

Participant Handbook

Sector
Rubber Industry

Sub-Sector
Tyre & Non-Tyre

Occupation
Lab Chemist

Reference ID: **RSC/Q2301, Version 1.0**
NSQF Level 5



Lab Chemist - Rubber

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Shri Narendra Modi
Prime Minister of India

“ Skilling is building a better India.
If we have to move India towards
development then Skill Development
should be our mission. ”



**COMPLIANCE TO
QUALIFICATION PACK – NATIONAL OCCUPATIONAL
STANDARDS**

is hereby issued by the

RUBBER SKILL DEVELOPMENT COUNCIL

for

SKILLING CONTENT : PARTICIPANT HANDBOOK

Complying to National Occupational Standards of

Job Role/ Qualification Pack: **'Lab Chemist - Rubber'** OP No. **'RSC/Q2301 NSQF Level 5'**

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We are also grateful to the partner organizations for their efforts in reviewing and endorsing this participant handbook.

About this book

The participant handbook for 'Lab Chemist - Rubber' is designed for participants to enable them to get trained and upgraded for the knowledge and basic skills of 'Lab Chemist - Rubber' in 'Rubber Industry' sector. All the aspects of skills required by the participant, are covered in this handbook. This participant handbook is designed to enable training for the specific Qualification Pack (QP) drafted by Rubber Skill Development Council (RSDC) and ratified by National Skill Development Corporation (NSDC). It covers following National Occupational Standard (NOS) across Unit/s:

- RSC/N2302 - Collect rubber samples and prepare equipment
- RSC/N2303 - Conduct testing of rubber products at various stages of production
- RSC/N2304 - Analysis, reporting and recording of test results
- RSC/N5001 - Carry out housekeeping in rubber product manufacturing
- RSC/N5002 - Carry out reporting and documentation
- RSC/N5003 - Carry out quality checks
- RSC/N5004 - Carry out problem identification and escalation
- RSC/N5007 - Carry out health and safety

This handbook is designed to provide the necessary knowledge and skill to the participants to carry out their duties in an organized and disciplined manner by following safe working practices.

Key Learning Objectives for the specific NOS mark the beginning of the Unit/s for that NOS. The symbols used in this book are described below.

Symbols Used



Key Learning
Outcomes



Steps



Time



Tips



Notes



Unit
Objectives



Activity



Exercise



Summary



Practical



Example

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1. Introduction to Rubber

Unit 1.1 – Introduction to Rubber Industry

Unit 1.2 – Rubber Related Basic Terminology

Unit 1.3 – Equipment used in Rubber Lab

Unit 1.4 – Job Role of a Lab Chemist - Rubber



Key Learning Outcomes

At the end of this module, you will be able to:

1. Discuss about rubber industry
2. Explain different sources of rubber
3. Discuss about major Indian rubber associations
4. Explain the common terminology used in rubber industry
5. Describe the ingredient of the rubber compound
6. Explain types of rubber compound
7. Explain equipment used for lab testing of rubber
8. Define Roles and responsibilities for lab chemist - rubber

UNIT 1.1: Introduction to Rubber Industry

Unit Objectives

At the end of this unit, you will be able to:

1. Discuss rubber and rubber industry
2. Identify types of rubber
3. Explain about rubber manufacturing processes
4. Explain different uses of rubber
5. Discuss functions of various rubber bodies and associations in India

1.1.1 The Rubber

Rubber is a polymer material, which has elastic properties. It is also called as 'Caoutchouc'. It normally has long chain molecules known as "polymers". Rubber being elastic, is also called "elastomers". Products made from rubber have a flexible and stable – three-dimensional chemical structure and are able to withstand higher force and large deformations. For example: the material can be stretched repeatedly to at least twice of its original length and upon immediate release of the stress, will return with force, approximately to its original length. Under load, the product should not show creep or relaxation. Besides these properties, the modulus of rubber ranges from hundred to ten thousand times lower, as compared to other solid materials like steel, plastics and ceramics. This combination of unique properties, gives rubber its specific applications like seals, shock absorbers and tyres.

Based on the source of raw material, there are two kinds of rubber, natural rubber (NR) and synthetic rubber (SR). However, there is third type of rubber - reclaimed rubber, which is produced by recycling scrap rubber.

