CRNL RESEARCH REACTOR RETROFIT EMERGENCY FILTRATION SYSTEM

by

H.M. Philippi
Plant Design Division

Atomic Energy of Canada Limited
Research Company
Chalk River Nuclear Laboratories
CHALK RIVER, Ontario, Canada
KOJ 1J0

CRNL RESEARCH REACTOR RETROFIT EMERGENCY FILTRATION SYSTEM

ABSTRACT

This paper presents a brief history of NRX and NRU research reactor effluent air treatment systems before describing the selection and design of an appropriate retrofit Emergency Filtration System (EFS) to serve these reactors and the future MX-10 isotope production reactor. The conceptual design of the EFS began in 1984. A standby concrete shielded filter-adsorber system, sized to serve the reactor with the largest exhaust flow, was selected. The standby system, bypassed under normal operating conditions, is equipped with normal exhaust stream shutoff and diversion valves to be activated manually when an emergency is anticipated, or automatically when emergency levels of gamma radiation are detected in the exhaust stream. The first phase of the EFS installation, that is the construction of the EFS and the connection of NRU to the system, was completed in 1987. The second phase of construction, which includes the connection of NRX and provisions for the future connection of MX-10, is to be completed in 1990.

1.0 INTRODUCTION

Conceptual design of the Emergency Filtration System (EFS) to serve the Chalk River Nuclear Laboratories (CRNL) NRX and NRU research reactors and the future MX-10 isotope production reactor began in 1984. Before describing the new system the following brief description of NRX and NRU and the development of their exhaust air (effluent) treatment systems will place the EFS system in historical contect. NRX, commissioned in 1947, was originally designed to be exhausted directly through underground concrete ducts to an adjacent 61 m (200') stack without filtration, however, particulate filtration (Building 101X) was added soon after startup [Fig. 1]. In 1957 NRU was commissioned complete with its own underground steel ducts, particulate filter house (Building 162), a new multiple exhaust fan installation (Building 163) and stack [Fig. 1]. The fans and the stack (on a hill about 1 km from the reactor) were designed to be shared by both NRX and NRU. Both filter houses had 300 mm (12") thick shielding walls but little roof shielding. Filter changing was designed to be done through removable roof panels. The E, F and G exhaust fan system consisted of two 50% capacity fans and one 50% capacity standby fan. It is of interest that the NRX design preceded the advent of large positively sealed ventilation shut-off valves and designers therefore chose to use water traps to shut off ventilation flow paths and to isolate fan installations. These traps provided effective shut-off capability but were very slow to fill, required an active drainage system and had a high pressure drop.

2.0 PURPOSE AND CONCEPT DEVELOPMENT

The 1984 decision to retrofit an Emergency Filtration System (ESF) was based on the need to capture radioactive iodine in case of abnormal reactor operating conditions and severe reactor fuel failure resulting from a loss of coolant. A committee was formed to define the requirements and to review the various concepts developed by CRNL Plant Design Division to meet the requirements. Concepts presented varied from systems with 100% on-line shielded exhaust air treatment paralleled by a second identical standby system to relatively simple unshielded systems reusing as much of the existing fan and filtration equipment as possible. For operational, economic and site limitation reasons the committee selected a shared standby (bypass) EFS (Building 160) [Fig. 1] located upstream from the existing fan installation (Building 163), equipped with seismically designed concrete shielding and self-contained HEPA filter-adsorber trains [Fig. 2]. Its capacity was to accommodate NRX which has the largest exhaust flow requirement. The reactors were to continue the use of the existing filter, fan and stack installations for normal reactor operations. The new installation was to be shared and automatically engaged when abnormal fission products were detected in either the NRX-MX-10 or the NRU reactor exhaust stream.

3.0 BUILDING DESIGN

Design of the EFS began in 1986. Shielding calculations indicated requirements for 900 mm (36") normal concrete on all four sides and the top of the filter-adsorber room. The seismic design of this concrete shielding proved to be the major element in the design effort. The entire structure and the connecting underground ducts were designed using forces generated by a dynamic, computer simulated, soil model excited by a simulated earthquake using horizontal bedrock accelerations of 0.22 g and a frequency spectrum typical of the site. Extra concrete reinforcing steel and extensive rock pining was required to accommodate the seismic forces and site bedrock features.

