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10 CFR 830 Major Modification Determination for Advanced Test Reactor RDAS and LPCIS Replacement

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DEFINITIONS

Major modification - A modification to a DOE nuclear facility that is completed on or after May 9, 2001 that substantially changes the existing safety basis for the facility. (10 CFR 830)

Nuclear facility - A reactor or a nonreactor nuclear facility where an activity is conducted for or on behalf of DOE and includes any related area, structure, facility, or activity to the extent necessary to ensure proper implementation of the requirements established by 10 CFR 830. (10 CFR 830)

Safety basis - The documented safety analysis and hazard controls that provide reasonable assurance that a DOE nuclear facility can be operated safely in a manner that adequately protects workers, the public, and the environment. (10 CFR 830)

Simple modification - A modification to a DOE nuclear facility not requiring a new or revised hazard analysis and accident analysis and new safety controls. (DOE-STD-1189)

ACRONYMS and ABBREVIATIONS

ASUDAS	ATR surveillance data system
ATR	Advanced Test Reactor
CDS	console display system
CFR	Code of Federal Regulation
CSAP	core safety assurance package
DAC	data acquisition (computer)
DAN	data analysis (computer)
DEC	Digital Equipment Corporation
DEV2	ASUDAS Nuclear Engineering (computer)
DEV3	RDAS development (computer)
DOE	U.S. Department of Energy
DOE-NE	DOE Office of Nuclear Energy
ECC	Emergency Command Center
EIA	Electrical Industries Association
FTP	file transport protocol
GFE	government furnished equipment
HC	hazard category
INL	Idaho National Laboratory
LCO	limiting condition for operation
LDAS	Loop Data Acquisition System
LPCIS	Lobe Power Calculation and Indication System
MAR	material-at-risk
NDMAS	NGNP Data Management and Analysis System
NGNP	Next Generation Nuclear Plant
NPH	natural phenomena hazards
PDSA	preliminary documented safety analysis
PPS	Plant Protection System
RCR	reactor control room
RDAS	Reactor Data Acquisition System
RMAS	Reactivity Measurement and Analysis System
RMS	Radiation Monitoring System
RMSS	Radiation Monitoring Seal System
RRCS	Regulating Rod Control System

SAR	safety analysis report
SC	safety class
SDS	safety design strategy
SR	surveillance requirement
SS	safety significant
SSC	structure, system or component
SSE	safe shutdown earthquake
STD	standard
TSR	technical safety requirements
UFSAR	updated final safety analysis report
UPS	uninterruptable power supply
USQ	unreviewed safety question
VAC	volts alternating current
VAX	ATR digital equipment corporation computer system
VMS	virtual memory system
VVS	Vessel Vent System
WPC	Water Power Calculator

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1. INTRODUCTION

The Advanced Test Reactor (ATR), located in the ATR Complex of the Idaho National Laboratory (INL), was constructed in the 1960s for the purpose of irradiating reactor fuels and materials. Other irradiation services, such as radioisotope production, are also performed at ATR.

The Department of Energy (DOE) Office of Nuclear Energy (DOE-NE) is currently leading an international effort to develop the next generation of nuclear power plants. The ATR has and will continue to play a vital role in support of nuclear research as a test bed for the development of new nuclear power technologies. The Energy Policy Act of 2005 established the "Next Generation Nuclear Plant (NGNP) Project," and designated the INL as the lead laboratory for the project. The policy states that the project "shall use, if appropriate, reactor test capabilities at the Idaho National Laboratory." The continued safe and reliable operation of the ATR is critical to the DOE-NE mission.

While the ATR is safely fulfilling current mission requirements, a variety of aging and obsolescence issues challenge the ATR engineering, operations, and maintenance personnel's capability to operate and sustain its operation over the long term. The replacement of the ATR's obsolete computer based reactor data acquisition system (RDAS) and its safety related lobe power calculation and indication system (LPCIS) software application is vitally important to ensure the ATR remains available to support this national mission. The RDAS supports safe operation of the reactor by providing real-time plant status information (indications and alarms) for use by the reactor operators via the console display system (CDS). The RDAS is a computer support system that acquires analog and digital information from various reactor and reactor support systems. The RDAS information is used to display quadrant and lobe powers via the user friendly CDS interface in the reactor control room (RCR). RDAS provides input to the Nuclear Engineering ATR surveillance data system (ASUDAS) for fuel burn-up analysis and the production of cycle data for experiment sponsors and the generation of the core safety assurance package (CSAP). RDAS also archives and provides for retrieval of historical plant data which may be used for event reconstruction, data analysis, training and safety analysis. The RDAS, LPCIS and ASUDAS need to be replaced with state-of-the-art technology in order to eliminate problems of aged computer systems and difficulty in obtaining software upgrades, spare parts, and technical support.

