

SECTION 01 91 14
EQUIPMENT TESTING AND FACILITY STARTUP

PART 1 GENERAL

1.01 SUMMARY

- A. This section establishes the overall framework and procedures of the startup and testing program to be used with the requirements specified for checking, testing, and starting equipment, systems, and unit processes after their installation. Refer to detailed testing requirements in the individual Technical Specifications.
- B. Detailed descriptions and requirements of each element of the startup and testing program are included herein.
 - 1. The program includes the following major phases in chronological order:
 - a. Planning: Meetings, submittals, schedules, and plans in preparation for startup and testing activities.
 - b. Factory Testing: Testing required by individual equipment Technical Specifications to be performed at the factory before shipment to the Project Site.
 - c. Component Testing: Complete testing by Contractor, including physical installation, electrical and communication checks, of each individual project component, including equipment, piping, valves, instruments, and electrical gear.
 - d. Functional Testing: Complete testing by Contractor, in presence of Contracting Officer, of each project System. For example, a pump system could include the pump, piping, valves, associated electrical gear, all wiring, instrumentation, and communications.
 - e. Software Testing: Work under this section does not include Software Testing. See Section 40 90 00, Instrumentation and Control for Process Systems, for definitions, testing, and certification requirements related to Process Integration and Controls. Software Testing is done by the PIC System Integrator, must be successfully completed prior to Performance Testing.
 - f. Performance Testing: As required by individual equipment Technical Specifications.
 - g. Demonstration Testing: Testing of all Unit Processes of the Work concurrently to demonstrate full, uninterrupted operation.
 - h. Construction, Installation, and Training will necessarily occur parallel and in coordination with the major phases. For Training see Section 01 79 00, Demonstration and Training.

2. This section establishes the Contractor's responsibilities for developing and executing the complete testing and startup program. Involvement of the following is required and described herein:
 - a. Contractor.
 - b. Subcontractors.
 - c. Suppliers.
 - d. Manufacturers.
 - e. Contracting Officer.
- C. Work under this section does not include buildings and building systems. See Section 01 91 15, Total Building Commissioning, for definitions, testing and certification requirements related to the buildings and building systems.

1.02 RESOURCES AND RELATED WORK SPECIFIED UNDER OTHER SECTIONS

- A. Related and referenced sections include, but are not limited to the following:
 1. Section 01 31 00, Project Management and Coordination.
 2. Section 01 32 16, Construction Schedule.
 3. Section 01 33 23, Submittal Procedures.
 4. Section 01 43 33, Manufacturers' Field Services.
 5. Section 01 50 00, Temporary Facilities and Controls.
 6. Section 01 67 00, Product Requirements.
 7. Section 01 77 00, Closeout Procedures.
 8. Section 01 78 23, Operation and Maintenance Data.
 9. Section 01 79 00 Demonstration and Training.
 10. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
 11. Section 26 08 00, Commissioning of Electrical Systems.
 12. Section 40 90 00, Instrumentation and Control for Process Systems.

1.03 DEFINITIONS

- A. General: Definitions herein describe how the parts of the wastewater treatment plant are defined for commissioning and startup purposes. The wastewater treatment plant is made up of Facilities; Facilities are made up Unit Processes; Unit Processes are made up of Systems; Systems are made up of Components. If any discrepancies exist between the definitions listed below and explicit or implicit definitions in the equipment specifications, the definitions in this section will take precedence. Any conflicts resulting from differing interpretations between this section and the equipment specifications are to be resolved by the Contracting Officer.
- B. Component:
 1. All mechanical equipment, other equipment, piping, electrical, instrumentation, controls, and package system equipment. Individual equipment items include fans, pumps, tanks, valves, instruments, motor

control centers, local controls, other equipment, equipment control panels, and all items associated with packaged equipment. The following are examples of Components:

- a. Equipment.
 - b. Tanks.
 - c. Piping.
 - d. Control valves.
 - e. Operators.
 - f. Actuators.
 - g. Monitoring equipment.
 - h. Protective switches.
 - i. Instrumentation.
 - j. Variable frequency drives (VFDs).
 - k. Motor control centers (MCCs).
 - l. Package system PLC/IO and Logic.
 - m. Local control panels.
 - n. Human Machine Interfaces (HMI).
 - o. Alarms.
 - p. Networks.
- C. Facility: An individual building, structure or area, or an agreed-upon group of buildings, structures or areas, including all of its Unit Processes.
- D. System: A System consists of a group of Components that perform a specific contributing function of a Unit Process. For Equipment Testing and Startup Purposes, field testing starts at the System level (an individual Component cannot be field tested without the other Components in its System).
- E. Unit Process: The overall process or a portion thereof, that performs a specific function. A Unit Process may consist of one or more Systems. A Unit Process may be located across one or more Facilities.
- F. Organization of the Components of the replaced wastewater treatment plant at South Rim Village as it pertains to Equipment Testing and Facility Startup: All Components that are part of the Project can be organized sequentially by System, Unit Process, and Facility. The list below includes most but not necessarily all Systems by Unit Process, and Unit Process by Facility.
1. Facility 18 – Septage Receiving:
 - a. Septage Receiving Unit Process: Septage Receiving System.
 2. Facility 20 – Headworks:
 - a. Influent Monitoring Unit Process:
 - 1) Influent Flow Measurement System.
 - 2) Influent Sampling System.
 - 3) Influent Screening Unit Process: Screening System.

