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Standard Guide for Acceptance, Checkout, and Pre-Operational Testing of a Nuclear Fuels Reprocessing Facility[1]

This standard is issued under the fixed designation C 1010; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—Section 10, Keywords, was added editorially in November 1992.

1. Scope

1.1 This guide sets forth those criteria necessary for the acceptance, checkout, and pre-operational testing of a nuclear fuels reprocessing facility.

1.2 This guide is specifically applicable to a nuclear fuels reprocessing facility employing the Purex process; however, a large portion of this guide is also applicable to other facilities employing different processes.

1.3 This guide provides recommendations for procedure preparation, acceptance criteria following construction, training, component and systems tests, and final integrated testing. These procedures[2] when utilized in accordance with the prescribed quality assurance (QA) requirements should provide permanent QA records.

1.4 This guide deals primarily with the mainline aqueous/organic (Purex) sections of a nuclear fuels reprocessing facility. Operations such as fuel receipt, headend (shearing and dissolution), plutonium conversion, waste immobilization, and others of this nature are not included.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ANSI Standard:*

N15.19 Volume Calibration Techniques for Nuclear Materials Controls[3]

3. Significance and Use

3.1 Most reprocessing facilities in existence today in the United States were designed to use the Purex solvent extraction process, in either mixer settlers, pulsed columns, or centrifugal contactors to recover, purify, and separate uranium and plutonium from spent reactor fuel. The complexity of these plants and the nature of the material to be handled dictate the need for a comprehensive testing, evaluation, and documentation program following the turnover from construction through hot startup of a facility. The testing, evaluation, and documentation program must be tailored to meet applicable state and federal regulations.

3.2 The test program starts during the design and construction phases with approval of detail designs, specifications, construction procedures, and actual construction activities in new facilities and during the pre-planning stages for the restart of mothballed or partially shutdown facilities. An engineering staff must be assembled to establish the overall testing program and to prepare the necessary, written test programs and procedures. Early in the planning stages, a training program must be instituted to provide trained personnel for every phase of the startup.

3.3 Procedures for acceptance, checkout, and preparation for operation of reprocessing facilities are the primary subject of this guide and should be written in such a manner as to provide permanent, documented records of the test and training programs and their results. Since the plant is complex, a sequential testing program must be devised to test individual components, then individual systems, and finally, the entire plant as an integrated unit. This approach assures that all items in the plant are adequately tested.

4. Procedure Preparation

4.1 The planning for a smooth takeover and operation of the facility can only be accomplished by the development of a set of procedures (checkout, operations, administrative, etc.). These procedures will provide the assurance that all portions of the facility have been evaluated to the appropriate standard. Take care in setting up the format for these procedures so that they define the goals that are to be achieved, the limits within which the results are acceptable, and the approvals required for acceptance.

4.2 Divide the facility into small segments for procedure preparation. These segments shall follow the normal process system breakdown of the facility, as well as general facility

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[2] Quality Assurance Programs should maintain the design intent of ANSI N46.211, Quality Assurance Requirements for the Design of Nuclear Fuel Reprocessing Facilities, and be conducted in accordance with ANSI N46.2, Quality Assurance Program Requirements for Post Reactor Nuclear Fuel Cycle Facilities.

[3] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

item breakdown such as Feed Preparation, Product Concentration, Utilities, etc. Prepare generic procedures for those components which are common to all segments (pumps, air lifts, instruments, vessels, samplers, and others of this type). Next, reference these generic procedures in the main procedures as often as required.

4.3 During this preparation period, review all aspects of preparation of the facility and prepare procedures for:

4.3.1 Acceptance of the facility from construction or turnover from mothballing,

4.3.2 Training of personnel for checkout, testing, and operation of the facility,

4.3.3 Checkout of the facility,

4.3.4 Testing in the normal operating mode,

4.3.5 Testing of emergency equipment and shutdown plans,

4.3.6 Operation of the system under normal and emergency conditions, and

4.3.7 Development of run plans which specify the conditions of operation.

5. Acceptance of the Facility

5.1 The requirement for acceptance of a facility will differ depending on its condition at the time of takeover. The three conditions reviewed for acceptance are receipt of a new facility, reactivation of a mothballed facility, and the restart of a partially operating facility.