Completion of this age-related project will resolve one of several major age-related operational issues plus make a significant contribution in sustaining the ATR safety and reliability profile.

2. PROJECT DESCRIPTION

This project description is based on the drafted functional and operational requirements for the ATR RDAS and LPCIS Replacement Project,[1] the system design description for the ATR RDAS[2] and the draft technical and functional requirements for the ATR RDAS and LPCIS Replacement Project.[3]

The RDAS, LPCIS, and ASUDAS provide critical data for operation of the ATR located in building TRA-670. The RDAS acquires data from various instruments, provides parameter displays and reports, archives data, calculates reactor lobe power and core operating parameters, and provides the data to the ATR CDS for display to the reactor operators. The LPCIS software runs on the RDAS computers and provides values used to establish and maintain test reactor power within planned cycle limits and are a

safety-related function required by SAR-153, "Upgraded Final Safety Analysis for the Advanced Test Reactor."[4] Figure 1 depicts the RDAS functional block diagram.

The purpose of the RDAS is to support safe operation of the reactor by providing real-time plant status information for use by the reactor operators. Included in this information is the calculation of lobe power and data for the calculation of the thermal power to N-16 quadrant power ratio, which is required by SAR-153. The RDAS archives plant operating data and provides for the retrieval of this data. This can be used for event reconstruction, data analysis, training, and safety analysis. The information from the RDAS to the CDS is used to indicate whether plant safety functions are being accomplished in a display interface to the operators. The RDAS only displays plant status. There are no control functions performed by the RDAS. The RDAS contributes to safe operation of the ATR by monitoring the following systems:

- Reactivity control
- Core cooling
- Primary coolant system boundary integrity
- Fuel integrity
- Confinement integrity.

The only part of RDAS that is safety-related is the LPCIS.[2,3] The LPCIS software is used to calculate lobe and quadrant power levels and power ratios. Residing on RDAS, the LPCIS program uses inputs from the N-16 system, the water power calculator (WPC) System (being updated in another project and not included in this replacement project), and binary inputs proportional to reactor power level to calculate power level for the five lobes. The power levels of the nine flux traps are derived from the lobe powers. The resulting calculated lobe and quadrant powers and the power ratios are transmitted to the CDS. The CDS displays the lobe powers on the power split display screen which is used for the technical safety requirement (TSR) required surveillance of lobe powers (TSR-186-3/4.6, "Appendix A- Fuel Elements - Technical Safety Requirements for the Advanced Test Reactor"[5]). The reactor cannot be operated without an operable LPCIS. Once at power, the reactor must be shut down if the LPCIS is or must be placed out of service and cannot be repaired or restored within 48 hours.

The LPCIS provides real-time reactor performance safety calculations for reactor lobe power and the RDAS provides the display of the reactor power. The RDAS executes the LPCIS algorithms at least twice a second to produce the following parameters:

- Lobe power levels
- Quadrant power levels
- Thermal quadrant to N-16 quadrant power ratios
- Power MW-days
- Power MW-days integration
- Total thermal water power.

As required by TSR-186, the LPCIS must be operable for reactor power operation and must have output at the point of surveillance. The TSR also requires the RDAS to provide display of the reactor power during power operation at the point of surveillance.

