REMOVAL OF COPPER AND ZINC FROM A COBALT ELECTROLYTE 
BY ION EXCHANGE AT KAMOTO COPPER COMPANY’S LUILU PLANT

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ABSTRACT

The Luilu cobalt plant at Kolwezi, Democratic Republic of Congo, has been operating since the 
late 1950s, using a conventional precipitation flowsheet for removal of impurities from the cobalt process 
stream. Most impurities are, however, incompletely removed using this technology. Copper and zinc, both 
of which quantitatively deposit at the cathode in the cobalt electrowinning process, are two of the main 
impurities contaminating the cobalt metal product. Ion exchange offers a modern approach to removing 
these impurities from the cobalt advance electrolyte.

Following a laboratory testwork programme to identify a suitable ion-exchange system, an on-site 
pilot-plant trial, treating 1500 to 3000 L/d of electrolyte, was operated for a period of six weeks to optimise 
the operating conditions and to determine full-scale design criteria. Copper removal was carried out using a 
fixed-bed lead-polish configuration with the Lanxess iminodiacetic acid resin, TP 207. Zinc removal was 
subsequently carried out in a similar configuration using the Lanxess aminophosphonic acid resin, TP 260. 
The optimised system proved capable of removing both copper and zinc from 20 to 30 mg/L to <1 mg/L 
from plant electrolyte containing ~20 g/L Co. Selective elution allows co-loaded cobalt to be returned to 
the main circuit and value to be obtained for the copper impurity. The process shows operational and 
economic advantages over the traditional flowsheet. Full-scale implementation of the developed process is 
in progress and some design considerations are discussed.

KEYWORDS

Luilu, ion exchange, cobalt, copper, zinc, TP 206, TP 207, pilot plant, design
INTRODUCTION

The Luilu cobalt plant at Kolwezi, Democratic Republic of Congo (DRC), has been operating since the late 1950s (Bouchat and Saquet, 1960), but subsequently fell into considerable disrepair and disuse due to lack of investment in the war-torn country. In 2008, Glencore-owned Katanga Mining took over ownership of this operation, and considerable refurbishment and upgrading of the processing plant has since been undertaken. One initiative involves improving the quality of the cobalt cathode.

The Luilu flowsheet employs conventional precipitation for removal of impurities from the cobalt process stream (Fisher, 2011). Iron and copper are removed under pH-controlled conditions using milk of lime, after which zinc is removed by H₂S precipitation. In addition to employing a toxic chemical, the sulfide precipitation is unselective and does not go to completion: the zinc precipitation tailings residue typically contains ~1% Zn and ~20% Co. Copper and zinc are two of the main impurities reporting to the cobalt advance electrolyte. These elements quantitatively deposit at the cathode in cobalt electrowinning, thereby contaminating the electrowon cobalt metal product (Jeffrey et al., 2000; Kongolo et al., 2005; Louis, 2009). Kamoto Copper’s specification for cobalt metal is given in Table 1. To achieve electrowon cathode of this quality, a 20 g/L Co electrolyte should contain <1 mg/L Cu and <2.5 mg/L Zn.

Table 1 – Specification for maximum permitted impurity levels in cobalt metal (>99.3% Co)

<table>
<thead>
<tr>
<th>Element</th>
<th>Concentration (ppm)</th>
<th>Element</th>
<th>Concentration (ppm)</th>
<th>Element</th>
<th>Concentration (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>500</td>
<td>Fe</td>
<td>2000</td>
<td>Pb</td>
<td>100</td>
</tr>
<tr>
<td>Ca</td>
<td>250</td>
<td>Mg</td>
<td>250</td>
<td>S</td>
<td>500</td>
</tr>
<tr>
<td>Cd</td>
<td>100</td>
<td>Mn</td>
<td>1000</td>
<td>Zn</td>
<td>500</td>
</tr>
<tr>
<td>Cu</td>
<td>200</td>
<td>Ni</td>
<td>5500</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Various technologies have been investigated for the removal of low levels of base metal contaminants from cobalt electrolytes, including precipitation and solvent extraction (Fisher & Treadgold, 2008; Roux et al., 2007; Swartz et al., 2009). Ion exchange (IX) is, however, the preferred separation technology when impurity concentrations are low (typically <0.1 to 0.5 g/L). Ion exchange does not require pH adjustment during the process, is easily automated, and the plant footprint is smaller than that of solvent extraction. Furthermore, ion exchange uses benign reagents and does not contribute to carbon emissions or environmental damage. Ion exchange is widely used in impurity removal from waste waters throughout the world. Resins are also extensively employed for removal of heavy metals (Pb, Cd, Cu, Zn, Sr, etc.) from various high ionic strength base metal solutions, particularly in the electroplating industry. In the hydrometallurgical industry, many examples are available of gold, uranium, and base metals applications (Kotze, 2012; van Deventer, 2011).

