Radiation Protection Program

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1 INTRODUCTION

To ensure the health and safety of persons in proximity to the Aurora plant, a radiation protection program for the Aurora facility is designed and implemented in accordance with Federal safety standards for minimizing radiation exposure to onsite personnel and to members of the public.

The objectives of the Radiation Protection Program are as follows:

- Ensure the effective monitoring and control of internal and external radiation doses to onsite personnel and the public
- Ensure the effective monitoring and control of releases of radioactive material to the environment
- Keep radiation exposure as low as is reasonably achievable (ALARA)

The Radiation Protection Program considers radiation protection in both normal and off-normal modes of operation and is based on sound engineering principles and proven practices. The Radiation Protection Program ensures that over the lifetime of the Aurora, any exposure to onsite personnel or individual members of the public will be within the limits established in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 20, "Standards for protection against radiation." Further information on shielding design incorporated into the reactor and facility and radioactive materials produced during operations can be found in Part II, "Final safety analysis report."

1.1 Sources of radiation exposure

The Aurora is a fast reactor designed to produce heat from fission to be used for heating or electricity. In producing power, the reactor generates neutron and gamma radiation. During plant operation, exposure of personnel to radiation is limited by the reactor design, shielding design, and area access restrictions. Collectively, these measures ensure that radiation levels in unescorted and accessible areas of the facility are very low or indiscernible from background radiation. During initial reactor operations, gamma and neutron radiation surveys are conducted in areas surrounding the reactor module to verify the adequacy of these measures. During reactor shutdown, access is allowed to the Aurora powerhouse basement, and personnel could potentially be exposed to radiation from the following radiation sources:

- Fission products and special nuclear material in the core
- Activated core materials
- Activated structural materials
- Activated heat removal materials
- Activated instrumentation
- Activated gases used to inert the reactor enclosures

Additionally, during both operation and shutdown, onsite personnel might be exposed to radiation from radioactive sources used for operational testing and calibration of radiation detection instrumentation.

1.2 Sources of radioactive contamination

The Aurora fuel, a uranium-zirconium alloy, is designed to maintain its integrity under normal and off-normal conditions. The burnup of the fuel is very low, and fission products are largely retained in the fuel matrix. Heat pipes are used to cool the fuel, which operate at near-atmospheric pressure and cannot leak to areas accessible to personnel, therefore contamination is not expected in accessible plant areas during normal operation. Low-level contamination is possible in the Aurora powerhouse basement during intrusive maintenance activities that involve opening the reactor module.

2 RADIATION PROTECTION PROGRAM OVERVIEW

2.1 Management commitment

The preparation, audit, and review of the Radiation Protection Program is the responsibility of the Director of Reactor Operations and is expected to be delegated to the Radiation Protection Personnel. Radiation Protection Personnel are led by a Certified Health Physicist (CHP), who reports to the Director of Reactor Operations. Oklo Power, LLC (Oklo Power) is committed to the following:

- Assure that the Aurora facility is designed, constructed, and operated such that occupational and public radiation exposures and releases of licensed radioactive materials meet ALARA
- Comply with radiation requirements, dose limits, and limits on release of radioactive materials
- Implement and maintain a radiation protection program to keep radiation doses below the regulatory limit and ALARA
- Assure that each individual working at the facility understands and accepts the responsibility to follow radiation protection procedures and instructions provided by Radiation Protection Personnel and to maintain his or her dose ALARA
- Provide delegable authority to stop work or order an area to be evacuated, according to the Emergency Plan
- Establish an appropriate and direct reporting chain

2.2 ALARA

Procedures and engineering controls, including shielding, are designed and implemented to ensure that occupational doses and doses to members of the public are ALARA. Experience and insights gained from operating the Aurora will be used during annual reviews to update and improve the Radiation Protection Program, as needed. This process will include reviews of radiation protection systems that mitigate exposure to onsite personnel and to the public, as well as a dose assessment from potential sources of exposure from radioactive materials produced during operation of the plant.

2.3 Program review

Before initial operation of the reactor, the Radiation Protection Program is reviewed by qualified personnel, as delegated by the Director of Reactor Operations. Successful completion of the review is a prerequisite for startup.