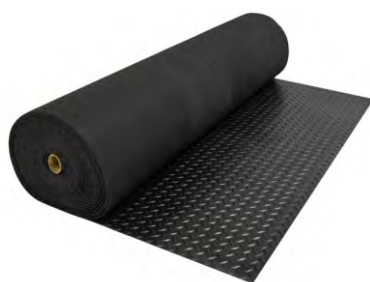


Fig. 1.1.1. Rubber

Natural rubber

Natural rubber is mainly harvested from rubber plants. There are many plant species that generate natural rubber and there are many other plants that contain rubber latex. For quality and economic considerations, rubber plant is a major source of natural rubber. 'Latex' is a sticky, milky white, liquid material. The process used for extracting latex is called 'tapping'



Fig. 1.1.2. Rubber Plant



Fig. 1.1.3. Collection of rubber by tapping process

This latex is further processed for making rubber, which can be used for making some useable products. Latex is processed in following ways –

1. Sheets
2. Creps
3. Block rubber
4. Preserved latex concentrates

Most of the natural rubber is sold in the form of sheets, creps and block rubber.

Sheets

This form is most easy to produce; hence it is the most saleable form of natural rubber. There are 2 types of sheets –

1. Ribbed Smoked Sheets (RSS)
2. Air Dried Sheets (ADS)

Out of above types, ribbed smoked sheets are more common in market. There are five grades of ribbed smoked sheets based on quality. These grades are established by international rubber quality and packing conference. Only completely dried sheets are allowed to be sold in this category. Based on different conditions, these ratings are called as RSS1, RSS2, RSS3, RSS4 and RSS5



Fig. 1.1.4. Rubber sheets

Creps

Creps are derived from coagulated latex / field coagulum after getting rolled many times between rollers and then dried in Air. There are many types of creps, namely – Pale latex creps, estae brown creps, Thin brown creps, thick blanket creps, flat blanket creps, standard flat bark crepe and pure smoked blanket crepe.

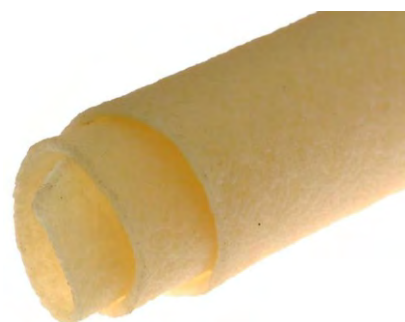


Fig. 1.1.5. Rubber creps

Technically specialized Natural Rubber

Natural dried rubber is graded based on technical specification. It was initially proposed by ISO (International Standard Organization) and then Malaysia adopted it in 1965. Later on all natural rubber producing countries adopted the system. In this system, two letters of the countries name used for making code. For ex - Indian natural rubber is coded as ISNR (Indian Standard Natural Rubber)



Fig. 1.1.6. TSR rubber

Synthetic Rubber

As the name suggest, it is man made rubber, which is derived from petroleum, coal, oil, natural gas and acetylene. It has more than 10 major classes, many of these are copolymers i.e. polymers consisting more than one monomer. Initially, Styrene-Butadiene Copolymers (SBR) synthetic rubbers were invented. Which is one of the widely used elastomer. Synthetic rubber is used as a replacement for natural rubber in many cases, especially when improved material properties are needed. Common used synthetic rubber are –

1. Emulsion Styrene Butadiene (ESBR)
2. Butadiene Rubber (BR)
3. Solution Styrene Butadiene (SSBR)
4. Isobutylene Isoprene Butyl (IIR)
5. Acrylonitrile Butadiene (NBR)
6. Ethylene Propylene Diene Monomer (EPDM)



Fig. 1.1.7. Synthetic rubber

Used or Reclaimed Rubber

Used or reclaimed rubber is the product, which is recovered from the processing of vulcanized scrap rubber tyres, tubes and miscellaneous waste rubber goods. The process includes use of heat and chemical agents. The process also includes heavy mechanical working. This reclaimed rubber has plasticity which is near to the original plasticity. This rubber can be compounded, processed and re-vulcanized as fresh rubber. During the process of reclamation the molecular weight of the elastomeric component is substantially reduced.



