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Project Summary

Operation and Maintenance of Selected Ozone and Ultraviolet Disinfection Systems

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A series of onsite evaluations were made of wastewater and drinking water treatment plants that use ozone or ultraviolet (UV) light disinfection in place of chlorine disinfection. The object was to compile design and operational information on such plants. The evaluations were conducted at 10 municipal wastewater treatment plants (7 that have used or are using ozone for disinfection and 3 that have used or are using UV disinfection) and at 5 drinking water treatment plants (all of which use ozone for disinfection or odor control or both). During these plant visits, operating data were reviewed, operational practices were observed, and operating personnel were interviewed to establish factors related to both poor and efficient process performance. Typical operation and maintenance problems are listed, and the recommended remedial actions for correcting those problems are presented.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Alternatives to chlorine disinfection of municipal wastewater have been given increased attention in recent years. Two alternative approaches that have generated particular interest are ozone and ultraviolet (UV) light disinfection. This project was initiated to identify operation and maintenance (O&M) factors affecting the performance of ozone and UV disinfection systems. The study was part of U.S. Environmental Protection Agency (EPA) efforts to compile and promulgate design and operational information on ozone and UV light disinfection of municipal wastewater.

The object of the study was to determine, analyze, and set priorities for those O&M factors that affect the operational efficiencies of ozone and UV disinfection systems. During the study, onsite evaluations were conducted at 10 municipal wastewater treatment plants and 5 municipal water treatment plants that use ozonation or UV irradiation for disinfection or taste and odor control or both. During these plant visits, operating personnel were interviewed, operational practices were observed, and operating data were reviewed to identify O&M factors related to both poor and efficient process performance. The information compiled was documented in individual plant evaluation reports, which are summarized in the final project report. The project report presents the O&M problems encountered, conclusions drawn concerning their cause, and recommendations for their resolution.

Results

Fifteen sites were visited during the study. Twelve of the facilities used ozone systems for disinfection or taste and odor control or both, and three of the plants used UV disinfection systems. Data concerning the ozone and UV systems evaluated are presented in Tables 1 and 2, respectively.

Table 1. System Data for Ozone Plants

Plant No.	Number of Generators	Generator Manufacturer	Total Capacity kg/day (lb/day)	Carrier Gas	Actual O_3 Transfer Efficiency* (%)
1	17	Union Carbide	2,082 (4,590)	O_2	50
2*	2	Welsbach	69 (152)	Air	50
3	3	Emery	782 (1,725)	Air	60
4	13	Union Carbide	1,562 (3,445)	O_2	95
5†	2	Emery	113 (250)	Air	67
6†	3	Emery	381 (840)	O_2	84
7†	3	Union Carbide	571 (1,260)	O_2	--
8	2	PCI	204 (450)	Air	--
9	4	Welsbach	453 (1,000)	Air	85
10	6	Trailigaz	3,479 (7,680)	Air	80
11	4	Trailigaz	204 (450)	Air	--
12	4	Degremont	227 (500)	Air	94

*Transfer efficiency = $\frac{O_3(in) - O_3(out)}{O_3(in)}$

†Not in operation.

Table 2. System Data for UV Plants

Plant No.	UV Manufacturer	No. of Sections	Total Number of Lamps	Lamp Length m (in.)	Cleaning Mechanisms	Flow/Unit m^3/d (mgd)	Arc Length Unit of Flow, m/m^3/per day (in./gpm)
13	Pure Water Systems	6	392	1.5 (60)	Mechanical Wiper	2,839 (0.75)	44,451 (4.6)
14	Aquafine	4	128	1.5 (60)	Mechanical Wiper	4,163 (1.25)	28,990 (330)
15	Ultraviolet Technology, Inc.	3	48	0.8 (30)	Chemical Detergent	113 (0.03)	289,902 (30)

Costs

Annual costs for ozone plants with compiled historical cost data are presented in Table 3. The average ozone production cost for the 12 plants surveyed is $4.20/kg ($1.90/lb) of ozone generated. Very few operating cost data were available for the UV plants surveyed during the project. One plant reported a UV disinfection operating cost of approximately $0.18/1,000 gallons treated.

