COVER SHEET FOR GRANT PROPOSALS

State Board of Education

SBOE PROPOSAL NUMBER: (to be assigned by SBOE)	AMOUNT REQUESTED:

TITLE OF PROPOSED PROJECT: Idaho Incubation Fund Program

SPECIFIC PROJECT FOCUS:

This project will design, build and test a system to recycle tritium EXIT signs. The system will include two devices, which will be patentable: the tritium getter geometry and arrangement, and the argon/helium-3 separator. These two devices will be unique. The system will first crush the glass ampules, extract the tritium/ helium-3 mixture, combine that mixture with an argon carrier gas adsorb the tritium on the unique tritium getter, and then condense out the argon in the unique argon condenser leaving the harvestable helium-3. A scaled system will be designed, built, constructed and operated using hydrogen and standard helium at UI. Once it is operational, a larger system will be built and tested by our industrial partner, Alpha Tech, of Salt Lake City Utah using actual tritium EXIT signs. This technology will be applicable to commercial EXIT sign operations, but also applicable to molten salt reactors.

PROJECT START DATE: 01 July 2017	PROJECT END DATE: 30 June 2018
NAME OF INSTITUTION: University of Idaho-Idaho Falls Center	DEPARTMENT: Engineering

ADDRESS: 1776 Science Center Drive, Idaho Falls, Idaho

E-MAIL ADDRESS: rchristensen@uidaho.edu	PHONE NUMBER: 208-533-8102

	NAME:	TITLE:	SIGNATURE:
PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR	Richard N. Christensen, Ph.D	Director of Nuclear Enegineering, UI	Dick Christensen
CO-PRINCIPAL INVESTIGATOR	Vivek Utgikar, Ph.D	Associate Dean of Research, College of Engineering	[signature]

NAME OF PARTNERING COMPANY: Alpha Tech Research Corp.	COMPANY REPRESENTATIVE NAME: Nick Baguley, President

	NAME:	SIGNATURE:
Authorized Organizational Representative		
Director, Office of Sponsored Programs	Deborah N. Shaver	Deborah N. Shaver amB 5-24-17

SUMMARY PROPOSAL BUDGET

Name of Institution: University of Idaho

Name of Project Director: Richard N. Christensen, Ph.D.

A. PERSONNEL COST (Faculty, Staff, Visiting Professors, Post-Doctoral Associates, Graduate/Undergraduate Students, Other)

Name/ Title	Salary/Rate of Pay	Fringe	Dollar Amount Requested
Faculty-R. Christensen	$6,800	$2,100	$8,900
Faculty- V. Utgikar	$2,000	$600	$2,600
Graduate Student	$25,500	$500	$26,000
Undergraduate Student	$10,000	$200	$10,200
% OF TOTAL BUDGET:		**SUBTOTAL:**	47,700

B. EQUIPMENT: (List each item with a cost in excess of $1000.00.)

Item/Description	Dollar Amount Requested
Rolling Mill b.	$3,700
Jar for Rolling Mill	$3,000
Dry Vacuum Pump	$4,300
Cold Trap (flanges, pipe and welding)	$5,100
Zirconium and Cobalt Powder	$2,900
Getter Body Cylinder (flanges, pipe and welding)	$2,300
Miscellaneous pipe, valves and structure	$5,000
SUBTOTAL:	$26,300

C. TRAVEL:

Dates of Travel (from/to)	No. of Persons	Total Days	Transportation	Lodging	Per Diem	Dollar Amount Requested
4 Trips-IF to SLC	4	16	$800		$200	$1,000
					SUBTOTAL:	$1,000

D. Participant Support Costs:

	Dollar Amount Requested
1. Stipends	
2. Other	
SUBTOTAL:	$0

E. Other Direct Costs:	Dollar Amount Requested
1. Materials and Supplies	$0.00
2. Publication Costs/Page Charges	$0.00
3. Consultant Services (Include Travel Expenses)	$0.00
4. Computer Services	$0.00
5. Subcontracts	$0.00
6. Other (specify nature & breakdown if over $1000)	$0.00
SUBTOTAL:	$0.00
F.. Total Costs: (Add subtotals, sections A through E) TOTAL:	$75,000
G.. Amount Requested: TOTAL:	$75,000
Project Director's Signature: Richard W Christensen	Date: 24 May 2017

INSTITUTIONAL AND OTHER SECTOR SUPPORT
(add additional pages as necessary)

A. INSTITUTIONAL / OTHER SECTOR DOLLARS

Source / Description	Amount

B. FACULTY / STAFF POSITIONS

Description

C. CAPITAL EQUIPMENT

Description

D. FACILITIES & INSTRUMENTATION (Description)

1. **Name of Idaho public institution** : University of Idaho
2. **Name of faculty member directing project**: Dr. Richard N. Christensen
3. **Indicate if this technology been proposed and/or been awarded an Incubation Fund**.

