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D. L. Ziemann

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THRU: D. L. Ziemann, Chief, ORB #2, DRL

BIG ROCK POINT - TYPE "J-2" UO_2-PuO_2 FUEL

Introduction

Consumers Power Company, by letter dated December 9, 1971, proposed to insert two Type "J-2" UO_2-PuO_2 fuel assemblies into the Big Rock Point reactor core to replace two fuel assemblies to be removed during the scheduled February-March 1972 plant outage. The Type "J-2" UO_2-PuO_2 fuel assembly contains 1.5 kilograms of plutonium distributed in 24 plutonium-bearing mixed oxide fuel rods arranged about the center of the fuel assembly in a 5 x 5 array (center rod does not contain plutonium enriched fuel) and employs 50 mil cladding on the peripheral and other selected internal high power rods and a modified upper fuel rod tie plate design to facilitate the remote disassembly of fuel rods. In all other respects, except for the use of 35 grams of cobalt per foot of rod in the four cobalt rods per bundle instead of 70 grams of cobalt per foot, the "J-2" fuel assembly is identical to the "J-1" fuel assembly. (These loadings are used interchangeably in other Big Rock Point fuel bundles depending on cobalt demand.)

Description

The "J-1" and "J-2" bundles accommodate four cobalt target rods and four gadolinia-bearing fuel rods in the same relative positions (ref. Dwg "Fuel Bundle Details Big Rock Point" Figure 5.7 Proposed Technical Specification change). Eight tie rods and a central spacer capture rod also are used. With the exceptions noted, i.e., clad thickness and upper tie plate, all mechanical components are identical in the two designs, including spacers, lower tie plates, fuel rod assembly, fuel column length, the use of cold-pressed and sintered pellets and the basic 9 x 9 rod array with short diffuser at the inlet to improve flow distribution at the bundle entrance. The 48 plutonium rods within the two fuel assemblies are enriched to 3.6 w/o plutonium thereby increasing the initial enriched plutonium in the Big Rock Point in accordance with two previously approved Technical Specification changes*, by 3 kg to a total of 21.5 kg.

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*Amendment No. 3 dated April 18, 1969
Change No. 19 dated February 20, 1970

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Evaluation

Amendment No. 3 (dated April 18, 1969) authorized Consumers Power Company to possess 50 kg of plutonium in mixed oxide fuel rods for irradiation in the Big Rock Point core, and approved insertion of up to 32 fuel rods containing 1.3 to 1.5% plutonium enrichment, depending on pellet coring or dishing, into two diagonal positions in Type E-G fuel assemblies to replace 2.5% uranium enriched rods. We noted in our evaluation of the proposal to insert 32 plutonium fuel rods containing a total of 1 kg of plutonium (Proposed Change No. 17 DRL Evaluation dated April 18, 1969) that the total plutonium inventory of the Big Rock Point core was increased less than 4% at the beginning of that fuel cycle.

Proposed Change No. 19 authorized irradiation of three fuel assemblies containing plutonium fuel rods (designated as "EEI-UO_2-PuO_2" fuel). Memos to file dated February 18, 1970, and February 20, 1970, noted that the three "EEI-UO_2-PuO_2" fuel assemblies contained 17.5 kg total of plutonium. When added to the plutonium in the 32 fuel rods inserted into the core in May 1969, the total initial plutonium enrichment is 18.5 kg. The current proposal would increase the weight of plutonium in plutonium enriched fuel rods in the Big Rock Point reactor to 21.5 kg, 43% of the amount that CPC is authorized to receive, possess and use in PuO_2-UO_2 fuel rods in connection with operation of the Big Rock Point Nuclear Plant. We have determined that the 3.0 kg increase in the core plutonium inventory is modest when compared with the increase that accompanies extension of UO_2 fuel life to 20,000 MWD/MT where the initial fuel lifetime was 10,000 MWD/MT* and is therefore relatively unimportant with respect to potential increased plutonium inhalation hazard associated with fuel rod failure. We note that the "J-2" fuel is expected to remain in the core for 4 fuel cycles and is claimed to be mechanically capable of 25,900 MWD/MT average burnup compared with the expected 4 cycle operation for the "EEI-PuO_2-UO_2" fuel with an average burnup of 20,000 MWD/MT.

