

Gold recovery using a 6-column cascade scheme

Project goal

- Continuous sorption of gold on ion exchange resin MTA9920 (Purolite) in two parallel lines of six columns
- Through-hole recovery of at least 99% with a slurry flow rate of 120 m³/h and a total resin volume of 140 m³ (2 × 70 m³)
- The object is the Akbakai deposit (Zhambyl region): quartz-vein ores with free gold, sorption from cyanidation pulp
- Technological scheme and equipment are the property of Chemsol LLP (Chemsol)
- Sorption site operation services: control of operating parameters, resin working capacity and design recovery indicators

Sorption Site Feed · Akbakai Field, Zhambyl Oblast

Parameter	Value	Unit
Raw material base	Akbakai, quartz-vein ore	—
Preparation before sorption	Grinding + Gravity + Cyanidation	—
Pulp Capacity	120 (2 × 60)	m ³ /h
Solid content in the pulp	40	% wt.
Au content in the liquid phase	0,60	mg/l
Au content in the original ore	0,85	g/t
Concentration of free CN ⁻	150–250	mg/l
Pulp pH	10,2–10,8	—
Pulp temperature	18–32	°C
Grind coarseness, P ₈₀	74	μm
Working hours	330 days × 24 hours	—

Principle of resin sorption

Two options for organizing the process: resin in pulp and resin in leaching

Resin in Pulp (RIP)

Sorption from the deslimed leached pulp after cyanidation is completed. The leaching circuit and sorption are separated.

Resin in leaching (RIL)

The resin is injected directly into the leaching circuit: sorption runs parallel to the dissolution of gold.

Mechanism of sorption

- The dicyanoaurate ion $\text{Au}(\text{CN})_2^-$ is absorbed by the strongly basic anion exchange resin by the reaction $\text{R}-\text{Cl} + \text{Au}(\text{CN})_2^- \rightarrow \text{R}-\text{Au}(\text{CN})_2 + \text{Cl}^-$
- Counterflow: the slurry moves up the cascade, the saturated resin is taken from the head column, the regenerated resin is fed into the tail column
- Advantages over activated carbon sorption (CIP): resistance to organic poisoning, low mechanical wear, efficiency on clay slurries

Cascade scheme: two lines of 6 columns each

In each line, counter-flow: K-1 → K-6 pulp, K-6 → K-1 resin

Slurry flow $2 \times 60 \text{ m}^3/\text{h} \rightarrow$

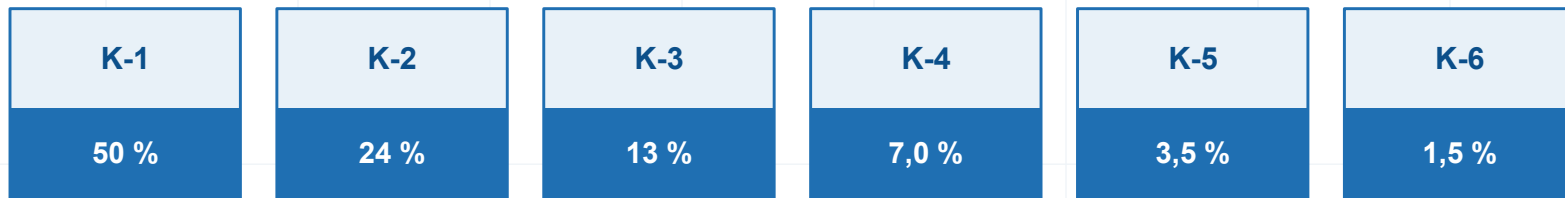
Line 1

70 m³ of resin



Line 2

70 m³ of resin



0.30 mg/l

0.16 mg/l

0.078 mg/l

0.036 mg/l

0.015 mg/l

0.006 mg/l

← Resin flow $2 \times 2.0 \text{ m}^3/\text{day}$

The lines are identical and operate in parallel: 60 m³/h of slurry and 70 m³ of resin per line; the numbers at the bottom are the residual Au at the outlet of the stage.

Saturated resin from both lines goes to a common desorption and electrolysis unit; either line is shut down separately.

Resin Parameters MTA9920

Strongly basic anion exchange resin, gold-selective

Indicator	Value	Unit
Matrix Type	polystyrene-DVB, gel	—
Functional group	Quaternary ammonium	—
Average pellet diameter	0,60–0,85	mm
Bulk density	670–700	kg/m ³
Operating Capacity by Au	4,0–6,0	kg/m ³ of resin
Design Resin Loading	0,43	kg Au/m ³
Resin volume (2 lines)	140 (2 × 70)	m ³
Resin Transfer	4,0 (2 × 2,0)	m ³ /day
Resin residence time	35	Days
Permissible abrasion	≤ 2	% per year

Cascade hydraulics

Upward Slurry Flow, Fluidized Resin Bed

7.5 m/h

Linear Pulp Velocity

15–20 %

Resin layer expansion

0.25 - 0.40 bar

Pressure drop on the string

1.8 - 2.4 bar

Total cascade head

47 min

Contact Time Per Step

25 % vol.

