NUCLEAR FUEL ACTIVITIES IN BELGIUM

presented by Hubert BAIRIOT
at the IWGFPT Meeting
Vienna - 21 May 1997

- FUEL FABRICATION
- NPP OPERATION
- FUEL PERFORMANCE
- R&D PROGRAMMES

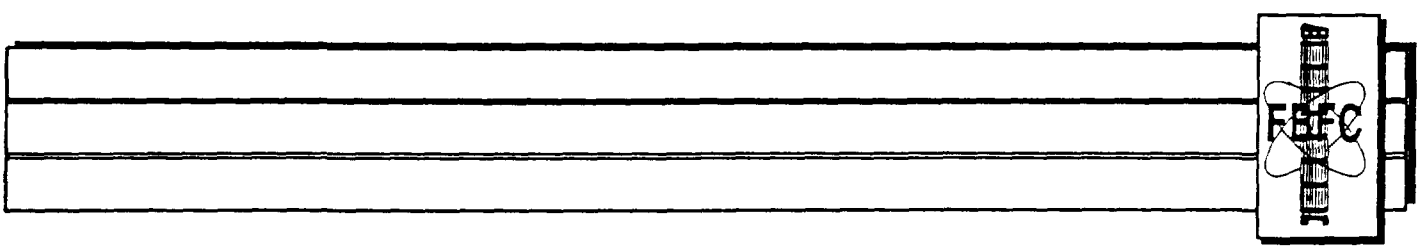
FBFC International

Ownership : 100 % FBFC FRANCE
(FBFC FRANCE = 51 % FRAMATOME,
49 % COGEMA)

- *Customers* F: EDF
  B : ELECTRABEL/TRACTEBEL
  D : All utilities
  Other : Swedisch and Swiss utilities,...

- *Designs currently available*
  Pellets/rods : from 14 x 14 to 18 x 18, UO_2 and UO_2/Gd_2O_3
  Fuel assemblies : 8 x 8, 9 x 9, 14 x 14 to 18 x 18, UO_2 and MOX

- *Safety record*
  From plant start-up (1961) to actual status
  No violation of legal limits on
  - Worker radiation exposure
  - Environmental releases



FBFC International

MAIN RECENT EVENTS

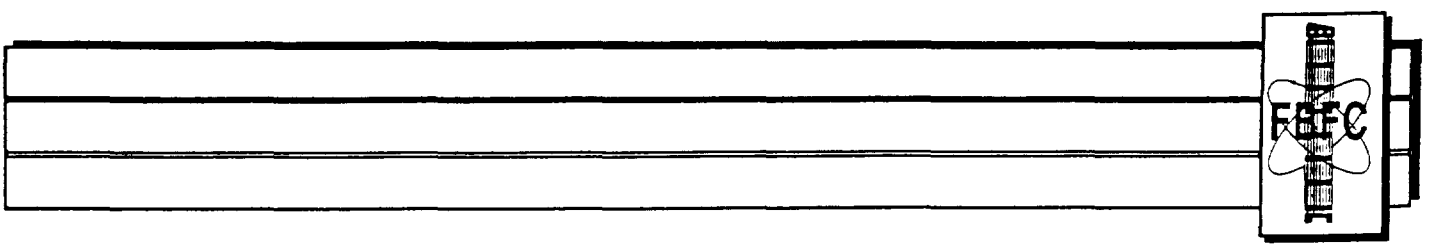
1992 :
- high fuel assembly load (953 including 104 MOX)
- first deliveries of pellets to Germany
- level 2 incident : rupture of a MOX fuel rod

1993 :
- implementation of lessons learned from MOX incident
- 557 fuel assemblies including 76 MOX
- 163 MT U of pellets to Germany
- introducing new designs (e.g. AFA2G)

1994 :
- 743 fuel assemblies including 132 MOX
- new building for MOX assembling under construction (study)
- realisation of the 2 first BWR 8 x 8 assemblies (prototype for Japan)

