



Creating a Cleaner World™

Asian Battery
Conference, 2021

**PowerFill™ Separator for
AGM Batteries**

HV Hollingsworth
& Vose®

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Overview

Headquarters

East Walpole, MA , USA / Origins in the 1700s / 7th generation- family owned

Sales offices in the Americas, Europe and Asia with:

13 manufacturing sites

9 research centers

2100+ employees worldwide

50+ PhDs in R&D

250+ patents and applications

Our global footprint

Corvallis, OR ●

Apizaco, Mexico ●

● East Walpole, MA
● West Groton, MA
● Easton, NY
● Greenwich, NY
● Floyd, VA
● Hawkinsville, GA

● Winchcombe, UK
● Kentmere, UK

● Hatzfeld, Germany

Mysore, India ●

Suzhou, China ●



HV PowerFill™
A Hollingsworth & Vose Innovation

**PATENT
PENDING**

- Increasing electrolyte filling speed
- Improving battery quality
- Increasing battery performance

- **Electrolyte Acid filling** is a critical step in assembly of AGM batteries, as it has significant effect on the assembly speed, the quality of plate formation and battery performance.
- Fast filling enables even wetting out the plates and AGM, and ensures battery performance.
- Slow filling not only slows down the assembly speed, but also tends to cause battery failures by inducing dendrite formation.



Slow Acid Filling

Filling



"Dry Spot" on Plate

Formation



Dendrite growth on AGM

- Pore structures of AGM and plates, compression pressure, size of batteries.
- Gaseous species remaining in the batteries.
 - Air remaining in the batteries after initial evacuation (~20-25%).
 - CO₂ formed from the reaction of acid with carbonates in plates.

During the acid filling, the gaseous species are pushed into the center of the plates, resisting the penetration of the acid into the area and causing incomplete acid filling and long battery assembly time

