper Door	None	–	–	45
5	Lower Ram	TEMP	–	158 [70]	45
6	Raise Ram	None	10	–	30
7	Charge White/Oil	None	20	–	30
8	Auto Charge Curatives	None	20	–	15
9	Close Hopper Door	None	–	–	15
10	Lower Ram	TEMP	–	185 [85]	15
11	Raise Ram	TIME	10	–	12
12	Lower Ram	TEMP	–	203 [95]	12
13	Discharge Warning	TIME	3	–	12
14	Open Drop Door	TIME	45	–	30
15	Close Drop Door	None	–	–	30

One-pass Mixing Curves

Mixing curves for the one-pass mixing process are included in Figure 1. Good temperature control and fast mixing cycles (<5 min) were achieved with this model formulation and mixing procedure. Good mixing power (180 kW) was also achieved, enabling good filler dispersion.

One-pass Compound Analysis

NORDEL™ 6555 OE EPDM-based one-pass sponge compound was designed to have a faster cure rate in order to balance curing and foaming properties during the vulcanization process (see Table 4). The target ts2 at 180°C was approximately 0.4 min.

Extrusion and Vulcanization

NORDEL™ 6555 OE EPDM-based sponge compounds were extruded on a 3.5-inch rubber cold feed extruder with a 10:1 L/D ratio to form the desired profile shape shown in Figure 2.

Figure 2: Omega Testing Profile Die Utilized for Extrusion

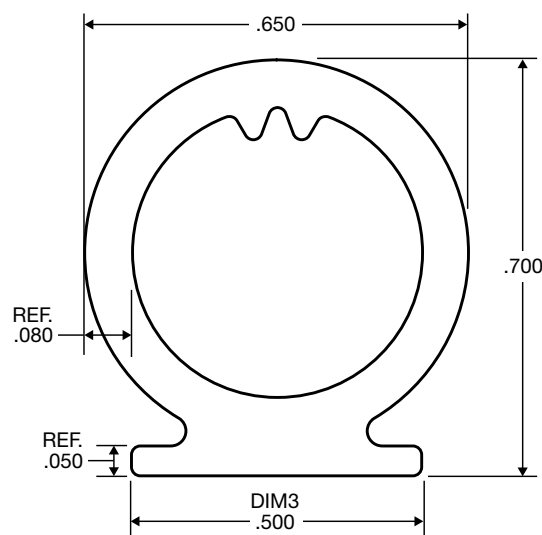


Figure 1: One-pass Mixing Curves⁽¹⁾

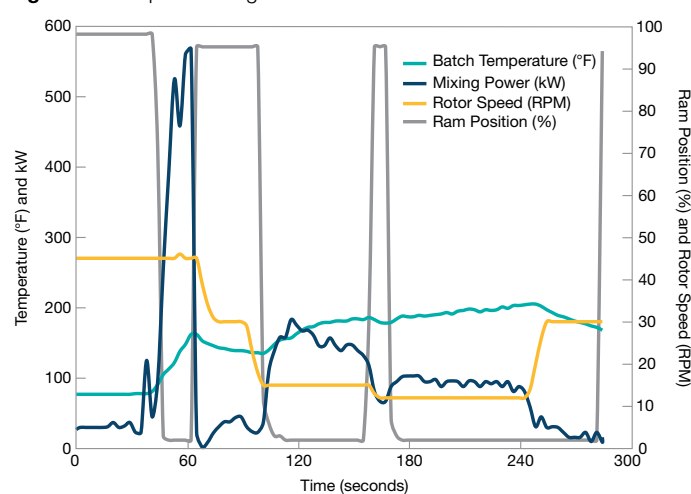


Table 4: One-pass Compound Analysis⁽¹⁾

Test Conditions	Properties	Units	One-pass Formulation
MDR @ 180°C and 8 min	ts1	min	0.40
	ts2	min	0.50
	t10	min	0.43
	t50	min	0.99
	t90	min	3.09
	ML	dNm	1.16
	MH	dNm	13.82

⁽¹⁾ Data per tests conducted by Dow. Additional information available upon request. Properties shown are typical, not to be construed as specifications. Users should confirm results by their own tests.

