Low Energy Desalination Options to Eliminate Sulfates from Discharge

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Problem: Reduced sulfate discharge limits, permits

> 30% sulfates come from drained acid

About 1/3 of sulfates in discharge comes from neutralization of drained acid in flooded batteries. Less for AGM.

Neutralized acid is hypersaline

Typically the neutralized water or scrubber blowdown is > 60,000 ppm

Treat with caustic or ammonia

Whether treated with caustic or ammonia, a high salinity liquid is produced.

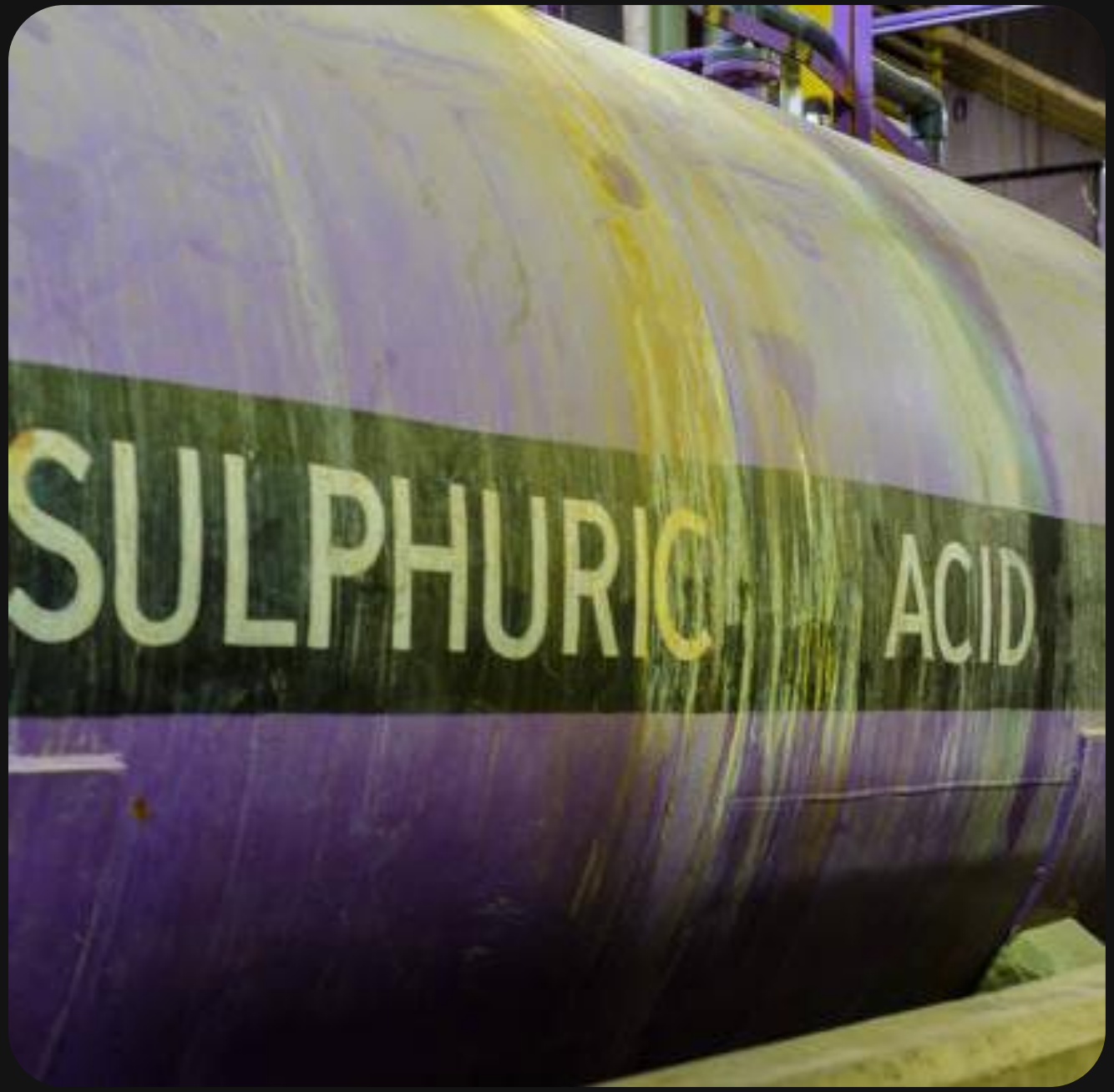
Stop neutralizing acid and solve > 30% of the problem!

