Mixed Oxidants versus Chlorine Gas

	Mixed Oxidants	Chlorine Gas
Disinfection	• Two to ten times more effective than chlorine • Broader inactivation range - can kill *Cryptosporidium* and *Giardia* • More rapid disinfection • Lower dose required	• Effective kill on certain microorganisms • Higher CT value (more time and higher dose required) • Cannot kill *Cryptosporidium* or other resistant organisms
Chlorine Residual Maintenance	• More stable throughout the entire distribution system • Lasts longer (maintained for at least 25 miles) • Up to 30% lower dosage required to maintain residual • Can eliminate the need for ammonia or booster stations	• Can vary widely throughout system • Must often be boosted or combined with ammonia to last throughout distribution system • A higher dosage is required to maintain equal residual
DBPs	• Reduces THM formation by ½ to $^{1}/_{5}$ as compared to chlorine • Chlorates and bromates are well below MCLs • Does not produce chlorites	• More likely to exceed MCL for TTHMs in highly organic surface waters
Regulations	• No DOT rules • No RMP or PSM planning • No safety equipment or training • Complies with Uniform Fire Code • Meets all EPA water regulations • Studies at the University of North Carolina/CDC demonstrate compliance with the Enhanced SWTR for *Crypto* inactivation	• Transportation of gas cylinders must comply with DOT regulations • Requires RMP or PSM planning for large quantities stored on-site • Requires specialized breathing apparatus, “buddy” rule for changing cylinders, and periodic HAZMAT training • Cannot meet Enhanced SWTR for *Cryptosporidium* inactivation
Safety	• Uses only salt water and 9 to 12 VDC electricity • Reduces liability exposure • No safety training or special equipment for workers • Operator and community safety • Avoids equipment corrosion • Hydrogen gas from electrolysis is safely vented from the system • Safer water – fewer DBPs and microorganisms than chlorine	• Gas under pressure creates potential for explosion or fire • Potential for poisonous gas leaks • Potential for chlorine burns • Dangerous for both the operator and the surrounding community • Liability exposure • Safety equipment and safety training is necessary • Creates a corrosion problem

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	Mixed Oxidants	Chlorine Gas
Taste & Odor	• Excellent taste – reactions with ammonia and phenols do not result in chemical taste or odor • Algacidal properties eliminate taste and odor caused by algae • Does not form di- or trichloramines when used for breakpoint chlorination • Oxidizes H_2S • No chlorine taste even at relatively high doses	• Often imparts a chlorine taste and odor, especially when combined with ammonia • Cannot eliminate H_2S taste or odor problems
Ease of Use	• Fully automated unit requires minimal training and operator attention • Cell replaced roughly every 5 years – takes only 10 minutes • Oxidant used as produced so there is no deterioration • No ionic membranes, gas exchange venturis, or complex changing and cleaning process • Safety gear is unnecessary • During initial startup, water system may have to be flushed as mixed oxidants clean out biofilms in distribution piping	• Regular change-out of cylinders requires complicated safety training and gear • Requires periodic cleaning and change-out of gas venturi injection system • May be necessary to scrape off corrosion
Pretreatment	• Acts like ozone in regard to enhanced microflocculation • Reduces coagulant consumption by up to 40% • Can cut corresponding fluoride dose requirements • Significantly reduces clarifier settling times • Reduces turbidity • Improves filter runs • Maximizes plant flow • Decreases sludge handling	• Can be used for pretreatment but typically results in high TTHMs
Iron & Manganese	• Effective at oxidizing iron and manganese • May eliminate use of $KMnO_4$ • A lower dosage and contact time achieves removal • Precipitate must be filtered out or settled before removal	• Is less effective at oxidizing iron and manganese
Cost Considerations	• Higher capital cost is usually offset by lower operating cost, resulting in a lower lifecycle cost	• Lower installation cost when gas scrubber is not considered, but higher lifecycle cost