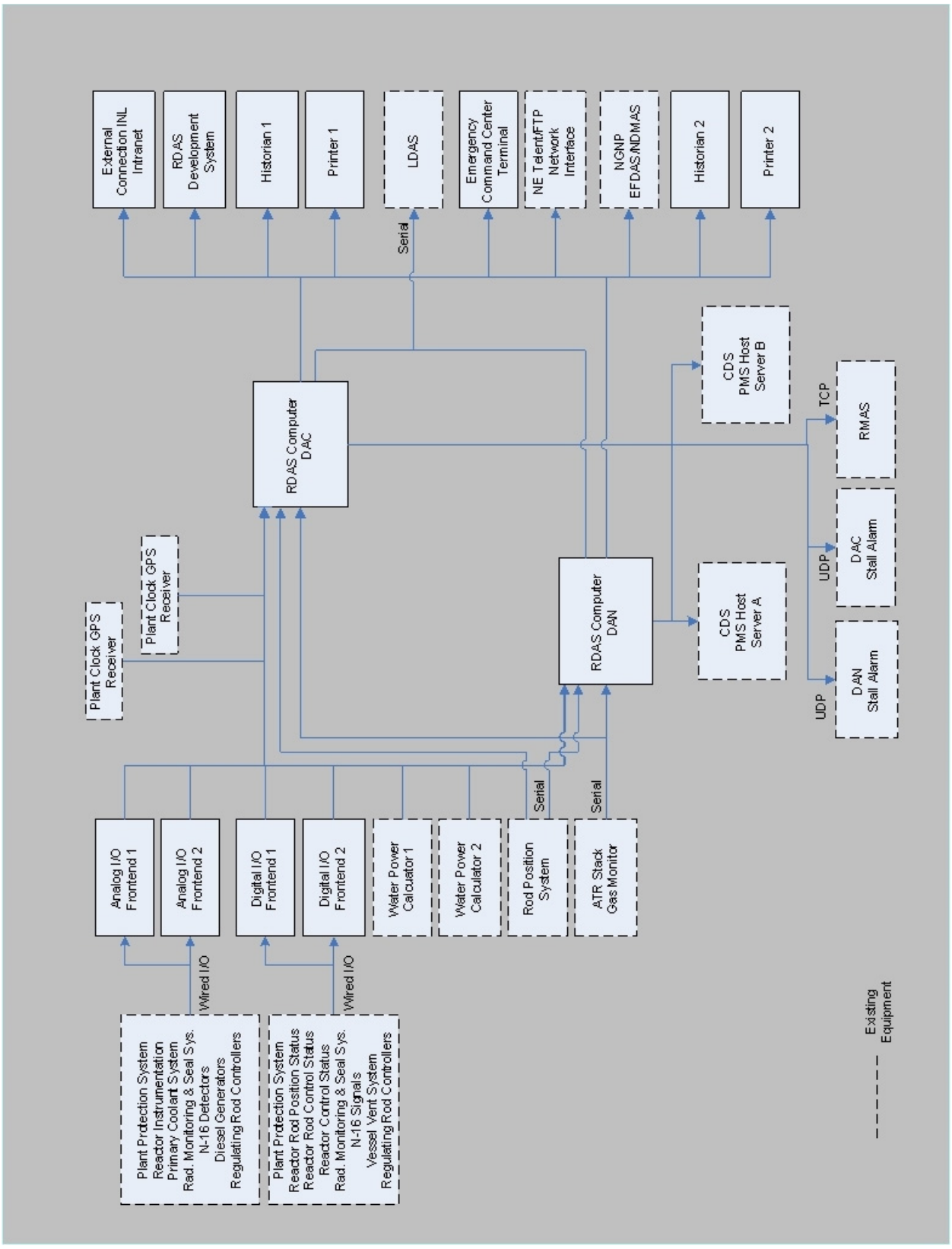

Figure 1. RDAS functional diagram.

As shown in Figure 1, RDAS acquires data from multiple sources and provides data or interface to other systems. Each RDAS computer acquires analog and digital data.

Analog data acquisition sources include:

- Plant protection system (PPS)
- Reactor instrumentation
- N-16 monitors
- Radiation monitoring system (RMS)
- Diesel generators.

Digital data acquisition sources include:

- PPS
- Reactor instrumentation
- N-16 monitors
- Reactor rod position controls and status
- Radiation monitor seal system (RMSS)
- Vessel vent system (VVS).

Other data acquisition sources include:

- The ATR plant clock
- Rod position graphics system
- Both WPCs
- The ATR stack gas monitor
- Both regulating rod control system (RRCS) controllers.