In this study, ion exchange was employed to remove low levels (<30 mg/L) of copper and zinc from the cobalt advance electrolyte at the Luilu refinery. Following laboratory testwork, which evaluated several resin functionalities and identified a suitable ion-exchange system, an on-site pilot-plant trial, treating 1500 to 3000 L/d of electrolyte, was operated for a period of six weeks to optimise the operating conditions and to determine full-scale design criteria.

BACKGROUND TO RESIN SELECTION

Iminodiacetic acid resin functionality is most commonly employed for the removal of trace levels of copper from aqueous solution, with an order of selectivity for base metal and alkaline earth cations of:

Fe(III) > Cu >> Pb > Ni > Zn > Cd > Co > Fe(II) > Mn > Ca > Mg > Sr > Ba.
Hydrometallurgical applications include the removal of Cu from nickel- and cobalt-containing electrolytes at Vale New Caledonia (Mihaylov et al., 2000) and Port Colborne (Canada), and recovery of copper from heap leach solutions and various mining wastes at Bor (Serbia), TACP (Bulgaria), and Boliden (Sweden).

Aminophosphonic acid resins have also been considered for the simultaneous removal of copper and zinc from cobalt electrolytes in several refineries. The order of selectivity of these resins is:

$$\text{Fe(III)} > \text{Pb} > \text{Cu} > \text{Zn} > \text{Ni} > \text{Cd} > \text{Co} > \text{Ca} > \text{Mg} > \text{Sr} > \text{Ba}.$$  

Such resins were successfully piloted for the Kakanda (DRC) flowsheet for the removal of trace copper (~70 mg/L) and zinc (~2 mg/L) from a cobalt electrolyte (50 g/L Co) prior to electrowinning using a leada-polish fixed bed configuration (Dry et al., 1998; Wyethe and Kotze, 2000) and in the development of the Kinganyambo Musonoi Tailings flowsheet (DRC) (Alexander, 2001). In assessing flowsheet options for the processing of Copper Belt ores, Swartz et al. (2009) recommended the simultaneous removal of copper and zinc, using an aminophosphonic acid resin, as the basis for a zinc-removal step in the purification of cobalt electrolytes. Bulong Nickel (now closed) implemented this technology on their cobalt refinery in Kalgoorlie, Western Australia (Pavlides & Wyethe, 2000).

**PROCESS DESCRIPTION AND CHEMISTRY**

Based on column laboratory testwork results, a two-stage purification process for the cobalt electrolyte was designed. Copper was first removed using an iminodiacetic acid resin, Lanxess TP 207, and then zinc was removed using an aminophosphonic acid resin, Lanxess TP 260 (Figure 1).

