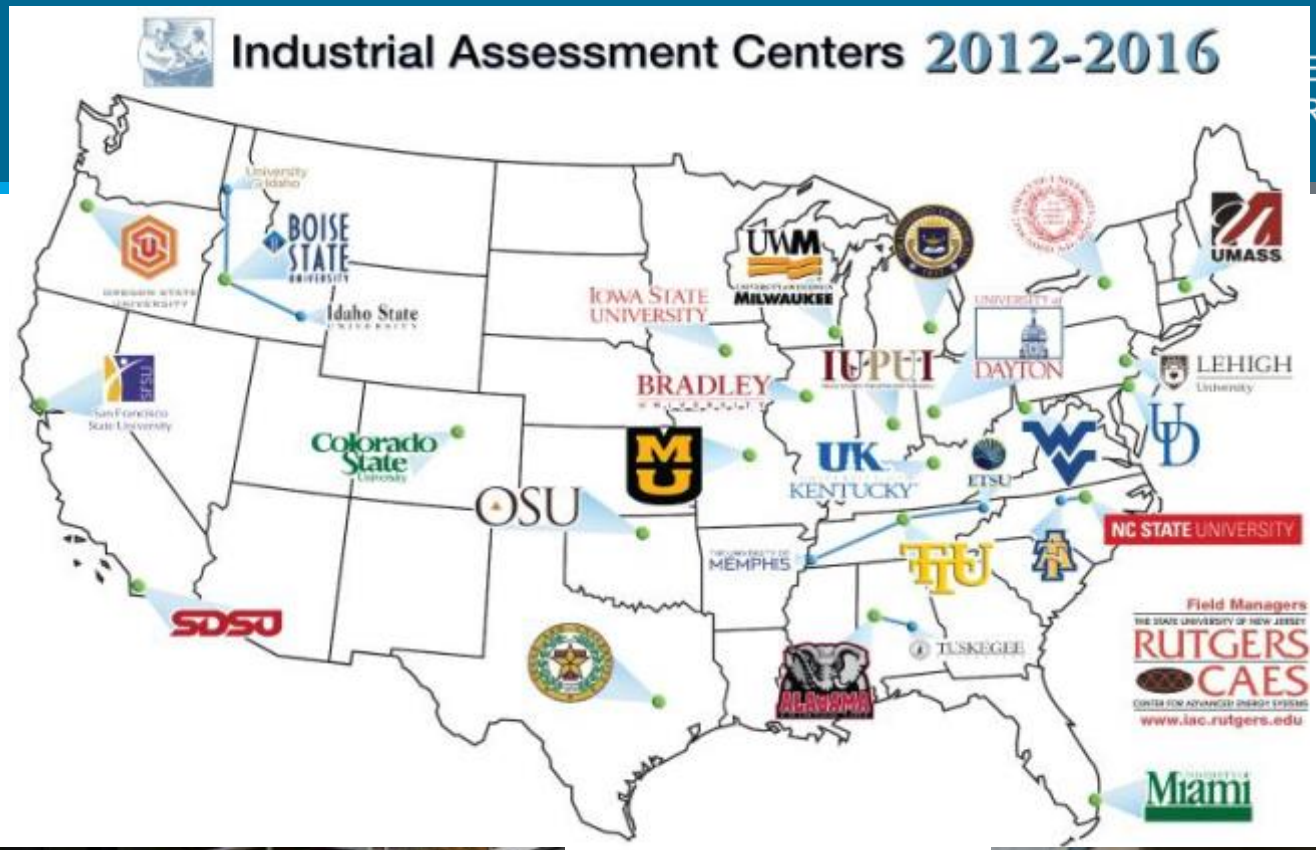
IAC Student Collaboration Webinar

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Thomas Wenning, PE
Oak Ridge National Laboratory

IAC Student Webinar Series
October 2015


Industrial Assessment Centers 2012-2016
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IAC Student-Led Webinars Intro

- Alternative to student meeting
- Monthly student-led webinars
- Proposed Structure:
  - 40 min student presentation
  - 20 minutes of Q&A/open dialogue
- Allow students to connect

Webinar Series Purpose

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- Mechanism for IAC-to-IAC student collaboration
- Possible topics:
  - Relevant items for day-to-day IAC operations (client recruitment, report writing, etc.)
  - New technologies and innovations
- Rotate speakers and topics each month
- Each center will lead or contribute a presentation to a future webinar

Feedback

We want your feedback (date, time, topics, etc)!

….and Volunteers!

Feedback

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Webinar Survey

1. Did you find this webinar helpful (1 being least helpful and 5 being most helpful) ?

   1 ○ 2 ○ 3 ○ 4 ○ 5 ○

2. What topic or topics would you like to see addressed in future IAC student-led webinars?

3. Would you be interested in leading a future webinar?

   ○ Yes

   ○ No

4. If interested in leading a future webinar, please list your name and contact email.

On to the Speaker…

- **Topic**: Pump Impeller Surface Treatment to Reduce Operating Cost
- **Who**: Sean Rosin, Boise State University IAC

SeanRosin@u.boisestate.edu

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IAC Excellence in Applied Energy Engineering Research

Pump Impeller Surface Treatment to Reduce Operating Cost

Sean Rosin, IAC Alum

Mechanical Engineering Graduate Student

Presentation Outline

- About our IAC Center
- Research Theory & Background
- Research Process
- Future Plans

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IAC in Idaho

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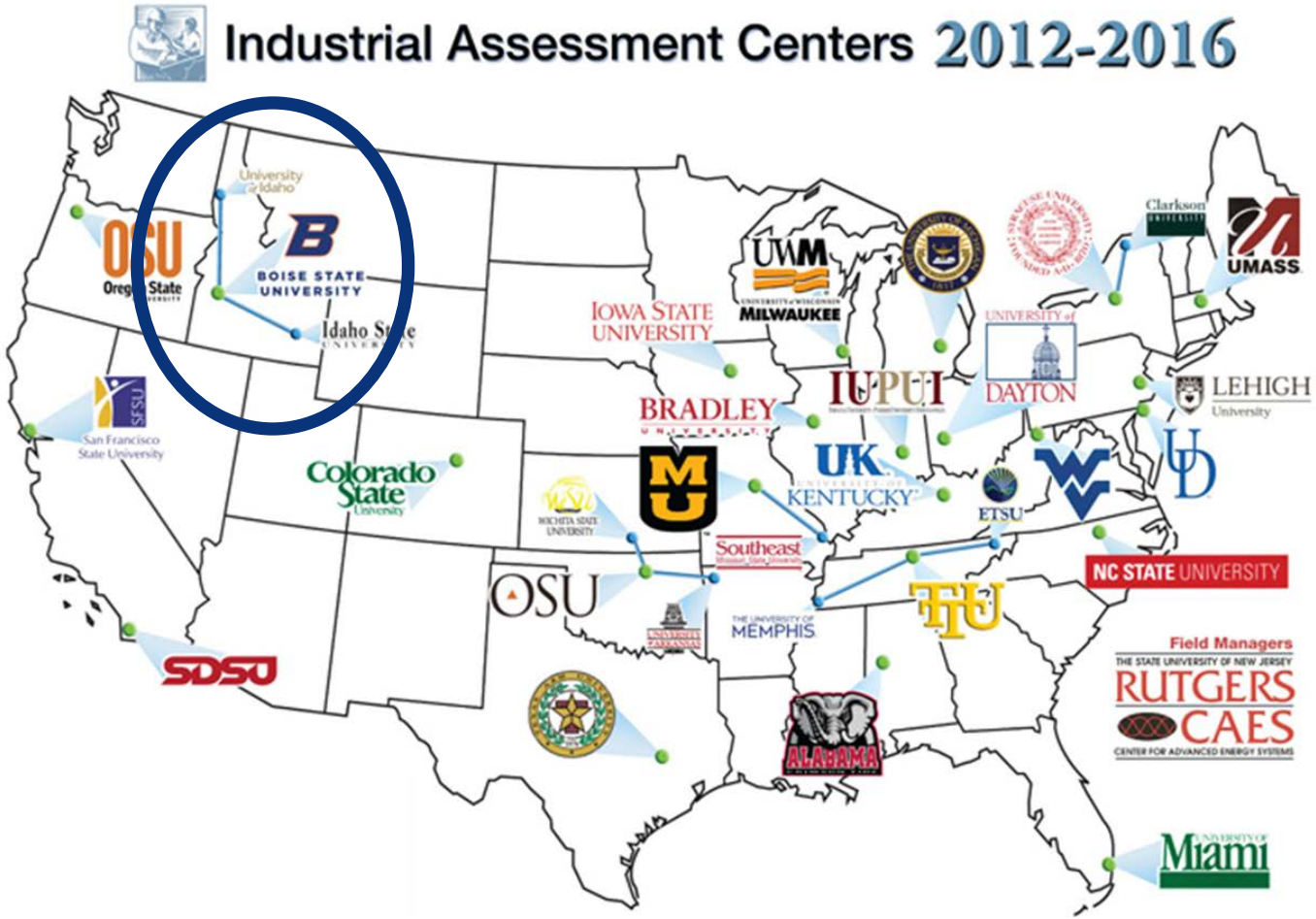
IAC in Idaho