RDAS provides data or has interface to the following systems:

- Terminals
    - Local operator terminals
    - System engineer and nuclear engineer secure remote Telnet/ file transport protocol (FTP) capability in buildings TRA-628 and TRA-1608
    - Emergency Command Center (ECC) terminal located in the building TRA-680
- CDS host computer (data packet at least twice per second)
- Loop data acquisition system (LDAS) (data packet once per minute)
- Stall alarms (registration of critical programs on RDAS computers)
- NGNP data management and analysis system (NDMAS) (data files)
- Data historians (archival data)
- Printers (various reports)
- Reactivity measurement and analysis system (RMAS) (data packets by Ethernet)
- Nuclear engineering ASUDAS
- RDAS development system
- ATR annunciator system
- LPCIS.

The RDAS, LPCIS, and CSAP software are considered safety software and are Quality Level 1. The software replacement will be developed according to project specific NQA-1 project requirements and the NQA-1 subpart 2.7 software quality requirements. Specific NQA-1 project requirements include software design control. RDAS requires configuration management for both equipment and software. The design process includes engineering change control, due to the Quality Level 1 status, that requires configuration

management and documentation to ensure that the design process, testing, verification and turn-over are completed correctly.[6,7]

The ATR RDAS and LPCIS Replacement Project includes all support activities necessary to convert the RDAS, LPCIS, and ASUDAS from legacy equipment and software to a redundant, expandable, and secure platform of commercially available equipment and software that meets the requirements for single failure and separation, a design life of 10 years, and interfacing with existing analog and digital signals. This replacement project will provide the functionally equivalent replacement, installation, and testing of the RDAS and LPCIS subsystems plus the ASUDAS computer, including necessary interface development, to ensure continued safe and reliable plant operations.

The project scope includes replacing the functionality of the following:

1) The RDAS equipment and software in the ATR building (TRA-670), including:
   a) Computers:
      i) DAC and DAN RDAS VAX virtual memory system (VMS) computers and the associated DELL Windows terminal computers.
      ii) RDAS data archival Sun Solaris computers.
   b) Equipment:
      i) RDAS Neff frontend data acquisition equipment and a portion of the I/O wiring to the frontend equipment.
      ii) RDAS equipment racks, network equipment and serial communications equipment, and associated cables.
      iii) RDAS remote terminal located at the ECC in building TRA-680.
      iv) Three printers.
   c) Software:
      i) RDAS and LPCIS software.
      ii) ASUDAS applications that run on DAC and DAN.
      iii) RDAS interfaces software (equipment, menus, reports, etc.).
2) The Nuclear Engineering equipment and software in TRA-628, including:
   a) DEV2 VAX VMS computer and the terminal monitor.
   b) RDAS network equipment, cables, and Digital Equipment Corporation (DEC) terminal servers.
   c) Nuclear Engineering ASUDAS applications that run on the DEV2 computer.
3) The RDAS equipment used to develop/modify/control existing RDAS software located in TRA-1608, including:
   a) Computers:
      i) DEV3 VAX VMS computer and the DELL Windows terminal computer.
      ii) Data archival Sun Solaris computer.
   b) Equipment:
      i) Neff frontend data acquisition equipment.

ii) RDAS network equipment and associated cables.

c) RDAS spare parts.

When completed, the RDAS and LPCIS Replacement Project will 1) replace obsolete equipment with a state-of-the-art modern platform of data acquisition, computer, and networking equipment, and 2) move legacy software functions (menus, applications, calculations, reports, data trending, data archival, surveillance programs and alarms) to the new platform. The replacement is a one-for-one replacement of existing safety related equipment and safety software with the advantage of operating on current technology that is more reliable and faster.

3. HAZARDS DISCUSSION

Material-at-Risk

The ATR material-at-risk (MAR) consists of the reactor core, the radioactive materials (irradiated fuel elements and other hardware) stored in the canal, isotope production targets, and experiments containing fuel and non-fueled components. The ATR is a Category A reactor with an operating power level up to 250 MW_t and, as such, has a radioactive material inventory with the potential for significant off-site consequences. The proposed project has no effect on the quantity of MAR.

Fires and/or Explosions

The RDAS and LPCIS replacement is a one-for-one replacement and does not introduce any new fire/explosion hazards.