Periodic reviews of the Radiation Protection Program are the responsibility of the Director of Reactor Operations and are delegated to qualified personnel. The focus of the periodic reviews is based on identified issues with the program, including industry experience and inspections.

2.4 Procedures

A thorough Radiation Protection Program is developed, documented, and implemented through plant procedures that address quality requirements commensurate with the scope and extent of licensed activities. Radiation Protection Personnel are involved in writing, reviewing, and approving the Initial Test Program procedures for activities that might have radiological impact during fuel loading, startup, normal, and off-normal operating conditions. The Radiation Protection Personnel assist in testing and revising the relevant procedures during the preoperational phase of the Initial Test Program before fuel is onsite. Radiation Protection Personnel help develop procedures for maintenance, decommissioning, emergency response, and other activities to ensure there is compliance with ALARA guidelines outlined in the Radiation Protection Program.

A matrix is used to verify that procedures are implemented and comply with all applicable requirements in 10 CFR Part 20 and other applicable documents. This matrix is a controlled document and available for review, as needed.

2.5 Organization

2.5.1 Director of Reactor Operations

- Oversees and approves the development and implementation of the Radiation Protection Program
- Approves exceeding administrative controls levels for external dose

2.5.2 Radiation Protection Personnel

- Establish, implement, and enforce the Radiation Protection Program practices and procedures
- Assist in relevant procedure creation for the Initial Test Program, maintenance, decommissioning, emergency response, and other needed areas
- Track and analyze trends in radiological surveillance reports performed by fixed onsite monitoring systems and take necessary action to correct adverse trends
- Ensure that exposures to site personnel are maintained ALARA
- Assure that site personnel are appropriately trained on radiation protection
- Support timely corrective action of radiation protection problems
- Periodically assess radiation conditions and confirm radiation protection requirements for access to and work within the facility
- Issue dosimetry
- Review and approve work permits, which include radiological and non-radiological hazards or those that only include radiological hazards

2.5.3 Plant Manager

- Review and approve work permits, which include radiological and non-radiological hazards

2.5.4 Onsite Monitors

- Perform dose rate and contamination surveys, as requested by the Radiation Protection Personnel

2.6 Radiological training

Prior to duty, plant personnel and relevant supporting offsite organizations must complete the Training Program. General training for all plant personnel includes radiation safety principles and procedures. Onsite personnel are responsible for providing site-specific radiological information to offsite personnel and to ensure that appropriate radiation practices and procedures are employed at the facility. Individuals not employed by Oklo Power but who require frequent or extended unescorted access to the facility, must complete additional radiation safety training, described in the Training Program.

The Training Program requires successful completion of a comprehensive examination prior to receiving certification. Any individual with unescorted access is subject to periodic retraining to ensure continued proficiency.

2.7 Work control program

Hazardous work activities performed at the Aurora are managed by a work control program. Non-radiological hazards include working at heights, performing lifts, working in confined spaces, and some types of hot-work. Radiological hazards include activities that involve contaminated or potentially contaminated systems, occur in radiation or high radiation areas, occur in areas with contamination or airborne radioactivity, or involve handling radioactive sources. Work controlled by the work control program must be documented, reviewed, and authorized with a safe work permit, radiological work permit (RWP), or both, before the work can begin. Work permits include the following information:

- Anticipated start and stop date and time for the work
- The locations where the work will occur
- The personnel performing the work
- The identified radiological and non-radiological hazards
- Personal protective equipment to be used by workers
- Prescribed radiological protection, dosimetry, required surveys, and other measures to achieve ALARA
- A work plan to minimize worker risk

Work that includes radiological and non-radiological hazards must be reviewed and approved by Radiation Protection Personnel and the Plant Manager and must have both a safe work permit and an RWP before work can begin. Work that only includes radiological hazards must be reviewed by Radiation Protection Personnel and requires only an RWP. The work control program does not preclude or delay any immediate actions required for plant, public, or worker safety.

