EVALUATION OF VARIOUS DURABILITY TESTS TO ASSESS RESINS FOR IN-PULP APPLICATIONS

V Yahorava, J Scheepers and M H Kotze (Mintek)
D Auerswald (Bateman Engineering)

ABSTRACT

Resin-in-pulp (RIP) technology, nowadays, is often considered for the direct recovery of base metals and uranium from dense pulps. Implementation of RIP will eliminate the requirement for any solid/liquid separation downstream of leaching and has the potential to combine the recovery and purification steps, hence reducing both capital and operating costs. The recovery of the valuable metal is expected to be higher when RIP is used, especially where the leached solids are difficult to settle or to filter. The primary unknown parameter of RIP is the resin loss that would be experienced on full scale operations, using Western technology. Resin degradation occurs as a result of osmotic shock in the varying chemical environments during loading and elution cycles, the harsh physical environment of a well-mixed, dense slurry, and resin handling (screens, pumps, etc.).

Currently, there are a number of improved RIP grade resins available on the market and it is important to choose the most cost effective resin for a specific application. As it is impractical to evaluate resin losses on a continuous plant of reasonable scale, different accelerated durability tests and demonstration plants were developed to evaluate the relative durability of potential RIP resins.

This paper provides results of the different methods used for durability testing of different RIP grade resins used for uranium recovery. A preliminary economical evaluation was done to estimate the impact of resin loss on the overall economic viability of a specific application and the outcome is discussed.

Keywords: *resin-in-pulp, resin loss, durability, mechanical strength, resistance to attrition*

1. INTRODUCTION

For more than two decades very little technical developments occurred around uranium and many operating mines were mothballed due to the low price. However, over the last 4 years Mintek has experienced a significant increase in the test work requested by clients on uranium projects, primarily because of a major increase in the uranium price caused by a higher demand, and predictions are that the demand would accelerate further in future. Uranium is also a strategically important metal for South Africa and hence Mintek obtained some state funding in order to do focused research and development around the recovery of uranium especially from low-grade ores. This includes quite a large programme around the development and demonstration of RIP technology for the

direct recovery of uranium from low-grade leached pulps. Mintek has been involved in the development of resin-in-pulp (RIP) and resin-in-leach (RIL) technologies since the 1970s. Originally envisaged as an alternative to carbon-in-pulp (CIP) for gold recovery, RIP (using the Mintek-developed gold-selective strong-base resin) has found a niche application for recovering gold from carbonaceous preg-robbing ores, which was implemented at the Barbrook mine in Mpumalanga and Penjom in Malaysia. More recently, RIP developments focus on base metal and uranium recovery.

Implementation of RIP will eliminate the requirement for solid/liquid separation subsequent to leaching and has the potential to combine the recovery and purification steps, hence reducing both capital and operating costs. Furthermore, higher recoveries of the valuable metal could be expected, especially where the leached solids are difficult to settle or filter and where water balance issues prevent excessive washing. Although RIP and RIL has been used in the former USSR for decades for the recovery of gold and uranium, resin loss predictions for full scale operations employing Western technology is still uncertain. A RIP uranium plant is currently being commissioned at Paladin's Kayelekera uranium operation in Malawi. It will be some time for information on resin loss to be forthcoming from this operation, and it would provide information only for the specific resin and plant design employed.

Resin degradation occurs as a result of osmotic shock taking place due to varying chemical environments during loading and elution cycles, and physical stresses when used in well-mixed, dense slurries that includes the associated resin handling (screens, pumps, etc.). Resin degradation would be responsible for a certain portion of resin loss, but it is a well-known fact in the gold industry where CIP has been used for decades that adsorbent loss is also directly linked to a well-designed plant and its efficient management.

At present, there are a number of improved RIP-grade strong-base resins for uranium recovery available on the market and it is important to choose the most cost effective resin for a specific application. In evaluating these resins, durability testing is one of the critical elements. It is impractical and very costly to evaluate resin losses on a continuous plant of reasonable scale, and hence various laboratory-scale accelerated durability tests were developed to evaluate the relative durability of potential RIP resins. The most promising resins are then also evaluated in the MetRIX™ demonstration plant at Mintek. Silica fouling of strong-base ion exchange resins used for uranium recovery from acidic sulphate leach liquors has been known in the past to adversely effect resin durability and hence losses on operating plants. Hence, the impact of silica on some mechanical characteristics of the resins was also investigated using the accelerated laboratory durability tests.

2. RIP-GRADE RESINS

A number of resin properties, including matrix, structure, physical form and size, operating capacity, resistance to fouling and osmotic shock, and chemical stability [1]

have to be taken into account when selecting the most economical resin for a specific application. Resin stability and strength is probably the most important factor to consider for RIP applications, as resin breakdown affects resin inventory replacement costs, as well as causing some loss of valuable metal species accompanying the abraded resin fines.

Osmotic shock and physical attritioning of resins are generally associated with the actual structure of the resin beads, so that gel resins usually are less resistant to osmotic effects, while macroporous resins lower resistance towards physical attrition. Gel resin beads are spheres permeated with micropores (<30 Å) and although this type of resin can be physically strong, it is unable to accommodate excessive swelling and shrinkage during chemical treatments, and hence fracture more easily. Each macroporous resin bead consist of a multitude of microspheres, all connecte through macro pores (pore size can vary between 50 and 1 000 000 Å). This type of structure is generally more flexible in accommodating changes in bead volume during chemical treatments, thus reducing the tendency to fracture. The increased porosity, however, generally reduces the physical strength of the beads which reduces their resistance to physical attrition [2].

Resin attrition has always been one of the critical aspects that hampered the commercial implementation of uranium and base metal RIP in the Western World. More recently resin suppliers have invested significant time and costs in developing larger and more durable resins that exhibit lower abrasive and impact losses. Almost all the major resin suppliers, including Purolite, Rohm and Haas, Dow, and Lewatit now have improved RIP-grade resins available for uranium and base metal RIP applications. Mintek is currently creating a data base of the performances of the available RIP-grade resins for their feasibility to be employed to recover uranium via RIP.

