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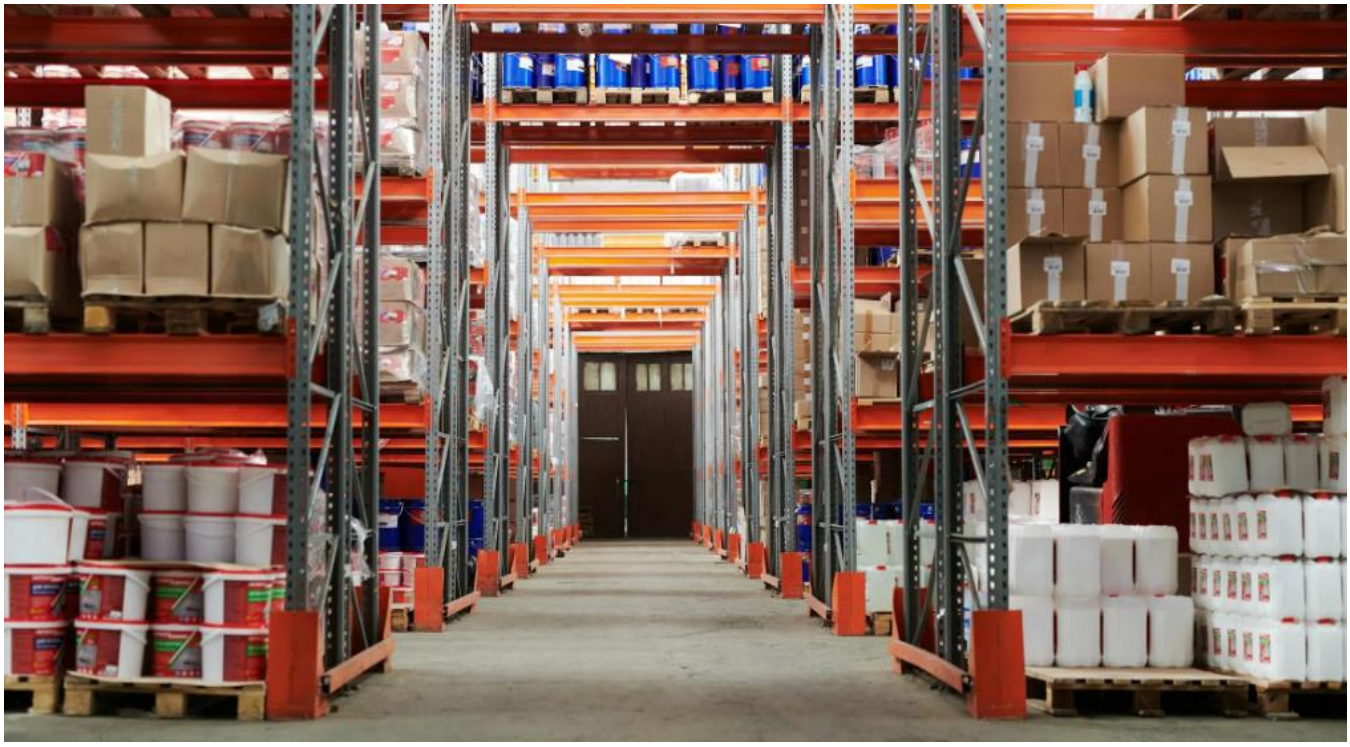
Industrial operating materials for maintenance and repair.

Review.