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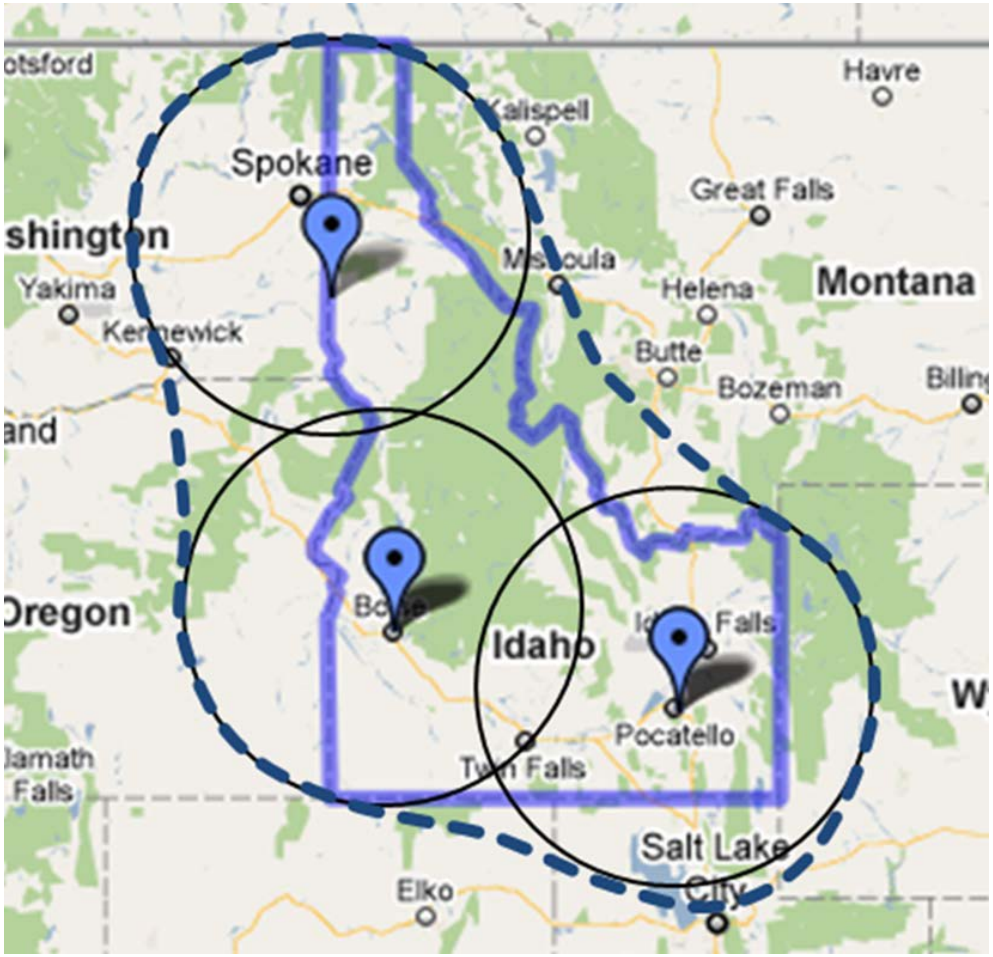
Idaho IAC Coverage



- Northern Idaho
  - University of Idaho – Moscow
- Southwest Idaho
  - Boise State University – Boise
- Southeast Idaho
  - Idaho State University – Pocatello

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Research Theory & Background

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Pumping Electrical Usage

- Worldwide pumping systems account for 20% of the electrical demand. The cost of electricity is 95% of the cost of operating those pumps.
- A small improvement in pump performance will result in a significant savings of energy and operating cost.

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IAC Pump Experience

- Many of the facilities investigated by our IAC team have had processes where a significant amount of energy used is for pumping fluids.
  - Dairy products
  - Beverage bottling
  - Waste water treatment

http://static.kavlico.com.s3.amazonaws.com/bnr_industrial-pumps.jpg

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Heat Exchangers and Super-Hydrophobic Coatings

- Dairy Processing Facilities
  - Reclaiming heat after the pasteurization process
  - The heated milk through ran through a plate heat exchanger
    - Leaves nasty residue in heat-exchanger decreasing heat exchange efficiency
  - But what if the surface of the heat-exchanger was super-hydrophobic?

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Common Pump ARs

- According to IAC Database:
  - Establish a maintenance program
  - Turn off equipment when not in use
  - Replace oversized pumps with optimum size
  - Install VFDs for variable loads

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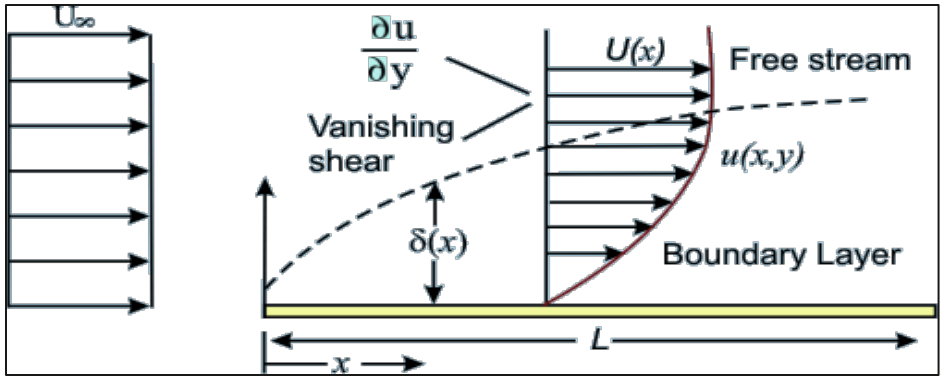
Concept

- This research will investigate a new means of reducing pump energy use by modifying the surface properties of a pump impeller creating a surface slip boundary condition reducing friction losses, thereby reducing pump energy use at all speeds of operation.



Boundary Layer and Free Steam Over a Flat Plate. Digital image. NPTEL. N.p., n.d. Web. 19 Oct. 2015.

