YEAR END TECHNICAL REPORT
August 29, 2015 to August 28, 2016

Waste and D&D Engineering and Technology Development

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FIU | Applied Research Center
FLORIDA INTERNATIONAL UNIVERSITY

Addendum:

This document represents one (1) of four (4) reports that comprise the Year End Reports for the period of August 29, 2015 to August 28, 2016 prepared by the Applied Research Center at Florida International University for the U.S. Department of Energy Office of Environmental Management (DOE-EM) under Cooperative Agreement No. DE-EM0000598.

The complete set of FIU's Year End Reports for this reporting period includes the following documents:

Project 1: Chemical Process Alternatives for Radioactive Waste
Document number: FIU-ARC-2016-800006470-04b-249

Project 2: Environmental Remediation Science and Technology
Document number: FIU-ARC-2016-800006471-04b-250

Project 3: Waste and D&D Engineering and Technology Development
Document number: FIU-ARC-2016-800006472-04b-238

Project 4: DOE-FIU Science & Technology Workforce Development Initiative
Document number: FIU-ARC-2016-800006473-04b-251

Each document will be submitted to OSTI separately under the respective project title and document number as shown above.

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PROJECT 4 OVERVIEW

The Waste and D&D Engineering and Technology Development Project (Project 4) focuses on delivering solutions under the waste, D&D and IT areas for the DOE Office of Environmental Management. This work is also relevant to D&D activities being carried out at other DOE sites such as Oak Ridge, Savannah River, Hanford, Idaho and Portsmouth and international efforts being conducted by EM-1 with the Nuclear Decommissioning Authority (NDA) in England and the International Atomic Energy Agency (IAEA). This project included the following tasks during the August 29, 2015 to August 28, 2016 period of performance:

Task 1: Waste Information Management System (WIMS)

This task provides direct support to DOE EM for the management, development, and maintenance of a Waste Information Management System (WIMS). WIMS was developed to receive and organize the DOE waste forecast data from across the DOE complex and to automatically generate waste forecast data tables, disposition maps, GIS maps, transportation details, and other custom reports. WIMS is successfully deployed and can be accessed from the web address http://www.emwims.org. The waste forecast information is updated annually. WIMS has been designed to be extremely flexible for future additions and is being enhanced on a regular basis.

Task 2: D&D Support for DOE EM for Technology Innovation, Development, Evaluation and Deployment

This task provides direct support to DOE EM for D&D technology innovation, development, evaluation and deployment. FIU focused on assisting DOE EM in meeting the D&D needs and technical challenges around the DOE complex. FIU concentrated its efforts during FIU Performance Year 6 on working with the Savannah River Site to identify and evaluate innovative technologies in support of the SRS 235-F project. FIU further supported the EM international program and the EM Infrastructure and D&D program by participating in D&D workshops, conferences, and serving as subject matter experts.

Task 3: D&D Knowledge Management Information Tool (KM-IT)

The D&D Knowledge Management Information Tool (KM-IT) is a web-based system developed to maintain and preserve the D&D knowledge base. The system was developed by Florida International University's Applied Research Center (FIU-ARC) with the support of the D&D community, including DOE EM, the former ALARA centers at Hanford and Savannah River, and DOE's Energy Facility Contractors Group (EFCOG). The D&D KM-IT is a D&D community driven system tailored to serve the technical issues faced by the D&D workforce across the DOE Complex. D&D KM-IT can be accessed from web address http://www.dndkm.org.

TASK 1.
DOE'S WASTE INFORMATION MANAGEMENT SYSTEM

TASK 1: EXECUTIVE SUMMARY

For Task 1, FIU has developed a Waste Information Management System (WIMS) to receive and organize the DOE waste forecast data from across the DOE complex and to automatically generate waste forecast data tables, disposition maps, and other displayed reports.

TASK 1: INTRODUCTION

The Applied Research Center (ARC) at Florida International University (FIU) in Miami, Florida, has completed the deployment of a fully operational, web-based forecast system: the Waste Information Management System (WIMS). WIMS is designed to receive and organize the DOE waste forecast data from across the DOE complex and to automatically generate waste forecast data tables, disposition maps, and other displayed reports. This system offers a single information source to allow interested parties to easily visualize, understand, and manage the vast volumes of the various categories of forecasted waste streams in the DOE complex. The successful web deployment of WIMS with waste information from an initial 24 DOE sites occurred in May 2006. Annual waste forecast data updates are added to ensure the long-term viability and value of this system. Individuals may visit the web site at http://www.emwims.org/.

TASK 1: EXPERIMENTAL

The initial requirement from DOE Headquarters was to consolidate waste forecast information from separate DOE sites and build forecast data tables, disposition maps and GIS maps on the web. An integrated system was needed to receive and consolidate waste forecast information from all DOE sites and facilities and to make this information available to all stakeholders and to the public. As there was no off-the-shelf computer application or solution available for creating disposition maps and forecast data, FIU built a DOE complex-wide, high performance, n-tier web-based system for generating waste forecast information, disposition maps, GIS Maps, successor stream relationships, summary information and custom reports based on DOE requirements. This system was built on Microsoft.net framework1.1 and SQL server 2005. Visual Studio 2003, SQL server reporting services, Dream Weaver and Photoshop were also used as development tools to construct the system. Since the initial requirements were met, additional features have been developed and deployed on WIMS.

TASK 1: RESULTS AND DISCUSSION

FIU regularly performed database management, application maintenance, and performance tuning to the online WIMS in order to ensure a consistent high level of database and website performance. New waste forecast and transportation forecast data is imported into WIMS on an annual basis.

The 2016 waste forecast and transportation data was collected, reviewed, and transmitted from DOE to FIU on April 8, 2016. The revised waste forecast data was received as formatted data files and, to incorporate these new files, FIU built a data interface to allow the files to be

received by the WIMS application and import it into SQL Server, the database server where the actual WIMS data is maintained. FIU then modified the WIMS modules (Forecast, Disposition Map, GIS, and Transportation) to incorporate the new data set. FIU completed the data import and deployed it onto the test server for DOE testing and review on May 13, 2016 (completing milestone 2015-P3-M1.1). FIU received feedback from the DOE data review on June 13, 2016, incorporated the recommended revisions, and deployed the new data on the public server on June 14, 2016. The 2016 data set included low-level and mixed low-level radioactive waste forecast data and transportation information supplied by all DOE programs.

The data in WIMS can be viewed by site managers, stakeholders, and interested members of the public. Anyone with internet access may register and use WIMS (http://www.emwims.org).

Figure 1 provides a screenshot of the GIS map displaying the 2016 data update and Figure 2 provides a screenshot of the waste disposition map displaying the 2016 data update.

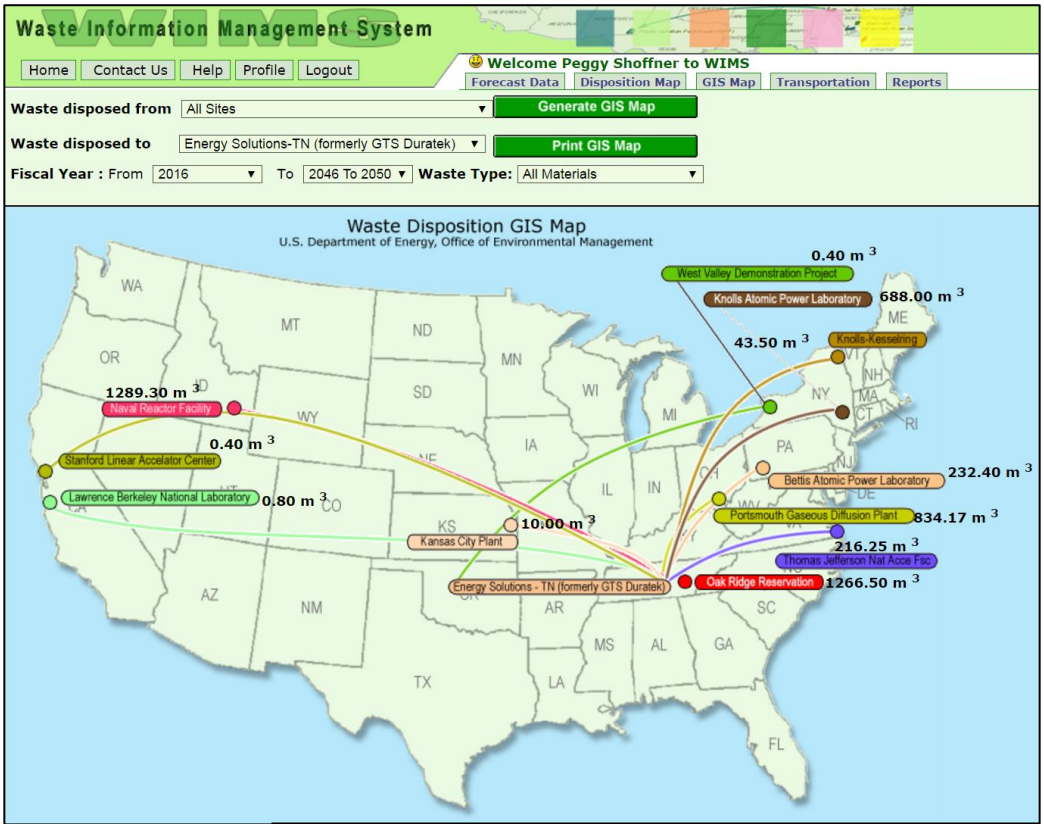


Figure 1. WIMS screenshot displaying new 2016 data set as GIS map.

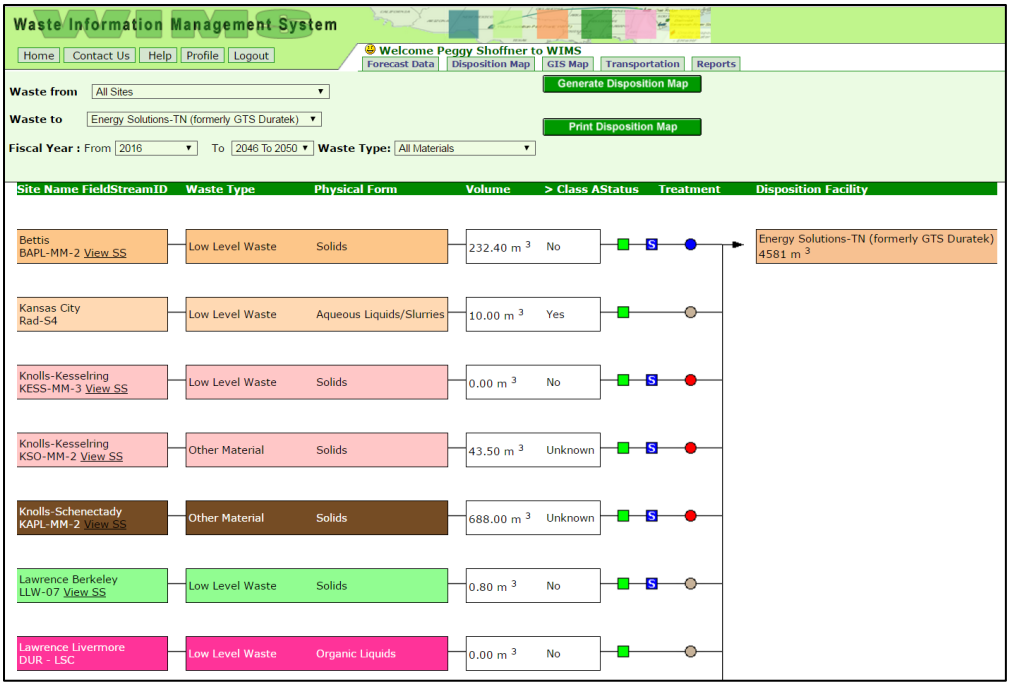


Figure 2. WIMS screenshot displaying new 2016 data as a waste disposition map.

WIMS Picklists for Querying Forecast Data

Upon entrance into WIMS, the information for display as a forecast data table, a disposition map, or a GIS map can be filtered in many ways through the provided drop-down menus. The updated filtration choices for each field of data are shown in the following lists. The fiscal year ranges are adjusted forward one year with each annual data update.

Waste type:

- All Materials
- Unknown
- Low Level Waste
- Mixed Low Level Waste
- 11e.(2) Byproduct Material
- Other Material

Fiscal Year:

- 2016
- 2017
- 2018
- 2019
- 2020
- 2021-2025
- 2026-2030
- 2031-2035
- 2036-2040
- 2041-2045
- 2046-2050

Waste from:

- All Sites
- Ames Laboratory
- Argonne National Laboratory
- Bettis Atomic Power Laboratory
- Brookhaven National Laboratory
- Energy Technology Engineering Center
- Fermi National Accelerator Lab

- Hanford Site – RL
- Hanford Site – RP
- Idaho National Laboratory
- Kansas City Plant
- Knolls Atomic Power Laboratory – Kesselring
- Knolls Atomic Power Laboratory – Schenectady
- Lawrence Berkeley National Lab
- Lawrence Livermore National Lab
- Los Alamos National Laboratory
- Naval Reactor Facility
- Nevada Test Site
- NG Newport News
- Norfolk Naval Shipyard
- Nuclear Fuel Services, Inc.
- Oak Ridge Reservation
- Pacific Northwest National Laboratory
- Paducah Gaseous Diffusion Plant
- Pantex Plant
- Pearl Harbor Naval Shipyard
- Portsmouth Gaseous Diffusion Plant
- Portsmouth Naval Shipyard
- Princeton Plasma Physics Laboratory
- Puget Sound Naval Shipyard
- Sandia National Laboratories – NM
- Savannah River Site
- Separations Process Research Unit
- Stanford Linear Accelerator Center
- Thomas Jefferson National Accelerator Facility
- Waste Isolation Pilot Plant
- West Valley Demonstration Project

Waste to:

- All Facilities
- 200 Area Burial Ground (HANF)
- 746-U Landfill (Paducah)
- Area 5 LLW Disposal Unit (NTS)
- Area 5 MLLW Disposal Cell (NTS)
- Clean Harbors
- Commercial TBD
- E-Area Disposal (SRS)
- EMWMF Disposal Cell (ORR)
- Energy Solutions-Clive (formerly Envirocare)
- Energy Solutions-TN (formerly GTS Duratek)
- ERDF (HANF)
- Impact Services - TN
- INL CERCLA Cell (INL)
- Integrated Disposal Facility (HANF)
- New RH LLW Vaults (INL)
- ORNL Liquid LLW System
- OSWDF (Portsmouth)
- Paducah CERCLA
- Paducah WW Trt
- Perma-Fix Gainesville
- Perma-Fix-Diversified Scientific Services, Inc.
- Perma-Fix-Northwest (formerly PEcoS)
- Perma-Fix-Materials & Energy Corp
- River Metals
- RMW Trenches (MLLW/LLW)(HANF)
- RMW Trenches/IDF (HANF)
- RWMC (LLW disposal) (INL)
- Siemens
- Studsvik/RACE, LLC
- TA 54/Area G (LLW disposal) (LANL)
- To Be Determined
- Waste Control Specialists

Waste Management Conference

FIU also participated in relevant meetings and conferences in support of this project. FIU completed an abstract in August 2015 (milestone 2015-P3-1.2) and a technical paper in November 2015 for WIMS and submitted these to the Waste Management Symposium 2016

(WM16). WM16 accepted the technical paper and a professional poster entitled, *Waste Information Management System with 2015-16 Waste Streams*, was presented during poster session 050A on March 8, 2016. This poster presented WIMS with the 2015 dataset of wastestream and transportation forecast information from the various DOE sites and facilities. FIU also demonstrated WIMS to interested conference attendees at the FIU exhibitor booth during the conference. Figure 3 is a photograph the poster being presented at the conference.

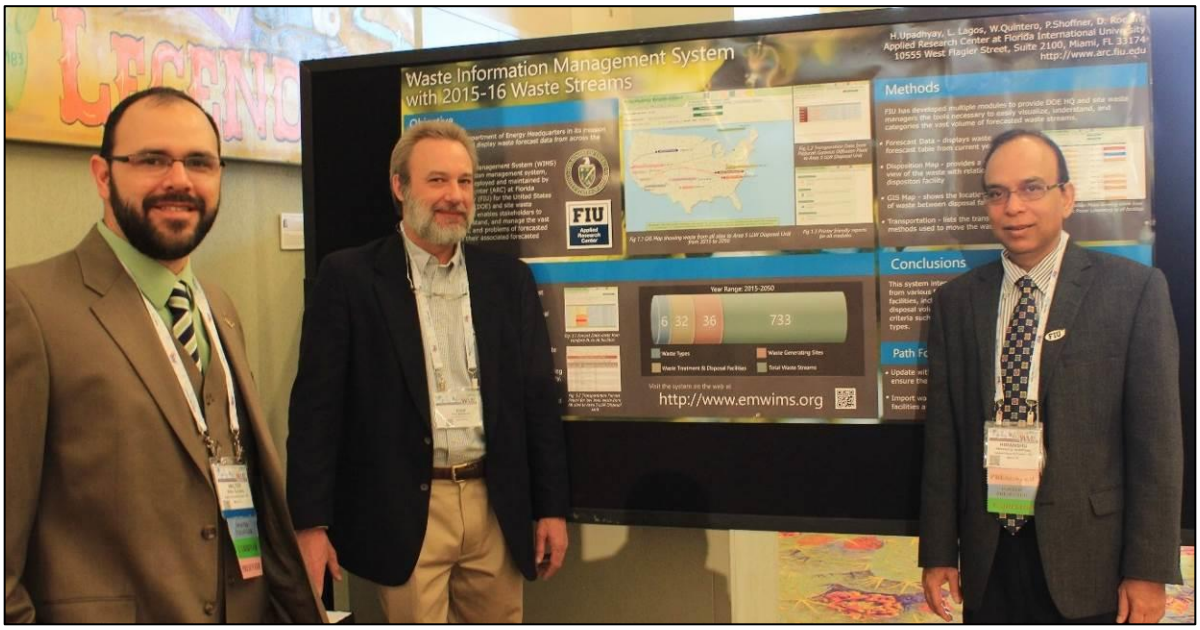


Figure 3. ARC staff Walter Quintero (left) and Himanshu Upadhyay (right) presenting WIMS at Waste Management 2016.

