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Results of CLEVASOL Sorbent Testing at FSUE Mayak PA

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Test object: liquid high-level waste

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Monitored parameter	Unit	Value
Cs-137	Bq/L	$(2\text{-}5)\cdot10^{10}$
Cs-134		$(2\text{-}3)\cdot10^{8}$
∑α		$(1\text{-}100)\cdot10^{4}$
∑β		$(2\text{-}6)\cdot10^{10}$
Total dissolved solids	g/L	400-450
Al		4.3
Na		162
Fe		0.3
Cr (CrO4)		2
Ca		3
Mg		0.8
Si		0.4
NO_3^-		161

CLEVASOL sorbent description

Full capacity (min.): 5,4 meq/g (H+ form)

Humidity: 45-55% (H+ form)

Grain Size: 200±100 μm

Iron Impurity (max): 50 ppm

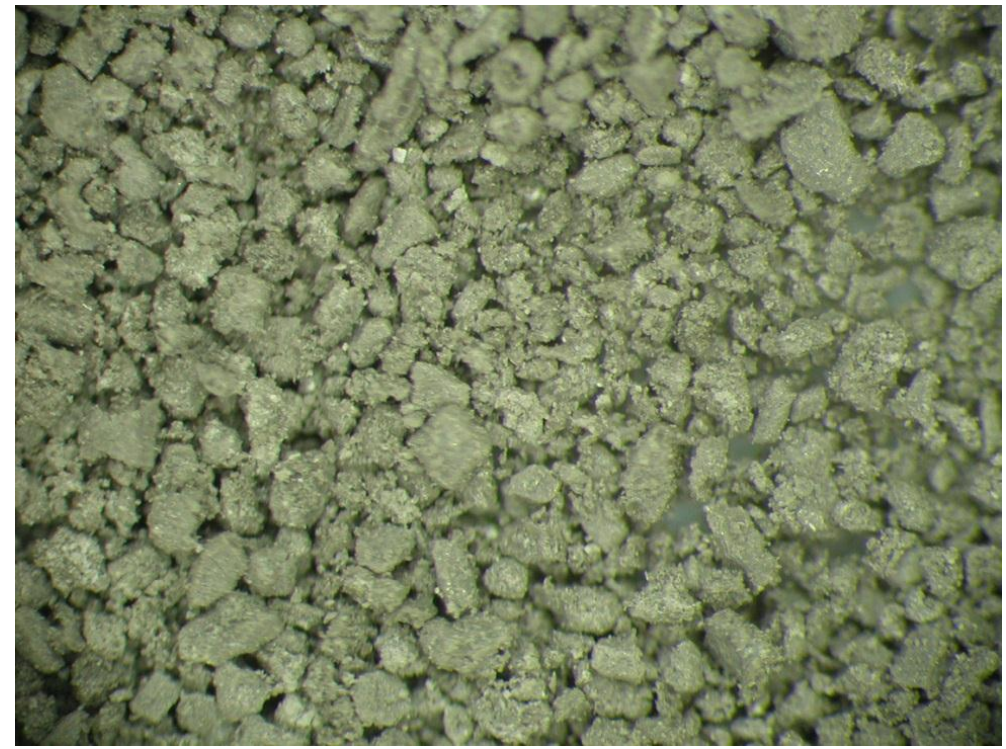
Sodium Impurity (max): 40 ppm

Heavy Metall Impurity (max): 40 ppm

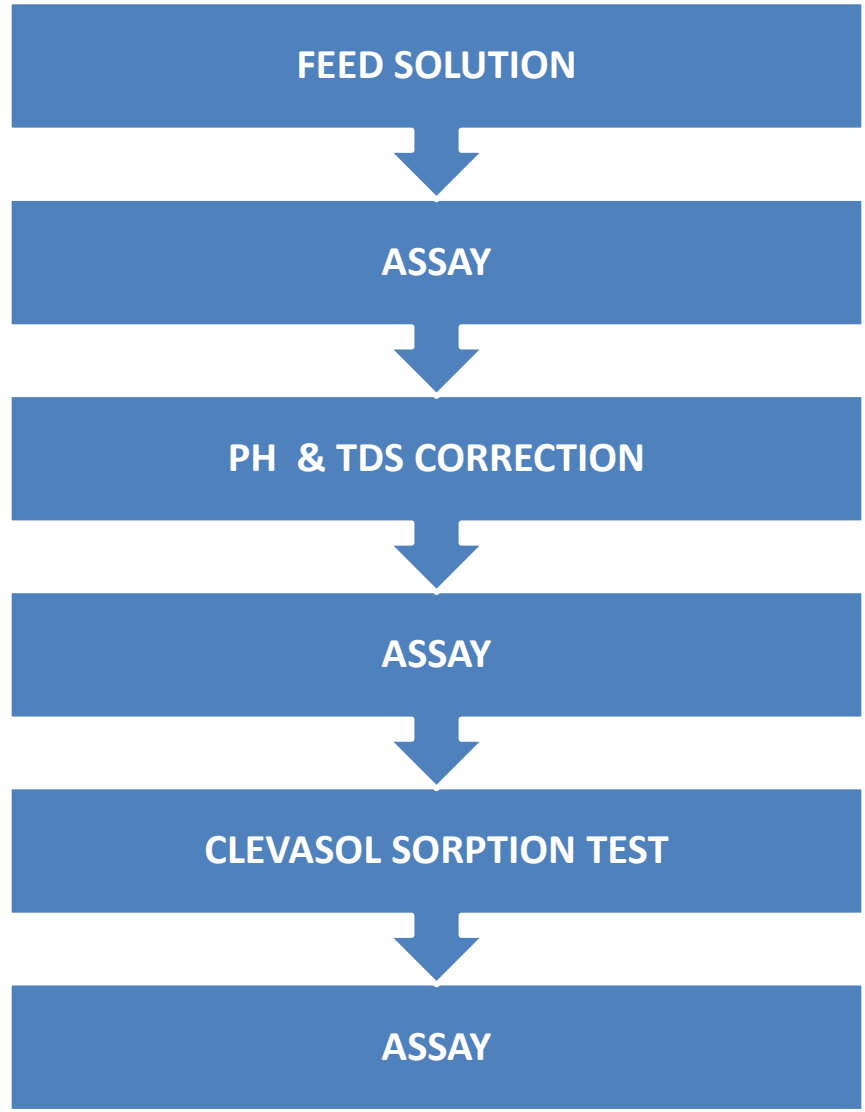
Maximum Temperature: 160 °C

Density (approx.) (H+ form): 550 g/L

Insoluble in water, acids, alkalis in pH range from 0 to 14 and organic solvent



Plan of experiments



10-fold dilution for pH adjustment and competitive Na^+ concentration reduction

CLEVASOL static sorption test with simulated solution

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Simulated solution

Waste Component	Concentration, mg/L			
	pH=12		pH=9	
	Feed Solution	Filtrate	Feed Solution	Filtrate
Na	9,900	3,064	8,650	5,310
Cs	5	0.281	1.9	<0.3

