ISO 29461-5 Draft: Air intake filter systems for rotary machinery - Part 5: Test methods for static filter systems in marine and offshore environments

Test Method

European Turbine Network
Air Filtration Working Group
Genoa, Italy
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Outline

- Challenges for offshore intake air filtration
- Test method developed by Gore
- Alternative procedures
- Results and discussions

Challenges of Offshore Air Filtration

- Common Contaminants
  - **Sea Salt**
  - Dust
  - Soot particles
  - Bulk water: fog, mist, rain
  - Lube oil vapor and mist

Ref.: Orhon, D., Hiner, S. Kurz, R., and Benson, J. (2015) GAS TURBINE AIR FILTRATION SYSTEMS FOR OFFSHORE APPLICATIONS. 44th Turbomachinery, Houston, Texas, United States, Sept 14-17, 2015

Sea Salt

- Varies with platform height and wind speed (Kimm, 1985)

Test No.	Atmospheric Concentration Salt PPM (by weight)	Wind Speed (Knots)
1	0.266	37
3	0.127	29
5	0.0744	25

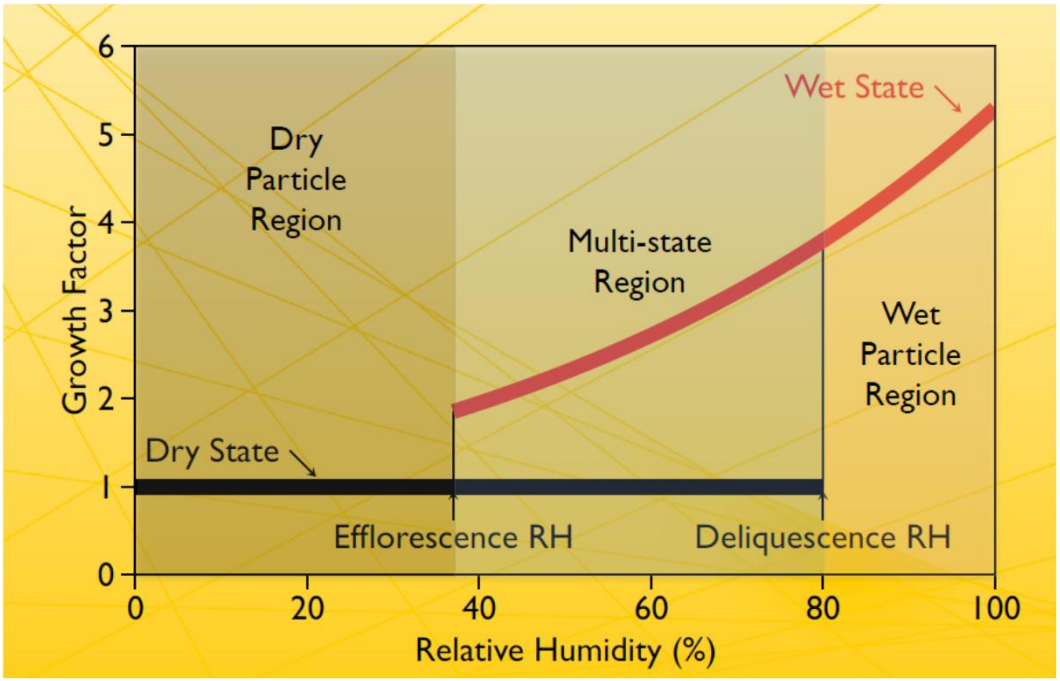
- A filter operating at 3400 m^3/h will be challenged with 2.7 to 9.7 kg of salt per year

Ref. Kimm, M., Langlands, D. Gas Turbine Intake Filter Systems Related to Offshore Platform Installations. ASME 85-GT-109

Sea Salt

- Salt exists in multiple states: dry, wet and transient

Dry Salt



Wet Salt

Dust

- Regional dust storms occurs seasonally
  - Gulf of Guinea - Harmattan
  - Arabian Pennisula - Haboob
  - Baohai – Yellow sand
- Some air filters on offshore facilities are clogged in less than 1 year

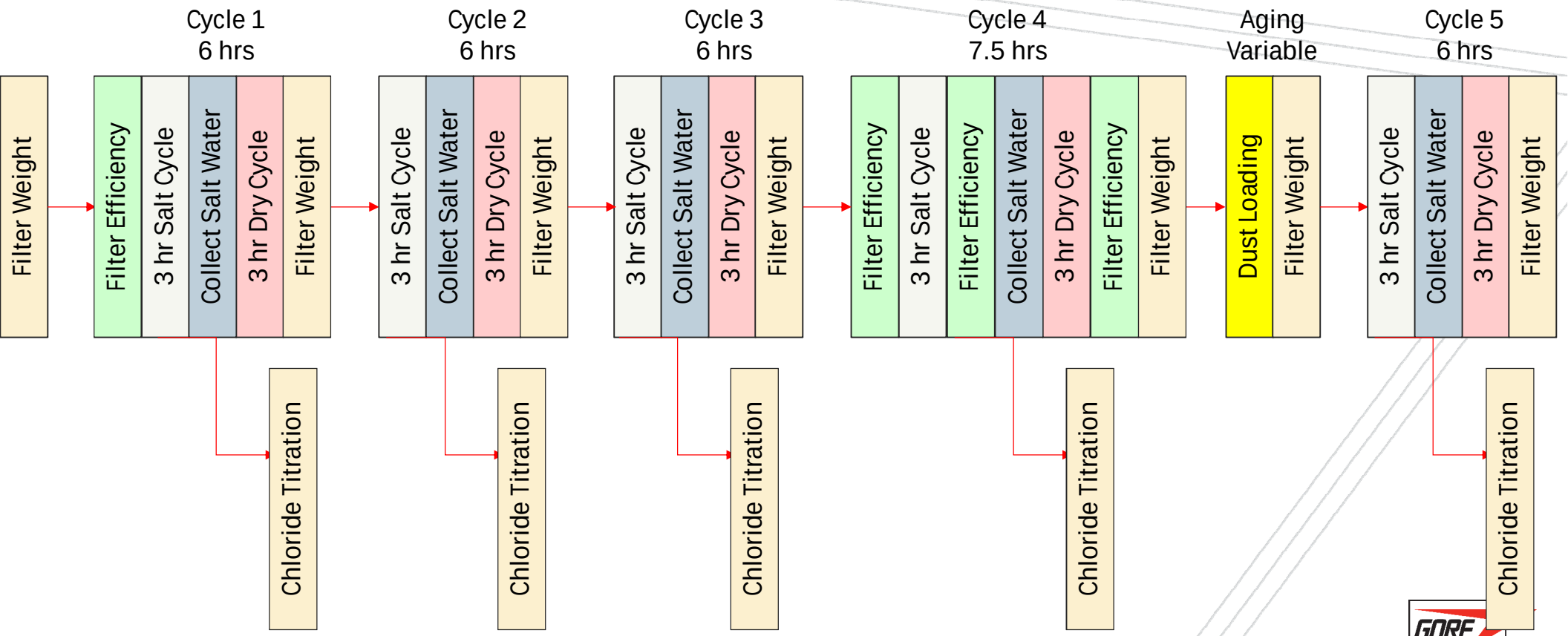
Mist and Fog

- Droplet size 1 to 20 um dia.
- 50% of droplets 1-10 um dia.
- LWC 0.5 to 1 g/m3 corresponds to 50 m visibility
- High bulk water causes rapid rise in filter pressure drop and breaching of contaminants into downstream