4.0 FILTER-ADSORBER DESIGN

The exhaust stream filter-adsorber trains [Fig. 2] utilize 150 mm (6") pleated 45-55% roughing filters, 472 l/s (1000 cfm) self-contained, metal 99.97% efficient HEPA filters and CRNL designed, 99.95% efficient gasketless 50 mm (2") bed TEDA impregnated charcoal adsorber units. The filter and adsorber design efficiencies meet the requirements of Canadian standards [3]. A total of 16 parallel trains provide a maximum of 7550 l/s (16,000 cfm) filtration capacity. No special exhaust stream pre-treatment is provided. This decision is based on studies of various fuel failure and reactor loop incidents which indicated that high steam and humidity were unlikely to occur [1].

5.0 FILTER AND ADSORBER TESTING

All HEPA filters and adsorbers are equipped for in-place testing with all test points piped to convenient stations on the wall at the end of each train. Access to leak testing stations and to any filter or adsorber is facilitated by removable metal deck panels over the entire filter-adsorber area [Fig. 3]. In-place HEPA testing is done using cold, poly-dispersed D.O.P. and in-place adsorber testing is done using radioactive iodine. These are standard CRNL tests done routinely on all plant HEPA filters and adsorbers and required no new methods or retraining of technicians. Laboratory testing of adsorber carbon is required to prove the ability of the carbon to adsorb and retain the radioiodines released by a major reactor incident. These retention tests were described by J. Slade et al. in a paper given at the 19th Air Cleaning Conference in Seattle [2]. They can be done by taking a sample directly from an adsorber unit which is temporarily removed and then replaced or by using the bypass canisters installed on several trains. Experience to date indicates that carbon iodine retention data obtained by testing the canister carbon samples does not give reliable (representative) results. Carbon samples taken directly from the beds indicate that the carbon is still within specifications after almost three years of standby service.

6.0 ISOLATION AND DIVERSION VALVES

The reactor exhaust stream diversion valving required by NRX and NRU to access the standby EFS consists of two valves in series to shut off (isolate) the normal exhaust line and two valves in parallel to open the exhaust diversion line. 900 mm (36") wafer-butterfly type valves are used for this service on the NRU connecting ducts. The leak rate of these valves must be consistent with the HEPA filter and carbon adsorber efficiency. That is, the percentage that leaks past the valves should not be greater than the percentage that leaks through the filter or adsorber. The speed of valve closure or opening must be high enough to divert the normal exhaust stream to the EFS before significant fission products are released to the environment through the normal exhaust treatment system. The speed of closing and opening for the EFS valves is under 10 seconds.

7.0 VALVE CONTROL

Exhaust stream diversion and isolation may be manually initiated by the reactor operator by means of an absolute switch in cases where an abnormal condition is anticipated or slowly developing. Diversion and isolation may also be automatically initiated by means of an absolute switch activated by an exhaust duct mounted gamma detector. The first reactor to access the EFS has sole use of the facility. There is also a conditional system switch option available to the reactor operator allowing diversion of the exhaust stream for extra filter-adsorber protection during non-routine reactor loop experiments. This conditional diversion can be instantly over-ridden by an absolute manual or automatic gamma actuated switch in any of the reactors sharing the system.

8.0 CONSTRUCTION

Design and construction of the abnormal conditions filter system and the underground duct connection to NRU were completed in 1987 at a cost of less than 2 million dollars. In 1989 a second connection will be made to serve NRX and the future MX-10 isotope production reactor which will be located near it.

9.0 CONCLUSION

In conclusion, it can be said that the provision of this emergency filtration system provides a vital environmental protection system required to extend the useful life of CRNL research reactors and to serve the future MX-10 reactor.

10.0 REFERENCES

[1] MCAULEY, S.J., Status Report on the NRU/NRX Emergency Ventilation/ Filtration System, CRNL Nuclear Safety Note NSN-NSTB-22, Chalk River Nuclear Laboratories, (1984).