Fig. 1.1.8. Reclaimed rubber

1.1.2 Uses of rubber

Rubber is a widely used product now a days. It is used in automobiles, household and industrial applications. Some of the most common uses are as following -

- Tyres and tubes - automobile and agriculture tyres and tubes are the largest consumers of rubber. This category consume around three fourth of total rubber consumption.
- 'Under the bonnet' products for automobile - It includes, door and window profiles, noses, bells, matting, flooring and dampeners (anti-vibration mounts).
- Conveyor belt – for various industrial use.
- Hoses and pipes – for air and water circulation.
- Medical equipment - gloves (medical, household and industrial), toy balloons, rubber bands, etc.
- Adhesives – many manufacturing industries and products also use rubber product as adhesives. It is mostly used in paper and the carpet industry.
- Textile industry – rubber is also widely used in textile industry.
- Shock absorbers – impact absorbing property of rubber is very useful in shock absorber application.
- Machine mounting pads – it is widely used as a machine mounting mount, which helps in reducing vibration transfer to floor from machine.



Fig. 1.1.9. Rubber products

1.1.3 Rubber industry

Initially rubber industry started in South America during 19th century. Where it was restricted for a long time from export. In 1876, english brought it to India, Sri Lanka and other parts of Asian countries. Initially rubber trees were planted in Kolkata and then later it was grown in coastal areas of Kerala, Tamil Nadu and Karnataka.

Rubber products manufacturing started in India, in the year 1920. Now, rubber industry is one of the key industries of the Indian economy.

Following are some of the facts on rubber industries –

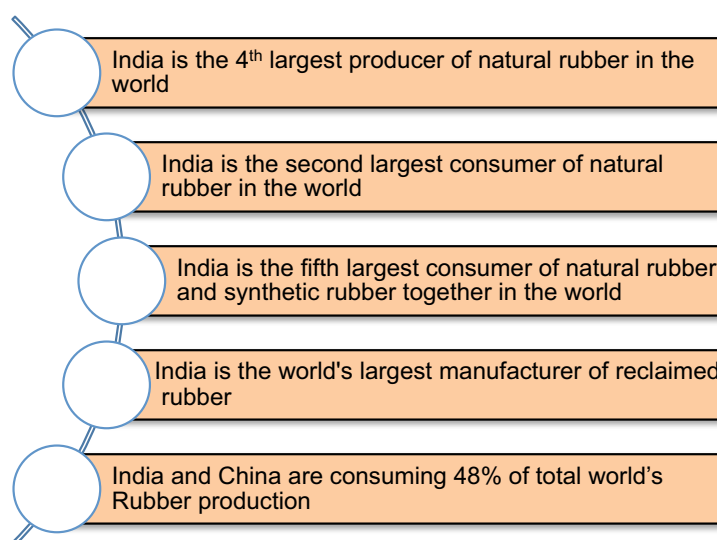


Fig. 1.1.10. Rubber industry facts

1.1.4 Overview of Indian Rubber Industry

India produces approx. 7 Lakh tons of rubber, annually . In India there are approximately 6000 rubber product companies. Out of these some 35 large scale companies, 320 medium scale and more than 5000 small scale industries. These companies do total turnover of around Rs. 12,000 Crore. These units are manufacturing more than 35000 rubber products, employing four crore people, which also includes 22000 technically qualified support personnel. India's rubber industry has growth rate of 8-9% per annum.

India consumes nearly 20 lakh tones of rubber (including natural, synthetic and reclaim) annually (as per the data of 2018-19) for producing a wide range of rubber products. Tamil Nadu (3.7 lakh tones), Maharashtra (2.09 lakh tones) and Kerala (2.02 lakh tones) are the top three rubber consuming states in the country (as per the data of 2018-19).