Salt Breach Test Overview (ETN May 2017)

- 4 Salt breach cycles
  - 3 hours salt mist + 3 hours dry cycles
- Aging of filter with dry dust loading
  - 1kPa final dP
- One final salt breach test
  - 3 hours salt mist + 3 hours dry cycles

Salt Breach Test Overview



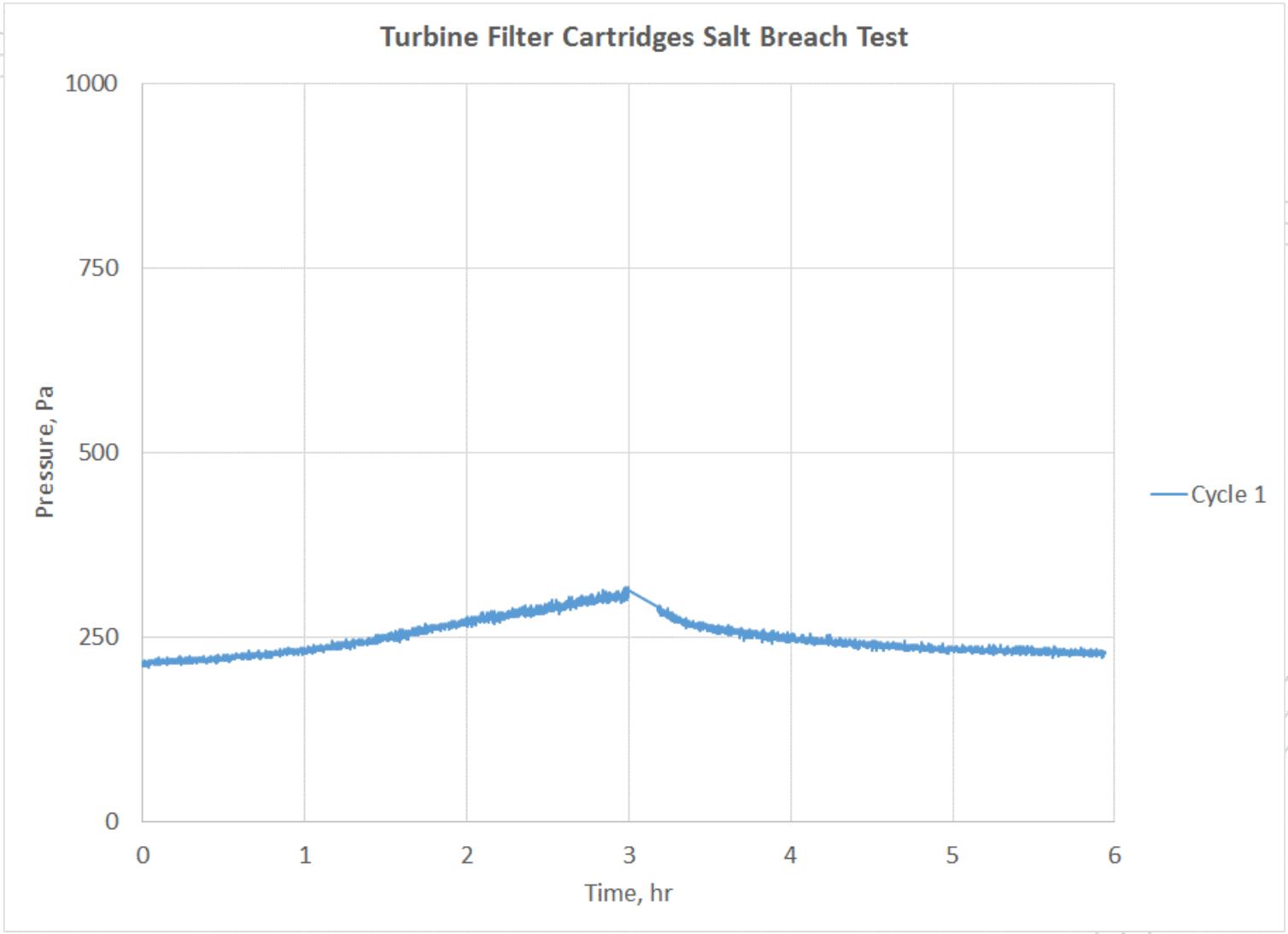
Measurements

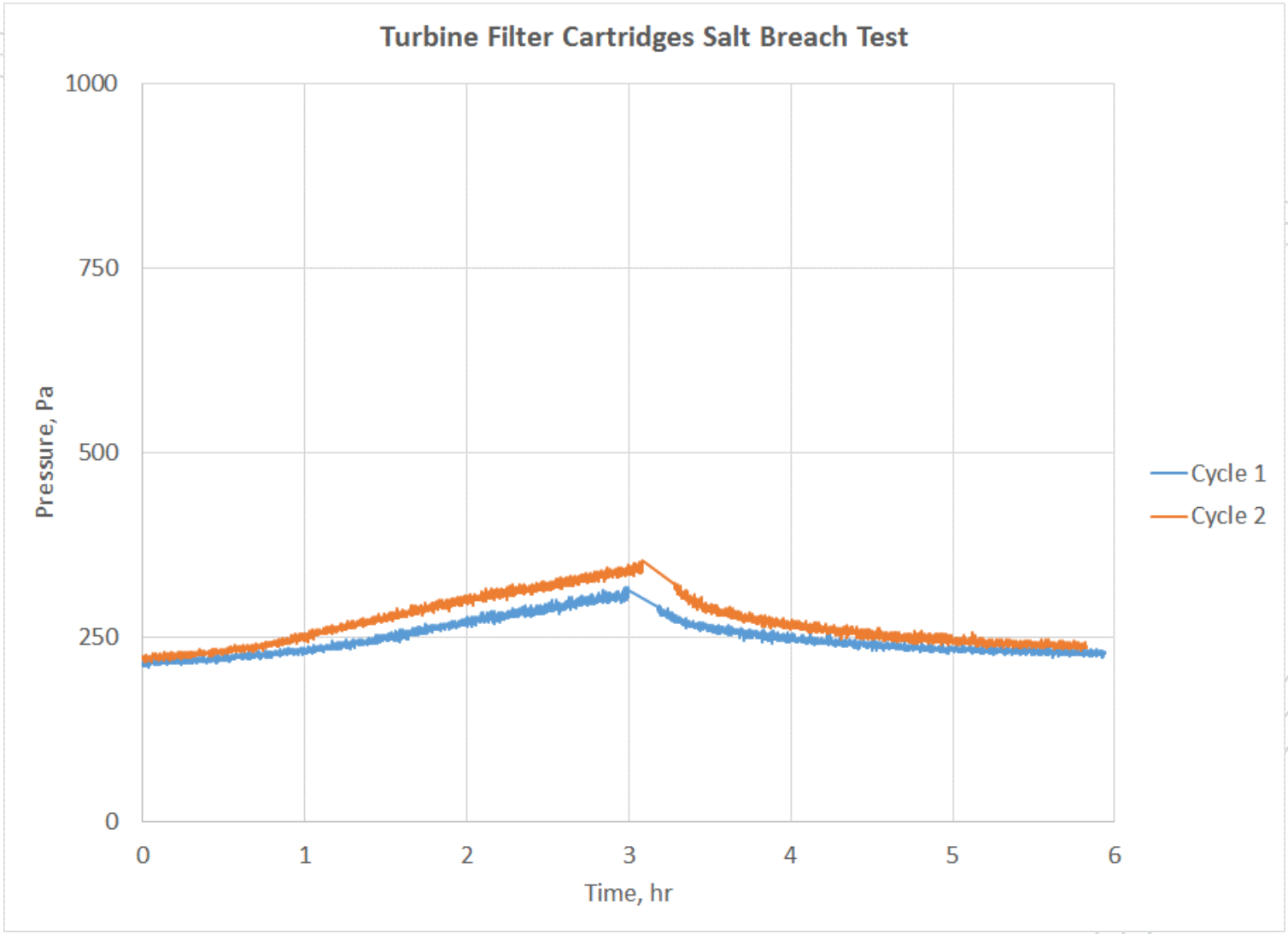
- Filter pressure drop in dry and wet cycles
- Dust loading capacity in aging cycle
- Amount of water and salt bypass