![Resin Structures](image_url)

(a) Iminodiacetic acid and (b) aminophosphonic acid resin functionalities (Na\(^+\) form)

**Removal of Copper From Cobalt Electrolyte**

The iminodiacetic acid resin is used in the hydrogen form for the removal of copper. The ion-exchange reaction can be represented (where R is the resin backbone and functional group) as:

$$\text{Cu}^{2+} + \text{R–H}_2 \rightarrow \text{R–Cu} + 2 \text{H}^+ \quad (1)$$

The copper-free barren solution increases in acidity due to displacement of H\(^+\) ions from the resin. Because of the high cobalt concentration in the feed solution, Co\(^{2+}\) will also load onto the resin while capacity is available and will be progressively displaced by the more strongly complexed Cu\(^{2+}\) ions:

$$\text{Co}^{2+} + \text{R–H}_2 \rightarrow \text{R–Co} + 2 \text{H}^+ \quad (2)$$
$$\text{Cu}^{2+} + \text{R–Co} \rightarrow \text{R–Cu} + \text{Co}^{2+} \quad (3)$$

Split elution allows separation of Cu and Co into separate eluate streams, which can then be returned to appropriate places in the upstream circuits for recovery. A weak acid solution is employed to first remove any co-loaded Co\(^{2+}\) from the resin (the reverse of reaction (2)), followed by a stronger acid to then elute the more strongly complexed Cu\(^{2+}\) and to regenerate the resin in its hydrogen form:

$$\text{R–Co} + 2 \text{H}^+ \rightarrow \text{Co}^{2+} + \text{R–H}_2 \quad (4)$$
$$\text{R–Cu} + 2 \text{H}^+ \rightarrow \text{Cu}^{2+} + \text{R–H}_2 \quad (5)$$
Removal of Zinc From Cobalt Electrolyte

The aminophosphonic acid resin requires a higher pH for effective removal of Zn and the resin is used in the sodium form. In this case, sodium ions report to the zinc-barren cobalt solution on loading:

\[ \text{Zn}^{2+} + \text{R}^-\text{Na}_2 \rightarrow \text{R}^-\text{Zn} + 2 \text{Na}^+ \]  
(6)

The small, gradual accumulation of Na\(^+\) ions in the cobalt electrolyte increases the conductivity of the electrolyte, which has a beneficial effect on the current efficiency in electrowinning (Louis, 2009). Existing bleed streams from the main cobalt circuit ensure that the sodium will not accumulate to detrimental levels. Co\(^2+\) also loads onto the resin, but is less strongly bound than Zn\(^2+\):

\[ \text{Zn}^{2+} + \text{R}^-\text{Co} \rightarrow \text{R}^-\text{Zn} + \text{Co}^{2+} \]  
(7)

The Zn\(^{2+}\) impurity is separated from the co-loaded valuable Co\(^{2+}\) by sequential elution with weak and then strong H\(_2\)SO\(_4\) to regenerate the resin in its hydrogen form:

\[ \text{R}^-\text{Co} + 2 \text{H}^+ \rightarrow \text{Co}^{2+} + \text{R}^-\text{H}_2 \]  
(8)

\[ \text{R}^-\text{Zn} + 2 \text{H}^+ \rightarrow \text{Zn}^{2+} + \text{R}^-\text{H}_2 \]  
(9)

The resin is reconditioned to the Na\(^+\) form using NaOH before the next loading cycle:

\[ \text{NaOH} + \text{R}^-\text{H}_2 \rightarrow \text{R}^-\text{NaH} + \text{H}_2\text{O} \]  
(10)

PILOT-PLANT TRIAL

Feed Composition

The feed to the pilot plant was taken from a tie-in to the main plant cobalt advance electrolyte. Since this electrolyte had already been purified, the solution was spiked with zinc and copper using sulfate salts to the expected impurity concentrations in the absence of the H\(_2\)S precipitation and to simulate plant upset conditions. No pH adjustment was carried out: the electrolyte was usually near pH 6, but occasional upstream process upsets allowed evaluation of conditions as low as pH 3. Typical composition of the feed is shown in Table 2. The electrolyte is calcium-saturated due to the upstream lime precipitation processes.