Inroduction

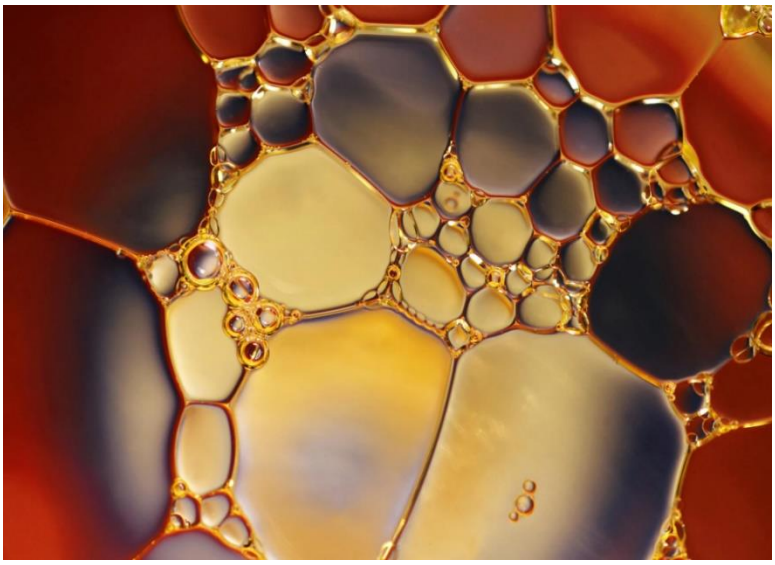
Industrial maintenance, repair, and operations (MRO) *materials are specialized substances and composites designed to maintain the performance of industrial equipment, restore damaged components, and protect against wear.*

Unlike materials included in finished products, MRO materials are used to ensure the continuity of production processes and extend the service life of equipment. These materials form the basis of a regular and preventive maintenance program at any industrial facility and serve as a "first aid kit" and "toolkit" for industrial assets.

Their proper use directly impacts the continuity of production processes, equipment service life, lifecycle costs, and environmental safety. Investments in high-quality specialized MRO materials always pay off in reduced costs for major repairs and replacement of failed equipment.

Main categories of MRO materials

The main categories of industrial operating materials include:



- Polymer repair composites (epoxy, polyurethane)
- Ceramic coatings and fillers
- Industrial lubricants and oils
- Adhesives, sealants, and gaskets
- Cleaners and degreasers
- Protective coatings against corrosion and abrasive wear

Functionality of operating materials

MRO operating materials perform the following key tasks:

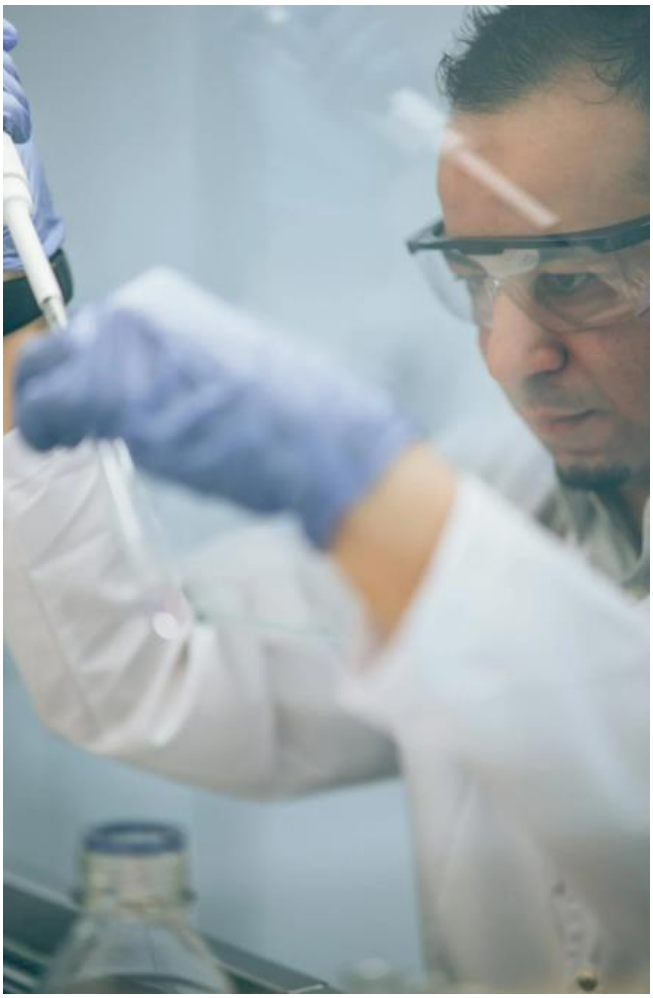
1. Repair of damaged components — repair composites based on epoxy resins with metal fillers allow for the restoration of worn surfaces of shafts, pump housings, heat exchangers, and pipelines without dismantling the equipment.
2. Protection from corrosion and wear — ceramic and polymer coatings create a barrier against chemical attack, cavitation, and abrasive wear, significantly extending the service life of the equipment.
3. Sealing and gasketing — specialized sealants and gasket materials provide reliable sealing of joints under high temperatures and pressures.
4. Reduction of friction and wear — industrial lubricants reduce equipment energy consumption and prevent premature wear of bearings, gears, and guides.
5. Rapid emergency response — repair kits contain all the necessary components for emergency restoration of critical equipment with minimal downtime.

