POST-IRRADIATION EXAMINATION OF HIGH TEMPERATURE REACTOR FUEL ELEMENTS

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900° alg.
1250°c in de centen.

ABSTRACT[1]

In the framework of the Share Cost Actions (SCA) of the European Commission, a European Project of Development of High Temperature Reactor (HTR) technology has been approved. The project includes developments in the fields of reactor physics, fuel technology, safety, material needs and feasibility of key components and systems.

In the domain of fuel technology a key point is represented by the testing of the irradiation behaviour of new type of fuels and their fabrication methods. In this context, the post-irradiation examination (PIE) of irradiated fuels will be needed to assess the quality of new concepts. Among the PIE-methods the verification of the release behaviour of fission gases (Xe, Kr) and solid fission products (Cs, Sr, Ag, etc) under accident conditions will be of paramount importance.

In the past, the so-called Cold Finger Apparatus (KÜFA) was developed in the Forschungszentrum Jülich (FzJ) to test HTR-fuel design and fabrication methods. Using this device, the fission product release from fuel spheres can be tested up to 1800 °C.

In the framework of the SCA/HTR-technology, an up-dated version of the KÜFA will be installed in the hot cells of the Institute for Transuranium Elements. In the paper, a description of the apparatus will presented and the experimental programme discussed.

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[1] **To be presented to the European Working Group "Hot Laboratories and Remote Handling", to be held from 27th to 29th September, 2000, at Paul Scherrer Institute, Villigen, Switzerland.**

ADVANTAGES OF HTR's

- INHERENTLY SAFE
    - Low response to T-transients
    - Highly negative T-coefficient (U-fuel)
- PUBLIC ACCEPTANCE
- PROCESS HEAT / ELECTRICITY PRODUCTION
- LOW COSTS
- CAPACITY OF BURNING DIFFERENT FUEL TYPES
    - U, Pu (also military), Th, etc.
- VERY HIGH BURN-UP CAN BE ACHIEVED
    - more than 20 FIMA
- VARIABLE SIZE
    - Modular concept
- LOW WASTE BURDEN
- LOW ATMOSPHERIC POLLUTION
- PROLIFERATION RESISTANT
- He-COOLANT ADVANTAGES
    - good heat transfer coefficient
    - compatibility at all T with all materials
    - practically no activation
    - ***tendency to leak***

PREVIOUS EXPERIENCE WITH HTRs IN THE WORLD

USA

- Peach Bottom: 40 MWe (compacts)
- Fort St. Vrain: 330 Mwe (compacts)

GERMANY

- AVR: 15 MWe (pebble bed)
- THTR: 300 MWe (pebble bed)

GREAT BRITAIN

- DRAGON: compacts
- GCRs: fuel rods

GAS cooled reactor

NEW HTRs IN THE WORLD

RUSSIA

↳ met framatome.