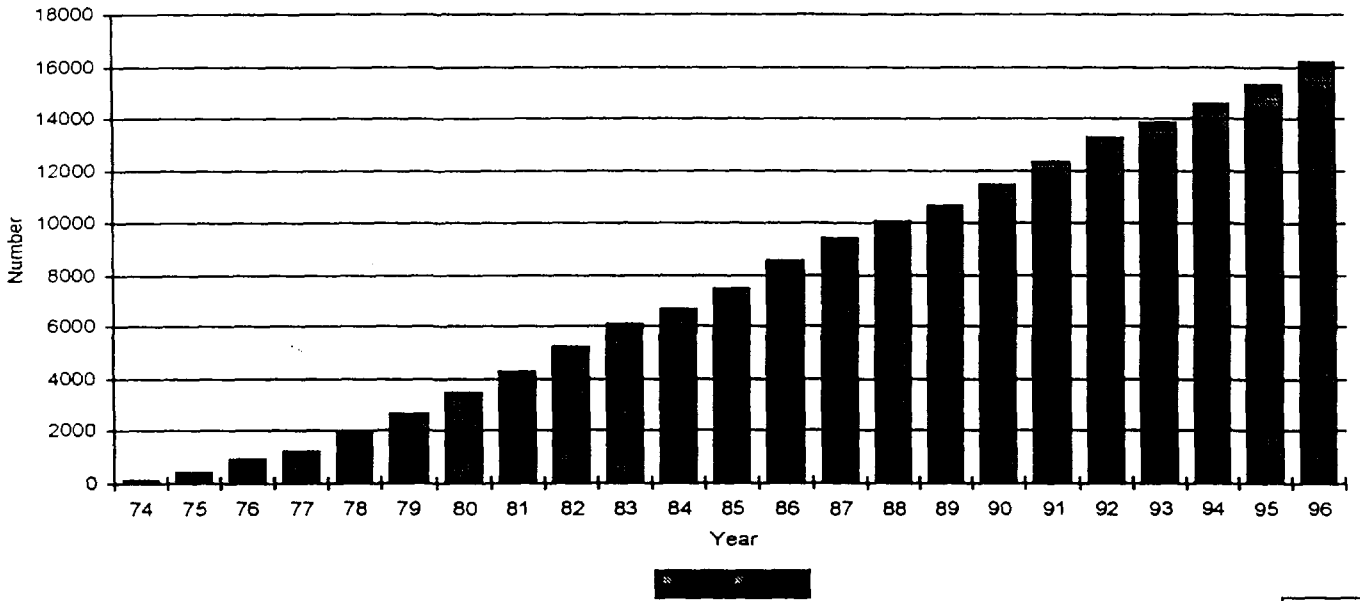
1995 :
- 758 fuel assemblies, including 104 MOX
- first reload BWR 9 x 9 MOX for Germany
- 156 fuel assemblies to Siemens PWR designs
- qualification steps to design 8 x 8 Toshiba

1996 :
- 828 fuel assemblies, including 88 MOX and 289 Siemens-design
- MOX-building in operation for storing and packing fuel assemblies
- safety-improvements