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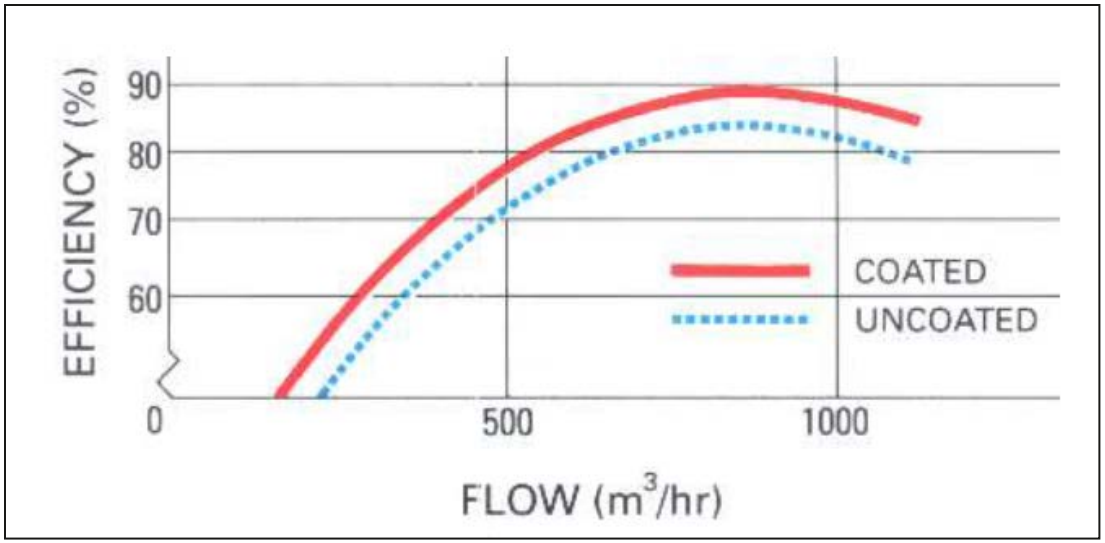
Hypothesis

- A pump with an impeller that has been treated to be hydrophobic will be more efficient than one with a non-treated impeller.



Pump protection and repair, Wilson, Bill. Industrial Lubrication and Tribology 49.1 (1997): 10.

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Hydrophobic

- Lacking affinity for water
  - Hydro = water
  - Phobic = fear

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Research Goals

- Treat a pump impeller to be super-hydrophobic
- Compare the as received vs. super-hydrophobic surface processed pump efficiency and flow characteristics to evaluate the potential pumping energy savings

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Impeller Types

- Open & Closed / Shrouded
- Using open impeller configuration for this research for ease of treatment and verification, but results may be applied to closed impellers as well.
- 304SS 316SS

a) Open impeller & b) close or shrouded impeller

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Past Research

- "The low surface energy hydrophobic resinous surface coatings repel water with resulting lower boundary layer friction losses than with readily wetted metal surfaces."
  - (Pump protection and repair, Wilson, Bill. Industrial Lubrication and Tribology 49.1 (1997): 10)
- "Look for ways to reduce friction factor. If your application permits, epoxy-coated steel or plastic pipes can reduce friction factor by more than 40%, proportionately reducing your pumping costs."
  - (Improving Pumping System Performance: A Sourcebook for Industry, Second Edition, May 2006, U.S. DOE Energy's Industrial Technologies Program (ITP), Lawrence Berkeley National Laboratory, Resource Dynamics Corporation, Alliance to Save Energy, and the Hydraulic Institute (HI))

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Past Research – Boise State

- Prior work at Boise State University has demonstrated that by etching stainless steel, passivating the post etched surface, and finally treating the finished nano-structured topology with FAS-17, one can produce super-hydrophobic surfaces from 304SS.

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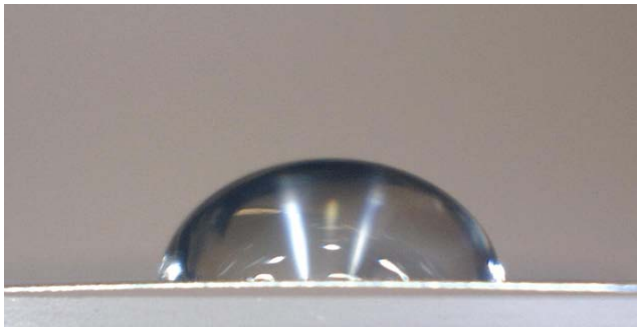
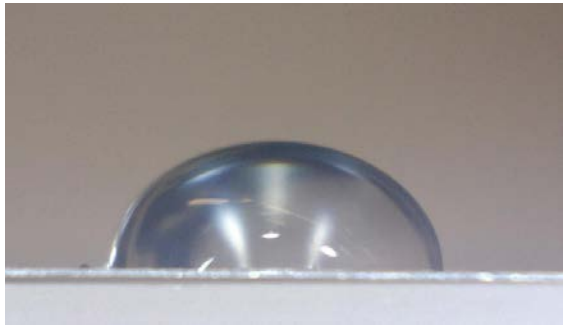
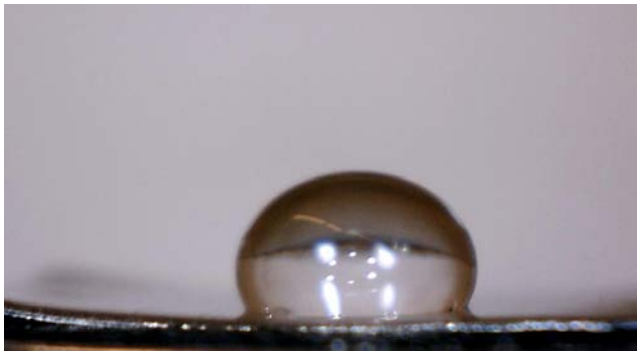
Past Research



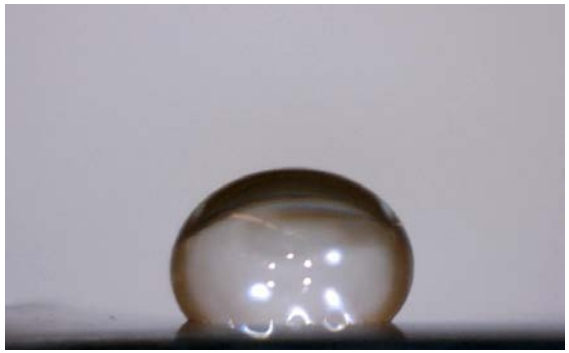
316SS as received



304SS as received



316SS Treated



304SS Treated

Topology Effect Only

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Implementation

- Retrofit of existing pumps
- Treatment of new impellers

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Potential Impact

- Our expectation is this super-hydrophobic 304SS surface treatment will reduce pumping energy by 10% to 40%

Pump Power	1.5 hp	Super-hydrophobic Impeller Savings	10%
Pump Runtime	8760 hrs / yr		
National Average Industrial kWh Rate (March 2014)	$ 0.0699 / kWh	Cost to Process Impeller and Replace in Pump	$ 125

Annual Pump Electrical Usage	= 1.5 hp * 0.746 kW / hp * 8760 hr/ys	= 9,802 kWh
Annual Savings	= 9,802 kWh * 10%	= 980 kWh
Annual Cost Savings	= 931 kWh * $ 0.0699	= $ 68.52
Simple Payback	= $ 125 / $ 68.52	**= 1.82 years**

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Research Process

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Student Research Team

- Sean Rosin
- Dennis Twitty
- Michael Armstrong
- Vitor Da Silva Santos

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Research Objectives

- Test the hypothesis that a super-hydrophobic impeller surface coating will increase overall pump efficiency. *(primary goal cited in research proposal)*

- Design pump bench that can be utilized as a test platform in engineering lab courses. *(secondary goal identified after project start-up)*

