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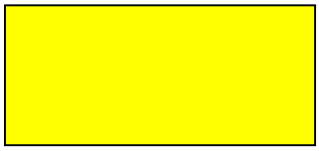

High-Temperature Reactor Fuel Technology

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HTR FUEL DATA BASE

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I. HTR FUEL DATA BASE

The main goal of the HTR-F project was and is refabricating and testing new HTR fuel. At the very beginning of the project it became obvious that the investigation of the results and experience from fuel production and fuel testing in the past would be the ideal basis to start from.

An important aspect is certainly to provide the possibility to retrieve relevant documents and extract data for this purpose from appropriate archives and prepare these materials for dissemination to all partners. For convenience, it seemed to be the best way to digitize the paper documents and store them as electronic files in a repository for further use. In order to be able to run a search for important data and results, the development of additional software tools was required. This has eventually led to the idea to build up an HTR Fuel Data Base (DB).

The requirements to that DB are such that it should not only serve as a repository for documents from the past, but also as a means to retrieve data and results to be evaluated and used as input for further calculations. Thus the data base should consist of two parts:

1. Documentary Data Base
2. Relational Data Base.

Now it was the question how to realize such a proposed data base.

At the Institute for Energy of the JRC Petten (NL), a group of experts had developed computer-based data bases, which are widely being used in the EU. A prominent example is the Alloys-DB (Engineering alloys). At CEA Cadarache, an other group had built up and gained experience with a data base for PWR fuel.

Comparing both concepts, it was finally decided to establish the collection of all relevant documents on a central server located at the JRC Petten. The development of the Relational DB should be conducted in close collaboration between CEA Cadarache and JRC Petten. It was stated that the requirements, which the data base should meet, have to be formulated before deciding at what place and in what manner the data base should be developed.

The JRC Petten has formulated seven basic steps as the prerequisites to build up the HTR Fuel Data Base. The database system should consist of the data base itself and an application interface that allows the user to interact with the data base system.

1. DMD (stands for Data Management and Dissemination) sector receives a request to develop a data base application for a particular subject area i.e. gasket, nuclear fuels, composites, etc.
2. Before software can be developed, a data model must be formulated that describes the data coverage and the arrangement of the data .
3. Based upon their understanding of the user requirements, DMD sector staff first formulates a draft data model.
4. In collaboration with the respective experts on the particular subject matter, the draft data model is then refined.

5. In parallel with data model development, DMD sector staff uses DBA tools to populate the database.
6. DMD sector staff develops data retrieval and data entry application interfaces.
7. After shipping the data base system to the clients, system features are further refined according to the user feedback.

CEA provided the structure of the data base that is used for PWR fuel. It contains information about:

- Pre-characterisation data
- Irradiation history
- Post Irradiation Examination data
- In-pile data
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According to this, the information demands for HTR fuel were formulated as follows:

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- Characterisation data:

  - Fuel element
  - Kernel
  - Coatings

- Test results:

  - Irradiation
  - PIE (Post Irradiation Examination)
  - PIE Heating

Based on the above structure, a draft Relational Data Base model was formulated and developed by JRC Petten and placed at a server at JRC. After some improvements and refinements, the HTR Fuel Data Bank (HTR-Fuel-DB) has been developed within the FP5-HTR-F project as a preliminary prototype Web-enabled data base application for HTR fuel data.

The HTR Fuel-DB offers intelligent user-guidance for data retrieval. Data output is shown in the HTML tables, images, and documents described in the manual (see Chapter II). The database contains source information for traceability, information about the fabrication, dimensions, materials, etc. of both fuel elements and coated particles from a certain production batch. Furthermore, if inserted in a specific irradiation experiment, the data base includes the irradiation characteristics and all information on post-irradiation examinations, e.g., accident simulation testing of the fuel elements and/or coated particles.

Because of data confidentiality only HTR-TN members and related HTR projects can register as a user and will have access to the HTR Fuel-DB data.

In parallel, a user-friendly Documentary Data Base was established at the server in Petten and the upload (and download) of documents was tested. Lists of documents available up to now are given in Chapter III.

II. HTR-FUEL-DB MANUAL

1. INTRODUCTION

The **HTR Fuel D**ata **B**ank (**HTR-Fuel-DB**) has been developed as a preliminary prototype Web-enabled database application for experimentally measured HTR fuel data within the FP5 - HTR-F project.

The **HTR Fuel-DB** offers intelligent user-guidance for data retrieval. Data output is shown in HTML tables, images and documents.

Because of data confidentiality only HTR-TN members and related HTR projects can register and have access to **HTR Fuel-DB** data.

The database contains source information for traceability, information about the fabrication, dimensions, etc. of the fuel elements and particles, irradiation and heating of the fuel elements and the tests performed on fuel elements and particles with or without irradiation and/or heating. Figure 1 shows the simplified entity relationship model of the database.

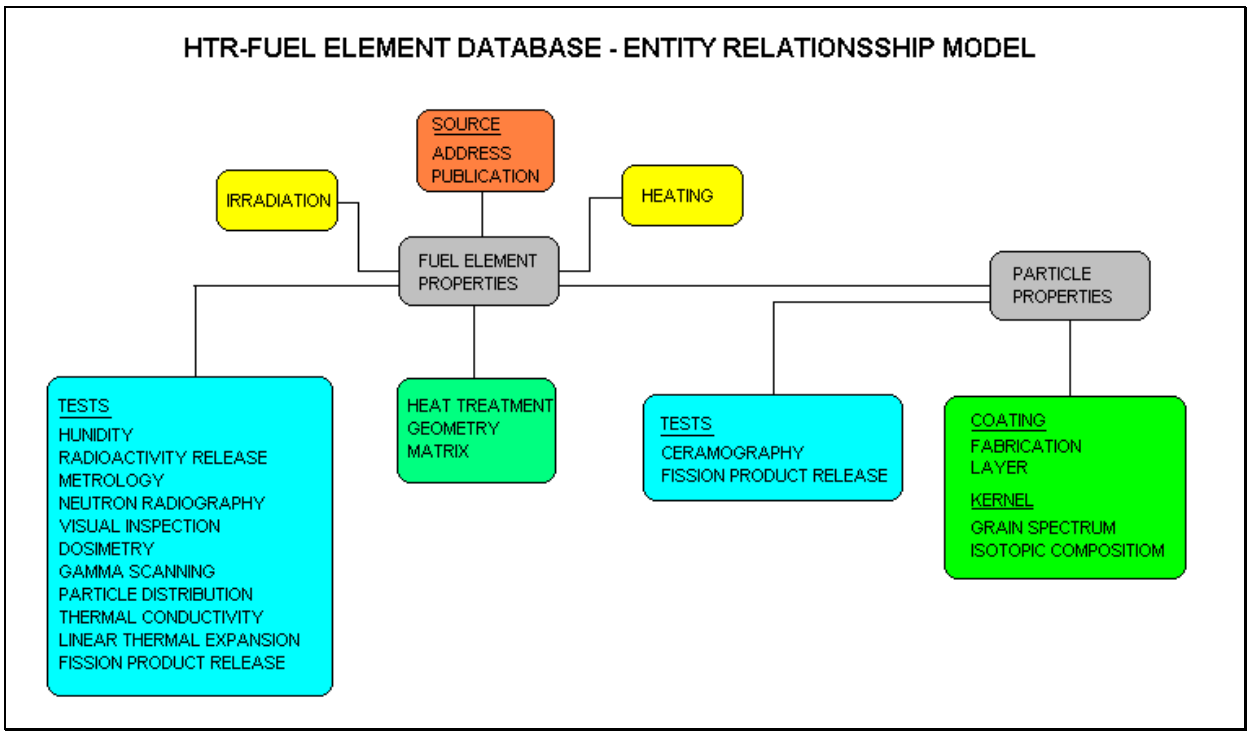


Figure 1: Simplified entity relationship model of **HTR-Fuel-DB**

2. DATABASE CONTENT

The full database content is shown in the following acronym list, which contains information about the field names (acronyms and full names), type & length and additionally information about units, thesauri and comments is shown. Not everything is shown in the following extract.

