UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

DEC 17 1996

MEMORANDUM FOR: Timothy Collins, Acting Chief
Reactor Systems Branch
Division of Systems Safety and Analysis

FROM: Laurence E. Phillips, Chief
BWR System Section
Reactor Systems Branch
Division of Systems Safety and Analysis

SUBJECT: FOREIGN TRIP REPORT: CSNI SPECIALISTS MEETING IN SPAIN

The purpose of this trip was to participate in the CSNI Specialists meeting on Nuclear Fuel and Control Rods, November 5-7, 1996, and to exchange information pertaining to recent fuel and core performance experience and regulatory positions on the extended burnup operation of nuclear fuel. In addition to the participation of regulatory representatives from the OECD member countries, there was substantial participation by invited representatives of the nuclear industry, including experts from research institutes, utilities, and fuel vendors. Other NRC attendees at the meeting were Jack Rosenthal (AEOD) and Harold Scott (RES).

On November 4, 1997, the day preceding the CSNI meeting, I met with Jose Villadoniga, Jose Conde, M. Recio, and other staff of Consejo de Seguridad Nuclear (CSN) at their offices to discuss the CSN experience and policies with respect to several fuel and core issues of mutual interest. The discussion items had been identified in advance of the meeting.

The objective of this report is to highlight major aspects of these meetings. The program of the CSNI meeting is provided as Attachment 1. Most of the papers presented are available on request.

Summary of CSN Meeting

Seven pressurized water reactors (PWRs) and two boiling water reactors (BWRs) are currently in operation in Spain. The General Electric BWR designs are S.M.Garona (BWR3) and Cofrentes (BWR6). The Empresa Nacional del Uranio, S. A. (ENUSA) manufactures and supplies fuel assemblies for both PWRs and BWRs. Westinghouse PWR fuel is fabricated to meet Westinghouse design specifications and GE BWR fuel conforms to General Electric fuel design specifications. Siemens fabricates in Germany the fuel for its Spanish PWR designs. Fuel burnup in Spanish reactors is limited to 62 gigawatt days per metric ton of Uranium (GWd/MTU) lead rod average and oxidation is limited to 100 microns. Siemens maintains oxidation limits on its fuel via statistical oxidation checks after each operating cycle and predictive calculations of the oxidation during the following cycle.

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CSN issues and concerns with mixed cores are similar to ours, and CSN is increasing its surveillance and inspection activities associated with mixed core designs. Recent BWR incidents discussed included an inadequate criticality prediction in Garona and a GE-11 handling problem at Cofrentes.

CSN also provided information concerning an incomplete control rod insertion event that happened at Almaraz in August 1955. A stuck control rod very low in the core (about 8 steps) was attributed to debris or crud deposition after the original inspection identified an obstruction in only one of the guide thimble tubes of the affected fuel bundle. After the Wolf Creek and South texas events, a more detailed inspection was scheduled to confirm the initial conclusion. In a follow-up communication, CSN informed us that the reason for the obstruction was not found, and that an inspection of about 20 fuel bundles has revealed an "S" shaped deformation in many of them with the most distortion occurring in the vicinity of the stuck rod. The deformation could be correlated with an observed degradation of the control rod scram time since the beginning of cycle. Incipient "S" shaped deformation was detected in one fuel assembly with only 20 GWd/MTU burnup; all the other inspected bundles were 40 GWd/MTU or greater. ENUSA found that there was no unusual corrosion of the deformed bundles and that the power history and fuel growth were not distinctive. There appears to be some coherence among the deformation of neighboring bundles. CSN believes that the problem is similar to that in the USA and other countries but does not believe that the Westinghouse explanation of excessive irradiation induced fuel rod growth is valid. The licensee and ENUSA are continuing to evaluate the problem.

CSN was questioned about Lead Test Assembly (LTA) programs for in-service testing and evaluation of new fuel designs in Spanish reactors. They require that a topical report describing the LTA design and planned operation be submitted for CSN review. A maximum of eight fuel bundles at quarter core symmetrical locations are permitted for each LTA design. The LTAs are located and operated to preserve thermal margin from the peak power location. A maximum of two coexistent LTA programs are permitted during any operating cycle. CSN was also queried concerning the resolution status of stability issues for its BWR reactors. Garona has selected Long Term Stability Solution 1D and Cofrentes has selected Solution 1A to provide protection against power oscillations during normal operation. Both plants have adopted the Boiling Water Reactor Owners' Group (BWROG) designed "boiling boundary" algorithm for radial and axial peaking factor control, and have installed it in the plant process computers. Revision of Emergency Procedure Guidelines consistent with NRC approved BWROG recommendations to protect against power oscillations during ATWS is planned but has not been initiated.

