Continous backfitting measures for the FRG-1 and FRG-2 research reactors

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Abstract

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The GKSS-research centre Geesthacht GmbH is operating the research reactors FRG-1 and FRG-2 with power levels of 5 MW and 15 MW since 31 a and 26 a. Safe operation at full power level over so many years with an average utilization between 180 d to 250 d per year is not possible without main efforts in modernization and upgrading of the research reactors. Overproportional pressure on backfitting has been coming up since around 1975. At that time within the Federal Republic of Germany many new guidelines, rules, ordinances, standards in the field of (power) reactor safety have been published. Many efforts for the modernization of the FRG-1 and FRG-2 research reactors are being made therefore within the last ten years.

The efforts for the modernization of the FRG-reactors within the last two years and at present are:

- measures against water leakage through the concrete and along beam tubes
- repair of both cooling towers
- modernization of the ventilation system
- measures for fire protection
- activities in water chemistry and water quality
- installation of a double tubing for parts of the primary piping of the FRG-1
- replacement of instrumentation, process control system (operation and monitoring system) and alarm system
- renewal of the emergency power supply (2 out of 3 and today demands)
- installation for internal lightning protection
- installation of a cold neutron source
- enrichment reduction for the FRG-1.

These efforts will continue to allow safe operation of our research reactors over their whole operational life.

1. The FRG-research reactors

The GKSS-research centre is operating two research reactors of the swimming pool type fueled with MTR-type elements. The research reactors FRG-1 and FRG-2 having power levels of 5 MW and 15 MW are in operation since 31 a and 26 a. The reactors are operated at present at ca. 180 d and ca. 210 d (up to 250 d) per year. Both reactors are located in the same reactor hall in a connecting pool system [1, 3, 4, 6].

2. Backfitting-reasons

Backfitting measures are needed for research reactors to ensure a high level of safety and availability.

Generally reasons for backfitting can be:

- operating experience;
- main modifications related to e.g. power increase, changes in utilization or lack of spare parts;
- accidents or severe damage to comparable facilities;
- changes in safety philosophy;
- updated risk analyses and recent research results;
- necessary repairs.

3. Summary of the main backfitting activities within the last ten years [2,3,4,6]

Midth of the seventeeth there were plans to increase the power of the FRG-2 from 15 MW to 21 MW. This was the reason for the following activities e.g.:

- comparison of the existing design with today demands (criterias, guidelines, rules etc.);

- probability approach for events from outside like aeroplane crashes and earthquakes. To summarize: the risk coming from events from outside is acceptable for the operation of FRG-1 and FRG-2;

- rediscussion of main accidents
  startup from low power, startup from full power, loss of coolant flow, loss of heat sink, loss of coolant and fuel plate melting;

- installation of a new reactor protection system [2] following today demands on redundancy (2 out of 3), diversity etc.;*

- a new crane with power reactor demands.
  Before designing and installing the new crane a risk estimation has to be made giving the demands on the design [7]. The crane load has been increased from 12,5 t to 16 t.

- Operation manual and inspection manual.
  In the meantime we have operation and inspection manuals for the research reactors FRG-1 and FRG-2, the cold neutron source [1] and the hot cells.

4. Backfitting activities within the last two years

Especially within the last two years larger backfitting and modernization activities have been made to enable reactor operation for the following ten and more years.

4.1 Installation of a cold neutron source [1]

In operation since June 1989.

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*) A list of relevant KTA (Kerntechnischer Ausschuß) german standards is given in table 1. These standards have to be looked at during the backfitting of the FRG-research reactors.

4.2 Enrichment reduction to LEU fuel for FRG-1 [8]

The FRG-1 is being converted from 93 % enriched U with UAl_x fuel to 20 % enriched U with U_3Si_2 fuel.

4.3 Measures for fire protection

The gap between an old building and new standards on fire protection has to be closed

- all three stairways have to be separated from the floors
- increase of fire resistance for walls and doors
- remove not used cables from cable channels
- installation of smoke flaps and smoke ventilators
- protection of cable penetrations
- fire detection monitoring in all technically rooms and fire alarm control panel.

