LAS/ANS 2010 Symposium

New Technology for the Nuclear Fuel Cycle

DEVELOPMENT AND IMPLEMENTATION OF A 16x16 NEXT GENERATION FUEL (16NGF) FOR WESTINGHOUSE 16x16 TWO LOOP CORES (ANGRA-1 AND KORI-2)

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INDÚSTRIAS NUCLEARES DO BRASIL

16NGF Development Background

- 2001
  - INB, KNF and Westinghouse have jointly decided to design an advanced 16x16 Westinghouse type PWR fuel assembly
- 2002 to 2004
  - Fuel Assembly design and tests phases
    - 2002 → Preliminary design
    - 2003 to 2004 → Final design and physical tests
- 2005 to 2007
  - Angra-1 Safety Analysis (16NGF, RSG and Uprating)
    - INB, Eletronuclear (ETN) and Westinghouse

16NGF Design Objectives and Characteristics

- 16NGF Program Major Objectives
  - Update the current 16x16 Standard (16STD) fuel assembly utilized at the Angra-1 and Kori-2 sites making it compatible with current Westinghouse technology
    - Batch average burnup greater than 55 MWd/kgU
    - More than 20% increase in DNB Margin
    - Mid Grid dynamic strength and dynamic stiffness sufficient to meet LOCA/Seismic design criteria.
    - Demonstration of compatibility between the 16NGF and the existing 16STD fuel assemblies in use in the Republic of Korea and Brazil.

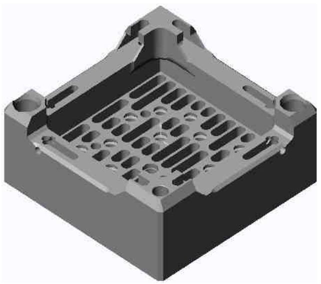
16NGF Design Objectives and Characteristics

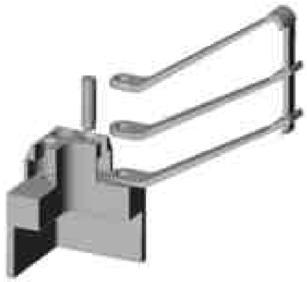
➢16NGF Main Characteristics

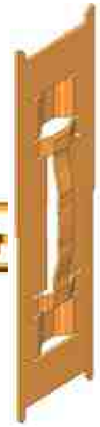
Item	Previous ١٦STD	١٦NGF	Enhancement/Benefit
Fuel Rod	Zirc-٤	ZIRLO® Clad Optimized Rod Dia. Axial Blanket (Opt.)	High Burnup (>٧٠ GWD/MTU) Neutron Economy
Mid & IFM Grid	Inconel Mid Grid No IFMs	ZIRLO® Mid Grid New Spring/Dimple Optimized Mixing Vane Enhanced IFMs	Neutron Economy Fretting Wear Resistance DNB Margin(>٢٠%)
Guide Thimble	Zirc-٤ Swaged Dashpot	ZIRLO® Tube-in-Tube	Robust & IRI Free
Top Nozzle	Welded to Skeleton	Modified ICTN with RTN	Spring Screw Failure Free Reconstitutible
Bottom Nozzle	DFBN/Standard	DFBN	
Protective Grid	None	Protective Grid	Debris Filtering
End Plug	STD End Plug	Long Solid End Plug	

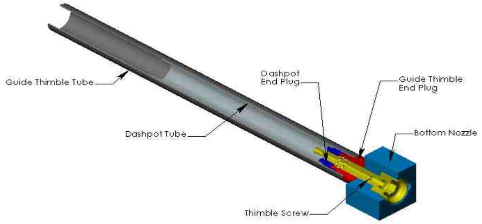
16NGF Design Objectives and Characteristics