TASK 1: CONCLUSIONS

WIMS continues to successfully accomplish the goals and objectives set forth by DOE for this project. WIMS has replaced the historic process of each DOE site gathering, organizing, and reporting their waste forecast information utilizing different database and display technologies. In addition, WIMS meets DOE's objective to have the complex-wide waste forecast information available to all stakeholders and the public in one easy-to-navigate system. The data includes low-level and mixed low-level radioactive waste forecast data supplied by all DOE programs in addition transportation information.

TASK 1: REFERENCES

Office of Environmental Management (DOE-EM), http://www.em.doe.gov, U.S. Department of Energy.

Waste Information Management System (WIMS), http://www.emwims.org, Applied Research Center, Florida International University.

Upadhyay, H., W. Quintero, P. Shoffner, L. Lagos, *Waste Information Management System with 2015-16 Waste Streams*, Waste Management 2016 Conference, Phoenix, AZ, March 2016.

TASK 2. D&D SUPPORT FOR DOE EM FOR TECHNOLOGY INNOVATION, DEVELOPMENT, EVALUATION AND DEPLOYMENT

TASK 2: EXECUTIVE SUMMARY

This task provides direct support to DOE EM for D&D technology innovation, development, evaluation and deployment. FIU focused on assisting the DOE Office of Infrastructure and D&D (EM-4.11) in meeting the D&D needs and technical challenges around the DOE complex. FIU concentrated its efforts during FIU Performance Year 6 on working with the Savannah River Site to identify and evaluate innovative technologies in support of the SRS 235-F project. FIU further supported the EM International Program and the EM Infrastructure and D&D Program by participating in D&D workshops, conferences, and serving as subject matter experts.

TASK 2: INTRODUCTION

FIU directly supports DOE-EM's Office of D&D and Facility Engineering and affiliated DOE sites, national laboratories, and institutions contributing to the development of innovation in D&D. This task also collaborates with DOE-EM's international partnerships and agreements, when appropriate, by providing D&D expertise, knowledge and support. The technical approach for this task is to identify and demonstrate new technologies, methodologies, and approaches to support the D&D of facilities across the globe. In this report, FIU will present the accomplishments achieved during FIU Performance Year 6 in support of technology innovation, development, evaluation and deployment.

TASK 2: EXPERIMENTAL

For FIU Performance Year 6, FIU performed testing and evaluation of intumescent coatings technologies with the objective of enhancing the stabilization of radioactive contamination under fire and extreme heat conditions; completed development of a fixative module to better guide end users on the selection of appropriate strippable and fixative coatings based on their specific site needs; closed out the fogging research and evaluation effort in collaboration with INL; worked with ASTM International E10 Committee on Nuclear Technologies and Applications to begin development of testing protocols and performance metrics for testing and evaluating D&D technologies; and performed a search for robotic technologies with possible application to the area of D&D. FIU also participated in workshops and conferences and served as subject matter experts.

TASK 2: RESULTS AND DISCUSSION

Incombustible Fixatives

The main objective for the research under this task is to enhance the stabilization of radioactive contamination when a facility is subjected to a fire or extreme heat conditions. During FIU Performance Year 5, FIU completed the baseline testing to evaluate selected fixatives, strippable coatings, and decontamination gels for incombustibility characteristics. The results indicated that most fixatives begin to see degradation between 200-400ºF, at which time radioisotopes could

potentially be released into the environment. In close communication and collaboration with SRNL, FIU researched fire resiliency products being used by other agencies and industries for possible application to DOE's facilities and identified intumescent coatings as a possible solution. Since 9/11/2001, there have been significant improvements in fire retardant/fire resistant technologies, with intumescent coatings being at the forefront of this development. Intumescent coatings develop a thick char to insulate the substrate and protect it from fire and extreme heat conditions. Applying that technology to fixatives through layering and combining should increase its fire resiliency and mitigate the risk of contamination under those extreme conditions.

During FIU Performance Year 6, FIU completed Phase I of the proof-of-principle series of tests (milestone 2015-P3-M2.1) which were designed to expose a selection of fixatives, strippable coatings, and decontamination gels alongside fixatives layered with an intumescent coating to a direct flame source (Figures 4 and 5). At the conclusion of Phase I, the initial results were promising. All of the fixatives-only test coupons that were exposed to the direct flame began to display significant degradation in less than two minutes, with some of the fixatives actually igniting and becoming flammable upon contact with a direct flame source. However, the fixatives that were layered with an intumescent coating developed a thick insulating char as designed, thereby protecting both the fixative and substrate for upwards of 35 minutes from the direct flame. Most promising was the discovery that in most instances, the fixative under the intumescent coating was relatively intact with no noticeable signs of degradation. There was sufficient data to support further testing and the proof-of-concept that the fire resiliency of fixatives used in D&D activities can be significantly enhanced by layering with an intumescent coating, thereby mitigating any potential release of radioisotopes during fire or extreme heat conditions.

Figure 4. Wood only (left), wood with a leading industry fixative (middle), wood with a leading industry fixative layered with an intumescent coating (right). At the 2-minute mark, both the left and middle panels began to show significant degradation and burn through while the right panel began to develop a thickening char from the expanding intumescent coating.

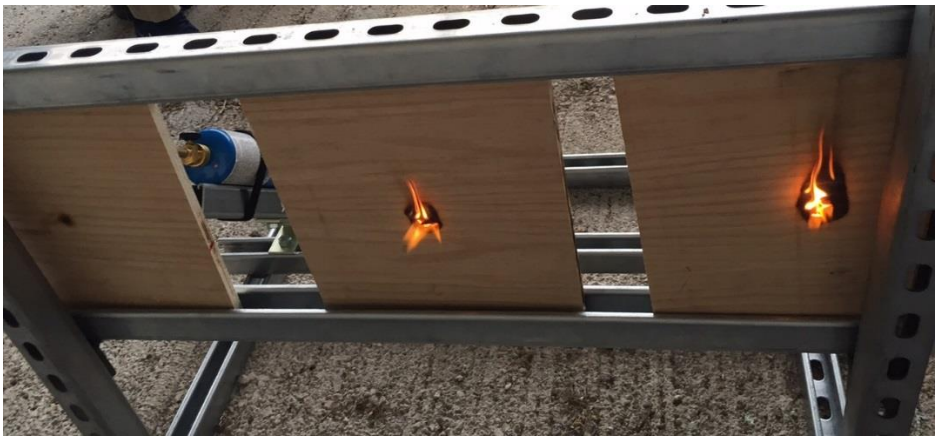


Figure 5. At 5-minute mark, both the left and middle panels displayed serious degradation and burn through while the right panel with an intumescent coating remained largely intact.

Due to results from the Phase I proof-of-principle series of tests, there was sufficient data to support the hypothesis that fire resiliency of fixatives used in D&D activities can be enhanced by layering them with an intumescent coating, and therefore preparations began for Phase II testing. Phase II, which began in December 2015, included conducting controlled tests on uncontaminated coupons using different substrates by incrementally increasing the temperature in a muffle furnace. Similar to Phase I, FIU applied each of the 5 fixatives to coupons in accordance with the manufacturer's directions (fixative-only coupons), and also applied the various fixatives plus a layer of intumescent coating to a second series of coupons (fixatives plus intumescent coating). Coupons included 4" x 4" red oak and sheet metal in order to facilitate placement in the muffle furnace. The same application and curing procedures as in Phase I was followed.

FIU subjected the coupons to incrementally increasing temperatures (100°F, 200°F, 300°F, etc.) in a muffle furnace for 2 hours at each temperature, allowed the coupons to cool for 1 hour, and then recorded the effect of the heat on the fixative. Effects observed and recorded include the amount of weight lost, thickness degradation, and a visual inspection for evidence of failure, including peeling, cracking, blistering, abnormal discoloration, or loss of adhesion. The intent was to determine at what temperature each of the designated fixatives begin to breakdown and display negative effects that could degrade its intended purpose, specifically fixing radioactive contaminants. Once the temperature threshold was reached for a particular coupon, the incremental heating process ceased for that sample and the results were recorded.

Results for the fixatives baselined demonstrated significant degradation at temperature ranges between 250-300°F within five minutes of exposure. During this phase of testing, FIU used a product called GloGerm to simulate a radioactive contaminant. GloGerm is useful to track potential migration of particles on the coupon and in the fixative during degradation. When exposed to a black light, the GloGerm glows.

Figure 6 shows a sheet metal coupon to which the GloGerm gel was applied followed by the application of an industry fixative to the manufacturer's recommended thickness. Once allowed to cure, the coupon was placed in a muffle furnace and exposed to heat. At 250°F, the fixative began to melt and flow into the petri dish, carrying along with the simulated contaminant.

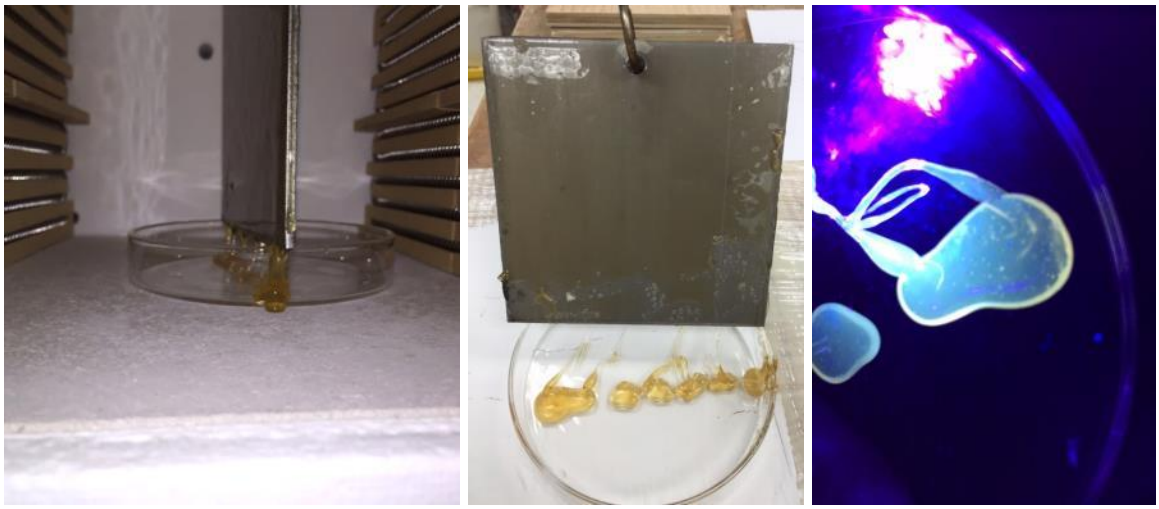


Figure 6. Sheet metal coupon placed in muffle furnace (left), fixative flowed from metal coupon into petri dish with exposure to heat at 250° F (middle); GloGerm transported from coupon to petri dish fluorescing under black light.

Similarly, Figure 7 shows a coupon where GloGerm gel was applied to a red oak substrate and then layered with an industry fixative to the recommended thickness. Note there is initially no contamination in the petri dish. At approximately 200°F, as the fixative expanded, so did the GloGerm. At 250-300°F, the fixative began to melt and flow into the petri dish along with the simulated contaminant.

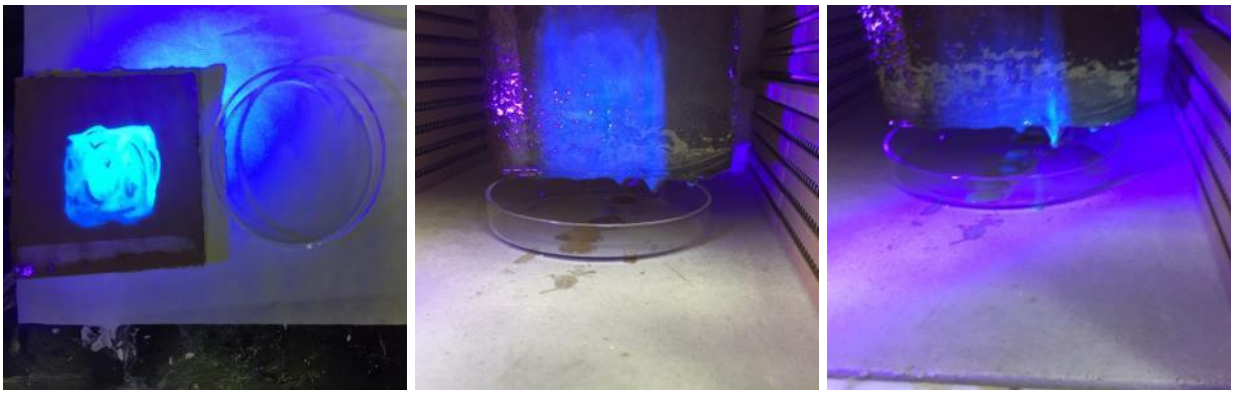


Figure 7. Red oak coupon and clean petri dish (left), fixative began to flow from coupon into petri dish with exposure to heat at 250° F (middle and right).

The next step for the Phase II testing was adding a layer of an intumescent coating on top of the fixative to determine the increase in the resiliency of the fixatives when exposed to heat. Initial attempts at layering the intumescent coating presented challenges with small fissures and cracks developing in the intumescent coating during the curing process. During preliminary tests, the fixative began to flow through these cracks and fissures in the intumescent coating once exposed to temperatures between 400 and 500°F (Figure 8).

Figure 8. Fixative with GloGerm flowing through fissure in intumescent coating when exposed to heat at 400-500° F (left); image of petri dish showing fluorescing GloGerm.

The results of exposing Fixative A to increased temperatures are shown in Figure 9. After exposure to 400°F, the fixative exhibited discoloration, expansion, and minor mass loss. After exposure to 600°F, the fixative exhibited additional discoloration, bubbling, continued expansion, off gassing, desiccation and increased mass loss. After exposure to 800°F, significant mass loss, extreme discoloration, desiccation, cracking, and flaking were evident; even slight abrasion with the fixative resulted in total loss of adhesion.

Figure 9. From left: Fixative A after exposure to 400°F, 600°F, and 800°F.

The results of exposing Fixative B to increased temperatures are shown in Figure 10. After exposure to 200°F, the fixative exhibited slight discoloration, expansion, and minor mass loss. After exposure to 400°F, the fixative exhibited additional discoloration, bubbling, continued expansion, off gassing, and increased mass loss. After exposure to 500°F, significant discoloration, continued expansion, off gassing, additional mass loss, desiccation, cracking, and brittle composition were evident. After exposure to 800°F, extreme discoloration, significant mass loss, desiccation, cracking and flaking were evident; even slight abrasion with the fixative resulted in total loss of adhesion.

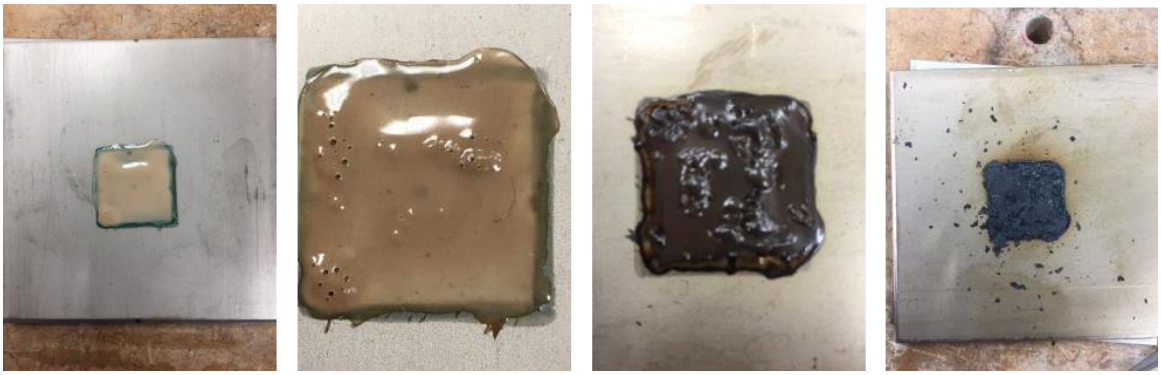


Figure 10. From left: Fixative B after exposure to 200°F, 400°F, 600°F, and 800°F.

The results of exposing Fixative C to increased temperatures are shown in Figure 11. After exposure to 200°F, the fixative exhibited slight discoloration, bubbling, expansion, off gassing and minor mass loss. After exposure to 500°F, the fixative exhibited significant discoloration, continued expansion, off gassing, increased mass loss, desiccation, cracking, and brittle composition. After exposure to 800°F, extreme discoloration, significant mass loss, desiccation, cracking and flaking were evident; even slight abrasion with the fixative resulted in total loss of adhesion.

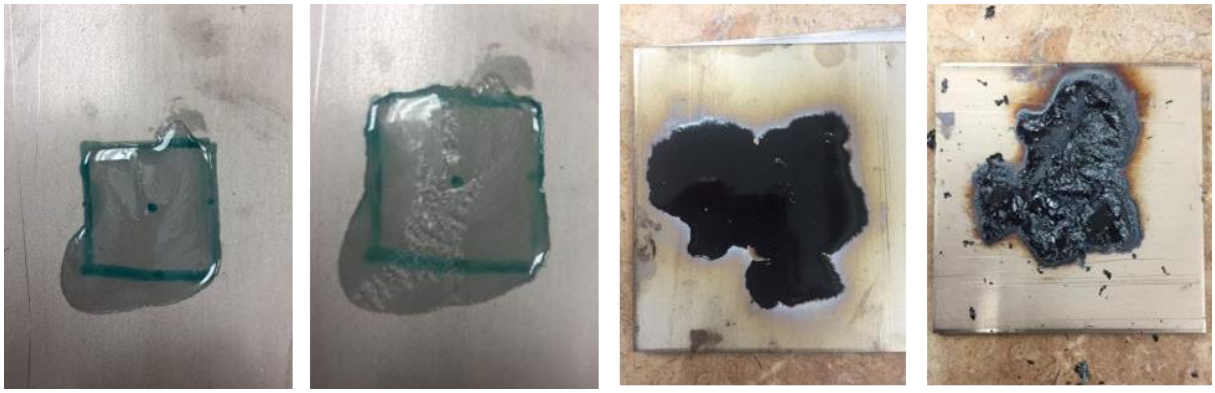


Figure 11. From left: Fixative C before exposure and after exposure to 200°F, 500°F, and 800°F.

