TOSOH

# TOSO-CSM®

Chlorosulphonated Polyethylene

# extos®

Alkylated Chlorosulphonated Polyethylene


**TOSOH CORPORATION**

TOSO-CSM® Chlorosulphonated Polyethylene extos® Alkylated Chlorosulphonated Polyethylene

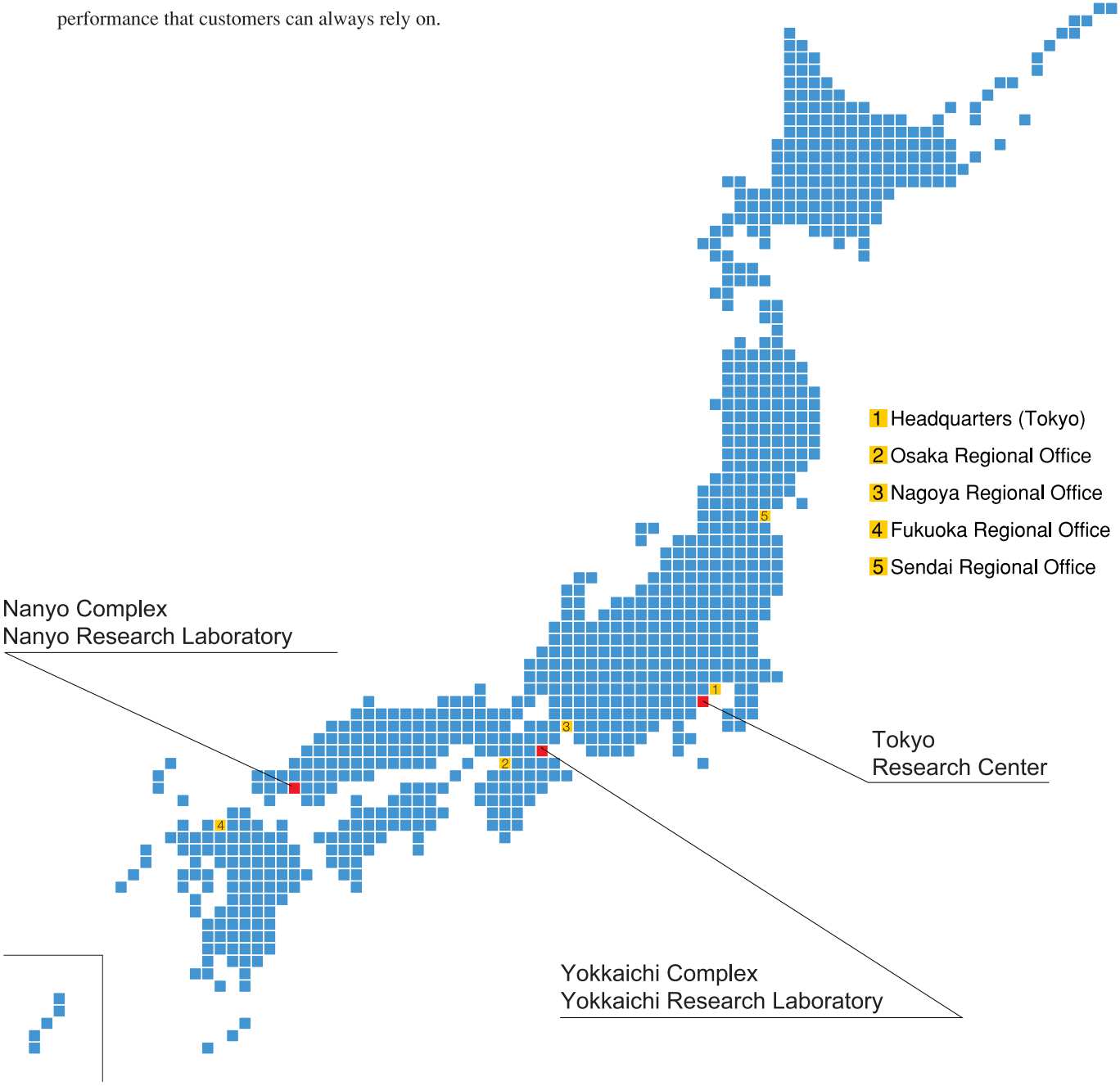
CONTENTS

# Introduction

Tosoh Corporation was established in 1935 as a manufacturer of inorganic chemical products that were centered around caustic soda and soda ash. Since then, Tosoh has developed into a general chemical manufacturer with entry into the petrochemical industry and metal fields, as well as acquiring the Yokkaichi ethylene cracker complex.

