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THE DESIGN, TEST AND USE OF THE BROOKHAVEN NATIONAL LABORATORY (BNL) REACTOR BYPASS FILTER FACILITY*

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ABSTRACT

The purpose of the BNL Reactor Bypass Filter Facility is to provide improved air cleaning in the event of a fuel element failure at either the Brookhaven Graphite Research Reactor (BGRR) or the High Flux Beam Reactor (HFBR). It also provides sufficient air cleaning to allow the use of air cooling as a method of combating a graphite fire at the BGRR. For normal BGRR cooling, approximately 365,000 ft^3/min. is required. Although the filters provided are sufficient for normal operation, additional cleaning is required for fuel rupture and graphite fire situations. This system was therefore designed to accommodate 100,000 ft^3/min. with high filtering efficiency under emergency conditions.

The bypass filter facility contains ninety-six 24 in. x 24 in. x 11.5 in. absolute filters backed by a like number of activated charcoal filters. Each filter combination has a capacity of 1,000 ft^3/min. at a face velocity of 70 ft/min. with a pressure drop of less than 1 in. of water. Under normal operation the facility is closed off so that the cooling air passes directly to the stack. A description of the valving design and procedures will be presented.

Each filter unit was tested for both particulate efficiency and iodine retention. The particle efficiency test used DOP smoke and the iodine test was made using ^{128}I vapor. In-place tests were conducted using DOP and the radioactive effluent from the BGRR during a graphite annealing run. All tests showed the facility to be over 99.98% efficient for particle removal while at the same time removing 99.9% of the detectable iodine vapors.

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DISCLAIMER

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Introduction

The purpose of the Brookhaven National Laboratory's Reactor Bypass Filter Facility is to provide improved air cleaning in the event of a fuel element failure at either the Brookhaven Graphite Research Reactor (BGRR) or the High Flux Beam Reactor (HFBR). It also provides sufficient air cleaning to allow the use of air cooling as a method of combating a graphite fire in case one should occur at the BGRR.

The BGRR is an air cooled, graphite moderated, enriched uranium fueled research reactor. The reactor core consists of a graphite cube 25 ft. on a side constructed from over 60,000 individual pieces of graphite. The fuel elements each contain 15 grams of 93% enriched uranium. The fissionable material is a uranium-aluminum alloy slab covered on the top and bottom by aluminum sheets at least 20 mils thick with the edges welded all around. The reactor is cooled by air drawn through the core by three 1,000 hp. fans. The air is precleaned by glass fiber filters before passing through the core. The exit air then passes through deep pocket woven-glass fiber filters whose efficiency is only 80% for particulates in the 0.3 micron range and is released at the top of a 320 ft. stack.

Under normal conditions the present air cleaning is satisfactory. Although small amounts of radioactive contamination are generated in the cooling air by activation of impurities in the air, the levels produced fall well below the Radiation Protection Guides for both occupational and non-occupational situations. Extensive on and off-site monitoring programs at BNL indicated that about 25 curies of short half life particulate activity and 130 millicuries of ^{131}I are released per month from the reactor stack. Off-site environmental surveys[1] show that even under the worst meteorological conditions these releases will remain well below the Radiation Protection Guides.

Possible Reactor Accidents

Although the normal release of radioactive material to the environment is very low, an analysis of maximum possible reactor accidents indicates the need for improved reactor air cleaning. A study conducted at BNL[2] postulated an accident which could involve a meltdown of up to four fuel elements and which could release as much as 400 curies of ^{131}I. Against assuming the worst possible meteorological conditions and assuming that no countermeasures were taken, this could conceivably result in a thyroid dose to humans in excess of 200 rads. Although countermeasures such as withholding milk from the public, selected temporary evacuation, etc., are planned, it was felt that an improved air cleaning capability was appropriate for upgrading control of airborne contamination.

A second possible accident involving the release of large amounts of radioactive materials is a graphite fire in the reactor core. Emergency procedures and equipment have been provided for shutting down the fans, blocking the graphite openings, and introducing carbon dioxide within the confined area[3]. Graphite oxidation and heat transfer studies conducted by the BNL Metallurgy Division have indicated that the most effective means of combating a graphite fire is by cooling the graphite with air[4]. Since the air can now be cleaned, air cooling of the graphite can be used as an emergency procedure for combating a graphite fire.

