A NEW METHOD FOR THE INDIVIDUAL DETECTION OF FAILED FUEL ELEMENTS IN SWIMMING POOL REACTORS

UM NOVO MÉTODO PARA A DETEÇÃO INDIVIDUAL DE ELEMENTOS COMBUSTÍVEIS DEFEITUOSOS, EM REATORES DE PISCINA

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INTRODUCTION

During the initial period of operation of the IEAR-1 swimming pool reactor at a power level of 5 megawatts, an abnormal increase in the radioactivity-levels in water and air was observed, which could not be ascribed either to N16 and Na24 or to the activation of impurities present in the water in concentrations smal ler than one part in one million (1) (2).

Since the fuel elements used are of the MTR type and it was known that in some other reactor installations similar elements had shown a serious cor rosion around the brazed edges of the fuel plates, with a release of fission produ- cts, it was suspected that the abnormal activities were due to a failure of one or several fuel elements.

A procedure was sought, therefore, to examine the behaviour of each fuel element for a release of fission products; such a procedure should be able to supply an unambiguous information on each fuel element in order to provide a well established rejection criterion for failed fuel elements.

All the known methods used in the detection of cladding failures in swimming pool reactor fuel elements were able only to give an indication that a failure had occurred; there was no way, however, to identify the elements respons- ible for the release of fission products except by comparison of the behaviour of each suspected element when inserted in a new core.

The method described in this paper was developed to allow an unam- biguous identification of a failed fuel element even when one or more fuel elements of the reactor core are releasing fission products as well.

Essentially, the method developed at the Atomic Energy Institute- consists in submitting a fuel element to the leakage neutron flux from the reactor operating at about 10 kw power level by placing the said element close to the core; the measurement of the activity carried out by an air stream bubbled through the fuel element plates can then give a definite indication of a cladding failure.

The activity carried out by the air stream is adsorbed in activated carbon and easily measured. In order to account for the activities induced in the air or due to impurities in water, a dummy fuel element is used and the measured air activity taken as a comparison standard.

DESCRIPTION OF THE APPARATUS

A schematic diagram of the apparatus used is given in figure 1.

There is a long aluminium tube 1/2" I.D., ending in a sort of hood that can be put on the top of the fuel element to be tested. This aluminium tube is connected through rubber tubing to a Venturi flow meter, followed by a Kitasato flask for retaining any eventual water overflow. After this flask there is a millipore filter and finally a plastic tube containing activated carbon; the air outlet is connected to the contaminated exhaust system of the reactor building.

The fuel element to be tested can be positioned near to the core, inserted in an aluminium plug provided with an air inlet below the hollow bottom of the fuel element; this aluminium plug is inserted into one of the holes of the reactor grid plate at a distance of about 6 inches from the core face. Finally, the air inlet is connected by pressure-rubber tubing to a compressed air line through an adjustable pressure reducing valve. Two valves located between the Kitasato flask and the millipore filter permit the adjustement of the air pressure and flow; one valve, B in the figure, allows the millipore line to be open or closed and the other one, C, is adjusted to give the desired pressure and flow in this line. A by-pass line leads the air from the Kitasato flask to the contaminated air exhaust system of the reactor building through a second activated carbon filter ; this line is controlled by valve A.