- b. Grit Removal Unit Process:
 - 1) Grit Pumping System.
 - 2) Grit Classifying System.
 - 3) Fine Screening Unit Process: Fine Screening System.
 - 3. Facility 22 – Odor Control:
 - a. Odor Control Unit Process: Odor Control System.
 - 4. Facility 25 – Process Tanks:
 - a. Secondary/Tertiary Unit Process.
 - 1) Bioreactor Inventory System
 - 2) Bioreactor Monitoring System.
 - 3) Bioreactor Mixing System.
 - 4) Bioreactor Aeration System.
 - 5) Bioreactor Wasting System.
 - 6) RAS Pumping System.
 - 7) Membrane System.
 - b. Equalization Unit Process:
 - 1) Equalization System.
 - 2) Tank Drain Pumping System.
 - 5. Facility 32 – Process Building:
 - a. Secondary/Tertiary Unit Process (across Facilities 25 and 32):
 - 1) Bioreactor Blower System.
 - 2) Membrane System (across Facilities 25 and 32).
 - 3) Membrane Cleaning System.
 - 4) RAS Pumping System (across Facilities 25 and 32).
 - 5) Carbon Dosing System.
 - 6) Alkalinity Dosing System.
 - 7) Bioreactor Wasting System (Across Facilities 25 and 32).
 - b. Reclaimed Water Unit Process (Across Facilities 32 and 70):
 - 1) Reclaimed Water Pumping System.
 - 2) Reclaimed Water Disinfection System.
 - c. Disinfection Unit Process:
 - 1) Disinfection System.
 - 2) UV Effluent Booster Pump System.
 - 6. Facility 70 – Reclaimed Water Tank Facility:
 - a. Reclaimed Water Unit Process (Across Facilities 32 and 70): Reclaimed Water Tank.
 - 7. Facility 80 – Digester Facility:
 - a. Aerobic Digestion Unit Process.
 - 1) Digester Inventory System.
 - 2) Digester Blower System.
 - 3) Digester Mixing/Aeration System.
 - 4) Digestion Monitoring System.
 - 8. Facility 85 – Drying Beds:
 - a. Digested Sludge Drying Unit Process: Digested Sludge Drying System.

9. Facility 86 – Plant Drain Pump Station:
 - a. Plant Drain Pumping Unit Process: Plant Drain Pumping System.
10. Facility 87 – Composter Facility:
 - a. Composting Unit Process: Composting System.
11. Emergency Generator Facility:
 - a. Emergency Generator Unit Process: Emergency Generator System.

1.04 SUBMITTALS

- A. Specific submittal content requirements are included throughout this section. The following submittals are required:
 11. Startup and Commissioning Manager's Qualifications, including a minimum of two project references with contact names, addresses, and current telephone numbers.
 12. Contractor's operations staff or operations subcontractor's Qualifications and Certifications to operate the new SR WWTP.
 13. Master Startup and Testing Plan.
 14. Comprehensive Testing Schedule.
 15. Master Operation and Maintenance Training Schedule.
 16. Individual System (or group of Systems) Startup and Testing Plans.
 17. Individual System (or group of Systems) Startup and Testing Results.
 18. Demonstration Startup and Testing Plan.
 19. Demonstration Startup and Testing Results.
 20. Letter verifying completion of all startup activities including receipt of all specified items from manufacturers or suppliers.

1.05 STARTUP AND TESTING PHASES

- A. Refer to the entire Technical Specifications for detailed field-testing requirements that shall be completed in the framework of the startup and testing program described herein.
- B. Planning:
 1. Refer to the Technical Specifications for additional submittal requirements specific to each project component.
 2. Comprehensive Testing Schedule:
 - a. Provide a detailed comprehensive schedule for all field testing and startup activities for all facilities, unit processes, systems, and equipment, including training, types of tests, plans, procedures, and dates.

- b. Startup Constraints: Work constraints are identified in Section 01 31 00, Project Management and Coordination, which provides constraints associated with the construction work sequencing and startup and testing periods. The constraints shall be used by the Contractor in conjunction with this section and requirements specified in the individual Technical Specifications to develop the Comprehensive Testing Schedule.
- c. List all equipment testing by specification section number and name. Include the following for each equipment/system:
 - 1) Specification section, paragraph number, and applicable equipment tags.
 - 2) Forecasted installation completion dates.
 - 3) Manufacturer representative visit dates.
 - 4) Operation and Maintenance Training Schedule.
 - 5) Test type. For example, pressure, leak, watertightness testing, functional, operational, demonstration.
 - 6) Test Plan and procedure submittal dates.
 - 7) Testing and startup dates.
 - 8) Equipment rotation schedule.
 - 9) Test Report submittal dates.
- d. Minimum Scheduling Requirements:
 - 1) Incorporate the work constraints specified in Section 01 31 00, Project Management and Coordination, and the testing prerequisites as specified herein.
 - 2) Master Operation and Maintenance Training Schedule to be submitted 30 calendar days (minimum) prior to first training session of Contracting Officer's personnel. Refer to submittal requirement and detailed training requirements specified in Section 01 43 33, Manufacturers' Field Services.
 - 3) Training occurs during when the equipment can be energized and operated, at a minimum, locally during hands-on training by the equipment supplier. Training shall occur before Operational Testing is completed and not before Preliminary O&M Manuals have been approved. Training Schedule shall be approved by Contracting Officer, see Section 01 79 00, Demonstration and Training.
 - 4) Workdays are only Monday through Friday. Testing activities will require a pause on Friday and restart on Monday. Continuous, uninterrupted operation may continue during non-workdays to support operation of the treatment plant.

