Zirconium Fire Mitigation Methods

| **Available Extinguishing Methods** | **Pros** | **Cons** | **Recommendations or Cost Benefit Results** |
|---|---|---|---|
| Portable Fire Extinguishers | (1) Fire extinguishers or extinguishing agents with Class[1] D ratings can be provided for zirconium fires. | (1) Require personnel to remain in vicinity while fighting fire. (2) Fire extinguishers are designed for incipient fires (flame production limited and restricted to small areas which are accessible). (3) Limited amount of extinguishing agent. (4) Limited range of the discharge agent. | Additional investigations into this alternative are not considered to be technically viable, due to large quantities necessary to cool the pool and personnel limitations. |
| High-Expansion Foam | (1) Cuts off oxygen supply to burning area by covering/coating the fuel surface. | (1) No available water sources outside of fire department for seismic. (2) High-expansion foam's principal application is for fighting Class A fires. (3) Turbulent air or uprising combustion gases can divert foam from burning area. (4) Manning concerns. | Additional investigations into this alternative are not technically viable, based on concerns associated with implementation of a portable high-expansion foam system and heat transfer. |

[1] Class A Fires: Fires in ordinary combustible materials such as wood, paper, rubber and many plastics. Agents: Water, loaded stream, medium/high expansion foam.
Class B Fires: Fires in flammable liquids/gases, combustible liquids, tars, oils, paints, solvents. Agents: Carbon dioxide, dry chemicals, AFFF (use on hydrocarbon fuel surfaces).
Class C Fires: Fires that involve energized electrical equipment. Agents: Carbon dioxide, dry chemicals.
Class D Fires: Fires in combustible metals, such as magnesium, titanium, zirconium, sodium, lithium, and potassium. Agents: Dry Powder

| **Available Extinguishing Methods** | **Pros** | **Cons** | **Recommendations or Cost Benefit Results** |
|---|---|---|---|
| Total-flooding Carbon Dioxide | (1) Extinguishes a fire by dilution of air. (2) Readily available. | (1) Carbon dioxide will not extinguish reactive metal fires due to the active involvement of these materials in the combustion process. (2) Beyond design basis seismic event will crack SFP liner and allow fresh air to enter into the pool from below. | Additional investigations into this alternative are not considered to be technically viable. |
| Halon | (1) Extinguishes a fire by chemically interrupting the combustion process. | (1) Halon is no longer available due to ozone layer issues/ban. | Additional investigations into this alternative are not considered to be technically viable. |
| Total-Flooding Dry Chemical Agent for Metal Fires | (1) Inhibits or breaks the combustion chain process by smothering the flame. Dry chem. must be applied to the heat source. (2) Dry Chemicals that are effective on Class D fires include Met-L-X and Pyromet. | (1) Only UL approved for use with manually operated hose lines. (2) Some dry chem. are slightly corrosive to surfaces. (3) Large amounts of dry chem., which are costly, would be required to completely fill the SFP. | Additional investigations into this alternative are not considered to be technically viable. |
| Inert Gas - Argon | (1) "Gas blanketing," effectively controls zirconium fires if all air can be excluded from area of application. | (1) Beyond design basis seismic event will crack SFP liner and allow fresh air to enter into the pool from below. | (1) Additional investigations into this alternative are not considered to be technically viable. |

| **Available Extinguishing Methods** | **Pros** | **Cons** | **Recommendations or Cost Benefit Results** |
|---|---|---|---|
| Install Seismic Cat. 1 Safety Grade Water Spray System (NUREG -5281 [2] and 1353 [3]) | (1) Pool spray decontaminates the radiological release.<br>(2) Reduction in offsite consequences.<br>(3) Lower consequences of a spent fuel accident. | (1) Oxidation could be aggravated by slow spray actuation. Considered beyond the scope of report.<br>(2) System would not withstand a beyond design basis seismic event.<br>(3) Require new equipment or modify existing safety system for SFP.<br>(4) No available water source for seismic. | (1) Hardware: 1.2 million/per SFP 1988 [4].<br>(2) Best estimate value/impact ratio: $3,340 per averted / person-rem (exceeds limit) |
| *Cover Spent Fuel Debris with Solid Material - Sand, clay, dolomite, boron compounds, lead, etc... (NUREG - 1353) | (1) Reduces radiological releases from SFP.<br><br>(2) Covers debris if zirc fire progressed to melting, relocation, and rubble bed. | (1) Transportation of materials in time to reduce radiological pool releases is highly unlikely. (Based on ad hoc measures)<br>(2) Materials would not be stored onsite. | (1) Cost not explicitly quantified.<br>(2) A generic contingency plan was not cost-effective for an operating plant, but could be considered for a decommissioned plant with no or reduced EP. |
| Ventilation Gas Treatment System (NUREG - 1353) | (1) Ventilation & filter system capable of reducing airborne radioactivity concentration before discharge. | (1) SF building ventilation could not cope with a beyond design basis earthquake. The same earthquake that cracks the SFP would destroy the system. | (1) Cost not explicitly quantified.<br>(2)Additional investigations into this alternative are not considered to be technically viable. |

[2] Jo, J.H., et. Al., "Value/Impact Analyses of Accident Preventative and Mitigative Options for Spent Fuel Pools", NUREG/CR-5281 (BNL-NUREG-5281), March 1989.

[3] Throm, E.D., "Regulatory Analysis for the Resolution of Generic Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools", NUREG-1353, April 1989.

[4] NUREG 1353, Page 5-17, "Costs of Installing Spray Systems": Category I tank of 200,000 capacity, a spray system, pumps, spray nozzles, and associated hardware. NRC review of effort per pool and TS development/approval costs at an additional 100,000 per staff-year. (1988 dollars)

Staff Recommendations:

(1) Do nothing initially for mitigative actions. In line with our staff recommendations, just focus on increasing preventative measures for heavy loads and seismic.

(2) For those plants that are identified as being vulnerable due to heavy load concerns or seismic concerns, perhaps look further into:

(A) The development of a generic contingency plan that would allow these plants to state that if an unrecoverable SFP draindown occurred, they have a plan which would ship in materials to cover the SFP in a reasonable amount of time before radiation release or before oxidation occurs. The plan could include storage of the materials, the transportation and time it takes to transport materials to the affected site, costs, etc..

(B) The other option would be to have them modify an existing SR train for SFP use. However, this system would not be guaranteed to survive a beyond design basis earthquake and then you have problems again with guaranteeing a water source is available.