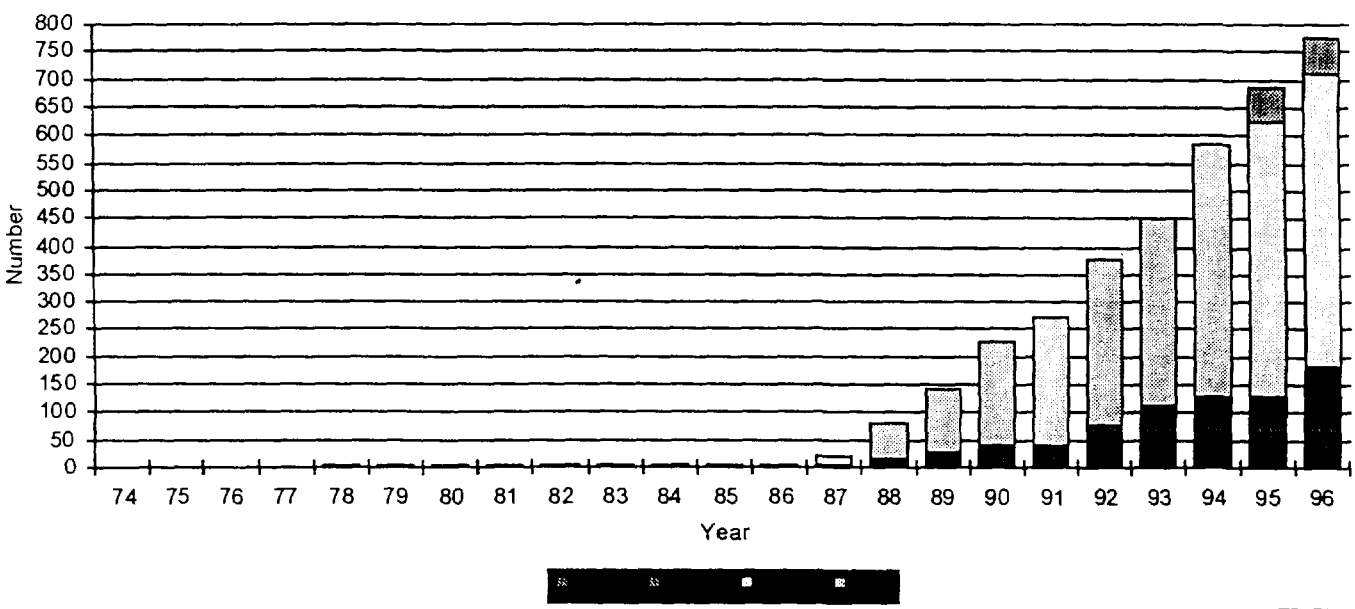
FBFC International

CUMULATED PRODUCTION
Number of Assemblies (PWR)



FBFC International

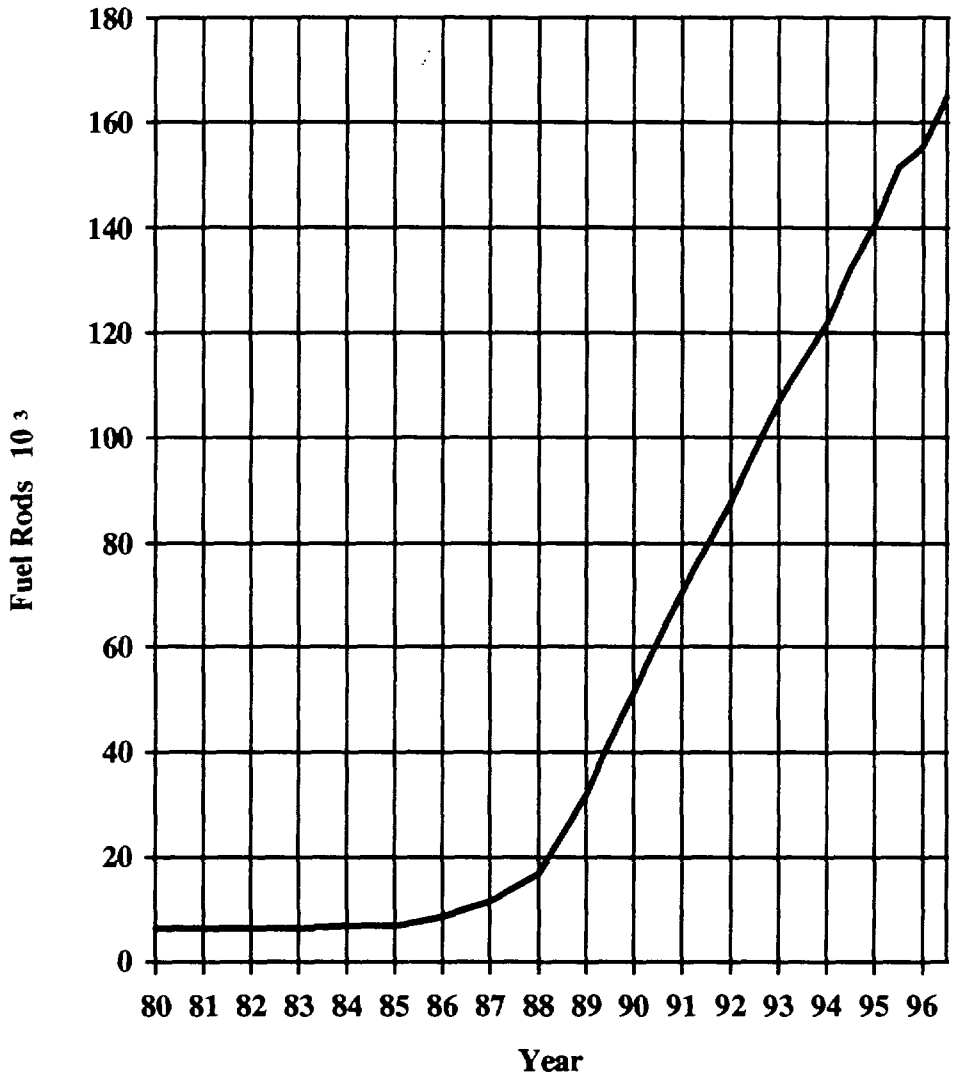
Cumulated MOX-Production - Number of Assemblies