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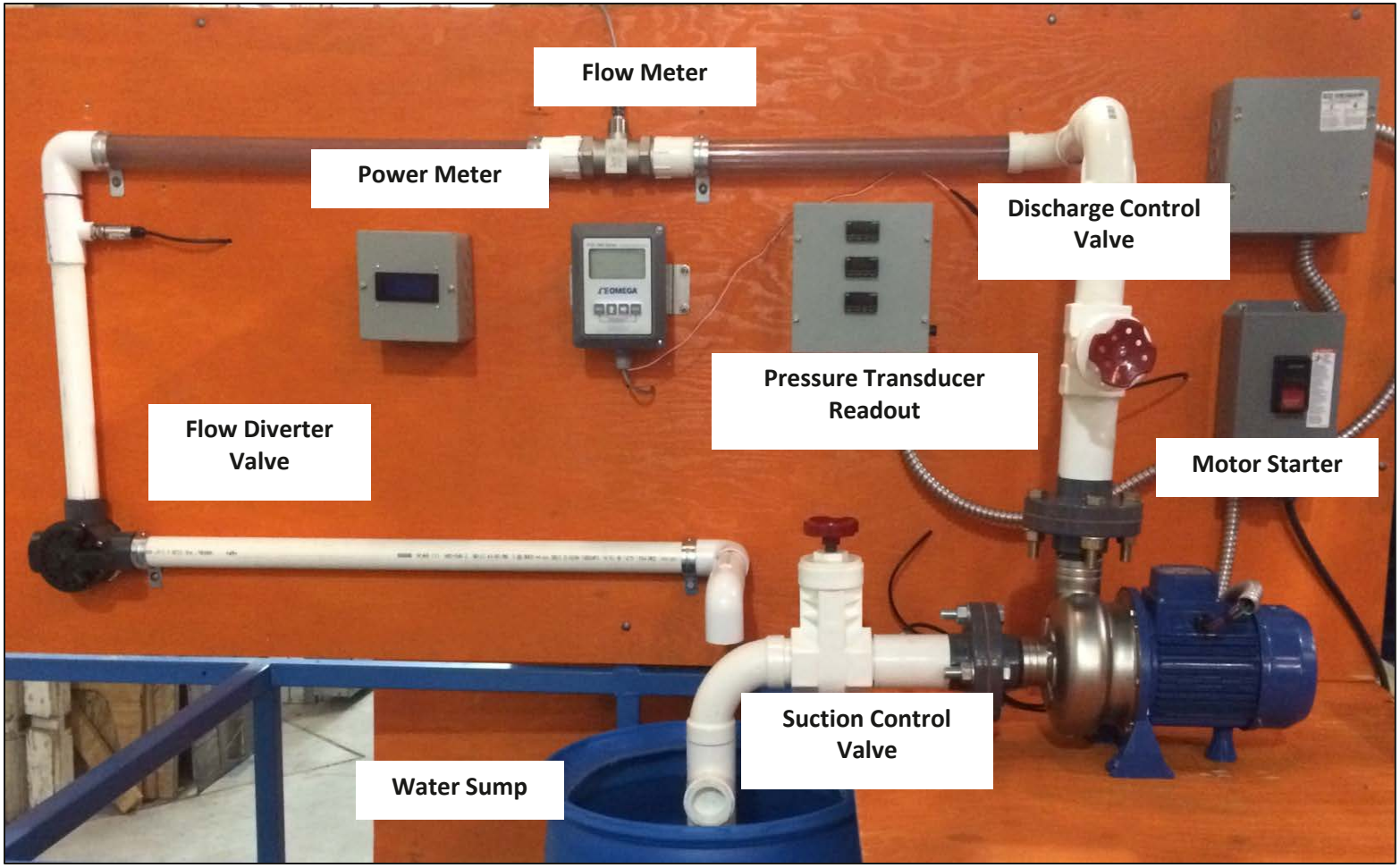
Pump Test Bench Layout



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Instrumentation

- Three Pressure Transducers
  1) 0 – 15 psia (Pump suction pressure)
  2) 0 – 50 psig (Downstream discharge pressure)
  3) 0 – 100 psig (Pump discharge pressure)
- Paddle Wheel Flow Meter
  - 15 – 150 GPM
- 3 Phase Energy Meter
  - Accounts for power factor

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Testing Procedure

- Run pump until steady state conditions are achieved.
- Take suction pressure and discharge pressure reading to calculate pump head.
- Obtain time-averaged flowrate.
- Use power meter readings to calculate pump horsepower.
- Using standard pump equations find the pump efficiency at each operating point.
- Increase pump head by adjusting discharge control valve.

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Pump Equations

$$WHP = \frac{QH}{3,960}$$

$$H = \left[P_{d(psia)} - P_{s(psia)} + P_{g(psia)}\right] * 2.31$$

$$\eta_{Pump} = \frac{WHP}{BHP}$$

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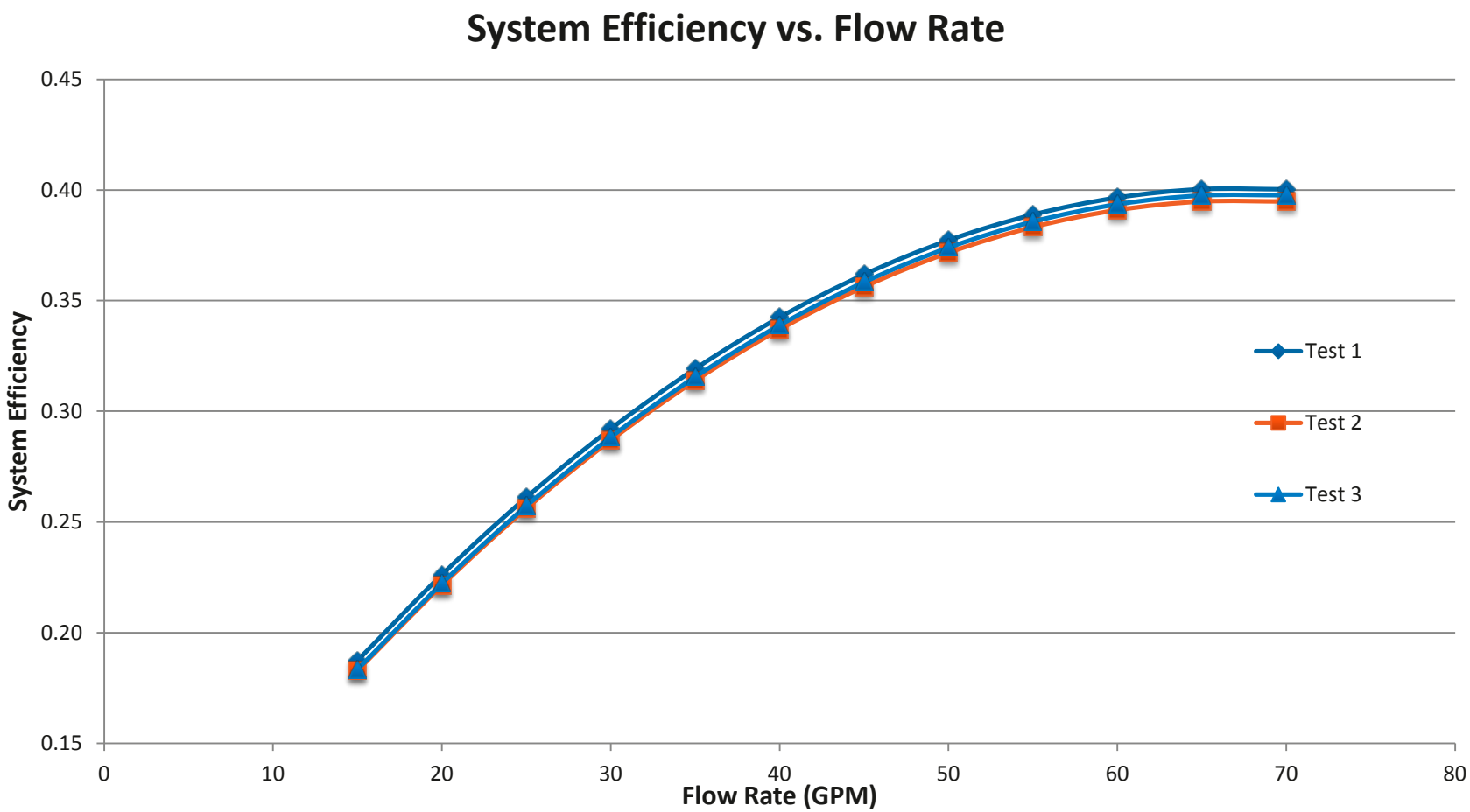
System Efficiency Curve



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Impeller Characterization Results

