PROCESSING GUIDELINES

TUBALL™ MATRIX 605
for high consistency silicones
in the hardness range from 30 to 70 shore A

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V07_20231213

1. MIXING EQUIPMENT

Figure 1. 2-roll mill

Figure 2. Kneader

2. DILUTION PRINCIPLES

Uniform distribution of TUBALL™ MATRIX in the silicone plays a key role in enhancing the electrical conductivity of the final compound. In order to obtain a high-quality TUBALL™ MATRIX dispersion, OCSiAl recommends that close attention be paid to the dilution procedure.

- The resistivity level achieved will depend on the loading of TUBALL™ MATRIX. The target dosage of TUBALL™ MATRIX refers to the loading in the whole HCR formulation by weight.
- The mixing time, number of mixing cycles and mixing speed may need to be adapted for different machinery size/type to obtain a final mixture that is homogeneous.
- The dilution ratio depends on the required level of resistivity and the loading of TUBALL™ MATRIX.

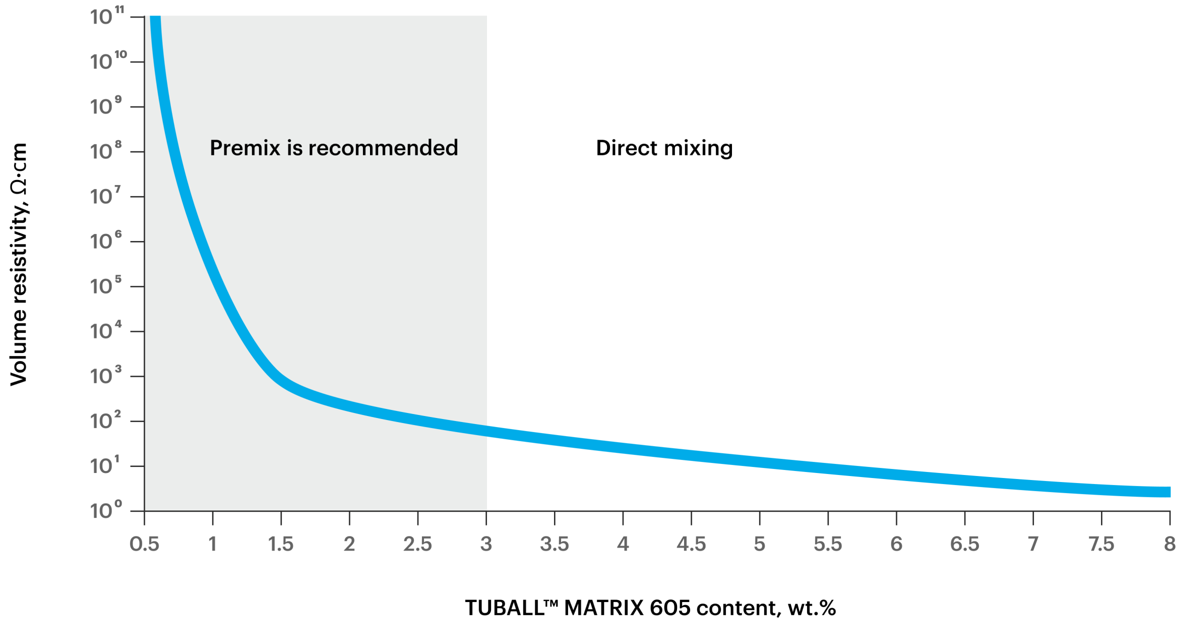


Figure 3. Volume resistivity of 60 Hardness HCR silicone (ELASTOSIL® R 401/60) with TUBALL™ MATRIX 605 in the range 10–10^{11} Ω·cm (sample shape: **compression-molded** rubber sheet of 2 mm thickness, compounded on two-roll mill)

! Please do mention, that due to extremely low dosage of conductive filler active content in HCR, percolation threshold could be affected by type of the filler in HCR (fumed silica based and precipitated silica based).