2.8 Routine survey and air sampling program

Radiation Protection Personnel perform or may require Onsite Monitors to perform dose rate and contamination surveys to monitor radiation levels and verify the absence of contamination. The frequency of these surveys is determined by the likelihood of changing radiological conditions in the facility, previous operational experience, and the frequency of access to the area.

During the startup phase of the Initial Test Program, fixed air samplers or continuous air monitors may be used to sample the air in the reactor basement and normally occupied areas for airborne radioactivity. If using air samplers, filters are analyzed for beta- and gamma-emitting radionuclides (e.g., noble gases released from the fuel). Radioanalytical services are expected to be provided by an offsite contractor or vendor that meets Oklo Power quality assurance standards.

3 OCCUPATIONAL DOSE MONITORING AND LIMITS

3.1 Monitoring for external dose

All onsite personnel with unescorted access to the facility are monitored by wearing whole-body gamma and neutron personnel dosimeters issued by Radiation Protection Personnel. The dosimeters have sensitivities and ranges appropriate to measure the expected levels and types of radiation. Additionally, special dosimeters may be issued to monitor other doses (e.g., extremity dose) as determined by Radiation Protection Personnel.

3.2 Monitoring for internal dose

No contamination of the facilities is expected during operation of the Aurora due to design features that include the following:

- The retention of the majority of fission products in the fuel matrix
- Operation at near-atmospheric pressure
- Low activation of all onsite fluids

Because of the design features and precautions for effluent monitoring, routine monitoring for internal dose (e.g., whole body counting and urine bioassay analyses) is unnecessary. The routine surveys and air sampling program adequately monitor for the presence of contamination and airborne radioactivity in accessible areas.

3.3 Evaluation of internal dose

Internal dose is not expected at the facility because of design features that limit the potential for exposure to removeable surface contamination or airborne radioactivity.

If an internal dose to an individual is suspected, the dose is evaluated using past air sampling data recorded when the suspected exposure occurred or under direct measurements of radioactive material in the individual. The evaluation of internal dose may be performed by an outside contractor or vendor that meets Oklo Power quality assurance program. If nonzero internal dose is calculated, it is summed with external dose in accordance with 10 CFR 20.1202, "Compliance with requirements for summation of external and internal doses."

3.4 Administrative control levels for external dose

Administrative control levels for non-emergency conditions for occupational external dose are established below the limits in 10 CFR Part 20 for whole body, extremity, skin, and dose to the embryo or fetus. If administrative control levels need to be exceeded, approval by the Director of Reactor Operations, or delegated employee, is required in advance of exceeding the original administrative control level. The process of approving administrative control levels that exceed the limits of 10 CFR Part 20 for emergency conditions is dictated by the Emergency Plan.

3.5 Exposure to the embryo or fetus

All declared pregnant onsite personnel are issued additional personnel dosimetry as soon as possible after the declaration of pregnancy. The personnel dosimetry is to be worn at work for the duration of pregnancy. The dosimetry is exchanged at least monthly, and the dose is evaluated for compliance with control levels and analyzed for trends.

3.6 Planned special exposures

Planned special exposures are not anticipated at the facility.

3.7 Exposure to minors

Occupational exposure to minors is not expected at the facility.

4 RADIATION DOSE LIMITS FOR INDIVIDUAL MEMBERS OF THE PUBLIC

4.1 External exposure to the public

External dose rates outside the Aurora are expected to be very low and consistent with natural background levels.

4.2 Internal exposure to the public

There are limited potential internal exposure pathways to the public from the Aurora. Due to design features of the Aurora, any release of fission products or activation gases would be small and substantially less than limits set in 10 CFR Part 20. Therefore, air filtering is not needed to protect the public from an internal dose.

4.3 Compliance with 10 CFR 50.34a

Because minimal or zero release is expected from the Aurora, it inherently meets 10 CFR 50.34a, "Design objectives for equipment to control releases of radioactive material in effluents — nuclear power reactors."

5 RADIOLOGICAL CRITERIA FOR LICENSE TERMINATION

5.1 Expected actions for license termination

The small design of the Aurora is expected to allow complete relocation of the reactor and secondary system to an offsite facility for disposal or refurbishment. This allows removal of the vast majority of radioactive material from the site. Because of the reactor design and the plans to minimize contamination, any remaining radioactive material will be located by detailed surveys of the facility. If found, the radioactive material will be removed by standard industrial techniques (e.g., scabbling) and disposed as radioactive waste. When surveys indicate radiation levels consistent with background, the facility can be decommissioned as a nonradioactive facility.