Summary of CSNI/PWGI Specialists' Meeting

The meeting was opened with a welcoming address by A. G. de Ubieta, Director of Nuclear Energy, UNESA. Professor A. Alonso, Commissioner and CSNI Vice-Chairman followed with summary of the past safety record of light water reactor core components and an expression of meeting objectives to discuss current core problems and provide recommendations for resolution. Invited papers in the opening session included "Update of High Burn-up Fuel Issues" by

which indicate that the safety criteria formulated on the basis of fresh or low-burnup fuel experiments may not be applicable to high-burnup fuel rods. He concluded that present fuel rod designs beyond the burnup level of 50 GWd/MTU have a higher risk for failure and post failure dispersion when compared to fresh or low burnup fuel subjected to rapid power transients. However, he acknowledged the non-typicality of the experiments and recommended the installation of a pressurized-water-loop in CABRI which will have the capability to perform experiments important to the development of new safety criteria and to the evaluation of improved fuel designs at high burnup and under representative conditions.

Prior to the start of the Opening Session, Jose Conde (Chairman of the Program Committee) and Dr. Schmitz requested that I follow his presentation with some remarks regarding the impact of the RIA experiments on regulatory reviews of high burnup fuel applications in the USA. My remarks, were substantially as follows:

(1) The recent high burnup RIA data have deepened regulatory concerns about the adequacy of: (a) fuel behavior models used in the licensing evaluations of fuel for its design burnup lifetime, (b) fuel failure criteria used in the safety analyses of high burnup fuel transient response behavior, (c) enhanced fission gas release compared to accident analysis models, and (d) the safety implications of enhanced low energy fuel particle dispersal into the coolant, plant contamination, and enhanced plant release.

(2) An industry evaluation of high burnup operation in the USA has concluded: (a) all plants are in compliance with existing licensing acceptance criteria for RIAs, (b) all current and planned USA reactor cores operating within approved fuel burnup limits could demonstrate continued compliance with licensing basis requirements for response to design basis RIAs by using more detailed 3-D analytical models in conjunction with more realistic failure criteria for high burnup fuel, and (c) ECCS evaluation issues for current and planned core operation are more limiting early in the fuel life.

(3) Fuel Design Acceptance Criteria for high burnup fuel transient response are incorrect and must be improved before burnup limits can be extended. The acceptance criteria do not necessarily need to coincide with actual fuel behavior limits, but can be a failure limit assumed in the safety analyses and imposed as a fuel design requirement (e.g., 100 cal/g for cladding integrity) that must be demonstrated, including corrosion/oxidation performance data at the design burnup level, for each new fuel design. The design acceptance criteria must be evaluated for completeness and adequacy with respect to any new high burnup safety concerns, e.g., low enthalpy fuel dispersal.

(4) Each country should evaluate its own operating reactor situation for burnup levels permitted and the operating service conditions (e.g., load following, use of MOX fuel, etc.) employed in its reactors. Following this opening session were four technical sessions:

Technical Session 1 Operating Experience and Safety Concern
Technical Session 2 Fuel Performance and Operational Events
Technical Session 3 Control Rod Issues
Technical Sub-Session 4.a Improvement on Fuel Design
Technical Sub-Session 4.b Improvement on Fuel Fabrication and Core Management

Technical Session 1 was opened with my paper on "Operating Experience Identified Core Performance Problems". The conclusions attributed many of the operating performance failures of fuel and control rods to inadequate preservice testing of new design features or inadequate evaluation of the component's capability to withstand more severe service requirements. The conclusions turned out to be somewhat prophetic as there were numerous examples of preservice design and testing inadequacies as contributors to the root cause of operational problems discussed in subsequent technical papers.