Average Efficiency	Flow Rate (GPM)											
	15	20	25	30	35	40	45	50	55	60	65	70
Test 1	0.187	0.226	0.261	0.292	0.319	0.342	0.362	0.377	0.389	0.397	0.400	0.400
Test 2	0.183	0.221	0.256	0.287	0.314	0.337	0.356	0.372	0.383	0.391	0.395	0.395
Test 3	0.183	0.222	0.257	0.288	0.315	0.339	0.358	0.374	0.386	0.394	0.398	0.398
Anova-Results	6.91E-05	1.18E-05	4.42E-06	4.44E-06	6.01E-06	1.25E-05	2.17E-05	7.03E-05	2.00E-04	9.00E-04	3.40E-03	1.18E-02

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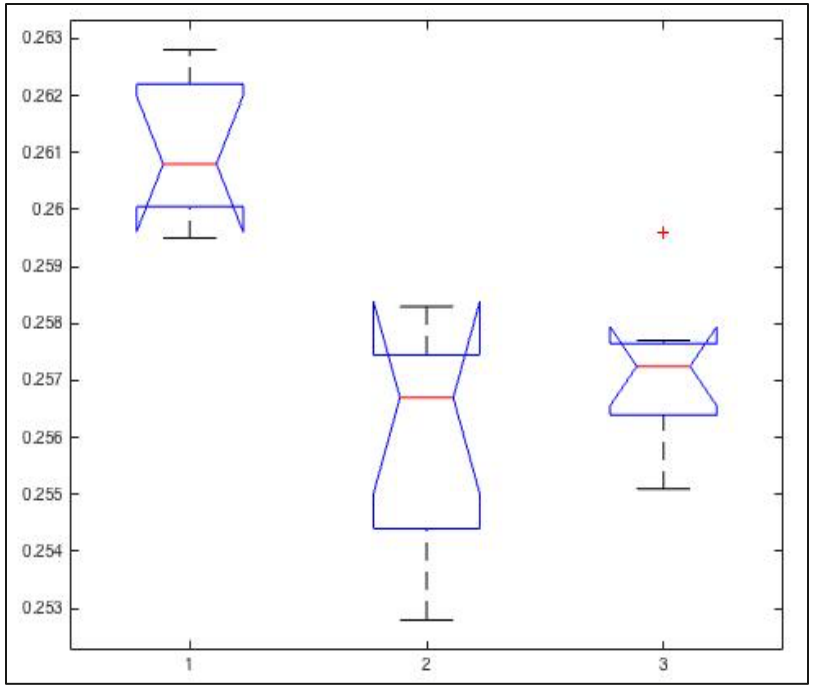
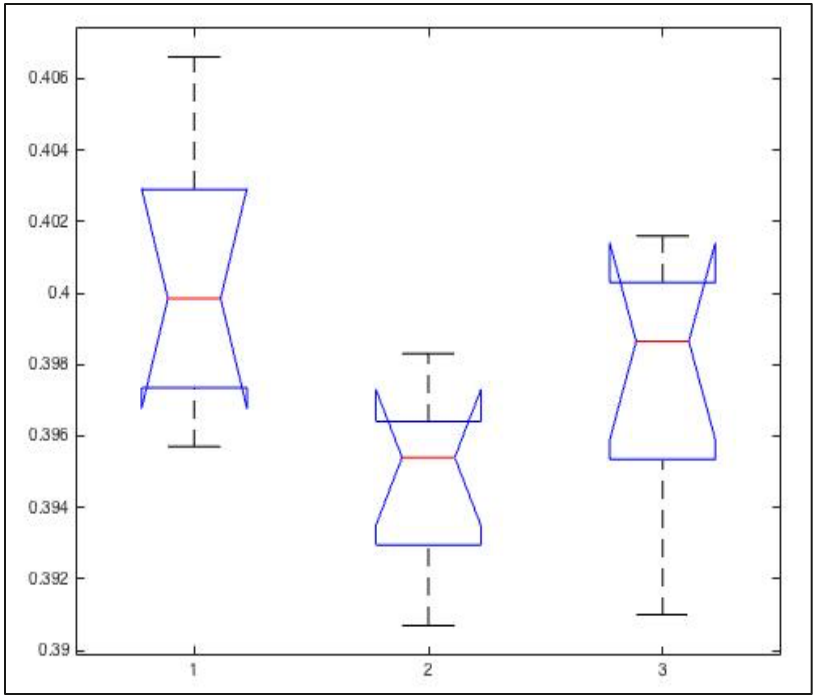
Box and Whisker Plot



25 GPM



75 GPM

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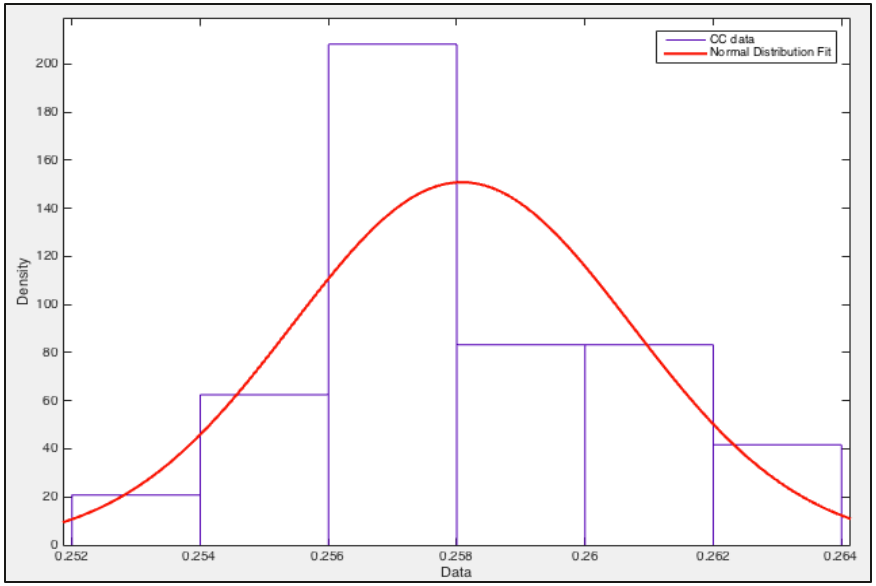
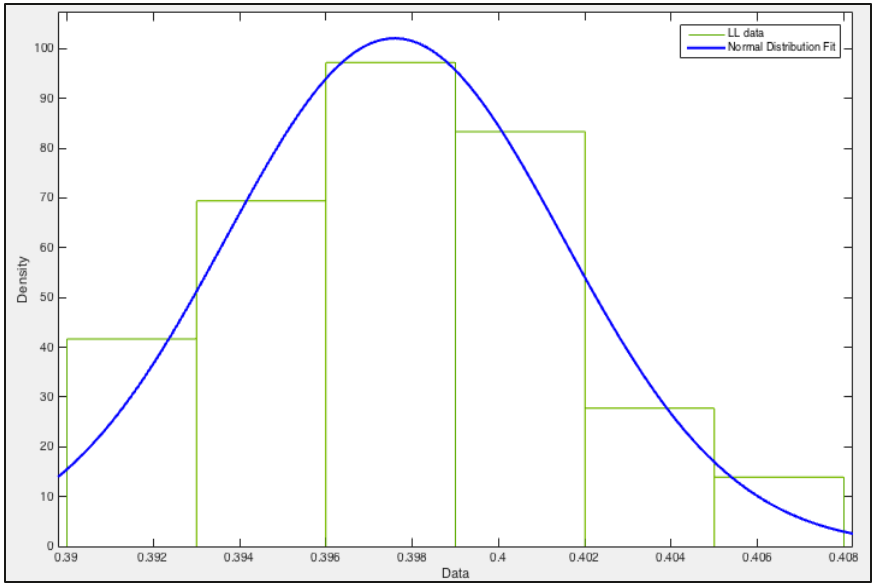
Density Distribution



25 GPM



75 GPM

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Impeller Coatings

Various coatings will be tested and the results compared.

