ANL-ARC-222

Archival of the ZPPR-15B Physics Experiment: Report for Year 2

Nuclear Engineering Division

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Abstract

This I-NERI collaboration between Argonne National Laboratory (ANL) and Korea Atomic Energy Research Institute (KAERI) began mid-year (April, 2010). This report summarizes the progress for year two of the proposed three-year collaboration to generate a physics validation database of integral experiments for metallic fueled fast reactor systems. The objective of the proposed project is to archive and evaluate the integral experiment data, analyze the experiments, and prepare detailed computational models to be used for validating the modern suites of fast reactor design analysis tools which are under development at ANL and KAERI.

A series of mockup experiments for a 330 MWe Integral Fast Reactor (IFR) at ANL under the ZPPR-15 Program, also known as the IFR Benchmark Physics Test Program will be retrieved and analyzed in this project. The ZPPR-15 program was conducted in four phases. Each phase was marked by a particular composition of the reference assembly. In the first phase (15A), only plutonium, depleted uranium, stainless steel and sodium were included in this very clean physics assembly. This allowed examination of the effect of removing oxygen from the typical oxide-fueled sodium fast reactor. Zirconium was added in the second phase (15B). Additionally, 13 control rods and channels were added after the first phase. In the third phase (15C), roughly half of the core volume was fueled by enriched uranium to simulate a fast reactor transition composition. In the final phase (15D), the enriched uranium component was increased to 90%, simulating a near-beginning-of-life composition.[1] In addition to criticality, control rod worths, reaction rate distribution, reactivity coefficients, gamma heating, neutron spectrum and kinetics, there were a number of measurements aimed at addressing special issues of safety, economics and metal fuel composition. The BFS-73-1 and BFS-75-1 experiments of KAERI carried out as the mockup experiment of KALIMER-150 at the Russian BFS-1 facility will also be compiled in this project. ANL will also participate in KAERI's transuranics (TRU) burner physics experiments which are now in progress at the BFS-2 facility to validate the physics performance of its metal-fueled TRU burner reactor design and design analysis tools. This burner reactor physics experiment data will be a valuable addition to the existing experiment database for breeder reactors.

The principal outcomes of this project include 1) compiled sets of measured physics parameters and uncertainties of ZPPR-15 experiments and consistent sets of as-built Monte Carlo models and 2) compiled sets of measured physics parameters and uncertainties and consistent sets of as-built Monte Carlo models for BFS-73-1, BFS-75-1 and a mock-up of a 300 MWe-rated TRU burner reactor (BFS-76-1). Since both the U.S. and the Republic of Korea (ROK) are interested in a TRU burning option using metal-fueled fast reactors, it is mutually beneficial to generate the physics validation database of metal-fueled fast reactors using the ZPPR-15 experiments and the new TRU burner physics experiments at the BFS-2.

On the current year task of generating the ZPPR-15B experimental database, the complete loading records for all of the ZPPR-15B configurations have been captured, verified and entered into a database for the generation of the as-built models. All ZPPR-15B drawer master identifications and logbooks have also been reviewed. Detailed as-built Monte Carlo models

[1] The small plutonium fraction was retained in the loading to provide a distributed neutron source for subcritical measurements.

have been completed and analyzed for all of the twelve planned ZPPR-15B configurations, including the reference critical configuration, the sodium void worth measurements, and the worth measurements of the control rod and control rod positions. These experiments have been analyzed with continuous-energy Monte Carlo using both ENDF/B-V.2 and ENDF/B-VII.0. Criticality results with ENDF/B-VII.0 data are good, although exhibiting a slight underprediction (~200 pcm) of k_{eff} values. This is a slightly larger underprediction (~100 pcm) than obtained with ENDF/B-VII.0 for ZPPR-15A. Sodium void worth results with ENDF/B-VII.0 data are generally within ~5-10%. The positive worths of voiding the central zones are slightly underpredicted. Results with ENDF/B-VII.0 data are good (within ~5%) for the control rod and control rod position measurements. Furthermore, the performance of the ENDF/B-VII.0 data for ZPPR-15B was consistent with the performance for ZPPR-15A, indicating good performance by the zirconium evaluation for these experiments.

On the task of compiling TRU burner physics experiments at BFS, the as-built model of BFS-73-1 provided by KAERI has been reviewed and analyzed. Criticality results for BFS-73-1 are underpredicted by ~340 pcm with both ENDF/B-VII.0 and -VII.1 data. ANL has provided comments on a draft report of the BFS-76-1 measurements and discussions of the current BFS-76-1 experiments are on-going.

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1 Introduction

There are great expectations that current activities in advanced simulation will realize improved reactor designs with enhanced economics. Ever increasing computer technology combined with the continued improvements in nuclear data and neutronics methods gives the promise of improved predictions, smaller uncertainties and reduced conservatism in reactor designs. However realization of these gains will require rigorous validation of these advanced methods and data – a process which will require precise experimental measurements and accurate models of these experiments.

As part of the Nuclear Energy Advanced Modeling and Simulation (NEAMS) program, ANL is developing a suite of high-fidelity, multi-physics simulation tools for the analysis and design of sodium cooled fast reactors. At the same time, KAERI is developing a modern suite of fast reactor design analysis tools by improving the legacy codes, aiming at obtaining a license for safety analysis application from the Korea Institute of Nuclear Safety (KINS) by 2017. Both code systems of ANL and KAERI must be well validated against experiments.

ANL has a long record of integral experiments for fast reactor physics validation, including the ZPPR-15 experiments which are unique critical experiments for full metal-fueled cores. However, these experiments were documented and analyzed with the legacy codes available at that time (more than 20 years ago). Models representing these experiments were necessarily limited by neutronics capabilities available at the time, such as one- or two-dimensional representations; and in most cases, much of the precision of the experimental measurements could not be retained in these models.

On the other hand, KAERI has only limited integral experimental data obtained through experiments at the Russian BFS facility, and thus KAERI has developed a plan to perform TRU burner reactor physics experiments at the BFS facility in FY 2011 to validate the physics performance of its metal-fueled TRU burner reactor design and design analysis tools.

Burner reactor physics experiment data are scarce worldwide and thus will be a valuable addition to the existing experiment database for fast reactors. Since both the U.S. and the Republic of Korea (ROK) are interested in a TRU burning option using metal-fueled fast reactors, it is mutually beneficial to generate the physics validation database of metal-fueled fast reactors using the ZPPR-15 experiments and the planned TRU burner physics experiments at the BFS-2. The principal outcomes of this collaborative project will include: (i) compiled sets of measured physics parameters and uncertainties of the ZPPR-15 experiments and consistent sets of detailed as-built Monte Carlo models and (ii) compiled sets of measured physics parameters and uncertainties and consistent sets of as-built Monte Carlo models for BFS-73-1, BFS-75-1 and a mock-up of a 300 MWe-rated TRU burner reactor.

The remainder of Section 1 provides a brief overview of the I-NERI Project Number 2009-001-K, "ZPPR-15 and BFS Critical Experiments Analysis for Generation of Physics Validation Database of Metallic-Fueled Fast Reactor Systems" and a summary of the Work Package Tasks for Year 2. U.S. funding for the Year 1 was $258K. Funding and work started in April, 2010. Funding and work for Year 2 began in Q3 of FY11 with completion by the end of Q2 of FY12. A review of the progress and status of the ANL tasks for Year 2 is given in Section 2.

1.1 Work Plan for Years 1, 2 and 3

The R&D work plan for this collaboration specifies three closely related tasks as shown in Figure 1. The tasks are designed such that each contributes an essential component to the overall goal of generating the compiled sets of measured physics parameters and uncertainties and the consistent sets of as-built Monte Carlo models for ZPPR-15 and BFS-2 TRU burner experiments. Subtasks in each of these three tasks are identified in Table I.

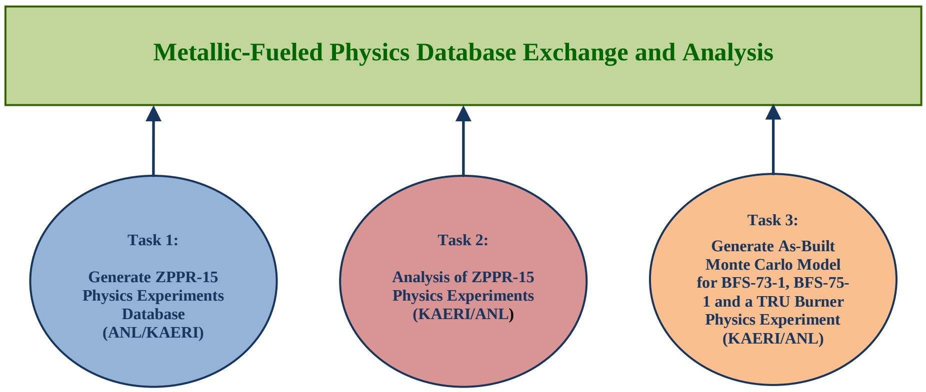

Figure 1. R & D Work Plan for I-NERI.

Table I. List of Task Activities.

Task Number	Task Activity Description	Lead Organization	Milestone Date
0.0	Project Management	ANL/KAERI	
0.1	Annual Progress Reports	ANL/KAERI	Annual
1.0	**Task 1. Archival of the ZPPR-15 Physics Experiment Database**	ANL	
1.1	• Archival of the ZPPR-15 Phase A		12 months
1.2	• Archival of the ZPPR-15 Phase B		24 months
1.3	• Archival of the ZPPR-15 Phase C and D		36 months
2.0	**Task 2: Generate As-built Monte Carlo Model for BFS-73-1, BFS-75-1 and a TRU Burner Physics Experiment**	KAERI	
2.1	• Generate As-built Monte Carlo Model for BFS-73-1		12 months
2.2	• Generate As-built Monte Carlo Model for BFS-75-1		24 months
2.3	• Generate As-built Monte Carlo Model for a TRU burner physics experiment		36 months
3.0	**Task 3. Analysis of ZPPR-15 Physics Experiment**	KAERI	
3.1	• Analysis of ZPPR-15 Phases A		18 months
3.2	• Analysis of ZPPR-15 Phases B, C, D		36 months

1.1.1 Task 1: Archival of the ZPPR-15 Physics Experiment Database

This task will archive the ZPPR-15 loading records for Phases A, B, C and D, and will generate high-fidelity as-built Monte Carlo models to be used in the validation of advanced design analysis tools.

This task consists of the following sub-tasks:

- Data collection and review of critical experiments,
- Generate As-built Monte Carlo model for ZPPR-15 Phases A through D and compile measured data, and
- Document measurement uncertainties for the reactor physics parameters.

1.1.2 Task 2: Generate As-built Monte Carlo Models for BFS-73-1, BFS-75-1 and a TRU Burner Physics Experiment

The BFS-73-1 is a simple one-zone mock-up of KALIMER-150 design of KAERI representing a core loaded with U-Zr metal alloy fuel. The BFS-75-1 experiment is a two-zone mock-up of KALIMER-150 design. BFS-75-1 assembly consists of two fuel regions, LEZ (15% enriched) and HEZ (20% enriched) surrounded by two composite radial blankets. A planned TRU physics experiment to be included in this task is a mock-up of 300 MWe sodium cooled TRU burner reactor. No blanket is used and the active core is directly surrounded by stainless steel reflectors.

This task consists of the following sub-tasks:

- Generate As-built Monte Carlo model for BFS-73-1 and provide measured data,
- Generate As-built Monte Carlo model for BFS-75-1 and provide measured data,
- Generate As-built Monte Carlo model for a TRU burner physics experiment and provide measured data, and
- Document measurement uncertainties for the reactor physics parameters.

1.1.3 Task 3: Analysis of the ZPPR-15 Physics Experiments

KAERI will analyze the ZPPR-15 physics experiment data that will be provided by ANL. In task 1, ANL provides Monte Carlo models and a measurement uncertainty for each measured parameter. KAERI will use each Monte Carlo model as a starting point and generate a corresponding deterministic calculation model. By performing the deterministic analysis, the adequacy of the effective cross section generation schemes and core neutronics calculation methods will be examined. The biases/uncertainties related to analysis methods and cross section data will also be evaluated.

This task consists of the following sub-tasks:

- Analysis of ZPPR-15 Phases A through D experiments with a conventional design method and a Monte Carlo code,
- Cross section sensitivity analysis,
- Evaluate the prediction uncertainties due to basic cross section data uncertainties, and
- Evaluate the modeling errors subject to neutronics analysis methodologies.

1.2 ANL Work Package for Year 2

ANL will perform Task 1 for the ZPPR-15B assembly in Year 2 of the collaboration. Relevant experimental data, specifically, loading records, drawer master identifications, experimental results and reports for ZPPR-15B will be collected and reviewed. For select experimental configurations (i.e., specific matrix loadings), detailed as-built Monte Carlo models will be generated. These configurations, summarized in Table II, include the critical reference, a subcritical reference plus three sodium-voided configurations (shaded in yellow), and a subcritical reference plus six control rod configurations (shaded in blue). The location of the central void region and the control rod locations and number scheme are indicated in Figure 2.

ANL effort for Task 2 in Year 2 will include planning discussions with KAERI and receipt and analysis of the KAERI-generated as-built Monte Carlo model of BFS-73-1.

Table II. Proposed As-Built Monte Carlo Models of ZPPR-15B Configurations

Case	ZPPR-15B Loading	Description	Date
1	88	Critical reference	November 27, 1985
2	91	Subcritical Reference for Sodium Void Worth	December 5, 1985
3	92	8 in. (203.2 mm) Sodium Void in 52 Drawers/Half	December 5, 1985
4	93	14 in. (355.6 mm) Sodium Void in 52 Drawers/Half	December 6, 1985
5	94	18 in. (457.2 mm) Sodium Void in 52 Drawers/Half	December 9, 1985
6	96	Subcritical reference for CR[a] worth	December 10, 1985
7	100	CR's 8-12	December 12, 1985
8	102	CR's 1-13	December 12, 1985
9	103	CR's 1,8-13 Half-inserted	December 13, 1985
10	104	CR's 1,8-13 with CRP's[a] elsewhere	December 13, 1985
11	105	Primary CR's plus 5 Secondary CR's and 1 CRP	December 13, 1985
12	106	CRP's 1-13	December 13, 1985

[a] CR = Control Rod;
CRP = Control Rod Position;
Primary CR's were 1,8-13;
Secondary CR's were 2-7.

2 PROGRESS AND STATUS OF ANL TASKS FOR YEAR 2

All of the loading records for ZPPR-15B (Loadings 68 - 150) have been captured, verified and entered into a database for the generation of the as-built models. All drawer master identifications and logbooks have also been reviewed. Data for each of the individual ZPPR-15B loadings have been analyzed (i.e., superimposed upon the previous loadings) to determine the Half 1 (stationary) and Half 2 (movable) matrix configurations for all twelve of the ZPPR-15B indicated in Table II.