SOURCE

Acronym	Name	Units	Type	Size
ENTITY: SOURCE_ADDRESS				
TABLE: SourceAddress (SOURCE_ADDRESS)				
SOURCE_NUM	Source Number		VARCHAR2	50
AUTHOR	Author		VARCHAR2	50
CITY	City		VARCHAR2	
COUNTRY	Country		VARCHAR2	50
DATA_ENTRY_DATE	Data Entry Date		DATE	10
ORGANISATION	Organisation		VARCHAR2	255
POST_CODE	Post Code		VARCHAR2	
REMARK	Remark		VARCHAR2	
TABLE: Publication (PUBLICATION)				
SOURCE_NUM	Source Number		VARCHAR2	20
REPORT_NUM	Report Number		VARCHAR2	50
REPORT_NAME	Report Name		VARCHAR2	50
REPORT_CODE	Report Code		VARCHAR2	130
TITLE	Title		VARCHAR2	4
YEAR	Year		NUMBER	

FUEL ELEMENT

ENTITY: FUEL_ELEMENT				
TABLE: Properties (PROPERTIES)				
SOURCE_NUM	Source Number		VARCHAR2	20
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
FUEL_EL_TYP	Fuel Element Type		VARCHAR2	20
FILL_FACT	Filling Factor		NUMBER	
PART_NUM	Number of Particles		NUMBER	
FISSILE_URAN	fissile Uranium	g	NUMBER	
HEAVY_METAL_LOAD	Heavy Metal Loading	g	NUMBER	
URAN_CONTAM	Uranium Contamination		NUMBER	
VOL_PACK_FRAC	Volume Packing Fraction	volume %	NUMBER	
MOULD_TYP	Moulding Type		VARCHAR2	50
MANUFACTURER	Manufacturer		VARCHAR2	50
REMARK	Remark		VARCHAR2	255

TABLE: Fabrication Heat Treatment (HEAT_TREAT)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
HEAT_TREAT_STEP	Heat Treatment Step		NUMBER	
HEAT_TREAT_TEMP	Heat Treat. Temperature	°C	NUMBER	
HEAT_TREAT_TYP	Heat Treatment Type		VARCHAR2	50
HEAT_COOL_RAT	Heating/Cooling Rate	K/min	NUMBER	
REMARK	Remark		VARCHAR2	255
TABLE: Geometry (GEOMETRY)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
FUEL_ZON_DIA	Fuel Zone Diameter	mm	NUMBER	
OUT_DIA	Outer Diameter	mm	NUMBER	
HEIGHT	Height	mm	NUMBER	
MASS	Mass	g	NUMBER	
REMARK	Remark		VARCHAR2	255
TABLE: Matrix (MATRIX)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	50
DENSITY	Density	g/cm^3	NUMBER	
GRADE	Grade		VARCHAR2	50
MATERIAL	Material		VARCHAR2	50
REMARK	Remark		VARCHAR2	255

PARTICLE

PART: PARTICLE				
TABLE: Particle (PARTICLE)				
PART_BATCH	Particle Batch		VARCHAR2	20
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
KIND	Kind of Particle		VARCHAR2	20
PART_TYP	Particle type		VARCHAR2	20
OUT_DIA	Outer Diameter	□m	NUMBER	
MASS	Mass	mg	NUMBER	
VOLUME	Volume	mm^3	NUMBER	
SPHERICITY	Sphericity		VARCHAR2	50
SURFACE_CONTAM	Surface Contamination	□Ci	NUMBER	
REMARK	Remark		VARCHAR2	255
TABLE: Coating Layer (COAT_LAYER)				
PART_BATCH	Particle Batch		VARCHAR2	20
LAY_NUM	Layer Number		NUMBER	
LAY_MAT	Layer Material		VARCHAR2	50
ANIS_FAC	Anisotropy Factor		NUMBER	
DENSITY	Density	g/cm^3	NUMBER	
LAY_DESCR	Layer Description		VARCHAR2	50
MEAN_THICK	Maximum Thickness	□m	NUMBER	
MAX_THICK	Mean Thickness	□m	NUMBER	
MIN_THICK	Minimum Thickness	□m	NUMBER	
REMARK	Remark		VARCHAR2	255

TABLE: Coating Layer Fabrication (COAT_FABRIC)				
PART_BATCH	Particle Batch Number		VARCHAR2	20
LAY_NUM	Layer Number		NUMBER	
ATMOSPHERE	Atmosphere		VARCHAR2	50
TEMPERATURE	Temperature	°C	NUMBER	
DURATION	Duration	min	NUMBER	
FLOW	Flow	l/min	NUMBER	
PLATING_SPEED	Plating Speed	□m/min	NUMBER	
REMARK	Remark		VARCHAR2	255
TABLE: Kernel (KERNEL)				
PART_BATCH	Particle Batch Number		VARCHAR2	20
FORM	Form		VARCHAR2	50
DENSITY	Density	g/cm^3	NUMBER	
MASS	Mass	g	NUMBER	
ENRICHMENT	Enrichment	%	NUMBER	
IMP_CONT	Impurity Content		NUMBER	
MAX_AX_DIM	Maximum Axial Dimension	□m	NUMBER	
MEAN_AX_DIM	Mean Axial Dimension	□m	NUMBER	
MIN_AX_DIM	Minimum Axial Dimension	□m	NUMBER	
MAX_RAD_DIM	Maximum RadialDimension	□m	NUMBER	
MEAN_RAD_DIM	Mean Radial Dimension	□m	NUMBER	
MIN_RAD_DIM	Minimum Radial Dimension	□m	NUMBER	
REMARK	Remark		VARCHAR2	255
TABLE: Kernel Grain Spectrum (KERNEL_GRAIN)				
PART_BATCH	Particle Batch		VARCHAR2	20
MAX_SIZ	Maximum Size	□m	NUMBER	
MIN_SIZ	Minimum Size	□m	NUMBER	
GRAIN_PERC	Grain Percentage	%	NUMBER	
REMARK	Remark		VARCHAR2	255
TABLE: Kernel Isotopic Composition (KERNEL_ISO)				
PART_BATCH	Particle Batch		VARCHAR2	20
ELEMENT	Element		VARCHAR2	20
MAX_CONT	Maximum Content		NUMBER	
MEAN_CONT	Mean Content		NUMBER	
MIN_CONT	Minimum Content		NUMBER	
REMARK	Remark		VARCHAR2	255

IRRADIATION EXPERIMENT

ENTITY: IRRADIATION EXPERIMENT				
TABLE: Irradiation Experiment (IRR_EXPER)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
IRRAD_CODE	Irradiation Code		VARCHAR2	20
CAP_LAB	Capsule Label		VARCHAR2	50
BURN_UP	Burn Up	% FIMA	NUMBER	
IRR_REAC	Irradiation Reactor		VARCHAR2	50
IRR_RIG	Irradiation Rig		VARCHAR2	50
SAMP_HOLD	Sample Holder		VARCHAR2	50
COR_POS	Core Position		VARCHAR2	50
THERM_FLUX	Thermal Flux	n/m^2/s	NUMBER	
THERM_FLU	Thermal Fluence	n/m^2	NUMBER	
FAST_FLUX	Fast Flux E > 0.1 MeV	n/m^2/s	NUMBER	
FAST_FLU	Fast Fluence E > 0.1 MeV	n/m^2	NUMBER	
POW_DENS	Power Density in Fuel	W/m^2	NUMBER	
TEST_START	Irradiation Start		DATE	
TEST_END	Irradiation End		DATE	
DURATION	Irradiation Duration (h)	(h)	NUMBER	
EQ_DAYS	Equivalent Full Power Days	efpd	NUMBER	
TEMP_CENT	Temperature Centre	°C	NUMBER	
TEMP_SURF	Temperature Surface	°C	NUMBER	
TEST_OBJ	Test Objectives		VARCHAR2	255
TEST_RES	Test Responsible		VARCHAR2	50
REMARK	Remark		VARCHAR2	255

