

Short Notice

AVR Operational Experience, Overview

Edgar Wahlen, AVR
Peter Pohl, AVR

Executive Statements Summary

1 History

- 1956 Engagement of AVR in HTGR from the very beginning
- 1961 Begin plant construction
- 1964 First core ordered (UCC)
- 1966 First core delivered, First criticality

2 Overall achievements

- 2.1 The plant has been operated for 21 years (1967 – 1988). Given the experimental and first-of-its-kind character of the plant, the achieved time availability with a record value of 92 % in 1976 is quite remarkable (Fig. 1).
- 2.2 Starting in 1974, operation at 950 °C had a share of nearly 30 %.
- 2.3 The personnel dose uptake records show significant improvements in the course of the years due to better components and procedures (lessons learned, Fig. 2).
- 2.4 Radioactivity release to the atmosphere remained well below licenced levels (Fig. 3).

3 Fuel

- 3.1 AVR was the indispensable mass test facility for all development steps of pebble fuel (Table 1).
- 3.2 Pebbles with oxide fuel, and no matter if HEU or LEU, BISO or TRISO coatings, showed at max. fuel temperatures of > 1300 °C and burnups of partly > 20 % fima excellent fission product retention (Table 2).

3.3 In the modern UO_2 , TRISO pebble the fission product release is practically exclusively determined by the little as-manufactured free uranium outside of the coatings.

4 Pebble cycling

During plant operation, 2.4 million pebbles were cycled. The cycling system as a first of its kind needed frequent maintenance but worked well after various improvements, and accounted for only 3 % of the generator non-availability (Fig. 4).

5 Water ingress

A water ingress in 1978 due to a steam generator leak did in the end not affect continued plant operation, and there was no need to replace fuel.