4.4 Activities in water chemistry and water quality

Due to some corrosion occurrences which lead to unforeseen repairs within the secondary circuit of both research reactors activities were undertaken to review the quality of all kind of water and the water flow diagram. Many measures were taken:

- additional continuously or daily measurements of e.g. pH, degree of turbidity, conductivity, pH 4.3 and 8.2 values, hardness of water, thickening
- instead of using decarbonized water in the secondary circuits we are using with excellent success an own water supply with gravel filters
- remove chloric acid and sodium hydroxide storage into two separate (new) buildings to reduce corrosion impacts on piping, valves and electronic components.

4.5 Installation of a double tubing for parts of the primary piping of the FRG-1

The piping, valves, pumps etc. of the FRG-1 are located in the cellar below the FRG-1 reactor pool. Between ceiling and the first valve there was nothing to stop leaking water. For this reason between the ceiling and the first automatic operated valve a double tube has been installed for the water inlet and water outlet pipings. Parts of these installation can be seen in fig. 1. In the space between the tubes 3 water detectors (heated thermocouples) have been installed giving an alarm in 2 out of 3 mode.

4.6 Repair of both cooling towers

The internals of both cooling towers consisted of wooden materials for the distribution and spraying of the cooling water. The following actions were taken

- The FRG-1 cooling tower
  e.g. replacement of all wooden internals by polystyrol and increase of the coolant capacity to 5.5 MW.
- The FRG-2 cooling tower
  e.g. renewing of the water distribution system.

4.7 Modernization of the ventilation system

Old flaps were partially removed and hose flaps were installed. Within the exhaust air channels the conventional filtering system has been replaced totally. Now all inspections can be made leaving the filters in place and the main flaps can be operated automatically.

4.8 Measures against water leakages

Two kind of damages were known: Water leakage from the ceiling in the cellar below the reactor pools and some defect ceramics (fig. 2) at walls of the FRG-1 pool.

4.8.1 In pile repairs

The licensing authorities demand to present a repair program for the pool and for avoiding water leakage into the cellar.

To understand the considerations and the proposed repair program a brief design description of the biological shield must be taken from fig. 3. It is clear that there were rised the following questions:

- quality of the internal part of the 60 cm concrete ($\rho = 2.3\ g/cm^3$)
- quality and γ-resistance of the epoxy resin concrete layer
- status of the steel liner
- status of the thiokol waterproofing between steel liner and Al beam tubes.

Steps of the repair program were:

- the reactor bridge of FRG-1 including core and grid plate was moved to an other pool;

- radioactive components like the inpile parts of the beam tubes, etc. were removed by three divers. A maximum whole body dose of 0,9 mSv was achieved by the divers;

- removing parts of the ceramics, of the sealing epoxy resin and of the internal concrete (fig. 4);

- inspection of the internal concrete by the consultants. This includes optical inspection, compression measurements on selected samples and hardness measurements. The results are found to be good;

- inspection of the steel liner at two different positions:
  In both cases the liner was found to be in an excellent condition (fig. 5);

- injection of polyurethan to tighten the thiokol seal between steel

liner and Al beam tubes. There are 20 of these penetrations of liner and concrete;
- repairing of the 60 cm concrete ($\rho = 2.3$ g/cm³);
- sealing the concrete with unsaturated polyester;
- placing the ceramics;
- cleaning the pool. Fig. 6 is showing a section of the repaired pool I.

4.8.2 Carbonized concrete

In a separate part of the cellar (3 x 12.5 m²) which is below pool 3 and 4 there were a few small cracks within the concrete of the ceiling (fig. 7). Removing these damaged parts in a small region and to a depth of ca. 2 cm we checked the pH of the concrete which gives good information about the quality of the concrete. With a great surprise to the involved parties a carbonization depth of ca. 12 cm was found (fig. 8). This carbonized conrete must be removed totally and new concrete has to be placed there as otherwise the whole structure may loose its stability.

Finally: All repair actions were fully accepted by the licensing authorities and their consultants and til today the status of the repaired parts is excellent.

4.9 A new lead cell in the reactor hall has been build for improving the handling of radioisotope samples.

5. Ongoing and planned backfitting activities

At present there are some ongoing and planned backfitting activities e.g.

5.1 Replacement of instrumentation etc.

As it could be seen that there will be within the next future increasing difficulties for maintaining and repairing the process control system and for getting new spare parts it was decided to renew the instrumentation, the process control system and the alarm system. The order was placed end of 1988. The system is under construction and will be implemented beginning of 1990.

