Results of New Fuel Design with Higher Uranium Mass Implementation in Dukovany NPP

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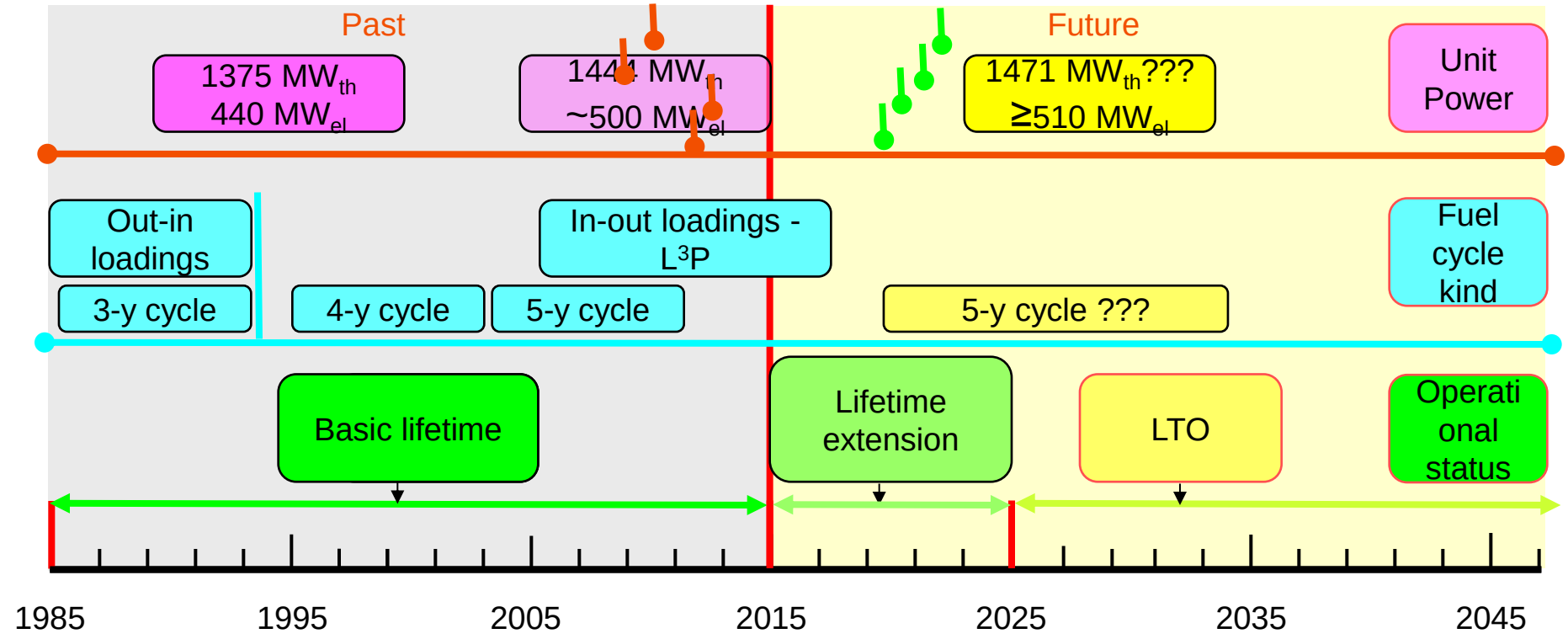
Josef Bajgl
ČEZ, a.s.

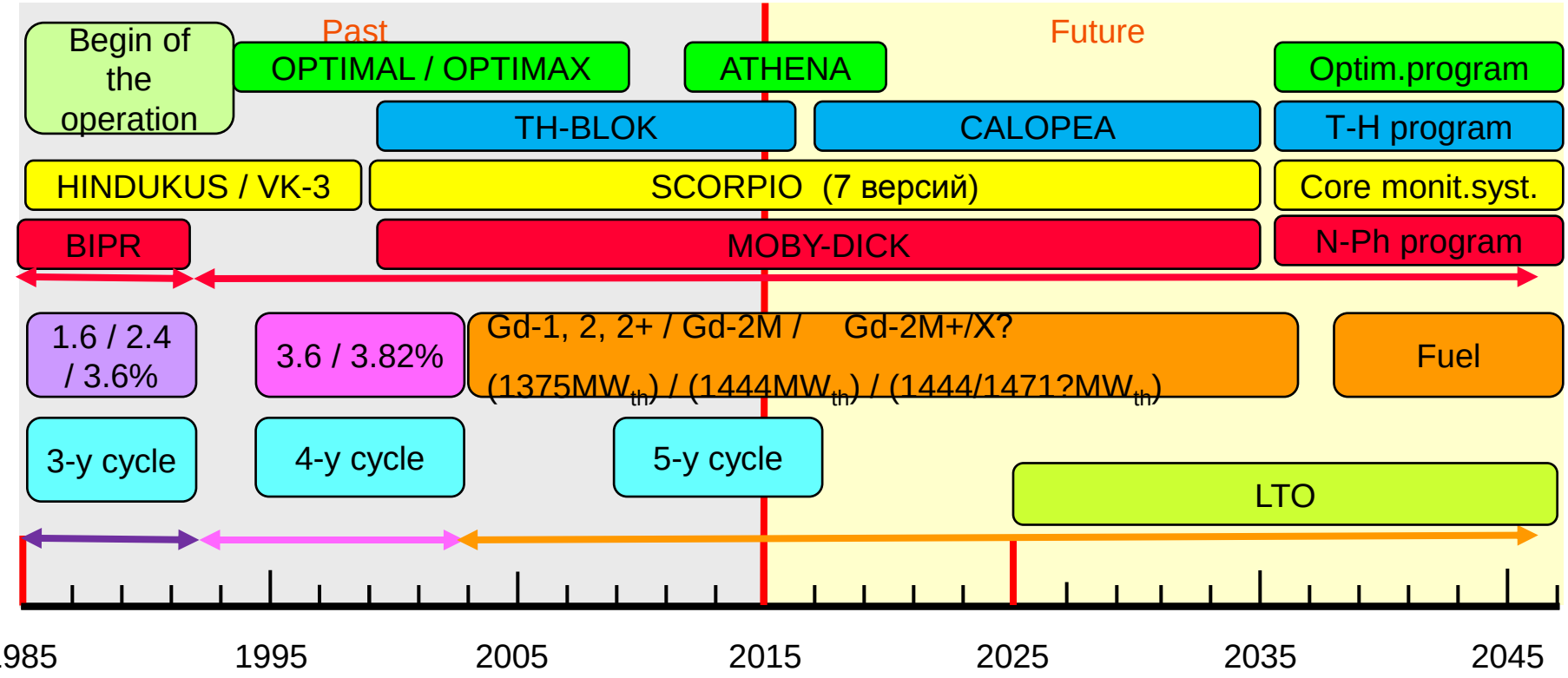
Introduction

1. Project objectives and restrictions
2. Fuel Gd-2M+ characterisation
3. Fuel Gd-2M+ licencing process
4. Operational experience
5. Conclusion

Dukovany NPP General Information



Dukovany NPP General Information



Project Objectives and Restrictions

Objectives:

To implement new fuel design, which allows the continuation of Dukovany NPP effective operation, including LTO, and which uses the VVER-440 fuel production progress.