5.2 Acceptance of a new facility is not always as smooth or as well defined as may be expected. Acceptance procedures must identify: (*1*) those individuals in each organization who are responsible for the turnover and acceptance, (*2*) the criteria used for inspection and acceptance, (*3*) the final conditions of acceptance or repair, or both, (*4*) the procedure for repair once an area has been accepted, and (*5*) definition of the point at which the operating organization accepts the responsibility for the facility.

5.3 The acceptance of a mothballed facility will take as much, if not more, planning than the acceptance of a new facility. Acceptance in this case shall cover everything defined in the new facility acceptance section (5.2), as well as the performance of equipment and retesting of systems previously tested by the construction organization. The procedures for this activity shall include the following:

5.3.1 A review of all operating and technical data,

5.3.2 Definition of the criteria for acceptance of a facility as it presently exists,

5.3.3 A procedure for the performance of modifications,

5.3.4 Preparation for redesign and updating of the existing design data,

5.3.5 A plan for inspecting the facility,

5.3.6 A program for leak (pressure) testing of equipment and systems, and

5.3.7 The requirements for upgrading the systems.

5.4 The acceptance of a partially operating facility will be the same as the acceptance of a mothballed facility with one exception. That exception is that procedures shall be prepared that will allow continued safe operation of those operating systems during checkout and startup.

6. Training

6.1 A certification and licensing program will be required for operating personnel in a governmental licensed and certified facility. Candidates for certification shall be required to complete a training program prior to performing in any operating position.

6.2 This training program shall be sufficiently comprehensive to include everyone from management to operators. All personnel (management, supervision, engineering, or plant operators) requiring operating certification shall complete the applicable portions of the training program.

6.3 *Training Program*—The training program can normally be divided into two segments:

6.3.1 *Formal Classroom Training*—Training that will provide the operator or technician with special academic background to assist in the subsequent understanding of the technical aspects of the facility operation that are required in developing individual job-related skills.

6.3.2 *On-the-Job Training*—Training to assist in the development of the operators' knowledge to equipment location and training on the physical operation of that equipment.

6.4 Handle training as one formal classroom training session, followed by development levels of on-the-job training or formal classroom sessions mixed with on-the-job training. The facility management, depending upon the designation of the work level, shall specify the number and type of operator classifications that will be required for operation of the facility. Establish the program so that normal progression from one level of certification to the next is allowed.

6.5 Develop the training program in stages to provide certified personnel for every phase of operation of the facility as follows:

6.5.1 For checkout, personnel shall be certified as checkout operators. This means that each individual has completed the formal classroom training and has read and understands the applicable procedures to be completed during checkout.

6.5.2 Each operator shall be trained and certified as a plant operator in the job classification before the start of chemical and integrated runs. To be certified as a plant operator, the operator shall read and understand all applicable preliminary operating procedures and shall pass operating walk-through exams on equipment specified for the job classification.

6.5.3 Prior to operations with radioactive material, the final phase is governmental licensing of certified plant operators. To qualify as a certified licensed plant operator, the candidate must be certified as a plant operator, then pass the governmental written and oral examinations required for licensing.

7. Component Tests

7.1 When the facility has been accepted from construction or turned over for modifications and testing, the first step is to individually check and test all components of the facility from the smaller line to the largest crane. In some instances, some of this checking and testing can proceed prior to formal turnover from construction.

7.1.1 *Line Checks*—These checks will start during the final stages of construction. Line checks usually involve visual

inspections and tracing of installed piping and tubing. Following these checks, line locations shall be verified against the individual prints, and a simple materials check performed (for example, test for stainless steel). Labeling of the out-of-cell lines and penetrations shall begin, once the line locations have been established and approved. After any errors discovered have been corrected, a valve identification and location system shall be initiated. It should be recognized that during this and the following period, changes shall be made and a system to handle the as-building of the existing design information shall be required.