The results of exposing Fixative D to increased temperatures are shown in Figure 12. After exposure to 500°F, the fixative exhibited slight discoloration, bubbling, expansion, off gassing, and mass loss. After exposure to 700°F, the fixative exhibited significant discoloration, continued expansion, off gassing, increased mass loss, desiccation, cracking, and brittle composition. After exposure to 800°F, extreme discoloration, significant mass loss, desiccation, cracking and flaking were evident; even slight abrasion with the fixative resulted in total loss of adhesion.

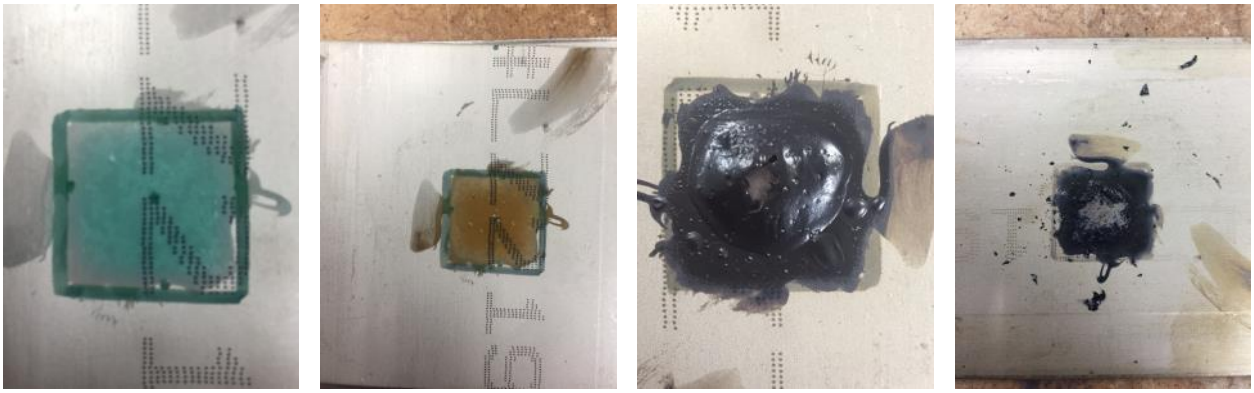


Figure 12. From left: Fixative D before exposure and after exposure to 500°F, 700°F, and 800°F.

The results of exposing Fixative E to increased temperatures are shown in Figure 13. After exposure to 500°F, the fixative exhibited slight discoloration, off gassing, and mass loss. After exposure to 700°F, the fixative exhibited significant discoloration, continued expansion, off gassing, increased mass loss, desiccation, cracking, and brittle composition. After exposure to 800°F, extreme discoloration, significant mass loss, desiccation, cracking and flaking were evident; even slight abrasion with the fixative resulted in total loss of adhesion.

Figure 13. From left: Fixative E before exposure and after exposure to 500°F, 700°F, and 800°F.

After discussion with the SRNL collaborators, FIU also performed additional proof-of-principle testing in January 2016. The concept discussed and subsequently tested was the potential for an intumescent coating on the exterior of a surface to provide thermal protection for a fixative on the interior of a surface, given the increased probability of a fire starting outside the hot cell area.

FIU prepared and tested three (3) steel coupons (4” x 4” and ¼” thick), as follows:

- A steel coupon with a fixative applied to both sides was exposed to a direct flame 3 to 4” away on one side. The fixative on the side exposed to the flame proved flammable and actively burned. The fixative on the back side not exposed to the flame completely bubbled and burst due to the heat transfer and off-gassing.
- A steel coupon was prepared with a fixative and a layer of intumescent coating on both sides. The coupon was then exposed to a direct flame, ~3-4 inches away. Charring occurred on the side exposed to the direct flame and the underlying fixative remained intact. Furthermore, the back side did not exhibit any signs of off-gassing or damage. When using the intumescent coating layer, temperature differences between 150° and

300° F were observed between the front of the coupon exposed to the direct flame and the back of the coupon. By producing an immediate char when exposed to flame, the intumescent coating instantly creates a thermal barrier, providing a protective layer to the fixative and substrate beneath.

- A steel coupon was prepared with a 1-cm strip of fixative down the center and edged by an intumescent coating on two sides. Two propane torches were set at both outer edges (~1¾") from the center line. Immediate charring occurred at both outer edges of the steel coupon and appeared to prevent heat transfer to the exposed fixative for upwards of 5 minutes (Figure 14).

Similar testing was then performed using sheetrock substrates and yielded the same general observational results.

Figure 14. Charred intumescent coating provided thermal protection to bordering fixative.

FIU performed data analysis on the results of the Phase II testing performed, including controlled tests on uncontaminated coupons using different substrates, five commercially available fixatives, and a commercially available intumescent coating. All fixatives began to exhibit minor mass loss starting at temperatures as low as 200°F, but most significant degradation appeared to occur between 600°F and 800°F (Figure 15). The fixatives lost anywhere from 50% to upwards of 90% mass when exposed to incremental temperature increases (200-800°F).

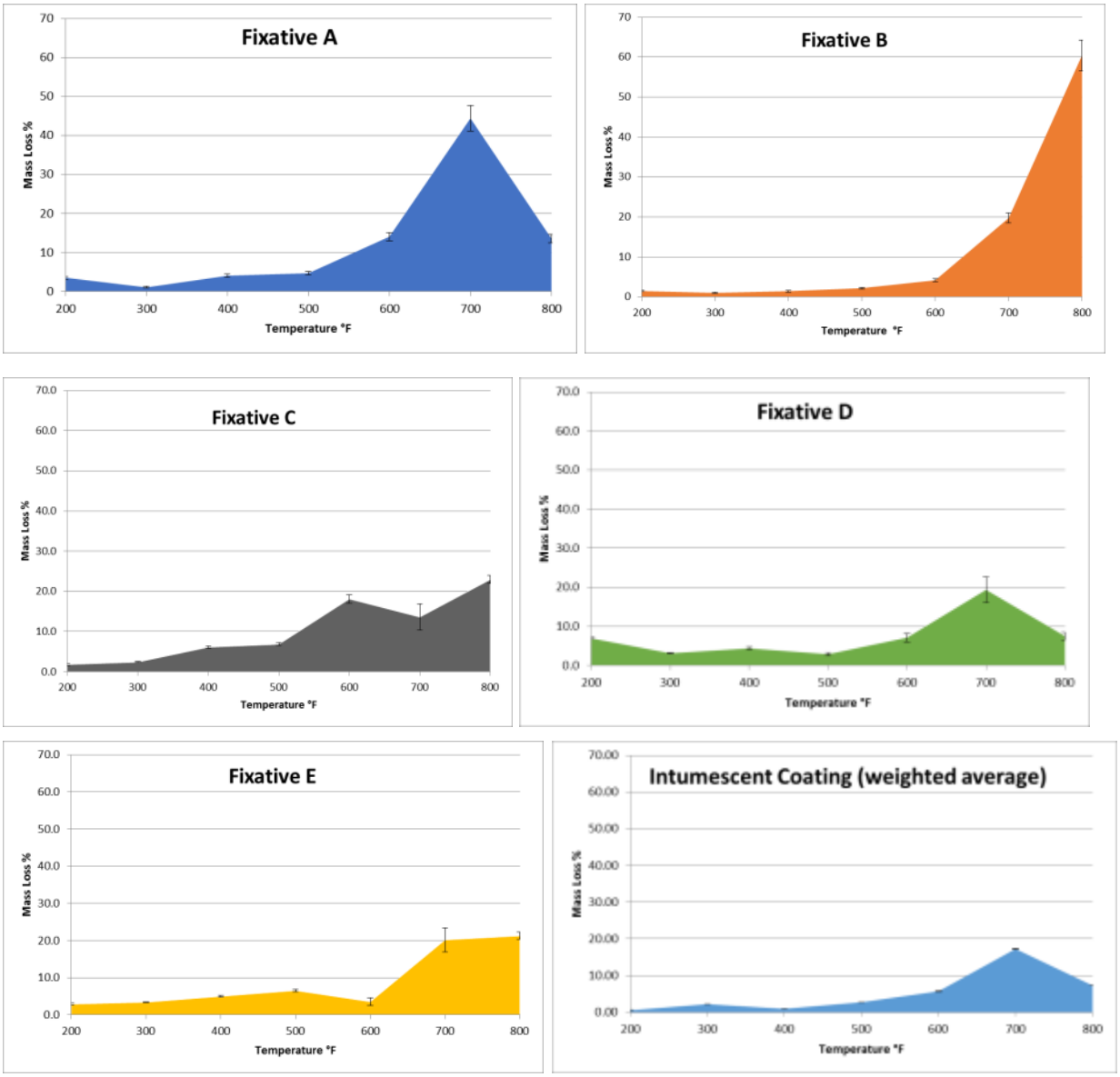


Figure 15. Mass loss of fixatives and intumescent coating versus temperature in muffle furnace.

As shown in Table 1, the intumescent coating mass loss is significantly lower than for the fixative products.

Table 1. Total Mass Loss

Fixative	Total Mass Loss (%)
A	85.2 ± 7.4
B	90.6 ± 8.2
C	71.6 ± 2.1
D	51.3 ± 7.8
E	62.6 ± 4.1
IC	40.5 ± 0.2

The next objective of the experiments was to test if layering the IC over a fixative would reduce the total mass loss of the sample. Developing the mass loss profiles for each intumescent coating is critical due to its expected correlation to enhancing a fixative's operational performance and fire resiliency under a layering configuration. Sample coupons were prepared by layering the IC over Fixative A on a glass petri dish. The choice of the substrate was due to the transparency of the glass that allowed the investigators to visually inspect the fixative sample during cooling intervals. Once subjected to heat in the muffle furnace, the mass loss of the sample cannot be specifically attributed to either the fixative or the IC. However, if one assumes that the previous mass loss profiles measured individually remain consistent for the combined sample, then the combined mass loss profile can be predicted. By comparing the predicted combined mass loss with the actual combined mass loss, a determination can be made for whether the IC layer inhibited the mass loss of the fixative. Specifically, if the IC layer provided mass loss protection to the fixative layer, the actual total mass loss of the combined sample should be less than predicted.

The use of an intumescent coating did succeed in reducing the total mass loss when layered over the fixative. For coupon #1, the total measured mass loss was 47.8 ± 0.49% versus an expected mass loss of 61.6 ± 0.53%. For coupon #2, these results were repeated, with slightly better protection being afforded by the intumescent coating; total measured mass loss was 53.4 ± 0.44% versus an expected total mass loss of 59.7%.

With the promising results of the initial intumescent coating tested, FIU proceeded to obtain three additional commercial-off-the-shelf intumescent coatings to baseline. These include Intumax, Interchar, and Fire Dam. FIU began baselining these intumescent coatings utilizing the same testing protocols developed by FIU and SRNL during the initial testing in order to ensure integrity in the testing, evaluation, and direct comparison of the various intumescent materials.

As depicted by the data shown in the graphs below, 2 of 3 of the additional ICs (Fire Dam and Interchar) performed exceptionally well, with one (Fire Dam) identifying itself as a possible candidate for a standalone fixative. Fire Dam exhibited the least amount of mass loss thus far with an average weighted profile of 36%. More importantly, as depicted in Figure 17, Fire Dam displayed the least observable damage when exposed to extreme temperatures for extended periods. It did not exhibit the same degree of discoloration, desiccation, or chemical breakdown, and demonstrated an improved overall adhesion to the substrate.

Initial results associated with layering Fire Dam (FD) over fixatives and exposing to high temperatures (800ºF) for 15 minutes in the muffle furnace showed that the fixatives were significantly protected by the overlaying IC. Figure 18a shows a test coupon of stainless steel with fixative E (fixative only) after being exposed to 800ºF for 15 minutes in the muffle furnace. The fixative had significant mass loss, discoloration, desiccation, cracking, and significant

flaking. Figure 18b shows a glass test coupon with an application of fixative E (white in color) and the intumescent coating FD applied over the fixative (red in color). FD was then also applied to the opposite side of the glass test coupon so that that fixative had the IC layered on both sides. Finally, Figure 18c shows the same glass test coupon after being exposed to 800ºF for 15 minutes in the muffle furnace, with the bottom layer of IC (dark red in color) scraped away to show the fixative layer. The fixative remained largely intact, with the outer edge showing some color change and bubbling.

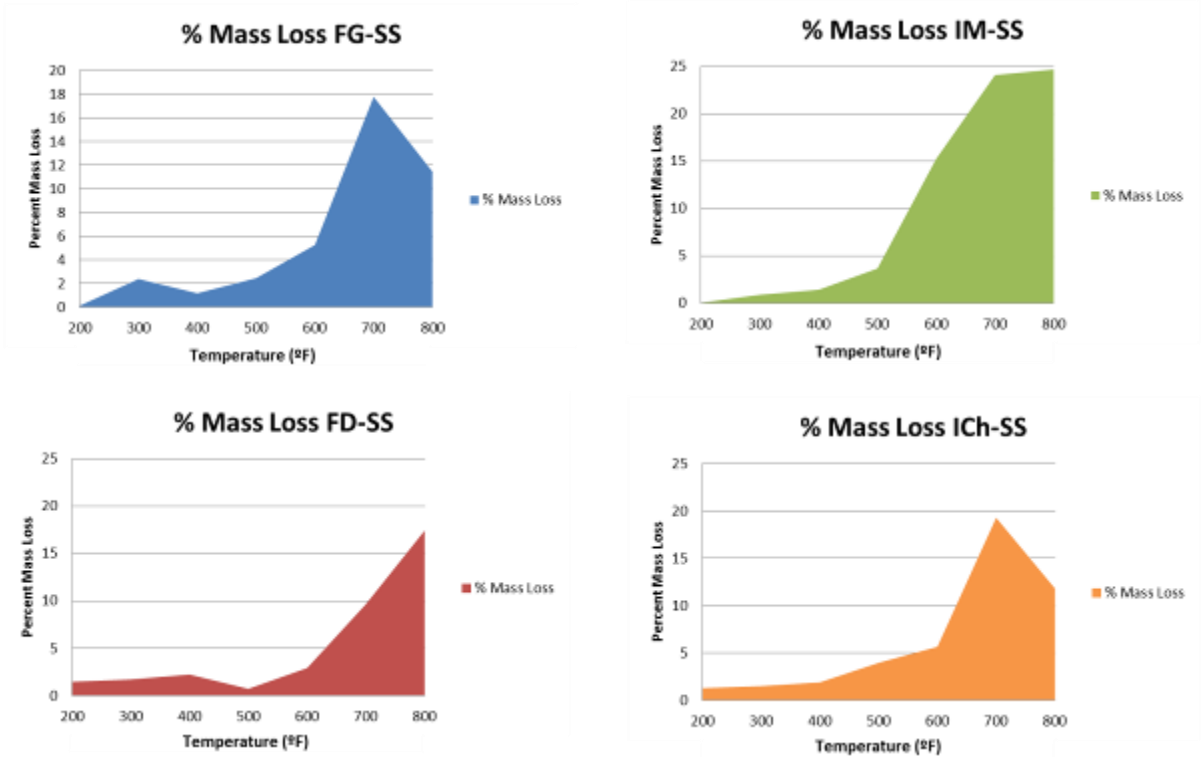
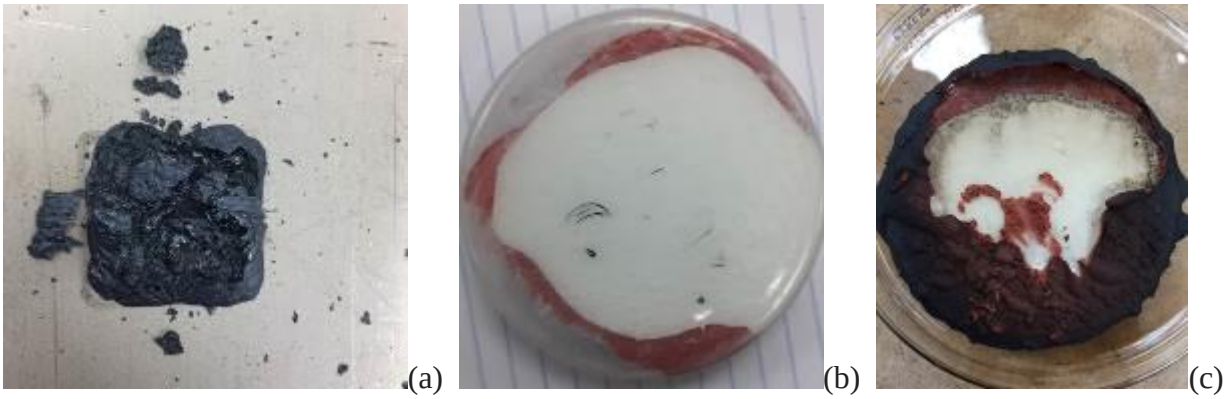


Figure 16. Mass loss profiles of intumescent coatings.

Figure 17. Fire Dam intumescent coating after exposure to 800º F.



(a) (b) (c)

Figure 18. Fixative E after exposure to high heat (a), Fixative E (white) layered with FD intumescent coating (b), and Fixative E layered with FD after exposure to 800ºF (c).

