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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

SUPPORTING AMENDMENT NO. 14 TO

FACILITY OPERATING LICENSE NO. R-81

UNION CARBIDE CORPORATION

DOCKET NO. 50-54

Introduction

The operating license for the Union Carbide Corporation (the licensee) pool-type nuclear reactor was originally issued in 1961. As required by 10 CFR Part 50, Section 50.36(d)(1), in the absence of a specific document designating Technical Specifications (TS), the entire Safety Analysis Report, including all amendments, shall constitute the TS. In the case of the Union Carbide Research Reactor (UCRR), the Final Hazards Summary Report (FHSR) serves as the Safety Analysis Report, and therefore, the TS. Since the FHSR represents a large volume of extraneous material, review of this material in TS change submittals complicates the licensing process. As a result, we requested the licensee, by letter dated January 8, 1973, to propose TS for the UCRR in the format described in Section 50.36(c) of 10 CFR Part 50.

By letter dated December 10, 1973, as supplemented by letters dated November 1 [illegible] 1976, and June 21, 1977, the licensee submitted proposed TS. Based [illegible] our review and upon discussions with the licensee, the final version of the proposed TS was submitted by letter dated December 15, 1978. Minor changes were made to this final version of the TS which were discussed with and agreed to by the licensee.

By letters dated February 14, 1978, we approved the UCRR Security Plan submitted by the licensee's letter dated October 27, 1977, as modified in an enclosure to the licensee's letter dated January 26, 1978. In keeping with current Commission practice, this amendment incorporates the approved Security Plan as a license condition.

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Evaluation

A. Technical Specifications

The revised TS set forth the requirements for safe reactor operation in the current format for research reactors and in conformance with Section 50.36(c) of 10 CFR Part 50. This format includes:

1. definitions of key terms used in the specifications,

2. delineation of safety limits and limiting safety system settings for those process variables important to reactor safety,

3. delineation of the limiting conditions for operation which define the lowest acceptable performance level for equipment, and the technical conditions necessary for continued operation,

4. requirements for surveillance of equipment essential to reactor safety,

5. description of those facility features important to reactor safety, and

6. administrative controls required for safe facility operation.

Presentation of the UCRR TS in the above format provides a more concise and definitive statement of the limits on reactor operational parameters. In addition, these specifications establish surveillance requirements which ensure that the operability and accuracy of required safety related instrumentation and equipment is determined at intervals acceptable to the NRC Staff.

The new TS generally include the design features and operating characteristics described in the original Operating License and in the FHSR. The TS also incorporate additional surveillance requirements and administrative controls which will enhance the performance of safety related equipment and the licensee's review and reporting of operations. Consolidation of this information in the revised, more standardized format will provide an increased level of assurance that the health and safety of the public will not be endangered. The revised format of the TS reflects current Commission guidance for research reactor TS and will facilitate future licensing reviews of the UCRR Operating License.

The new TS contain additional limitations and restrictions which do not exist in the license as currently written. Supplements to the FHSR showing an adequate level of safety exists in these additional limitations and restrictions were submitted to the Commission for review. All of these supplements to the FHSR were found acceptable by the NRC

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Staff. The transfer of certain design characteristics and operating parameters to the TS as limiting conditions for operation consolidates all of the license restrictions and requirements in a single document. Operation in conformance with the TS will provide an increased level of assurance that the health and safety of the public will not be endangered.

The licensee has proposed changes to the existing requirements of the license and FHSR and requested these changes be incorporated as part of the limitations and restrictions of the proposed TS. Each of these changes has been included in the proposed TS and is evaluated below.

1. Power Increase from 100 to 250 kw in the Natural Convection Mode

In the proposed TS (Section 2.2.2), the licensee increased the limiting safety system setting (LSSS) from 100 kw (the current requirement) to 250 kw in the natural convection mode. The licensee desires this increase in power level in the natural convection mode in order to broaden the experimental envelope for the UCRR. The purpose of this LSSS is to ensure that automatic action is initiated so that the safety limit (6.7 Mw) will not be exceeded during the natural convection mode of operation.

Natural convection is the most limiting flow condition because the only driving force for flow is the buoyancy force caused by the difference in temperatures between the coolant in the core and that above the core.

The LSSS of 250 kw is determined to meet the criterion that incipient boiling will not occur which results in the absence of steam bubble formation on the fuel surface. However, if the safety limit power level of 6.7 Mw is reached, the density of the steam bubbles on the fuel surface would be sufficient to prevent adequate cooling of the fuel, resulting in overheating and possibly melting of the fuel plates. This condition is known as "burnout."

