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DATE : June 5, 1996

TO : K.C. Leu, U.S. NRC

FROM : John R. Stokley, SAIC
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SUBJECT : Gas Burn at the Point Beach Power Station

BACKGROUND

During the past week a gas fire occurred at Point Beach nuclear power plant operated by Wisconsin Electric Power Company at Manitowoc, WI. The event occurred during weld-closure of a Pacific Sierra Nuclear (PSN) spent fuel storage cask containing 24 PWR assemblies. No radioactive material was released to the environment and the assemblies were not damaged but the 2,860 kg (6,300 lb) cask shield lid was reported to be moved a vertical distance on the order of 10 cm (4 in). The gravitational energy would be on the order of 2,850 J (2.7 BTU). Prior to the event the cask was loaded with spent fuel in the storage pool over a period of approximately 12 hours. While in the storage pool, the shield lid was put in place. After lifting the cask out of the pool approximately 114 liters (30 gallons) of water was drained from the cask. Draining of the water would produce a 2-inch thick air space at the top of the canister. Water inside the cask was reported to be at a pH of approximately 4.0. The cask was moved to a wash-down pit were it remained for 11 hours prior to initiation of the welding operation. According to present reports, the gas burn occurred immediately upon stiking of the arc and not after heating of metal due to the welding operation.

Post-event inspections indicated that the cask water contained elevated levels of hydrogen and that the underside of the shield lid was covered with a white, creamy substance containing zinc, silica, iron, and boron. Reports on physical examination of the cask internal coating are not yet available. An energy balance was made and indicates that combustion of a hydrogen mixture within it's flammability limits in the reported available volume would be adequate to provide the energy required to move the shield lid.

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ENERGY GENERATION MECHANISMS

Materials used in fabrication of fuel assemblies and spent fuel casks, that is carbon and stainless steels and zircalloy, are not generally reactive under anticipated operating conditions. In the PSN design, the underside of the shield lid and the interior surface of the cask are coated with a material containing potentially reactive constituents. Reportedly, some portion of the inside surface of the cask from the top to the vicinity of the seal weld joint may not have been coated with the primer material. Physical and chemical mechanisms which could generate reactive components include:

- o improper formulation and/or thermal, radiative, or chemical breakdown of the cask interior coating
- o H_2 generation through radiolysis of water
- o H_2 generation through electric arc decomposition of water
- o steam explosion
- o H_2 generation through corrosion
- o inadvertant introduction of combustible material during welding.

Of these potential mechanisms, the first two are considered credible enough for immediate consideration. Given the present description of the event, the remaining four mechanisms are considered as unlikely explanations for observed event.

Cask Interior Coating

The cask interior coating is formulated prior to application from 3 separate components; a base material, zinc powder, and thinners. The thinners, comprised of ethyl glycol, monobutyl ether, and propylene glycol may be used to facilitate application and are expected to evaporate rapidly from the newly applied coating. The following mechanisms exclude any combustible contribution from the thinners. The base material, ethylsilicate, is mixed with the zinc powder prior to application and is designed to form an ethyl-zinc-silicate chemical complex which places the zinc in a non-reactive state. Several mechanisms may be proposed for generation of a combustible atmosphere:

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Organic and inorganic compounds are subject to chemical and radiative decomposition. The product data sheet for this coating specifies that the material is not recommended for exposure to acids. No specifications are provided for exposure to radiation fields. Thus, chemical or radiation damage are candidate decomposition mechanisms. A mass balance was made using manufacturer product data. The balance indicated that degradation of a small percentage of the cask interior coating would generate the quantity of hydrogen needed as the energy source.

In addition, improper formulation of the coating could result in incomplete oxidation of the zinc powder which if released could react with water producing additional hydrogen.

The material safety data sheet (MSDS) provided for this coating indicates that thermal breakdown is possible with the generation of combustible fumes. A mass balance made using MSDS information indicated that degradation of 0.4 % of the shield lid coating or 3.0 % of a 2-inch height of the cylindrical cask interior wall coating would produce the quantity of hydrogen needed as the energy source. As above, thermal breakdown could also release potentially reactive zinc powder.

Radiolysis of Water

Exposure of water to the alpha, beta, or gamma radiation produced in decay of spent fuel radionuclides will generate H_2 and O_2 through decomposition of the water. Because the fuel cladding will absorb alpha and beta particles, only the gamma field is of concern in this case. The PSN cask SAR reports that the design basis gamma field for a MSB-24 cask is $4.835x10^{+15}$ MeV/s/MTHM. With 24 assemblies at 0.467 MTHM per assembly, the total gamma energy production rate is $5.42x10^{+16}$ MeV/s. NRC Regulatory Guide 1.7 includes recommendations for estimation of rates of radiolysis for intact fuel immersed in water. In particular, H_2 generation rates of 0.5 molecules/100 eV and water absorption of 10 % of the gamma energy are recommended values. Using these data and a time interval of 11 hours, a total H_2 generation of 3.75 g was estimated. This quantity is orders of magnitude greater than that required to generate the energy required for the observed effects.

SUMMARY

Analysis of the gas-burn event at the Point Beach plant indicates that chemical or radiative degradation of the cask interior coating or radiolysis of water could generate quantities of H_2 gas large enough to produce the observed effects. It seems prudent to investigate these two mechanisms in greater detail with physical/chemical analysis of the coating and modeling of radiolytic gas generation and leakage rates.