Plant Performance

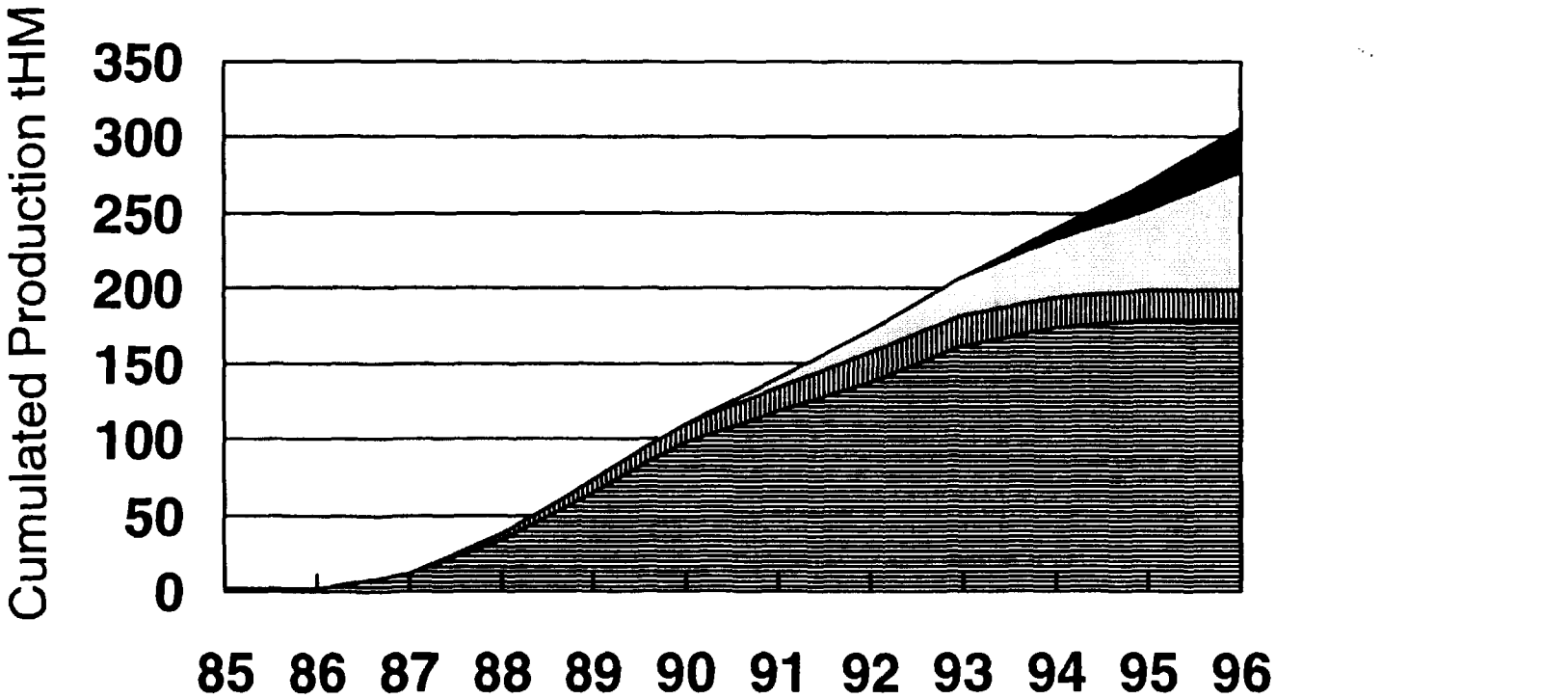
	Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
BN Dessel	Capacity (tHM)	4	8	15	25	35	35	35	35	35	35	35	35
	Actual production (tHM)	1	6	15	26	35	37	30	32	36	32	30	36

