

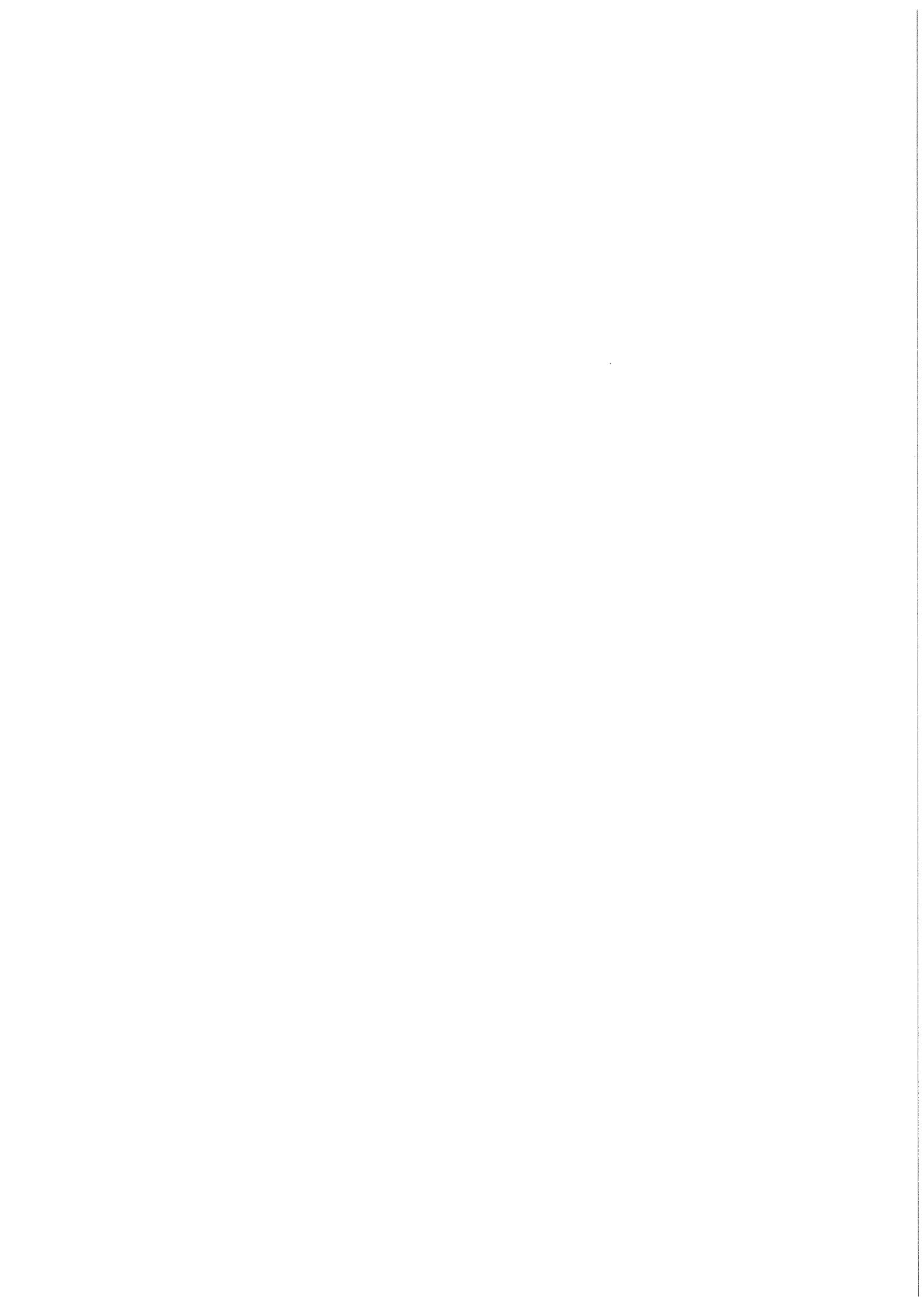
**KfK 3922
EUR 9608e
Mai 1985**

Fusion Technology Programme

**Semi-annual Report
October 1984-March 1985**

**Compiled by
D. Finken
Projekt Kernfusion**

Kernforschungszentrum Karlsruhe



KERNFORSCHUNGSZENTRUM KARLSRUHE

Projekt Kernfusion

KfK 3922

EUR 9608 e

Fusion Technology Programme

Semi-annual Report

October 1984 - March 1985

Compiled by

D. Finken

Kernforschungszentrum Karlsruhe GmbH, Karlsruhe

Als Manuskript vervielfältigt
Für diesen Bericht behalten wir uns alle Rechte vor

Kernforschungszentrum Karlsruhe GmbH
ISSN 0303-4003

CONTENTS

page

Preface		1
Description of Technical Work		
B 1	Blanket Design Studies	3
B 2	Development of Computational Tools for Neutronics	5
B 6	Corrosion of Structural Materials in Flowing $\text{Li}_{17}\text{Pb}_{83}$	6
B 9	Tritium Extraction based on the Use of Solid Getters	7
B 11 - B 16	Ceramic Breeder Materials	8
M 1	LCT-Project	13
M 3	Development of High Field Composite Superconductors	15
M 4	Superconducting Poloidal Field Coils	17
MAT 1	Post Irradiation Testing of Stainless Steel	19
MAT 6/MAT 13	Ceramics for First Wall Protection, Insulators and Windows	20
S+E 1	Radioactive Effluents: Behaviour of gaseous Tritium in the Air, Plant, Soil System	21
S+E 2	Accident Analysis	22
T 1	Fuel Clean-up System	24
T 5	Development of Tritium Decontamination Systems	25
T 6	Industrial Development of Large Components for Vacuum Systems	26
	Studies for NET/INTOR	27
	Development of ECRH Power Sources at 150 GHz	29
Publications		30
Appendix I:	Participation of KfK Departments in the Fusion Technology Programme	34
Appendix II:	Table of NET Contracts	35
Appendix III:	KfK Departments and Project Management Group	36

P r e f a c e

In the current Fusion Technology Programme of the European Community the KfK association is working at present on 16 R&D contracts. Some additional effort is being spent on system studies, preparation of the follow-on programme and on planning of test facilities. In the Physics Programme, KfK contributes by a study on 150 GHz Gyrotron development.

Most of the work is strongly oriented towards the Next European Torus. Direct support to NET is given by three KfK delegates being member of the NET study group. In addition to the R&D contracts the association is working on 11 NET study contracts. Though KfK contributes to all areas defined in fusion technology, the main emphasis is put on superconducting magnet and breeding blanket development. Other important fields are tritium technology, materials research, and remote handling.

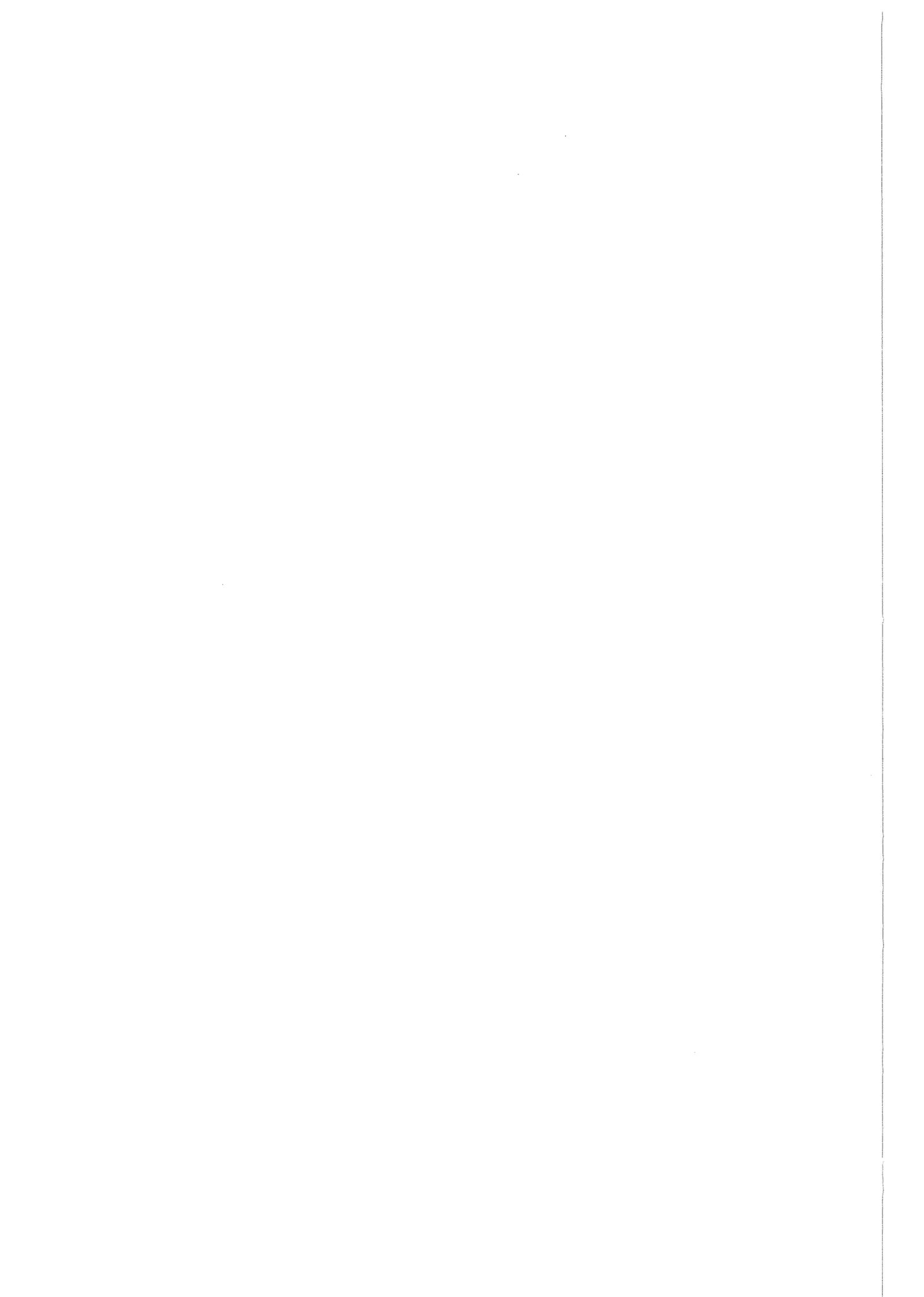
Some effort has been spent to define new activities for the forthcoming 1985/89 programme. These proposals are at present discussed in the European expert groups.

For the future evolution of the technology programme, test facilities will be of great importance. KfK has continued to define and plan such testing facilities. Fast reactor (KNK II) and the novel dual beam irradiations are planned for the irradiation programme of structural materials. A central laboratory for the development of remote handling methods and for manipulation of NET components has been proposed by KfK. Conceptual design of a superconducting magnet test arrangement is carried on with the aim to create a suitable high field environment for the test of toroidal field coils relevant for NET. The tritium laboratory planned by KfK to house experiments using larger amount of tritium is proceeding to detailed design. Feasibility studies of reactor and out of pile testing of blanket elements are underway to define future test installations.

The present report reviews the progress of the work under contract with the CEC in the period October 1984 to March 1985.

The annexes may help to relate the reported actions to the participating KfK departments and to give information on task sharing with partner laboratories.

J.E. Vetter



B 1 Blanket Design Studies

Helium Cooled Ceramic Breeder Blanket

Engineering studies of the poloidal tube concept, as described in the last semi-annual report, were continued. Fabricability considerations required tubes with circular bending and one bending radius only. This leads to relatively poor coverage and some shielding problems.

For comparison the engineering aspects of a lobular design for NET were studied. This concept, which is the most favourable from the neutronics and thermo-hydraulics point of view, has some difficult engineering problems, for instance:

- The compensation of pressure forces of neighbouring flat walls fails in case of single element depressurization,
- the forces on the structure frame are quite high and difficult to analyze,
- the number and length of welds is much higher than for the poloidal concept,
- quality control is difficult,
- differential thermal expansion of the elements may lead to difficulties in plasma chamber evacuation.

As a next step a lobular concept will be studied in which the individual elements can keep their flat wall pressure forces without contact to the neighbouring elements.

Separation of Tritium from Helium Coolant and Purge Circuits

Different processes were investigated for the separation of Tritium from the purge and coolant circuit of Helium-cooled blankets. The concepts mostly proposed, use either the freezing out in cold traps or the adsorption in molecular sieves. For these concepts an estimation of the plant dimensions was performed for NET characteristic blanket conditions. Parameters were the tritium partial pressure and systems pressure in the purge circuit. The use of cold traps yields to extremely unfavourable plant dimensions for low partial pressures and high system pressures. If molecular sieves are used, the results are much more favourable. However, it has to be proven experimentally that tritium-loaded molecular sieves can be perfectly desorbed.

Liquid Metal Cooled Blanket

The design study for a liquid metal cooled NET blanket was continued. Investigated were the mechanical design, the MHD pressure drop and the temperature profiles across the coolant channels.

Different methods for the attachment of the blanket segments in the torus geometry were suggested and the mechanical forces caused by the MHD pressure drop were estimated. It has been found that these forces do not create a feasibility problem. The largest uncertainty is the MHD pressure drop. Estimates based on the present knowledge show that no excessive large stresses are caused in the structural material by the MHD pressure drop but more experimental and theoretical information is needed.

Calculations of the temperature profiles across the coolant channels showed rather large temperature differences in the toroidal channels.

In the case that there is no flow component perpendicular to the main flow direction, the depth of these channels has to be reduced in order not to exceed temperature limitations given by corrosion limits.

A more detailed analysis of the temperature field will be performed in order to obtain the boundary conditions for stress analysis.

First estimates showed that the tritium permeation losses can be reduced considerably by using an intermediate sodium loop. This task will be continued by comparing different tritium extraction methods.

MHD-Study

A study to describe and judge MHD-key problems using liquid metals in blankets of fusion reactors with magnetic confinement was carried out. Main issues were the MHD-pressure losses and friction coefficients for different liquid metal flow configurations (e.g. straight channels, bends etc.). Additionally the influence of strong outer magnetic fields on the velocity distribution and the resulting effects on heat transfer and corrosion were discussed.