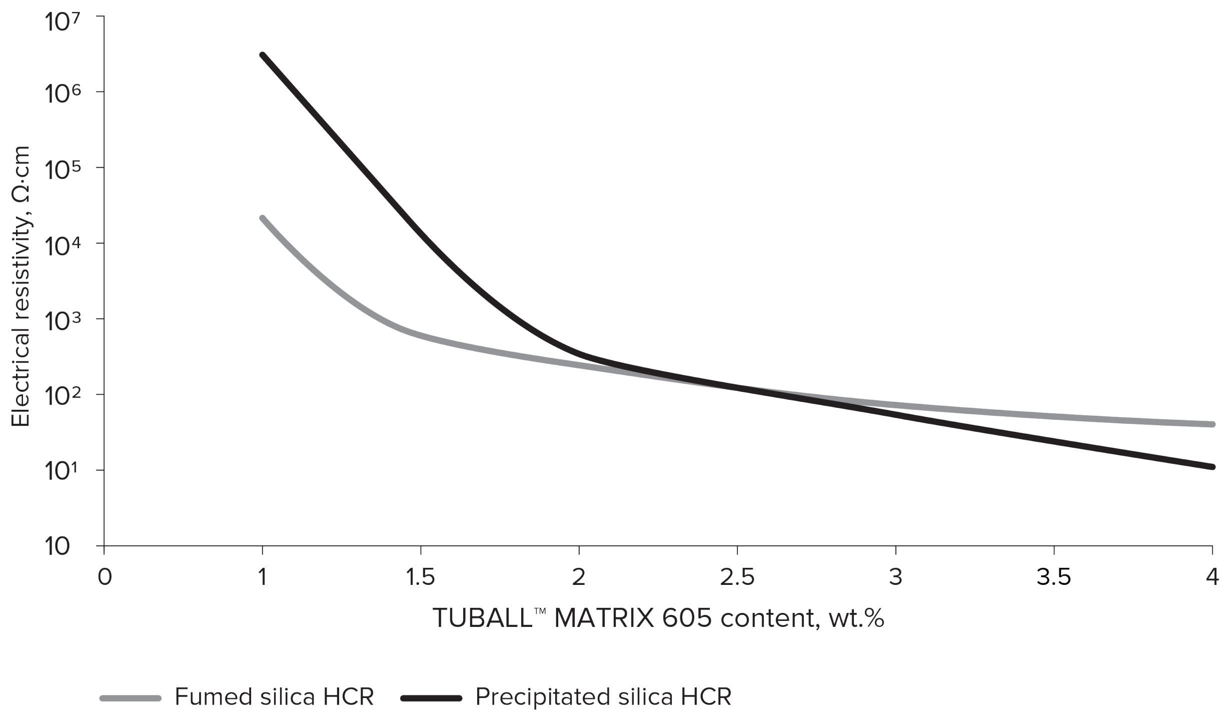


Figure 4. Volume resistivity of two types of 60 Hardness HCR silicone (fumed silica-based and precipitated silica-based) with TUBALL™ MATRIX 605 in the range 10^1–10^7 Ω·cm (sample shape: compression-molded rubber sheet of 2 mm thickness, compounded on two-roll mill)

Key principles of dispersion of TUBALL™ MATRIX:

The dispersion quality depends strongly on two factors:

a) the mechanical dispersion characteristics (shear forces during the compounding):
   - type of machinery
   - mixing modes

b) the carrier compatibility:
   - viscosity of silicone base.

TUBALL™ MATRIX 605 is a high viscous carrier and thus the best compatibility is achieved with HCR in the hardness range from 50 to 70 Shore A. For HCR with lower hardness, such as 30 Shore A, a slightly higher concentration of TUBALL™ MATRIX 605 is required than that discussed in the guidelines below, because of the different shear force.

! For exact percolation curves for low Hardness HCR (30 Shore A) and high Hardness (50-70 Shore A) mixed on two-roll mill and kneader please refer to Technical datasheet for TUBALL™ MATRIX 605.

Figure 5 shows how the volume resistivity, the number of cycles on a two-roll mill and the TUBALL™ MATRIX distribution correlate. Plotting such a graph allows the optimal number of cycles to be determined.