3. Master Startup and Testing Plan (Plan):
- a. The Plan shall describe how each test phase will be implemented for each System within the Work. At a minimum, the project-specific Systems identified in 1.03.F must be incorporated into the Plan. For Plan organizational purposes, systems may be grouped together.
 - b. Electronic and physical organization requirements shall be similar for the Operations and Maintenance (O&M) Manuals specified in Section 01 78 23, Operation and Maintenance Data.
 - c. The Plan shall include the following content:
 - 1) The following items as separate submittals; final versions shall be included within the Plan for organizational purposes:
 - a) Comprehensive Testing Schedule, to be coordinated with construction schedule.
 - b) Startup and Commissioning Manager's qualifications.
 - c) Master Operation and Maintenance Training Schedule.
 - d) Testing Forms.
 - e) Individual System Startup and Testing Plans (see below).
 - f) Individual System Startup and Testing reporting parameters.
 - g) Demonstration Test Plan (see below).
 - h) Demonstration Test reporting parameters.
 - i) Letter verifying completion of all startup activities including receipt of all specified items from manufacturers or suppliers.
 - 2) Each startup activity schedule can be prepared as a separate schedule from the Project Schedule if the two schedules can be readily correlated with each other.
 - 3) List of applicable Facilities, Unit Processes, and Systems and proposed Facility, Unit Process, and System groupings for startup.
 - 4) Test phase sequencing by facility, facility grouping, with breakdown to the system or grouping of systems level.
 - 5) Startup/Commissioning team members, inclusive of all equipment suppliers.
 - 6) Detailed startup and commissioning content for each System, to include specific testing requirements from each technical specification and any startup checklists from the manufacturer.
 - 7) Safety Plan: Develop a safe work practice procedure (e.g., lockout/tagout procedures) and personnel protective equipment policies that will be followed during all field-testing activities. At a minimum the Contractor must

comply with OSHA and the Contracting Officer's established safety guidelines. It shall be the Startup and Commissioning Manager's responsibility to ensure all safety procedures are always followed.

- d. Individual System (or grouping of Systems) Startup and Testing Plans, to include the following startup and commissioning content:
 - 1) Summary of all planned work leading up to startup and testing.
 - 2) List of other required Systems, and their respective completion status, prior to the system test. Examples of this include, but not limited to, HVAC, life safety, and power.
 - 3) Testing Plan Narratives:
 - a) Factory Testing: Factory Test Plan and documentation including deficiencies and corrections.
 - b) Component Testing:
 - (1) Organized approach to testing and documenting testing for each component. Include:
 - (a) Checkoff at each step.
 - c) Functional Testing:
 - (1) Description of all scenarios to be tested. Include:
 - (a) Checkoff at each step.
 - (b) P&ID markup noting temporary isolation features and flow path of process fluid.
 - d) Performance Testing:
 - (1) Describe the performance testing requirements defined in the individual equipment Technical Specifications. Include:
 - (a) Schedule.
 - (b) Daily test activities.
 - (c) Special data collection needs.
 - (d) If required, presence of Manufacturer Representative.
 - (e) Any temporary systems or connections needed to conduct this testing.
 - 4) List of the relevant specification sections including all contract changes, equipment system submittal, references, systems equipment, and components to be included in the test.
 - 5) List of all Field Tests: List of all individual inspections and testing to demonstrate that equipment and structures operate properly and reliably, including, but not limited to, pressure and leak tests, vibration testing of equipment, setting limits, implementing initial setpoints.

- 6) Reference Information:
 - a) Control descriptions, including all contract changes.
 - b) P&IDs, mechanical and electrical drawings, including wiring diagrams, for all components and systems subject to testing, including for package systems.
 - c) Equipment drawings, electrical drawings, and panel wiring diagrams.
 - d) I/O lists and related panel wiring diagrams, including for package systems.
 - 7) Testing Reports:
 - a) Field test reports.
 - b) Test instrument calibration reports.
 - c) Pressure and leak tests forms.
 - d) Factory test reports.
 - e) Test reports and test check off sheets as required by related Technical Specifications.
 - 8) Job Hazard Analysis: Contractor safety plan specific to testing for each system.
 - 9) Testing Consumables Plan: Narrative plan and tables describing consumables and estimated quantity, and contingency quantities required during testing.
 - 10) Testing Medium Plan: Narrative plan describing method to introduce test medium (water, wastewater, sludge, biosolids, chemicals, or air as applicable), and how it will be managed during each phase.
- e. Demonstration Test Plan to include the following startup and commissioning content:
- 1) Summary of all planned work leading up to testing.
 - 2) Demonstration Test Plan Narrative: Describe how all Unit Processes will be brought online if not already online.
 - a) Schedule.
 - b) Daily test activities.
 - c) Special data collection needs, including but not limited to:
 - (1) SCADA output from all components included in testing for duration test.
 - (2) All water quality parameters that would otherwise be required for regulatory reporting for the duration of the test.
 - (3) All standard process monitoring parameters that may not be tracked in SCADA for the duration of the test. Complete list at the discretion of the Contracting Officer.
 - d) If required, presence of Contracting Officer.
 - e) Any temporary systems or connections needed to conduct this testing.

- f) Detailed procedures for systematic shutdowns for all systems at the facilities shall also be described.
 - 3) Testing Consumables Plan: Narrative plan and tables describing consumables and estimated quantity, and contingency quantities required during testing.
 - 4) Demonstration Test Report to include all results collected during testing.
- f. Provide a proposed checklist to be used and maintained by the Startup and Commissioning Manager to document the status of each testing item.
- 4. Startup Planning and Coordination Meetings: Quarterly to weekly meetings, led by the Startup and Commissioning Manager and attended by the Startup and Commissioning Team.
 - a. Agenda items shall include, but not be limited to, content of the Master Startup Test Plan, coordination needed between various parties in attendance, responsibilities of the various parties, ongoing and upcoming activities, and potential problems associated with startup activities.
 - b. The Startup and Commissioning Manager will conduct meetings at the following times:
 - 1) At least 6 months prior to submitting the draft Startup and Testing Plan.
 - 2) At least 90 calendar days prior to first anticipated training session.
 - 3) At least monthly throughout the Planning Phase.
 - 4) At least weekly, beginning at the start of Functional Testing and through Demonstration Testing.

