2. Accordingly, the license is amended by changes to the license conditions and paragraph 2.C(9) of Possession-Only License No. NPF-1 is hereby added to read as follows:

   2.C.(9) Spent Fuel Pool Debris Processing

   The licensee is authorized to process spent fuel pool debris in accordance with PGE letter dated October 23, 1996.

3. This license amendment is effective as of the date of issuance. This amendment shall be implemented within 30 days of issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

Marvin M. Mendonca, Acting Director
Non-Power Reactors and Decommissioning
Project Directorate
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Date of Issuance: June 9, 1997

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 198 TO POSSESSION-ONLY LICENSE NO. NPF-1

PORTLAND GENERAL ELECTRIC COMPANY

EUGENE WATER AND ELECTRIC BOARD

PACIFIC POWER AND LIGHT COMPANY

TROJAN NUCLEAR PLANT

DOCKET NO. 50-344

1.0 INTRODUCTION

By letters dated October 23, 1996; December 12, 1996; March 31, 1997, and April 9, 1997, Portland General Electric Company, et al. (PGE or licensee) submitted a request for changes to the Possession-Only License for Trojan Nuclear Plant. The proposed changes would allow processing of fuel and debris in the Trojan Fuel Building as described in the October 23, 1996 letter. The processing will volatilize and eliminate organic material (polypropylene filter media) which is currently commingled with fuel pellets, pellet fragments, and small metal particles. The consolidated fuel can then be stored in canisters without the potential for radiolytic decomposition of organic material and resultant generation of combustible gases.

2.0 BACKGROUND

The licensee announced permanent cessation of power operations of the Trojan Nuclear Plant on January 4, 1993. The licensee submitted a proposed decommissioning plan on January 26, 1995, which was approved by the NRC on April 15, 1996. The facility is currently undergoing active decontamination and dismantlement. In order to complete decommissioning and permit radiological release of the spent fuel pool for unrestricted use PGE must remove the fuel, commingled debris, and all other radioactive components stored in the pool. PGE has proposed to store the fuel in an Independent Fuel Storage Installation (ISFSI) and has submitted a license request to construct and operate the ISFSI. The licensee has proposed to process the fuel pellets and debris in order to make them suitable for future storage in the ISFSI.

The licensee will first place the commingled materials in process cans and store them in the fuel transfer canal. One at a time the cans will be transferred via a shielded transfer bell to the processing station in the new fuel storage pit. After processing with dry 1100 degree F steam to remove the organic material and water, the cans will be inerted and transferred back to the fuel transfer canal. They will be placed in process can capsules which hold five process cans each. The process cans will be inserted with helium, seal welded, and stored in an under water storage rack in the fuel transfer canal.

3.0 EVALUATION

The staff has evaluated and analyzed the licensee's proposed activities. The staff's analyses include a review of criticality prevention, radiation protection, the potential to form combustible gas mixtures, materials of construction, heavy load handling, and accident analysis.

Criticality Prevention

The potential for inadvertent criticality due to rearrangement of the fuel debris was evaluated at Savannah River based on critical mass calculations which were benchmarked to critical experiments. These experiments have shown that a uniform array of rods at optimal spacing results in the most reactive configuration. Therefore, the evaluation assumed that the pellets were arranged in an optimally moderated lattice geometry in nonborated water and surrounded by an infinite water reflector. The critical mass of U-235 for 0.6-inch diameter UO_2 rods enriched to 5 weight percent U-235, optimally spaced and reflected by one foot of water (infinite reflector) is greater than one kilogram. This corresponds to a UO_2 mass of approximately 23 kilograms. Assuming a maximum pellet weight of 5.6 grams, the number of pellets required for criticality would be greater than 4,000. Based on the number of pellets that were estimated to have been released during the baffle jetting problems in 1982, a conservative estimate of the total quantity of potential fuel debris to be processed is approximately the equivalent of 375 fuel pellets. Therefore, the NRC staff concludes that even in the unlikely event that all of the processed pellets were collected in one place, criticality could not occur.

