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Statement of Work

Advanced Test Reactor Non-Destructive Examination System (ANDES) Underwater Laser Metrology Support

ADVANCED TEST REACTOR NON-DESTRUCTIVE EXAMINATION SYSTEM (ANDES) UNDERWATER LASER METROLOGY SUPPORT	Identifier: SOW-14532 Revision: 1 Effective Date: 01/10/18 Page 1 of 14

Manual: Procurement

REVISION LOG

Rev.	Date	Affected Pages	Revision Description
0	12/12/17	All	Final document
1	01/10/18	12	Enhanced shared data collection and control hub requirement and added OPC requirement.

CONTENTS

1. INTRODUCTION

1.1 Background

The Idaho National Laboratory's (INL's) Advanced Test Reactor (ATR) is one of the worlds' most consistently updated and capable materials test reactors. With over 40 years of experience, ATR is the only U.S. research reactor capable of providing large-volume high-flux neutron irradiation in a prototypic environment. The majority of ATR experiment post-irradiation examination (PIE) is currently completed off-site at the INL's Materials and Fuels Complex.

During reactor operation outages, experiments and driver fuel either wait in the large canal nearby for transportation to MFC or re-insertion for more irradiation (Figure 1). If a "poolside" non-destructive PIE system was available in the ATR canal, these outages could present an opportunity for ATR operations and nuclear science and technology researchers to safely characterize radioactive specimens. This ATR Non-Destructive Evaluation (NDE) capability (herein referred to as ANDES) would result in obtaining material performance data shortly expeditiously after irradiation for the benefit of both researchers and ATR operations personnel.

***Figure 1**: ATR personnel conduct routine maintenance at the west end of the storage canal*

One of the key ANDES desired functions is high-resolution dimensional analysis. One of the premier concepts chosen to conduct this function was underwater laser metrology to collect high-resolution dimensional data on exposed surfaces of ATR driver fuel assemblies and experiments (e.g., fuel rodlet capsules or fuel plate capsules).

1.2 Purpose / Objectives

The purpose of this SOW is to identify, design and procure a laser scanner, adaptable to the ANDES system and capable of collecting high-resolution dimensional data on exposed surfaces of cylindrical capsule experiments, plate type specimens, exposed-cladding fuel rodlets, slender flux wires and ATR driver fuel assemblies

The entire ANDES structure will be designed to operate in the working canal and will occupy a footprint of approximately 125” (L) x 42” (W) x 300” (H). This footprint does not include any analysis and handling equipment located adjacent to ANDES. Figure 2 shows a conceptual schematic of a cross-section of the working canal and how ANDES equipment could be laid out.

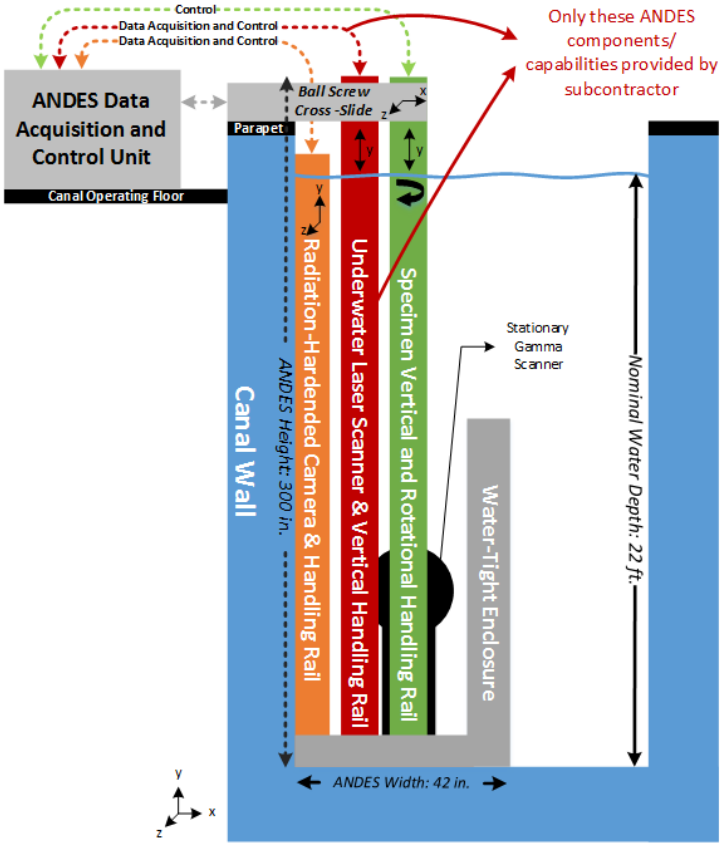

Figure 2: Conceptual schematic of ATR working canal cross-section and ANDES equipment layout