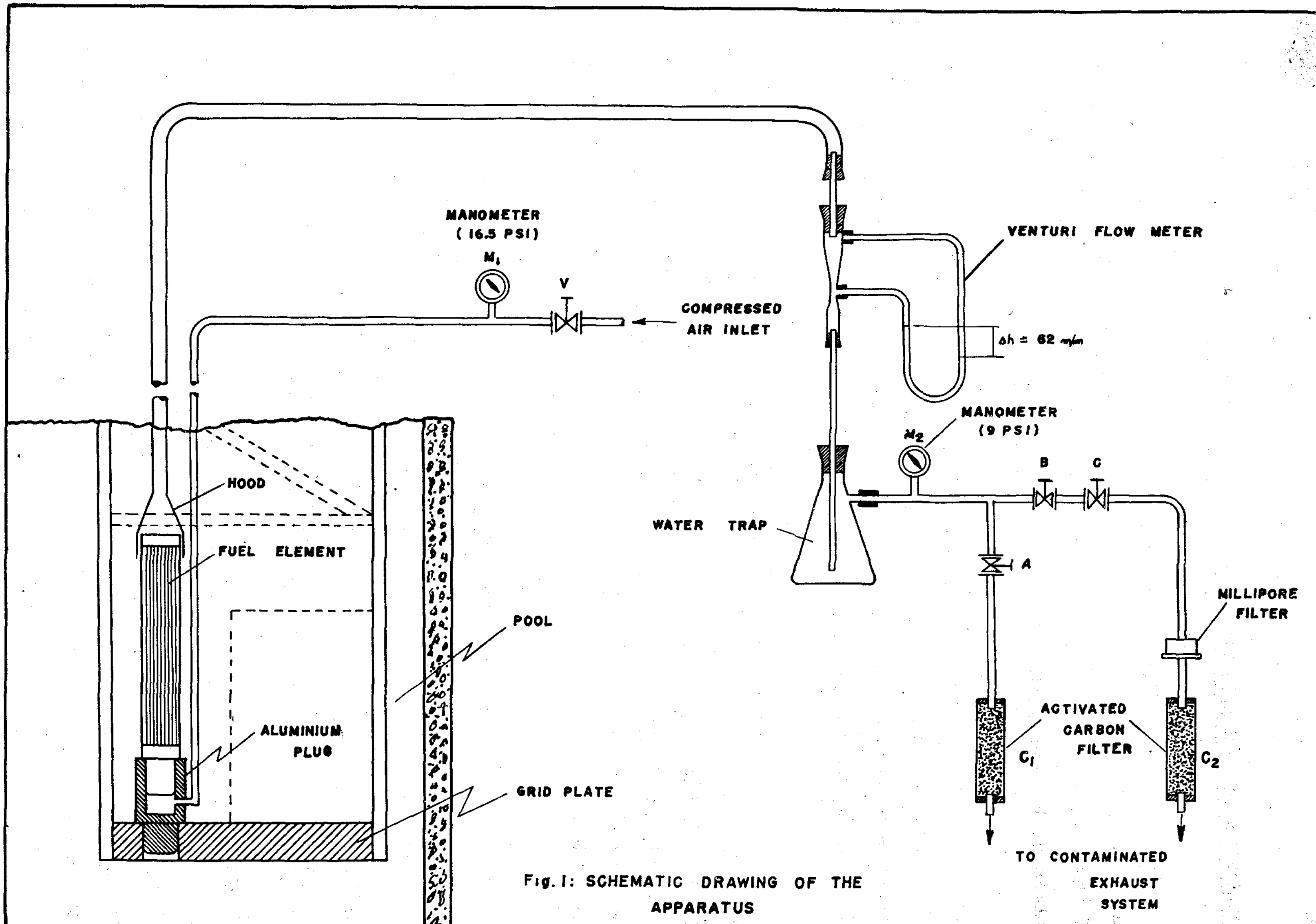

Fig. 1: SCHEMATIC DRAWING OF THE APPARATUS

OPERATION OF THE APPARATUS

With the reactor critical at 1 kw, the fuel element to be tested was inserted carefully in the positioning plug. After the hood was put on the top of the fuel element, air under pressure was admitted to the system, with all the valves A, B, and C closed.

After the pressure reached 9 psi, valve A was open till the Venturi flow meter showed a pressure difference of 62 mm of water. This pressure difference was maintained during the whole test by adjusting the pressure reducing valve of the compressed air line.

The reactor power was then raised to 10 kw and after 5 minutes - the millipore line valves were open and the by-pass line valve closed; the air flowing through the plates of the fuel element passed then during 15 minutes through the millipore filter and the activated carbon. The test ended with the millipore line valves closed, the by-pass line valve open and finally the pressure reducing valve closed.

The millipore filter paper and the activated carbon activities - were measured after 2 minutes of waiting time.

For the purpose of comparison, and in order to know the background due to activities present in the water and induced directly in the air, the experiment was repeated with a dummy fuel element.

EXPERIMENTAL RESULTS

During a few days of operation, all the fuel elements were tested and the results obtained from measurements with the activated carbon are given in the table.

TABLE

Fuel Element Number	Total Gamma Activity (cpm)	Fuel Element Number	Total Gamma Activity (cpm)
13	275 312	30	15 377
28	198 739	14	15 021
34	186 574	25	13 660
9	156 046	31	13 233
20	141 909	3	12 060
23	99 543	10	11 222
22	95 692	29	10 319
24	81 368	2	9 758
17	48 190	16	8 816
18	41 132	21	8 109
5	34 148	40	7 988
12	31 138	26	7 018
33	29 046	15	6 561
6	28 846	8	5 797
7	19 519	27	5 462
32	19 517	4	4 490
1	17 980	11	3 533
19	17 729		

Mean value of total activity for the dummy element... 3 900 cpm

The activity of the activated carbon, measured in a standard scintillation counting system, with a 2 1/2" x 1 1/2" well crystal, is quite reproducible in different experiments either for the dummy or for the same fuel element.

An examination of the data presented in the table shows that fuel elements ns. 9-13-17-18-20-22-23-24-28-34 were definitely bad, since the activities of the activated carbon were more than 10 times higher than the background of the dummy.