7.1.2 *Equipment Inspection*—Perform a visual inspection of all vessels, pumps, blowers, etc. and compare these to the fabrication and installation design data. Review the orientation of all equipment plus nozzle locations on all vessels. Inspect all equipment for shipment and construction damage, and evaluate the cleanliness of the equipment and the general area. Measure wall thickness on all equipment to provide a basis for corrosion evaluations.

7.1.3 *Instrument Activation and Calibration*—Prior to the start of this function, collect and calibrate, to National Institute of Standards and Technology (NIST) traceable (or specified equivalent) standards, all of the required test equipment. Standards for calibration of the test equipment should be available. Activate instrumentation and perform operability checks. Make preliminary calibrations of all instrumentation. The department in charge of recalibration shall set up a log and schedule for recalibration of all instruments.

7.1.4 *Mechanical Equipment Activation*—Make a preliminary mechanical inspection, adjust, lubricate, and load test (when running) all pumps, motors, blowers, pulsers, agitators, cranes, and other such equipment and complete an electrical checkout. Start up the equipment and verify the correct functional operation. After startup checks have been completed, operate the equipment under design conditions for an extended period of time so that the vibration and bearing temperatures can be monitored and adjustments made as required. Balance large equipment; inspect bearings; check cleanliness; test switch gear including all breakers and interlocks; measure normal/load amperage; and measure the vibration spectrum.

7.1.5 *Vessel Volume and Dip Tube Calibrations*—Measure all vessel liquid levels and densities. Calibrate instruments used for this purpose then calibrate the vessels. This can be accomplished by filling the vessel to overflow with water. Make volume calibrations by logging weighted additions of water to the vessel. All measurements must be traceable to NIST standards. A precise relationship of vessel volume versus liquid level[3] must be established for normal plant operation and for nuclear materials accountability. Guidance for vessel calibration is provided in ANSI N15.19.

7.1.6 *Vessel Packing and Filter Media Verification*—Packed vessels are generally shipped without the packing material installed. Depending on the conditions specified, the fabricator may provide the packing materials, if not, procure packing material. Examples of packing materials requiring installation are Pall rings, Raschig rings, silica gel, ion exchange resins, silver zeolite, and other materials of this type. Filter vessels are, in most cases, provided with the filter media (sintered metal, fiber pads, metal pads, etc.) installed. Inspect and test all of these filter vessels in place, to verify that the media was installed free from any damage that may have occurred during shipment or installation.

7.1.7 *Pulser Calibrations*—Make tests to establish the relationship between the pulser frequency and the amplitude of the liquid in the pulse column, when using pulser systems to agitate the liquid in the columns. Make static calibrations using water in the column. A set of curves is generated to show the pulse amplitude versus operating pressure at constant frequency. Verify calibration data during column operations while testing integrated chemical and uranium runs.

7.1.8 *Special Calibrations,* (pumps, air lifts, flowmeters)—Test special types of measuring devices utilized in the reprocessing facilities to establish liquid flow relationships to the monitored condition, such as air flow for air lifts, level for metering headpots, pump stroke for metering pumps, etc. Calibration curves are then developed for the selected flow monitoring device.

8. System Tests

8.1 Upon completion of component testing, divide the process into sections and perform system tests as follows:

8.1.1 *Ventilation System Tests*—Activate and test the ventilation system of the buildings for operability and control. To ensure that the process equipment will be operating as near to hot operating conditions as possible, make a preliminary air balance. Make final balancing and control system checks prior to hot operation.

8.1.2 *Off-Gas System Tests*—Activate the system in a closed condition with only those required in-flow areas and the pressure control regulators in operation. Start instrument purges to all vessels. Start off-gas treament systems, iodine scrubbers, NO_x absorbers, HEPA filters, etc. and verify operating conditions. Gradually increase the off-gas load to maximum to verify the ability of the system to provide in-flow to the required areas under all conditions.