It was shown that there exists a lack of experimental data concerning the MHD-effects in strong magnetic fields. Therefore an MHD-programme was proposed to provide basic information on liquid metal MHD that

will permit designers to assess the feasibility and viability of LMFBR concepts for NET and to identify any technical problems arising from MHD-effects.

Staff:

L. Barleon
M. Dalle Donne
S. Dorner
U. Fischer
H: Kreuzinger
M. Küchle
S. Malang
R. Melcher
I. Michael
J. Reimann

B 2 Development of Computational Tools for Neutronics

The development of the general anisotropic neutron transport system, GANTRAS, has been continued. Some processing modules have already been set up and tested. At present the development work is concentrated on the one-dimensional transport module ANTRA 1, which is based on the S_N -programme ONETRAN. After finishing and testing the one-dimensional module, it is intended to establish a two-dimensional module ANTRA 2 in a similar manner.

After the implementation of the LANL Monte Carlo Code MCNP in 1984, it was decided to implement also the CEA Monte Carlo Code TRIPOLI. The main reason for establishing a second Monte Carlo Code at KfK was the possibility to cooperate with CEA in developing the TRIPOLI code further (e.g. inclusion of double-differential cross-sections) and thus to gain more experience in this area. TRIPOLI has been implemented meanwhile, and the sample problems included in the code package were run successfully.

For calculating group constants from nuclear data libraries using the ENDF/B format (e.g. the European Fusion File EFF), the processing code system NJOY has been implemented on the Siemens computer at KfK. During the testing phase, several programme errors of the IBM version of NJOY were detected and removed. For a selection of materials, a thorough comparison between group constants calculated by NJOY and by the KfK processing code MIGROS-3 is being performed. After finishing these investigations, NJOY will be applied to calculate group constants from EFF.

The transformation of the VITAMIN-C nuclear data library to the KAPROS programming system is being finalized. A condensed version of VITAMIN-C, using 25 neutron and 21 gamma groups, has already been transformed and tested. First efforts have been made to fix an optimized coarse group structure, appropriate for the neutronics of fusion blankets containing strong resonance absorbers. These investigations are being carried on in greater detail.

The ${}^7\text{Li}(n,n't)$ α cross-section has been reanalyzed in the light of new experimental data published in 1984. Good agreement could be found between the 1981 KfK-evaluation and the new data (Fig. 1). Thus a revision of the KfK-evaluation does not seem to be necessary.

The neutron Kerma factors for Zr, being missed in the commonly used libraries for fusion application, have been calculated on the basis of the Lawrence Liver-

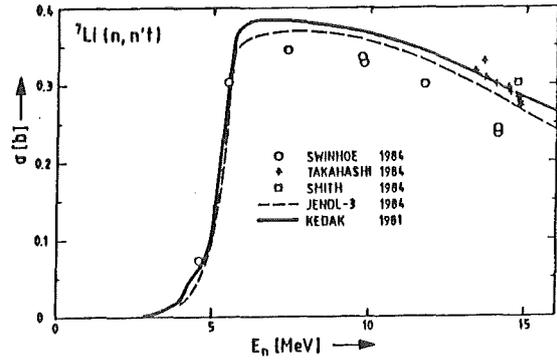


Fig. 1: ${}^7\text{Li}(n,n't)$ α cross-section. Swinhoe Data are a Recalculation of Older Measurements. Takahashi and Smith are Precision Measurement Published Recently.

more nuclear data library ENDL 82. The results are shown in Fig. 2. To check the nuclear data and the evaluation procedure, Kerma factors have also been calculated for Pb. The agreement of the Pb Kerma factors with those of MACKLIB-IV is satisfactory for elastic scattering. There are larger discrepancies for the neutron capture Kerma factors involving small differences of equally large numbers.

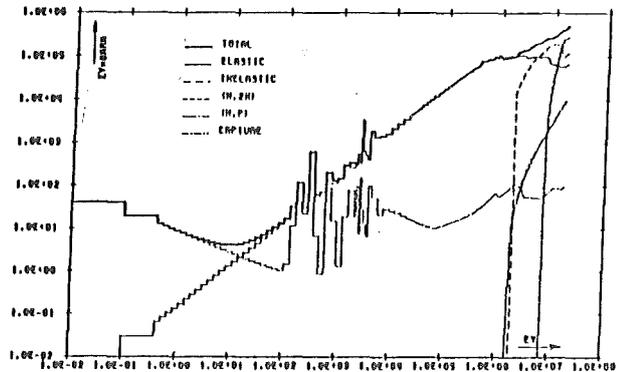


Fig. 2: Kerma Factors for Zr

Publications:

21046
20722

Staff:

C. Broeders
I. Broeders
U. Fischer
B. Goel
B. Krieg
H. Küsters
A. Schwenk
E. Stein
E. Wiegner

B 6 Corrosion of Structural Materials in flowing
Li₁₇Pb₈₃

The pumped Li₁₇Pb₈₃ loop for corrosion and chemical tests /19969/ was commissioned in January 1985. Operation has started in February 1985. Melting of the Li₁₇Pb₈₃ alloy, delivered by Metallgesellschaft AG, Frankfurt, in the inert gas glove box did not cause any problems. The filling of the loop at ~ 360 C was easily done. The magnetic trap acted as a temperature sink, where the alloy was solidified. This was later cured by better thermal insulation of this component. The loop was maintained at operation at temperatures of 300 - 400 C for about 500 hours. The flow characteristics of the liquid alloy in the test section are shown in Fig. 3.

The experience of the first run was, that thermocouples did not work properly in the test section. This might be due to insufficient wetting or unfavourable positioning of the thermocouples. The problem is under study.

Samples of the alloy were taken for analytical purposes during the filling procedure and after 250 hours of operation.

Publication:
19969

Staff:
H.U. Borgstedt
G. Drechsler
G. Frees
M. Grundmann
Z. Perić

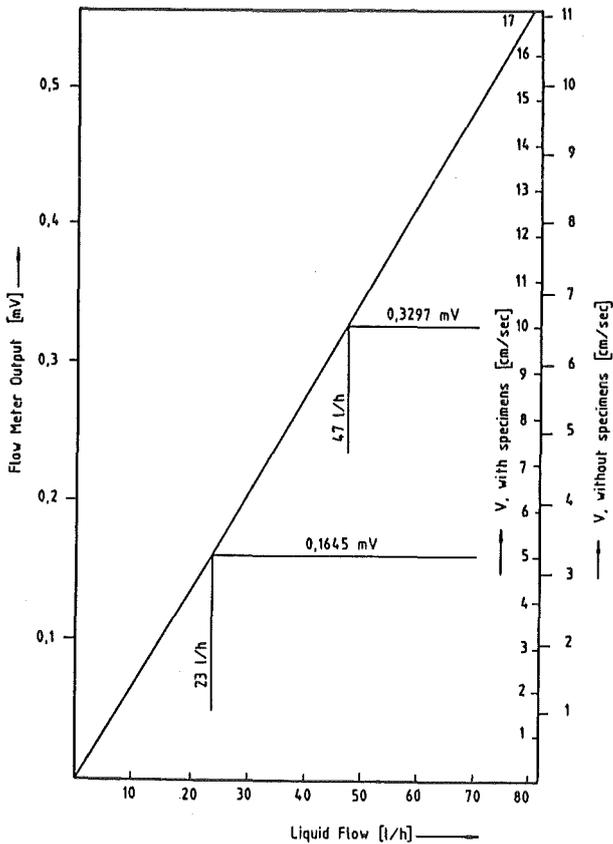


Fig. 3: Flow Velocity in the Test Section of the LiPb Loop as a Function of the EM Pump Energy (with and without specimen holder inserted).

B 9 Tritium Extraction based on the Use of Solid Getters

Titan_{as received}: 2,0 [cm³ / cm² · h]
 Titan_{degassed} : 3,9 [cm³ / cm² · h]

Several methods were proposed to extract tritium from the liquid Li₁₇Pb₈₃ getter material. Task B 9 will study the use of solid getters. The advantage of this method is its simplicity and a low tritium inventory in the blanket, while most of the bred tritium is fixed in the getter.

A criterion for the choice of appropriate getter metals for hydrogen is the H₂ solubility and the kinetic behaviour, the rate at which hydrogen can be absorbed and desorbed.

The candidate getters are transition metals such as titan, zirconium, hafnium, vanadium, niobium, tantalum, yttrium, and uranium as reference substance. Alternate metals as the rare earths and some alloys will be checked later, if necessary. The metals are used as foils, 100 µm thick, with highest purity to exclude impurity effects.

The effect of various reaction parameters such as temperature, initial gas pressure and pretreatment of the metal on the rate of the hydrogen absorption has been examined. The temperature is very important for further investigations of the compatibility with liquid Li₁₇Pb₈₃. With an initial pressure of 800 mbar H₂ we have received the following absorption rates [cm³ H₂(STP) / cm² · h]:

Titan	590 C	2,0
Zirconium	590 C	3,6
Hafnium	570 C	1,4
	660 C	2,0
Vanadium	420 C	2,3
Niobium	490 C	2,2
Tantalum	450 C	0,2
	550 C	0,36
Yttrium	300 C	0,5
	400 C	2,0
Uranium	300 C	23

The kinetic can be drastically enhanced by variation of the form of the metal, by increase of the surface:

Titan_{foil}: 80 [cm³H₂ / g h]
 Titan_{sponge}: 700 [cm³H₂ / g h]

Another improvement is obtained by pretreating the surface of the metals, vacuum annealing at 800 C - 1000 C:

Raising of the temperature is limited by the equilibrium pressure and the loss of hydrogen solubility.

The absorption curves of some getters are presented in Fig. 4.

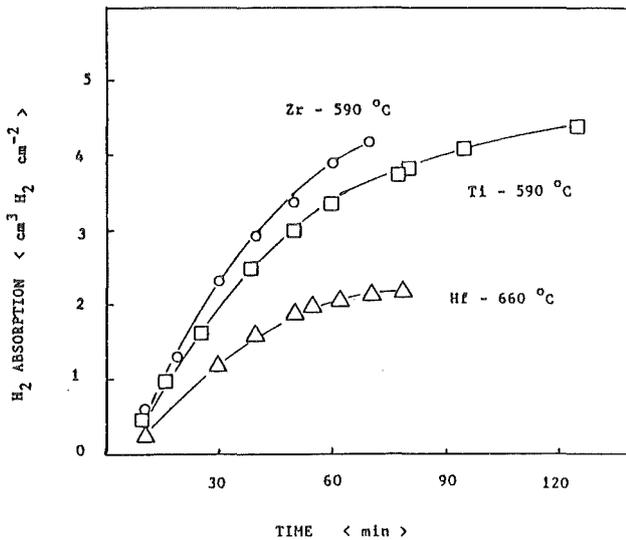


Fig. 4: Hydrogen Absorption on Titanium, Zirconium and Hafnium at 800 mbar

Investigations at low hydrogen pressures show a very strong decrease of the absorption rates. It appears, the rates of vanadium, niobium and zirconium are approximately proportional to $\sqrt{p_{H_2}}$.

During the next reporting period the absorption experiments will be continued and first compatibility tests will be started.

Staff:
 H. Feuerstein
 H. Gräbner

lithium metasilicate samples, because nearly the same preparation technique has been used.

1. Preparation of Li_2SiO_3 Powders and Pellets

The preparation and fabrication of lithium containing monosilicates, Li_2SiO_3 and Li_4SiO_4 , are discussed to be used as breeder materials for fusion reactors within the European Fusion Programme (Tasks B 11 - B 12). The experience, gained in the development of lithium metasilicate /V 19929/, has been used within the development of lithium density and the diffusion coefficient of tritium /V 20581/.

The methods of preparation have been developed under the aspect of a possible technological fabrication within the kg-scale using spray-drying methods and densification of the powders by granulation and sintering.

A number of Li_2SiO_3 pellets have been prepared to obtain information on the physico-chemical and mechanical properties, based on the preparation method already described in detail. The preparation of further samples is foreseen for neutron irradiation tests at Saclay (OSIRIS-reactor) and for an exchange of samples between the French and German groups to compare the methods of characterization and property measurements.

The construction of a small pilot plant facility has been started for the fabrication of powders and pellets of Li_2SiO_3 to obtain more technological experience and a higher degree of reproducibility.

The preparation method, developed for Li_4SiO_4 , is based on the preparation method of Li_2SiO_3 and to be seen as a variation of this technique. Within this method an aqueous suspension of LiOH and amorphous SiO_2 (Aerosil) is prepared in stoichiometric amount, whereas the metasilicate, $\text{Li}_2\text{SiO}_3 \times \text{H}_2\text{O}$, is precipitated. The excess LiOH is then also precipitated by addition of CO_2 or H_2O_2 in the form of Li_2SiO_3 or Li_2O_2 , respectively. A homogeneous Li_4SiO_4 powder is obtained from such a suspension after spray-drying (see Fig. 5) and calcination of the spray-dried powder. Pellets have been prepared from this powders by pressing and sintering with densities of up to 85 % th.d. X-ray-diffraction measurements showed the lithium orthosilicate samples to be monophasic. It is possible to prepare pellets from these powders with defined open porosity in the range of 0.1 to 10 μm using the press-granulation technique, as shown with the lithium metasilicate powders. The chemical analysis showed no further impurities as analyzed at the

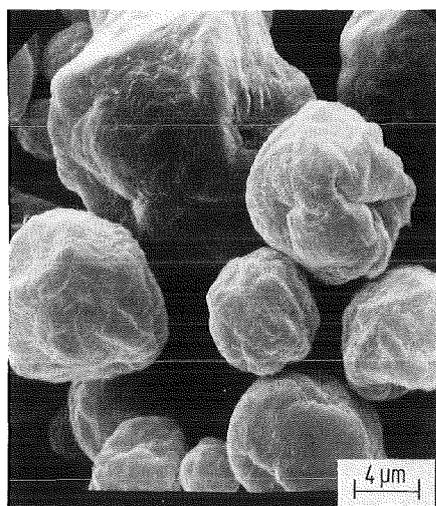


Fig. 5: Spray-dried Powder for Li_4SiO_4 Preparation

Orthosilicate pellets are on the way to be neutron irradiated for about 12 days in the FRU-1 at Jülich at a low specific power in a first test. In a first larger experiment the lithium orthosilicate material shall be irradiated in the SILOE-reactor at Grenoble. The preparation of this experiment is just under way.