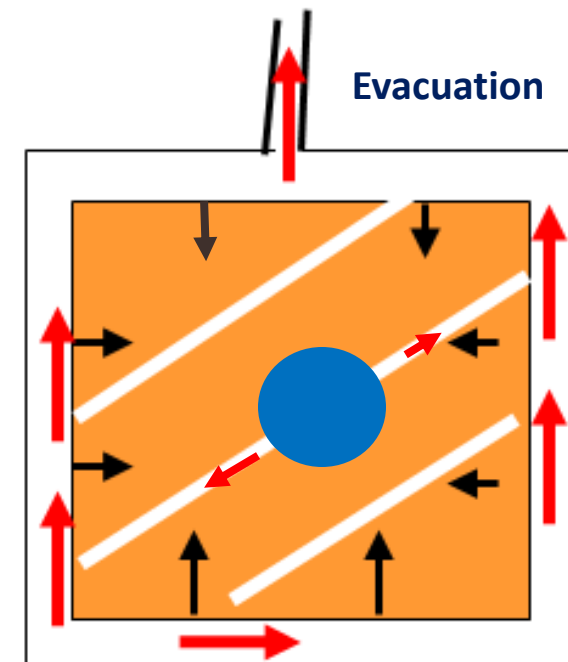


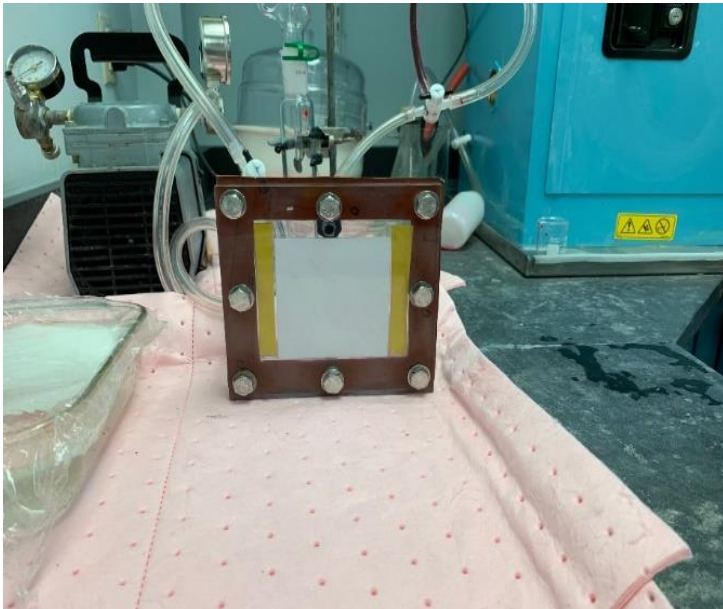


- PowerFill has open channels (indentations) on surface of AGM separator.
- The channels facilitate the escape of the gas.
- Ideal for tough to fill Industrial & Automotive batteries.



Open channels release
entrapped gas

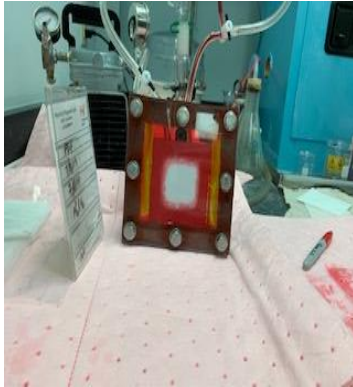




- AGM sample is sealed between two polycarbonate plates.
- The AGM sample is compressed at ~ 50 kPa.
- The interior of the fixture is connected to tubing switched to either an acid reservoir or a vacuum pump, with a T valve.

Step	Test Procedure	Time (min)
Step 1	Evacuate the fixture until the vacuum is stabilized	
Step 2	Switch the valve to acid reservoir	0
Step 3	Switch the valve to vacuum for 5 seconds then switch back to acid reservoir	2
Step 4	Switch the valve to vacuum for 5 seconds then switch back to acid reservoir	4
Step 5	Switch the valve to vacuum for 5 seconds then switch back to acid reservoir	10
Step 6	End the test	20