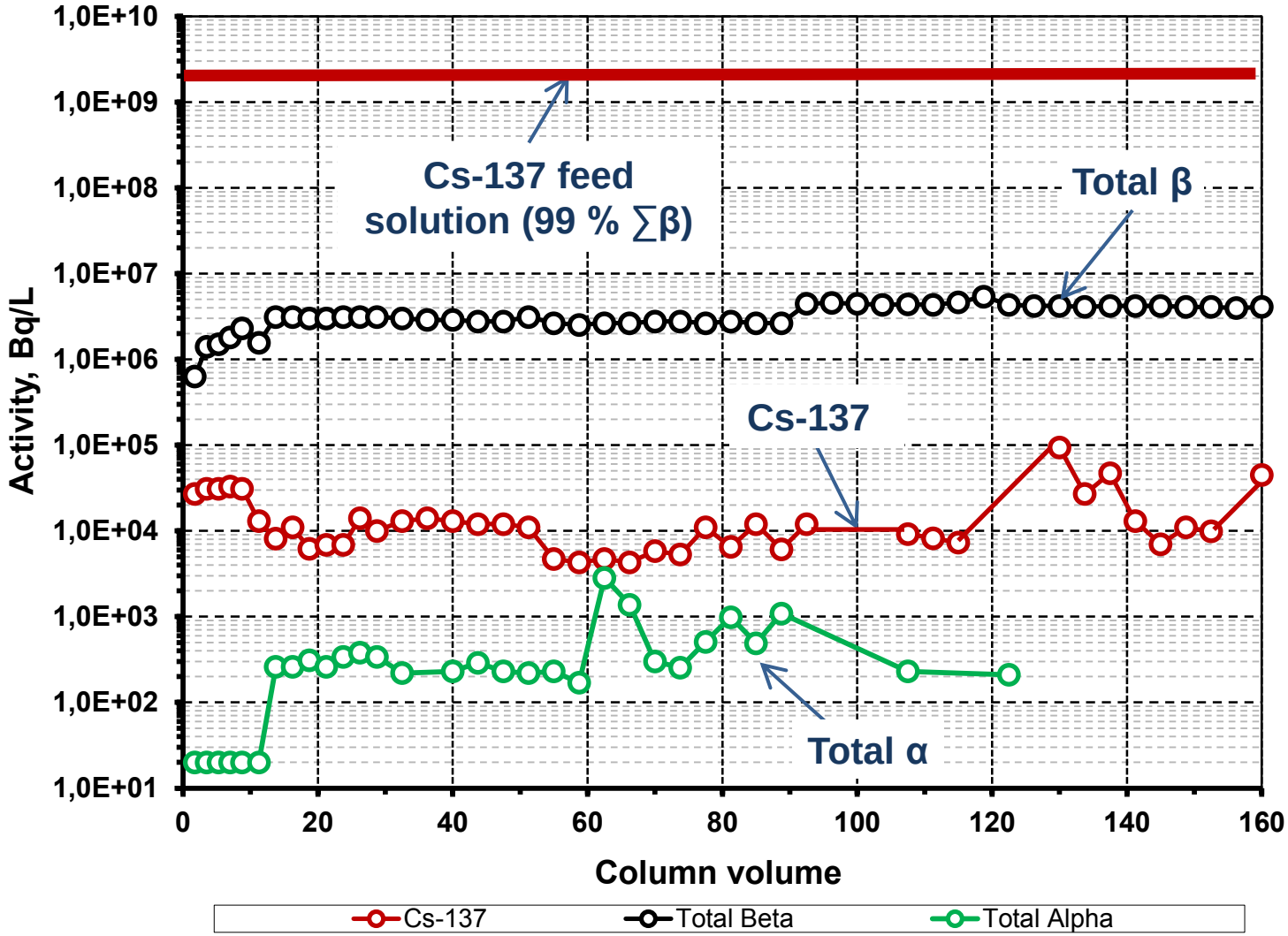
Solids : liquid = 1:10 Decontamination factors (DF) derived: 18 (94.4 %) for Cs

Active solution

Waste Component	Specific activity, Bq/L			
	pH=12		pH=9	
	Feed Solution	Filtrate	Feed Solution	Filtrate
Cs-137	$4.2 \cdot 10^9$	$2.0 \cdot 10^8$	$4.2 \cdot 10^9$	$1.7 \cdot 10^9$
∑β	$3.4 \cdot 10^9$	$9.4 \cdot 10^7$	$3.4 \cdot 10^9$	$1.7 \cdot 10^8$

Solids : liquid = 1:10
Decontamination factors (DF) derived: 21 (95.2 %) for 137Cs
36 (97.2 %) for ∑β

CLEVASOL dynamic sorption test with HLW solution (test 1)



Feed solution

$1.7 \cdot 10^9$ Bq/L ^{137}Cs

$1.2 \cdot 10^7$ Bq/L ^{134}Cs

$6.0 \cdot 10^6$ Bq/L ^{125}Sb

$2.6 \cdot 10^6$ Bq/L ^{106}Ru

pH ~ 10.0

Averaged test results:

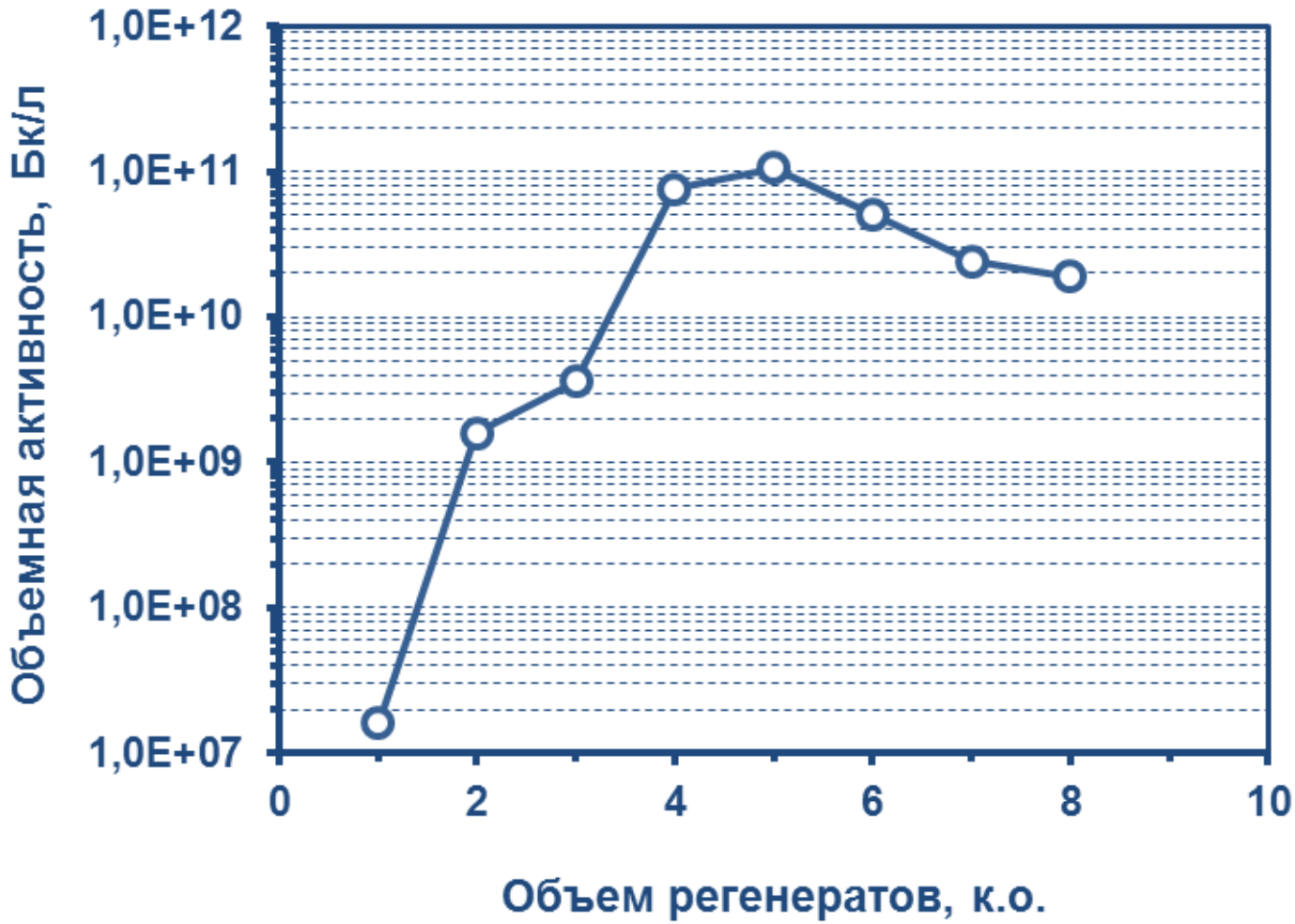
~ $7.4 \cdot 10^4$ Bq/L ^{137}Cs, DF = 23,000 (99.996 %)

~ 4,500 Bq/L ^{134}Cs, DF = 2,700 (99.96%)

$5.4 \cdot 10^5$ Bq/L ^{125}Sb, DF ~ 11 (91 %)