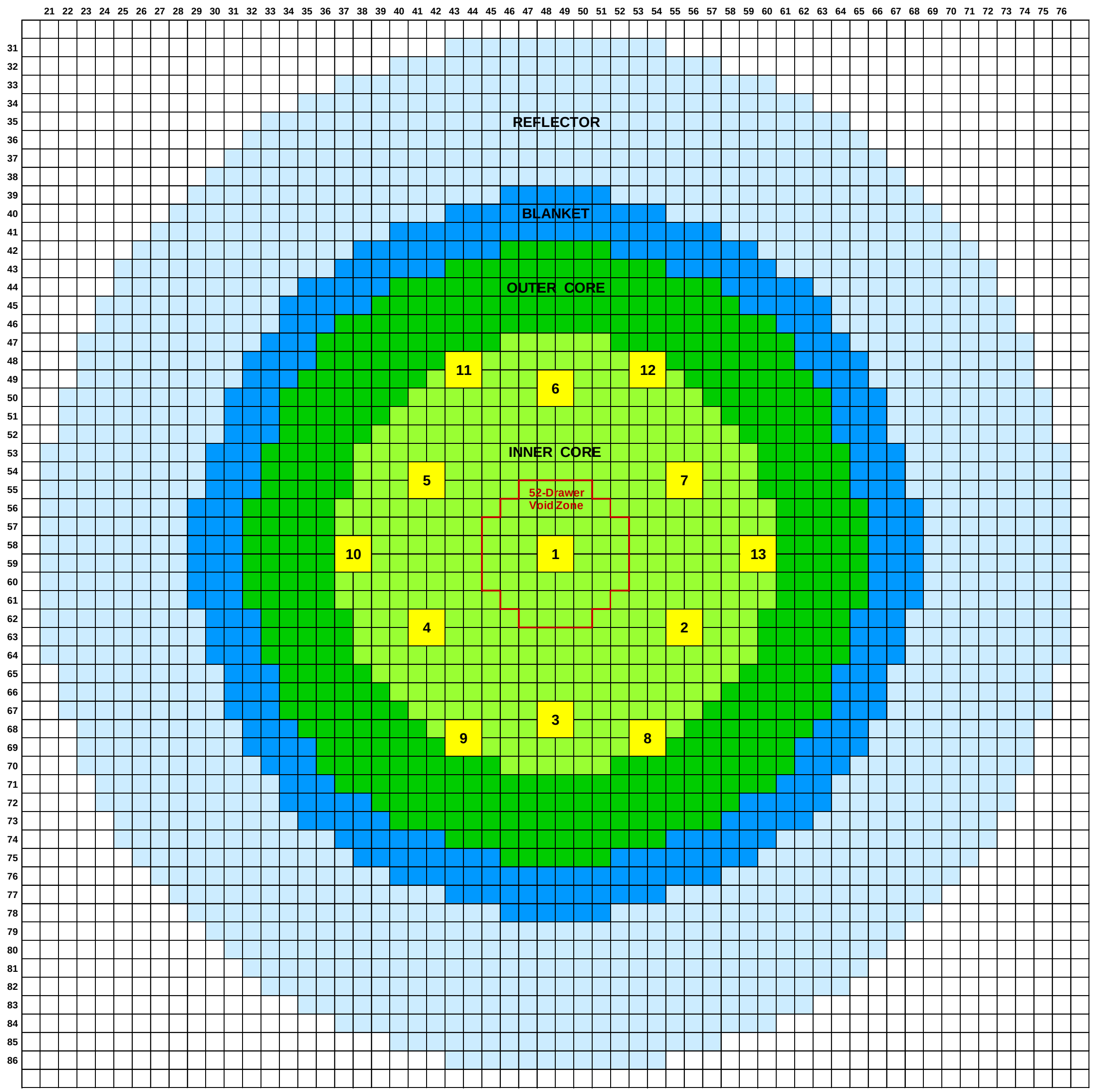

Figure 2. Location of the Central Void Region and the Control Rod Locations and Numbering Scheme in ZPPR-15B.

2.1 Status of ZPPR-15B Database

An as-built model of a ZPR or ZPPR assembly is the most faithful model that can be constructed and provides a level of modeling detail that was never possible when the experiments were performed or originally analyzed. The as-built model includes every plate at the correct position in every drawer, every drawer at the correct position in the matrix, all of the matrix tubes and all of the small gaps between the plates, drawers and matrix tubes. There are no significant geometry approximations, and all heterogeneity effects are explicitly accounted for. Each individual region has the correct composition. There is no homogenization of discrete regions in the as-built models. The end products are input files for the VIM and MCNP5 continuous energy Monte Carlo codes.

Detailed as-built models have been generated for all twelve of the ZPPR-15B configurations identified in Table II. That is, the reference critical configuration of ZPPR-15B (Loading 88), four sodium void worth configurations, including one subcritical reference configurations (Loading 91) and three stages of sodium voiding by region (Loadings 92,93 and 94), and seven control rod configurations, including one subcritical reference configuration (Loading 96) and five distinct control rod configurations (Loadings 100, 102, 103, 104, 105 and 106). Detailed VIM and MCNP5 models have been generated for all twelve of these ZPPR-15B configurations. These detailed models are not included in this Year 2 report because of their size; however, the models have been provided separately to KAERI. Table III provides some simple statistics regarding the Monte Carlo input decks for these models to provide the reader some sense of their detail. Each configuration contains 61 nuclides in 144-159 unique compositions in ~15,000 unique zones or regions. Each of the VIM inputs requires ~9000-10,000 lines; each of the MCNP5 inputs requires ~18,000-20,000 lines.

Table III. Statistics of ZPPR-15B As-Built Models

Loading Number	Nuclides	Compositions	VIM Model			MCNP5 Model		
			Zones[a]	Cells[b]	Lines	Cells[a]	Universes[b]	Lines
88	61	144	14759	69	9430	14762	70	18512
91	61	144	14759	69	9430	14762	70	18512
92	61	148	15433	71	9735	15436	72	19246
93	61	152	15491	71	9905	15494	72	19364
94	61	156	15421	71	9831	15424	72	19354
96	61	144	14759	69	9430	14762	70	18512
100	61	159	15329	71	10172	15332	72	19279
102	61	159	15329	71	10172	15332	72	19247
103	61	159	15484	72	10333	15487	73	19400
104	61	159	15769	73	10586	15772	74	19687
105	61	159	15769	73	10586	15772	74	19687
106	61	144	15199	71	9918	15202	72	18910

[a] A VIM zone corresponds to an MCNP5 cell.
[b] A VIM cell corresponds to an MCNP5 universe for these models.

Core layouts for Half 1 and Half 2 for these twelve ZPPR-15B configurations for which the as-built Monte Carlo models have been generated to date are shown in Figures 3-26.

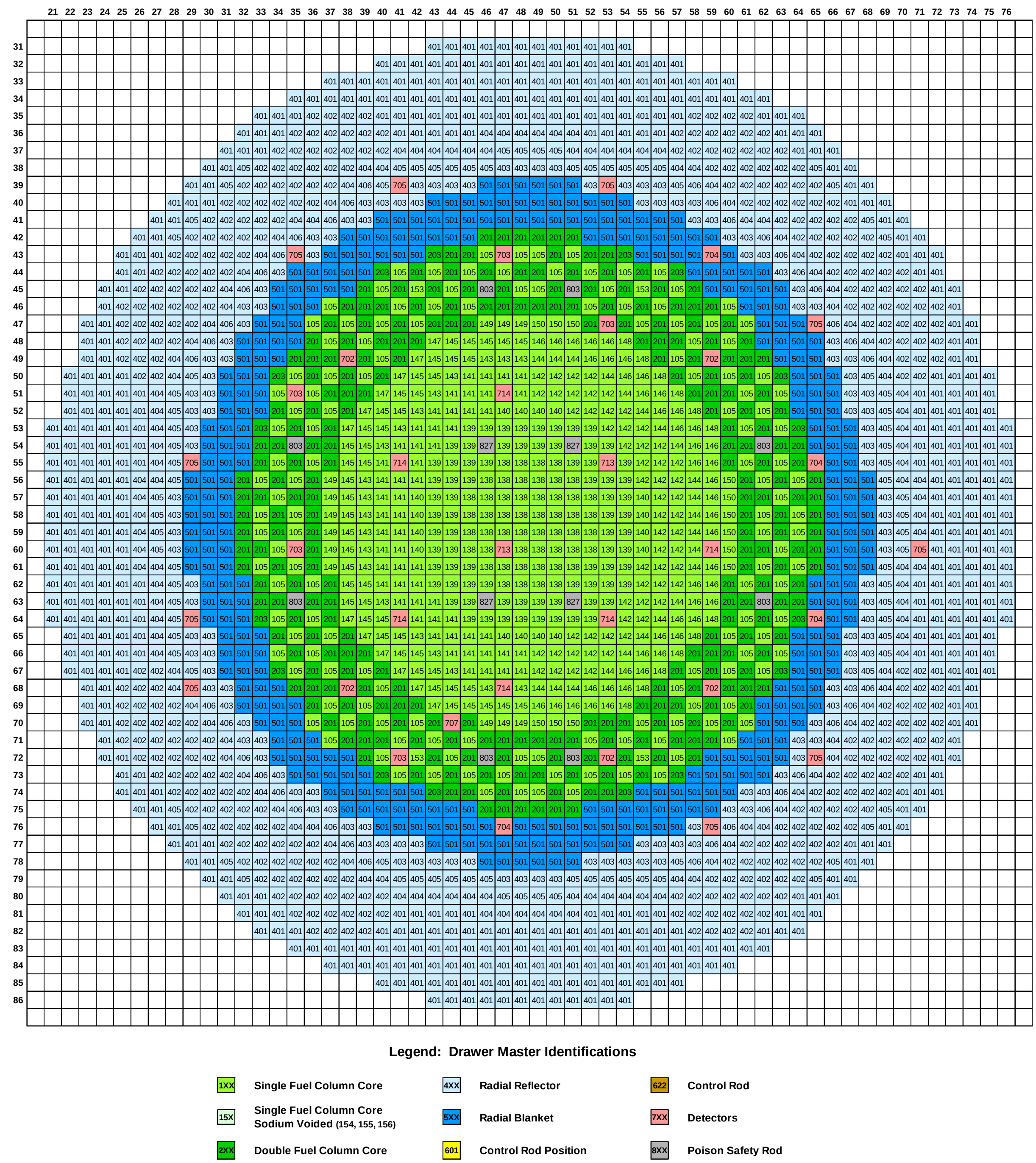

Figure 3. ZPPR-15B – Loading 88 – Half 1 – Critical reference – 27 November 1985.

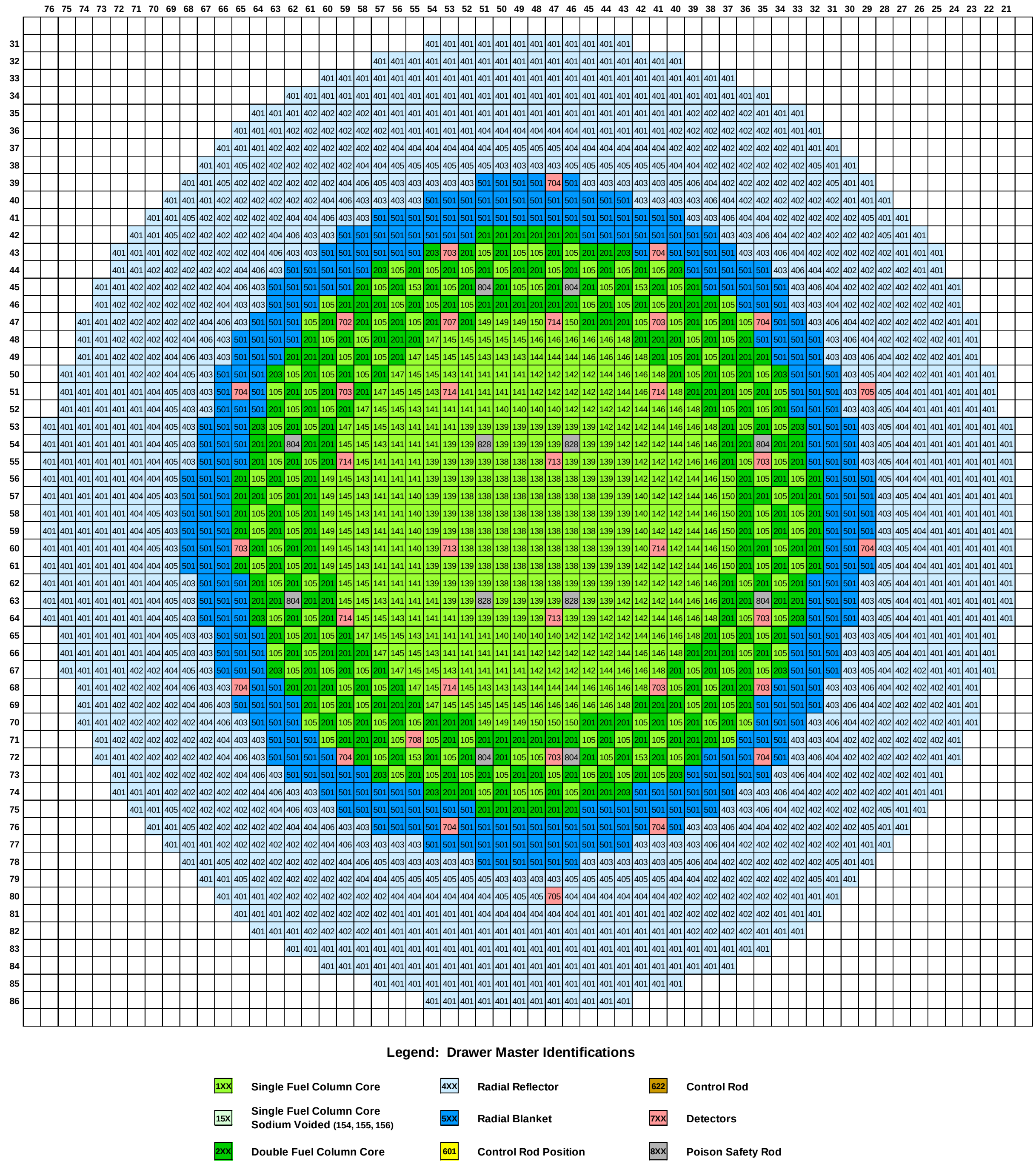

Figure 4. ZPPR-15B – Loading 88 – Half 2 – Critical reference – 27 November 1985.

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86																							401	401	401	401	401	401	401	401	401	401	401	401																						

Legend: Drawer Master Identifications

1XX	Single Fuel Column Core	4XX	Radial Reflector	622	Control Rod
15X	Single Fuel Column Core Sodium Voided (154, 155, 156)	5XX	Radial Blanket	7XX	Detectors
2XX	Double Fuel Column Core	601	Control Rod Position	8XX	Poison Safety Rod

Figure 5. ZPPR-15B – Loading 91 – Half 1 – Subcritical Reference for Sodium Void Worth – 5 December 1985.

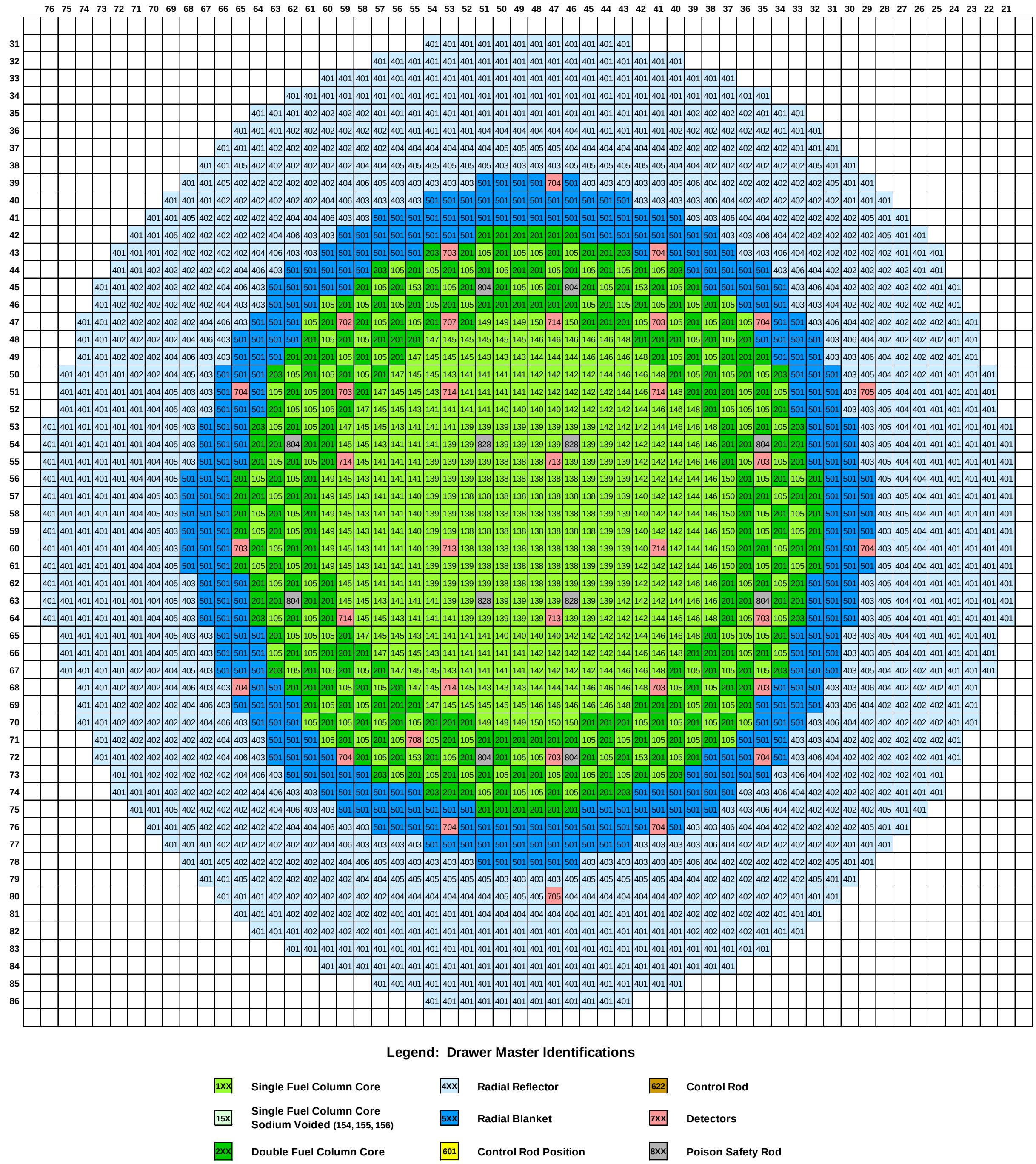

Figure 6. ZPPR-15B – Loading 91 – Half 2 – Subcritical Reference for Sodium Void Worth – 5 December 1985.

