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RELEASE OF FISSION GASES FROM THE
AE-6 REACTOR ON MARCH 25, 1959 *

by

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* Based on an IOL by G. L. Blackshaw dated April 1, 1959

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On March 25, 1959, a release of fission gases during a pressure pumpdown of the AE-6 Reactor core caused slight contamination of the reactor room and several members of the operating staff. What follows is a description of normal core pumping procedures, how these procedures were altered during the incident, the discovery of the contamination, its possible causes, and the remedial actions taken. At the end of the report are listed some steps to be taken which will minimize the chance of occurrence of such contamination hazards in the future.

1. Normal Pumping Procedure

The accompanying diagram shows the system involved in the pumping procedure. Valves (1), (2), (3), and (4) are permanently attached valves in the system. Valve (5) is a permanent fixture on the exhaust tank. The piping connecting various components of the system consists of 3/8" I.D. copper tubing. In this line are combinations of both soldered and flared connections and fittings.

When steady running causes the core gas pressure to rise to 20 cm Hg, the permitted upper limit, and 12 hours of recombination does not restore the pressure to an operable value, then the core is pumped down. The shielding on the north side of the reactor, consisting of a double layer of concrete blocks, is removed. An exhaust

tank which has been previously evacuated through the KEWB stack is attached as shown. The vacuum pump is turned on and with valves (1) and (2) remaining closed, valves (3), (4), and (5) are opened. This evacuates the system beyond valve (2) to a pressure of approximately 1 cm Hg absolute. This pressure reduction of the exhaust tank and system beyond valve (2) enables the core to reach a lower equilibrium pressure with the exhaust tank. The core pressure reduction process is done at lengthy enough intervals so that all fission gases which may be present in the external system and tank have decayed sufficiently so as not to be a contamination hazard. After a 1 cm pressure is attained, valve (4) is closed, the pump shut off, and valves (1) and (2) opened. When equilibrium is reached, valves (1), (2), (3), and (5) are closed in that order, the exhaust tank is removed, and the gas evacuated through the KEWB stack. A second exhaust tank, which has been evacuated through the KEWB stack just prior to use, is then attached to the system. With valve (4) remaining closed, valves (5), (3), (2), and (1) are opened in that order. This is done to further reduce the core pressure, if required. If the pressure is sufficiently low after one pumpdown, then after the second tank is attached, only valves (5) and (3) in that order are opened. This clears the lines between the valves (2) and (4) of active fission gases. If the second tank is used to

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further reduce the core pressure, then a 3rd tank is used to clear the lines. A pressure pumpdown of the core is usually done only after the reactor has been shut down for at least 12 hours. This greatly reduces the radiation field of fission gases in the recombiner.

2. Pumpdown on March 25

Prior to pumping down the core, the reactor had been run for one minute at 0745. Because of faulty operation of the recorder of the logarithmic amplifier, the reactor was inadvertantly operated at 4 kw. This lasted for only one minute, however, when the core pressure built up sufficiently to scram the reactor. The only factor that influenced the release of radioactivity in the afternoon was the fact that the reactor had been run in the morning. Its operation for a short period above the 2 kw limit is not of importance in considering the radioactive release since the run amounted to, at most, 0.1 kw hour. A usual run on the reactor uses somewhat more than this amount of energy.

To meet the run schedule, it was decided that if the pressure did not return to 16 cm Hg absolute by 1200, the pressure would be reduced by the procedure described above. At 0900 the shielding was removed. The B - γ radiation field 6" from the recombiner was about 25 R. Upon consulting with Health Physics, it was determined that personnel could work in the recombiner area for purposes of

carrying out the pumping procedure when the radiation field 6" from the recombiner had diminished to 5 R. Since the Jordan meter on the north wall of the reactor room had read 7.5 mr/hr at 0900 when the shielding was removed, the room was closed to all personnel except for very brief instances. At 1145 it was considered safe to work. Due to the 25 R field in the immediate vicinity of the recombiner (as compared to the usual value of 100-200 mr after an overnight wait), only 8 shielding blocks had been removed instead of the usual 16. This made it difficult to reach the exhaust tank in its usual position in a wooden container next to the reflector. The tank was laid, instead, on a shielding block approximately 3' north of its normal position and half-way through the gap in the shielding wall. The tank was connected and the normal procedure initiated in evacuating it and the system beyond valve (2). With the pressure at less than 1 cm, valve (4) was closed but the pump was not turned off. Valves (1) and (2) were opened and the core pressure dropped steadily to from 19 cm to 1.8 cm. During this time, the indicator for the Jordan on the north wall of the reactor room rose to from 7.5 mr to 13 mr. This, however, was attributed to the exhaust tank being nearer to the outer section of shielding. A drop from 19 cm to 1.8 cm exceeded a normal drop for the first tank; however,

