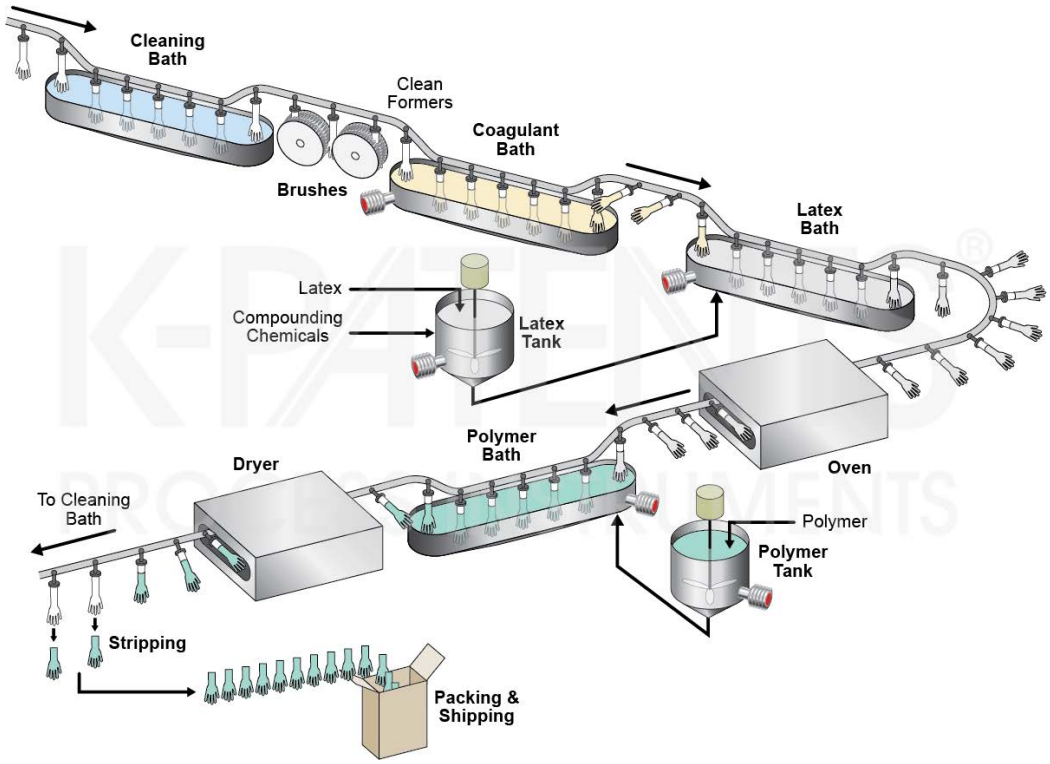
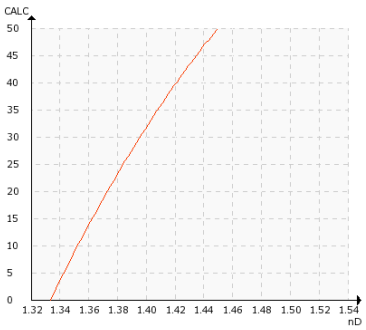


NATURAL LATEX, NITRILE BUTADIENE RUBBER (NBR), COAGULANT SOLUTIONS, POLYMER SLURRY

Typical end products

Gloves made of natural or synthetic rubber for different uses in the healthcare, food, chemical, pharmaceutical, automotive finishing and oil and gas industries.

Chemical curve: R.I. vs. Latex % b.w. at Ref. Temp. of 20˚C



Introduction

Rubber gloves are used for protecting skin against physical and chemical injuries as well as against infection by viruses and bacteria. Rubber gloves can be made from natural rubber *(latex)* or from synthetic rubber such as *nitrile butadiene rubber (NBR)* and *chloroprene rubber (CR)*.

Rubber gloves are for different tasks in several industries, ranging from healthcare to food processing and services, automotive to construction and chemical industries.

Application

Natural rubber gloves

Natural rubber gloves are manufactured by a *dipping technology*, where ceramic or metal formers that mimic the shape of a hand are dipped in liquid latex, and then dried. This process has many variations, and production is done in batches or continuously.

The manufacturing process starts with cleaning the formers to remove any residual particle or dirt that could cause defects in the final glove product, and to ensure latex adhesion to the formers during latex dipping. In cleaning, the formers are sunk in acid and alkali baths and are brushed mechanically for thorough cleaning. After that, the formers are rinsed with clean water.