→ military Pu

- GT - MHR: - 600 MWth
  - compacts

JAPAN

- HTTR: - 30 MWth
  - compacts

CHINA

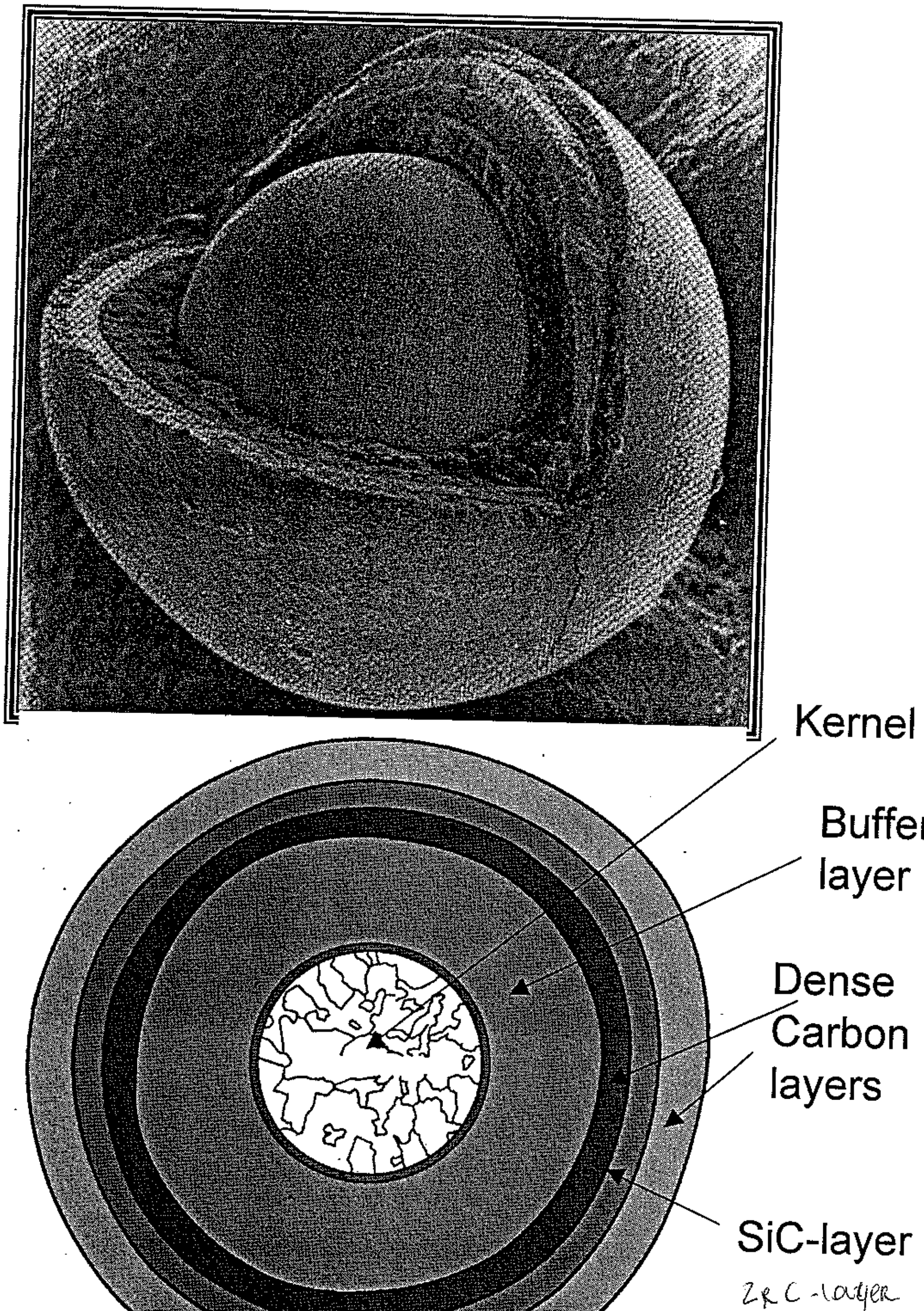
- ***HTR-10: - 10 MWe***
  - ***pebble bed***

SOUTH AFRICA

- ***PBMR: - 10 MWe***
  - ***pebble bed***

all fuel is based on particles.