   This technology has not been proposed to or awarded an Incubation Fund Award in the past.
4. **Executive Summary:** This project will design, build and test a system to recycle tritium EXIT signs. The system will include two devices, which will be patentable: the tritium getter geometry and arrangement, and the argon/helium-3 separator. These two devices will be unique. The system will first crush the glass ampules, extract the tritium/ helium-3 mixture, combine that mixture with an argon carrier gas adsorb the tritium on the unique tritium getter, and then condense out the argon in the unique argon condenser leaving the harvestable helium-3. A scaled system will be designed, built, constructed and operated using hydrogen and standard helium at UI. Once it is operational, a larger system will be built and tested by our industrial partner, Alpha Tech, of Salt Lake City Utah using actual tritium EXIT signs. This technology will be applicable to commercial EXIT sign operations, but also applicable to molten salt reactors.

5. **"Gap" Project Objective and Total Amount Requested** –The objective of this proposal is to finish the development of an economical method for the recycling of used tritium EXIT signs. Currently, tritium EXIT signs are sent to a disposal facility for an ever-increasing fee. The proposed method of recycling would cut the current disposal cost in half and save the valuable resources of tritium and helium-3. A total amount of $75,000 is requested. Explanation of this amount is shown in the budget, which is contained in **Item 7, Specific Project Plan and Budget.**

6. **Resource Commitments:** The goal of the University of Idaho is to put new knowledge into action and to expand the University of Idaho's intellectual and economic impact. This project will create new IP for the university. As in any project of this nature, the students who work on this project will publish scientific articles, which will enhance the university's status. As we collaborate with our industrial partner, Alpha Tech, scholarly and creative productivity will be enhanced. Dr. Christensen and Dr. Utgikar are committed to mentor the students who will be participating in the research. The University has received two Nuclear Regulatory Fellowships, which we award each year. In addition to the one graduate student paid by this contract, the Nuclear Engineering Program will assign an NRC Fellow to work on the project. The University already has a glove box that will be used in the project, as well as a gas chromatograph. The gas chromatograph will be used to determine product Helium and Tritium purity.

7. **Specific Project Plan and Budget:**

The Market Opportunity: It is estimated that there are over 2 million tritium EXIT signs used in office buildings, theaters, stores, schools, churches and other buildings within the United States [1]. These signs contain small glass vials filled with tritium and lined with a phosphorescing substance. Tritium, which has a half-life of 12.2 years, emits a β-particle (or electron) when it decays, becoming helium-3. The emitted electron from the decay is then absorbed by the phosphorescing substance to emit a green light wave. Thus the emission of the green light, will occur nearly continuously in a 20 Ci sign for approximately 20 years. At this point, 67.5% of the original tritium has decayed into helium-3. With only 32.5% of the tritium remaining, further tritium decays do not happen consistently enough to emit constant light, and the signs need to be disposed of and replaced. Current tritium sign disposal consists of shipping the sign to a disposal company, which then removes the glass vials filled with tritium and helium-3 and sends them to a permanent repository. This process costs $65 for each sign originally purchased from the company, and $85 per sign not purchased from the company. However, these costs have been consistently rising by around 20% per year for the past 5 years, and this rate of increase is assumed to continue indefinitely. **This method of disposal is not an economically viable option for large organizations and is a waste of tritium and helium-3, both of which are in high demand throughout the United States.** An alternative to the disposal of the tritium EXIT signs is to extract the tritium and helium-3 for resale at $30,000/g and $16,500/g, respectively. The remaining glass is disposed of as low-level radioactive waste for $13.16 per pound [2, 3, and 4], which is a lower cost than for the Tritium and He-3 filled glass ampules. Removing the Tritium and Helium-3 for recycling, leaving only the glass and container to be disposed of, reduces the cost of disposal from $65 to $85 to less than $45 per sign because these radioactive isotopes no longer need to be stored as waste. The sale of the amount of recycled tritium and helium per sign, based on the prices quoted above, would yield about $41. Since the disposal of the glass costs less than $45, and since the resale of the constituents generates $41, the net disposal cost is negligible. With this being the case, the cost charged per sign for disposal is profit. If that charge remained in the $60 to $80 range per sign, it would be a very lucrative business. Currently, the Savannah River Site is the only operating tritium recycling plant and the sole provider of helium-3 in the United States [5]. Tritium is a valuable substance in its gaseous form, used for a variety of purposes, including new tritium EXIT signs, rifle sighting scopes, and several research applications. Helium-3 is also a valuable product, used primarily for neutron detection in academic, medical, and commercial applications, as well as border security applications. The commercial demand for tritium exceeds 400 grams/yr., creating a tritium market of approximately $12M per year [6]. Further, the market price of helium-3 is approximately $16,500/g, with a commercial demand of 5200 g/yr. [3, 7]. Thus, the helium-3 market is $78M per year. Therefore, if an inexpensive and simple method were to be commercialized to extract the tritium and helium-3 from the EXIT signs, the revenue stream could offset the cost of disposing of the glass and container. Thus the disposal fee would be profit.

