Storage, Mobilization, And Retrieval Of Very High Yield Strength Sludges

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Storage, Mobilization, and Retrieval of Very High Yield Strength Sludges

Sellafield Site in the UK

Magnox Storage Pond

- Constructed in 1940's
- Major D&D project

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Magnox Sludge

•Up to 1200m3 arising from the corrosion of magnesium alloy clad Magnox reactor fuel in storage primarily magnesium and uranium corrosion products

•small percentage of un-corroded Magnox metal

•fission and activation products and their corrosion products

•aluminium corrosion product

•trace levels of fine carbon particles

•traces of wind blown debris e.g. sand and organic material.

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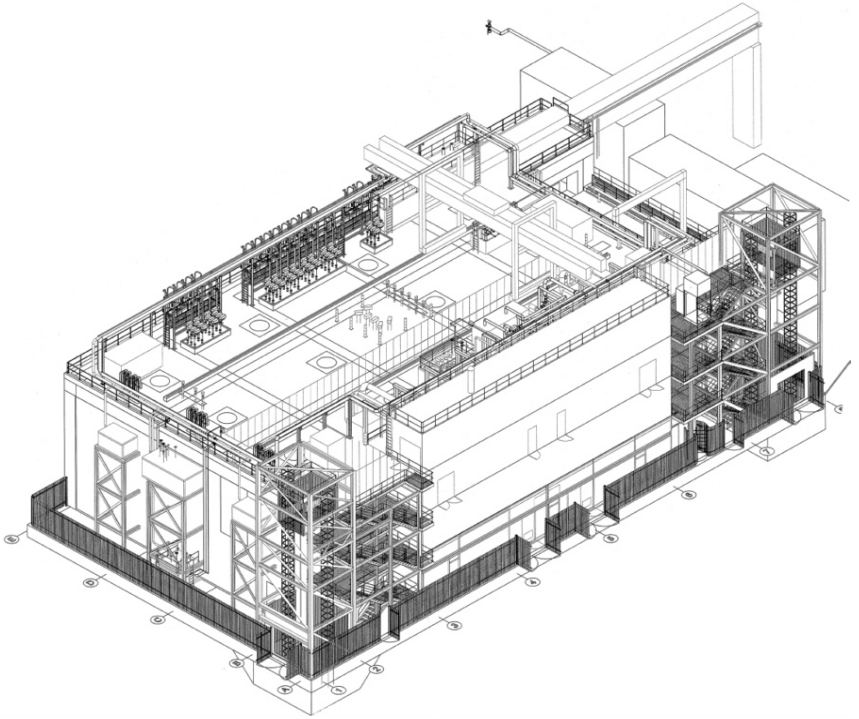
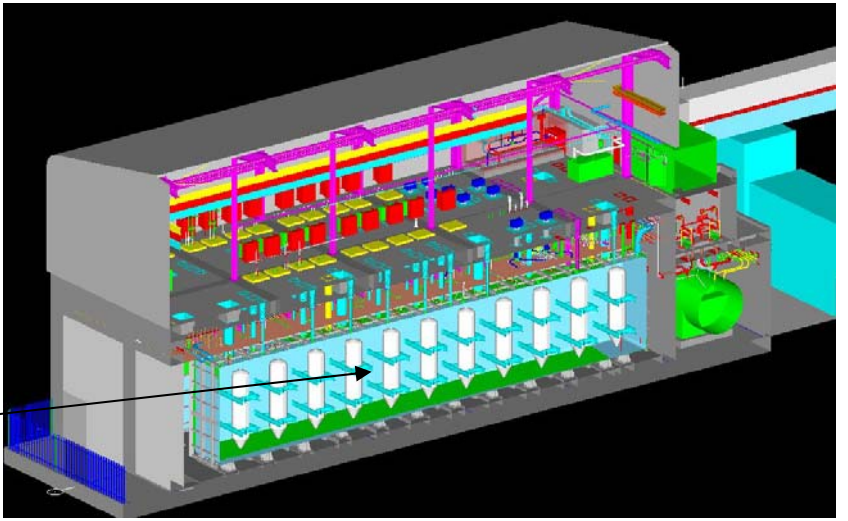


Proposed Buffer Storage Building



Section showing Bulk Storage Vessels

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Bulk Storage Vessel Agitation Options considered

- Mechanical
- Air Agitators
- Jet Mixers
  - Fluidic Mixers
  - Pulse Jet Mixers
  - Russian Pulsating Mixer Pump
- Others Technologies
  - Air Lift circulation
  - Vibration
  - Ultrasonics
  - Screw agitators

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Pulse Jet Mixers (PJM) selected primarily for the following reasons:

- Best potential of dealing with poorly understood and arduous sludge properties
- Recommended by Independent Review (BHR)
- No parts requiring maintenance exposed to radiation
- No moving parts within mixer itself
- All flow passages are of large diameter (reduces blockage risk)
- Technology well known within Sellafield Ltd

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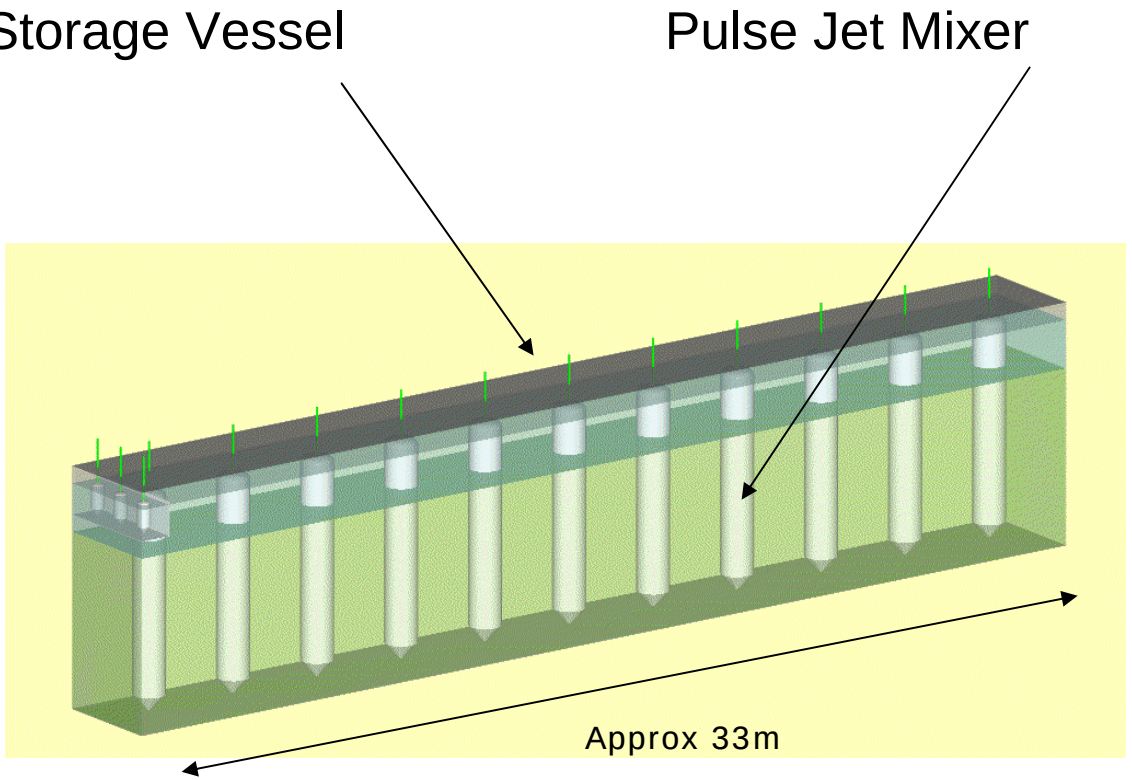
3 Bulk Storage Vessels (BSVs), approximately 30m long x 3m wide x 7m deep