MOX Fuel Rods from the BN-Dessel Plant (cumulated delivered quantities) by Oct. 1, 1996



Rods : 164913	159976 MIMAS
tHM : 302.8	294.8
for assemblies :980	(759 with MIMAS)

Cumulated MIMAS production at BELGONUCLEAIRE



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MIMAS Fuel Commercial Deliveries

Status on end of 1996

Delivery Year	Utilities	MOX Deliveries
1987	EdF CNA	1 2
1988	EdF Beznau 1	2 1
1989	EdF Beznau 1	4 1
1990	EdF Beznau 1	4 1
1991	EdF	4
1992	EdF Beznau 1 Unterweser	2 2 1
1993	EdF Grafenrheinfeld Philippsburg	2 1 1
1994	EdF Brokdorf Electrabel	5 1 2
1995	Gundremmingen B Gundremmingen C Electrabel	1 1 2
1996	Brokdorf Philippsburg Electrabel	1 1 2

EdF : St-Laurent B1/B2
Gravelines 3/4
Dampierre 1/2
Blayais 2

Electrabel : Doel 3
Tihange 2

OPERATION OF NPPs IN BELGIUM

NPP (PWRs)	KCD1	KCD2	KCD3	KCD4	CNT1	CNT2	CNT3
MW th	1192	1192	3064	3000	2875	2905	3000
UPRATING	-	-	10%	-	8%	4.3%	-
Mwe NET	393	393	1006	1001	931	955	1015
LOAD FACTOR 1996	92%	84%	84%	70%	88%	88%	81%
LAST CYCLE							
BOC - EOC months	10	12	9	10	13	13	14
BOC - BOC months	11	13	11	13	14	15	15
BURNUP GWd/t	11	12	11	10	15	15	13
AVERAGE LAST 3 CY							
BOC - EOC months	11	11	10	9	14	14	14
BOC - BOC months	12	12	11	12	16	16	15
BURNUP GWd/t	12	11	12	9	16	16	14
SG REPLACEMENT	-	-	93	96	95	01	98

FUEL PERFORMANCE IN BELGIAN NPPs

(burnups expressed in GWd/tHM)

NPP (PWRs)	KCD 1	KCD 2	KCD 3	KCD 4	CNT 1	CNT 2	CNT 3
FA/CORE	121	121	157	157	157	157	157
LAST CYCLE							
FA/reload	32	36	44	52	64	52	56
Gd/MOX/RepU	-/-/32	-/-/-	-/8/-	24/-/-	56/-/-	20/12/-	44/-/-
Aver Discharge BU	44	39	44	27	40	47	41
TYPICAL LAST 3 CY							
FA/reload	32	36	44	32	57	52	56
Gd/MOX/RepU	-/-/32	-/-/-	-/8/-	-/-/-	48/-/-	20/8/-	28/-/-
Aver Discharge BU	43	40	44	44	44	46	41
FA vendor							
Present	F	S	S+F	E	F	A+F	F
Previous	id	id	id	F	S	F	id

FAILED FAs IN BELGIAN NPPs

NPP	ft	1996	94 + 95 + 96
KCD 1	8	-	-
KCD 2	8	1 U	3 U
KCD 3	12	-	1 t
KCD 4	14	1D + 1G + 1U + 1d + 3dg + 8g	1D + 1G + 3U + 1d + 4dg+ 11g
CNT 1	12	-	-
CNT 2	12	1 U	1 U
CNT 3	14	1G + 1U + 2g	3G + 2U + 1d + 3 dg + 6g

Leakers	Mechanical failure
D : debris	d : debris
G : grid	dg : debris + grid
	g : grid
U : unhnown	t : guide-thimble