- **The Technology and Path to Commercialization:**

The current process for the disposal of Tritium EXIT signs is explained in the paragraph above. The Canadian Nuclear Safety Commission (CNSC) directed its staff to investigate tritium releases and mitigation tactics in Canada [8]. The resulting study produced a commercial process for reprocessing tritium, and detailed reports on this process are publicly available. These reports include the getter technology used, shielding and ventilation requirements, plant design principles, equipment specifications, and even best practices for handling and processing tritium. This process does not however, recycle the helium-3. Within the United States, the Savannah River Site (SRS), owned by the U.S. Department of Energy and operated by Savannah River Nuclear Solutions, LLC, has developed a tritium recycling plant and is currently the only operating plant in US. [5.] They recycle tritium for the US Nuclear Weapons Program and do not accept tritium from EXIT signs or other sources.

Getter technology or more specifically, tritium getters have been used in industry for many years. A tritium getter is a material, usually a metal that interacts with the tritium or hydrogen and chemically binds it. Research has identified a zirconium / cobalt mixture that will work very well for the proposed project (and is commercially available) [9.].

The proposed technology would separate the tritium from the helium-3 and then recycle (resell) both products. The process would be as follows: The ampules would be separated from the EXIT sign backing and placed in a rolling mill. The mill would contain several medium weight steel rods in addition to the ampules. The mill would be sealed, purged with argon to eliminate all other gases and rotated until all ampules had been broken, releasing the tritium and helium-3 gas into the sealed mill and the argon fill gas. The gases would then be drawn out of the mill using a vacuum pump, combined with additional argon carrier gas, and pumped through two in-line tritium getters [10.]. The tritium getters would be a powdered / sintered Cobalt Zirconium mixture, used to interstitially bind the tritium. To extract the tritium, the getters are heating to 300-400 C. The helium-3 would be separated out of the gas stream using a cold trap and then placed in a transportation cask. The cold trap would use liquid nitrogen as the cold source, which boils at 77.4 K. A proper design of the cold trap heat exchanger will allow the argon to be condensed out of the stream (Argon condenses at 87.3 K), leaving the gaseous Helium-3 to be collected for sale.

The intellectual property (IP) developed for this project will include a mass transfer exchanger, which will allow through-flow to purify the He-3 stream and the exact arrangement of components to allow safe, reliable and efficient separation of tritium and He-3. IP will also include the cold trap design and configuration. The concepts developed for the separation of tritium and He-3 build on technology that is currently part of the open market. For example, rolling mills are commonly used and the Cobalt Zirconium compound is on the open market and not subject to any restrictions. The mass transfer exchanger has been developed without external funding by Richard N. Christensen, as a faculty member of the Nuclear Engineering Program at the Idaho Falls Center of the University of Idaho.

The steps necessary to bring the technology to market include: (a) Perform multiphysics calculations of the flow area and length of flow passage necessary for 99.9% adsorption and or adsorption of tritium. (b) Fabricate two tritium getters. (c) Fabricate the other components and assemble the system. (d) Test the system using hydrogen, nitrogen and He-4. (e) Fabricate the system at Alpha Tech. (e) Test the system using Tritium EXIT signs at Alpha Tech.

- **Commercialization Partners (Public or Private)**

Commercialization Partner: Alpha Tech Research Corp ("Alpha Tech"), Salt Lake City, Utah, Nicholas Baguley, President. Alpha Tech is interested in licensing tritium separations technology from UI and commercializing it as a means of recycling EXIT signs. They are in the process of getting a license to handle radioactive materials, specifically Tritium and Helium-3. Alpha Tech has a team that can dedicate approximately 450 hours over the life of the project. They will develop or partner with a local university to use space for the experimentation/testing on the process using actual Tritium EXIT signs. UI, in collaboration and concurrence with them, will develop the most reasonable process. UI will test the process using Hydrogen and Helium (natural He). Pending final cost estimates and viability, Alpha Tech will then duplicate the system designed by UI and test the process using Tritium EXIT signs.