FIU provided a detailed briefing to Mr. Andrew Szilagyi and Mr. John De Gregory with DOE EM-4.11 on the efforts and results related to this task to date on May 11, 2016. The update was well received with additional guidance provided by EM-4.11 on the path forward. During this briefing, the proposed scope of work for FIU Performance Year 7 for the overall D&D task (Task 2) of Project 3 was also presented and discussed in support of the development of the Continuation Application.

During July, FIU completed coupon preparation using FIREX intumescent coating on both stainless steel and wood substrates, applying the product to the requisite thickness. For these coupons, FIU did not use a primer in order to replicate the field site application methods preferred by SRS 235-F site personnel. For the 1/8" stainless steel coupon, FIU applied FIREX to one side of the coupon and Fixative A to the other side. For the wood coupon, FIU layered the FIREX over Fixative A.

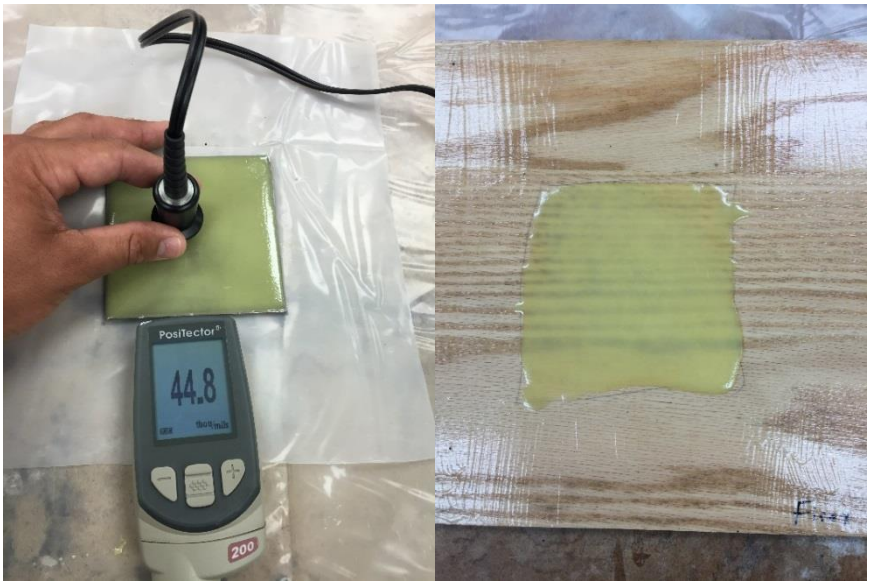


Figure 19. Stainless steel (left) and wood (right) test coupon substrates with FIREX intumescent coating.

FIU subjected the 1/8" stainless steel coupon (FIREX on one side and Fixative A on the other side) to a direct flame source (i.e., propane torch) at distances from 3" to 6" for 5 minutes. As can be seen in the figure below, the FIREX intumescent coating began to char in a similar manner to FireDam, creating a leather-like protective layer. Based on the infrared (IR) sensor measurements, temperatures on the surface ranged between 500º-700º F.

Figure 20. Stainless steel test coupon with FIREX intumescent coating after exposure to direct flame.

On the back of the stainless steel coupon, coated with Fixative A, no damage was noted and the fixative appeared intact (no discoloration, no melting, no off-gassing, etc.) and the temperature never rose above 120º F (see figure below). The fixative remained tacky to the touch and appeared to maintain its primary functions as a permanent fixative. The FIREX provided the

same level of protection to Fixative A when layered over it on the wood coupon and subjected to the same flame source. The only deficiency noted in the layering configuration was a loss of adhesion between FIREX and the fixative.

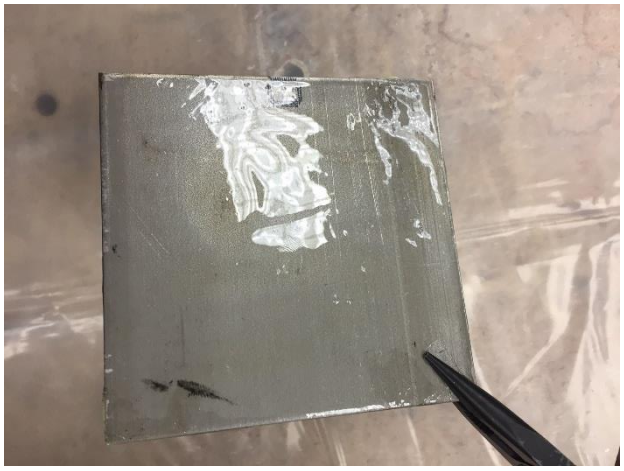


Figure 21. Back of stainless steel test coupon with Fixative A coating after front side (with FIREX IC) was exposed to direct flame.

During August, FIU began a series of tests to subject test coupons with intumescent coatings only to increasing temperatures using a muffle furnace. With this series of tests, FIU will be focused on adhesion and impact testing on various substrates, both before and after exposure to extreme heat conditions, to access the ability of the IC to function as a stand-alone fixative (i.e., without layering it over an established industry fixative).

FIU visited SRNL on August 8-9, 2016, and provided a joint presentation with SRNL research scientists to SRS 235-F facility personnel, including project managers as well as safety and fire division representatives, on the potential of adapting intumescent coatings as standalone fixatives to assist with the overall safety basis of the site. The brief was exceptionally well received, and there was general concurrence to further the research through a scaled demonstration in a radioactive environment.

Throughout FIU Performance Year 6, FIU also prepared test coupons of the fixatives and IC products being tested at FIU and, along with liquid samples of the products, shipped them to the SRNL collaborators to support their parallel research on the products under varying environmental and radioactive conditions.

Development of a Decision Model for Contamination Control Products

During prior performance years, FIU conducted a focused literature review (using D&D KM-IT, archived ALARA Reports, internet research, and vendor info) on contamination control products for radiological surface decontamination in support of the SRS 235-F Risk Reduction Project. The resulting summary report will be used by the project team to develop their decontamination concepts for the PuFF process cells and define the out year's technical activities. FIU compiled data on each of the 40 products identified in the study and developed a matrix spreadsheet. Due to the large variety of products available for decontamination, FIU began to work on a tool to assist in the appropriate selection of contamination control products for specific site conditions. Criteria considered included the type of radiation contamination, surface type, and location. Each one of these criteria was then further expanded into sub-criteria.

During FIU Performance Year 6, FIU reviewed and updated the contamination control product list. This list was then used to develop a web-based fixative module on the D&D KM-IT framework to aid in the selection of appropriate contamination control products (fixatives, strippable coatings, and decontamination gels) during D&D activities. A mobile web application was also developed to optimize the fixative module for mobile devices. Details are included under Task 3 of this report.

Robotic Technologies for SRS 235-F

This was a new task for FIU Performance Year 6. The SRS 235-F facility has a need to identify a remote system that can make one-time entry to highly contaminated areas. The one-time-entry requirement indicates that the technology will not be retrieved at the end of the work but would remain inside the facility due to the high levels of contamination. FIU performed research to identify robotic technology systems applicable to the challenges and needs of the SRS 235-F Facility. Research utilized the Robotic Database in D&D KM-IT to search and identify potential robotic technologies and compiled a spreadsheet of all of the available robotic technologies in the database. A summary report deliverable was prepared and sent to SRNL and DOE HQ on August 12, 2016.

A poster titled, "Cooperative Robotic Scheduling and Path Planning for D&D Applications," was prepared and presented by DOE Fellow Sebastian Zanlongo during the student poster session at the Waste Management Symposia in Phoenix.

Fogging Research and Evaluation

During FIU Performance Year 5, the objective of this research task was to collaborate with SRNL and INL to perform a technology demonstration to test and evaluate the FX2 advanced fogging technology, developed at INL, for potential implementation at the SRS 235-F facility. The technology demonstration was performed from March 30 to April 8, 2015 at the ARC Technology Testing & Demonstration Facility in Miami where an existing hot cell mockup facility was modified to meet the objectives of the demonstration. Overall, the technology was capable of successfully achieving the objectives of this demonstration. The FX2 advanced fogging agent technology demonstration report and fact sheet as well as photographs and videos taken during the testing and evaluation have been published on the D&D Knowledge Management Information Tool (www.dndkm.org).

Subsequently, during the summer of 2015, two DOE Fellows completed 10-week internships at INL under the mentor and guidance of Mr. Steve Reece and Mr. Rick Demmer, providing support in the research on strippable coating development for fogging applications (Jesse Viera) and mercury abatement through the use of an advanced fogging technology (Janesler Gonzalez). Details of the summer internships as well as research results are detailed in the summer internship technical reports that are available on the DOE Fellows website (fellows.fiu.edu).

This task was concluded during FIU Performance Year 6. A poster titled, "Innovative Process for Abatement of Mercury," was prepared and presented by DOE Fellow Janesler Gonzalez during the student poster session at the Waste Management Symposia 2016 in Phoenix. The poster presented the research performed by the DOE Fellow during his summer 2015 internship at INL.

Technology Demonstration and Evaluation

The primary objective of this new task is to standardize and implement proven processes to refine and better synchronize DOE-EM technology needs, requirements, testing, evaluation, and acquisition by implementing a three-phased technology test and evaluation model. The development of uniformly accepted testing protocols and performance metrics is an essential component for testing and evaluating D&D technologies. Toward these goals, FIU engaged the international testing community and the DOE complex's stakeholders during FIU Performance Year 6 to begin developing: 1) Uniform testing protocols and performance metrics for the various categories of D&D technologies (e.g.; fixatives, decon gels, robotics, etc.), and 2) Standardized methods to conduct cost savings / cost avoidance assessments for D&D technologies. The objectives for FIU Performance Year 6 included:

1. Obtain official membership on ASTM International's E10 Committee on Nuclear Technologies and Applications.
2. Introduce a requirement for standardized testing protocols and performance metrics for D&D technologies as an agenda item for the E10 Committee meeting in January 2016.
3. In collaboration with E10 Committee membership, develop a detailed plan for implementing the initiative, and gain concurrence from the ASTM International Executive Steering Committee in June 2016.

A member of the FIU ARC staff completed the first objective by obtaining official membership on ASTM International's E10 Committee on Nuclear Technologies and Applications. FIU coordinated agenda items and the committee schedule with ASTM International's E10 Committee on Nuclear Technologies and Applications and E10.03 - Radiological Protection for Decontamination and Decommissioning of Nuclear Facilities and Components for the January 2016 conference in San Antonio, TX.

Mr. Joseph Sinicrope attended the ASTM International Conference in San Antonio, TX on January 24-27, 2016, where he presented an executive brief to support the initiative of developing and promulgating uniform testing protocols and performance metrics for D&D technologies across the stakeholder community and outlined the proposed way ahead for bringing this initiative to fruition (milestone 2015-P3-M2.2). Mr. Sinicrope was elected Chairman for the E10.03 Subcommittee on Radiological Protection for Decontamination and Decommissioning of Nuclear Facilities and Components. Subsequently, FIU began identifying and inviting potential members across the stakeholder community to join the subcommittee.

A general approach was agreed upon as a starting point for the working group members. There are some existing testing protocols associated with various R&D efforts for D&D technologies that have gained informal acceptance. Identifying these, codifying them, then reformatting into the ASTM standard and staffing across community stakeholders for review will allow the formal process of standards development to occur. This will allow for the development of not only uniform testing protocols and performance metrics to justify test and evaluation methods, but also facilitate institutional objectives related to capturing, preserving, and sharing information.

FIU led the standards development process for D&D technologies through the ASTM International E10.03 Subcommittee. An agenda for the scheduled June Working Group on this initiative was developed and distributed to the working group members. New members from

SRNL and INL were recruited into the Working Group, and clear objectives for the June meeting were outlined. These included:

1. Confirm/modify operational characteristics and requirements for fixatives used in support of D&D technologies. We will capture these and then begin a DRAFT standard for D&D coatings similar to ASTM E-2731 above.

2. Begin initial standards development for testing protocols related to determining radiation resiliency of fixatives used for long-term D&D requirements.

3. Begin initial standards development for testing protocols related to determining the decontamination factor (DF) of fixatives/decon gels on contaminated concrete for D&D (and possibly other substrates).

4. Begin initial standards development for testing protocols related to fixative/decon gel/coating performance on contaminated steel for D&D.

FIU participated in the ASTM International's Executive Steering Committee Meeting from June 27 to June 29, 2016 (completing milestone 2015-P3-M2.3) and led the E10.03 Subcommittee meeting to develop standardized testing protocols and performance metrics for D&D technologies. Participating members of this subcommittee meeting included Joe Sinicrope (FIU ARC), Rick Demmer (INL), Steve Reese (INL), Aaron Washington (SRNL), Connor Nicholson (SRNL), Andy Jung (Areva), Edward Walter (consultant), Steve Halliwell (VJT Technologies), and Bob Walcheski (UESI). Accomplishments during the meeting and the next steps identified included:

1. Completed the development of two (2) new draft standard specifications on fixative technologies: a) strippable/removal coatings, and b) permanent coatings and fixatives. The standard specifications outline the performance, mechanical, chemical, and physical requirements expected of the technology with the associated performance criteria.
2. Connor Nicholson will forward those drafts to Ed Walker and Joe Sinicrope to refine before distribution to the entire working group for one final review/edit.
3. Joe Sinicrope will engage the Staff Manager (Steve Mawn) and acquire official working document numbers for the 2 drafts so they can begin to be formally tracked.
4. The working group's final drafts for the 2 standard specifications will be sent to the E10.03 Subcommittee members for a Subcommittee vote. Incorporation of any comments from the Subcommittee will be incorporated prior to submitted the specifications for a full E10 Committee vote.
5. Bob Walcheski and Rick Demmer will forward the specified data to support drafting of a third standard specification for fixatives used in basin operations. The two existing drafts will be used as the foundation and the necessary requirements from Rick and Bob will be integrated.
6. Will begin the initial development of a DF Testing Protocols using Rick Demmer's past work as the basis. This will be the priority development effort during the subcommittee's January 2017 meeting.
7. A second priority development effort in January 2017 will be a testing protocol for an "immobilization factor" associated with both of the standard specifications.

During July, FIU followed up with the participants of the subcommittee meeting to develop standardized testing protocols and performance metrics for D&D technologies and the two (2) new draft standard specifications on fixative technologies (strippable/removal coatings and permanent coatings and fixatives) were forwarded to Ed Walker and Joe Sinicrope for refinement before distribution to the entire working group for one final review/edit. The standard specifications outline the performance, mechanical, chemical, and physical requirements expected of the technology with the associated performance criteria. The Staff Manager (Steve Mawn) was contacted and official working document numbers for the two drafts were assigned so they can begin to be formally tracked. The working group's final drafts for the two standard specifications will be sent to the E10.03 Subcommittee members for a Subcommittee vote. Incorporation of any comments from the Subcommittee will be incorporated prior to submitting the specifications for a full E10 Committee vote.

FIU completed a deliverable for a decision brief to Andrew Szilagyi and John De Gregory with DOE EM-4.11 on recommended technologies to test for FIU Performance Year 7 on May 11, 2016, as part of a larger briefing on FIU's current and future D&D research activities.

FIU drafted and finalized a manuscript based on this task effort titled, "The Expanding Nuclear Niche and Growing Requirement for Standardized Testing Protocols and Performance Metrics for D&D Technologies," which was published in the March/April 2016 ASTM International's Standardization News magazine (Figure 22).

FEATURE
NUCLEAR PLANT DEACTIVATION

The Expanding Niche in Nuclear Plant Deactivation

Nuclear power plants are being closed at a growing rate. Standardized testing and performance metrics for their deactivation and decommissioning **will help ensure public safety.**

By Joseph Sinicrope, Peggy Shoffner, Edward Walker and Leonel Lagos

Based on estimates provided by the U.S. Nuclear Regulatory Commission and the International Atomic Energy Agency, the deactivation and decommissioning, or D&D, of nuclear facilities worldwide is forecast to grow exponentially over the next 10 to 20 years.

The resurgence in nuclear power, predicted only a few years ago, has not materialized. First generation nuclear facilities are rapidly approaching their initial licensing limitations. Though extensions could be granted, drivers such as the public's negative perception of safety and the lack of political will after the Fukushima accident are now significant obstacles to overcome.

Furthermore, price competition from fossil fuels and the allure of renewable energy have made the decommissioning decision a largely economic one, rather than an operational and technical one. This will result in the premature closure of even more facilities.

Consequently, the industry and its governing regulatory agencies have found themselves faced with a strategic shift in focus — an expedited, and daunting, D&D requirement.

HUNDREDS OF CLOSURES

According to the World Nuclear Association, approximately 100 uranium mines, 110 commercial power reactors, 46 experimental or prototype reactors and 250 research reactors have been retired from operation worldwide. Of these, only a handful have been fully dismantled, with the most complex D&D activities associated with each still remaining. Conservative projections have more than 200 of the 434 active nuclear reactors currently operating across the globe being retired by 2040, with total estimated costs exceeding well over $300 billion.

Several factors, with perhaps the most prominent in recent history being the Fukushima nuclear accident in Japan, have prompted other countries to accelerate their plans to shut down nuclear facilities. For example, both Germany and Switzerland have established timelines for closing all their facilities (17 and 5 reactors, respectively).

In short, the sheer magnitude and scope of the effort will catapult deactivation and decommissioning as a major operation for governments and the industry on a global

March/April 2016 www.astm.org/sn ASTM Standardization News 29

Figure 22. March/April 2016 ASTM International's Standardization News magazine article.

A poster titled, "ASTM Testing Standards Development for D&D Technologies" was prepared and presented by DOE Fellow Jesse Viera at the student poster session at the Waste Management Symposia in Phoenix in March 2016.

Presentations, Meetings and Conferences

FIU also participated in relevant meetings and conferences in support of this task. On April 5-7, 2016, a program review via videoteleconferencing was conducted between DOE EM and FIU ARC as part of the DOE Cooperative Agreement. The presentations included one on the D&D and IT for Environmental Management applied research. All presentations are available for downloading on FIU's DOE Research webpage at http://doeresearch.fiu.edu.