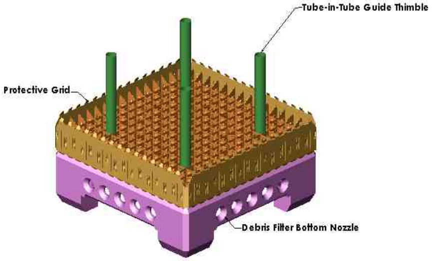
➢16NGF Main Characteristics

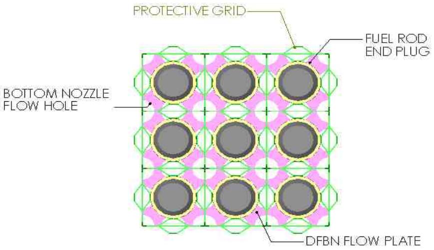


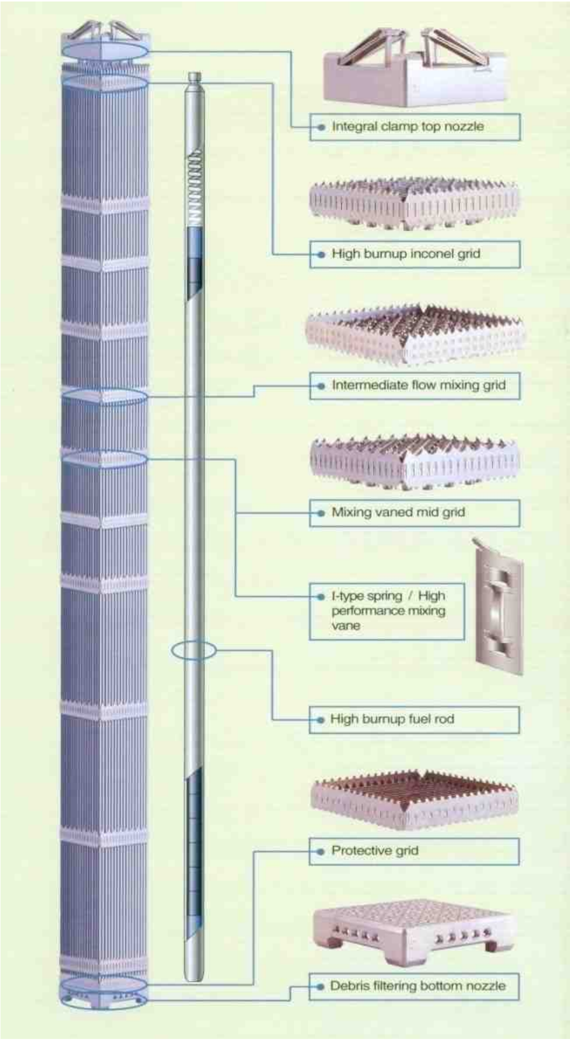












16NGF LTA and Full Region Implementation

- 16NGF LTAs Implementation
  - Four LTAs in both utilities (Angra-1 and Kori-2)
  - LTAs fuels are to be burned for three consecutive cycles
  - LTAs fuels are supposed to be examined after each cycle (PSE - Pool Side Examination)

16NGF LTA and Full Region Implementation

- 16NGF LTAs Pool Side Examination
  - Visual inspection
  - Fuel assembly axial growth
  - Fuel assembly bowing
  - Fuel assembly twist
  - Fuel rod axial growth
  - Fuel rod Bowing
  - Fuel rod diameter
  - Fuel rod corrosion layer thickness
  - Grid width growth
  - Holddown spring force and rate

INDÚSTRIAS NUCLEARES DO BRASIL

16NGF LTA and Full Region Implementation

- 16NGF LTAs Angra-1 Implementation
  - INB and ETN (Angra-1 utility) has decided to take advantage of the new fuel design just after replacing Angra-1 Steam Generators (concluded in 2008)

16NGF LTA and Full Region Implementation

➢16NGF Implementation Strategy for Angra-1 NPP

RSG

First PSE Campaign

Cycle	Year	LTA	NGF	STD	STD/Zirlo	106%
16	2009	-	-	81	40	No
17	2010	4	-	37	80	No
18	2011	4	-	-	117	Yes
19	2012	4	-	-	117	Yes
20	2013	1	40	-	80	Yes
21	2014	-	80	-	41	Yes
22	2015	-	121	-	-	Yes

16NGF LTA and Full Region Implementation

- 16NGF Implementation Strategy for Angra-1 NPP
  - INB investments to fabricate 16NGF fuels
    - New dies to produce UO_2 pellets
    - Design and qualification of a semi-automatic 16NGF skeleton fabrication bench
    - Qualification of an internal Gadolinium pellets supplier (CTMSP)
    - New line to Gadolinium FR fabrication

16NGF LTA and Full Region Implementation

- 16NGF LTAs Kori-2 Implementation
  - KNF and Kori-2 (utility) have chosen insert the 16NGF LTAs fuels immediately after design phase had been finalized (2005)

16NGF LTA and Full Region Implementation

➤16NGF Implementation Strategy for Kori-2 NPP

Cycle	Year	LTA	NGF	STD	STD/Zirlo	106%
20	2005	4	-	117	-	No
21	2006	4	-	117	-	No
22	2007	4	-	117	-	No
23	2008	-	48	73	-	No
24	2009	-	96	25	-	No
FMO* → 25	2010	-	121	-	-	No
26	2011	-	121	-	-	No

* Fuel Management Optimization → 56 fuels (492 EFPD)

Conclusion

- INB and KNF have been adopting different 16NGF implementation strategies that better meets their requirements, objectives and needs

- Taking account PSE results so far, 16NGF fuel assemblies have been showing an excellent operational performance.