Summary Information for the Experiment:

FAST CRITICAL EXPERIMENTS IN PLATE AND PIN GEOMETRY FORM. THE ZEBRA CADENZA CORES: ASSEMBLIES 22, 23, 24 AND 25.

1. Experiment Identification Number
   ZEBRA-LMFR-EXP-001
   CRIT-SPEC-REAC-RRATE
2. Date 1980 to 1982
3. Name of Experiment The ZEBRA CADENZA Programme
   - 3.1. Purpose of Experiment
     The experiment comprised a series of four simple geometry cores, built using plates and pins and both with and without sodium. Intermediate cores containing plate geometry elements in the central region and pin geometry elements in the outer core region were also built and the differences in reactivity between these and the reference cores were measured.
     The purpose was to compare the characteristics of cores built in pin geometry and plate geometry, and both containing sodium and voided of sodium. The differences between the k_{eff} values of the different cores are key aspects of the experiments.
   - 3.2. Phenomena measured and Scope:
     The reactivities of the four cores and several intermediate cores were measured, together with other neutronics characteristics, in particular reaction rate ratios and the reactivity worths of elements and materials.
4. Name or Designation of Experimental Programme
   The ZEBRA Cadenza Programme
5. Description of Test Facility
   The ZEBRA Zero Energy Critical Assembly Facility was sited at the Winfrith Atomic Energy Establishment of the United Kingdom Atomic Energy Authority and was designed to accommodate assemblies simulating fast reactors, or to test the methods and nuclear data used in fast reactor design and operational calculations. The assemblies were built from 5 cm square plates of various thicknesses stacked in square tubes made of stainless or mild steel. Alternatively arrays of pins could be assembled in the square tubes.
6. Description of Test or Experiment
   - 6.1. Experimental Configuration
     - 6.1.1. Types of Assemblies
       Assemblies 22 and 24 were built using components in plate form. Assembly 22 included sodium filled plates while in Assembly 24 so-called "dummy" plates, voided of sodium, replaced the sodium filled plates. Assemblies 23 and 25 were the corresponding pin geometry cores, with and without sodium, respectively.
     - 6.1.2. Assembly Details
       - 6.1.2.1. Type
         Fast Reactor
       - 6.1.2.2. Fuel
         Assemblies 22 and 24 uranium dioxide plus plutonium metal
         Assemblies 23 and 25 mixed uranium-plutonium dioxide
         The uranium in core and blanket regions is natural.
         The average plutonium enrichment, [Pu/(U+Pu)], is ~24%
         The fissile content of the plutonium, [(Pu239+Pu241)/Total Pu] is ~80%
       - 6.1.2.3. Moderators and diluents
         Sodium, steel
       - 6.1.2.4. Absorbers
         Nine element positions were occupied by control and safety rods. These had similar compositions to the core elements

but also had a boron absorber section above the narrow upper axial blanket region.

6.1.2.5. Critical Mass
313 kg fissile Pu in Assembly 22

6.1.2.6. Core Volume
565 litres in Assembly 22

6.1.2.7. Blanket
Natural Uranium

6.1.2.8. Reflectors
Steel

6.1.2.9. Reactivity adjustment
By the addition of elements at the core edge and adjustment of the insertion of the regulating control rod.

6.1.2.10. Other

6.1.3. Assembly Variants
Plate geometry, Pin geometry, with sodium, without sodium.

6.2. Core Lifecycle
BOL

6.3. Experimental Limitations or Shortcomings

7. Phenomena Measured

7.1. Description of Results and Analysis

7.1.1. Data Measured

7.1.1.1. Reactivity Control for Criticality
Fine, or regulating, control rod (calibrated by inverse kinetics measurements)

7.1.1.2. Reaction rates/ratios
Capture - ^{238}U
Fission - ^{235}U, ^{238}U, ^{239}Pu, ^{240}Pu and ^{241}Pu.

7.1.1.3. Reactivity Worth
The reactivity worths of different types of element, plate and pin geometry, were intercompared.
Sodium voiding measurements were made.
Special plates and pins were introduced into cells in the central region to provide material worths (PuO_2, Al, Al_2O_3, C, SS, Cu, Na)

7.1.1.4. Sample Doppler Reactivity
No measurement

7.1.1.5. Temperature Coefficients
Measured to provide temperature corrections for criticality

7.1.1.6. Control Rod or Rod Banks Worths
No measurements.

7.1.1.7. Soluble Boron Worth
No measurements

7.1.1.8. Gamma Heating Distributions
No measurements

7.1.1.9. Neutron Spectrum
Spectral indices only (see 7.1.1.2)

7.1.1.10. Kinetics parameters
Only for control rod calibration by inverse kinetics.

7.1.1.11. Reactor Power Distributions
No measurements.

7.1.1.12. Isotopic Measurements

No measurements.

7.2. Special Features and Characteristics of Experiment.

7.2.1. Moderator/Fuel Ratio

Fast reactor spectrum system

7.2.2. Spectral index

F28/F25 = 0.036

7.3. Measurement System and Uncertainties:

8. Duplicate or Complementary Experiments / Other Related Experiments

The criticality measurements in the four cores are interrelated.

9. Status of Completion of the Evaluation

Complete

10. References.

The UKAEA AEEWinfrith ZTN22 series of Zebra Technical Notes to Assembly 22, and other technical documents.

11. Authors/Organisers

11.1. Establishment

The measurements were carried out at the Winfrith Establishment of the UK Atomic Energy Authority (current contact Serco-Assurance, Winfrith, Dorchester, UK.).

11.2. Staff Involved in Experiment

B L H Burbidge, B Franklin, M Grimstone, G Ingram, S E Johnson, A D Knipe, J Marshall, Miss A M Osmond, Miss P A Smart, Miss M P Smith, P M J Stone, and J M Stevenson.

11.3. Contact information

John L Rowlands, e-mail: rowlandsjl((AT))aol.com
81 South Court Avenue, Dorchester, Dorset DT1 2DA, UK

11.4. Reviewers of Compiled Data

Internal Reviewer: Peter Smith, Serco-Assurance, Winfrith, Dorchester, Dorset, UK
Reviewers: Makoto Ishikawa, Masayuki Nakagawa, Udo Wehmann.

12. Material Available

12.1. Data and Format

The compositions of the assemblies and the results of the measurements are specified as benchmarks, with revised specifications being given in Revision 1 (February 2010).