Applications of MRO materials

- **Chemical and oil and gas industries:** cleaning and protecting equipment from aggressive environments.
- **Mechanical engineering and metalworking:** surface preparation (degreasing, etching) before coating application, machine protection**.**
- **Transport and logistics (automotive, rail, navy):** cleaning units, anti-corrosion treatment of bodies and frames, component maintenanc**e.**
- **Energy and utilities:** scale and corrosion control in heat exchangers, valve maintenance.
- **Food industry:** cleaning and sealing equipment with special non-toxicity requirements.

The world's largest producers of MRO materials

The global market for MRO materials manufacturers is fragmented, but dominated by a few types of companies: multinational chemical conglomerates, specialized industrial brands, and engineering companies:



- **Henkel (Germany) —** a global leader in adhesives and sealants under the LOCTITE® brand, specializing in solutions for industrial MRO.
- **Sika AG (Switzerland) —** a supplier of bonding, sealing, and protection systems for industrial equipment.
- **FUCHS SE (Germany) —** the largest European manufacturer of industrial lubricants, offering a full range of oils, greases, and process fluids.
- **BASF SE (Germany) —** a leading supplier of chemical solutions for industrial cleaning and maintenance.
- Klinger Group (Austria) — a global leader in the production of industrial gaskets and sealing systems.
- **3M (USA) —** provides comprehensive solutions for industrial MRO, including abrasives, adhesives, cleaning agents, and protective coatings.
- **Dow Inc. (USA) —** produces adhesives, sealants, and chemical solutions for industrial equipment maintenance.
- **ExxonMobil (USA) —** one of the world's largest producers of base oils and industrial lubricants under the Mobil™ brand.
- **Shell (UK/USA) —** a supplier of industrial lubricants for various industries, including energy, mining, and metallurgy.
- **Belzona (UK) —** specializes in polymer repair composites and protective coatings for industrial equipment restoration.

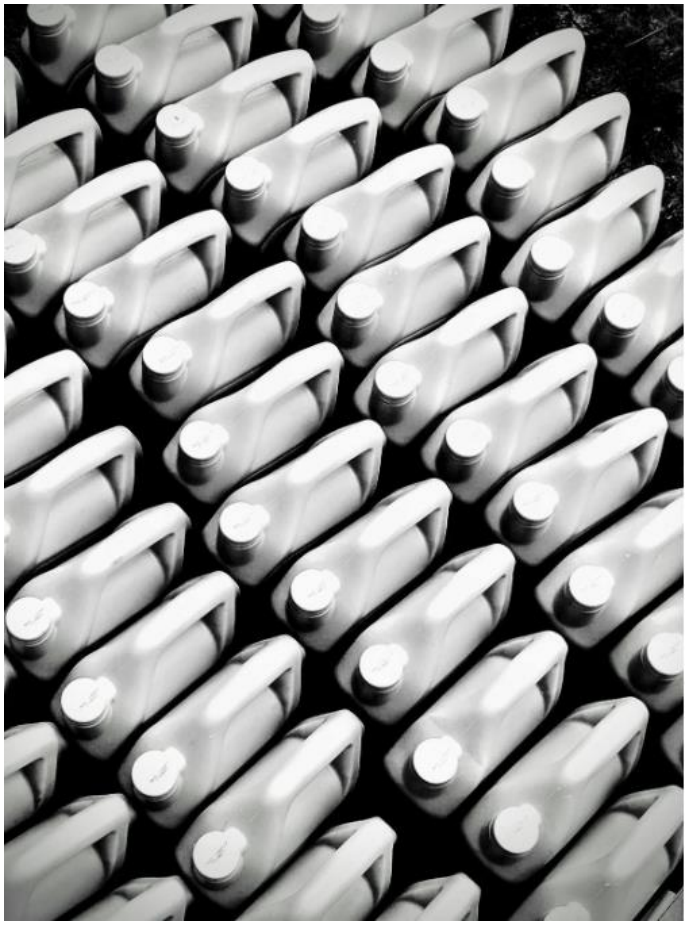
Let's look at six different professional tools for maintenance, repair and operation.