The three approved type "EEI-PuO_2-UO_2" fuel assemblies each contain 68 plutonium fuel rods with five different enrichments varying from 1.6 to 9.0 w/o plutonium. The CPC safety evaluation for these plutonium enriched fuel assemblies (dated December 22, 1969) revealed that the plutonium fuel density, reduced by about 10% compared with the standard UO_2 fuel density, resulted in less heat storage capacity. In combination with the assumption that the prompt threshold of failure for non-homogeneous plutonium enriched fuel is 265 cals/gm (425 cals/gm for homogeneous UO_2 fuel), the DBA reactivity excursion caused by a control

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*Ref. Conference 660308 - Commercial Fuels Conference, March 1-2, 1966, Figure 11 rod drop of 0.021 delta k/k reactivity results in approximately 12 kg of fuel with enthalpies in excess of 265 cals/gm and a prompt energy deposition in the coolant of 14 MWsec.

CPC has noted that information previously provided by them to support the proposal for irradiation of three Type "EEI-PuO_2-UO_2" fuel assemblies (Change No. 19 and two supplements) can be applied to evaluate Type "J-2" fuel behavior during and following a DBA reactivity excursion. Since the total fissile content is 3.52 w/o for the "J-2" fuel assemblies in contrast to 4.84 w/o for the "EEI-UO_2-PuO_2" fuel bundles as reported by CPC on page 8 of the "J-2" proposal and therefore is less reactive, we agree that a simple reactivity excursion analysis for the "J-2" fuel bundles based on the information previously submitted is conservative. Thus, 3 kg of "J-1" plutonium, when related to 17.5 kg of "EEI-PuO_2-UO_2" plutonium, omitting the corrections for non-fissile plutonium isotopes, yields an energy burst of 2.5 MWsec. Neglecting plutonium depletion in the three "EEI-PuO_2-UO_2" fuel assemblies currently being irradiated results in a cumulative release, if centermelt fuel bundles are inserted into the core, of 64 MWsec, a value previously determined to be acceptable. The margin for rapid energy burst resulting from prompt energy deposition in water for fuel enthalpies in excess of 265 cals/gm is recognized to be appreciable if centermelt fuel is not simultaneously irradiated in the core, since the prompt release for centermelt fuel was calculated to be 47.5 MWsec, nearly 2.5 times greater than the prompt release from all of the enriched plutonium initially in the core, including that to be inserted in February-March 1972. We have concluded, on this basis, that the consequences of the DBA reactivity excursion are acceptable, and considering depletion of the fissile plutonium enrichment in the three Type "EEI-PuO_2-UO_2" fuel assemblies currently being irradiated and the 32 low enrichment plutonium rods inserted nearly two years ago, the total energy deposition due to a control rod drop accident may be less than the value calculated for the three unirradiated Type "EEI-PuO_2-UO_2" fuel assemblies when initially placed in the core.

The use of increased cladding thickness on peripheral and selected internal high power fuel rods, i.e., 50 mils instead of 40 mils, improves the fuel rod integrity but increases the thermal flux slightly as a result of the small increase in water to fuel ratio in the vicinity of the thick clad rods. The increase in control rod reactivity worth is, however, negligible according to the CPC evaluation. We have concluded that the increased clad thickness improves fuel integrity without changing significantly the consequences of the DBAs. However, we note that the bundle uses fuel rods with 5 different fuel compositions and a variety of fuel pellet density (dished ends, cored centers, fuel compaction). The possibilities for fuel rod loading mixups during fabrication are increased further by the necessity to employ pellets with 2 different outside diameters. We believe that with proper quality controls and frequent inspection the two fuel assemblies can be fabricated in accordance with the design requirements, but such a variety of fuel pellet combinations might be unacceptable for the fabrication of large numbers of product line fuel assemblies because of the high probability of fuel loading errors.

