Successful High Density Sludge (HDS) Treatment Plant Design for Acid Mine Drainage

Presented by:

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Presentation Overview

- Objective: Provide a working-level understanding of the basic HDS process and information needed for successful design
- Part 1: History and Description
- Part 2: Process Basics
- Part 3: Major Component Design
- Part 4: HDS plant Photos
- Questions?

HDS History

- HDS = High Density Sludge
- Developed in late 1960s by Bethlehem Steel Corporation, Pennsylvania
- Bethlehem was struggling with large volumes of lime treatment sludge
- Developed to improve metal removal treatment of acidic waters and reduce sludge volumes
- Initial focus was coal mine drainage

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What HDS Does

- Compared to conventional lime treatment
  - Provides enhanced removal of dissolved metals
  - Is a more stable process
  - Produces denser and better handling sludge
  - Reduces equipment scaling

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Scaling Caused by Conventional Lime Treatment

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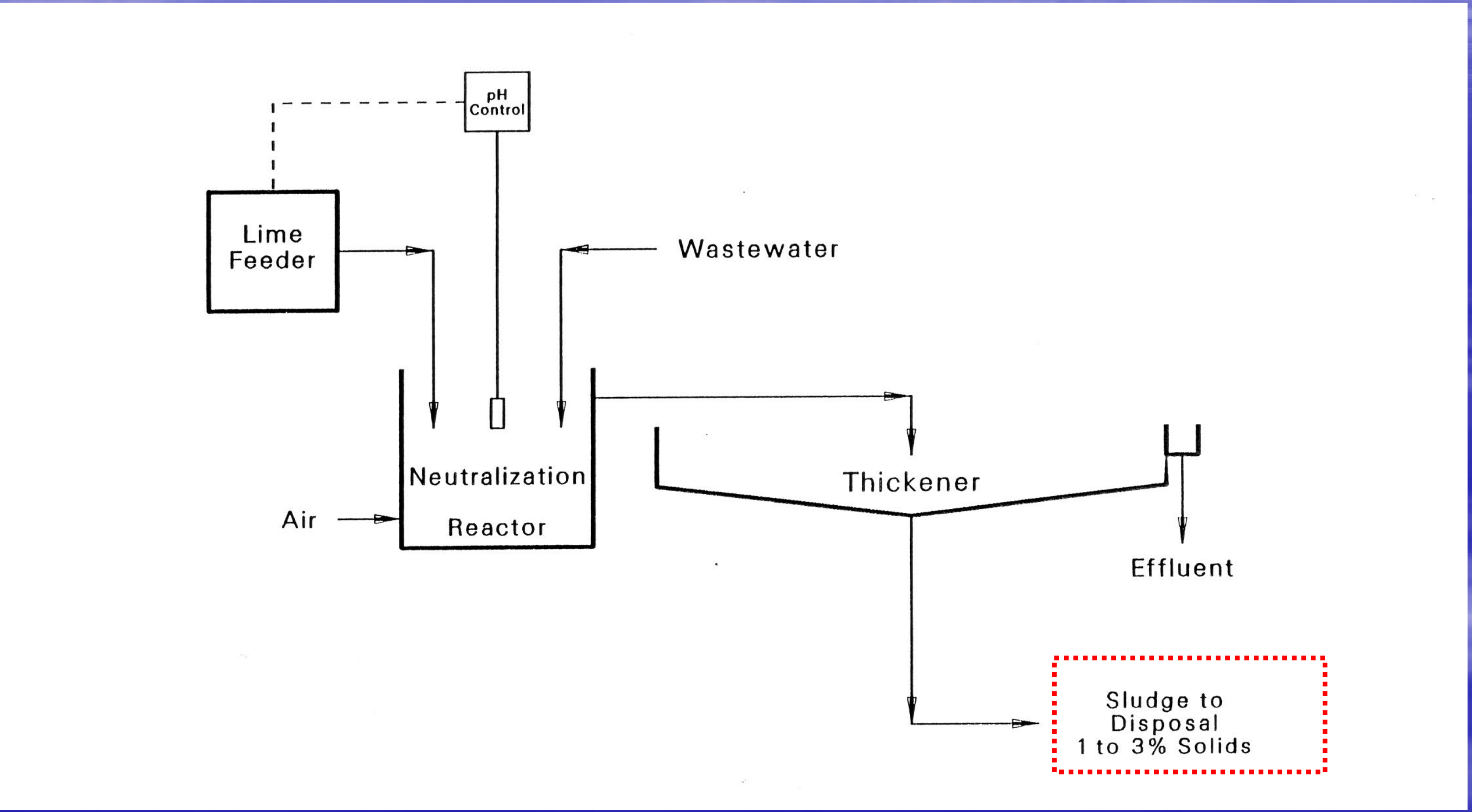
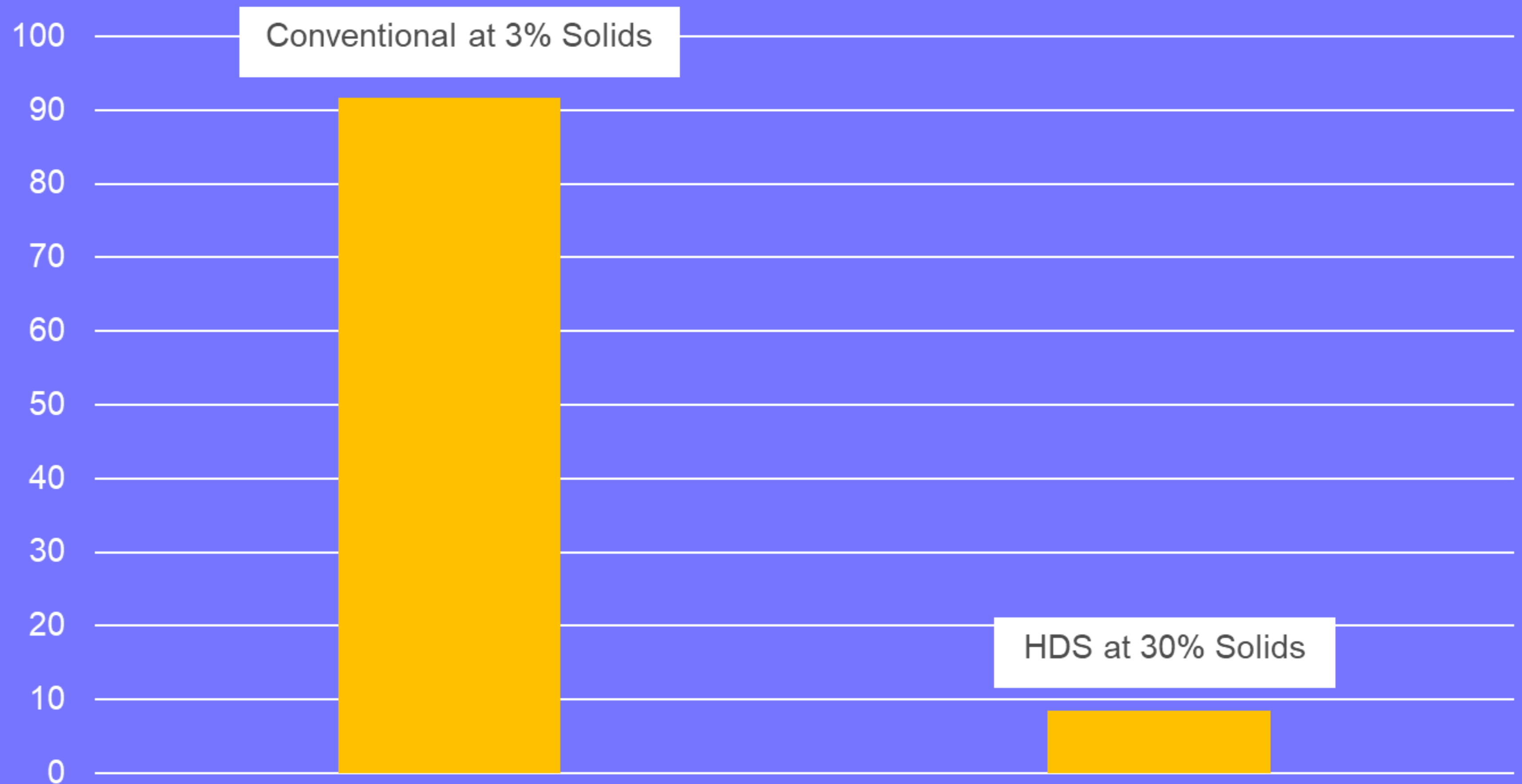
Conventional Lime Treatment