Today, Tosoh is developing global businesses in four areas. (1) Basic raw materials that focus on inorganic chemicals, (2) the petrochemical field that includes vinyl chloride monomer, polyethylene, and synthetic rubbers, (3)the specialty and fine chemical fields, such as ceramics, quartz, ethylene amines, and, (4)biotechnology that consists of scientific and diagnostic instruments.

**TOSO-CSM**® and **extos**® are special synthetic rubbers that utilize various processes cultivated by Tosoh through proprietary technologies. These unique synthetic rubber products are based on Tosoh technology that has been developed and perfected over years of experience. Used in for example vital security parts, **TOSO-CSM**® and **extos**® have earned a solid reputation based on consistent quality and performance that customers can always rely on.



# Production method of TOSO-CSM® and extos®

Chlorosulphonated polyethylene (CSM) is a special synthetic rubber manufactured through chlorination and chlorosulphonation of polyethylene.
extos® is a new type of CSM with improved dynamic and low temperature properties.

## Structural features

Chlorine

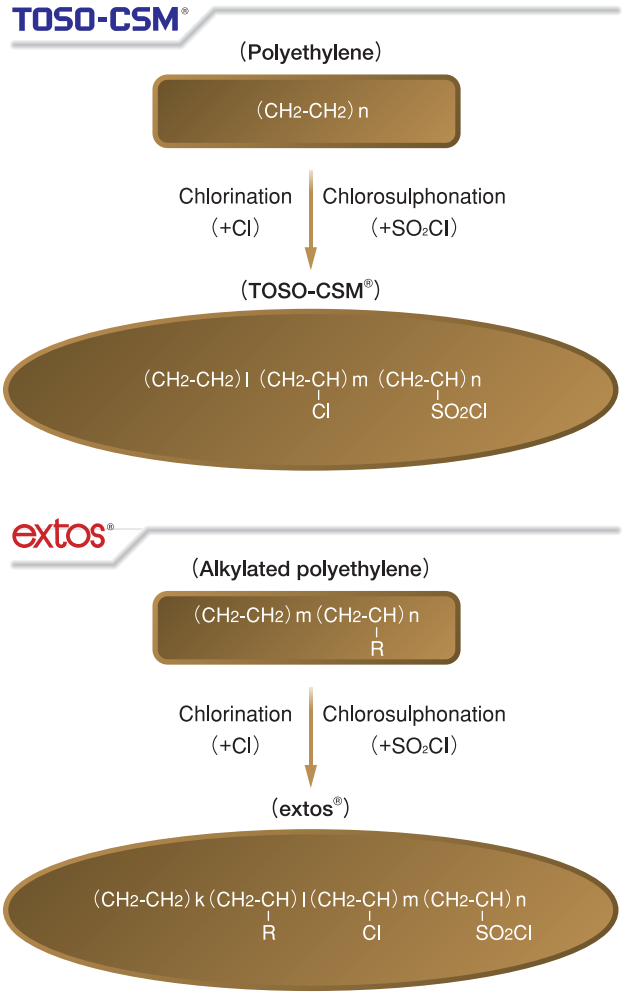
- Destruction of the crystalline segments
- Oil resistance
- Solubility
- Higher glass-transition temperature

Sulphonyl chloride groups

- Cross-linking point

Single bond on the main chain

## Production process





ISO 9001
BUREAU VERITAS
Certification

TOSO-CSM® and extos® are manufactured under certified ISO-9001 conditions at Tosoh Nanyo Complex