5.2 Renewal of the emergency power supply

At present we have since many years in operation a flying wheel diesel generator and a diesel generator for the emergency power supply (1 out of 2). The capacity of these generators is large so that they are not only used for the needs of an emergency power supply. Probable faults can be caused by other reasons.

Considering this situation the decision was made to build a new station for (2 out of 3) diesel generators to be used only for the emergency power supply for our two reactors. The principal design work is being finished and GKSS asked for inquiries from competent suppliers.

5.3 Lightning protection

The standard conventional lightning protection is present and inspected annually by consultants. Due to research results taking into account damages in modern electronics (IC) arising from induced voltages and currents a by far more increased lightning protection is necessary. A consultants report is being made.

5.4 Additional measures are undertaken for:

- pneumatic system
- water retention system
- training personnel
- chimney repair
- physical protection.

6. Resumee

The GKSS research centre intends to operate their research reactors safe to prevent undue risks from the public and the operational staff. Therefore many actions have been made

- to follow present safety philosophies
- to replace old equipment to have an installation which is near the state of the art
- to learn from operation experience got in our and other facilities.

These efforts will continue to allow safe operation of our research reactors over their whole operational life.

Table 1: List of most relevant criterias, guidelines, standards for the backfitting measures of the FRG-research reactors.

1. Safety criterias for power reactors, edited by the federal ministry of interior 06.25,74, revised 11.03,77.

2. Guidelines for pressurized power reactors, edited by the reactor safety commission 04.24,74 revised 10.14,81.

3. Nuclear standards

KTA 1201	Operation manual
KTA 1202	Inspection manual
KTA 2101	Fire protection
KTA 2206	Lightning protection
KTA 3501	Reactor protection system
KTA 3702.1	Design of diesel emergency power supplies
KTA 3702.2	Inspection of diesel emergency power supplies
KTA 3901	Communication systems
KTA 3902	Design of lifting equipments
KTA 3903	Operation and inspection of lifting equipments
KTA 3904	Control room

Figures:

Literature:

[1] W. Krull: Die Kalte Neutronenquelle am Forschungsreaktor FRG-1, Atomwirtschaft 33 (1988) 43-47

[2] E. Klar, W. Krull: Demands Made on Reactor Protection Systems and the Design of such Systems for Research Reactors, Siemens Power Engineering II (1980) no 4, 95-98

[3] W. Krull: Upgrading of the Research Reactors FRG-1 and FRG-2, IAEA-SR-77/27, Seminar on Research Reactor Operation and Use, Jülich 14.-18. September 1981

[4] W. Krull: Backfitting and Upgrading Measures for Research Reactors, Reactor meeting, Aachen, 9.-11. April 1986

[5] W. Krull: Experiences with Interpretation and Application of the German Atomic Energy Act for the German Research Reactors in Geesthacht, FRG-1 and FRG-2, GKSS 80/E/16 (1980)

[6] W. Hajek, H.-J. Kriks, W. Krull: Backfitting Safety Measures in FR Germany, Nuclear Engineering International, December 1988, 58-59, Atomwirtschaft 33 (1988) 454-457

[7] W. Krull: Störfallüberlegungen für einen 15 t Kran in der Reaktorhalle, GKSS 81/I/2, GKSS 83/I/15

[8] W. Krull: Enrichment Reduction Activities for the FRG-1 and FRG-2 Research Reactors, RERTR meeting, San Diego, 19.-22. September 1988