1. NeverWet® Super-hydrophobic Coating
2. Surface treatment recommended by John Simpson @Oak Ridge National Laboratory
3. Fluorinated Alkyl Silane (FAS – 17) treatment recommend by BSU Material Science Faculty

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Neverwet®

- 2-part aerosol coating quickly deteriorated
  - No usable data

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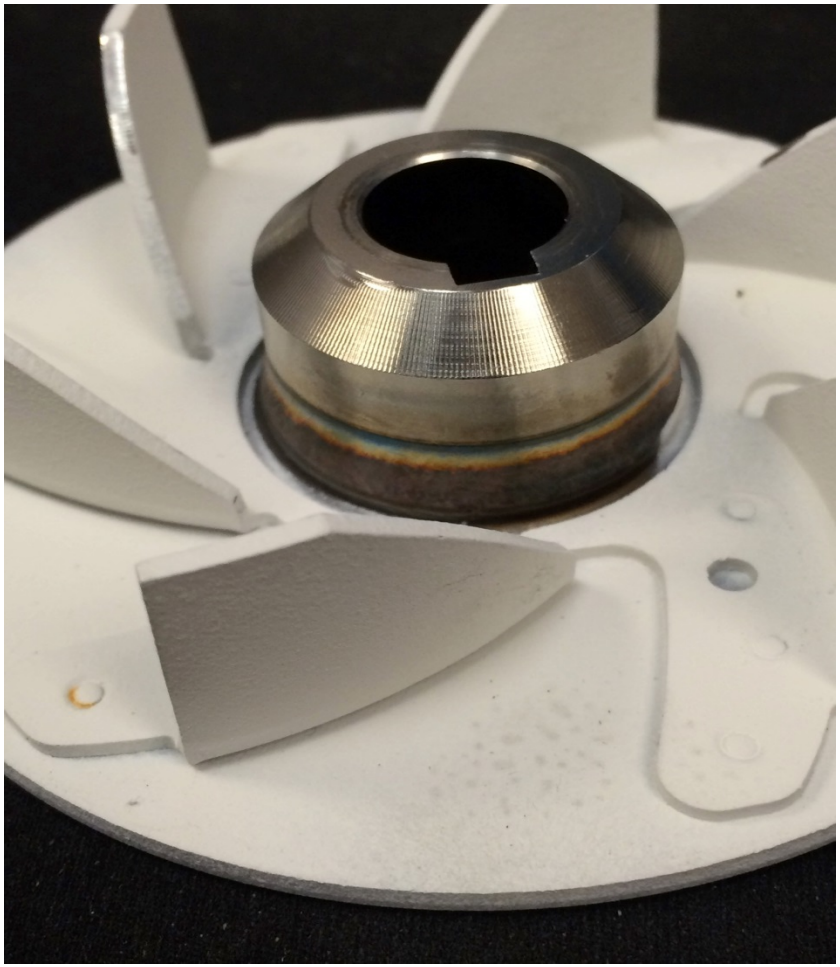
ORNL - John Simpson's Coating

- Paint based coating
  - Failed during testing



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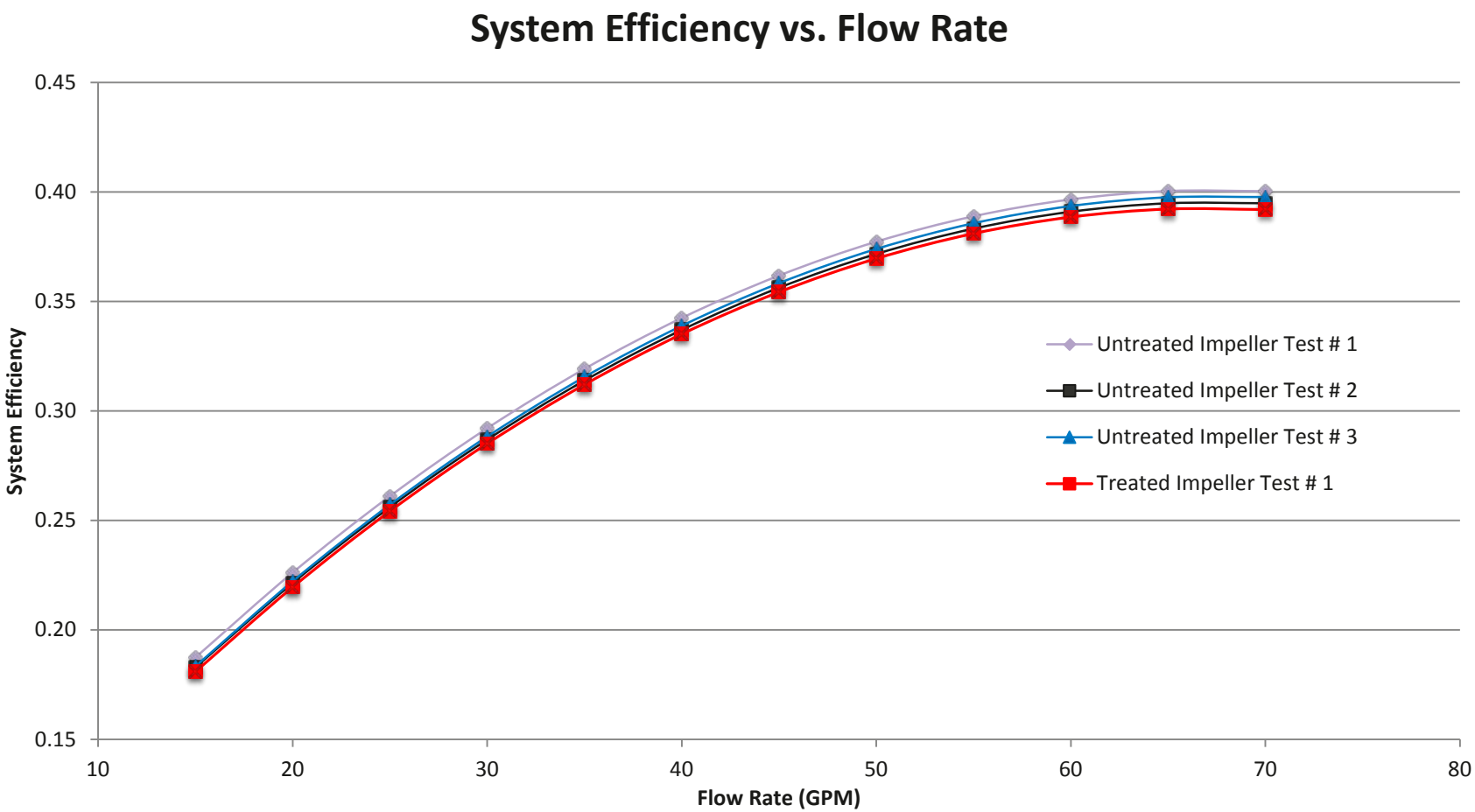
Treated Impeller Data



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Future Plans

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Next Steps

- Remaining research has been turned into an independent graduate student study *(Sean Rosin)*.
- Continue tests with FAS-17 Surface Treatment
- Install VFD on pump/motor to enhance educational opportunities associated with the pump bench.
- Integrate pump bench into Mechanical Engineering Lab curriculum for the 2016 Spring semester.