11 Power Fluidic Pulse Jet Mixers in each BSV



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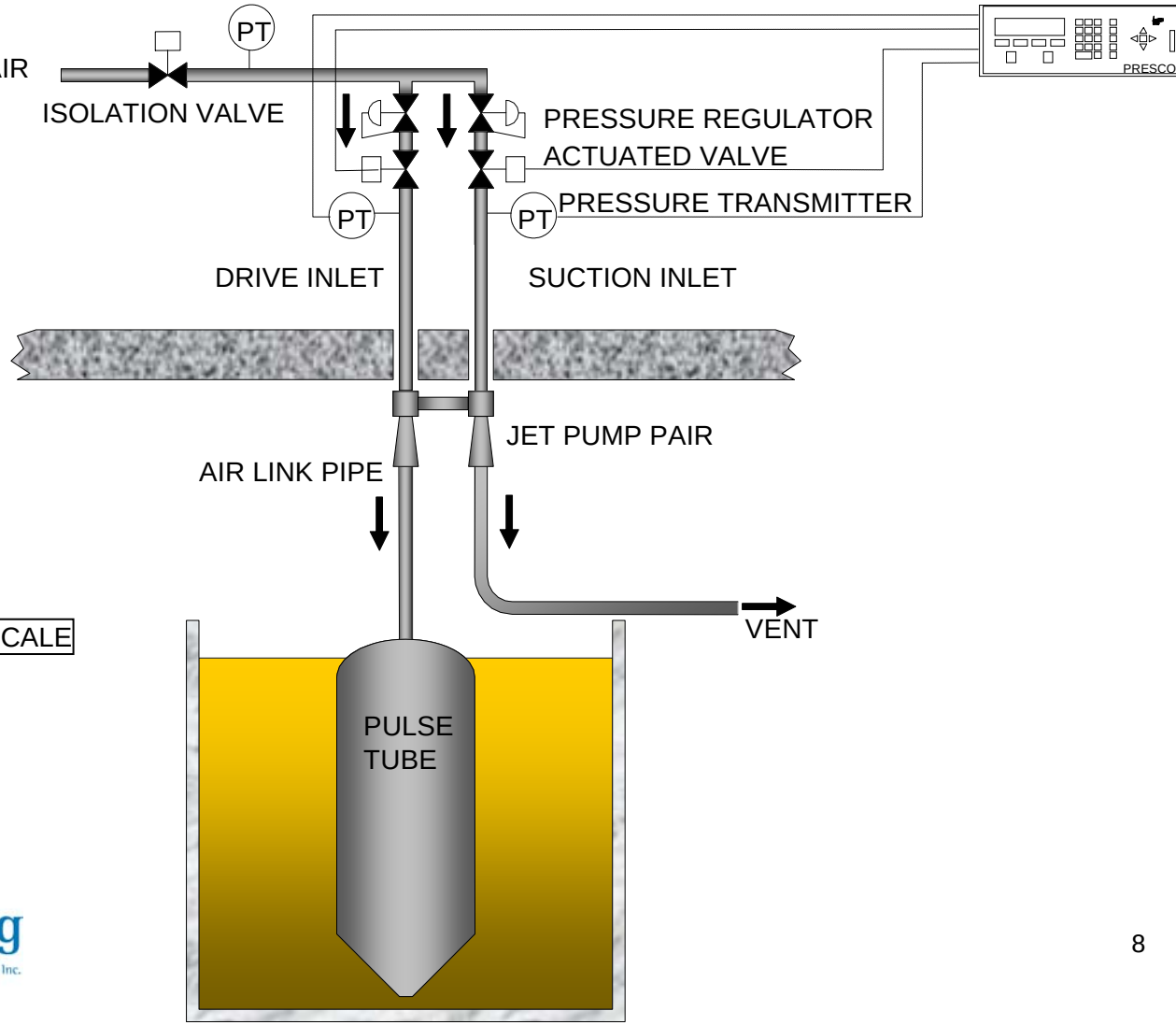
Basic Components

Of PJM System



NOT TO SCALE

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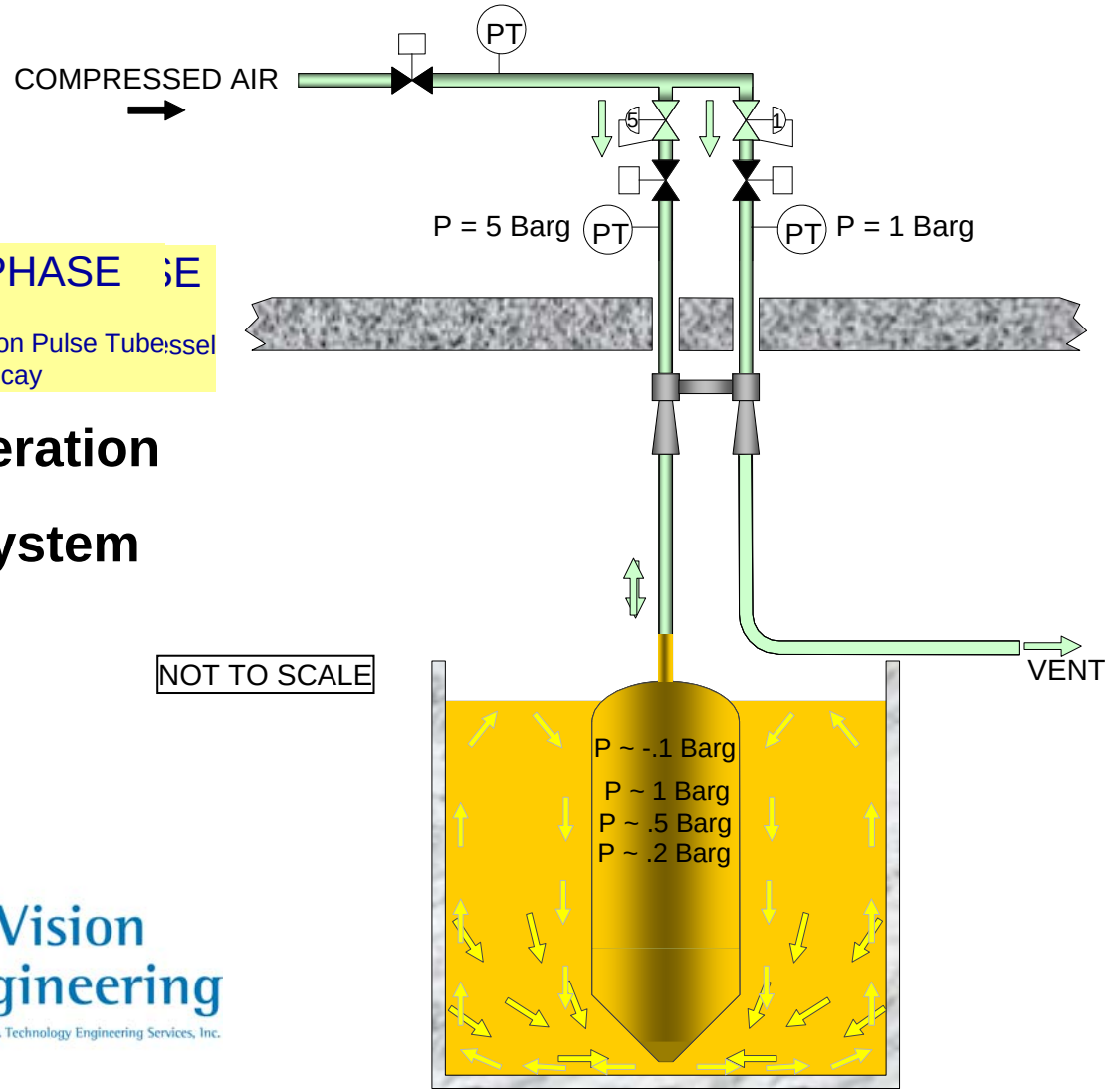

