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Operator Training Standards for Active Treatment Systems: Topics, Procedures, and Trainer Qualifications

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Active Treatment Systems (ATS) are used with increasing frequency to control the quality of construction site runoff. An ATS removes fine suspended sediment through a coagulation/flocculation process followed by settling and/or filtration. These systems are particularly attractive where discharge quality standards are very high, where clay or highly erosive soils are present, where long or steep slopes lead to significant erosion, or where site constraints preclude other treatment systems. To be successful and to avoid potential risks to water quality from chemical releases or equipment failure, an ATS must be operated effectively. For this reason, the California Construction General Permit (CGP, Attachment F) specifies operator training in ATS design and operating principles, coagulant selection and handling procedures, aquatic safety, monitoring practices, reporting and recordkeeping practices, and emergency response procedures. A minimum of eight hours in the classroom and 32 hours in the field are required.

This paper represents the collective efforts of an *ad hoc* group of ATS practitioners to begin the development of a curriculum by adding detail to the general list of topics in the CGP and to fill in some perceived gaps and needs. The goals of this effort were: (1) to produce a detailed set of learning objectives for the two training sessions, and (2) to specify the desired qualifications of would-be trainers.

The authors hope to inspire further thought on this important topic in the industry. Suggestions for improvements can be sent to any of the contributing authors.

Overview of ATS Types Commonly Used in California

A variety of ATS types are used in California. The essential component, however, is coagulation either by direct addition of chemicals (coagulants) or by passing an electric current through the water (electrocoagulation). With either method, the goal is to condition fine sediment particles so that when they come into contact with each other, they stick together and form "flocs". Floc growth is encouraged by gentle mixing of the conditioned particulate suspension to increase the number of particle-to-particle contacts. The advantage of forming flocs is that large particles are more efficiently settled and filtered than small particles. Settling can be accomplished in tanks or in earthen basins dug at the site. Filtration is most commonly done in pressurized sand filters with backwash equipment.

At this time, coagulation is most commonly accomplished with chemical addition. The most commonly used coagulants are chitosan, polyaluminum chlorides (PACls), and polyacrylamide-based polymers (PAMs). For each of these coagulants, training is needed on materials handling and safety, dose selection, chemical feed equipment, and residuals control (i.e., preventing excess chemical from being released in the ATS discharge). Other coagulants may be introduced in the future, at which time these training requirements would need to be reviewed and revised.

Systems are individually designed by different vendors, but many elements are common to all. In every ATS, water needs to be moved through the system in a controlled manner, and the quality needs to be monitored regularly. ATS training should address the typical categories of equipment used—pumps, valves, controls, flow measurement devices, and water quality monitoring instruments.

Training Content

Training consists of both classroom and field components, plus a site-specific orientation required for each job.

Classroom Training

Classroom training covers the objectives described in Appendix A. Classroom training should cover common classes of chemicals used in ATS rather than focusing exclusively on a single chemical. Consequently, it will not be necessary for the ATS operator to repeat the classroom training when operating with different chemicals.

Learning objectives cover safety, regulations, erosion, toxicity, ATS processes, ATS components, and startup and shutdown procedures. The effectiveness of the classroom training is assessed using a 10-minute quiz that covers a selection of classroom learning objectives.

Field Training

Field training covers the objectives described in Appendix B. Field training should be exclusive to a single class of chemicals. An operator should repeat the field training for each class of chemicals that will be used. For example, if an operator receives field training on a chitosan system, but wishes to operate a polyaluminum chloride system, then the operator should complete additional field training on a polyaluminum chloride system.

Learning objectives cover safety, components, and operations. There are additional learning objectives that are specific to the class of chemicals used in the ATS. Effectiveness of the field training is assessed via four practical exams. The first exam requires successful identification of all ATS components. The other exams are hands-on, requiring the operator to startup, troubleshoot a problem (caused by the trainer), and shut down the ATS successfully. Field training should be limited to 5 operators at a time. The ATS need not be on an actual construction site. Dirty water can be synthesized as long as the installation is typical (including set up for power and plumbing). This could allow the trainers greater control of influent conditions, which would offer a wider variety of training scenarios.