Natural Phenomena Hazards

Natural phenomena hazards (NPHs), including earthquakes (seismic events), extreme wind, tornado, flood, volcanic, and lightning, are potential hazards to the facility for causing building damage and/or failure of safety related operational equipment. These NPH hazards were evaluated in the ATR updated final safety analysis report (UFSAR) for existing facilities in support of current operations. All the ATR control system components are to survive a safe shutdown earthquake (SSE) without subsequent performance degradation as defined in SAR-153. The LPCIS exists on the existing RDAS and inherits its SSE classification. The existing RDAS is classified as safety-related due to the LPCIS being classified as safety-related. Based upon this criterion, the RDAS and LPCIS replacement shall meet Performance Category 2 (PC-2) seismic design criteria in accordance with the Department of Energy (DOE)-STD-1020-2002 and IBC 2000. RDAS is not identified as a system that must survive an earthquake because other systems will scram the reactor in the event of an earthquake.[3]

4. MAJOR MODIFICATION EVALUATION CRITERIA

DOE-STD-1189-2008, "Integration of Safety into the Design Process,"[8] was developed to provide consistent DOE complex-wide criteria to be used in determining if a change constitutes a major modification. The standard includes Table 8-1, "Major Modification Evaluation Criteria." The table provides a methodology for evaluating a project against the 10 CFR830, "Nuclear Safety Management,"[9] major modification evaluation criteria and was used as a basis for this major modification determination. The table is reproduced herein as Table 1, "Major Modification Evaluation Criteria." The purpose of Table 1 is to focus on the nature of the modification and the associated impact on the existing facility safety basis for the ATR facility.

Major modifications are defined as those changes that "substantially change the existing safety basis for the facility." The guidance for applying the table states that in applying the criteria, the intent is not to automatically trigger the need for a preliminary documented safety analysis (PDSA) if one or more of the criteria are met. Rather, it is intended that each criterion be assessed individually and then an integrated

evaluation be performed based on the collective set of individual results. In performing this evaluation, the focus should be on the nature of the modification and its associated impact on the existing facility safety basis. Even a project that results in changes that ripple through the safety basis documents does not "substantially change the existing safety basis for the facility" solely because many parts or pages of the safety basis documentation need to be revised.

A major modification requires the development of a PDSA per 10 CFR 830.206, following the facility modification process as depicted in Figure 2. Since DOE-STD-3009, "Preparation Guide for U. S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses,"[10] is not the safe harbor format for the ATR UFSAR, the safety design strategy (SDS) must establish the expectations and the format for integrating the subject major modifications to the update of the UFSAR.

Table 1. Major modification evaluation criteria.

Major Modification Evaluation Criteria (DOE-STD-1189, Table 8-1)
Project Information The proposed project will replace the equipment and software associated with the RDAS and LPCIS and the Nuclear Engineering ASUDAS computer and software. This major modification evaluation will specifically evaluate the criteria against the ATR reactor safety basis. If, on this basis, the modification is determined to be a major modification, then the integration of safety into design provisions of DOE-STD-1189 are applicable to the project. The scope of this task is to replace the legacy RDAS and LPCIS equipment and software to a redundant, expandable, and secure platform of commercially available equipment and software that meets the requirements for single failure and separation, a design life of 10 years, and interfacing with existing analog and digital signals while retaining all credited functional and safety characteristics of the existing safety basis. The RDAS, LPCIS, and CSAP software are considered safety software. To demonstrate that the RDAS and LPCIS replacement can meet the updated final SAR safety requirements, an orchestrated replacement process will be initiated following software quality assurance protocols. Essentially, an entire one-for-one replacement of equipment and related software functions are required to completely address all functional and operational requirements as credited by the safety basis.

Evaluation Criterion No.	Evaluation Criteria	DOE-STD-1189 Discussion	RDAS and LPCIS Replacement
1	Add a new building or facility with a material inventory ≥ Hazard Category 3 (HC 3) limits or increase the HC of an existing facility?	A new building may be a structure within an existing facility segment. That structure may or may not have direct process ties to the remainder of the segment/process. The requirements of DOE-STD-1027-92, Change Notice 1, September 1997, are used in evaluating Hazard Categorization impacts.	No. The ATR Complex Advanced Test Reactor is a DOE Category A reactor. As such, it is classified as a DOE Hazard Category (HC) 1 nuclear facility. The proposed modification to replace the equipment and software associated with the RDAS and LPCIS and the Nuclear Engineering ASUDAS computer and software does not change the HC of the existing facility or add any new buildings.