Typical Problems Encountered

Typical O&M problems encountered with ozone disinfection systems were maintenance-related and are as follows:

- Multiple and frequent failures occur in the ozone generator cell.
- Failures occur in the silicone control rectifier (SCR).
- Severe foam problems occur with the contact tank gas recovery system.
- Ozone system electronics are too complicated for plant personnel to perform routine maintenance and repair work.
- Corrosion problems occur with O_3 analyzer valve components.
- Ozone contact tanks were constructed below the system control room, and O_3 leaks cause instrumentation rubber seals to corrode.
- System equipment (i.e., generators and compressors) is very noisy.
- The system includes numerous pieces of equipment that must be maintained.
- System instrumentation must be continually calibrated.
- Ozone generators are a high maintenance item and continually blow fuses.
- Corrosion problems with compressors occur because of wet gases.
- Catalyst poisoning occurs in O_3 destruction system.
- No dew point monitoring equipment is provided with the ozone system.
- Excessive heat buildup in the O_3 generator room causes generator heaters to shut down units.
- Noncompatible materials are used in construction: Rubber sleeves are used on compressors, and chlorinated, rubber-based paint is used to seal the ozone contact chamber.
- Dew point meters are not reliable.
- Improper (i.e., too high) dew point setting causes dielectric failures.
- Improper cleaning procedures for dielectric tubes cause pitting and cracking of tubes.

Typical O&M problems encountered with UV disinfection systems included the following:

- Ballasts on the UV lamps overheat and shut down the system.
- Unit does not consistently disinfect plant effluent to the degree required by National Pollution Discharge Elimination System (NPDES) permit.
- Foam buildup interferes with operation of the cleaning mechanism.
- Low flow rate causes the unit to overheat.
- Algae accumulations in the unit interfere with system operation.

Conclusions

Most of the O&M problems experienced with the ozone disinfection systems surveyed were site-specific and not prevalent problems that repeatedly occurred at all the sites visited. The most common problems identified were the following:

- Inefficient ozone destruction in the destruct unit.
- Ozone generator cell failure.
- Ozone leakage from the generator.
- Inadequate air-drying in the inlet air desiccant dryer.
- Improper sealing of the ozone contact tank.
- Malfunctioning of the ozone concentration monitors.

Limited information was available concerning the operation of UV disinfection systems; but as with ozone disinfection, most of the O&M problems identified were site-specific and not widespread occurrences.

Remedial Actions Recommended

Remedial actions recommended for correcting O&M problems observed at ozone and UV plants are presented in Tables 4 and 5.

Table 3. *O&M Cost Summary for Ozone Systems*

Plant No.	Plant Name	Current Average Flow m^3/day (mgd)	Ozone Production kg/day (lb/day)	Ozone Production Cost: ¢/kg Ozone Produced (¢/lb)	Ozone Production Cost: ¢/m^3 of O_2 Treated (¢/1,000 gal)
1	Rocky River WWTP	45,420 (12.0)	1,010 (2,227)	63 (28)	1.4 (5.2)
2	Upper Thompson WWTP*	2,271 (0.6)	22 (49)	602 (272)	5.8 (22)
3	Frankfort WWTP	17,033 (4.5)	85 (187)	382 (173)	1.9 (7.1)
5	Brookings WWTP*	8,327 (2.2)	27 (60)	488 (221)	1.2 (5.9)
8	Monroe WTP	26,469 (7.0)	36 (79)	903 (408)	1.2 (4.8)
9	Bay Metro WTP	37,851 (10.0)	97 (214)	575 (261)	1.5 (5.8)
10	Charles J. Des Baillets WTP	798,656 (211)	1,740 (3,836)	191 (86)	0.4 (1.4)
11	Pierrefonds WTP	56,800 (15)	135 (298)	342 (154)	0.8 (2.9)
12 0.5	Sherbrooke WTP	58,700 (15.5)	113 (250)	259 (116)	(2.0)

*Not in operation.

Table 4. *Recommended Remedial Actions for Correcting O&M Problems Observed at Ozone Plants*

Problem	Remedial Actions
Foam buildup in O_3 contact tank	Provide foam sprayer in contact tank or separate foam spray tanks between O_3 contact tanks and O_3 destruct unit.
O_3 generator cell failure	Purge O_3 generator before startup to ensure the unit is clean and free of dust or rust particles.
Poor O_3 transfer efficiency in the O_3 contact tank	Routinely inspect O_3 diffusers and clean when required.
O_3 leakage from generator	Replace damaged cells in generator; adequately ventilate the O_3 generator room.
Poor O_3 destructor performance	Increase the quantity of catalyst in the destruct unit; install an electric air preheater before the destruct unit; check for leakage from destruct unit; replace catalyst.
Premature shutdown of feed-gas compressor	Replace faulty surge/vibration monitor.
Failure of silicone control rectifier	Determine cause of problem and replace faulty silicone control rectifier.
System air compressors discharge more air than required	Change pulley size to reduce operating speed.
Refrigerant dryer overloaded	Check the inlet air compressor water seal system to ensure that the compressor is not overheating and heating the inlet air to the dryer.
Inefficient performance of inlet air desiccant dryer	Recharge the dryer with new desiccant material; check that the desiccant generation heaters are not operating at too high a temperature; install a dew point indicator/controller to initiate the desiccant regeneration cycle automatically when "wet air" is being discharged from dryer; check the desiccant to ensure it is not being contaminated with sulfate, chloride, iron (rust) or some other constituent; clean the purge-air filter.

