OXIDATION: Materials & Methods

By Jim Hunt

Summary: Oxidation is not just about using the strongest oxidant. Rather, it's about choosing the appropriate oxidant and a well-designed delivery system. The practical information in this article will improve your oxidation success rate.

Oxidation is one of the oldest and most widely practiced water treatment tools, yet the process cannot be predicted from theory alone. Oxidation is universally used for disinfection; precipitation of iron, manganese and arsenic; color removal; taste and odor control, and trihal-omethane (THM) precursor removal. Because the "success" of oxidation depends on the thermodynamic potential of the oxidants, chemical kinetics (rate of reaction), pH, temperature, chemical dose, use of catalysts and the delivery system, it's virtually impossible to predict results in advance.

Oxidation, more accurately the reduction-oxidation process (redox), is the exchange of electrons between chemical species so as to change the valence or "oxidation state" of the substance being oxidized.

Oxidants

There are a variety of commonly used oxidants from which to choose including air injection (oxygen), chlorine, potassium permanganate ($KmnO_4$), hydrogen peroxide and ozone (O_3). Potency is measured in "electrode potentials" (E°). While thisis a good indication of the oxidizing ability of various oxidants, the electrode potential isn't the sole consideration as oxidants react differently to different water chemistries. Simply choosing the oxidant at the top of an electrode potential chart is not always an appropriate choice. However, oxidation reactions have been observed, timed and recorded for many common substances.

There is a good discussion of oxidation reactions and a helpful chart to be found by William Glaze in "Chemical Oxidation," Water Quality and Treatment (see *Chart I*).[3] Through professional observation and trial and error, dealers also have found which oxidants work best for each application. The results of this discovery effort are often surprising to those of us that don't have a chemistry background. For instance, dealers report that hydrogen peroxide is a powerful oxidizer for sulfur, but not iron bacteria. And injecting air (oxygen), admittedly the weakest oxidant, seems to deal effectively with anaerobic bacteria like iron bacteria. Ozone oxidizes iron, manganese and even color very well, but is not the first choice for hydrogen sulfide. All these oxidants, to some

Chart 1
Application of Common Oxidants[3]

Problem	Chlorine	Chloramine	Ozone	Chlorine Dioxide	Potassium Permanganate	Oxygen
Iron	E	N	E	E	E	E
Manganese	S	N	E	E	E	N
Sulfide	E	N	S	S	S	E[b]
Taste & Odor	S	N	E	E	S[c]	S[c]
Color	E	N	E	E	S	N
Floc aid	E	N	E	U	S[d]	N
THMFP	N	N	E[e]	E	S	N
Syn organics	S[f,g]	N	S[f]	S[f]	S[f]	N
Biological growth	E	S	N[h]	E	S	N

Key: E= effective, S= somewhat effective, N=not effective, U=unknown
[a]Above pH 7
[b]By stripping
[c]Except earthy-musty odor-causing compounds
[d]May involve adsorption at MnO_2
[e]May increase at low doses
[f]Depending on compound
[g]May form chlorinated by-products
[h]Except with dual-stage ozonation