1. **Industrial Surface Cleaning Fluid**

Purpose:

Professional product for intensive cleaning and degreasing of various industrial surfaces: metal, plastic, ceramics, painted surfaces, floors, equipment, and vehicles.

Key Features:



- **Powerful degreasing:** effectively removes oils, greases, petroleum products, and process contaminants.
- **Versatility:** suitable for most materials.
- **Fast action:** does not require long contact time**.**
- **Easy rinsing:** leaves no streaks when using water.
- **Concentration:** concentrated, requires dilution (often 1:5 – 1:50)**.**
- **Application method:** can be used by hand, with brushes, or in high-pressure washers, foam generators, or wash basins.

Compound:

- **Surfactants (surface-active agents):** for wetting and emulsifying fats.
- **Alkaline components:** hydroxides, silicates, carbonates – for breaking down organic contaminants.
- **Complexing agents:** for softening water.
- **Solvents (in some versions):** for enhancing action against resins and complex contaminants.
- **Corrosion inhibitors** (in high-quality formulations)**.**

Application areas:

- **Motor vehicles and special equipment:** engine, chassis, and body cleaning.
- **Metalworking:** cleaning machine tools and parts before painting or assembly.
- **Warehouses and logistics:** washing floors and loading equipment.
- **Food industry (only specialized compounds with approvals):** cleaning the external surfaces of equipment.
- **Agriculture:** washing agricultural machinery**.**

Precautionary measures:

- Wear personal protective equipment (gloves, goggles).
- Avoid contact with skin and mucous membranes.
- Ensure adequate ventilation.
- Dispose of in accordance with local environmental regulations.

2. Acid Clean Professional

Purpose:

A specialized concentrated acidic cleaner for removing inorganic (mineral) deposits: rust, limescale, cement films, salt deposits, and corrosion products from various surfaces. This is not a universal cleaner, but rather "heavy artillery" for specific, complex tasks. Its use requires strict adherence to safety precautions and compatibility testing with the surface being cleaned.

Key Features:

- **Acid action:** effectively dissolves and removes metal oxides, calcium and magnesium carbonates (scale).
- **Fast action:** works in a short contact time (5-15 minutes).
- **Anti-corrosion additives:** often contains inhibitors that protect the metal base from acid damage.
- **Concentration:** highly concentrated, requires dilution with water (usually 1:5 - 1:20).
- **Gel/liquid form:** available as a gel for vertical surfaces or as a liquid for soaking and spraying.
- **Effective** in cold water.

Typical composition:

- **Inorganic acids:** hydrochloric (HCl), phosphoric (H_3PO_4), sulfamic – for dissolving mineral deposits.
- **Corrosion inhibitors:** for protecting treated metals (steel, cast iron).
- **Surfactants:** for improving wetting and penetration.
- **Dispersants:** for retaining dissolved particles in solution.

Application areas:

- **Plumbing and utilities:** cleaning boilers, heat exchangers, and pipes from scale.
- **Car washes and auto repair shops:** removing rust from wheels and body parts (only for stable surfaces).
- **Construction and repair:** cleaning brick and concrete surfaces from cement films and efflorescence.
- **Food industry (only compounds based on approved acids, such as phosphoric acid):** descaling equipment.
- **Metalworking:** etching and cleaning metal before further processing or painting**.**

Precautions (critical):

- **Mandatory use of personal protective equipment:** acid-resistant gloves, goggles, protective clothing, and a respirator (when working with vapors).
- **Proper dilution:** add acid to water, not the other way around! To avoid a violent reaction and splashing.
- **Work in well-**ventilated areas.
- **Compatibility:** Do not use on acid-sensitive surfaces (marble, limestone, aluminum, some types of plastic). Test on an inconspicuous area before use**.**
- **Special disposal of neutralized solutions according to regulations**

3. **Corrosion Inhibitor**

Purpose:

A specialized chemical agent for preventing and slowing corrosion (rusting) of metal surfaces. It does not remove existing rust, but creates a protective layer that blocks the metal's contact with oxygen and moisture.