Two types of resins produced by two different suppliers, i.e. gel (GT) and macroporous (MP) resins, were tested during the current investigations. The particle size distribution (PSD) of each of these resins in the sulphate form is presented in Figure 1.

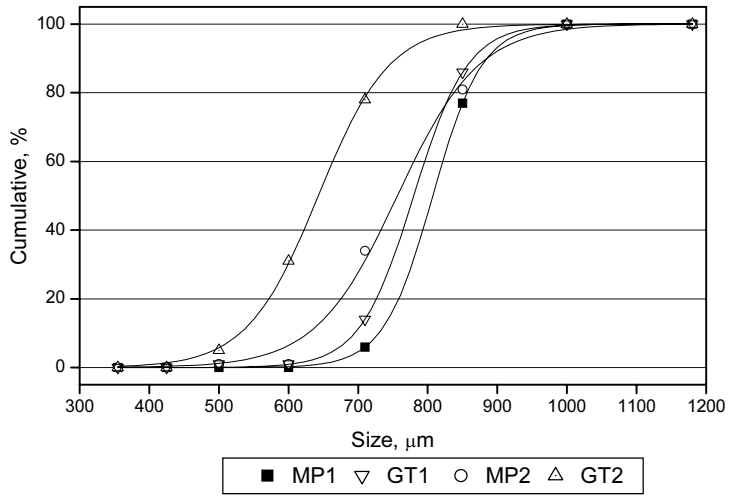

Figure 1: Particle size distributions

Some of the main ion exchange characteristics provided by the suppliers and determined during the test work (i.e. density) are given in Table 1.

Table 1: Main characteristics of the resins tested "as received"

Resin characteristic	Supplier 1		Supplier 1	
Code name	MP1	GT1	MP2	GT2
d_{50}, µm	807	780	756	643
ρ, g/L (based on dry resin, >600µm)	330 (±1%)	380 (±0.2%)	300 (±1%)	420 (±2%)
Theoretical capacity*, eq/L	≥1.15	≥1.3	≥1.0	≥1.4
Moisture retention capacity*, %	53-58	40-50	48-60	40-47
Max reversible swelling Cl-→OH-, %	15	20	20	30
Matrix	Macroporous polystyrene crosslinked with DVB	Gel polystyrene crosslinked with DVB	Macroporous polystyrene crosslinked with DVB	Gel polystyrene crosslinked with DVB
Functional group	Quaternary ammonium			

[a] – Code names were used for the various resins to simplify discussion

3. RESINS PRE-FOULING WITH SILICA

Silica fouling of strong-base resins during recovery of uranium from acidic leach liquors is a problem that is well-known since ion exchange (IX) has been introduced for uranium recovery. This primarily results in poorer metallurgical performance when compared to fresh resins, but silcia fouling is also notorious for increasing the brittleness of the resins once the silica level was allowed to increase above a certain minimum level (for gel-type resins). With the development of new resins for uranium recovery, the resistance to silica fouling and the impact of silica fouling on the metallurgical and durability performance became important criterion in the choice of an optimum resin [3].

Silica fouling tests were done on the two gel type and two macroporous resins, in order to provide silica-containing samples for durability tests. A portion of resin in the sulphate form was contacted with a freshly-prepared 3 g/L SiO_2 solution (using sodium silicate) during 24 hours in rolling bottles at pH 1. The solution-to-resin volumetric ratio was 10 to 1. At the end of the first cycle of fouling, the resin was washed with de-ionised water to remove entrained solution and a third of the resin was removed for further test work and analysis of loaded SiO_2. The remainder of the resin (two thirds of the volume) were subjected to a second cycle of fouling using a similar procedure as described for the first cycle. A total of 3 cycles of fouling were done this way. The results of silica loading per cycle of fouling are presented in Figure 2.

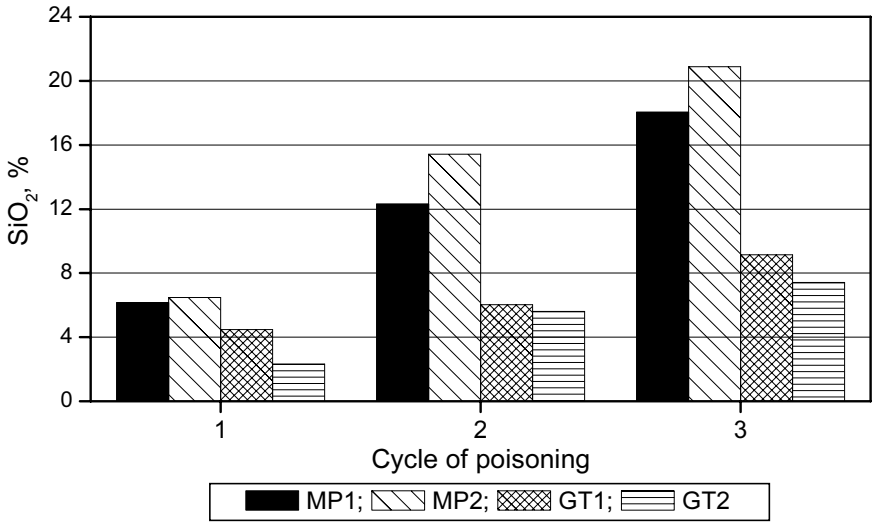

Figure 2: Resin fouling with silica in synthetic fouling tests

The MP2 resin loaded SiO_2 at a higher rate than the MP1 resin from the synthetic solutions containing 3 g/L of SiO_2 at pH 1, while the GT2 resin adsorbed less silica compared to GT1. The macroporous-type resins loaded silica at a significantly higher rate than the gel-type resins, so it will be critical to estimate the metallurgical and durability performances of the two resin types so that the optimum product can be selected for use in the MetRIX™ technology. The impact of silica on the metallurgical performance of the silica-fouled resins was reported elsewhere [4], while the impact on the physical strenght or durability of the resin is reported in this paper.

