



PROCESSING GUIDELINES

for TUBALL™ MATRIX 603
for Rubber Compounds

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1. RECOMMENDATIONS ON USE OF TUBALL™ MATRIX 603

TUBALL™ MATRIX 603 is a series of industrial modifiers based on TUBALL™ single wall carbon nanotubes and plasticisers.

TUBALL™ MATRIX 603 for rubber products is a versatile masterbatch designed to enhance the physical and mechanical properties of rubbers and to increase electrical conductivity.

The versatility of this product lies in its potential to be utilised in blends of other rubber and filler products without having to adjust the formulation or the technological process.

TUBALL™ MATRIX 603 is an oil that contains 10 wt.% of TUBALL™ single wall carbon nanotubes.

The component structure is specified in the Technical Data Sheet supplied with the material.

2. RECOMMENDATIONS ON WHEN AND HOW TO INTRODUCE TUBALL™ MATRIX 603

Concentration

A typical good loading level to be tried is between 0.05% and 0.3% of nanotubes, which means between 0.5% and 3% of TUBALL™ MATRIX 603 (weight %).

Introduction sequence

TUBALL™ MATRIX should be introduced as early as possible in the mixing process, preferably at the same time as the usual oil if it is introduced early, or on its own just after the polymer if the usual oil is introduced much later.

Mixing tool

The best mixing is achieved with a combination of an internal mixer and several passes in a two-roll mill. The two-roll mill is useful for creating the high shear strain that is needed for dispersion of small objects such as nanotubes.

Mixing temperature

No special steps to control the mixing temperature are required. The nanotubes can resist much higher temperatures than polymers, so the usual steps to avoid polymer degradation are sufficient.

Tuning of oil content in formulation

The total oil content should be increased compared with the reference compound, in order to avoid a large increase in viscosity and stiffness, and to optimise the dispersion of TUBALL™ and the final properties.

For example, if 1.7 phr of TUBALL™ MATRIX 603 is introduced, which contains 1.53 phr of oil (90%), then don't remove 1.53 phr of oil from initial formulation. Remove less (for example 0.8 phr, as shown in the table below). The optimum content of oil should be determined based on several trials.

3. CALCULATING THE DOSAGE OF TUBALL™ MATRIX 603

An example of calculating the concentration of TUBALL™ MATRIX 603 (10%) in a rubber compound is shown below.

	Reference	0.05% CNTs	0.1% CNTs	0.2% CNTs	0.3% CNTs
Natural Rubber (phr)	100	100	100	100	100
Carbon black (phr)	45.00	45.00	45.00	45.00	45.00
Oil plasticiser (phr)	5.00	4.60	4.20	3.40	2.60
TUBALL™ MATRIX 603 (phr)	–	0.90	1.70	3.40	5.20
Chemicals (phr)	21.00	21.00	21.00	21.00	21.00
Total (phr)	171.00	171.50	171.90	172.80	173.80

It is recommended that laboratory tests be carried out to study the effect of intermediate concentrations on the properties of samples in order to optimise the formula used. The most efficient working concentration of TUBALL™ MATRIX 603 needs to be determined directly at the production facility, as it depends on the purpose of the prepared rubber mixture and on the process.

Vulcanisation

Prior to vulcanisation it is necessary to conduct a preliminary study of the vulcanisation kinetics, as this can change for each formula. Based on the obtained data, vulcanisation and further testing of samples are conducted.

Depending on the tests, the vulcanisation modes for the rubber mixture may need to be adjusted.

Determination of sample quality

The quality of the samples should be determined according to the following international standards:

- ASTM D412 – strength indices;
- ASTM D2240 – Shore A hardness;
- ASTM D395 – compression set;
- ASTM D1646 – Mooney viscosity;
- ASTM D257, ASTM D991 – electric resistance;
- ASTM D5289 – rheometric data;
- ASTM D5963 – abrasion indices;
- ASTM C518 – thermal conductivity.

If there are special requirements for the rubber, or other operational needs, other tests as defined by the user might need to be conducted.

During the formula optimisation phase, the degree of TUBALL™ dispersion in the rubber mixture needs to be monitored, e.g. by means of a scanning electronic microscope. Sample preparation for such an analysis includes formation of a rod-like piece 3–5 mm in diameter, frozen in liquid nitrogen at 77 K, and further fracturing. The degree of dispersion should preferably be analysed at a fresh fracture surface.