HEATING

TABLE: HEATING (HEATING)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
HEAT_CODE	Heating Code		VARCHAR2	20
STEP	Step		NUMBER	
TEST_START	Start		DATE	
TEST_END	End		DATE	
DURATION	Total Heating Time	h	NUMBER	
MAX_TEMP	Maximum Temperature	°C	NUMBER	
TIME_TEMP	Hold Time at Maximum Temperature	h	NUMBER	
HEAT_RATE	Heating Rate	K/h	NUMBER	
HEAT_MODE	Heating Mode		VARCHAR2	
HEAT_FACILITY	Heating Facility		VARCHAR2	100
REMARK	Remark		VARCHAR2	256

TEST RESULT - THERMO-PHYSICAL PROPERTIES

ENTITY: TEST RESULT				
TABLE: LINEAR EXPANSION (LIN_EXPAN)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
TEST_NUM	Test Number		NUMBER	
SEQ_NUM	Sequential Number		NUMBER	
IRRAD_CODE	Irradiation Code		VARCHAR2	20
HEAT_CODE	Heating Code		VARCHAR2	20
TEST_SITE	Test Site		VARCHAR2	100
TEMP	Temperature	°C	NUMBER	
LIN_EXP	Linear Expansion	E-6/K	NUMBER	
ORIENTATION	Orientation		VARCHAR2	20
REMARK	Remark		VARCHAR2	255
TABLE: THERMAL CONDUCTIVITY (THERMAL_COND)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
TEST_NUM	Test Number		NUMBER	
SEQ_NUM	Sequential Number		NUMBER	
IRRAD_CODE	Irradiation Code		VARCHAR2	20
HEAT_CODE	Heating Code		VARCHAR2	20
TEST_SITE	Test Site		VARCHAR2	100
TEMP	Temperature	°C	NUMBER	
CONDUCT	Conductivity	W/(m*K)	NUMBER	
REMARK	Remark		VARCHAR2	255

TEST RESULT – DESTRUCTIVE TESTS – FUEL ELEMENT

TABLE: PARTICLE DISTRIBUTION (PART_DISTRIB)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
TEST_NUM	Test Number		NUMBER	
SEQ_NUM	Sequential Number		NUMBER	
IRRAD_CODE	Irradiation Code		VARCHAR2	20
HEAT_CODE	Heating Code		VARCHAR2	20
TEST_SITE	Test Site		VARCHAR2	100
EXAM_AX	Examination Axis		VARCHAR2	50
EXAM_TYP	Examination Type		VARCHAR2	50
TEST_DATE	Date		DATE	
REMARK	Remark		VARCHAR2	255
TABLE: FISSION PRODUCT RELEASE - FUEL ELEMENT (FISS_PRO_REL)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
TEST_NUM	Test Number		NUMBER	
ELEMENT	Element		VARCHAR2	10
IRRAD_CODE	Irradiation Code		VARCHAR2	20
HEAT_CODE	Heating Code		VARCHAR2	20
MAX_CONT	Maximum Content	%	NUMBER	
MEAN_CONT	Mean Content	%	NUMBER	
MIN_CONT	Minimum Content	%	NUMBER	
TIME	Time	h	NUMBER	

TEMPERATURE	Temperature	°C	NUMBER	
DOSE_RATE	Dose Rate	Sv	NUMBER	
DECO_FLAG	Deconsolidation Flag		VARCHAR2	20
TEST_SITE	Test Site		VARCHAR2	100
REMARK	Remark		VARCHAR2	255
TABLE: DOSIMETRY (DOSIMETRY)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
TEST_NUM	Test Number		NUMBER	
SEQ_NUM	Sequential Number		NUMBER	
IRRAD_CODE	Irradiation Code		VARCHAR2	20
HEAT_CODE	Heating Code		VARCHAR2	20
TEST_SITE	Test Site		VARCHAR2	100
NEUT_FLUX	Neutron Flux	n/m^2/s	NUMBER	
AV_NEUT_FLUENCE	Average Neutron Fluence	n/m^2	NUMBER	
TEST_DATE	Date		NUMBER	
REMARK	Remark		VARCHAR2	255
TABLE: GAMMA SCANNING (GAM_SCAN)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
TEST_NUM	Test Number		NUMBER	
POSITION	Position		NUMBER	
IRRAD_CODE	Irradiation Code		VARCHAR2	20
HEAT_CODE	Heating Code		VARCHAR2	20
TEST_SITE	Test Site		VARCHAR2	100
NEUT_FLU	Neutron Fluence	n/m^2	NUMBER	
RELATION	CS137 / CE144 Relation		NUMBER	
TEST_DATE	Date		NUMBER	
REMARK	Remark		VARCHAR2	255

TEST RESULT – NON-DESTRUCTIVE TESTS – FUEL ELEMENT

TABLE: METROLOGY (METROLOGY)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
TEST_NUM	Test Number		NUMBER	
IRRAD_CODE	Irradiation Code		VARCHAR2	20
HEAT_CODE	Heating Code		VARCHAR2	20
TEST_SITE	Test Site		VARCHAR2	100
DIA_CHANGE	Diametral Change	%	NUMBER	
AX_CHANGE	Axial Change	%	NUMBER	
VOL_CHANGE	Volumetric Change	%	NUMBER	
MASS_CHANGE	Mass Change	g	NUMBER	
ANISOTROPY	Anisotropy	%	NUMBER	
DIM_IMAG	Dimension Image		VARCHAR2	50
TEST_DATE	Date		DATE	
REMARK	Remark		VARCHAR2	255

TABLE: NEUTRON RADIOGRAPHY (NEU_RAD)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
TEST_NUM	Test Number		NUMBER	
IRRAD_CODE	Irradiation Code		VARCHAR2	20
HEAT_CODE	Heating Code		VARCHAR2	20
TEST_SITE	Test Site		VARCHAR2	100
FUEL_ZON_DIA	Fuel Zone Diameter	mm	NUMBER	
OUT_DIA	Outer Diameter	mm	NUMBER	
HEIGHT	Height	mm	NUMBER	
TEST_DATE	Date		DATE	
REMARK	Remark		VARCHAR2	255
TABLE: RADIOACTIVITY RELEASE (RAD_REL)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
TEST_NUM	Test Number		NUMBER	
IRRAD_CODE	Irradiation Code		VARCHAR2	20
HEAT_CODE	Heating Code		VARCHAR2	20
TEST_SITE	Test Site		VARCHAR2	100
ISOTOPE	Isotope		VARCHAR2	20
TEST_START	Test Start		DATE	
TEST_END	Test End		DATE	
RADIATION_TYPE	Radiation Type		VARCHAR2	10
DOSE_RATE	Dose Rate		NUMBER	
REMARK	Remark		VARCHAR2	255
TABLE: HUMIDITY (HUMIDITY)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
TEST_NUM	Test Number		NUMBER	
IRRAD_CODE	Irradiation Code		VARCHAR2	20
HEAT_CODE	Heating Code		VARCHAR2	20
TEST_SITE	Test Site		VARCHAR2	100
TEST_START	Test Start		DATE	
TEST_END	Test End		DATE	
START_TEMP	Start Temperature	°C	NUMBER	
END_TEMP	End Temperature	°C	NUMBER	
HUMIDITY	Humidity	vppm	NUMBER	
REMARK	Remark		VARCHAR2	255
TABLE: VISUAL INSPECTION (VIS_INSP)				
FUEL_EL_LAB	Fuel Element Label		VARCHAR2	20
TEST_NUM	Test Number		NUMBER	
IRRAD_CODE	Irradiation Code		VARCHAR2	20
HEAT_CODE	Heating Code		VARCHAR2	20
TEST_SITE	Test Site		VARCHAR2	100
TEST_DATE	Date		DATE	
OPT_DIAGNOSTIC	Optical Diagnostic		VARCHAR2	100
FAILURE	Failure	%	VARCHAR2	20
KIND_FAILURE	Failure		VARCHAR2	20
REMARK	Remark		VARCHAR2	255

