potassium permanganate has a long history of successful application in drinking water treatment, providing both primary and secondary benefits. It is widely used by facilities to help meet regulatory rules and public pressures to produce quality drinking water.
What is potassium permanganate?

Potassium permanganate is a strong oxidant used in combination with other treatment technologies to solve specific water treatment problems caused by organic and inorganic contaminations in both ground (well) and surface water supplies.

Is permanganate new?

Potassium permanganate was first discovered in 1659, but was not developed for commercial use until the 1800s, when it became a common household and institutional disinfectant.

It was first used for water treatment in 1910 in London but did not begin to grow in use until the 1960s, when successful application for taste/odor control was publicized. Since then, permanganate has been accepted by the water industry as one of the most versatile oxidants available.

What are the problems that permanganate helps to solve?

In ground waters, permanganate is primarily used to help control iron, manganese, sulfides, and color. In addition, it is used in conjunction with manganese-treated greensand to reduce high concentrations of radionuclides and arsenic.

In surface water treatment plants, permanganate is applied primarily for taste/odor, manganese, and trihalomethane (THM) problems. However, a number of other benefits are reported by users. These include improved coagulation, color improvement, and zebra mussel control.

How widely is permanganate used?

The latest American Water Works Association (AWWA)/American Water Works Association Research Foundation (AWWARF) survey of surface water treatment plants serving >10,000 people shows that 36.8% use potassium permanganate for Pretreatment/Preoxidation/Organics Removal, second only to chlorine.

Thousands of very small groundwater treatment plants use permanganate. The estimate is that about 25% of the plants practicing iron/manganese removal are employing permanganate.

Is permanganate a cure-all?

No single treatment process or product is a cure-all. Each product or process has advantages and disadvantages. Problems can vary throughout the seasons and from year to year, especially with surface supplies. The most cost-effective process will sometimes include combinations of all of the available technologies, each being applied at the most strategic point in the plant. At times permanganate followed by activated carbon will be most effective. Other water problems may require chlorine addition after permanganate.

Although the USEPA has established Best Available Technologies (BATs) for controlling specific contaminants, very seldom is there only one problem being addressed at a time. It takes combinations of complementary products and processes to treat today’s complex problems and to do so in the most cost-effective manner.
How does permanganate work?

Chemically, potassium permanganate is classified as an oxidant. It converts oxidizable chemicals, such as ferrous iron, into their corresponding oxides that are removed by subsequent treatment steps or remain soluble and no threat.

Oxidation is also described as a chemical “burning up” of organic matter converting contaminants into less odorous, harmless by-products.

Which odors are most effectively controlled by permanganate?

Customers report that the FISHY, GRASSY, SEPTIC, PHENOLIC, SULFUR, and CUCUMBER odors are easily controlled by potassium permanganate. EARTHY, MUSTY, and some FLOWERY type odors are more difficult to control using permanganate alone.

Combinations of permanganate with activated carbon have been reported to be used very successfully to produce an acceptable odor level when MIB (methyl iso borneal) and Geosmin were found in raw waters.

How effective is permanganate for color removal?

Most raw water color is caused by decayed vegetation and minerals such as manganese. Anaerobic conditions in raw water reservoirs cause leaching of the bottom sediments that contain many of these contaminants. Because the problem was caused by reducing conditions, an oxidizing agent can be very effective in treating colored waters. Some raw water color is effectively treated by good coagulation.

What about trihalomethanes (THMs)?

The main cause of THMs is chlorination of raw water that contains precursors, primarily humic and fulvic acids. By delaying the chlorination to an application point after coagulation, the formation of THMs can be reduced 40% to 70%. This change in chlorination point must be coupled with good coagulation to remove the precursors. The addition of an alternate oxidant to the pretreatment step is advisable. Preoxidation with potassium permanganate will maintain an oxidizing environment, control taste and odor, oxidize manganese, and assist with the removal of the precursors. An additional 5%, up to as much as 40%, THM control has been reported by plants utilizing permanganate.

Permanganate is listed by the USEPA in the Federal Register as one of the alternative oxidants that can be used for THM control.

Does permanganate have any disinfection properties?