The second BNL reactor connected to the Bypass Filter Facility, the HFBR, is a D_2O cooled and moderated, enriched uranium fueled research reactor. As with the BGRR ordinary air cleaning is satisfactory under normal operating conditions. The building exhaust, 12,000 ft^3/min., comes mainly from the building air with smaller amounts from hoods, experimental facilities and process off-gas lines. The reactor itself is not connected to the building air exhaust except through a system which, during reactor depressurization, releases off-gases through two charcoal iodine filters to the building exhaust system. The building exhaust passes through a bank of absolute filters, silver-plated copper mesh iodine filters, and then up the reactor stack.

As with the BGRR, a review of potential accidents indicates that improved air cleaning would be beneficial. The maximum credible accident taken from the HFBR Safety Analysis Report[5], indicates that here too thyroid exposures in excess of 200 rad are possible. Again this assumes all equipment and procedures malfunction, no countermeasures are taken and the worst meteorological conditions prevail. Since these possibilities for accidents do exist, although the chance of their occuring seems very small, it is only prudent to improve the air cleaning capability in the event of a fission product release from either the BGRR or the HFBR.

Construction

The Bypass Filter Facility is located below ground to the east of the fan house, parallel to the BGRR air discharge duct (see Fig. 1). It is approximately equidistant from both reactors and next to the reactor stack. The building is constructed of reinforced concrete with a minimum wall thickness of 12 in. The roof is constructed of reinforced concrete with six removable covers over the filter racks. Access ports were provided to the filter area and all valves. Prefilter and postfilter sampling ports were installed in the system to facilitate the testing program.

The filter racks consist of ninety-six 24 in. x 24 in. x 11.5 in. absolute filters backed by a like number of activated charcoal filters. The facility is designed to filter approximately 100,000 ft^3/min., thus each filter combination has a capacity of 1,000 ft^3/min. The face velocity at each filter is 70 ft./min. with a pressure drop of less than 1 in. of water.

The absolute filters use cadmium-plated carbon steel frames bolted together with glass fiber membrane filter media. The carbon steel frames were used instead of wood frames for greater fire protection and to lower the cost of decontamination and waste disposal of the filter units if they become highly contaminated. The filters are of non-combustible material and were designed to withstand a surface pressure of 6 in. of water, and 75% relative humidity. All filter units are gasketed against steel framing, using a silicone rubber sealant. The charcoal filters for removing iodine are flow rated the same as the absolute filters and the filter medium is a hard, activated cocoanut shell carbon in natural grain form. The grain size distribution is from 0.039 in. to 0.131 in. with packing such that there are no straight-through holes. The frames are also cadmium-plated carbon steel with silicone rubber gaskets.

Construction of the facility presented no unusual problems although special care was taken during the installation of the filters themselves. Previous communications[6] have indicated that improper installation and filter damage during installation are the two important reasons for poor efficiency of a filter system. Therefore, each set of filters was set in place, individually tightened and visually inspected for damage. Only two filters showed visible damage after installation and these were removed, retested, and replaced.

Operation

The downstream duct (see Fig. 2) of the facility is connected to the reactor stack by means of an air expansion joint. The upstream BGRR connection is joined to a 48 in. diameter discharge pipe from the Number 5 BGRR cooling fan. The upstream HFBR connection is joined to a 30 in. diameter inlet air duct from the HFBR building exhaust line. Quick opening butterfly valves are installed at all connections.

During normal conditions valves Number 1 through 4, as seen in Fig.2, are closed and Number 5 is open. The Number 5 cooling fan is not operated at this time, the exhaust air from the BGRR passes through fans Number 1, 2 and 3. To filter the BGRR effluent valves Number 1 and 4 are closed, Number 5, 2 and 3 are open. Reactor cooling fans Number 1, 2 and 3 are turned off and Number 5 is turned on. To filter the HFBR effluent valves Number 1, 2 and 5 are closed and Number 3 and 4 are open. Reactor cooling fan Number 5 is turned off.

Filter Testing Program

A filter testing program was initiated to accomplish three purposes. First, the filters were to be individually tested by the manufacturer and by BNL after delivery to assure that all filters met specifications and that no damage was done in shipment. After installation any filters showing signs of physical damage were to be retested and replaced if necessary. Second, the filters were to be tested in place periodically, to assure that the initial installation was satisfactory and to assure continued satisfactory system performance. Finally, from the above tests the efficiency of the system was determined to assist in emergency planning.