Restrictions:

- to fulfill the conditions for discharged fuel storage, it means conditions for the residual power
- to support 5-years fuel cycle with neutron low leakage design (L^3P) for nominal power 1444MW and for increased power 1485MW (it means to find optimal radial fuel pin enrichment profile for working fuel assemblies and for control fuel assemblies)

Chosen Solution

Preliminary analyses show that

- it is not sufficient operational experience with 3-rd generation fuel (shroudless design)
- there is positive operational experience with 2-nd generation fuel (Dukovany NPP and other VVER-440 NPPs).

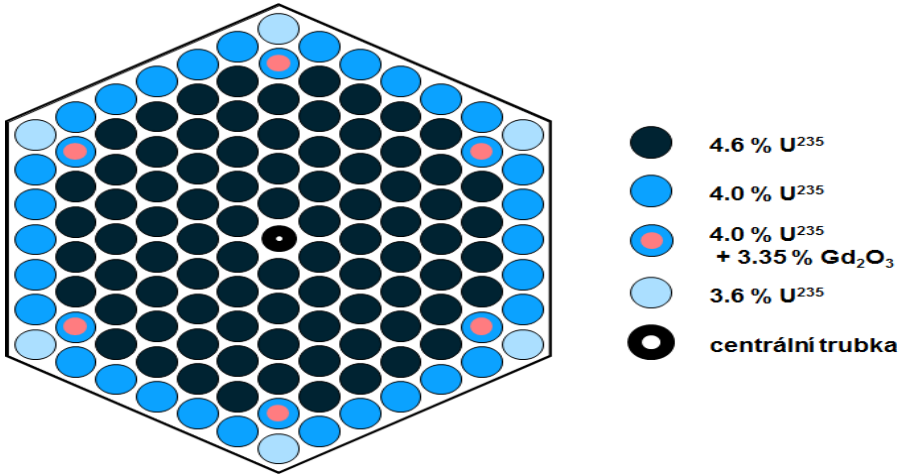
Conclusions:

1. To keep 2-nd generation fuel design (pin pitch, fuel stack height, the shroud thickness).
2. To use 3-rd generation fuel pin design, it means to reduce the fuel pin wall thickness, to increase the fuel pellet diameter and to remove the central hole.
3. To use the anti-debris filter (ADF) in WFA.