3. ACCELERATED LABORATORY ABRASION TESTS

Generally, the preferred resin for a RIP application would not be the product that achieves the highest uranium loading, but the product that better conforms to the various requirements of the RIP process. Particle size and physical strength of the resin are two of the most important considerations in this regard. The resin should be strong enough to limit resin losses due to osmotic shock as well as the physical handling of the resin during mixing of dense slurry, screening, pumping, etc.).

The costs and practicality of evaluating resins on a continuous plant of a reasonable scale made it essential that Mintek investigates accelerated laboratory durability tests so that a database of the results on current and future resins can be developed. These methods would not provide information with regards to the ultimate loss on a full-scale plant, but it would provide information on the relative behaviour of the products.

The breakdown or loss of resin per cycle is represented as the percentage volume decrease during a cycle (i.e. based on the volume of resin at the beginning of that specific cycle). Volume measurements were done on resins in the sulphate form. Results of resin

abrasion tests done in the laboratory using sand or uranium ore as abrasion medium are discussed. One more method can be used to measure abradability of the resins, i.e. Russian ball mill test. This test consists of milling the resin in a small ball mill for 1 hour with steel balls and then measuring the volume of the resin which is coarser than a specified size.

4.1. DENVER FLOTATION CELL IN PRESENCE OF SILICA SAND

The influence of silica content on the resin and NaOH treatment on the abrasion resistance of gel and macroporous resins was tested. The primary objective of these tests was to establish the relative breakdown rates of RIP-grade resins by subjecting them to a standard accelerated durability test procedure.

Only fresh resins (without silica) were used to determine the influence of NaOH treatment (large pH swing) on the durabilities of the resins. Tests started with 200 mL of resin in the sulphate form, and resins were pre-screened to eliminate beads smaller than 600 µm. Excess water was removed. The resin was transferred to a Denver flotation cell (2000 L 16×16 cm) with 1400 mL de-ionised water (see Figure 3). The agitator assembly consisted of an impeller housing (Ø=11 cm, tooth 12×8 mm) and impeller (Ø=10 cm, blade 30×7 mm). Graded sand (75 -212 µm; 725 g) was added. The resin and sand were agitated in the flotation cell for 60 minutes at 1500 rpm. The sand was washed away with de-ionised water, and the wet-settled resin fraction > 300 µm was screened and measured, and the PSD determined. The resin fraction greater than 300 µm in diameter was mixed and transferred into a clear Perspex column for osmotic shock treatment using the conditions listed in Table 2.

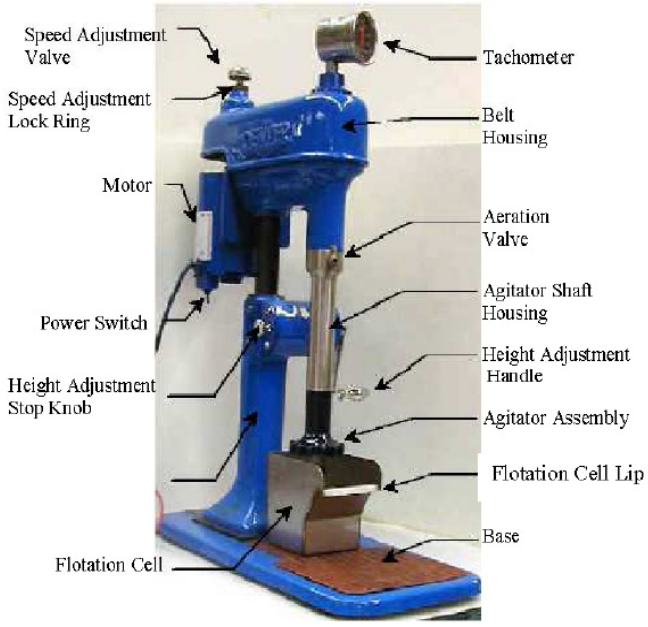

Figure 3: Denver floatation machine

Table 2: Osmotic shock procedure

Reagent	Concentration, g/L	Duration, min	Flow rate, mL/min	Volume, mL
NaOH	80	30	20	600
H_2O	-	30	50	1500
H_2SO_4	200	30	20	600
H_2O	-	-	50	Up to pH 2

Fresh and silica-fouled resins were subjected to this procedure, but the NaOH/water treatment of the silica-fouled resins was excluded from the chemical treatment step as NaOH would strip silica off the resin. Thus only the acid treatment step was used to represent osmotic shock for the silica-fouled resins. The sand-water mixture was prepared using pH 2 water to eliminate silica stripping from the resin. The resin loss per cycle was calculated taking into the account fractions bigger than 600 μm.

Figure 4 depicts the results of the Denver flotation cell attrition tests for macroporous and gel type RIP-grade resins with different silica levels (including resin without silica). Results of the tests done with fresh resin treated with sodium hydroxide/acid are also presented.

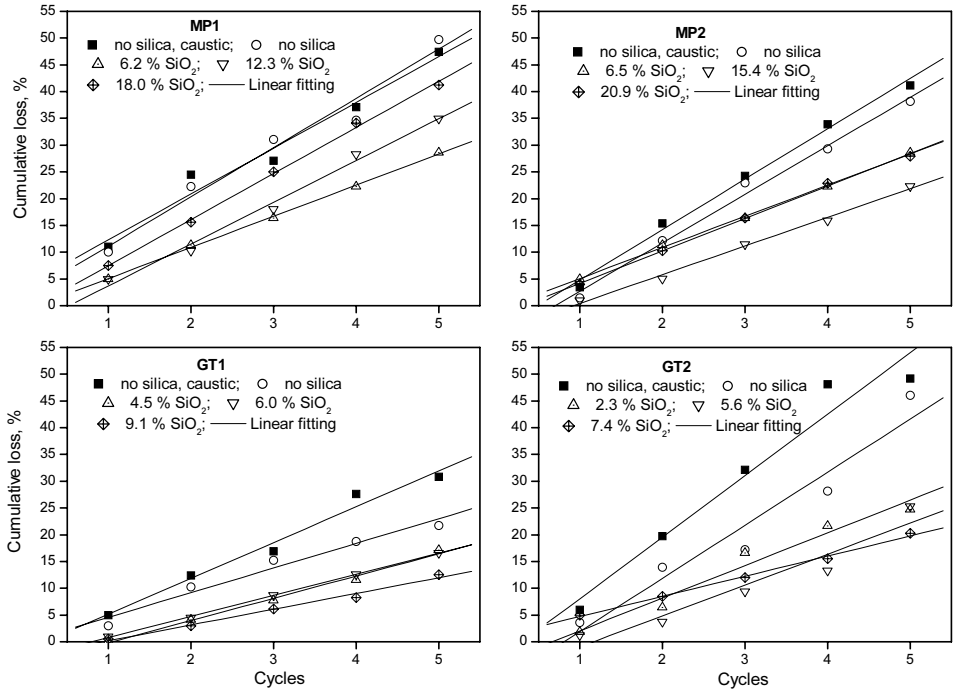

Figure 4: Denver flotation cell attrition tests: effect of silica levels and sodium hydroxide treatment on attrition results