Evaluation Criterion No.	Evaluation Criteria	DOE-STD-1189 Discussion	RDAS and LPCIS Replacement
2	Change the footprint of an existing HC 1, 2 or 3 facility with the potential to adversely affect any safety class (SC) or safety significant (SS) safety function or associated structure, system and component (SSC)?	A change in the footprint of an existing facility requires the identification and evaluation of any potential adverse impacts on SC or SS safety functions or associated SSC (e.g., structural qualification, evacuation egress path, fire suppression spray pattern) or safety analysis assumptions. Changes that may involve adverse impacts require careful attention to maintaining adherence to applicable engineering standards and nuclear safety design criteria.	No. The ATR footprint will not be changed. The proposed RDAS equipment will fit within the existing ATR building (TRA-670), Rooms 110 and 111 floor plans. The proposed Nuclear Engineering replacement computer, DEV2, will fit within the existing ATR building (TRA-628) floor plan. The proposed RDAS remote terminal, computer, and printer replacement will fit into the existing ATR building (TRA-680) floor plan. The proposed development system replacement computer, DEV3, and related equipment will fit within the existing ATR building (TRA-1608) floor plan. The new equipment cabinets are designed to be floor anchored to meet the equipment PC-2 seismic requirements and to prevent interaction with other equipment during a seismic event. The weight of the RDAS equipment cabinet and all internal components are designed to not exceed the rated ATR floor loading of 100 pounds per square foot. The power requirements for the RDAS are provided by 120 VAC power panels 670-E-30 and 670-E-106. Power panel 670-E-30 is fed from the utility uninterruptible power supply (UPS) 670-E-115 and power panel 670-E-106 is fed from the instrument UPS 670-E-117. The power supply to the new equipment will not be modified from the existing redundant electrical power sources from the instrumentation and the utility battery-backed power systems that have automatic transfer to the active source to prevent loss of power from one source.

Evaluation Criterion No.	Evaluation Criteria	DOE-STD-1189 Discussion	RDAS and LPCIS Replacement
3	Change an existing process or add a new process resulting in the need for a safety basis change requiring DOE approval?	A change to an existing process may negatively affect the efficacy of an approved set of hazard controls for a given event or accident. Likewise, potential safety concerns associated with a new process may not be adequately addressed by the existing approved control sets. In this case, it is assumed that the existing analyses addressed the hazards associated with the new or revised process, but the specified control set(s) may no longer be valid. The evaluation of any new hazards introduced by the revised or new process should be addressed via Criterion 6	No. The proposed RDAS and LPCIS replacement is a one-for-one replacement of existing safety related equipment and safety software. The purpose of the RDAS is to support safe operation of the reactor by providing "real-time" plant status information for use by the reactor operators. The RDAS and LPCIS involve only display for indication of system status during operation and for assessment of past operation. There are no control functions performed by the RDAS. Since there will be no major changes to the process control software logic (the legacy safety functions will be maintained), the safety software replacement does not alter the process design or its bases. Although it is anticipated that the current software functionality will not be altered, it will be developed on the newer platform. Software quality assurance and configuration management programs are essential requirements. Software development will be controlled by properly documenting changes and formal testing of functionality will be verified and documented. Upgrades to RDAS have been implemented in the past that adequately addressed the safety concerns using the existing approved control sets (i.e., LPCIS is a TSR-186 required system). A similar process is planned for this RDAS and LPCIS replacement project. The equipment and software replacement does not affect the efficacy of the current facility safety basis and does not result in a safety basis change requiring DOE approval.

