Mitigation of the Effects of the U1 Steam Leak on U2 Outage & Turbine Building Operations

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Abstract

In early April 1999, Brunswick U2 was in a refueling outage. On April 19, 1999 a severe steam leak occurred and caused the airborne activity levels to increase substantially. Increasing iodine levels in the Turbine Building as a result of the steam leak, coupled with the residual affects of a prior fuel leak in U1 (at 100% power), created very undesirable conditions. The elevated activity levels resulted in substantial delays for personnel working in the Turbine Building when they exited the protected area. The increase in exposure and the negative impact on the outage schedule was unacceptable.

After reviewing the problem, I determined that if the effluent from the steam leak could be diverted to the swamp cooler room (spray wash system in the Turbine Building Supply Fan Room) the spray would remove iodine and other isotopes from the supply air going to the Turbine Building. This would reduce the airborne activity level and result in reduced time for workers leaving the protected area.

The activity levels in the air decreased and increased in the water in the swamp cooler basin as expected. This resulted in a substantial improvement in the offgas levels. It was stated in Steve Taylors "Outage Update Report" to E&RC on April 25, 1999, "Offgas Mitigation: The U/1 steam leak under the Main Turbine has been successfully diverted into the ventilation system. There has been a very noticeable improvement resulting from this effort. "

Introduction

BWR Fuel Leakage

The Brunswick Nuclear Plant has periodically experienced fuel leaks in both reactors. Leaks have resulted from foreign material in the core. Small metal shavings which had become lodged against fuel rods and, as a result of normal cooling flow past these shavings a fretting action causes perforations in the fuel cladding. Fission products are released to the coolant. Small quantities of coolant are released into the Turbine Building. This raises the airborne activity levels. Even after the leaking fuel bundle is replaced, the airborne activity continues from the tramp uranium that is left behind from the fuel leak. The radioactive material referred to as tramp uranium releases iodine and noble gases for several fuel cycles after the leaking bundle has been removed from the core.

Steam Leak

The steam leak that developed was located in the first stages of the high pressure turbine. There is a very short duration between the time that the steam leaves the reactor and is released under the first stage of the high pressure turbine. The initial effort focused upon attempting to perform a temporary leak repair to eliminate the problem. The leak was initially thought to be coming from a flange connection on the bottom of the turbine. Attempts made to determine exact location and extent of the leak were unsuccessful due to the large amount of condensing steam in the area as well as the high radiation levels. After the turbine was shut down for a refueling outage early in 2000, the source of the leak was determined to be a ½ inch diameter pipe which was for an instrument tap. The pipe cap on the instrument tap had dislodged during normal operations and allowed high pressure steam to leak.

Development of the Concept to Use the Normal Ventilation System to Remove Radioactive Isotopes

There were several considerations for eliminating or mitigating the steam leak. The first was to perform a temporary leak repair. The second was to use a portable HEPA unit. The third was to attempt to adjust the ventilation system to contain the steam leak in the portion of the turbine building away from the outage work area. The final consideration was for the diversion of the steam leak into the turbine building ventilation system which contained an evaporative cooler.

Initial inspections were conducted to assess the leak and determine how to implement a temporary leak repair. Radiation levels under the high pressure stages of the turbine were prohibitively high. In addition the condensing steam made it virtually impossible to visually determine the exact location of the leak. This option was quickly eliminated as impractical.

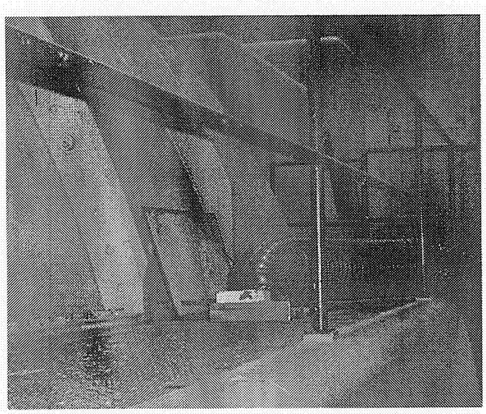
A HEPA unit was considered. It was eliminated as a possible method for mitigating the leak since there was such a high volume of moisture from the condensing steam.