# Comparison of TOSO-CSM® with other synthetic rubbers

| | TOSO-CSM® | CR | EPDM | NBR | SBR | IIR | NR |
|---|---|---|---|---|---|---|---|
| Tensile strength (pure gum) | ◎ | ◎ | △ | △ | △ | ◎ | ◎ |
| Tear strength | ○ | ○ | △ | ○ | △ | ○ | ◎ |
| Abrasion resistance | ◎ | ◎ | ○ | ◎ | ◎ | ○ | ◎ |
| Compression set | ○ | ◎ | ○ | ◎ | ○ | △ | ◎ |
| Anti-gas permeability | ○ | ○ | △ | ○ | △ | ◎ | △ |
| Weather resistance | ◎ | ○ | ◎ | △ | △ | ○ | △ |
| Ozone resistance | ◎ | ○ | ◎ | × | × | ○ | × |
| Heat resistance | ◎ | ○ | ◎ | △ | △ | ○ | △ |
| Flame resistance | ○ | ○ | × | × | × | × | × |
| Discolor resistance | ◎ | × | ◎ | ○ | ○ | ○ | ○ |
| Strong acid resistance | ◎ | ○ | ◎ | ○ | △ | ○ | △ |
| Alkali resistance | ◎ | ◎ | ◎ | ○ | ○ | ◎ | ○ |
| Gasoline resistance | ○ | ○ | × | ◎ | × | × | × |
| Oil resistance | ○ | ○ | × | ◎ | × | × | × |