C. Factory Testing:

- 1. Perform Factory Testing for individual equipment, as specified in equipment Technical Specifications, at the factory and prior to shipping.
- 2. Factory Testing need not be witnessed by the Contracting Officer unless a special Witness Testing paragraph is included in this section or the individual Technical Specifications. However, the Manufacturer's Representatives shall certify and provide copies of test reports and guarantee the equipment's performance as specified in the individual Technical Specification. All certifications of Factory Testing shall be submitted and approved by the Contracting Officer, prior to shipping equipment.
- 3. The Contractor shall provide the Contracting Officer a minimum of 30-day notice prior to conducting factory tests.

D. Component Testing:

1. Required for all mechanical equipment, other equipment, piping, electrical, instrumentation, controls, and package system equipment. Individual equipment items include but not limited to screens, washer/compactors, vortex grit chamber, blowers, diffusers, mixers, membranes, mixer/aerators, decanters, pumps, UV vessels, tanks, fans, valves, instruments, motor control centers, local controls, other equipment, equipment control panels, and all items associated with an individual equipment package.
2. Perform component testing as specified herein in Part 3 and as specified in the individual Technical Specifications and by component manufacturer.
3. Component installation testing shall be completed per the individual Technical Specifications, and documented using standard forms, including:
 - a. Equipment installation checklists, hydrostatic pipe tests, hydrostatic tank tests, and other field functional reports defined in the technical specifications.
 - b. Manufacturer's Certificate of Proper Installation (MCOPI) included as a supplement in Section 01 43 33, Manufacturers' Field Services.
4. Field testing shall be completed on electrical equipment as required by Section 26 08 00, Commissioning of Electrical Systems, prior to issuance of the MCOPI.
5. Testing of HVAC equipment shall be in accordance with the requirements of and Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
6. Network Communications Testing:
 - a. Network installation and communication test for all networks associated with a given component.
 - b. Refer to Section 26 05 10, Network Communication System, for requirements.
7. Component Operational Testing: Operational testing of components, including complete loop testing. Operation of the equipment shall be operated from minimum to maximum to verify the equipment can be operated from minimum speed to maximum speed, minimum opening to maximum opening, or similar. Component Operational Testing shall be in accordance with manufacturer recommendations without use of media.

E. Functional Testing:

1. Perform Functional Testing as specified herein in Part 3 and as specified in the individual Technical Specifications.

2. Functional Testing shall not proceed until all relevant life safety systems and building equipment startup and acceptance phases have been successfully completed per Section 01 91 15, Total Building Commissioning.
3. The Contractor shall inspect, test, and document that all Systems are ready for energization and operation. Testing shall verify completion of the installation, including wiring continuity, terminations, labelling, grounding, and shielding as well as completion and accuracy of documentation and all other work by the Contractor to verify readiness for operation

F. Performance Testing:

1. Performance Testing shall not proceed until the applicable Software Testing has been successfully completed. See Section 40 90 00, Instrumentation and Controls for Process Systems.
2. Performance Testing shall occur in the presence of Contracting Officer, where specified in the Technical Specifications, to demonstrate that equipment meets specified performance requirements.
3. If requested by the Contractor in the Plan and approved by Contracting Officer, Performance Testing of some systems may occur during Functional Testing. Performance Testing shall not occur during Software Operational Testing.

G. Demonstration Testing: Demonstration Testing integrates and automatically operates all project Unit Processes and Systems of the Work together to demonstrate system readiness, simulating real process conditions as much as practical for a fixed duration.

1.06 TRAINING

A. Prior to Starting Training:

1. Functional testing shall be completed so that equipment can be energized.
2. Operation and Maintenance Manuals shall be submitted by the Contractor and reviewed without comment by the Contracting Officer.

B. Training is Categorized into Two Groups: Equipment/Component Training and System Training.

1. Equipment/Component Training:
 - a. Equipment/component training is provided by the Contractor for Contractor furnished equipment to the Contracting Officer's personnel using factory authorized trainers. The training shall address normal operation, common faults and operational limits, preventative maintenance, fault recovery, troubleshooting and the

theory of operation. Training shall be provided in accordance with Section 01 43 33, Manufacturers' Field Services.

- b. Equipment/component training will be held across all Operations shifts on subsequent days in accordance with the approved training schedule.
- 2. System Training: Training on unit processes will be provided by the Contracting Officer's personnel. The classes shall be included in the Master Operation and Maintenance Training Schedule to facilitate coordination with Contractor, Contracting Officer personnel and other activities.

1.07 STARTUP AND COMMISSIONING MANAGER RESPONSIBILITIES AND QUALIFICATIONS

- A. Startup and Commissioning Manager: Contractor shall employ a testing and commissioning expert who is responsible for overseeing, organizing, compiling, and administering all field testing for the overall work and managing the Startup Commissioning Team.
- B. Startup Commissioning Team: A team comprised of the Startup and Commissioning Manager, key members from the Contractor staff, subcontractors, and the Contracting Officer.
- C. The Startup and Commissioning Manager's responsibilities shall include, but are not limited to, the following activities:
 - 1. Overall responsibility and coordination for all elements of the Startup and Testing Program, including:
 - a. Submittals.
 - b. Schedules.
 - c. Meetings.
 - d. Field testing activities and documentation.
 - e. Scheduling of Startup Commissioning Team members.
 - f. Training.
 - g. Safety.
 - 2. Be the liaison between the Contractor and the Contracting Officer for all field testing and startup activities.
- D. Contractor's Startup and Commissioning Manager's Statement of Qualifications:
 - 1. The Startup and Commissioning Manager is required to be responsible for managing, coordinating, and supervising all work related to the planning, testing, startup, and commissioning of the systems described

in this section, and elsewhere in the Technical Specifications and shall have:

- a. At least 3 years' experience as a Startup and Commissioning Manager.
- b. Experience in the startup of similar systems on at least two completed wastewater facilities, each with a minimum construction cost of \$20 million; and included wastewater treatment, pumping, SCADA, pipeline, and electrical infrastructure.