Task	**Responsible**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**
A. Quarterly Meetings	Rich Christensen												
B. Burn Rate and Project Plans Report	Rich Christensen												
C. End-of-Project Report	Rich Christensen												

D. Calculate flow area and length	Graduate Student												
E. Fabricate tritium getters	Graduate Student												
F. Fabricate other components	Graduate Student												
G. Assemble system	Graduate Student												
H. Test system	Graduate Student												
I. Assemble system at AT	Alpha Tech												
H. Test system at AT	Alpha Tech												

Personnel Responsibilities: In all activities listed, where UI is listed (Rich Christensen or Graduate student), UI will take the lead, with support and consultation from Alpha Tech. Where Alpha Tech is listed in the schedule, Alpha Tech will take the lead and UI will add support and consultation. See schedule below.

Potential Future Activities: This project with tritium EXIT signs is a forerunner of future potential work with tritium produced by molten salt reactors. Molten salt reactors produce an order of magnitude greater amount of tritium that a conventional light water reactor. As such, that tritium must be sequestered. This program will provide a gateway to determining process for sequestering that tritium. Alpha Tech, working in conjunction with a consortium of universities, is pursuing molten salt technology. This is an opportunity for the University of Idaho to become part of that consortium and take advantage of future intellectual property developed by UI as part of the consortium.

Institutional Support: UI and the Idaho Falls Center are committed to this project. The University provides computer and physical facilities that are commensurate with this project.

The university also is making available a student who has received an NRC Fellowship. The project will be supporting one graduate student and the university is supplying one graduate student. Thus, the University is providing support equivalent to that being provided by HERC.

Facilities, Equipment, Expertise: UI Idaho Falls Center has a laboratory that is ideally suited for this project, which contains all utilities necessary, a suitable glove box and a gas chromatograph, which will directly support the project. Dr. Christensen is a recognized expert with patents related to heat and mass transfer. Dr. Utgikar has specific expertise in hydrogen and tritium properties and behavior that will directly support this project.

Budget:

Anticipated Expenditures			
Category	**Salary**	**Fringe**	**Total**
Faulty-R. Christensen	$6,800	$2,100	$8,900
Faculty- V. Utgiker	$2,000	$600	$2,600
Graduate Student	$25,500	$500	$26,000
Undergraduate Student	$10,000	$200	$10,200
Equipment			
Rolling Mill	$3,700		$3,700
Jar for Rolling Mill	$3,000		$3,000
Dry Vacuum Pump	$4,300		$4,300
Cold Trap (flanges, pipe and welding	$5,100		$5,100
Zirconium and Cobalt Powder	$2,900		$2,900
Getter Body Cylinder (flanges, pipe and welding)	$2,300		$2,300
Miscellaneous pipes, valves and structure	$5,000		$5,000
Travel	$1,000		$1,000
4 day trips to Salt Lake City, UT; 4 people, lunch & miles			
Other Expenditures	$0		
Total Direct Costs	$71,600	$3,400	$75,000
Indirect Costs	$0	$0	$0
Total Costs	$71,600	$3,400	$75,000
buyfittingsonline.com/stainless-steel-blind-flange.aspx			
certifiedmtp.com/jar-mill-1-tier-2-jar-capacity			

micronmentals/com/products/zr-105 industrial grade
micronmentals/com/products/co-102-cobalt-metal powder
certifiedmtp.com/grinding-jar-hi[alumina-1-5 gallon

Description of personnel costs:

- Graduate Student will be doing calculations, assembling, and testing the equipment.
- Faculty: Richard N. Christensen will supervise and work with the student to fabricate, assemble, and test the system. Dr. Vivek Utgikar will help mentor the students. Dr. Utgikar has specific expertise in Hydrogen and Tritium migration and mitigation.
- Undergraduate students will help assemble the system.

Description of need for and purpose of equipment for all expenditures over $1,000.