[2] SLADE, J.A., Nuclear-Grade, Gas-Phase Adsorbent Iodine Retention Test, 19th DOE/NRC Nuclear Air Cleaning Conference, Seattle, Washington. (1986).

[3] CANADIAN STANDARDS ASSOCIATION, CSA N283.3.2-M85, High Efficiency Air-Cleaning Assemblies for Normal Operation of Nuclear Facilities.

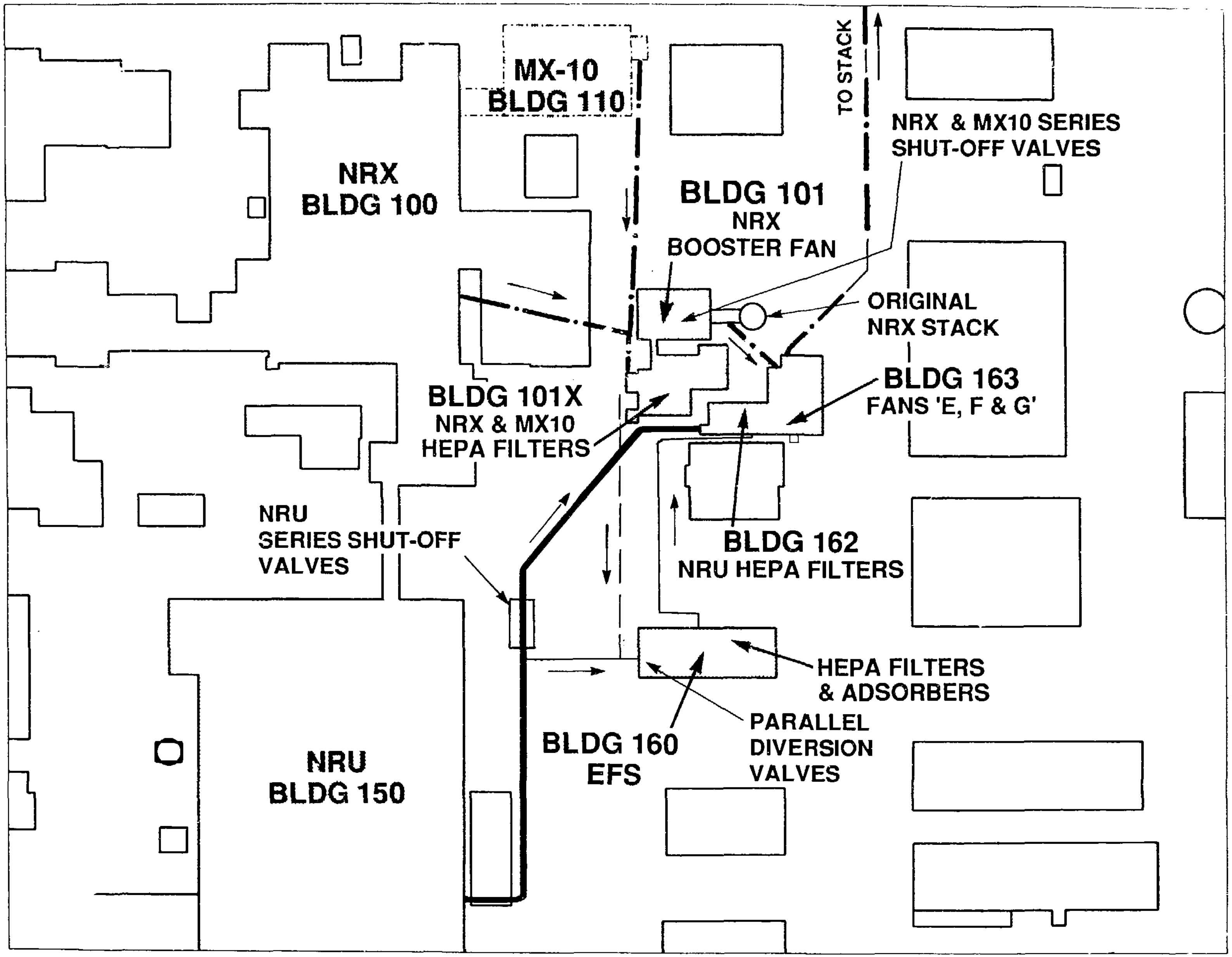
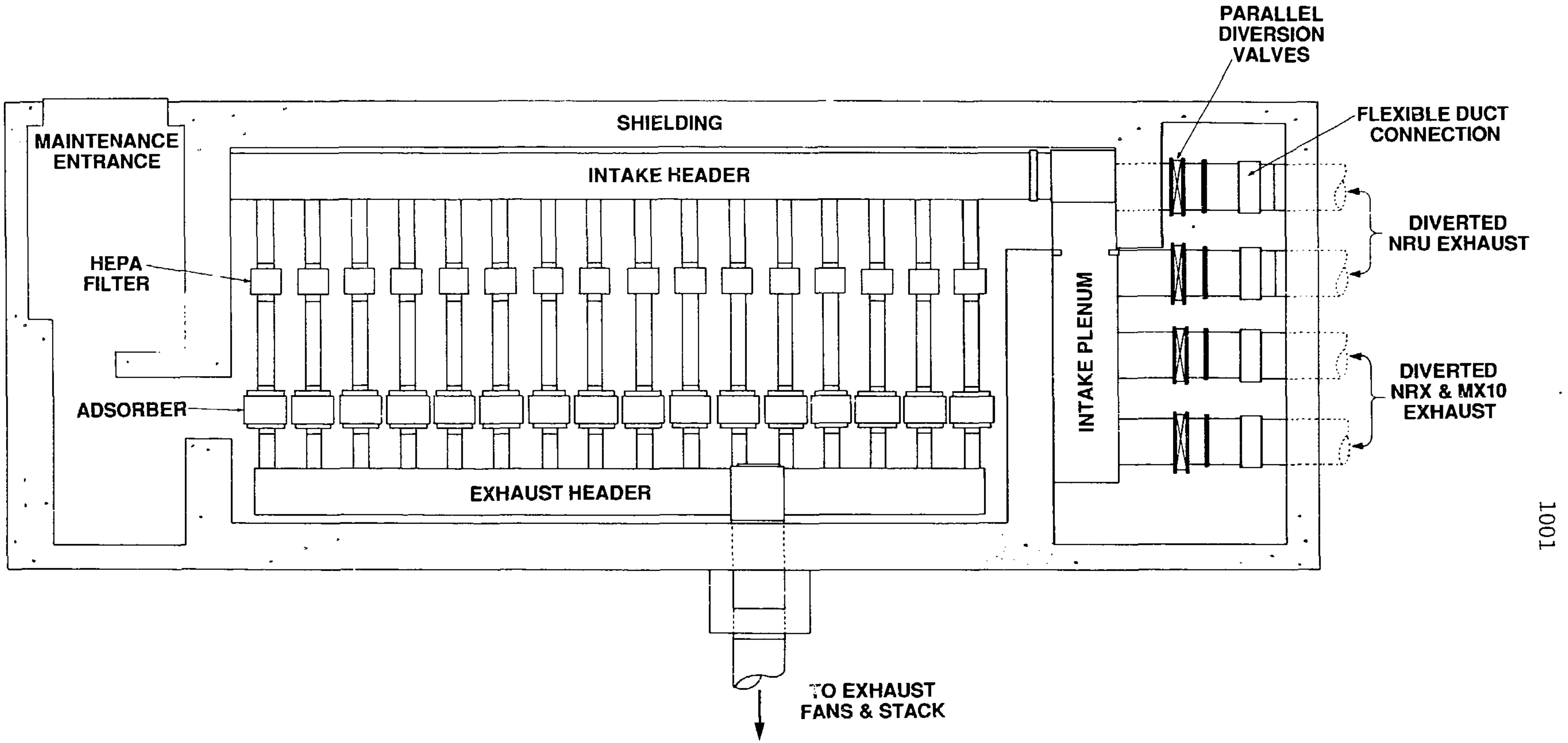