- E. Approval of Contractor's Startup and Commissioning Manager: Proposed manager resume and qualifications shall be submitted within 60 calendar days of Notice to Proceed. Qualifications submittal shall include a minimum of two project references with contact names, addresses, and current telephone numbers. Proposed manager shall be subject to interview by the Contracting Officer as part of the review process. The Contractor shall promptly remove the manager if they fail to perform to the Contracting Officer's satisfaction and shall propose alternate manager for the Contracting Officer's consideration and approval.

1.08 COST OF STARTUP

- A. Startup costs will be paid by Contractor unless noted otherwise.
- B. The Testing Consumables Plan shall be provided to estimate quantity and contingency quantities required during testing.

1.09 EXTRA MATERIALS/SPARE PARTS

- A. Furnish special tools, materials, and supplies required to install, commission, and startup equipment. This may require temporary provisions, including systems, components, materials, or equipment necessary to allow the equipment or component to function for testing.
- B. Contractor shall furnish to Contracting Officer, prior to startup, all accessories and spare parts required by the Contract Documents. These accessory items include, but are not limited to, all spare parts, adequate oil and grease as required for first lubrication of equipment, light bulbs, fuses, hydrant wrenches, valve keys, handwheels, chain operators, special tools, and other items as required for operation.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. The Contractor shall oversee all field Component, Functional, Performance, and Demonstration Testing of all installed equipment and systems, unless otherwise noted. The Contractor shall coordinate with the Contracting Officer and PIC System Integrator for software testing. See Section 40 90 00, Instrumentation and Controls for Process Systems.
- B. The Contractor shall complete all testing following the test procedures approved by the Contracting Officer.
- C. All testing of any equipment that may affect the operation of the existing Government facilities shall be coordinated with the Contracting Officer.
- D. At the satisfactory conclusion of each test phase, dismantle and remove all temporary valving, hoses, and other equipment used during the test.
- E. All deficiencies found during any test phase and subsequent correction thereof, must be inspected and approved by the Contracting Officer.
- F. During the Performance and Demonstration Testing Phases, equipment will be rotated in and out of service to equalize run times.

3.02 CONTRACTOR'S PERSONNEL

- A. The Contractor shall provide the services of all technical and craft personnel required to support the Startup and Testing Program. Additionally, the Contractor shall arrange for on-call services of these personnel as needed to respond to emergencies.
- B. Contractor shall maintain the appropriate staff (either onsite or on-call) to be able to respond immediately (24 hours per day) to system or equipment-related questions, and to correct deficiencies.
- C. Certified operators are required to operate any systems that handle, process, or pump wastewater. The Contractor will provide certified operations staff to support the Operational, Performance and Demonstration Testing phases.

3.03 MANUFACTURERS' SERVICES

- A. A Manufacturer's authorized representative (Manufacturer's employee, unless approved by Contracting Officer otherwise) shall perform all services when manufacturers' services are specified in the technical specifications. The authorized representative shall be factory-trained and experienced in the

technical applications, installation, operation and maintenance of the equipment or system.

- B. Manufacturer's representatives shall be subject to the acceptance of the Contracting Officer. The Contractor shall submit the qualifications of the Manufacturer's representative to the Contracting Officer for review and approval. No substitute representatives will be allowed without prior written approval by the Contracting Officer.
- C. Refer to Section 01 43 33, Manufacturers' Field Services.

3.04 EQUIPMENT AND MATERIALS REQUIRED FOR TESTING

- A. It shall be the Contractor's responsibility to ensure that all required material and test and repair equipment are on hand during all testing, unless otherwise specified to be provided by others.
- B. All instruments used to measure equipment performance shall be calibrated. Certificates of calibration shall be current, and shall be at the Job Site during testing, and provided upon request or when specified. Copies of the calibration records shall be submitted to the Contracting Officer for review and approval prior to the start of testing.
- C. Normal wear parts that require replacement during testing (e.g., filters, belts, etc.) shall be provided by the Contractor. Any spare parts that are used during the testing phases shall be replaced by the Contractor.

3.05 STARTUP CONSTRAINTS

- A. Startup constraints are as follows:
 - 5. Reclaimed water (RW) is available up to 100,000 gpd for hydrostatic testing and functional testing throughout the plant during commissioning. Availability of RW varies seasonally. NPS will limit RW available for construction depending on South Rim Village RW demand. RW will be available from RW Fill Station or on-site hydrant.
 - a. Coordinate daily RW requirements for filling facilities with NPS Operations and Contracting Officer with 2-week advanced notice.
 - b. Coordinate any discharges back to existing SR WWTP of RW used for testing including but not limited to disposal location, flow rate, volume, start and stop time of day. Allowable discharges will be limited seasonally and diurnally.
 - 6. The Systems of the Unit Processes that support the Systems of the Secondary/Tertiary and Disinfection Unit Processes must undergo

testing through Performance Testing prior to testing those that perform treatment.