NaOH treatment caused the resins to weaken the most, especially in the case of gel-type resins. For MP1, the difference in the results of the attrition tests done with and without NaOH treatment was negligible. Hence, the impact of NaOH treatment on the full scale plant during regeneration of the macroporous-type resins on its durability is expected to be limited.

From these results it appeared that silica fouling of the resins to the levels tested caused some improvement of their resistance to attrition compared to the "fresh" resins.

4.2. STIRRED REACTOR USING DENSE PULP MEDIUM

In the past gel-type resins have primarily been considered for uranium recovery, as the rate of silica fouling of macroporous resins was significantly higher. However, since then some work done by Rohm and Haas indicated that although macroporous resins fouled faster, the impact of the silica level on the resin on its metallurgical performance was less [5]. Hence, only macroporous-type resins were tested in the lab for their resistance to attrition using unleached uranium pulp.

Resins MP1 and MP2, fouled with silica to different extents, were subjected to 5 cycles of physical and chemical (osmotic) shock treatments and the percentage of resin loss per cycle was determined. Physical treatment of the resins consisted of aggressive agitation at 1140 rpm over 4 hours in a 50 % (m/m) solids slurry and a resin concentration of 10 % (v/v). Pulp was prepared by mixing milled ore (< 150 μm) with distilled water to prevent uranium leaching, as uranium leaching and loading would have complicated the way in which the test work could be done. Resin in the sulphate form, pre-screened to > 600 μm, was used. Table 3 shows the equipment specifications and operating conditions for the abrasion test.

Table 3. Equipment specifications and operating conditions for abrasion tests

Average agitation speed	~1140 rpm
Impeller level above the bottom of contactor	2 cm
Impeller profile (paddle) Blade Dimensions	4 rectangular blades, 90° pitch 2 cm height, 3.5 cm width, 2 mm thick
Contactor configuration Dimensions	Flat bottomed with baffles 19.5 cm ID X 30 cm Height
Baffles Blade Dimensions	4 narrow plastic blades (29 cm height, 2.1 cm width, 5 mm thick)

After physical treatment or shock, the resins were treated in a column with 110 g/L H_2SO_4 at 4 bed volumes per hour (BV/h) over 1 hour, followed by a wash cycle with distilled water to about pH 2. Particle size distribution (PSD) of each of the resins was determined after 5 cycles of abrasion. Volume measurements were done on resin in the sulphate form and the results are shown in Figure 5.

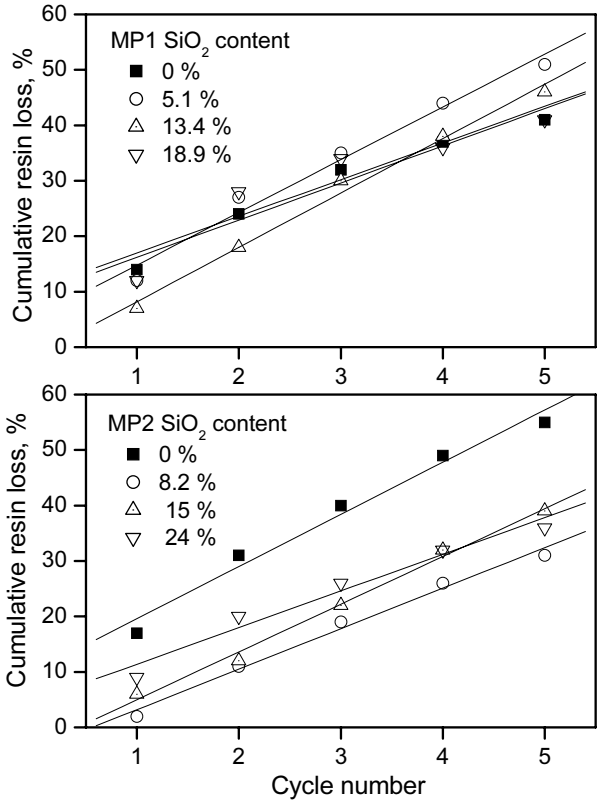

Figure 5: Influence of different silica levels on resistance of resins to attrition with pulp

Variations observed during the accelerated durability tests of the MP1 resin, fouled with silica to different extents, were relatively small. The average resin loss per cycle, irrespective of silica loading, was 10-11 % and the total loss after 5 cycles of attrition was on average 54 %. The relative variation was 7 %, which is within experimental error.

Based on all the attrition results it seems that silica, up to the levels tested during this work, makes the resin a bit more resistant to attrition. Resins containing higher levels of silica have to be tested to see whether the resins become more brittle. The results obtained for MP1 and MP2 using sand and siliceous uranium-containing pulp were somewhat different. In the case of the test using pulp, the MP1 resin was rather insensitive to the silica content compared to the MP2 resin.

5. METRIX® DEMONSTRATION DURABILITY TRIAL

Mintek and Bateman designed and constructed a MeTRIX® (MeTal Recovery Through Ion-eXchange) RIP modular, demonstration plant under a collaboration agreement. The plant was built and commissioned on site at Mintek. The plant is used to demonstrate the potential of RIP and to enable prospective clients to test aspects of the technology on

site [2] or to move the plant to an operating site for test work. The modular skid-mounted MeTRIX® demonstration plant consists of four adsorption stages (Figure 6) of 2 m^3 each and an elution circuit (Figure 7).