FIU prepared and presented a professional presentation titled, "A Novel Approach to Mitigating the Potential Release of Radioisotopes under Fire Conditions: Enhancing Fire Resiliency in Facilities and Fixatives during D&D and Storage Activities," during the March 6-10 Waste Management 2016 conference in Phoenix, AZ (Figure 23).

Figure 23. Joe Sinicrope presenting at WM16.

In addition, four DOE Fellows prepared and presented student posters based on the research under this project at the Waste Management Symposium 2016 held in Phoenix, AZ in March. Jorge Deshon presented a student poster entitled, "Fixatives Decision Model on KM-IT Platform"; Sebastian Zanlongo presented a student poster entitled, "Cooperative Robotic Scheduling and Path Planning for D&D Applications"; Janesler Gonzalez presented a student poster entitled, "Innovative Process for Abatement of Mercury" which presented the research performed during his summer 2015 INL internship; and Jesse Viera (Figure 24) presented a student poster entitled, "ASTM Testing Standards Development for D&D Technologies."

Figure 24. DOE Fellow Jesse Viera presenting his research poster at WM15.

FIU also participated in the Decommissioning and Remote Systems (D&RS) conference at the American Nuclear Society (ANS) 2016 Annual Meeting in Pittsburg, PA, on July 31 to August 4, 2016. A professional oral presentation was given titled, "Robotics for Deactivation and Decommissioning."

TASK 2: CONCLUSIONS

Planning for the D&D of facilities across the DOE complex is a tremendous undertaking, especially considering that a significant number of the facilities contain hazards to human health and the environment: seriously deteriorated structural integrity, very high dose rates, high levels of fixed and removable contamination on/in facility surfaces and equipment, and chemically hazardous materials. Providing support for technology innovation, development, evaluation, and deployment is critical to the safe and efficient completion of facility D&D.

TASK 2: REFERENCES

Florida International University, *Enhancing Operational Performance of Fixatives and Coatings for D&D Activities: Baselining and Proof of Concept,* Test Plan, June 2015.

Florida International University, *Incombustible Fixatives – Adapting Intumescent Coatings as Fire Retardant Fixatives to Support D&D Activities,* Technical Progress Report, June 2016.

Sinicrope, J., P. Shoffner, E. Walker, L. Lagos. The Expanding Nuclear Niche: Meeting the Growing Need for Standardized Testing and Performance Metrics for the Deactivation and Decommissioning of Nuclear Facilities. *ASTM International Standardization News*, March 2016.

Sinicrope, J., P. Shoffner, L. Lagos. The Pursuit of Incombustible Fixatives: Mitigating Release of Contaminants in Fire Conditions. Waste Management 2016 Conference, Phoenix, AZ, March 2016.

TASK 3.
D&D KNOWLEDGE MANAGEMENT INFORMATION TOOL

TASK 3: EXECUTIVE SUMMARY

FIU has developed a D&D Knowledge Management Information Tool (D&D KM-IT) to maintain and preserve the D&D knowledge base and to provide a focused web-based tool to assist the DOE D&D community in identifying potential solutions to their problem areas by using the vast resources and knowledge-base tools available through the web. During FIU Performance Year 6, FIU performed several subtasks, including community outreach and training, application development, system/database/network administration, and data mining.

TASK 3: INTRODUCTION

Planning for the D&D of facilities across the DOE complex is a tremendous undertaking. Capturing the knowledge, experience, and lessons learned from historic D&D activities at DOE sites is imperative to the successful and safe management of future D&D projects. The D&D Knowledge Management and Information Tool is a central initiative to accomplish these goals.

The D&D KM-IT is a web-based system developed to maintain and preserve the D&D knowledge base. The system was developed by FIU-ARC with the support of the D&D community, including DOE-EM (EM-4.11 & EM-5.12), the former ALARA centers at Hanford and Savannah River, and the DOE's Energy Facility Contractors Group (EFCOG). The D&D KM-IT is a D&D community driven system tailored to serve the technical issues faced by the D&D workforce across the DOE Complex. D&D KM-IT can be accessed from web address http://www.dndkm.org. as well as via mobile devices at http://m.dndkm.org.

TASK 3: EXPERIMENTAL

The D&D KM-IT is a web-based knowledge management information tool custom built for the D&D user community by FIU. The objective of the D&D KM-IT is to provide a focused web-based tool to assist the DOE D&D community in identifying potential solutions to their problem areas by using the vast resources and knowledge-base tools available through the web. One such knowledge-base tool includes solutions provided by subject matter specialists who respond to specific questions. The D&D KM-IT archives, in a retrievable module within the system, information collected from the subject matter specialists, thereby building a knowledge repository for future reference. The primary subtasks for FIU Performance Year 6 included community outreach and training, application development, system/database/network administration, and data mining.

TASK 3: RESULTS AND DISCUSSION

Outreach and Training

Significant effort was made towards community outreach in support of the D&D KM-IT system during FIU Performance Year 6. FIU participated in meetings and conferences, hosted conference exhibitor booths, held workshops, contributed D&D information to Wikipedia, and disseminated newsletters on D&D KM-IT to registered users, subject matter specialists, and conference attendees.

Metrics

FIU completed the development of a metrics progress reports for outreach and training activities for D&D KM-IT and submitted these to DOE on February 29 and August 15, 2016. These documents provided reports of the progress being made towards accomplishing the outreach and training goals and objectives set forth in the document titled, "Metric Definition for D&D KM-IT Outreach and Training," which was developed during FIU Performance Year 5 and expanded on the outreach and training activities for D&D KM-IT as described in the annual PTP by defining specific metrics and capturing the tools and techniques that will be applied to track and report the results. Outreach and training is a critical element towards the long-term sustainability of knowledge and essential for the long-term strategic vision of D&D KM-IT: it will continue to grow and mature into a self-sustaining system through the active participation of the D&D community it was designed to serve.

Conferences and Workshops

FIU participated in relevant meetings and conferences in support of this project, including the Decommissioning and Remote Systems (D&RS) conference at the American Nuclear Society (ANS) 2016 Annual Meeting in Pittsburg, PA and the Waste Management Symposium 2016 in Phoenix, AZ.

A professional poster titled, "Robotics Technologies on Knowledge Management Information Tool (KM-IT) Platform," was prepared and presented during the March 6-10 Waste Management 2016 conference in Phoenix, AZ (Figure 25). In addition, a poster titled, "Fixatives Decision Model on KM-IT Platform," was prepared and presented by DOE Fellow Jorge Deshon at the student poster session at the Waste Management Symposia in Phoenix.

FIU also hosted a booth in the exhibitor hall during the conference (Figure 26). FIU hosted workshops on D&D KM-IT during the conference by providing live demonstrations of the system and showing the available features and the newly added content, with emphasis on the robotic technologies. During the operation of the exhibitor booth and poster presentation of D&D KM-IT, FIU encouraged conference attendees to become active users of the system as well as to register as subject matter specialists. Significant interest was shown in the knowledge management of D&D as reflected by the increase in user registrations during the conference, increasing the total number of registered users from 846 to 903 (+57). In addition, the number of subject matter specialists increased from 93 to 104 (+11).

In addition, FIU participated in the Decommissioning and Remote Systems (D&RS) conference at the American Nuclear Society (ANS) 2016 Annual Meeting in Pittsburg, PA, on July 31 to August 4, 2016. A professional oral presentation was given titled, "Robotics for Deactivation and Decommissioning" which highlighted the availability of the robotics database within the D&D KM-IT.

Figure 25. Robotics on D&D KM-IT poster being presented at WM16.

Figure 26. DOE Fellows and ARC staff at FIU booth during WM16 Exhibit Hall.

Website Analytics

FIU developed a D&D KM-IT Website Analytics Performance Report on a quarterly basis and summarized the information is graphically-rich annual web analytics reports. These reports included information from Google Analytic and Google Web Master tools and provide multiple graphics and a narrative to explain the results. FIU completed the development of an annual Google Web Analytic report for D&D KM-IT for calendar year 2014 (January to December) and

submitted it to DOE on September 22, 2015. During this period, D&D KM-IT was visited from every state in the union with the top three being Florida, District of Columbia and Tennessee. D&D KM-IT was also visited from 116 countries with the top five being the United States, United Kingdom, Canada, India and South Korea, with a combined 6,003 visits (Figure 27).

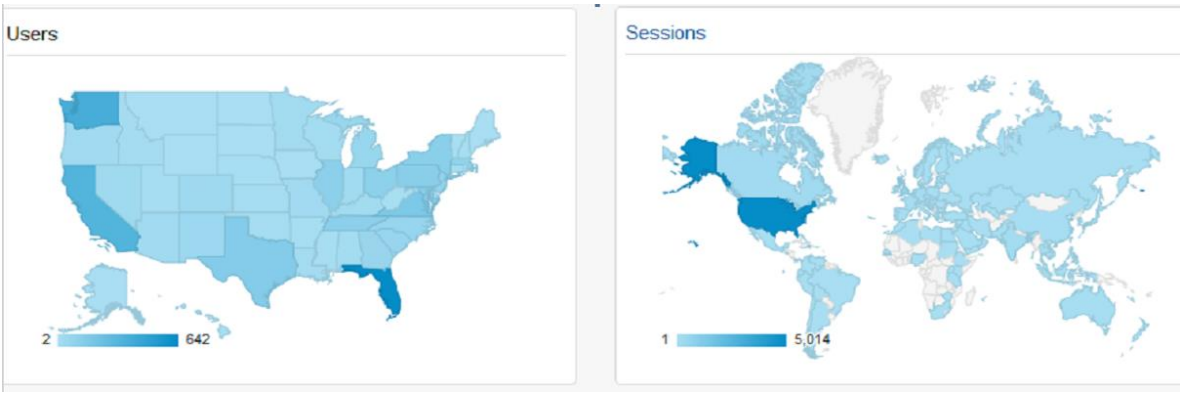


Figure 27. Location of visitors to D&D KM-IT.

An infographic was provided for visual representation of key information in this report. It is intended to present information quickly and clearly (Figure 28).

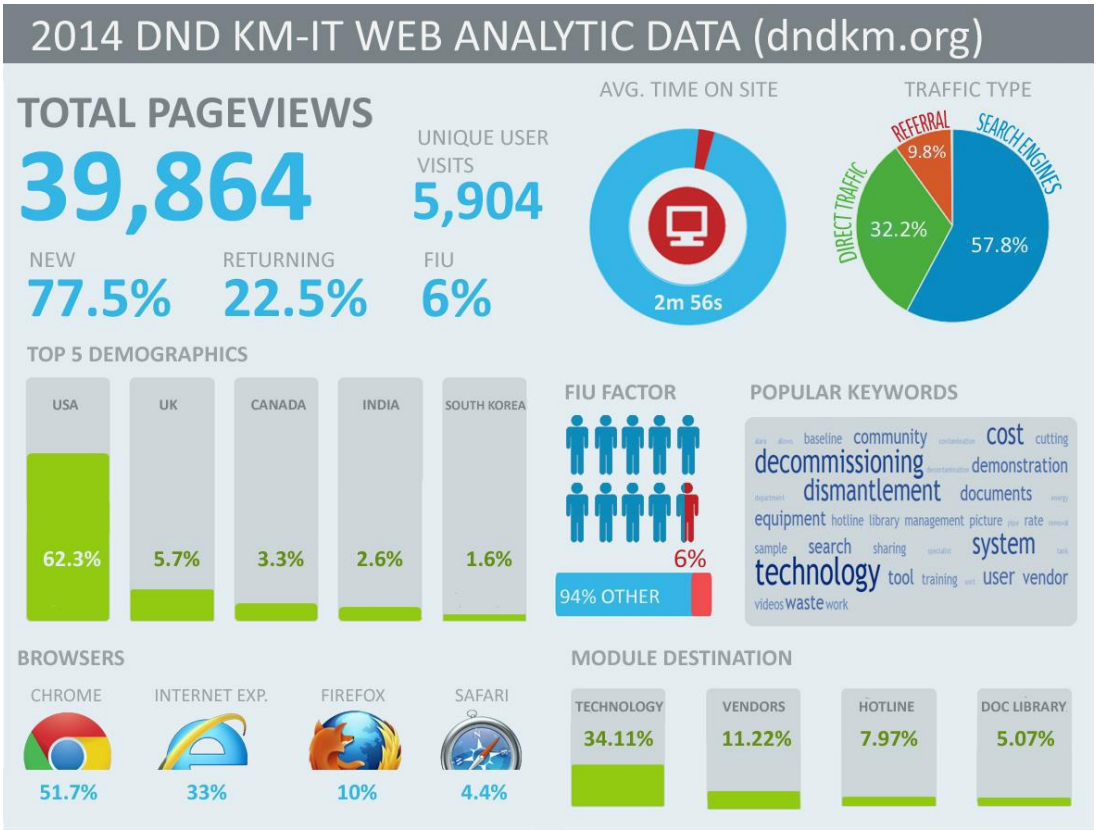


Figure 28. Web analytics infographic for calendar year 2014.

FIU also completed the development of a Google Web Analytic reports for D&D KM-IT for the second, third, and fourth quarters of 2015 as well as the first quarter of 2016 (Figure 30). These

reports included information from Google Analytics and Google Web Master tools and a narrative to explain the results. A few of the highlights from these reports include:

- There was a noticeable increase in visits from "other" countries outside the United States. These visits are an encouraging sign of increasing global participation.
- Registered users increased by 97 while SMS increased by 7 after the system was demonstrated at the 2015 ANS Utility Working Conference and Vendor Technology Expo that took place at Amelia Island, FL during August 2015. Registered users increased by 64 and subject matter specialists (SMS) increased by 7 after the Waste Management Symposia 2016 in Phoenix, AZ during March 2016. Conferences continue to prove to be the best platform to recruit new users and SMS to the system.
- Innovative Technology Summary Reports (ITSRs) were the most visited documents on D&D KM-IT.
- Google Chrome has become the browser used by almost half of the users who visit the site.
- Wikipedia is one of the top ten domains linking to D&D KM-IT.
- "Mobile Systems" is top query impression for D&D KM-IT.
- The most visited modules include Technology, Vendors and Training.

The following figure shows the demographics of D&D KM-IT registered users and subject matter specialists (SMS) across the United States.

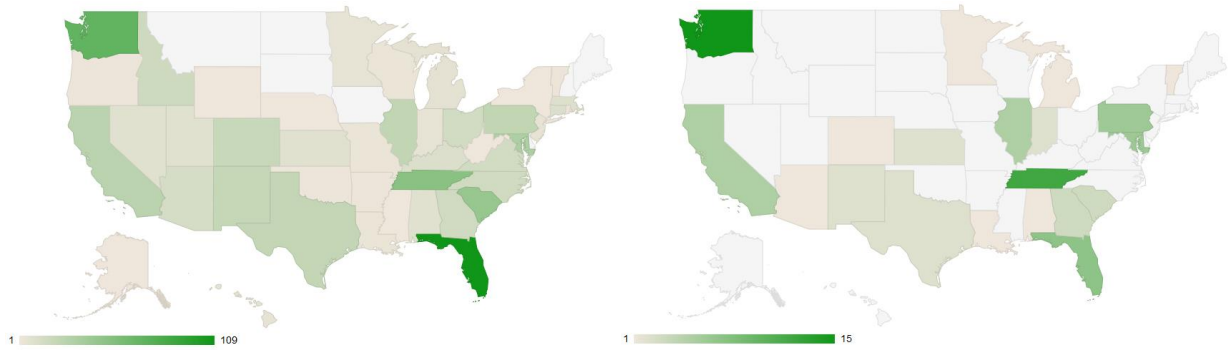


Figure 29. Demographics of D&D KM-IT registered users (left) and SMS (right).

Figure 30. Infographics based on web analytic data for D&D KM-IT.

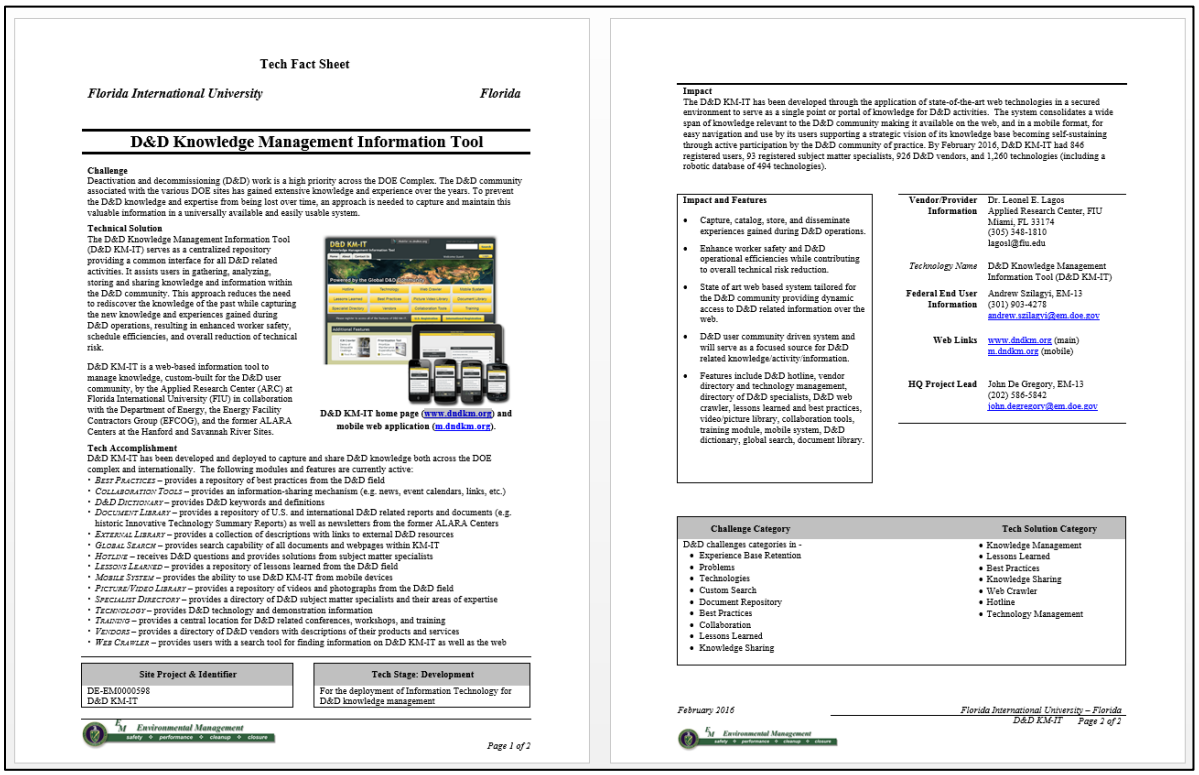
Strategic Plan

A strategic plan document for D&D KM-IT titled, *D&D Knowledge Management Information Tool – A Strategic Approach for the Long-Term Sustainability of Knowledge*, offers a strategic vision for the long-term sustainability of knowledge through the D&D KM-IT by applying the system's assets together with good web practices; thereby, promoting and enhancing the collaborative sharing of knowledge and work experiences across the D&D community.