15 sec

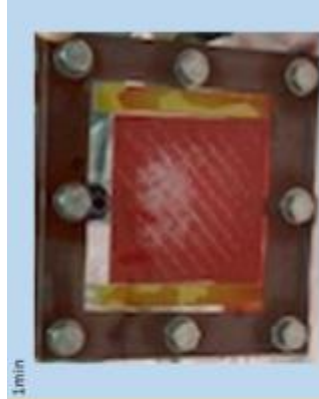


gsm: 275

BET SSA:
0.95 m²/g



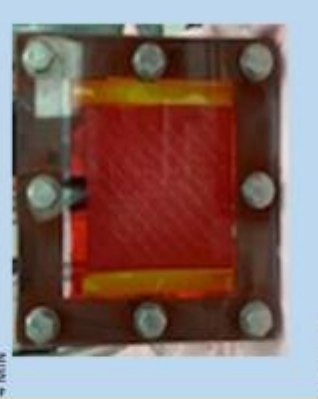
1 min



2 min



4 min



No entrapped gas



1 min

2 min

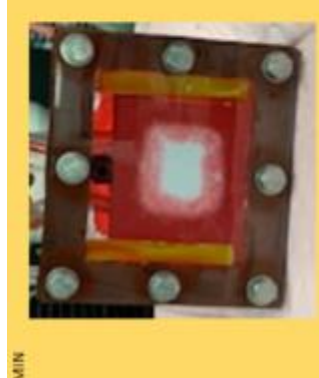
4 MIN

4 MIN BACK

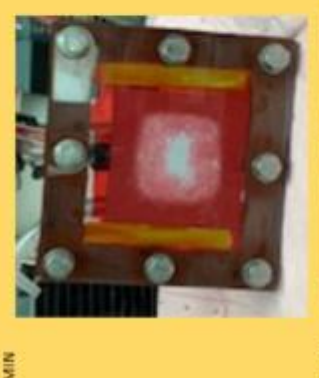
15 sec



1 min



2 min



20 min



Entrapped gas

Standard
AGM Control

1 MIN

2 MIN

20 MIN

20 MIN BACK

Front of AGM

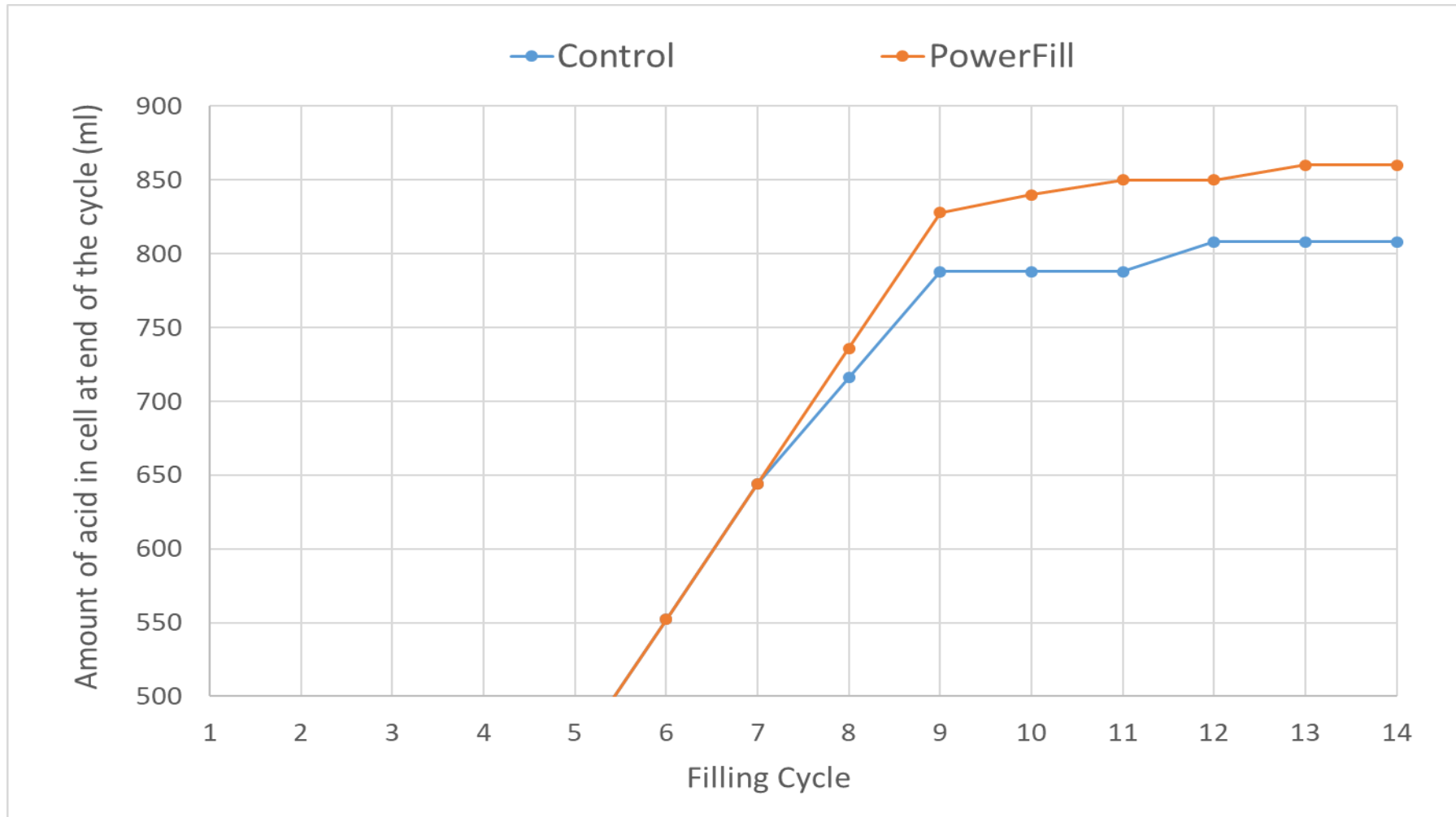
Back of AGM

- PowerFill AGM has been tested in cells (5N/4P).
- The cells are connected to tubing switched to either an acid reservoir or a vacuum pump, with a T valve.
- Filling is conducted in multiple cycles; each cycle includes:

- 1/evacuate for 10 sec
- 2/fill acid for 5 sec
- 3/rest for 5 sec
 - 92 ml of acid added each cycle from cycle 1 to 9
 - 52 ml of acid added in cycle 10; no more acid addition in the subsequent cycles

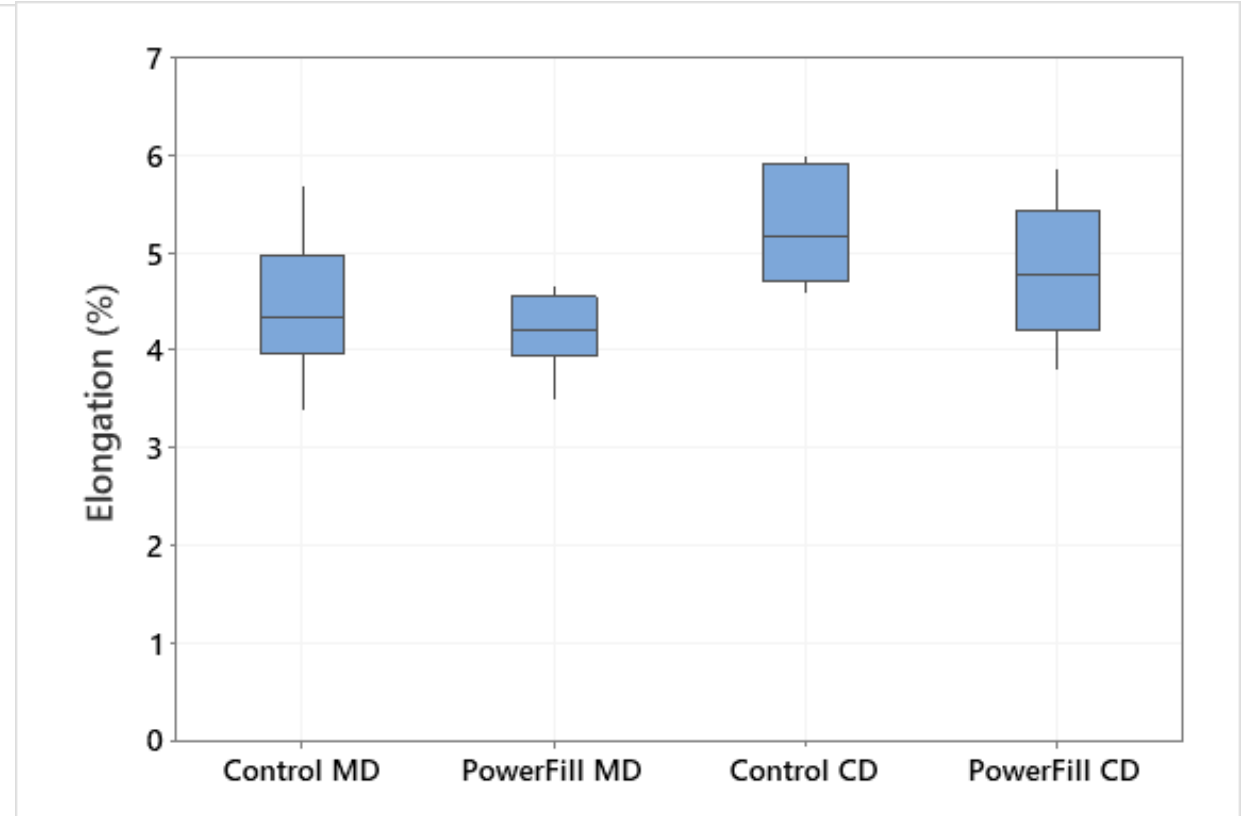
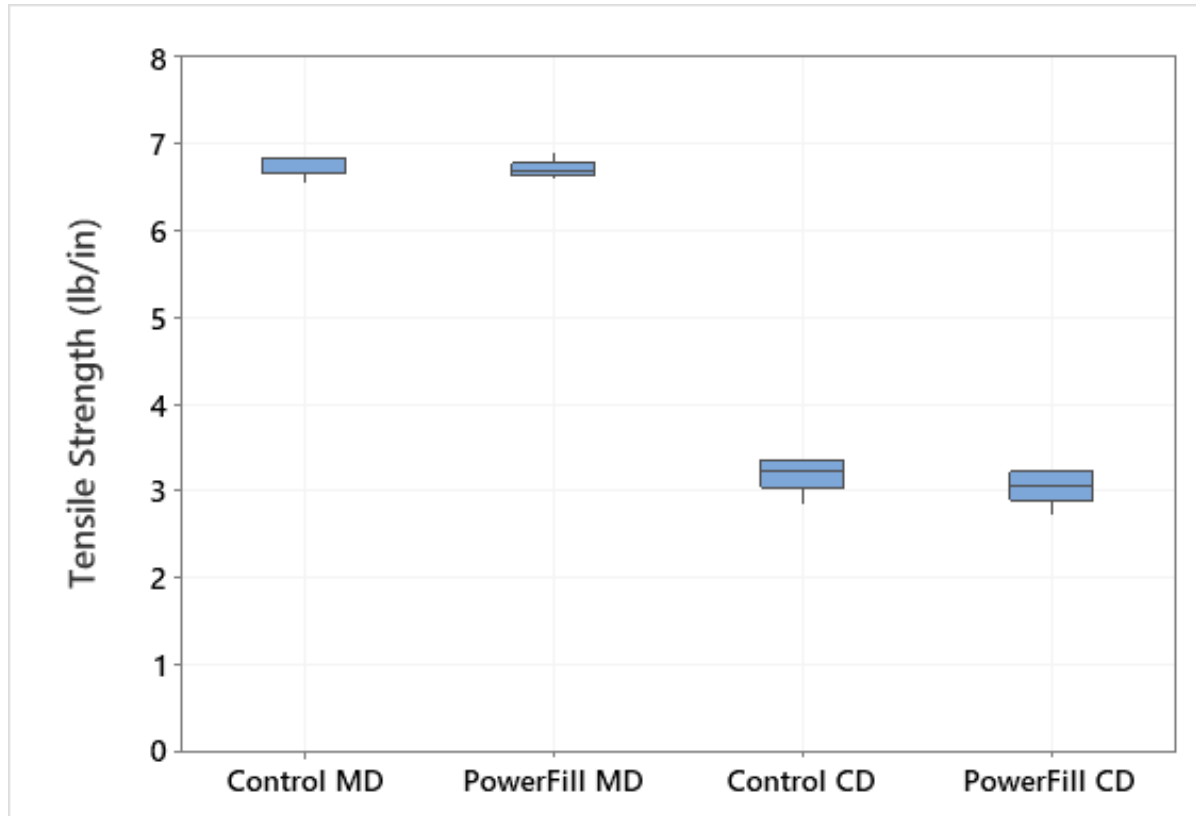