1.3 Anticipated Benefits of Underwater Metrology Measurement System

Successful development of an underwater laser metrology system will enable characterization of post-irradiation specimen deformations down to 10 µm (0.0004 in.) spatial resolution in a high-radiation (> 1 rad/hr) environment. This system will be

capable of providing both accelerated scans (e.g., 2 hours) with lower resolution and higher resolution with long scan times.

2. SCOPE

2.1 Work to be performed

The work to be performed for procurement of the underwater laser metrology technology and the underwater laser metrology handling system (herein referred to as "scanner" and "scanner handling system", respectively) is broken out into four phases. Execution of each subsequent phase is pending (1) INL, Battelle Energy Alliance funding and (2) successful completion of previous phases, as determined by the INL ANDES Design Team.

Phase 1 – Scanner Data and Conceptual Design of Handling System:

This phase includes the following:

- Continued coordination with INL on the selected laser scanning equipment data to provide functionality and compliance with the requirements found in Section 4. Coordination includes facility connectivity coordination, adaptability to the ANDES system, cabling paths and functionality, data collection system interfaces, proof of compliance with ATR safety basis requirements, design compliance with requirements;
- Participation in ANDES design team teleconference meetings hosted by INL every other week;
- Provide a conceptual design for the handling and positioning system;
- Provide a conceptual design for connections to the ANDES system;
- Provide conceptual design for data acquisition system software and interface to ANDES system;
- Provide conceptual design for control system software and interface to ANDES system;
- Provide a Rough Order of Magnitude (ROM) cost estimate for the fabrication, development and/or procurement of the handling and positioning system, connections, data acquisition system and control system.

The laser scanner will be required to scan material positioned approximately 6-20 feet under water. Therefore it is anticipated that the scanner will also be required to be under water. If the laser scanner is not waterproof at these depths, it shall be demonstrated that the enclosure protecting the equipment is waterproof and can perform scanning functions underwater.

The scanner handling system need only provide independent vertical displacement (i.e., y direction in Figure 2) for the scanner, and not horizontal or diagonal displacement (i.e., x and z directions in Figure 2). The scanner and the specimen will be attached to a handling rail designed by the INL ANDES Design Team. The handling rail will provide

horizontal and diagonal displacement via. a ball screw cross-slide system. The slides will simultaneously control the scanner and the specimen (see Appendix A). The handling system designed by the subcontractor must be mechanically and electronically interoperable with this top-side ball screw cross-slide system. The interface between the cross-slide and scanner handling system will be coordinated between the subcontractor and INL ANDES Design Team. The scanner handling system designed by the subcontract is intended to attach to the handling rail. Phase 1 includes the development of the handling system and the connection to the handling rail.

Phase 2 – Scanner Data and Final Design of Handling System:

This phase will include the following:

- Continued coordination with INL on the selected laser scanning equipment data to provide functionality and compliance with the requirements found in Section 4. Coordination includes facility connectivity coordination, adaptability to the ANDES system, cabling paths and functionality, data collection system interfaces, proof of compliance with ATR safety basis requirements, design compliance with requirements;
- Participation in ANDES design team teleconference meetings hosted by INL every other week;
- Provide final design package for the handling and positioning system including specifications, shop drawings, parts list, assembly drawings, and maintenance plans;
- Provide final design for the connection system including specifications, shop drawings, parts list and assembly drawings.
- Provide final design for data acquisition system including software, cabling types, lengths and mounting equipment lists, connections lists and any other parts lists.
- Provide final design for control system including software, cabling type's lengths and mounting equipment lists, connections equipment lists and any other parts lists.
- Final estimate for fabrication, development and/or procurement of handling and positioning system, connections, data acquisition system, and control system.

