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To: E. P. Lee

From: W. K. Woods

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of _____

THIRD SAFETY CONSIDERATIONS

The present liquid third safety is considered undesirable for the piles at their present power levels. Any increase in power level and graphite temperature makes the need for an alternative third safety increasingly imperative.

The use of the third safety is envisioned under conditions where the supply of cooling water to an operating pile is interrupted and concurrently the safety rods fail to enter the pile because of slight shifting of the top shield or larger shifting of the winches, relative to the pile proper. Under these conditions, the following undesirable properties of a liquid third safety are present:

- (1) There is no assurance that the volatile liquid will enter the thimbles at a sufficiently rapid rate to shut down the pile, because of flashing of the initial amount of liquid entering the thimbles.
- (2) Vapor formation may build up pressures sufficiently high to rupture a thimble especially if the thimble has been weakened by creep, corrosion, or rod abrasion. Flow of liquid into the pile would then permanently poison the pile and make it inoperable.
- (3) Even if the pile were brought under control the effect would only be temporary, for heat from the residual radioactivity of the uncooled slugs and the sensible heat of the graphite would boil the solution from the thimbles.
- (4) The risk involved in item (2) is so tremendous that unusual precautions must be taken to preclude admission of the third safety except under conditions of extreme emergency; those precautions in themselves may prevent sufficiently rapid admission of the third safety if the emergency really exists.

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The Pile Technology Division is working on the development of a ball-third safety which could be adapted to the present piles and which would be free of the above disadvantages. The current development status of the ball third safety is described in the attached appendix.

With provision of a satisfactory ball third safety, further increases in graphite temperature and in associated power level could be attempted with much greater safety. However, it is not known how much the temperature of the graphite can be increased before serious chemical reaction between the graphite and the pile atmosphere will be encountered; it is possible, although improbable, that such adverse effects may result after an increase of only 10% in present central graphite temperature (as measured above inlet water temperature).

An additional barrier to higher power levels results from the lack of knowledge regarding the reactivity effects which will be encountered as an uncooled shut-down pile is heated by the residual radioactivity of the fission products. If this gain in reactivity is too great, and if it is postulated that the changing face of the pile may be inaccessible for many hours, it may be advisable to compensate by operating at lower power levels in order to restrict the reactivity gain which follows decay of the xenon. It is expected that further information on this point can be developed during start-up of the DR Pile.

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APPENDIX

PRESENT STATUS OF THIMBLE REMOVAL PROGRAM

- Reference doc: (1) HW-15221 "Preliminary Survey of Safety Rod Thimble Elimination" 2/15/50 by W. K. Alexander
- (2) HW-17592 "Progress Report Number 1 - Thimble Removal Program" 4/21/50 by W. K. Alexander, et.al.
- (3) HW-17246 "Calculations of Reactivity Effects of Falling Balls"
- (4) HW-17678 "P.T.-105-338-P - Pile Test of Special Stepped Plug and Gas Seal" by W. K. Alexander

References (1) and (2) give a good description of the proposed design of the ball system together with a summary of the tests conducted up to their date of issue.

The essential features of the method which at the present time appears most feasible are:

1. Removal of the present VER thimbles, stepped plugs and rod guides.
2. Replacement of present rod ends and tips with gas tight pieces.
3. Reaming of the top six inches of the graphite hole to a slight taper.
4. Replacement of the present stepped plugs with ones having special flutes and solenoid gates.
5. Removal of the present XX system and installation of individual hoppers at each rod for the balls.
6. Installation of gas seals on the rods just above the stepped plug.
7. Blocking the bottom of the graphite hole with lead wool so that the balls cannot escape into the drain slots.
8. Provision of equipment to remove the balls from the pile and to check for "lost" balls.

Present Status

Gas Seal

A satisfactory gas seal has been developed and tested on the DR Pile. The use of this seal requires that the rods be sealed internally and have a smooth continuous cylindrical surface at the position of the gas seal in both the "in" and "out" position.

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Dropping Balls into the Pile

A number of ball flow tests conducted in mock-ups under various conditions have demonstrated that a control power equivalent to 75% of the vertical rods can be obtained two seconds after trip with the proposed design.

One E, D, F type stepped plug has been built and is now being tested in a mock-up. Installation of this stepped plug in the D Pile is planned for about September 1 under P.T.-105-338-P. The initial phase of this test will demonstrate the gas seal, radiation shielding, and rod operation.

The installation will require thimble removal, reaming of the top six inches of graphite, plugging of the drain hole and replacement of the present rod end and tip with gas tight pieces. The reamer has been built and will be tried in a mock-up during the next two weeks. This reaming of the top six inches is advisable because tests indicated a 20% reduction in flow rate if the 1/4 inch shoulder between the 4 1/2 inch hole in the cast iron and the 4 inch hole in the graphite is not removed. A tamper is now being built for use in plugging the drain in the bottom of the vertical hole with lead rope.

At the present time the problem of dropping the balls into the pile appears to be straight forward.

Removal of Balls

Mock-up tests have demonstrated that the balls can be removed by an industrial vacuum cleaner provided they do not become lodged in cracks in the pile.

At the present time the major problem which has not been solved appears to be the problem of removing balls which might become lodged in the spaces between the vertical blocks lining the holes in the B, D and F Piles. The loss in reactivity from such balls depends on whether or not the balls melt and distribute the boron over a large area. A production test has been submitted for approval to determine by "in-pile" tests whether or not the balls will melt. The Instrument Development Group is working on a "mine detector" to locate "lost" balls. Special tools are being designed to remove any balls which become lodged. A satisfactory solution to this problem cannot be scheduled; the present effort is directed towards having a solution demonstrated by November 1 when delivery of the boron steel balls is expected.

This problem is not present in the DR and H Piles because there are no vertical liner blocks in the graphite holes.

DR and H Piles

All development work has been directed towards the B, D and F Piles. Although a large part of the work will also apply to the DR and H Piles the detailed design of the stepped plug will be different because of the three inch rods.

At the present time consideration is being given to the advisability of conducting tests on one rod at DR or H Pile concurrently with the tests planned for F Pile.

W. R. Lewis
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