Twelve 4.2 w/o enriched UO_2 rods in each of the two "J-2" fuel assemblies have been designated experimental rods because of small but carefully controlled variations in the fuel rod fabrication. The objectives of this program are to develop a fabrication process that results in the lowest fabrication costs and a fuel product of superior performance without increasing the probability of accidents or changing the consequences of such accidents. We were informed during a telecon with CPC personnel on December 22, 1971, that the test pellets will be approximately one half of the normal length, i.e., about 0.36" instead of 0.72", to reduce the hour glass effect due to irradiation. The fuel rods normally are designed for 40,000 MWD/T without excessive clad strain due to clad fuel interaction. Providing a fuel-clad gap of 0.011 ± 0.003 inch in the experimental rods in contrast to the normal "J-2" fuel rod gap of 0.011 ± 0.002 inch causes negligible change since the planned irradiation lifetime is 20,000 MWD/T and there is ample margin before fuel clad strain limits are reached. The minimum clearance of 0.008 inch compared with the normal minimum of 0.009 inch is of no consequence for the planned irradiation period. The possibility of eliminating autoclaving to reduce the possibilities of water entrapment will be explored by irradiation of 3 experimental rods in each bundle which have not been processed in the autoclave. Two other rods will be autoclaved at reduced steam pressure.

Normally the fuel pellets pass through a grinding and polishing operation using a water slurry. Elimination of this operation results in a small increase in the pellet diameter, but a potential source of water and resultant zircaloy hydriding is eliminated. Some of the experimental fuel rods will employ fuel pellets that have not received the grinding-polishing operation. The effect on fuel reliability by the omission of this process will not be significant unless fuel irradiation is extended beyond the planned 20,000 MWD/T average fuel depletion. We have concluded that 12 "experimental" rods within the limits described may be inserted in each of the "J-2" fuel assemblies with reasonable assurance that the hazards to the public will not be increased beyond those previously evaluated and accepted.

Conclusion

We have concluded that insertion of two Type "J-2" fuel assemblies into the Big Rock Point core (March 1972) increases the enriched plutonium within the core by 3 kilograms to a total of 21.5 kilograms. The total core plutonium inventory is not changed significantly, and prompt energy deposition in water following the DBA reactivity excursion is less than 2.5 MWsec, an insignificant amount in contrast to the 65 MWsec prompt energy deposition that can be tolerated without damage to the backup core spray system. Fuel temperatures in the "J-2" fuel assembly following the loss of coolant flow accident are no greater than the values calculated and found acceptable for the Type "EEI-PuO_2-UO_2" fuel. The increased clad thickness for some of the Type "J-2" fuel rods, modifications to the upper tie plate to facilitate remote disassembly of the fuel rods, and twelve 4.2 w/o enriched UO_2 experimental rods per assembly introduce no new safety considerations. The 3.65 w/o plutonium enrichment is within the range of fuel rod enrichments currently being irradiated in the Big Rock Point core and from the materials behavior standpoint is acceptable. The fuel temperature, following loss-of-coolant accidents, is comparable to that for the enriched plutonium fuel rods previously approved by DRL and currently being irradiated in the Big Rock Point core.

We have concluded that the insertion of two Type "J-2" fuel assemblies into the Big Rock Point core does not increase the probability of the DBAs or significantly change the consequences of such improbable accidents. Accordingly, the Technical Specifications may be changed as indicated in Attachment A to permit insertion of two Type "J-2" fuel assemblies into the Big Rock Point core in March 1972.

James J. Shea
Operating Reactors Branch #2
Division of Reactor Licensing

cc: DJSkovholt, DRL
RHVollmer, DRL
DLZiemann, DRL
JJShea, DRL
RMDiggs, DRL
MJinks, DR (2)