- Rolling Mill- necessary to release tritium and helium from glass ampules
- Vacuum Pump - necessary to retrieve tritium and helium from rolling mill
- Cold Trap - necessary to separate Helium from Argon carrier stream
- Tritium Getter - necessary to capture of tritium from the Argon / Helium stream

D**escription of purpose and destination of proposed travel expenditures**:

Trips to consult with industrial partner. Most interaction will be via internet, but a kickoff meeting will be necessary, as well as a quarterly conference with all participants. University Personnel will make four one-day trips to Salt Lake City, Utah. Expenditures will include mileage and meals. Mileage to Salt Lake from Idaho Falls is 430 miles @ $0.50 per mile is $860. Lunch for four individuals for four trips @$15/meal is $240.

References

[1.] https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/fs-tritium.html

[2.] "Report on Waste Burial Charges, Changes in decommissioning Waste Disposal Costs at Low-Level Waste Burial Facilities." NUREG-1307 Rev. 15, Office of Nuclear Reactor Regulation, United States Nuclear Regulatory Commission, 2002.

[3] S. Willms, “Tritium Supply Considerations”, Los Alamos National Laboratory. 2003, Retrieved 1 August 2010.
[4.] Helium-3 private communication
[5.] “Savannah River Site Tritium Facilities” http://www.srs.gov/general/programs/dp/index.htm, updated 4/2011, extracted 8/11/2016.
[6.] Zerriffi, Hisham (January 1996). “Tritium: The environmental, health, budgetary, and strategic effects of the Department of Energy’s decision to produce tritium”, Institute for Energy and Environmental Research, Retrieved 15 September 2010.
[7.] D. A. Shea, D. Morgan, “The Helium-3 Shortage: Supply, Demand, and Options for Congress”, Congressional Research Service, 2010.
[8.] “Evaluation of Facilities Handling Tritium, Part of the Tritium Studies Project”, INFO-0796, CNSC, ISBN 978-1-100-14916-5, 2010.
[9.] T. Nagasaki, S. Knoishi, H. Katsuta, Y. Naruse, “A Zirconium-Cobalt Compound as the Material for a Reversible Tritium Getter”, Tritium Systems Technical Note, 1985.
[10.] P. J. Nigrey, "An Issue Paper on the Use of Hydrogen Getters in Transportation Packaging", Sandia Report SAND2000-0483, 2000.

Appendices:

1. Facilities and Equipment:

Center for Advanced Energy Studies. A unique feature of the University of Idaho - Idaho Falls campus is its connection to the Center for Advanced Energy Studies (CAES). UI was a founding member of this collaborative initiative that provides for close collaboration with cutting edge researchers in all areas of Nuclear Energy and System Security at the Idaho National Laboratory (INL).

Idaho National Laboratory High Performance Computing Center (HPC). UI researchers can access the High-Performance Computing systems at INL. Several of the Idaho Falls faculty are currently on joint appointments with INL. These systems allow researchers to use advanced modeling techniques with high-performance computing capabilities, which enhance modeling and simulation of complex systems and processes.

Eastern Idaho Technical College (EITC): EITC has several buildings located in Idaho Falls just 20 minutes from the University of Idaho - Idaho Falls Campus. Space is available in a warehouse area of the EITC that has a high bay area. UI has a memorandum of understanding with EITC that allows use of this space. The power has been recently upgraded in the EITC high bay area so that 480, as well as 220, VAC are available. EITC also has available a 3-D printer that will be invaluable in making some of the required parts for the system.

Chemical Laboratory in basement of CHE: A chemistry laboratory is available in Room 204 of the CHE building at University Place in Idaho Falls. The laboratory has a glove box, which will be used to house the system and allow access to the specific pieces of equipment. This hood will also provide proper ventilation of the setup. The other equipment housed in CHE is a gas chromatograph. This will be used to quantify the degree of separation obtained at various points in the process.

Current Funding of PI and Co-PI

PI Richard N. Christensen

1. Avista Energy Conservation. Sept 23, 2016- Sept 22, 2017, $97,000. Avista
2. Steam Ingress in HTGR’s. Oct 1, 2014 – Sept 31, 2017, $800,000 USDOE NEUP (Ohio State University
3. USNRC Fellowship Grant. Oct 1, 2016 – Sept 31, 2019 $400,000.

Co-PI Vivek Utgikar

1. Off-Gas Treatment: Evaluation of Nano-structured Sorbents for Selective Removal of Contaminants. January 1, 2014 – December 31, 2017, $777,437. USDOE, NEUP.
2. University of Idaho Nuclear Engineering Faculty Development Program. September 30, 2015 – Sept 29, 2018, $434,048. USNRC.