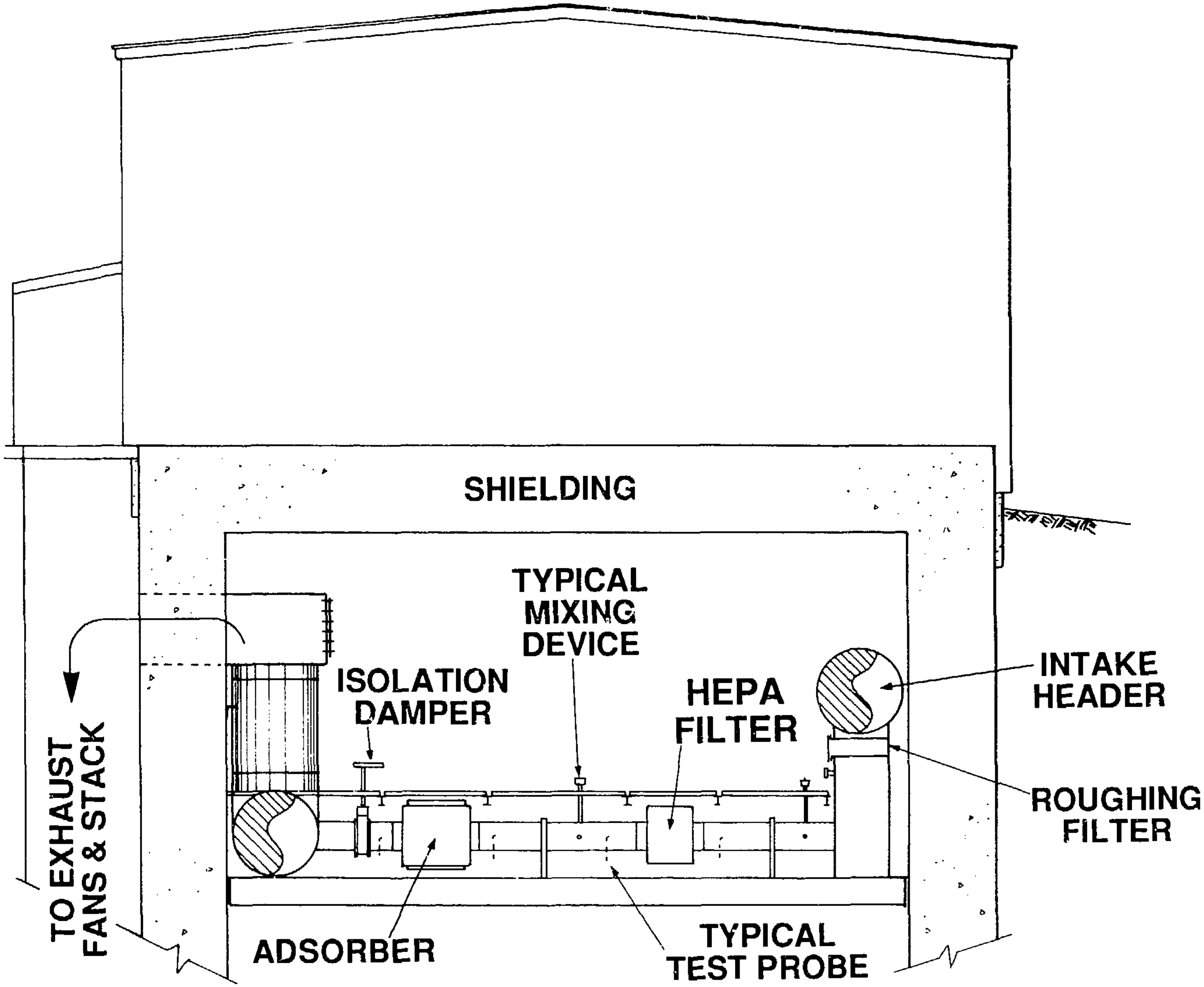
FIG. 1 SITE LAYOUT

1000



1001

FIG. 2 EFS BUILDING PLAN



1002

FIG. 3 EFS BUILDING SECTION