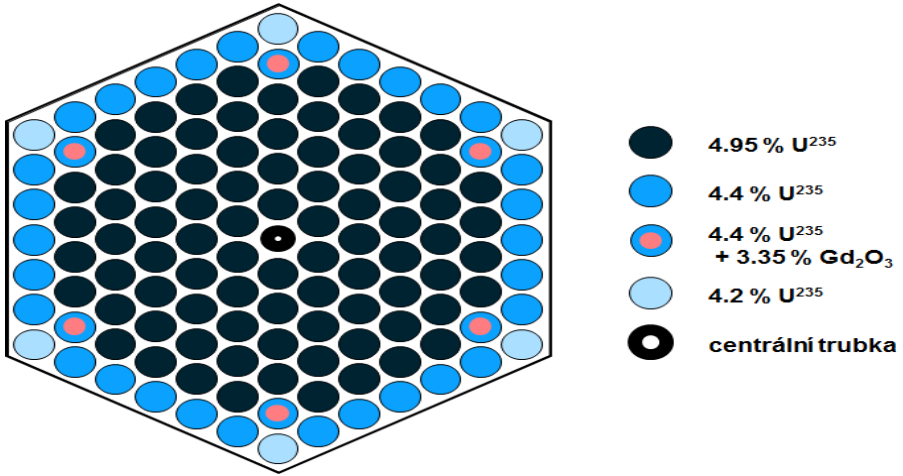
=> new fuel design abbreviation is

Chosen Solution:
Fuel Pins Enrichment Profile

Average enrichment 4,38 %

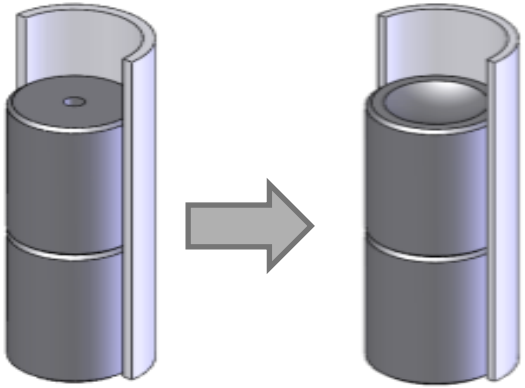


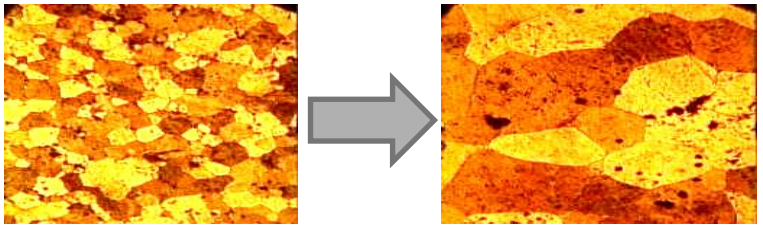
Average enrichment 4,76 %



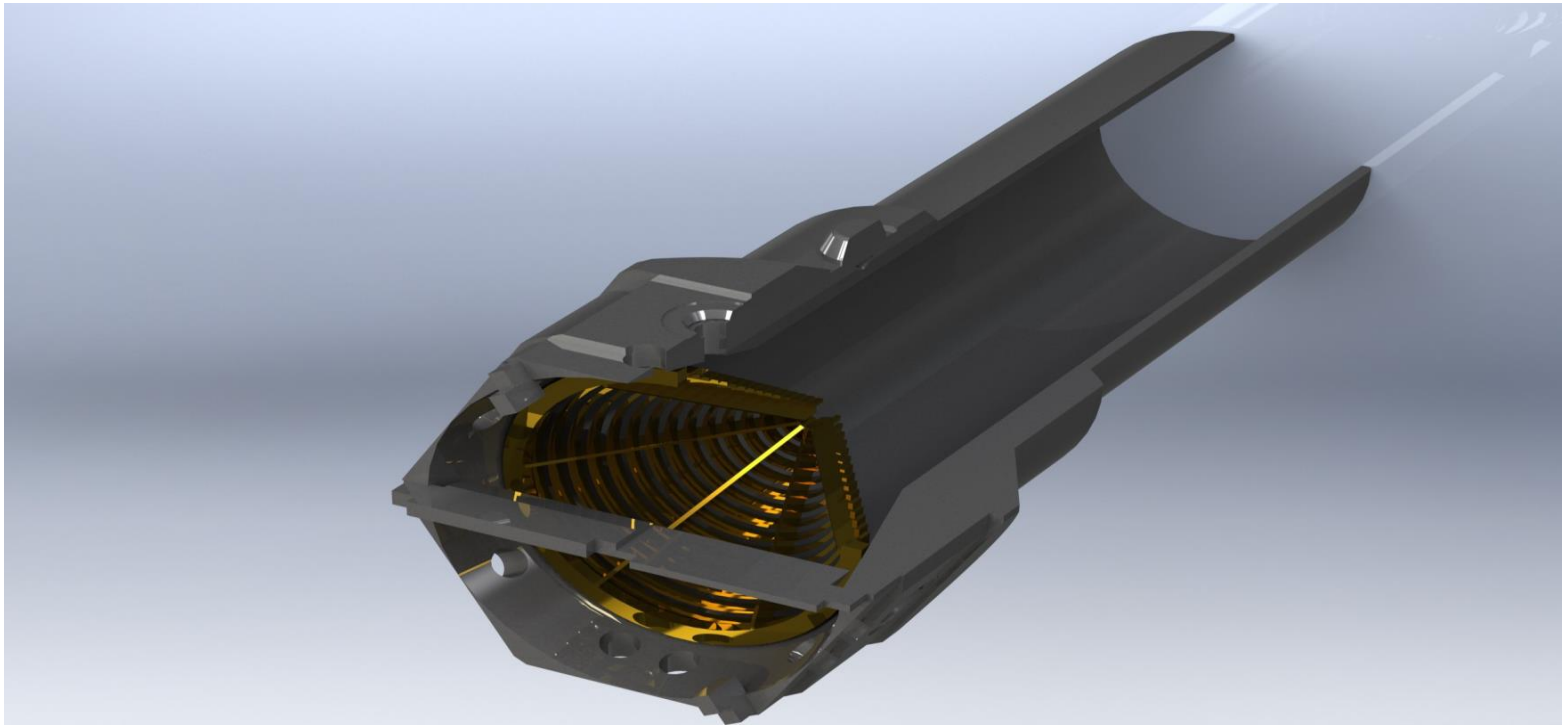
Chosen Solution: Pellet Characteristics

	Gd-2M	Gd-2M+
Wall thickness, mm	≈0.68 (ø 9,10/7,73)	≈0.58 (ø 9,10/7,93)
Pellet diameter, mm	7.60	7.80
Central hole diameter, mm	1.2	0
Average grain diameter, μm	10	≥ 25

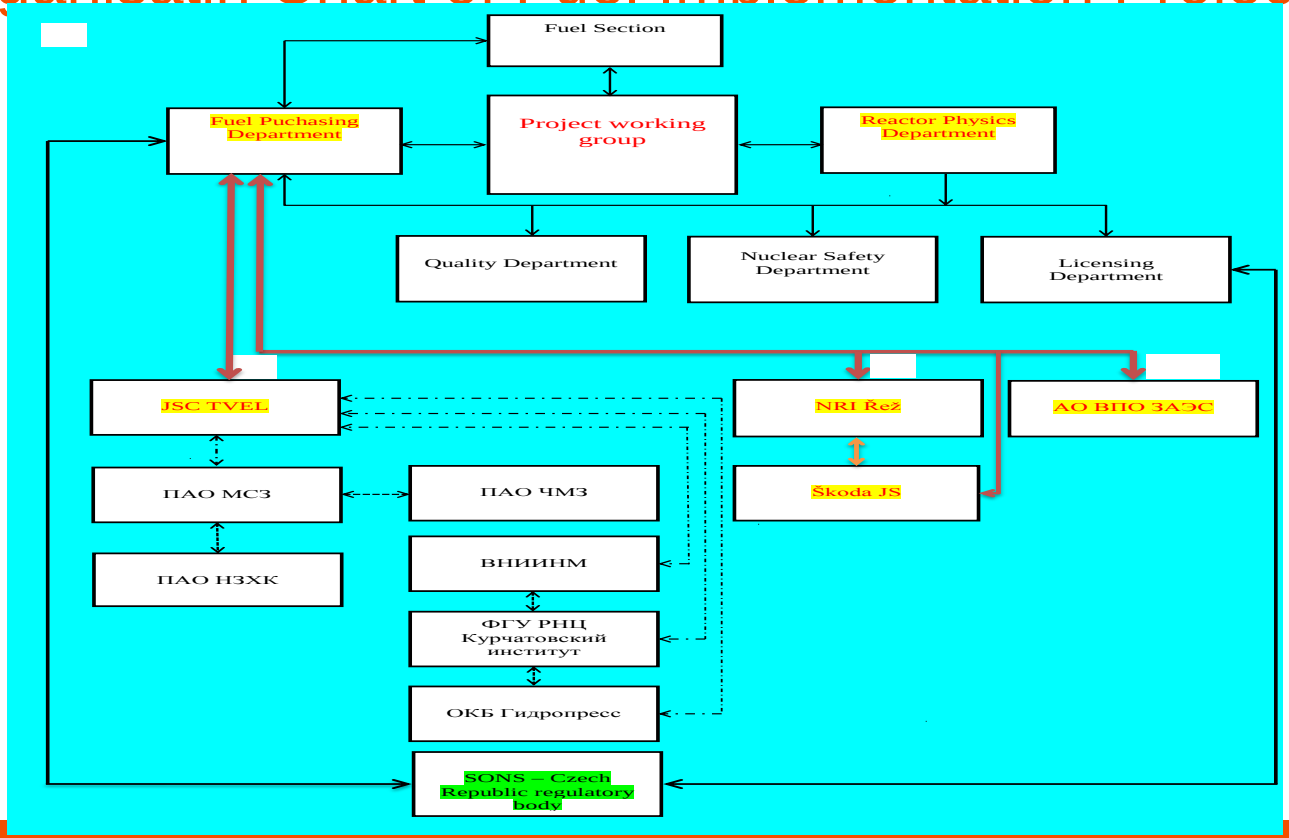




Chosen Solution: ADF in WFA Bottom End



Gd-2M+ Licensing Process:
Organisatin Chart of Fuel Implementation Project



Gd-2M+ Licensing Process:
Analyses given to the SONS

ČEZ, a.s. gives to the SONS documentation prepared by:

- JSC TVEL and subcontractors – 29 documents (NPh+TH+MC+SA + documentation for computer programs licensing), fuel project – max. enrichment 4,76 %U^{235}

- czech organisations - ÚJV / EGP and Škoda JS – 70 documents, including SAR Dukovany NPP - ch. 4 and ch. 15 (NPh and TH, including basic parameters of U- and Gd-pin behavior in normal conditions and in abnormal conditions, other chapter corrections, special analyses for reactor and spend fuel pond)