8.1.3 *Flush and Operability Tests*—Divide the process into sections that have definite boundaries that can be adhered to during testing. Water shall be added to the base vessels in the system and routed to every other vessel through all possible lines. Operate individual equipment pieces (evaporators, condensers, jets, pumps, etc.) at flowsheet and maximum rates to check their capacities (at least maximum design rates should be demonstrated). Clear and repair all plugged lines and damaged valves. During this period and until flushing is complete, install screens in lines and sumps to prevent solids from plugging jets, pumps, and air lifts. Flush low points and trapped sections of lines.

Provide vessels with man ways or cleaning ports. Flush all lines, both internal vessel lines and external penetration lines, such as dip tubes, spargers, chemical add, etc.

8.1.4 *Sampler System Tests*—Test the sampling systems for all tanks and streams during the latter part of the system flushing stages to determine operating parameters and recirculation rates. Perform additional tests during the integrated acid and uranium runs to determine sampler recirculation times, vessel mixing times, and the accuracy of the sample analyses.

9. Integrated Testing

9.1 When the systems have been flushed, calibrated, and made ready for operation, test all systems to ensure that they will function as designed. This is the time when all systems are tested as a unit to determine the operating characteristics of the facility. Recommendations for conducting these tests are as follows:

9.1.1 *Integrated Water Run(s)* (operating time, 2–3 months)—This (these) test(s) involves startup and operation of the entire process system with water only. In this segment, the capacity of the plant utility (steam, air, etc.) systems will be tested since this is the first time that all systems willl be in operation at the same time. Test startup, shutdown, and preliminary emergency procedures. Perform any modifications to eliminate hydraulic problems following this test period.

9.1.2 *Integrated Acid Run(s)* (operating time, 2–3 months)—Introduce nitric acid into the facility for the first time, and operate the entire plant with dilute acid in the streams. This allows flushout and cleanup of the equipment and piping before the addition of solvent. Start up and test the acid recovery system. Check out the acid distribution and make-up systems. Further test the sampling systems for mixing times and reliability. Test systems which require density changes (such as the dissolvers) to simulate operation. Carefully check the systems for mild steel and other noncorrosion resistant components (valves, pumps, gaskets, etc.).

9.1.3 *Integrated Chemical Run(s)* (operating time, 2–4 months)—This is the time when solvent (30 % tributyl phosphate in a normal paraffin hydrocarbon diluent) is introduced into the system. It should be recognized at this point that addition of the solvent will provide an excellent degreasing function for the entire system. First add the diluent alone and operate the system; then discard and replace this material with solvent. Place in operation the solvent treatment systems. Calibrate column pulser or make mixer settler operating tests and perform flooding tests. Test startup, shutdown, and normal operating procedures. Following this test period, any identified hydraulic problems shall be corrected. Perform special tests or checks, or both, to check for the presence of solvent in abnormal locations such as aqueous feed tanks, condensate systems, vent headers, and drain tanks. If found, locate the sources and correct.

9.1.4 *Integrated Uranium Run(s)* (operating time, minimum 5 months)—This test involves the introduction of natural or depleted uranium as a test material into the system. Include in the testing operability, reliability, capacity, and rate checks (flowsheet and maximum) for the process. Repeat flooding tests to verify the results using uranium-bearing solutions. Test any special equipment for operability under plant operating conditions. Test the accountability measurement and material control system. Perform special tests to test the emergency operating procedures. After completion of an extended run (minimum two months), shut down the process to provide time for modifications which have been identified. This should take about two months for cold facilities and three to four months for mothballed facilities. Prior to hot operation, perform an extended (minimum three months, recommended six months) cold run to provide operating training time, system reliability testing, and final equipment operability checks. Repeat the following tests and checks utilizing the uranyl nitrate solutions; recalibration of selected tankage, sampling, and mixing tests.

9.2 Following these tests, revise and upgrade all procedures to include data generated during testing. Include all available test data on operating procedures for hot (contaminated) operation.

10. Keywords

10.1 acceptance testing; checkout; pre-operational testing; reprocessing