FIU developed a quarterly update document for the *D&D KM-IT Strategic Approach for the Long-Term Sustainability of Knowledge* document. The strategic plan for D&D KM-IT is a living document and the projected schedule and status evolve over time as the recommended strategic approaches are implemented. The update document, developed on a quarterly basis, provides an update to the table of recommended actions contained in the original document.

Fact Sheet

FIU updated the DOE Technical Fact Sheet for D&D KM-IT and sent the document to DOE in February 2016 (Figure 31). The updated fact sheet was also posted to the D&D KM-IT Document Library.



Tech Fact Sheet

Florida International University *Florida*

D&D Knowledge Management Information Tool

Challenge
Deactivation and decommissioning (D&D) work is a high priority across the DOE Complex. The D&D community associated with the various DOE sites has gained extensive knowledge and experience over the years. To prevent the D&D knowledge and expertise from being lost over time, an approach is needed to capture and maintain this valuable information in a universally available and easily usable system.

Technical Solution
The D&D Knowledge Management Information Tool (D&D KM-IT) serves as a centralized repository providing a common interface for all D&D related activities. It assists users in gathering, analyzing, storing and sharing knowledge and information within the D&D community. This approach reduces the need to rediscover the knowledge of the past while capturing the new knowledge and experiences gained during D&D operations, resulting in enhanced worker safety, schedule efficiencies, and overall reduction of technical risk.

D&D KM-IT is a web-based information tool to manage knowledge, custom-built for the D&D user community, by the Applied Research Center (ARC) at Florida International University (FIU) in collaboration with the Department of Energy, the Energy Facility Contractors Group (EFCOG), and the former ALARA Centers at the Hanford and Savannah River Sites.

D&D KM-IT home page (www.dndkm.org) and mobile web application (m.dndkm.org).

Tech Accomplishment
D&D KM-IT has been developed and deployed to capture and share D&D knowledge both across the DOE complex and internationally. The following modules and features are currently active:
- *Best Practices* – provides a repository of best practices from the D&D field
- *Collaboration Tools* – provides an information-sharing mechanism (e.g. news, event calendars, links, etc.)
- *D&D Dictionary* – provides D&D keywords and definitions
- *Document Library* – provides a repository of U.S. and international D&D related reports and documents (e.g. historic Innovative Technology Summary Reports) as well as newsletters from the former ALARA Centers
- *External Library* – provides a collection of descriptions with links to external D&D resources
- *Global Search* – provides search capability of all documents and webpages within KM-IT
- *Hotline* – receives D&D questions and provides solutions from subject matter specialists
- *Lessons Learned* – provides a repository of lessons learned from the D&D field
- *Mobile System* – provides the ability to use D&D KM-IT from mobile devices
- *Picture/Video Library* – provides a repository of videos and photographs from the D&D field
- *Specialist Directory* – provides a directory of D&D subject matter specialists and their areas of expertise
- *Technology* – provides D&D technology and demonstration information
- *Training* – provides a central location for D&D related conferences, workshops, and training
- *Vendors* – provides a directory of D&D vendors with descriptions of their products and services
- *Web Crawler* – provides users with a search tool for finding information on D&D KM-IT as well as the web

Site Project & Identifier	Tech Stage: Development
DE-EM0000598 D&D KM-IT	For the deployment of Information Technology for D&D knowledge management

Environmental Management safety ◇ performance ◇ cleanup ◇ closure

Page 1 of 2

Impact
The D&D KM-IT has been developed through the application of state-of-the-art web technologies in a secured environment to serve as a single point or portal of knowledge for D&D activities. The system consolidates a wide span of knowledge relevant to the D&D community making it available on the web, and in a mobile format, for easy navigation and use by its users supporting a strategic vision of its knowledge base becoming self-sustaining through active participation by the D&D community of practice. By February 2016, D&D KM-IT had 846 registered users, 93 registered subject matter specialists, 926 D&D vendors, and 1,260 technologies (including a robotic database of 494 technologies).

Impact and Features
- Capture, catalog, store, and disseminate experiences gained during D&D operations.
- Enhance worker safety and D&D operational efficiencies while contributing to overall technical risk reduction.
- State of art web based system tailored for the D&D community providing dynamic access to D&D related information over the web.
- D&D user community driven system and will serve as a focused source for D&D related knowledge/activity/information.
- Features include D&D hotline, vendor directory and technology management, directory of D&D specialists, D&D web crawler, lessons learned and best practices, video/picture library, collaboration tools, training module, mobile system, D&D dictionary, global search, document library.

Vendor/Provider Information	Dr. Leonel E. Lagos Applied Research Center, FIU Miami, FL 33174 (305) 348-1810 lagosl@fiu.edu
Technology Name	D&D Knowledge Management Information Tool (D&D KM-IT)
Federal End User Information	Andrew Szilagyi, EM-13 (301) 903-4278 andrew.szilagyi@em.doe.gov
Web Links	www.dndkm.org (main) m.dndkm.org (mobile)
HQ Project Lead	John De Gregory, EM-13 (202) 586-5842 john.degregory@em.doe.gov

Challenge Category	Tech Solution Category
D&D challenges categories in - • Experience Base Retention • Problems • Technologies • Custom Search • Document Repository • Best Practices • Collaboration • Lessons Learned • Knowledge Sharing	• Knowledge Management • Lessons Learned • Best Practices • Knowledge Sharing • Web Crawler • Hotline • Technology Management

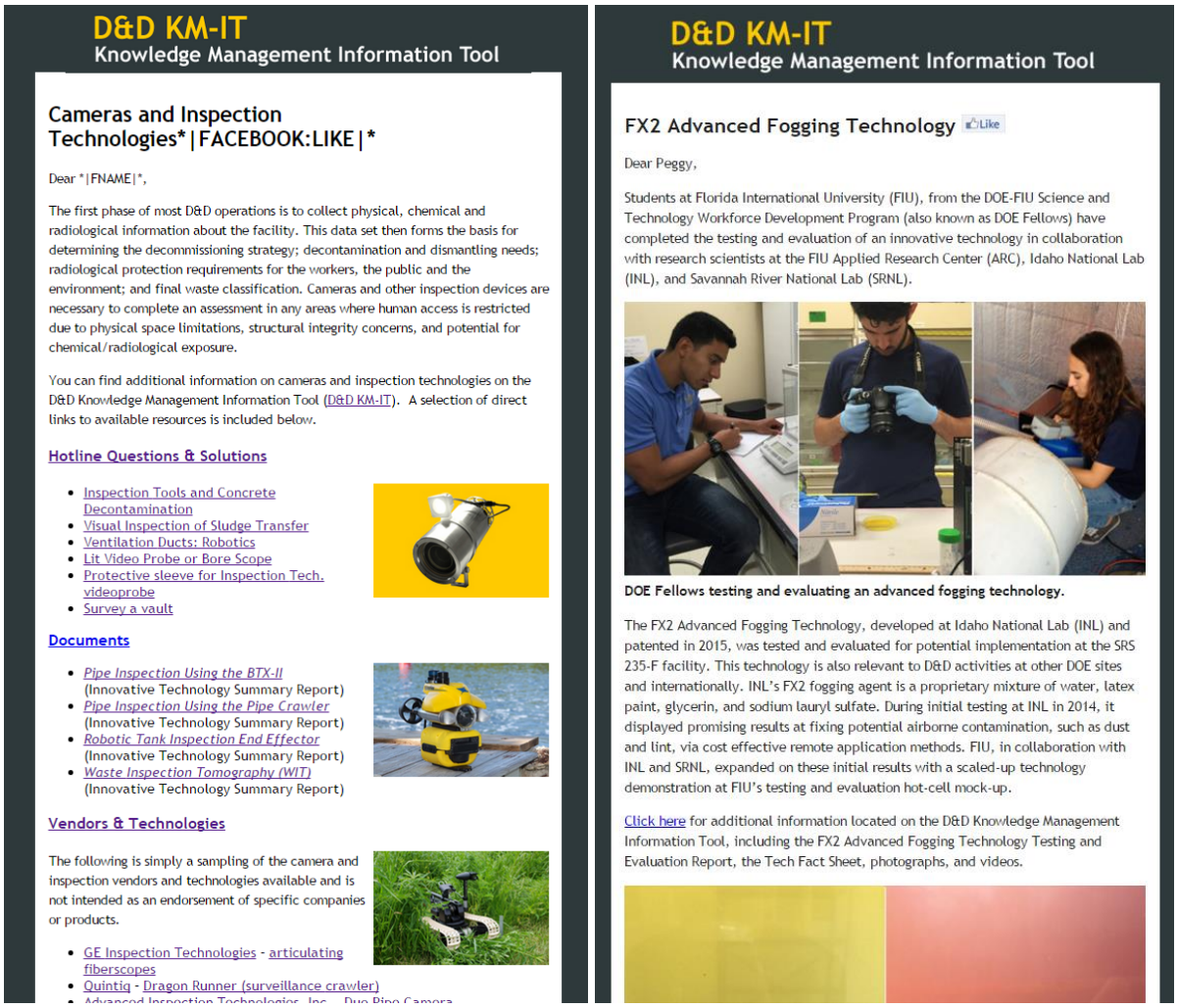
February 2016 *Florida International University – Florida*
D&D KM-IT Page 2 of 2

Environmental Management

Figure 31. DOE Technical Fact Sheet for D&D KM-IT.

Newsletters

Also as part of the outreach effort, FIU created targeted newsletters to send electronically to D&D KM-IT registered uses, subject matter specialists, and Waste Management Conference attendees. These newsletters informed the recipients of current and newly added features of D&D KM-IT and provided quick links to the system website so that they could immediately try out the enhancements. Newsletters are a digital medium of communication and are a great outreach technique to bring waves of traffic to the website. By using the registered users as recipients, KM-IT can keep the users up to date on new features and content. FIU is employing an expanded use of infographics and interactive newsletters (e.g., embedded video, graphics and short simulations) to present graphically interesting information. Partial screenshots of the newsletters developed and/or sent during the performance year are included below. One newsletter provided information on the inspection technologies and cameras that are in the KM-IT Technology Module and was sent to the KM-IT users on October 8, 2015 (Figure 32). A newsletter on the FX2 advanced fogging agent testing and evaluation that was performed at FIU was sent out on November 23, 2015 with links to the test/evaluation fact sheet, photos, and videos on the system (Figure 32). Another newsletter was developed to announce the student activities that would take place during the Waste Management 2016 and was distributed to the WM16 attendee list (Figure 33). A newsletter on the availability of the new D&D Fixative Module on D&D KM-IT was developed and was sent to KM-IT users on August 1, 2016 (Figure 34). Finally, a newsletter on solar power in the southeastern U.S., based on research performed by DOE Fellows during their summer internships, was also developed and sent to DOE (Figure 34).



D&D KM-IT
Knowledge Management Information Tool

Cameras and Inspection Technologies*|FACEBOOK:LIKE|*

Dear *|FNAME|*,

The first phase of most D&D operations is to collect physical, chemical and radiological information about the facility. This data set then forms the basis for determining the decommissioning strategy; decontamination and dismantling needs; radiological protection requirements for the workers, the public and the environment; and final waste classification. Cameras and other inspection devices are necessary to complete an assessment in any areas where human access is restricted due to physical space limitations, structural integrity concerns, and potential for chemical/radiological exposure.

You can find additional information on cameras and inspection technologies on the D&D Knowledge Management Information Tool (D&D KM-IT). A selection of direct links to available resources is included below.

Hotline Questions & Solutions

- Inspection Tools and Concrete Decontamination
- Visual Inspection of Sludge Transfer
- Ventilation Ducts: Robotics
- Lit Video Probe or Bore Scope
- Protective sleeve for Inspection Tech. videoprobe
- Survey a vault

Documents

- *Pipe Inspection Using the BTX-II* (Innovative Technology Summary Report)
- *Pipe Inspection Using the Pipe Crawler* (Innovative Technology Summary Report)
- *Robotic Tank Inspection End Effector* (Innovative Technology Summary Report)
- *Waste Inspection Tomography (WIT)* (Innovative Technology Summary Report)

Vendors & Technologies

The following is simply a sampling of the camera and inspection vendors and technologies available and is not intended as an endorsement of specific companies or products.

- GE Inspection Technologies - articulating fiberscopes
- Quintiq - Dragon Runner (surveillance crawler)

D&D KM-IT
Knowledge Management Information Tool

FX2 Advanced Fogging Technology

Dear Peggy,

Students at Florida International University (FIU), from the DOE-FIU Science and Technology Workforce Development Program (also known as DOE Fellows) have completed the testing and evaluation of an innovative technology in collaboration with research scientists at the FIU Applied Research Center (ARC), Idaho National Lab (INL), and Savannah River National Lab (SRNL).

DOE Fellows testing and evaluating an advanced fogging technology.

The FX2 Advanced Fogging Technology, developed at Idaho National Lab (INL) and patented in 2015, was tested and evaluated for potential implementation at the SRS 235-F facility. This technology is also relevant to D&D activities at other DOE sites and internationally. INL's FX2 fogging agent is a proprietary mixture of water, latex paint, glycerin, and sodium lauryl sulfate. During initial testing at INL in 2014, it displayed promising results at fixing potential airborne contamination, such as dust and lint, via cost effective remote application methods. FIU, in collaboration with INL and SRNL, expanded on these initial results with a scaled-up technology demonstration at FIU's testing and evaluation hot-cell mock-up.

Click here for additional information located on the D&D Knowledge Management Information Tool, including the FX2 Advanced Fogging Technology Testing and Evaluation Report, the Tech Fact Sheet, photographs, and videos.

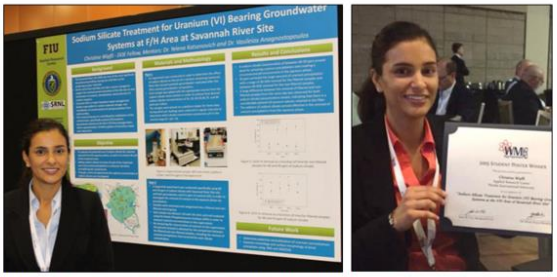
Figure 32. Newsletters on cameras and inspection technologies (left) and advanced fogging technology (right).

D&D KM-IT
Knowledge Management Information Tool

STEM Student Participation at WM2016
|FACEBOOK:LIKE|

Dear *|FNAME|*, will you *be attending Waste Management 2016? Be sure to take advantage of the opportunities to meet the next generation of scientists and engineers that will continue moving our industry forward into the future. You will be able to meet and see these students in action throughout the WM conference: participating in the WMS Student Exhibition/Competition, working as student assistants in the various sessions and panels, participating in the Student/Industry Reception on Monday evening, representing and speaking on behalf of their generation in panel session 42, and enjoying WM16 in general.*

Student Poster Exhibition/Competition - Students from colleges and universities from across the United States will be presenting their research topics during the Student Poster Exhibition/Competition on Monday afternoon (Session 031) of the conference in the Exhibit Hall. All posters will remain on display through Wednesday of the conference.



WM15 Student Poster Winner - Christine Wipfli (DOE Fellow)

Student/Industry Reception - Student/Industry Reception - WMS will be hosting a special student reception on Monday evening (6 pm - 8 pm) to promote interaction between the student attendees and industry representatives. Everyone is encouraged to attend and talk to some of the brightest and most accomplished science, technology, engineering, and mathematics (STEM) students as they approach the completion of their education and look forward to starting their professional careers.

Student Panel Session 42 - In panel session "Graduating Scientists and Engineers:

opportunity to connect and interact with students participating in WM16.

The Waste Management Symposia provides an excellent forum for government and industry to meet and greet the next generation of scientists and engineers that will continue moving our industry forward into the 21st Century. WMS provides an excellent opportunity for the "next generation" to learn first-hand the industry's challenges. So take the time to meet some of these great students and share your experiences, knowledge, and lessons learned. You will be amazed at the readiness and eagerness of these students to learn and find solutions to our industry's most difficult challenges. Florida International University's Applied Research Center is proud to join WMS in welcoming the next generation of scientist and engineers to the 2016 Waste Management Symposia.

FIU DOE Fellows at FIU booth during WM15 Exhibit Hall

Meet the "next generation"

Visit the Florida International University's booth (#409) to learn more about STEM student research fueling DOE-EM projects like the D&D KM-IT.

WM2016 CONFERENCE
MARCH 6 - 10, 2016
PHOENIX CONVENTION CENTER

WM Symposia 2016
March 6-10, 2016
Phoenix, Arizona
#WMS2016

Figure 33. Student participation at Waste Management 2016.