<table>
<thead>
<tr>
<th>Element</th>
<th>Concentration (mg/L)</th>
<th>Element</th>
<th>Concentration (mg/L)</th>
<th>Element</th>
<th>Concentration (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co</td>
<td>17 000</td>
<td>Fe</td>
<td>1.5</td>
<td>Pb</td>
<td>60</td>
</tr>
<tr>
<td>Al</td>
<td>2.5</td>
<td>Mg</td>
<td>6000</td>
<td>Zn</td>
<td>10 – 30</td>
</tr>
<tr>
<td>Ca</td>
<td>710</td>
<td>Mn</td>
<td>3350</td>
<td>pH</td>
<td>5.8</td>
</tr>
<tr>
<td>Cu</td>
<td>10 – 30</td>
<td>Ni</td>
<td>66</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Resins and Other Reagents

Lanxess TP 207 was employed for copper removal and Lanxess TP 260 for zinc removal. Chemically pure H\(_2\)SO\(_4\) and 40% NaOH solution were respectively employed for make-up of eluants and conditioning solution. Plant process water was used for intermediate washing steps and reagent make up.
Pilot-plant Equipment

The pilot plant, comprising two sets of three fixed-bed columns, was designed by Cwenga and constructed by Controlled Dosing (South Africa). The columns (140 mm diameter, 820 mm height) were constructed of transparent polyvinylchloride (PVC) to allow the colour changes of the resins on loading and elution to be monitored and assist in analysing the circuit performance. Inter-column piping and all ball valves were of non-transparent PVC. The piping arrangement allowed any column to be in any position (lead, polish, or elution/standby) and for the column sequence to be varied at will. The ion-exchange pilot plant, installed in a 6.1 m container, was connected by flexible plastic hoses to the feed, reagent, eluate, and product tanks, which were located outside within a concrete-walled bunded area.

Pilot-plant Operation

Each circuit operated in a lead-polish-standby/elution configuration (Figure 2). Each column contained 12.5 L (1 bed volume (BV)) of resin (as received). The feed passed first through TP 207 for removal of copper. The copper-depleted electrolyte was then pH-adjusted using 100 g/L Na₂CO₃ solution before passing through TP 260 for zinc removal. All solutions were fed down-flow to the columns. Following loading, a split elution was carried out, using a weak acid eluant to initially remove any co-loaded cobalt from the resin, followed by a strong acid eluant to remove the target copper or zinc from the resin. TP 260 was converted back to the Na⁺ form using 40 g/L NaOH. Each resin bed was washed with process water after the loading, elution, and conditioning steps to ensure that the correct pH was available for the subsequent step and to avoid wastage of reagents in reacting with the solution remaining in the void volume between the resin beads. The beds were periodically subjected to up-flow fluidisation with water, to remix the resin beads and to remove any fine solids that may have accumulated at the top of the bed.

Figure 2 – Pilot-plant lead-polish fixed-bed configuration for sequential removal of copper and zinc

The pilot plant operated continuously for 4700 h, staffed by one operator per shift. Feed flowrates and pH were measured and adjusted as necessary on an hourly basis. Samples of the feed solutions to each circuit were taken every 4 h and column outlet samples were taken every 2 h during the loading cycles. Eluates were sampled every 2 min during elution cycles.

Analytical Methods

The samples were analysed for all elements given in Table 2 by inductively coupled plasma optical emission spectroscopy (ICP-OES) using matrix-matched standards. The acid and NaOH contents of the eluant and conditioning streams, respectively, were determined by titration.
RESULTS AND DISCUSSION

Operating conditions were varied during the trial to study the effects of loading and elution flowrates, feed pH, Cu and Zn concentrations in the feed, and acidity of eluants, with the objectives of maximising the removal of Cu and Zn while minimising cobalt losses. The deportment of other impurities present in the electrolyte was also evaluated.

Copper Removal Using TP 207

Effect of Feed Flowrate on Loading

Figure 3 shows the effect of feed flowrate on the breakthrough of copper in the lead column. As expected, the feed volume processed before reaching breakthrough increased with decreasing flowrate. The optimum flowrate, in terms of operating capacity, was ~7.5 BV/h, with breakthrough occurring after 700 BV.