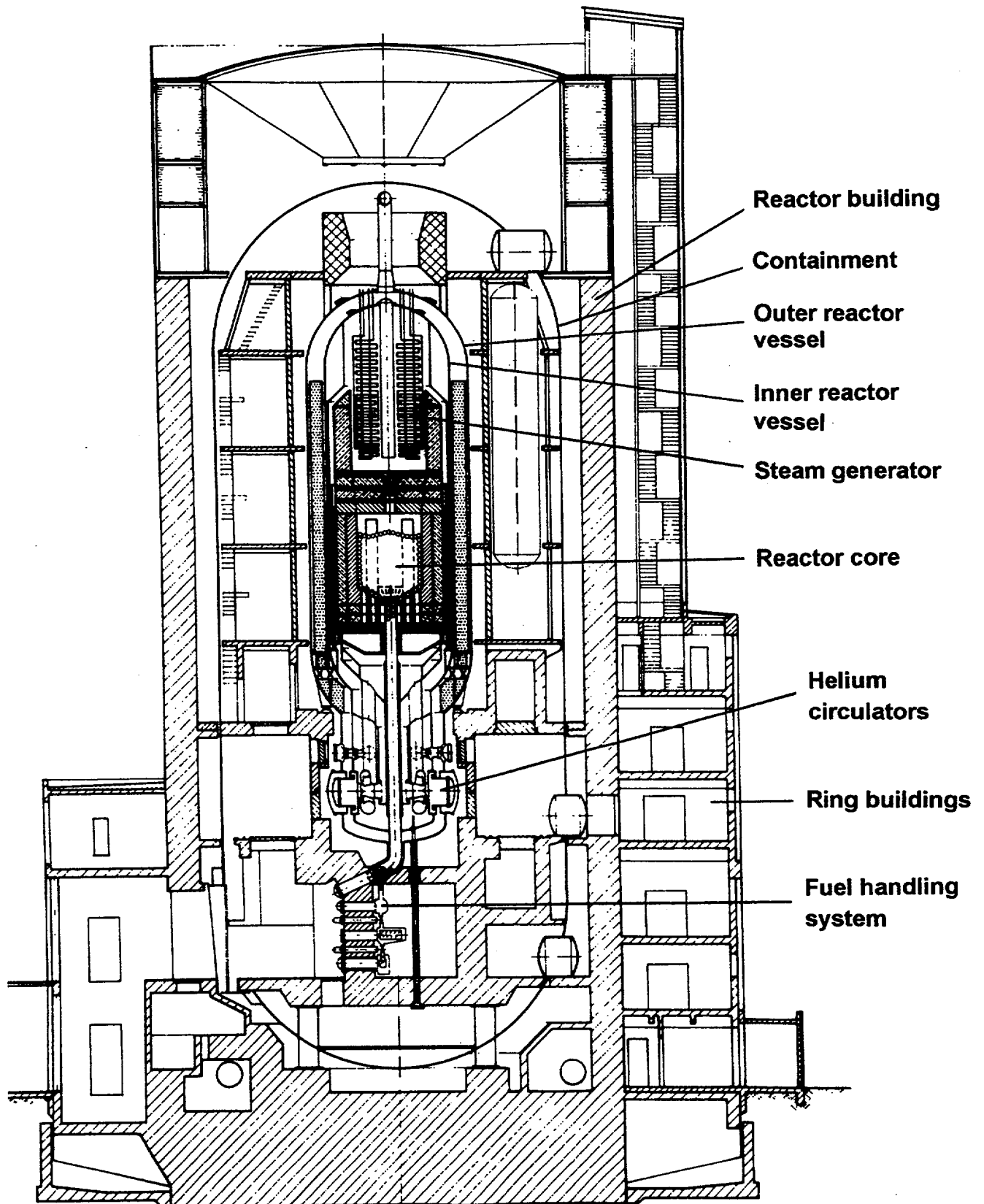
6 Safety demonstrations

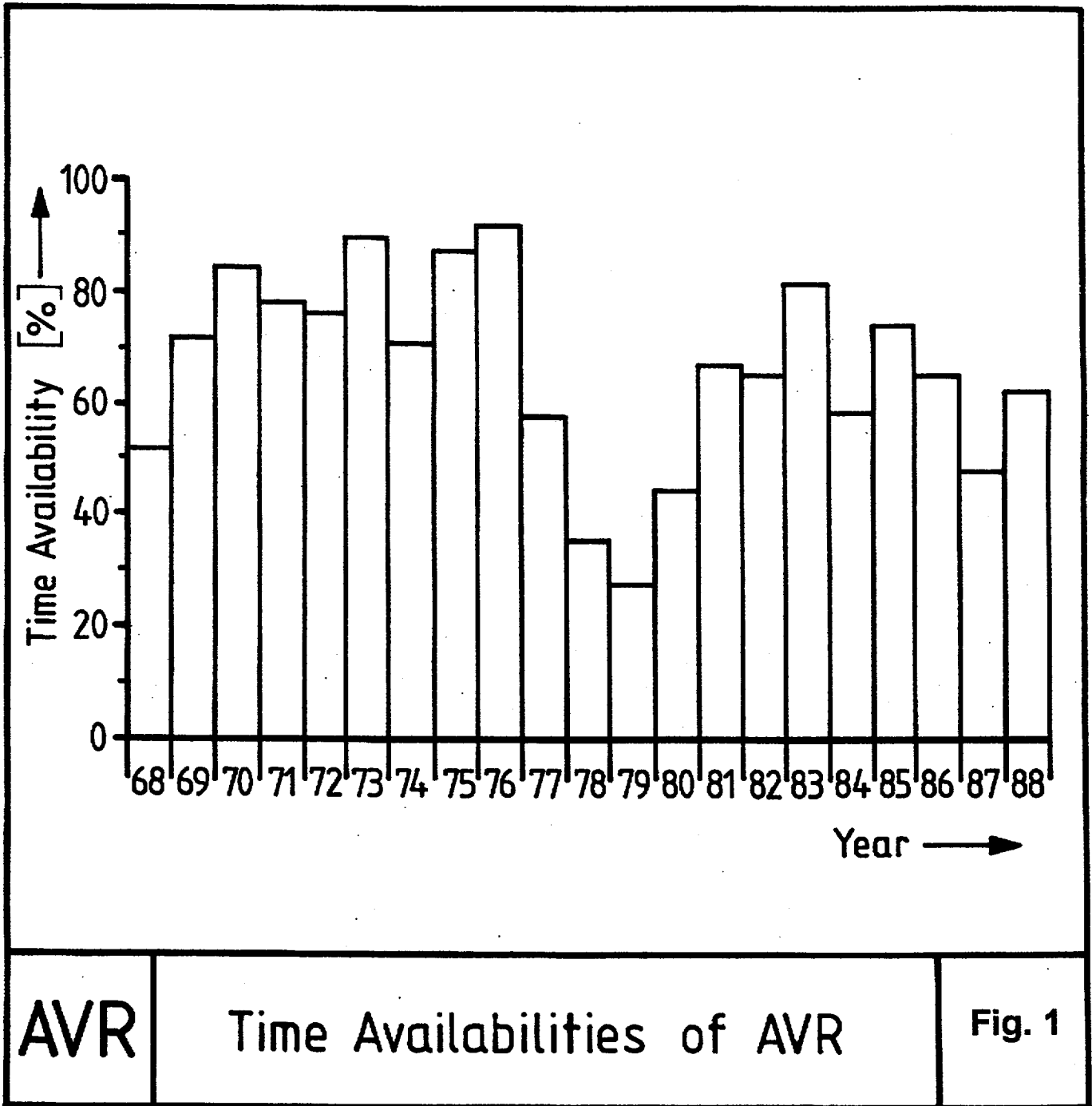
6.1 Experiments simultaneously simulating the loss of forced cooling and stuck rods resulted in a simple shut-down and, with the rods kept withdrawn, in a recriticality with the reactor stabilizing at a very low core power (Fig. 5).