Phase 3 – Procure Laser Scanner and Support Equipment:

This phase includes procurement and/or fabrication and delivery of the approved laser scanner equipment, data acquisition software and supporting documents as noted in section 3.3.

Phase 4 – Procure Handling System:

This phase includes procurement and/or fabrication and delivery of the handling system, data acquisition system and control system, along with any connections to the ANDES system. Includes also delivery of supporting documents as noted in section 3.4

2.2 Work Excluded

- Installation of the system at ATR.

2.3 Place of Performance

Primary place of performance is anticipated to be off-site from the INL.

2.4 Miscellaneous

The ANDES INL Design Team will lead the integration of ANDES instrumentation and components outlined in Section 1.2. INL will also lead installation activities. Project management and other project leadership tasks will be performed by INL staff.

The ANDES INL Design Team will be comprised of:

- Nic Woolstenhulme - (Principal Investigator) - nicolas.woolstenhulme@inl.gov
- Evan Nef - (Project Manager) - evan.nef@inl.gov
- Devin Imholte - (Lead Design Engineer) - devin.imholte@inl.gov
- Dong Choe (Neutronics Subject Matter Expert) - dong.choe@inl.gov

No travel needs are anticipated by the sub-contractor.

3. DELIVERABLES, SCHEDULE AND MILESTONES

3.1 Phase 1 deliverables:

- 50% Progress Conceptual Design Package (One months after contract release)
    - Hold Point: Progress design to be discussed in the following team meeting.
- 80% Progress Conceptual Design Package (One months after the following team meeting)
    - Hold Point: INL approval of conceptual handling system and cross-slide connection designs in a conceptual design review.
- Address INL comments and provide Final Conceptual Design Report (One month after hold point release)
- Milestone—Completion of Phase 1 by June 15, 2018

Each progress report to be sent electronically by email to the members of the ANDES INL Design Team at the email addresses provided. Following each progress report, the ANDES INL Design Team will notify the subcontractor of any needed changes to the scanner and handling system design within 7 calendar days of INL having received said progress report, or at the next team meeting (whichever comes first).

Each progress report shall include information for both the scanner and handling system, including:

- Electronic copies of engineering drawings
- Performance specifications (resolution, field-of-view requirements, operating temperature requirements, etc.)
- Electrical interface requirements
- Line item ROM cost estimates for design and construction of each component within the scanner and handling system

The primary ANDES INL Design Team point-of-contact will be Devin Imholte.

3.2 Phase 2 deliverables:

- 25% Progress Final Design Package (Two months after phase release)
- 50% Progress Final Design Package (Four months after phase release)
- 80% Final Design Review (Six months after phase release)
    - Hold Point: INL approval of handling system and cross-slide connection to final design package.
- Final Design Package (One months after hold point release)
- Milestone—Completion of Phase 2 by June 29, 2019

- Each progress report to be sent electronically by email to the members of the ANDES INL Design Team at the email addresses provided. Following each progress report, the ANDES INL Design Team will notify the subcontractor of any needed changes to the scanner and handling system design within 7 calendar days of INL having received said progress report, or at the next team meeting (whichever comes first).

Each progress report shall include the following:

- Electronic copies of engineering drawings
- Performance specifications (resolution, field-of-view requirements, operating temperature requirements, etc.)
- Electrical interface requirements
- Line item cost estimates for design and construction of each component within the scanner and handling system

The primary ANDES INL Design Team point-of-contact will be Devin Imholte.

Final Design Package to include the following:

- One set hard copy of final drawings, specifications, maintenance plan, replacement instructions and parts list.
- Final cost estimate for fabrication and or procurement of handling system.
- Installation instructions.

3.3 Phase 3 deliverables:

- Delivery of laser scanner;
- Delivery of data acquisition software;
- Delivery of cabling and other connect-ability/support equipment;
- Delivery of quality and performance reports;
- Leak testing reports;
- Delivery of maintenance plans;
- Parts list;
- User Manual;
- Certificates of Conformance, Test Certificates or Inspection Reports;
- UL/FM listings;
- Warranty.

