Abrasion Testing of Critical Components of Hydrokinetic Devices

Project Team

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  - Faculty
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    - Muhammad Ali
  - Research Assistants
    - Tim Kirk
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    - Angus Bromaghin

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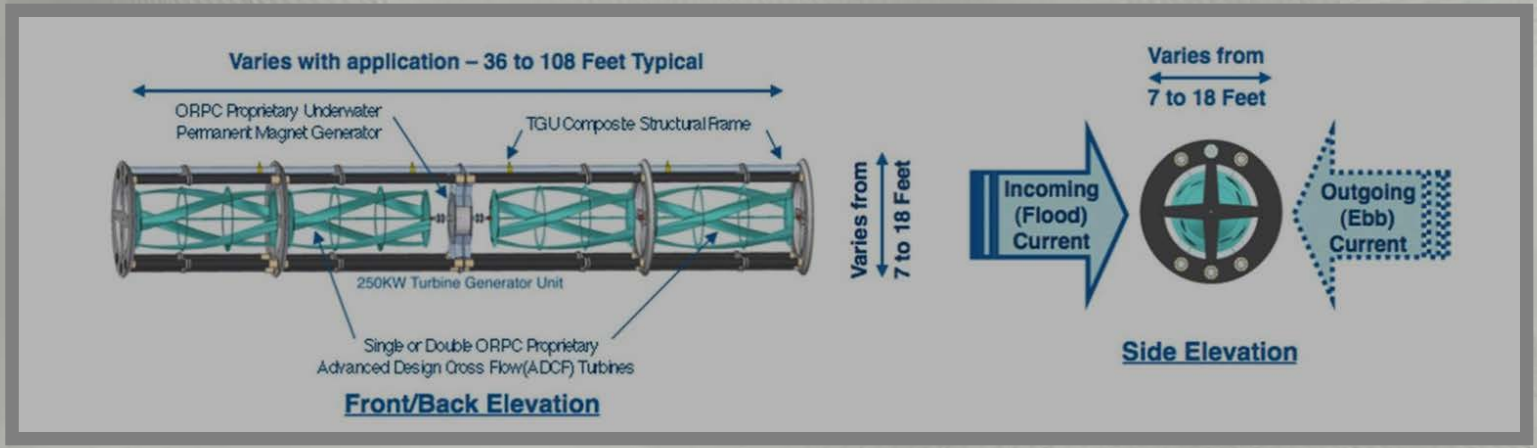
ORPC Technology

- TideGen Power System (TGU)
- Designed to generate electricity at water depths of 50 to 100 feet



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ORPC Technology

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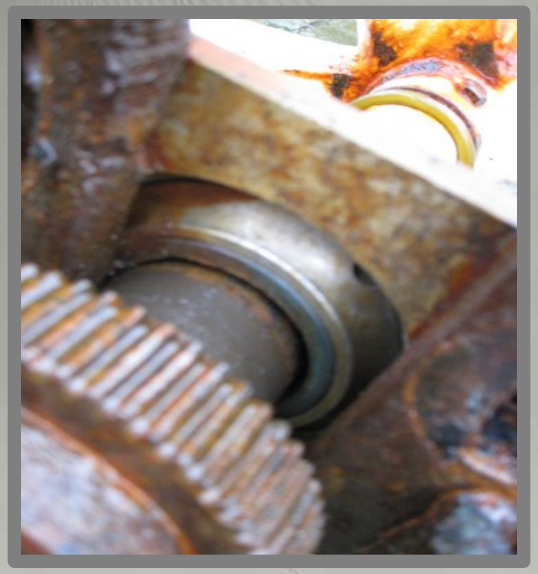
TGU Performance Test Results

- ORPC field testing on TGU prototype in 2008 showed significant wear on bearings and seals.



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TGU Performance Test Results

- Vibrations induced due to bearing wear caused seal failures

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TGU Performance Test Results

- TGU Beta test results

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Abrasion Study Project

- Motives
  - Abrasive sediment particles in Cook inlet, Alaska, will mostly likely increase bearing wear rate
  - Excessive bearing wear will lead to less efficient energy capture, vibrations, and load transfer to seals causing their premature failure
  - Seal failure could lead to water intrusion and catastrophic generator failure
  - The seal and bearing manufacturer's have not tested their products in sedimented (Cook inlet) salt water and, therefore, have no performance data to share with consumers