TEST RESULT – DESTRUCTIVE TESTS – PARTICLE

TABLE: FISSION PRODUCT RELEASE - PARTICLE (FISS_PRO_REL_PART)				
PART_BATCH	Particle Batch		VARCHAR2	20
TEST_NUM	Test Number		NUMBER	
ELEMENT	Element		VARCHAR2	10
IRRAD_CODE	Irradiation Code		VARCHAR2	20
HEAT_CODE	Heating Code		VARCHAR2	20
MAX_CONT	Maximum Content	%	NUMBER	
MEAN_CONT	Mean Content	%	NUMBER	
MIN_CONT	Minimum Content	%	NUMBER	
TIME	Time	h	NUMBER	
TEMPERATURE	Temperature	°C	NUMBER	
DOSE_RATE	Dose Rate	Sv	NUMBER	
TEST_SITE	Test Site		VARCHAR2	100
REMARK	Remark		VARCHAR2	255

TEST RESULT – NON-DESTRUCTIVE TESTS – PARTICLE

TABLE: CERAMOGRAPHY - PARTICLE (CERAMOGRAPHY)				
PART_BATCH	Particle Batch		VARCHAR2	20
TEST_NUM	Test Number		NUMBER	
IRRAD_CODE	Irradiation Code		VARCHAR2	20
HEAT_CODE	Heating Code		VARCHAR2	20
STRUC_COATING_LAYER_1	Structure Coating Layer 1		VARCHAR2	50
STRUC_COATING_LAYER_2	Structure Coating Layer 2		VARCHAR2	50
STRUC_COATING_LAYER_3	Structure Coating Layer 3		VARCHAR2	50
STRUC_COATING_LAYER_4	Structure Coating Layer 4		VARCHAR2	50
STRUC_KERNEL	Structure Kernel		VARCHAR2	50
STRUC_MATRIX	Structure Matrix		VARCHAR2	50
TEST_DATE	Date	DD:MM:YY :HH:MM:SS	DATE	
TEST_SITE	Test Site		VARCHAR2	100
OBSERVATION	Observation		VARCHAR2	100
OBSERV_IMAGE	Observation Image		VARCHAR2	100
REMARK	Remark		VARCHAR2	255

3. WEB-ENABLED USER-INTERFACE

The data retrieval part of the user-interface is Web-enabled. To access the **HTR-Fuel-DB data** and related documentation the user has to register on the JRC Petten Data Management & Dissemination Website **MATDB.JRC.NL** by sending an e-mail and explaining the partnership in the project. After confirmation of the partnership by the project responsible the user receives password and user-identification. Before starting **HTR-Fuel-DB** he first has to login (see figure 2. From the **HTR-Fuel-DB** page he then can start data retrieval (see figure 3). Figure 4 shows the **HTR-Fuel-DB** User-interface for data retrieval. This prototype allows only a selection on fuel elements. The output is then a small report on related information (see figure 5), which contains further links to source, matrix and particle. Figure 6 shows an output on particles in reference to the selected fuel element f815. Figure 7 shows finally a report on the coating layers of particle MG178.

Data entry is for the time being performed manually. HTR-Fuel data are sent to JRC Petten within pre-prepared EXCEL templates (see figure 8) and then pasted into the database by using basic database administration tools.

Related documents of the HTR-F project could be stored under ODIN. Figure 2 shows the link to the ODIN sites. Figure 9 shows the nuclear ODIN site and figure 10 HTR-F related documentation.