Key properties and operating principle:

- Protective/Passivative action: forms an invisible film (adsorption or phosphating) on the metal surface, altering electrochemical processes and inhibiting oxidation.
- Penetration: penetrates micropores and under existing rust residue, stopping its spread.
- Water-repellent: possesses hydrophobic properties.
- Adaptability: can be used as a stand-alone coating (temporary protection) or as a primer-modifier for subsequent painting.
- Long-lasting protection: provides protection for a period of months to several years, depending on the composition and operating conditions

Typical composition:

- **Volatile Compound Inhibitors (VCI):** Compounds that evaporate and condense on metal in a closed space (for packaging and storage)**.**
- **Contact Inhibitors:** Based on phosphates, nitrites, silicates, and organic salts (benzoates, amines).
- **Solvent:** White spirit, water (for water-based products).
- **Binding resins** (in film-forming compounds).
- **Acid corrosion inhibitors** (included in cleaners)**.**

Application areas:

- Treatment of hidden vehicle cavities (sills, doors, frames).
- Preservation of equipment and tools during storage or transportation.
- Protection of metal structures (trusses, hangars, fences) between painting periods.
- Flushing and filling of cooling and heating systems.

- Anti-corrosion treatment of welded seams and damaged factory coatings.
- Protection of parts in mechanical engineering and metalworking

Precautionary measures:

- **Ventilation:** Especially important when working with solvent-based compounds.
- **PPE:** Protective gloves and goggles to prevent skin and mucous membrane irritation.
- **Removal of excess:** Before painting, remove any unabsorbed excess to avoid impairing paint adhesion.
- **Fire hazard:** Many solvent-based compounds are flammable. Avoid open flames.
- **Testing:** Before large-scale application, check compatibility with the specific metal type and subsequent coatings**.**

4. **Water Displacing Protective Film**

Purpose: A specialized product based on volatile solvents that performs two key functions: displacing water from the metal surface and creating a thin protective film to prevent corrosion. It is used where it is necessary to displace moisture from microcracks, joints, and hard-to-reach areas and provide rapid protection**.**

Key properties and operating principle:

- **Water displacement effect:** due to low surface tension and high penetrating ability, it actively replaces the water film on the surface, “repelling” it
- **Forms a protective barrier:** After the solvent evaporates, a thin oil or wax film remains on the surface, protecting it from oxygen and moisture.
- **Penetrating ability:** penetrates gaps, under threaded connections, and into microscopic pores of metal.
- **"Wets and protects":** works on wet surfaces, which is its main advantage over many other inhibitors.
- **Multifunctionality**: often has a mild cleaning and lubricating effect (for non-power components).

Typical composition:

- **Volatile solvents (e.g., white spirit) –** provide penetration and rapid drying.
- **Protective bases:** mineral or synthetic oils, waxes, fatty acids – form a barrier film after the solvent evaporates.
- **Corrosion inhibitors:** special additives that enhance the passivation of the metal surface.
- Propellants (in aerosol versions)**.**

Application areas:

- **Electrical equipment and contact treatment:** to displace moisture and prevent oxidation of terminals, connectors, and fuse boxes.
- **Post-wash/storage protection:** treatment of chains, cables, tools, and weapons after cleaning or for long-term storage.
- **Automotive and motorcycle service:** protection of electrical components, treatment of hidden body cavities, battery terminals, and suspension components.
- **Shipping and marine engineering:** critical protection of metal parts in conditions of constant humidity and salt spray.
- **Preservation of precision mechanisms and bearings.**

Precautionary measures:

- **Ventilation:** Required when working indoors due to volatile solvents.
- **PPE:** Gloves and safety glasses. Avoid inhaling vapors.
- **Flammability:** Vapors are flammable.
- **Compatibility:** May soften some plastics and rubber.

