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TO: Office of Drinking Water Technical Staff

THROUGH: J. Wesley Kleene, Ph.D., P.E., Director, Office of Drinking Water

FROM: Susan E. Douglas, P.E., Technical Services Director

SUBJECT: System Evaluation, Design & Construction - MIOX Mixed Oxidant Treatment Systems

RELATED: WM 841(Interim Guidance on Waterworks Classification)

Revision Highlights:
Deleted requirement for Temporary or Provisional permit,
Clarified capacity and standby equipment requirements,
Revised design to include hydrogen gas ventilation, water temperature considerations,
Added initial and routine monitoring requirements,
Deleted schematic diagrams,
Added water quality factors - oxidant demand table as appendix.

SUMMARY STATEMENT
Disinfection by on-site generation of “mixed oxidants” using the proprietary MIOX Corporation treatment process is an option for waterworks to meet the disinfection requirements in 12VAC5-590-500 of the *Regulations*. This memo addresses the process design features and controls, approval procedures, waterworks classification, monitoring and reporting requirements for these systems.

I. BACKGROUND

The MIOX On-Site Mixed-Oxidant Generation System produces a chlorine-based disinfectant solution using a proprietary electrolytic cell. The cell generates the disinfectant from a sodium chloride salt solution, eliminating the transport of chlorine gas or hypochlorite solution to the site. Another purported advantage of using the mixed oxidant system over a conventional hypochlorite feed system is the elimination of biofilm on pipes and membranes. Removal of the biofilm on piping results in lower chlorine demand / dosage, a more durable free chlorine residual in the distribution system, and reduction in distribution system TTHM levels.

The MIOX mixed oxidant onsite generators have been certified under ANSI / NSF Standard 61, Drinking Water Components – Health Effects.

EPA has determined that waterworks using MIOX generators will have the same monitoring requirements as other chlorine systems under the Stage 1 Disinfection Byproduct Rule. This in effect eliminates the earlier concern for disinfection byproducts or residuals that are produced by ozone and chlorine dioxide systems. EPA has also stated that inactivation credit under the Surface Water Treatment Rules for MIOX systems will be determined based on chlorine CT tables.[1] We can infer from this decision that the MIOX "mixed oxidants generator" should be considered to be solely a hypochlorite generator, and the "mixed oxidants" (such as ozone, chlorine dioxide) produced by the equipment are negligible.

MIOX mixed-oxidant systems may be used to provide disinfection at wells and surface water treatment plants, distribution booster pump stations, and as a pre-oxidant for iron, manganese, hydrogen sulfide, and taste and odor control.

II. DESIGN FEATURES

A. General Description

MIOX on-site mixed-oxidant generators are automated, and available in different configurations and capacities. Components typically include a brine tank, ion exchange water softener, automated control unit, oxidant solution tank, booster pump(s), flow meter, solution inductor or chemical metering pumps, hydrogen gas vents and hydrogen gas monitor. Items which may need to be added include a pre-filter (for particulate removal in groundwater well applications), feed water heater, feed water chiller, mechanical ventilation of hydrogen gas (larger systems), and electronic interface for remote monitoring and alarms. Application design information, typical installation schematics and case study summaries are provided at the manufacturer's website (www.miox.com).

The MIOX generation system combines feed water and brine solution through an electrolytic cell to produce a mixed oxidant solution. The feed water booster pump, or pressure reducing valve, maintains feed water pressure between 60 and 100 psig into the generator. The brine feed rate is controlled by an automatic system to maintain a preset generator amperage. This feature provides a consistent oxidant solution concentration. The on/off operation of the generator system is controlled by level sensors in the mixed oxidant solution tank.

Output from the generator includes oxidant solution, hydrogen gas, and heat. The oxidant solution strength is typically 0.4%, measured as free available chlorine. Hydrogen gas will be released in the process, which must be vented to prevent a potentially dangerous situation. For small systems, venting of the oxidant solution tank and the feed line from the generator to the solution tank is adequate. Large systems may require a blower for ventilation of hydrogen gas. In either case, a hydrogen gas monitor with alarm must be included with the system.

B. Design Elements

Since the MIOX mixed-oxidant generator is a proprietary product, the manufacturer (MIOX Corporation) will advise on the appropriate generator model selection and sizing of major components. However, the existing conditions and operational requirements of the equipment, which form the basis for the manufacturer's recommendations, and

[1] Memo from EPA Director Ephraim King to EPA Region 1-10 Water Division Directors, dated July 18, 2001.

integration of the equipment into the waterworks must be verified by ODW. These include, but are not limited to:

1. Adequacy of MIOX generator capacity and chlorine demand – dose requirements. This shall be accomplished by:
   a. Multiple generators capable of a combined total delivery capacity of 15 mg/L chlorine dose for unusual water quality or emergency conditions, and a firm capacity (with the largest generator out of service) capable of meeting the normal maximum chlorine dose required
   b. Multiple booster pumps, if used
   c. Multiple brine feed pumps
   d. Multiple solution metering pumps or eductor systems
2. Hydraulic capacity of individual components, especially injector system: backpressure, sizing of booster pump(s), flow meter, venturi inductor
3. Tank overflows and drains
4. Controls
5. Quality of MIOX generator feed water (see Appendix A)
6. NSF 60 certification for salt and chemical cleaning solution (muratic acid). The manufacturer recommends a special high purity salt to avoid the need for excessive cleaning, and to prolong equipment life.

