U. S. Army Corps of Engineers
Advance Oxidation Technologies
Checklist

Installation Name ____________________

Site Name / I.D. ____________________

Evaluation Team ____________________

Site Visit Date ____________________

This checklist is designed to facilitate the performance evaluation of Advanced Oxidation Technologies (AOT) used to remove organic compounds from aqueous streams. The checklist includes information for systems that use ultraviolet light, ozone, and hydrogen peroxide. The checklist may be adapted for evaluation of other AOT that do not use all the aforementioned systems or other alternative technologies classified as AOT. Many times pretreatment is necessary to optimize AOT performance; these pretreatment technologies are addressed in other checklists. The AOT checklist is divided into the following sections:

1) Evaluation team composition
2) Typical treatment objectives
3) References
4) Data collection requirements
5) Performance analysis calculations
6) Adequacy of operations and maintenance
7) Typical performance problems
8) Alternatives for possible cost savings
9) Effects on Human Health and the Environment
10) Supplemental notes and data

The checklist provides suggestions for information gathering, and space has been provided to record data and notes from the site visit. Supplementary notes, if required, should be numbered to correspond to the appropriate checklist sections.

1) Evaluation Team Composition

The following disciplines should be included in the evaluation team for the Advanced Oxidation Technologies system.

- Process Engineer (site visit, treatment system evaluation)
- Chemist (treatment chemistry)
- Regulatory Specialist (regulatory requirements)
- Cost Engineer (cost of alternatives)
- Industrial Hygienist (potential risks from operations)

2) Typical Treatment Objectives

Review the treatment objectives established when the AOT system was designed and installed to verify that the objectives are clear and still valid.

Advanced Oxidation Technologies are used to destroy organic contaminants from a groundwater or wastewater stream. AOT are most effective on unsaturated aliphatic and aromatic compounds. If complete oxidation occurs, the resulting products are CO2, H20, and salts.

Major operation and maintenance costs associated with the technology include: power for the ultraviolet lamps and ozone generation; hydrogen peroxide chemical costs; lamp and the protective sheath surrounding the lamp replacement; cleaning the protective sheaths; and if ozone is used, off gas collection and destruction. Efforts should be made to implement actions to minimize these costs.

3) References

This checklist should be coordinated with the Process Instrumentation and Control, and Liquid Process Piping Systems, Chemical Feed and Storage Systems, Metals Precipitation, Filtration System checklists. The following references may also be helpful:

CEGS 11377 [1]: Advanced *Oxidation Processes*.
ETL 1110-1-263 [2]: *Ultraviolet/Chemical Oxidation.*

4) Data Collection Requirements

The following is information needed to assess the performance of the Advanced Oxidation Technology treatment system. Record the appropriate units with each value.

a) What type of AOT unit is at this site (e.g., UV lamp (give wattage), oxidizer(s))?

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b) Sketch a process flow diagram (PFD), including valves and instrument locations, on the back of this sheet or on a separate sheet.

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c) Record the nameplate information from AOT reactors, compressors, ozone generators, off gas destruct equipment, pumps, and other mechanical equipment for future reference.

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d) Has the process been changed since start-up? Are the process changes recorded on the as-built drawings?

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e) Are all federal (e.g., RCRA, CWA, CAA), state, and local regulatory requirements being met? Attach copies of permits, notices of violation, and monitoring reports.

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(This can include source and ambient monitoring, emission limits, and permits.)

4.1) General Treatment Process

The following information is needed to assess the performance of the treatment process. Record the appropriate units with each value.

a) Treatment Requirements—Target organics which require removal prior to discharge:

Organic Contaminant (e.g., TCE, benzene)	Influent Conc. (mg/L or mg/L)	Measured Eff. Conc. (mg/L or mg/L)	Required Eff. Conc. (mg/L or mg/L)

b) Process Data:

Treatment plant flow rate: _____ gpm

Water temperature: Influent _____ degrees C Effluent _____ degrees C

Influent pH ______ Effluent pH ______ Influent Alkalinity ______ mg/L

Ultraviolet Lamps (low pressure) (medium pressure) (other) (none)

Wattage _________ Number of lamps per reactor ______

Number of lamps operating per reactor ______

Number of Reactors/configuration _______________________

Automatic lamp cleaner? (yes) ___ Type ___________________ (no) __

Liquid Operating Pressure: _____ psi. ______ Atmospheric

Off Gas Treatment (yes) (no)

Frequency of Use (continuous) (intermittent) explain:

____

____

Upstream Treatment Processes. Metals Precipitation ____ Biological ____
Filtration ____ Other

ORP Readings for the system ____________.

c) Is any portion of the flow being recirculated? Where and why is this being done?
(Note: Show the recirculation stream on the PFD)

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4.2) Chemical Addition Processes

a) Oxidants added:

Oxidant (e.g. ozone, hydrogen peroxide)	Dosage (mg/L)	Point of Addition

Catalyst Addition?		
pH Adjustment (e.g., lime, caustic, acid)		

b) Are periodic tests being conducted to ensure optimal chemical dosages are being applied? Can any of the oxidant dosages be reduced or UV lamps turned off without reducing treatment efficiency?