It has been shown, that lithium orthosilicate powders and pellets can be prepared by nearly the same technique as used for the preparation of lithium metasilicate materials. It seems to be necessary to vary this method, if sintered bodies of high density (90 % th.d.) are preferred for fusion technology.

2. Constitution and Thermodynamics

A reexamination of the linear thermal expansion of Li_4SiO_4 , calculated from the cell constants measured by high-temperature X-ray diffraction, resulted in a smooth curve with two different coefficients of expansion: between 25 and 550 C, $\alpha = 2.06 \times 10^{-5} \text{ K}^{-1}$ and between 600 and 850 C, $\alpha = 4.42 \times 10^{-5} \text{ K}^{-1}$.

Experimental work on the phase and stability relations of the Li_2O -rich part of the binary $\text{Li}_2\text{O-SiO}_2$ phase diagram confirmed the existence of a new binary phase that contains more Li_2O than Li_4SiO_4 . Its composition is about 4:1 $\text{Li}_2\text{O:SiO}_2$, its crystal structure is unknown.

The adsorption of water vapor was studied using gas mixtures with controlled water content. The results of preliminary experiments on Li_2O are shown in Fig. 6, where the H_2O partial pressures belonging to the equilibrium $\text{Li}_2\text{O}/\text{LiOH}$ are represented as a function of the temperature. The agreement between these results and literature data /1-3/ is sufficient. Subsequent experiments will be conducted on the water adsorption of lithium silicates.

The phase relations of ternary and multinary oxides containing lithium were compiled in a literature study.

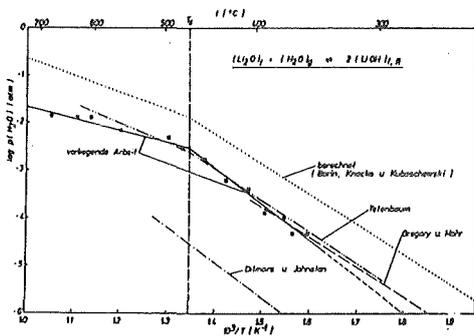


Fig. 6: H_2O Partial Pressures in Equilibrium with $\text{Li}_2\text{O}/\text{LiOH}$ as a Function of the reciprocal Temperature; Comparison of own experimental Data (= vorliegende Arbeit) with calculated Values (= berechnet) and Literature Data /1-3/

3. Thermal Diffusivity and Conductivity of Li-Silicates

Data on the thermal diffusivity or conductivity of Li_2SiO_3 have not been published. We measured on hot pressed samples (1275 K, argon atmosphere, 500 bar, 20 min) of $\sim 5\%$ porosity (measured with an image analyser) and $2\ \mu\text{m}$ mean grain size, the thermal diffusivity up to 1200 K. A laser-flash-diffusivity equipment was used, the atmosphere was vacuum. No hysteresis effect during cooling could be detected. The data are given in Fig. 7. For comparison one value at 875 K measured by Kennedy (calculated from $\alpha = \frac{\lambda}{c_p \cdot \rho}$) is given, too.

Furthermore the diffusivity measurements of Baker and Hollenberg on Li_4SiO_4 are shown in Fig. 6. Baker and Hollenberg calculated from diffusivity data on 90% dense samples, with their data of specific heat and density, the thermal conductivity of Li_4SiO_4 with 10% porosity, these values were corrected for porosity. We recalculated from their equation:

$$\lambda_p = \left(0.0198 + \frac{8.5}{T}\right) \frac{1-P}{1 + (1.95 - 8 \cdot 10^{-4} \cdot T)}$$

[λ] = W/cmK [T] = K

λ_p = thermal conductivity of porous sample,
P = porosity

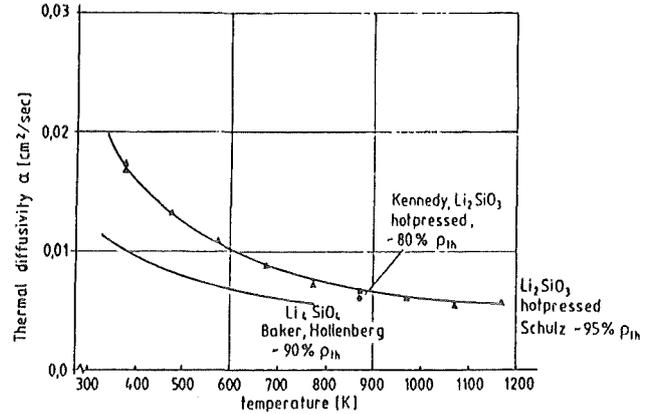


Fig. 7: Thermal Diffusivity of Li-silicates

and the specific heat and density, the thermal diffusivity of Li_4SiO_4 with 10% pores. These data are shown in Fig. 6 and should represent the variation of diffusivity with temperature as measured directly by Hollenberg and Baker.

Since we need much more information on the microstructure of the samples as we really have, it is too early to correct diffusivity or conductivity data for porosity. As long as there are no more data sets to ensure our knowledge of the specific heat it is indeed even too early to convert thermal diffusivity into thermal conductivity values.

4. Mechanical Properties

For the determination of the Young's modulus and of the compressive strength, pellets of four laboratory manufacturing series with different densities were available. The Young's modulus was evaluated from the ultrasonic velocity which was determined by the pulse-echo method. Based on these results and on two values found in the literature it is concluded that the Young's modulus of 100% dense polycrystalline Li_2SiO_3 is between 100 and 125 GPa. The compressive strength of 92% dense Li_2SiO_3 pellets with a mean grain size of $25\ \mu\text{m}$ was found to be about 250 MPa. There seems to be a strong dependence on the density and on the grain size.

The results on the creep behaviour obtained up to now are shown in Fig. 8. The creep rate was measured under uniaxial compressive load in the temperature range

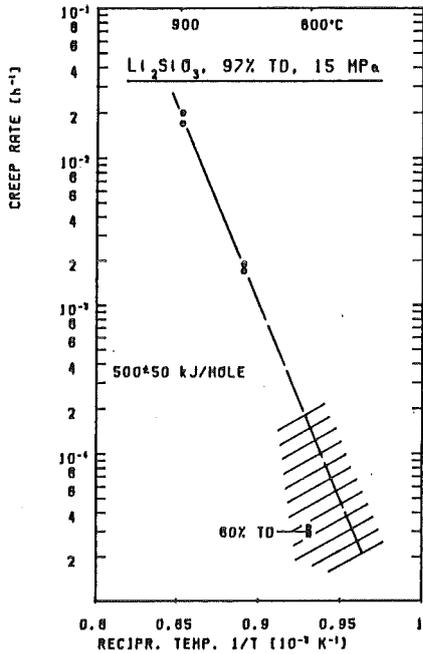


Fig. 8: Compressive creep of Li_2SiO_3 pellets

between 800 and 900 °C. Pellets of 97 % TD (diameter 9 mm, height 8 mm) and pellets of 80 % TD (diameter 5 mm, height 6 mm) were tested. The high density pellets were tested under a stress of 15 MPa, the pellets with 80 % density at various levels of stress (10 to 40 MPa). The measuring period of each data point was ≤ 200 h (down to only some hours at 900 C). The data at 800 C (with the wide scattering range for the few measurements on 97 % TD samples) indicate that, up to now, no considerable dependence of the creep rate on the density can be discerned.

5. The Solubility of Hydrogen in Solid Breeding Materials

One of the objectives of NET is to demonstrate that tritium breeding is feasible in a tokamak reactor. To evaluate candidate breeding materials, data are needed on their compatibility with structural materials within which they will be contained. Further information are required on the extraction properties of tritium but of breeding materials.

Numerous investigations have dealt with the evaluation of diffusion coefficients for tritium in potential ceramic breeders such as Li_2O , LiAlO_2 , LiSiO_3 , etc. Though equally important for an assessment of candidate lithium compounds, the tritium solubility in

these solids has remained largely ignored. Thus a programme to fill this gap has recently been started at KfK.

So far several hundred pellets of Li_2SiO_3 and Li_4SiO_4 having a diameter of 4.5 mm have been pressed from granular powder employing conventional techniques. Powders were either of commercial origin or synthesized at KfK by an improved spray dry method /V 19929, 21158/. Lithium silicates are known to be highly aggressive chemicals. To reduce incorporation of die metal into the pellets during pressing a carefully cleaned and paraffined die in a dry atmosphere was employed for compaction. Sintering was carried out in an oven programmed up to 1100 C. Promising results were also obtained by hot impact densification. The samples were characterized by thermogravimetry, differential thermal analysis and heat Guinier. With the latter technique the reversible and probably displacive transformation of orthosilicate that occurs at 680 C became clearly apparent. The results also suggest that heating of Li_4SiO_4 up to high temperatures promotes the formation of Li_2SiO_3 .

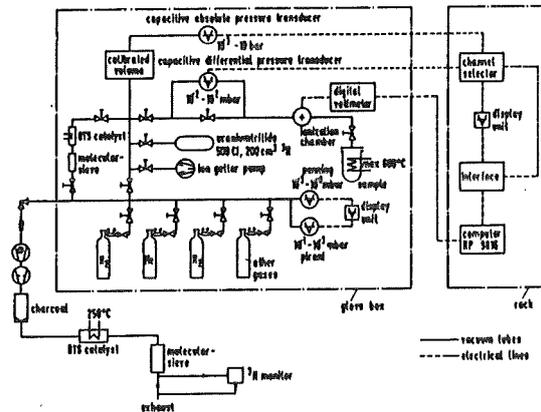


Fig. 9: Simplified Scheme of the Apparatus for Solubility Measurements

The pellets will first be dried in an appropriate containment under high vacuum at elevated temperatures (~ 900 C). After that the closed containment will be transferred into a glove box containing a very dry atmosphere (< 1 ppm H_2O) and opened. The pellets will then be stacked inside a 70 ml SS sample vessel provided with a UHV flange. To minimize hydrogen permeation the vessel has an aluminum lining covered with a Al_2O_3 coat which has been shown to reduce permeation of Al by several orders of magnitude. The sample vessel will then be transferred into another inert gas glove box containing UHV equipment designed for a volumetric determination of tritium solubility in ceramic material (see Fig. 9). Pressure decrease or

increase depending on whether uptake or release is measured in the externally heated sample vessel will be followed with a capacitive differential transducer in the temperature range 300 - 600 C. In addition experiments with H₂/D₂ mixtures as well as with tritium have been planned. Nearly 500 Ci are available as uranium tritide in a double wall containment that permits tritium circulation. The partial pressure of tritium can be determined with a small ionization chamber having a volume of only 3 ml. Two BTS catalyst/molecular sieve systems serve to prevent tritium losses.

6. Thermal Properties of Breeding Material

One critical property for the evaluation of proposed breeding material is the rate of vaporization. This rate may become important as high temperatures of blanket operation are reached. As a consequence of vaporization lithium transport to cooler areas and, if significant, blanket depletion is likely to occur.

The identification of thermally volatile species and the determination of their equilibrium vapor pressures will be carried out employing a single-focusing sector type mass spectrometer provided with a Knudsen cell. Preliminary measurements on the Li vapor pressure over Li₂SiO₃ in the temperature region 1230 - 1385 C substantiate the only other previous results obtained by Nakagawa et al. /4/.

The combination mass spectrometer /Knudsen cell is also a powerful tool for the evaluation of thermodynamic properties of chemical reactions occurring in the gas phase.

7. Compatibility with Stainless Steels

Recent compatibility tests at KfK have been concentrated on Li₂SiO₃ and Li₄SiO₄ with 316-type stainless steel. Powder samples pressed into cladding material capsules, which were filled and closed under highly pure helium, were annealed for 125 h and 500 h at 500, 700 and 800 C. No measurable cladding attack was detected with Li₂SiO₃ of controlled water content < 0.2 mole % H₂O per mole Li₂O at 500 and 700 C. Concerning the time dependence of the penetration depth, a marked saturation tendency was often observed already between 125 h and 500 h.

Fig. 10 shows a comparison of rate constants of the attack on Cr-Ni steel cladding represented by the square of the penetration depth at a fixed reaction

time of 100 h. The above-mentioned Li₂SiO₃ and Li₄SiO₄ results are given with a Li₂O background taken from a recent IMF literature study. The tests with Li₂O gave the impression that the Li₂O scattering range shown below 800 C is in correlation with a water impurity range of about 0.2 - 1.0 mole %. As far as IMF results are concerned in Fig. 10, the H₂O content of Li₂SiO₃ was 1 mole % and that of Li₄SiO₄ was 0.4 - 1 mole %.

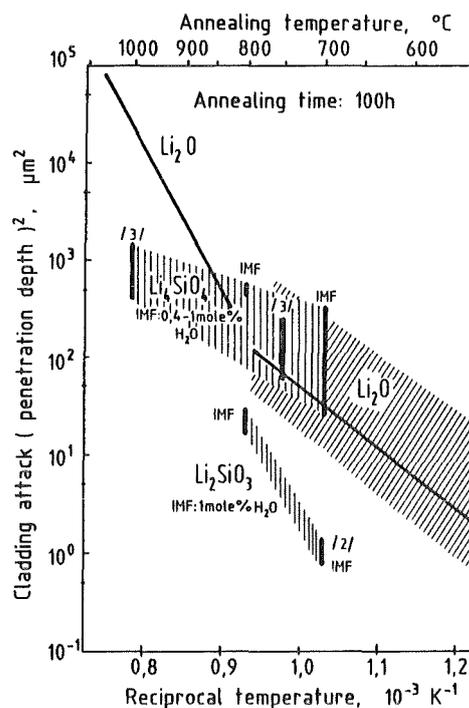


Fig. 10: Chemical Reaction of oxide Breeder Materials with Austenitic Stainless Steel (with literature data of /2/ and /3/)

8. Irradiation Testing of Ceramic Breeder Materials

In the frame of the cooperation contract between KfK and CEA, a first B 15 irradiation of German Li₂SiO₃ samples was performed in the OSIRIS reactor at Saclay. This first short term irradiation which utilized a modified COLIBRI rig (called DELICE 01) filled with 360 pellets, took place from December 27th, 1984 to January 22nd, 1985. The 45 pellet columns were arranged in six channels, according to Fig. 11. In the lower region of the irradiation rig, the aspired sample temperatures of 500 C were obtained quite closely, whereas in the upper section the temperatures were between 660 C and the expected 700 C. For the power density in the samples 6 to 60 W/cm³ were foreseen, and for the tritium production rate .8 · 10¹³ to 8 · 10¹³ atoms /cm³s, yielding a respective Li-6 burn-up between 1 and 11 %.