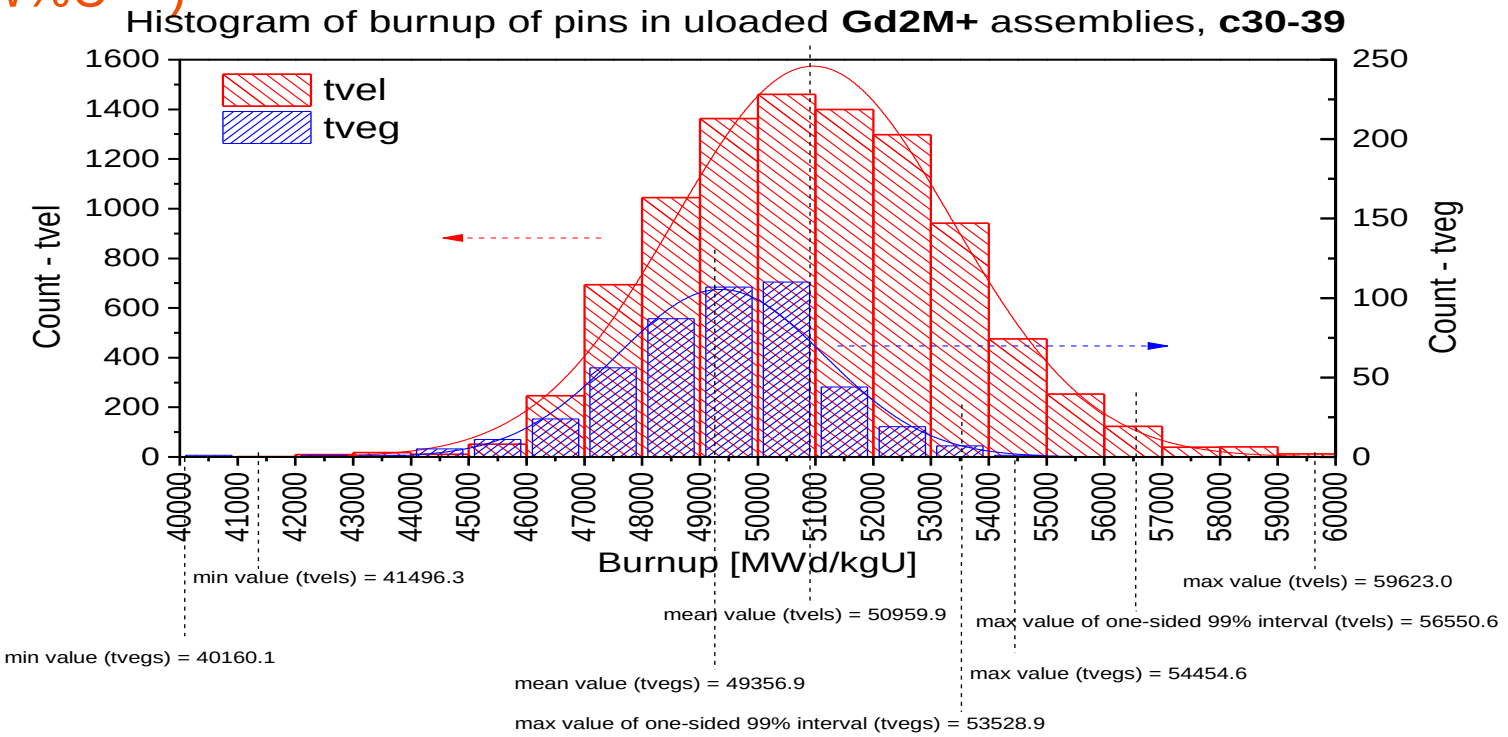
Gd-2M+ Licensing Process:
Basic Statements of SONS Permission

Permission SÚJB/ORFBA/16660/2014 25.07.2014
for fuel Gd-2M+ utilisation in Dukovany NPP:

- includes 13 requirements – ČEZ a.s. is obliged to fulfill them and to inform their fulfillment SONS
- max .pin power is limited by 59 kW
- max. Burn-up Gd2M+ by 62 MWd/kgU
- WFA nad CFA max. enrichment by 4,38+/- 0,05 % U^{235}
- Burn-up limit for Gd2-M fuel – correspond with its license
- in the case of mixed core utilisation – to fulfill specific design criteria for different fuel design

Gd-2M+ Licensing Process: Implementation Project(Škoda JS a.s.)

U-pins (Gd-pins) Burn-up Distribution in Discharged Fas (4.38w%U^{235})



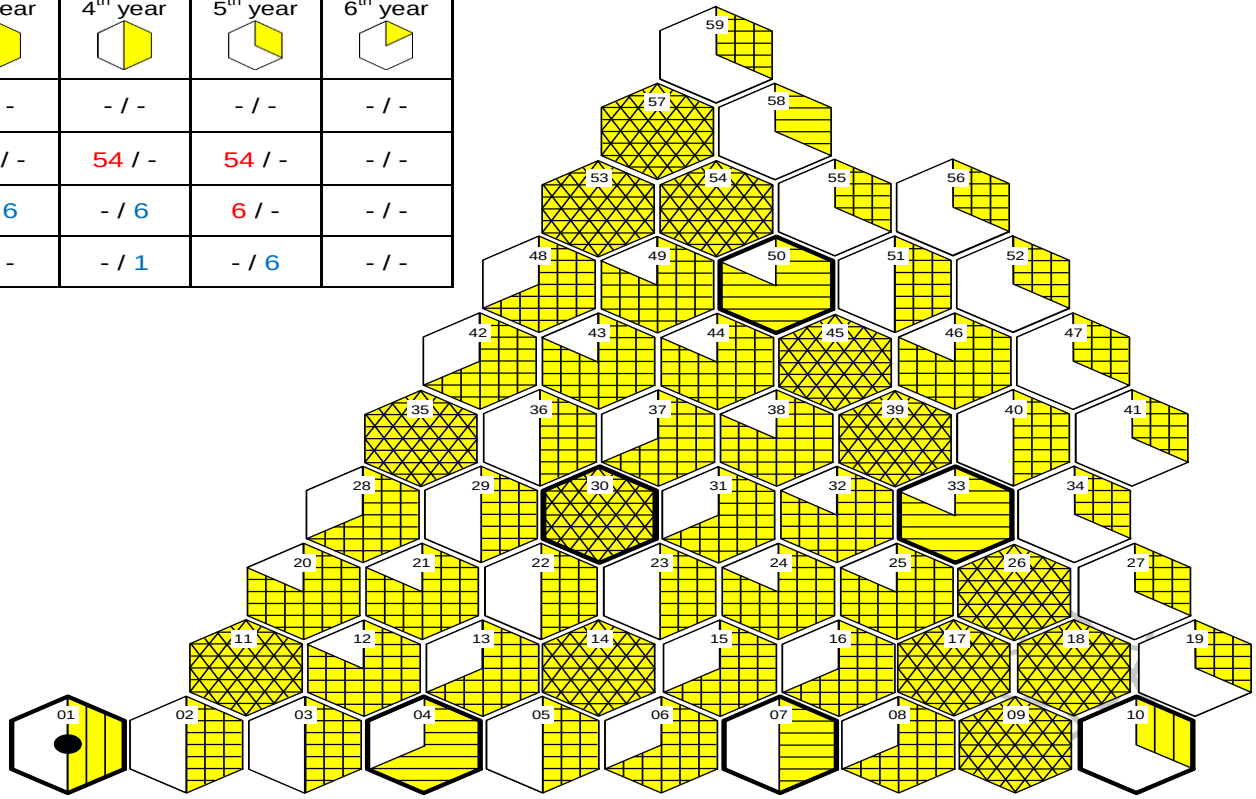
U-1 – cycle 30 – 1st transient LP with Gd-2M+