The manufacturer's test, to meet AEC specifications for filter efficiency, used standard DOP test aerosol methods, and the test for the activated carbon filters used chemical methods. Upon arrival at BNL, approximately 10% of the filters were tested using the equipment pictured in Fig. 3. Test methods and equipment are similar to those reported in previous Air Cleaning Conferences. The filters were placed in the system with special care to assure no leakage around the gaskets. Smoke was generated using BNL-fabricated Model II NRL-type DOP smoke generators. Baffle plates were installed in the system to assure complete mixing of the smoke, and sample ports were located to allow sampling over any portion of the filter. The smoke was drawn through the filter using a 1,000 ft^3/min. blower fan. Finally the smoke was measured using an aerosol photometer. All filters tested were 99.98% efficient or better.

Approximately 10% of the charcoal filters were tested using the same test stand. After the filter was in place one-half gram of stable iodine was irradiated in the BGRR pneumatic tube facility. The resultant ^{128}I was vaporized in the filter test stand using the same mixing conditions used during the DOP test. Prefilter and postfilter samples were taken by drawing 1 ft^3/min. through two small charcoal traps. These traps were then counted on a 100 channel analyzer and the relative sizes of the 0.45 MeV ^{128}I peaks were compared. The results in all cases showed 99.9% of the detectable iodine vapors were removed. It is recognized that some small error is introduced by using a sample collection medium that is the same as the filter medium. The tests did, however, prove the filters were uniformly good with no leaks and will be used as a basis for comparison with future tests. It is also interesting to note that several silver-plated copper mesh filters of the same size, which are also used at other installations at BNL for removing iodine, were tested using the same procedure. The results indicated only 94% to 97% removal of the detectable iodine vapors .

After installation the filter system was tested for the removal of particulates and iodine vapor. This test was conducted during a BGRR annealing run. The purpose of these runs is to heat up the reactor and cause a controlled release of Wigner energy[7]. To do this the air cooling on the reactor is cut back and valved through the bypass filters. During these runs approximately 100 millicuries of particulate contamination and radioactive iodine vapors are produced in the air stream. Although these amounts are small, they were large enough to be used to test the filters. Prefilter and postfilter samples were drawn through a Millipore absolute filter and a charcoal trap at a rate of 1 ft^3/min. The samples were then counted and compared. The results showed greater than 99.98% removal of the detectable particulate contamination and 99.9% of the radioactive iodine vapors.

Summary

Although the facility has been in operation for over a year there are no significant operational data to report. Since its installation the Bypass Filter Facility has been used only for two routine operations, the HFBR fuel discharging and BGRR anneal. Even in these cases it was used for an emergency safeguard rather than for air cleaning. Although there has not been, and hopefully will never be, any emergency need for the facility, it has allowed the Reactor Division to improve their procedures and thus produce more effective emergency planning.