Evaluation Criterion No.	Evaluation Criteria	DOE-STD-1189 Discussion	RDAS and LPCIS Replacement
4	Utilize new technology or government furnished equipment (GFE) not currently in use or not previously formally reviewed / approved by DOE for the affected facility?	This assessment should include consideration of the impact that the use of new technology (including technology scale-up issues) or GFE may have on the ability to specify the applicable nuclear safety design criteria with a high degree of certainty in the early stages of the project. Additionally, refer to GFE discussion in Section 8.3. GFE may have a technical baseline that is not directly and fully supportive of the project functional and performance requirements. An example would be employing a new technology for removal of certain nuclides from a waste stream.	No. The RDAS and LPCIS equipment and safety software replacement project will not utilize new technology or GFE not previously formally reviewed and approved by DOE for use at ATR. The equipment is composed of commercial, industrial grade components that meet the applicable environmental and seismic requirements configured in Electrical Industries Association (EIA) standard 19-in. rack or mounted into control panels. The equipment is designed to achieve the same level of performance as credited in the existing safety basis with respect to structural capability, environmental compatibility, reliability, inspectability, testability, accuracy, and similar processes. Although the software functions (menus, applications, calculations, reports, data trending, data archival, surveillance programs and alarms) are unique to the ATR, the software is not new technology. The RDAS and LPCIS software has been ported from obsolete equipment over the last 25 years without the benefit of modern programming tools. The quality of RDAS and LPCIS development during this replacement project will benefit from the use of these tools.

Evaluation Criterion No.	Evaluation Criteria	DOE-STD-1189 Discussion	RDAS and LPCIS Replacement
5	Create the need for new or revised safety SSCs?	Consideration should be given to the relative complexity of the controls and the ease with which the controls can be implemented. The use of a complicated multi-channel Safety Class seismically qualified instrumented system to provide multiple interlock and alarm functions would typically pose a higher risk to the project than the use of a safety significant passive design feature. The degree of design and regulatory uncertainty should be addressed for this criterion for the development, review, and approval of new or revised safety analysis and attendant controls (e.g., presence of multiple regulatory/technical agencies on a single project).	No. The replacement of the legacy RDAS and LPCIS equipment and software does not create the need for new or revised safety basis controls due to new processes. The current DOE-approved safety basis already addresses the use of the RDAS and LPCIS. RDAS is a safety related system as listed in SAR-153, Chapter 3, Appendix A, "Master List of Safety Related Equipment." The only part of RDAS that is safety-related is the LPCIS and is the subject of a limiting condition for operation (LCO) and surveillance requirements (SRs) in TSR-186. The safety classification for these SSCs will not change with the proposed project replacement. The replacement project activities are considered Quality Level 1 as documented by safety software determinations. Computer systems and software configuration and management will be governed under configuration control (LWP-13620, “Software Quality Assurance”[11]).

Evaluation Criterion No.	Evaluation Criteria	DOE-STD-1189 Discussion	RDAS and LPCIS Replacement
6	Involve a hazard not previously evaluated in the Documented Safety Analysis?	Hazards can include the introduction of an accident or failure mode of a different type from that previously analyzed in addition to radiological or toxicological hazards. The need to address a new hazard early in the design process may lead to some degree of uncertainty related to the proper specification of applicable nuclear safety design criteria. In such cases, this uncertainty should be addressed within this evaluation.	No. No new accidents and failure modes are expected. The proposed RDAS and LPCIS replacement is a one-for-one replacement of existing safety related equipment and software. The replacement of the equipment and software does not involve a hazard not previously evaluated in the SAR. The current DOE approved safety basis already addresses the use of the RDAS and LPCIS.
Summary and Recommendation: No criteria were tripped in this PDSA evaluation. Based on this finding, it is concluded that this project does not involve a major modification and, therefore, no PDSA is required. The changes to the existing SAR/TSR to reflect this project will be made following the normal unreviewed safety question (USQ) process and SAR/TSR change process. Therefore, it is recommended that the project proceed accordingly.			