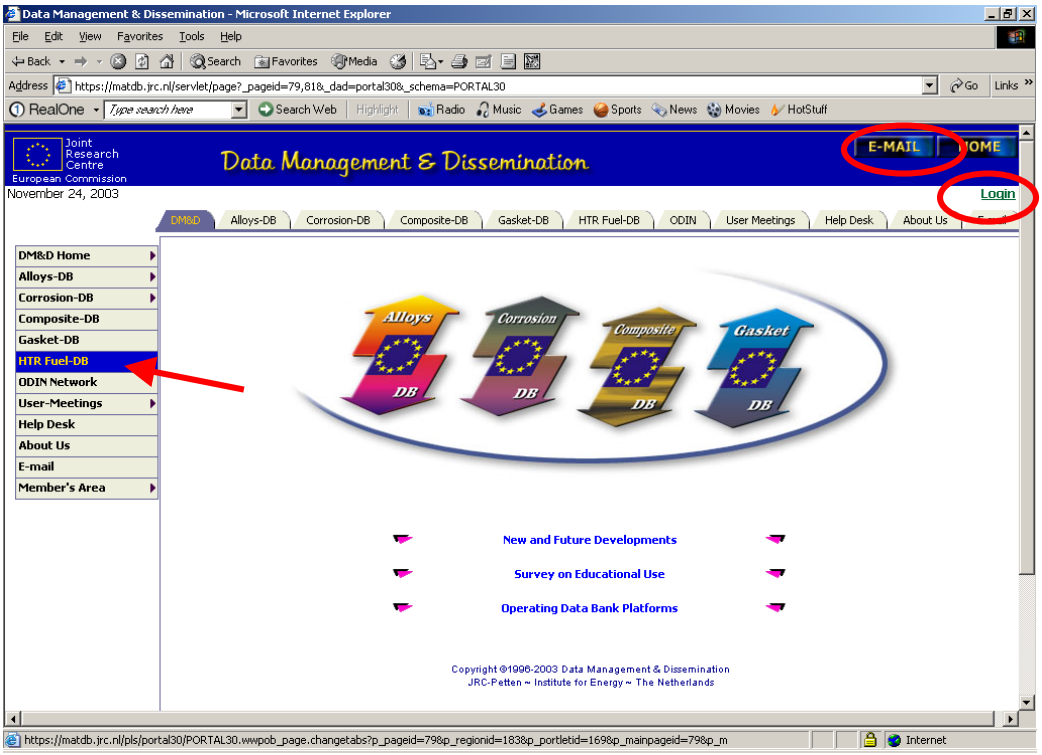


Figure 2: Data Management & Dissemination starting page

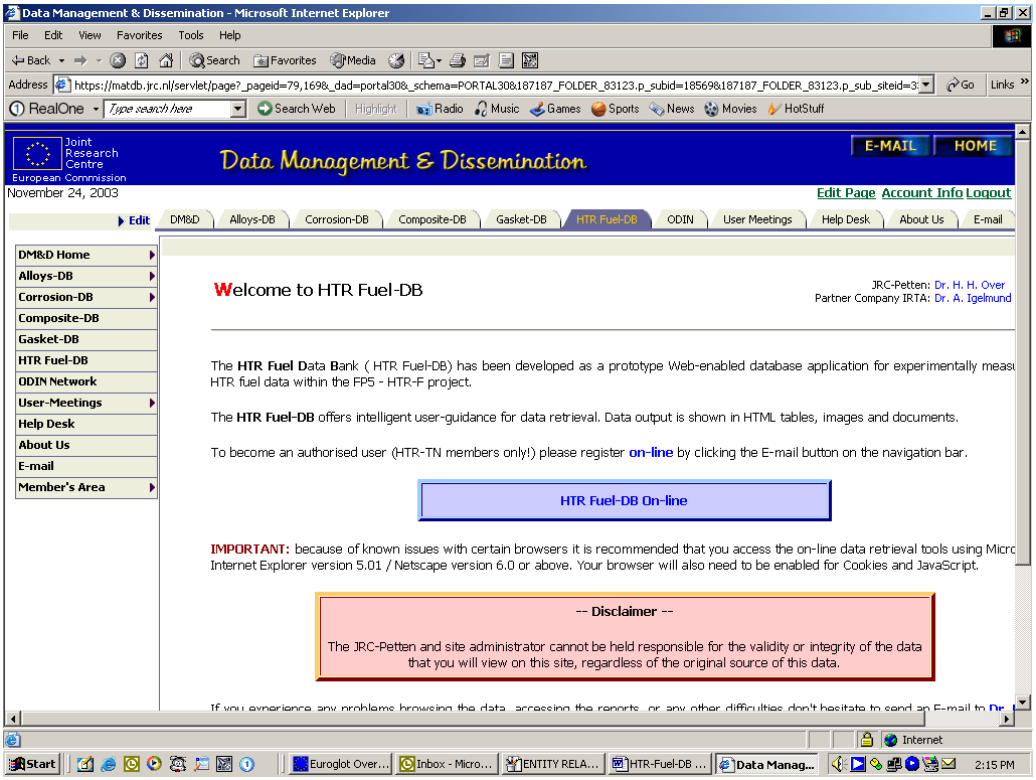


Figure 3: **HTR-Fuel-DB** page

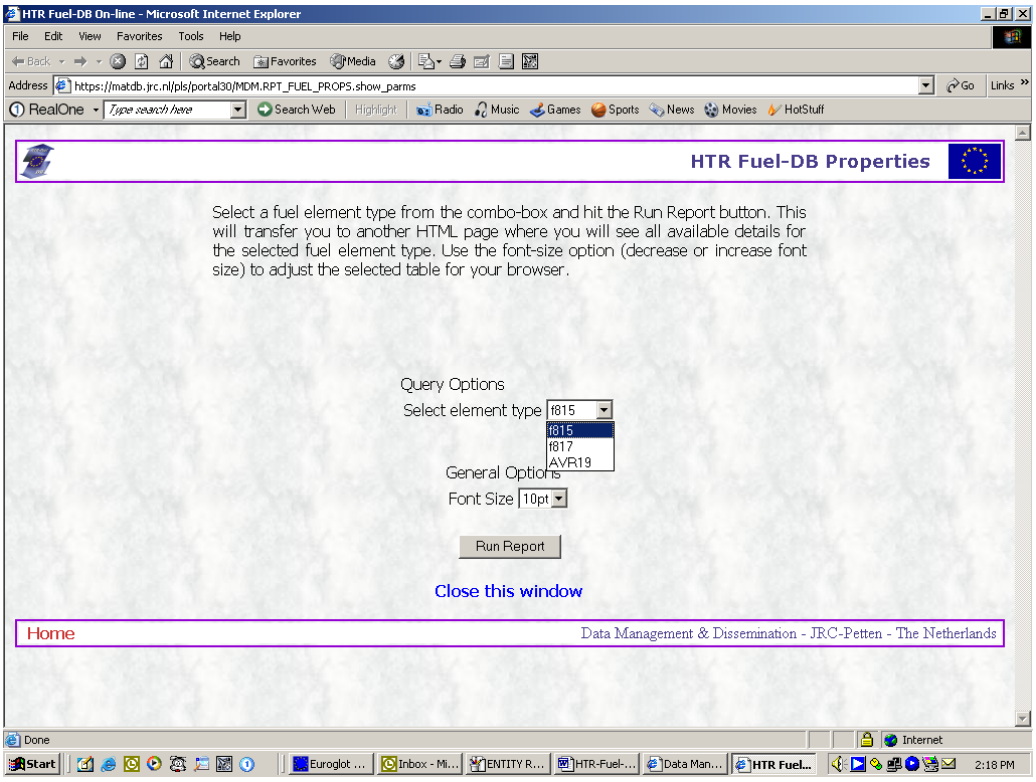