Site-Specific Orientation

In addition to the classroom and field training, ATS operators should also receive an on-site orientation lasting at least one hour, provided by the ATS designer. This orientation should be accomplished at every job site, regardless of the similarities in ATS design. Site-specific issues regarding power supply, health and safety, source water, schedule, and proximity and path to receiving water should be covered. In California, it is recommended that the Qualified Stormwater Pollution Prevention Plan (SWPPP) Practitioner (QSP) be present for the orientation.

Training Documentation

Each ATS operator should obtain two documents that certify they have been trained in compliance with these guidelines. The first document, signed by the trainer, certifies that the operator has successfully completed the 10-minute classroom quiz, the identification of ATS components practical exam, the startup practical exam, the troubleshooting practical exam, and the shutdown practical exam. This document should specify the chemical used in the field training. The second document, signed by the ATS designer, certifies that the operator has been given an orientation on the particular ATS they are currently operating. A copy of both documents should be kept with the on-site operations manual (ATS plan). ATS plans completed (and submitted to the State Water Resources Control Board (SWRCB), if in California) prior to operator training and orientation should add an addendum that includes the training documentation.

Operator Trainer Qualifications

The California CGP specifies the qualifications required of ATS designers, but it does not specify the qualifications of ATS operator trainers. Trainers of ATS operators should meet at least one of the following criteria:

- Coursework in the sciences needed for Bachelor's degree or the two-year Associate's; plus 4 years field experience with ATS at six or more sites
- A California Department of Public Health (CDPH) T-2 license and chemistry coursework that covers pH, acid/base, stoichiometry, and mineral solubility; plus two years field experience with ATS at three or more different sites
- An ABET Civil Engineering degree; plus two years field experience with ATS at three or more different sites

Appendix A: 8-Hour Classroom Training Learning Objectives

Safety (SAF8) – The learning objectives for safety cover the topics of personal protective equipment (PPE), material safety data sheets (MSDS[1]), communication, and pre-work tailgate safety meetings. The heading designation "SAF8" used in the following differentiates these objectives in the 8-hr classroom from additional objectives in the 32-hour field training.

SAF8-1. Describe PPE used in lab and field operations, and identify the circumstances that require different types of PPE to be used.

SAF8-2. Interpret the information on a sample MSDS sheet and identify the hazards, the PPE needed, spill clean-up procedures, and other emergency response requirements for the material in question.

SAF8-3. Plan a pre-work tailgate safety meeting, and specify the documentation required and the records to be kept.

Regulations (REG) – The learning objectives for regulatory concepts cover CGP requirements and the environmental and construction impacts of ATS failures.

REG-1. Identify major environmental impacts from construction-related erosion.

REG-2. Describe how an ATS can reduce negative impacts from construction on local receiving waters.

REG-3. Define the acronyms: CEQA, NPDES, RWQCB, MATC, NAL, NEL, CGP, and CWA.

REG-4. State the general discharge requirements for turbidity specified in the CGP, including the measurement method and performance period.

REG-5. State the residual requirements for an ATS specified in the CGP and describe what is required if a coagulant residual test is not performed or available.

REG-6. List the five types of records that must be kept during operation of an ATS.

REG-7. Differentiate testing requirements between flow-through and batch ATS as described in Attachment F of the CGP.

Erosion (ERO) – This section covers erosion principles and erosion mitigation practices. The relationship between erosion and contaminated runoff is also addressed.

ERO-1. List the primary types of suspended matter and explain how they adversely affect the environment.

ERO-2. Describe how the following characteristics affect suspended soil particle settling times: particle composition; particle charge, size, and shape; water temperature; and flow/turbulence.

ERO-3. List common erosion Best Management Practices (BMPs) that could be used prior to an ATS.

ERO-4. Compare and contrast erosion control and sediment control.