Next, the formers are dipped in a coagulation tank containing a solution of calcium nitrate or calcium carbonate. The coagulant is applied to enhance

polymer flocculation and to ensure the latex is distributed equally on the surface of the formers. The Total Dissolved Solids (TDS) concentration of the coagulation bath is maintained at its optimal level to prevent sedimentation of ingredients, as it could cause weight variation or weak spots on the gloves.

After mild drying, the formers are dipped into the latex dipping tank. This tank contains c*ompounded mature latex* that has been prepared by mixing latex with various compounding chemicals. The concentration of latex is carefully monitored and controlled as it has a crucial effect on the final quality, durability and product specification. The concentration of latex for dipping should be kept between 10 and 60 %.

A leaching process follows, where the formers are dipped into hot water to dissolve proteins, water-soluble residues and other chemicals from previous steps. Proper leaching of the gloves improves the strength of the latex film but not without replenishment of water to prevent build-up of extracted chemicals.

The next step is vulcanization. In this step, the material is heated at a high temperature to allow the compounding chemicals to form a cross-link with the polymer molecules. Cross-linking gives strength and elasticity to the physical properties of the rubber.

After vulcanization, the surface of the gloves might be treated to facilitate release from the hand former, to prevent gloves adhering to one another, and to ensure the gloves fit smoothly. For instance, the gloves may be dipped in a polymer coating solution for easier donning and to ensure the inner part of the glove is smoother and not sticky. Typical polymer coatings are aqueous dispersions of acrylic or polyurethane. The polymers are diluted and maintained at the required concentration (up to 20 %) to ensure high quality of the glove product.

The last part of the manufacturing process is the stripping phase where the gloves are removed from the formers. The gloves are tested for quality and packed for delivery to the customers.

Synthetic rubber gloves

The manufacturing process for synthetic rubber gloves is similar to latex production besides that they are manufactured from synthetic materials such as nitrile, vinyl and synthetic polyisoprene.

The main difference is that in this process the synthetic material needs to be created first. The rubber raw material used is commonly a copolymer, a plastic material produced by the copolymerization of two or more different molecules or monomers. In the case of nitrile butadiene rubber (NBR), the two monomers are butadiene and acrylonitrile. Synthetic rubber is manufactured by emulsion polymerization or polymer emulsification by means of mechanical shearing.

Once the synthetic materials are available, they go to the factory for production. The required processes are relatively the same to those in latex rubber gloves manufacturing, but the dipping line requires different operating parameters.

Instrumentation and installation

The K-Patents Process Refractometer PR-43-G is installed at different stages of the rubber gloves line to measure the concentration of dipping baths solutions. The refractometer provides continuous TDS concentration measurement to ensure operation within the specifications and to guarantee high-quality rubber gloves. The in-line measurement by the refractometer eliminates the need for sampling and long laboratory tests, providing immediate data for real-time process control.

The K-Patents refractometer can be installed directly on a pipe or tank. At the compounding latex, polymer and coagulant preparation steps, the refractometer monitors the desired TDS concentration is consistently used and provides important information to keep it to the pre-determined level. The measurement is also useful for monitoring the concentration of different baths and for adjusting it only when needed, reducing the consumption of raw materials and minimizing operating costs.

If the factory operates from synthetic rubber made at the same facilities, the K-Patents refractometer can also be used in the polymerization vessel. The refractive index measurement provided by the refractometer helps to follow in real-time the progress of the reaction and to determine the degree of polymerization. The refractometer can be installed in-line in the bypass line of the reactor or directly at the bottom of the vessel through the steam jacket, eliminating the need for sampling and off-line testing (see also Application Note *Control of Polymerization and Nitrile Butadiene Rubber Production process*).

Automatic prism wash with high pressure water is required in this application for concentrations above 40 % by weight or when flow velocity is below 1.5 m/s. Hazardous and intrinsic safety approvals are available also when required.

The reliable in-line measurement by the K-Patents refractometer helps rubber glove manufacturers to improve product quality, enhance productivity and reduce production costs.

Instrumentation	Description
	K-Patents Process Refractometer PR-43-GP is a general industrial refractometer for pipes and vessel installations. The PR-43-GP can be installed with 2, 3 and 4 inch flange and 3 inch Sandvik L coupling process connections and a variety of flow cells for pipe sizes of 1 inch and larger.
User Interface	Selectable multichannel MI, compact CI or a web-based WI user interface options allow the user to select the most preferred way to access and use the refractometer measurement and diagnostics data.
Automatic Prism Wash	**Prism wash with high pressure water:** The components of a high-pressure water system are a sensor with integral water nozzle mounted at the sensor head, a high pressure pump together with a power relay unit and an indicating transmitter equipped with relays.
Measurement range	Refractive Index (nD) 1.3200 – 1.5300, corresponding to 0-100 % by weight.