2. Biographical Sketches and Individual Support:

Dr. Richard N. Christensen, PI

CONTACT INFORMATION

University of Idaho/Center of Advance Energy Studies 955 University Blvd Idaho Falls ID 83401, Office Phone (208) 533-8102; Cell Phone (208) 398-9275; Email: rchristensen@uidaho.edu

EDUCATION

Ph.D. Mechanical Engineering: Nuclear; Stanford University, 1974
M.S. Mechanical Engineering, Stanford University, 1970
B.S. Physics, Brigham Young University, 1968

RESEARCH AND PROFESSIONAL EXPERIENCE

2015 to Present, Professor, Nuclear Engineering (NE), University of Idaho (UI), Idaho Falls, ID. He upgraded and enhanced the graduate level NE curriculum for the UI at Idaho Falls, ID. He brings to the UI and the Center of Advanced Energy Studies (CAES) a level of leadership experience to support the academic needs and challenges of the nuclear industry. Dr. Christensen linked the needs of the Idaho National Laboratory (INL) NE programs with the UI staff and other universities to support the INL mission. In addition, he interfaces with the CAES core universities to support them in their programs and to provide a path forward for graduate students and for industrially based research opportunities to enhance their educational experience.

1978 to 2015, Professor emeritus and professor of Mechanical Engineering, The Ohio State University, Columbus, OH. Dr. Christensen taught nuclear and mechanical engineering classes for 43 years at the OSU, and generated $12.2 million worth of research. His research spans such diverse areas as Nuclear Thermal-hydraulics, Advanced Reactor Concepts with a focus on Inherently Safe Nuclear Reactors, Thermally Activated Heat Pumps, Waste Heat Recovery, and a variety of fundamental Convective and Condensation Heat Transfer investigations. During his OSU tenure, he obtained 13 patents on a variety of heat transfer and heat exchanger topics. In addition, he wrote 90+ archival publications in the areas of nuclear power and related topics. He has supported the Technical Advisory Group for Emergencies at Licensed Nuclear Facilities, Review of the Department of Energy's Office of Science and Technology sponsored Nuclear Engineering Education Research Program, and the Independent Safety Review of the Gorky District Heating Plant in the USSR. He pioneered the establishment of multi-disciplinary teams for large externally funded research programs with participants and support from universities, large corporations (such as nuclear vendors), utility companies, small businesses, regulatory agencies, and state and federal agencies. His research has led to several "first of its kind" components and numerous patents in the areas of gas-fired absorption heat pump cycles and nuclear power plant cycles
.

1972-1978 Associate Professor, Department of Mechanical Engineering, and Chief Operator and Director, Nuclear Reactor Laboratory, California Polytechnic State University, San Luis Obispo, CADr. Christensen taught undergraduate thermodynamics and heat transfer engineering courses at Cal Poly. He obtained an operating license for and operated the AGN 201 research and teaching reactor.

PUBLICATIONS (2 out of 100+)

1. X. Wu, I.H. Kim, D. Arcilesi, X. Sun, R. Christensen, and P. Sabharwall, "Computer Simulation of Tritium Removal Facility Design," NUTHOS10-1204, The 10th International Topical Meeting on Nuclear Thermal Hydraulics, Operation and Safety (NUTHOS-10), Okinawa, Japan, December 14-18, 2014.
2. X. Wu, D. Arcilesi, X. Sun, R. Christensen, and P. Sabharwall, "Conceptual Design of Tritium Removal Facility for FHRs," *Proceedings of the 16th International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH-16)*, Chicago, IL, pp. 4935-4948, August 30-September 4, 2015.

RECENT PROJECTS (Out of 10 Million in Funding)

1.Sun (PI) and Christensen (co-PI), "Advanced reactors – intermediate heat exchanger (IHX) coupling: Theoretical modeling and experimental validation," University of Idaho, 2012-2015.
2.Sun (PI) and Christensen (co-PI), "Design, testing and modeling of the direct reactor auxiliary cooling system for AHTRs, Battelle Energy Alliance, 2010-2014.
3.Sun (PI) and Christensen (Co-PI), "Compact heat exchanger design and testing for advanced reactors" USDOE, 2014-2017
4.Sun (PI) and Christensen (co-PI), "Design, testing and modeling of the direct reactor auxiliary cooling system for AHTRs, Battelle Energy Alliance, 2010-2014.