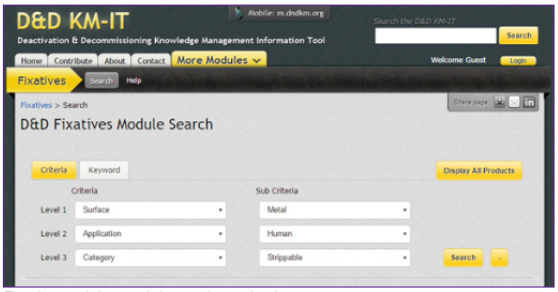
D&D KM-IT
Knowledge Management Information Tool

D&D Fixative Module Now Available *|FACEBOOK:LIKE|*

Dear *|FNAME|*,

Fixatives, strippable coatings, and decontamination gels are contamination control products that have been used by DOE and the commercial nuclear industry for decades to minimize contamination on radioactive surfaces and fix contamination in place. A *fixative* product functions as a permanent coating to stabilize residual loose/transferrable radioactive contamination by fixing it in place; this aids in preventing the spread of contamination and reduces the possibility of the contamination becoming airborne, reducing workforce exposure and facilitating future D&D activities. *Strippable coating* products are used for their decontamination abilities. They are applied to surfaces with loose/transferrable radioactive contamination and peeled off once dried, removing loose/transferrable contamination along with the product and significantly reducing the residual radioactive contamination on the surface. *Decontamination gels* work in much the same way as other strippable coatings. The results obtained through the use of these products is variable and depends on the type of substrate, the selected contamination control product, the contaminants, and the environmental conditions (e.g., temperature, humidity, etc.).

A D&D Fixative Module is now available on the D&D Knowledge Management Information Tool (D&D KM-IT) to assist in the selection of commercially available fixatives, strippable coatings, and decontamination gels for application during D&D activities. The module includes a comprehensive database of commercially available fixatives and other contamination control products and is capable of filtering and sorting the available products according to the criteria entered by the user. The initial product list was from the former DOE Hanford ALARA Center. This list was reviewed in order to eliminate products which were discontinued or not commercially available and a search was conducted to add newer commercial products which fit the criteria.



Fixative module search by product criteria.

Benefits of the D&D Fixative Module include:

D&D KM-IT
Knowledge Management Information Tool

Solar Power in the Southeastern United States *|FACEBOOK:LIKE|*

Dear *|FNAME|*,

Solar energy generation has been widely studied in the western United States, but not many studies have been conducted for the southeastern region. An analysis was performed to better understand the seasonal variations of photovoltaic (PV) power generation, its availability when it is most needed in the power grid, and the difference in electricity yield between single-axis tracking systems and optimally tilted fixed axis panels.

The efficiency of photovoltaic (PV) systems greatly depends on geographic location and system configuration; this efficiency is increased with tracking systems which follow the sun as its position changes throughout the day (single-axis), and also throughout the year (double-axis). Data from Colleton Solar Farm, located in Walterboro, South Carolina, was analyzed, including a total of 10,010 PV modules, of which 60% of the panels (6,006) were on a fixed axis with a latitude tilt of 25˚ and 40% of the panels (4,004) were on a single-tracking axis with a horizontal (parallel to the ground) orientation (Figure 1).

An analysis to compare the difference in energy generation between the fixed panels and the single-axis panels concluded significantly more electricity (22%) was produced by the single-axis tracking panels during the warmer months, April through August. During the colder months, November through February, the amount of power generation was similar, with the fixed panels generating slightly more. One suggestion to improve the generation output of the tracking panels in wintertime is to tilt the panel at an optimal angle towards the south to increase the solar radiation incident (Figure 2).

An analysis of peak power generation and peak power demand was also performed to understand whether or not PV energy is being generated when it is most needed. A strong direct correlation between power generated and electricity demand (ρ>0.70) suggested that peak PV power generation coincides with peak demand. A strong direct correlation can be observed in the summer months, from April to October, and almost no correlation is observed in the other months. This indicated that during the summer, PV energy is delivered to the power grid when it is most needed, making the renewable source of energy more valuable since it aids the grid when the electricity cost per kWh is more expensive to generate.

Figure 34. Announcement of new Fixative Module available on D&D KM-IT (left) and newsletter on solar power in the southeastern U.S. (right).

Wikipedia

D&D knowledge management through contributions in Wikipedia was a part of the outreach and training (D&D community support) subtask. FIU completed the related milestone, 2015-P3-M3.4, and sent a draft summary report to DOE on April 15, 2016. The general D&D knowledge which has been gained through this project offers an opportunity to expand access to a broad audience via Wikipedia, which has a significant presence on the web, thereby offering greater opportunities for collaboration on D&D knowledge. FIU researched and targeted D&D information on Wikipedia where D&D KM-IT could provide additional relevant information while citing the source of the original information on D&D KM-IT.

During the completion of this task, four Wikipedia articles were edited with information. For each of these articles, relevant and significant text was added to the body of the article and a reference to the information source on D&D KM-IT was included. The edited entries included the following Wikipedia articles with the displayed text:

1. **Nuclear Decommissioning – Cost Section** with information from the best practice titled, "SRS P and R Reactor Disassembly Basin *In Situ* Decommissioning."

   New methods for decommissioning have been developed in order to minimize the usual high decommissioning costs. One of these methods is *in situ* decommissioning (ISD), which was implemented at the U.S. Department of Energy Savannah River Site in South Carolina for the closures of the P and R Reactors. With this tactic, the cost of decommissioning both reactors was $73 million. In comparison, the decommissioning of each reactor using traditional methods would have been an estimated $250 million. This results in a 71% decrease in cost by using ISD.

2. **Occupational Safety and Health – Hazard Identification Section** with information from the following best practice: "Historical Hazard Identification Process for D&D." The reference linking back to the best practice document on D&D KM-IT was subsequently removed by another Wikipedia editor. It is important to note that the information available on wikis is continually evolving and may be further edited by other participants at any time. FIU has further edited the entry to add the title and link to the best practice under the Further Reading section of the Wikipedia entry.

   The information that needs to be gathered from sources should apply to the specific type of work from which the hazards can come from. As mentioned previously, examples of these sources include interviews with people who have worked in the field of the hazard, history and analysis of past incidents, and official reports of work and the hazards encountered. Of these, the personnel interviews may be the most critical in identifying undocumented practices, events, releases, hazards and other relevant information. Once the information is gathered from a collection of sources, it is recommended for these to be digitally archived (to allow for quick searching) and to have a physical set of the same information in order for it to be more accessible. One innovative way to display the complex historical hazard information is with a historical hazards identification map, which distills the hazard information into an easy to use graphical format.

3. **Robotics – Applications Section** with information about the use of robotics for D&D.

   Another application area for robotics that is receiving increased interest is in the effort to deactivate and decommission (D&D) unnecessary and/or unusable facilities across the U.S. Department of Energy (DOE) complex. Many of these facilities pose hazards which prevent the use of traditional industrial demolition techniques. Such hazards include radiological, chemical, and hazardous materials contamination and structural instability. Efficient and safe D&D of the facilities will almost certainly require the use of remotely operated technologies to protect personnel and the environment during potentially hazardous D&D activities and operations. One database, developed by DOE, contains information on almost 500 existing robotic technologies and can be found on the D&D Knowledge Management Information Tool.

   Radioactive Contamination – Decontamination with information about fixatives and other contamination control products.

   Contamination control products have been used by the U.S. Department of Energy (DOE) and the commercial nuclear industry for decades to minimize contamination on radioactive equipment and surfaces and fix contamination in place. "Contamination control products" is a broad term that includes fixatives, strippable coatings, and decontamination gels. A fixative product functions as a permanent coating to stabilize residual loose/transferrable radioactive contamination by fixing it in place; this aids in preventing the spread of contamination and reduces the possibility of the contamination becoming airborne, reducing workforce exposure and facilitating future deactivation and decommissioning (D&D) activities. Strippable coating products are loosely adhered paint-like films and are used for their decontamination abilities. They are applied to surfaces with loose/transferrable radioactive contamination and then, once dried, are peeled off, which removes the loose/transferrable contamination along with the product. The residual radioactive contamination on the surface is significantly reduced once the strippable coating is removed. Modern strippable coatings show high decontamination efficiencies and can rival traditional mechanical and chemical decontamination methods. Decontamination gels work in much the same way as other strippable coatings. The results obtained through the use of contamination control products is variable and depends on the type of substrate, the selected contamination control product, the contaminants, and the environmental conditions (e.g., temperature, humidity, etc.).

Powerpedia

DOE established a department-wide wiki, *Powerpedia*, in early 2010 to facilitate knowledge capture and collaboration, increase efficiency, increase transparency, and connect people and information together. During FIU Performance Year 6, FIU provided information to DOE to enhance two entries on their internal Powerpedia system: *Green and Sustainable Remediation* and the *D&D Knowledge Management Information Tool*.

Infographics

FIU also developed a set of infographics for use in sharing knowledge and information about the DOE EM Cooperative Agreement and the research being performed at FIU for DOE EM. The first one to be developed was for the DOE-FIU Science and Technology Workforce Development Program. A second infographic was developed to provide an overview of the DOE

EM Cooperative Agreement. After several reviews at FIU and DOE and subsequent revision iterations, these infographics were revealed during the FIU Research Review presentations in April 2016. FIU subsequently completed an initial draft of a new infographic on the topic of knowledge management (KM), including the importance of KM and highlighting examples from KM-IT. The draft infographic was sent to DOE for review and input on August 8, 2016. An image of the draft infographic on KM is included below.

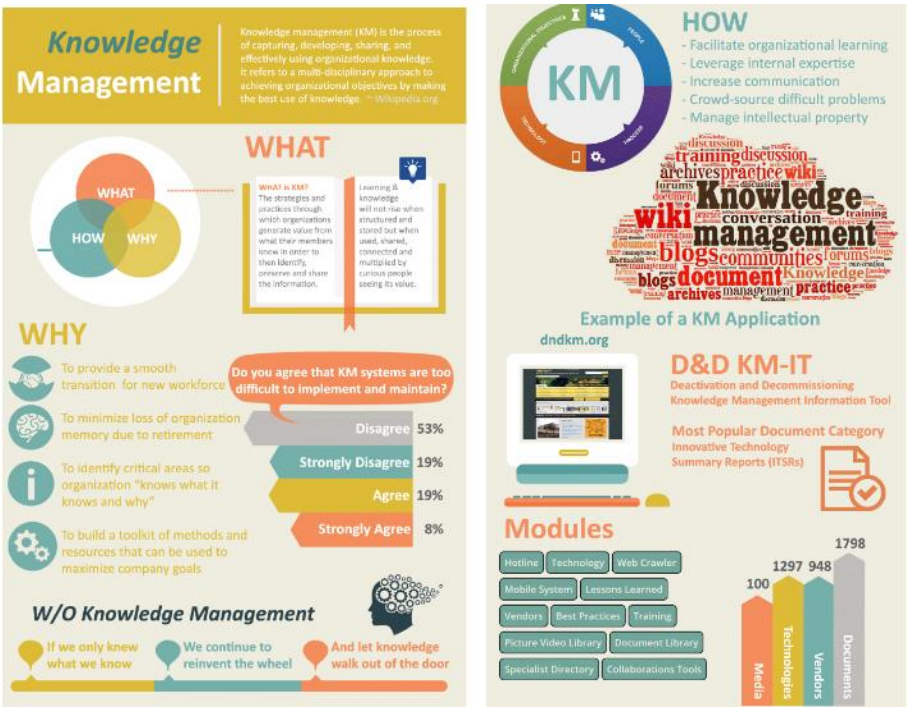


Figure 35. Draft infographic on knowledge management.

Case Study for IAEA

FIU supported the completion of a draft case study on D&D KM-IT at the request of DOE for an International Atomic Energy Agency (IAEA) report titled, *Challenges and Approaches to Knowledge Management for Decommissioning and Environmental Remediation*. The IAEA report provides guidance to decision makers in government and private industry, including regulators, facility operators and contractors. It covers the planning, implementation and sustenance of critical nuclear and institutional knowledge necessary for the safe and efficient management of decommissioning and environmental remediation projects. The draft case study on D&D KM-IT was sent to IAEA by DOE on March 22, 2016.

Application Development

During FIU Performance Year 6, FIU added features to the D&D KM-IT application and maintained the system for the D&D community.

D&D Fixative Module

The FIU team completed the development of a desktop and mobile web application for the D&D Fixative Module. The latest Bootstrap framework was used to develop the front-end tier of the application for the home screen and summary search. FIU developed the DSS model and implemented the application on a Microsoft.Net platform. The fixatives database was developed

by defining criteria, sub-criteria, and product information with three levels for the selection and search processes using a SQL server database. The data tables and relationships were established for all the entities (criteria, sub-criteria, and products). The database was developed in SQL Server Management Studio. The tables were constructed by taking each entity into consideration; each entity is a table with its attributes as columns and the values of the attributes as rows. The relationship between these tables is specified in the database and required settings were defined. The data was then loaded to the tables in the database. Stored procedures were written based on the type of desired results from the decision support model (stored procedures are a set of SQL statements that need to be written once and stored in the database for easy access and data integrity). The stored procedures were then tested.

The design of the web/mobile design with the Bootstrap framework was developed to fit to the D&D KM-IT theme. The code in the framework was developed to have the drop-down menus reflect the user's selections. Once completed, the backend work, such as linking the database to the design of the website, was performed.

The FIU team completed the development of the desktop D&D Fixative Module and deployed it on the test server for DOE review on January 15, 2015 (milestone 2015-P3-3.2). FIU also completed milestone 2015-P3-M3.5, deployment of a pilot mobile application for the D&D Fixative Module on D&D KM-IT on May 20, 2016, and sent to DOE for review and testing.

The FIU team incorporated revisions to the web-based decision support model for fixatives based on comments received from DOE, including the addition of a product disclaimer statement and the removal of product cost information. FIU then sent a link to the pilot web-based fixative module to a selected individuals at DOE sites and national laboratories for beta testing. Comments and input from the beta testers was received and FIU completed the incorporated of beta testing feedback to improve the tool before launching it on the public server. FIU also designed and developed a mobile application for this tool, which was sent to DOE for review and testing on May 20, 2016, completing milestone 2015-P3-M3.5. Where the beta testing feedback was relevant to the light version of the D&D Fixative Module for mobile devices, FIU also incorporated the feedback into the mobile version.

The D&D Fixative Module can assist in the selection of commercially available fixatives, strippable coatings, and decontamination gels for application during D&D activities. The model includes a comprehensive database of commercially available fixatives and other contamination control products and is capable of filtering and sorting the available products according to the criteria entered by the user. The initial product list was from the former DOE Hanford ALARA Center. This list was thoroughly reviewed in order to eliminate products which were discontinued or not commercially available and an extensive search was conducted to add newer commercial products which fit the criteria. Manufacturers were also contacted to update the product list.

Benefits of the D&D Fixative Module include:

1. Cuts down research time to identify contamination control products to use depending on site-specific conditions.
2. Provides an instant overview of the commercially available products filtered and sorted for the criteria entered.

3. Provides access to concise information on over 40 commercially available contamination control products.
4. Can be easily expanded to include more criteria or newly available products.

Both the web-based (https://www.dndkm.org/FixativeModule/) and mobile (https://m.dndkm.org/FixativeModule.aspx) versions of the D&D Fixative Module were deployed live on June 29, 2016. Figures 36 through 40 show screenshots of the web-based and mobile web applications for the fixative module.

Figure 36. Fixative module home page.

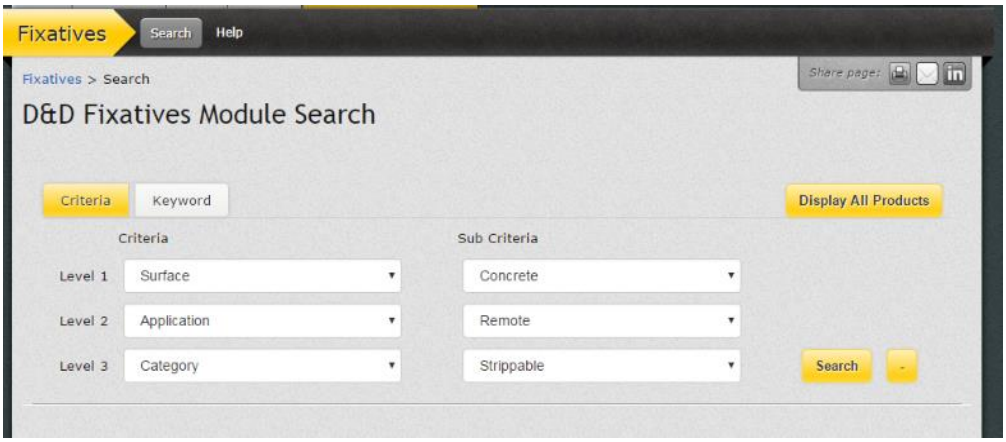


Figure 37. Fixative module search by product criteria.