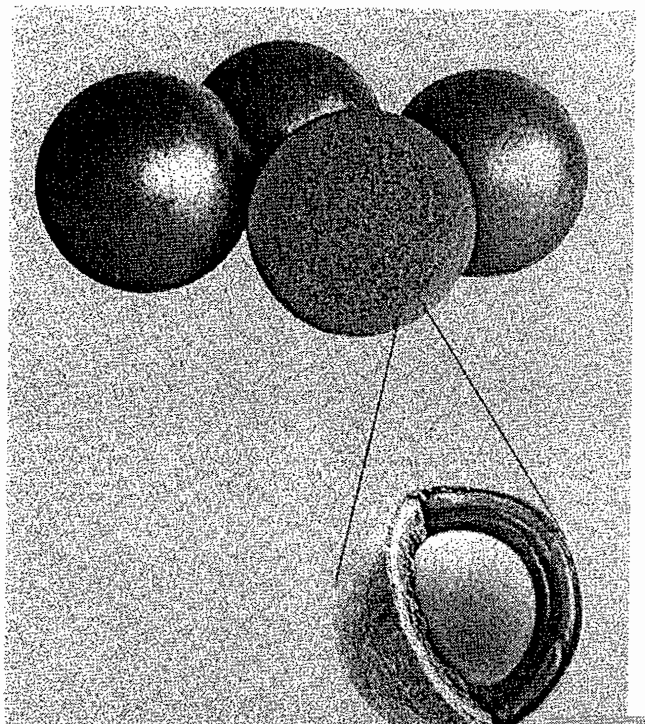
BROKEN PARTICLE AND SCHEMATIC BUILT-UP

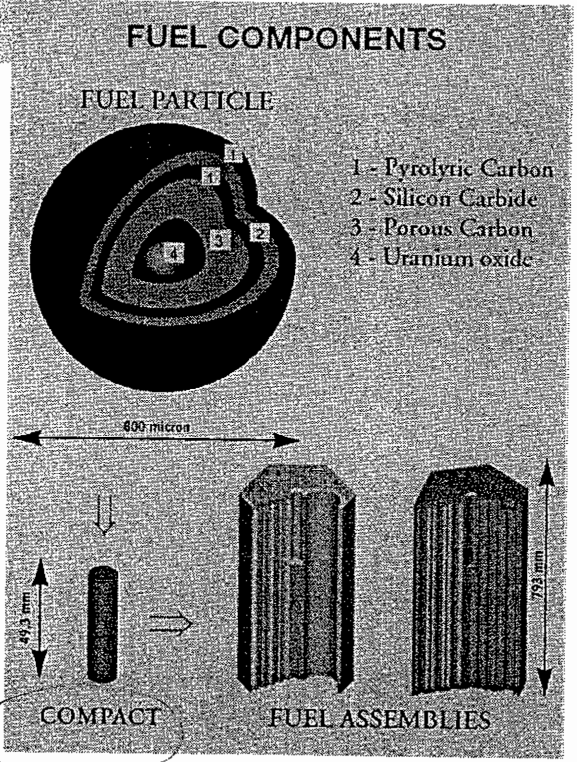


porous graphite

ZrC-layer

FUEL ELMENTS AND COATED PARTICLES





- framatome, BNFL ... -

SHARED-COST ACTION
HTR-F1

Maintain the strategic advantage of
mastering a high quality of fuel
fabrication achieved in Europe in the past

1) Data collection

2) Kernel fabrication (UO2, PuO2, etc.)

3) Advanced coatings (ZrC, etc.)
   modelling.