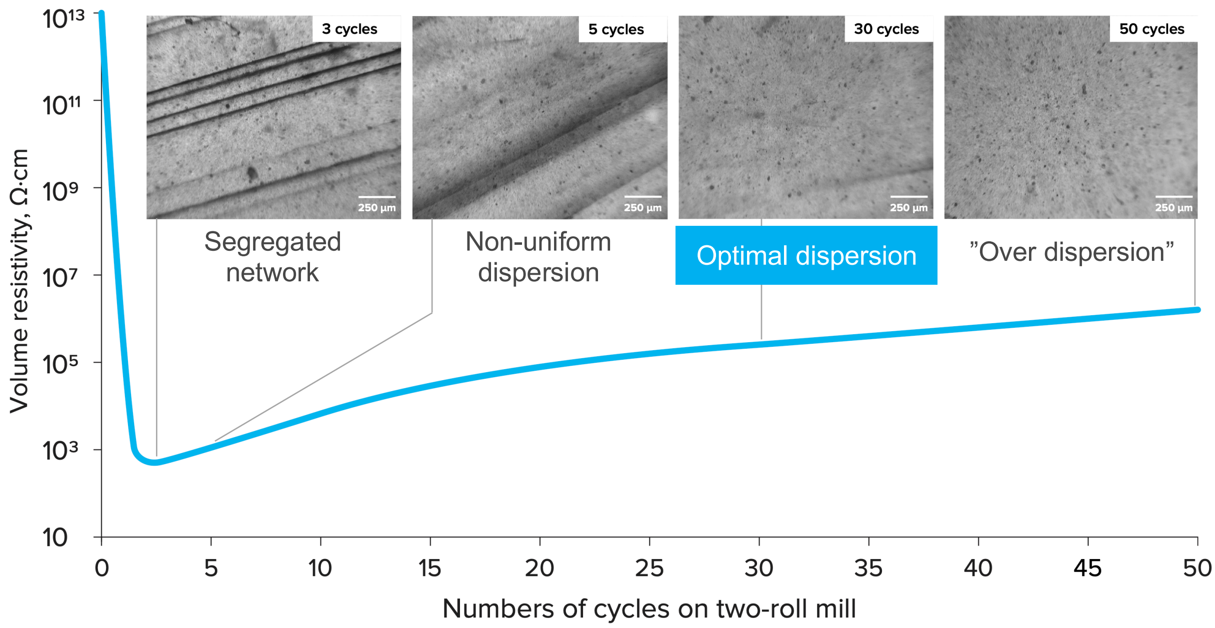


Figure 5. Correlation of volume resistivity, number of cycles on a two-roll mill and TUBALL™ MATRIX 605 distribution, TUBALL™ MATRIX 605 content — 0.8 wt. %

3. DILUTION WITH A 2–ROLL MILL WITH AND WITHOUT PREMIXING

Below is a description of the cycle on a 2-roll mill (“Roll and upend” mixing):

1. Turn on the machine and feed the materials between the rollers.
2. Remove material and form it into a tube – this is called a “cycle”.
3. Turn the material by 90° and feed it back between the rollers as shown below.
4. Repeat steps 2 and 3 until **required number of cycles** have been fed through.

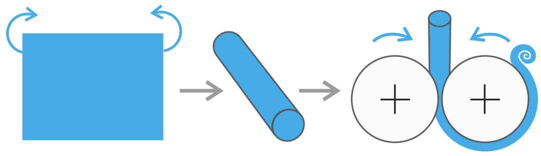


Figure 6. "Roll and upend" mixing

DILUTION PROCEDURE

INITIAL STAGE

Basic compound preparation

Prepare compound with HCR, peroxide and other components (pigments, etc.) according to your standard procedure

VOLUME RESISTIVITY OF 10^3–10^9 Ω•cm – ANTI-STATIC COMPOUNDS

Loading 0.5–3 wt.% of TUBALL™ MATRIX

a) Premixing stage of TUBALL™ MATRIX 605

Set the gap between rollers ⟶ Add 10% TUBALL™ MATRIX 605 and 90% HCR into 2-roll mill ⟶ Number of cycles 30