Fuel assembly / control rod assembly		fresh	2nd year	3rd year	4th year	5th year	6th year
	Gd–2M+ 4,38 %	72 / 6	- / -	- / -	- / -	- / -	- / -
	Gd–2M 4,38 %	- / -	66 / -	60 / -	54 / -	54 / -	- / -
	Gd-2+ 4,25 %	- / -	- / 12	- / 6	- / 6	6 / -	- / -
	Profiled 3,82 %	- / -	- / -	- / -	- / 1	- / 6	- / -

● - FA/CRA from Spent Fuel Pool

3,82 w/o
4,25 w/o
4.38 w/o
4.38 w/o

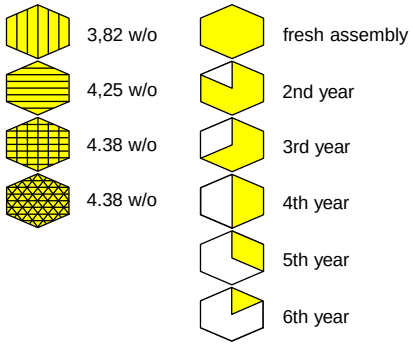
fresh assembly
2nd year
3rd year
4th year
5th year
6th year

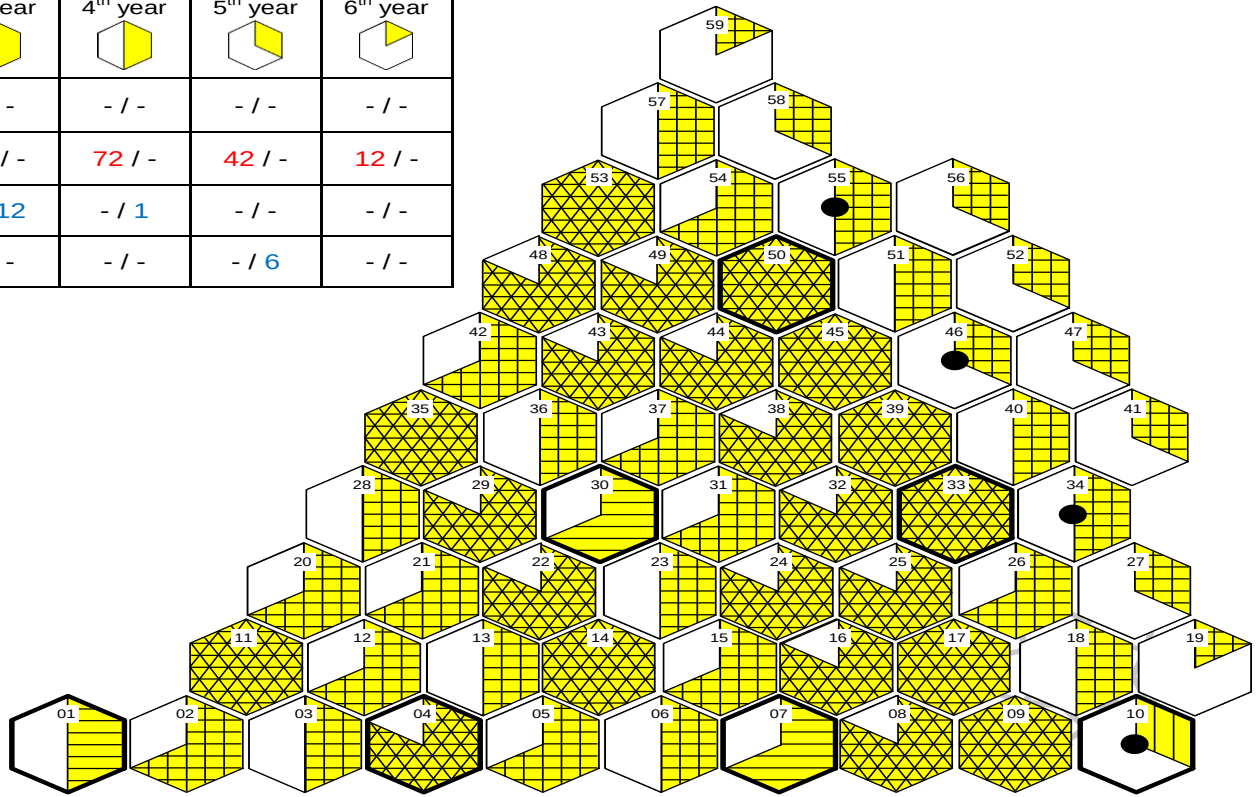


U-1 – cycle 31 – 2nd transient cycle with Gd-2M+

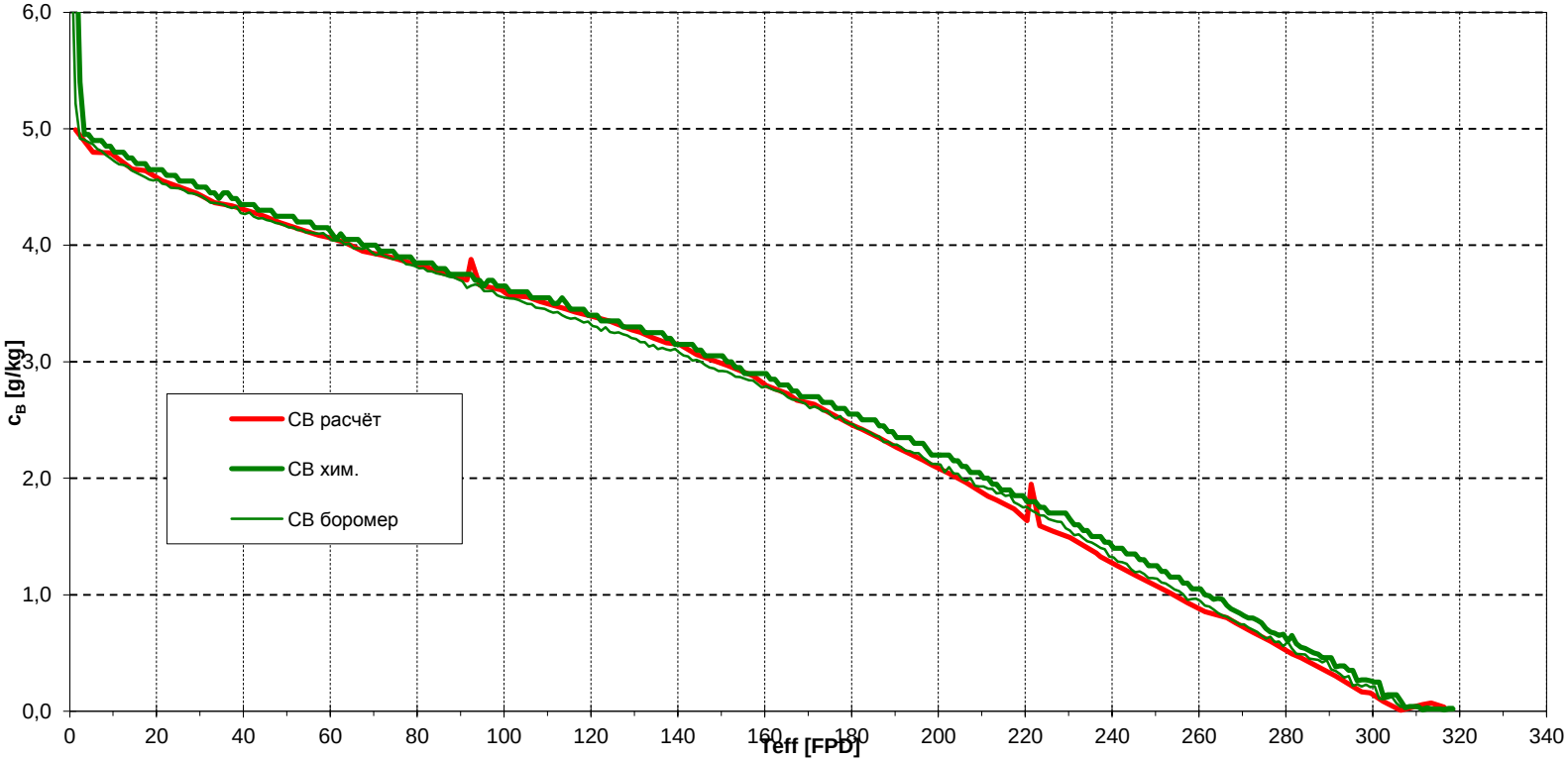
Fuel assembly / control rod assembly		fresh	2nd year	3rd year	4th year	5th year	6th year
	Gd–2M+ 4,38 %	48 / 12	72 / 6	- / -	- / -	- / -	- / -
	Gd–2M 4,38 %	- / -	- / -	66 / -	72 / -	42 / -	12 / -
	Gd-2+ 4,25 %	- / -	- / -	- / 12	- / 1	- / -	- / -
	Profiled 3,82 %	- / -	- / -	- / -	- / -	- / 6	- / -