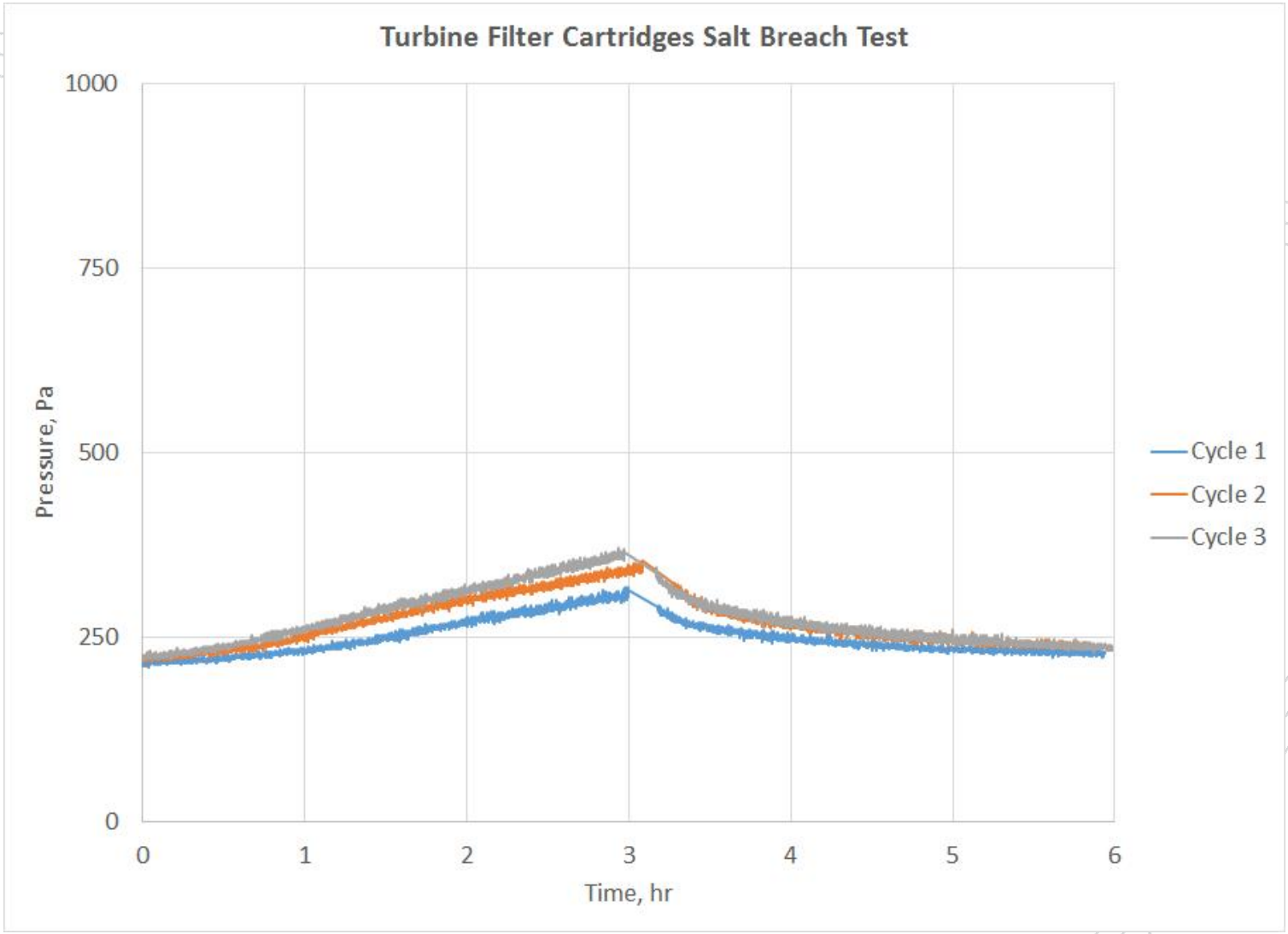
Relevant to user's benefits: power efficiency, corrosion protection, machine uptime, filter lifetime