Source: S.T. Herman

Relative Sludge Volumes



Negatives of Conventional Lime Treatment

- Creates very small particles (sludge)
- Particles difficult to settle
- Sludge is mostly water, typically 97-99%
- Sludge takes considerable disposal space
- Equipment prone to scaling
  - Scale caused by chemical precipitation due to super-saturation. This is different than “caking” due to drying

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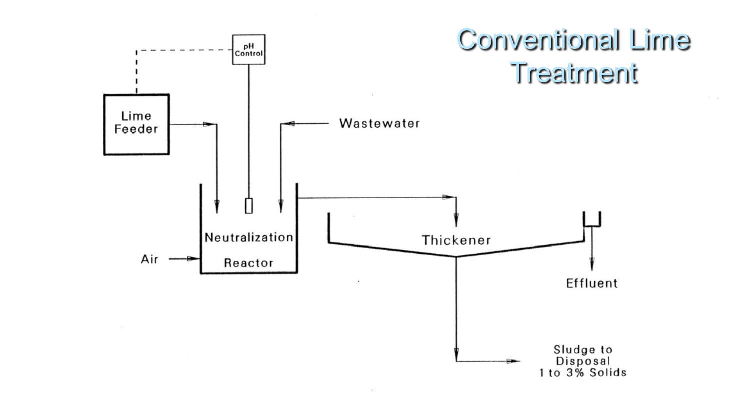

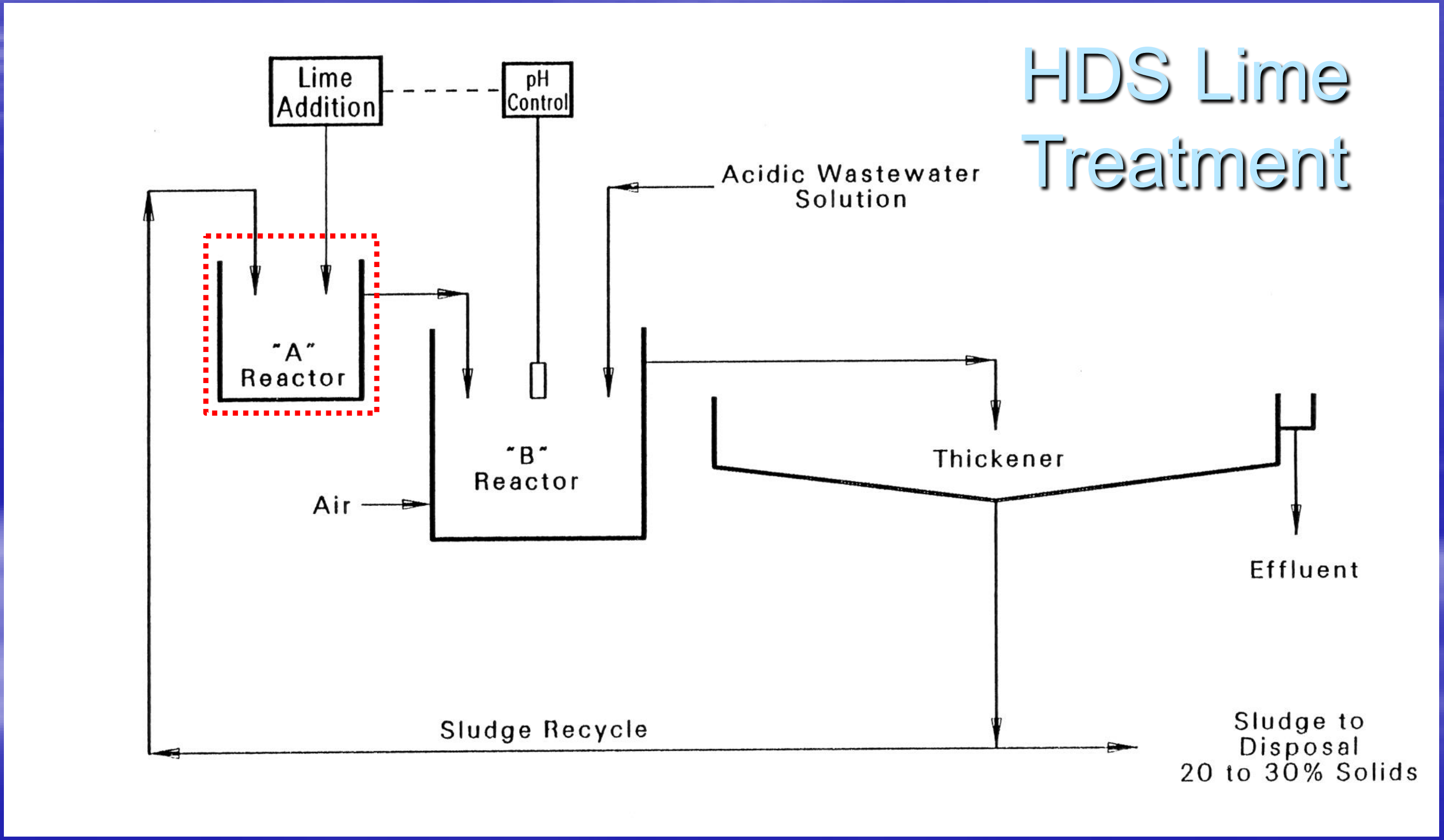

Source: S.T. Herman

Development of the First HDS Plant by Bethlehem Steel

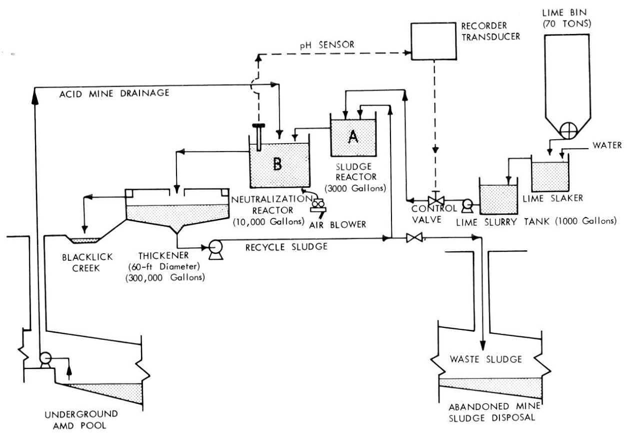

Fig. 4—Flow diagram: HDS demonstration plant at Coal Mine 32.