Diameter of rollers	Gap
6, 10 14 inch	3 mm

b) Final mixing

Set the gap between rollers ⟶ Add pre-mixed TUBALL™ MATRIX 605 (see (a)) and basic compound from initial stage into 2-roll mill ⟶ Choose number of cycles

Diameter of rollers	Gap
6 inch	<300 g batch – 3 mm, >300 g batch – 6 mm
10 inch	<0.5 kg batch – 3 mm, 0.5–3 kg batch – 8 mm
14 inch	5–10 kg batch – 12 mm

Compound	Number of cycles
Black compound	15
Color compound	30

VOLUME RESISTIVITY OF <10^3 Ω•cm – CONDUCTIVE COMPOUNDS

Loading 3–10 wt.% of TUBALL™ MATRIX

Direct mixing

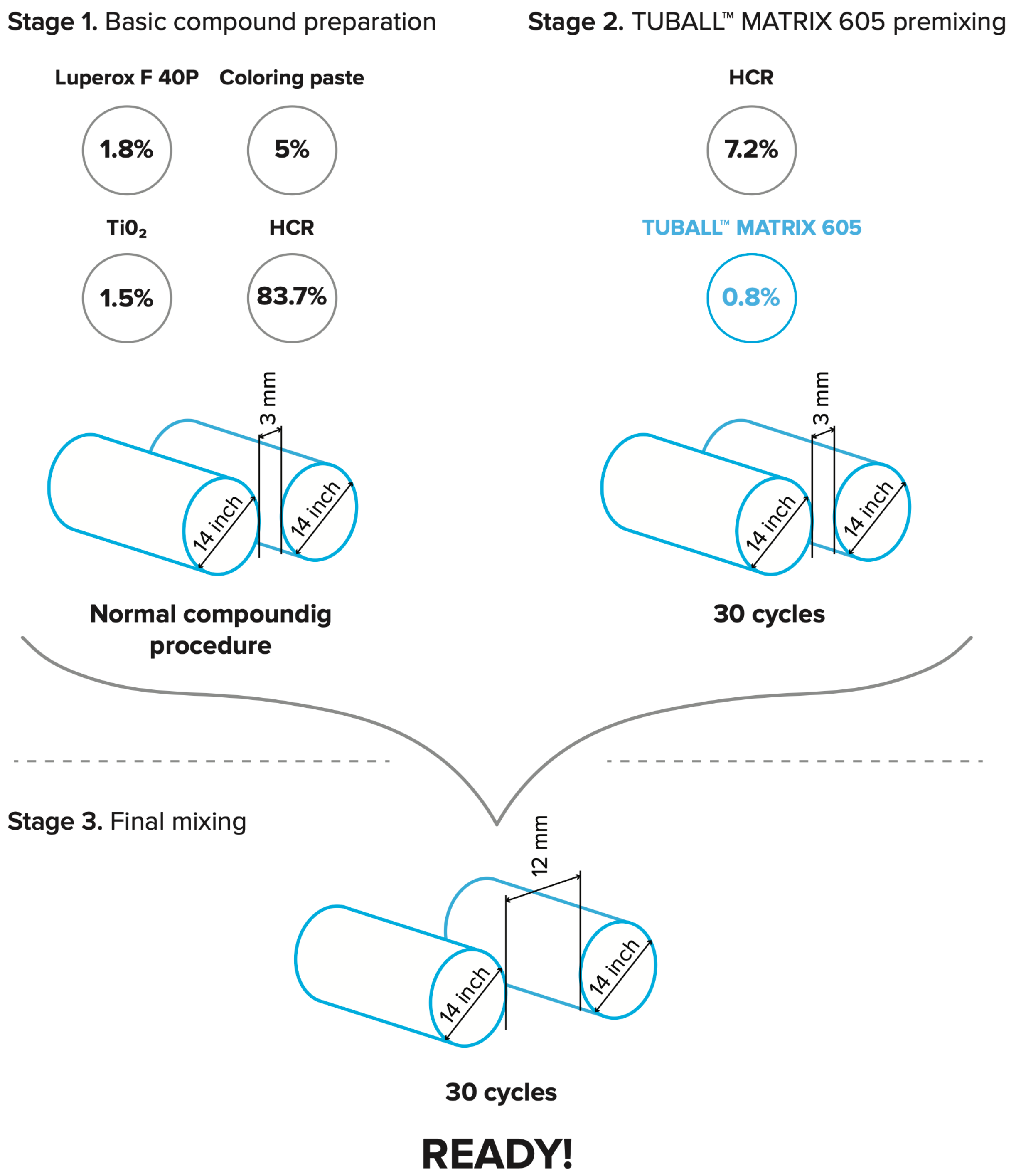
Set the gap between rollers ⟶ Add TUBALL™ MATRIX 605 and basic compound from initial stage into 2-roll mill ⟶ Number of cycles 30