Abrasion Study Project

- Project objectives
  - Study the abrasion resistance of different bearings in laboratory under conditions similar to those experienced by hydrokinetic devices in Cook inlet, Alaska, when deployed.
  - Study the performance of mechanical and polymer seals in the presence of sediments and develop a relationship between bearing wear rate and seal failures

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Test Apparatus

- UAA team designed, fabricated, assembled, and instrumented the abrasion study test flume

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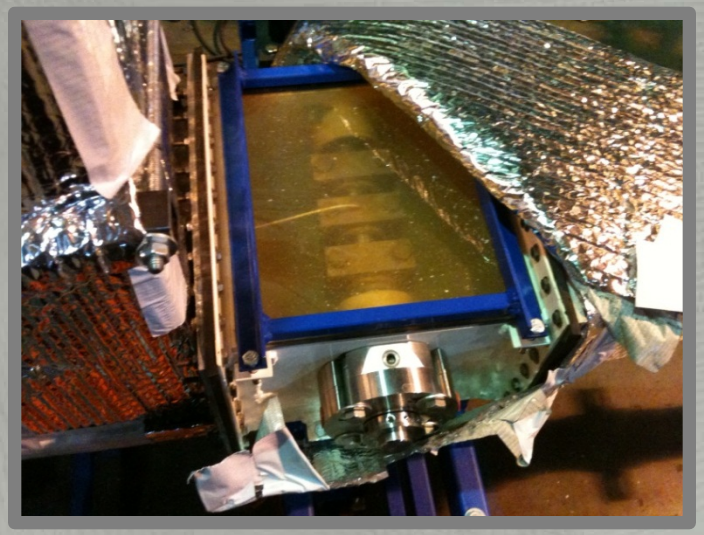
Test Apparatus



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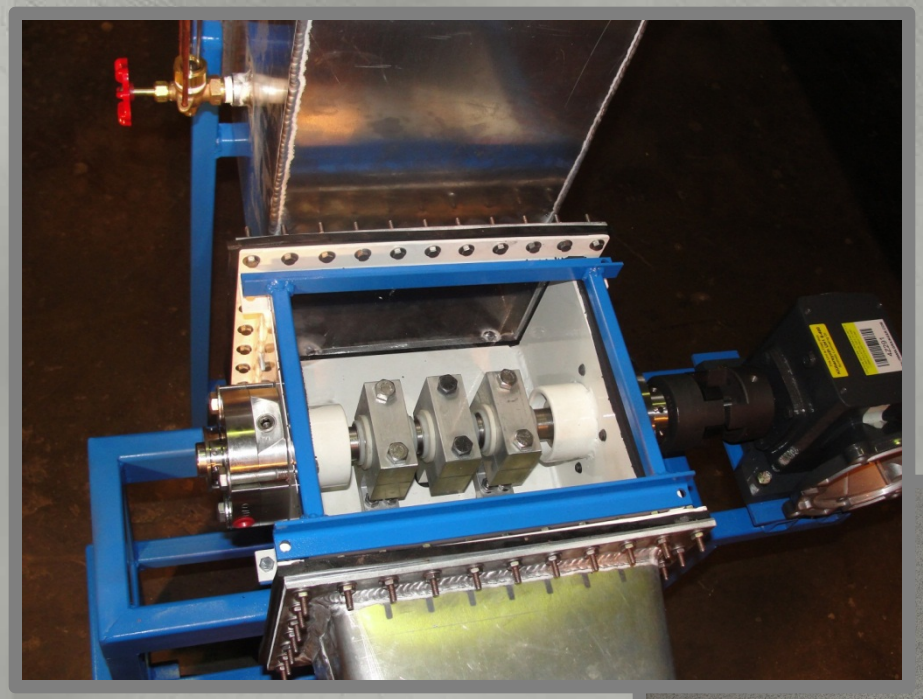
Test Apparatus