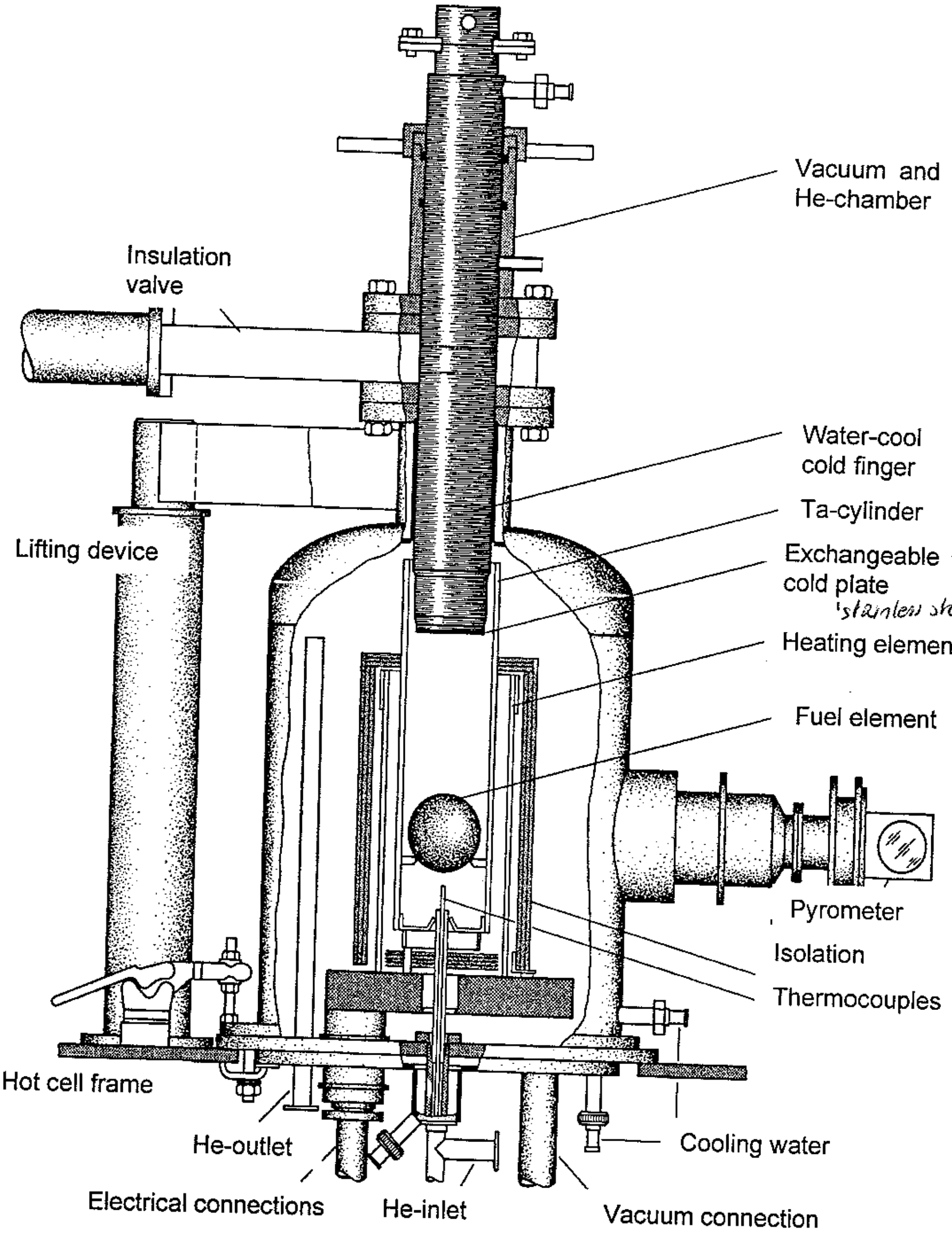
4) Very high burn-up (> 20 FIMA)

5) Fuel qualification:

   Irradiation program
   Post-irradiation examination

6) Modeling

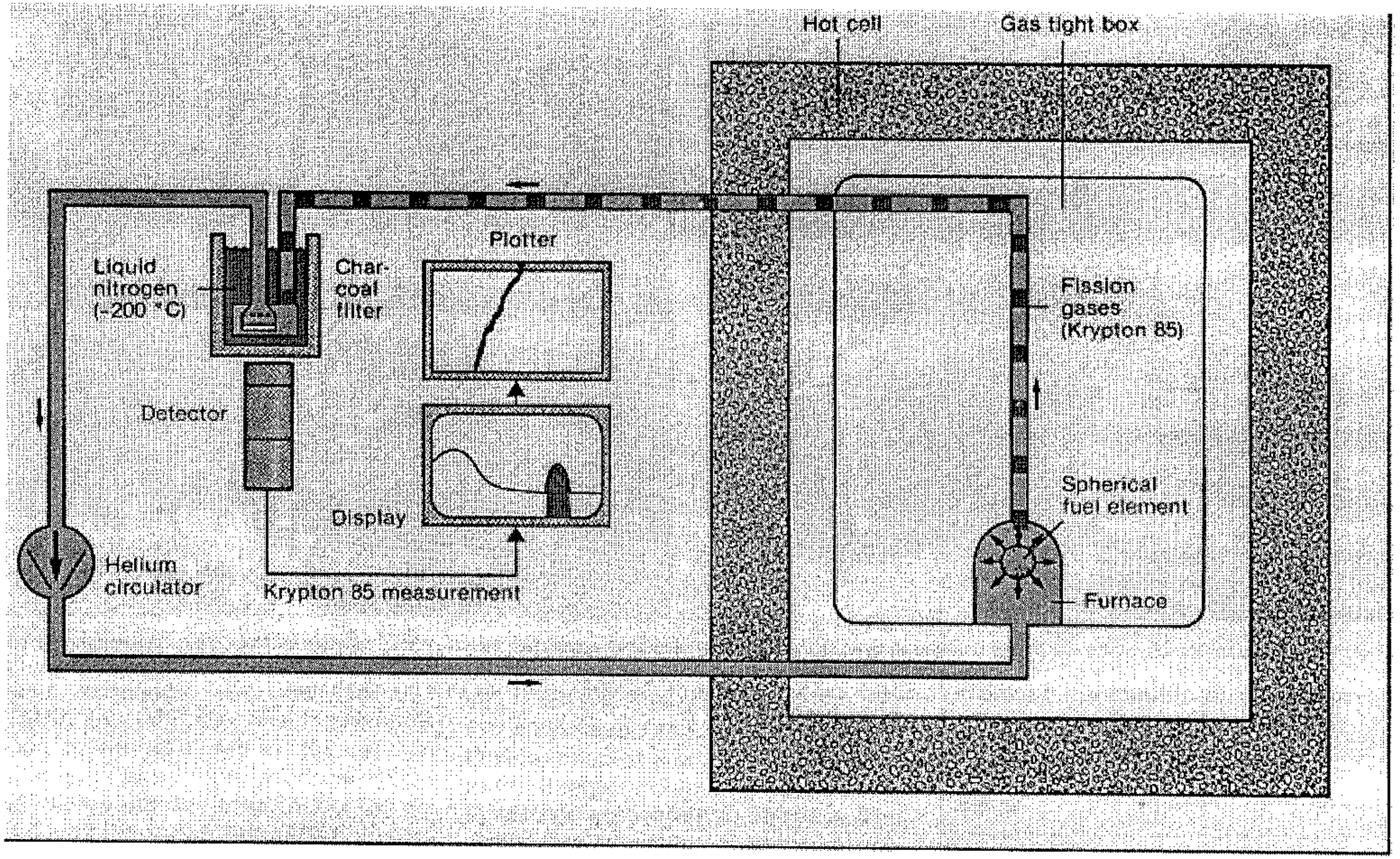
COLD-FINGER APPARATUS



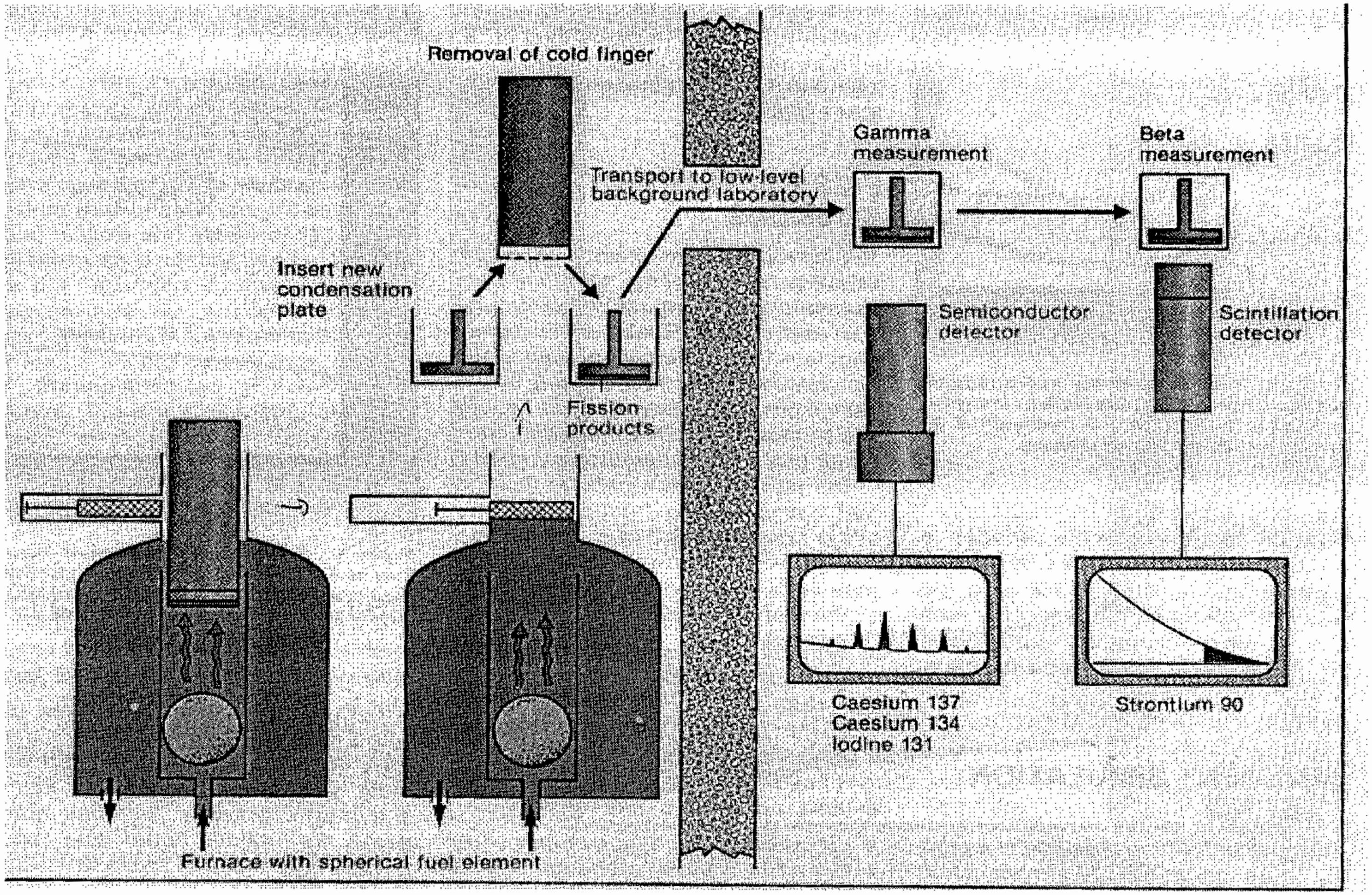
simuleer LOCA → He w̄ afgezet

max t°: 2000°c

MEASUREMENT OF THE GAS RELEASE



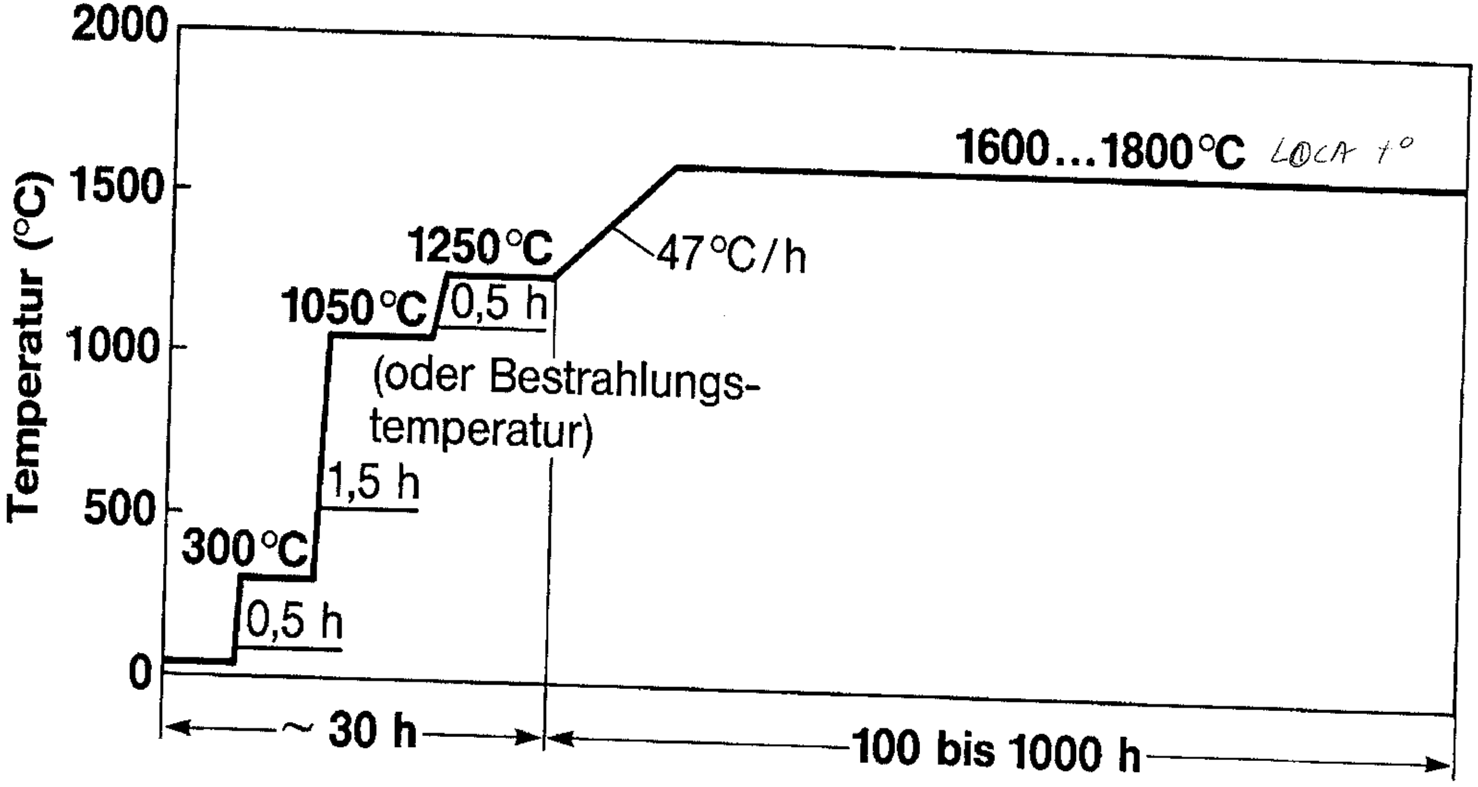
MEASUREMENT OF THE SOLID FISSION PRODUCTS



DATA OF IRRADIATED FUEL SPHERES

Experiment	***Particle number***	***Irrad. time (fpd)***	***Temperature surf./centre (°C)***	***Burnup (% FIMA)***	***Fluence (E>1MeV) 1E+25 $1/m^2$***	***Rel. at end of irrad.***	