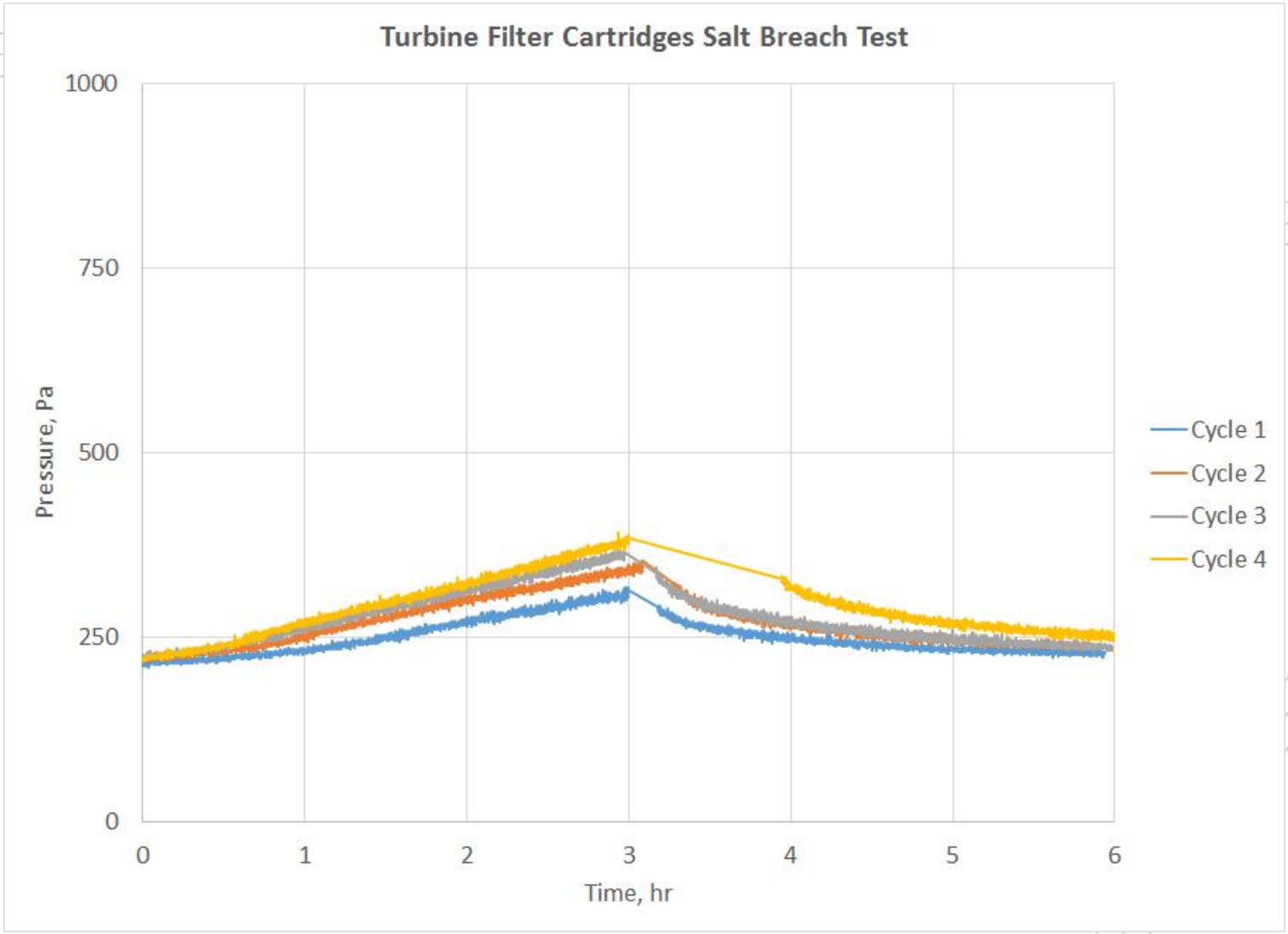
Examples

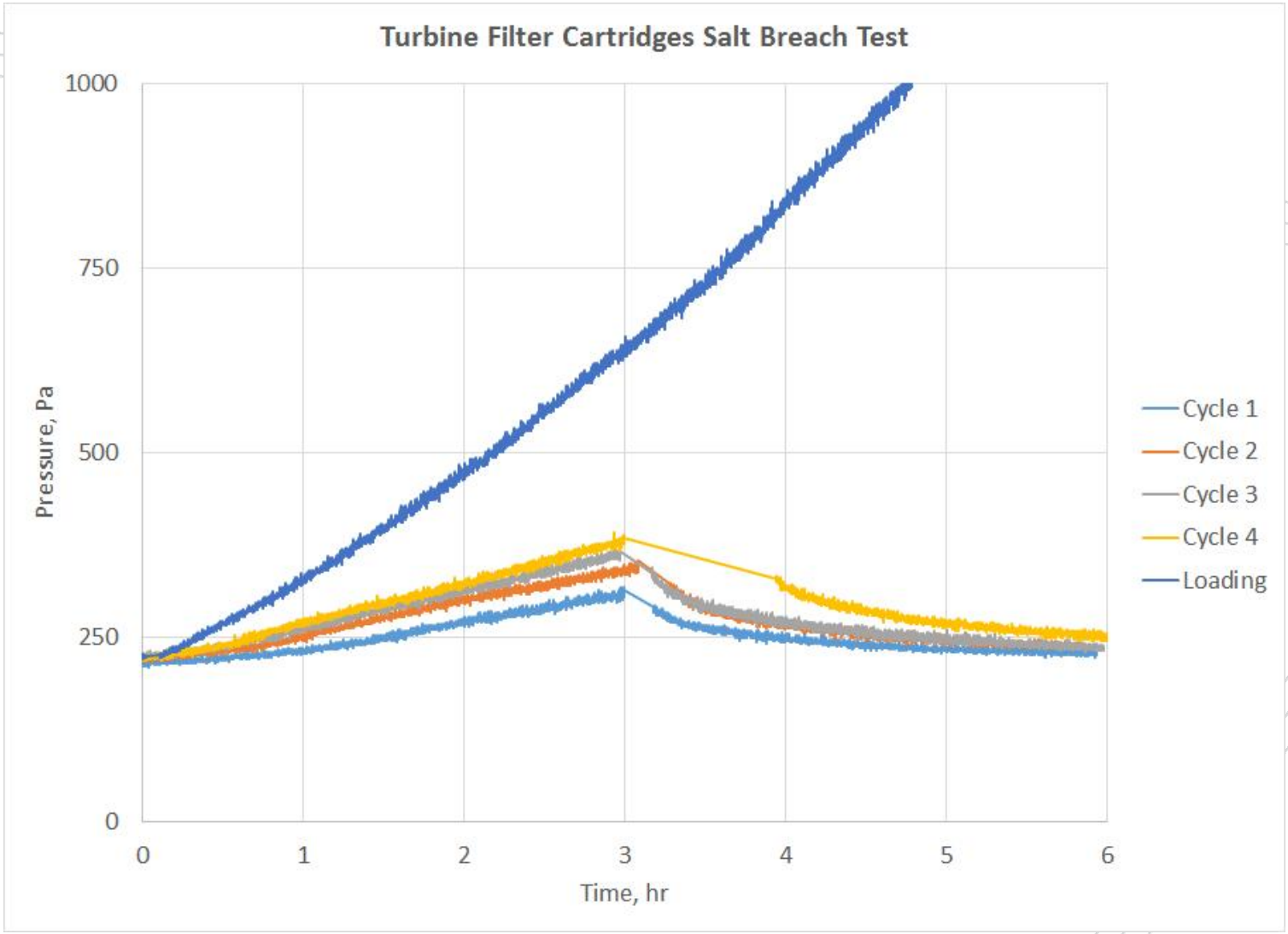
- 3 V-panels tested at 6,000 m3/h
  - presented at last ETN meeting May 2017
- Cylindrical/conical filer at 2,720 m3/h
- 3 V-panels tested at 3,400 m3/jh