Diameter of rollers	Gap
6, 10 14 inch	<0.5 kg batch – 3 mm, >0.5 kg batch – 6 mm

4. EXAMPLE OF COMPOUNDING WITH A TWO–ROLL MILL

Example of preparation of a colored anti-static compound, based on 60 Shore A Hardness HCR:

- Targeted level of volume resistivity is 10^5–10^7 Ω·cm.
- Required dosage of TUBALL™ MATRIX 605 is 0.8 wt.%.
- **Equipment: a 2–roll mill with 14 inch roll diameter.**



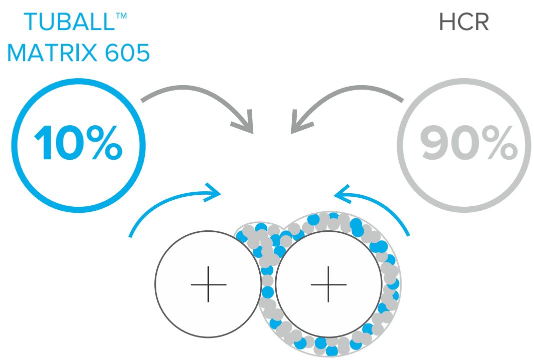
5. DILUTION WITH A KNEADER WITH PREMIXING

Equipment

Kneader (rotors speed 20:25 rpm)
2-roll mill

Stage 1

PREMIXING
2-roll mill

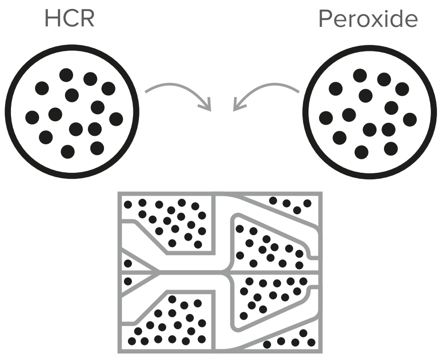


Mixing time – 5 min

Stage 2

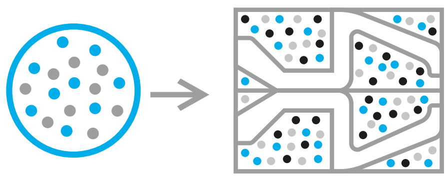
DISPERSION OF PEROXIDE AND PREMIX FROM THE STAGE 1 IN HCR
Kneader

2.1. Dispersion of peroxide in HCR



Mixing time – 20 min

2.2. Add pre-mixed TUBALL™ MATRIX 605 from the stage 1



6. MOLDING, CURING AND OTHER TECHNICAL ASPECTS

1. Shelf life of compound.

The shelf life of the final compound in the uncured state must be determined experimentally for each particular compound.

2. Curing agents.

Compatibility of curing agents with TUBALL™ MATRIX.

Standard curing agents that are compatible with TUBALL™ MATRIX:

- 2,5-bis(tert-butylperoxy)-2,5-dimethylhexane (example trademark DBPH-45-PSI);
- 1,3(4)-bis(tert-butylperoxyisopropyl)benzene (example trademark Luperox F40P);
- dicumyl peroxide, also known as bis(1-methyl-1-phenylethyl)peroxide or bis(α,α-dimethylbenzyl) peroxide;
- platinum catalyst and crosslinker.

NOTE!

2,4-dichlorobenzoylperoxide (DCBP), is unsuitable as it is strongly inhibited by any carbon filler.