The licensee has calculated the LSSS based on a calculated Nusselt number for natural convection flow through the space between two heated parallel plates of finite size. The calculated power level when incipient boiling would commence is 350 kw. This power is adjusted by a factor-of-safety of 1.3 and then rounded off to give an LSSS value of 250 kw. The rounding-off of the final calculated

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value gives an effective factor of safety of 1.4. No justification was provided by the licensee for this factor-of-safety; however, we agree with the licensee that the 40% adjustment is reasonably conservative and therefore judged acceptable.

The safety limit of 6.7 Mw was determined by the Gambill and Bundy method in which the pressure drops are equated to the driving head to obtain the flow through the core for natural convection conditions. Having established the flow, the burnout heat flux is calculated using the Lowdermilk burnout correlation recommended by Gambill and Bundy. Gambill and Bundy further recommend that a reduction factor of 0.8 should be applied to account for the method of calculating the burnout heat flux. This reduction factor compensates for the difference in the burnout heat flux determined from test data in the subcooled region (80 to 130°F) and that determined by the calculated method. The licensee has applied the 0.8 factor in calculating the safety limit of 6.7 Mw which we find acceptable.

Any further uncertainties in these calculational methods are accommodated by the conservatism existing in the large power spread between the reactor scram setting at 250 kw and the safety limit at 6.7 Mw. Because of this large spread as compared to the change between 100 and 250 kw, increasing the LSSS from 100 kw to 250 kw will not result in a significant decrease in the margin of safety.

Based on the above we conclude that this proposed change in the TS is acceptable and adequate assurance exists that the health and safety of the public will not be endangered.

2. Allowable Reactivity Worth for Movable Experiments

In the proposed TS (Section 3.5.1.c(4)), the licensee increased the reactivity worth from .15 to .25% of an experiment that can be moved while the reactor is critical. Reactivity worths of recent experiments at the UCRR have been falling in the range of .15 and .25%. The existing license requires a reactor shutdown each time these experiments are moved. The licens[illegible] [illegible]esires to reduce the number of reactor shutdowns for experim[illegible] by increasing the level of reactivity worth for movable experiments to .25%. Our review for this proposed change is summarized as follows.

Movement of an experiment of the maximum allowed worth when the reactor is critical could result in the relocation of the experiment within the core in such a way that the reactor effective multiplication factor, k_{eff}, could rapidly increase to 1.0025%.

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Reactor power would increase until the control rods, responding to a scram signal, would move far enough into the core to return the reactor to a critical state. Then the power would decrease to shutdown levels as the control rods continue to move to their fully inserted position.

The safety concern regarding such an event is whether the maximum power attained will exceed the safety limit power level. The proposed TS indicate that the safety limit power level for the most restrictive mode of forced circulation operation is 14 Mw, and that the safety-limit for the natural circulation mode is 6.7 Mw.

The licensee analyzed the consequences of an increase in k_{eff} by 0.25% ΔK in both the forced circulation and natural circulation modes.

We have reviewed the analyses of reactivity insertion transients and conclude that acceptable nuclear kinetic methods and nuclear input parameters were used in these analyses. We also conclude that the control rod insertion time assumed for compensation of the positive reactivity which initiates the transient is consistent with the TS on control rod scram time (Reference Section 3.21 of Supplement No. 2 to FHSR, April 1977), and that the initial power assumed at the beginning of the transient corresponds to the appropriate limiting safety system set point. Although the time assumed in the analyses for the insertion of the postulated 0.25% ΔK reactivity is difficult to justify, it is not an important factor and could cause only a small error in the maximum predicted power. Even if the insertion time were assumed to be zero, which is the most conservative value, the peak transient power would be well below the safety limit power.

For the forced circulation mode and the natural circulation mode, the analyses show that the maximum transient power would be well below the safety limit power. The proposed increase in reactivity insertion (from .15 to .25% ΔK) would result in a 14 and 0.8% decrease in the margin of safety for the forced circulation mode and the natural circulation mode respectively. We have judged these values as an insignificant decrease in the margin of safety. As just discussed, this is true even if reactivity insertion time is assumed to be zero. Based on these results, we conclude that the proposed TS increasing the reactivity worth for movable experiments from .15 to .25% are acceptable.

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3. Pool Water Quality

TS Change No. 10 dated January 12, 1973, of the facility license allows operation with pH between 5.0 and 7.5 and water resistivity below 200K ohm cm but not lower than 70K ohm cm for periods up to seven (7) days. The proposed TS (Section 3.7.c(2)) extend the period of seven (7) days to fourteen (14) days with all other operating conditions remaining the same.

The licensee requested this extension to prevent a reactor shutdown during the work week when the water resistivity falls below the TS limit. A reactor shutdown is required to rejuvenate the resin columns, which is followed by a few days of full flow circulation before the water resistivity is raised above the minimum TS limit of 200K ohm cm. Such conditions usually occur three to four times a year. The licensee, for economic reasons, desires to postpone all resin column rejuvenation pe iods to the normal weekend shutdowns, allowing a few additional da s in the following week for the water resistivity to increase above the minimum 200K ohm cm limit.