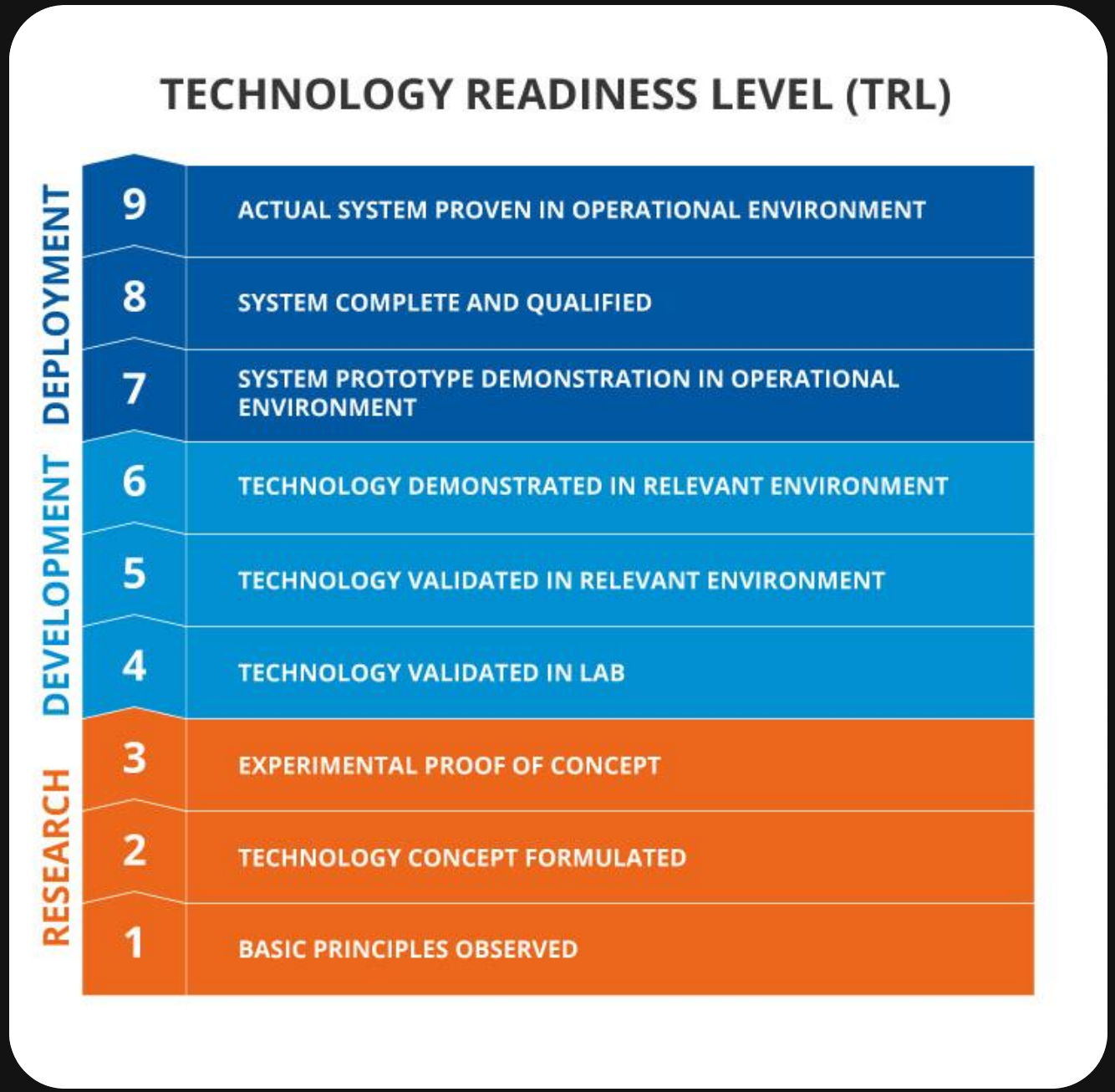
Its not a technology problem

There are commercially available technologies that can clean and concentrate the acid.

It’s a logistics problem

Need to find a home and match the process to the client specifications.





Technology options to treat hypersaline discharge

- **Mechanical Vapor Recompression with Crystallizer. TRL-9**
- **Ultra High-Pressure Reverse Osmosis. TRL-8**
- **Electro Hydrodynamic Evaporation. TRL-7**
- **Cavitation. TRL - 6**

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Mechanical Vapor Recompression with Crystallizer