The irradiation rig was disassembled in mid March and the transport of the samples to Karlsruhe will take place in April 1985. Subsequently, the samples will be taken apart and investigated in the hot cells. First results of the post-irradiation examinations will be presented in the coming semi-annual report. The next irradiation DELICE 02 is planned for end of 1985.

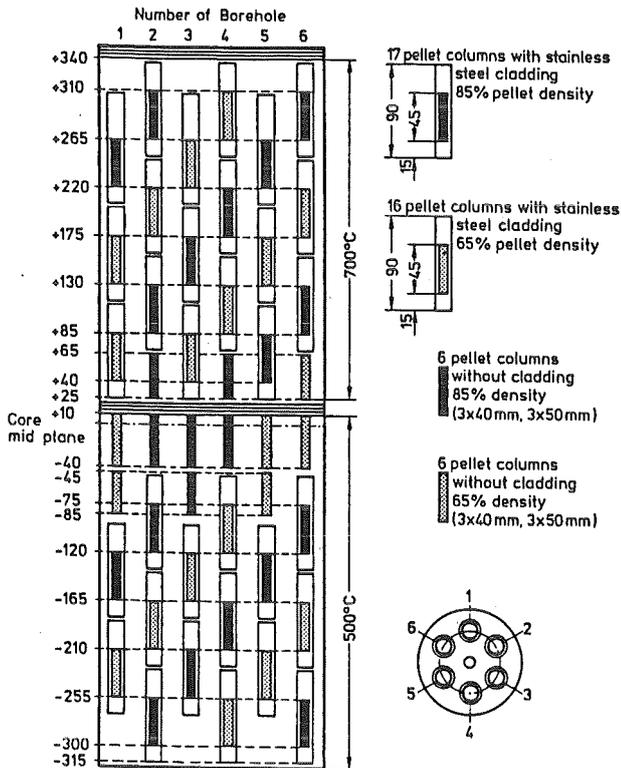


Fig. 11: Arrangement of the Samples in the DELICE 01-Irradiation Experiment

9. Tritium Recovery from Ceramic Breeder Materials

LILA 1, the first test of an experiment train for continuous measurement of tritium release from lithium-aluminate samples, was performed in the SILOE reactor at Grenoble. The test rig contained two sample stacks in quartz tubes and two in stainless steel tubes, additional purification steps for water vapour and oxygen in the purge gas, reduction of oxidized tritium, the first irradiation of five KfK lithium-silicate sample columns and one CEA lithium-aluminate stack for comparison, is expected for September 1985. Pre-samples of meta- and ortho-silicate were already delivered for activation measurements. The total measured impurity content was minor, below 12 ppm.

Literature:

- /1/ N.W. Gregory, R.H. Mohr: J. Am. Chem. Soc., 77 (1955) 2142
- /2/ W.E. Ditmars, H.L. Johnston: J. Am. Chem. Soc., 75 (1953) 1230
- /3/ M. Tetenbaum, C.E. Johnson: J.Nucl.Mat., 126 (1984) 25
- /4/ H. Nakagawa, M. Asano, K. Kubo: J.Nucl.Mater. 102, 292 (1981)

Publications:

- 21158
- V 19929
- V 20581

Staff:

- M. Blumhofer
- E. Bojarsky
- W. Breitung
- W. Dienst
- B. Dörzapf
- H. Elbei
- E. Günther
- M. Glugla
- G. Haase
- H.E. Häfner
- R. Hanselmann
- J. Heger
- W. Jahraus
- E. Kaiser
- H. Kleykamp
- K.-H. Kurz
- W. Laub
- W. Laumer
- H. Nagel
- R.-D. Penzhorn
- V. Schauer
- R. Scherwinsky
- G. Schlickeiser
- B. Schulz
- P. Schuster
- K.H. Simon
- A. Skokan
- H. Strömann
- H. Späte
- D. Vollath
- H. Wedemeyer
- M. Wittmann
- H. Werle
- H. Zimmermann

M 1 LCT Project

In the beginning of the reporting period the LCT coil was removed from the TOSKA facility and prepared for sending the coil and its special equipment to the LCTF (Large Coil Test Facility) in Oak Ridge. The coil left KfK-Karlsruhe on October 18th, 1984, and arrived on November 21st, 1984, in Oak Ridge. Some of the acceptance tests (leak-, sensor- and high voltage tests) were successfully repeated. No damage during shipment was noticed. The coil arrived in excellent condition. After mounting some facility specific instrumentation (quench detection compensation coils, acoustic emission sensors) the coil was brought in an upright position and prepared for installation in the LCTF vacuum vessel. In a ceremony on December 13rd, the arrival of the Euratom LCT coil as the fourth one was celebrated by representatives of the U.S. DOE, Euratom, the operating agent and other participants. After the installation of a further important component, the torque beam of the pulse coil system, the Euratom LCT coil was placed into on December 17th (Fig. 12).

Special instrumentation specifically for the forced-cooled Euratom LCT coil (flow rate measurement, guide duct and its vacuum pumping system, quench detection

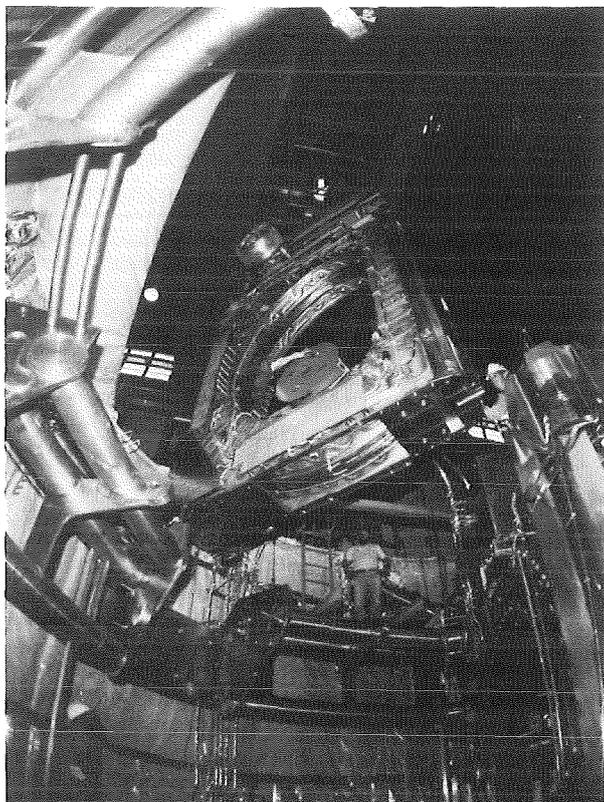


Fig. 12: The Euratom LCT Coil was Placed on the LCTF Test Stand, December 17th, 1984.

system) was installed with KfK representatives observing and participating. So far it was possible under the present conditions the systems were taken into operation. Routing of capillary tubes for flow rate measurements and soldering of sensor cables to the vacuum tank, feedthrough connectors are running now. The sensors will be checked out by the present available data acquisition system. It is scheduled that installation work will be finished by the mounting of the superconducting buses and vapour cooled leads at the end of May.

The TESPE Experiment

The first cooldown of the completed superconducting six coil torus (Fig. 13) was performed successfully. The total mass to be cooled was 8000 kg. For a maximum temperature difference of 50 K stable cryogenic operation was achieved after 150 hrs. During cooldown cold leaks showed up which could be monitored from 200 K

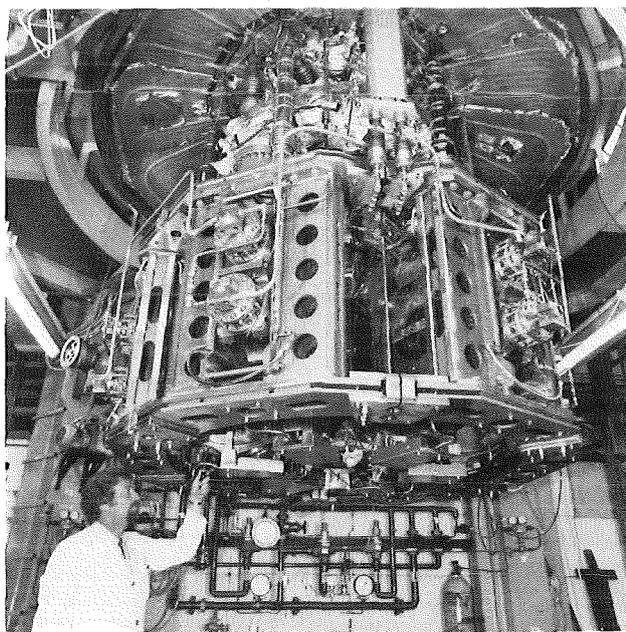


Fig. 13: Completed Six Coil Torus with Opened Cryostat

steadily growing with further cooldown until finally the vacuum was deteriorated. While the increasing vacuum pressure did not strongly affect cryogenic operation, safe magnet operation including fast discharges could not be guaranteed and magnet tests therefore were postponed. At room temperature the leaks were too small to be found. Extensive tests with temperature, pressure and mass flow variations had to be performed at reduced temperature discovering two faulty cooling circuits out of ten. Measurements of

local helium concentrations at selected spots of these two cooling loops allowed determination and localization of two leaks. The first one had its origin in a defect in material of the intercoil structure and the second one was caused by a faulty seal at the current feedthrough of coil D1. Repair and exchange of components were accomplished. The system is ready for test in March 85. The next steps thereafter belong to the magnet safety programme and the first experiment will study the buckling behaviour of the magnet system. In parallel, small laboratory experiments have been prepared for simulation and performance of conductor burning.

Publications:

18225
18463
18944
18950
20189
20291
20292
20480
20700
V 19877
V 19957
V 20175
V 20219
V 20266
V 20339
V 20515
V 20622
V 20690
V 20727

Staff:

H. Bayer
P. Duelli
S. Förster
G. Friesinger
W. Geiger
A. Grünhagen
W. Herz
K.P. Jüngst
H. Katheder
H. Kiesel
P. Komarek
H. Krauth
T. Krüger
J. Lühning
G. Nöther
G. Obermaier
L. Schappals
F. Spath
E. Süß
M. Süßer
A. Ulbricht
H. Veit
R. Wagner
F. Wüchner
G. Zahn

M 3 Development of High Field Composite Superconductors

1. The HOMER Test Facility

The HOMER Conductor Test Facility is planned to be upgraded stepwise from 10 over 12, 15 to finally 18 T background field. It thus serves as a test bed for conductors test at even higher field strengths.

The HOMER test facility was upgraded from 10 T to 11.7 central field by an insert coil wound from a NbTiHf conductor. This field is available in an experimental volume of 268 mm dia. Because that NbTiHf conductor did not fulfil the required specifications, a reduction of 0.5 T in the design field must be accepted at present. A coil with an improved conductor will be delivered by the manufacturer in October 85.

As the background field was lower by 0.5 T as compared to the rated value, testing of another insert coil for 15 T was hampered. However, the Nb₃Sn compound conductor, developed by KfK, could be tested close to its specifications. This conductor consists of about 40 m of a prereacted Nb₃Sn flat cable and a copper clad aluminum tape. The cables were soldered to form the composite conductor which was then wound to form a small coil, similarly constructed as the planned 15 T insert coil. In the background field of 1.5 T, 12.8 T field strength at the conductor were obtained at a current of 1390 A. Comparison with short sample tests indicated an adequate performance under the rated background field. The Lorentz forces caused a stress load on the Nb₃Sn conductor of about 260 N/mm² which is roughly double the value as in the planned 15 T coil. Thus, by achieving practically the critical value under the heavy force load the conductor demonstrated, that the Nb₃Sn conductor can be handled successfully even after the heat treatment.

An experimental arrangement was designed and partially constructed for mechanical load tests on a conductor loop carrying transport current in the applied field of the HOMER magnet. The first conductors to be tested are internally cooled cabled Nb₃Sn conductors encased in a quadratic steel sleeve of 6 x 6 mm² containing 54 strands of Nb₃Sn-bronze and copper. Two types of conductors are already delivered from two different suppliers.

It is planned to finish the 15 T insert coil at the end of summer 1985 and to start then the final completion of the test facility to 18 T. At the moment the preparations for the heat treatment of the necessary

100 m length of the Nb₃Sn flat cable are carried out. The soldering line for manufacturing the composite conductor is being installed in industry.

First studies on commercially available ternary Nb₃Sn conductors, e.g. (NbTa)₃Sn, have shown, that the aim of 18 T might be achievable with an insert coil of 55 mm i. dia. and 150 mm o. dia. in a background field of 15 T. A suitable conductor is already ordered in industry.