[1] OSHA plans to replace MSDS with the Globally Harmonized System (GHS).

ERO-5. Compare and contrast conventional sediment control and ATS.

Residual Toxicity (TOX) – These learning objectives cover topics of test types, recordkeeping, and reporting.

- TOX-1. Describe the starch iodine test.
- TOX-2. Describe testing requirement differences for a batch system versus a flow-through system.
- TOX-3. Explain various data collection methods while operating an ATS.
- TOX-4. List the record storage requirements or recommendations for storage of operation records.
- TOX-5. Distinguish representative samples vs. non-representative samples.
- TOX-6. List sample preservation methods for third-party sample evaluations.
- TOX-7. Describe the purpose and elements of chain-of-custody documentation.
- TOX-8. Use a general chain-of-custody document to initiate the tracking of a sample.
- TOX-9. Describe preservation methods for metals testing (total and dissolved) of any water sample.

Major Processes (PRO) – Learning objectives for water treatment concepts cover the topics of water chemistry, conveyance, flow stabilization, pretreatment, polymer coagulation, flocculation, sedimentation, filtration, recirculation, and discharge.

- PRO-1. Define the freeze point.
- PRO-2. Define the boil point.
- PRO-3. Define a non-compressible liquid and the water hammer effect.
- PRO-4. Describe polarity of the water molecule, and identify the characteristics that keep solids suspended.
- PRO-5. Define pH and identify acidic, basic, and neutral conditions on the pH scale.
- PRO-6. State the pH of stormwater.
- PRO-7. List common chemicals used to raise and lower pH.
- PRO-8. Describe how polymers improve sedimentation/filtration between coagulant polymers and suspended matter in construction-caused turbidity.
- PRO-9. Draw a typical flow diagram for raw water conveyance to an ATS, showing pipes and pumps.
- PRO-10. List common pump types and their uses within ATS.
- PRO-11. List the ranges of acceptable velocities for raw water conveyance pipes to prevent sedimentation and damage to valves and pipes.
- PRO-12. List pipe materials: PVC, HDPE, etc.
- PRO-13. Calculate the gallons of water in a rectangular holding tank.
- PRO-14. Describe the flow stabilization zone in a settling system and explain what happens in that zone.
- PRO-15. Knowing settling tank dimensions in feet and flow in gpm, calculate the settling velocity (overflow rate).

PRO-16. Describe the relationship between flow and settling tank discharge turbidity.

PRO-17. Describe the pretreatment, coagulation, flocculation, sedimentation processes, and how the water, suspended solids, and the polymer work through these systems.

PRO-18. Knowing the filter dimensions and flow in gpm, calculate the filtration rate (gal/ft^2) in a multi-pod filter system.

PRO-19. List the pressures for the footer and header in a typical ATS filter.

PRO-20. Describe the relationship between flow and pressure, and how those interact to properly backwash filters.

PRO-21. List common contaminants removed in each of these filter types: sand, bag, inert fabric cartridge, carbon, resins, organoclay.

PRO-22. Draw the following filters and show typical flow paths and backwash: sand, bag, inert fabric cartridge, carbon, resins, organoclay.

PRO-23. Compare/contrast pressure and flow in the header and footer of the sand filter between backwash and normal operations.

PRO-24. Describe the recirculation system and how that system works in relation to discharge.

PRO-25. Discuss disadvantages of recirculation to the pretreated or main holding ponds/tanks.

PRO-26. Define “scour” and adverse conditions due to scour within sedimentation tanks and basins.

PRO-27. Define “scour” and adverse conditions due to scour caused by filter effluent.

PRO-28. List the three most common handheld meters used in ATS operations.

PRO-29. Demonstrate the calibration of the following: pH meter, turbidimeter, and conductivity meter.

PRO-30. Identify the required equipment and standard procedure for the ASTM D2035 jar test.

PRO-31. Explain how jar test results influence system design and operation.

Components (COMP8) – These learning objectives cover knowledge of ATS components.