PATENTS

1.Double effect air conditioning system, RN Christensen, AC DeVuono, WH Wilkinson, DK Landstrom, US Patent 4,926,659, Yr. 1990
2. Heat transfer apparatus for heat pumps, FB Cook, SE Petty, HC Meacham Jr, RN Christensen, KR McGahey, US Patent 5,067,330, Yr. 1991
3. Header and Tube for Use in a Heat Exchanger, Geppelt; EW. Poore; WH, Christensen; RN, US Patent 5,002,119, Yr. 1991
4. Dispersed Bubble Condensation, Talbert; SG, DeVuono, AC, Christensen, RN, George, II, US Patent 5,097,819, Yr. 1992
5.Heat transfer apparatus, FB Cook, SE Petty, HC Meacham Jr, RN Christensen, KR McGahey, US Patent 5,339,654, Yr. 1994
6. Heat transfer apparatus for heat pumps, FB Cook, SE Petty, HC Meacham Jr, RN Christensen, KR McGahey, US Patent 5,533,362, Yr. 1996
7. Generator for absorption heat pumps, FB Cook, SE Petty, HC Meacham Jr, RN Christensen, KR McGahey, US Patent 5,546,760, Yr. 1996
8. Enhanced fluid-liquid contact, RN Christensen, SE Petty, US Patent 5,636,527, Yr. 1997, US Patent 4,926,659, Yr. 1990
9. Capillary fluted tube mass and heat transfer devices and methods of use, RN Christensen, FB Cook, YT Kang, US Patent 5,617,737, Yr. 1997
10. Perforated fin heat and mass transfer device, RN Christensen, S Garimella, YT Kang, M Garrabrant, US Patent 5,704,417, Yr. 1998
11. Mass and heat transfer devices and methods of use, RN Christensen, MA Garrabrant, RF Stout, US Patent 6,314,752, Yr. 2001
12. Heat engine, RN Christensen, J Cao, ET Henkel, US Patent 7,062,913, Yr. 2000

Dr. Vivek P. Utgikar, P.E, Co-PI
Professor, Department of Chemical and Materials Engineering
Associate Dean of Research and Economic Development, College of Engineering
University of Idaho, Moscow, ID 83844
Phone: 208-885-6970, Fax: 208-885-7462, Email: vutgikar@uidaho.edu

Academic and Professional Credentials

Education and Training

University of Bombay, Mumbai, India; Bachelor of Chemical Engineering; Chemical Engineering; 1983.

University of Bombay, Mumbai, India; Master of Chemical Engineering; Chemical Engineering, 1985.

University of Cincinnati, Cincinnati, Ohio; Ph.D.; Chemical Engineering, 1993.

Post-doctoral Training

University of Cincinnati, Cincinnati, Ohio; Chemical/Environmental Engineering; 08/1993 – 08/1994.

University of Dayton, Dayton, Ohio; Environmental Technology; 08/1994 – 08/1995.

Professional Experience

1. University of Idaho, Moscow, Idaho

08/2015 – present: Associate Dean of Research and Economic Development 09/2014 – 09/2015: Interim Director, Nuclear Engineering Program

07/2014 – present: Professor; 07/2007 – 06/2014: Associate Professor; 07/2001 – 06/2007: Assistant Professor, Department of Chemical and Materials Engineering

Administration and management of research and economic development activities of the College of Engineering; Administration and leadership of the nuclear engineering program; Instruction of chemical/nuclear engineering courses and research. Research interests and areas include energy systems design and analysis with focus on advanced nuclear reactors, spent nuclear fuel treatment, life cycle assessment.

2. National Research Council, National Risk Management Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio

06/1998 – 07/2001: National Research Council Associate

Investigated acid mine drainage remediation using sulfate-reducing bacteria. Specific areas studied included biokinetics, toxicity and inhibition by heavy metals, and metal recovery using biosorption.

3. University of Dayton, Dayton, Ohio

08/1995 – 01/1998: Assistant Professor, Department of Engineering Technology Instruction in pollution control, engineering sciences and fundamental chemistry areas. Curriculum development for baccalaureate program in environmental engineering.

Publications

Chen M, Kim I, Sun X, Christensen RN, Utgikar V, Sabharwall P. 2015. Transient analysis of an FHR coupled to a helium Brayton cycle. *Progress in Nuclear Energy*, 83: 283-293.

Bartel N, Chen M, Utgikar VP, Sun X, Kim I-H, Christensen R, Sabharwall P. 2015. Comparison of compact heat exchangers for application as the intermediate heat exchanger for advanced nuclear reactors. *Annals of Nuclear Energy*, 81: 143-149.

Utgikar VP, Vijayakumar J, Thyagarajan K. 2011. Refinement of Motivity Factor in Comparison of Transportation Fuels. *International Journal of Hydrogen Energy,* 36: 3302-3304.