2. Subsize Conductors for Toroidal Field Coils

The realization of the future NET conductor requires practical experience of the individual fabrication steps. Thus, an appropriate programme was started to investigate the relevant fabrication steps occurring during the assembly of the NET conductor. The Nb₃Sn subsize conductor model NR was constructed and tested. It is represented in Fig. 14 and is based on

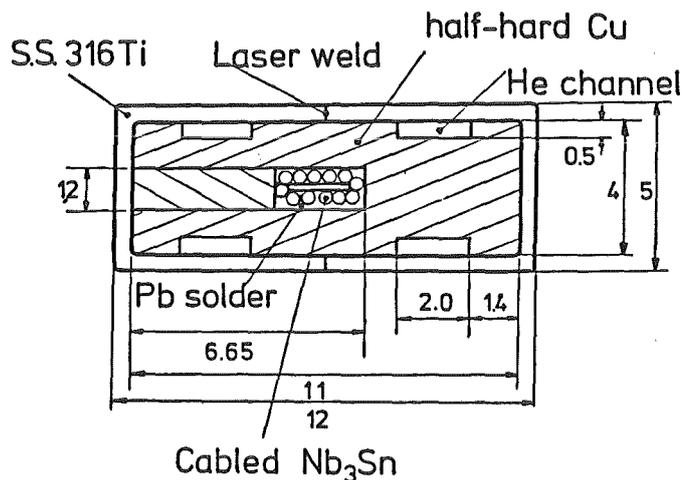


Fig. 14: A Subscale Nb₃Sn Conductor (12 x 5 mm² Cross Section) with NET-like Configuration (Model NR)

commercially available A15 superconductor cable, composed of 12 strands, five strands of stabilizing Cu and seven strands of bronze processed Nb₃Sn wire. The strand dimension is 0.4 mm, the strands being cabled on a stainless steel core. The copper block around the Nb₃Sn cable simulates the electrical stabilization and the cooling channels, but acts in addition as a mechanical stiffener. The conduit of the conductor is fabricated with two U-profiles of stainless steel AISI 316Ti, which were laser processed in the continuous wave mode with a CO₂ 3kW laser. The actual length of the subsize conductor was fixed to be ~500 mm, which is the minimum necessary size to measure I_C vs. ε (the

strain sensitivity of the critical current) in magnetic field environment attaining up to 13 Tesla.

The conductor represented in Fig. 14 was measured under two different aspects, without and with the external steel conduit, after a reaction of 64 hours at 700 C (the reaction occurred prior to the soldering of the Nb₃Sn cable with the copper block and the laser welding of the steel conduit). No difference in the critical current behaviour was observed between 6 and 12 Tesla.

The strain sensitivity of the critical current on the NR conductor is represented in Fig. 15. From these first measurements on conductors with such large cross

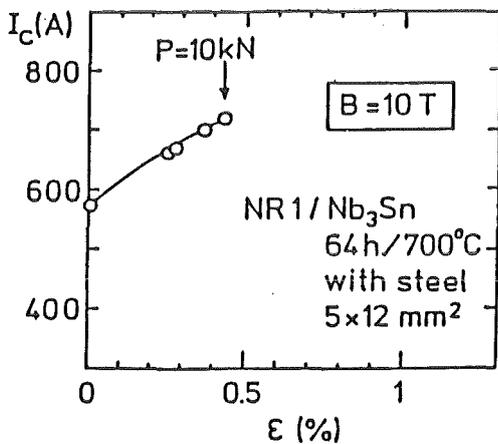


Fig. 15: I_c vs. ϵ of the $12 \times 5 \text{ mm}^2$ Subscale Nb₃Sn Conductor with Steel Conduit (NR)

sections (it should be noted that the total cross section of 60 mm^2 is small with respect to NET dimensions, but is rather large when compared to those of the wires currently described in the literature, e.g. 1 to 2 mm^2), it can be concluded that the prestress in such conductors is slightly higher than for the single Nb₃Sn strands. Indeed, $I_c(\text{max})$ in Fig. 15 was not attained at a strain value of $\epsilon = 0.43 \pm 0.1 \%$, while it is expected at $\epsilon = 0.3 \%$ for single Nb₃Sn strands. In the present case, the highest attainable strain was limited to 0.43% due to the limited force of the tensile machine, 10 kN . A strain rig for forces up to 100 kN is actually under construction. A correct interpretation of these results needs further measurements on the initial strands and on the Nb₃Sn cable without Cu. Nevertheless, these first experiments demonstrate the usefulness of measuring I_c vs. ϵ for characterizing even complex subsize conductors.

It is remarkable that the applied strain caused an increase of I_c at 10 T from 575 to 717 A , i.e. ca.

24% , which is markedly higher than the values for single Nb₃Sn strands. This shows that the expected effects after bending or after transversal force application will be considerable.

Publications:

- 18793
- 18794
- 19662
- 19875
- 19966
- 20028
- 20696
- 21160
- V 18856
- V 19663
- V 19775
- V 19872
- V 19873
- V 20027
- V 20115
- V 20154
- V 20155
- V 20156
- V 21054

Staff:

- W. Barth
- M. Beckenbach
- R. Berggötz
- N. Brünner
- E. Drost
- P. Duelli
- R. Flükiger
- S. Förster
- F. Gauland
- E. Gorenflo
- A. Kling
- P. Komarek
- W. Lehmann
- B. Lott
- G. Nöther
- H. Orschulko
- J. Pytlík
- A. Nylas
- H. Raber
- T. Schneider
- E. Seibt
- W. Specking
- S. Stumpf
- D. Tabarsi
- M. Thöner
- P. Turowski

M 4 Superconducting Poloidal Field Coils

Further test lengths of the ordered low loss superconducting wires were obtained from one industrial company. Measurements of the coupling loss time constants of the different wires yielded values between $\tau = 0.2$ ms and $\tau = 0.5$ ms. The envisaged design value was $\tau = 0.2$ ms.

Critical current measurements show, that still some optimization work during the wire drawing process has to be done in order to obtain the design critical current of $I_C = 150$ A at $B = 5$ T in the 1 mm \varnothing Cu/CuNi/NbTi wire.

After this optimization procedure a fabrication route will be available to get the required low loss wires. The industrial development of the superconducting cable will be started immediately after the optimized wires (as basic elements of the cable) have been obtained.

Parameters of the model coils have been fixed and are given in Table 1.

Mean diameter	1.5 m
Cross section (width x height) of the winding	0.15×0.26^2
Critical current	30 kA
Design current	15 kA
Number of turns	40
Number of pancakes	2
Discharge voltage	23 kV
Discharge time constant (at critical current)	11.25 ms
Maximum induction change rate at discharge initiation	200 T/s
Max. induction at the conductor (at critical current)	2.3 T
Stored energy (at design current)	1 MJ

Table 1: Design Values for the Model Coil

A comparative study for the coil winding and vacuum impregnation is under way to explore the best way to combine winding and impregnation tools with the envisaged outer glass fibre epoxy coil structure.

Intensive design work has been spent and brought into discussions with industry to fix a suitable electrical circuit for the test of the model coil. High current up to 30 kA and high voltage up to 23 kV simultaneously are the loading conditions.

Specifications of two alternative circuits were worked out and a final call for tender within the European Community was sent to industry.

Fig. 16 shows a circuit based on diodes and mechanical switches in order to simulate the specific load case of the equilibrium field coil in TORE SUPRA. At every time during charging, discharging and steady state operation a high voltage pulse (duration some ms) can be added to the coil terminals from the capacitor bank C. A safety discharge at 900 V is possible in every phase of operation.

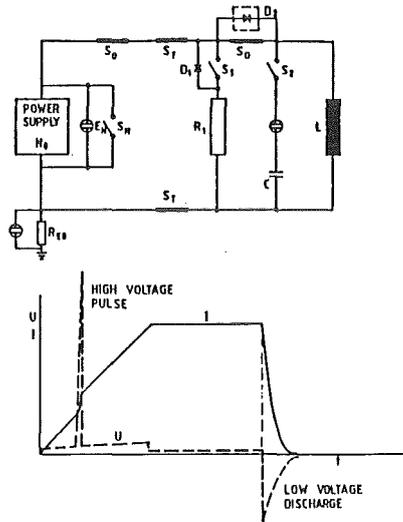


Fig. 16: Circuit for Coil Loading by High Voltage Pulses at Every Time of Operation

Work for a Pretest in the TOSKA Facility

The detailed design for the two phase flow experiment was finished as well as the design of the support structure for the model coil. All parts are now in the workshop and will be installed during the following month. We intend to start first runs with the 2-phase flow setup in summer 85. The necessary changes in our measuring and regulating equipment including the computer software are under way.

Current leads

During the recent period the existing current leads, which have been used in our TOSKA facility (for the LCT coil test), were installed in a bath cryostat with a short bar and additional sensors. First tests with zero current will start after easter. As soon as the 30 kA current supply is ready the complete test programme will be started and the boundaries of the present design can be explored without the problems of having a big superconducting coil connected. This test programme should eventually lead to a new design capable of 30 kA at 25 kV with small cryogenic losses.

Planning of cryogenic cooling loops

Alternative solutions (supercritical He or dual Z-phase He) for cooling of the later Tore Supra coil are being evaluated. The boundary conditions are based on the extrapolation of the newest a.c. loss measurements on the basic conductor and the transient heat loss measurements (described above). The testing of the model coil will be carried out at the existing TOSKA facility. Here the cryogenic loop will be based on the installations for the two phase flow experiment already in progress.

Publications:

18463
19478
V20030
V20175
V20465

Staff:

H. Bayer
F. Beckenbach
F. Becker
S. Förster
G. Friesinger
A. Hofmann
U. Jeske
H. Katheder
P. Komarek
W. Lehmann
G. Nöther
A. Nyilas
H. Orschulko
H. Raber
A. Rung
L. Schappals
G. Schenk
C. Schmidt
L. Siewerdt
E. Specht
M. Süßer
A. Ulbricht
R. Wagner
D. Weigert
F. Wüchner

MAT 1 Post Irradiation Testing of Stainless Steel

1. Test Specimens and Stress Analysis

The development of test specimens appropriate for in-beam LCF experiments (MAT 9) has been finished. Calculations revealed that the stress distribution in the central (active) part of the elastically strained hollow hour glass shaped specimens is uniaxial. Under same conditions the stress distribution in pressurized specimens is biaxial, corresponding to that of an ideally cylindrical tube. Approximately similar results are derived from calculations assuming elasto-plastic behaviour. Finite element calculations for cylindrical deformed specimens are on the way. Experiments conducted on these specimens revealed that the reproducibility of the number of cycles to failure is at least the same as for other characteristic quantities. Push-pull LCF test on pressurized specimens (LCF under biaxial stress conditions) brought first evidence about the influence of stress biaxiality on the lifetime of fatigued specimens.

2. The Influence of azimuthal Temperature Gradients upon the LCF Behaviour

Non-uniform azimuthal temperature distributions are expected during irradiation. Their influence upon the mechanical stability as well as upon the LCF behaviour has to be examined first by means of "simulation" experiments. This is done through spot heating the specimens additionally by focused light rays. In the next step the latter will be replaced by laser light.

3. Constitutive Equation

On the basis of a phenomenological creep damage model a constitutive equation for high temperature plastic deformation was derived. In this equation, applicable for non-stationary stress and/or temperature tensile loading conditions, the role of cavitation is taken into account. The latter is treated as a variable structure parameter. The way is indicated to extend the model also for radiation loaded materials.

Publication:

21090

Staff:

W. Baumgärtner

M. Boček

C. Petersen

W. Scheibe

R. Schmitt

R. Tinivella

M. Pfeifenroth

MAT 6/MAT 13 Ceramics for First Wall Protection,
Insulators and Windows

Structural ceramic parts will be necessary for the protection of the first wall and for windows and insulators in testing devices or for diagnostics. Their physical and mechanical properties after irradiation need to be established.

A coordinated irradiation and test programme has been prepared with CEA-Paris and UKAEA-Harwell. The first wall materials will be irradiated at high temperature (1200 C) in MTR to 10 dpa ($E > 0.1$ MeV); the materials for windows and insulators will be irradiated at 400 C in the same reactor. The tests before and after irradiation and the types of specimens for these tests have been specified.

Materials to be included are commercial grades of SiC (MAT 6), Al_2O_3 , AlN and Si_3N_4 (MAT 13). Pre-irradiation tests have been started with hot isostatic pressed silicon carbide (HPSiC). This material contains only minor amounts of sintering aids (B + Al 0.06 %) and has an uniform fine grained microstructure with a mean grain size of 2.5 μm . Investigations with a high resolution Auger electron spectrometer revealed the presence of the additives at the grain boundaries.

Mechanical tests with four point bending bars have been performed. With a number of 21 samples the average fracture strength at room temperature was found to be 521 MN/m^2 ; the Weibull-modulus is 8. Creep properties up to 1400 C and 190 MN/m^2 are good.

The thermal diffusivity was measured using a laser flash apparatus. Fig. 17 shows the strong temperature dependence of the thermal diffusivity. At 1000 C the diffusivity is only about 15 % of the value at room temperature.

Further pre-irradiation measurements will be performed especially with the materials for insulators and windows.

Publication:
V 20458

Staff:
Ch. Adelhelm
G. Grathwohl
H. Iwanek
F. Porz
B. Schulz

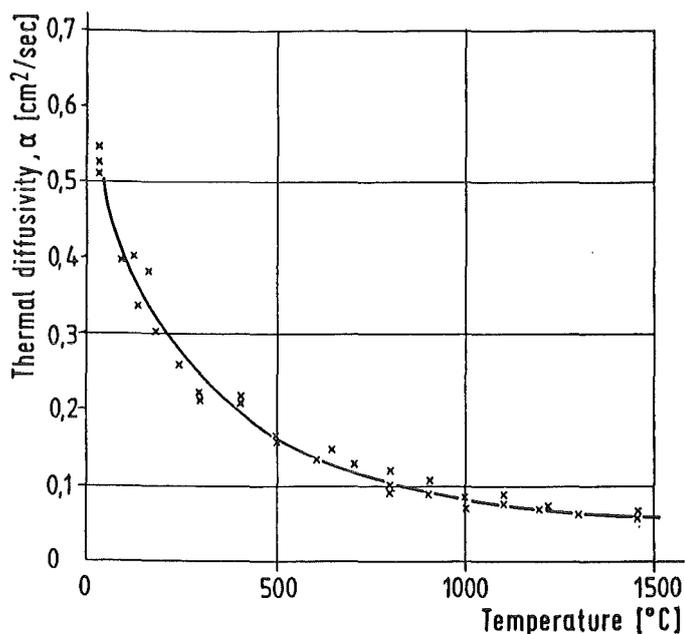


Fig.17: Temperature Dependence of Thermal Diffusivity for Unirradiated Hot Isostatic Pressed SiC ($\Delta\alpha/\alpha = \pm 7\%$)

S+E 1 Radioactive Effluents: Behaviour of Gaseous
Tritium in the Air, Plant, Soil System

Setting-up of equipment including GC, LSC and an electrophoretic system and the production of lysimeters for soil samples has been finished. A literature survey on the theme mentioned above has been completed.