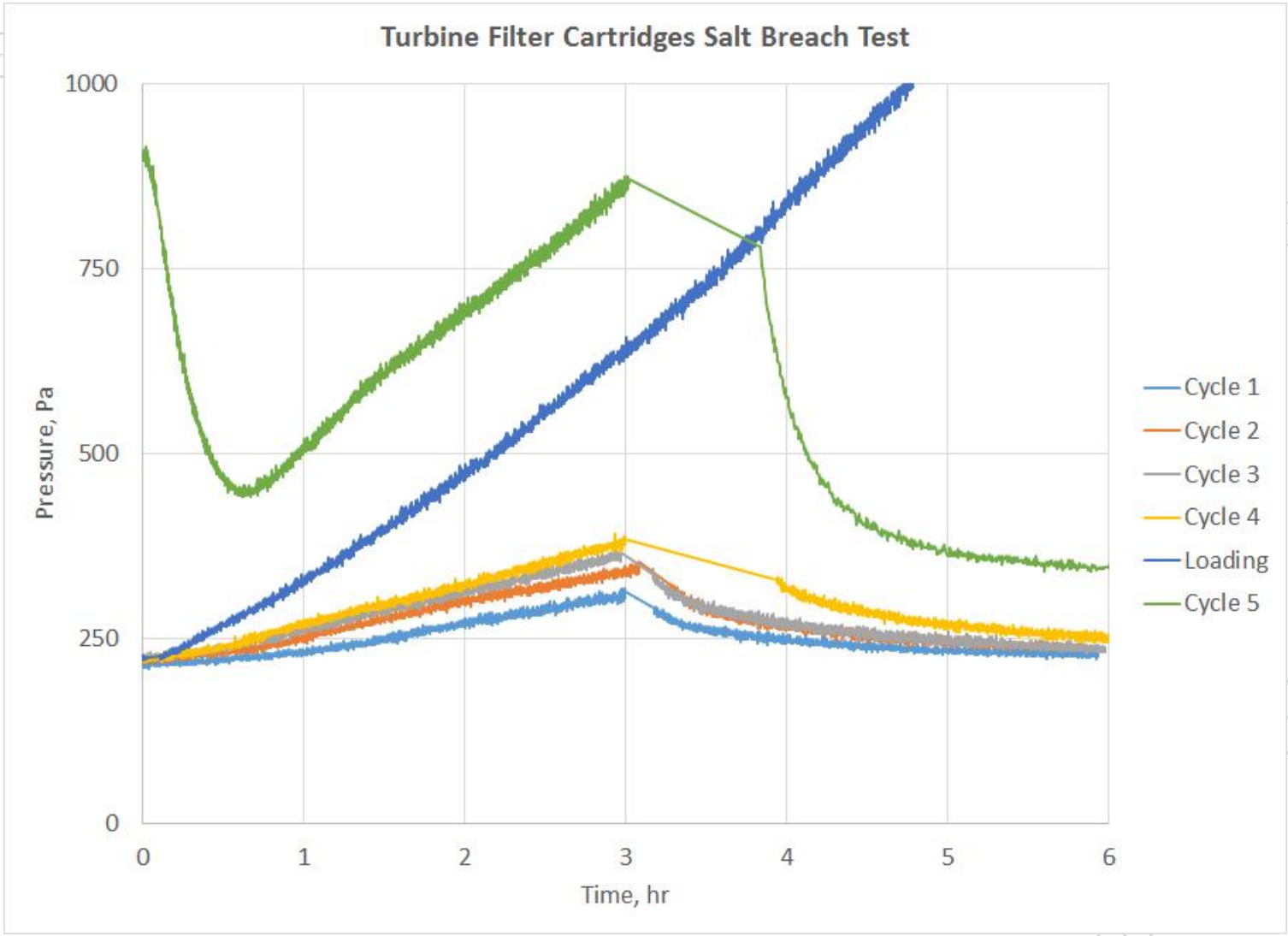


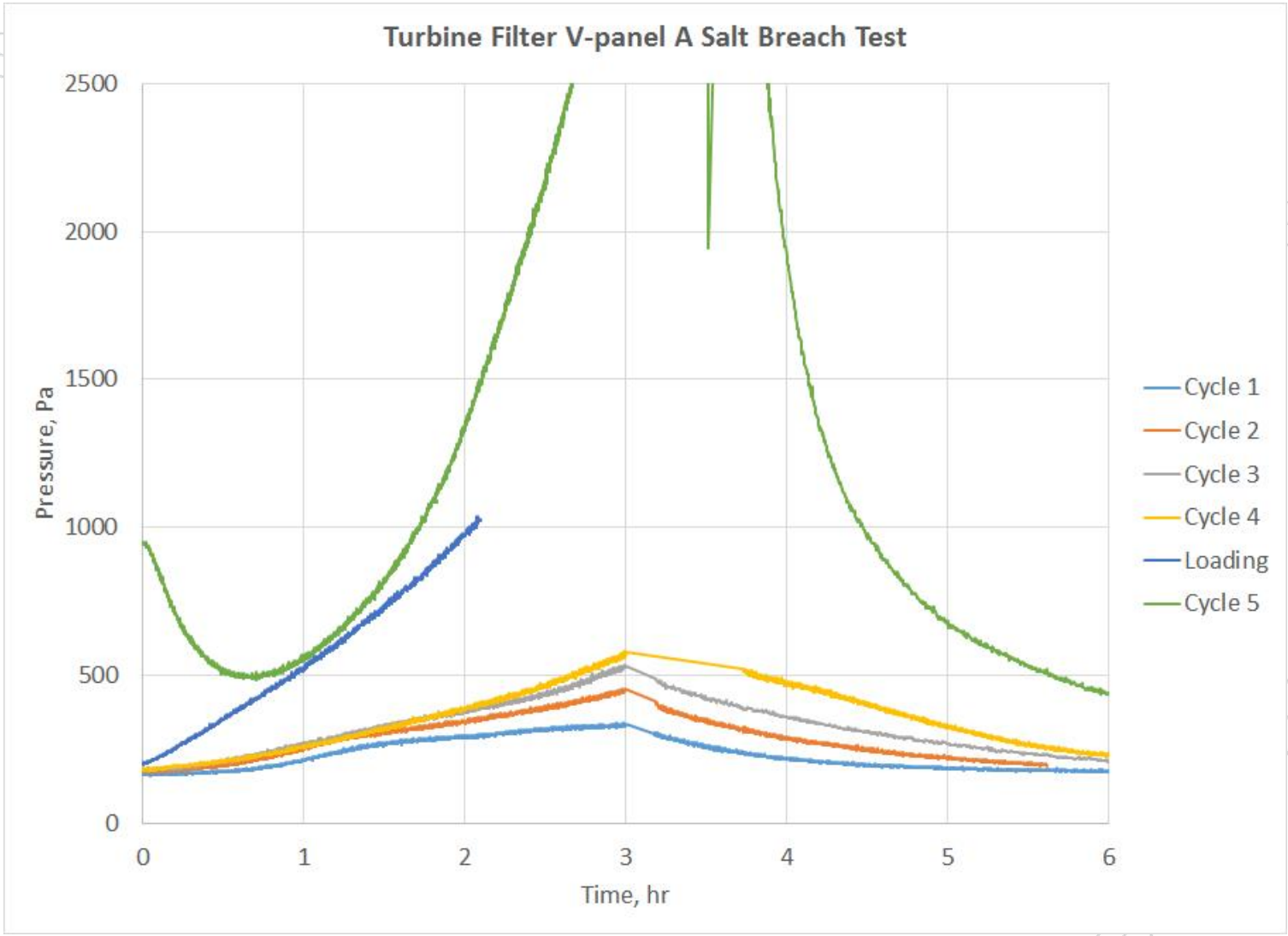


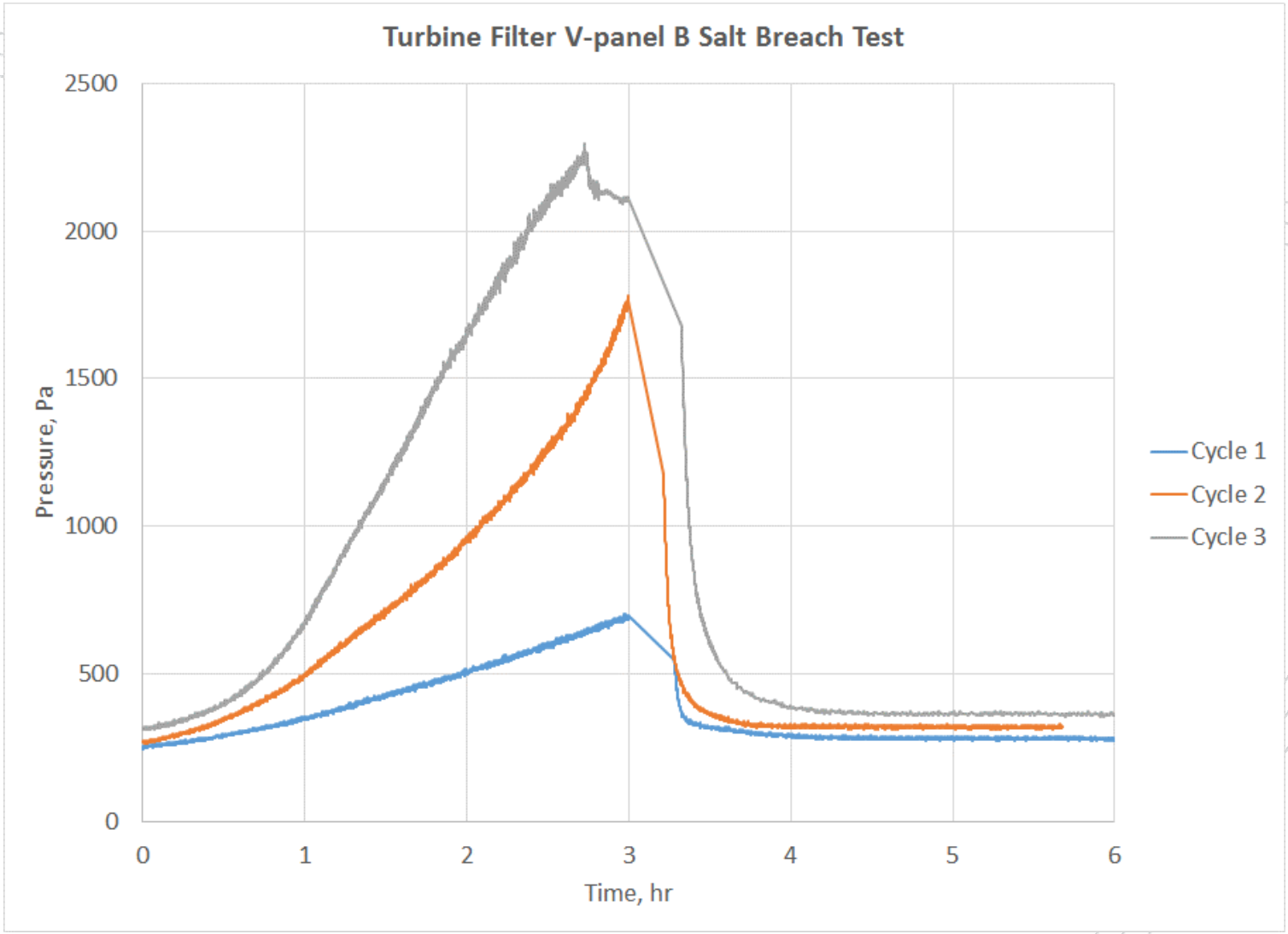


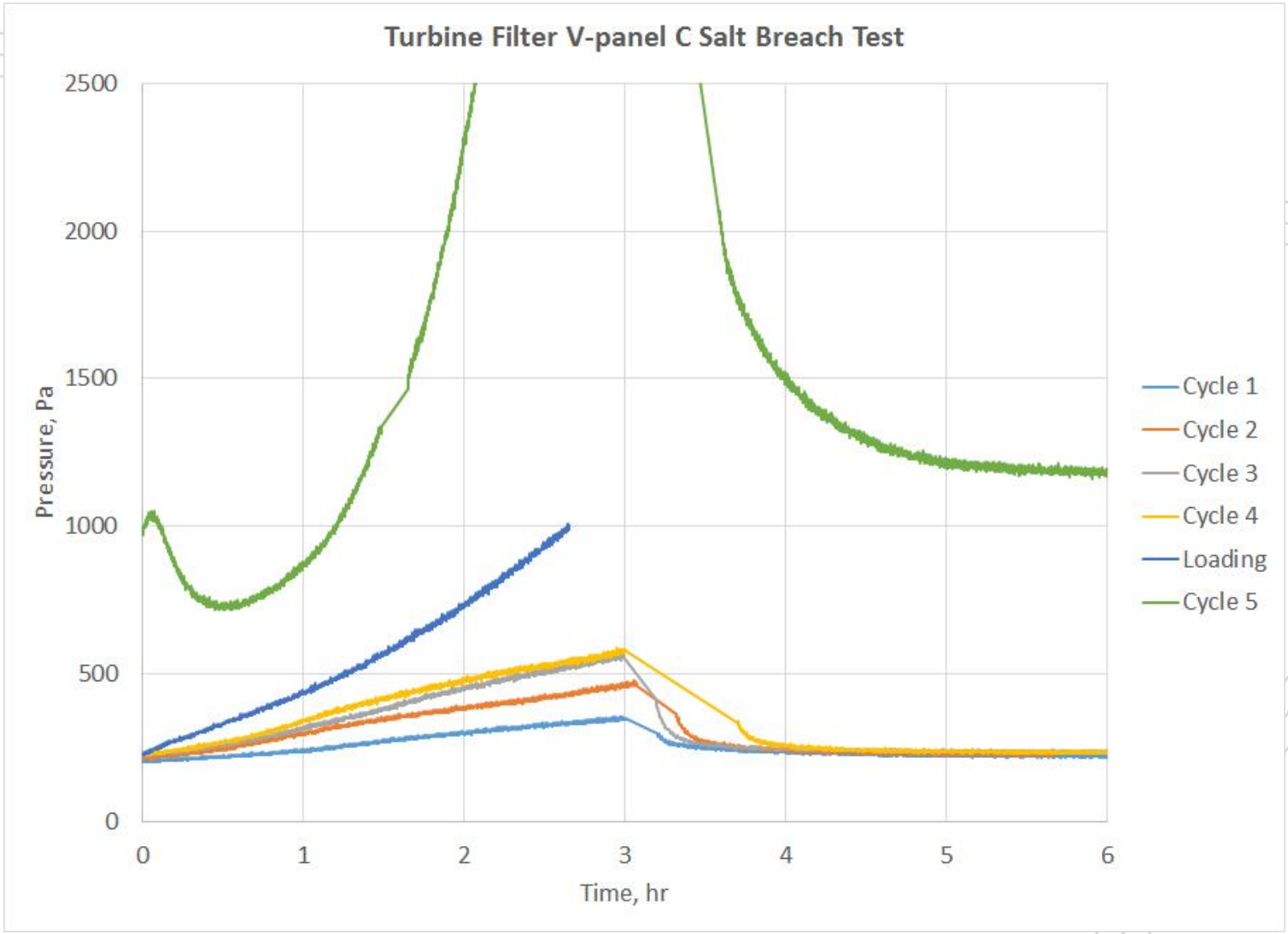












V-panel Test Results

Salt breach – mass of salt collected downstream

	A	B	C
Cycle 1	0.0	146.2	32.9
Cycle 2	0.0	178.8	49.7
Cycle 3	0.0	233.4	67.9
Cycle 4	0.0	NA	107.8
Cycle 5	3.6	NA	93.8

	A	C
4th Cycle Wet dP, Pa	569	573
Dust Capacity, Kg	4.2	5.3