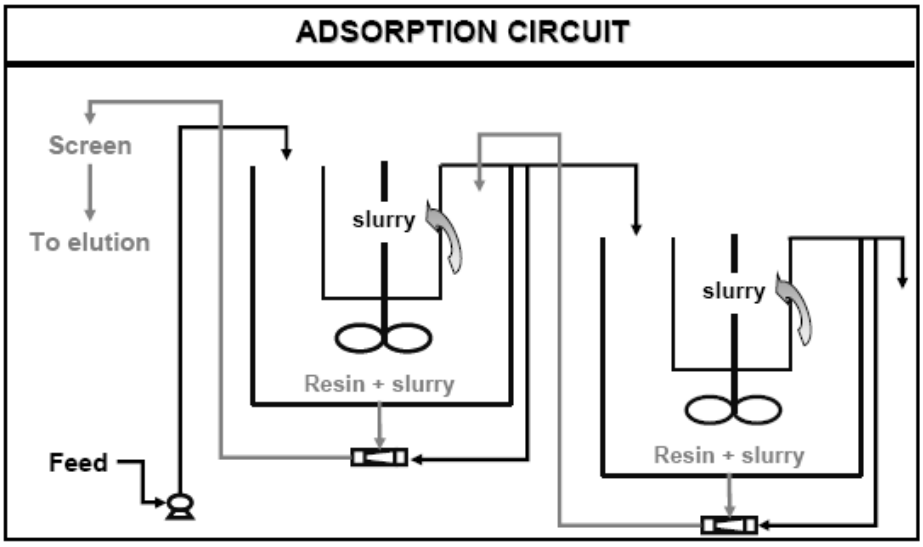

Figure 6: Adsorption circuit

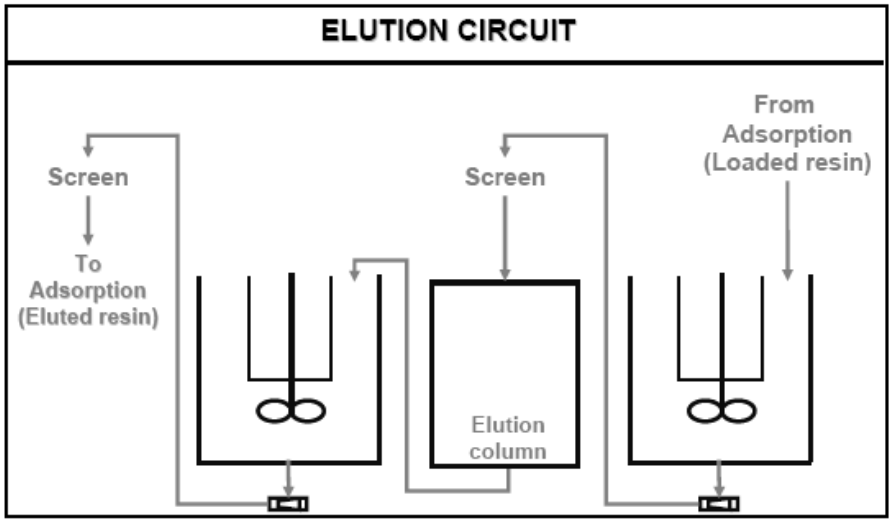

Figure 7: Elution circuit

Durability of two RIP-grade macroporous resins pre-fouled with silica up to 12-15% (using a similar procedure as described in section 0) was evaluated using the MeTRIX® technology. The resins were passed through their normal cycles of adsorption and elution during the durability trial. Schematic flow diagrams of the "adsorption" and transfer stages are shown below in Figures 8 to 10. Table 4 provides the operating parameters of the plant.