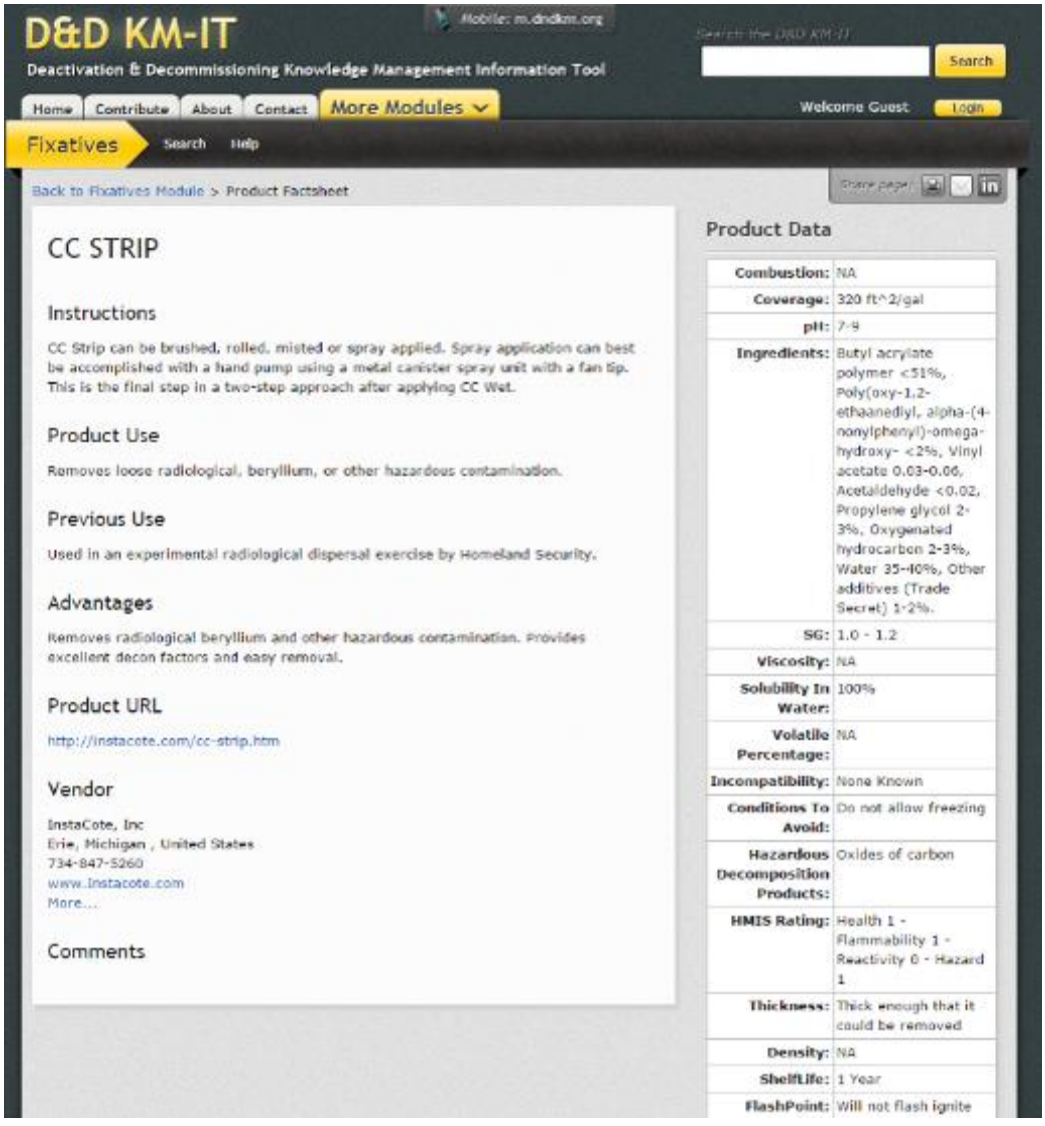


Figure 38. Fixative module sample product factsheet.

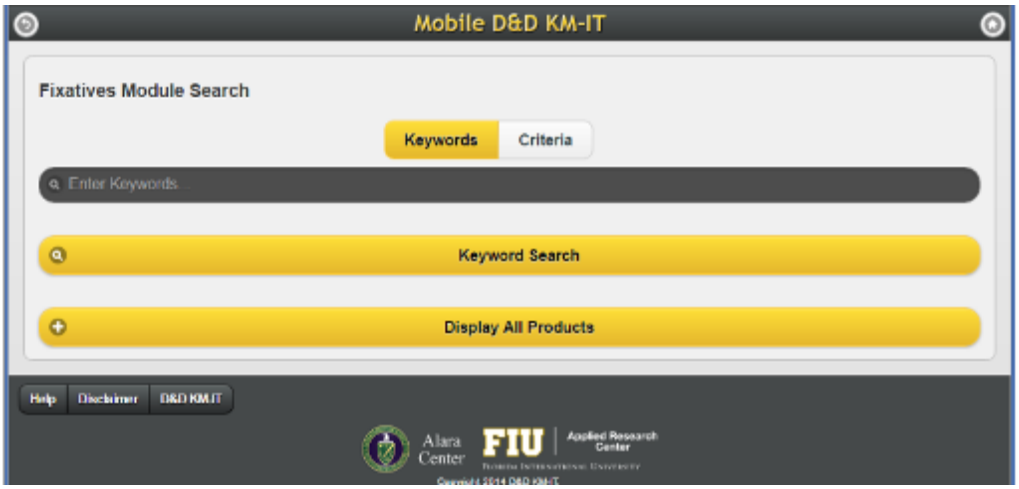


Figure 39. Fixative mobile app homepage.

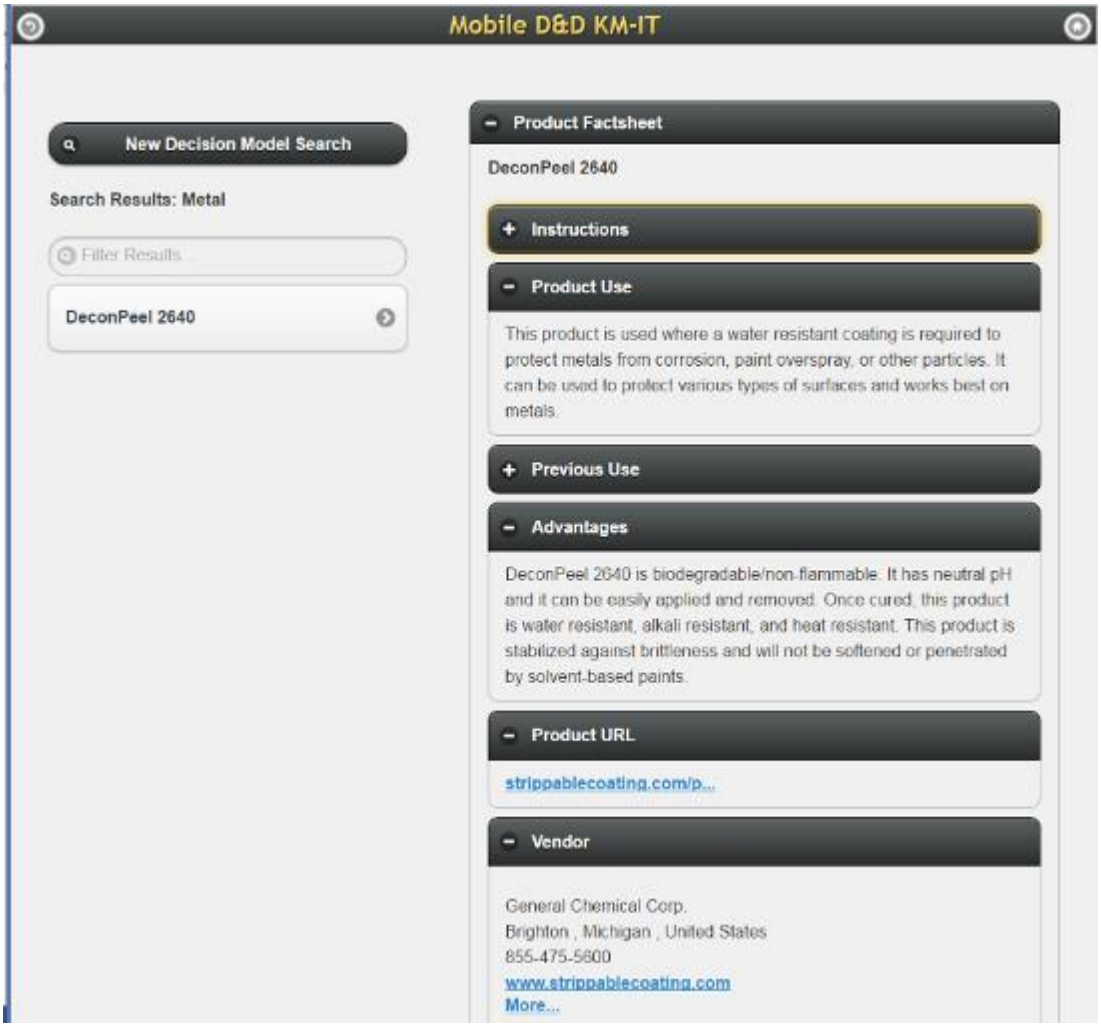


Figure 40. Fixative mobile app sample product factsheet.

International KM-IT Pilot

FIU completed of development and integration of the Global Knowledge Sharing Platform (for collaboration with the United Kingdom), FIU milestone 2015-P3-M3.3, and sent the link to DOE for their review on March 4, 2016 (Figure 41).

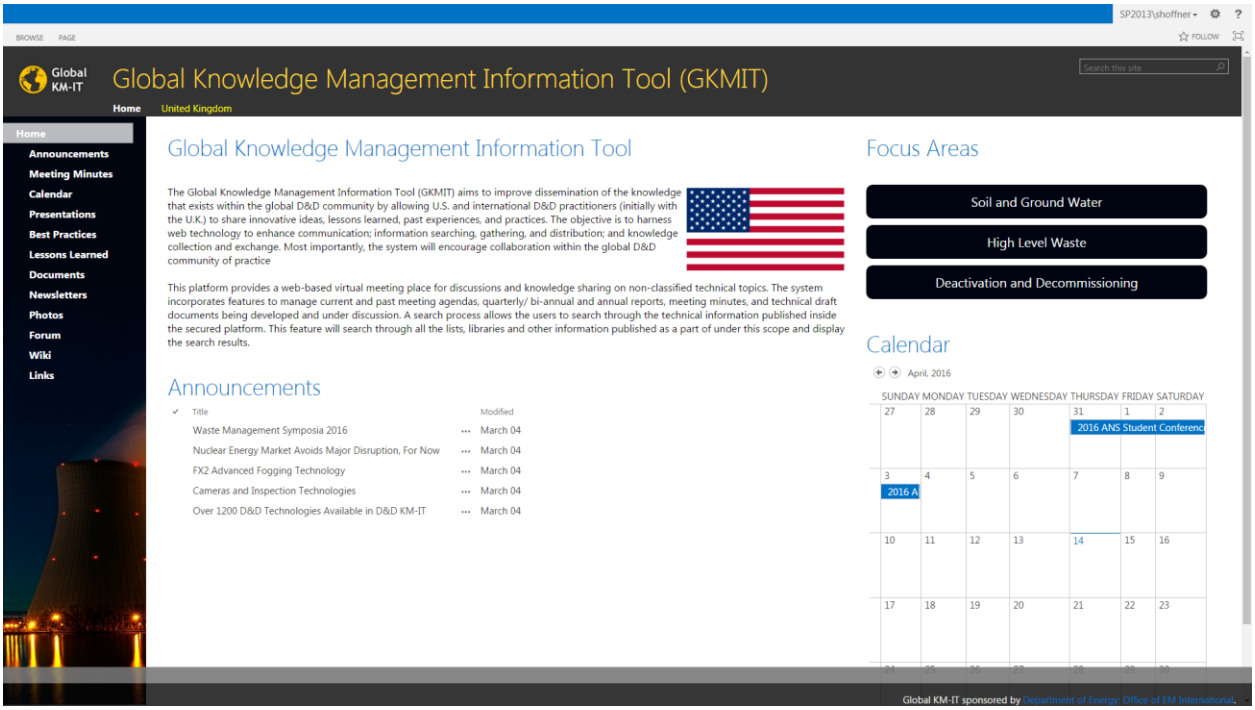


Figure 41. Screenshot of the Global Knowledge Management pilot.

The platform was developed based on the protocols and standards for knowledge sharing of non-classified information with a focus on the U.K. and includes features like Newsletters, Meeting Minutes, Technology, Lessons Learned, Best Practices, Documents, Announcements, Calendars, Link, FAQ, Wikis, etc. The Global Knowledge Sharing Platform aims to improve dissemination of the knowledge that exists within the global D&D community by allowing U.S. and international D&D practitioners (initially with the U.K.) to share innovative ideas, lessons learned, past experiences, and practices. The objective is to harness web technology to enhance communication; information searching, gathering, and distribution; and knowledge collection and exchange. Most importantly, the system will encourage collaboration within the global D&D community of practice. A search process allows the users to search through the technical information published inside the secured platform. This feature will search through all the lists, libraries and other information published as a part of under this scope and display the search results.

Administration

System, database, and network administration are ongoing activities that FIU undertakes to maintain servers and applications to ensure a consistent high level of performance. FIU continued these efforts during this reporting period. System administration included the day-to-day maintenance and administration of the D&D KM-IT servers. Major tasks involved load balancing, active directory accounts, security patches, operating system updates, system optimization, server monitoring, and emergency problem resolution. Database administration

included database backup, optimization, performance tuning, system security, controlling and monitoring user access to the database, and maintaining the database cluster. Finally, the network administration involved monitoring the network and server traffic, installing and maintaining the network hardware/software, assigning addresses to computers and devices on the network, troubleshooting network activities and performance tuning.

Data Mining

Vendors and Technologies

DOE Fellows and FIU graduate students performed data management activities in order to add current and relevant data to the D&D KM-IT System. Their efforts included identifying and adding additional D&D vendors and technologies from industry journals, conference publications, and news announcements as well as researching additional relevant D&D technologies offered by existing vendors. As of the end of August 2016, the Vendor module included a total of 948 vendors, an increase of 39 (4.3%) since August 2015, and the Technology module included a total of 1297 technologies, an increase of 65 (5.3%). Over the same timeframe, the number of registered users increased by 175 (23.5%) to 919 and the number of subject matter specialists increased by 15 (17.4%) to 101.

News

FIU explored potential sources of information for D&D related news and is gathering and updating D&D KM-IT with D&D related news around the globe from multiple news sources. Figure 42 shows a screen shot of the industry news displayed on the homepage of D&D KM-IT.

Figure 42. Industry news links displayed on homepage of D&D KM-IT.

TASK 3: CONCLUSIONS

Planning for the D&D of facilities across the DOE complex is a tremendous undertaking, especially considering that a significant number of the facilities contain hazards to human health and the environment: seriously deteriorated structural integrity, very high dose rates, high levels of fixed and removable contamination on/in facility surfaces and equipment, and chemically hazardous materials. Capturing the knowledge, experience, and lessons learned from historic D&D activities at DOE sites is imperative to the successful and safe management of future D&D

projects. The D&D Knowledge Management and Information Tool is a central initiative to accomplish these goals.

TASK 3: REFERENCES

D&D Knowledge Management Information Tool (D&D KM-IT), www.dndkm.org, Applied Research Center, Florida International University.

Florida International University, *D&D Knowledge Management through Contributions in Wikipedia*, Summary Report, April 27, 2016.

Quintero, W., *Web Analytics Narrative Report for D&D KM-IT: Second Quarter 2015 (July 1 to Sept 30, 2015)*, Applied Research Center, Florida International University.

Quintero, W., *Web Analytics Narrative Report for D&D KM-IT: Third Quarter 2015 (July 1 to Sept 30, 2015)*, Applied Research Center, Florida International University.

Quintero, W., *Web Analytics Narrative Report for D&D KM-IT: Fourth Quarter 2015 (Oct 1 to Dec 31, 2015)*, Applied Research Center, Florida International University.

Quintero, W., *Web Analytics Narrative Report for D&D KM-IT: First Quarter 2016 (Jan 1 to March 31, 2016)*, Applied Research Center, Florida International University.

Quintero, W., *Web Analytics for D&D KM-IT for Calendar Year 2015*, Applied Research Center, Florida International University.

Upadhyay, H., L. Lagos, W. Quintero, P. Shoffner, J. De Gregory. *Robotics Technologies on Knowledge Management Information Tool (KM-IT) Platform*, Waste Management 2016 Conference, Phoenix, AZ, March 2016.

OVERALL PROJECT CONCLUSIONS

WIMS continues to successfully accomplish the goals and objectives set forth by DOE for this project. WIMS has replaced the historic process of each DOE site gathering, organizing, and reporting their waste forecast information utilizing different database and display technologies. In addition, WIMS meets DOE's objective to have the complex-wide waste forecast information available to all stakeholders and the public in one easy-to-navigate system. The enhancements to WIMS made over the last year include annual updated data sets.

The D&D support work for this period of performance included testing and evaluation of intumescent coatings technologies with the objective of enhancing the stabilization of radioactive contamination under fire and extreme heat conditions; completing development of a fixative module to better guide end users on the selection of appropriate strippable and fixative coatings based on their specific site needs; closing out the fogging research and evaluation effort in collaboration with INL; working with ASTM International E10 Committee on Nuclear Technologies and Applications to begin development of testing protocols and performance metrics for testing and evaluating D&D technologies; and performing a search for robotic technologies with possible application to the area of D&D. These activities provide DOE with the information necessary to complete D&D safely and effectively for facilities which contain hazards that prevent the use of safe manual techniques; enhance safety while reducing risk to workers, the public, and the environment; reduce the future cost, schedule, and risk for similar work through a thorough understanding of existing technologies and technical approaches from past D&D projects, and provide the tools necessary to successfully complete difficult D&D tasks that can then be applied complex-wide to similar DOE facilities.

Planning for the D&D of facilities across the DOE complex is a tremendous undertaking. Capturing the knowledge, experience, and lessons learned from historic D&D activities at DOE sites is imperative to the successful and safe management of future D&D projects. The DOE D&D support task and the D&D KM-IT are two central initiatives to accomplish these goals and FIU has made significant contributions towards developing these tools. The D&D KM-IT system was developed by FIU in collaboration with DOE, EFCOG, and the former ALARA Center at Hanford and former ISSC at Savannah River. The D&D KM-IT system is ultimately a tool for and by the D&D community. Its success will be dependent on the participation and cooperation of those for whom it was designed. FIU will continue to work closely with DOE and the D&D community to ensure that the KM-IT system meets their needs for accurate and timely D&D information.

APPENDIX

The following reports are available at the DOE Research website for the Cooperative Agreement between the U.S. Department of Energy Office of Environmental Management and the Applied Research Center at Florida International University: http://doeresearch.fiu.edu

1. Florida International University, *Incombustible Fixatives – Adapating Intumescent Coatings as Fire Retardant Fixatives to Support D&D Activities*, Technical Progress Report, June 2016.
2. Florida International University, *Robotic Technologies for the SRS 235-F Facility*, Technical Progress Report, August 2016.
3. Florida International University, *D&D Knowledge Management through Contributions in Wikipedia*, Summary Report, April 2016.
4. Florida International University, *Project Technical Plan*, Project 3: Waste and D&D Engineering and Technology Development, October 2015.