practically no decontamination in terms of ^{106}Ru, ^{144}Ce

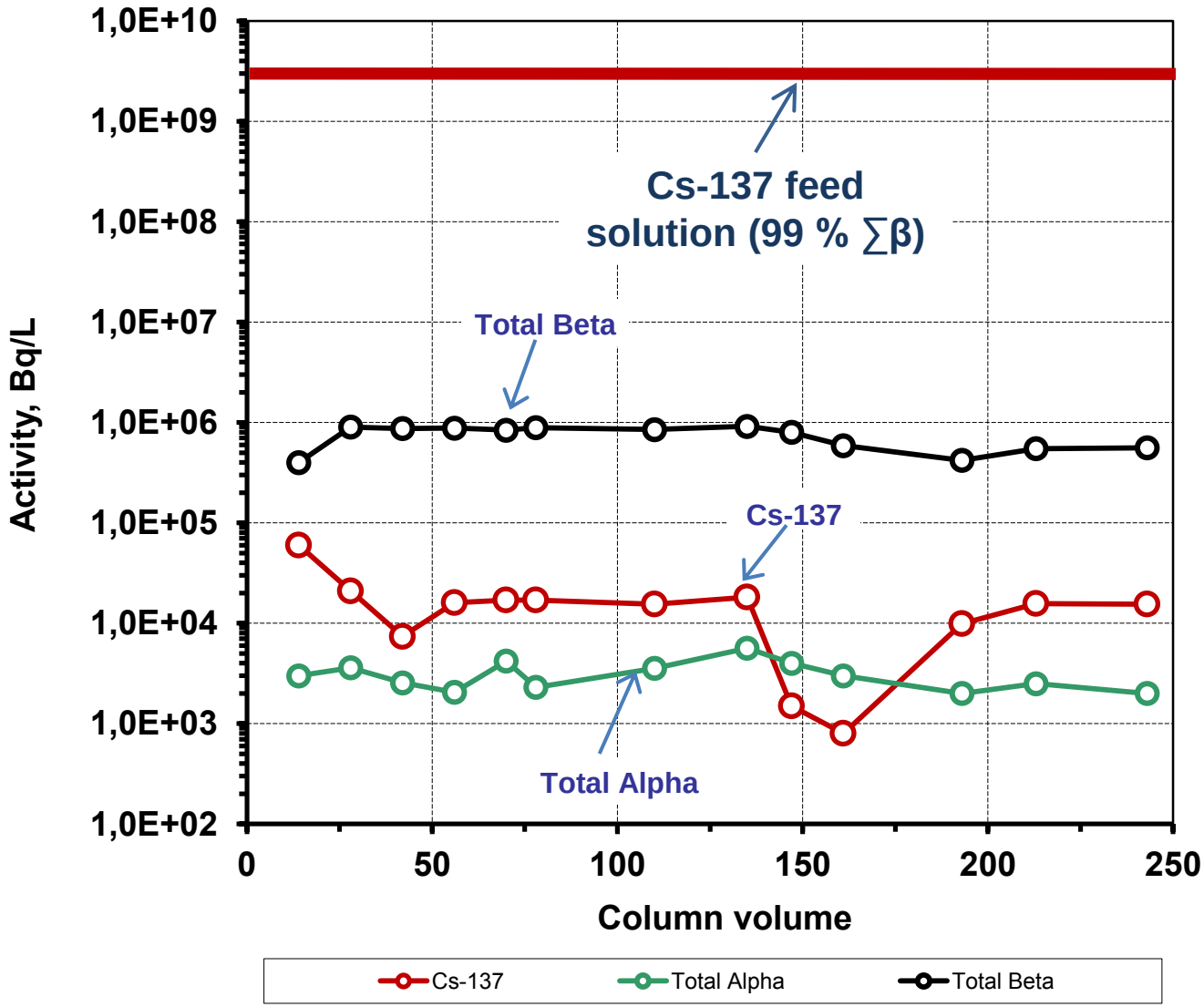
CLEVASOL regeneration (test 1)



98% Cs-137 were removed with wash-off solution

Filter MED decreased from 600 μR/s to 10 μR/s after regeneration

CLEVASOL dynamic sorption test with HLW solution (test 2)