◎ excellent ○ good △ possible × impossible

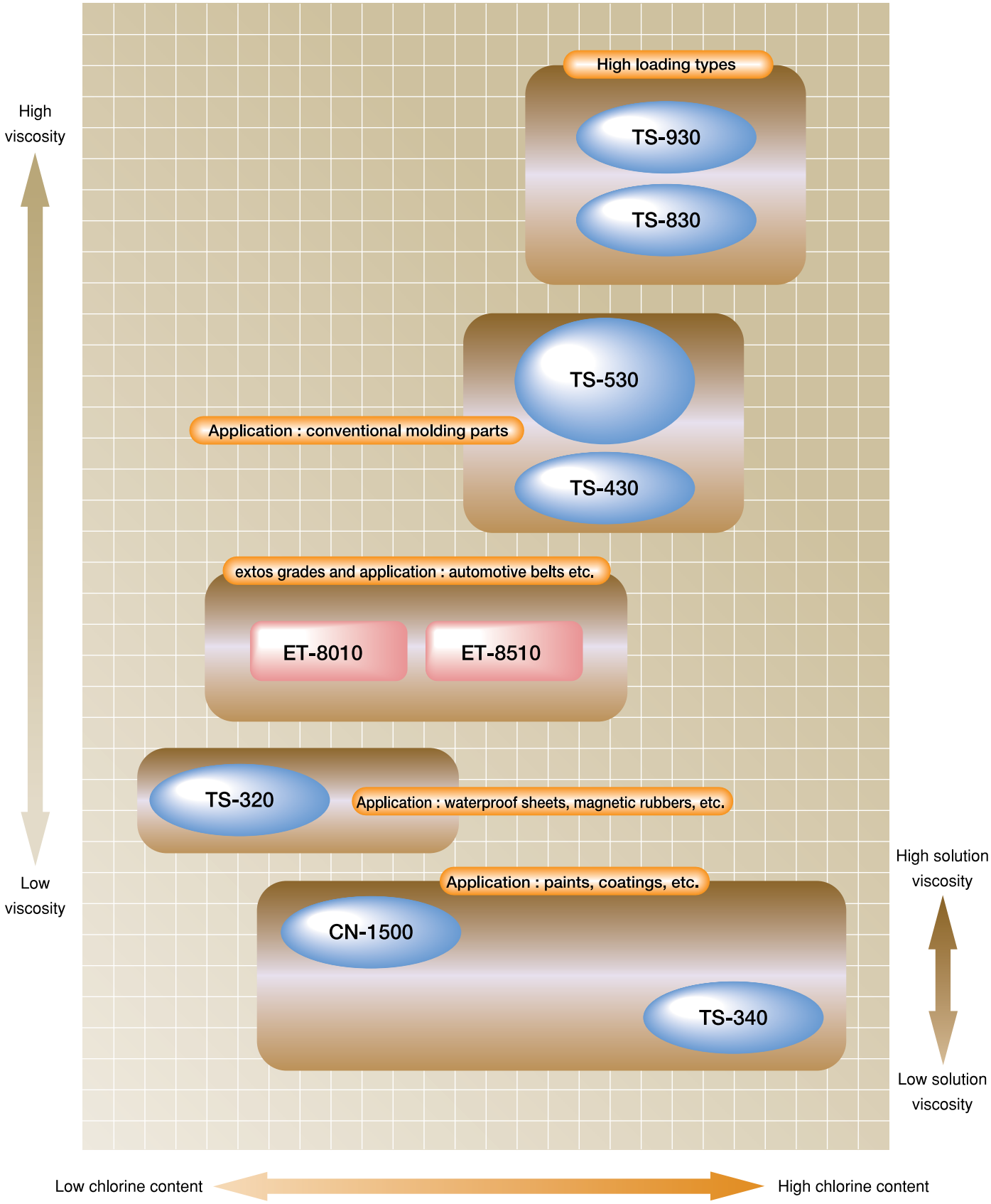
Automobile rubber parts

Escalator handrails


Protective barriers on public transportation systems (Urban liner/Kintetsu Corporation)

Rubber panels for railroad crossings

# TOSO-CSM® and extos® Grades



# Features and specifications

| | Grades | Chlorine content (%) | Sulfur content (%) | Mooney viscosity ML(1+4) 100℃ | Features |
|---|---|---|---|---|---|
| **TOSO-CSM®** | | | | | |
| | TS-530 | 35 | 1.0 | 56 | General-purpose grade that achieves balance in physical properties and processability |
| | TS-430 | 35 | 1.0 | 46 | Similar to the TS-530 with low Mooney viscosity |
| | TS-830 | 36 | 1.0 | 90 | Similar to the TS-530 with high Mooney viscosity |
| | TS-930 | 36 | 1.0 | 105 | Similar to the TS-530 with high Mooney viscosity |
| | TS-320 | 23 | 1.0 | 37 | Thermoplastic that can be used without curing |
| | TS-340 | 43 | 1.1 | 350※ | Good solubility, low solution viscosity, oil resistance |
| | CN-1500 | 30 | 1.4 | 1400※ | Good solubility, low solution viscosity |
| **extos®** | | | | | |
| | ET-8010 | 26 | 0.7 | 40 | Good dynamic and low temperature properties Vulcanizing adhesion with EPDM is possible |
| | ET-8510 | 30 | 0.9 | 40 | Oil resistance |

※ 25% tolunen solution viscosity {(mPa･s/Brookfield(BL) type viscometer, 23℃)}

## TOSO-CSM®

**TS-530** Most well-balanced grade, superior in physical properties anti-degration, and processability
**TS-430** Low viscosity form of the TS-530, with good processability
**TS-830** Visocity is between TS-530 and TS-930
**TS-930** Highest visocity of the TS-series. Suitable for expansion using large amounts of filler or oil in order to reduce costs
**TS-320** Lower chlorine content than general grades, with high hardness and good resistance to cold
**TS-340** Superior solubility as an organic solvent
**CN-1500** Superior solubility as an organic solvent

## extos®

**ET-8010** Good resistance to cold, offering better dynamic fatigue resistance
**ET-8510** Similar to ET-8010 in all respects, with good resistance to oil