COMP8-1. Identify the following parts/tools: pumps, valves (screw, gate, auto), and mixers.

COMP8-2. Describe the functional differences in auto/butterfly valves and flow-control valves.

COMP8-3. Describe the purpose or operation of any mixer, static or otherwise.

COMP8-4. Identify submersible and centrifugal pumps, and discuss high head, low head, and velocity.

COMP8-5. Given a water flow, desired polymer concentration (ppm), and specific gravity of the neat polymer, calculate the injection rate.

COMP8-6. Discuss injection location in an ATS.

COMP8-7. Describe a gas, liquid, and solid pH correction system used in an ATS.

COMP8-8. List the three common in-line measuring instruments in an ATS that are used to take the automatic measurements required in the permit.

COMP8-9. Draw a diagram of various flow meter configurations.

COMP8-10. State how often calibrations should be performed and the required recordkeeping for calibrations.

COMP8-11. Describe typical electronic controls (e.g. PLC) and data acquisition systems (e.g. modems and web-based data loggers).

Startup/Shutdown (SUSD) – Learning objectives for startup and shutdown cover procedures.

SUSD-1. Describe the general procedure for startup of an ATS.

SUSD-2. Describe the general procedure for shutdown of an ATS.

Appendix B: 32-Hour Field Training Learning Objectives

Safety (SAF) – The learning objectives for safety cover the topics of protective equipment and safety meetings.

SAF32-1. Demonstrate donning of PPE used in the field.
SAF32-2. Lead a site-specific tailgate safety and site orientation meeting.

ATS Components (COMP32) – The learning objectives for ATS components cover identification and maintenance, including all functional elements, controls, and monitoring equipment.

COMP32-1. Identify the components where the five steps in ATS treatment (pretreatment, coagulation/flocculation, sedimentation, filtration, discharge scour prevention) occur in this ATS treatment train.
COMP32-2. Identify the raw water conveyance system at this site, and describe how water is moved (pumps and power source) to the pretreatment step.
COMP32-3. Identify the following pretreatment equipment in this ATS: pumps, chemical metering pump, mixers, flow meters, pH meter, holding tanks or basin, weir walls, and sludge management.
COMP32-4. Describe the pretreatment sludge management system used at this site, including power, accumulation, removal, and dewatering (if applicable).
COMP32-5. Distinguish pretreatment pumps by type, function, and location.
COMP32-6. Identify the coagulation section of this system.
COMP32-7. Identify the flocculation section of this system.
COMP32-8. Identify the sedimentation tanks or basins in this system.
COMP32-9. Describe the flow path through the sedimentation system.
COMP32-10. Describe the type(s) of filters and identify the operation controls for the filter type(s) at the site.
COMP32-11. Compare operational differences in main and pretreatment pumps.
COMP32-12. Describe how the filter at the site functions during routine operation.
COMP32-13. State general operating flows and pressures on the footer and the header of the filter at the site.
COMP32-14. Identify the sight glass or sample port from the backwash.
COMP32-15. Describe flow path through the 3-way valve during backwash and during normal operation.
COMP32-16. Check pneumatic diaphragm operation, and conduct a leak check.
COMP32-17. Describe pump replacement procedure.
COMP32-18. Set proper compressor pressure and regulation to the various components serviced by the compressor.
COMP32-19. Grease the 3-way valve.
COMP32-20. Walk through and identify the water conveyance system at this site.
COMP32-21. Identify the discharge plumbing and the recirculation plumbing.

COMP32-22. Calibrate the in-line turbidimeter, or off-line meter for a batch system.
COMP32-23. Replace the desiccant pad in the turbidimeter.
COMP32-24. Demonstrate cleaning, replacement, and inspection of the cuvette.
COMP32-25. Calibrate the pH meter.
COMP32-26. Demonstrate probe maintenance.
COMP32-27. Test the pH probe for proper function.
COMP32-28. Describe inspection and maintenance of erosion control at the discharge point.
COMP32-29. Identify the discharge location.
COMP32-30. Identify all sample ports for in-line meters and manual grab samples.