BNP is a two-unit plant. The turbine for each unit is housed is a common building. It was hypothesized that the steam leak might be mitigated if the ventilation system could be balanced in such a manner as to create a lower pressure at the end of the building that housed the U1 turbine. The expectation was that the lower pressure would partially contain the effluent at that end of the turbine building. The ventilation system was operated with two exhaust fans (93,000 scfm each) operating on the U2 end of the turbine building and three exhaust fans (93,000 scfm each) operating on the U1 end of the turbine building. This operating arrangement did not measurably improve conditions and was abandoned.

The technique to divert the steam leak into the Turbine Building ventilation system was conceived based upon knowledge obtained from emergency preparedness training in severe accident mitigation. When there is a core melt condition, the use of containment sprays is recommended. It was reasoned that if the steam leak could be diverted into the Turbine Building ventilation system, the evaporative cooler (spray wash system) would scrub out a portion of the airborne isotopes. This technique was applied with good success.

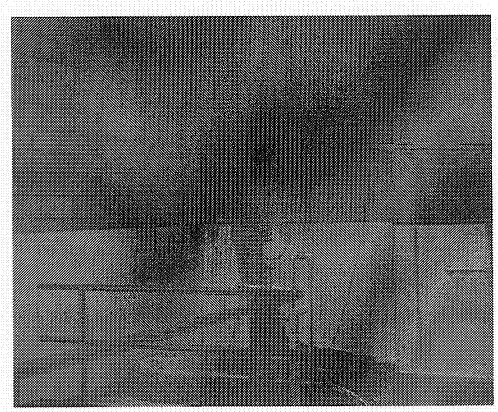
Design Considerations

The objective was to direct as much of the steam leak from under the high pressure turbine into the return air register for the Turbine Building exhaust fan plenum. HEPA hose was used for the temporary ducting. To improve the flow a 3000 cfm smoke removal fan was located a short distance from the return air register (see figure 4). A flanged adapter was fabricated to attach the ducting hose to the intake register. A sheet metal funnel- shaped adapter was fabricated and attached to the end of the HEPA located under the turbine to facilitate drawing as much of the condensing steam as possible. The following series of photographs illustrate the arrangement.



Outlet point from under U1 Turbine

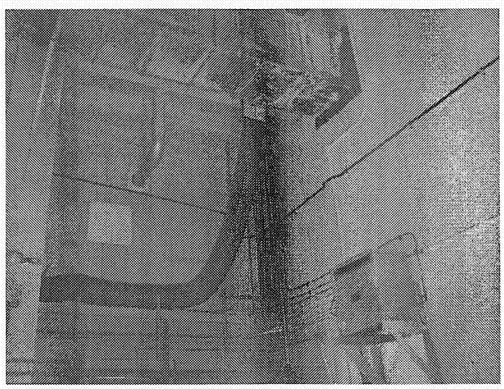
Figure 1

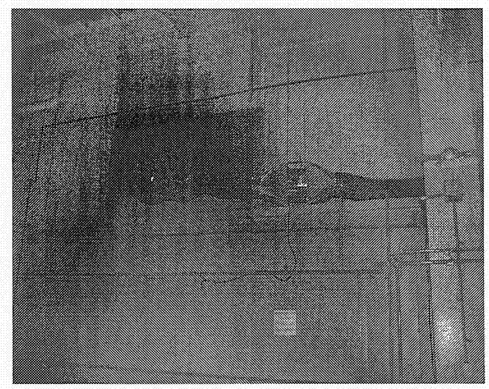


HEPA hose routed over the shield wall

Figure 2

A leak-off line for condensate was added between the outlet from under the turbine and where the hose goes over the shield wall. When the hose became blocked with condensate, the activity levels rose quickly in the turbine building.