6.2 A complete loss-of-coolant accident was realistically simulated with the AVR at depressurized conditions (Fig. 6). A maximum temp. of $1090\text{ }^\circ\text{C}$ occurred in the core center in less than 10 hrs after accident initiation.

AVR

Reactor building

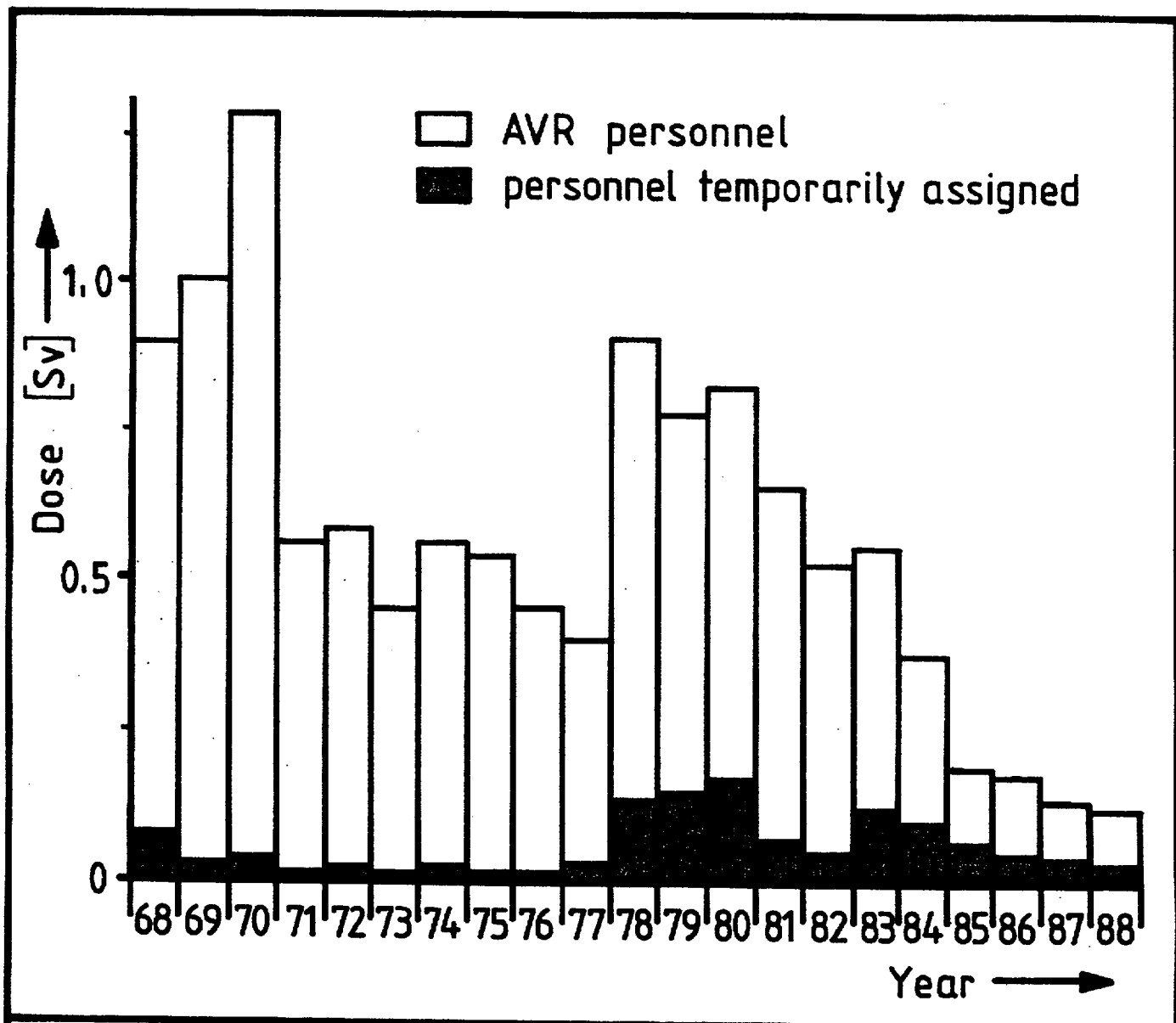




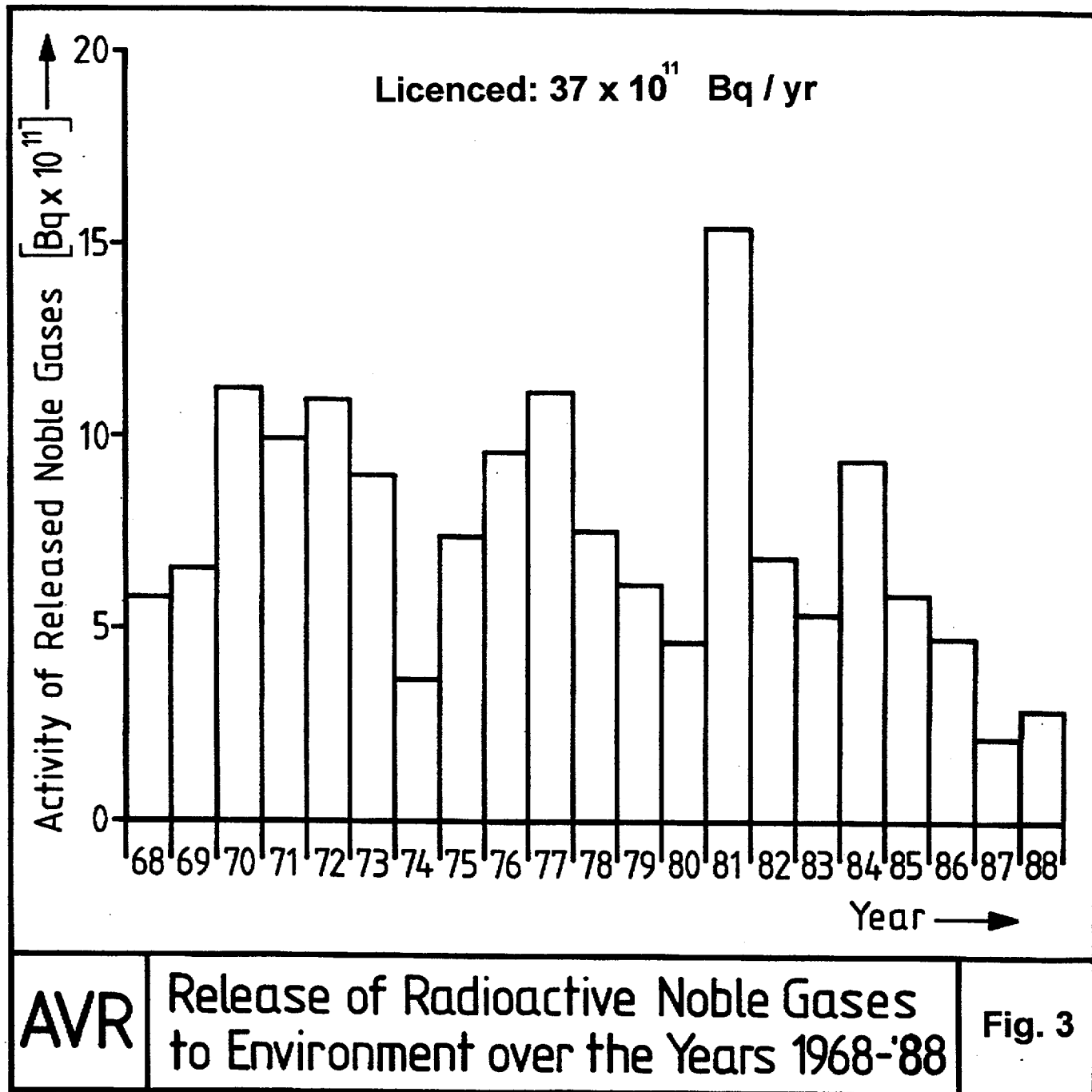
AVR

Time Availabilities of AVR

Fig. 1



AVR	Personnel Radiation Exposure Data for AVR Annual Collective Doses	Fig. 2
------------	---	--------



AVR as mass test bed**Pebble structure**

- | | |
|----------------|---------|
| ▪ Shell type | 37,700 |
| ▪ Pressed type | 253,000 |

Fuel design**HEU**

- | | |
|---|---------|
| ▪ (U / Th) C ₂ with 5 g Th | 87,600 |
| ▪ (U / Th) O ₂ with 5 or 10 g Th | 129,400 |
| ▪ Feed / Breed, UO ₂ , UC ₂ , UCO, ThO ₂ | 20,300 |

LEU

- | | |
|---|--------|
| ▪ UO ₂ , different enrichments | 53,400 |
|---|--------|

Coating design

- | | |
|-------------------------------------|---------|
| ▪ BISO type | 202,900 |
| ▪ TRISO type | 74,300 |
| ▪ Feed / Breed (TRISO / BISO mixed) | 13,500 |

Stationary operation at 950 °C**Activity concentrations in Bq / m³ and descending order**

▪ Total fission gases	4.6 E 08
▪ Tritium	3.7 E 07
▪ C 14	1.9 E 07
▪ J 131	5.2 E 02
▪ Cs 137	3.0 E 02
▪ Sr 90	2.0 E 02
▪ Ag 110m	4.9 E 01
▪ Co 60	1.0 E 01