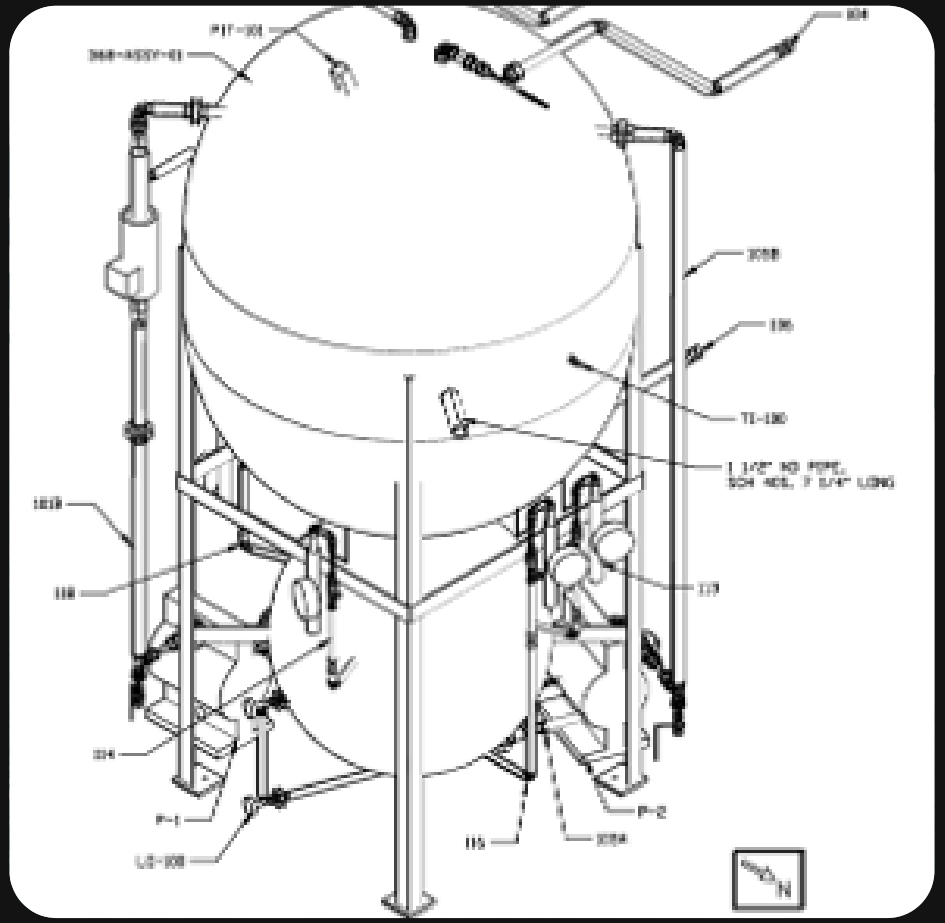
- **Most common technology set to treat hypersaline brine**
- **Produces clean water and dry salt (ZLD)**
- **MVR stage concentrates the brine, crystallizer drops out the salts**
- **High capital costs - $375,000 per m3**
- **High energy usage – 80 kWhr/m3**
- **High maintenance due to exotic alloys and moving parts**
- **High cost of ownership.**

Ultra High-Pressure Reverse Osmosis

- **Can treat up to 60,000 ppm inlet water**
- **Produces super brine and clean water**
- **MLD (minimal liquid discharge), requires additional processes to produce dry salts such as crystallizer**
- **Low capital costs - $44,000 per m3 by itself**
- **Low energy usage – 5 kWhr/m3 by itself**
- **Medium maintenance for membranes**

Electro Hydrodynamic Evaporation

- **Produces clean vapor and dry salt (ZLD)**
- **Single stage process**
- **Medium capital costs - $54,000 per m3**
- **Low energy usage – 20 kWhr/m3**
- **Low maintenance due low pressure and few moving parts**
- **Low cost of ownership**



Hydrodynamic Cavitation

- **Produces partially desalinated water plus dry salts**
- **Requires additional process such as UHPRO & MVR**
- **Low capital costs - $35,000 per m3**
- **Low energy usage – 4 kWhr/m3**
- **Low maintenance due to simple pump and nozzle**
- **Low cost of ownership**

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Normalized Cost of Ownership Comparison

Technology	Addition Process Needed	Energy (USD/m3)	Deprec (USD/m3)	Mainten (L/M/H)	Cost of Ownership (USD/m3)	MVR-Cryst Comparison
MVR Crystallizer	None	$12.00	$2.16	$6.49	$20.66	---
Ultra High-Pressure RO	Crystallizer	$6.75	$1.59	$4.77	$12.74	-38.3%
Electro Hydrodynamic Evaporation	None	$3.00	$0.89	$1.78	$5.67	-72.5%
Cavitation	UHPRO & Crystallizer	$3.56	$1.00	$3.00	$7.56	-63.4%

Conclusions

Isolate acid & treat

This will reduce sulfates to be treated by at least 30%

High TRL Alternatives

There are high TRL options that can lower cost of ownership by up to 72%.

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