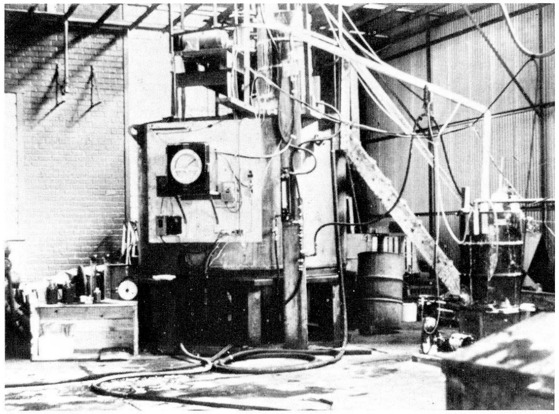

Fig. 6—High density sludge pilot plant.

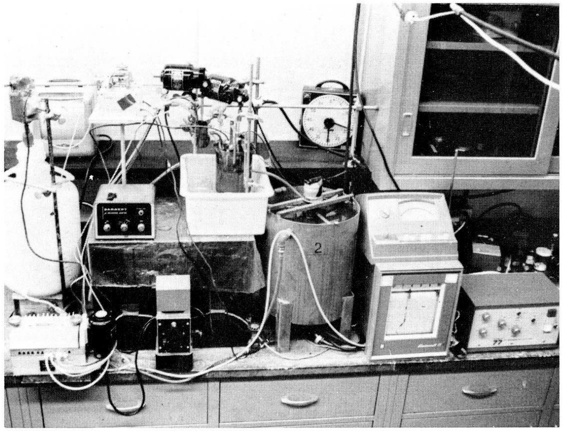

Fig. 5—Laboratory high density sludge plant.

Fig. 7—High density sludge demonstration plant.

Source: F.M. Temmel, 1971

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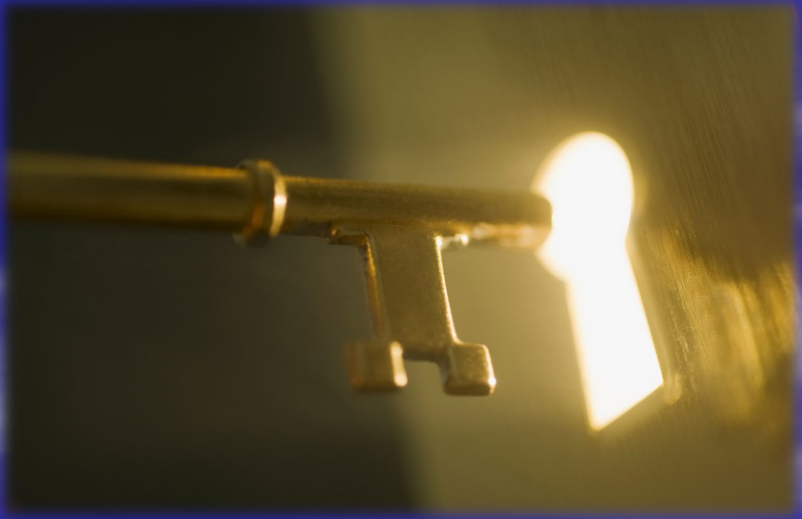
Part 2: Process Basics

- Topics Covered:
  - How and why HDS works
  - Basic design concepts

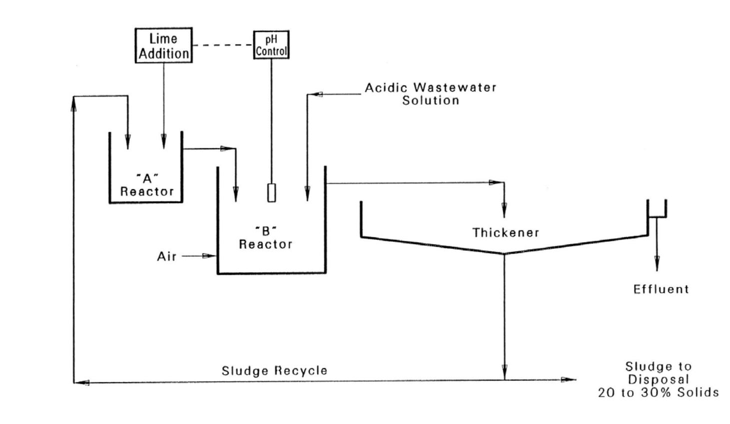
The "Key" to HDS

- Sludge recycle with lime (hydroxide) coating



The 5 Basic HDS Steps

- Step 1: Recycle sludge to small mixed tank (A Reactor)
- Step 2: Add lime to the tank
- Step 3: Mix lime/sludge with mine water in Reactor B and aerate if needed
- Step 4: Settle sludge
- Step 5: Repeat Steps 1 – 4



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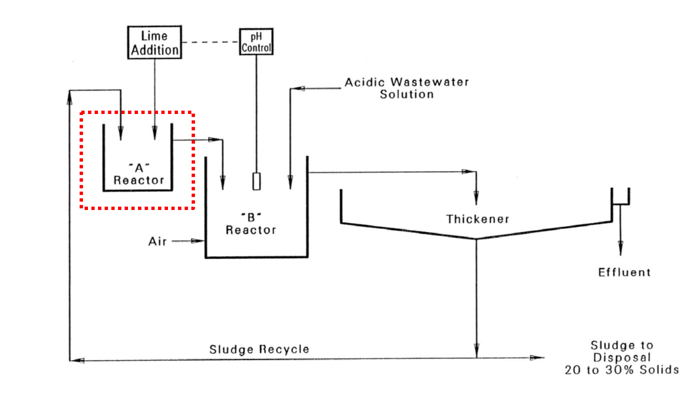
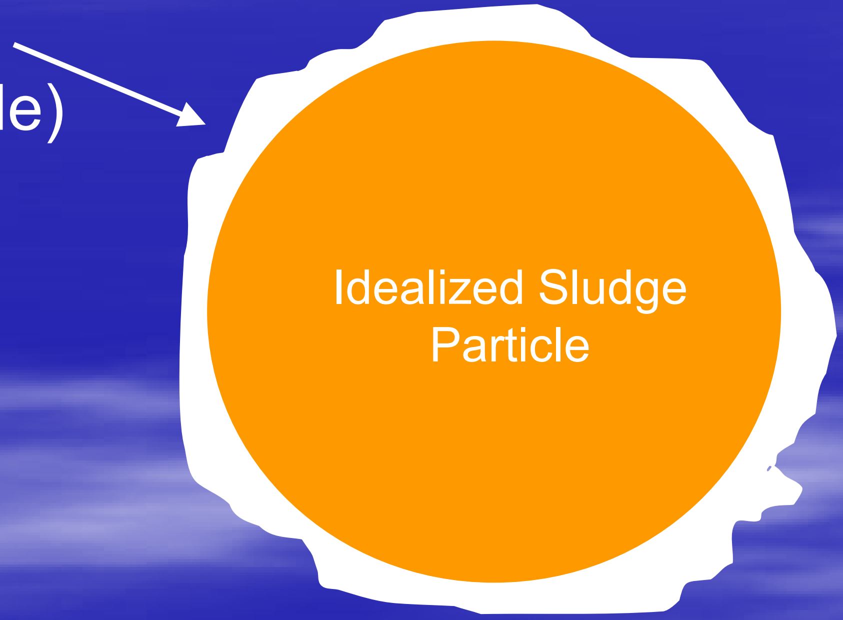
Inside Reactor A (Sludge/Lime Mix Tank)