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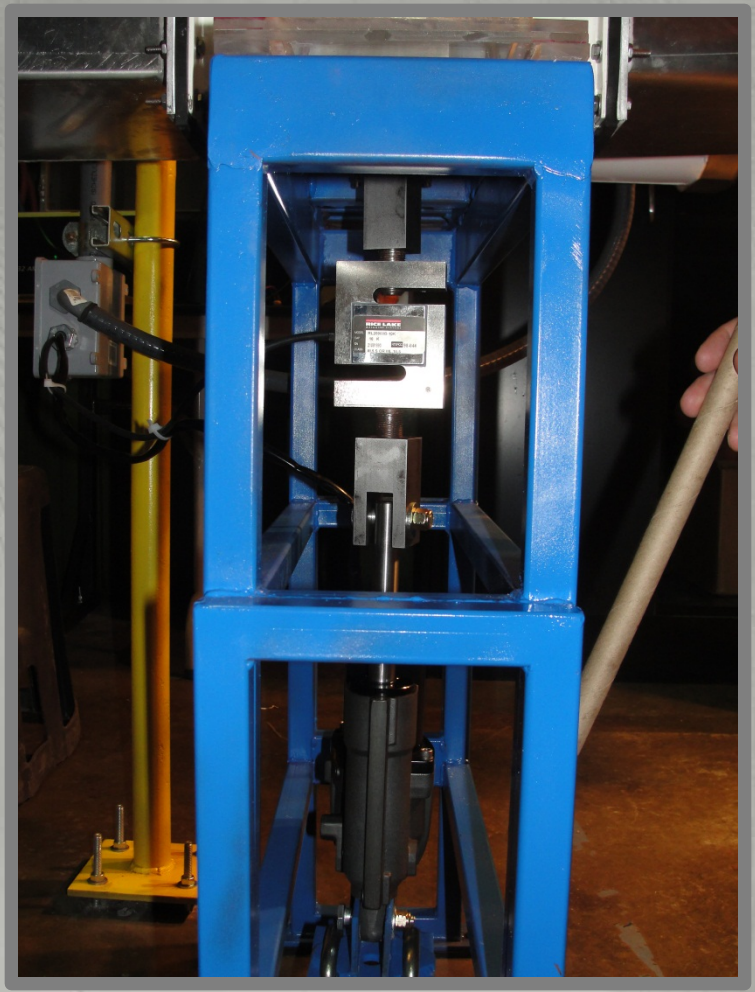
Test Apparatus



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Test Details

- Candidate bearings for testing
  - Polymer based bearings
    - Vesconite
    - CIP
    - Feroform T814
  - Hybrid bearings
    - Polycrystaline diamond radial coated bearings

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Test Details

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Test Details

- Candidate seals for testing
  - Dual cartridge seal
  - Single cartridge seal
  - Lip seal

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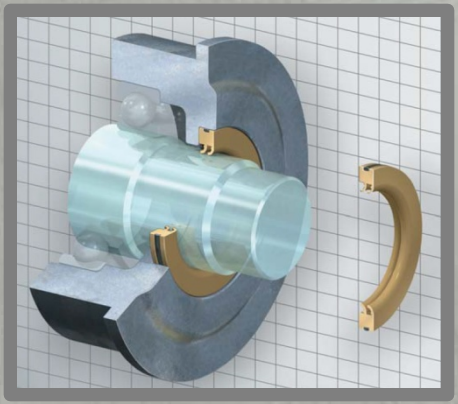
Test Details



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Test Details

- Measurements
  - Bearing wear
    - Bearing dimensions through internal gauges, micrometer, and 3D scanners.
    - Weighing
    - Visual inspection
    - Vibration
    - Motor power consumption
  - Seal performance
    - Pressure in seal (between cartridges)
    - Volume of water leaked through seals

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Test Details

- Measurements
  - Seal performance Contd.
    - Mass of sediments in leaked water
  - Control parameters
    - Water temperature
    - Suspended sediment concentration
    - Pressure in flume
    - Flow rate in flume
    - Load on shaft
    - Motor RPM
    - Salinity

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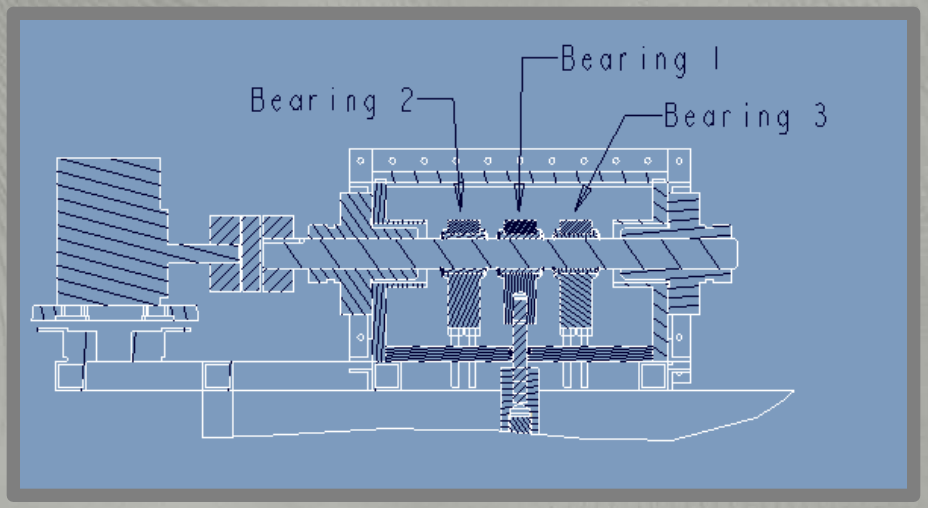
Test Results