● - FA/CRA from Spent Fuel Pool

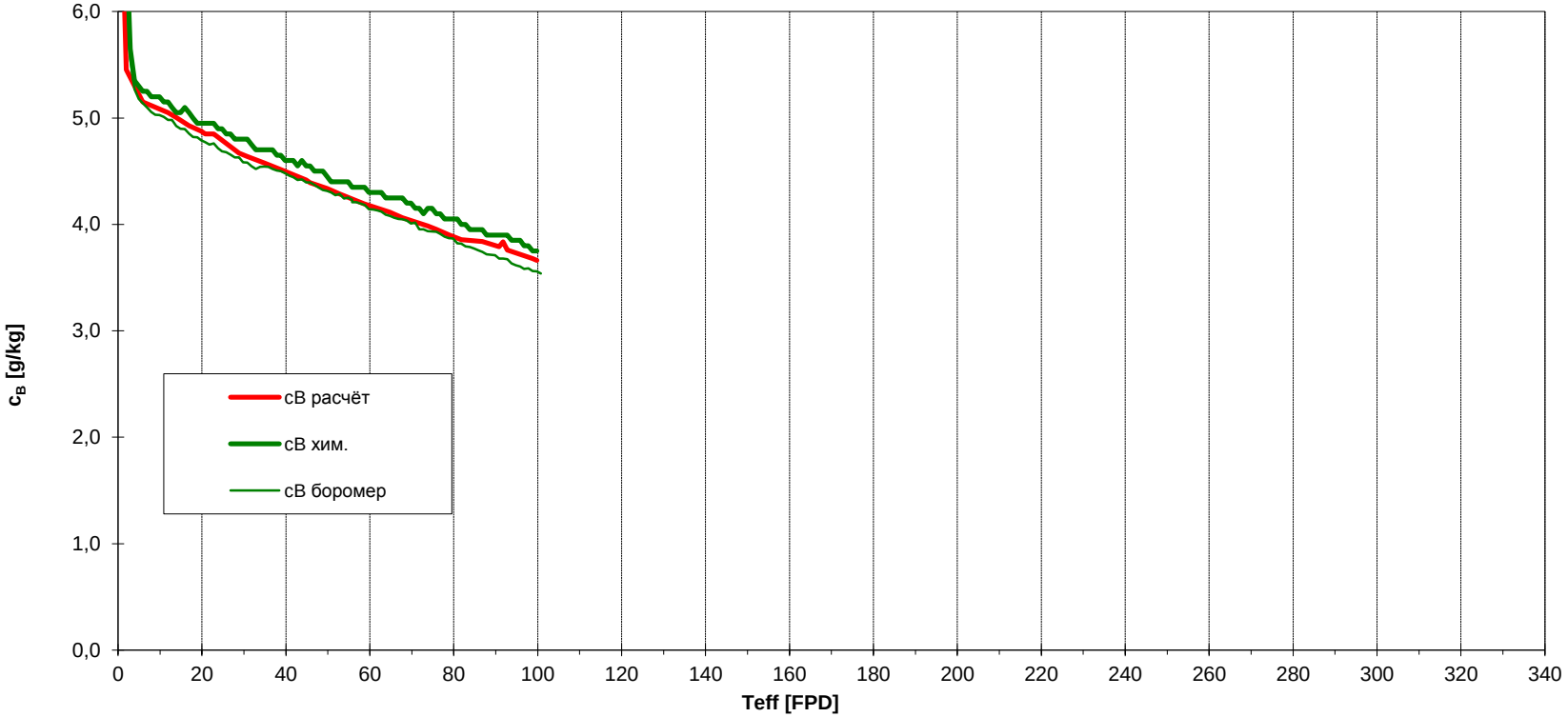




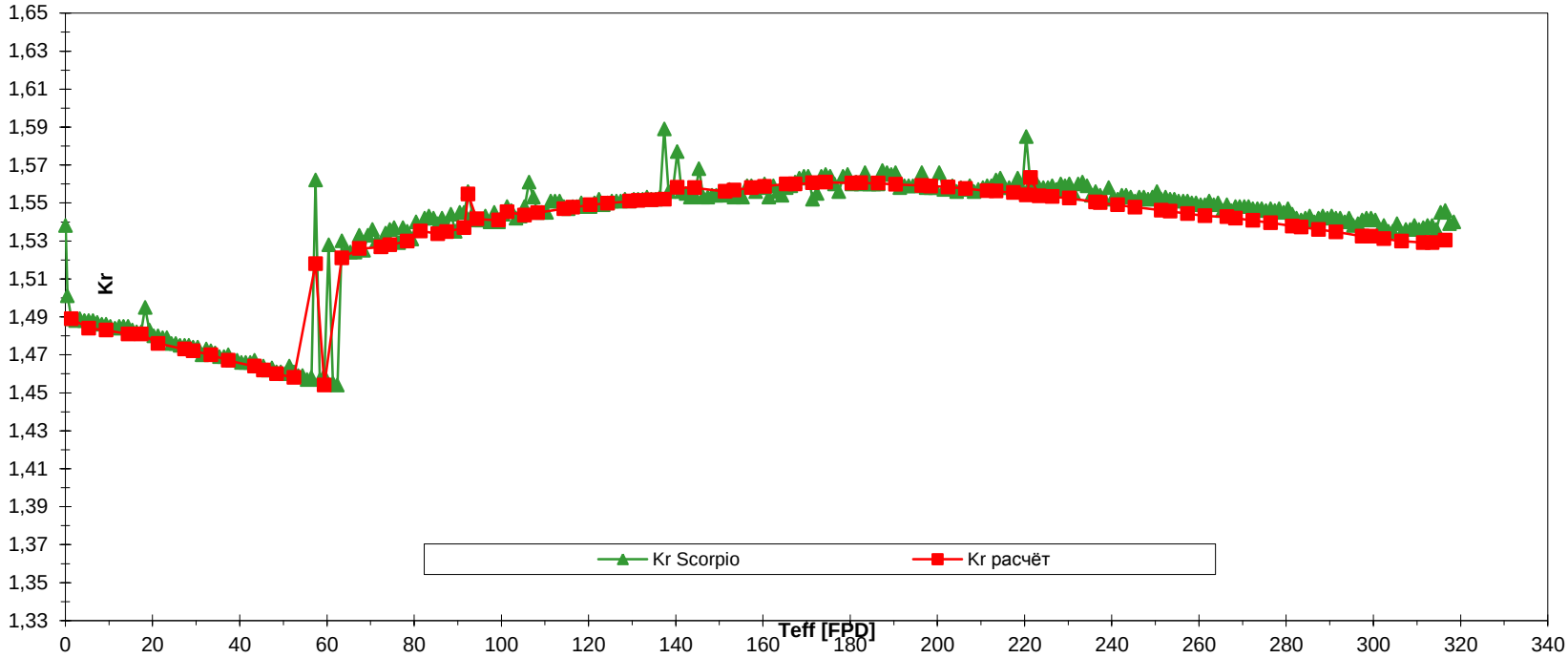
Boric Acid Letdown Curve – 1st trans.



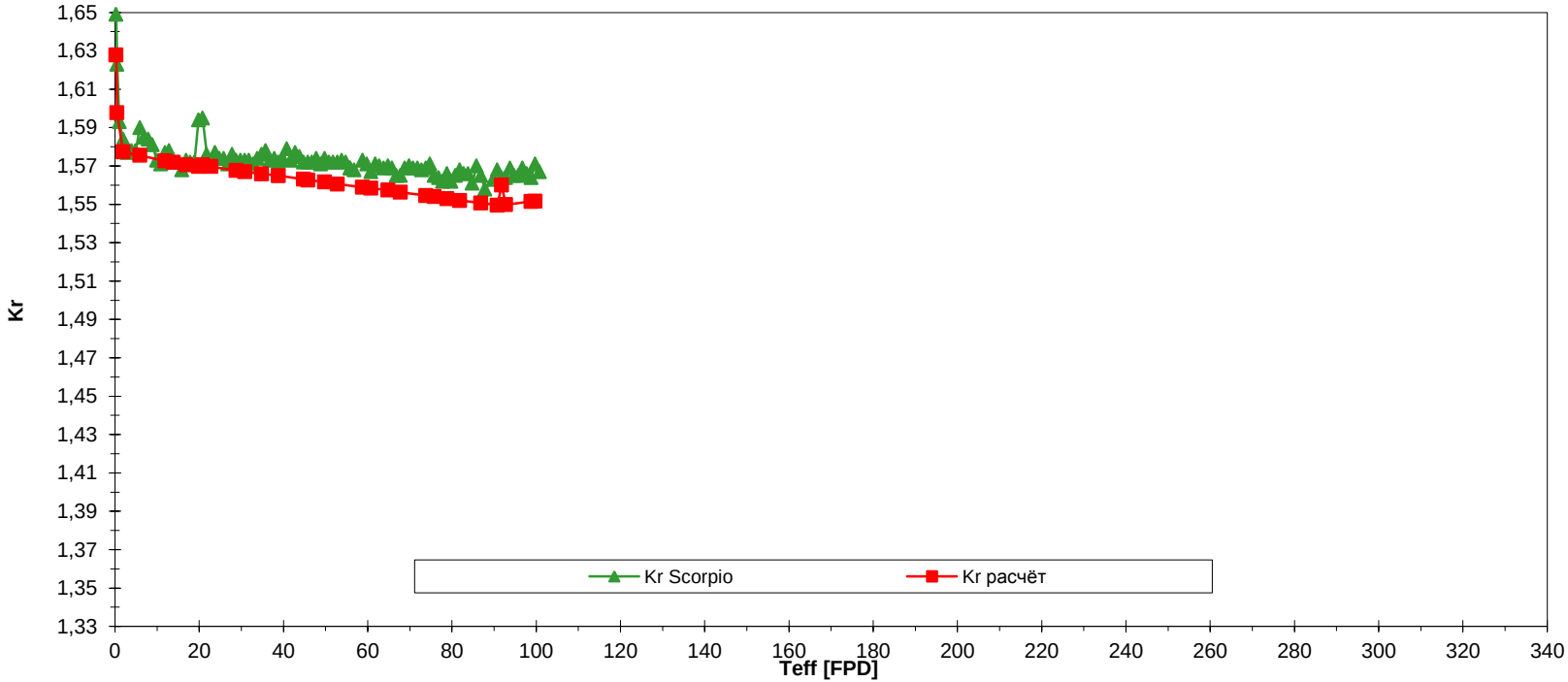
Boric Acid Letdown Curve – 2nd trans.



Kr – 1st trans.


Kr
Teff [FPD]
Kr Scorpio
Kr расчёт
1,65
1,63
1,61
1,59
1,57
1,55
1,53
1,51
1,49
1,47
1,45
1,43
1,41
1,39
1,37
1,35
1,33
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340

Kr – 2nd trans.