III. WATERWORKS CLASSIFICATION & OPERATOR REQUIREMENTS

Waterworks employing the MIOX process will be designated as a minimum Class VI. (The waterworks may be further restricted to a Class V through I depending on its size and use of other treatment technologies. Refer to WM 841 for further information.)

IV. START UP CONSIDERATIONS

The use of mixed oxidants has been reported to cause elimination of biofilm on pipes. Sloughing of existing biomass should therefore be considered in the initial phase of operation. Persistent/aggressive flushing may be warranted, for a period of at least 3 months. The length of time will depend on the age and extent of the water distribution piping.

V. INITIAL OPERATION MONITORING

Monitoring and reporting requirements (identified below) shall be performed in addition to any standard monitoring required per 12 VAC 5-590-370 and 530 of the *Regulations*, for an initial period, to be established during the construction permit process:

A. Free and total chlorine residual, collected downstream of the solution injection point, at a minimum frequency of three/week.
B. Free and total chlorine residual, collected in the distribution system at locations representative of average and maximum residence time, at a minimum frequency of three/week
C. Oxidant dosage delivered, measured as total chlorine.
D. Distribution pipe flushing activities – location, duration, dates - along with chlorine residual measurements before and after.

An engineering report summarizing the results of this initial monitoring, and all conclusions and recommendations resulting from it, shall be submitted to ODW for approval.

VI. ROUTINE OPERATION MONITORING AND REPORTING–In addition to routine chlorine disinfection monitoring and reporting, the operator shall follow manufacturer's recommended monitoring of the MIOX system, including:

A. Salt level in brine tank,
B. Quantity of salt used,
C. Feed water pressure,
D. Softener effluent hardness,
E. Generator(s) operating voltage and amperage,
F. Strength of mixed oxidant solution, measured as free chlorine (report once weekly),G. Check and replace, as necessary, cartridge filters on feed water and brine feed lines,
H. Clean electrolytic cells, as needed.

Appendix A Water Quality

(From MIOX O&M Procedures)

The factors listed below can affect the oxidant demand of each individual water system, the mixed-oxidant production of the MIOX OSG, or the life of the cell itself. It is important to use "worst case" measures since water quality can vary from season to season. Concentrations or measurements in brine feed water and/or treated water that are less than the stated limit are not anticipated to have and impact.

			WHAT IS IMPACTED		
	MEASURE	**LIMIT**	**Oxidant Demand**	**Chlorine Production**	**Cell Life**
Total Hardness**	mg/L (or grains/gal)	<17.1 mg/L (1 grain/gallon)		X	X
Iron (Fe)†**	mg/L	< 1 mg/L	X		X
Manganese (Mn)**	µg/L	< 50 mg/L	X	X	X
Fluoride (Fl)	mg/L	< 1 mg/L			X
Silica (SiO_2)	mg/L	< 80 mg/L		X	X
Bromide	mg/L	< 50 mg/L			X
Cyanide	mg/L	< 1 mg/L			X
Lead	mg/L	< 2 mg/L			X
Dissolved Sulfides (as H_2S)	mg/L	***	X		
Ammonia Nitrogen (NH_3-N)	mg/L	***	X		
Organic Nitrogen (Org - N)	mg/L	***	X		
Total Organic Carbon (TOC)	mg/L	***	X		
pH	-	5-9		X	X
Water Temperature Range (for M-module)	°C (or °F)	> 10°C < 29°C (> 50°F < 75°F)		X	X
Water Temperature Range (for H-module)	°C (or °F)	> 10°C < 29°C (> 50°F < 85°F)		X	X

Cation water softeners will remove these components up to a limit. See references to maximum ferrous iron and manganese in water softener documentation. Total hardness affects cell life only in that higher hardness requires acid washing to remove carbonate deposits from the cell. Use of water softened < 1 grain hardness should not require acid washing of the cell. * Oxidant demand is affected by any level of H_2S, ammonia or organic nitrogen, or TOC.

† Iron may deposit $Fe(OH)_3$ on the anode, causing an electrical "blind", which would increase the brine pump signal voltage (brine pump speed) needed for the system to reach the operating window. Chlorine production would remain the same, but salt conversion efficiency will decrease. The same effect is true of silica on the cathode.

END OF MEMO