Lime Coating (hydroxide)



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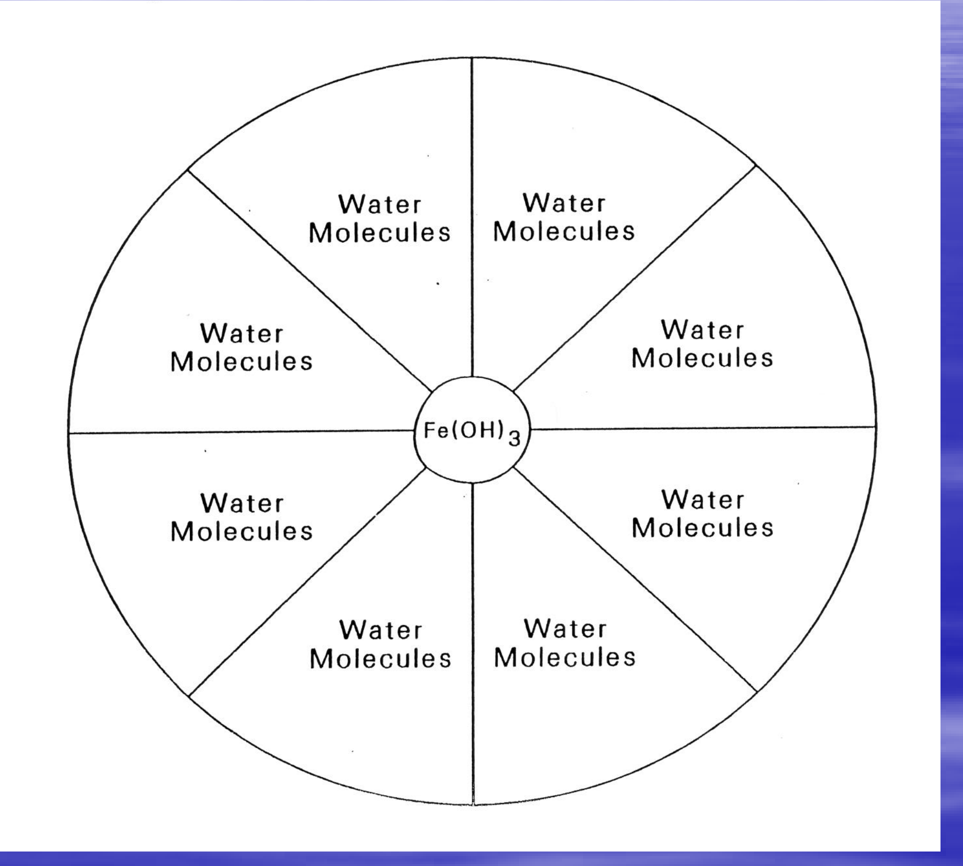
Representation of Conventional Ferric Hydroxide Particle with Attached Water

Reactor A removes the water so particles can grow



Source: S.T. Herman

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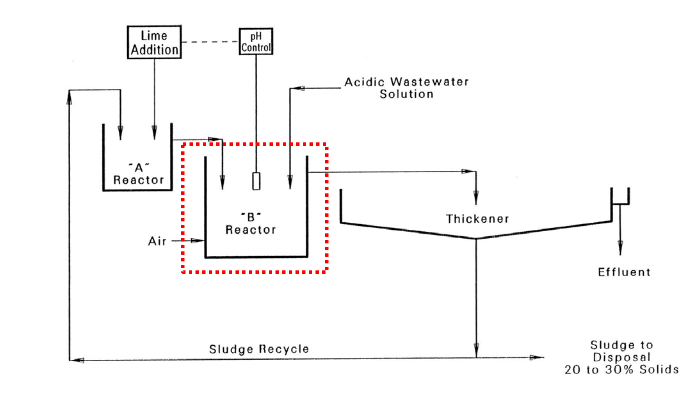
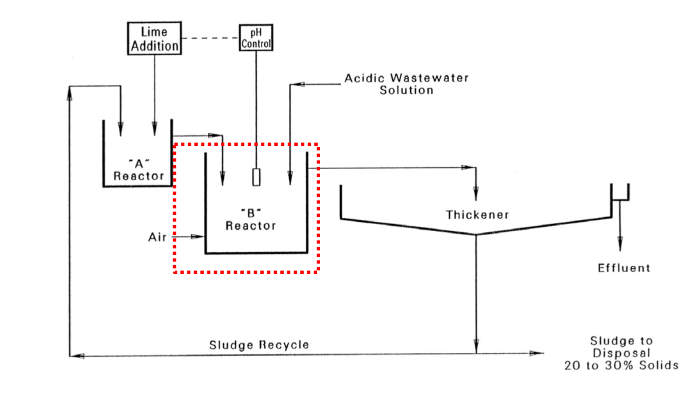
Inside Reactor B