3.4 Phase 4 deliverables:

- Shop Drawings;

- Welding Procedures (if applicable);
- Welder qualifications (if applicable);
- Welding Reports (if applicable);
- Material certifications (if applicable);
- Parts list;
- Delivery of handling system including handling material and connections;
- Delivery of interface equipment including data collection cables and software;
- Installation instructions and/or manual and maintenance plan;
- Delivery of quality and performance reports;
- Warranty

4. COMPLETION CRITERIA AND FINAL ACCEPTANCE

The scanner and handling system shall satisfy the requirements outlined below, along with any further requirements established by the ANDES INL Design Team. If the ANDES INL Design Team determines that the list below need be altered in any way, the contractor will be notified within 21 days for confirmation of the proposed change. If the original schedule need be altered because of adjustment to requirements, adjustments to the deliverable schedule will be made by the ANDES INL Design Team as necessary.

Requirements are specifically identified by the inclusion of one and only one of the terms "shall," "shall where practical," or "may." The use of the term "shall" indicates a mandatory provision for which the design must satisfy. The user of the term "shall where practical" likewise indicates a mandatory provision, from which a deviation must be justified. The user of the term "may" indicates a provision, the satisfaction of which is optional.

4.1 General Requirements:

4.1.1 Any scanner and handling system components that will come in contact with the demineralized water in the ATR canal shall not be composed of any of materials as defined in SP-10.3.1.13, "Material Practices and Restrictions for ATR PCS and Experiment Loops." These materials include:

- Temperature Indicating Crayons, Component Marking

- Mercury
- Aluminum: Prohibited use of alloys containing more than 50 weight percent aluminum for use as soft pads or hammers.
- Gold and Silver
- Low Melting Point Metals (Lead, Antimony, Arsenic, Bismuth, Cadmium, Magnesium, Tin and Zinc): Prohibited use of these materials and alloys containing these materials in excess of 250 ppm on wetted surfaces.
- Nickel Bearing Material
- Copper: Prohibit use of copper and its alloys that contain more than 50 weight percent copper for use as soft pads or hammers.
- Halogens
- Teflon: See 4.5.10.2.1 for permitted uses.
- Polyvinylchloride (PVC): See 4.5.10.2.2 for permitted uses.
- Sulfur: Prohibit use of sulfur or materials containing sulfur compounds in excess of 700 ppm.
- Phosphorus: Prohibit use of phosphorous or materials containing phosphorous in excess of 250 ppm. See 4.5.12.1 for acceptable uses.

4.1.2 All equipment and materials provided shall be accompanied by material certifications identifying the materials used for fabrication of the equipment or materials.

4.1.3 Submerged scanner and handling system components shall not exceed a 30.5” (L) x 39” (W) area footprint

4.1.4 Top-side scanner controller and data acquisition units shall be integrated into and interoperable with the ANDES data acquisition and control unit, and will not exceed a 60” (L) x 60” (W) footprint adjacent to the operating floor adjacent to the canal.

4.1.5 Any scanner and/or scanner handling equipment that extends to a depth of 6 feet or more into the canal water without being fully enclosed by water shall isolate radiation dosage coming from the equipment to at least the 6 ft. depth.

Note: ATR facility requirements specify that any structure that is inserted into the water must maintain some kind of shielding from

potential gamma radiation. For example, a tube that spans the depth of the canal could have holes drilled axially along the tube to allow water into the tubing to provide shielding. A dry box cannot extend below the 6 foot level and to the surface with a continuous air space.

4.2 Scanner Requirements:

4.2.1 The scanner shall collect high-resolution dimensional data consisting of specimen physical dimensions and quantification of surface features (rust, wear, fissures and corrosion).

4.2.2 The scanner shall consistently collect high-resolution dimensional data at a minimum of 25 μm (0.00039 in.) resolution.

4.2.3 The scanner shall where practical consistently collect dimensional data at a minimum of 10 μm (0.00039 in.) resolution.

4.2.4 The scanner shall collect high-resolution (i.e., 25 μm) dimensional data across a stationary 210 in^2 area in less than four (4) hours for precision scans.