6 MINIMIZATION OF CONTAMINATION

6.1 Facility layout

The Aurora facility layout is designed such that radiological materials are fully contained in the reactor enclosures, which are inaccessible during operations. Continuous air monitors monitor the air in the building basement to detect any unexpected airborne radioactive material.

The radiological materials expected to be produced during operation and the control of these materials, as well as necessary shielding are discussed in detail in Chapter 3, "Radioactive materials to be produced in operation," and Chapter 2, "Description and analysis of structures, systems, and components," of Part II, respectively. No other radioactive materials, except instrument check sources, are stored onsite during normal operations. During maintenance, and other modes that might require the storage of radioactive materials onsite, appropriate radiation protection procedures are implemented, as dictated by the Radiation Protection Program.

The unique structures, systems, and components (SSCs) in the Aurora design minimize the inventory of liquids that could leak or spill. The only fluid that enters or exits the reactor enclosures is the secondary system coolant. Due to the shielding and the location of the heat exchanger system with respect to the active core region, there is minimal activation of the coolant, therefore minimizing the possibility of contamination. The results of the coolant activation analysis are described in Chapter 3 of Part II.

The reactor enclosures are backfilled near atmospheric pressure with an inert gas prior to startup. The gas is expected to receive very little activation. There is no backfill system to maintain the inventory of the inert gas during normal operations. For operations that necessitate opening of the reactor enclosure, the work control program is used to prescribe appropriate control measures to minimize contamination.

6.2 Detection of leakage

Design of the Aurora reduces the potential leak sources to two systems: (1) the secondary system coolant, and (2) the inert reactor enclosure backfill. The air in the building basement is constantly monitored with continuous air monitors. Radiation monitoring in the building basement is performed with remote instrumentation, with readings displayed in the monitoring room.

The SSCs that are potential sources of leaks are located to ensure easy detection of leaks; therefore, undetected leaks are unlikely at the Aurora facility. Personnel are not expected to be present in the building basement during normal operation but may need to access this area in special circumstances. After accessing the building basement during normal operation, or accessing material or equipment used in the building basement, personnel are monitored for contamination through appropriate procedures under the Radiation Protection Program.

6.3 Reducing the need for decontamination

The following items have been considered and implemented to reduce radioactive contamination, and consequently, the need for decontamination:

- The small size of the facility
- Design features, which limit the number of SSCs that contain radioactive or activated materials
- Periodic inspection and testing of SSCs, which allows prompt detection of contamination
- Quality control procedures during installation of components with the potential for activation or that contain radioactive or activated materials

Implementing the above considerations minimizes the potential for contamination, and consequently, the need to decontaminate components of the facility during normal operations and during decommissioning.

7 SURVEYS AND MONITORING

7.1 Radiation protection instrumentation

Radiation protection monitoring instrumentation and equipment is selected, maintained, and used to provide the appropriate detection capabilities, ranges, sensitivities, and accuracies required for the types and levels of radiation anticipated at the plant and in the surrounding environments. Adequate radiation protection instrumentation is provided to support implementation of the Radiation Protection Program during operations which include the Initial Test Program, normal operation, off-normal events, maintenance, major outages, and decommissioning. During initial plant testing, the radiation detection and monitoring instruments are tested as required by 10 CFR 30.53, "Tests."

The following radiation protection instrumentation, at a minimum, is available onsite for use by trained and qualified personnel:

- Gamma dose rate survey meters
- Microrem dose rate survey meters
- Neutron dose equivalent rate survey meters
- Alpha-, beta-, and gamma-emitting contamination survey meters

Portable radiation protection instrumentation is calibrated and functionally checked in accordance with ANSI-N323A-1997, "American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments," or another applicable standard. Portable radiation survey instrumentation is stored onsite and available for qualified personnel to use as necessary.