RCCA Insertion Problems in Belgian NPPs

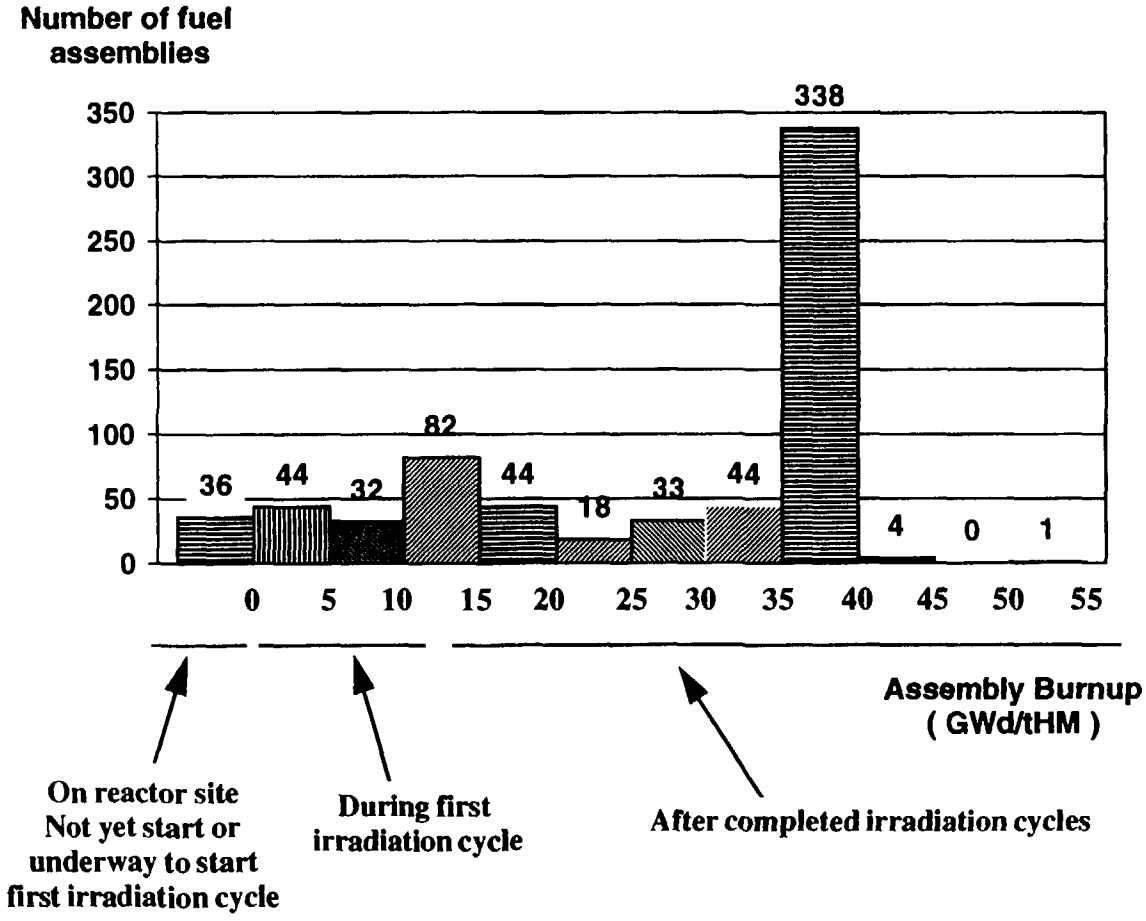
(status 97 05 07)

- Only in 14 ft cores

- KCD4 :
  cy 11 (9508 - 9608) : 5 blocked in F FAs at EOC
  cy 12 (9609 -) : OK

- CNT 3 :
  cy 10 (9510 - 9611) : 8 blocked in F FAs near EOC
  cy 11 (9612 -) : OK

MIMAS FUEL IRRADIATION EXPERIENCE by Oct. 1, 1996



Total : 697 FUEL ASSEMBLIES WITH MIMAS
154630 Fuel Rods

France	:	27 reloads in 8 PWRs
Germany	:	6 reloads in 4 PWRs
	:	2 reloads in 2 BWRs
Switzerland	:	5 reloads in 1 PWR
Belgian	:	4 reloads in 2 PWRs + experimental assemblies in BR3 PWR
The Netherlands	:	experimental assemblies in DODEWAARD BWR

MP 96/01

Recent International Programmes for MOX Fuel Validation and Licensing

1. Neutronic - Core physics validation

Experimental investigation : Critical values, reactivity effects, radial and axial power distribution, spectral indexes, detector responses, source term and actinides, ...