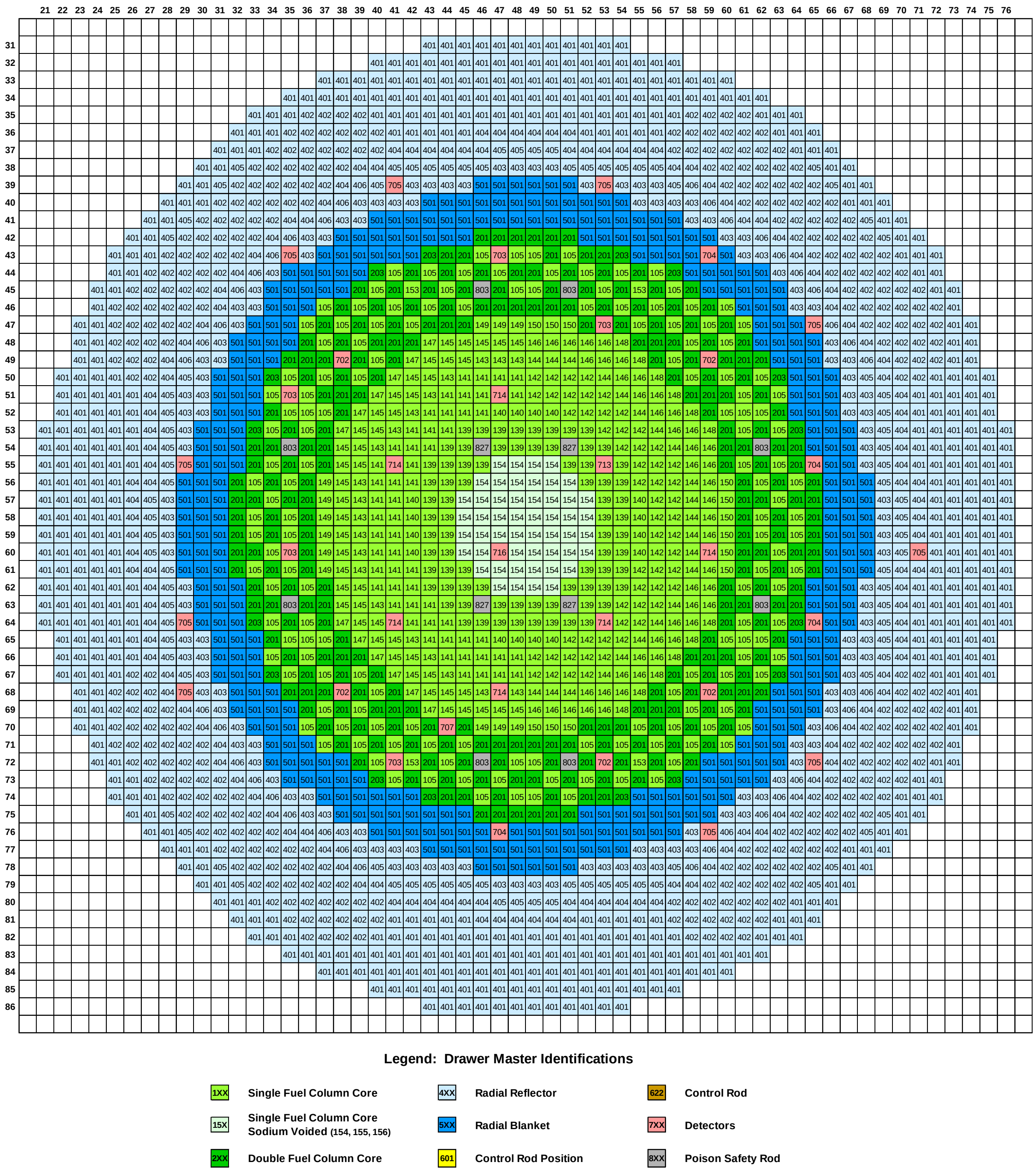

Figure 7. ZPPR-15B – Loading 92 – Half 1 – 8 in. (203.2 mm) Sodium Void in 52 Drawers/Half – 5 December 1985.

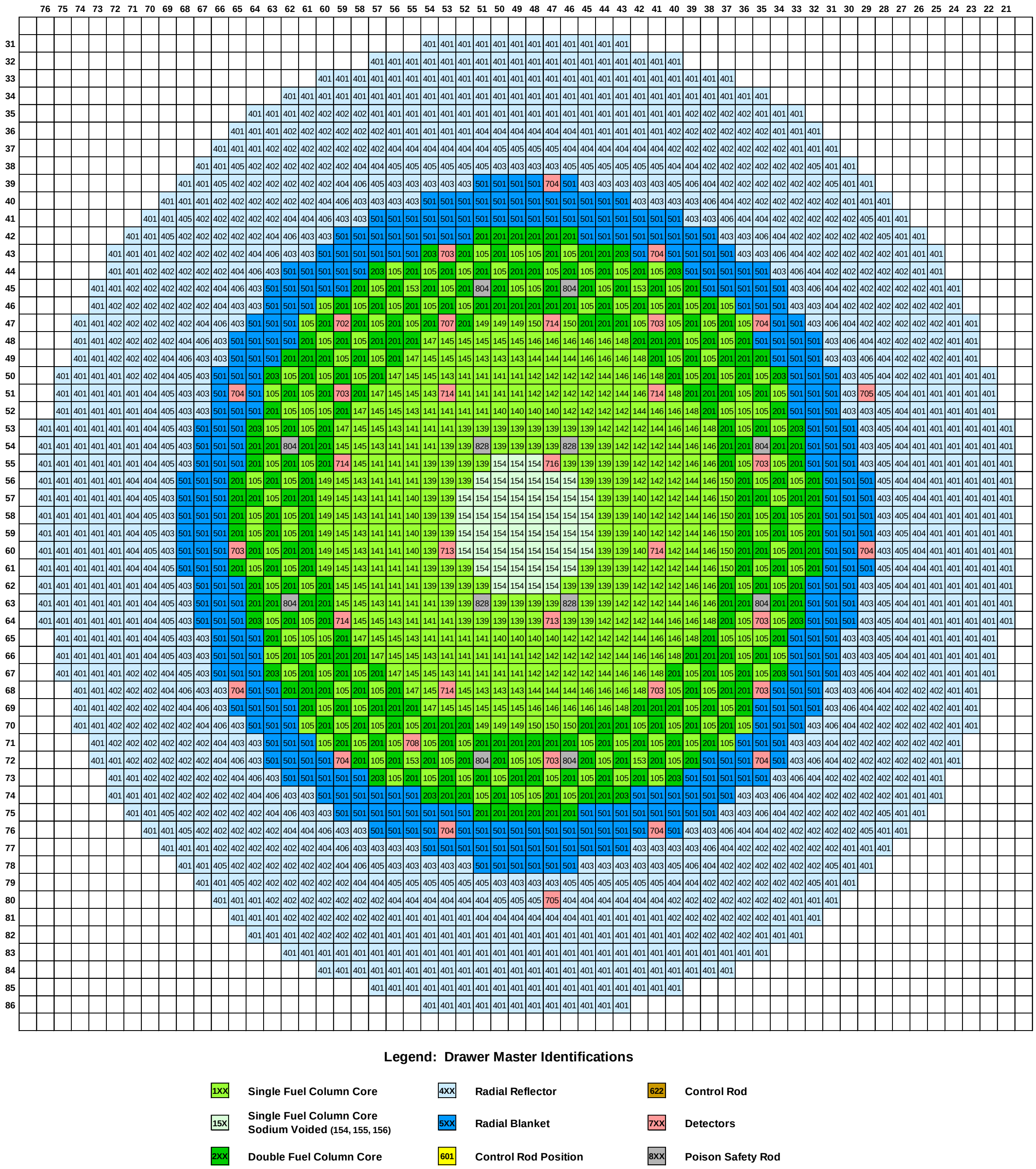

Figure 8. ZPPR-15B – Loading 92 – Half 2 – 8 in. (203.2 mm) Sodium Void in 52 Drawers/Half – 5 December 1985.

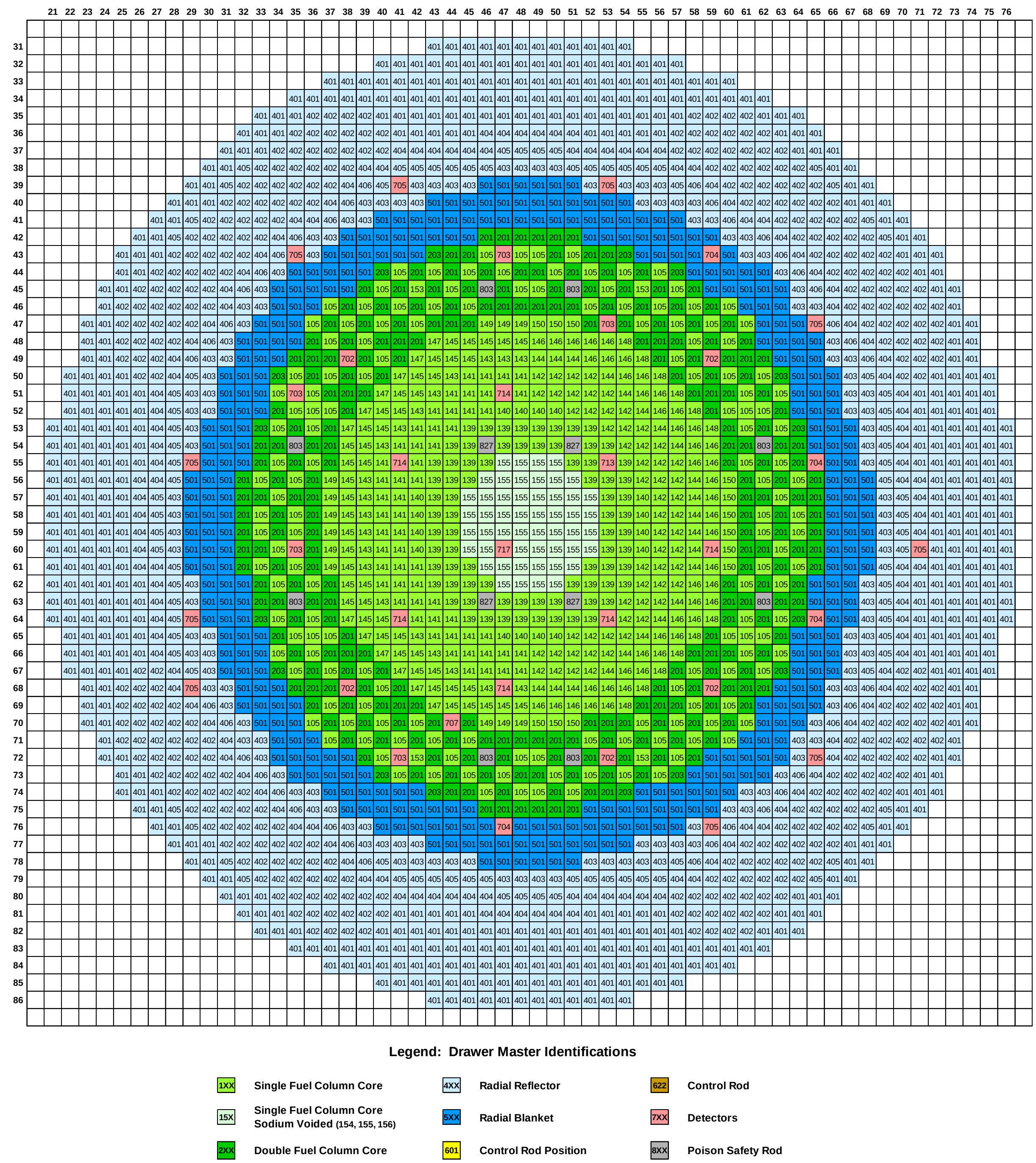

Figure 9. ZPPR-15B – Loading 93 – Half 1 – 14 in. (355.6 mm) Sodium Void in 52 Drawers/Half – 6 December 1985.

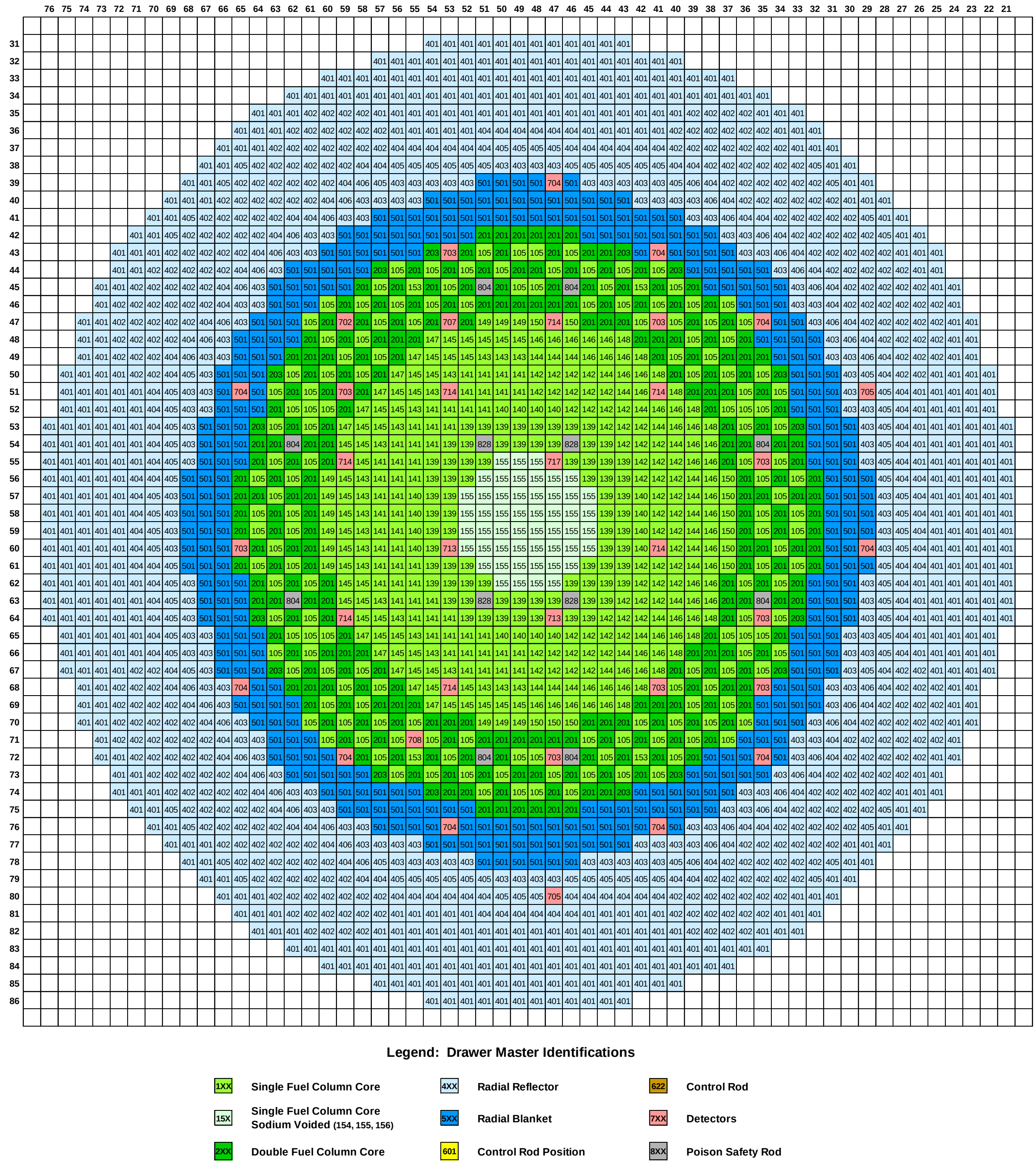

Figure 10. ZPPR-15B – Loading 93 – Half 2 – 14 in. (355.6 mm) Sodium Void in 52 Drawers/Half – 6 December 1985.