# TOSO-CSM® Properties

| Grades | | | TS-430 | TS-530 | TS-830 | TS-930 | TS-320 | TS-340 | CN-1500 |
|---|---|---|---|---|---|---|---|---|---|
| Formulation | TOSO-CSM® | | 100phr | | | | | | |
| | MgO (High activity) | | 4 | | | | | | |
| | Pentaerythritol | | 3 | | | | | | |
| | Accelerator DPTT | | 2 | | | | | | |
| Compound Properties | Mooney viscosity ML (1+4) 100 ℃ | | 58 | 66 | 111 | 114 | 49 | 37 | 41 |
| | Mooney Scorch ML (1) 125 ℃ | | | | | | | | |
| | Vm | | 28 | 34 | 64 | 66 | 25 | 12 | 20 |
| | $t_5$ | min | 23.1 | 21.0 | 20.0 | 20.0 | 20.2 | 31.9 | 31.4 |
| Vulcanizate Properties | 100% Tensile stress($M_{100}$) | MPa | 1.1 | 1.1 | 1.2 | 1.2 | 3.0 | 3.3 | 1.3 |
| | 300% Tensile stress($M_{300}$) | MPa | 2.3 | 2.4 | 3.0 | 2.9 | 4.4 | 12.5 | 3.6 |
| | Tensile strength($T_B$) | MPa | 20.6 | 20.3 | 21.0 | 21.3 | 30.6 | 18.1 | 7.4 |
| | Elongation at break($E_B$) | % | 550 | 540 | 530 | 520 | 520 | 410 | 420 |
| | Hardness($H_S$) | JIS-A | 56 | 55 | 57 | 57 | 80 | 82 | 55 |
| | Resilience | % | 40 | 42 | 38 | 37 | 61 | 4 | 49 |
| | Compression set (25% compression, aging for 70hrs. at 70℃) | % | 79 | 73 | 72 | 69 | 72 | 83 | 83 |
| | Oil resistance (ASTM#3oil, aging for 70hrs. at 125℃) Change rate in volume | % | 81 | 80 | 73 | 71 | 230 | 35 | 200 |
| | Heat resistance (Aging for 70hrs. at 100℃) Residual rate for $T_B$ | % | 134 | 126 | 131 | 128 | 48 | 122 | 103 |
| | Residual rate for $E_B$ | % | 80 | 80 | 75 | 77 | 67 | 71 | 64 |
| | Change in $H_S$ | point | +2 | +3 | +3 | +3 | +1 | +10 | +3 |
| Curing conditions | Sheet 160 ℃ | min | 20 | 20 | 20 | 20 | 25 | 35 | 35 |
| | Compression set 160 ℃ | min | 25 | 25 | 25 | 25 | 30 | 40 | 40 |

※ Figures are provided only as a reference and do not serve as exact specifications

# extos® Properties

| | Grades | | ET-8010 | ET-8510 |
|---|---|---|---|---|
| Formulation | extos® | | 100phr | |
| | MgO (High activity) | | 4 | |
| | Pentaerythritol | | 3 | |
| | Accelerator DPTT | | 2 | |
| Compound Properties | Mooney viscosity ML (1+4) 100 ℃ | | 52 | 50 |
| | Mooney Scorch ML (1) 125 ℃ | | | |
| | Vm | | 26 | 25 |
| | $t_5$ | min | 14.1 | 21.6 |
| Vulcanizate Properties | 100% Tensile stress($M_{100}$) | MPa | 1.3 | 1.3 |
| | 300% Tensile stress($M_{300}$) | MPa | 2.4 | 2.7 |
| | Tensile strength($T_B$) | MPa | 22.5 | 17.8 |
| | Elongation at break($E_B$) | % | 570 | 540 |
| | Hardness($H_S$) | JIS-A | 56 | 56 |
| | Resilience | % | 70 | 60 |
| | Compression set (25% compression, aging for 70hrs. at 70℃) | % | 70 | 70 |
| | Oil resistance (ASTM#3oil, aging for 70hrs. at 125℃) Change rate in volume | % | 260 | 184 |
| | Heat resistance (Aging for 70hrs. at 100℃) Residual rate for $T_B$ | % | 56 | 67 |
| | Residual rate for $E_B$ | % | 65 | 68 |
| | Change in $H_S$ | point | +2 | +3 |
| Curing conditions | Sheet 160 ℃ | min | 20 | 25 |
| | Compression set 160 ℃ | min | 25 | 30 |