Feed solution

4.1· 10^9 Bq/L ^{137}Cs

5.7· 10^7 Bq/L ^{134}Cs

pH ~ 13.3

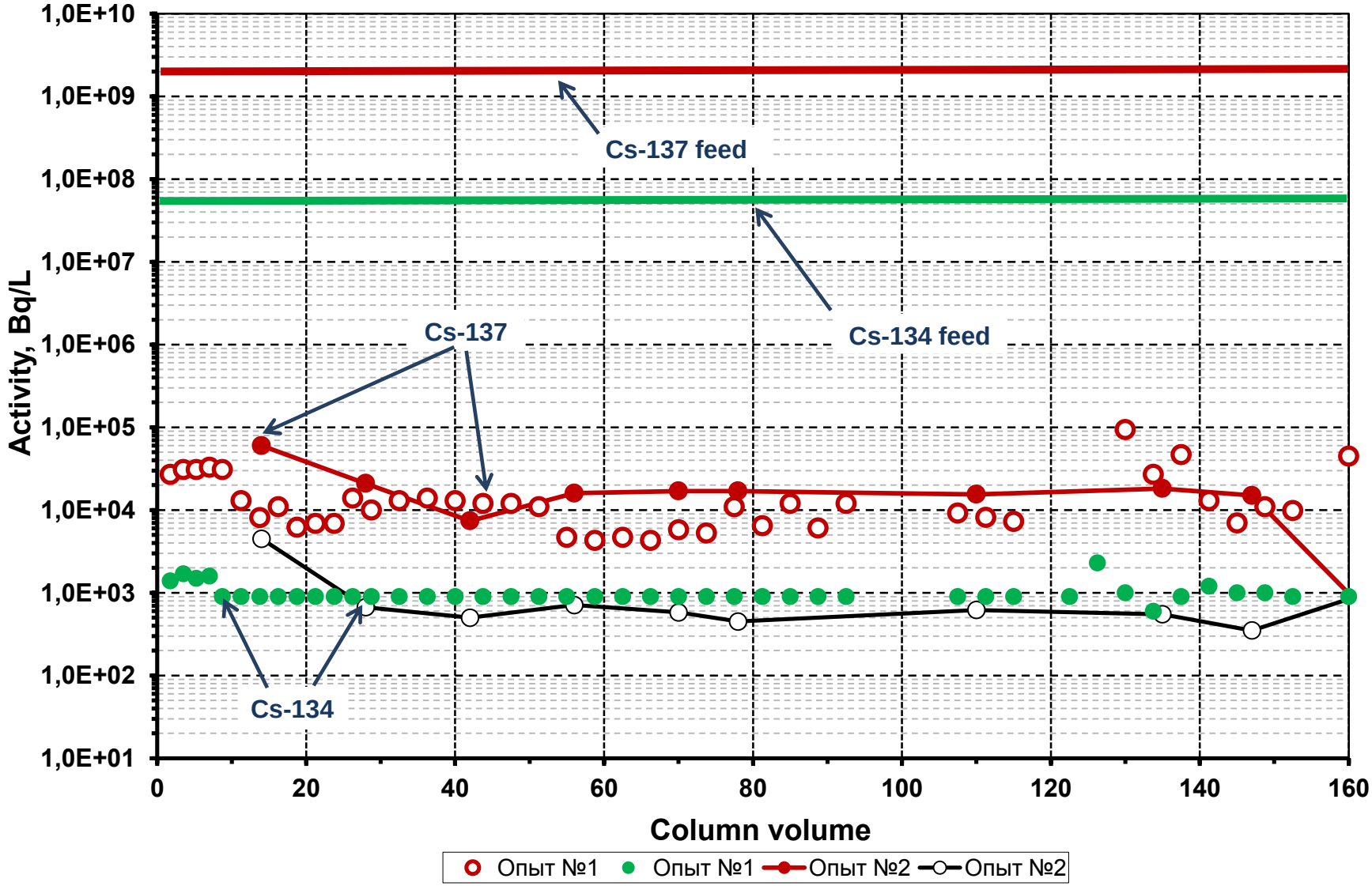
Averaged test results:

Filtrate activity

~ 1.8·10^4 Bq/L ^{137}Cs, DF = 300,000 (99,999%)

< 900 Bq/L ^{134}Cs, DF ~ 150,000 (99,999 %)

Comparison of HLW solution purification degree resulting from tests 1 and 2



Testing results summary

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Static tests	Dynamic tests	
	pH 10	pH13
Solid/liquid = 1/10	Filter cycle 160 column volumes	Filter cycle 240 column volumes
Cs-137 DF ~ 20	Cs-137 DF ~ 23,000	Cs-137 DF ~ 300,000
Contact period: one day	Filtration rate ~ 1 to 5 column volumes	Filtration rate ~ 1 to 5 column volumes
Average activity $2.0 \cdot 10^8$ Bq/L	Average activity of the filtrate $7.4 \cdot 10^4$ Bq/L	Average activity of the filtrate $1.9 \cdot 10^4$ Bq/L
K_d = 200	Sorbent activity $2.5 \cdot 10^8$ Bq/g (6.8 Ci/kg)	Sorbent activity $4.0 \cdot 10^8$ Bq/g (10.8 Ci/kg)

Dynamic examinations of the CLEVASOL sorbent in test 1 were terminated because of the radiation safety requirements (MED 600 μR/s). Sorbent capacity was not completely exhausted. Dynamic examinations of the CLEVASOL sorbent in test 2 are in progress.

Dynamic tests of the CLEVASOL sorbent demonstrated decontamination factors (DF) up to 10^6 in terms of Cs-137.