- a. The Plant Drain Pump Station System must undergo testing through Performance Testing prior to testing any other System that drains to the Plant Drain Pump Station.
 - b. The Septage Receiving System must undergo testing through Performance Testing prior to introducing process fluids and Performance Testing any Systems within the Digester Facility.
 - c. Any Mixed Liquor Suspended Solids, Waste Activated Sludge, or Digested Sludge added to the Digestion Unit Process from the existing SR WWTP including but not limited to biological process seeding must undergo screening and grit removal.
 - d. No more than 75 percent of existing aerobic digester volume can be transferred to the new aerobic digesters for seeding/dewatering in order to avoid transferring any rags or grit that may have accumulated in the existing aerobic digesters to the new aerobic digesters. The quantity of digester contents to be transferred to the new aerobic digesters may be reduced at the discretion of the Contracting Officer depending on the quality of the digester contents.
 - e. The Tank Drain Pump Station System must undergo testing through Performance Testing prior to any Systems within the Headworks Facility or any Systems of the Digester Facility. Temporary bypass pumping from the Tank Drain pump Station to the existing plant Headworks must be provided per Section 01 57 28, Temporary Flow Control, Article Temporary Flow Control and Bypass Pumping Systems Identified to Complete the Work.
 - f. Temporary flow control must be provided and fully tested between the Raw Sewage (RS) piping delivering screened, degritted and fine-screened wastewater to the bioreactors and the RS/Bypass piping that would normally divert screened and degritted wastewater to the EQ tank per Section 01 57 28, Temporary Flow Control, Article Temporary Flow Control and Bypass Pumping Systems Identified to Complete the Work, to allow for split-plant flow downstream of the Headworks Facility.
7. All Systems part of the Headworks Facility must successfully complete testing through Performance Testing with 100 percent of plant influent raw sewage prior to introducing process fluids and Performance Testing any Systems within the Secondary/Tertiary Unit Process. During Performance testing of the Systems of the Headworks Facility all RS must be sent back to the existing SR WWTP via the Tank Drain Pump Station and temporary bypass pumping.
 8. Any Raw Sewage or Mixed Liquor Suspended Solids added to the Secondary/Tertiary Unit Processes from existing SR WWTP including

- but not limited to biological process seeding must undergo screening, grit removal, and fine screening to protect the Membrane Equipment.
9. When testing Systems of the Secondary/Tertiary, UV, and Reclaimed Water Unit Processes with process fluid, Contractor shall control flow split downstream of the Headworks Facility, sending some RS to the existing SR WWTP via the Tank drain Pump Station and temporary bypass pumping, and splitter box of the new Secondary/Tertiary Unit Process. The flow split between the RS and RS/Bypass piping on the north side of Facility 15 is accomplished by using the temporary piping, flow meters, and flow control valves that are provided in the design. See Section 01 57 28, Temporary Flow Control, Article Temporary Flow Control and Bypass Pumping Systems Identified to Complete the Work and Section 01 91 14, Equipment Testing and Facility Startup, Supplement A.
 - a. Coordinate daily flow requirements for testing with NPS Operations and Contracting Officer with 2-week advanced notice. Flow will be limited seasonally and diurnally.
 - b. Return partially treated wastewater to existing SR WWTP until the new WWTP successfully completes the Demonstration Test:
 - 1) Secondary/Tertiary Unit Process effluent (PERM) may be sent to the existing SR WWTP Headworks via the Tank Drain Pump Station and temporary bypass pumping or to the existing SR WWTP Reclamation Plant;
 - 2) UV Unit Process effluent (UVE) may be sent directly to the existing SR WWTP Reclamation Plant;
 - 3) Coordinate with the contracting officer any discharges back to existing SR WWTP and the SR WWTP Reclamation Plant including but not limited to disposal location, flow rate, volume, start and stop time of day.
 10. All Systems of the Digestion Unit Process must be tested through Performance Testing prior to Performance Testing any Systems within the Secondary/Tertiary Unit Process.
 11. No discharge from new SR WWTP to RW distribution system, outfall or ponds shall occur until the new facilities successfully complete Demonstration Test.
 12. Any Plant Effluent that is chlorinated cannot be discharged to Bright Angel Wash.
 13. One possible sequence for commissioning is shown in Supplement A as a series of steps, showing process fluid flow paths and temporary pumps and piping needed to facilitate testing at each step. This sequence is consistent with the constraints above and is intended to provide an example approach to commission the new SR WWTP facilities. The first two figures show the groupings of Systems within Unit Processes. The next eight figures show how the Unit Processes constructed in Phase I might be commissioned in sequence. The next two figures show the Demonstration Testing of the liquid and solid Unit Processes,

respectively. The last figure shows the commissioning of the odor control Unit process constructed in Phase II.

- B. All the life safety systems and building equipment startup and acceptance phases shall be completed, per Section 01 91 15, Total Building Commissioning, prior to Functional Testing of any System defined in Section 01 91 14, Equipment Testing and Facility Startup. These include, but are not limited to, the following:
 - 1. Fire protection systems and alarms.
 - 2. Communication systems.
 - 3. Gas monitoring systems.
 - 4. Cranes.
 - 5. Fall protection and handrails.
 - 6. Lighting.
 - 7. Life safety signage.
 - 8. Protective barriers.
 - 9. HVAC systems.
- C. All electrical system commissioning shall be complete and accepted in accordance with Section 26 08 00, Commissioning of Electrical Systems, prior to Component Testing, except for those electrical commissioning activities that are required to occur as part of Component Testing in accordance with Section 26 08 00, Commissioning of Electrical Systems.
- D. Process piping, valves, instruments, equipment, panels, and electrical components shall have permanent labels and nameplates/tags.
- E. All performance testing, adjusting, and balancing for HVAC, odor control systems, as defined by Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, must be complete prior to introduction of process fluids.
- F. All testing of permanent power, SCADA, plant sewer, high pressure/low pressure/instrument air, natural gas, potable water systems, plant water systems, and any other systems as required must be complete prior to introduction of process fluids.

3.06 INSTALLATION PERIOD

- A. Test items at the place of manufacture during or on completion of manufacture.
- B. When items are delivered to the Site, remove all coverings, containers, or crates in order to permit the Contracting Officer to conduct the inspection to determine if the items are of the specified quality and workmanship, and are visually in good condition at the time of delivery. Should the Contracting Officer find indication of damage or deficient quality of workmanship, replace

the equipment at no additional cost to the Contracting Officer and repeat the Factory Tests to demonstrate compliance.