- **Before painting:** Complete removal or special cleaning of the surface is required, as the film will impair paint adhesion.

5. **High-Performance Degreaser**

Purpose:

A professional concentrated cleaner for the fast and deep removal of stubborn oil, grease, grease, and petroleum stains from industrial surfaces and equipment. Designed for tasks where standard cleaners fail.

Key Features:

- **Powerful solvent action:** effectively breaks down old and polymerized fats, oils, bitumen stains, and graphite grease.
- **Fast action:** works with minimal contact time, often without the need for mechanical action.
- **Deep penetration:** due to its high wetting ability, it penetrates microcracks and pores.
- **Versatility and material safety:** suitable for most surfaces (metal, plastic, rubber, painted surfaces) when used according to instructions. Often contains corrosion inhibitors.
- **Biodegradability and eco-friendliness:** many modern high-performance degreasers are based on rapidly biodegradable, low-VOC chemicals.
- **Concentration:** highly concentrated, economical to use (standard dilution 1:10 – 1:30)**.**

Typical composition:

- **Biodegradable surfactants and solvents:** a combination of effective and environmentally friendly surfactants and modern solvents.
- **Emulsifiers:** to bind broken down fat into a stable emulsion, preventing redeposition.
- **Alkaline or neutral complexes:** can be either alkaline (for maximum power) or neutral (for delicate surfaces).
- **Corrosion** inhibitors, stabilizers, fragrances.

Application areas:

- **Automotive and transport:** washing engines, chassis, transmissions, and parts before repair.
- **Food industry:** cleaning external surfaces of equipment, ventilation systems, and floors from edible fats (requires appropriate certifications).
- **Mechanical engineering and metalworking:** degreasing parts before painting, welding, or assembly; cleaning machine tools.
- **Power generation and railways:** cleaning power units, assemblies, and components.
- **Warehouse and logistics complexes:** cleaning floors and equipment from oils and greases**.**

Precautionary measures:

- **PPE:** Wear gloves and safety glasses. When handling concentrates and aerosols, wear a respirator.
- **Compatibility check:** Test on an inconspicuous area before first use, especially for plastics and painted surfaces.
- **Ventilation:** Ensure fresh air supply in enclosed spaces.
- **Disposal:** Comply with local waste disposal regulations, especially for waste containing petroleum products**.**

6. **Packing (Sealing material/Gland packing)**

Purpose:

A material for creating a hermetic, movable or fixed seal in

glands (glands) of pumps, mixers, shutoff valves, piston rods, and valves. Prevents leakage of working media (liquids, gases, vapors) and protects against contaminants.

Key Features:

- **Tightness:** Ensures a tight seal between the stem and body to prevent leaks.
- **Wear resistance:** Resistant to friction from moving parts.
- **Thermal and chemical resistance:** Maintains properties over a wide temperature range and when exposed to aggressive environments (acids, alkalis, hydrocarbons).
- **Ductility:** Ability to seal under the load of the packing bushing and adapt to uneven surfaces.
- **Low coefficient of friction:** Minimizes stem wear and heating.
- **Antifriction properties:** Often contain lubricating impregnations (graphite, PTFE).

Typical materials and composition:

- **Asbestos-free packing:** impregnated with graphite or PTFE. For high temperatures.
- **Non-asbestos packing:**

o Aramid fiber-based: high strength, abrasion resistance.

o Carbon fiber-based: excellent chemical and temperature resistance, low friction.

o PTFE (Teflon)-based: ideal chemical inertness, suitable for the food and pharmaceutical industries.

o Graphite-based: for extreme temperatures and aggressive environments.

o Fiberglass-based: for acidic environments. Based on aramid fibers: high strength, abrasion resistance.

- **Impregnations:** graphite, molybdenum disulfide, silicone, synthetic oils to reduce friction and improve sealing**.**

Release forms and types:

• Spooled (wound): Square or rectangular cross-section, wound onto a spool.