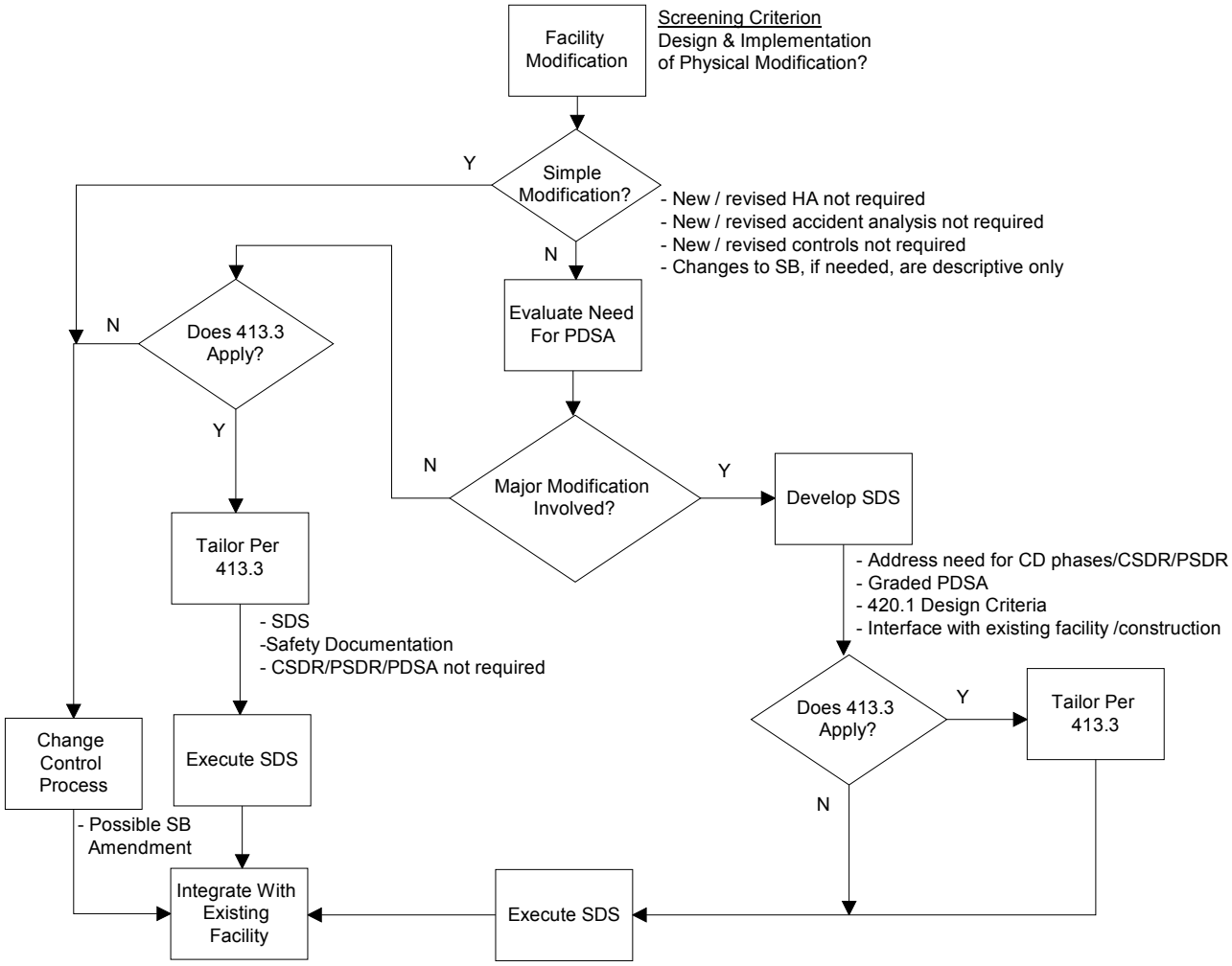

Figure 2. Facility modification process (taken from DOE-STD-1189, Figure 8-1).

5. CONCLUSION

The major modification criteria evaluation of the project design did not lead to the conclusion that the project is a major modification. The negative major modification determination is driven by the fact that the project requires a one-for-one equivalent replacement of existing systems that protects and maintains functional and operational requirements as credited in the safety basis.

6. REFERENCES

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6. PLN-4108, "RDAS/LPCIS Replacement Project Software Configuration and Control Management Plan," Rev. 0, DRAFT.
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8. DOE-STD-1189-2008, "Integration of Safety into the Design Process," Department of Energy, March 2008.
9. 10 CFR 830, Subpart B, "Nuclear Safety Management," *Code of Federal Regulations*, Office of the Federal Register, current revision.
10. DOE-STD-3009-94, Change 3, "Preparation Guide for U. S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses," Department of Energy, March 2006.
11. LWP-13620, "Software Quality Assurance," Rev. 11, September 2010.