

ATTACHMENT 27

Infrastructure Construction and Delivery Effectiveness Quality Assurance / Quality Control (QA / QC)

This attachment contains guidelines for QA/QC of infrastructure construction and delivery of the various oxidant/activator delivery techniques. It lists the major delivery techniques, their primary construction elements, and the associated QA / QC inspections/tests that should be conducted to verify their integrity and effectiveness. These procedures should be executed by the contractor and oversight personnel to verify achievement of design conditions or trigger initiation of contingency response actions.

Delivery Technique	Applicable Oxidant(s)	Element	Data Objective	QA/QC Procedure	Troubleshooting Measure
Direct-push probe	Permanganate Catalyzed hydrogen peroxide (CHP) Activated persulfate	Drilling	Injection point coordinate accuracy Depth accuracy Lithologic verification at injection depth	Surveying Probe rod or auger flight accounting Blow counting	Cone penetrometer technology (CPT) survey to verify lithologic interfaces Continuous soil sampling and logging
		Discrete depth injection	Injection effectiveness Hydraulic radius of influence (ROI) Oxidant/activator delivery ROI	Injection pressure and flow rate Injectate oxidant/activator concentration Surrounding monitoring point pressure Monitoring well water level Monitoring well oxidation-reduction potential (ORP)	Adjust delivery sequence (e.g., top-down or bottom-up) Continuous soil sampling and logging Electrical resistivity tomography (ERT) survey Tracer injection and perimeter monitoring Use continuous down-well ORP dataloggers and/or specific conductivity
		Borehole abandonment	Borehole plug effectiveness	Grout from bottom-up and account grout quantity	Over drill and re-abandon borehole Offset injection location if old borehole is causing injectate short-circuiting
Well	Permanganate CHP Ozone Activated persulfate	Drilling	See Objectives and Procedures for "Direct-push probe" Delivery Technique above		
		Injection well installation and completion	Bentonite seal integrity Proper well development	Filter and bentonite seal material accounting Purge water quantity and quality monitoring	Pressure test Re-evaluate screen slot and filter pack design Over drill and reinstall well
		Injection	Injection effectiveness Hydraulic ROI Oxidant/activator delivery ROI	Injection well efficiency Injection pressure and flow rate Injectate oxidant/activator concentration Surrounding monitoring point pressure Monitoring well water level Monitoring well ORP	Tag injection well total depth to assess sedimentation Adjust delivery sequence (e.g., top-down or bottom-up) Continuous soil sampling and logging ERT survey Tracer injection and perimeter monitoring Use continuous down-well ORP dataloggers and/or specific conductivity

Delivery Technique	Applicable Oxidant(s)	Element	Data Objective	QA/QC Procedure	Troubleshooting Measure
Recirculation	Permanganate	Drilling	See Objectives and Procedures for "Direct-push probe" Delivery Technique		
		Injection/extraction well installation and completion	See Objectives and Procedure specified above for "Well" Delivery Technique		
		Process equipment construction	Process piping integrity Equipment performance verification	Hydraulic pressure testing Functionality testing (process, instrumentation, and controls)	Mechanical and control logic repair
		Groundwater extraction	Extraction effectiveness Hydraulic ROI – capture zone Influent water quality	Extraction pressure and groundwater flow rate Monitoring well water level Extraction water quality sampling (field parameters and COCs)	Re-evaluate screen slot and filter pack design
		Oxidant dosing	Oxidant usage rate	Oxidant consumption monitoring	Re-evaluate oxidant measurement technique Assess dosing system stability (hydraulic and concentration)
		Oxidant injection	Injectate oxidant concentration Hydraulic injection ROI Oxidant delivery ROI	Oxidant concentration Injection pressure and flow rate Surrounding monitoring point pressure Monitoring well water level Monitoring well ORP	Adjust delivery pressure Evaluate injection well efficiency Continuous soil sampling and logging ERT survey Tracer injection and perimeter monitoring Use continuous down-well ORP dataloggers and/or specific conductivity
Trench and curtain	Ozone	Drilling	See Objectives and Procedures for "Direct-push probe" Delivery Technique		
		Injection well installation and completion	See Objectives and Procedures specified above for "Well" Delivery Technique		
		Process equipment construction	See Objectives and Procedures specified above for "Recirculation" Delivery Technique		
		Oxidant dosing	See Objectives and Procedures specified above for "Recirculation" Delivery Technique		
		Oxidant injection	See Objectives and Procedures specified above for "Recirculation" Delivery Technique		
Soil mixing	Permanganate CHP Activated Persulfate	Process equipment construction	See Objectives and Procedures specified above for "Recirculation" Delivery Technique		
		Soil mixing	Mixing effectiveness	Post-mixing soil sampling and analysis for [COC] and oxidant/activator Visual inspection or grab sampling during mixing	Evaluate mixing tool device consistency with site-specific soil type Premix soil with an excavator to loosen it prior to oxidant/activator mixing
		Oxidant/activator dosing	See Objectives and Procedures specified above for "Recirculation" Delivery Technique		

Delivery Technique	Applicable Oxidant(s)	Element	Data Objective	QA/QC Procedure	Troubleshooting Measure
Fracture-emplaced	Permanganate Activated Persulfate	Drilling	See Objectives and Procedures for "Direct-push probe" Delivery Technique		
		Fracturing	Fracture break Fracture propagation Fracture ROI	Continuous fracture borehole pressure monitoring Continuous fracture borehole gas flow rate monitoring Monitoring wellhead pressure (maximum drag-arm gauges or data logging) Surface heave surveying Visual inspection	CPT survey to verify lithologic interfaces Continuous soil sampling and logging Ascertain packer integrity, use double packer assembly Use steel casing to maintain borehole integrity Perform fracturing in offset borehole(s)
		Discrete depth oxidant/activator injection	See Objectives and Procedures specified above for "Direct-push probe" Delivery Technique		
		Borehole abandonment	See Objectives and Procedures specified above for "Direct-push probe" Delivery Technique		
Surface application and infiltration gallery	Permanganate Activated Persulfate	Process equipment construction	See Objectives and Procedures specified above for "Recirculation" Delivery Technique		
		Groundwater extraction	See Objectives and Procedures specified above for "Recirculation" Delivery Technique		
		Oxidant/activator dosing	See Objectives and Procedures specified above for "Recirculation" Delivery Technique		
		Oxidant/activator injection	See Objectives and Procedures specified above for "Recirculation" Delivery Technique		