Gaschromatographic studies on permeation of HT into different types of soils and humus layers under various climatic conditions are envisaged. Inactive tests with the climatic chamber will be carrying on.

Staff:

D. Honig

L. König

H. Schüttelkopf

S+E 2 Accident Analysis

First safety related activities were initiated towards the end of 1983. Up to now investigations on three subjects were performed: (1) Availability and reliability analysis of the protection system for a neutral beam injector, (2) stress analysis of the first wall and (3) investigations of buckling phenomena of a vacuum container.

1. Analysis of the Protection System for a Neutral Beam Injector (NBI)

For the reference accident plasma disruption the probability for the event "no interruption of the neutral beam" was determined. This is the case when the accelerating voltage fed to the accelerator grid of the NBI can't be interrupted. Therefore the TOP event in the analysis is "no current interruption on demand". The probability for this event is expressed by the unavailability of the system upon demand.

In any quantification of reliability data the uncertainty or lack of data for special fusion technology components should be kept in mind.

One of the components which influences the safety of the NBI in an important way is the high voltage (HV) switch tube. For this tetrode tube a failure rate of $1 \cdot 10^{-3}/h$ was assumed for the failure mode "short of the tube". According to Green and Bourne (UKAEA, AHSB(S) R117, 1973) an overall failure rate for commercial tetrodes of $2.1 \cdot 10^{-5}/h$ is recommended. However, the transfer is problematic. If the design lifetime for the JET NBI control system (1 pulse every 600 s, 10^5 pulses, H. Astin et al., 12. Symposium on Fusion Technology, Jülich, 13-17 Sept. 1982) is used, we get a theoretical failure rate of about $6 \cdot 10^{-5}/h$. By this consideration the assumed value could be accepted. The future will show if this estimation is really conservative when more operating experience is available. The limit value processing was assumed according to the German and to the American risk studies (WASH 1400).

In the American Risk Study for Common Mode Failures (CMF) in channel groups of three redundant signal channels, an unavailability of $1 \cdot 10^{-4}$ is recommended. Own studies in German plants on the basis of the German risk study lead to an unavailability value of $1.5 \cdot 10^{-6}$ for the similar event. The difference in the data is mainly caused by differences in the calibration procedures.

The fault tree analysis was performed in two different ways, with the computer programmes MUSTAFA/MUSTAMO and with a special Monte Carlo Code. The results of both calculations were in good coincidence. In the table below, some results of the Monte Carlo calculation are given. This programme calculates the confidence limits on the basis of the confidence limits for the failure rates of the primary events. The error factor was estimated with 10 and 3 depending on the hardness of data. In the table the mean value and the lower and upper bounds for the occurrence probability of the TOP event are listed in relation to the CMF probability as discussed before.

CMF Probability	Unavailability per Demand		
	Lower Bound	Mean Value	Upper Bound
1.0 10^{-4}	2.81 10^{-5}	1.0 10^{-4}	2.47 10^{-4}
1.5 10^{-6}	6.87 10^{-7}	3.7 10^{-6}	1.05 10^{-5}

In spite of the uncertainties and the conservatism in the data estimation the results are in an acceptable order of magnitude. CMF's in limit value processing could be minimized as the data show, by precautions according to the commercial nuclear power plants, quality assurance and administrative precautions.

The analysis performed has shown that it is possible to yield acceptable results. This is true even with an unreliable but conservative data base. The analysis of the protection system for a neutral beam injector will be terminated in a few weeks. As a next task in this field of investigation safety related analysis for superconducted magnet systems will be started.

2. Stress Analysis of the First Wall

As it was announced in the previous half-year report, the investigations on the stress behaviour of first wall structures have been finished in the meantime. The code TSTRELT which has been developed within this framework, is now available for further use. The theory on which it is based, its scope, the results from exemplary applications as well as a guide to use the code have been documented in two internal reports.

With TSTRELT an efficient tool has been prepared for estimating the thermo-mechanical behaviour of heavily loaded structural components. The geometrical restrictions to which it is subject, appear to be adequate to the present phase of preliminary designs for fusion devices. It may become necessary in the near future, however, to consider also geometrically more complex structures. In this case, it could turn out to be

advantageous if at least the long-term extrapolation techniques of TSTRELT are combined with more powerful basic structural models.

3. Analysis of Buckling Phenomena

The development of an approximative method for the buckling analysis of the "bell jar" has been continued. Meanwhile the applicability of the new method on circular cylindrical shells under axial compression as well as under uniform lateral and hydrostatical pressure has been proved.

used proportional to the ideal buckling mode. In the next step the method will be generalized to any imperfections. It is necessary, that the imperfection used in the calculation must contain the critical mode. Usually imperfections fulfill these requirements. On the other hand users knowledge of "dangerous" modes will abbreviate the calculation procedure using only relevant modes for calculations.

Parallel to these theoretical investigations experiments with laterally pressure loaded cylindrical shells will be initiated. These simple experiments are aimed at

- the development of nondestructive buckling load determination methods,
- the experimental investigation of the influence of imperfections,
- the verification of the computer model.

These tests provide a basis for final tests with a cryostat model at full complex geometrical conditions but reduced scale envisaged later on.

Staff:

- B. Dolensky
- W. Kramer
- R. Krieg
- A. Ludwig
- S. Raff
- H. Schnauder
- A. Wickenhäuser

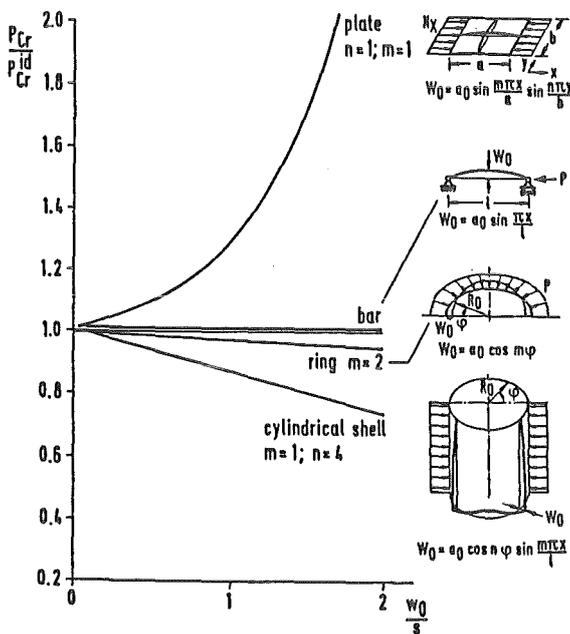


Fig. 18: Critical Load for Imperfect Structures

Fig. 18 shows the calculated critical loads versus the imperfection w_0 related to the wall thickness s for the geometrics investigated till now. For small imperfections ($w_0/s \ll 1$) the critical load determined by the approximative method converges towards the analytic solution of an ideal geometry. Whereas the critical load of the crooked bar is showing no dependence on the imperfection magnitude, the critical values for plate, ring and cylindrical shell increase or decrease with growing initial imperfections. These results qualitatively describe the known influence of imperfections on the critical load. However, it remains to be proven whether the method investigated here gives also quantitatively a sufficient approximation for this imperfection sensitivity.

So far for analytical reasons, imperfections have been

T 1 Fuel Clean-up System

After reviewing the concept of the planned technical scale fuel clean-up unit, taking into consideration the changed collaboration basis with KFA Jülich and the actual NET-concept for the fuel circuit, KfK has modified the operation-conditions for the clean-up process - running a metal-getter at low pressure seems no longer to be adequate for NET-requirements.

Consequently, AlZr-alloy as an impurity getter will no longer be taken into account for this task, because of its high hydrogen inventory at 1 bar of pressure.

The peripheric system of the proposed test unit will be kept as described in the previous report. Following the conclusions of the CEA-study of the fuel clean-up processes, in the modified concept a process-line consisting of the combination of an Uranium-getter and a permeation-membrane shall be tested as a technical system. Alternatively a permeation-membrane protected by a cryogenic adsorption-unit shall be investigated.

The components of the facility are being specified. A quadrupole mass spectrometer was ordered. It allows to analyse the gas components down to 1 ppm. Furthermore a glove-box to take up the apparatuses is available. A room in a controlled area is dispoible.

Further discussions with CEA on a coherent programme are underway.

Staff:

J. Hanauer
E. Hölzchen
E. Hutter
G. Neffe
P. Schira
U. Tamm

T 5 Development of Tritium Decontamination Systems

Staff:

R.D. Penzhorn

M. Sirch

E. Willin

Selective permeation has been used to dry gases, including those that are highly corrosive. It has already been applied elsewhere in monitors capable of distinguishing between tritium hydrogen and tritium water. Depending upon the permeation rate of gases other than water and their resistance of selective membranes towards radiation damage, a number of other applications relevant for tritium technology can be thought of. To investigate these properties a simple apparatus has been constructed, which essentially consists of two loops (see Fig. 19). One loop with a volume of 240 l contains argon carrier gas at a pres -

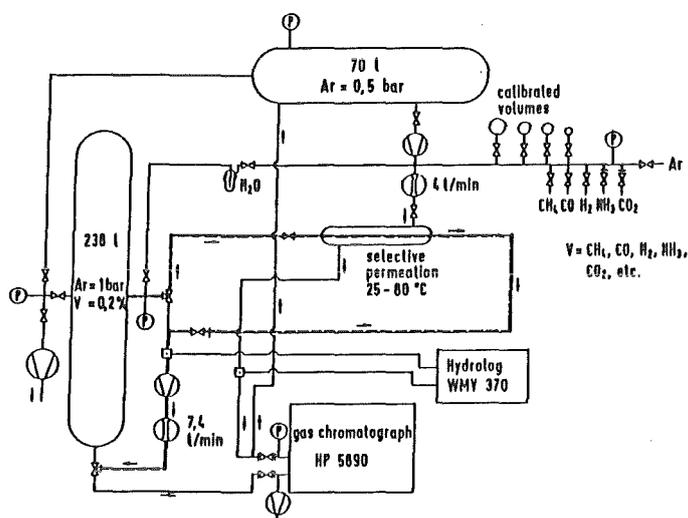


Fig. 19: Apparatus to Investigate Properties of Permeable Tubes

sure of 1 bar and less than 1 % by vol. of impurities such as NH_3 , CH_4 , CO , CO_2 , H_2 etc. The other loop has a volume of 70 l and contains dry argon purge gas at considerably lower pressure. With this arrangement the permeation rate of gases can be examined over an extended period of time as a function of flow rate, temperature, concentration of impurity and relative pressure. First results with 50 tubes 290 mm long yielded permeation rates for CO and CO_2 at temperatures below 80 C over a period of 5 hours that were below the gas chromatographic detection limit.

To test the radiation stability several polymer tubes 1.4 mm in diameter were irradiated with an increasing dose up to 1.3×10^6 rad, employing a Co-source. None of the tubes showed morphological changes, when observed with a scanning electron microscope. Mechanical test will follow. Experiments with HTO and Kr-85 are in progress.

T 6 Industrial Development of Large Components for Vacuum Systems

Staff:

J. Hanauer
W. Höhn
U. Kirchhof
H. Lukitsch
A. Mack
D. Perinić

1. Component Development

The feasibility of turbomolecular pump and gate valve development was discussed with the manufacturers. Based on these investigations proposals were submitted to the CEC regarding the performance of studies by industrial firms as a first step in the placement of orders for development. The necessary specifications were worked out. In the European area three potential manufacturers have been found for the turbomolecular pumps and five candidates for the gate valves.

The technical specification for the roughing vacuum pump units was prepared. The preliminary inquiry will be made after approval of the list of potential firms by the CEC has been obtained.

Work has started on preparing the technical specification for the cryocompound vacuum pump units. However, prior to the definition of the pump data, investigations have to be made related to the overall concept of the NET torus vacuum system in order to be able to compare and evaluate various technical system versions possible. This work is not yet contained in the programme of task T 6. KfK has submitted to the CEC a proposal for a contract on performing a study on the vacuum concept.

2. Component Testing

A technical concept proposal of the testing facility for large components is presently elaborated at KfK. Several versions of the testing facility are being investigated, namely tests of single components, tests of individual vacuum trains (divertor to pump), and tests under tritium. These latter tests will be executed in the KfK tritium laboratory.

The integral tests of the individual components are considered to be indispensable. It is planned to simulate all operating conditions of a fusion machine except for nuclear radiation.

The tritium inventories required in each case have been determined for the facility. Depending on the version, the maximum tritium inventory in the facility ranges from 35 to 105 g.

Studies for NET/INTOR

At present 12 NET study contracts are proceeding or have been finished recently. The following status can be reported:

1. A 15 conductors for the NET TF-Coils

This study has been completed, the final report has been discussed with the NET Team. The major content has already been described in the last semi annual report. A conductor concept is proposed, which consists of a flat Nb₃Sn cable, soldered to a surrounding CuNi tape after reaction. Around this rectangular conductor core Cu profiles are cabled on distance by the Roebel-process and subsequently soldered at the bottom onto the CuNi tape. The whole system is surrounded by a steel conduit. The present conductor data with a critical current of 30 kA at 12 T (20 kA rated current) resulted from electric, thermohydraulic and stability calculations as well as mechanical evaluations and take into account nuclear heat. Expected fabrication processes are discussed too. It is shown that the fabrication should be possible within the capabilities of European industry. A cost estimate indicates that it will be worthwhile to consider NbTi-Nb₃Sn graduation for the winding. The study is now followed by a thorough TF-coil design based on the NET III parameter set.