Topics of particular interest to the NRC staff at this time and reference to the technical papers addressing these topics follow:

TOPIC	Reference/Comments
1) High Burnup Issues	a) Opening Session - Update of High Burnup Fuel Issues, F. Scmitz, IPSN
2) Cycle Length Issues	b) Session 1 - Nuclear Fuel in France - most recent safety concerns of DSIN / includes regulatory
3) MOX Fuel Issues	oversight practice, introduction of foreign fuel products, adoption of MOX fuel, etc.
4) Debris Fretting	c) Experience in Spain with Fuel and Control Rods / includes discussion of regulatory practice and
5) RCCA Rodlet Performance	policies on many core issues d) TVO's Experiences with Fuel and Control Rods / discussion of regulatory supervision program and some
6) RCCA Scram Performance	fuel and control rod inspection results e) Review of Safety Related Aspects in the Operational Experience of Fuel Assemblies and Shut-down Systems in
7) Incomplete RCCA Insertion	Germany / slow and incomplete control rod insertions, fuel failures, corrosion experience, etc.
8) High Burnup Fuel Designs	f) Performance of KOFA Fuel for PWRs in Korea / design and operating performance data g) Session 2 - Debris Mitigation Features and Their Impact on Fuel Performance / debris induced fuel rod
9) MOX Fuel Design	fretting in Westinghouse PWRs - effectiveness of DFBN h) Development and Experience of Debris Resistant Lower Tie Plates for BWR and PWR Fuel / Siemens PWR and BWR fuel experience since 1990 (including Atrium 10 FUELGUARD) i) Session 3 - EDF Experience about RCCA Behaviour / swelling and wear experience with poison pins j) Rod Cluster Control Assembly Management for PWRs / operating performance of Siemens-supplied (KWU) RCCAs k) PWR RCCA Rodlet Performance for Cladding Tube Cracking caused by Absorber Swelling / operating

experience of RCCAs in Japan
l) Incomplete Control Rod Insertion due to Fuel Element Bow / describes the Vattenfall and Framatome/Fragema evaluation of the Ringhals guide thimble tube bowing problem and corrective actions for resolution
m) Incomplete RCCA Insertion Observations in Westinghouse-Fueled Plants / describes US events and evaluation
n) Optimization Study of AP-600 Grey Control Rod Design / describes the AP-600 Mechanical Shim Reactivity Control System for enhanced load following capability
o) Control Rod Cluster Drop Time Anomaly / describes the investigation and resolution of degradation in control rod cluster drop times in Elecricite De France and Guandong Power Stations contrary to pre-service test results on the Hermes test loop
p) Belgian Operating Experience with RCCA Behaviour / describes inspection program and corrective actions to mitigate fretting wear and rodlet tip cracking phenomena that were reducing the RCCA 15 year design lifetime; describes evaluation and corrective actions relating to failure of 5 of 52 RCCAs to completely insert in the 14 foot fuel assemblies at Doel 4
q) Sub-session 4.a - ABB Fuel Design and Development / describes adverse experience and design development of improved ABB (Sweden) BWR and ABB C-E (USA) PWR fuel
r) An Advanced 9x9 Fuel Design with Offset Water Channel for D-Lattice BWR Plants \ describes the high burnup design features of the NFI fuel assembly supplied for Japanese BWRs
s) The Design Method for the ATR High Burn-up MOX Fuel \ describes the design method for high burnup MOX fuel prior to licensing for operation in the Japanese advanced thermal reactor (ATR)
t) Sub-session 4.b - Impact of Present Fuel Management strategies on maintaining safety margins - Mixed Core Aspects, ENUSA's experience in the PWR area \ describes the ENUSA compatibility assessments and design approach to preserving safety margins in mixed core designs

u) Belgian Licensing Requirements: mixed cores and control rods insertion problem aspects \ describes Belgian approach to compatibility verification for mixed cores and licensing aspects of the incomplete control rods insertion problem at Doel 4

Attachment:
As stated

cc: File Center
PDR
FMiraglia/AThadani
BSheron
FEltawila/RMeyer (RES)
HScott (RES)
MCullingford
GHolahan/MVirgilio
JRosenthal(AEOD)
ACRS
LPhillips
EWeiss
EKendrick
SWu
MChatterton

ATTACHMENT 1

Unidad Eléctrica (UNESA)

OECD/Nuclear Energy Agency (NEA) Consejo de Seguridad Nuclear (CSN)

Empresa Nacional del Uranio (ENUSA)

CSNI/PWG1

Specialists' Meeting on Nuclear Fuel and Control Rods:
Operating Experience, Design Evolution and Safety Aspects,
Madrid, Spain, 5 - 7 November 1996