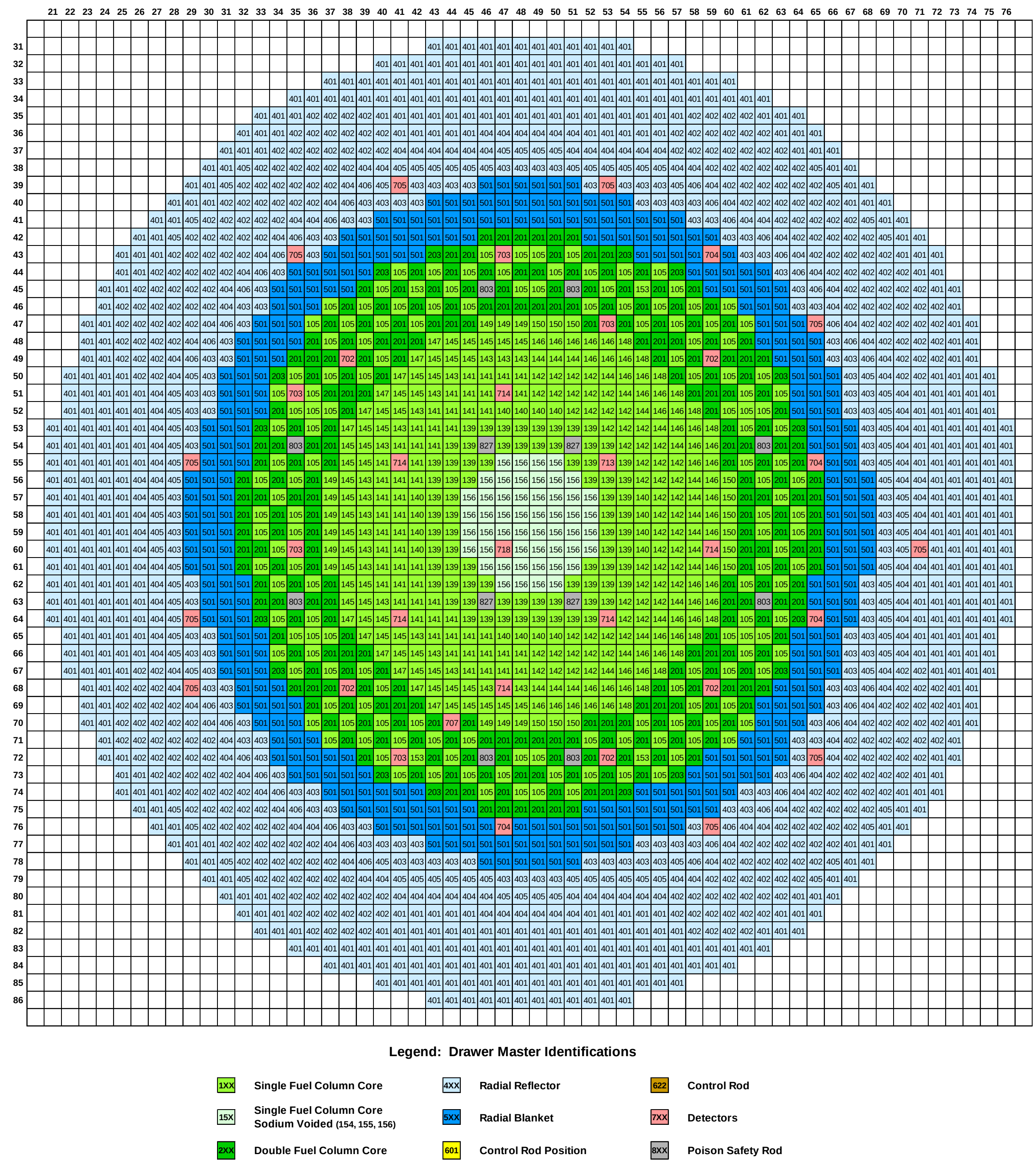

Figure 11. ZPPR-15B – Loading 94 – Half 1 – 18 in. (457.2 mm) Sodium Void in 52 Drawers/Half – 9 December 1985.

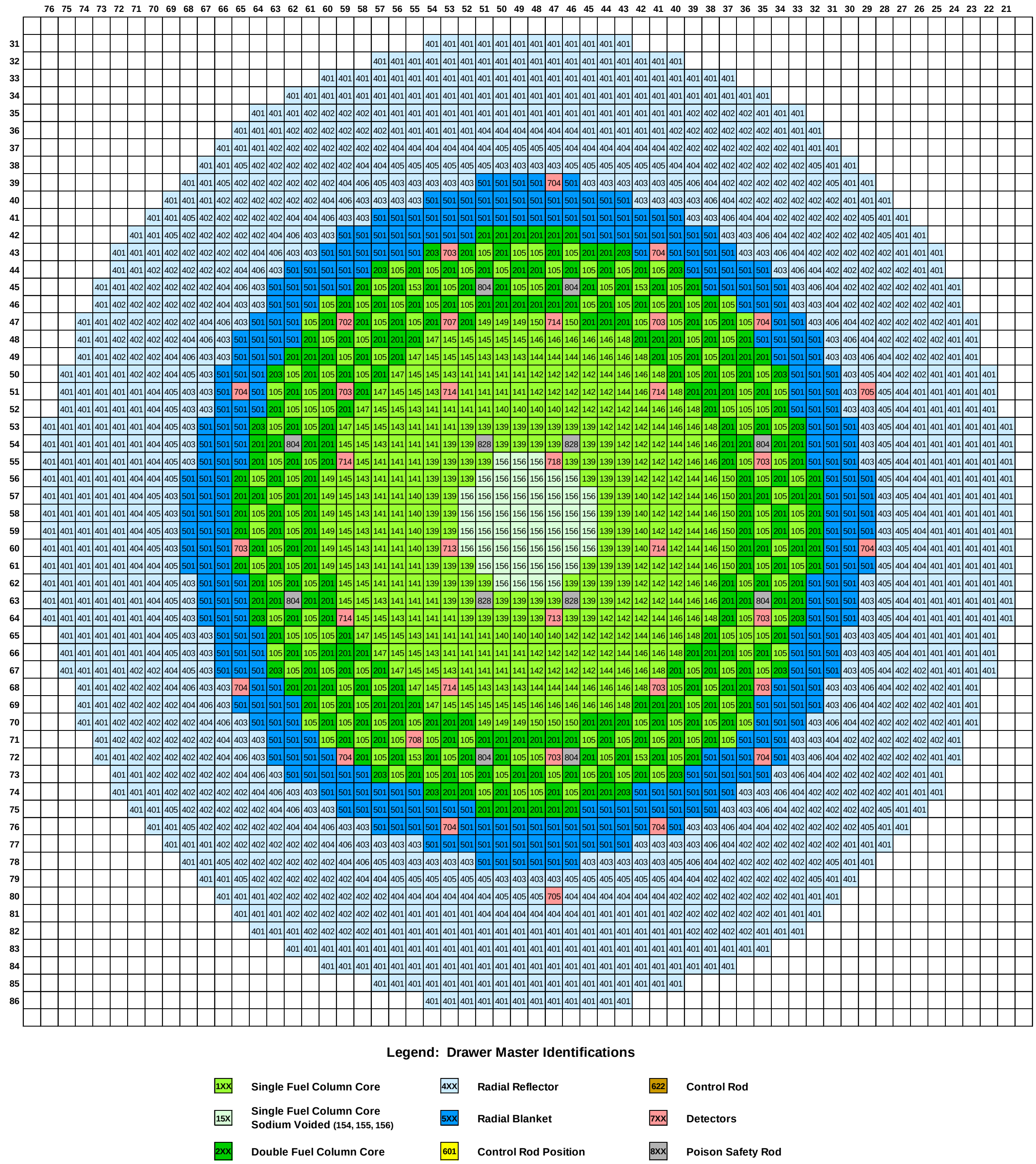

Figure 12. ZPPR-15B – Loading 94 – Half 2 – 18 in. (457.2 mm) Sodium Void in 52 Drawers/Half – 9 December 1985.

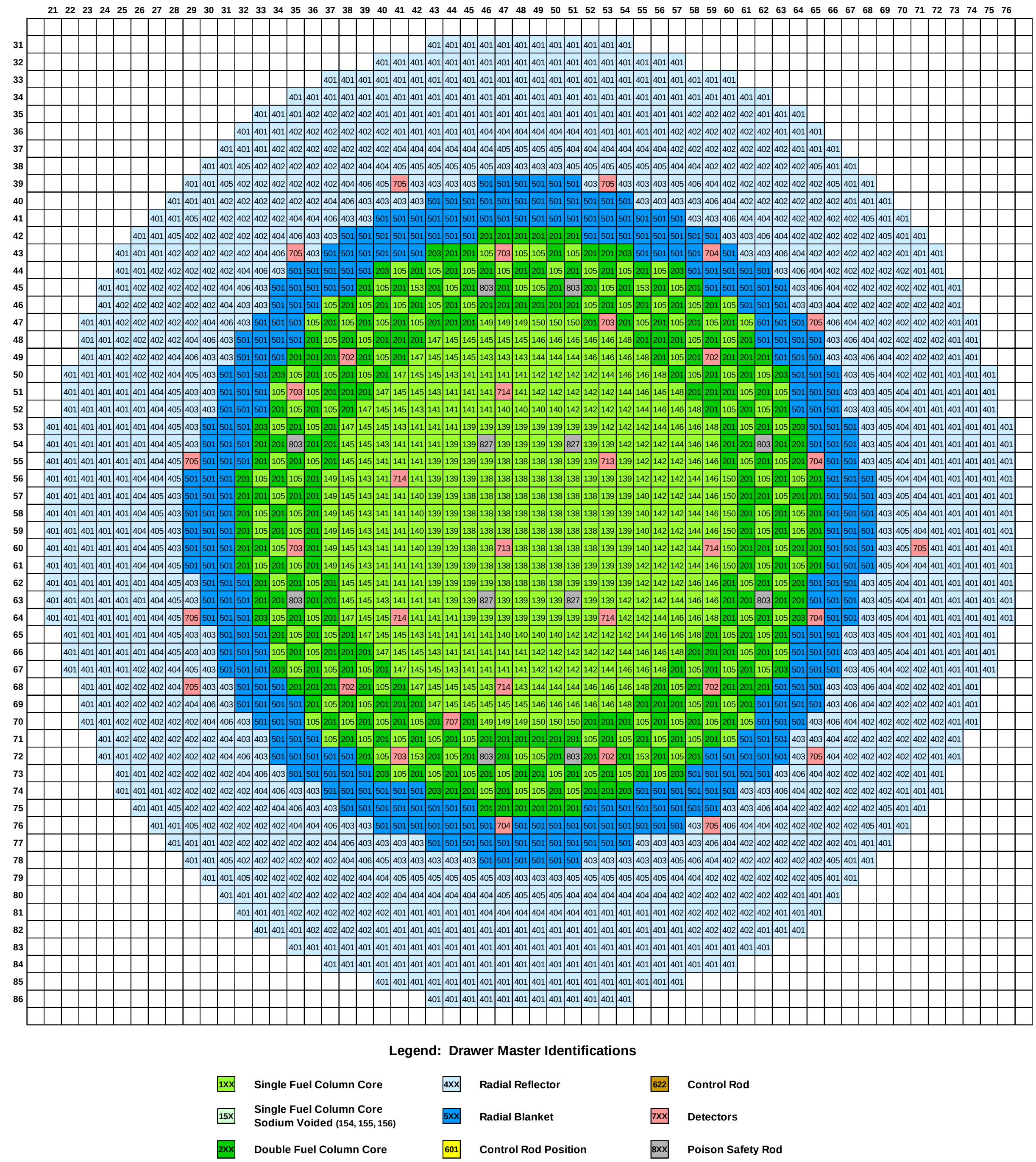

Figure 13. ZPPR-15B – Loading 96 – Half 1 – Subcritical Reference for Control Rod Worth – 10 December 1985.

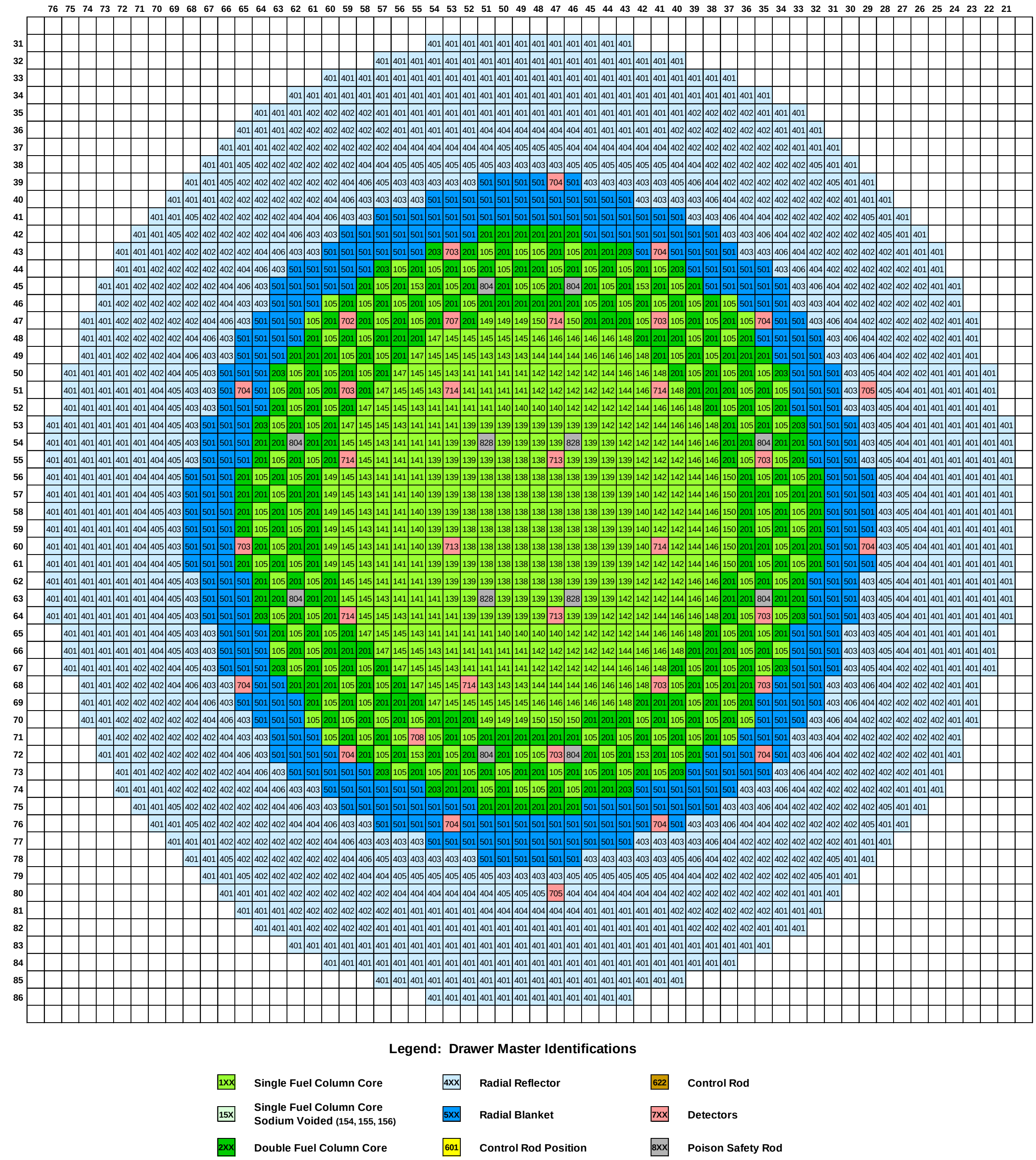

Figure 14. ZPPR-15B – Loading 96 – Half 2 – Subcritical Reference for Control Rod Worth – 10 December 1985.