- Bearing performance in fresh clean static water (72 min run time)



Initial

Bearing #	ID 1 (mm)	ID 2 (mm)	ID 3 (mm)	ID ave. (mm)	ID ave. (in.)
1	25.38	25.39	25.38	**25.38**	**0.999**
2	25.38	25.39	25.39	**25.39**	**0.999**
3	25.38	25.39	25.38	**25.38**	**0.999**

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Test Results

- Bearing performance in fresh clean static water (72 min run time)

After Test

Bearing #	Meas. Dir.	ID 1 (mm)	ID 2 (mm)	ID 3 (mm)	Ave. (mm)	Ave. (in)	Change (mm)	Change (in.)
1	Vert	25.63	25.55	25.64	**25.61**	**1.008**	**0.22**	**0.009**
1	Horiz	25.36	25.51	25.47	25.45	1.002	0.06	0.002
2	Vert	25.42	25.39	25.40	**25.40**	**1.000**	**0.02**	**0.001**
2	Horiz	25.41	25.39	25.40	25.40	1.000	0.01	0.001
3	Vert	25.53	25.62	25.49	**25.55**	**1.006**	**0.16**	**0.006**
3	Horiz	25.40	25.62	25.47	25.50	1.004	0.11	0.004

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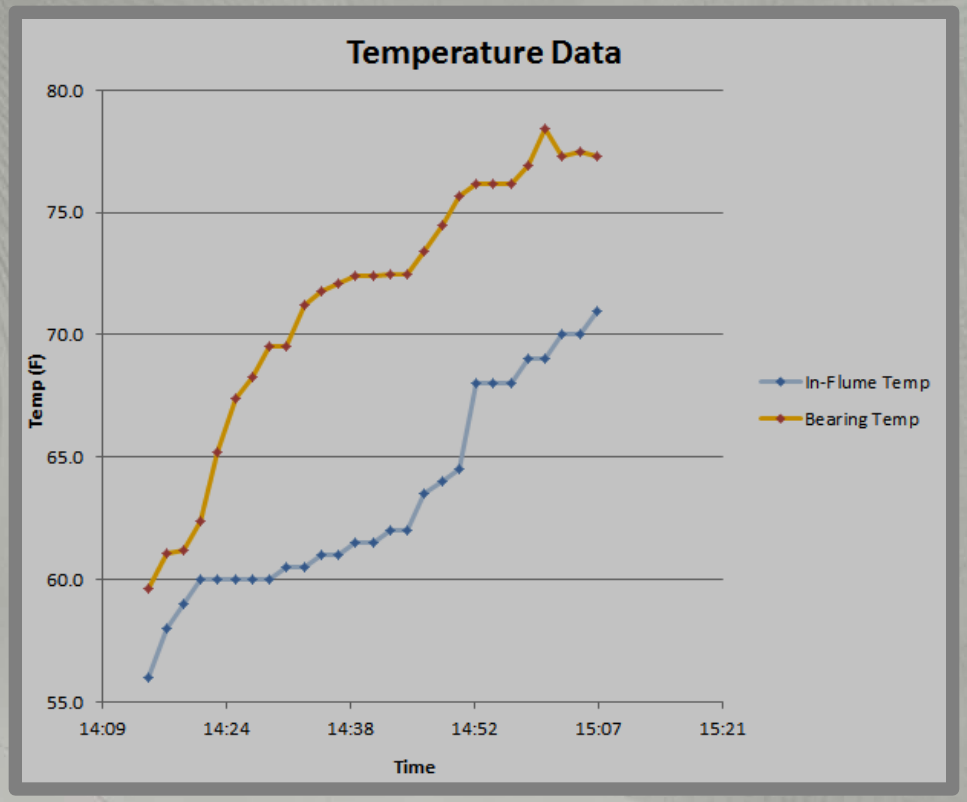
Test Results