4.2.5 The scanner shall collect moderate resolution (> 100 μm) dimensional data across a stationary 210 in^2 area in less than two (2) hours for accelerated scans.

4.2.6 The scanner shall collect high resolution (i.e., 25 μm) dimensional data from a stationary cylinder in the axial direction with the following dimensions: 0.327” (diameter) x 4.0” (length).

4.2.7 The scanner shall maintain normal data collection, operability, and resistance to radiation environments with a maximum 500 rad/hr gamma dose rate.

4.2.8 The scanner shall maintain normal data collection, functionality and resistance to a cumulative lifetime gamma dose of 500,000 rad.

4.2.9 Scanner equipment or scanner housing (if a dry box is needed) shall have a water depth rating of ≥ 50 ft.

4.2.10 Data obtained from laser scanner shall be transmitted from the submerged location to a top-side data acquisition unit no further than 30 ft. from the scanner when the scanner is placed at the bottom of the canal.

4.2.11 Gathered data shall be presentable in the form of a computer 3 dimensional model demonstrating the high resolution required.

4.2.12 Laser scanner software shall be coordinated with the ANDES system to provide a central ANDES computer which serves data acquisition, modeling, and controls functions for both the laser scanner, the ANDES system, and other examination equipment.

4.2.13 Laser scanner shall use Open Protocol Communication (OPC) interfaces.

4.2.14 Scanner components shall be capable of ascent above water to a location reachable by ATR personnel for any necessary maintenance activities

4.2.15 Scanner components, once topside, shall be capable of manual disassembly for any necessary maintenance activities.

4.2.16 Scanner technology shall collect high-resolution dimensional data from submerged specimens through demineralized water having the following nominal parameters and properties listed in SDD-7.4.6.1, "ATR Canal Recycle":

- Conductivity: < 3.0 μmho/cm
- pH: 5.0-7.0
- Total suspended solids: < 5 ppm
- Total organic solids: 2.8 ppm
- Total dissolved solids: < 2 ppm
- Total activity: $< 4.03 \times 10^{-5}$ μCi/mL

4.2.17 No wireless technology is allowed for functionality of the scanner, data collection or associated equipment.

4.3 Handling Requirements:

4.3.1 Scanner handling shall be sufficient for satisfying requirements listed above (Section 5.2 – Scanner Requirements).

4.3.2 Scanner handling system shall permit vertical mobility of the scanner for collecting high-resolution dimensional data. The scanner shall not require movement of specimens longer than 4 ft. to obtain high-resolution dimensional data.

4.3.3 Scanner handling shall provide 23 ft. of independent vertical displacement of any scanner components.

4.3.4 Scanner handling shall operate in water from 0 ft. to 23 ft. deep

4.3.5 Scanner handling shall where practical, avoid using submerged motorized components.

4.3.6 Any submerged motorized handling components shall be capable of remote-control ascent above water to any necessary maintenance activities.

4.3.7 Any submerged motorized handling components shall be capable of continuous submerged operation in demineralized water having the composition listed in Requirement 5.2.13.

4.3.8 Handling equipment shall mount to the ANDES handling rail

Handling equipment shall position the scanner the appropriate distance from specimen to obtain resolutions quality and scan speeds noted in section 4.2.

Note: Specimen area will typically be between 0” and 5” in diameter as mounted axial in the ANDES handling system. See Figure 2 and Appendix A.

5. Appendix A – Conceptual ANDES Drawings

Figure A1: Conceptual isometric drawing of ANDES in ATR canal. Left figure shows ANDES with leak-proof container and gamma scanner. Right figure shows ANDES with the container and gamma scanner hidden.