VIP - PWR (PWR 17 x 17 MOX assemblies simulation)

Facility : • VENUS

Support : BN, CEN/SCK, MHI (NFI,NEL and Japanese PWR utilities), BNFL.

Status : Completed (1990-1993)

VIP - BWR (BWR 8 x 8 MOX bundles simulation)

Facility : • VENUS

Support : TOSHIBA, HITACHI (Japanese BWR utilities), BN, CEN/SCK.

Status : Completed (1989-1993)

VIPO (Void simulation within high enriched MOX fuel slabs)

Facility : • VENUS

Support : BN, CEN/SCK, EdF, NFI (and Japanses PWR utilities), BNFL, MHI.

Status : completed at the end of 1996.

VIPEX - P **(Extension of VIP-PWR for Am 241 effect, water density effect, control rod worth for MOX versus UO_2, flux profile within MOX fuel rods, Beta effective, overmoderated configuration, Detector Response)**

Facility : • **VENUS**

Support : BNFL, KAERI, BN, CEN/SCK, CRIEPI, MHI (Japanese PWR utilities)
Status : Start up at mid 1996 (duration 1.5 year)

ARIANE **(Source term for high B.U. MOX and UO_2 fuel)**

Facilities :
- **LWR irradiated commercial fuel from**
  - **Beznau-1 and Gösgen (PWR samples)**
  - **Dodewaard (BWR samples)**
- **Laboratories : TUI, CEN/SCK, PSI.**

Support : TOSHIBA, HITACHI (Japanese BWR utilities),
TRACTEBEL (ELECTRABEL), NOK,
GKN, PSI, CEN/SCK, JRI, GNB, BN.
MHI (NFI, Japanese PWR utilities) NEL, ORNL, BNFL.
Status : Underway since early 1995, duration 3 years including scope extension.

2. Rod Thermomechanical behaviour

Experimental investigation : Fission gas release, geometry, fuel and clad structure analyses, power ramping, extended PIE etc.

DOMO (MOX segments versus UO_2 segments behaviour up to high burnup conditions)

Facilities :
- Irradiation in Dodewaard
- PIE and ramps in CEN/SCK
- PIE at PSI.

Support : BN, CEN/SCK, TOSHIBA, HITACHI (PNC, NFD, Japanese BWR utilities), PSI, GKN.
Status : Under way. (duration : about 10 years)
End of the programme : early 1997.

FIGARO (Instrumentation of MOX PWR irradiated fuel segments for investigating fission gas release and central temperature versus power)

Facilities :
- Irradiation in Beznau-1
- PIE + preparation at PSI
- Instrumentation at Kjeller
- Ramp testing at Halden
- PIE after ramp at Kjeller

Support : BN, NOK, PSI, MHI, EdF, KAERI, CEN/SCK.
FRAGEMA (Cogema, Framatome), TRACTEBEL (Electrabel)
Status : Starting early 94, duration about 3 years.

NOK - M109 (Investigation of MOX PWR irradiated fuel rods on fission gas release and PCI)

Facilities :
- Irradiation in Beznau-1.
- PIE at PSI .

Status : Starting August 1995 (about 2 years)
Support : MHI, BNFL, SIEMENS, NOK, BN.

ZODIAC An experimental programme to study the Zircaloy high dose irradiation creep.

Objectives

- to assess the mechanical properties (primary creep) of zircaloy claddings irradiated in power reactors.

Main features of the programme

- Zy4 irradiated claddings in Blayais
- Zy2 irradiated claddings in Ringhals.
- Biaxial tensile tests, biaxial creep tests, axial creep tests, relaxation tests, low cycle fatigue tests at temperatures 350-400°C

Schedule 1992-1997