1.1.5 Trend of Rubber Consumption in India

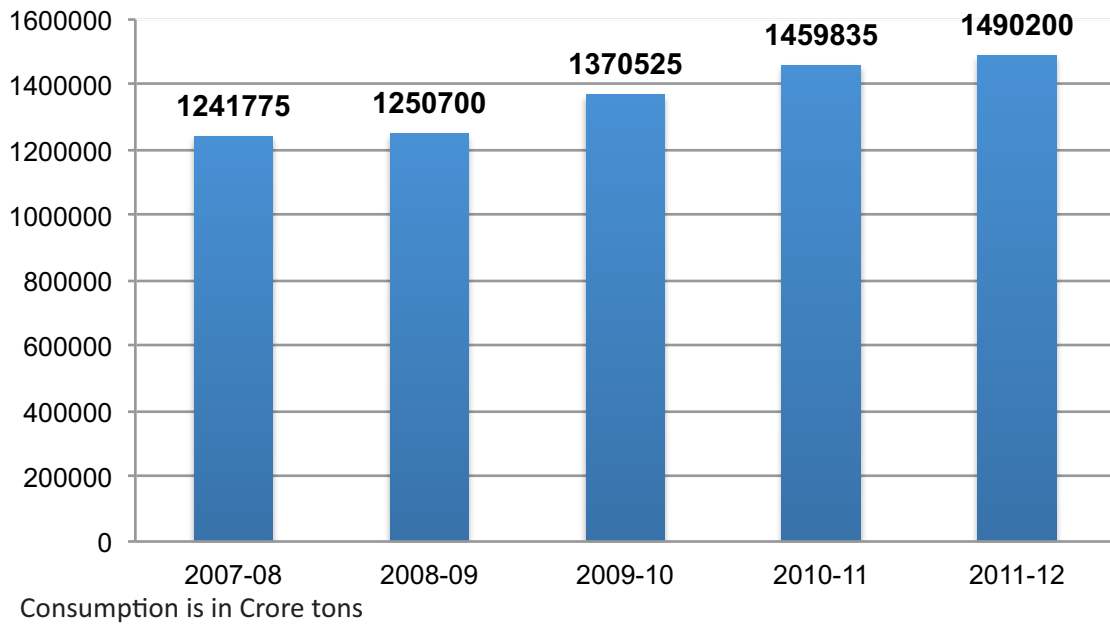


Fig. 1.1.11. Trend of rubber consumption

1.1.6 Rubber Consumption in India

The major rubber consuming sectors in India are as follows:

- 1 Automotive tyre sector
- 2 Bicycles tyres and tubes
- 3 Footwear
- 4 Camelback and latex products
- 5 Belts and hoses
- 6 Rest of products

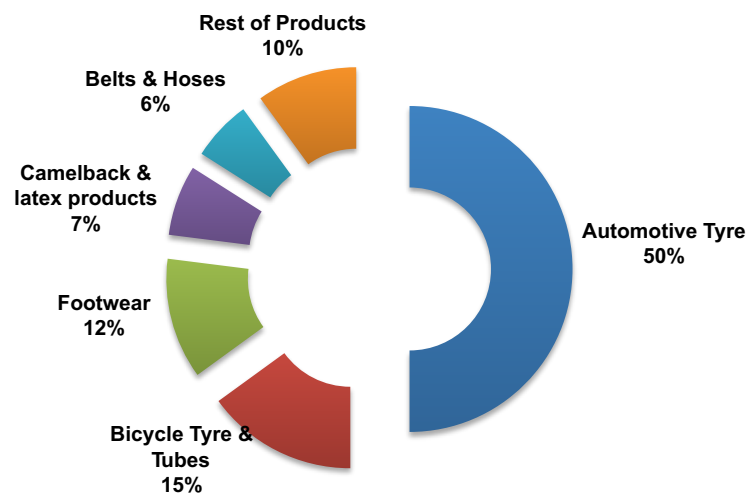


Fig. 1.1.12. Rubber consumption details

UNIT 1.2: Rubber Related Basic Terminology

Unit Objectives

At the end of this unit, you will be able to:

1. Describe common terminology used in rubber industry
2. Describe the ingredient materials of the rubber compound
3. Define type of rubber compounds

1.2.1 Basic terminology

Before studying about rubber lab, we will learn basic terminology which is commonly used in rubber industry. These are as follows -

Accelerator - Chemicals which are used for expediting vulcanization or curing process, called Accelerator. Example - aldehyde amine or thiophosphate .

Autoclave - An equipment used for vulcanization of rubber with heat and pressure.

Batch size - Batch size is number of parts in production lot. It is decided by the many factors, like – customer shipment size, machine production capacity for a shift or a day, raw material batch size, finished goods storage capacity, etc.

Compression moulding - It is a process of rubber moulding by heat and pressure. Due to heat rubber softens (plasticizes) and flows into the mould cavity.

Compound - A homogenition mixture of many polymers and other chemicals like - zinc oxide, carbon black and oil etc.