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31																							401	401	401	401	401	401	401	401	401	401	401	401																						
32																				401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401																			
33																	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401																
34															401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401														
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70			401	401	402	402	402	402	402	404	406	403	501	501	501	105	201	105	201	105	201	105	201	707	201	149	149	149	150	150	150	201	201	201	105	201	105	201	105	201	105	501	501	501	403	406	404	402	402	402	402	402	401	401		
71				401	402	402	402	402	402	402	404	403	403	501	501	501	105	201	105	201	105	201	105	201	105	201	201	201	201	201	201	105	201	105	201	105	201	105	201	105	501	501	501	403	403	404	402	402	402	402	402	402	401			
72				401	401	402	402	402	402	402	404	406	403	501	501	501	501	501	201	105	703	153	201	105	201	803	201	105	105	201	803	201	702	201	153	201	105	201	501	501	501	501	501	403	705	404	402	402	402	402	402	401	401			
73					401	401	402	402	402	402	402	404	406	403	501	501	501	501	501	203	105	201	105	201	105	201	105	201	201	105	201	105	201	105	201	105	203	501	501	501	501	501	403	406	404	402	402	402	402	402	401	401				
74					401	401	401	402	402	402	402	402	404	406	403	403	501	501	501	501	501	501	203	201	201	105	201	105	105	201	105	201	201	203	501	501	501	501	501	501	403	403	406	404	402	402	402	402	402	401	401	401				
75						401	401	405	402	402	402	402	402	404	406	403	403	501	501	501	501	501	501	501	501	201	201	201	201	201	201	501	501	501	501	501	501	501	501	403	403	406	404	402	402	402	402	402	405	401	401					
76							401	401	405	402	402	402	402	402	404	404	406	403	403	501	501	501	501	501	501	501	704	501	501	501	501	501	501	501	501	501	501	403	705	406	404	404	402	402	402	402	402	405	401	401						
77								401	401	401	402	402	402	402	402	402	404	406	403	403	403	403	501	501	501	501	501	501	501	501	501	501	501	501	403	403	403	403	406	404	402	402	402	402	402	402	401	401	401							
78									401	401	405	402	402	402	402	402	402	404	406	405	403	403	403	403	403	501	501	501	501	501	501	403	403	403	403	403	405	406	404	402	402	402	402	402	402	405	401	401								
79										401	401	405	402	402	402	402	402	402	404	404	405	405	405	405	405	405	403	403	403	403	405	405	405	405	405	405	404	404	402	402	402	402	402	402	405	401	401									
80											401	401	401	402	402	402	402	402	402	402	404	404	404	404	404	404	405	405	405	405	404	404	404	404	404	404	402	402	402	402	402	402	402	401	401	401										
81												401	401	401	402	402	402	402	402	402	401	401	401	401	401	404	404	404	404	404	404	401	401	401	401	401	402	402	402	402	402	402	401	401	401											
82													401	401	401	402	402	402	402	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	402	402	402	402	401	401	401												
83															401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401														
84																	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401																
85																				401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401																			
86																							401	401	401	401	401	401	401	401	401	401	401	401																						

Legend: Drawer Master Identifications

1XX	Single Fuel Column Core	4XX	Radial Reflector	622	Control Rod
15X	Single Fuel Column Core Sodium Voided (154, 155, 156)	5XX	Radial Blanket	7XX	Detectors
2XX	Double Fuel Column Core	601	Control Rod Position	8XX	Poison Safety Rod

Figure 15. ZPPR-15B Loading 100 - Half 1 - 12 December 1985 - Control Rod Worth - CRs 8, 9, 10, 11 and 12 Inserted.

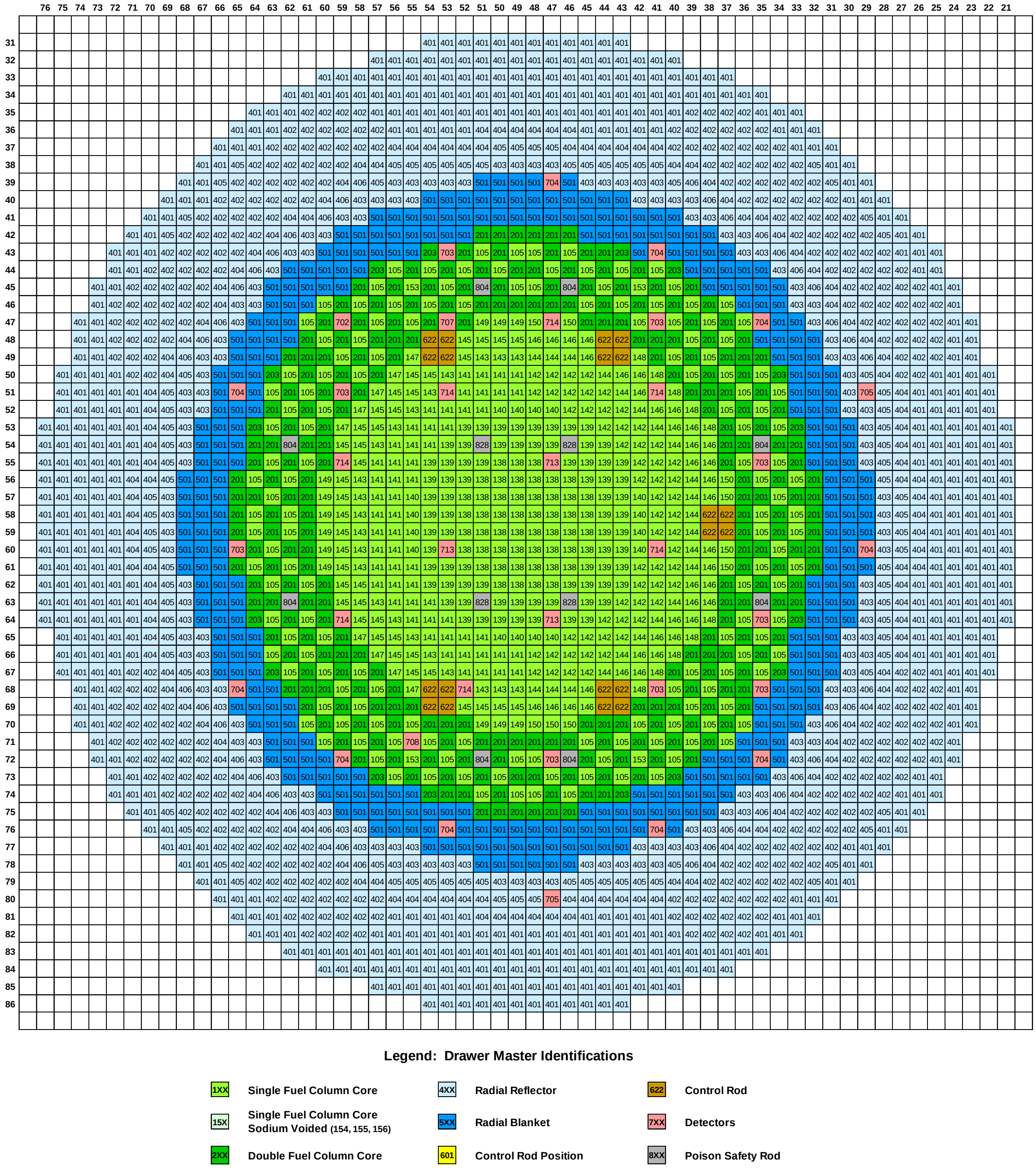

Figure 16. ZPPR-15B Loading 100 - Half 2 - 12 December 1985 - Control Rod Worth - CRs 8, 9, 10, 11 and 12 Inserted.

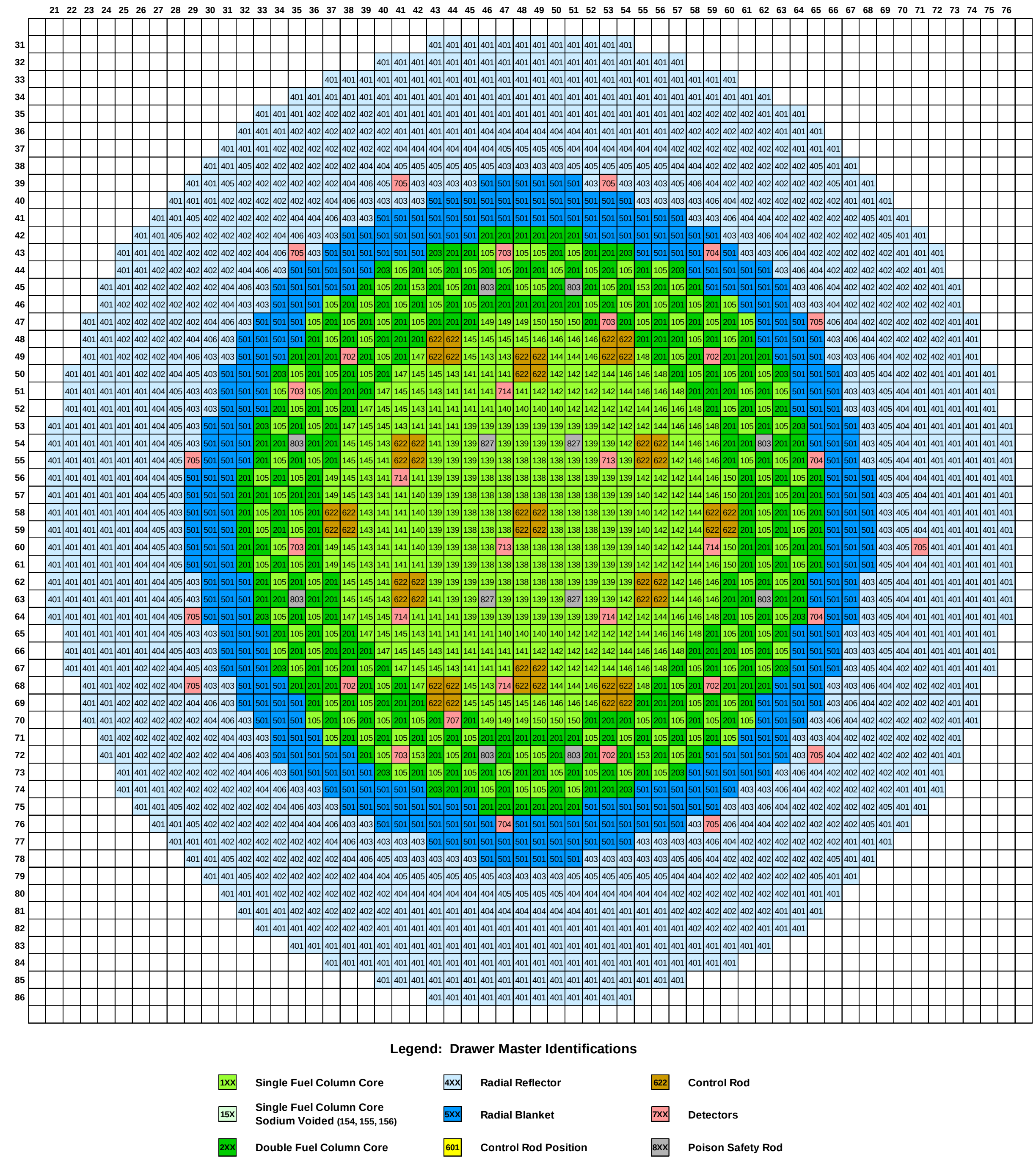

Figure 17. ZPPR-15B Loading 102 - Half 1 - 12 December 1985 - Control Rod Worth - CRs 1 - 13 Inserted.

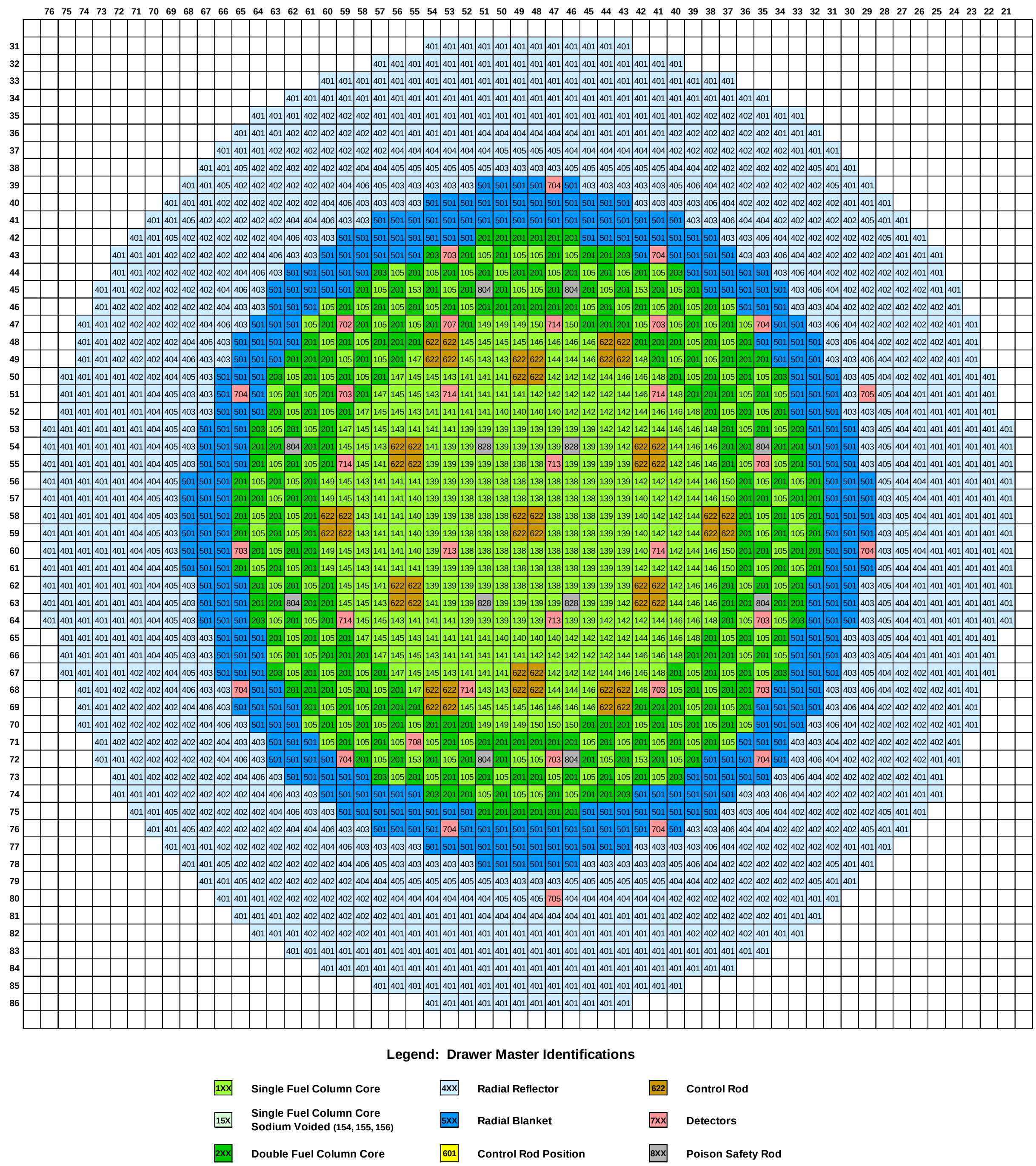

Figure 18. ZPPR-15B Loading 102 - Half 2 - 12 December 1985 - Control Rod Worth - CRs 1 - 13 Inserted.

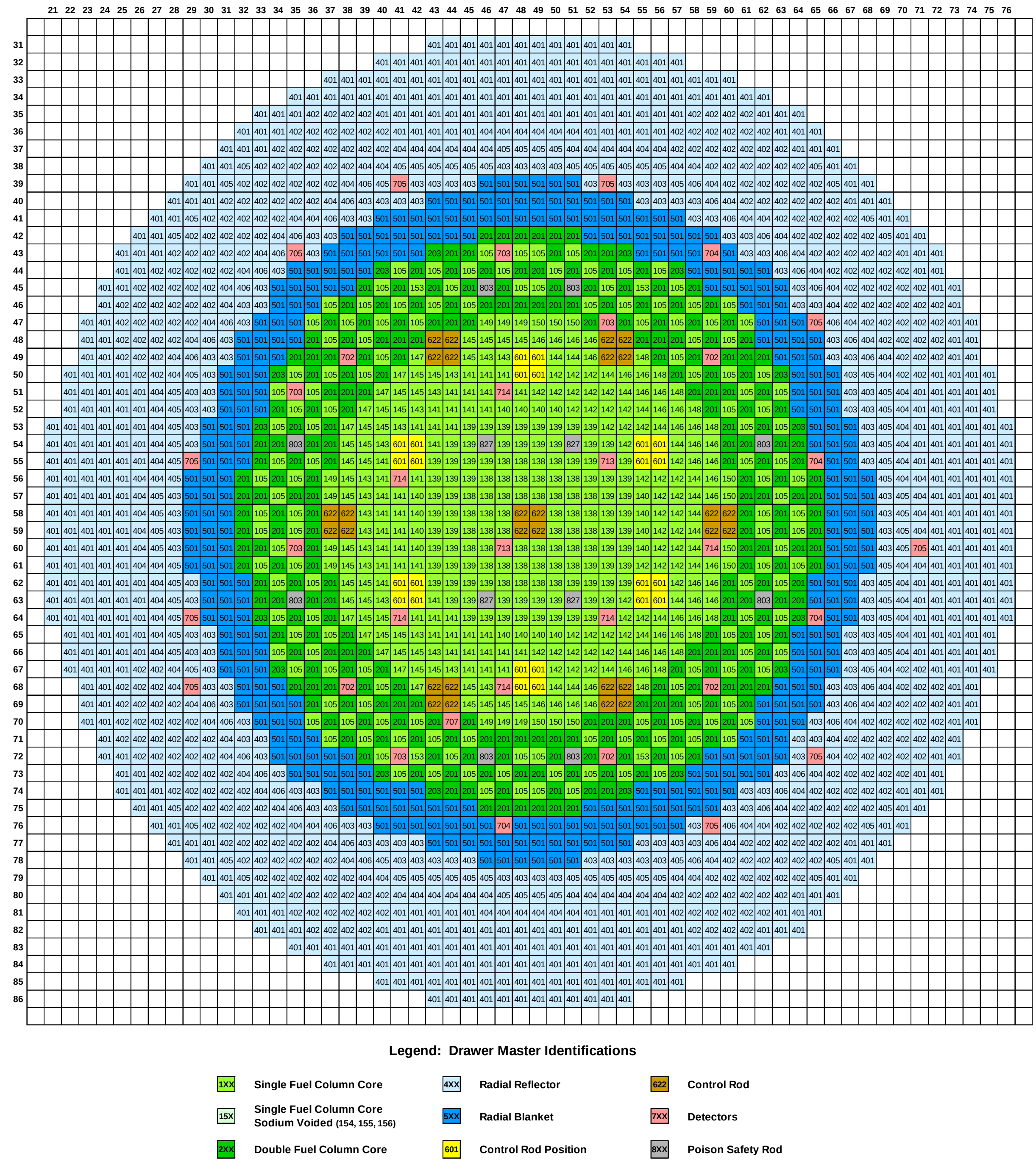

Figure 19. ZPPR-15B Loading 103 - Half 1 - 13 December 1985 - Control Rod Worth - CRs 1, 8 - 13 Half Inserted.