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Figures

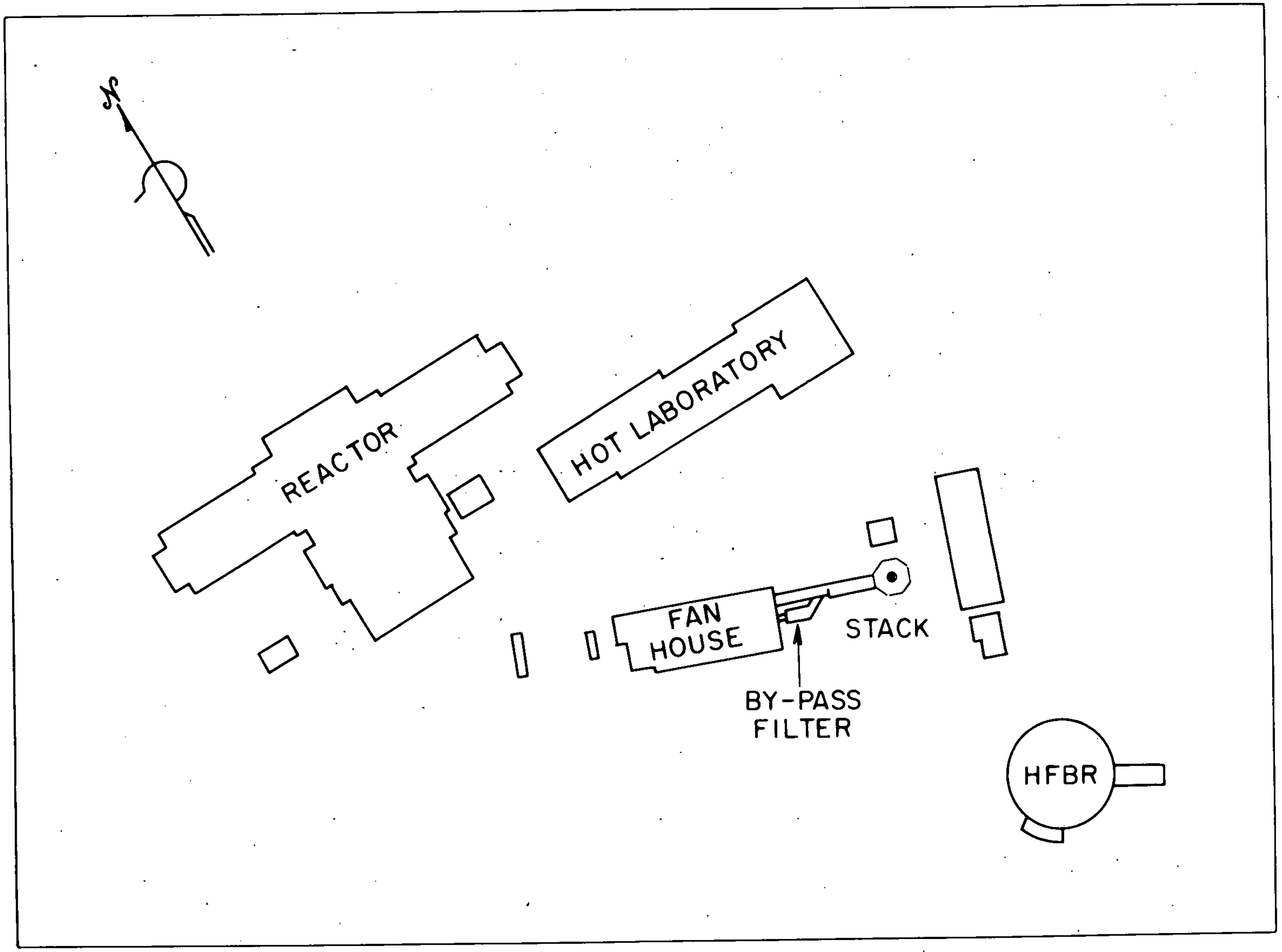
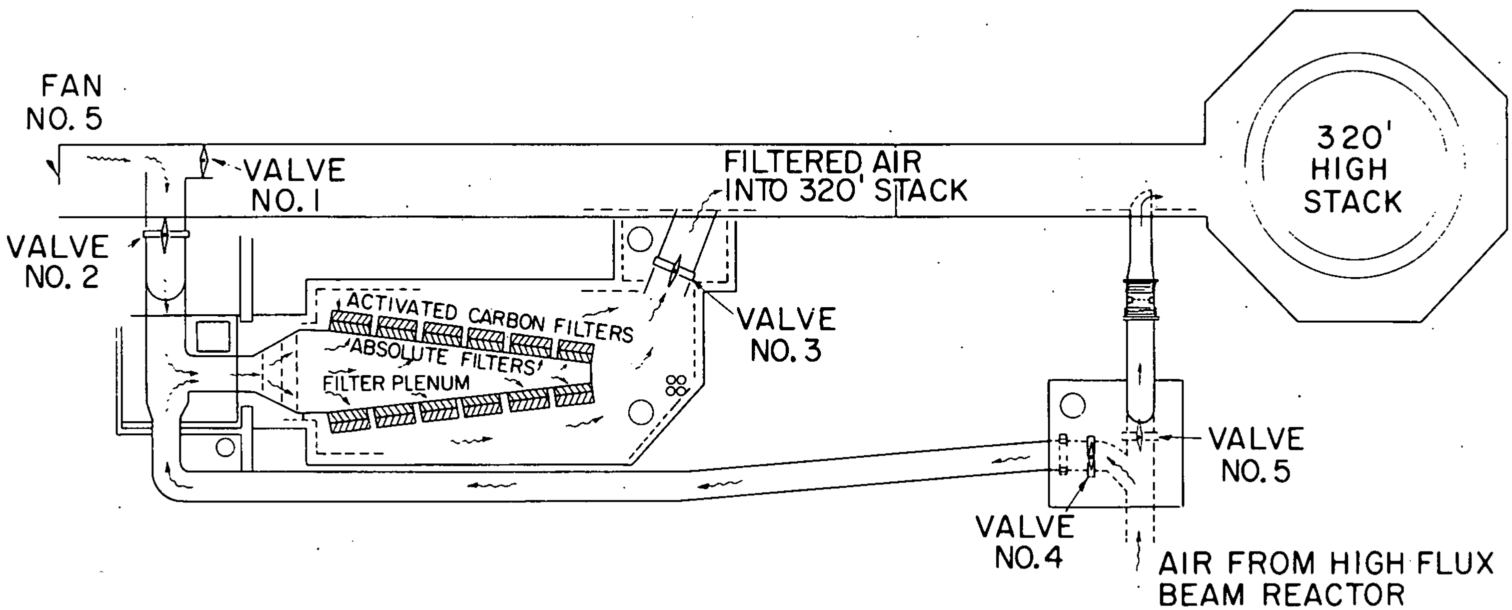