The purpose for imposing a limit on water resistivity is to prevent the possibility of fuel cladding failure by corrosion attack. The licensee, in support of his request, submitted laboratory corrosion test data (Report CT 3027, Corrosion of Aluminum in Dilute Solution Laboratory Studies, University of Chicago, 1945). After reviewing the data, we concluded the following:

a. Test data showed that simulated river water having resistivities as low as 5-6K ohm cm had minimal affect on the corrosion rate of aluminum similar to that used as cladding material for the fuel elements. The proposed TS does not permit the reactor to operate when the water resistivity falls below 70K ohm cm.

b. Corrosion attack during testing on aluminum was less than 1 mil. per year under more severe conditions than those existing in the reactor. These severe test conditions that existed when the resistivity was as low as 5-6K ohm cm included the addition of impurities (calcium, magnesium sulfate and sodium chloride) in the simulated river water and high fluid velocity and temperature. Such conditions do not exist in the pool water at UCRR. The measured corrosion rate from the test data is equivalent to that observed in distilled water indicating the high corrosion resistance of aluminum. If such a severe condition were to exist in the pool water, a 1.5 mil reduction in clad thickness (the nominal clad thickness is 15 mils) would occur during the service life of the fuel elements. Such a reduction will not result in clad failure nor result in a reduction in the margin of safety because it falls within the design tolerance of the fuel elements.

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c. Conditions that affect the corrosion rate of aluminum are pH, temperature and velocity. These conditions are not changed by this request.

Based on the above, we conclude that the proposed TS is acceptable and adequate assurance exists that the health and safety of the public will not be endangered.

4. Proposed Use of Uranium Oxide-Aluminum (U_3O_8-Al) Manufactured by Powder Metallurgy Process

The proposed TS (Section 5.1) allow the use of fuel fabricated from Uranium Oxide-aluminum (U_3O_8-Al) using the powder metallurgy process. The licensee proposes to add U_3O_8-Al to the list of the types of fuel elements that could be used at the UCRR allowing flexibility in the selection of alternate suppliers and thus enhancing economic competition. Furthermore, presently the licensee is procuring fuel elements from a European supplier, whereas the acceptance of this change will enable the licensee to obtain powder metallurgy fuel elements in the United States.

In evaluating reactor fuel elements, the major concerns are the degree of dimensional stability during operation and the ability of the clad surrounding the fuel matrix to contain fission products throughout the incore service life and during postulated accidents. Operating parameters that affect the dimensional stability are fuel temperature, heat generation rate and burnup. In general, fuel swelling will increase with the increase of these parameters.

On October 12, 1978, the Commission issued Amendment No. 25 to the University of Michigan authorizing the use of the U_3O_8-Al fuel in the Ford Nuclear Reactor (FNR). Union Carbide Corporation also submitted experimental data supporting the safe use of U_3O_8-Al fuel in the High Flux Isotope Reactor (HFIR) at the Oak Ridge National Laboratory, Oak Ridge, Tennessee. For comparison purposes, the table below shows pertinent operating parameters for U_3O_8-Al fuel elements from the FNR which were found acceptable by the NRC Staff, and these same parameters will exist in the UCRR. Illustrating the data base that exists for the proposed fuel, the table also shows typical operating parameters.in the HFIR.

Operating Parameters	UCRR	FNR	HFIR
Fuel Temperature °F	201	181	300
Heat Generation watts/cc	315	689	1500
Burnup Fissions/cc $X10^{21}$	1.5	1.5	1.9

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Since the magnitude of these operating parameters for the proposed fuel elements at the UCRR are similar to those at the FNR, our Safety Evaluation for Amendment No. 25 for the University of Michigan would also apply to this proposed TS (Enclosure 1). It should further be noted that operating parameters of the proposed fuel at the UCRR will be well below those at the HFIR. We conclude, therefore, that this proposed TS will not increase the potential of the existing hazard level nor will the margin of safety be reduced.

Based on the above evaluation, we find this proposed TS limiting the fuel operation to 1.5×10^{21} fission/cc acceptable.

B. Physical Security Plan

By letters dated October 27, 1977 and January 26, 1978, Union Carbide Corporation submitted a complete revision of the Security Plan for the Union Carbide Corporation Research Reactor. The Commission reviewed the plan against the requirements of 10 CFR Part 50, Section 50.34(c) and 10 CFR Part 73, and by letter dated February 14, 1978, approved the revision of the Security Plan. This amendment, in keeping with the current Commission practice, adds a paragraph to the license which identifies the Security Plan and incorporates the plan as a condition of the license.