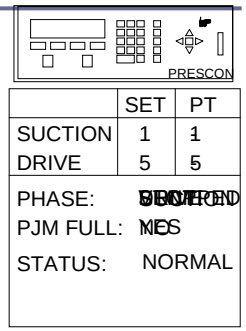

Basic Operation

Of PJM System

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Operations in the buffer storage vessels will take place in three distinct phases;

- Filling
- Storage
- Retrieval

The proposed operational strategy requires the following:

- Capability to maximize available storage volume in the BSVs through operation of the PJMs to level the bed of sludge
- Start-up and operation of the PJMs in a high yield stress material (should it develop)
- Provision of contingencies and recovery options into the system to cope with un-planned circumstances

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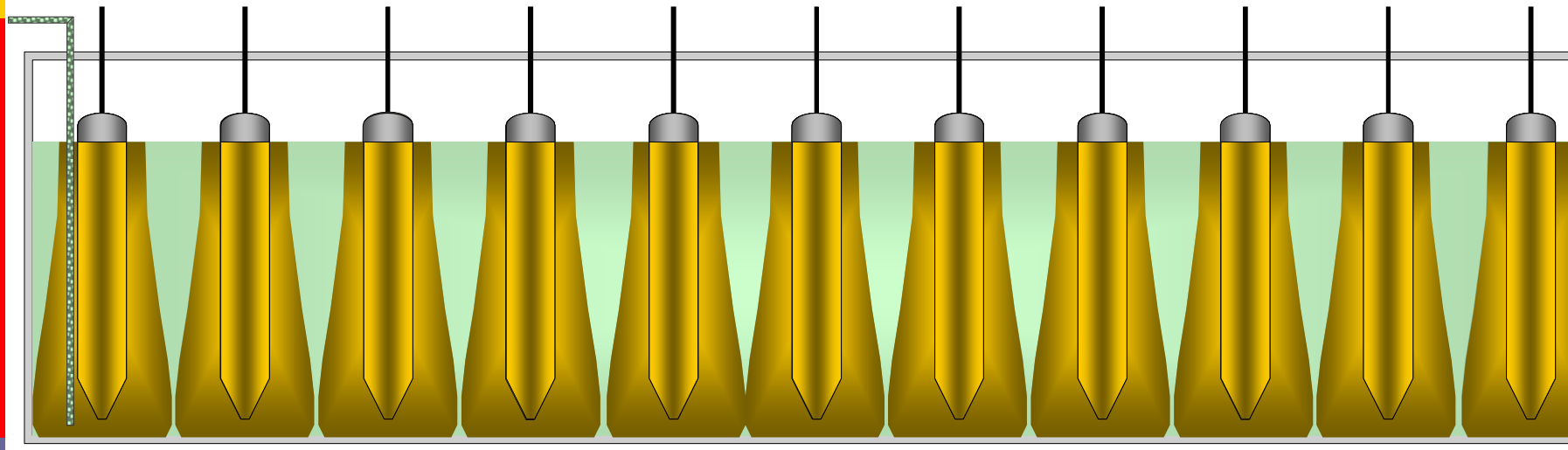