Figure 4: **HTR-Fuel-DB** User-interface for data retrieval

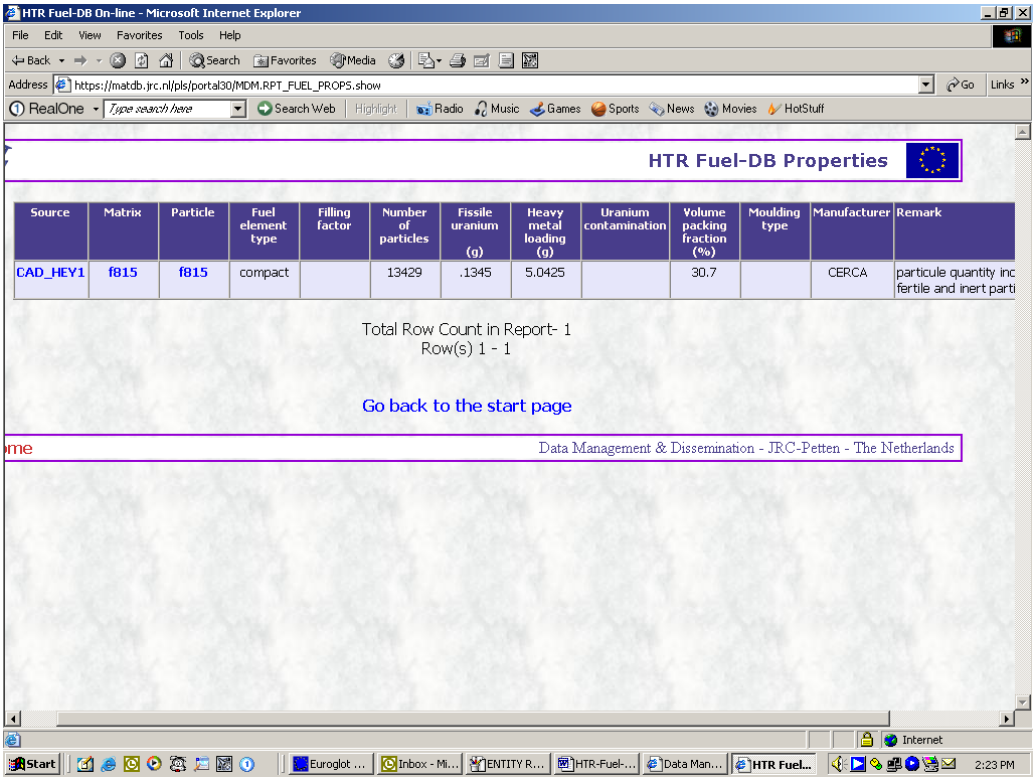


Figure 5: **HTR-Fuel-DB** report

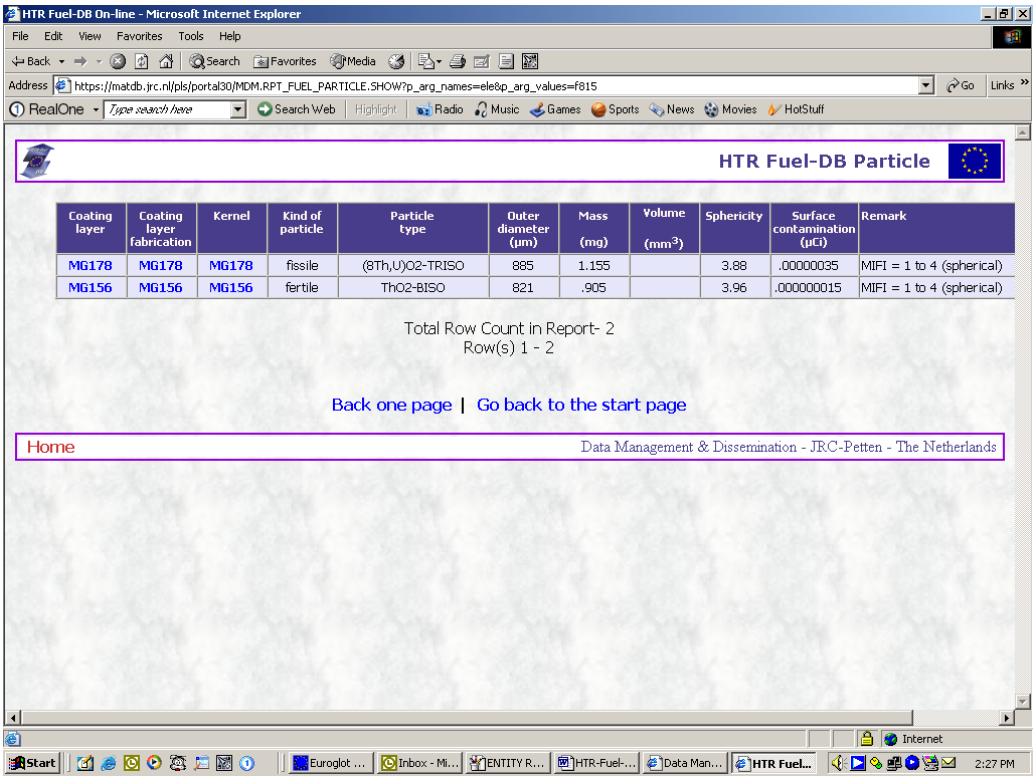
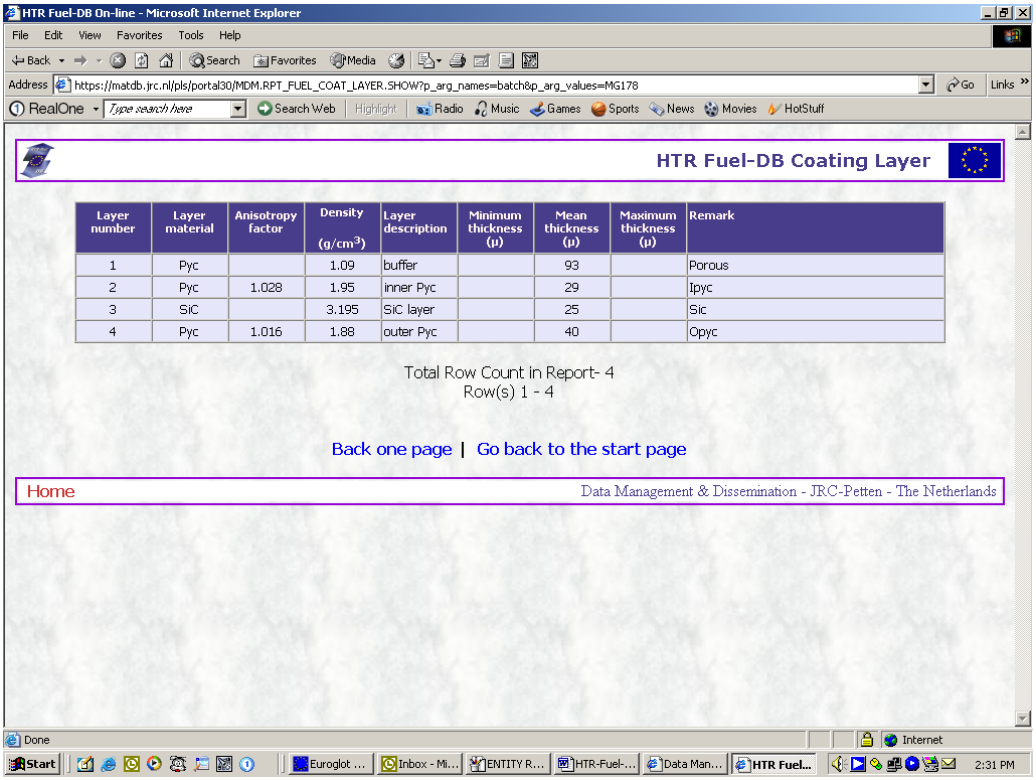
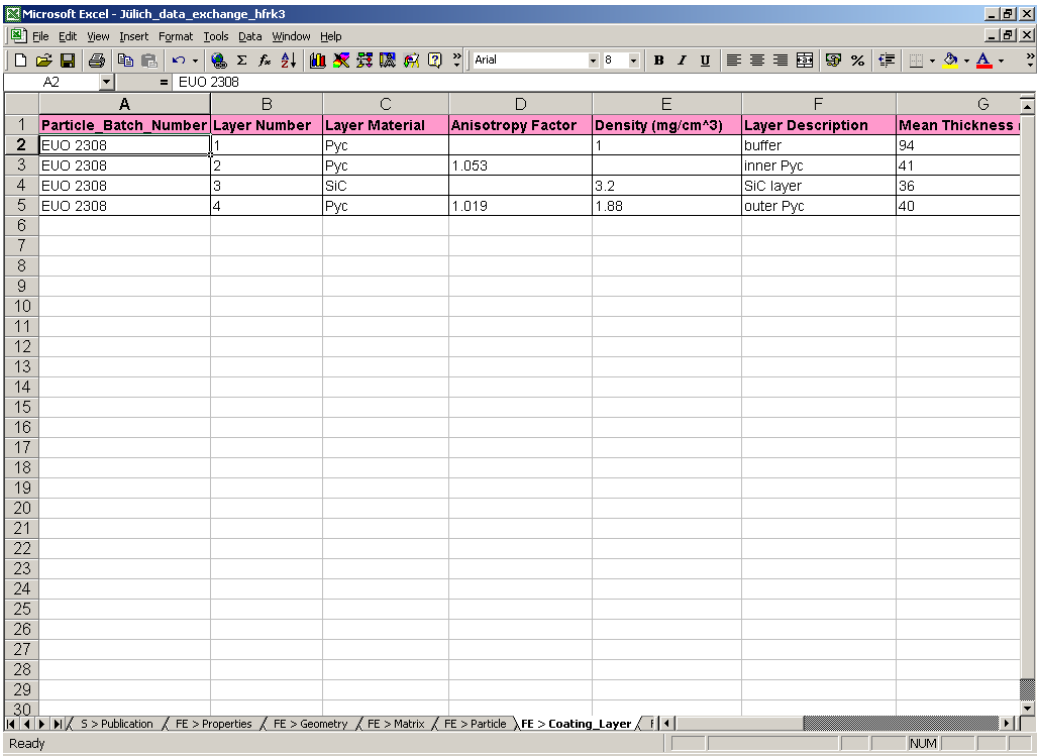