![Figure 3 – Effect of feed flowrate on copper loading efficiency and lead column breakthrough volume](image)

Conditions: Cu in feed 17 – 23 mg/L, feed pH 5.7 – 6.0

Effect of Feed pH on Loading

The cobalt advance electrolyte was typically pH 5.8. For a few days during the trial, this dropped as low as pH 4 due to upstream process upsets, allowing the effect of pH to be assessed. Although the loading did not cease completely during this period, the rate of copper uptake was reduced. In full-scale operation this would, however, not be catastrophic: any copper leakage through the lead column loads on the polish column, so product quality would not be affected unless the low pH situation persists for an extended period. The cycle time will, however, be reduced (i.e., more frequent elution is required).

A more extreme process upset, during which the feed pH dropped to ~3, resulted in elevated levels of iron in the feed. Fe³⁺ loads more strongly than Cu²⁺ and a build-up of Fe³⁺ on the lead column was observed. This highlighted the necessity of ensuring that the ion-exchange feed contains <2 mg/L Fe and is of appropriate pH.

Efficiency of Copper Removal

Figure 4 compares the copper concentration in the feed with that exiting the polish column for the entire running time of the pilot plant. The efficiency of TP 207 for copper removal from the cobalt electrolyte is excellent, with the product stream consistently achieving below 1 mg/L Cu.
Selectivity and Capacity of Loading

TP 207 is extremely selective for the loading of copper over cobalt and all other divalent cations present in the electrolyte, when expressed as a percentage of the feed concentrations (Figure 5). Zn\(^{2+}\) and small amounts of Ni\(^{2+}\), Pb\(^{2+}\), and the alkaline earth cations load strongly at the beginning of the loading cycle but are pushed off by the more strongly complexed Cu\(^{2+}\) as the available resin capacity decreases. Because of the relative differences in the concentrations of the impurities in the feed (Table 2), however, the actual masses of Ca\(^{2+}\), Mn\(^{2+}\), and Mg\(^{2+}\), as well as Co\(^{2+}\), that co-load, are not insubstantial (Table 3). The loading capacity of TP 207, under the conditions of this trial, averaged 1.82 eq/L.

<table>
<thead>
<tr>
<th>Resin</th>
<th>Co(^{2+}) (g/L)</th>
<th>Cu(^{2+}) (g/L)</th>
<th>Ca(^{2+}) (g/L)</th>
<th>Mg(^{2+}) (g/L)</th>
<th>Mn(^{2+}) (g/L)</th>
<th>Zn(^{2+}) (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP 207</td>
<td>34.4</td>
<td>36.7</td>
<td>2.9</td>
<td>2.7</td>
<td>1.4</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Lead-Polish Configuration and Selection of Breakthrough Target

Due to the low target for Cu in the cobalt electrolyte (<1 mg/L), completion of a loading cycle was defined as the lead column outlet reaching 1 mg/L Cu. Figure 6 shows the copper profiles in the feed and exiting the lead and polish columns for a cycle that ran to complete breakthrough (i.e., the lead outlet reached the same value as the feed). Breakthrough of 1 mg/L Cu occurred after treatment of ~700 BV feed at a flowrate of 5 BV/h. The ability of the polish column to maintain the target specification under these extreme conditions is demonstrated. This indicates the resilience of this ion-exchange configuration to process upsets, high copper concentrations in the feed, and other disruptions that may cause malfunction of the lead column: the polish column remains consistently able to achieve the required performance.
Figure 6 – Comparison of copper concentrations in the feed and lead and polish outlets

Conditions: Zn in feed 10 – 26 mg/L, average feed pH 5.7, feed flowrate 5 BV/h

Efficiency of Split Elution

As indicated in Table 3, TP 207 has considerable Co$^{2+}$ co-loaded with Cu$^{2+}$ at breakthrough. A split elution, using a relatively low acid (~10 g/L H$_2$SO$_4$) eluant for selective removal of the weakly complexed Co$^{2+}$, followed by a stronger acid (~50 g/L H$_2$SO$_4$) eluant for removal of the more strongly complexed Cu$^{2+}$, was attempted. Typical results are shown in Figure 7. Although separation of the two cations is evident, some copper reported to the cobalt-containing eluate. The piloting equipment was unfortunately limited to a minimum eluant flowrate of 8 to 10 BV/h: chromatographic separation of these two cations requires a much lower flowrate of 1 to 2 BV/h. In fact, good elution separation of these cations was achieved at 1.5 BV/h during laboratory testwork, indicating that this non-optimised result is equipment – rather than chemistry – constrained. Subsequent assessment of the data led to the decision to only use a strong acid eluant for the TP 207 system, removing both Cu$^{2+}$ and Co$^{2+}$ to a single eluate, which can be recycled upstream for recovery of both metals in the main plant circuit. A single elution is simpler to operate and will also accrue operating cost savings on the eluant reagents.