FUEL HANDLING SYSTEM

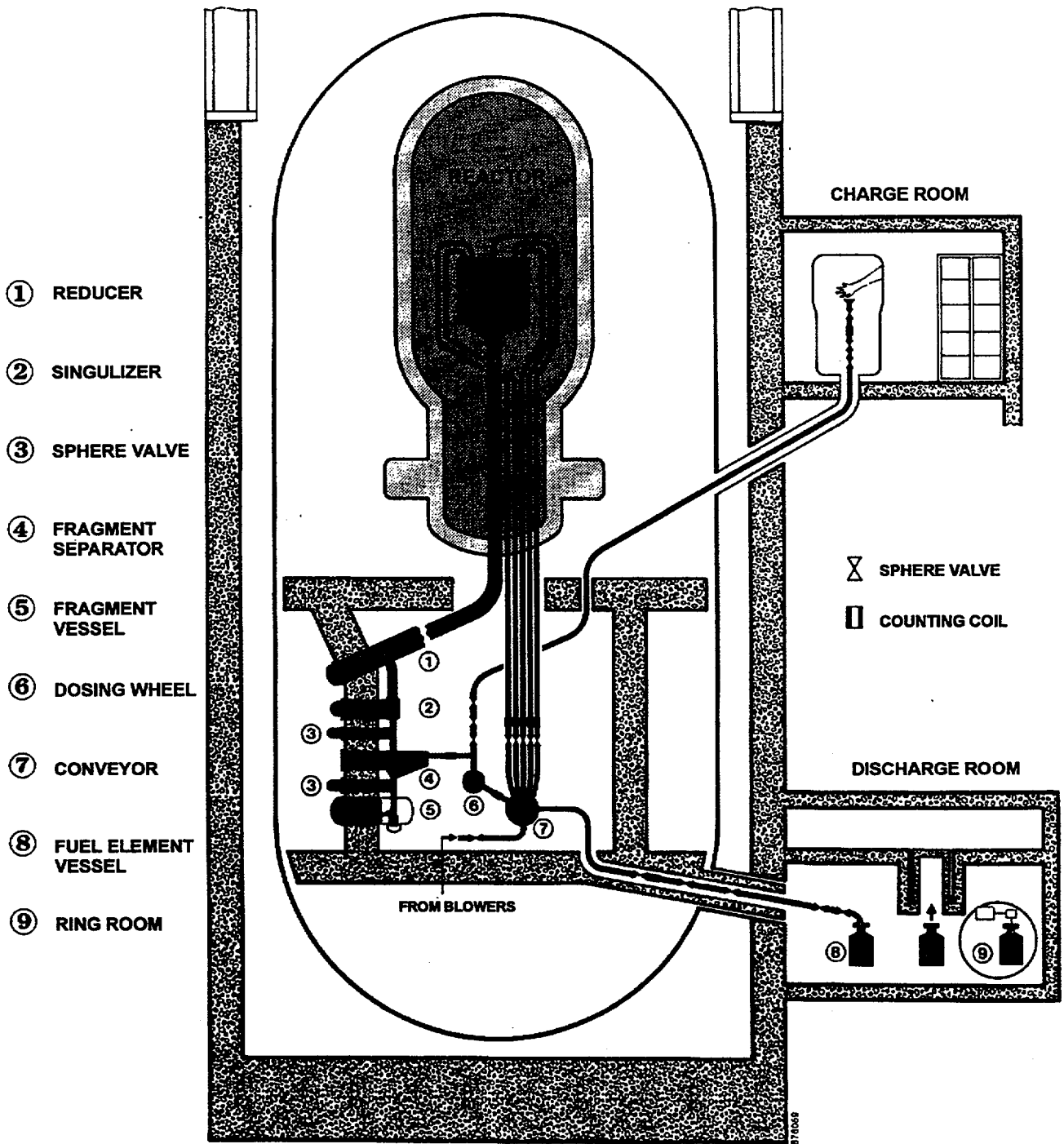