Figure 6: Report on particles of fuel element f815



Layer number	Layer material	Anisotropy factor	Density (g/cm³)	Layer description	Minimum thickness (µ)	Mean thickness (µ)	Maximum thickness (µ)	Remark
1	Pyc		1.09	buffer		93		Porous
2	Pyc	1.028	1.95	inner Pyc		29		Ipyc
3	SiC		3.195	SiC layer		25		Sic
4	Pyc	1.016	1.88	outer Pyc		40		Opyc

Figure 7: Report on coating layers of particle MG178



	A	B	C	D	E	F	G
1	Particle_Batch_Number	Layer Number	Layer Material	Anisotropy Factor	Density (mg/cm^3)	Layer Description	Mean Thickness
2	EUO 2308	1	Pyc		1	buffer	94
3	EUO 2308	2	Pyc	1.053		inner Pyc	41
4	EUO 2308	3	SiC		3.2	SiC layer	36
5	EUO 2308	4	Pyc	1.019	1.88	outer Pyc	40

Figure 8: Data exchange template with FZ Jülich AVR19/ EUO 2308 coating data

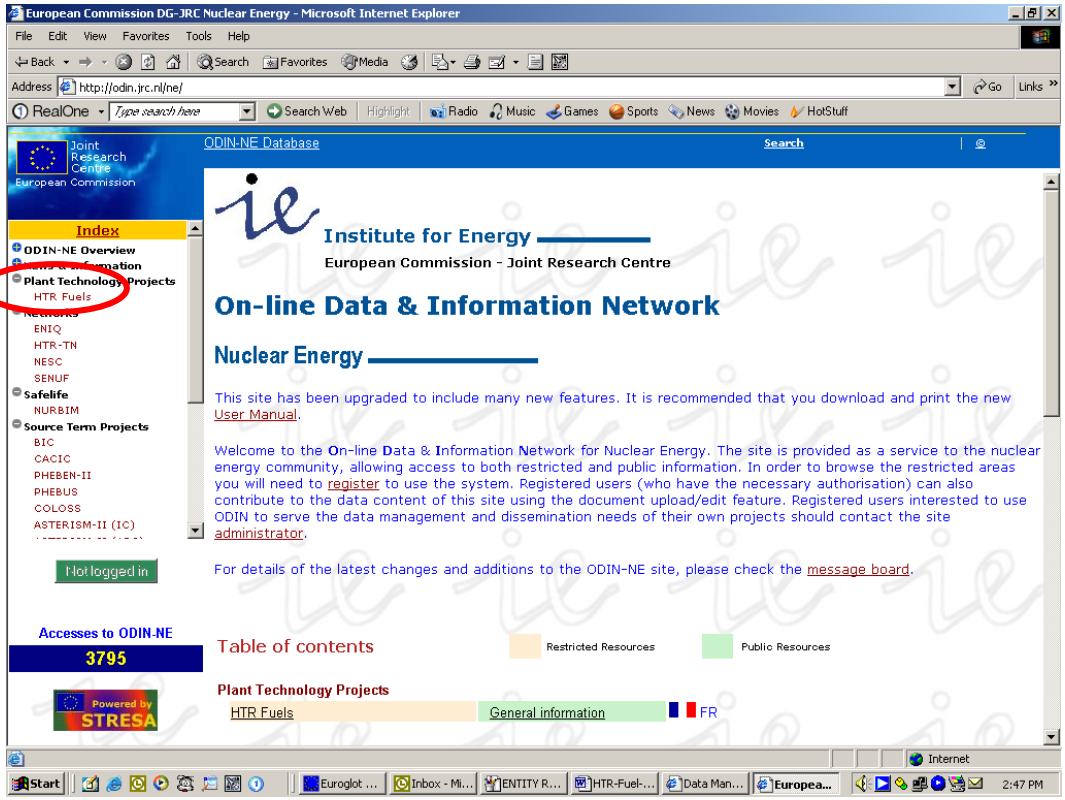


Figure 9: ODIN site on nuclear energy

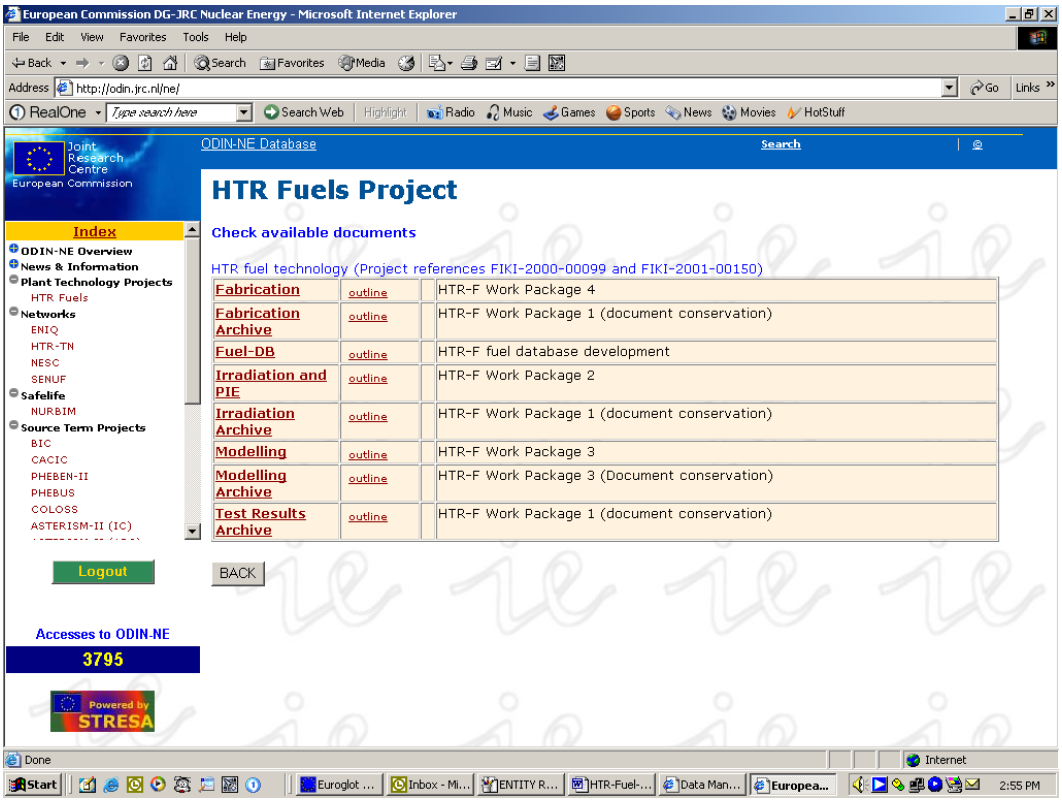


Figure 10: **HTR-F** related documentation

4. EXPERIMENT DESCRIPTION

4.1. CEA Cadarache Example: GF3

The example selected by CEA to be loaded into **HTR-Fuel-DB** is the experiment GF3 in order to have a better comprehensive knowledge on fuel performance and fission product release behavior to qualify particles BISO and TRISO (U,Th)O2 particles and to the manufacturing process for HTR French plant. Two compact elements (F815 et F817) including fissile and fertile particles have been irradiated during 8714 h in the SILOE experimental reactor. Fission gas release and temperature have been measured during the irradiation.

Several post irradiation examination have been made on compact and particles: visual inspection and radiography on particle batch MG178 and metrology examination to observe dimensional change of the compact element.

In addition, both fuel elements have been later deconsolidated, which allowed the measurement of fission product in the matrix graphite. This experiment has demonstrated a good irradiation rate with low failure on the particle batch MG178.

4.2. FZ Jülich Example: HFR-K3

The example selected by FZJ to be loaded into **HTR-Fuel-DB** is the experiment HFR-K3, which provided comprehensive knowledge on fuel performance and fission product release behavior. Four spherical fuel elements have been irradiated in the HFR Petten and achieved the target range of future HTGRs in terms of burnup, fast neutron fluence, and irradiation temperature.