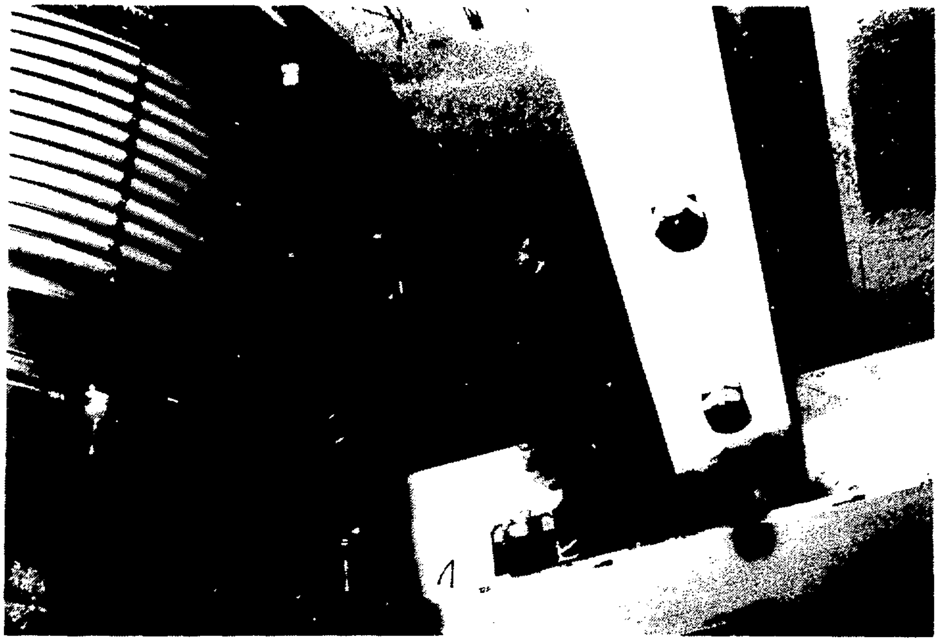

Fig.: 1

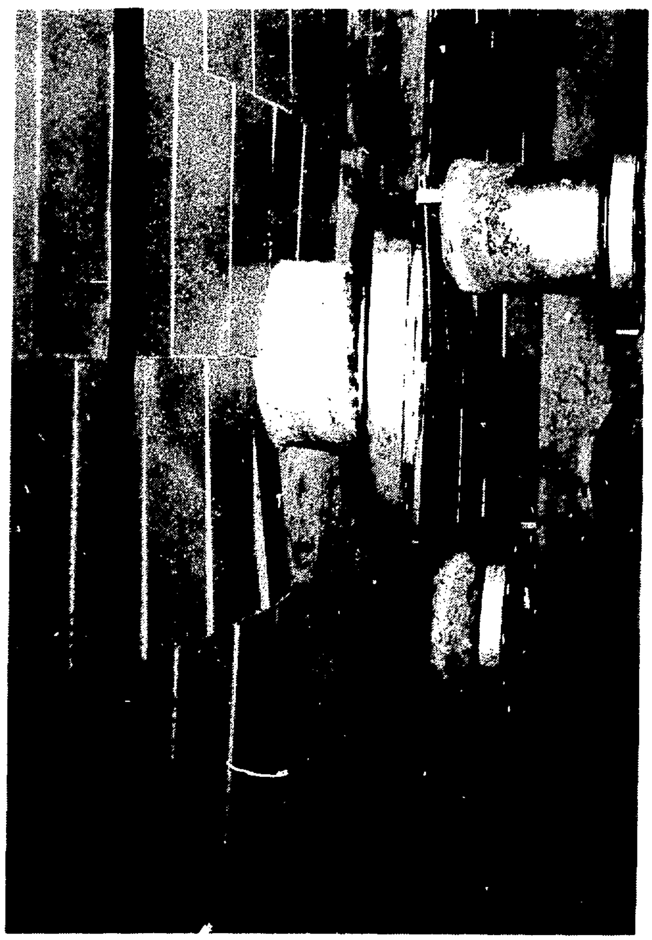

Fig.: 2