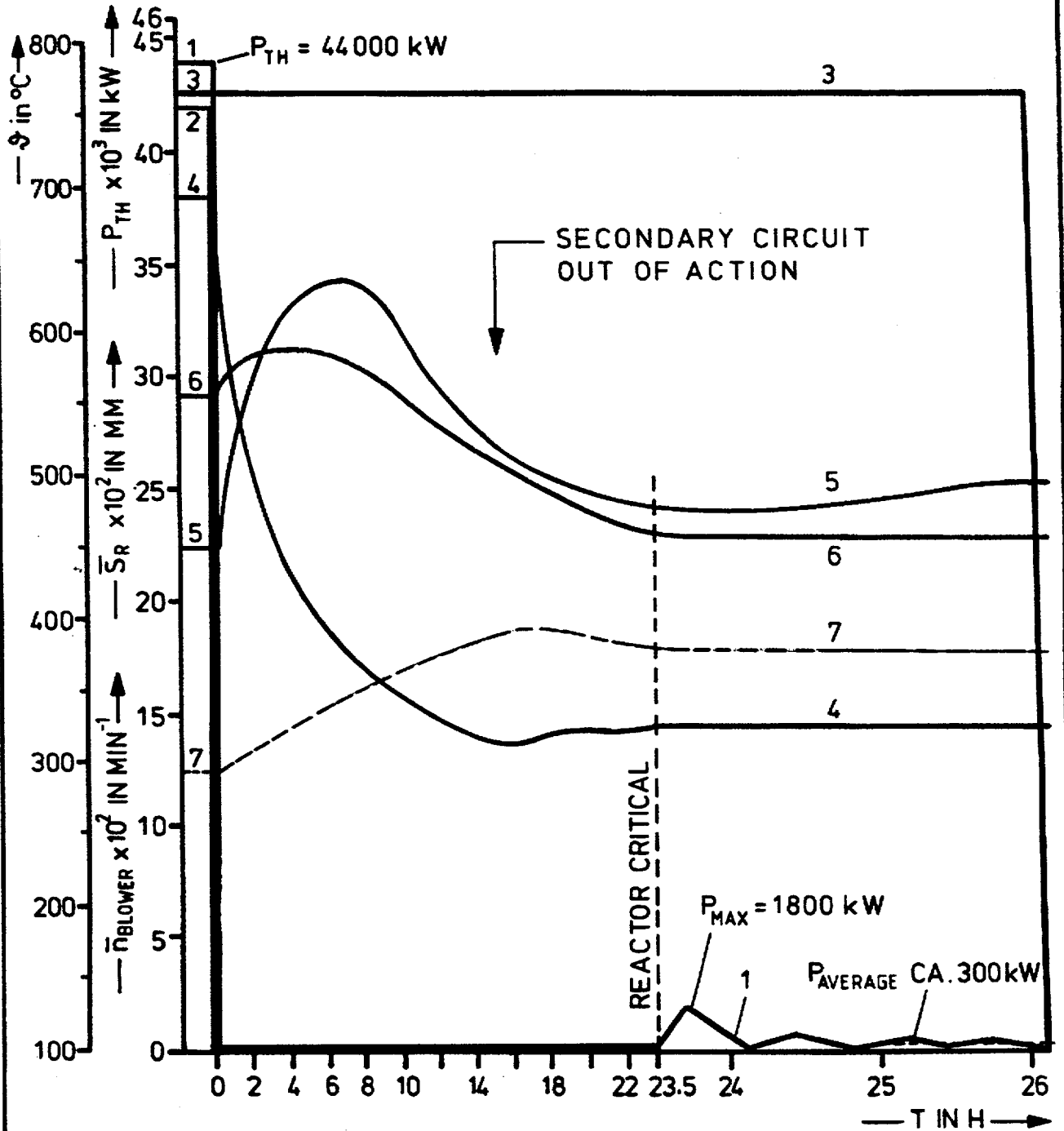