Resin retention in the column

- Phase separation – slotted screens with a gap of 0.4 mm; resin is retained, slurry passes freely
- Interstage resin transport – by airlifts, 1 cycle per day, 2.0 m³/day per line, carryover of no more than 8 g/t of ore
- Periodic backwashing of screens to prevent overgrowth and pressure drop growth

Column dimensions

Twelve identical machines: two lines of six

Parameter	Value	Unit
Number of columns	12 (2 lines × 6)	pcs.
Line load	60	m ³ /h
Inner Diameter	3,2	m
Cross-sectional area	8,04	m ²
Overall Body Height	7,2	m
Height of the working area	5,8	m
Single Column Displacement	46,6	m ³
Total Displacement	559	m ³
Volume of resin in the column (25% vol.)	11,7	m ³
Resin volume per line / total	70 / 140	m ³
Body Material	steel 09G2S + gumming	—

Material balance of gold

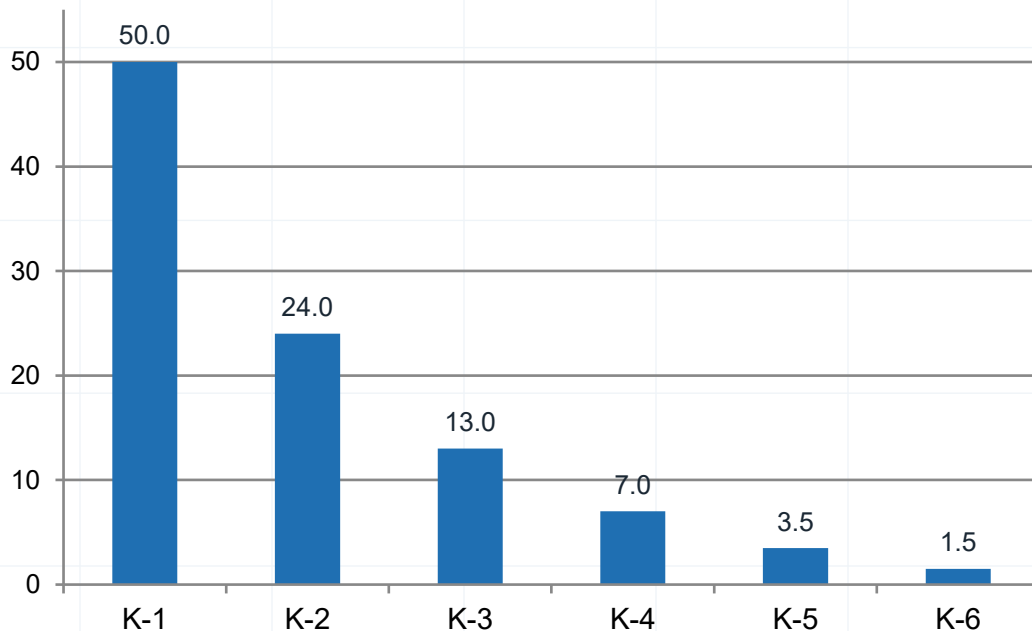
Daily balance of the site, 2,880 m³/day on two lines

Torrent	Volume	C(Au)	Au, kg/day	Share
Pulp for sorption	2,880 m ³	0.60 mg/l	1,73	100 %
Sorption tailings	2,880 m ³	0.006 mg/l	0,02	1,0 %
Resin-Sorbed	4.0 m ³	428 g/m ³	1,71	99,0 %
Tar losses (carryover)	—	—	0,01	0,6 %
Marketable product (after desorption)	—	—	1,70	98,4 %

The balance is given for the site as a whole; each line accounts for half of the flows: 1,440 m³ and 0.86 kg Au per day.

Extraction distribution by stage

Contribution of each column to end-to-end extraction



99,0 %

End-to-end Cascade Extraction

- The first two columns provide 74% of the recovery - they bear the main load on the resin.
- K-5 and K-6 work as polishing agents: the contribution is 5%, but they are the ones who set the quality of the tailings of 0.006 mg/l.
- The profile is the same for both lines: 70 m³ of resin at 60 m³/h gives 47 min of contact per stage.

Daily and annual indicators

Working hours 330 days a year

2,880 m³

pulp processing, day

1.71 kg

gold sorbed, day

2 × 2.0 m³

resin transfer, day

950,000 m³

Pulp processing, year

564 kg

gold sorbed, year

45.2 t

NaCN consumption, year

- The annual gold output at the sorption site is about 0.56 tons with a recovery of 99.0%
- Maintenance is done line by line: shutting down one line retains 50% of site capacity
- Annual fresh resin feed – 2.8 m³ (2% of cascade load) to compensate for wear

Technological limitations

Boundaries of stable cascade operation

Factor	Limitation	The consequence of going beyond the limit
Pulp pH	9,5–11,0	HCN release, cyanide loss
Temperature	15–35 °C	Thermal degradation of resin above 40 °C
Solid content	≤ 45% wt.	Increase in pressure drop, clogging of screens
Feed size	$P_{80} \leq 100 \mu\text{m}$	Classification of resin, carryover
Competing ions	Cu, Fe, Ni, Zn, SCN^-	Reduced Au Operating Capacity
Gravity gold	recovered before sorption	Coarse Au is not absorbed, it goes into tails
Feed slimes	≤ 15% of the cell –20 μm	Clogging of screens, tar carryover
Upflow Speed	≤ 12 m/h	Resin carry-over
Mechanical wear of resin	≤ 2 %/year	Rising replenishment costs

Conclusions

Main results of the scheme development

Scheme confirmed

Two lines of six columns with 140 m³ of MTA9920 resin (2 × 70) yield 99.0% recovery at 0.60 mg/l feed and 0.006 mg/l tailings.

Equipment Defined

Two lines of six columns Ø 3.2 × 7.2 m: 70 m³ of resin per line, 11.7 m³ per apparatus.

Indicators calculated

1.71 kg Au/day and about 564 kg Au/year for 330 days.

What do two lines give?

Redundancy and load flexibility at the cost of doubling valves and instrumentation; resin loading 0.43 kg Au/m³.