Hydrogen Management Strategy

Retrieval:

- Required before agitation commences
- Sequentially operate each pulse tube in BSV
- Repeat the cycle 6 more times (Total time ~ 1 hour)

Mobilise/Dilute

Transfer to P&E

Add supernate

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Proof of Principle Testing Program Objectives

- To substantiate the PJM design basis operating parameters (up to 2 Barg drive pressure and -0.3 Barg vacuum) over a range of Test Material Yield Strengths; the target range was 10kPa to 50kPa
- To determine the conditions under which operation of contingency measures will be required.
- To demonstrate that PJM operation is consistent and repeatable when operated under the design basis conditions.
- Investigate the range / reach of the PJM jet to verify interaction or ‘ link-up’ of adjacent PJM’s in the BSVs

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Approximately ½ scale fully functioning PJM system

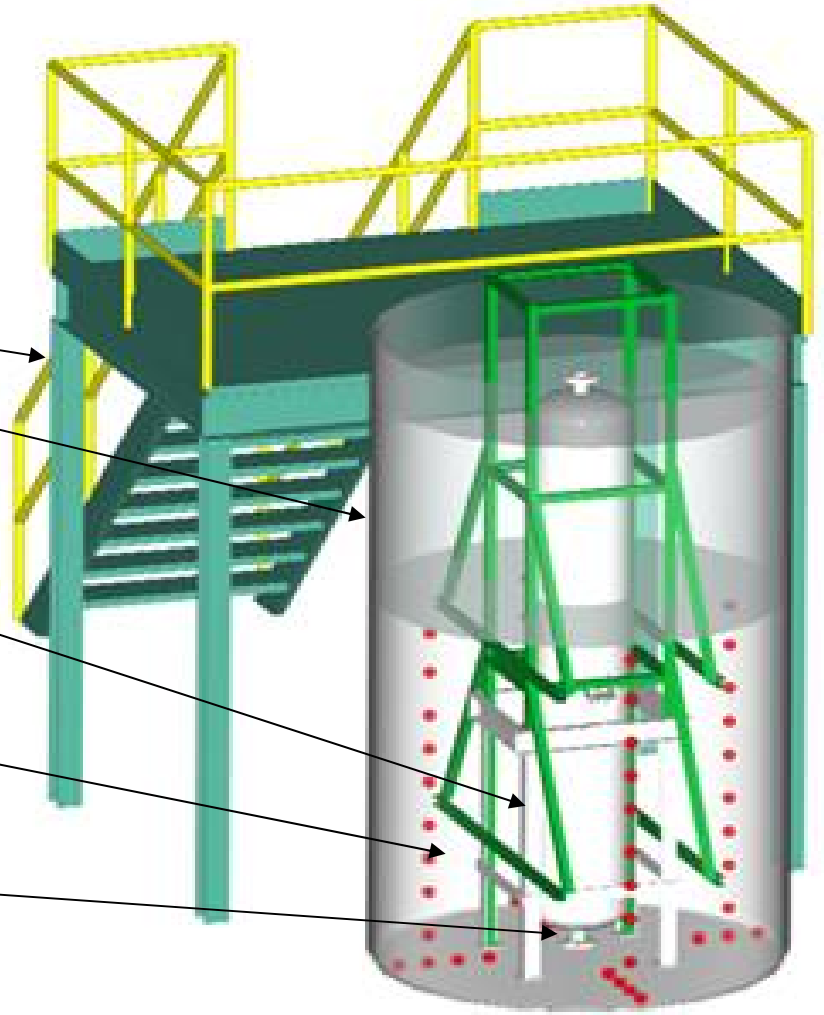
Access platform

3m tall x 2m dia polythene test tank

Single 288L capacity PJM

Steel supporting frame

Fluidizing Nozzle



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Test Material Constituents

Versamag
Versamag (trade name) - a precipitated fine white magnesium hydroxide.

Hydromag G(s)
Hydromag (trade name) - magnesium hydroxide in pellet form.

Crushed Slate
Crushed slate with a particle size ranging 0-4mm.