C. Completion of Construction Work:

1. Complete the filing of all required submittals.
2. Complete the Work to a state of readiness for testing described herein and as defined in the individual Technical Specifications.

3.07 COMPONENT TESTING PHASE

A. Required for all mechanical equipment, other equipment, piping, electrical, instrumentation, controls, and package system equipment.

B. Prior to energizing equipment, the Contractor shall perform all testing and adjustments according to the manufacturer's recommendations and instructions, including, but not limited to, the following:

1. Confirm physical installation.
2. Pass the manufacturer's pre-startup checklist.
3. Verify wiring continuity for all components, equipment, instruments, panels, and devices. Check power, control, and monitoring circuits for continuity prior to connection to power source.
4. Cleanliness of connecting piping systems.
5. Alignment of connected machinery.
6. Vacuum and pressure of all closed systems.
7. Lubrication.
8. Valve orientation and position status for MANUAL operating mode.
9. Tankage integrity using clean water.
10. Tagging and identification systems.
11. Insulation level (megger) tests.
12. Short circuit test.
13. Proper connections, alignment, calibration, and adjustment.
14. Manually rotate or move moving parts to assure freedom of movement.

C. Perform Component Network Communications Testing for all network panels, network hardware, network cables, and all other network systems that are required to be installed and operational prior to the commencement of individual equipment components that are to be component tested. Some components may not require any network testing, whereas other components may require multiple network tests.

1. Refer to Section 26 05 10, Network Communication System, for the general network communication testing requirements.
2. Refer to Section 26 08 00, Commissioning of Electrical Systems, for MCC network testing requirements.

- D. Component Testing shall be completed for all components, including the following checks:
1. Verify correct voltage and phase sequence of all circuits.
 2. Measure amperage per Section 26 08 00, Commissioning of Electrical Systems.
 3. Continuity testing per Section 26 08 00, Commissioning of Electrical Systems.
 4. Verify rotation, vibration, and other tests as defined in the individual Technical Specifications.
 5. Bump electric motors to verify power and direction of rotation.
 6. Verify that every component is operational through its entire range of operation as available.
 7. Instrumentation and control signal generation, transmission, reception, and response.
 8. Devices, instruments, elements or encloses, etc. are installed in accordance with Contract Documents and industry standards.
 9. Instrument Ranges:
 - a. Factory calibration is acceptable unless otherwise noted in the Contract Documents.
 - b. Confirm and document that instrument ranges agree with Contract Documents or are otherwise corrected on Contract Documents. Instrument ranges are to be included on the form used to document Functional Testing.
 - c. Where calibration requires process fluid or is dependent on other equipment or interlocks, some calibration activities may occur during Functional Testing.
 10. Installations are visually checked for the absence of physical damage, dirt accumulation, and corrosion.
 11. Components are permanently identified with an enclosure nameplate, an instrument tag or equipment identification label.
 12. Conductor wire labels are as shown on the Contract Documents. Wire labels are visible and mechanically imprinted, not manually written.
 13. Verify conductors are terminated correctly. Connections are checked to be tight and without unterminated strands.
 14. Shielding and Grounding:
 - a. Verify grounding conductor installation and shield integrity and grounding.
 - b. Confirm that the shield (drain) wire is protected by an insulated sleeve.
 15. Verify Readiness and Continuity:
 - a. Fuses are in place and the ohm rating is correct.
 - b. Terminal block knife switches closed.
 - c. Resistors are terminated, they have the correct rating, and they are confirmed to have tight connections.
 - d. Circuit breakers are closed, as appropriate for safety.

- E. Field testing shall be completed on electrical equipment as required by Section 26 08 00, Commissioning of Electrical Systems.
- F. Testing of HVAC equipment shall be in accordance with the requirements of Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
- G. At the end of Component Testing, Contractor shall review documentation with Contracting Officer as a prerequisite to beginning the Functional Testing phase.

3.08 FUNCTIONAL TESTING PHASE

- A. Contractor shall verify that the work is complete and ready for energized testing and operation of systems.
- B. Functional testing includes the following elements:
 - 1. Component input/output (I/O) testing.
 - 2. Complete testing functionality of all control circuits.
 - 3. Testing functionality of instrumentation, including calibration that could not occur during Component Testing.
 - 4. Perform equipment field Functional Testing as specified in individual Technical Specifications. Refer to Division 11 through Division 44 for equipment testing requirements.
 - 5. Where specified in the individual Technical Specifications, equipment manufacturer's representative shall complete Manufacturer's Certificate of Proper Installation (MCOPI). Refer to Section 01 43 33, Manufacturers' Field Services. Submit completed MCOPI form and functional testing report as required by individual Technical Specifications.
 - 6. Documentation:
 - a. Document the progress of testing of all project equipment and systems.
 - b. For all equipment, component, systems or similar that have any interface to the control system, document the progress of testing using a Functional Testing form in accordance with Section 40 90 00, Instrumentation and Control for Process Systems.
 - c. In addition to the test form, loop diagrams, electrical schematics, cable schedules and instrument or equipment data sheets may be used. The circuits tested and the data verified are to be highlighted or otherwise identified on the document.
 - d. Terminations and labels are to be verified against Contract Documents. Red-line corrections are required which are to be turned over to the Contracting Officer in accordance with Contract Documents.

- e. The personnel performing the test, the Contractor, and the Contracting Officer, are each to add their name to the test documentation along with the date of the tests.
- 7. Scheduling:
 - a. Functional Testing is the responsibility of the Contractor as the Work is completed. As such, the required duration is a function of the performance of the Contractor's work.
 - b. The Contractor shall include sufficient workdays for Functional Testing.