Fixed instrumentation such as area radiation monitors may be placed in the facility to supplement portable radiation protection instrumentation.

7.2 Records of surveys

Records are generated to document measurements with radiation protection instrumentation. These records include, at minimum, the measurement location, the measurement result, date and time of measurement, instrument type and serial number, most recent calibration date, surveyor name, and surveyor signature. Surveys are reviewed and approved by a qualified individual who is not the surveyor.

7.3 Personnel dosimetry

Personnel dosimetry is issued to monitor personnel to ensure compliance with the dose limits in 10 CFR Part 20 in accordance with Section 3. Because of the small expected number of personnel monitored, dosimetry services are expected to be provided by offsite contractors or vendors. The dosimeters have National Voluntary Laboratory Accreditation Program (NVLAP) accreditation to measure dose from photons and neutrons consistent with the radiation types

and energies at the facility. Personnel dosimetry results are reviewed by Radiation Protection Personnel, and the dosimetry records are retained as described in Section 13.

8 CONTROL OF EXPOSURE FROM EXTERNAL SOURCES IN RESTRICTED AREAS

The only area at the facility with the potential to be a high radiation area is the Aurora powerhouse basement. To minimize exposure from this source, access to this area is controlled. Access points to the building basement are secured during normal operation, and if access to the area is needed during normal operation, Radiation Protection Personnel equipped with dose rate instrumentation perform the initial entry. Further information regarding access authorization is discussed in the Physical Security Plan.

9 RESPIRATORY PROTECTION AND CONTROLS TO RESTRICT INTERNAL EXPOSURE IN RESTRICTED AREAS

The use of respiratory protection equipment for protection from airborne radioactivity is not necessary because of design features that limit the potential for exposure to removeable surface contamination or airborne radioactivity. If respiratory protection is required by the work control program, it is worn by personnel that are medically qualified to wear respiratory protective equipment. Personnel must be qualitatively fit tested and trained to correctly use the respiratory protective equipment.

If respiratory protection is necessary, National Institute for Occupational Safety and Health (NIOSH) certified respirators are used. The protection factors assigned to using respiratory protection are in accordance with Appendix A to Part 20, “Assigned protection factors for respirators.”

10 STORAGE AND CONTROL OF LICENSED MATERIAL

The start-up neutron source for the reactor is expected to include one or more licensed sources. These sources remain in the reactor after start-up for the duration of the operating life of the plant.

Some of the sources used to check operability of radiation protection instrumentation may be licensed. Check sources are stored to prevent loss and unauthorized use and are inventoried at least annually.

Fuel is loaded into the reactor at the beginning of life and remains in the reactor for the duration of the facility lifetime. No fuel is stored on site at any time outside of the reactor.

11 PRECAUTIONARY PROCEDURES

Radiation areas in the Aurora facility are posted, and radioactive materials are labeled in accordance with 10 CFR Part 20, Subpart J, “Precautionary procedures.” Procedures are developed to receive packages containing radioactive material in accordance with 10 CFR Part 20, Subpart J.

12 WASTE DISPOSAL

Oklo Power is responsible for low level radioactive waste management through the site preparation, construction, and operation of Aurora. Only small amounts of low level radioactive waste are anticipated since there are no planned refueling. During operations, no high level radioactive waste is anticipated to be generated outside the reactor. Therefore, the only significant amount of radioactive waste will be managed during the decommissioning process.

It is expected that the facility will have no liquid radioactive effluents and little or no gaseous effluents. Solid radioactive waste generated at Aurora is disposed by transfer to an authorized recipient as provided in 10 CFR 20.2006, "Transfer for disposal and manifests," or in the regulations in Parts 30, 40, 60, 61, 63, 70, and 72 of 10 CFR.

13 RECORDS

Records of the Radiation Protection Program are retained in accordance with 10 CFR Part 20, Subpart L, "Records." It is expected that records of individual dosimetry monitoring are maintained by the offsite vendor supplying dosimetry. Appropriate methods are used to ensure records are retained safely and may include locked fireproof cabinets, duplication, digital backup, or a combination of the methods.

14 REPORTS

Reports are made in accordance with 10 CFR Part 20, Subpart M, “Reports.”

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