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Tests, Measurements & Records

- 13 separate tests carried out at varying starting yield stresses from 10-70kPa since 2008
- Yield Strength measurements of the tank contents using a Shear Vane
- Visual (remote camera) observations in the test tank
- Manual probing in the test tank to determine sludge levels & locations etc
- Data recording of operating parameters (pressures and cycle times) via the Prescon PC controller
- Tank Load cell & deflection measurement during start-up
- Fluidising nozzle flow rate and duration
- Video recordings

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High Yield Strength
Test Material

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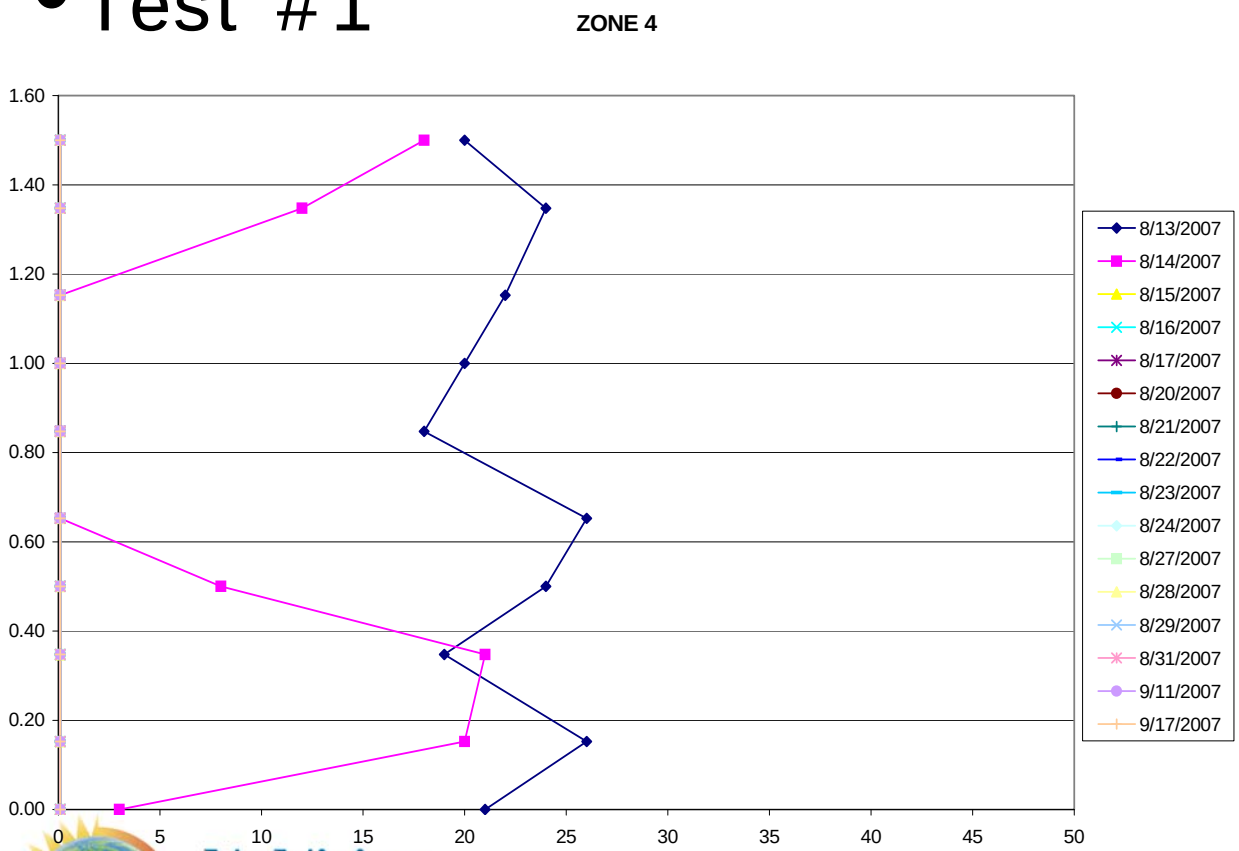
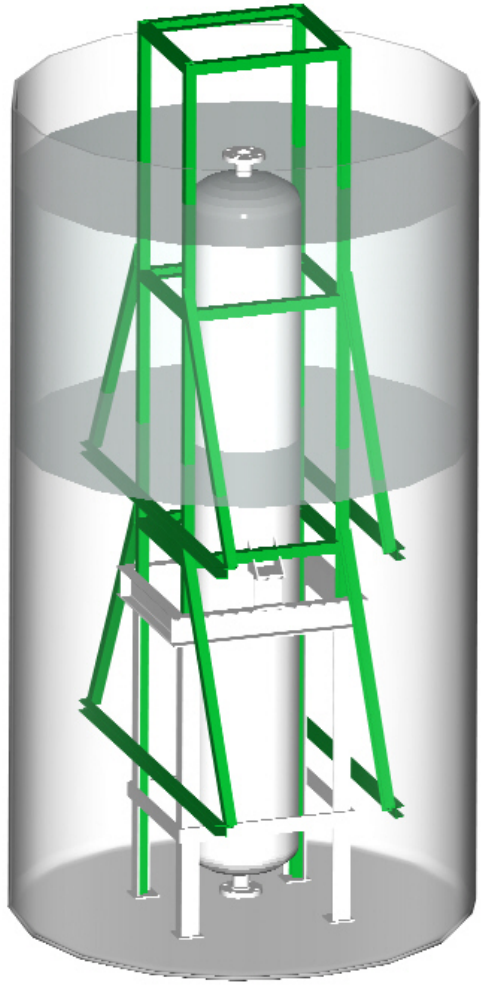
- Test #1