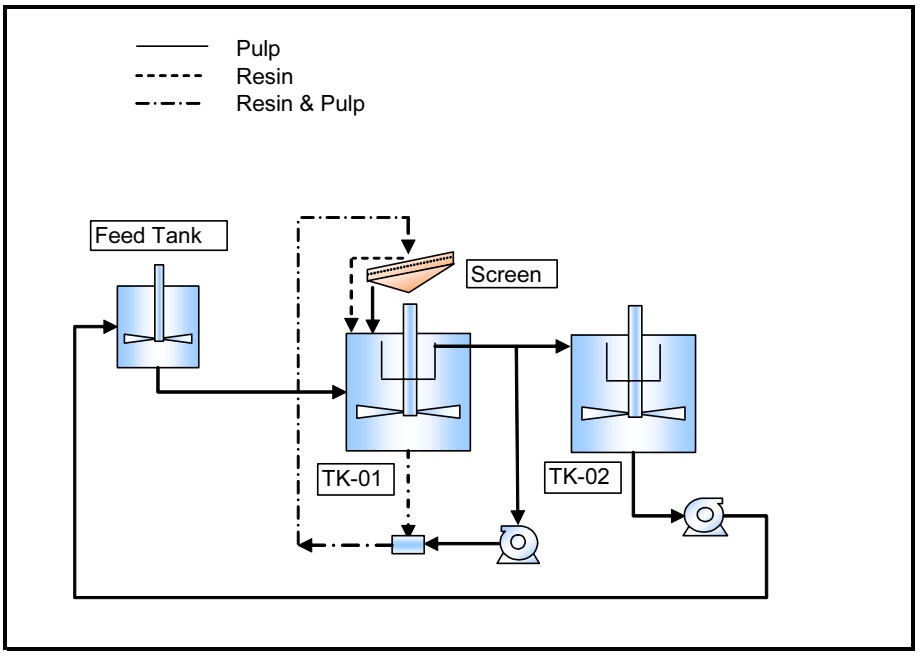

Figure 8: Adsorption stage

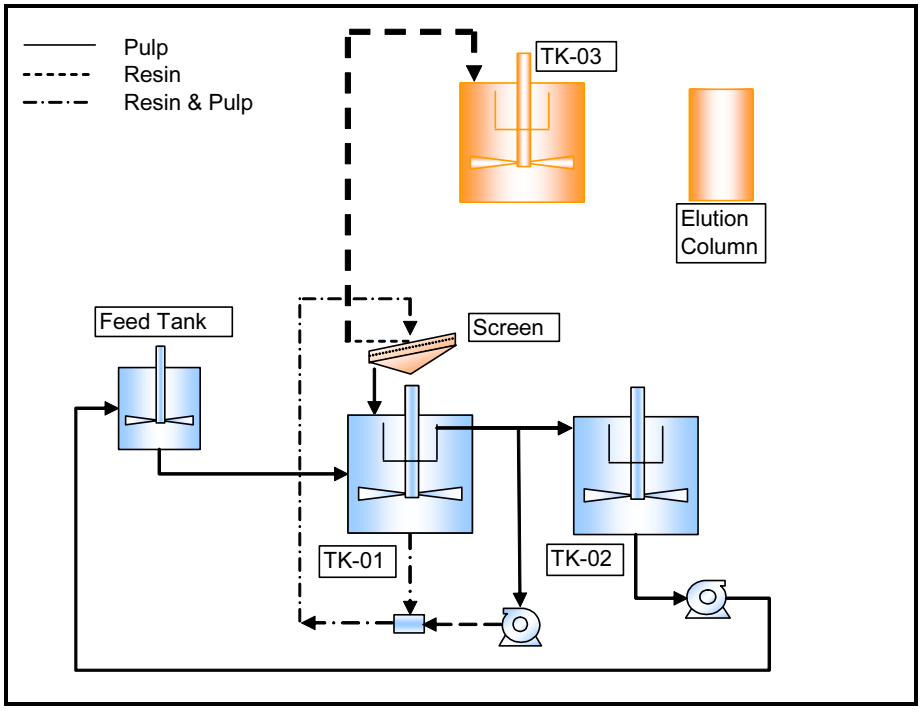

Figure 9: Resin transfer stage 1

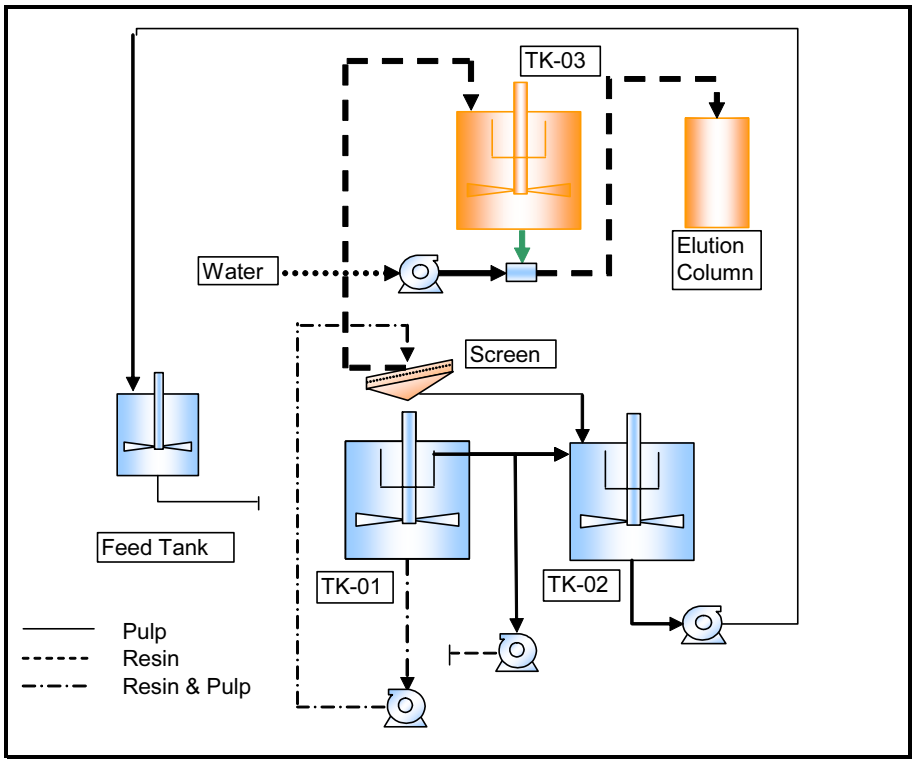

Figure 10: Resin transfer stage 2

Table 4: Operating conditions for MeTRIX® RIP durability trial

Pulp		
Pulp density	1.46	kg/L
Residence time	0.50	h
Volume (TK-01)	2.30	m^3
Flow rate	4.60	m^3/h
Mass flow rate pulp	6.72	t/h
Mass flow rate solids (50 % m/m solids)	3.36	t/h
Solution flow rate (density of 1 kg/L)	3.36	m^3/h
Resin		
Resin flow rate*	86	L/h
Resin residence time/stage	1.3	h
Concentration	4.8	%
Resin volume	110	L

**Limitation of pump. Should be 1 h*

Feed slurry containing 50 % (m/m) solids (100% -212 µm) was pumped into TK-01 until it started to overflow. The overflow from TK-02 was pumped back into the feed tank to keep a recirculating feed going. Once the overflow stabilised, resin was added to TK-1 and the "adsorption stage" (shown in Figure 8) was started.

The "adsorption stage" involved agitation of the resin in the tank, whilst it was pumped over the sieve bed screen. The screen overflow (resin) and underflow (pulp) were allowed to return to TK-01 during this period. This "adsorption stage" lasted for three hours.

After three hours the resin transfer stage started. The overflow (resin) from the screen was shifted to TK-03 as depicted in Figure 9 for 2 hours, which removed approximately 55 % of the resin from the tank (Figure 9). The remainder of the resin and pulp were pumped out mechanically over the next 2-3 hours, and the resin was screened out (Figure 10). The underflow from the screen (pulp) was pumped to the feed tank which acted as a holding tank until such time as the next "adsorption stage" started. The resin transferred to tank 3 was then transferred to the elution column where it was fluidised and subjected to 100 g/L H_2SO_4 acid treatment (representing elution).

The process described above constituted one cycle. Six to eight cycles were performed per week and at the end of each week the resin was transferred completely into a separate measuring cylinder, which was fluidised to determine the free settling volume.