Co-polymer - This is polymer which is made by mixing two different monomers. Some of the examples are EPDM, NBR and SBR etc.

Cure - A chemical reaction activated by heat and pressure in rubber compound which enables rubber compound to change from semi plastic stage to elastic stage and provide useful properties such as good tensile, hardness, resistance to ageing, swelling in oil etc.

Elasticity - It is a property of rubber, due to which it comes back to its original shape after leaving from a pulled or pressed condition

Elongation - This is a ratio of original length of rubber and maximum elongated length.

FIFO - Full form of word 'FIFO' is First in, First out, which means the material received first should be used first. This is a widely used term in industry and has very significant meaning especially in rubber industry.

Why is FIFO important

Since all the material is prone to some level of degradation over period of time due to – its shelf life, environmental effects on it, such as – humidity, temperature, light. Hence it is advisable to use it in a certain period of time. But if the material come first is not used and next arrived material is used there are high chances that the material came first might get rejected. This rule is made so that all material will be used timely by default.

Flashes - This is extra rubber which comes out from various exit points and joints of mould, like - air vent or mould closing surfaces.

Fillers - Fillers are of three kinds namely reinforcers, semi reinforcers and fillers. They improve physical properties such as tensile strength, tear resistance, enhance durability, help cost savings etc.

Hardness - This is a way of measuring rubber's relative resistance towards pre-defined indentation.

Estimate of specific gravity of compound

You can estimate the density of your compound by multiplying the quantity of each ingredient by its individual density. The specific gravity of individual ingredients can be obtained from its supplier. Add individual results and then divide this number by the total sum, it is called phr. The result will give you the estimated density of the compound (In an open mixer or internal mixer fly loss of 2 to 3 % Carbon and silica occur. This needs to be taken into account for calculations of gravity). We can understand it by the example given below:

Recipe Ingredients	Volume (L)	Density kg/L	Volume x Density (kg or PHR)
SMR 10	106.4	0.94	100.0
Zinc Oxide	1.8	5.55	10.0
Stearic Acid	2.2	0.92	2.0
N550 Carbon Black	27.8	1.80	50.0
Oil	10.9	0.92	10.0
Antioxidant TMQ	1.9	1.08	2.1
Antiozonant DPPD	1.6	1.22	2.0
Sulphur	0.1	2.07	0.2
TBBS	1.6	1.29	2.1
TMTD	0.7	1.35	0.9
Total	155		179.3
Compound SG	(179.3/155)	1.16	

Table 1.2.1. Specific gravity calculation

Calculating, the **SG of this Compound** mix is arrived at 1.16 (=179.3/155).

Master Batch

Master batches mixed and kept for usage in preparing various compounds. They are of different kinds could be sulfur-rubber, accelerator-rubber or carbon black filler type, or natural - peptide type. These master batches act as a common mix for many compounds, thus facilitating minimum losses of chemicals during mixing and help in better dispersion of these chemicals and fillers.

Moulding

It is a process of making usable rubber parts by using moulds.

Polymer

A material which has a molecular structure built up chiefly or completely from a large number of similar units bonded together, e.g. many synthetic organic materials used as rubber, plastics and resins.

PLC

Full form of PLC is 'Programmable Logic Control. It is a computer which is used to run a machine. This is used for automation of the machine. Through PLC we can program the machine, so that it can perform without any manual intervention.



Fig. 1.2.1. PLC

PQCDS

PQCDS are the most important factor for running a factory operation. Where P stands for Productivity, Q stands for Quality, C stands for Cost, D stands for Delivery and S stands for Safety. If PQCDS is under control for any company then the following will be the benefits –

- Profitability will be high
- Customer will be happy
- Employees will be happy

Shelf Life

Shelf life is the period by which a product maintains all of its properties and it can safely be used without any ill effects. All manufacturers declare shelf life for their product based on the ingredient and its specification. Since the rubber compound is prone to vulcanize with temperature and time, hence it is kept in a temperature-controlled environment. It has a different storage limit based on its specification.

Shrinkage

A decrease in rubber volume during moulding and due to the prevailing environment is called shrinkage.

Swell

An increase in rubber volume due to oil, liquids, and other things, is called swell.

Unit of measurement

Unit of measurement is the standard for defining the physical quantity of characteristics of any object. For example – a gram is a unit of measurement for the weight of any object. There are two systems of measurement.