Two of the fuel spheres were later exposed to PIE heating in the KüFA furnace at 1600 °C for 500 h (HFR-K3/1) and at 1800 °C for in total 100 h (in two tests) (HFR-K3/3), respectively. Evaluation of the cold finger plates was conducted both at the Research Center Jülich and at AERE Harwell. Fission product release measurements have demonstrated the good retention capability of the coating and the SiC layer in particular, but on the other hand revealed also the limits of that material.

In addition, both heated fuel elements have been later deconsolidated, which allowed the measurement of radial fission product profiles in the matrix graphite. Insertion of all adequate single coated particles in the IMGA facility in Oak Ridge for gamma analysis has shown the cesium inventories still left in the particles.

III. LIST OF DOCUMENTS

The following lists provide the references of documents on different levels, such as officially issued reports, internal reports, technical notes. The first part lists documents of general interest, followed by lists with information specific to certain experiments. The latter lists contain only the names of the electronic files.

It should be noted that the documents available now are still far away from being complete. However, they represents a good basis, which is to grow in future.

Report 1:

Karl Verfondern und Heinz Nabielek
Forschungszentrum Jülich, Germany

The Mathematical Basis of the PANAMA-I Code for Modelling Pressure Vessel Failure of TRISO Coated Particles under Accident Conditions

HTA-IB-03/90
1. August 1990

Report 2:

Kernforschungs- Anlage Jülich GmbH IRE

JÜL – 1731
Dissertation

August 1981

EXPERIMENTAL INVESTIGATIONS ON THE MIGRATIONAL BEHAVIOUR OF SILVER IN COATED PARTICLE FUEL FOR HIGH TEMPERATURE REACTORS

By

Winfried Amian

Report 3:

Karl Verfondern (Research Center Jülich)

T. D. Dunn (General Atomics San Diego)
J. M. Bolin (General Atomics San Diego)

COMPARISON OF
US/FRG ACCIDENT CONDITION MODELS
FOR HTGR FUEL FAILURE
AND RADIONUCLIDE RELEASE

Jül – 2458
March 19

Report 4:

Werner Schenk

Dieter Pitzer
Heinz Nabielek
Research Centre Jülich, Germany

FISSION PRODUCT RELEASE PROFILES
FROM SPHERICAL HTR FUEL ELEMENTS
AT ACCIDENT TEMPERATURES

Jül – 2234
September 1988

Report 5:

Werner Schenk

Heinz Nabielek
Forschungszentrum Jülich, Germany
FZJ Report Juel-Spez-487 from January 1989

Kugelbrennelemente mit TRISO-Partikeln
bei Störfalltemperaturen

(Zahlenwerk zum Bericht Jül-2091
und neue Ergebnisse von 1986 bis
Oktober 1988)

Report 6:

Werner Schenk

Renate Gontard
Heinz Nabielek
Forschungszentrum Jülich, Germany
FZJ Report Juel-3372 from April 1997

Performance of HTR Fuel Samples
under High-Irradiation and
Accident Simulation Conditions,
with Emphasis on Test Capsules
HFR-P4 and SL-P1

Report 7:

H L Gehr

Siemens Interatom Bensberg, Germany
Interatom Technischer Bericht ITB 54.3285.1 from January 1979

Bestimmung der Spannungsverteilung in beschichteten Brennstoffteilchen und deren Auswirkungen auf das Bruchverhalten der einzelnen Schichten

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Report 8:

Heinz Nabielek, Forschungszentrum Jülich, Germany

Peter Edwin Brown, AEA Harwell, UK
Peter Offermann, Hahn-Meitner-Institut Berlin, Germany

Silver Release from Coated Particle Fuel

FZJ Juel Report 1407 from March 1977, also
Nuclear Technology 35 (1977), 483

Report 9:

Karl Verfondern (ed.), Forschungszentrum Jülich, Germany

Fuel performance and fission product behaviour

In gas cooled reactors

IAEA-TECDOC-978 from November 1997

Report 10:

Paul Kasten (ed.), ORNL USA

International Workshop on the Closed-Cycle Gas-Turbine Modular
High-Temperature Gas-Cooled Reactor

Massachusetts Institute of Technology
Cambridge, Massachusetts
June 17-19, 1991

Report 11:

Paul Kasten

Joel McDuffee

Anthony Taylor
University of Tennessee-Knoxville, USA

Heinz Nabielek
Karl Verfondern
Forschungszentrum Jülich, Germany

Development of Correlations
Between Fuel Performance and
Test Parameters in Modular HTGRs

FZJ-ISR-IB-9/94 from September 1994

Report 12:

Paul Kasten

Daniel A Smith

Jerry J Lichtenwalter
University of Tennessee-Knoxville, USA

Heinz Nabielek
Karl Verfondern
Forschungszentrum Jülich, Germany

Fuel Performance in Modular
High Temperature Gas-Cooled Reactors

FZJ-ISR-IB-12/94 from October 1994

Report 13:

Renate Gontard and Heinz Nabielek,
Forschungszentrum Jülich, Germany

Performance Evaluation of Modern HTR TRISO Fuels

FZJ-HTA-IB-5/90 from July 1990

Report 14:

IAEA Technical Committee Meeting Report 13-15
November 1996 in Johannesburg, South Africa

Report 15:

Egon Ziermann and Günther Ivens, AVR Jülich, Germany

Final Report about Operation of the AVR Experimental Nuclear Power Station

FZJ Report Juel-3448 from October 1997

Report 16:

Johannes Mertens (ed.), Forschungszentrum Jülich, Germany

Safety Related Studies
On the Accident Behaviour of the HTR-Modul

SUPPLEMENTARY VOLUME WITH DETAILED INDIVIDUAL CONTRIBUTIONS
ON THE JÜL-SPEZ-260 REPORT

FZJ Report Juel-Spez-335 from October 1985

Report 17:

E Wallura, H Hoven, H Koizlik, J Linke
Forschungszentrum Jülich, Germany

Silicon Carbide Coatings of Nuclear Fuel Particles
-A Characterization Study –

FZJ Report JUEL-1871 from October 1983

Report 18:

Rodger C Martin

COMPILATION OF FUEL PERFORMANCE AND FISSION PRODUCT TRANSPORT MODELS AND DATABASE FOR MHTGR DESIGN

ORNL-NPR-91/6 from October 1993

Report 19:

POST IRRADIATION EXAMINATION OF CAPSULES GF-1, GF-2 AND GF-3

GA-A15859, September 1980

Report 20:

RAPPORT DE SYNTHÈSE DES IRRADIATIONS GF-1, GF-2, GF-3

DMG DR 34/78, November 1978

Report 21:

IRRADIATIONS GF-1, GF-2, GF-3 DOSSIER N°3

DMG DR 26/75, 1975

Report 22:

CONTRÔLE DES PARTICULES GF2, GF3 BISO

DMG DR 35/74, 1974

Report 23:

CONTRÔLE DES PARTICULES GF2, GF3 TRISO

DMG DR 41/74, 1974

Report 24:

IRRADIATION DU COMBUSTIBLE GF3, DOSSIER N°4

Pi/SEDTI 86/76, 1974

Report 25:

PREIRRADIATION REPORT :GAC FUEL MATERIALS FOR GF1, GF2 AND GF3 IRRADIATION CAPSULES

GA D 13155

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6. AVRmodulheatingpostcalcfzjisr.pdf
7. FRJ2-K13_gammaspek_fzjirw.pdf
8. pieresults-ceramography-fzjirw.pdf
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