A total of 36 (5 weeks of operation) and 21 (3 weeks of operation) cycles were performed on the MP1 and MP2 resins, respectively.

A comparison of the durability trial results for the MP1 and MP2 resins appears in

Table ***5***. No measurable resin loss was noticed after 5 weeks of operation or 34 cycles for the MP1 resin, which is unrealistic for an operating plant.

Table 5: Results on resin durability trial

Parameter	MP1		MP2	
	Initial	End Week 5	Initial	End Week 3
Average volume (L)	110	111	109	99
Change in resin volume based on initial volume (%)	n/a	No loss	n/a	9.2
Number of cycles	0	34	0	21
Days of operation [a]	0	46	0	28
Predicted resin loss/cycle (%)	n/a	0.22	n/a	0.44
Predicted resin loss/year[b] (%)	n/a	50	n/a	101
Predicted resin loss (g/t) [c]	n/a	4.3	n/a	8.5

[a] *Assuming a 36 hour cycle on an operating plant & 90 % plant availability*
[b] *Assume 50% of resin loss for MP2, as no loss on an operating plant is unrealistic*
[c] *Loss of dry resin per ton of air-dried ore*

A cumulative resin loss of 9.2 % was recorded over 3 weeks of operation or 21 cycles for the MP2 resin. The resin volume measurements over the three week period indicated that the resin loss was initially very high (5.4%), it then dropped to 3.5% for the following week and after that to 0.9% for the final week of operation (week on week loss) with an average loss of 0.44% per cycle. This sequential loss is divided by the number of cycles

in each week of operation and converted to a loss in g/t. An initial loss of around 16.2 g/t reduced to 2.4 g/t with a median loss of 8.5 g/t over a three week period. The loss per cycle (0.44 %) would result in approximately 100 % of resin loss per annum.

The data obtained with the MetRIX® demonstration plant appear to be somewhat different to those obtained during the laboratory attrition tests. The laboratory results indicated that MP2 was somewhat more resistant to attritioning than MP1, while the MetRIX™ results suggested that lower operating losses could be expected with the MP1 resin. Based on this information it was concluded that a further test method on tensile strength has to be added to the methods of resin evaluation.

Optical imaging (using a stereo microscope) conducted on the samples indicated that breakage of MP1 resin occurred even though it was not evident from the resin volume measurements. These broken beads however were still larger than 600 µm and hence retained on the screen. A picture of these broken beads can be seen in Figure 11 at 35 x magnification. Closer investigation indicated that most of the resin was broken and very little or none resin "peeling" was observed.

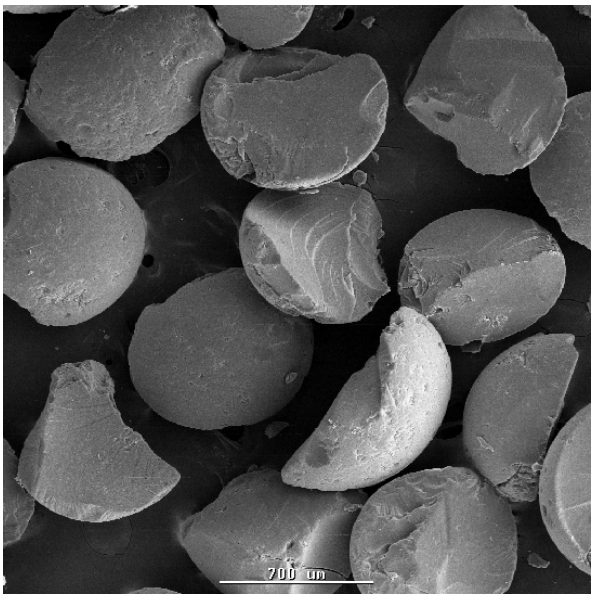

Figure 11: Broken resin beads in + 600 µm fraction

6. RESIN LOSS COMPARISON TO SOME GOLD RIP OPERATING DATA

Operational losses for the Minix and Duolite A161 RIP resins were previously reported as <5 g/t in the Penjom and <10 g/t in the Golden Jubilee RIP plants. These are both strong-base resins, and althought the Minix gold selective resin has a different structure and composition to the current strong-base resins considered for uranium, the Duloite A161 RIP resin is very similar. These two resins were therefore included in the accelerated degradation test work as described in section 0. Cumulative resin loss per cycle of physical/chemical treatment for the resins tested is presented in Figure 12.

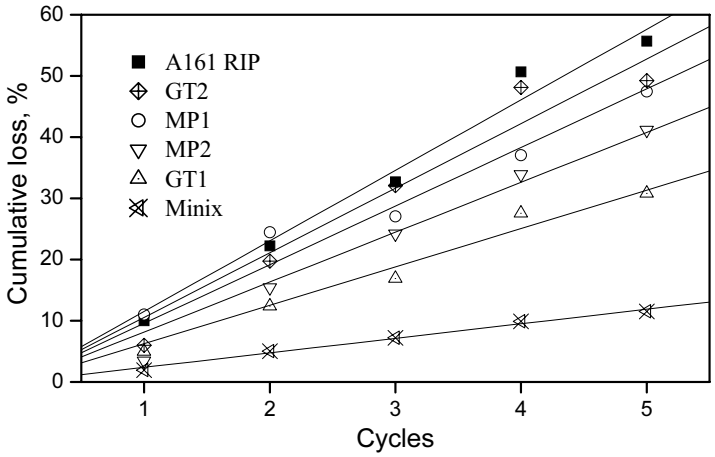

Figure 12: Comparison of resistance to attrition between new RIP-grade size resins, Minix and Duolite A161 RIP

It was clear that the Minix resin was by far the most robust product and cannot be used as a basis to compare the current uranium resins with. However, the behaviour of the A161 RIP resin was quite similar to that of the macroporous resins in these tests. Although the results on these two resins might not give an accurate reflection of potential resin losses on a uranium RIP plant, it probably is a reasonable indication of what the full scale resin loss could be.

It seems that gel-type resins were not considered for current RIP applications, but results on the GT1 resin appear promising and this resin would also be subjected to durability test work in the MetRIX™ demonstration plant.