1. SI or FPS system
2. MKS system

The metric system is an international decimalized system of measurement, first adopted by France in 1791, that is the common system of measuring units used by most countries in the world. All measuring tools have metric or imperial graduations or a combination of both. One big advantage of the metric scale is that it eliminates the necessity for a range of fractional sizes. The markings on a metric rule are every millimeter with the figures marked at 10-millimeter intervals. The unit of weight in FPS system is pound, while in MKS system it is a gram. Fractions are not used in the MKS system. In India, the metric or MKS system is more popular. Hence weight measurement is done in grams or kilograms.

Vulcanization

This is another term used for cure.

1.2.2 Compounding

Compounding is to decide that what ingredients to mix in which proportions. The ingredients and their proportions are decided based on the desired properties for the final product and their application. Its importance is very high since compounds constitute the largest part of any rubber part. Following are some of the examples as per the usage of the compound -

1. Tubes - 98%
2. Moulded parts - 20-100% (depending on the insert)
3. Tyres - 75-80%
4. Conveyor belts - 40-50%

1.2.3 Rubber Mixing

Rubber mixing is a specified and proven method of combining different ingredients together and creating new homogenous material. The new material has a property that is different from basic ingredient's properties.

1.2.4 Ingredients of Compound

Any Rubber compound is primarily made of below ingredients -

1. Polymer - 50% of compound
2. Filler - 15 - 30% of compound
3. Antioxidant - 0.5 - 1.5% of compound
4. Antiozonants - 0.5 - 1.5% of compound
5. Oil - 2.5 - 15% of compound
6. Cure - 2.5 - 5% of compound

Polymer

This is the first and foremost ingredient of any rubber compound. This acts as a base for a rubber compound and primarily responsible for the chemical, physical, and molding properties of a compound. The polymers are rated for their chemical properties and viscosity rating. Examples of polymers are - natural rubber, nitrile rubber, etc.



Fig. 1.2.2. Polymer stored in Raw Material Store

Filler

The filler used for giving strength and color to the compound. Carbon black is the most used filler in the rubber industry. It comes in various particle sizes. By changing the particle size one can change the physical properties and compression set too. There are some other fillers also, like white clay. It helps in keeping compound color white wherever necessary.



Fig. 1.2.3. Carbon black stored in Raw Material Store

Antioxidants

As the name suggests, it prevents oxidative degradation caused by oxygen by absorbing free radicals. It ensures that bonds between polymers remain strong and compound lasts its intended work life.

Antiozonants

Similarly, as antioxidants, it helps in keeping away the ozone, which affects the work-life of rubber compounds. An example of antiozonants is wax.

Oil

Oils are termed as physical plasticizers. They make the ingredients wet, facilitate mixing, improve plasticity and act as tackifiers. They also help in adjusting physical properties such as hardness.



Fig. 1.2.4. Oil stored in Raw Material Store

Curing Agent

It is also known as vulcanizing agents, it is mixed just before the part-making process, whether it is moulding or extruding. Sulphur is the most common curing agent. Peroxide or any other sulfur donor such as thiuram disulfide can be used as a curing agent. Curing agents ensures chemical bonding and increases the strength of rubber.

1.2.5 Types of Rubber Compound

Following are some of the commonly used rubber compounds -

1. NR (Natural Rubber)
2. NBR (Nitrile Butadiene Rubber)
3. SBR (Styrene Butadiene Rubber)
4. EPDM (Ethylene Propylene Diene Rubber)
5. FPM (Fluorocarbon Rubber)
6. CR (Chloroprene Rubber)

Natural Rubber

The main ingredient of this compound is natural rubber, which is derived from rubber plants. It has properties of -

- low compression set,
- high tensile strength,
- resilience,
- abrasion and tear resistance,
- good friction characteristics,
- excellent bonding capabilities to metal substrate,
- good vibration dampening characteristics.

NBR

This is the highest-used elastomer in the sealing component industry. It is used is due to its resistance property to petroleum products and its ability to withstand a temperature range of -22°F to 212°F. It is a copolymer of butadiene and acrylonitrile. We can make various types of compounds by varying their proportions. By increasing acrylonitrile content we can increase resistance to temperature and petroleum products and fuels. At the same time, it decreases flexibility in low temperatures.



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