- Bearing performance in fresh clean static water (72 min run time)



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Test Results

- Visual comparison of wear of test bearing with actual field bearing

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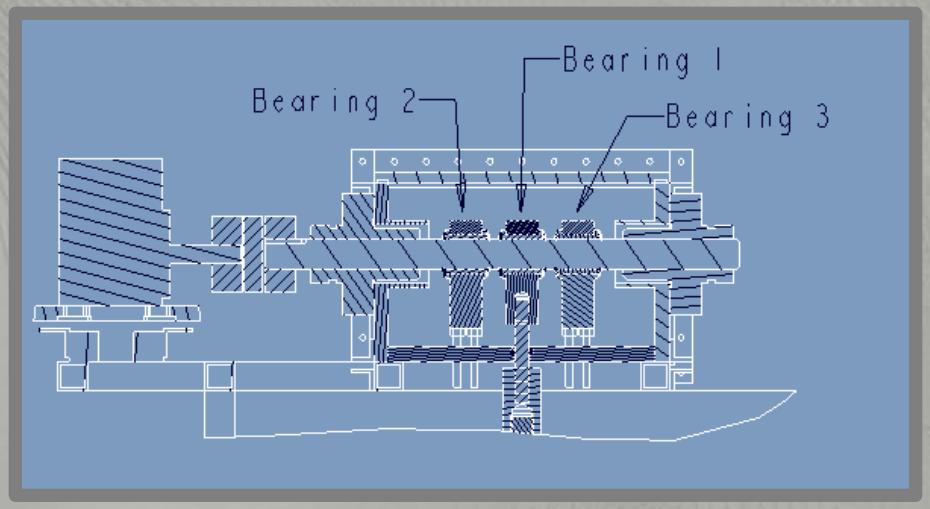
Test Results

- Bearing performance in (fresh) clean flowing water with constant temperature at 77 F and 60 hrs of run



Initial

Bearing #	ID 1 (mm)	ID 2 (mm)	ID 3 (mm)	ID ave. (mm)	ID ave (in)
1	25.38	25.39	25.38	25.38	0.999
2	25.38	25.39	25.39	25.39	0.999
3	25.38	25.39	25.38	25.38	0.999

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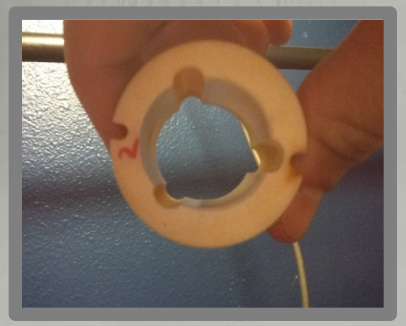
Test Results

- Bearing performance in (fresh) clean flowing water with constant temperature at 77 F and 60 hrs of run

After Test

Bearing #	Measured Direction	ID 1 (mm)	ID 2 (mm)	ID 3 (mm)	ID ave. (mm)	ID ave (in)	Change (mm)	Change (in)
1	vert.	26.88	26.63	26.79	26.77	1.054	1.39	0.055
1	horiz.	25.45	25.44	25.41	25.43	1.001	0.05	0.002
2	vert.	25.64	25.62	25.65	25.64	1.009	0.26	0.010
2	horiz.	25.59	25.5	25.47	25.52	1.005	0.14	0.006
3	vert.	26.05	26.18	26.67	26.3	1.035	0.92	0.036
3	horiz.	25.7	25.48	25.48	25.55	1.006	0.17	0.007



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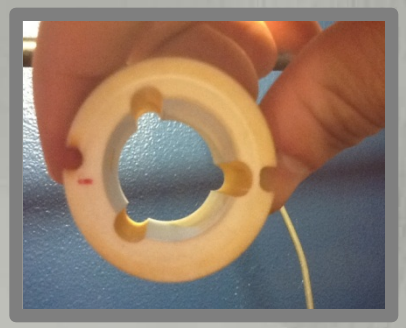

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Future Work

- The flume is being assembled to conduct test on Vesconite and diamond coated bearings simultaneously at 50 F in fresh clean (flowing)water.
- Same series of tests will be conducted in sedimented flowing water collected from Cook inlet test site. The wear rate of each bearing will be compared with the fresh water wear rate. The bearing with the least amount of wear among the candidate bearings group will be recommended for application to ORPC in their TGUs.

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Acknowledgements

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Questions

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