• Sectional (ring): Ready-made sectional rings, matched to the rod and body diameter.

• Braided, molded.

- **Application types: for rotary, reciprocating, or valve motion.**

Application areas (almost all industry):

- **Chemical and oil and gas industries:** sealing pumps and valves on process lines.
- **Water supply and housing and utilities:** stuffing box seals for valves and pumping stations.
- **Shipbuilding:** sealing propeller shafts (ship packing).
- **Food and pharmaceutical industries:** specially approved materials (PTFE, aramid).
- **Power engineering:** sealing valves on boilers and turbines**.**
- **Pumping** equipment of any type.

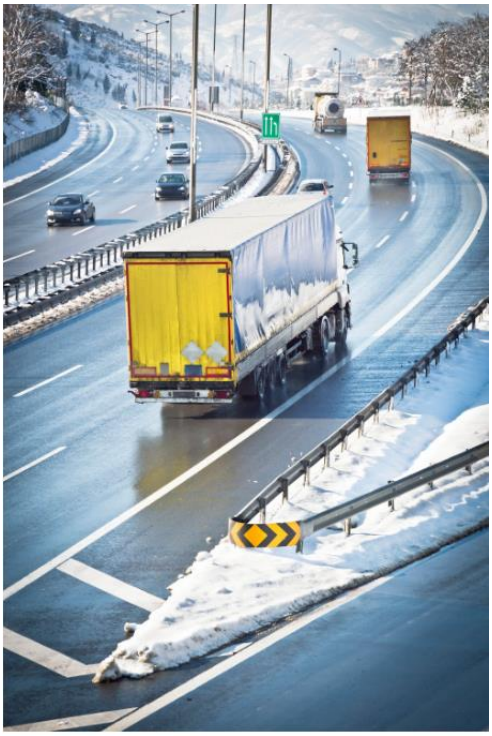
Key points when choosing and working:

- Medium-Material Selection: Selecting a material compatible with the operating environment, temperature, and pressure is critical.
- Proper Installation: Packing rings should be installed with the joints offset by 90° and pressed in with the recommended torque.
- Adjustment: After installation, rolling and adjusting the pressure is necessary to minimize leakage and lubrication (a drop per minute is often normal).
- Safety: When handling worn asbestos packing, exercise caution to avoid inhaling dust.
- Standards: Refer to DIN and API standards for dimensions and application conditions.

Conditions for transportation and storage of industrial operating materials

The presented materials, which fall under the category of industrial chemicals, have many common requirements, but there are also critical differences for individual types; let's consider them in more detail:

General conditions for all MRO materials



Transportation:

- **Container:** Only original, hermetically sealed, undamaged containers (canisters, barrels, aerosol cans) are permitted.
- **Position:** Canisters and barrels must be transported upright to prevent leaks.
- **Compatibility:** Do not transport together with food products, feed, or strong oxidizing agents.
- **Securing:** Containers must be securely fastened in the vehicle body to prevent movement and impact.
- **Climate:** Protect from direct sunlight and heat sources during loading/unloading and transportation.

Storage:

- **Storage:** A specially equipped warehouse complex for industrial chemicals. A dry, well-ventilated area.
- **Temperature:** Generally recommended storage temperatures are between +5°C and +25°C. Avoid freezing and overheating.
- **Separate storage:** Materials should be stored separately from food products, feed, and incompatible substances (e.g., acids and alkalis).
- **Shelving:** Storage on pallets or racks is preferred, rather than directly on the floor.
- **Safety:** The warehouse must be equipped with fire extinguishing equipment (class B, E fire extinguishers), neutralizing agents (sand, sorbent), and have access to water for eye/skin rinsing (if necessary).

Product-specific conditions

1. Industrial Surface Cleaning Fluid и High-Performance Degreaser (alkaline/neutral)

- **Transportation:** Standard for non-hazardous/low-hazardous goods (usually ADR Class 9, unless containing strong solvents).
- **Storage:** Primary risk is freezing of aqueous solutions. After thawing, the composition may separate. Store in a tightly closed container to prevent evaporation of water or volatile components.