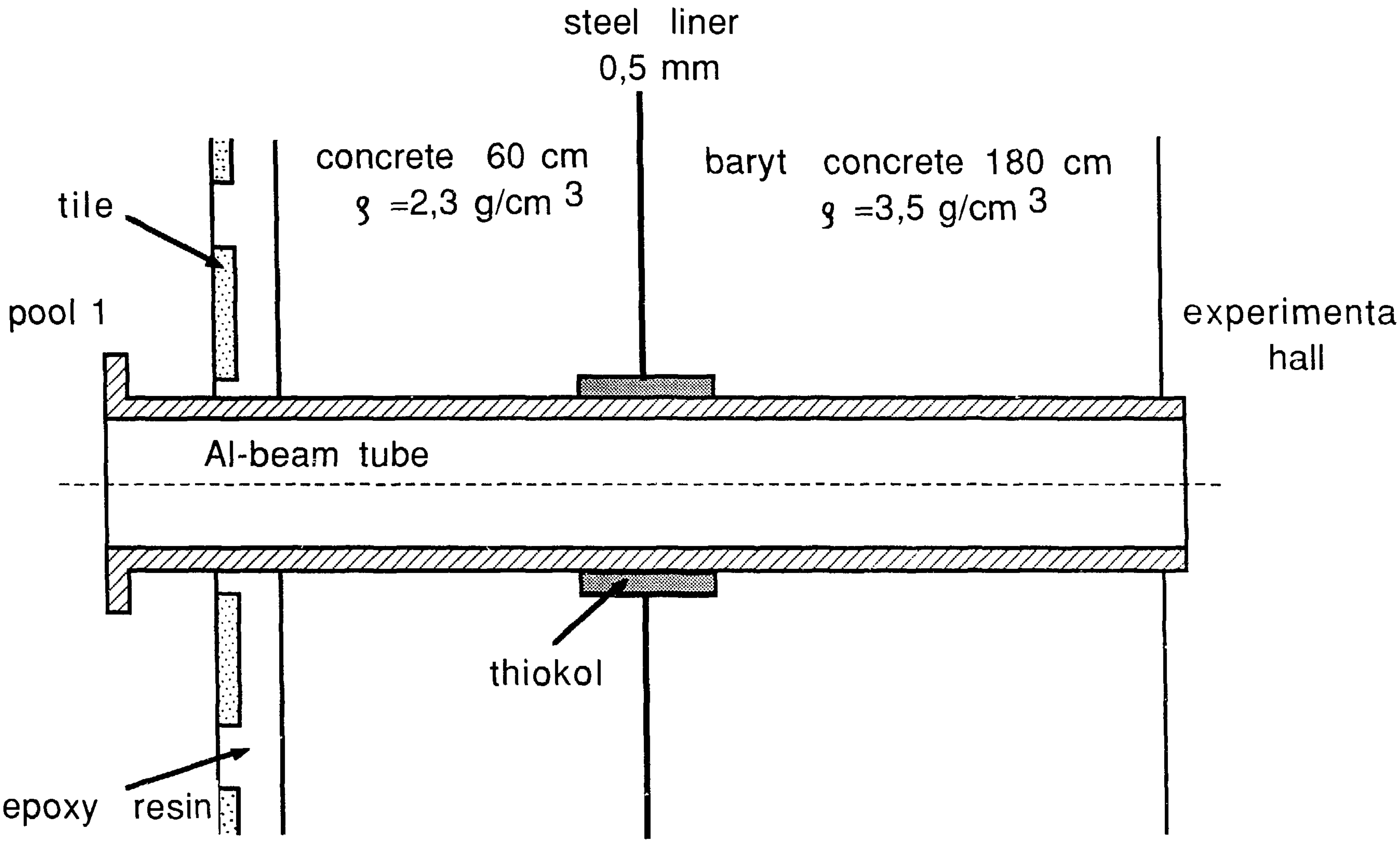

Fig. 3: Cross section of the biological shield

Fig.: 4

Fig.: 5

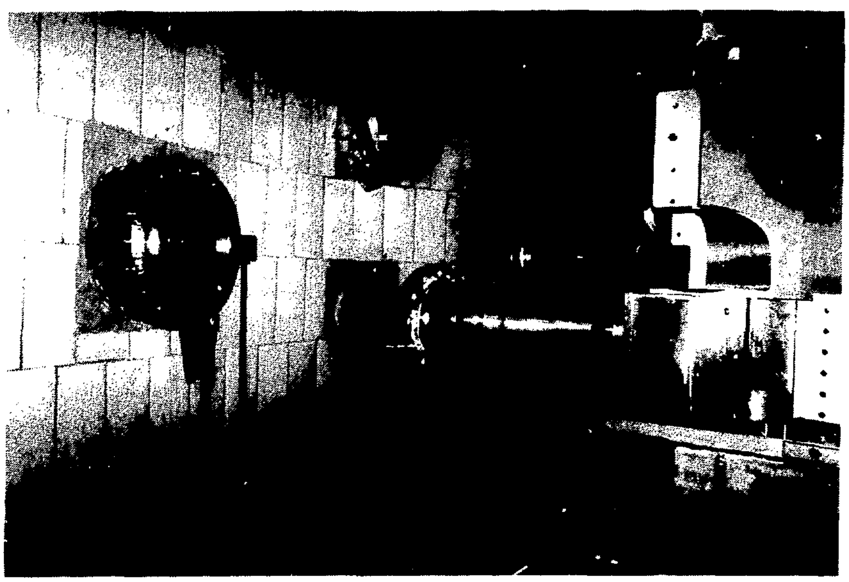