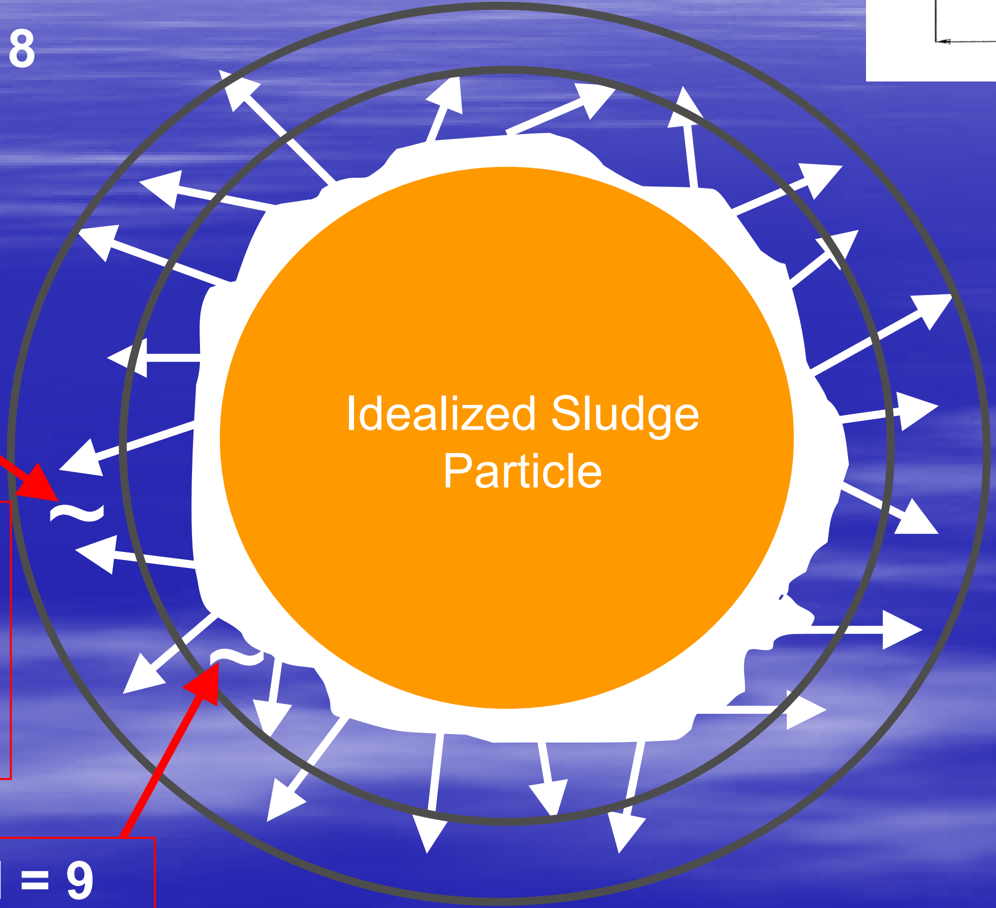
New layer of sludge

Particles "grow" with every recycle

Inside Reactor B



Probe pH = 8



pH = 8.5

Effective HDS pH for metal precipitation

pH = 9

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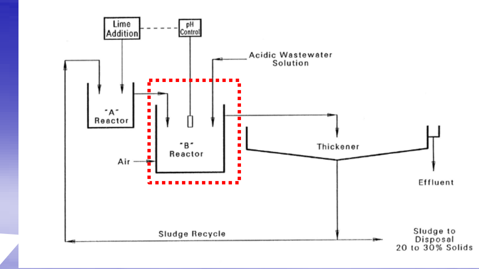
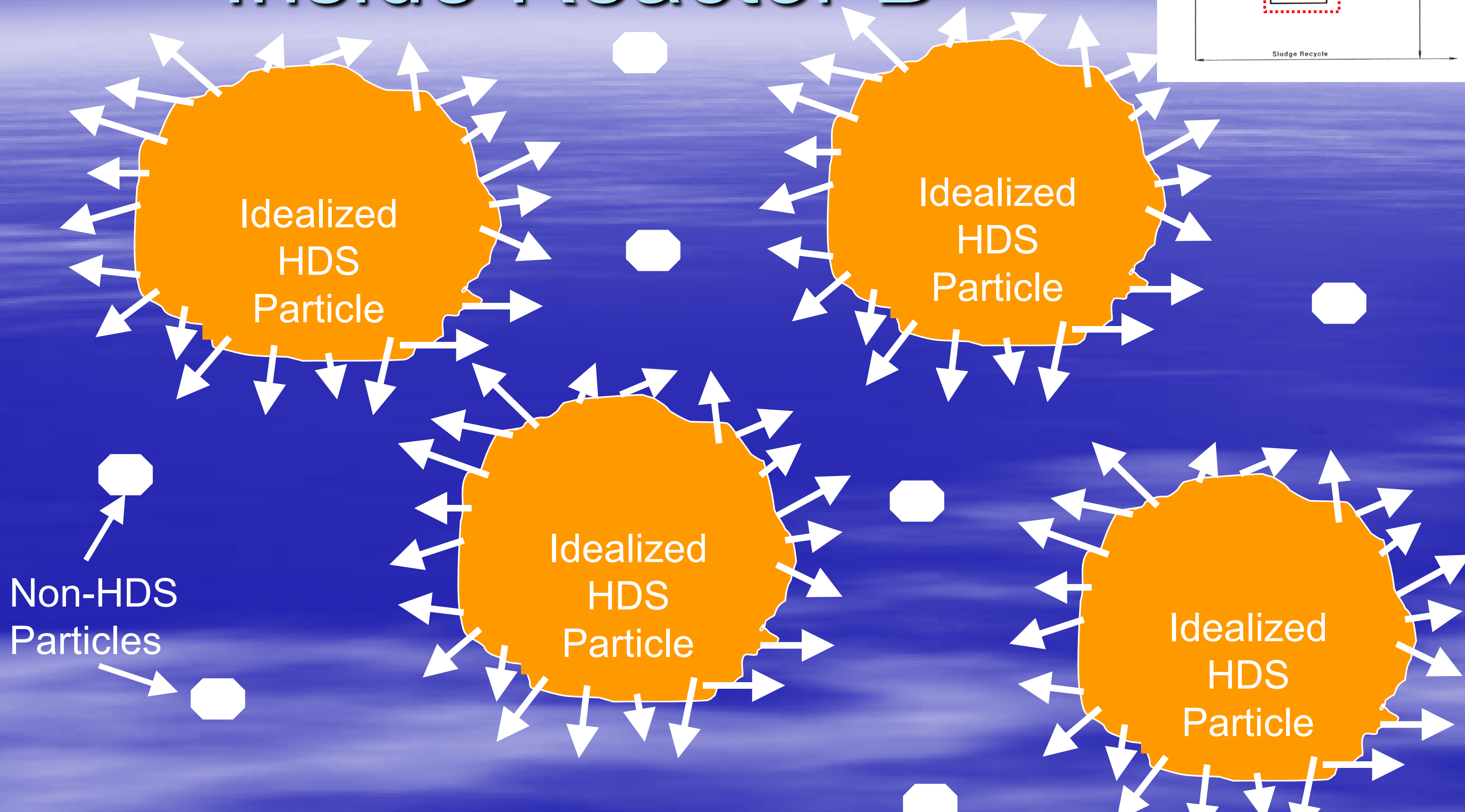
Inside Reactor B





We do **NOT** want non-HDS particles because they will attract new precipitates—we want the new precipitates to grow on the HDS particles