2. Acid Clean Professional (acidic agent)

- **Transportation:** Dangerous goods! Most often classified as Class 8 (Corrosives). Marking with the appropriate hazard label and accompanying documentation (emergency card, TN) are required. Transportation must be carried out by specialized vehicles with trained personnel.

- **Storage:** Keep separate from alkalis and metals! A secondary container (drip tray) is required to collect any spillage. Acid fumes can cause corrosion of metal structures and equipment in the warehouse**.**

3. Corrosion Inhibitor и Water Displacing Protective Film (often solvent-based)

- **Transportation:** Flammable liquids! Belong to Class 3 (Flammable Liquids) or 9, depending on flash point. Protection from sparks, open flames, and heat is essential.
- **For Water Displacing Film (aerosol):** also considered a gas under pressure (Class 2). Do not expose cylinders to temperatures above +50°C (risk of explosion).
- **Storage:** Preferably in a cool, insulated area. Keep away from heat sources, sparks, and heating devices. The area must be equipped with explosion-proof electrical fittings**.**

4. Packing (Sealing packing)

- **Transportation:** The easiest material to handle. Not classified as hazardous goods. Protect from mechanical damage, contamination, and direct exposure to oils/chemicals.
- **Storage:** Store in a dry place. Key requirements include protection from UV rays, moisture, and aggressive vapors, which can degrade the material's properties (drying out, loss of plasticity). Store in the original packaging until use**.**

Therefore, it is always necessary to first consult the Material Safety Data Sheet (SDS, MSDS), Sections 7 and 9, which specify the exact conditions for a specific product from the manufacturer. This overview covers typical, but not all, cases.

Modern trends (2026):

- Switching to biodegradable and pH-neutral formulations (e.g., Udevicx ultrasonic cleaners)
- Closed-loop filtration and recirculation systems for cleaning fluids (e.g., Ecochem (India) offers products based on natural antibacterial herbs and plants)
- Reducing VOC (volatile organic compounds) levels under regulatory pressure (EU, USA, Canada, China)
- Automation: robotic systems and AI-powered dispensers

The global industrial cleaning chemicals market was valued at $49.61 billion in 2024, with a projected growth rate of 4.5% annually through 2034.

Sourses:

- *Henkel Adhesives Technologies: https://www.henkel-adhesives.com*
- *BASF: https://products.basf.com*
- *3M: https://www.3m.com/3M/en_US/industrial-manufacturing-us/*
- *WD-40 Specialist: https://www.wd40specialist.com/*
- *CRC Industries: https://www.crcindustries.com/products/*
- *John Crane: https://www.johncrane.com*
- *EagleBurgmann: https://www.eagleburgmann.com*
- *Garlock (EnPro Industries): https://www.garlock.com*
- *Databases of safety data sheets (SDS/MSDS): https://www.chemsafetypro.com/Topics/HazCom/Where_to_Find_SDS.html . https://www.sdsource.com*
- *European Chemicals Agency (ECHA): https://echa.europa.eu/information-on-chemicals*
- *US National Institutes of Health (NIH), PubChem: https://pubchem.ncbi.nlm.nih.gov/*
- *UNECE - List of Dangerous Goods (ADR): UN Model Regulations: https://unece.org/transport/dangerous-goods/un-model-regulations*
- *International Civil Aviation Organization (ICAO): Dangerous Goods Section: https://www.icao.int/safety/DangerousGoods/Pages/default.aspx*
- *Occupational Safety and Health Administration (OSHA), US: https://www.osha.gov*
- *UL Solutions (safety standards and certifications): https://www.ul.com*
- *ICIS (Independent Commodity Intelligence Services): https://www.icis.com/explore/*
- *Chemical & Engineering News (C&EN): https://cen.acs.org*
- *Udevicx: https://udevicx.com/*
- *Ecochem: https://ecochem.ind.in/*
- *Bunzl: https://bunzlch.ca/*
- *Polaris Market Research: https://www.polarismarketresearch.com/*

All links are provided for informational purposes only and are current at the time of writing.

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