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a pressure of less than 1 cm in the system beyond valve (2) obtained during the beginning of the pump-down was unusually low so the final equilibrium pressure did not seem low at the time. Because of the radiation intensity, it was decided to use only one tank and, thus, limit the working time in the recombiner area. Gloves were worn by all personnel during the pumping procedure. At the conclusion of the pumpdown, the replacement of the shielding was begun.

However, because of the heavy concrete dust in the region of the recombiner and because personnel were not, at this time, using gloves in replacing the shielding blocks, it was decided to check the cement dust on hands and clothing by means of a survey meter at the KEWB. G. L. Blackshaw initially was checked over and found to have contamination on the face, hands and clothing of intensity 1.5 to 2.0 mr. Subsequent checks made on D. J. Miller, G. Schumann, and R. K. Paschall showed similar results. The affected personnel donned redlines and proceeded to the ETB to shower. The reactor building was locked and access to the AE-6 - KEWB area closed off. KEWB personnel proceeded to the KEWB reactor area. The S.S. Control Center was notified of the incident. An air sampler was set up in the reactor room by Health Physics. Also, various smear tests were taken in the AE-6 Control Room and outside the building. The air sample showed rather

heavy air contamination in the reactor room; however, the smear tests elsewhere showed negative. Further surveys, urinalyses, and exhalation tests showed that all personnel contamination was removed by showering. Also, the intensity of the clothing contamination fell below tolerance several hours after the incident. The air sampler also showed a great reduction of air contamination in the reactor room during this period. At approximately 1330, the doors to the reactor room were opened to facilitate the removal of contamination inside the shielding by increasing the air circulation. At 1630, the AE-6 reactor room was sufficiently clear of contamination to permit re-entry. A sample of vacuum pump oil (from the pump inside the shield) was taken and a smear test made on it. A count rate of 111,000 c.p.m. was registered at 1630; however, at 0800 on March 26, the c.p.m. was 500. This indicated the presence of short-half lived fission products in the pump oil. At 0830 on March 26, the shielding was replaced and the AE-6 resumed normal operations.

Several factors give evidence that fission gases were drawn directly from the core and recombiner through the pump exhaust and released to the outside air: (1) the pump was left running during the time when valves (1) and (2) were open. (2) The rapidly decaying oil sample indicating the presence of short half-lived fission

products in the pump oil. (3) The abnormally low equilibrium pressure after the core was connected to the exhaust tank. (4) The rise in radiation level as indicated by the Jordan meter during the core gas evacuation into the exhaust tank. At first this was attributed to the new positioning of the exhaust tank; however, a survey of the exhaust tank soon after pump-down indicated a β, γ level of only 20 mr. The Jordan Chamber, which was over 15' from the tank in the reactor room and partially shielded from it, read 13 mr.

It is not likely that such a degree of contamination could be caused by some fission gases which naturally escape from the 8" length of 3/8" copper tubing between valves (4) and (5) when the tank is removed. Also, although the system may have leaks at the valve joints, valve packings or soldered joints and elbows, fission gases could not be released through these places to the air when the system is below atmospheric pressure.

If valve (4) were leaky or not tightly shut during the period when valves (1) and (2) were open, the release of active gas could occur and this is probably what happened. A valve check was made after re-entry and all valves were found to be closed tight.

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3. Proposed Action

The following steps will be taken to lessen the chances of such a contamination incident occurring in the future.

- a. The present external gas system will be replaced by one that has fewer joints, eliminates the cold traps, and has high quality valves more conveniently arranged.
- b. A pumpdown procedure will not be started unless the radiation level 6" from the recombiner is less than 300 mr.
- c. A pumpdown procedure will not be started sooner than 15 hours after the last reactor operation.
- d. Protective clothing is to be worn during the pumpdown procedure.
- e. Radiation monitoring during the procedure will be done with an air sampler, a Jordan Chamber, and a Juno hand monitor.
- f. A written procedure will be prepared so that all AE-6 reactor operators will become familiar with it.

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