The extruded profile was continuously cured on a continuous vulcanization (CV) line, which is a combination of multiple hot air and microwave ovens. High quality, closed cell sponge profiles were successfully produced via the previously mentioned process. In this particular study, the CV line consists of a total of three 20-foot ovens (see Table 5). The first and third ovens are hot air ovens with adjustable speed, temperature, and air velocity. The second oven is a 20-foot microwave oven with three adjustable power outputs (max power 6 kW) as well as adjustable speed, temperature, and air velocity.

Table 5: Extrusion and Vulcanization Settings

Extruder	Units	One-pass Formulation
Screw Temperature	°F (°C)	125 (52)
Zone 1 Temperature	°F (°C)	150 (66)
Zone 2 Temperature	°F (°C)	150 (66)
Zone 3 Temperature	°F (°C)	150 (66)
Zone 4 Temperature	°F (°C)	150 (66)
Speed	RPM	19
Hot Air Oven # 1		
Oven Length	ft	20
Temperature	°F (°C)	450 (232)
Speed	fpm	30
Microwave Oven		
Oven Length	ft	20
Temperature	°F (°C)	450 (232)
1-Bottom	kW	0.5
2-Top	kW	0.5
3-Bottom	kW	0.5
Speed	fpm	33
Hot Air Oven # 2		
Oven Length	ft	20
Temperature	°F (°C)	450 (232)
Speed	fpm	35
Last Belt		
Speed	fpm	44

EPDM Sponge Profile Properties

Good surface quality and a uniform closed cell structure were achieved for the one-pass model formulation (see Figure 3).

The model formulation based on NORDEL™ 6555 OE EPDM yielded sponge profiles with low water absorption, low compression set, and good surface quality at target densities. Additionally, the tensile and tear properties exceeded specification targets (see Table 6).

Figure 3: Cross-sectional Morphology of EPDM Sponge Profile Based on One-pass Model Formulation

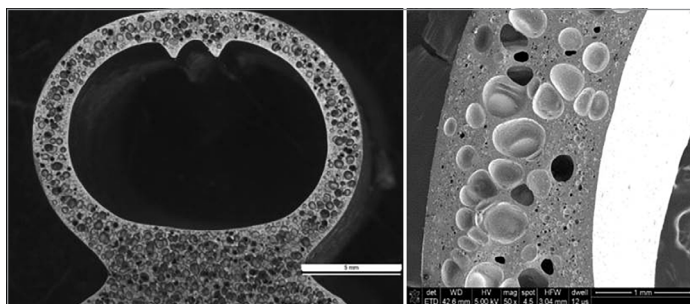


Table 6: EPDM Sponge Profile Properties⁽¹⁾

Properties ⁽²⁾	Units	Specification ⁽³⁾ VW-TL52704 & Chrysler-MS-AK-92/ Sponge Grade 2	One-pass Formulation
Density	pcf (g/cc)	28-41 (0.45-0.65)	41.5 (0.66)
CLD ⁽⁴⁾	lbf (kgf)	—	1.58 (0.72)
CLD ⁽⁵⁾	lbf (kgf)	—	2.53 (1.15)
Compression Set ⁽⁶⁾	%	—	3.2
Compression Set ⁽⁷⁾	%	—	25.0
Water Absorption	%	≤5	0.26
Tensile Strength	psi (MPa)	≥435 (≥3)	695.0 (4.8)
Tear (Die °C) Strength	lbf/in (kN/m)	≥11.4 (≥2.0)	63.4 (11.1)

⁽¹⁾ Data per tests conducted by Dow. Additional information available upon request. Properties shown are typical, not to be construed as specifications. Users should confirm results by their own tests.

⁽²⁾ Measurements were taken on fabricated sponge profiles.

⁽³⁾ This term and any corresponding data refers to typical performance in the specific tests indicated and should not be construed to imply these materials meet VW-TL52704 and Chrysler-MS-AK-92/Sponge Grade 2 sponge specifications.

⁽⁴⁾ Compression Load Deflection: Compress 25% on a 100 mm profile. The profile was pre-flexed three times at 40% deflection.

⁽⁵⁾ Compression Load Deflection: Compress 40% on a 100 mm profile. The profile was pre-flexed three times at 40% deflection.

⁽⁶⁾ Compression Set: Compress 50% deflection for 22 hours at room temperature on 100 mm piece and recovery for 24 hours.

⁽⁷⁾ Compression Set: Compress 40% deflection for 22 hours at 70°C on 100 mm piece and recovery for 2 hours.

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