3.09 TRAINING

- A. Training shall be provided in accordance with Section 01 43 33, Manufacturers' Field Services, and the individual equipment specification sections.
- B. Schedule training after associated equipment is certified by the manufacturer as properly installed and ready for operation using the MCOPI, and after the equipment is energized and the controlling software is sufficiently complete to run the equipment for which training is being conducted.
- C. Training shall follow the Training Schedule required per Section 01 43 33, Manufacturers' Field Services.
- D. Contractor shall maintain a log of classroom training provided, including instructor name and contact information, topics, dates, time, duration, and attendance.

3.10 SOFTWARE TESTING

- A. Coordinate with the Contracting Officer and PIC System Integrator for Software Testing. See Section 40 90 00, Instrumentation and Controls for Process Systems.

3.11 PERFORMANCE TESTING

- B. Perform Performance Testing as specified in the individual Technical Specifications. Refer to Division 11 Equipment, through Division 44, Pollution and Waste Control Equipment, for equipment testing requirements.
- B. Show the System or group of Systems can operate in auto over the full range or capacity of the System or Systems under actual or approved simulated conditions with process fluid whenever possible. This may include flows, loads, solids residence times, air flow rates, recycle, return, or decant rates, MLSS or DS concentrations, etc.
- C. Provides the basis for equipment acceptance.

- D. Performance Testing shall not proceed until after the Pre-Performance Testing is complete where applicable.
- E. During Performance testing, all process criteria defined in the Technical Specifications will be verified by the Contractor.
- F. Performance Test Timing:
 - 1. Timing shall be determined in advance as part of the Plan and depends on availability of process conditions and approval of Contracting Officer. The testing may occur:
 - 1) During Functional Testing,
 - 2) After Operational Testing but before Demonstration Testing, or
 - 2. Performance Testing shall not occur during Software Operational Testing.

3.12 DEMONSTRATION TESTING

- A. During Demonstration Testing, all Unit Processes of the Work shall operate together as intended. All Unit Processes shall be fully operational, capable of accepting design flows and performing functions as designed.
- B. The Demonstration Testing phase shall not proceed until all of the following have been completed:
 - 1. All previous test phases have been performed, and records have been submitted and are available onsite.
 - 2. All O&M manuals have been submitted and approved by the Contracting Officer.
 - 3. Training is complete.
 - 4. System walkthrough performed, punchlist established, and correction of deficiencies to the satisfaction of the Contracting Officer.
- C. Demonstration Testing shall be conducted at a time and date to be mutually agreed upon by the Contractor and Contracting Officer. Demonstration Testing will require operation by the Contractor's operations staff or operations sub-contractors advanced schedule coordination is required. Contractor's operations staff or operations sub-contractor shall have the necessary qualifications and certifications to operate the new SR WWTP.
- D. During Demonstration Testing, Contractor shall anticipate interruption of testing and delays to allow for:
 - 1. Investigation by Contracting Officer of software problems.
 - 2. Changes to software configuration.
 - 3. Retesting.

4. Restart of Demonstration Testing if it is determined that Functional or Operational Testing items were not completed as required.
- E. Demonstration Testing shall be conducted with process fluid continuously and uninterrupted without a significant failure for 14 calendar days.
- F. Where Performance Testing involves biological treatment processes, reaching steady state conditions that prove performance may take longer than 14 calendar days. In this case, the uninterrupted 14 calendar days shall not commence until the performance conditions are met.
- G. In the event of a Significant Failure (as defined in this section), Demonstration Testing will restart after correction of the cause(s) of the failure. The new Demonstration Testing shall have the same requirements and duration as the Demonstration Testing previously conducted. Significant Failure is defined as:
 1. Significant Failure:
 - a. Component Failure:
 - 1) The failure of a duty component that can be replaced by a standby component without disruption to the system or testing will not be considered a significant failure, provided that:
 - a) The Testing is completed without additional failures. Failure of a standby unit or second duty unit will constitute a significant failure.
 - b) The failed component can be returned to service in less than 4 hours.
 - c) Performance of system is not impacted.
 - b. System Failure: The failure of any system or all the systems to not meet Performance requirements will be considered a significant failure.
- H. Contracting Officer reserves the right to simulate operational variables, equipment failures, routine maintenance scenarios, etc., to verify the functional integrity of automatic and manual backup systems and alternate operating modes.
- I. Time of beginning and ending of any Demonstration Testing Period shall be agreed upon by Contractor and Contracting Officer, in advance of initiating Demonstration Testing.
- J. Provide all labor, supervision, maintenance, equipment, vehicles, or any other item necessary to operate and demonstrate all systems being demonstrated. Provide on-call vendor and craft support as needed to support testing.

3.13 RETESTING

- A. If any portion of a test does not pass, the Contractor shall correct the problem in a timely manner and repeat the test until it passes to the satisfaction of the Contracting Officer.
- B. If a Significant Failure should occur during Demonstration Testing and results in additional work for the Contracting Officer (such as overtime labor outside of normal working hours), the Contractor shall be responsible for the cost.

3.14 AFTER TESTING

- A. Once testing has been completed, all components shall be visually inspected. Visual inspections shall be conducted with the Contracting Officer. All equipment shall be checked for loose connections, unusual movement, or other indications of improper operating characteristics. Any deficiencies shall be corrected to the satisfaction of the Contracting Officer. All components which exhibit unusual or unacceptable operating characteristics shall be disassembled, inspected, then repaired or removed from the Site and replaced at no cost to the Contracting Officer.

3.15 SUPPLEMENT

- A. The supplement listed below, following “End of Section,” is a part of this specification:
 - 1. Supplement A.

END OF SECTION