Salt Breach, g	3.6	352.0

Discussions

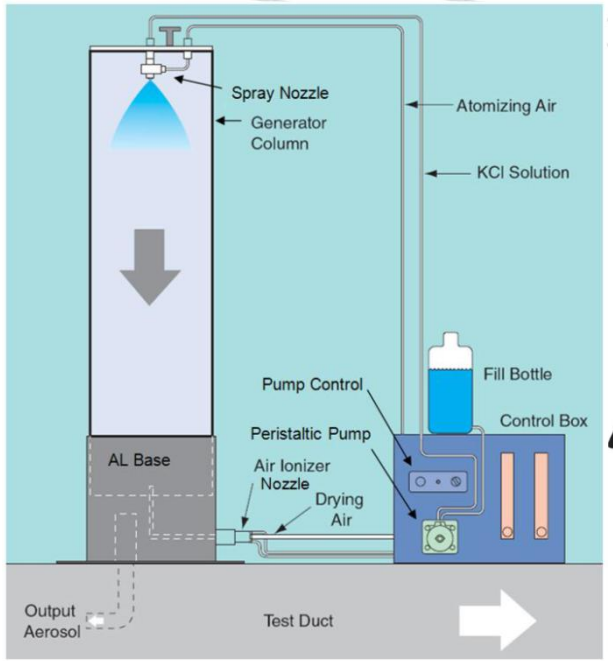
- Tests were successfully run on V-panel and cartridge filters
- Wet pressure drop continue to rise with each cycle due to accumulation of salt
- Dust loaded on filter changes the filter pressure drop behavior
- Final cycle simulates upset condition (eg. fog event)
- Test showed mechanical integrity of filter
- Cons: manual test; 4 days test

