# Technical Brief

## Technical Summary

Heat treating operations can cause a carbonaceous “smut” or metal scale on the surface of ferrous, stainless, and high temperature alloy rod, wire, or flat sheet products. The “hot-section” components of jet engines eventually build up a tenacious scale that must be removed prior to inspection and overhaul.

This smut and scale can be a combination of reduced carbon and metal oxides that are not acid soluble. Effective cleaning of the metal surface is essential prior to the finished coating or plating processes. Poor surface cleaning results in poor adhesion of the finish and excessive die wear.

An aqueous solution of alkaline potassium permanganate effectively converts or oxidizes the smut and scale to acid soluble forms that are removed in the subsequent acid pickling baths. This conditioning of the smut and scale reduces acid pickle time, minimizing acid attack on the base metal.

After rinsing in water or cleaner to remove shop soil and dirt, the metal is then dipped into the aqueous permanganate-caustic bath for 5 to 30 minutes. Treatment time can vary depending on the type and thickness of the smut and scale to be conditioned for removal in the acid pickle. The bath is made up to 3-5% potassium permanganate (KMnO₄) and 6-10% sodium hydroxide (NaOH), and is heated to 850° - 900°C (1850°-1950°F). Wire or rod with excessive oxide scale may require an acid bath prior to the permanganate-caustic step to remove the acid soluble scale.

**Chemistry**

Smut and Reduced Metal Oxides + KMnO₄ + NaOH → manganese dioxide + Acid Soluble Oxides

**Dosage**

The concentrations of permanganate and caustic should be monitored. The caustic concentration should not exceed 10%, at which point the permanganate will disproportionate and the conditioning will be adversely affected. Permanganate concentrations are normally controlled at ½ of the caustic concentration. Permanganate and caustic consumption will be dependent on the type and amount of reduced smut and scale.

A mild steel tank is suitable since the bath is not corrosive. The bath should not be heated with open steam. Operators should be trained to monitor permanganate and caustic concentrations. Temperature controls should be installed to maintain the temperature between 850°C and 900°C (1850°-1950°F). Operators should be trained in the proper methods for adding chemicals to the bath and in all the safety and emergency precautions.

**Benefits**

Potassium permanganate-caustic conditioning of smut and scale reduces the time in the acid pickle to obtain a clean metal surface suitable for finishing. Reduced acid pickling time reduces the chances for pitting and attack on the base metal.

**References**

Mack, Dr. E., *Cleaning and Descaling of Carbon and Alloy Steel Wires by Alkaline Potassium Permanganate Solution*. Reprinted for Carus Chemical Company, Peru, IL. Carus Form # 3015

Carus Chemical Company Brochure, *The CAIROX® Method Removes Smut and Scale*. Carus Form # 3016

Staff, Application of CAIROX® Potassium Permanganate in the Aerospace Industry. Carus Form # 440

For further information on CAIROX® potassium permanganate product characteristics and availability, contact Carus Chemical Company at 1-800-435-6856.
Other Applications

- Drinking Water Treatment
- Wastewater Treatment
- Organic Oxidation
- Industrial Wastewater Treatment

Carus Value-Added

LABORATORY SUPPORT

Carus Chemical Company has technical assistance available to answer questions, evaluate treatment alternatives and perform laboratory testing. Our laboratory capabilities include; Feasibility Studies, Treatability Studies and Analytical Services.

FIELD SERVICES

As an integral part of our technical support, Carus provides extensive on-site treatment assistance. We offer full application services, including technical expertise, supervision, testing, and feed equipment design and installation in order to accomplish a successful evaluation and/or application.

EQUIPMENT SERVICES

Standard feeders are designed specifically for CAIROX® potassium permanganate. Various options and accessories are available to meet a wide range of applications. Custom-Engineered Feed Systems are complete, pre-engineered and pre-packaged systems. They provide efficient, dust-free methods of storing, mixing, and feeding CAIROX® potassium permanganate. System designs are customized to meet specific applications and customer needs.

CARUS CHEMICAL COMPANY

During its more than 90-year history, Carus’ ongoing reliance on research and development, as well as its emphasis on technical support and customer service, have enabled the company to become the world leader in permanganate, manganese, oxidation, and base-metal catalyst technologies.