- The amount of acid going into the cells was recorded



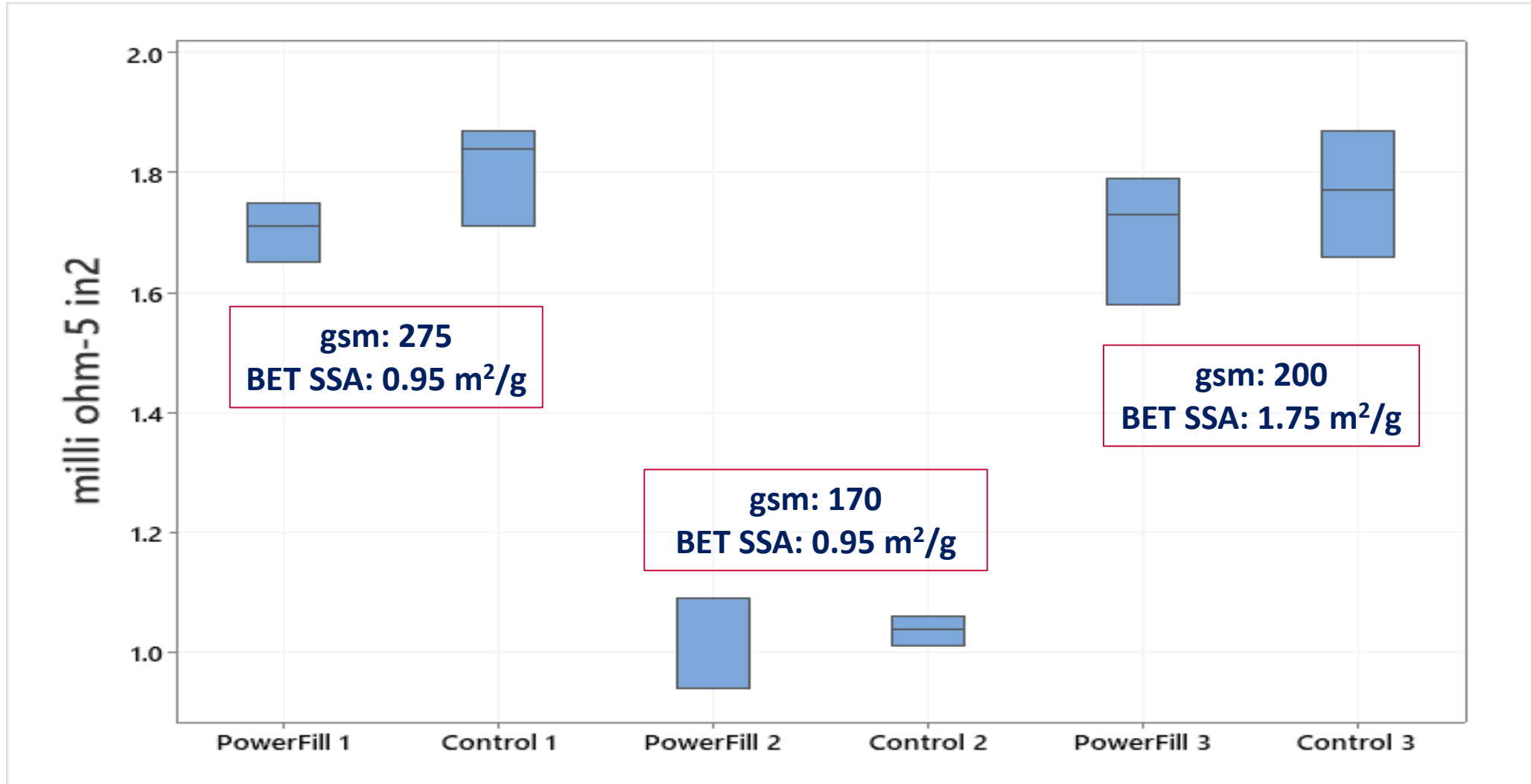
gsm: 250; BET SSA: 1.70 m²/g

PowerFill reduces acid-filling time prior to formation

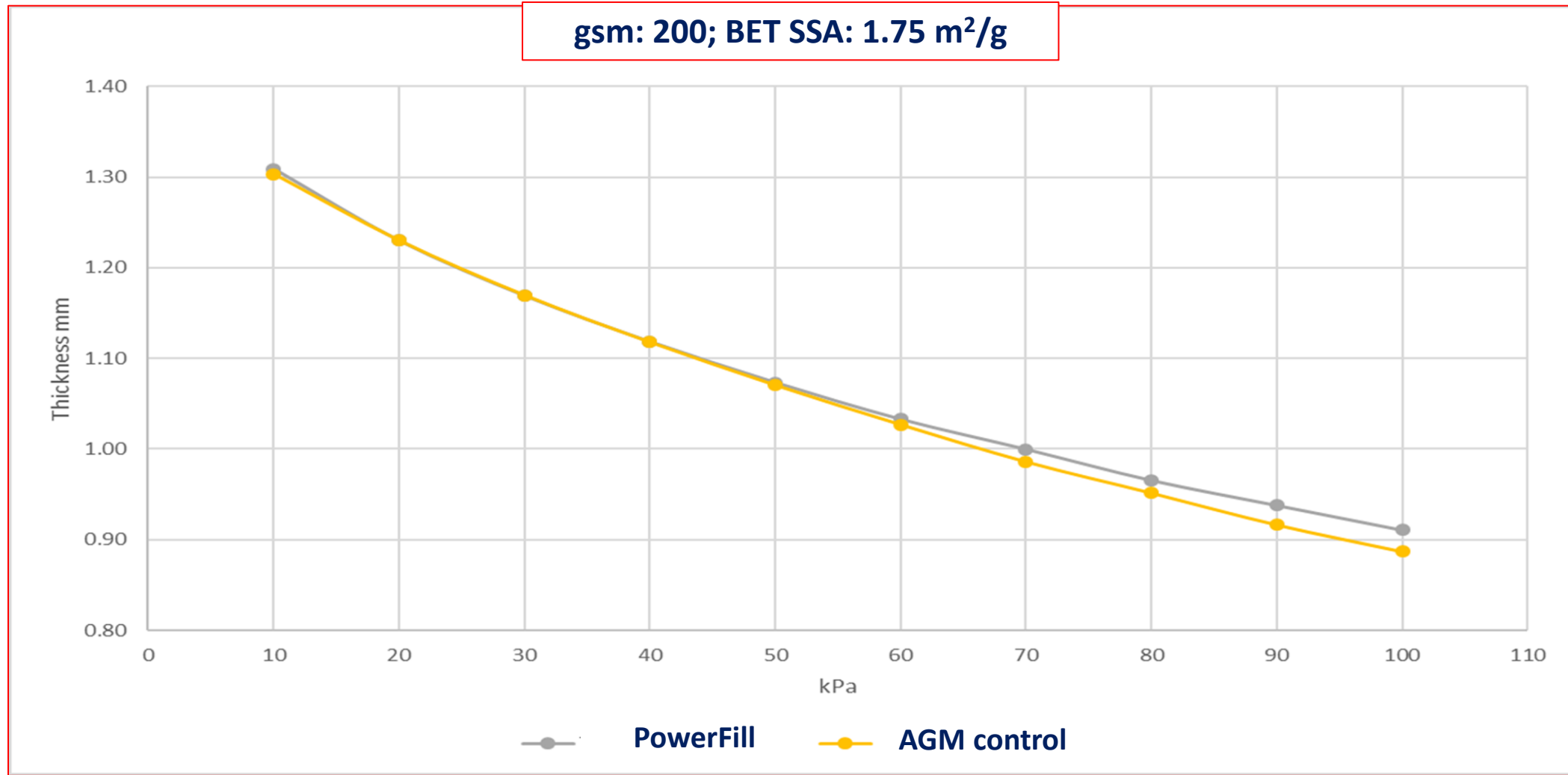


gsm: 200
BET SSA: 1.75 m²

The mechanical strength of PowerFill is comparable to its standard AGM control

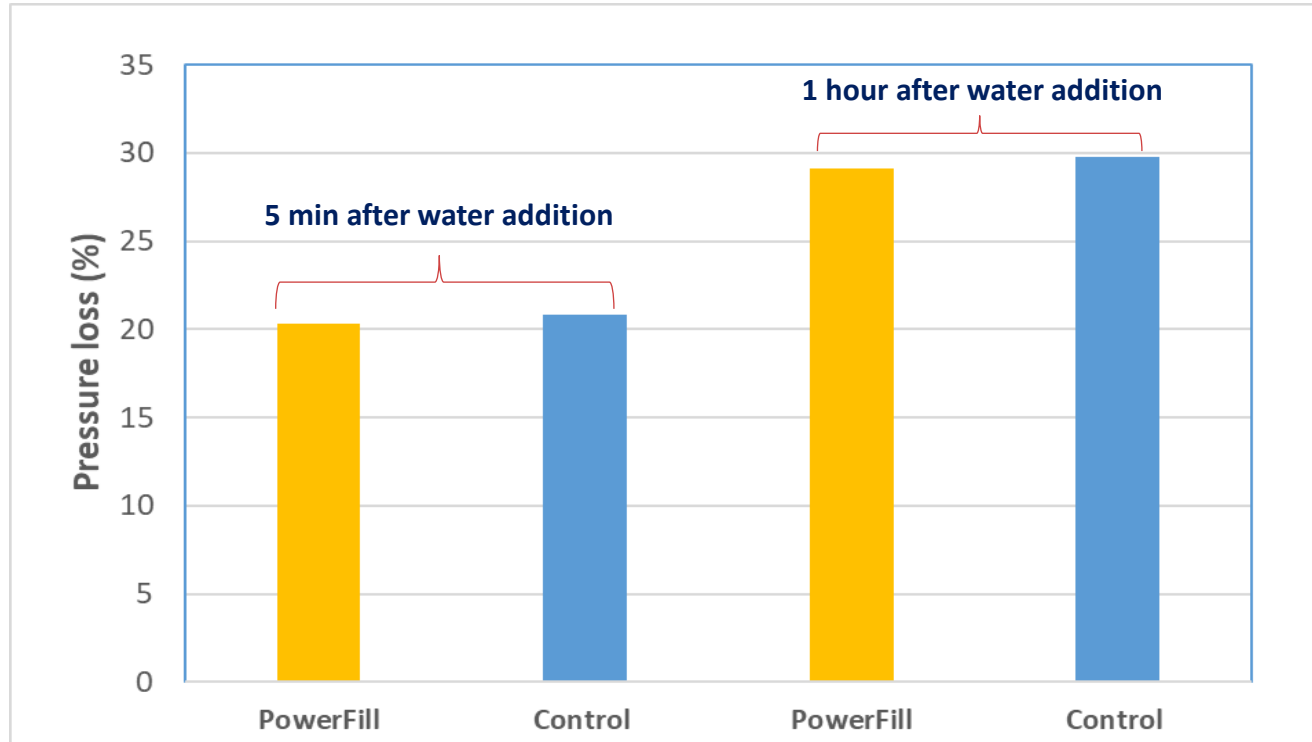


The electrical resistance of PowerFill is comparable to its standard AGM control



The thickness for PowerFill under compression is almost identical to its control up to 60 kPa, then becomes slightly higher at higher pressure

gsm: 200; BET SSA: 1.75 m²/g



- **The test is conducted with the following procedure:**

1. Compress the dry AGM sample to 30 kPa
2. Add water into the AGM sample to saturation
3. Record the pressure loss vs time up to 5 min and 1 hr

- **The thickness of the sample was kept constant during the test.**

- **Low pressure loss is preferred as it enables high compression pressure retention between the AGM and plates.**

PowerFill demonstrates retention behavior similar to the control AGM



- PowerFill™ is an AGM separator enhancement that **improves assembly speed, battery quality and battery performance**. Ideal for Industrial and Automotive designs.
- Compared with standard AGM, PowerFill retains its mechanical strength, electrical resistance in acid, thickness under compression as well as pressure retention in water.
- PowerFill is a “drop-in” separator and customers can easily change from standard AGM.



Thank You for Your Attention

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