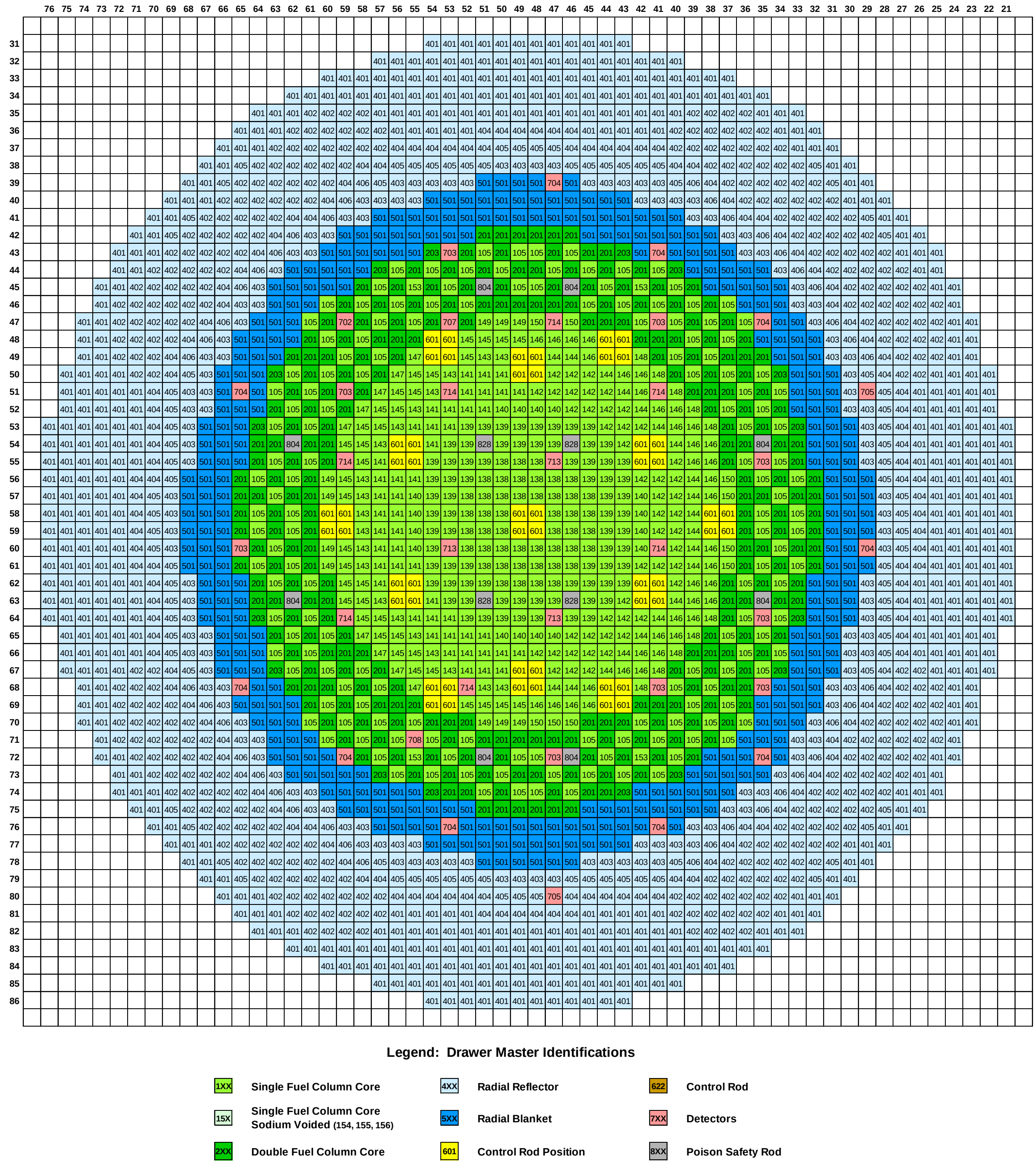

Figure 20. ZPPR-15B Loading 103 - Half 2 - 13 December 1985 - Control Rod Worth - CRs 1, 8 - 13 Half Inserted.

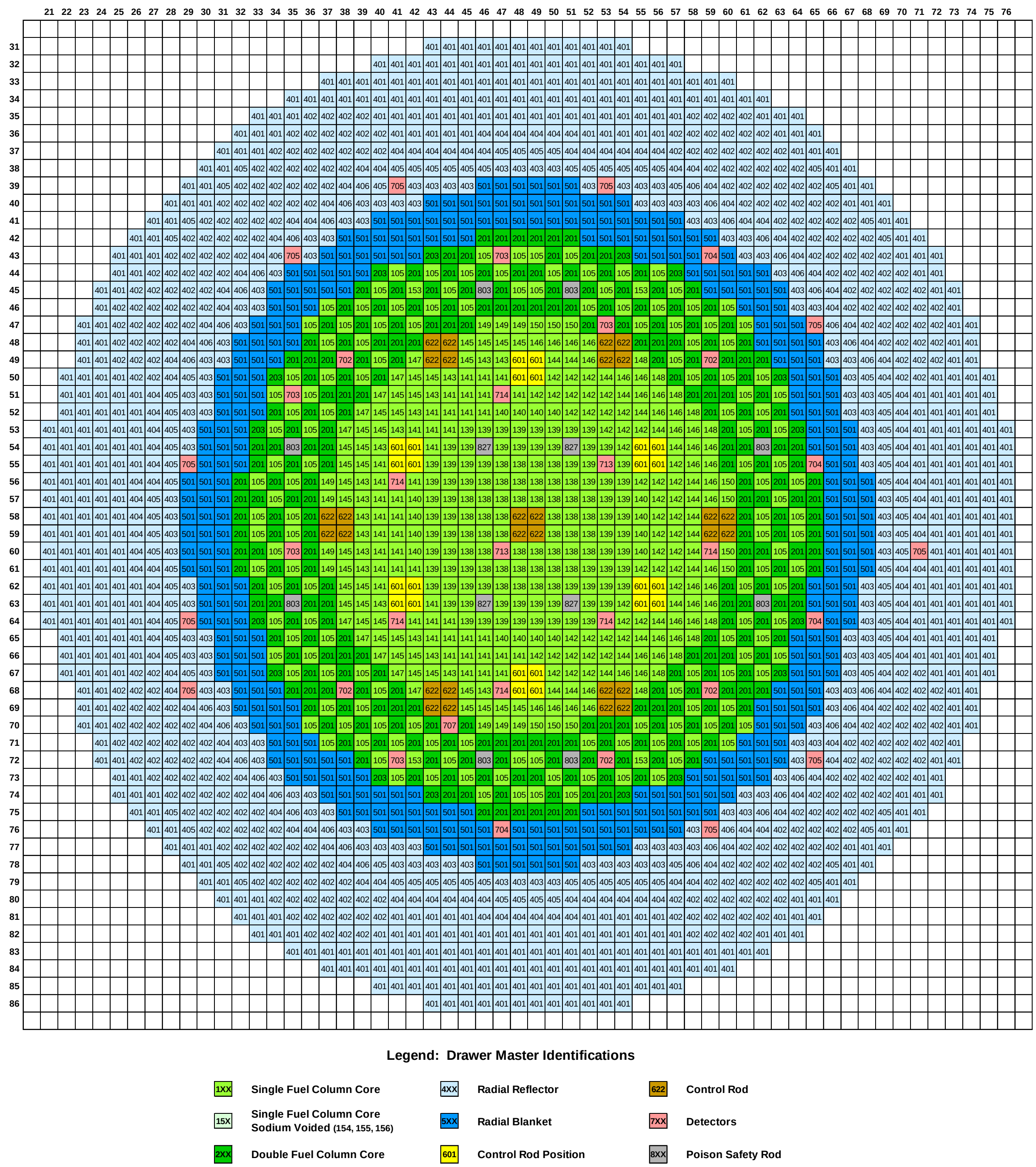

Figure 21. ZPPR-15B Loading 104 - Half 1 - 13 December 1985 - Control Rod Worth - CRs 1, 8 - 13 Inserted - CRPs in 2 - 7.

	76	75	74	73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21
31																							401	401	401	401	401	401	401	401	401	401	401	401																						
32																				401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401																			
33																	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401																
34															401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401														
35													401	401	401	402	402	402	402	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	402	402	402	402	401	401	401												
36												401	401	401	402	402	402	402	402	402	401	401	401	401	401	404	404	404	404	404	404	401	401	401	401	401	402	402	402	402	402	402	401	401	401											
37											401	401	401	402	402	402	402	402	402	402	404	404	404	404	404	404	405	405	405	405	404	404	404	404	404	404	402	402	402	402	402	402	402	401	401	401										
38										401	401	405	402	402	402	402	402	402	404	404	405	405	405	405	405	405	403	403	403	403	405	405	405	405	405	405	404	404	402	402	402	402	402	402	405	401	401									
39									401	401	405	402	402	402	402	402	402	404	406	405	403	403	403	403	403	501	501	501	501	704	501	403	403	403	403	403	405	406	404	402	402	402	402	402	402	405	401	401								
40								401	401	401	402	402	402	402	402	402	404	406	403	403	403	403	501	501	501	501	501	501	501	501	501	501	501	501	403	403	403	403	406	404	402	402	402	402	402	402	401	401	401							
41							401	401	405	402	402	402	402	402	404	404	406	403	403	501	501	501	501	501	501	501	501	501	501	501	501	501	501	501	501	501	501	403	403	406	404	404	402	402	402	402	402	405	401	401						
42						401	401	405	402	402	402	402	402	404	406	403	403	501	501	501	501	501	501	501	501	201	201	201	201	201	201	501	501	501	501	501	501	501	501	403	403	406	404	402	402	402	402	402	405	401	401					
43					401	401	401	402	402	402	402	402	404	406	403	403	501	501	501	501	501	501	203	703	201	105	201	105	105	201	105	201	201	203	501	704	501	501	501	501	403	403	406	404	402	402	402	402	402	401	401	401				
44					401	401	402	402	402	402	402	404	406	403	501	501	501	501	501	203	105	201	105	201	105	201	105	201	201	105	201	105	201	105	201	105	203	501	501	501	501	501	403	406	404	402	402	402	402	402	401	401				
45				401	401	402	402	402	402	402	404	406	403	501	501	501	501	501	201	105	201	153	201	105	201	804	201	105	105	201	804	201	105	201	153	201	105	201	501	501	501	501	501	403	406	404	402	402	402	402	402	401	401			
46				401	402	402	402	402	402	402	404	403	403	501	501	501	105	201	105	201	105	201	105	201	105	201	201	201	201	201	201	105	201	105	201	105	201	105	201	105	501	501	501	403	403	404	402	402	402	402	402	402	401			
47			401	401	402	402	402	402	402	404	406	403	501	501	501	105	201	702	201	105	201	105	201	707	201	149	149	149	150	714	150	201	201	201	105	703	105	201	105	201	105	704	501	501	403	406	404	402	402	402	402	402	401	401		
48			401	401	402	402	402	402	404	406	403	501	501	501	501	201	105	201	105	201	201	201	622	622	145	145	145	145	146	146	146	146	622	622	201	201	201	105	201	105	201	501	501	501	501	403	406	404	402	402	402	402	401	401		
49			401	401	402	402	402	404	406	403	403	501	501	501	201	201	201	105	201	105	201	147	622	622	145	143	143	601	601	144	144	146	622	622	148	201	105	201	105	201	201	201	501	501	501	403	403	406	404	402	402	402	401	401		
50		401	401	401	401	402	402	404	405	403	501	501	501	203	105	201	105	201	105	201	147	145	145	143	141	141	141	601	601	142	142	142	144	146	146	148	201	105	201	105	201	105	203	501	501	501	403	405	404	402	402	401	401	401	401	
51		401	401	401	401	401	404	405	403	403	501	704	501	105	201	105	201	703	201	147	145	145	143	714	141	141	141	141	142	142	142	142	142	144	146	714	148	201	201	201	105	201	105	501	501	501	403	705	405	404	401	401	401	401	401	
52		401	401	401	401	401	404	405	403	403	501	501	501	201	105	201	105	201	147	145	145	143	141	141	141	141	140	140	140	140	142	142	142	142	144	146	146	148	201	105	201	105	201	501	501	501	403	403	405	404	401	401	401	401	401	
53	401	401	401	401	401	401	404	405	403	501	501	501	203	105	201	105	201	147	145	145	143	141	141	141	139	139	139	139	139	139	139	139	142	142	142	144	146	146	148	201	105	201	105	203	501	501	501	403	405	404	401	401	401	401	401	401
54	401	401	401	401	401	401	404	405	403	501	501	501	201	201	804	201	201	145	145	143	601	601	141	139	139	828	139	139	139	139	828	139	139	142	601	601	144	146	146	201	201	804	201	201	501	501	501	403	405	404	401	401	401	401	401	401
55	401	401	401	401	401	401	404	405	403	501	501	501	201	105	201	105	201	714	145	141	601	601	139	139	139	139	138	138	138	713	139	139	139	139	601	601	142	146	146	201	105	703	105	201	501	501	501	403	405	404	401	401	401	401	401	401
56	401	401	401	401	401	404	404	405	501	501	501	201	105	201	105	201	149	145	143	141	141	141	139	139	139	138	138	138	138	138	138	139	139	139	142	142	142	144	146	150	201	105	201	105	201	501	501	501	405	404	404	401	401	401	401	401
57	401	401	401	401	401	404	405	403	501	501	501	201	201	105	201	201	149	145	143	141	141	140	139	139	138	138	138	138	138	138	138	138	139	139	140	142	142	144	146	150	201	201	105	201	201	501	501	501	403	405	404	401	401	401	401	401
58	401	401	401	401	401	404	405	403	501	501	501	201	105	201	105	201	622	622	143	141	141	140	139	139	138	138	138	622	622	138	138	138	139	139	140	142	142	144	622	622	201	105	201	105	201	501	501	501	403	405	404	401	401	401	401	401
59	401	401	401	401	401	404	405	403	501	501	501	201	105	201	105	201	622	622	143	141	141	140	139	139	138	138	138	622	622	138	138	138	139	139	140	142	142	144	622	622	201	105	201	105	201	501	501	501	403	405	404	401	401	401	401	401
60	401	401	401	401	401	404	405	403	501	501	501	703	201	105	201	201	149	145	143	141	141	140	139	713	138	138	138	138	138	138	138	138	139	139	140	714	142	144	146	150	201	201	105	201	201	501	501	704	403	405	404	401	401	401	401	401
61	401	401	401	401	401	404	404	405	501	501	501	201	105	201	105	201	149	145	143	141	141	141	139	139	139	138	138	138	138	138	138	139	139	139	142	142	142	144	146	150	201	105	201	105	201	501	501	501	405	404	404	401	401	401	401	401
62	401	401	401	401	401	401	404	405	403	501	501	501	201	105	201	105	201	145	145	141	601	601	139	139	139	139	138	138	138	138	139	139	139	139	601	601	142	146	146	201	105	201	105	201	501	501	501	403	405	404	401	401	401	401	401	401
63	401	401	401	401	401	401	404	405	403	501	501	501	201	201	804	201	201	145	145	143	601	601	141	139	139	828	139	139	139	139	828	139	139	142	601	601	144	146	146	201	201	804	201	201	501	501	501	403	405	404	401	401	401	401	401	401
64	401	401	401	401	401	401	404	405	403	501	501	501	203	105	201	105	201	714	145	145	143	141	141	141	139	139	139	139	139	713	139	139	142	142	142	144	146	146	148	201	105	703	105	203	501	501	501	403	405	404	401	401	401	401	401	401
65		401	401	401	401	401	404	405	403	403	501	501	501	201	105	201	105	201	147	145	145	143	141	141	141	141	140	140	140	140	142	142	142	142	144	146	146	148	201	105	201	105	201	501	501	501	403	403	405	404	401	401	401	401	401	
66		401	401	401	401	401	404	405	403	403	501	501	501	105	201	105	201	201	201	147	145	145	143	141	141	141	141	141	142	142	142	142	142	144	146	146	148	201	201	201	105	201	105	501	501	501	403	403	405	404	401	401	401	401	401	
67		401	401	401	401	402	402	404	405	403	501	501	501	203	105	201	105	201	105	201	147	145	145	143	141	141	141	601	601	142	142	142	144	146	146	148	201	105	201	105	201	105	203	501	501	501	403	405	404	402	402	401	401	401	401	
68			401	401	402	402	402	404	406	403	403	704	501	501	201	201	201	105	201	105	201	147	622	622	714	143	143	601	601	144	144	146	622	622	148	703	105	201	105	201	201	703	501	501	501	403	403	406	404	402	402	402	401	401		
69			401	401	402	402	402	402	404	406	403	501	501	501	501	201	105	201	105	201	201	201	622	622	145	145	145	145	146	146	146	146	622	622	201	201	201	105	201	105	201	501	501	501	501	403	406	404	402	402	402	402	401	401		
70			401	401	402	402	402	402	402	404	406	403	501	501	501	105	201	105	201	105	201	105	201	201	201	149	149	149	150	150	150	201	201	201	105	201	105	201	105	201	105	501	501	501	403	406	404	402	402	402	402	402	401	401		
71				401	402	402	402	402	402	402	404	403	403	501	501	501	105	201	105	201	105	708	105	201	105	201	201	201	201	201	201	105	201	105	201	105	201	105	201	105	501	501	501	403	403	404	402	402	402	402	402	402	401			
72				401	401	402	402	402	402	402	404	406	403	501	501	501	501	704	201	105	201	153	201	105	201	804	201	105	105	703	804	201	105	201	153	201	105	201	501	501	501	704	501	403	406	404	402	402	402	402	402	401	401			
73					401	401	402	402	402	402	402	404	406	403	501	501	501	501	501	203	105	201	105	201	105	201	105	201	201	105	201	105	201	105	201	105	203	501	501	501	501	501	403	406	404	402	402	402	402	402	401	401				
74					401	401	401	402	402	402	402	402	404	406	403	403	501	501	501	501	501	501	203	201	201	105	201	105	105	201	105	201	201	203	501	501	501	501	501	501	403	403	406	404	402	402	402	402	402	401	401	401				
75						401	401	405	402	402	402	402	402	404	406	403	403	501	501	501	501	501	501	501	501	201	201	201	201	201	201	501	501	501	501	501	501	501	501	403	403	406	404	402	402	402	402	402	405	401	401					
76							401	401	405	402	402	402	402	402	404	404	406	403	403	501	501	501	501	704	501	501	501	501	501	501	501	501	501	501	501	704	501	403	403	406	404	404	402	402	402	402	402	405	401	401						
77								401	401	401	402	402	402	402	402	402	404	406	403	403	403	403	501	501	501	501	501	501	501	501	501	501	501	501	403	403	403	403	406	404	402	402	402	402	402	402	401	401	401							
78									401	401	405	402	402	402	402	402	402	404	406	405	403	403	403	403	403	501	501	501	501	501	501	403	403	403	403	403	405	406	404	402	402	402	402	402	402	405	401	401								
79										401	401	405	402	402	402	402	402	402	404	404	405	405	405	405	405	405	403	403	403	403	405	405	405	405	405	405	404	404	402	402	402	402	402	402	405	401	401									
80											401	401	401	402	402	402	402	402	402	402	404	404	404	404	404	404	405	405	405	705	404	404	404	404	404	404	402	402	402	402	402	402	402	401	401	401										
81												401	401	401	402	402	402	402	402	402	401	401	401	401	401	404	404	404	404	404	404	401	401	401	401	401	402	402	402	402	402	402	401	401	401											
82													401	401	401	402	402	402	402	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	402	402	402	402	401	401	401												
83															401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401														
84																	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401																
85																				401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401	401																			
86																							401	401	401	401	401	401	401	401	401	401	401	401																						