Figure 7 – Split elution showing (a) partially selective cobalt elution by weak acid eluant, and (b) residual copper elution by strong acid eluant

Conditions: Weak acid eluant 8.4 g/L H$_2$SO$_4$ at 9 BV/h; strong acid eluant 53 g/L H$_2$SO$_4$ at 9 BV/h

Zinc Removal Using TP 260

Effect of Flowrate on Loading

Figure 8 shows the effect of flowrate on the breakthrough of zinc. Poor adsorption of Zn$^{2+}$ occurred at 10 BV/h. The breakthrough volume increased with decreasing flowrate: the optimum flowrate of 3 to 3.5 BV/h permitted ~150 BV of feed to be treated. With reference to the commercial design criteria, it is significant to note the much lower specific flowrate required for the TP 260 system, compared to that of TP 207, as well as the much lower breakthrough volumes.
Effect of Feed pH on Loading

The feed to the zinc circuit was varied from pH 4.5 to 6.2 by means of Na₂CO₃ addition. A small effect of pH was observed, but, provided the feed was above pH 4.5 and the resin was in the Na⁺ form, zinc loading was efficient. As the pH increased above pH 5.2, however, the loading capacity for Zn²⁺ dropped due to competition for resin sites by species such as Ca²⁺, Mg²⁺, and Mn²⁺.

Efficiency of Zinc Removal

Figure 9 compares the zinc feed concentration with that exiting the polish column for the duration of the entire trial. The efficiency of TP 260 for zinc removal from the cobalt electrolyte is extremely high, with the product stream consistently assaying <1 mg/L Zn. (The outliers correspond to periods when the lead column was pushed considerably past the target breakthrough value in order to obtain full loading curves.)

Selectivity and Capacity of Loading

TP 260 is very selective for the loading of zinc from cobalt and all other divalent cations present in the electrolyte (Figure 10). Small amounts of Ni²⁺, Pb²⁺, and Ca²⁺ initially co-load but are pushed off the resin by the more strongly complexed Zn²⁺ as the available capacity decreases. Due to the relative differences in the concentrations of the impurities in the feed (Table 2), however, substantial masses of Ca²⁺, Mn²⁺, Mg²⁺, and Co²⁺, remain loaded on the resin at breakthrough, occupying capacity on the resin (Table 4). This is why breakthrough occurs at much lower feed volumes compared to the copper loading of TP 207. The loading capacity of TP 260, under the conditions of this trial, averaged 1.84 eq/L.
Figure 10 – Selectivity of loading of zinc compared to other elements present in electrolyte
Conditions: Zn in feed 23 mg/L, feed pH 5, flowrate 5 BV/h

Table 4 – Average loadings of cations by TP 260

<table>
<thead>
<tr>
<th>Resin</th>
<th>Co²⁺ (g/L)</th>
<th>Ca²⁺ (g/L)</th>
<th>Mg²⁺ (g/L)</th>
<th>Mn²⁺ (g/L)</th>
<th>Zn²⁺ (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP 260</td>
<td>21.5</td>
<td>6.9</td>
<td>2.8</td>
<td>11.9</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Lead-Polish Configuration and Selection of Breakthrough Target

Figure 11 shows the zinc profiles of the feed and the lead and polish column outlets for a loading cycle that was run to complete breakthrough. In this trial, a loading cycle was usually stopped at a breakthrough of 1 mg/L Zn, i.e., after ~150 BV at a flowrate of 3 BV/h. Figure 9 shows, however, that if the target breakthrough value is increased to 2 mg/L Zn, then ~200 BV of feed could be processed before the need of an elution, thereby offering a saving on reagent consumptions. The effectiveness of the polish column in scavenging any remaining zinc that passes through the lead column, even at high breakthrough values, is evident, confirming the extremely efficient performance of this system for zinc removal.