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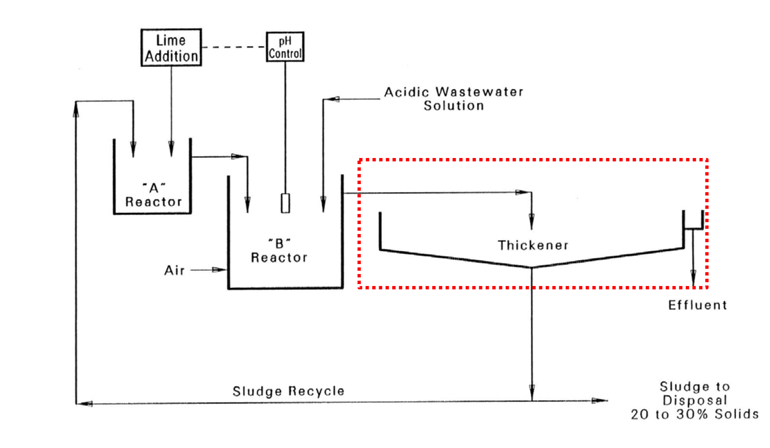
Thickener

of the HDS process



- Purpose
  - Performs solids settling and sludge thickening
- What Happens
  - Solids flocculate (combine) in the centerwell, then settle to the bottom, usually assisted with polymer flocculant
  - Bottom solids gradually compress (thicken) due to gravity
  - Rake gently stirs to release water and push solids to center for pumping

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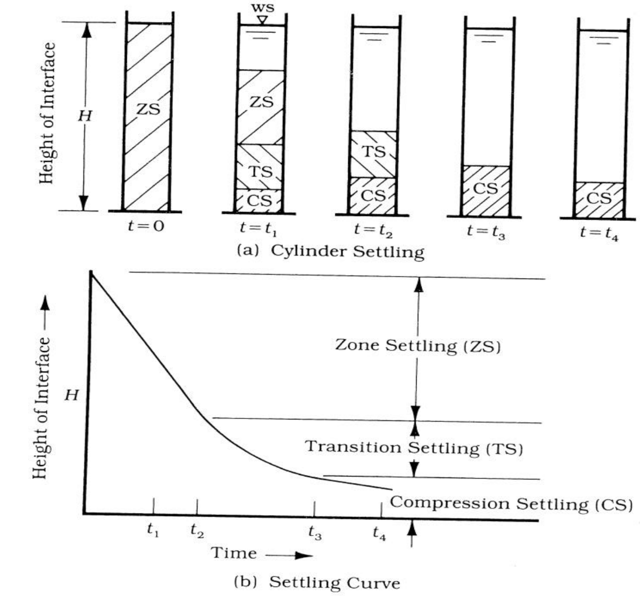
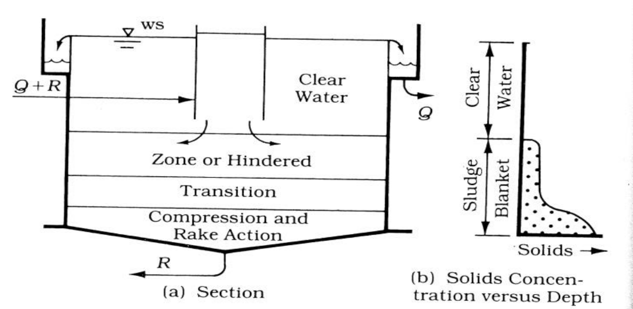
Clarification and Thickening Occur in Same Tank

Idealized Settling “Zones” in Lab Cylinder



Source: Sawyer/McCarty, 1978

Idealized Settling “Zones” in Thickeners



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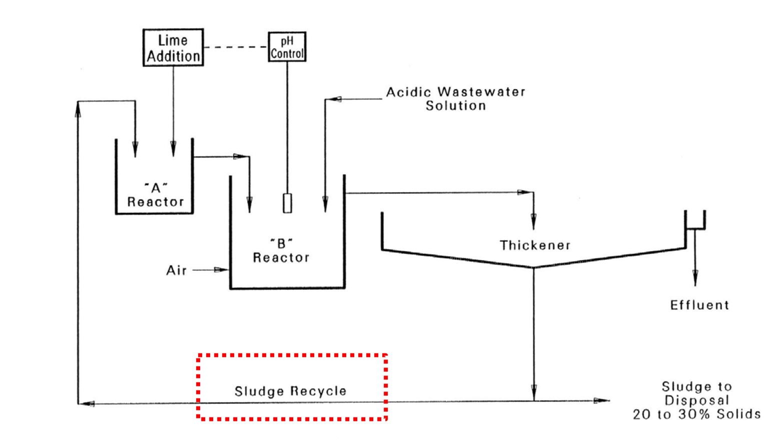
Solids Recycle Ratio (SRR)



- SRR = solids made ÷ solids recycled
- How Much Sludge to Recycle?
  - Need enough for lime adsorption
  - Solids recycle ratio (SRR) commonly used
- "Typical" SRRs between 20:1 and 50:1
- Best determined from pilot test

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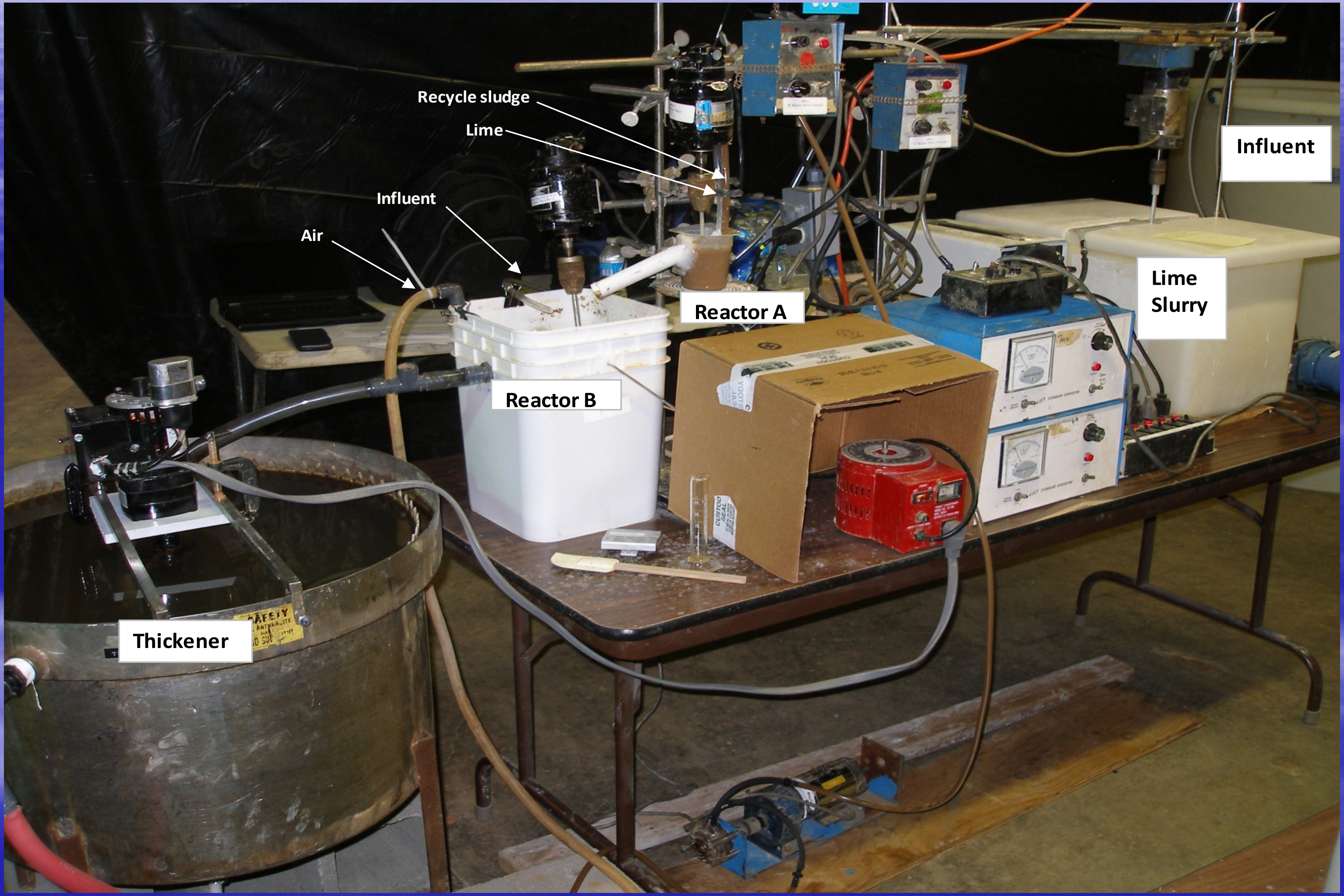
HDS Pilot Test Setup