It is possible to postulate off-normal events and accidents which could lead to an increase in reactivity, such as the drop of a process can loaded with spent fuel pool debris in the spent fuel pool or in the fuel transfer canal. However, for such events credit may be taken for the presence of boron in the pool water since the staff does not require the assumption of two unlikely, independent, concurrent events to ensure protection against a criticality accident. The reduction in k_{eff} caused by the boron more than offsets any reactivity addition caused by credible accidents and therefore there are no criticality concerns.

Radiation Protection

The licensee has described several features incorporated into the steam reforming process that are designed to minimize the radioactivity contained in the process effluent. The operating temperature of the can feed evaporator is below the boiling points of the non-organic debris materials; therefore, the radioactive materials are expected to stay in the debris matrix. However, a

Cesium trap is provided downstream of the evaporator to remove any Cesium from the waste gas (that may be volatilized in the feed evaporator) before it enters the steam reforming chamber. Organic materials in the steam/waste gas stream are broken down into simple molecules (e.g., H_2, and CO) in the steam reformer chamber before being vented to the Fuel Building. A high efficiency particulate (HEPA) filter is provided on the vent to remove any entrained particulates. The Fuel Building ventilation system also has a radiation monitor, as well as its own HEPA filter, so that any radioactive release is quantified and verified to be within the current Trojan effluent technical specifications.

The steam reforming process equipment has also been designed to minimize the radiation dose to the workers performing the operation. The sorting operation is performed under water in a coffer dam that mates with the top of fuel storage racks and has a connection to the fuel pool vacuum system. Radioactive particles in the debris stirred up during the sorting are collected by the vacuum system to maximize visibility through the water and minimize contamination of the pool. The can removal station, transfer bell, can feed evaporator and capsule loading station are all provided with sufficient radiation shielding so that the maximum external dose rate is 50 mrem per hour with a fully loaded process can (350 rem per hour) enclosed. In addition shielded lid plugs are provided for the process can capsules to permit hands-on welding. The licensee has estimated that the total cumulative dose from the entire spent fuel pool debris handling and processing operation to be less than 3.5 person-rem.

Potential to Form Combustible Gas Mixture

The material to be treated consists of fuel pellets and fuel pellet fragments, metal dross from reactor vessel internals machining, and filter bags used to collect the debris. Uranium oxide, stainless steel and its oxides, and polypropylene account for the bulk of the mass.

The licensee proposes to thermally treat the debris to convert it to a form suitable for storage in the fuel transfer canal and outside the spent fuel pool until such time as a waste disposal site will accept it for disposal. After processing in the steam reformer up to five process cans will be placed in each process can capsule which will then be filled with inert gas and welded shut. The process can capsules will be stored in the fuel transfer canal to await movement to an independent spent fuel storage installation (ISFSI). After placement in the ISFSI, the process can capsules will await shipment to a waste disposal site.

Holding the residue in a closed container while waiting for disposal may create a potential for generating a combustible gas mixture. Radiolysis of water and organic filter material could generate sufficient hydrogen and oxygen to form a flammable mixture, depending on the amounts of hydrogenous material present. Considering the eventual destination of the residue in a waste disposal facility, the staff used the guidance for the limiting amount of combustible gases found in IE Information Notice 84-72: Clarification of Conditions for Waste Shipments Subject to Hydrogen Gas Formation. That document limits hydrogen in the free space of a shipping package to 5 percent by volume.

The licensee's proposed treatment method relies on a process known as steam reformation. The treatment passes superheated steam over the debris, decomposing organic materials. The high temperature also drives off free, interstitial, and chemisorbed water. Pacific Northwest National Laboratory (PNL) performed an evaluation of the process, as reported in Summary Report PNWD-2350, Portland General Electric Trojan Nuclear Plant Spent Fuel Pool Project. PNL concluded that steam reformation will remove essentially all hydrogenous material from the debris.

In addition, PNL established an upper limit for hydrogen, 0.25 moles elemental hydrogen, for the total amount of hydrogen in an overpack. They based their limit on an analysis of the minimum free space available in the overpack. Their method yields the lowest credible limit for hydrogen. At the time the process can capsules are sealed, the limit applies to chemically bound hydrogen (as water or organic materials) in the steam reformer residue, since the atmosphere in the process can capsules will be flushed and filled with inert gas. In the event that radiolysis would decompose all remaining hydrogenous material, the hydrogen gas concentration in the free space will not exceed 5 percent by volume.