Portion of HEPA hose coming over shield wall from under the turbine

Figure 3

Blower and inlet to the exhaust fan room

Figure 4

Once the effluent was routed into the ventilation system it passed through the spray cooler arrangement illustrated below. The spray manifold consists of a four sections containing 6 two inch diameter pipes with 96 nozzles. The flow rate through this spray system is approximately 2000 gpm.

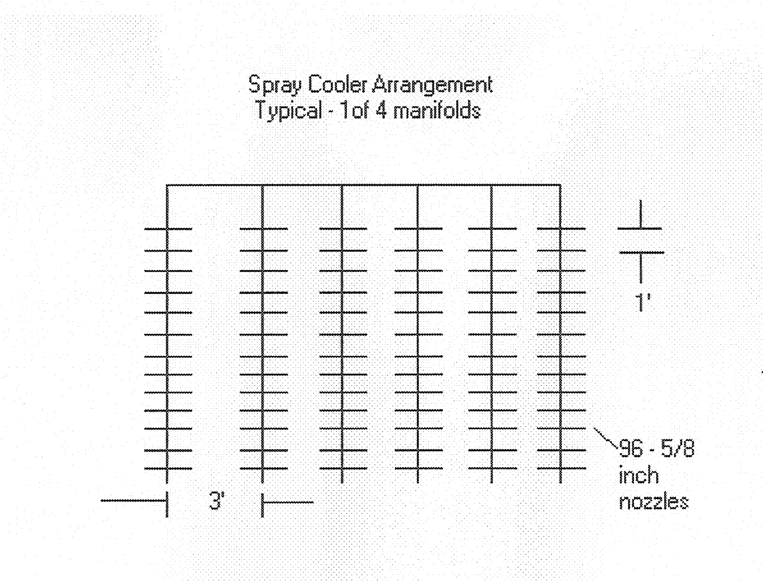


Figure 5

Implementation and Results

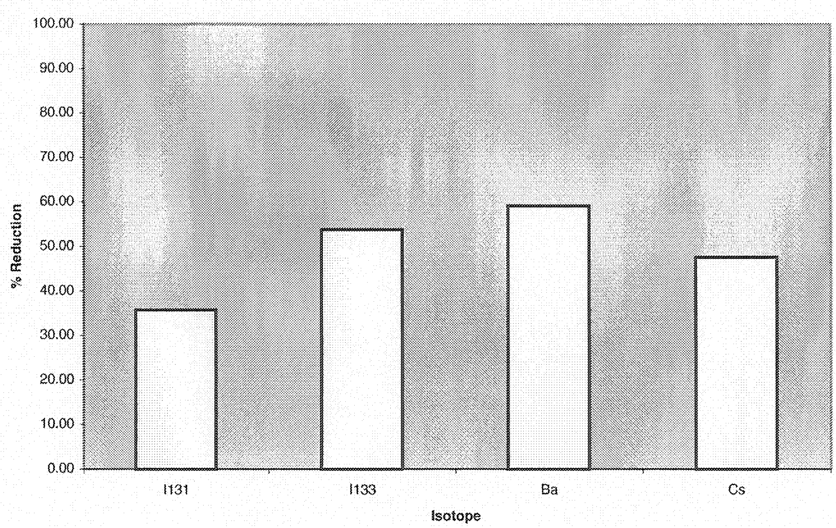
The impact of the diverting the steam leak into the return ventilation system was immediate. Activity levels were reduced as follows:

Isotope	Activity after Steam Leak-Curies	Activity Trend after Diversion - Curies
I131	5.04E-11	3.24E-11
I133	6.40E-10	2.96E-10
Ba	5.43E-12	2.22E-12
Cs	6.07E-09	3.19E-09