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Typical Test Results

- 720 gallons removed
- Average SG=1.21 (29%w/w, 14%v/v)
- 500 gallons water added

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Principal Conclusions from Proof of Principle Testing

- Applying shear alone to the test material will not reduce a yield strength measured in kilopascals down to the pumpable range (hundreds of Pascals)
- Dilution with water has a large, rapid impact on reducing yield strength.
- Dilution with supernate of SG=1.2 or greater has a smaller, slower impact on reducing yield strength
- Without agitation, the rate of absorption of diluent by the test material is slow and appears to be confined to the (~25mm thick) layer which is in contact with the diluent.

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Principal Conclusions from Proof of Principle Testing

- PJM system operates successfully at the design basis operating parameters (up to 2 Barg drive pressure and -0.3 Barg vacuum).
- Dilution is the predominant factor in reducing test material Yield Strength.
- Majority of Yield Strength reduction occurs in first 48 hours of PJM operation.
- Pump out when a pumpable volume is produced.
- Fluidising nozzle successful in providing dilution water at the PJM base & aiding mobilization

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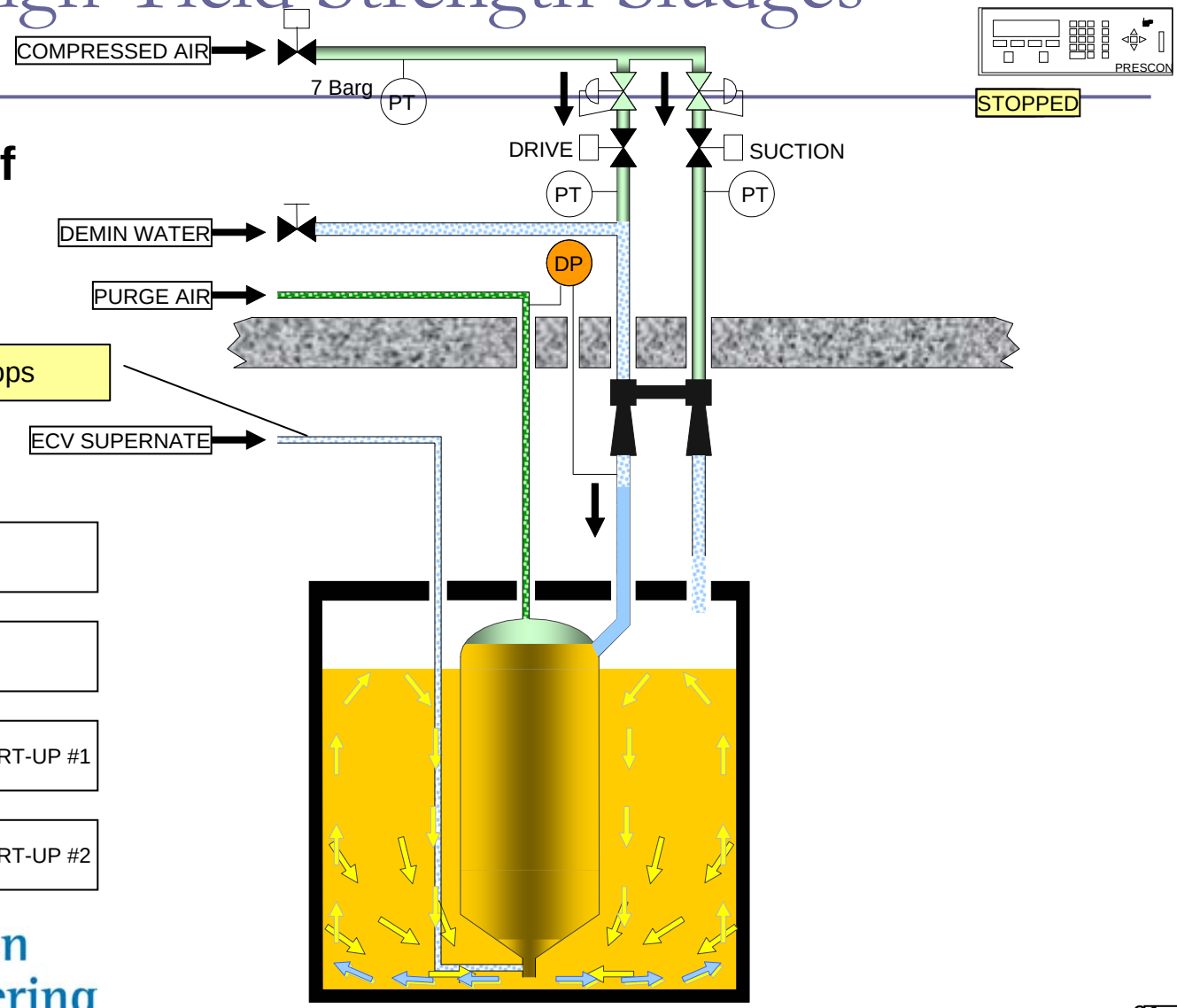
Final Features of Buffer PJM System