The licensee then carried out tests with simulated debris to determine the actual performance of the steam reformer. The simulated debris was processed at three temperature and duration combinations, to help establish optimum operating conditions. The process conditions set temperature at approximately 1100 degrees F.

A sample of the residue from each test run was taken and analyzed to determine how completely the steam reformation removed hydrogenous material. The reformer residue contained a small amount of char. To conservatively account for the largest credible amount of hydrogen, all the char from a test run was added to the sample. One additional sample, taken from reformer residue with no remaining char, was analyzed to observe the effect of char on hydrogen generation. The sample preparation included heating to 2000 degrees F, well above the steam reformer temperature, to assure that any remaining water or organic material would be removed. An inert gas was passed over the heated sample to carry the products of reaction through a water reactor which converted any water vapor to hydrogen. The gas stream was then analyzed for hydrogen and the results reported, as moles of elemental hydrogen, in Trojan Proof of Principle Test Summary, Revision 1, SEG/TRJ/PRO-030. All samples yielded hydrogen less than the limit established by PNL, less than 0.25 moles elemented hydrogen.

Selection of the sample preparation temperature included consideration of the heat needed to decompose or evaporate hydrogenous substances from all sources in the residue: (1) hydrocarbons, (2) chemically bound water (water of hydration), (3) inorganics, and (4) moisture. A survey of *CRC Handbook of Chemistry & Physics*, 75th edition, 1994, found that only sodium hydroxide (NaOH) contained hydrogen in a compound that decomposed or evaporated above 2000 degrees F. However, no sodium hydroxide, a strong base, is present in the debris due to the boric acid solution in the spent fuel pool.

The result of the proof of principle tests demonstrated that the steam reformation process removed hydrogenous materials suffiently to meet the molar limit established by PNL. Thus, the staff concludes that a combustible gas mixture will not form in the process can capsules.

There are two mitigating factors that provide additional assurance that a combustible gas mixture will not reduce the margin of safety. First, no ignition source exists in the inert materials contained in the process cans Second, insufficient oxygen is available to support combustion. Oxygen in water amounts to just half the molar amount of hydrogen. Polypropylene contains no oxygen. Thus, the percentage oxygen available from radiolysis is less than hydrogen, i.e., less than 5 percent by volume, which is insufficient to support combustion.

Steam Reformer Materials of Construction

The steam reformer is constructed of metallic and ceramic materials. The primary materials of construction are AISI Type 316L stainless steel and AISI Type 316 stainless steel where no welding is involved. Examples of where these materials will be used are in process piping, vessels, valves, sample ports, and sensor ports. In higher temperature regions, Incoloy 800 or Incoloy 800HT will be used. The parts subject to higher temperatures are the bottom of the heat exchanger portion of the main steam reforming reactor, the first stage plate-to-plate heat recuperating heat exchanger, and the interconnecting piping between these units.

The highest temperature portion in the process is the main reactor core tube and radiant tube in the reactor bottom heat exchanger. The main reactor core tube is constructed from Haynes 230. The radiant tube is made from APM, a proprietary alloy from Kanthal Corporation. The radiant tube is heated using electrical heaters made of molybdenum disilicide. It may be possible to make the core tube from Incoloy if the spent fuel pool debris processing temperature do not exceed 1800 degrees F.

Ceramics are also used in the highest temperature regions of the process. Large precast cylinders of fibrous alumina surround the Haynes 230 core tube. The inside of the cylinders are coated with a clay slip washcoat for flow abrasion protection. Loosely packed bulk alumina fiber is placed outside of the cylinders to allow for thermal expansion. The main reactor bottom heat exchanger contains zirconia porous ceramic disks and annular sectors to divert flow and provide optically active radiation coupling between the radiant tube and the forced convective heat transfer areas of the heat exchanger.