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Sean Rosin

Email seanrosin@boisestate.edu

THANK YOU

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Q & A…

www.IACForum.org

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Student Registry and Exit Interviews

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- **Lead Student Responsibilities**
  - Ensure all students complete registry entry
  - Ensure all students complete exit interview
  - Ensure that lead/active/inactive status is current
- Exit Interviews
  - Identify new lead students
  - Update contact information for alumni
  - Capture alumni career data

http://www.iacforum.org/

Student Registry and Exit Interviews

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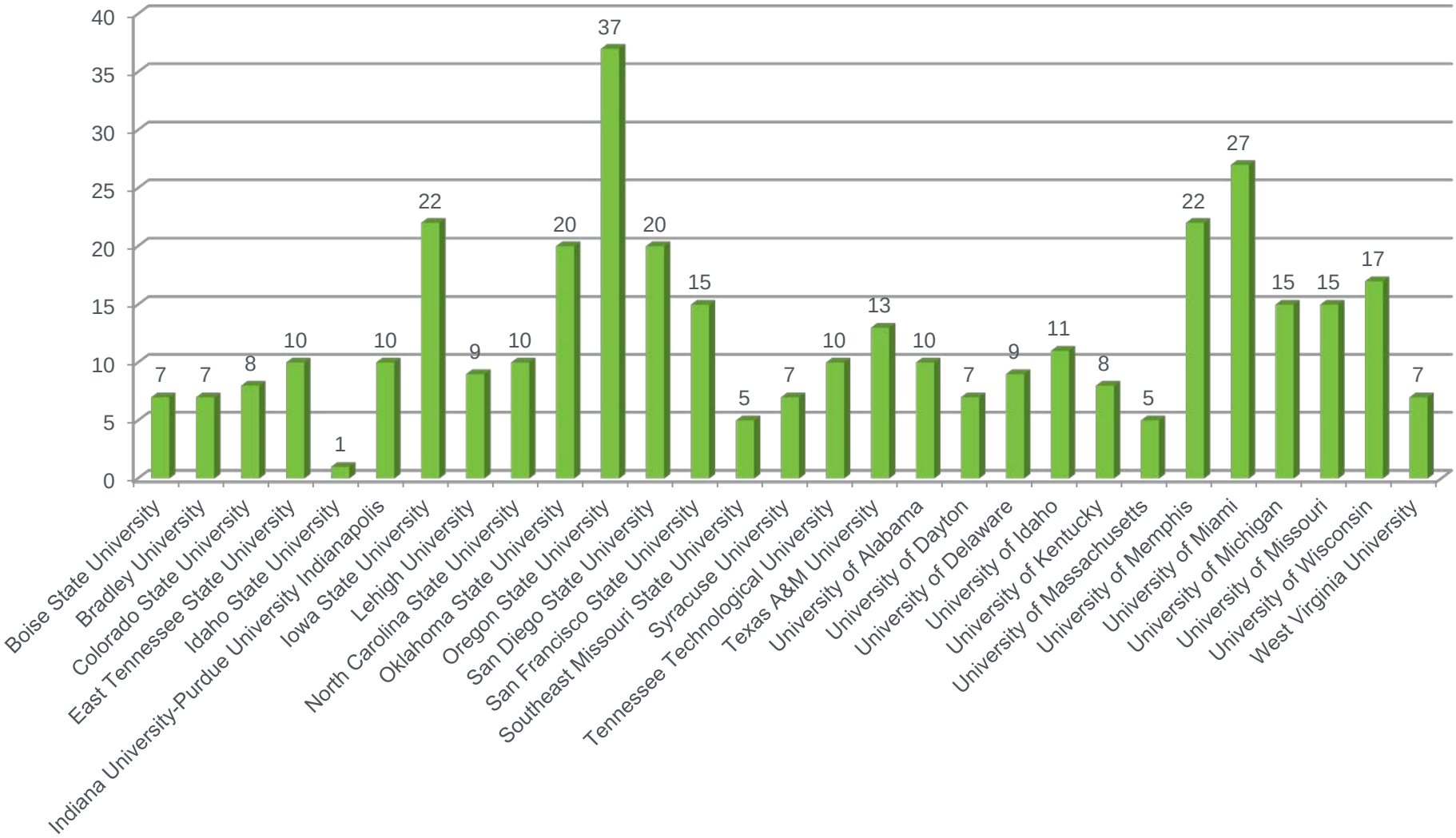
Number of Students Currently Listed as Active in the IAC Student Registry



Student Registry and Exit Interviews

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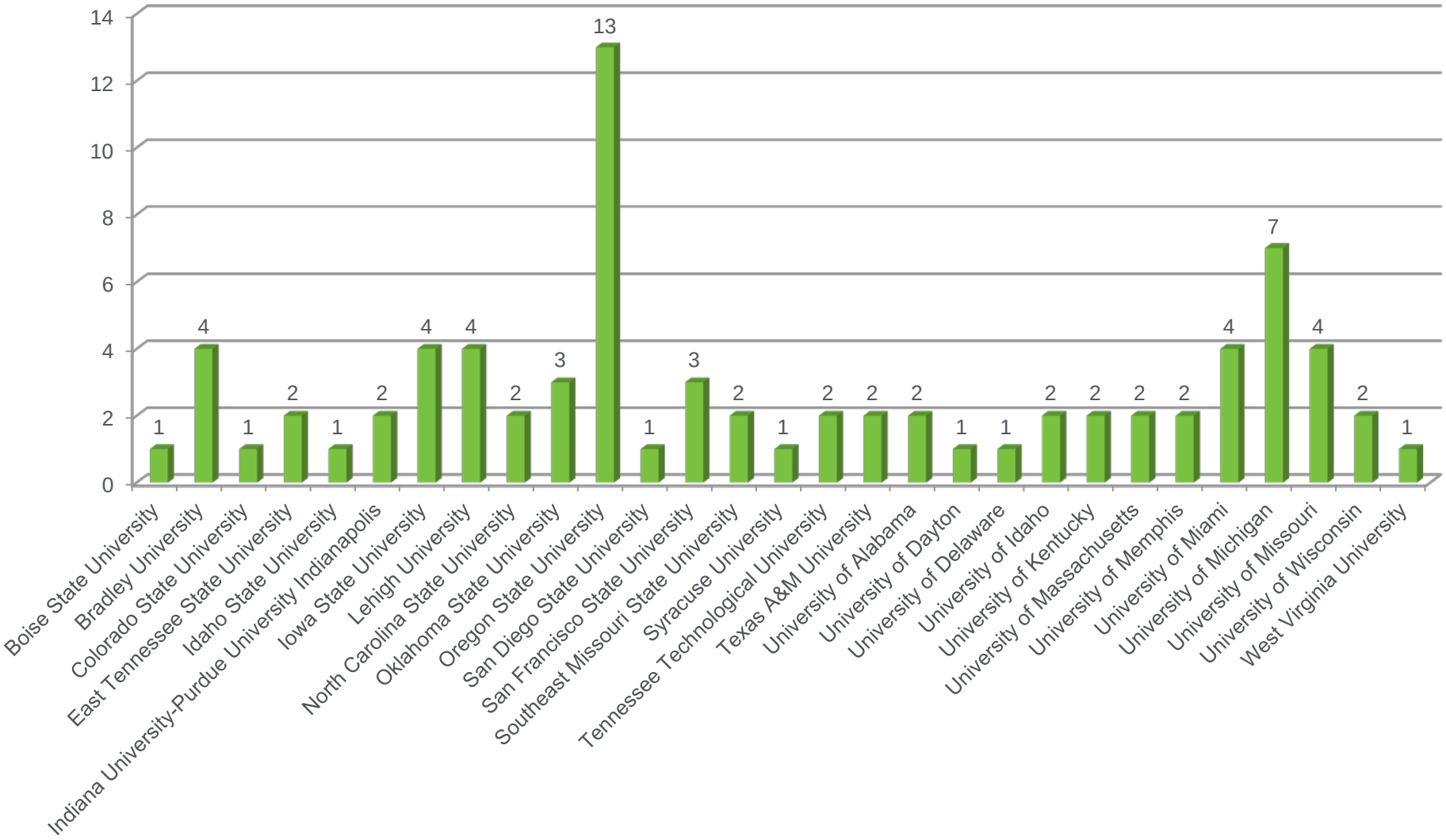
Number of Currently Active Students Listed as "Lead Student"