SRR Continued

- Careful!
  - SRR is a convenient “surrogate” for required surface area for lime adsorption
  - Mathematically speaking, could recycle a handful of lead bowling balls and meet the SRR “number”, but it won’t work
  - For the same SRR, recycling a denser sludge at a low flow rate is much better than a lighter sludge at a high flow rate

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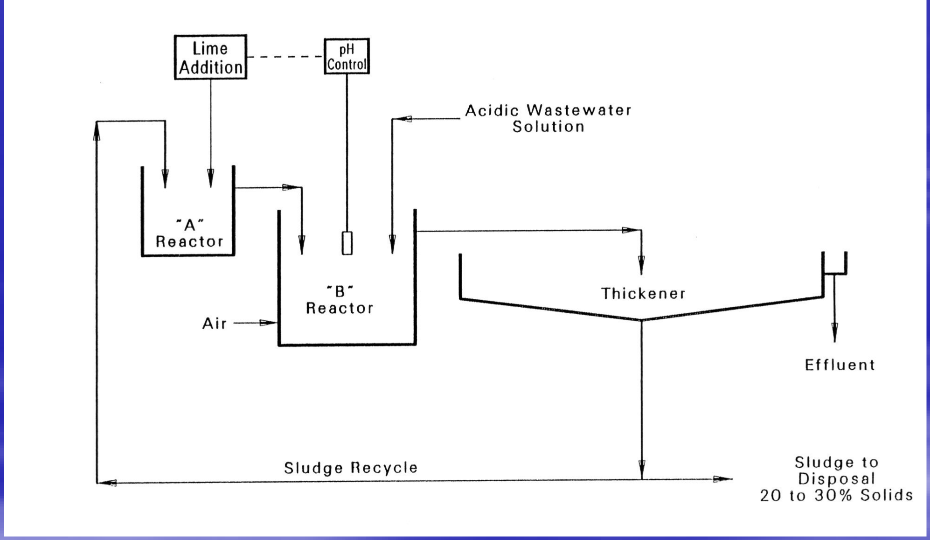
Part 3: Major Component Design

- Topics Covered:
  - Reactor A
  - Reactor B
  - Thickener



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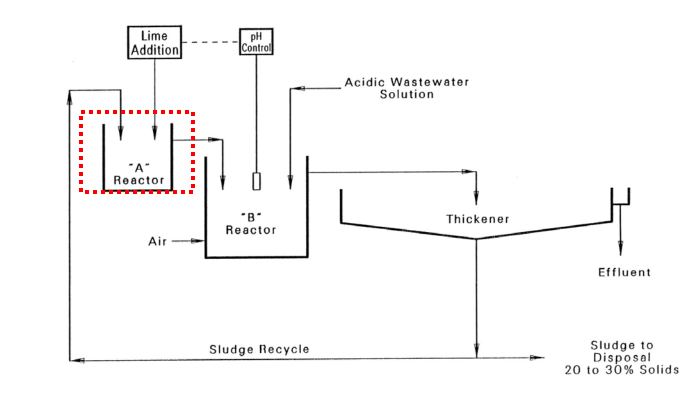
Reactor A (Sludge/Lime Mix Tank)



- Keys for Success:
  - Free discharge of lime and sludge into tank
  - Short retention time (1 to 5 minutes)
  - Baffles
  - Lots of freeboard
  - Lots of mixing
  - Open top with easy visual access
  - Hose with spray nozzle for frequent washdown
  - Very short and steep discharge to Reactor B

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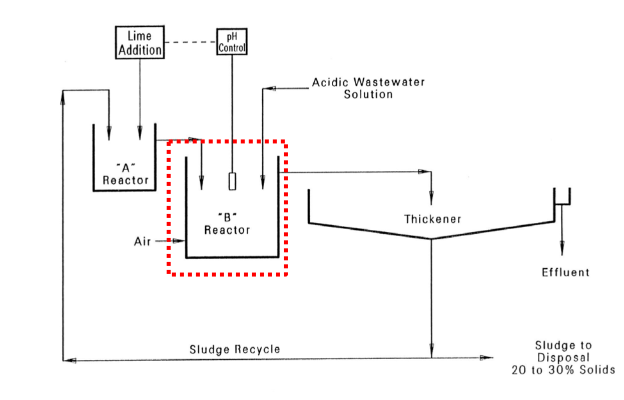
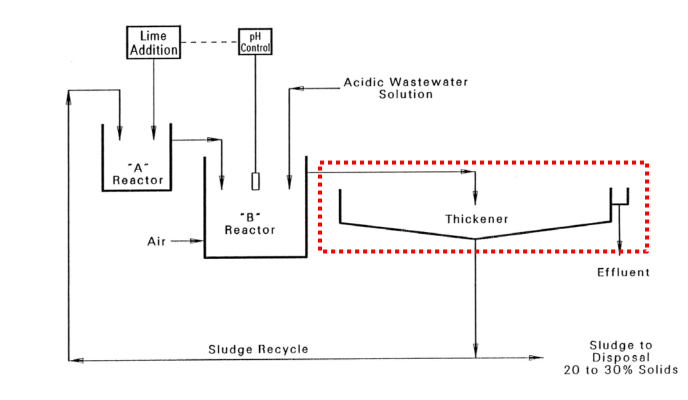
Reactor B



- Keys for Success:
  - pH selection
  - 30 to 40 minutes retention time typical
  - Baffled
  - Aeration for ferrous iron and manganese
  - Ample mixing
  - Ample freeboard

Thickener



- Keys for Success:
  - Sizing (diameter) based on either clarification or thickening
  - Anionic polymer flocculant often used
  - Thickening diameter often is largest
  - Sidewall height typically 10 – 12 feet
  - Open trough feed to feedwell for washdown
  - Underflow tunnel for sludge pumps
  - Ample torque
  - Rake lift

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Part 4: HDS Plant Photos

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Iron Mountain Mine HDS Plant California