Fig. 4

- 1 THERMAL POWER
- 2 SPEED OF BLOWERS
- 3 AVERAGE POSITION OF SHUT-DOWN RODS

- 4 REFLECTOR NOSE TOP
- 5 REFLECTOR NOSE MIDDLE
- 6 SIDE REFLECTOR INSIDE
- 7 REFLECTOR BOTTOM



AVR	SIMULATED FAILURE OF SHUT DOWN EQUIPMENT AND INTERRUPTED DECAY HEAT REMOVAL FOR THAT TIME	Fig.5
------------	--	--------------

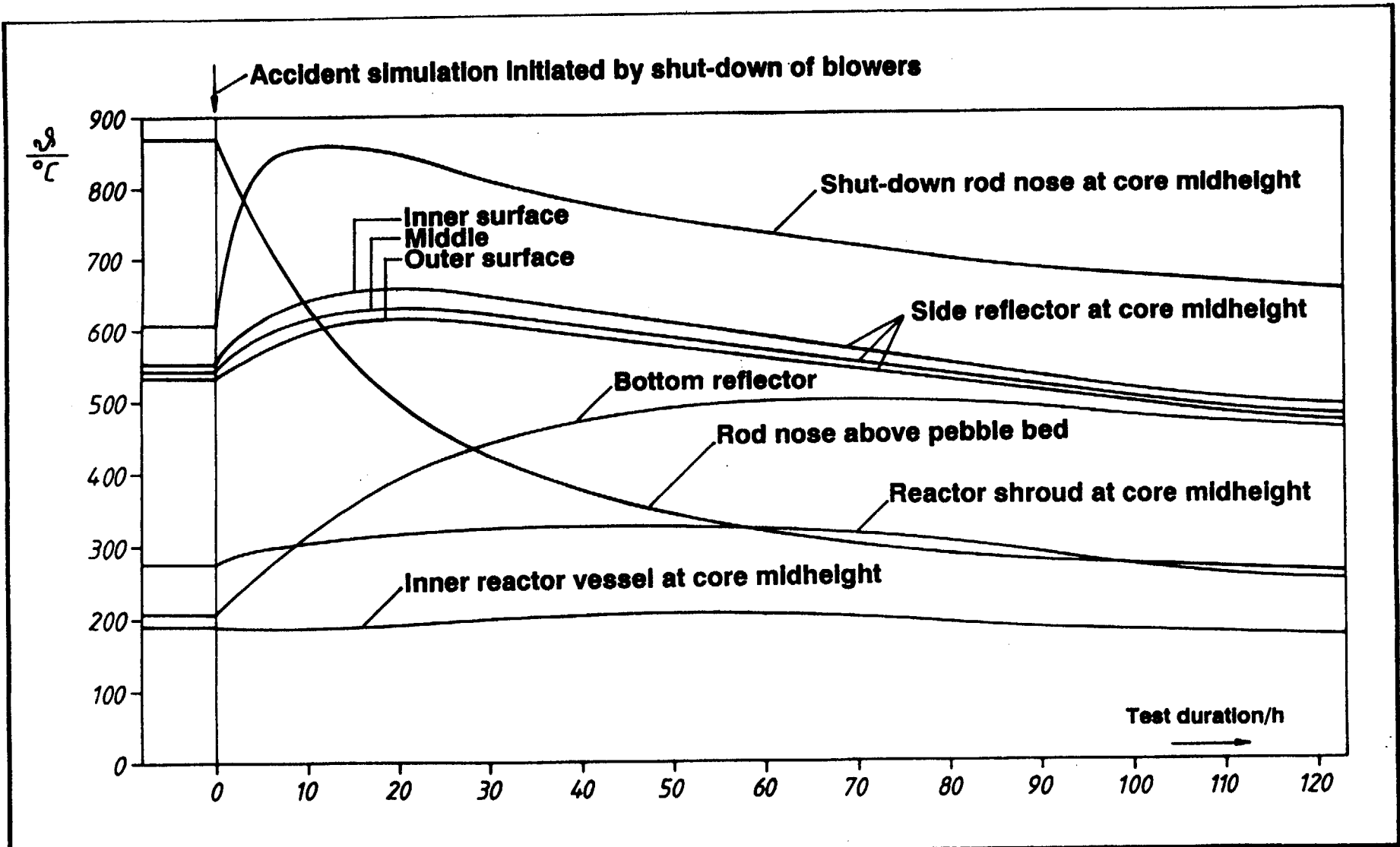


Fig. 6

Measured Temperature Curves during LOCA Simulation of October 14, 1988

AVR

Plant history

- **1956** **Engagement of AVR in HTGR, from the very beginning**
 - **1961** **Begin plant construction**
 - **1964** **First core ordered from Union Carbide**
 - **1966** **First criticality**
 - **1967 to 1988** **In operation as Experimental and Pebble Test Reactor**
-
- **Electricity production 1,670 GWh with about 300,000 pebbles.**
 That means an average production of 6 MWh from each pebble.