Fig.: 6

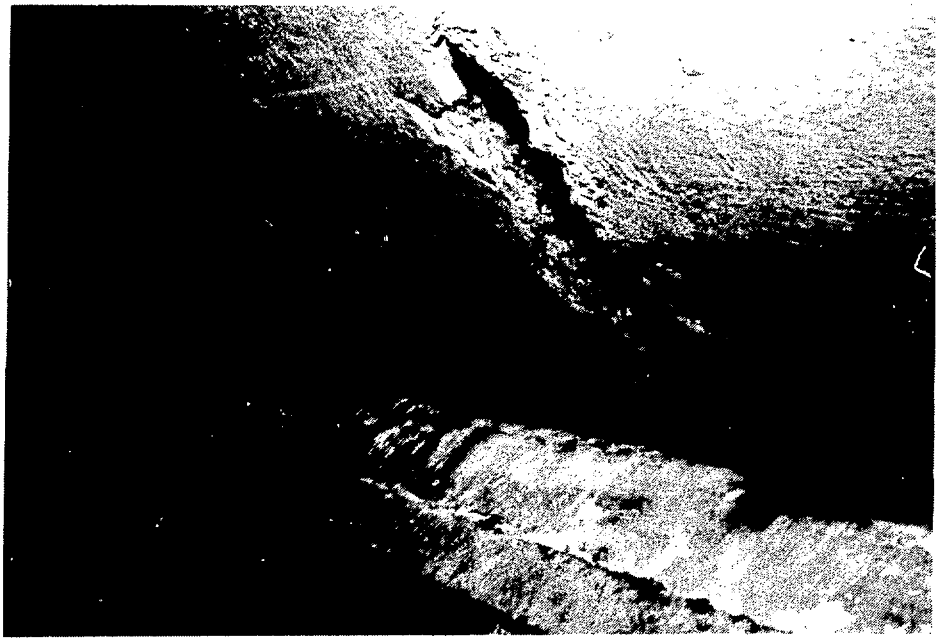

Fig.: 7

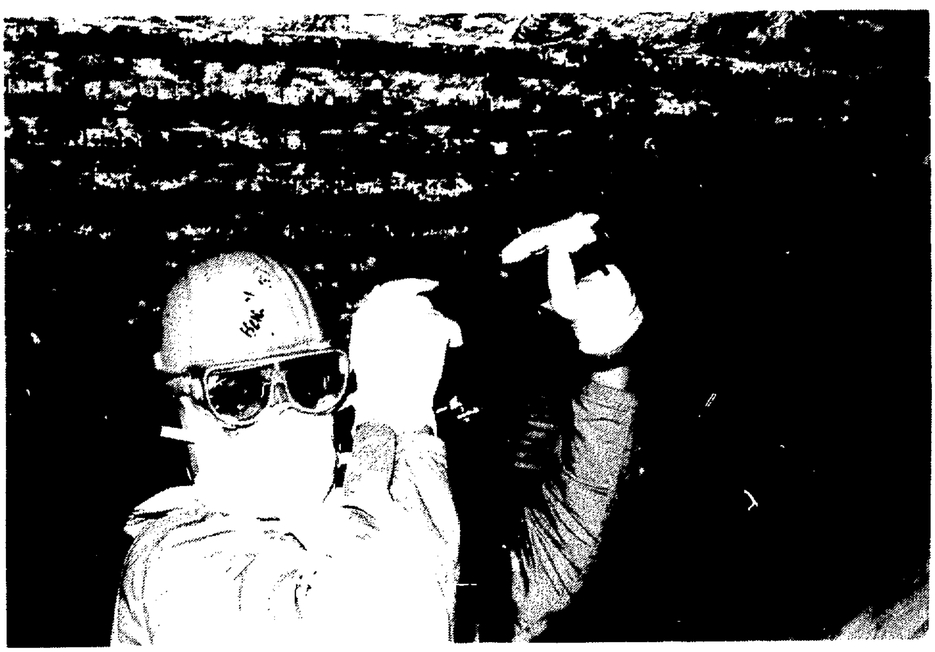

Fig.: 8