Kr
1,65
1,63
1,61
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1,57
1,55
1,53
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220
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280
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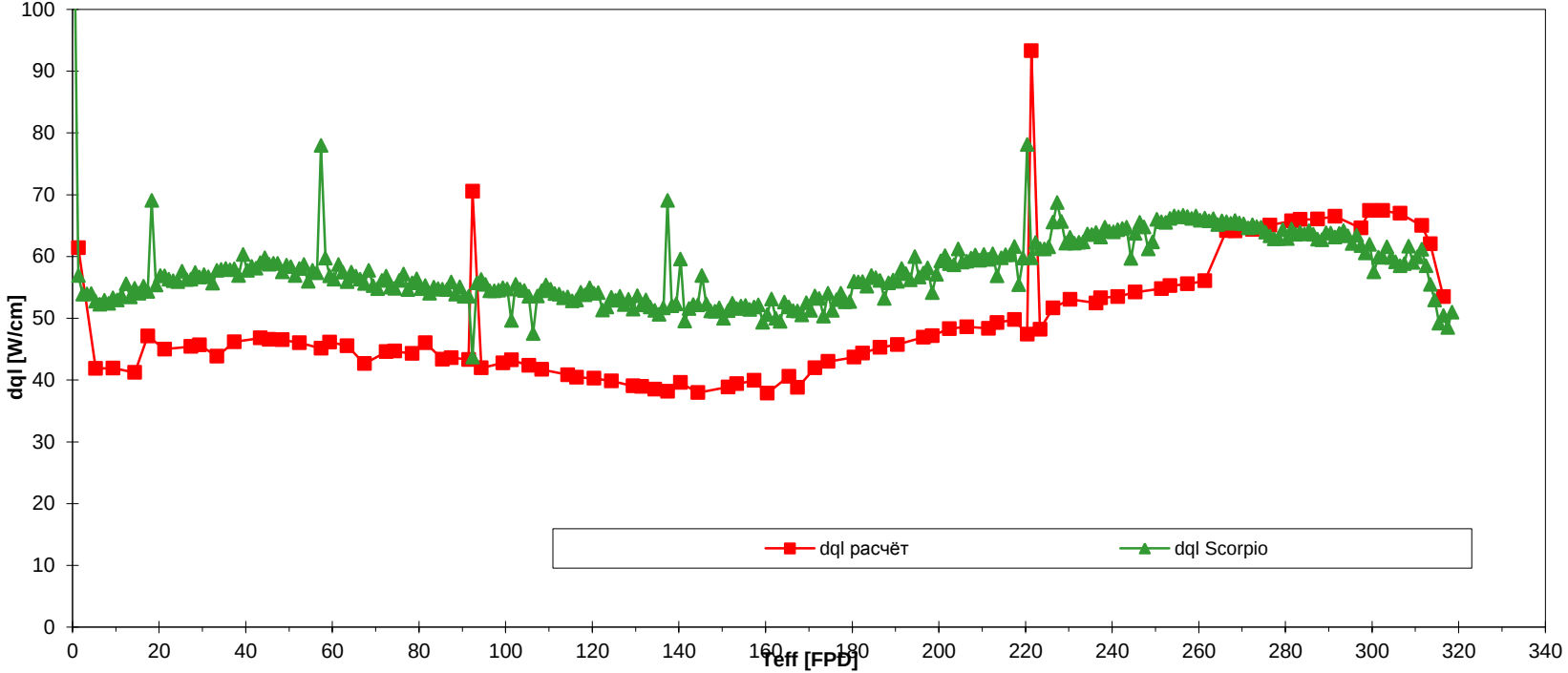
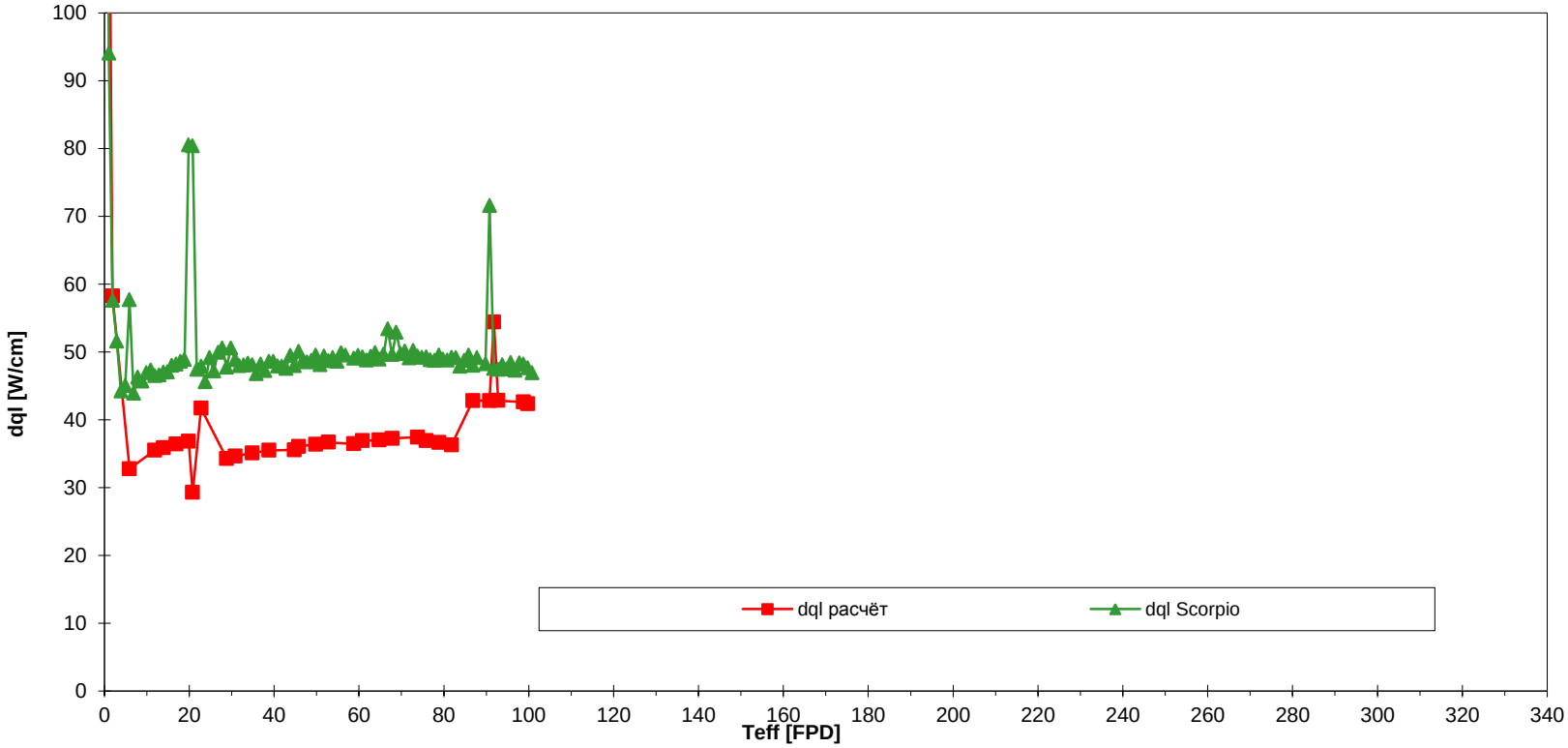
340
Teff [FPD]
Kr Scorpio
Kr расчёт

Minimal Reserve to the Linear Power Limit – 1st trans.



Minimal Reserve to the Linear Power Limit – 2nd trans.



Conclusions

1. Gd-2M+ fuel was licensed successfully thanks to tight and proper cooperation of the Fuel Supplier and the Customer.

2. Gd-2M+ fuel was operated during 1st and 2nd transient cycles successfully without unexpected behavior (including ADF) and it confirmed high quality of supplied fuel.

3. Core monitoring system SCORPIO assisted in reliable core and unit operation.

Thank you for your attention.