The NRC staff has reviewed the proposed materials of construction and finds that the 316 and 316L stainless steels are commonly used materials for this type of application. Incoloy 800 and Incoloy 800HT are nickel based alloys developed for higher temperature use. The Haynes 230 is a nickel superalloy and is adequate for the core tube. The APM from Kanthal was developed for use as radiant tubes. The ceramic materials are made for high temperature applications. On these bases, the staff concludes that the proposed materials of construction for the steam reformer are acceptable.

Heavy Load Handling

PGE will use administratively controlled safe load paths for all movements of the shielded transfer bell. There will be no heavy load handling over the spent fuel pool as this is outside the limits of the authorized heavy load paths. The safe load paths have sufficient structural strength to withstand a load drop without causing failure of structures, systems, and components important to safe storage of spent fuel. PGE's load handling program complies with Section 5.1.1 of NUREG-0612 "Control of Heavy Loads at Nuclear Power Plants." This program includes:

1. Definition of safe load paths
2. Development of load handling procedures
3. Periodic inspection and testing of cranes
4. Qualifications, training, and specified conduct of operators
5. Special lifting devices should satisfy the guidelines on American National Standards Institute (ANSI) N14.6.6
6. Lifting devices that are not specially designed should be installed and used in accordance with the guidelines of ANSI B30.9
7. Design of cranes to ANSI B30.2 or Crane Manufacturers Association of America (CMAA)-70.

The licensee has examined the various failure modes of the steam reforming operation to assess the potential for offsite release of radioactive material. The failure that has the highest potential for offsite release was determined to be dropping the shielded bell during transfer of a fully loaded process can. The licensee set (consistent with an agreement with the State of Oregon) an acceptance criteria for the radiological consequences of this event at 500 mrem committed dose equivalent (CDE) to any organ of an individual located at the site boundary for the duration of the radioactivity release. The licensee calculated the maximum activity in a process can that, if released during the postulated event, would not exceed this acceptance criteria. This maximum activity is approximately 533 curies based on the anticipated spectrum of radioactive isotopes in the mixed fuel debris. The corresponding dose rate at the surface of the process can is calculated to be 364 rem per hour. Therefore, the dose rate at the surface of a process can is limited to a maximum of 350 rem per hour to insure that the 500 mrem offsite organ dose can not be exceeded.

3.0 CONCLUSION

The staff has reviewed the licensee's submittals of October 23, 1996, December 12, 1996, March 31, 1997, and April 9, 1997, has concluded that the radiological impact calculations are technically sound and incorporate sufficiently conservative assumptions. Adequate controls over the fuel handling and processing operation are described to provide reasonable assurance that an accidental event will not result in an individual organ dose in excess of 500 mrem CDE at the site boundary. This acceptance criteria insures that the potential radiological consequences of the proposed fuel processing remains a small fraction of the Protective Action Guide for prompt response to a nuclear emergency. Therefore, this activity is within the basis for Trojan's exemption from the emergency planning requirements in 10 CFR Part 50 issued September 30, 1993. In addition, the licensee's proposal incorporates appropriate equipment design features and controls to insure that, during fuel debris processing, the off-site releases of radioactive material are within the current Trojan Technical Specifications; the occupational radiation doses are within the limits of 10 CFR Part 20; and that they both can be maintained as low as reasonably achievable (ALARA).

The staff has also found that the licensee has taken adequate measures to preclude inadvertent criticality and to prevent the formation of a combustible gas mixture in the process can capsules. The staff additionally concludes that the materials of construction and heavy load handling programs are acceptable.

The licensee conducted a successful full scale pilot test of the fuel debris program using a nonradioactive surrogate during the week of May 17, 1997. A representative of NRR and an NRC contractor witnessed the pilot test of the system.

4.0 STATE CONSULTATION

In accordance with the regulations of the Commission, the Oregon State official was notified of the proposed issuance of the amendment. The State official had no comments.

5.0 ENVIRONMENTAL CONSIDERATION

Pursuant to 10 CFR 51.21., 51.32, and 51.35, an environmental assessment and finding of no significant impact have been prepared and published in the Federal Register on June 9, 1997 (62 FR 31465). Accordingly, based upon the environmental assessment, the staff has determined that the issuance of this amendment will not have a significant effect on the quality of the human environment.