Future sorbent application

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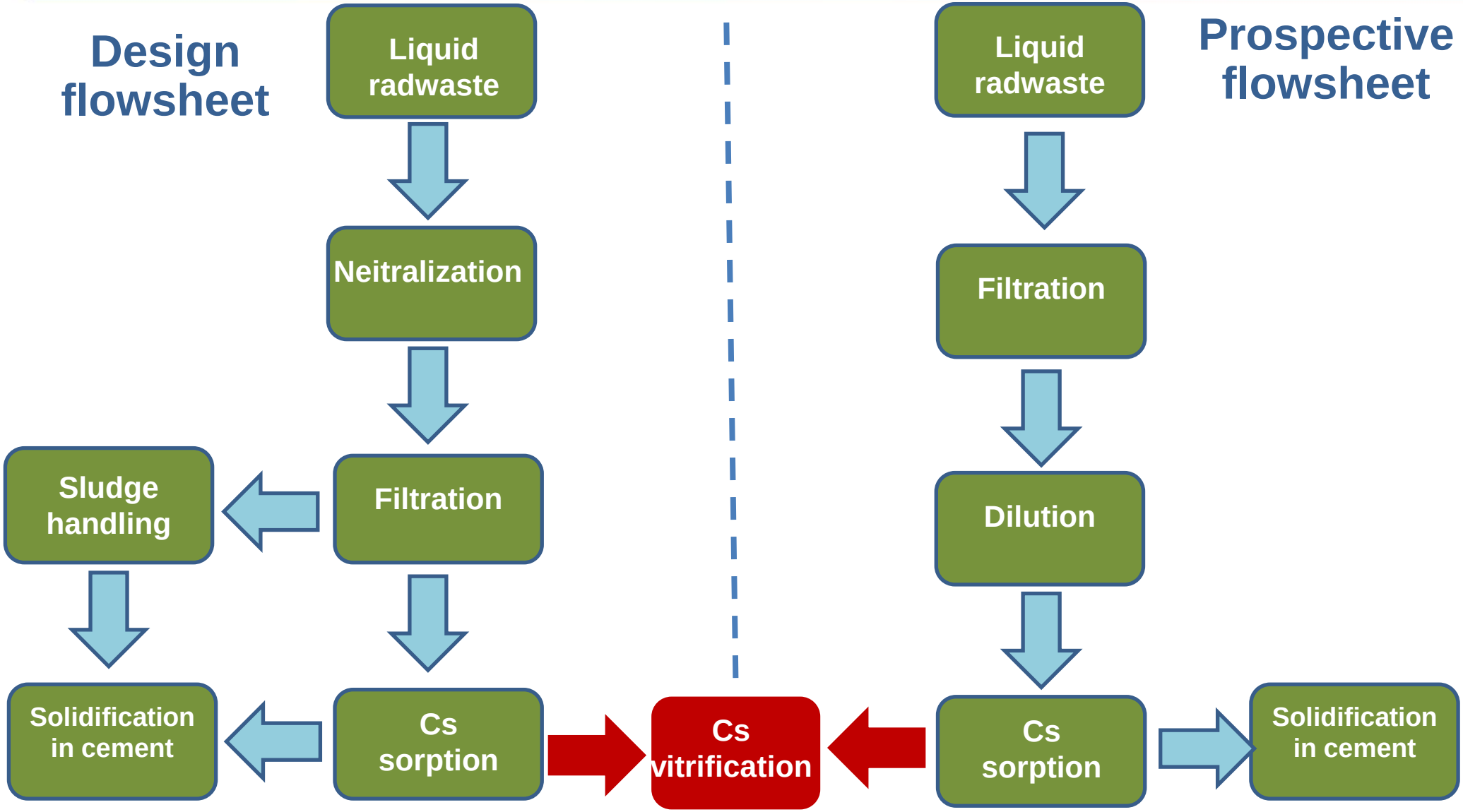

Conclusion

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Preliminary results of CLEVASOL sorbent tests can be considered as quite successful. Study of CLEVASOL sorbent are to be continued to specify its features and conditions (limits) of its applicability:

- effect of interfering cations (K, NH_4),
- radiation stability,
- chemical durability,
- regeneration efficiency, number of sorption/desorption cycles,
- spent sorbent management methods.

Successful implementation of the above mentioned tasks will allow large-scale reprocessing of legacy HLW.

Thank you for your consideration!