N
REACTOR
HOT LABORATORY
FAN HOUSE
STACK
BY-PASS FILTER
HFBR

FIGURE 1



BYPASS FILTER FACILITY

FIGURE 2

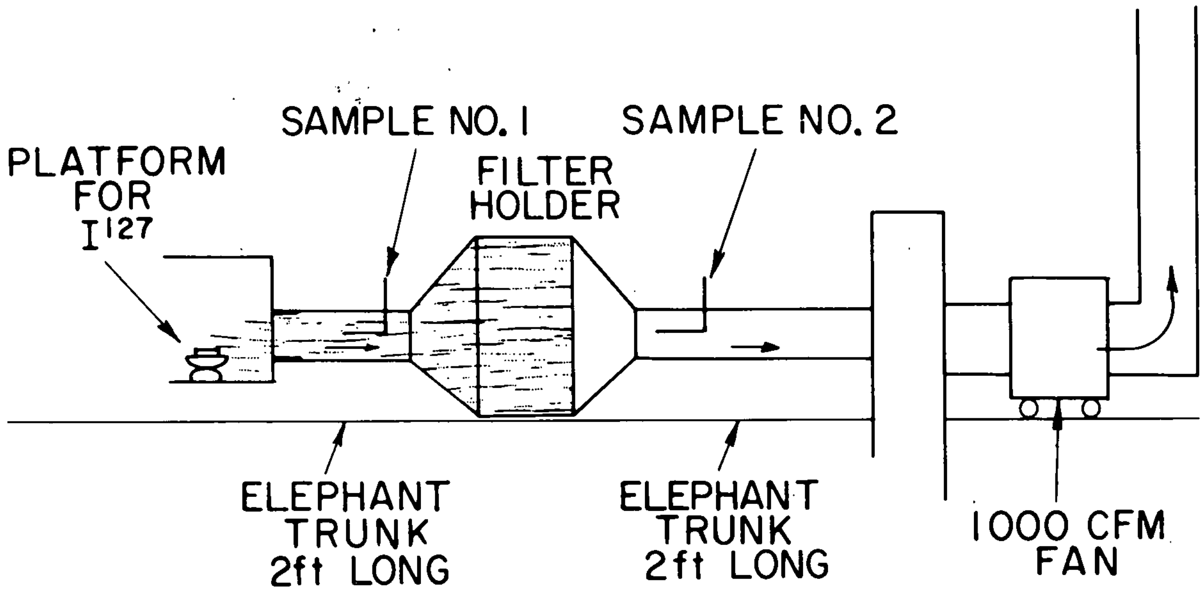

PLATFORM FOR I^{127}
SAMPLE NO. 1
FILTER HOLDER
SAMPLE NO. 2
ELEPHANT TRUNK 2ft LONG
ELEPHANT TRUNK 2ft LONG
1000 CFM FAN

FIGURE 3