7. EFFECT OF RESIN BREAKAGE ON OPEX

Previous work done by Bateman and Mintek [6], comparing various flow sheets for recovering uranium, has found that for uranium concentrations in leached pulp below 900 mg/L a combination of RIP and SX produces the lowest cost flow sheet. Above 900 mg/L a CCD-SX based flow sheet proved to be the cheapest to build and operate. A key parameter in the operating cost was the resin breakage cost. In a later paper [7], the sensitivity of the operating cost to resin breakage was investigated and the OPEX was found to be relatively insensitive to resin breakage.

Based on these results the conditions shown in Table 6 were chosen to evaluate the contribution of resin breakage to operating cost for a specific application using the durability data produced during the MetRIX™ demonstration plant durability test work.

Data used in this comparison are derived from a model developed by Bateman and Mintek which estimates the operating cost of the chosen flow sheets based various supplied parameters. The model was run using parameters typical of Witwatersrand gold ore-based slurries, using a range of values for RIP resin breakage. Resin losses measured in the MetRIX™ pilot plant for the two macroporous resins under consideration are summarized in

Table ***5***.

Table 6: Conditions for OPEX evaluation

Uranium production:	100 kg/h U_3O_8
Leached slurry concentration:	200 mg/L U_3O_8
RIP flow sheet:	MeRIX™ based RIP followed by SX using Bateman pulsed columns
Reference flow sheet:	CCD followed by SX using Bateman pulsed columns

At the rates of resin breakage measured, the contribution of resin replacement cost to the operating cost of the plant are estimated at 0.08 USD and 0.38 USD per pound of uranium produced for MP1 and MP2 respectively. To place these values in perspective, the total operating cost of a typical South African uranium plant, treating this type of ore, would be in the region of 20 – 30 USD / lb.

The resin replacement cost calculated above is of a similar order of magnitude to the estimated expenditure on reagents for a conventional uranium plant such as flotation reagents or SX plant organics. To illustrate this, the cost of annual RIP resin replacement is plotted at various breakage rates in Figure 13. The cost of the two major reagents in the CCD-SX flow sheet, flocculent usage and replacing organic losses for the equivalent plant, are plotted on the same graph.

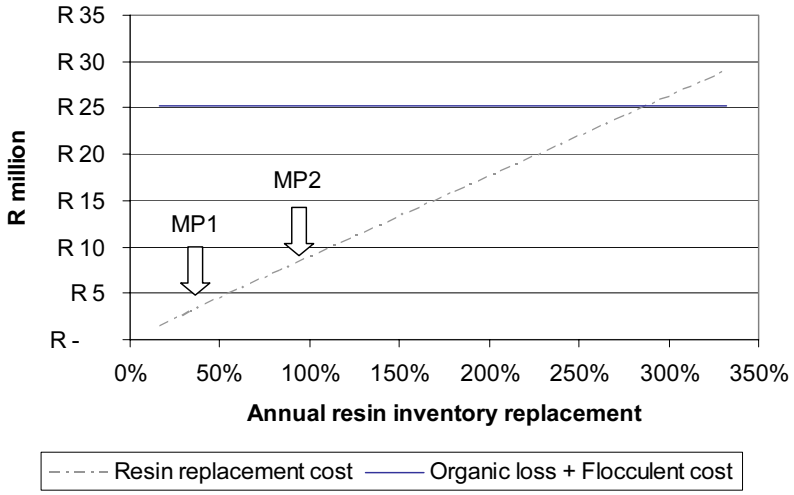

Figure 13: Cost of resin replacement

It can be seen that the annual resin cost only matches the cost of major reagents in a conventional plant at rates of resin breakage far higher than those measured in this test work programme. Although these high rates were not achieved during test work on the MetRIX® plant, it should be noted that higher silica loadings on the resin than those tested during this test work program may result in resin embrittlement and consequently higher resin breakage. Resin degradation is unlikely to influence the economic viability of uranium projects using RIP (if SiO_2 fouling is handled appropriately). However, significant cost savings can be achieved by selecting the correct resin for the application and having a plant design, such as the MetRIX™ technology, that minimise the impact of handling on the resin.

8. CONCLUSIONS

A test work program to determine mechanical characteristics of RIP-grade resins currently available on the South African market was initiated at Mintek. The effect of some factors such as silica fouling and chemical treatment of the resin was investigated. Different durability testing techniques were tested and compared in this study.
It was established that:

- Sodium hydroxide treatment resulted in weakening of primarily the gel-type resins. Weakening of the resins occurs due to swelling/shrinking of the resin during sequential chemical treatments, which has a bigger impact on gel resins. The macroporous resins were less susceptible to weakening during NaOH treatment, especially the MP1 resin.

- Silica fouling of the resins to the levels tested resulted in a slight improvement to their resistance to attrition compared to the “fresh” resins tested.

- Accelerated attritioning results indicated that the new gel resin, GT1 (big size, d_{50} = 780 μm), performed well in the attrition tests and should also be subjected to durability test work in the MetRIX™ demonstration plant.

- Laboratory results obtained with the macroporous resins were somewhat different to that determined using the MetRIX™ demonstration plant. Hence, it was decided to include tensile strength testing on the resins in future test work.

- Modeling of the impact of resin loss on the OPEX of a uranium RIP plant indicated that the annual resin loss cost only matches the cost of major reagents in a conventional plant at rates far higher than those predicted from the MetRIX® demonstration trials.

9. REFERENCES

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The Author

Volha (known as Olga) Yahorava, *Principal Scientist*, Mintek

2007 - present. Hydrometallurgy division, Mintek, South Africa, Principal Scientist.
Research in the field of uranium, base metals and noble metals hydrometallurgy; ion exchange (RIP, NIMCIX, fixed-bed) using traditional granular resins and fibrous ion exchangers

2002 - 2007 Laboratory of Ion Exchange and Sorption, Department of High Molecular Substances, Institute of Physical Organic Chemistry, National Academy of Sciences, Republic of Belarus. Research in the field of sorption and ion exchange using fibrous materials, synthesis and investigation of impregnated sorbents, purification of drinking water