Efficiency of Split Elution

Zinc removed from the cobalt electrolyte ultimately reports to tailings. Table 4 shows that a considerable mass of valuable cobalt is co-loaded with the zinc. Split elution was employed to separately recover the valuable Co²⁺. Figure 11 shows that separation of the two cations was achieved, but with some loss of cobalt with to the zinc-containing eluate. As with the copper system, the piloting equipment could not achieve low enough eluant flowrates to ensure clean separation of these cations. The split elution concept was, however, proven during the column laboratory testwork: an appropriate design flowrate for elution will minimise cobalt losses, such that the cobalt eluate can be recycled upstream for cobalt recovery, while the zinc eluate can be limed for disposal. Alternatively, the zinc eluate can be further treated in a small scavenger ion-exchanger to ensure that all cobalt can be recycled to the main circuit.
Figure 12 – Split elution showing (a) selective cobalt elution by weak acid eluant, and (b) zinc elution with residual cobalt removal by strong acid eluant.

Conditions: Weak acid eluant 8 g/L H₂SO₄ at 8 BV/h; strong acid eluant 31 g/L H₂SO₄ at 8 BV/h.

**PROCESS DESIGN CRITERIA**

Based on the successful piloting of this system, coupled with a favourable economic assessment and the opportunity to eliminate a chemical hazard from the flowsheet, a decision was made to implement this technology to treat 150 m³/h cobalt advance electrolyte for removal of trace copper and zinc impurities. Table 5 presents selected design criteria, based on the pilot-plant results.

**Table 5 – Recommended operating conditions for commercial ion-exchange plant**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Copper ion exchange</th>
<th>Zinc ion exchange</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin (form)</td>
<td>TP 207 (H⁺ or H⁺/Na)</td>
<td>TP 260 (Na⁺)</td>
</tr>
<tr>
<td><strong>Loading</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed composition and pH</td>
<td>Clarified cobalt electrolyte, pH 5.5 – 6 Barren from Cu IX, pH 4.5 – 5</td>
<td></td>
</tr>
<tr>
<td>Flowrate (BV/h)</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Breakthrough value</td>
<td>2 mg/L Cu</td>
<td>3 mg/L Zn</td>
</tr>
<tr>
<td><strong>Elution</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eluant 1 composition</td>
<td>50 g/L H₂SO₄</td>
<td>10 g/L H₂SO₄</td>
</tr>
<tr>
<td>Eluant 1 flowrate (BV/h)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Fate of eluate 1</td>
<td>Recycle to Cu/Co circuit</td>
<td>Recycle to Co circuit</td>
</tr>
<tr>
<td>Eluant 2 composition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eluant 2 flowrate (BV/h)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fate of eluate 2</td>
<td></td>
<td></td>
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<tr>
<td><strong>Conditioning</strong></td>
<td>40 g/L NaOH</td>
<td>Until outlet pH &gt; 13</td>
</tr>
<tr>
<td>Flowrate (BV/h)</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Volume</td>
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</table>

**CONCLUSIONS**

Ion exchange has been successfully demonstrated for the removal of trace copper and zinc from a cobalt electrolyte. Using fixed-bed lead-polish configurations, copper was removed by the iminodiacetic acid resin, TP 207, followed by zinc removal with the aminophosphonic acid resin, TP 260. The optimised system proved capable of achieving <1 mg/L Cu and Zn in plant electrolyte containing ~20 g/L Co. Selective elution allows copper and co-loaded cobalt to be returned to the main circuit, while the zinc eluate is discarded to tailings. The technology offers significant operational and economic advantages over the traditional flowsheet. Commercial implementation is in progress.
ACKNOWLEDGEMENTS

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REFERENCES