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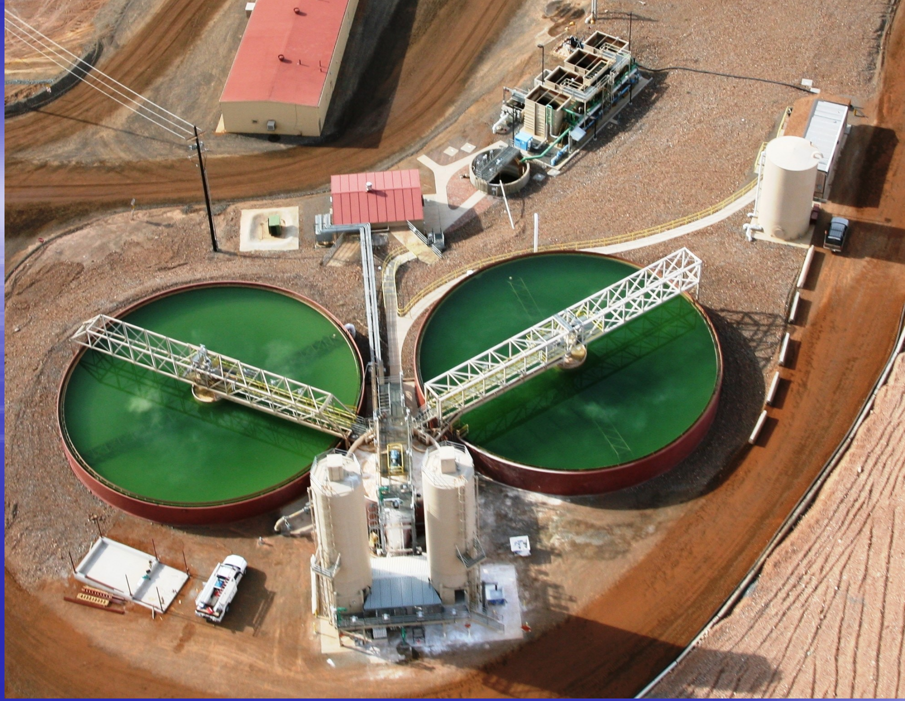
Resolution Copper HDS Plant Arizona



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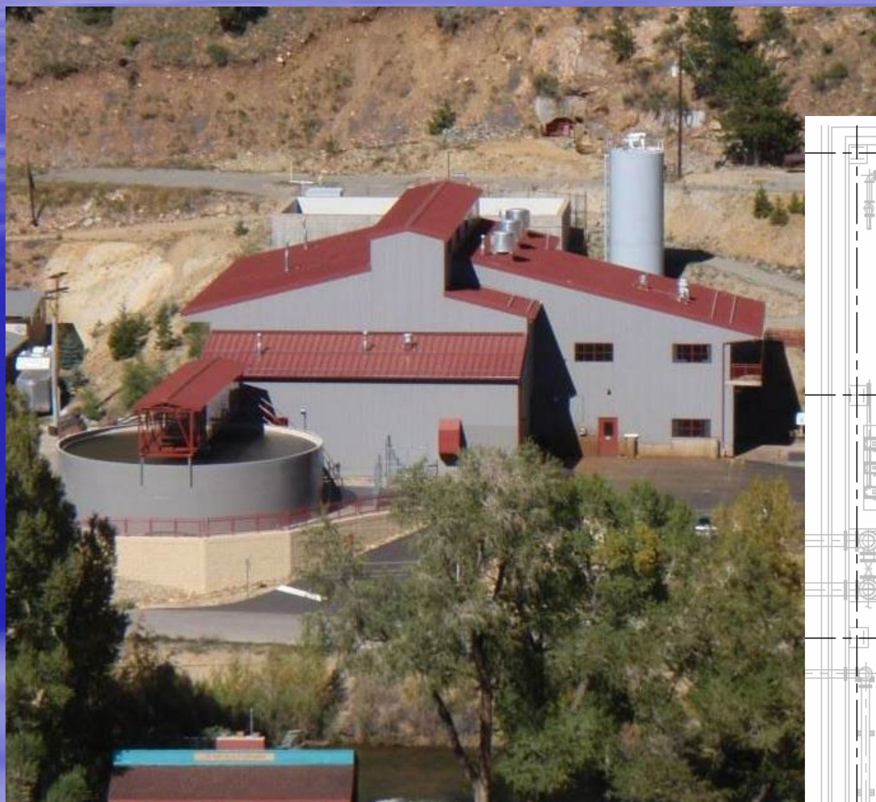
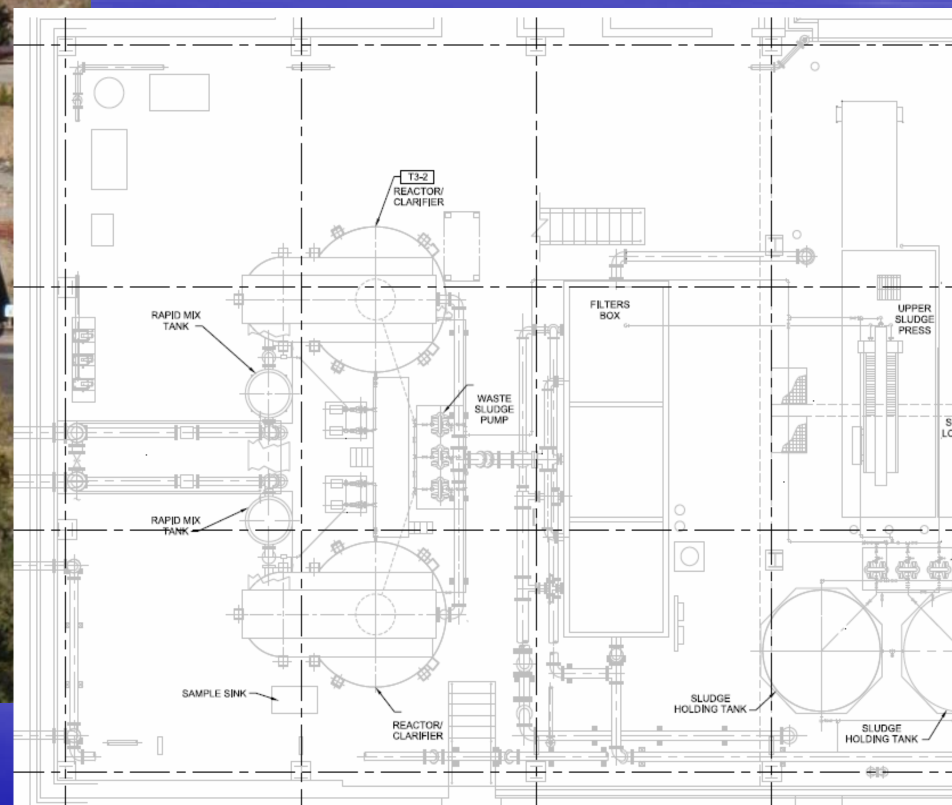
Argo Tunnel HDS Plant Colorado





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Thank You

- Questions?

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