Student Certificates

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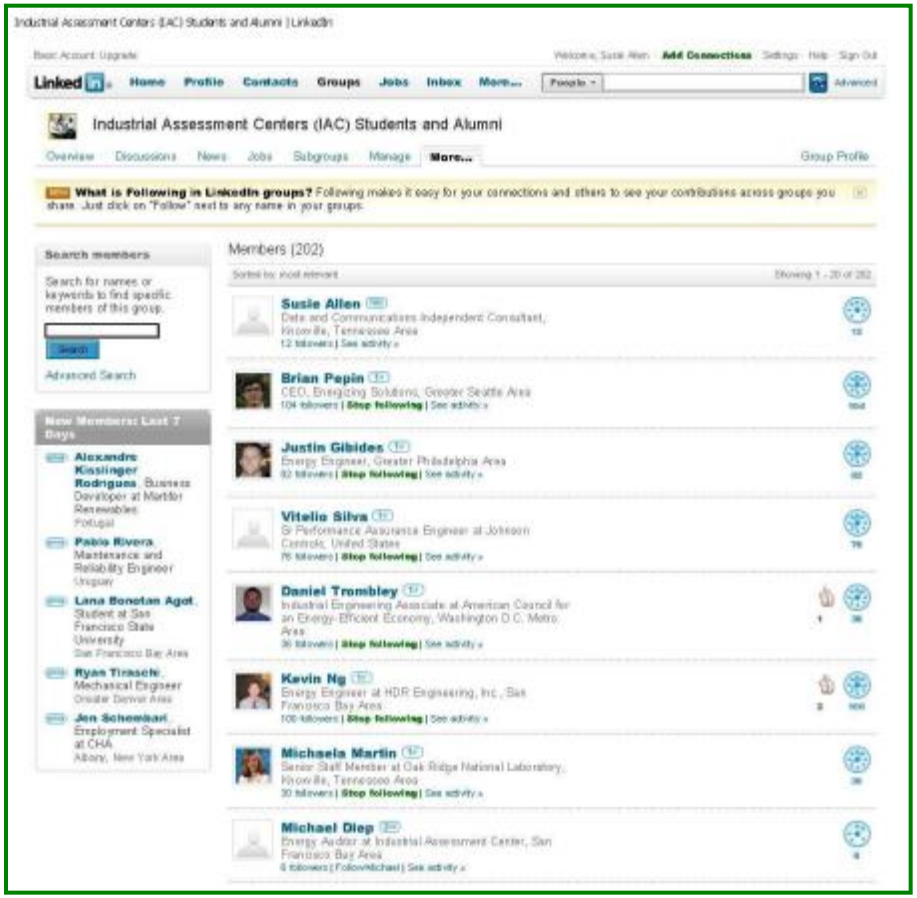
- On-line requests are processed through the certificates link on www.iacforum.org
- **Students and alumni must be in the IAC registry to receive certificates**
- Deadlines occur 3 times per year:
  - October 1, March 1, and July 1
- Certificate process
  - Student initiates request online,
  - Director/AD receives email notification with link
  - He/she completes the request online
  - Certificates arrive
- Certificates <u>are mailed to the Directors</u> within 30 days of deadline
- Applications for the October 2015 round of IAC Certificates have been processed and are expected in centers by the end of this month

Certificate of Participation
presented to
Name
For the completion of requirements mandated by the
U.S. Department of Energy's
Industrial Assessment Center Program at
Texas A & M University

LinkedIn IAC Group

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- Established in 2008
- Professional networking site for IAC students and alumni
- 570+ members
- News items, professional profiles, discussions
- **Please utilize for ongoing collaboration or technical questions**



https://www.linkedin.com/grp/home?gid=912947

NEW Facebook IAC Page & Group

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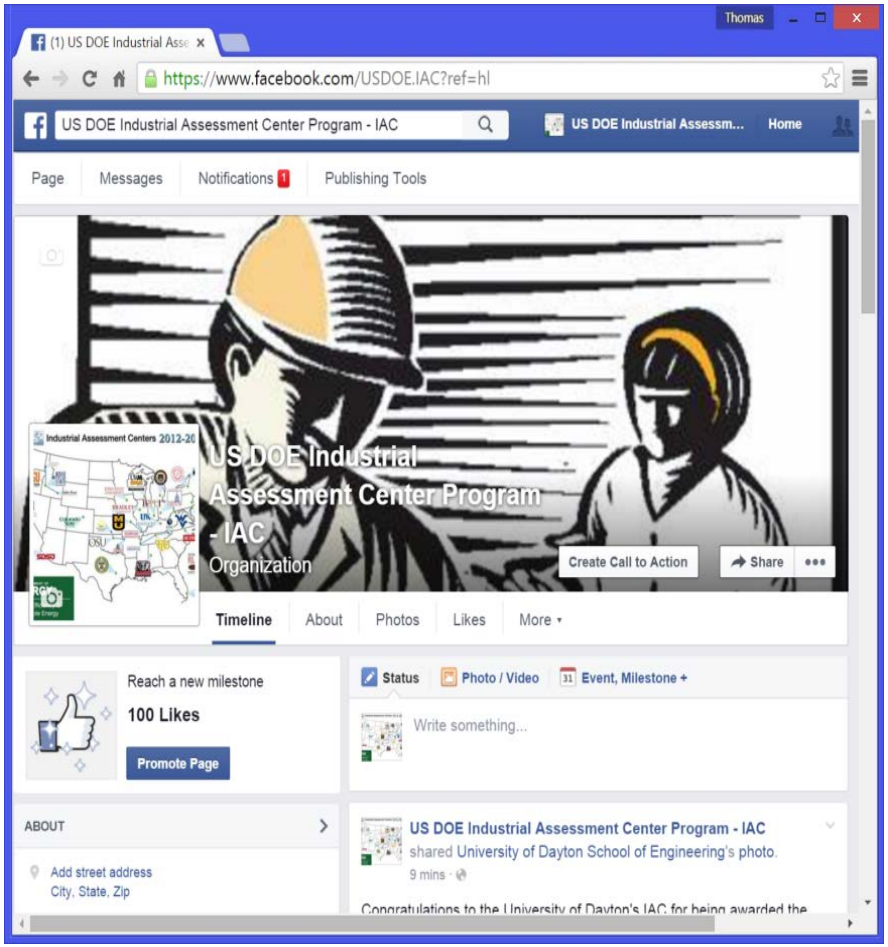

Page - https://www.facebook.com/USDOE.IAC

Group - https://www.facebook.com/groups/543916505784912/

Request: Pictures, Video Clips, Articles & Stories

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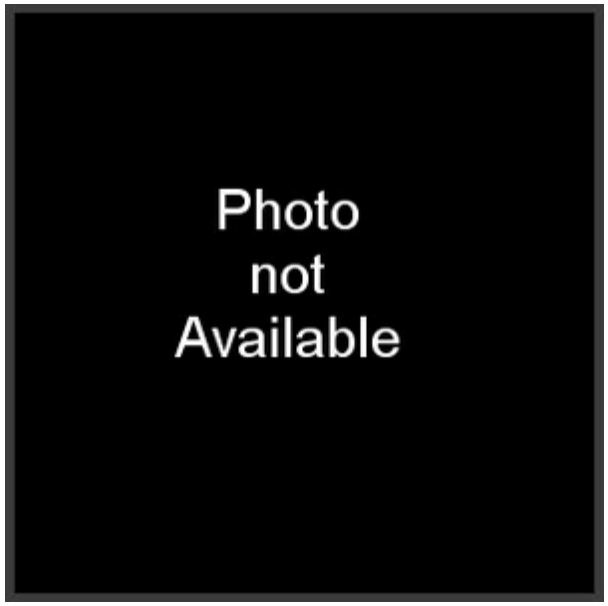

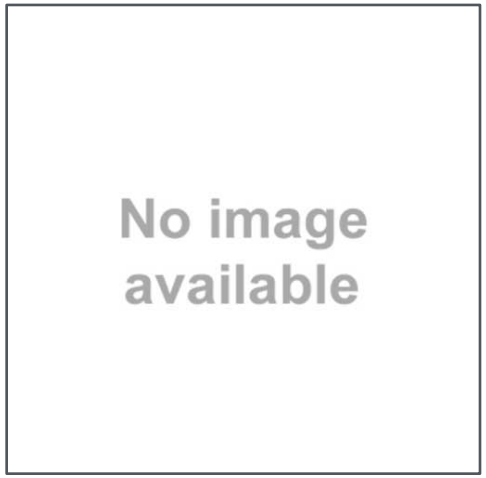

Please send to:
wenningtj@ornl.gov

Thank You!

Thomas Wenning, PE

IAC Student Activities Coordinator

Oak Ridge National Laboratory

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