An evidence that such activities were due to the release of fission products is given by the activity decay curve either in the activated carbon or in the millipore paper. One decay curve for the millipore paper is shown in fig. 2 and has the typical shape of the decay curve of gaseous fission products (3).

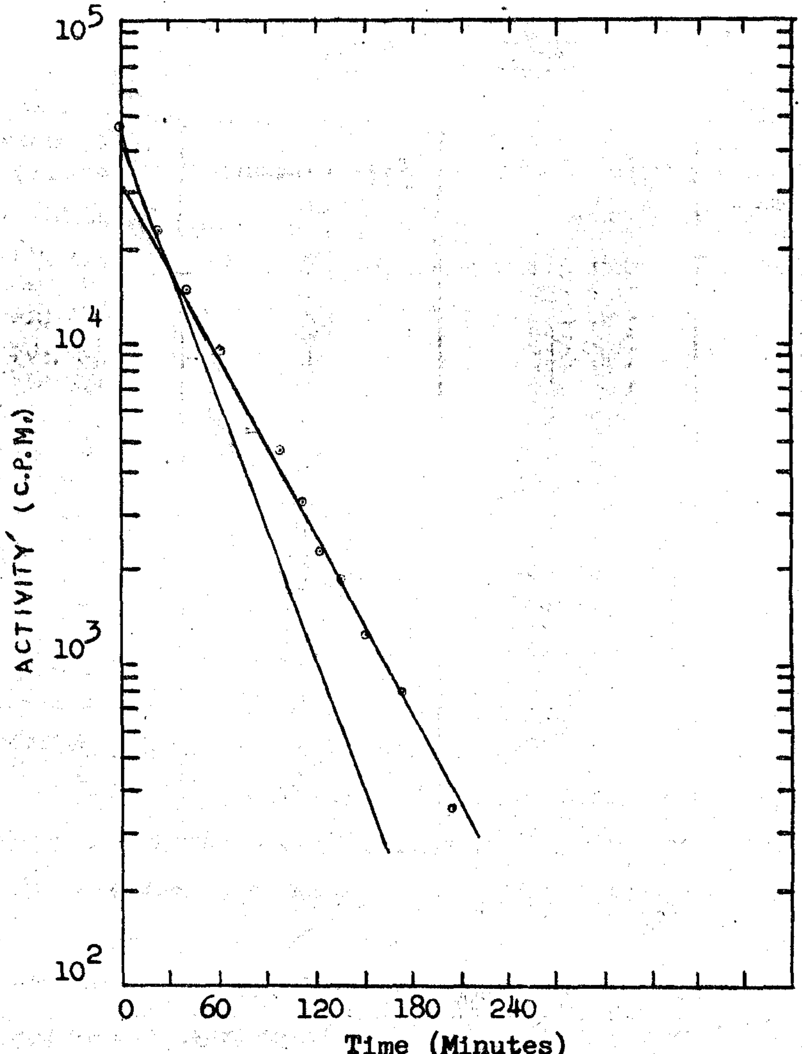

Fig. 2 - Decay curve of millipore paper activity

The operation of the apparatus is simple and it is possible to test a fuel element in about 30 minutes. It is important, however, to place the fuel element in the aluminium plug very carefully in order to avoid dangerous positive periods in the reactor. These positive periods would certainly occur if the fuel element, due to improper positioning would fall toward the core. This disadvantage will be eliminated in a new apparatus that is being designed at the Atomic Energy Institute and in which there will be a guide tube for the insertion of the fuel element under test and some minor improvements aimed to automatize the operations performed during the test.

ACKNOWLEDGEMENTS

The millipore filter paper measurements were made by prof. Fausto Walter Lima; prof. R. R. Pieroni was responsible for the activated carbon measurements and has given many helpful suggestions. Drs. E. Wilner and I. C. Nascimento helped in many experiments as reactor operators and Mr. J. Ferreira was responsible for the construction of the equipment. Their cooperation is deeply appreciated.

BIBLIOGRAPHY

1) Fausto W. Lima et al. - Fission Products in the Cooling Water of the Brazilian Swmming Pool Reactor - Proceedings of the Second International Conference on the Peaceful Uses of Atomic Energy - vol. 10 - page 532 - Geneve-1958. (See also: F. W. Lima et al. - Removal and Recovery of Cesium-137 from Swimming Pool Water - Industrial and Engineering Chemistry - 52, 147, 1960).
2) R. R. Pieroni et al. - Radiation Intensity Levels and Air and Water Activities Observed with the IEAR-1 Swimming Pool Reactor at 5 MW. - Proceedings - of the Second International Conference on the Peaceful Uses of Atomic Energy - vol. 10, page 542 - Geneve - 1958.
3) P. R. Bolton et al. - Aerosol Activity from Experimental Low Power Reactor Operation - WAPD - T - 444 (1957).