						R/B Kr 85m	***Fract. rel. Cs 137***
FRJ2-K15/1	9.600	533	800 / 970	14,1	0,2	1E-06	1E-06
FRJ2-K15/2	9.600	533	980 / 1150	15,3	0,2	5E-09	9E-07
FRJ2-K15/3	9.600	533	800 / 990	14,8	0,1	3E-09	4E-07
HFR-K5/1	16.400	564	cycled	6,7	4,0	2E-07	
HFR-K5/2	16.400	564	800/1000	8,8	5,8	1E-07	
HFR-K5/3	16.400	564	(centre)	9,1	5,9	1E-07	not
HFR-K5/4	16.400	564		8,7	4,9	3E-07	
HFR-K6/1	16.400	633	cycled	7,2	3,2	2E-07	measured
HFR-K6/2	16.400	633	800/1000	9,3	4,6	2E-07	
HFR-K6/3	16.400	633	(centre)	9,7	4,8	2E-07	
HFR-K6/4	16.400	633		9,2	4,5	6E-07	
5 FE AVR-GLE 3	16400						
5 FE AVR-GLE 4	9600						

TYPICAL HEATING CURVE



CONCLUSIONS:

- An existing equipment, developed at FZ-Jülich, will be up-graded and installed in the hot cells at ITU in the framework of a SCA of EC.

- After installation, already irradiated specimens and others to be irradiated in HFR-Petten up to ultra-high burn-up will be tested.