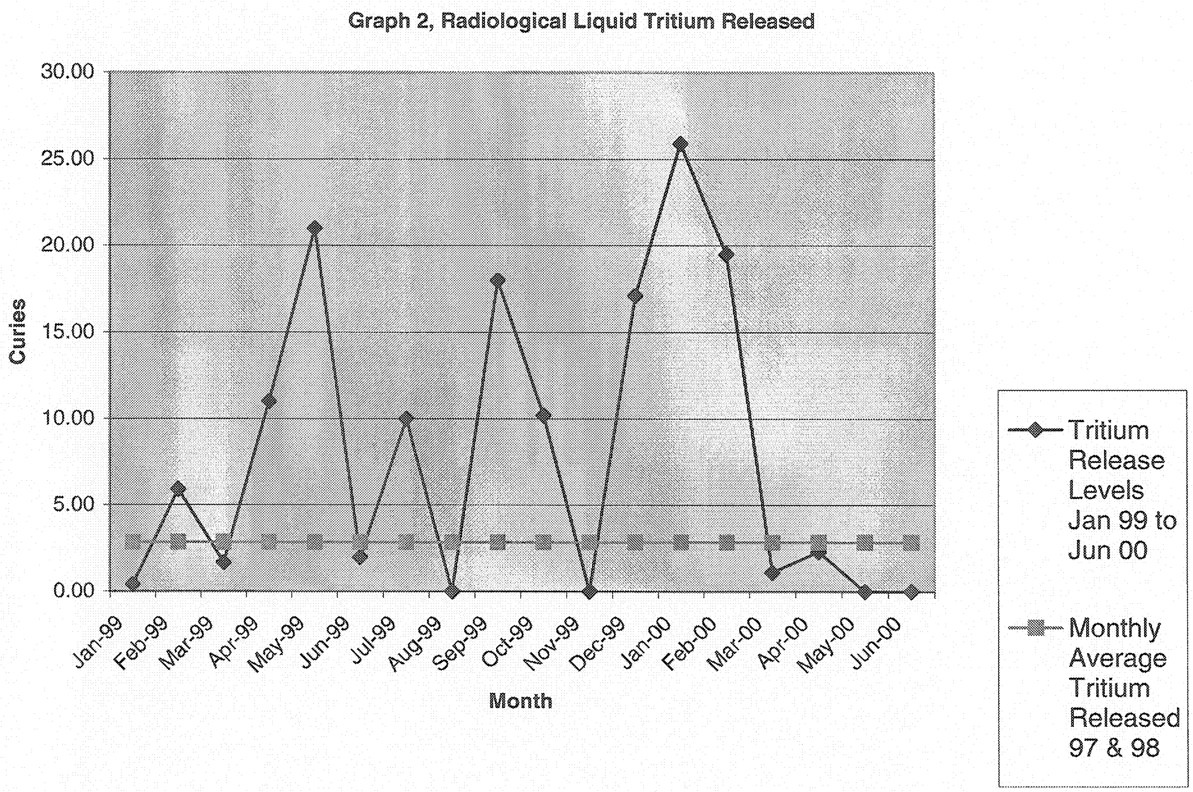
Table 1, Reduction in Activity

As can be seen in the following graph, there was a significant reduction in airborne activity. Depending on the isotope, the reduction was between 35% and 60%.

Graph 1, Reduction in Airborne Activity



Another indication of the affect of the scrubbing by the spray wash sub-system of the Turbine Building ventilation system was the increase in the level of tritium being released from the plant. As part of the ventilation system, water that overflows from the chill water basin is routed to a holding pond. It is sampled and then released in the discharge canal for the condenser cooling water. The average liquid tritium released for 1997 and 1998 was 2.3 curies per month. The level increased to approximately an average of 10 curies per month. There are large swings in the amount of radiological tritium released in a given month because it is controlled based upon the activity level in the holding pond and the level of the pond.



In conclusion, the high airborne activity level was substantially reduced by diverting the steam leak into the spray wash system of the Turbine Building ventilation system. The benefit of using water sprays to control air borne activity has been demonstrated by the implementation of this steam leak diversion technique. The effort to control steam leaks at the Brunswick Nuclear Plant is to repair the leak. If that is not possible, this technique for diverting steam leaks into the Turbine Building ventilation system is now an abnormal procedure that may be applied to mitigating the affects of steam leaks until a permanent repair can be implemented.