Programme

Monday November 4th

- 19:30 Meeting registration

Tuesday November 5th

- 08:00 - 09:00 Meeting registration
- 09:00 - 09:40 **Opening session**

  - Welcome by **A. G. de Ubieta**, Director of Nuclear Energy, UNESA.
  - Meeting Objectives by **Prof. A. Alonso**, CSN Commissioner and CSNI Vice Chairman
  - Introductory remarks by **J.P. Clausner**, OECD/NEA, PWG1 Scientific Secretary
  - Opening remarks by **J.M. Conde**, CSN, Chairman of the Programme Committee

I.1 - 09:40 - 10:10 Invited Paper: **OECD Halden Project**, C. Vitanza

I.2 - 10:10 - 10:40 Invited Paper: **BWR Instability: Impact on Fuel Behaviour**, F. Castrillo, IBERDROLA

I.3. - 10:40 - 11:20 Invited Paper: **Update of High Burn-up Fuel Issues**, F. Schmitz, IPSN

- 11:20 - 11:45 Coffee Break

Tuesday November 5th (cont'd)

Technical Session 1 — **Operating experience and Safety Concern**
Session Chairman and Co-chairman: J.M. Conde (CSN) and J.P. C usner (OECD/NEA)

1.1	· 11:45 - 12:10	"Operating Experience Identified Core Performance Issues". L.E. Phillips (US NRC)
1.2	· 12:10 - 12:35	"Nuclear Fuel in France: An Ever Changing World - Most Recent Safety Concerns of DSIN". S. Roudier (DSIN) and R. Béraha (DRIRE)
1.3	· 12:35 - 13:00	"Experience in Spain with Fuel & Control Rods". J.R. León (CNA), A. Pérez-Navas (ANA), J.L. Buedo (IBERDROLA)
	· 13:00 - 14:30	Lunch Break
1.4	· 14:30 - 14:55	"TVO's Experiences with Fuel and Control Rods". R. Lunabba and E. Muttilainen (TVO)
1.5	· 14:55 - 15:20	"Review of Safety Related Aspects in the Operational Experience of Fuel Assemblies and Shut-down Systems in Germany". U. Jendrich, H. Marx, M. Maqua and F. Michel (GRS)
1.6	· 15:20 - 15:45	"Performance of KOFA Fuel for PWR's in Korea". C. B. Lee, K.H. Kim, J.G. Chung, D.S. Sohn and D.H. Ahn (KAERI)
	Session Chairman's conclusions	
	· 15:50 - 16:15	Coffee Break

Technical Session 2 — **Fuel Performance and Operational Events**
Session Chairman and Co-chairman: B. Gautier (EDF) and J. Serrano (ENUSA)

2.1	· 16:15 - 16:40	"Exceptional Crud Build-up in Loviisa-2 Fuel Bundles". R. Teräsvirta and L. Hansson-Lyyra (IVO)
2.2	· 14:40 - 17:05	"Debris Mitigation Features and their Impact on Fuel Performance". H.W. Wilson, L.R. Scherpereel and G.B. Sieradzki (Westinghouse)
2.3	· 17:05 - 17:30	"Development and Experience of Debris Resistant Lower Tie Plates for BWR and PWR Fuel". S.Linden (ANF) and M. Rudolph (Siemens)
2.4	· 17:30 - 17:55	"The Influence of non-Penetrating Cladding Cracks on Rod Behaviour under Transient Operating Conditions - Data from the International Trans-Ramp IV Project at Studsvik". S. Djurle (Studsvik), D. Howl (BNFL), J. Joseph (FRAMATOME) and M. Grounes (Studsvik)
	· 19:30	Reception at the City Hall

Wednesday November 6th

Technical Session 2 **(cont'd)**

2.5	· 09:00 - 09:25	"The Automatical Reactor Trip with Neutron Flux High Signal during the Earthquake". T. Matsunaga (TEPCO)
2.6	· 09:25 - 09:50	"The Fuel Failure in Hamaoka NPP Unit 1". T.Kobayashi (Chubu EPC) and H.Matsuoka (TOSHIBA)
2.7	· 09:50 - 10:15	"SICOM - An Equipment for Very Accurate Dimensional and Corrosion Inspection of Irradiated Fuel Assemblies". B.Guemes (ENUSA), J. Guerra, J.R.Fernández (TECNATOM), J.Serra (IBERDROLA) and J. Vallejo (DTN)

Session Chairman's remarks

· 10:20 - 10:45 Coffee Break

Technical Session 3 **Control Rod Issues**
Session Chairman and Co-chairman: J. In de Betou (SKI) and N. Tricot (IPSN)