Modified Procedure

- Simplify the first 4 wet/dry test procedure to eliminate interruption
  - No measurement of filter weight and filtration efficiency
  - Fix damper position for partial recirculation to lower humidity
- Alternate between wet and dry every hour, 24 hours total
- Generate dry salt particles, continuously
- Wet cycle – water mist using DI water
- Collect downstream water after 24 hours and analyze chloride concentration

TSI 8108 Large Particles Aerosol Generator

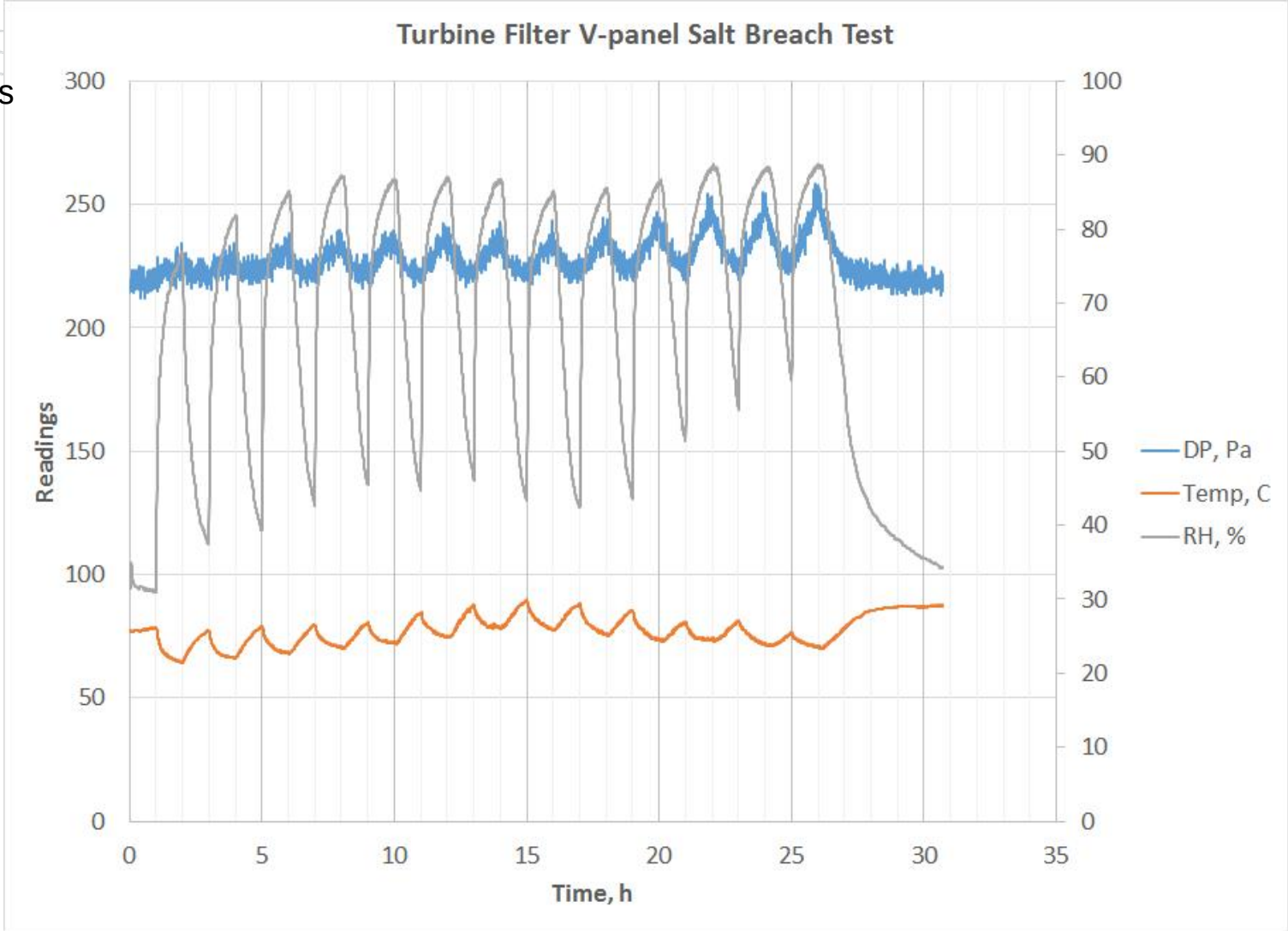
- Air atomizing nozzle produces fine mist particles from top
- Warm drying air injected from bottom to increase dwell time
- Used in ASHRAE 52.2 test method to produce 30% KCl particles between 0.3 to 10 micron
- An electrostatic ionizer acts as neutralizer
- Estimated count median and mass median diameters 0.4 μm and 1.6 μm