NORMAL CYCLE

FLUSH

WATER INJECTION FOR PJM START-UP #1

WATER INJECTION FOR PJM START-UP #2

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Future Technology Underpinning Work Proposed

- Future work will focus on developing more representative models to better define understanding of how mobilisation will proceed in the BSVs. This will require:-
  - Purpose designed and built, ¼ and ½ scaled multiple PJM rigs.
  - Scaling studies to increase confidence in relating the results of rig trials to actual performance in the BSVs.
  - Continued operation of the basic proof of principle rig, which allows typical test material challenges to be put against PJM system

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New PJM Scale Test Rigs - Benefits

- More representative design features and scaling
- Multiple (3 each) PJM's
- Rectangular test tank (same basic geometry as BSVs)
- Facility to increase tank depth (and sludge head)
- Comprehensive instrumentation & monitoring
- Can accommodate alternative test materials including inactive CMS
- Use of two rigs at different scales will help develop scale up relationships and underpin projections of real plant capabilities at full scale
- Operate ¼ scale rig with both CMS and VCHG - gives a comparison of performance with different materials at the same scale.

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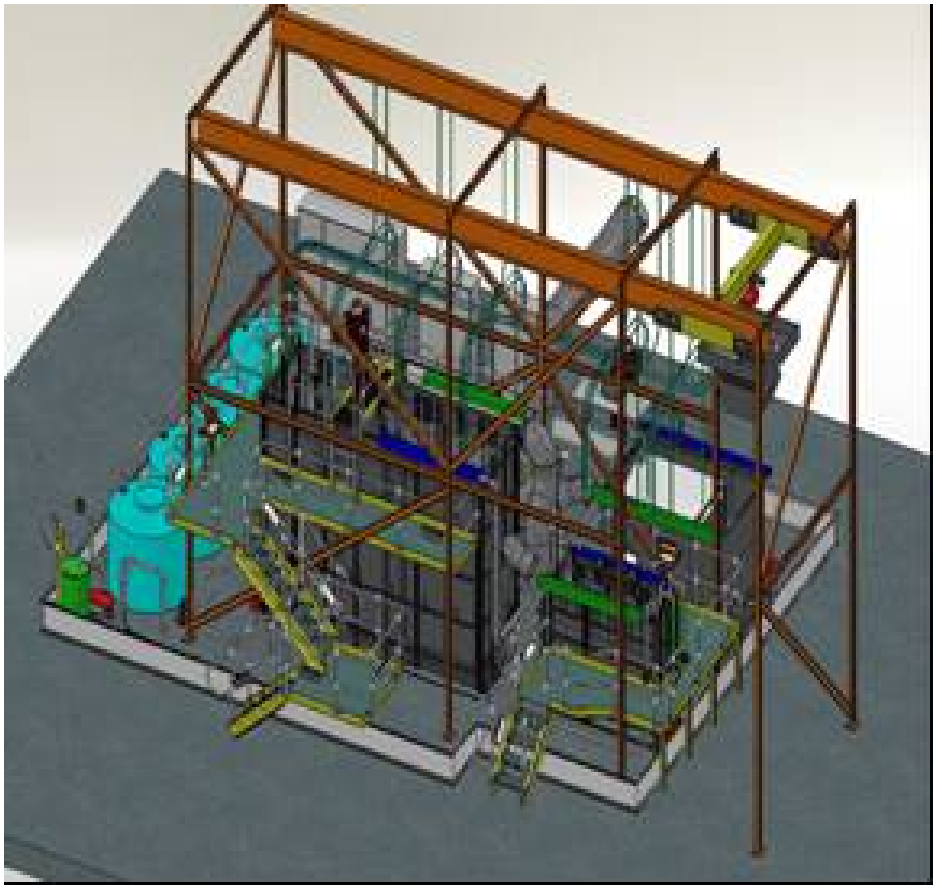
- 3 x 1/4 scale PJMs and test tanks
- 3 x 1/2 scale PJMs and test tanks
- Access and lifting structures
- Test material handling tanks



New PJM Scale Test Rigs Scheduled for Operation in 2011

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