Ion Exchange Resin Testing

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Introduction

• Power Industry Background (MUWTP and CPP)
• Consider the Life Cycle of Ion Exchange Resins
• From Manufacture through to eventual Disposal
One Possible Approach

- Consider Ion Exchange Resin Testing as part of a RESIN MANAGEMENT PROGRAMME
- “Do you want to pay me now or pay later?”
Content

- Introduction
- When to Test
- Why Test
- How to Test
- Routine Tests
- Specialised Testing
- Sampling
- Test Results
- Conclusions
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When to Test

- Manufacturing/Production
- Pre-delivery
- Before Loading into Service Vessel
- Periodically
- Troubleshooting
- Prior to Disposal
Manufacturer and Production

- Sampling and Testing for:
- Quality Assurance
- Traceability etc
- Specification Compliance
Resin Specification 1

- Resin Properties:
- Application e.g. Softening
- Polymer Structure
- Appearance
- Functional Groups
- Ionic Form
Typical Resin Specification for Cation Resin

- Total Capacity, Na\(^+\) Form (min) 1.8eq/l
- Moisture Retention, Na\(^+\) form 48 – 53%
- Mean Diameter 725 ± 125 µm
- Uniformity Coefficient (max) 1.7
- Reversible Swelling, Na\(^+\) to H\(^+\) 4%(max)
- Temperature limit, H\(^+\) form 120 °C
- Temperature Limit, Na\(^+\) form 140 °C
Pre Delivery Samples

- Special Applications
- Check for Compliance with Specification
- Procurement Contract
- Demonstrate Informed Client
Prior to Loading into Service Vessel

- Last Chance !!
- ARCHIVE SAMPLES
- No of Batches
- No of bags
- Visual Inspection
- Visual Microscopy
Periodically

- Expected Resin Life?

- 2 years? 5 years? 10 Years?

- Condition Monitoring Programme

- Helps to identify a potential problem before it becomes a performance issue

- Trending Analysis

- Forward Planning, Purchases and Budgets
Troubleshooting and Problem Solving

- Plant Performance Problems
- Investigations
- Resin Sampling and Testing
- One part of the Process
- Caution
Resin Testing

- Routine Tests
- More Specialised Testing
Routine Tests

- Visual Inspection
- Microscopic Inspection
- Separating the Resin
- Cation Capacity (total, strong and weak)
- Anion Capacity (total, strong and weak)
- Particle Size Distribution
- % Moisture retention
Visual Inspection

- % Perfect Beads
- % Cracked Beads
- % Broken Beads
- Surface Condition
- Gel or Macroporous
- Particle Size Distribution
- Supernatant Liquor
Capacity - Cation Resins

- Capacity
- Total
- Strong
- Weak (by difference)
- % Moisture Retention
Cation Capacity - Strong

\[ \text{CH}_2\text{CH-CH}_2\text{SO}_3\text{-H}^+ \]
Cation Capacity - Weak

Crosslinked Acrylic Acid
Cation Resin Degradation

% Retained Moisture

TIME

0 1 2 3 4 5

0 10 20 30 40 50 60
Anion Resins

- Capacity
- Total
- Strong
- Weak (by difference)
Anion Capacity - Strong

CH₂CHCH₂

CH₂

H₃C    N    CH₃

CH₃

Cl⁻

Type I
Anion Capacity - WEAK

- CH₂ - CH - CH₂
  - CH₂
  - H₃C - N - CH₃
Degradation of Anion Resins

% Remaining Capacity

TOTAL

STRONG

WEAK

TIME

% Remaining Capacity

SCI

where science meets business
Particle Size

- Standard Mesh (wet or dry)
- Visible Light or Laser
- Optical Cell
- Parallel light
- Gel resins
- Macroporous resins
Uniform Beads

No of Beads

μm

450 600 750 900

Uniformity coeff. ≤ 1.2
Particle Size

Number of Beads vs. Bead Size / microns

- The x-axis represents Bead Size in microns, ranging from 200 to 1000.
- The y-axis represents the Number of Beads.
- The chart shows a peak at approximately 600 microns, indicating a concentration of beads in that size range.
Particle Size

![Particle Size Graph](image-url)
Statistics of Measurement

Harmonic Mean

where science meets business
Anion Kinetics

- Condensate Polishing Plants (CPP)
- High Flow
Anion Kinetics

- Chloride
- Sulphate
- Carbon Dioxide
Exchange Kinetics
MTC = \frac{V \ln(C/C_0)}{SZA}

- MTC = Mass Transfer Coefficient (m/s)
- \(C_0\) = inlet anion concentration (mg/l)
- C = outlet anion concentration (mg/l)
- V = volumetric flow rate (m\(^3\)/s)
- S = specific surface area of anion resin (m\(^2\)/m\(^3\))
- Z = depth of resin bed (m)
- A = cross section of resin bed (m\(^2\))
Specific Surface Area

- \( S = \frac{3.9}{d_{\text{HMS}}} \)
- \( d_{\text{HMS}} = \text{harmonic mean diameter (m)} \)

\[
\text{MTC} = \text{Constant} \times d_{\text{HMS}} \ln(C/C_0)
\]
Effect of pH on MTC

![Graph showing the effect of pH on MTC for Cl and SO4](image-url)
Column Tests

- Various Sizes
- Small Scale Laboratory
- Pilot Plant
- Follower Rigs on Plant
Hydrazine Breakthrough for Resin A

Hydrazine Concentration (ppm)

Time (mins)
Organics

- Organic Extractables
- Organic Fouling
Organic Fouling Measurement (KMnO₄ method)

- **Principle**
  - Oxidise with potassium permanganate
  - Boil in acidic conditions
  - Titrate excess KMnO₄

- **Procedure**
  - 100 ml water + 2 ml 5 N H₂SO₄
  - Add 20 ml of 0.0125 N KMnO₄
  - Boil for 10 minutes
  - Add 20 ml of 0.0125 N Mohr’s salt \((\text{NH}_4)_2\text{Fe(SO}_4)_2\cdot6\text{H}_2\text{O}\)
  - Titrate the excess of Mohr’s salt with 0.0125 N KMnO₄
  - Read volume required for titration = \(y\) ml
  - Organic matter = 4 \(y\) in mg/L as KMnO₄ or \(y\) in mg/L as O₂

There is no direct relation between KMnO₄ and TOC measurement
Sampling

- Most Important left to the end!
- Should be Representative
- Representative of What?
- Whole Bed
- Top of the Bed
- Bottom of the Bed
Conclusions 1

- See Resin Testing as one part of the bigger picture
- Condition Monitoring – proactive
- Trouble shooting – reactive
- Trending
Conclusions 2

- Resin Testing is only one weapon in the armoury
- Best used in conjunction with other Plant Monitoring Tools
- Generally modern resins are strong and robust
- Causes of Plant Performance Problems frequently lie elsewhere
QUESTIONS