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# Formulations and properties for some applications

| Hose | | | |
|---|---|---|---|
| Formulation | **TOSO-CSM® TS-530** | | 100phr |
| | MgO(High activity) | | 20 |
| | Special wax | | 2 |
| | ACPE 617A | | 3 |
| | Struktol WB-222 | | 2 |
| | FEF Carbon Black | | 55 |
| | Hydrous silica | | 8 |
| | TOTM | | 20 |
| | DCP-40 | | 7.5 |
| | TAIC M-60 | | 6.7 |
| Compound Properties | Mooney Scorch ML (1) 125 ℃ | | |
| | Vm | | 67 |
| | $t_5$ | min | 24.7 |
| Vulcanizate Properties | 100% Tensile stress($M_{100}$) | MPa | 9.8 |
| | Tensile strength($T_B$) | MPa | 20.8 |
| | Elongation at break($E_B$) | % | 200 |
| | Hardness($H_S$) | JIS-A | 78 |
| | Compression set (25% compression, aging for 70hrs. at 150℃) | % | 39 |
| | Heat resistance (aging for 70hrs. at 150℃) Residual rate for $T_B$ | % | 92 |
| | Residual rate for $E_B$ | % | 76 |
| | Change in $H_S$ | point | +5 |
| Curing conditions | Sheet 160 ℃ | min | 40 |
| | Compression set 160 ℃ | min | 45 |

| Electrical wire and cable | | | |
|---|---|---|---|
| Formulation | **TOSO-CSM® TS-530** | | 100phr |
| | MgO(High activity) | | 5 |
| | Special wax | | 2 |
| | White vaseline | | 2 |
| | HAF Carbon Black | | 15 |
| | Dixie clay | | 50 |
| | Mistron vapor | | 40 |
| | Naphthenic process oil | | 15 |
| | Chlorinated paraffin (Cl:45%) | | 15 |
| | Antioxidant NBC | | 1 |
| | Pentaerythritol | | 3 |
| | Accelerator DPTT | | 2 |
| | Accelerator DM | | 0.5 |
| Compound Properties | Mooney Scorch ML (1) 125 ℃ | | |
| | Vm | | 23 |
| | $t_5$ | min | 18.6 |
| Vulcanizate Properties | 100% Tensile stress($M_{100}$) | MPa | 4.6 |
| | Tensile strength($T_B$) | MPa | 13.6 |
| | Elongation at break($E_B$) | % | 500 |
| | Hardness($H_S$) | JIS-A | 73 |
| | Compression set (25% compression, aging for 70hrs. at 150℃) | % | 74 |
| | Heat resistance (aging for 70hrs. at 150℃) Residual rate for $T_B$ | % | 89 |
| | Residual rate for $E_B$ | % | 58 |
| | Change in $H_S$ | point | +15 |
| Curing conditions | Sheet 160 ℃ | min | 15 |
| | Compression set 160 ℃ | min | 20 |

| Roofing sheet | | | |
|---|---|---|---|
| Formulation | **TOSO-CSM® TS-320** | | 100phr |
| | MgO(High activity) | | 4 |
| | ACPE 617A | | 2 |
| | Polyethlene glycol #4000 | | 1 |
| | Calcined clay | | 30 |
| | Light Calcium carbonate | | 50 |
| | Titanium dioxide (Rutile type) | | 25 |
| | DOP | | 7 |
| | Antioxidant BHT | | 2 |
| Compound Properties | Mooney Scorch ML (1) 125 ℃ | | |
| | Vm | | 50 |
| | $t_5$ | min | ＞100 |
| | 100% Tensile stress($M_{100}$) | MPa | 4.3 |
| | Tensile strength($T_B$) | MPa | 9.4 |
| | Elongation at break($E_B$) | % | 780 |
| | Hardness($H_S$) | JIS-A | 86 |
| Sheeting process conditions | Heating press : Preheating100 ℃×1min<br>Pressure100 ℃×5min×10MPa<br>Cooling23 ℃×1min×5MPa<br>Tensile test : Tensile rate50mm/min | | |