Potassium permanganate is not registered with the EPA as a disinfectant. CT credits are not available with permanganate use.
**What are some other benefits of permanganate treatment?**

When permanganate reacts it forms manganese dioxide. This precipitate is heavy and with its negative charge, acts as a nucleus for floc formation. It attracts positive ions and can help in the removal of some compounds that cause taste and odors. It has also been shown to increase settling which may lead to lower coagulant usage.

**Is permanganate safe to use?**

Because potassium permanganate is a strong oxidizing agent, care must be taken when handling the product. Permanganate is considered a “hazardous chemical” because it can react with certain reducing agents and generate heat. The proper handling and storage information is contained in the Material Safety Data Sheet (MSDS). When handled properly, it is safer than other commonly used oxidants.

**How much permanganate is needed to do the job?**

The effective dosage is determined by running laboratory jar tests.

More highly contaminated waters will need higher dosages. The average dosage is about 1 mg/L, but dosages as high as 10 mg/L may be needed during sieges of “bad” water. Jar testing will give a good idea of the approximated dose needed in a given situation. When running the jar tests, the effective dosage is determined through “permanganate profiling,” that is, finding out how much will react in a given period of time. This is done by setting up raw water jar samples, dosing them with permanganate, measuring the residual at given time intervals, and plotting the data. The effective dose is the amount used up in the time that it would take the raw water to pass from the intake (or other feed point) to the rapid mix where the coagulants are added.

**Where is permanganate fed?**

Normally, the chemical is applied as early in the treatment process as possible. It should be fed at the intake to take advantage of the time and mixing in the pipeline to the plant. Ideally, all the permanganate will be used up before the coagulants and other treatment chemicals are added. The permanganate will oxidize raw water contaminants, thus allowing other complementary processes to finish the treatment and “polish” the water.

The manganese dioxide should be completely formed before the coagulants are added to minimize any problems with colloidal by-products.
Although permanganate sells for more than $1/lb, the dosage usually does not exceed 1 mg/L, for a cost of less than one penny for every thousand gallons of treated water. When compared to other technologies, the cost of using permanganate is very competitive, and in combination with other technologies, the total cost of treatment is often less than any single technology.

A Western water utility had used an average of 25 mg/L of powdered activated carbon to control a persistent taste/odor problem. By incorporating 1 mg/L of permanganate into the treatment ahead of the carbon, the activated carbon dose was reduced dramatically to 8 mg/L. The resultant cost of the combination treatment was reduced to $30/MG, a savings of $36/MG, or at 40MGD, a savings of more than $1400/day. There was no change in finished water quality with the addition of permanganate to the treatment process, but there was significant reduction in total treatment cost.

Not every case will be this dramatic or even this successful. The case history does point out the value of having different complementary technologies available and to choose the most cost-effective combination to solve specific problems.
### How is permanganate shipped?

Potassium permanganate is shipped as a dry crystal product. It is manufactured as a free-flowing product that should be able to take up to 0.7% moisture before caking. The AWWA Standard B 603 describes the performance standards for permanganate.

For very large users, permanganate is available in bulk truckloads (45,000 lbs) or the 3300 lb returnable Cycle-Bins. Most users purchase the oxidant in either 330-lb (150 kg) drums or the convenient 55-lb (25 kg) pail.

### Where do I obtain more information on permanganate?


ANSI/NSF Standard 60 is the accepted health-effect standard for drinking water additives. CAIROX® Potassium Permanganate is certified by NSF to ANSI/NSF Standard 60 and CAIROX® carries the NSF Certification Mark. Information is available from the National Sanitation Foundation in Ann Arbor, MI., Telephone: 313-769-8010.

Application information is available from the local regulatory agencies, local chemical distributors, consulting engineers, or directly from Carus Chemical Company, the producer of CAIROX® Potassium Permanganate.

### Carus Value Added

**LABORATORY SUPPORT**

Carus Chemical Company has technical assistance available to its potential and current customers to answer questions or perform laboratory and field testing including:

*Feasibility Studies  *Toxicity Evaluations  *Treatability Studies  *Analytical Services  *Field Trials  

**FIELD/TECHNICAL 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.

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