As all curing agent systems are impacted by a high amount of fillers, adjustment of the curing system could be required for loadings of TUBALL™ MATRIX of more than 10% (which is required to achieve a volume resistivity of less than 10 Ω·cm).

3. Post curing.

Electrical conductivity is typically increased by the post curing process. For example, a volume resistivity of 10^8 Ω·cm after curing will improve further down to 10^6 Ω·cm after post curing for 4 hours at 200 °C. An exact impact depends on curing agents and molding process.

4. Molding process.

Electrical conductivity could be affected by the molding process due to differences in the shear forces. All the data provided in technical documents is based on a compression molding process.

- Compression molding – no impact on electrical conductivity.
- Extrusion, Transfer, Injection molding – resistivity is 2-3 orders of magnitude higher than with compression-molded parts, due to higher shear force.

An exact impact to electrical resistivity by molding process should be determined an experimental way and MATRIX dosage adjusted accordingly.

5. Optimization of parameters for a different sizes of two-roll mill.

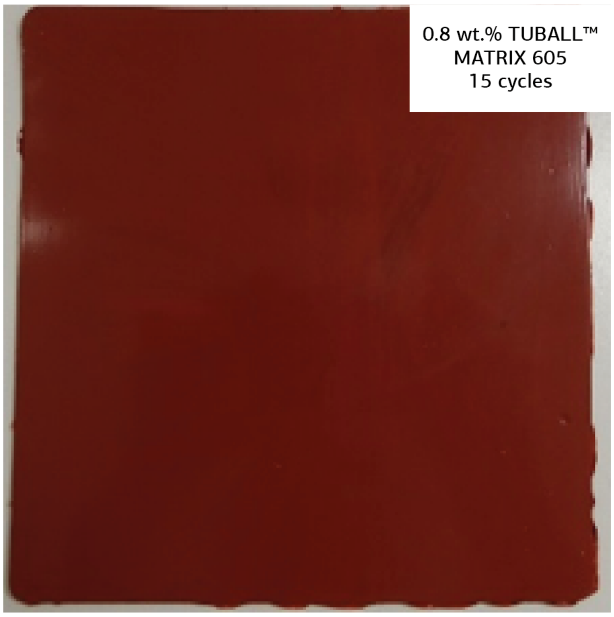
The optimal gap and number of cycles should be determined by experiment for each size of machinery to achieve the required parameters (electrical conductivity, color, etc.).

6. Colored compounds

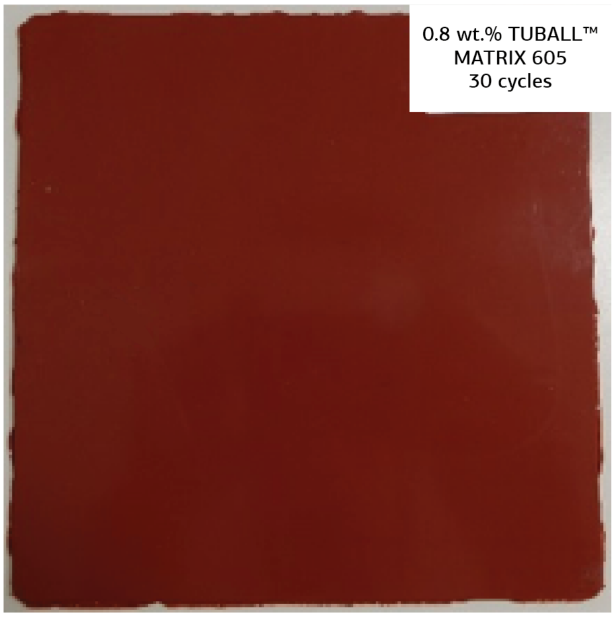
If the product is colored, then the number of cycles during final mixing should be optimized by considering the color uniformity. For this, visual analysis is needed. For example, for the color recipe shown below, it is evident that at least 30 cycles are needed to achieve the best color uniformity.

0.8 wt.% TUBALL™ MATRIX 605
3 cycles

0.8 wt.% TUBALL™ MATRIX 605
5 cycles



0.8 wt.% TUBALL™ MATRIX 605
15 cycles



0.8 wt.% TUBALL™ MATRIX 605
30 cycles

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