Wijayasekara D, Manic M, Sabharwall P, Utgikar V. 2011. Optimal Artificial Neural Network Architecture Selection for Performance Prediction of Compact Heat Exchanger – PCHE. *Nucl. Eng. Design*, 24: 2549-2557.

Utgikar V, Sabharwall P, Sun X. 2010. HTGR Process Heat Application – Nuclear Desalination. Paper 244, Proceedings of HTR 2010, Prague, Czech Republic, October 18-20, 2010.

Utgikar VP. 2009. Modeling in multiphase reactor design: solid phase residence time distribution in three-phase sparged reactors. *Industrial and Engineering Chemistry Research*, 48: 7910- 7914.

Lattin WC, Utgikar VP. 2009. Global Warming Potential of the Sulfur-Iodine Process using Life Cycle Assessment Methodology. *International Journal of Hydrogen Energy*, 34: 737-744.

Sabharwall P, Utgikar VP, Gunnerson F. 2009. Effect of mass flow rate on the convective heat transfer coefficient: analysis for constant velocity and constant area cases. *Nuclear Technology*, 166: 197200.

Sabharwall P, Utgikar V, Tokuhiro A, Gunnerson F. 2009. Design of liquid metal phase change heat exchanger for next generation nuclear plant process heat application. *Journal of Nuclear Science and Technology*, 46: 534-544.

Sabharwall P, Utgikar VP, Gunnerson F. 2009. Dimensionless numbers for boiling fluid flow in thermosyphon and heat pipe heat exchangers. *Nuclear Technology,* 167: 325-332.

Synergistic Activities

Off-Gas Treatment Project: Lead Principal Investigator of FY 13 NEUP project on treatment of off gas emissions from aqueous reprocessing operations focusing upon iodine and krypton.

Advanced Reactor-Heat Exchanger Project: Lead Principal Investigator of FY 12 NEUP project on modeling and experimental validation of advanced nuclear reactor-heat exchanger system.

Faculty Development Grant: Lead principal investigator for a three-year U.S. NRC faculty development grant.

Curriculum Development: Examined the needs for environmental engineering education (results presented in the article in the Journal of Environmental Engineering referenced above) and participated in the development of curriculum of the Baccalaureate program in Environmental Engineering at the University of Dayton.

Investigations in learning/teaching: Presented a poster entitled “Development of Positive Attitudes for Effective Teaching and Learning - A Case Study” at the 2000 Annual Meeting of the American Institute of Chemical Engineers (AIChE) held in Los Angeles, CA. The presentation discussed the problems of instruction and techniques used to instill active learning among the students in an undergraduate chemistry laboratory course.

Nick Baguley, President
Alpha Tech Research Corp
801 N. 500 W. Suite 150
Bountiful, Utah 84010

May 17, 2017

Higher Education Research Council (HERC)
650 West State Street, 3rd Floor
Boise, ID 83702

Subject: Letter of Support and Commitment for University of Idaho Tritium EXIT Sign Recycling Proposal

Dear HERC,

Alpha Tech Research Corp. ("Alpha Tech") hereby submits this Letter of Support and Commitment to participate in the University of Idaho's proposal to the Idaho Incubation Fund Program to develop a more economic method of recycling Tritium EXIT signs.

Alpha Tech is partnering with a consortium of Idaho and Utah universities, including the University of Idaho, to research and design new nuclear energy and medical technologies and to build up STEM jobs and industries in these states. Partnering with UI and Professor Richard Christensen on the proposed research and commercialization of a more efficient method of recycling Tritium EXIT signs is independently an important opportunity; however, it will also further develop techniques for tritium sequestration and help serve as an additional step in establishing a partnership with the University of Idaho across a broad scope of nuclear related research and commercialization projects.

Alpha Tech does not currently have a radioactive material license but is in the process of applying for one. The business plan of Alpha Tech involves handling radioactive medical isotopes, so we had already planned to acquire a radioactive material license for that purpose.

Alpha Tech anticipates working with Metro Recycling Group ("Metro") on the project. Metro has existing facilities capable of handling the logistics and security requirements of the project.

Alpha Tech anticipates potentially working with the chemical engineering department at Brigham Young University as a facility to test the processes developed by the University of Idaho with regard to the separation process relative to the Tritium and Helium-3 elements.

Final financial expenses will need to align with Alpha Tech's business plan, but we anticipate supporting the entire commercialization process for the proposed project.

Sincerely,

Nick Baguley
President, Alpha Tech Research Corp.