2. Fatigue Data Compilation of Low Temperature Structural Materials

This study has also been completed, the final report has been issued. Beside the survey on fatigue data of engineering materials for use in magnet system design, consideration for establishment of standard procedures for the use of fatigue data in an engineering design are discussed. It is proposed to use the relation between maximum tolerable crack size and component life time, which can be derived from fatigue crack growth measurements.

3. Evacuation Behaviour of NET

Two blanket options are considered for the study of the evacuation of the plasma chamber, an "open" one and a "closed" one with separate tight casing. A Monte Carlo programme for the calculation of the conductivity for molecular flow and complicated channel geometry has been developed.

4. CAD Techniques for NET

Following the presentation of the interim report in November 1984, work concentrated on the completion of a CAD model of NET version 2A (see Fig. 20) and on the development of CAD techniques for remote handling investigation with the CAD system BRAVO!. The newly developed BRAVO! extension allows the creation of movements paths, which are stored in a special library for later retrieval and analysis. Traces of critical points of the moving component can be generated, displayed and stored.

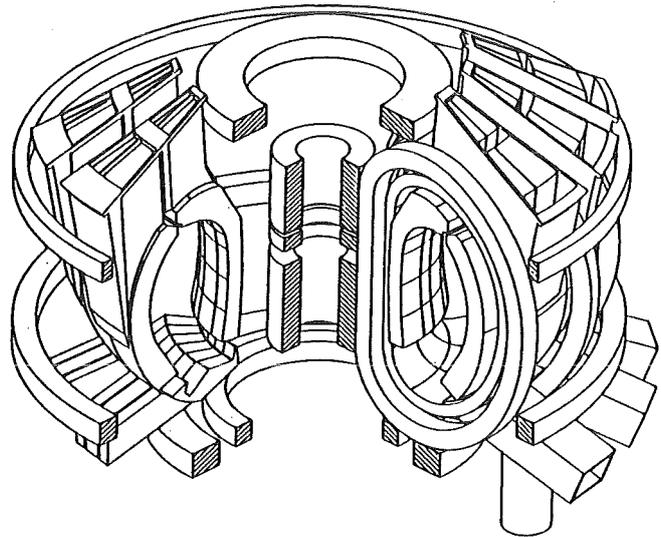


Fig. 20: NET 2A Modelled by CAD

With respect to CAD data transfer, the connection between the CAD computer and the IBM main frame at KfK has been established. Data transfer between the KfK and IPP main frames has been successfully tested. The procurement of processors for conversion of CAD data from and to the IGES standard has been initiated. Tests with these processors were successful. As soon as similar processors are available at NET, geometric information about NET design versions can be exchanged between KfK and NET.

5. Stress and Life Time Calculations for First Wall and Blanket Structures

A first report concerning the analysis of crack propagation in tubes of austenitic steel has been issued. The first investigations dealt with lifetime considerations of tubes acting directly as part of the first wall. Thereby, stresses due to thermal extension, swelling, irradiation creep and internal pressure were calculated and failure resulting by crack growth could be predicted.

In a next step temperatures and stresses in the first wall are investigated by FE and analytical calculations for several actual NET designs.

6. The further studies concerned the INTOR launcher system for ECRH heating (report for the INTOR workshops), design equations for 1.4914 martensitic steels, the NET PF-coils, the properties of Li_2SO_3 and pipe and vacuum duct connections. For the last case, the considerations have been extended to include in the recent developments at USA. Studies for design equations for 1.4914 martensitic steels, the NET PF-coils, the properties of Li_2SO_3 are in a rather early state.

Staff:

F. Arendt

F. Becker

J. Benner

M. Bocek

G. Böhme

G. Class

W. Dienst

K. Ehrlich

F. Engelhardt

T. Fett

R. Flükiger

L. Gumb

B. Haferkamp

A. Hofmann

U. Jeske

F. Katz

P. Komarek

M. Kuntze

W. Lehmann

K. Leinemann

W. Link

J. Lühning

B. Manes

U. Marek

W. Maurer

R.A. Müller

D. Munz

A. Nyilas

E.G. Schlechtendahl

K. Schramm

K. Trautwein

P. Turowski

H. Zehlein

Development of ECRH Power Sources at 150 GHz

1. Gyrotron Components

The gun section was operated with the specified beam power (68 kV/8A) at extended pulse duration (0.2 - 0.8 s). It was accepted but remains at the industry for an additional test run especially for beam diagnostics.

The valve section is in fabrication. Both the input taper section and the window section are finished. The collector section is almost completed. Based on conclusive parameter studies, different designs of TE_{031} resonators are under construction. In view of the machining problems of the resonator section, alternative technological solutions are under consideration.

2. Test Facility

The CAD of the magnet system was optimized and verified for beam compatibility by the Herrmannsfeldt Code. The magnet system including cryostat and power supplies is under construction at BBC/Mannheim. The LHe-supply for the new experimental area is in preparation.

For the beam voltage supply the capacitor bank and the series modulator (Siemens/Erlangen) are ordered. The gun modulator is under development at IPF Stuttgart for similar application at W VII AS. Upgrading of the μ s-pulse power supply is in course.

The building modifications for the new experimental area are started. The steel constructions for the hv-cage, the control room and the platform for microwave diagnostics are under construction.

3. Gyrotron Theory

A new code package suitable for extension has been developed for the calculation of eigenfrequency, Q-value, and field profile in weakly tapered open resonators. The eigenvalue search is done very efficiently by using the MINUIT Code from CERN. Extensions for beam interaction and mode coupling are in development.

Inspired by discussions with G. Nusinowich/Gorki whispering gallery modes are presently under consideration and have been verified by measurements in the S-band model resonator. The X-band test bench is now in operation, which is suitable for 3-dimensional measurements on complex cavities and on higher order modes by computer control.

4. Microwave Diagnostics

A preliminary test bench for dielectric measurements of window materials has been established at 35 GHz, using a quasioptical resonator. A research programme for window ceramics was initiated at KfK for the MAT 13 task.

In view of the planned mode competition studies a new system has been designed for identification of arbitrary TE-modes and for power measurement of each individual mode $TE_{m,n}$ ($m,n < \sim 20$)

Staff:

E. Borie
H. Budig
G. Dammertz
S. Fenyi
F. Graf
P. Grundel
R. Hietschold
G. Hochschild
A. Hornung
K. Jentzsch
R. Lehm
W. Maurer
N. Münch
H. Oppermann
B. Piosczyk
G. Redemann
H. Stichel
R. Vincon

External Contributors:

K. Behm and team (Valvo, Hamburg)
E. Jensen et al. (TU, Hamburg-Harburg)
M. Kitlinski et al. (IHE, Univ. Karlsruhe)
M. Thumm et al. (IPF, Univ. Stuttgart)

- 18225 ITP;
KOMAREK, P.
Die Entwicklung supraleitender Magnete fuer die Kernfusion, speziell am Beispiel des Projekts 'Large Coil Task'.
Aktuelle Aspekte der Kernfusionsforschung : Informationsstagung, Wien, 3.u.4.Maerz 1983
Wien : Verl.d. Oesterreichischen Akademie der Wissenschaften, 1983. - S.109-49
- 18463 ITP;
SCHMIDT, C.
A liquid helium piston pump with a superconducting drive.
Fast, R.W. [Hrsg.]
Proc.of the Internat.Cryogenic Engineering Conf., Colorado Springs, Colo., August 15-17, 1983
New York: Plenum 1984 S.821-28
(Advances in Cryogenic Engineering; Vol.29)
- 18793 ITP;
SPECKING, W.; FLUEKIGER, R.
A compact 5 kN test facility for superconducting conductors carrying up to 1,5 kA in magnetic fields up to 14 T.
8th Internat.Conf.on Magnet Technology (MT-8), Grenoble, F, September 5-9, 1983.
Proc.
Journal de Physique, 45(1984) Colloque C1, Suppl.au n° 1, S.C1/79-82
- 18794 ITP;
GOLDACKER, W.; FLUEKIGER, R.
Direct observation of crystallographical changes at 10 K caused by the application of varying stresses to Nb₃Sn wires.
8th Internat.Conf.on Magnet Technology (MT-8), Grenoble, F, September 5-9, 1983.
Proc.
Journal de Physique, 45(1984) Colloque C1, Suppl.au n° 1, S.C1/387-90
- 18944 ITP;
ALBRECHT, C.; SALZBURGER, H.; KRAUTH, H.; ULBRICHT, A.; NYILAS, A.
Manufacturing experience with the European superconducting coil for the Large Coil Task (LCT).
8th Internat.Conf.on Magnet Technology (MT-8), Grenoble, F, September 5-9, 1983.
Proc.
Journal de Physique, 45(1984) Colloque C1, Suppl.au n° 1, S.C1/135-38
- 18950 ITP;
HILAL, M.; ARENDT, F.; JENTZSCH, K.
Natural circulation and cable conductors.
Fast, R.W. [Hrsg.]
Proc.of the Internat.Cryogenic Engineering Conf., Colorado Springs, Colo., August 15-17, 1983
New York: Plenum 1984 S.215-23
(Advances in Cryogenic Engineering; Vol.29)
- 19478 ITP;
DITTRICH, H.; FOERSTER, S.; HOFMANN, A.; JESKE, U.; KATHEDER, H.; KHALIL, A.; KRAUTH, H.; LEHMANN, W.; NICK, W.; NYILAS, A.; SCHMIDT, C.; ULBRICHT, A.
Development of superconducting poloidal field coils for medium and large size tokamaks.
Fusion Engineering: Proc.10th Symp., Philadelphia, Pa., December 5-9, 1983
New York, N.Y.: IEEE, 1983. - Vol.2. - S.1350-57
- 19662 ITP;
FLUEKIGER, R.
Applicazioni superconduttive su larga scala. (Large scale applications of superconductivity).
Pavese, F. [Hrsg.]
Proc.of the 2nd Nat.Cryogenics Conf.and Workshop on Problems in the Use of Cryogenic Transducer, Torino, I, February 8-10, 1984
Torino: Istituto di Metrologia 1984 S.23-30
- 19875 ITP;
FLUEKIGER, R.
Nonequilibrium states in A15 type compounds after low temperature irradiation.
Eckern, U.; Schmid, A.; Weber, W.; Wuehl, H. [Hrsg.]
Proc.of the 17th Internat.Conf.on Low Temperature Physics, Karlsruhe, August 15-22, 1984. Part I.
Amsterdam [usw.] : North Holland 1984. S.609-10
- 19966 IDT; LAF;
NAGEL, K.; FURRER, J.
Berechnung der Aerosolfreisetzung durch das Aufloeserabgas.
Atomwirtschaft-Atomtechnik, 29(1984) S.235-37
- 19969 PKF;
FINNEN, D.; [HRSG.]
Fusion technology programme. Semi-annual report October 1983 - March 1984.
KfK-3727 (April 84)
- 20028 ITP;
FLUEKIGER, R.
A new disordering mechanism in A15 type compounds submitted to low temperature irradiation or to quenching from high temperatures.
KfK-3622 (Mai 84)
- 20189 IRB; ITP;
NYILAS, A.; KRAUTH, H.; METZNER, M.; MUNZ, D.
Fatigue response of materials used in large superconducting magnets for fusion technology.
Beevers, C.J. [Hrsg.]
Fatigue: Papers Pres.at the 2nd Internat.Conf.on Fatigue and Fatigue Thresholds, Birmingham, Gb, September 3-7, 1984
S.L.: Engineering Materials Advisory Services, 1984. - Vol. 3. - S.1637-46
- 20291 ITP;
KRAUTH, H.
Test der supraleitenden Toroidal-feldspule fuer das Grosse Spulenprojekt (LCT) in TOSKA.
KfK-Nachrichten, 16(1984) S.123-35
- 20292 ITP;
JUENGST, K.P.
'TESPE' ein supraleitender Torus.
KfK-Nachrichten, 16(1984) S.136-44
- 20480 ITP;
JUENGST, K.P.; SUESS, E.
Superconducting helium level sensor.
Cryogenics, 24(1984) S.429-32
- 20620 PKF;
FINNEN, D.; [HRSG.]
Fusion technology programme. Semi-annual report April - September 1984.
KfK-3823 (Oktober 84)
EUR-7994a (Oktober 84)
- 20696 ITP;
TUROWSKI, P.
The stability behaviour of a Cu-stabilized NbTi-multifilamentary conductor under different cooling conditions.
Cryogenics, 24(1984) S.629-35
- 20700 ITP;
SCHMIDT, C.
Stability tests on the Euratom LCT conductor.
Cryogenics, 24(1984) S.653-56

- 20722 INR;
GOEL, B.; BROEDERS, I.; FISCHER, U.; JAHN, H.; KRIEG, B.; KUESTERS, H.; SEGEV, M.; STEIN, E.; WIEGNER, E.
Neutron data for fusion applications.
In: Quaim, S.M. [Hrsg.]
Progress Report on Nuclear Data Research in the Federal Republic of Germany for the Period April 1, 1983 to March 31, 1984
NEANDC(E)-252 U Vol. 5 (June 1984) S.11-14
INDC(Ger)-27/LM + Special
- 21046 INR;
GOEL, B.; KRIEG, B.
Status of the nuclear data library KEDAK-4.
October 1984.
KfK-3838 (Februar 85)
- 21090 IMF;
BOCEK, M.; HOFFMANN, M.
High temperature thermal creep of materials under non-stationary stress and/or temperature loading conditions.
Nuclear Engineering and Design, 2(1985) S.29-52
- 21158 IMF;
WEDEMEYER, H.; VOLLATH, D.; GUENTHER, E.
Journal of Nuclear Materials (in press)
- 21160 ITP;
FLUEKIGER, R.; ARENDT, F.; HOFMANN, A.; JESKE, U.; JUENGST, K.P.; KOMAREK, P.; KRAUTH, H.; LEHMANN, W.; LUEHNING, J.; MANES, B.; MAURER, W.; NYILAS, A.; SPECKING, W.; TUROWSKI, P.; ZEHLEIN, H.
An A15 conductor design and its implications for the NET-II TF coils. Final study report.
KfK-3937