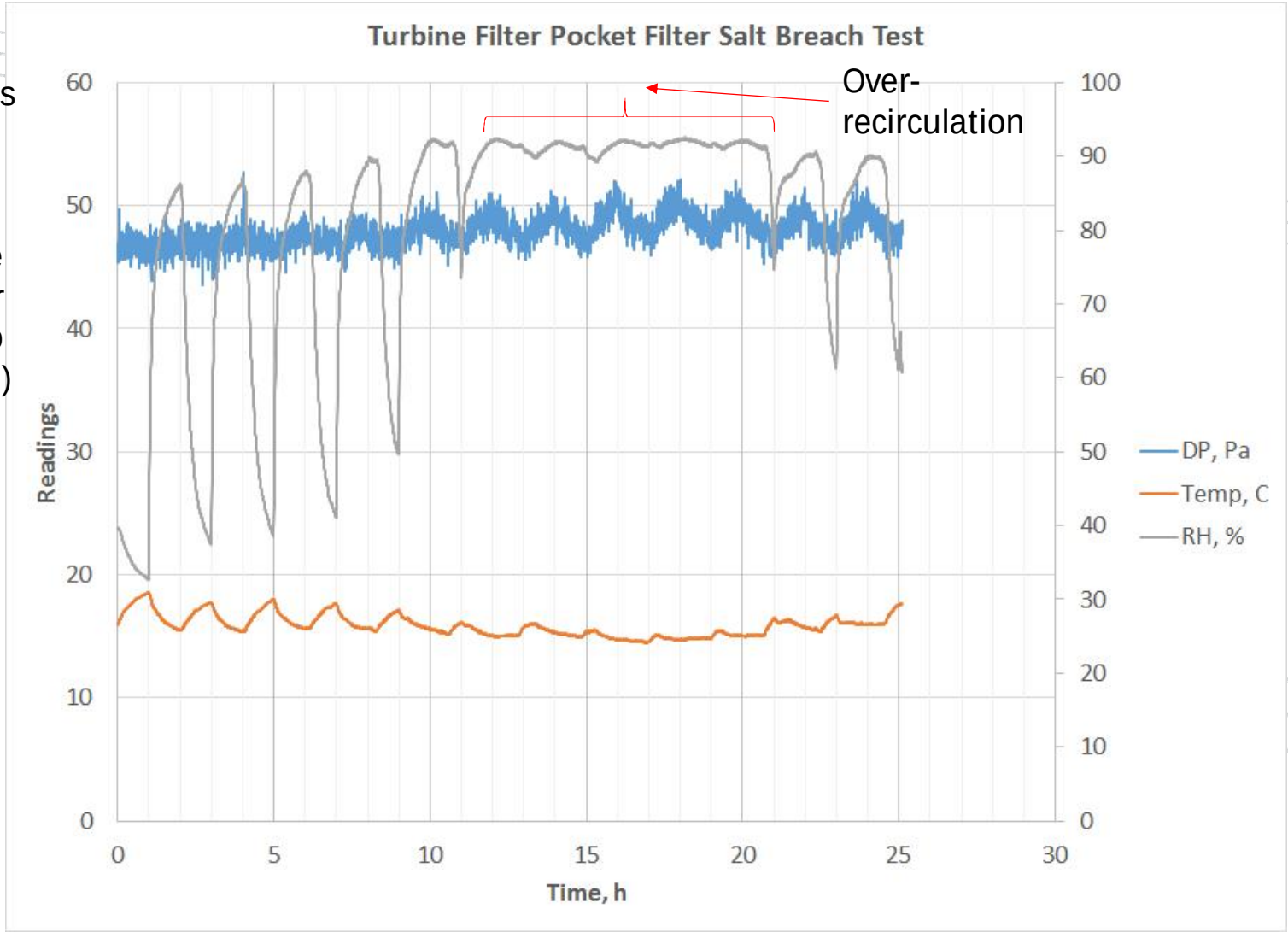
Controlling Humidity

- Chiller, heat exchanger
  - Pros: active control, wide range
  - Cons: expensive equipment, risk of corrosion to components
- Exchange with fresh air (active or passive damper)
  - Pros: inexpensive
  - Cons: limited range, noise

- Continuous salt particles loading
- DI Water Spray
- 1 hour cycle time
- No water breach



- Continuous salt particles loading
- DI Water Spray
- 1 hour cycle
- 250 ml after 24 hours (to be analyzed)



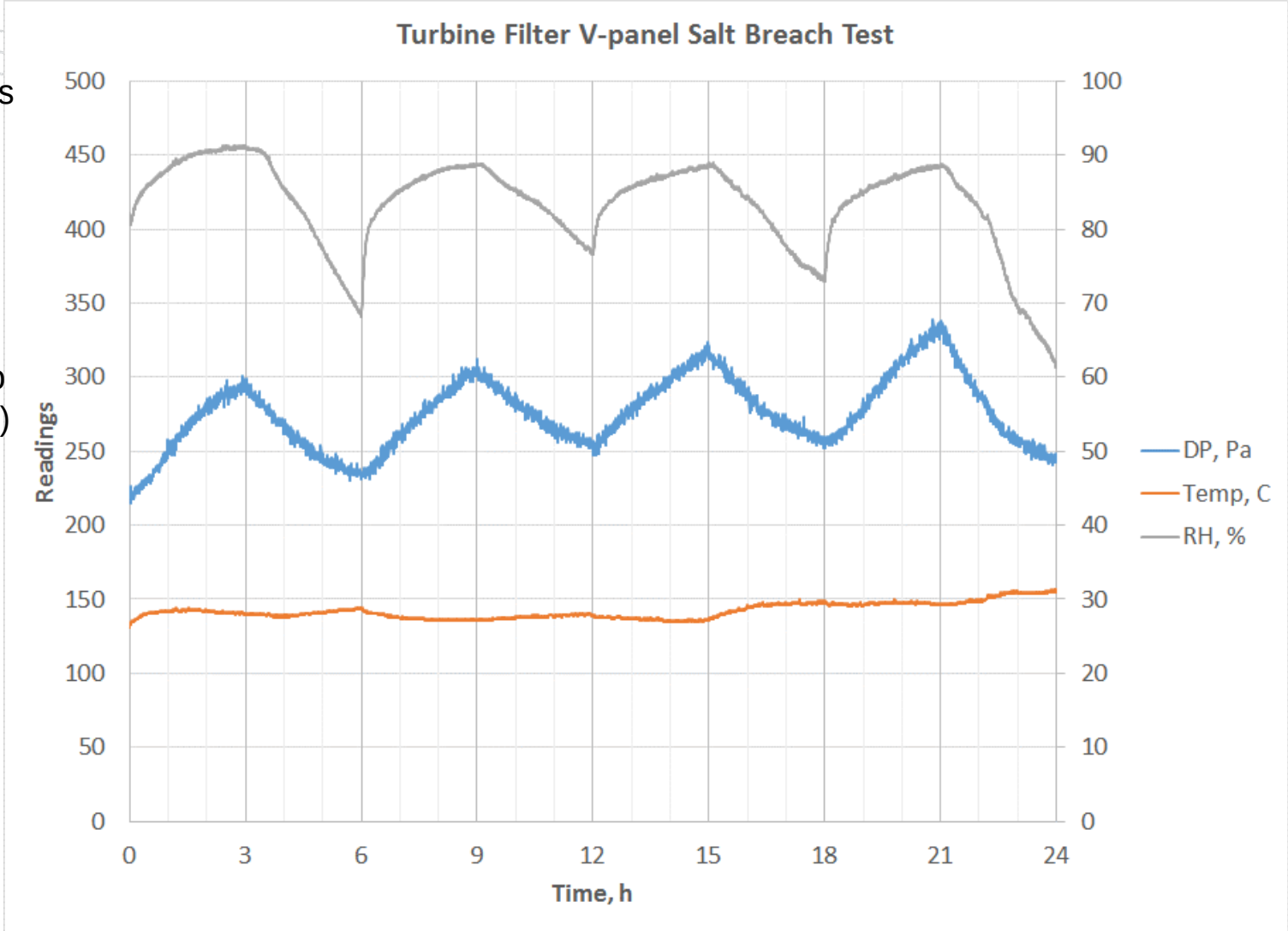
Discussion

- Slow increase in pressure drop due to low salt concentration
  - 5% NaCl solution, liq feed rate 100 ml/h, salt input rate 5 g/h
  - A filter operating at 3400 m3/h is challenged with 2.7 to 9.7 kg of salt per year, requiring over 540 hours (23 days) of loading

Modified Procedure II

- Increase salt challenge by using salt spray instead of DI water spray
- Increase cycle time from 1 hour to 3 hours

- Continuous salt particles loading
- Salt Water Spray
- 3 hour cycle time
- 20 ml water collected (to be analyzed)



Discussions

- New test procedure significantly reduces run time of first 4 cycles from 3 days to 24 hours
- Salt spray accelerates the aging of filter
- Humidity control can be improved by using active damper instead of passive damper
- No dust loading has been performed due to time constraint, but it can be added to the test procedure easily to simulate dusty environments

Salt Breach Test - Modified

- Phase 1: 24 hours salt breach – simulate aging with salt
  - Inject dry salt particles continuously
  - During wet cycle, inject salt water spray
  - Alternate between wet and dry cycles every 3 hours
  - Collect any salt water at the end of 24 hours and analyze the chloride concentration
  - If the salt dried into crystals, rinse the liner with known amount of DI water and analyze the chloride concentration
- Phase 2: Dust aging
  - Load filter with ISO fine dust xxx Pa(to be defined)
- Phase 3: Post aging – Fog Event
  - 3 hours wet cycle same conditions as to Phase 1