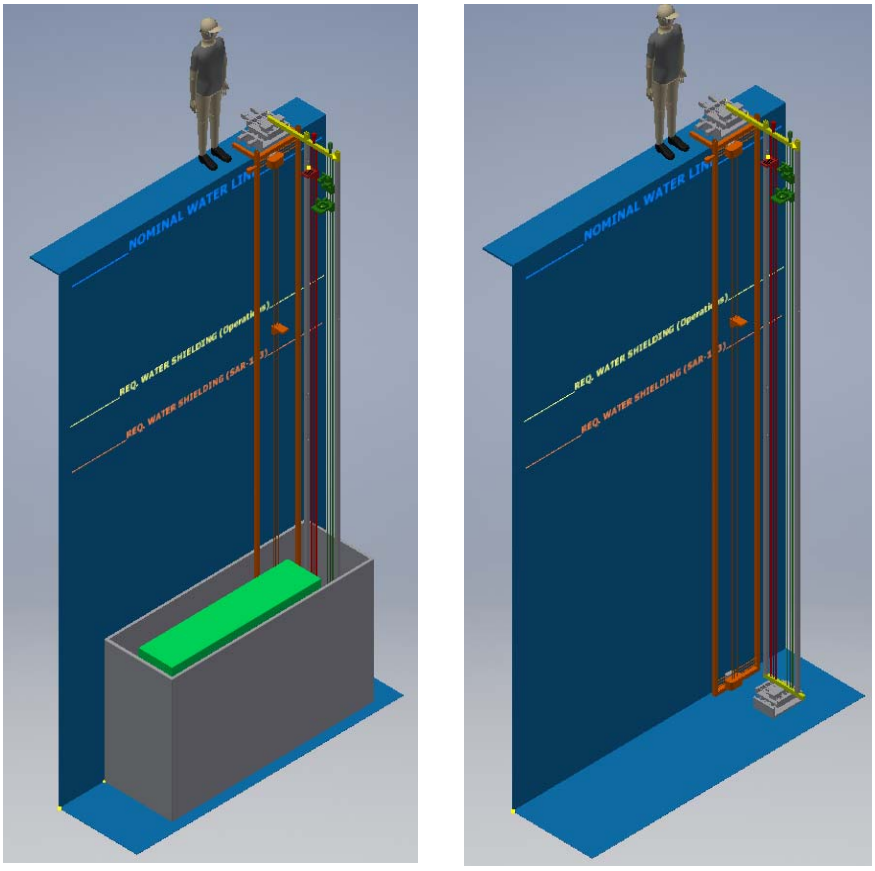

Figure A2: Close-up of ANDES top-side (left) and bottom (right) interface points of scanner handling system and ball screw cross-slide. Figures do not show cabling connections or data acquisition and control unit.

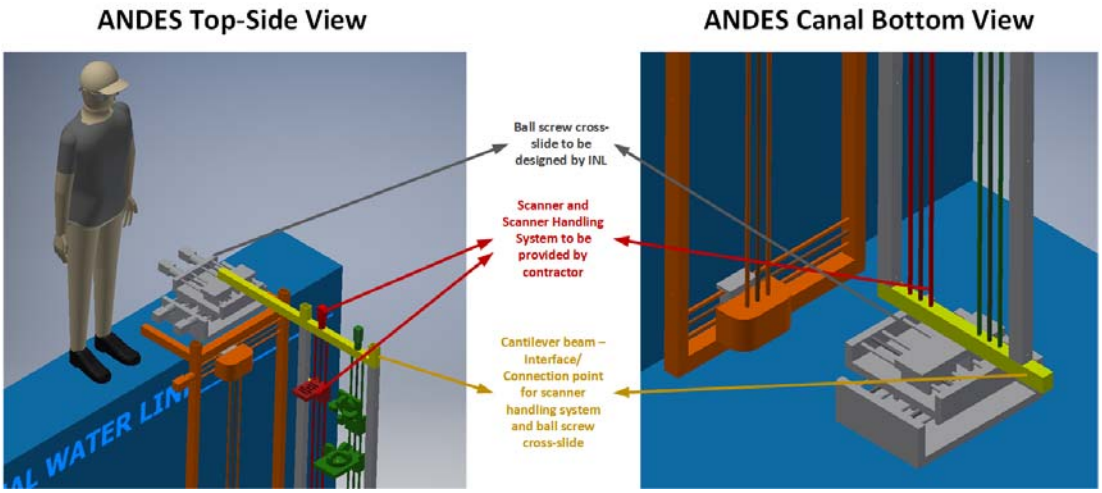

Figure A3: Close-up of ANDES top-side showing camera handling rail (orange), underwater laser scanner handling rail (red), specimen handling rail (green), ball screw cross-slide (gray) and connecting cantilever (yellow).