- V18856 IMF;
BOCEK, M.
Der quantitative Vergleich des Kriechverhaltens bei stationärer und nicht-stationärer Zugbelastung. Deutsche Gesellschaft fuer Metallkunde Hauptversammlung: Kurzfassungen d. Vortr. u. Poster, Erlangen, 24.-27. Mai, 1983 Oberusel: DGM, 1983.- S.133
- V19663 ITP;
FLUEKIGER, R.
Physik und Metallurgie in Nb₃Sn Multifilamentleitern.
Vortr.: Eidgenoessisch-Technische-Hochschule, Zuerich, CH, 7. Februar 1984
- V19775 ITP;
GOLDACKER, W.; FLUEKIGER, R.
Roentgenstrukturanalyse der Kristallstrukturaenderungen in Nb₃Sn-Leitern unter externem Zug bei 10 K. 48. Physikertagung gemeinsam mit der Fruehjahrstagung DPG, Festkoerperphysik, Muenster, 12.-17. Maerz 1984. Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, Bd.19(1984) S.512
- V19872 ITP;
FLUEKIGER, R.; NYILAS, A.
Controlled precompression in Nb₃Sn conductors by internal reinforcement with a steel/molybdenum composite. Applied Superconductivity Conf., San Diego, Calif., September 9-13, 1984
- V19873 ITP;
FLUEKIGER, R.; GOLDACKER, W.
The origin of prestress in binary and ternary Nb₃Sn multifilamentary wires. Applied Superconductivity Conf., San Diego, Calif., September 9-13, 1984
- V19877 ITP;
JUENGST, K.P.; YAN, L.
Stability of the TESPE superconducting torus magnets. Applied Superconductivity Conf., San Diego, Calif., September 9-13, 1984
- V19929 IMF;
VOLLATH, D.; WEDEMEYER, H.; GUENTHER, E.
Improved methods for fabrication of LiAlO₂ and Li₂SiO₃ pellets and spheres as breeder material for fusion reactors. 13th Symp. on Fusion Technology, Varese, I, September 24-28, 1984
- V19957 ITP;
JUENGST, K.P.
Operation experience with a 3-coil arrangement of the 'TESPE' superconducting torus. 13th Symp. on Fusion Technology, Varese, I, September 24-28, 1984
- V20027 ITP;
FLUEKIGER, R.
Metallurgie, proprietes supraconductrices et technologie des phases A15. Invited paper. Journees Materiaux Supraconducteurs, Rennes, F., 12-15 Juin 1984
- V20030 ITP;
SCHMIDT, C.
Transient heat transfer into a small volume of liquid helium. 10th Internat. Cryogenic Engineering Conf. and Exhibition, Espoo, SF, July 31 - August 3, 1984
- V20115 ITP;
GOLDACKER, W.; FLUEKIGER, R.
Crystal structure modifications in superconducting wires. Vortr.: ILL Workshop, Grenoble, F, 1.-3. August 1984
- V20154 ITP;
FLUEKIGER, R.
The application of niobium in future technologies based on superconductivity - the role of materials science. Status Seminar on Nb Technology, Lorena, BR, March 11-17, 1984
- V20155 ITP;
FLUEKIGER, R.
Phase diagrams of superconducting materials. Status Seminar Nb Technology, Lorena, BR, March 11-17, 1984
- V20156 ITP;
FLUEKIGER, R.
The effect of additions to Nb₃Sn on the critical current density. Status Seminar Nb Technology, Lorena, BR, March 11-17, 1984
- V20175 ITP;
KOMAREK, P.
Superconducting magnets in fusion research. Vortr.: Seminar 'Large Scale Application of Superconductivity', Karlsruhe, 22. August 1984
- V20219 HDI; ITP;
HERZ, W.; KATHEDER, H.; KRAUTH, H.; NOETHER, G.; PADLIGUR, U.; RIETZSCHEL, K.; SPATH, F.; SIEWERDT, L.; SUESSER, M.; ULBRICHT, A.; WUECHNER, F.; ZAHN, G.
Design and process engineering of the Karlsruhe toroidal coil test facility TOSKA. 10th Internat. Cryogenic Engineering Conf. and Exhibition, Espoo, SF, July 31 - August 3, 1984
- V20266 HDI; ITP;
HERZ, W.; KATHEDER, H.; KRAUTH, H.; NOETHER, G.; PADLIGUR, U.; RIETZSCHEL, K.; SPATH, F.; SIEWERDT, L.; SUESSER, M.; ULBRICHT, A.; WUECHNER, F.; ZAHN, G.
Test of the European LCT-coil in the Karlsruhe test facility TOSKA. 10th Internat. Cryogenic Engineering Conf. and Exhibition, Espoo, SF, July 31 - August 3, 1984
- V20339 HDI; ITP;
HERZ, W.; KATHEDER, H.; KRAUTH, H.; NOETHER, G.; PADLIGUR, U.; RIETZSCHEL, K.; SIEWERDT, L.; SUESSER, M.; ULBRICHT, A.; WUECHNER, F.; ZAHN, G.
Results of the test of the European LCT coil in the TOSKA facility. Applied Superconductivity Conf., San Diego, Calif., September 9-13, 1984
- V20458 IMF;
PORZ, F.; GRATHWOHL, G.; THUEMLER, F.
Silicon carbide as structural material in the plasma chamber of nuclear fusion reactors. Internat. Conf. on Engineering Ceramics, Jerusalem, IL, December 16-20, 1984
- V20465 ITP;
FOERSTER, S.; HOFMANN, A.; JESKE, U.; KATHEDER, H.; KRAUTH, H.; NYILAS, A.; LEHMANN, W.; SCHMIDT, C.; ULBRICHT, A.
Superconducting poloidal field coil development. 13th Symp. on Fusion Technology, Varese, I, September 24-28, 1984
- V20515 ITP;
ULBRICHT, A.
Das LCT-Projekt und Ergebnisse des Tests der Euratom-Spule in TOSKA. KIK/IPP-Seminar, Institut fuer Plasma-Physik, Garching, 10. Oktober 1984

V20581 IMF;
VOLLATH, D.; WEDEMEYER, H.; GUENTHER, E.
Improved methods for fabrication of lithium
silicates.
1st Internat. Conf. on Fusion Reactor Materials
(ICFRM-1), Tokyo, J, December 3-6, 1984

V20622 ITP;
NYILAS, A.; KRAUTH, H.
Ultrasonic inspection of the austenitic welds
in the coil case of the European LCT coil.
Internat. Cryogenic Materials Conf., Kiev, SU,
July 24-26, 1984

V20690 ITP;
NYILAS, A.; KOMAREK, P.
Structural material investigations in
conjunction with S.C. magnet projects at KfK.
NBS-DOE Workshop on Materials at Low
Temperatures, Vail, Colo., October 14-17,
1984

V20727 HDI; ITP;
HERZ, W.; KATHEDER, H.; KRAUTH, H.; HOETHER,
G.; PADLIGUR, U.; RIETZSCHEL, K.; SIENERDT,
L.; SUESSER, M.; ULBRICHT, A.; WUECHNER, F.;
ZAHN, G.
Testing of the European LCT coil in the TOSKA
facility.
13th Symp. on Fusion Technology, Varese, I,
September 24-28, 1984

V21054 ITP;
ARENDR, F.; FLUEKIGER, R.; HOFMANN, A.;
JESKE, U.; JUENGST, K.P.; KOMAREK, P.;
KRAUTH, H.; LEHMANN, W.; LUEHNING, J.; MANES,
D.; MAURER, W.; NYILAS, A.; SPECKING, W.;
TUROWSKI, P.
Conductor design for NET toroidal field
coils.
6th Topical Meeting on the Technology of
Fusion Energy,
San Francisco, Calif., March 3-7, 1985

Appendix I: Participation of KFK Departments in the Fusion Technology Programme

Task Code No.	Title	KFK Departments	Partners
B 1	Blanket Design Studies	Institute for Neutron Physics and Reactor Engineering (INR) Institute for Reactor Components (IRB)	CEA; ENEA; JRC Ispra; KFA; UKAEA; Industry
B 2	Development of Computational Tools for Neutronics	Institute for Neutron Physics and Reactor Engineering (INR)	CEA; ENEA; FOM/ECN
B 6	Corrosion of Structural Materials in Flowing $\text{Li}_{17}\text{Pb}_{83}$	Institute for Materials and Solid State Research (IMF)	CEA; SCK/Mol
B 9	Tritium Extraction Based on the Use of Solid Getters	Central Engineering Department (IT)	JRC Ispra; SCK/Mol
B 11-B 16	Ceramic Breeder Materials	Institute for Materials and Solid State Research (IMF) Institute for Neutron Physics and Reactor Engineering (INR) Institute for Radiochemistry (IRCh)	CEA; ENEA; FOM/ECN; KFA SCK/Mol; UKAEA
M 1	Large Coil Project	Institute for Technical Physics (ITP) Institute for Data Processing in Technology (IDT)	IEA agreement: USA, Japan, Switzerland, EC; Industry
M 3	Development of High Field Composite Superconductors	Institute for Technical Physics (ITP)	CEA; ENEA; FOM/ECN; SIN/EIR
M 4	Poloidal Field Coils	Institute for Technical Physics (ITP)	CEA
MAT 1	Post Irradiation Testing of SS	Institute for Materials and Solid State Research (IMF)	CEA; FOM/ECN; SCK/Mol; Studsvik
MAT 6/ MAT 13	Ceramics for First Wall Protection, Insulators and Windows	Institute for Materials and Solid State Research (IMF)	CEA; SCK/Mol; UKAEA
S+E 1	Radioactive Effluents: Behaviour of Gaseous Tritium in the Air, Plant, Soil System	Central Safety and Security Department (HS)	CEA; Studsvik
S+E 2	Accident Analysis	Institute for Reactor Development (IRE)	CEA; FOM/ECN; JRC Ispra; Risø
T 1	Fuel Clean-up System	Central Engineering Department (IT)	CEA; KFA
T 5	Decontamination System	Institute for Radiochemistry (IRCh)	CEA
T 6	Industrial Development of Large Components	Central Engineering Department (IT)	CEA
Gyrotron Studies		Institute for Nuclear Physics (IK) Institute for Data Processing in Technology (IDT)	Industry; Universities

Appendix II: Table of NET Contracts

Theme	Contract No.	Working Period
Fatigue Data Compilation and Evaluation of the Impact of Fatigue on Design	151/84-4/FU-D/NET	4/84 - 10/84
Stress and Lifetime Calculations for First Wall and Blanket Structural Components in NET	155/84-5/FU-D/NET	6/84 - 5/86
Initial Investigation of CAD Techniques for NET	164/84-7/FU-D/NET	6/84-5/85
Electron Cyclotron Wave Launcher for NET/INTOR	162/84-6/FU-D/NET	6/84 - 6/85
Evacuation Behaviour of NET Design Alternatives	173/84-10/FU-D/NET	8/84 - 12/84
Pipe and Vacuum Duct Connections	158/84-5/FU-D/NET	5/84 - 12/84
Design of the NET Equilibrium Poloidal Field Coils	172/84-9/FU-D/NET	9/84 - 2/85
Formulation of Initial Design Equations for Type 1.4914 Martensitic Steel	171/84-9/FU-D/NET	10/84 - 3/85
Compilation of Data and Properties of Lithium Silicate (Li_2SiO_3)	168/84-9/FU-D/NET	9/84-2/85
TF-Coil Design Contract	183/84-12/FU-D/NET	12/84 - 12/86
Vacuum Tight Connections and Closures on the Vacuum Vessel-Lip Welding and Cutting	185/84-12/FU-D/NET	12/84 - 7/85

Appendix III: KfK Departments and Project Management Group

Kernforschungszentrum Karlsruhe GmbH
 Postfach 3640
 D-7500 Karlsruhe 1
 Federal Republic of Germany
 Telephone (07247) 82-1
 Telex 7 826 484
 Telefax/Telecopies (0)07247/82 5503

KfK Department	KfK Institut/Abteilung	Director	Teil.
Central Safety and Security Department	Hauptabteilung Sicherheit (HS)	Prof. Dr. H. Kiefer	2660
Institute for Data Processing in Technology	Institut für Datenverarbeitung in der Technik (IDT)	Prof. Dr. H. Trauboth	4200
Institute for Nuclear Physics	Institut für Kernphysik II (IK)	Prof. Dr. A. Citron	3502
Institute for Materials and Solid State Research	Institut für Material- und Festkörperforschung (IMF)	I. Prof. Dr. F. Thümmler	2918
		II. Dr. K. Anderko	2902
		III. Prof. Dr. K. Kummerer	2518
Institute for Neutron Physics and Reactor Engineering	Institut für Neutronenphysik und Reaktortechnik (INR)	Prof. Dr. G. Keßler	2440
Institute for Reactor Components	Institut für Reaktorbauelemente (IRB)	Prof. Dr. U. Müller	3450
Institute for Radiochemistry	Institut für Radiochemie (IRCh)	Prof. Dr. H.J. Ache	3200
Institute for Reactor Development	Institut für Reaktorentwicklung (IRE)	Prof. Dr. D. Smidt	2550
Central Engineering Department	Hauptabteilung Ingenieurtechnik (IT)	DI W.P. Schmidt	3001
Institute for Technical Physics	Institut für Technische Physik (ITP)	z.Zt. Prof. Dr. P. Komarek	2653
Nuclear Fusion Project - Project Management	Projekt Kernfusion - Projektleitung (PKF-PL)	Dr. J.E. Vetter	5460
Secretary	I. Sickinger		5461
Administrator	Dr. D. Finken		5462
Blanket, Facilities	DI H. Sebening		5464
Superconducting Magnets, ECR-Heating	N.N. (Dr. J.E. Vetter)		5460
Tritium, Materials	Dr. H.D. Röhrig		5463
System Studies	Prof. Dr. P. Komarek		2653