Table 4. *(continued)*

Problem	*Remedial Actions*
Standby electrical generator will only operate one O_3 generator at a time	*Size standby electrical generator to operate sufficient number of O_3 generators.*
O_3 piping leakage	*Install O_3 resistant piping (stainless steel); use welded joints, not threaded joints.*
Ozone contact tank not covered and/or properly sealed	*Completely cover and tightly seal the O_3 contact tank; do not use the O_3 contact tank for a filter backwash supply tank; install additional seal/gasket material.*
High O_3 levels in the WWTP nonpotable water system	*Do not use ozonated water as a nonpotable water supply source.*
Insufficient number of O_3 monitors at WWTP	*Provide O_3 monitors for both the lab and other plant working areas; provide standby O_3 monitor.*
Dielectric tubes overheating and breaking because of corrosion problems	*Check for leaky air release parts in O_3 generator cooling water system; add corrosion prevention chemicals to the cooling water; thoroughly clean dielectrics and final rinse with alcohol.*
Malfunction of cooling H_2O flow and O_3 generator gas pressure sensors/ alarms	*Check for rust particle fouling; add rust prevention chemical to cooling H_2O; check for ozone destruction of diaphragms in pressure sensors.*
Fluctuating ozone generation	*Check operation of O_3 meters; increase frequency of cleaning and calibrating meters; check generator operation and power source.*
Voltage surges that damage electrical components and instrumentation	*Check for flow surges to plant resulting from on-off operation of pumping stations that cause O_3 dosage control to fluctuate; dampen flows to WWTP; install voltage-control transformer.*
Malfunction of O_3 concentration monitor	*Increase frequency of cleaning and calibration check to once per day if required.*
High noise levels around O_3 generation equipment	*Provide noise abatement provisions around compressors and generators; install acoustical material around equipment and in equipment rooms.*
Drive belts on exhaust fans in O_3 generation room frequently fail	*Install fans so drive belts have minimum exposure to exhausted air; use more ozone-resistant belts.*
O_3 generator side panel fasteners frequently fail	*Install heavy-duty, screw-type fasteners on side panels.*
O_3 gas sampling equipment leaks	*Ensure pumps, valves, connections, and piping are constructed of O_3-resistant material.*
O_3 generator shutdown because of high temperatures in generator room	*Provide ventilation in O_3 generator room.*
O_3 exhaust vent located too near building air intake causing high ambient O_3 concentration inside building	*Relocate exhaust vent; extend height of exhaust vent.*
Ice buildup at outlet of O_3 exhaust vent caused blockage of vent	*Heat trace and insulate the exhaust vent.*
Switchover valves on inlet air dryer towers malfunction	*Pneumatic cylinders must be rebuilt.*
Dielectric fuses allow current flow even when burned out	*Replace fuses with different type.*
Residual ozone meter readings O_3 contact tank are unstable	*Relocate probe closer to section of contact tank where O_3 is being injected.*
Recompression blowers at O_3 contact tank malfunction	*Check seals and bearings for deterioration as a result of O_3 attack.*

able 5. Recommended Remedial Actions for Correcting O&M Problems Observed at UV Plants

Problem	Remedial Actions
udden flow surge into UV hamber causes damage to V lamps	Slowly open inlet valve into UV chamber; position mechanical wiper mechanism in the middle of the chamber for added support.
aulty powerstat does not allow peration of UV system at low ower levels resulting in electrical nergy wastage	Replace powerstat with unit that allows finer adjustment; check minimum power requirements for UV lamps; replace powerstat with shut-off switch that shuts off lamps for close control.
ght-emitting diode (LED) does ot give true indication of whether V lamp is actually operational	Check for faulty LED, burned out LED, or malfunctioning ballast.
V lamp wiper mechanism equently jams	Before startup of unit, be sure that the wiper has not dried out and become stuck to UV lamps; routinely check wiper for proper alignment.
'ater level monitoring system in V chamber malfunctions.	Provide adequate difference in elevation between high- and low-level settings; use time-delayed relays for water level sensors.
V chamber influent flow meter faulty	Routinely check flow meter calibration; be sure that it accurately monitors entire flow range.
am builds up in UV chamber	Provide foam control measures such as water sprays before UV chamber; thoroughly clean tubes before startup to prevent scum buildup and jamming of lamp wiper.
'ological growth on teflon tubes curs during intermittent flow nditions	Slightly slope the teflon tubes to ensure that they remain full of water during no-flow periods.

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The complete report, entitled "Operation and Maintenance of Selected Ozone and Ultraviolet Disinfection Systems," (Order No. PB 84-180 124; Cost: $22.00, subject to change) will be available only from:
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