3.1	· 10:45 - 11:10	"EDF Experience about RCCA Behaviour". X. Thibault (EDF/SEPTEN)
3.2	· 11:10 - 11:35	"Rod Cluster Control Assembly Management for Pressurized Water Reactors". K. Knecht and L. Heins (KWU)
3.3	· 11:35 - 12:00	"PWR RCCA Rodlet Performance for Cladding tube Cracking caused by Absorber Swelling". T. Nagata (KANSAI), K. Murakami (MHI), T. Matsuoka (Nuclear Development Corporation)
3.4	· 12:00 - 12:25	"Lessons Learned from Control Rods Irradiation Experience, Development of Advanced Absorbers and their Refractory Properties under Accident Conditions". V.Chernishov (Moscow Polimetal Plant) and V. Troyanov (Institute of Physics & Power Engineering).
3.5	· 12:25 - 12:50	"Incomplete Control Rod Insertion due to Extreme Fuel Element Bow". S. Jacobson (Vattenfall AB), and E. Francillon (FRAMATOME)

· 12:50 - 14:30 Lunch Break

3.6	· 14:30 - 14:55	"Incomplete RCCA Insertion-Preliminary Report", C. Larsson (WESTINGHOUSE)
3.7	· 14:55 - 15:20	"Control Rod Cluster Drop Time Anomaly - Guangdong NPP (Daya Bay) and EDF NPPs (1450 Mwe N4 Series)" J.J. Olivera, S. Naury, N. Tricot, P. Tran Daï and J.M. Gama (IPSN)
3.8	· 15:20 - 15:45	"Optimization Study of AP-600 Grey Control Rod Design". F. Merino and C. Mildrum (ENUSA)

Session Chairman's remarks

· 15:50 - 16:15 Coffee Break

Wednesday November 6th (cont'd)

Technical Sub-session 4.a **Improvement on Fuel Design**
Session Chairman and Co-chairman: D. Molina (IBERDROLA) and T. Itaki (NUPEC)

4.a.1·	16:15 - 16:40	"ABB Fuel Design and Development". G. Vesterlund and S. Helmersson (ABB)
4.a.2·	16:40 - 17:15	"An Advanced 9x9 Fuel Design with Offset Water-Channel for D-Lattice BWR Plants". K. Tsuda, K. Oguchi and Y. Inaba (NFI)
4.a.3·	17:15 - 17:30	"The Design Method for the ATR High Burn-up MOX Fuel". I. Kurita, S. Uematsu, Power Reactor & Nuclear Fuel Dev. Corp.
4.a.4·	17:30 - 17:55	"Segmented Fuel Irradiation Program. Investigation on Advanced Materials". H. Uchida and I. Komine (NUPEC), K. Yamate (KANSAI), S. Abeta (MHI), J.M. Alonso (ENUSA)

Sub-session Chairman's remarks

· 21:00 Official Dinner

Thursday November 7th

Technical Sub-session 4.b **Improvement on Fuel Fabrication and Core Management**
Session Chairman and Co-chairman: J. Rosenthal (USNRC) and J. Segarra (GE)

4.b.1·	09:00 - 09:25	"Total Quality Project Initiatives and Fabrication Improvements at ENUSA Factory". J.I. Martín Galán, (ENUSA)
4.b.2·	09:25 - 09:50	"Application of Ultrasonic Inspection Technique on Fuel Rod Seam Weld". Y. Nishina, M. Inatani, N. Kamata (JNF)
4.b.3·	09:50 - 10:15	"Impact of Present fuel Management Strategies on Maintaining Safety Margins. Mixed Cores Aspects-ENUSA's Experience in the PWR Area". J. Andres (ENUSA)
·	10:15 - 10:40	Coffee Break
3.9 ·	10:40 - 11:00	"Belgian Operating Experience with RCCA Behaviour". H. de Baenst (ELECTRABEL)
4.b.4·	11:00 - 11:20	"Belgian Licensing Requirements: Mixed Cores and Control Rod Insertion Problem Aspects". N.A.Hollasky (AVN)
4.b.5·	11:20 - 11:45	"BWR Fuel Designs for Extended Operating Domains" J.J. Peña and G. Watford (GENUSA)
4.b.6·	11:45 - 12:10	"Impact of Low Leakage Pattern Strategy on Vessel Neutron Fluence". P. Ortego (ENUSA)

Sub-session Chairman's remarks

· 12:15 - 13:30 Final Panel. Chaired by Dr. Caro, CSN Commissioner