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Feeding oxidants in excess of the stoichiometric dosages results in scavenging, (reaction of oxidant with the hydroxyl radicals intended to oxidize the target contaminants).

c) Are chemical reagents being added upstream of the AOT system which may impact performance?

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5) Performance Analysis Calculations

a) Review the current and historical organic and inorganic contaminant composition to determine if the chemicals or their composition is changing over time.

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If unforeseen contaminants that are difficult for AOT to remove such as saturated alkanes, oil, grease, and certain metals are detected above levels of concern, additional treatment processes may be needed. Refer to ETL 1110-1-263, Table A-5.

b) Calculate the oxidizer flow rate and compare it with the flow rate, the concentrations of contaminants, and potential scavengers used for the initial design.

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Feeding oxidants in excess of the stoichiometric dosages results in scavenging, (reaction of oxidant with the hydroxyl radicals intended to oxidize the target contaminants).

c) Verify the emission rates do not exceed emission limits.

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6) Adequacy of Operations and Maintenance

a) Is there proper access for maintenance? If not, explain.

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b) Have Chemical Feed Dosages been optimized?

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______________________________*Feeding oxidants in excess of the stoichiometric dosages results in scavenging, (reaction of oxidant with the hydroxyl radicals intended to oxidize the target contaminants). If supplemental treatment such as GAC follows the AOT, then optimizing the energy consumption and chemical consumption by the AOT may necessitate discharging a higher concentration of contaminants to the GAC system:*

c) Visible leaks (explain):

____ *Visible leakage from tankage may indicate stress cracking due to siphoning within one of the chambers is taking place, some type of vacuum release may be needed. In some systems a rupture disc may be installed as a pressure relief, if so make sure the flanges where installed are secure, and also make sure the correct pressure disc and gasket material was installed. Ozone systems may cause corrosion to occur at sparge connections as well as viewing ports, verify the age of these components and the probability they need replacing (Refer to Section 9 of ETL 1110-1-263).*

d) Are the lamps changed out periodically?

____ *Lamp life varies based on the type of lamp used. The low wattage lamps typically have a useful life of one year. Medium pressure and medium pressure doped lamps have a useful life of less than six months. Although the lamps may still be operable, they lose the ability to emit light at the wavelengths necessary to promote oxidation of the primary contaminants of concern either through the photolysis or generation of hydroxyl radicals.*

e) Are the lamps cleaned periodically?

____ *Medium pressure or medium pressure doped lamps are generally provided with a cleaning mechanism as part of the equipment. The mechanisms can fail and must be checked occasionally to verify they are functioning properly. Low pressure lamps generally do not come with automatic cleaners but usually require cleaning with a mild acid solution every one to two years. Dirty lamps can result in reduced process efficiency.*

f) Are ozone generators (if used) cleaned periodically?

____ *Dirty dielectrics reduce generation efficiency resulting in greater power utilization.*

g) Any unusual observations regarding, oxidizer storage, ozone delivery or destruct systems, spare parts inventory, history of unusual repairs or control system incompatibility.

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h) Identify high cost maintenance equipment items or supplies. Do any items require frequent repairs?

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i) Identify any corrosion problems.

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7) Typical Performance Problems

a) Piping (liquid and gas) adequately supported and pitched.

____ *Ensure off gas piping does **not** drain back to the catalyst beds, causing fouling.*

b) H_2O_2 Feed Equipment has been properly calibrated.

____ *Equipment tends to get out of calibration over time. Periodic checks should be accomplished to make sure the equipment is functioning as expected.*

c) Adequate Conditioned Air Supply to the Ozone Generator Unit?

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______________________________ *If the air fed to the generator has a dew point above –60 C, the generator will produce high concentrations of nitric acid which will cause excessive corrosion in the generator and all downstream components.*

d) Ozone off-gas Treatment? Treatment included or required?

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____ *Generally off gas is treated by passing the ozone laden gas through a heated catalyst bed. If this bed gets wet, the ozone will not be reduced to oxygen prior to discharge. If the bed gets wet due to condensation or water getting into it, simply dry it out or replace it.*

e) High levels of ambient ozone.

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____*Ambient ozone levels should be checked via real time monitors. High concentrations may indicate the need to reduce oxidant concentration, cover sumps or check gas piping for leaks.*

f) Proper Lamp Disposal practices?

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____*The lamps contain mercury which should be recycled, refer to 'Disposal of Fluorescent Light Tubes and High Intensity Discharge Lamps; Fact Sheet Number 97-06.*

g) Excess or Inadequate Process Capacity Present?

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8) Alternatives for Possible Cost Savings

Determine if any of the following alternatives are cost-effective:

a) Options for Disposal/Sale of Equipment, or Modification of the Process?

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b) Can oxidizer dosages be reduced or some of the lamps turned off?

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c) Can savings be realized by changing the test methods/frequency?

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9) Effects on Human Health and the Environment

a) Determine if ambient concentrations of off-gases (ozone) are sufficiently high to be ignitable or pose a health threat inside buildings or exceed discharge limitations.

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10) Supplemental notes and data

There are __ pages of supplemental notes, figures, and data attached to this checklist

[1] CEGS: USACE Guide Specifications for Construction, available at www.usace.army.mil/inet/usace-docs/

[2] ETL: USACE Engineering Technical letters, available at www.usace.army.mil/inet/usace-docs/