| Belt | | | |
|---|---|---|---|
| Formulation | **extos® ET-8010** | | 100phr |
| | Hydrotalcite KW-2100 | | 12 |
| | Special wax | | 2 |
| | Struktol 40MS-F | | 5 |
| | FEF Carbon Black | | 50 |
| | Hydrous silica | | 2 |
| | DOS | | 16 |
| | Antioxidant NBC | | 0.7 |
| | Pentaerythritol | | 2 |
| | Accelerator DPTT | | 0.5 |
| | Vulcanizing agent PM | | 3 |
| Compound Properties | Mooney Scorch ML (1) 125 ℃ | | |
| | Vm | | 43 |
| | $t_5$ | min | 20.9 |
| Vulcanizate Properties | 100% Tensile stress($M_{100}$) | MPa | 5.6 |
| | Tensile strength($T_B$) | MPa | 18.8 |
| | Elongation at break($E_B$) | % | 330 |
| | Hardness($H_S$) | JIS-A | 72 |
| | Compression set (25% compression, aging for 22hrs. at 100℃) | % | 30 |
| | Heat resistance (aging for 70days. at 140℃) Residual rate for $T_B$ | % | 101 |
| | Residual rate for $E_B$ | % | 55 |
| | Change in $H_S$ | point | +13 |
| Curing conditions | Sheet 160 ℃ | min | 30 |
| | Compression set 160 ℃ | min | 35 |

※ Figures are provided only as a reference and do not serve as exact specifications

## TOSO-CSM® Applications

| | Fields | Applications |
|---|---|---|
| TOSO-CSM® | Automotive parts | Fuel hoses, power steering hoses, hydraulic hoses, brake hoses |
| | Electric parts, electric wire | High-tension cables, low-tension cables, communication cables, submarine cables, ship's wires, heat-resistant wire coverings, radioactive-resistant cables |
| | General industrial articles | High-pressure hoses, LPG hoses, chemical-resistant hoses, rolls, linings |
| | Engineering and building articles | Escalator handrails, building gaskets pond lining sheets, roofing sheets weather-resistant paints |
| | Others | Rubber boats, rainwears, chemical-resistant gloves adhesives, paints, coatings |

## extos® Applications

| | Fields | Applications |
|---|---|---|
| extos® | Automotive parts | Synchronous timing belts, poly-V-belts, coverings for the weatherstrips |
| | Train parts | Coupling coverings |
| | Engineering and building articles | Building gaskets |


Rubber boats


Rubber rolls for iron manufacturing

# Additives used in CSM

| Ingredients | The example of Agents | Notes |
|---|---|---|
| **Acid acceptors** | Magnesium oxide<br>Hydrotalcite $Mg_6Al_2(OH)_{16}CO_3 \cdot 4H_2O$<br>Lead monoxide PbO | Acid acceptors have to be added to CSM compound to catch acid when CSM is vulcanized. |
| **Reinforcing agents** | Carbon black | The effects of carbon black on vulcanized product are similar to other vulcanized rubber. They increase modulus and hardness, and improve abrasion resistance. SRF,FEF,FT and MT are used frequently. With a decrease in the particle size, the viscosity of the compounds, modulus and hardness of the vulcanized product are increased, working stability, elongation and rebound elasticity are decreased and tensile strength is increased slightly. |
| | Silica | Elongation and tear strength are increased but tensile strength and abrasion resistance are decreased when compared with carbon black. |
| **Fillers** | Calcium carbonate<br>Clay<br>Talc | Used as diluents for cutting down on expenses |
| **Oils<br>Plasticizers<br>Softeners** | Phthalic acid derivatives<br>Fatty acid derivatives<br>Mineral oils<br>Aromatic oils<br>Vegetable oils | The use of oils result in charasteristics of low temperature and flexibility of the vulcanized product. A larger amount of oil is required for obtaining the vulcanized products having the same hardness as other vulcanized rubber products. Naphthenic oil may be bled by adding an amount higher than 20 phr. When a large amount is to be used, aromatic oil or chlorinated paraffin is effective. |
| **Processing aid** | Vaseline, microcrystalline wax,<br>Low molecular weight polyethylene<br>Stearic acid | Added to improve the processability of compounds |
| **Antioxidants<br>Antiozonants** | | Added to improve ozone resistance. NBC is used generally. When NBC is used in an amount higher than 3 phr, the working stability is reduced. |
| **Tackifiers** | | Added to give tackiness to compound. Aromatic oil or low molecular weight indenecoumarone resin. |
| **Blowing agents** | | Used to make foaming products |
| **Flame retardants** | Antimony trioxide<br>Chlorinated paraffin<br>Aluminum hydroxide | |