Operations (OPS) – The following learning objectives cover the operation and monitoring of a typical ATS:

OPS-1. Discuss automatic operation requirements from Attachment F for the on-site system.
OPS-2. Demonstrate a proper startup from walking on-site to discharging water.
OPS-3. For compressor systems, check, drain, and operate the compressor system.
OPS-4. Adjust regulator pressures and discuss system pressure needs.
OPS-5. For the on-site system in place during field training, demonstrate the use of the auto control panel and set water quality parameters to control the automatic discharge/recirculation valves.
OPS-6. Actuate filter effluent auto valves for recirculation manually and return to auto configuration.
OPS-7. Identify the proper place to collect a representative sample for jar testing.
OPS-8. Perform a single bench-scale jar test with the raw water and determine needed treatment dose in ppm.
OPS-9. Measure flow and convert ppm dose into an injection rate in mL/min.
OPS-10. Set injection pump to the calculated injection rate.
OPS-11. Demonstrate how to flood the filter at the site.
OPS-12. Set valves at a starting point for filter backwash and check pressure and flow, and describe acceptable ranges for both.
OPS-13. Perform setup for automatic backwash based on pressure differential.
OPS-14. Perform setup for automatic backwash based on timing.
OPS-15. Start and stop a manual backwash of an individual pod.
OPS-16. Demonstrate how the sight glass works during backwash.
OPS-17. Describe expected conditions during the *first* backwash.
OPS-18. Perform a “power flush” of the filter.
OPS-19. Describe the maximum time intervals for recording water parameters at this site.
OPS-20. Take a grab sample from pretreatment, sedimentation, and filter effluent.
OPS-21. Preserve a residual test sample to be sent for third-party analysis.
OPS-22. Describe transportation methods used when sending samples out for third-party testing.
OPS-23. Demonstrate complete recordkeeping, legible writing, and proper strike-through of writing errors, etc.

OPS-24. Describe the on-site and off-site storage requirements for operator notes and other written documents.

OPS-25. Demonstrate a complete proper shutdown of the system from discharging to leaving the site.

OPS-26. Demonstrate troubleshooting procedures for the following system operation problems: turbidity, pH, flow and pressure, water hammer, treatability in relation to conductivity, pH, chemical injection correction, proper flow path, and electrical failure.

OPS-27. Convert gpm to Lpm (Example: 550 gallons per minute to liters per minute).

OPS-28. Calculate the volume in gallons of a rectangular basin.

OPS-29. Convert between pounds and grams.

OPS-30. Convert between ppm and percent solution.

OPS-31. Convert between mL/min and gpd.

OPS-32. Calculate how long a chemical will last given the target injection dose and flow rate. (Example: A system is set to inject 100 ppm of alum from a 50 gallon drum of 48% alum. Water is pumping at 350 gallons per minute. How long will 33 gallons of 48% alum last?)

OPS-33. Calculate the concentration of sodium bicarbonate used to correct pH given mass of sodium bicarbonate and volume of water. (Example: An operator is using 50 lbs of sodium bicarbonate to correct pH on six 20,000 gallon storage tanks. How many mg/L or ppm did the operator use to treat the six tanks?)

Chitosan (CHIT) – The following learning objectives are specific to chitosan-based ATS:

CHIT-1. Describe the quantitative limitations of the starch/iodine test.

CHIT-2. Describe when false positives can occur with the starch/iodine test.

CHIT-3. Identify all the equipment used in chitosan residual testing.

CHIT-4. Demonstrate sample collection, data recording, and perform the test.

CHIT-5. Review results and determine presence/absence of chitosan.

Polymers (POLY) -- The following learning objectives are specific to polymer-based ATS:

POLY-1. Explain when third-party testing is needed.

POLY-2. Collect a sample, preserve, document with chain of custody, prepare for shipping, and ship sample.

POLY-3. Describe data reporting from the lab and on-site recordkeeping.