Legend: Drawer Master Identifications

1XX	Single Fuel Column Core	4XX	Radial Reflector	622	Control Rod
15X	Single Fuel Column Core Sodium Voided (154, 155, 156)	5XX	Radial Blanket	7XX	Detectors
2XX	Double Fuel Column Core	601	Control Rod Position	8XX	Poison Safety Rod

Figure 22. ZPPR-15B Loading 104 - Half 2 - 13 December 1985 - Control Rod Worth - CRs 1, 8 - 13 Inserted - CRPs in 2 - 7.

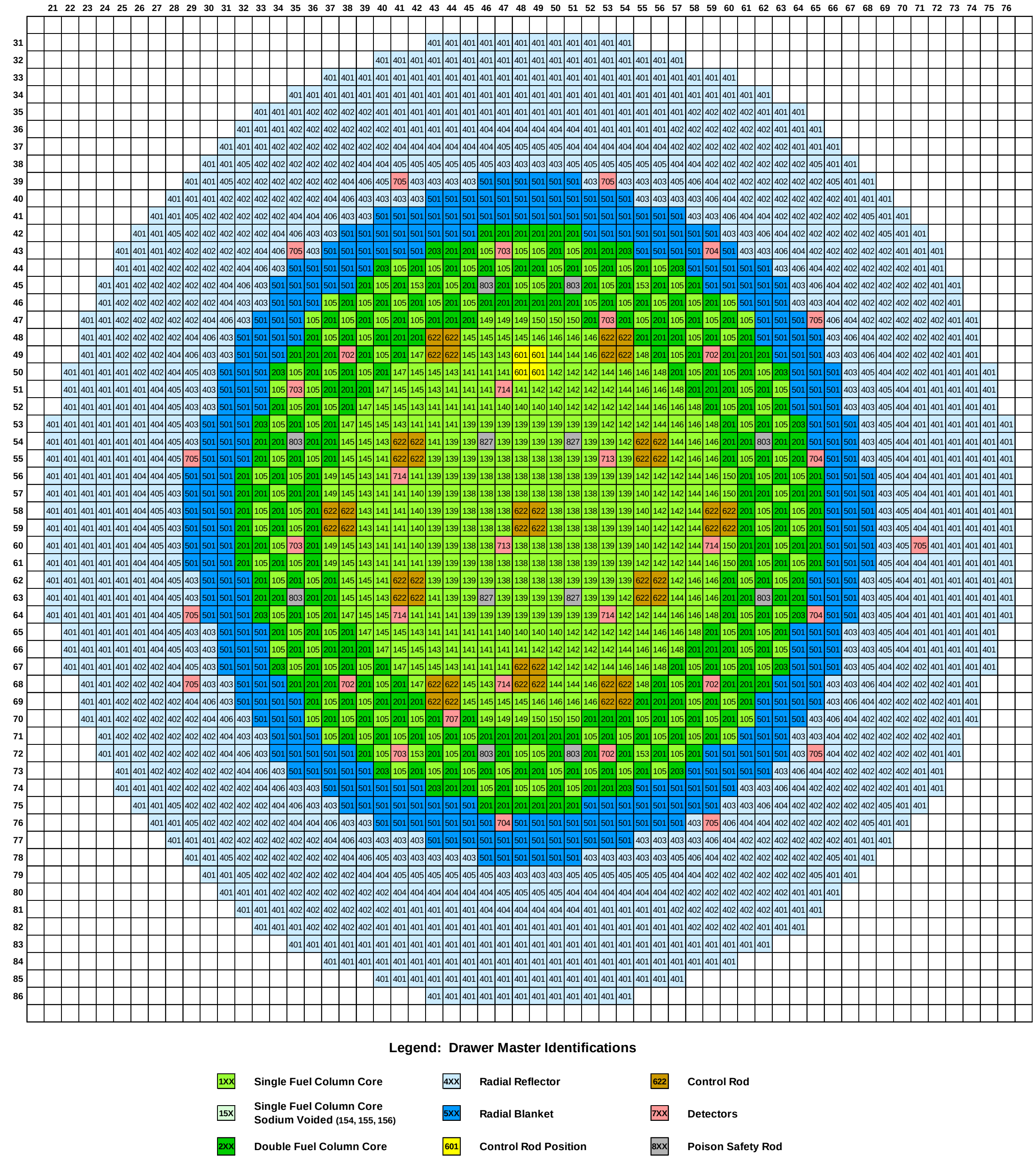

Figure 23. ZPPR-15B Loading 105 - Half 1 - 13 December 1985 - Control Rod Worth - 12 CRs Inserted - 1 CRP.

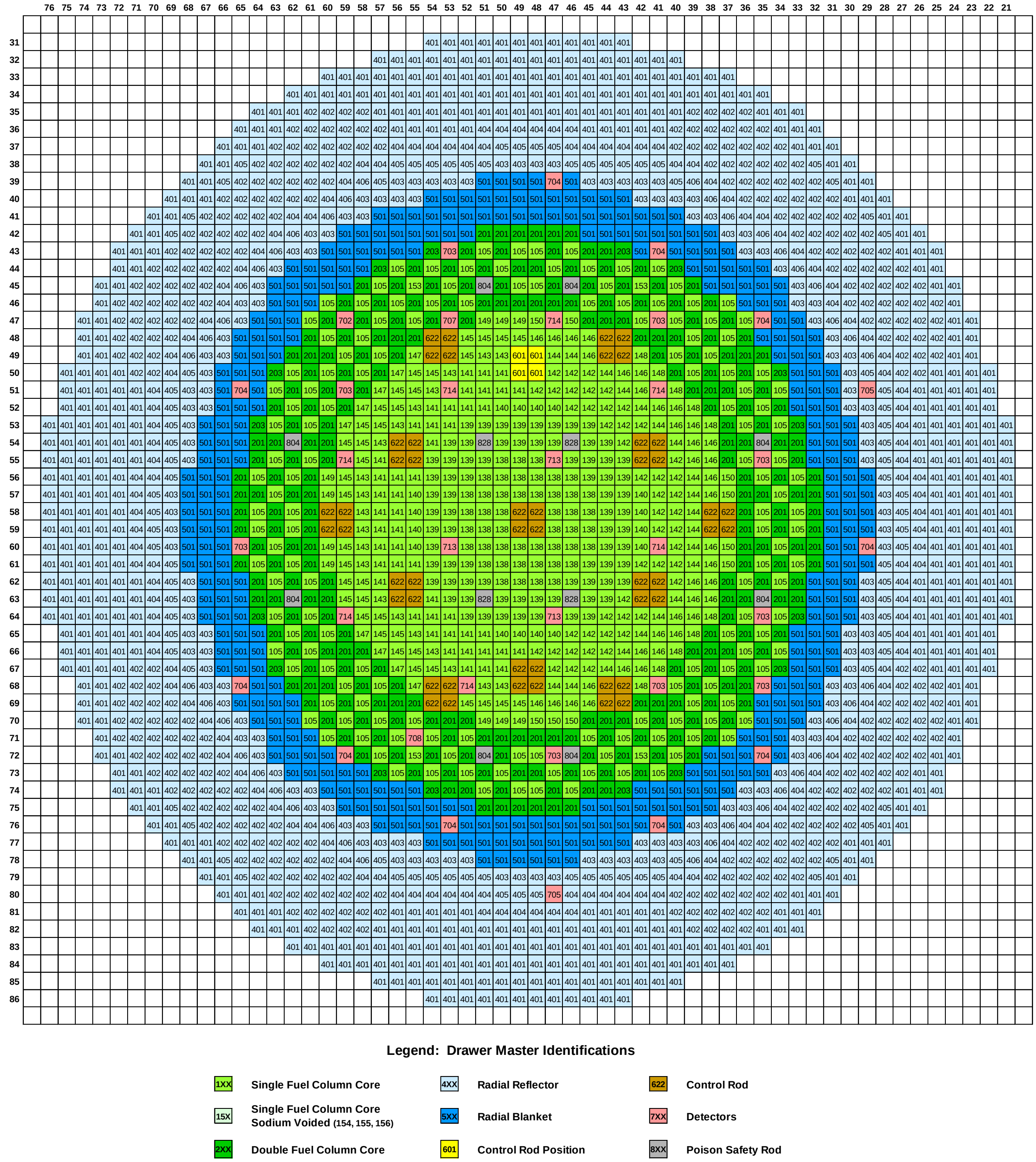

Figure 24. ZPPR-15B Loading 105 - Half 2 - 13 December 1985 - Control Rod Worth - 12 CRs Inserted - 1 CRP.

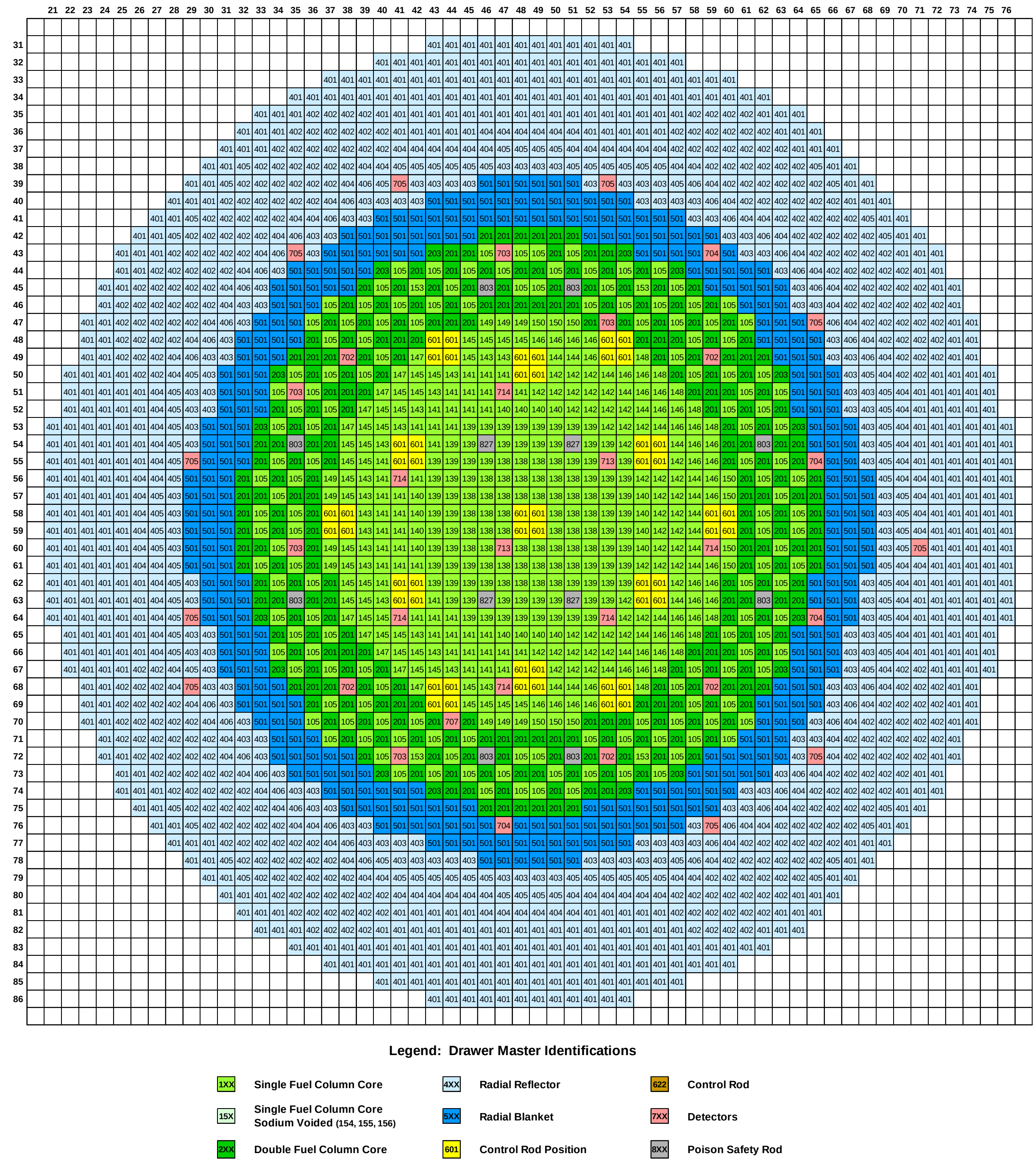

Figure 25. ZPPR-15B Loading 106 - Half 1 - 13 December 1985 - Control Rod Worth - 13 CRPs Inserted.