| Ingredients | The example of Agents | Notes |
|---|---|---|
| **Vulcanization agents** | Thiuram vulcanization system<br>・Dipentamethylenethiuram tetrasulfide, DPTT (TRA)<br>・Tetramethylthiuramdisulfide, TMTD (TT)<br>・Tetraethylthiuramdisulfide, TETD (TET)<br>＋<br>・Pentaerythritol | Merit<br>・Stability of compound during mixing process<br>・Tensile strength<br>・Elongation at break<br>Demerit<br>・Stability of compound under storage<br>・Compression set<br>・Heat resistance<br>・Discolor resistance |
| | Bismaleimide vulcanization system<br>・N, N'-m-phenylendimaleimide<br>＋<br>・Nickel dibutyldithiocarbonate<br>・6-Ethoxy-2, 2, 4-trimethyl-1, 2-dihydroquinoline | Merit<br>・Heat resistance<br>・Compression set<br>Demerit<br>・Stability of compound under storage<br>・Stability of compound during rubber mixing process<br>・Tensile strength<br>・Elongation at break |
| | Peroxide vulcanization system<br>・1,3-bis (tert-butylperoxy isopropyl) benzene<br>＋<br>・Trially isocyanurate | Merit<br>・Stability of compound under mixing process<br>・Heat resistance<br>・Compression set<br>・Discolor resistnace<br>Demerit<br>・Tensile strength<br>・Elongation at break<br>・Handling of peroxide<br>・Smell of peroxide |

※ Zinc oxide or Zinc stearate must not be used as this will result in extreme decreases in the heat resistance of the vulcanized product

# Mixing

**CSM compounds are mixed in internal mixers and on roll mills. Internal mixers are preferred for speed and batch sizes. For small batches mill mixing is satisfactory.**

### Internal Mixing
### A: Upside-down Mixing (Recommended)

1st stage (internal mixer)
- 1) Charging of all ingredients except accelerators
- 2) Charging of CSM
- 3) Cleaning
- 4) Mixing
- 5) Dumping
- 6) Sheeting off
- 7) Cooling and storage

2nd stage (mixing roll)
- 8) Banding of compound
- 9) Charging of accelerator
- 10) Mixing to adequate distribution
- 11) Release at mill
- 12) Cooling and storage

### Mill Mixing
- 1) Mastication of CSM
- 2) Charging of reinforcements(1/2) and acid acceptors
- 3) Charging of processing aids(1/2)
- 4) Charging of reinforcements(1/2) and processing aids(1/2)
- 5) Charging of fillers and plasticizers
- 6) Charging of accelerators
- 7) Mixing to adequate distribution
- 8) Release at mill
- 9) Cooling and storage

## Notes on mixing and storage

### Mixing

（1）Internal mixing
- ① The milling can be carried through normal procedure, however the up-side-down procedure is most effective.
- ② Charging : 70～75% as a proportion standard
- ③ Scorching can be prevented by
  - (a) controlling the temperature of dumped compound to a value of less than 100 to 110℃
  - (b) adding the vulcanizing agent and accelerator using the rolls
  - (c) cooling the compound. However when the compound is cooled by dipping it in cold water, the water that adheres should be completely removed and the sheets dried.

（2）Milling through rolls
- ① Suppression of heat generation by passing cooling water through the rolls.
- ② The milling is facilitated by passing the thin sheet 3 to 5 passes through the rolls.
- ③ Cool sheets quickly by reducing the thickness of sheet.

### Storage of compounds

- Mixed compounds should not be stored in conditions of high humidity.
- Mixed compounds containing accelerators should be used immediately.
- If the mixed compounds need to be stored, accelerators should be added just before use.

## Application of Tosoh Elastomers

### SKYPRENE®

Automotive parts ; Hoses, belts, boots, seals, wipers, etc
Industrial parts ; Belts, wire and cable, rubber vibration insulator, etc
Industrial and consumer adhesives
Wet suits
Rubber yarn
Rubber sheets and coated fabrics and many others

### TOSO-CSM® and extos®

Automotive hoses, industrial hoses
Jacketing and insulation for wire and cable
Rubber sheets and coated fabrics
Seals, gaskets
Rolls
Escalator handrails and many others