C. Environmental Consideration

The environmental portion of the proposed TS (Sections 3.8, 3.9 & 3.10) includes effluent release from the total facility which includes the reactor, under NRC license, and the hot cells, under New York State (NYS) license. Such a condition is necessary because of the use of a common stack release which makes it impractical to separate radioactive effluents from the two licensed activities. The conditions and requirements of these proposed specifications are interim because of the present unavailability of the meteorological data needed to establish final specifications.

Our review of onsite meteorological data submitted by the licensee revealed a lack of specificity of certain parameters needed to accurately predict the local meteorological dispersion (dilution) used in establishing radioactive release limits and objectives for keeping radioactive effluents to "As Low As Reasonably Achievable" (ALARA). Due to a degree of uncertainty in these parameters, the licensee proposed using three radioiodine samplers to calculate actual dispersion constants. This is accomplished by continual measurement of the actual concentration of radioiodine concentration at two offsite locations. The selection of these locations is based on the predictions of maximum concentrations from meteorological data and the highest concentration at a residential site. The measured concentrations of radioiodine will be used to determine when actions are required by the licensee. A factor of 2 for conservatism has also been applied to account for uncertainties in the measured concentrations at the actual locations of the offsite monitoring stations.

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We have accepted the licensee's proposal as the basis for interim specifications until further site meteorological information is supplied by the licensee. We have concluded that selected environmental radio-iodine monitoring to quantify doses for the purposes of establishing that exposures are as low as reasonably achievable cannot be presently justified on a long term basis. Such monitoring does, however, provide greater assurance than previously available that radioactive effluents from UCRR should not exceed the limits of 10 CFR Part 20 at offsite locations and that radiation doses to offsite individuals should not exceed 1% of the limits of 10 CFR Part 20.

These interim specifications include the following requirements:

(1) The release of radioactivity in airborne effluents is limited such that the calculated concentrations at unrestricted areas are less than one-third (1/3) of the concentration listed in Appendix B, Table II of 10 CFR 20. This provides assurance that radiation exposure due to airborne effluents from the facility to an exposed population group in an unrestricted area is within the limits specified in 10 CFR 20.106(e). To provide conservatism in the determination of the dispersion factor, the interim specifications require the measured and calculated values of the dispersion factors be increased by a factor of two.

(2) The proposed interim specifications establish ALARA objectives for radioactive effluents at a level corresponding to 1% of the limit of 10 CFR Part 20 (5 mrem/yr total body dose and 15 mrem/yr thyroid dose) at the critical residential site. These objectives are the same as those used for light water power reactors as described in Appendix I to 10 CFR Part 50. However, these objectives do not consider the cost-benefit aspect of further reductions of radioactive effluents below the above individual dose objectives based on population radiation exposures. As presented in Appendix I to 10 CFR Part 50, ALARA design objectives should be reduced below the individual dose objectives if a reduction in population dose corresponding to a licensee expenditure of $1,000 per man-rem of population dose can be achieved. To determine if the individual dose objectives should be lowered requires an evaluation of the feasibility and economic impact of engineering methods of reducing radioactive effluents and the resulting reduction in population dose to the public. If effluent reduction methods are determined to be feasible and cost effective, then the individual objectives specified in the interim specifications will be reduced. Further NRC review of this area will await the outcome of the New York State Department of Environmental Consideration (NYSDEC) review. NYSDEC has the lead in this matter because most of the facility effluents result from activities licensed by NYS.

(3) The licensee is required by the interim specifications to conduct environmental radiological monitoring and, at least once per year conduct a land use census. The environmental radiological monitoring provides additional assurance that radiation levels at unrestricted areas of the facility are within specified limits. The land use census provides assurance that the pathway(s) used in calculations to determine the dose to an individual at the unrestricted area is current and realistic.

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Based on the above, we have concluded that the proposed interim environmental portion of the TS would provide added assurance that the limits of 10 CFR Part 20 are not exceeded in the unrestricted areas and that doses to individuals should not exceed 1% of the limits of 10 CFR Part 20.

We have determined that the amendment does not authorize a change in effluent types or total amounts nor an increase in power level and will not result in any significant environmental impact. Having made this determination, we have further concluded that the amendment involves an action which is insignificant from the standpoint of environmental impact and, pursuant to 10 CFR §51.5(d)(4), that an environmental impact statement or negative declaration and environmental impact appraisal need not be prepared in connection with the issuance of this amendment.

Conclusion

We have concluded, based on the considerations discussed above, that: (1) because the amendment does not involve a significant increase in the probability or consequences of accidents previously considered and does not involve a significant decrease in a safety margin, the amendment does not involve a significant hazards consideration, (2) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, and (3) such activities will be conducted in compliance with the Commission's regulations and the issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public.

Dated: May 17, 1979

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