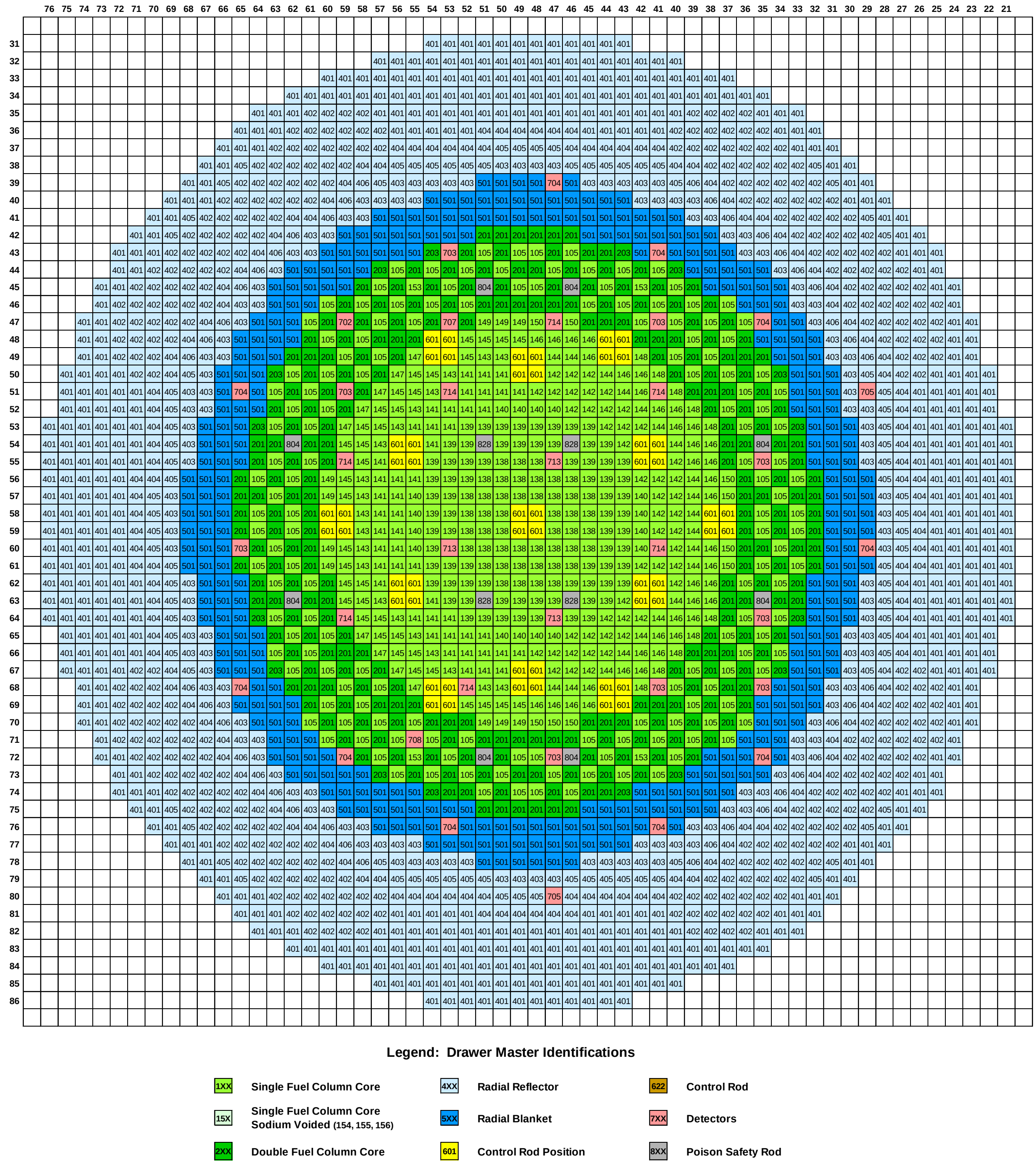

Figure 26. ZPPR-15B Loading 106 - Half 2 - 13 December 1985 - Control Rod Worth - 13 CRPs Inserted.

First, VIM input decks appropriate for use with ENDF/B-V.2 libraries were generated for each of these configurations. Next, each of these VIM decks was converted as appropriate for use with ENDF/B-VII.0 libraries. Finally, each of these decks was converted to an MCNP5 input deck for use with ENDF/B-VII.0 libraries.

Results of calculated k_{eff}'s for each of the 12 configurations were initially obtained using VIM with ENDF/B-V.2 and ENDF/B-VII.0 data and using MCNP5 with ENDF/B-VII.0 data. These initial calculations retained ten million neutron histories for each configuration resulting in statistical uncertainties of ~15-20 pcm. The results obtained with the two codes, VIM and MCNP5 (with ENDF/B-VII.0 data), were in excellent agreement – in all cases statistically identical. To reduce the effect of the Monte Carlo statistics on the calculated reactivity worths (which were obtained by eigenvalue differences), the calculations for all configurations were repeated using MCNP5 with ENDF/B-VII.0 data retaining 250 million histories[1] resulting in statistical uncertainties of ~3 pcm.

As shown in Table II, the reference critical configuration for ZPPR-15B was Loading 88 on November 27, 1985. The measured excess reactivity was 12.7 ± 0.1 cents,[2] or k_{eff} = 1.00043. Note the quoted uncertainty is only the uncertainty in the measurement of the excess reactivity. The full uncertainty in the experimental k_{eff} has not been evaluated; however, the 1σ uncertainty in the measured k_{eff}, including uncertainties in reactivity measurement, composition and geometry, is estimated to be ±0.1 % Δk or ±100 pcm. The calculated k_{eff} with MCNP5 using ENDF/B-VII.0 data was 0.99840 ± 0.00003; that is, the bias on the calculated value was -203 ± 100 pcm. That is, when the full uncertainty in the experimental value of k_{eff} is considered in the comparison, the ENDF/B-VII.0 calculated value is low – by ~2σ. These results for the reference critical configuration of ZPPR-15B are summarized in Table IV. It has been noted that subcritical reference configurations were also obtained for sodium void and control rod measurements (Loadings 91 and 96, respectively). These two subcritical reference configurations were obtained through only minor adjustments in the core loading of the reference critical configuration to obtain small negative excess reactivities. As such, it is not surprising that the calculational bias, ~200 pcm or -0.2 %, is virtually identical for these three configurations (as shown in Table IV).

[1] One-thousand batches of 250K neutron histories were retained after discarding the first 100 batches.
[2] The calculated β_{eff} reported with the measurement was 0.003361, which was in very close agreement with the value (0.003357) calculated for ZPPR-15A.

Table IV. Performance of ENDF/B-VII.0 for the Reference Critical and Subcritical Configurations of ZPPR-15B.

Reference Configuration Loading	Measured Excess Reactivity ± 1σ (¢)	Measured Excess Reactivity ± 1σ (pcm)	Calculated Excess Reactivity ± 1σ (pcm)	[C/E – 1] ± 1σ (%)
88	12.7 ± 0.1[(a)]	43 ± 0.3[(a)] 100[(b)]	-160 ± 3	-0.203 ± 0.003[(a)] 0.100[(b)]
91	-64.44 ± 0.14	-217 ± 0.5[(a)] 100[(b)]	-415 ± 3	-0.199 ± 0.003[(a)] 0.100[(b)]
96	-17.33 ± 0.14	-58 ± 0.5[(a)] 100[(b)]	-259 ± 3	-0.201 ± 0.003[(a)] 0.100[(b)]

(a) Includes only experimental uncertainty in measured excess.
(b) Includes full experimental uncertainties.

As shown in Table II, the series of sodium void measurements began with a subcritical reference measurement in Loading 91 on December 5, 1985. Subsequent loadings replaced sodium-filled cans with sodium-voided cans within a series of central regions to obtain the reactivity worth of removal of sodium using the Modified Source Multiplication (MSM) method. These results are summarized in Table V. Note the results in Table V are reported relative to the subcritical reference configuration, Loading 91. The measurement uncertainties given in these tables include statistical uncertainties derived from the distribution of reactivity estimates and reactivity corrections and correlated uncertainty from the reference reactivity and source ratio uncertainty. The ENDF/B-VII.0 calculated values for the positive worths of voiding the central zones are slightly underpredicted but are generally within ~5-10%.

Table V. Performance of ENDF/B-VII.0 for the Sodium-Void Worth Measurements of ZPPR-15B.

	Calculated k_{eff} ± 1σ MCNP5 V7			Calculated Void Worth ± 1σ (pcm)			Measured Void Worth ± 1σ (¢)			Measured Void Worth ± 1σ (pcm)			[C/E – 1] ± 1σ (%)		
Loading	k_{eff}	±	1σ	$\Delta k/k_1k_2$	±	1σ	ρ	±	1σ	$\Delta k/k_1k_2$	±	1σ	C/E – 1	±	1σ
91	0.99585	±	0.00003												
92	0.99719	±	0.00003	135	±	4	43.22	±	0.36	145	±	1.22	-7.1	±	3.0
93	0.99749	±	0.00003	165	±	4	54.56	±	0.09	183	±	0.31	-10.0	±	2.3
94	0.99745	±	0.00003	161	±	4	50.38	±	0.10	169	±	0.33	-4.9	±	2.5

Note: All Na-Void reactivity values above are relative to the reference subcritical configuration, Loading 91.
Loading 91 – Subcritical reference 1 for Na voiding – 5 December 1985
Loading 92 – 8 in. (203.2 mm) Na voiding in 52 drawers/half – 5 December 1985
Loading 93 – 14 in. (356.6 mm) Na voiding in 52 drawers/half – 6 December 1985
Loading 94 – 18 in. (457/2 mm) Na voiding in 52 drawers/half – 9 December 1985

As shown in Table II, the series of control rod worth measurements began with a subcritical reference measurement in Loading 96 on December 10, 1985. Subsequent measurements determined the worth of loading the matrix with:

1. Control Rods 8 – 12, Loading 100,
2. Control Rods 1–13, Loading 102,
3. Primary Control Rods[1] Half-inserted, Loading 103,
4. Primary CR's with CRP's elsewhere, Loading 104,
5. Primary CR's plus 5 Secondary CR's and 1 CRP (location 6), Loading 105, and
6. CRP's 1–13, Loading 106,

using the Modified Source Multiplication (MSM) method. These results are summarized in Tables VII. All of the CR and CRP worth measurements are well predicted, that is, predicted to within ~5%. The uncertainty in the worth measurements is ~300 pcm, which ranges from ~2-13%, depending on the magnitude of the measured worth. In the cases of the two highest worth measurements [insertion of all 13 CR's (Loading 103) and insertion of seven primary CR's plus five secondary CR's plus 1 CRP (Loading 105)], the 300 pcm measurement uncertainty is reduced to ~2%, and for these two cases the C/E biases are ~2σ and 3σ, respectively.

[1] CR = Control Rod; CRP = Control Rod Position; Primary CR's were 1, 8-13, and Secondary CR's were 2-7.

Table VI. Performance of ENDF/B-VII.0 for the Control Rod Worth Measurements of ZPPR-15B.

	Calculated k_{eff} + 1σ MCNP5 V7			Calculated Rod Worth + 1σ (pcm)			Measured Rod Worth + 1σ ($)			Measured Rod Worth + 1σ (pcm)			[C/E – 1] + 1σ (%)		
Loading	k_{eff}	±	1σ	$\Delta k/k_1k_2$	±	1σ	ρ	±	1σ	$\Delta k/k_1k_2$	±	1σ	C/E - 1	±	1σ
96	0.99741	±	0.00003												
100	0.95993	±	0.00003	-3915	±	4	-12.19	±	0.87	-4097	±	291	-4.4	±	6.8
102	0.89249	±	0.00003	-11786	±	5	-37.58	±	0.87	-12629	±	293	-6.7	±	2.2
103	0.95283	±	0.00003	-4691	±	4	-14.36	±	0.87	-4826	±	291	-2.8	±	5.9
104	0.92909	±	0.00003	-7373	±	5	-22.95	±	0.87	-7715	±	291	-4.4	±	3.6
105	0.89866	±	0.00003	-11017	±	5	-34.34	±	0.87	-11541	±	293	-4.5	±	2.4
106	0.97758	±	0.00003	-2034	±	4	-6.31	±	0.86	-2121	±	289	-4.1	±	13.1

Note: Control Rod (CR) and Control Rod Position (CRP) reactivity values above are relative to the subcritical reference Loading 96.
Primary CR's were 1, 8-13, and Secondary CR's were 2-7.
Loading 96 – Subcritical reference for CR worth – Dec. 10, 1985.
Loading 100 – CR's 8-12 – Dec. 12, 1985.
Loading 102 – CR's 1-13 – Dec. 12, 1985.
Loading 103 – CR's 1,8-13 Half-inserted – Dec. 13, 1985.
Loading 104 – CR's 1,8-13 with CRP's elsewhere – Dec. 13, 1985.
Loading 105 – Primary CR's plus 5 Secondary CR's and 1 CRP – Dec. 13, 1985.
Loading 106 – 13 CRPs inserted – Dec. 13, 1985.

2.2 Status of Collaboration on BFS Experiments

Although ANL and KEARI staff members did not meet regarding the current year's activities until late in the year, there has been a good exchange of physics data. Drs. Jaewoon Yoo (KAERI) and Richard McKnight (ANL) of Argonne each presented results of analyses from the collaboration at the BFS-50 Conference in Obninsk, Russia on February 27-March 2, and discussed the current IPPE measurements (BFS-76-1). KAERI has provided initial information regarding the BFS-76-1 experiments performed by IPPE, and ANL has provided comments on the draft report of those experiments. ANL has now provided the MCNP5 "as-built" decks, as well as complete details of the matrix and drawer loadings, to allow modeling and analysis with multigroup deterministic methods for all of the twelve ZPPR-15B configurations described herein. ANL has now reviewed a model of the BFS-75-1 experiment provided by KAERI.

The "as-built" MCNP5 model of BFS-73-1 provided to ANL by KAERI has been reviewed and analyzed with ENDF-B-VII.0 and –VII.1 data. Results are presented in Table VIII. It may be noted that k_{eff} is underpredicted by ~340 pcm with both data libraries; the small difference between the two calculated values (lower by 58 pcm with ENDF/B-VII.1) is expected as most of the major evaluations were carried over unchanged from Version VII.0 to VII.1.

Table VII. MCNP5 Calculations of BFS-73-1 Assembly using ENDF/B-VII.0 and ENDF/B-VII.1 Data.

Assembly Benchmark	Benchmark Experiment			Calculated [a]			C/E [a]		
	k_{eff}	±	σ	k_{eff}	±	σ	k_{eff}	±	σ
BFS-73-1 BFS1-LMFR-EXP-001	1.0008	±	0.0029	0.99695 0.99637	± ±	0.00003 0.00003	0.99615 0.99557	± ±	0.00289 0.00289

[a] Calculated and C/E values given in the first (upper) row are obtained with ENDF/B-VII.0 data; the values given in the **second** (**lower**) row are obtained with ENDF/B-VII.1 data.

KAERI has not yet received an official reply to release the full original data of the BFS-73-1 and BFS-75-1 experiments to ANL. Similarly, ANL is seeking approval to formally release some of the original documentation of the ZPPR-15 measurements to KAERI. In both cases this delay is considered temporary, and is not foreseen to impact the U.S./Republic of Korea ZPPR-15 and BFS data archival project.

3 SUMMARY AND OUTLOOK

Work on the ZPPR-15B database progressed well in the second year of this collaboration. Detailed as-built Monte Carlo models have been generated for all of the planned 12 configurations. Complete loading records for all of the ZPPR-15B configurations have been captured, verified and entered into a database for the generation of the as-built models. All ZPPR-15B drawer master identifications and logbooks have also been reviewed. This effort has effectively assured that this valuable integral data will not be lost and the availability of the detailed 'as-built" models will be of high value in the validation activities for programs such as the Nuclear Energy Advanced Modeling and Simulation (NEAMS) program. As this collaboration extends to archival of the remaining ZPPR-15 experimental program, including ZPPR-15C and -15D, in the outyears, additional effort to identify the remaining experimental measurements and their uncertainties in the ZPPR-15 experiments will continue. As noted above, the Pu-fueled ZPPR-15B assembly represented a mature equilibrium core; whereas the -15C and -15D assemblies provide measurements in a transition (mixed Pu and enriched uranium fuel) core and a near beginning-of-life core (90% of core fueled with enriched uranium), respectively.

The KAERI TRU burner experiments are being built at BFS and the bi-lateral discussions on these experiments and the eventual modeling and analysis of these experiments will continue.

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