Decision Point 1

of

Statement of Project Objectives (SOPO)

TOPICAL REPORT

April 2011

Task 30.1.2

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"Recovery Act: Development of ITM Oxygen Technology for Integration with Advanced Industrial Systems"

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Disclaimer

ABSTRACT

Air Products is designing, building, and operating a ceramic membrane fabrication facility (the "CerFab") to enable production of membrane modules to supply a conceptual 2000 ton per day (TPD) ITM Oxygen facility (the "ITM Oxygen Development Facility"). Air Products is executing this project under the American Recovery and Reinvestment Act (ARRA) with the objective to accelerate the adoption of ITM Oxygen technology to help meet the country's goals for deploying clean power plants. The objective of this Topical Report is to address the requirements of Decision Point 1, which pertains to the Site Selection for the CerFab. Air Products with subcontractor Ceramatec, Inc., has determined a ceramic membrane module manufacturing process and the building and site requirements of the process consistent with the manufacturing objectives of the ITM Oxygen development program and this ARRA project. Based on cost estimates for new construction and refurbishments of existing sites, Air Products chose to consider only existing buildings rather than new construction. The Salt Lake City, Utah, region was selected as the preferred location for the CerFab to enable Ceramatec, Inc., to support the Phase V project and on-going Phase III development activities. Twenty available properties were screened in this region, from which one property emerged clearly as the most suitable property to house the CerFab. The site meets the requirements of the CerFab in terms of floor space, power and other utilities, and building structural features. The site also meets criteria for ease of obtaining the requirement environmental permits, and is within the project cost allocation for the building site. Moreover, the site formerly housed a manufacturing company that ceased operations in 2010 as a result of the economic recession of 2008-9; the region of the site has experienced more than a doubling of the unemployment rate since 2007. Re-starting a manufacturing operation in the same facility will return employment to the area, consistent with the goals of the ARRA. Air Products recommends proceeding with procuring this preferred site and continuing to execute Task 30.1 to establish the CerFab at the site.

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Executive Summary

Air Products is executing this Recovery Act project with the objective to accelerate the adoption of ITM Oxygen technology to help meet the country's goals for deploying clean power plants. As part of this objective, Air Products is designing, building, and operating a ceramic membrane fabrication facility (the "CerFab") to enable production of membrane modules to supply a conceptual 2000 ton per day (TPD) ITM Oxygen facility (the "ITM Oxygen Development Facility").

The objective of this Topical Report is to address the requirements of Decision Point 1 (DP1) of the above-referenced SOPO which pertains to the Site Selection for the CerFab. The intent of the DP1 is to provide the opportunity for DOE-NETL to review the site details and facility requirements before the site is procured. DP1 entails two main elements:

1. A report on the preferred process scheme developed under Task 30.1.1 as it pertains to site selection; and
2. The suitability of the selected site to meet the needs of subsequent tasks and to meet requirements for NEPA approval.

Air Products, working with subcontractor Ceramatec, Inc., (Salt Lake City, Utah), has developed a preferred process scheme for ceramic membrane module production based on conventional ceramic processing techniques and previous development work under Phase III of the Cooperative Agreement. All of the manufacturing steps have been developed previously in a prototype Process Development Facility (PDF) established under the Cooperative Agreement. The PDF is currently sized only to meet the goals of the Phase III development work which culminates in the operation of a 100 TPD pilot plant.

The CerFab represents scale-up of the overall process and some of the equipment to achieve a production capacity consistent with supplying the 2000 TPD ITM Oxygen Development Facility. Supporting development work under Phase III and Task 28.0 will enable the implementation of effective processing steps in the CerFab. Equipment and equipment layout for the preferred process scheme have been specified based on the preliminary conceptual process developed by Ceramatec. Labor, materials, and utility requirements have been determined; a Building Project Definition was generated from these requirements. Air Products received estimates from contractors based on the Building Project Definition and concluded that the most cost-effective solution is to lease an existing facility and modify it for the purposes of housing the CerFab, rather than building on a greenfield site.

Based primarily on the need to establish the CerFab in close proximity to Ceramatec to enable Ceramatec to support both Phase III and Phase V activity, Air Products, through a local real estate firm, obtained a survey of facilities available for lease in the Salt Lake City region. Twenty sites were considered.

A single site met nearly all criteria for the CerFab project. The site, which is located within 40 minutes' drive of Salt Lake City, includes a building that had formerly been a furniture manufacturing facility until the owners had closed operations because of poor economic conditions during the recession in 2008-9. The building has the required square footage, and is already outfitted with many of the required utilities, including power feeds, HVAC, and fire protection. The existence of the building infrastructure will save the project infrastructure cost. Air Products has begun negotiations with the owner and has been successful in negotiating a lease rate within the Phase V project estimated lease rate, including real property taxes. (Separately, Air Products has applied for tax relief on some aspects of the costs of the CerFab through the state of Utah that will benefit the overall project through lowered state and local taxes.) Local economic conditions have deteriorated significantly during the recession of 2008-2009 with current unemployment rates nearing 9%; the location of the CerFab in this region is expected to have a very positive impact on employment in the local community.

Finally, Air Products has established that the site is highly likely to receive the required environmental permitting required for operating the CerFab facility. Air Products prepared a draft NEPA application with aid from its national environmental consultant. All of the data required to complete the NEPA questionnaire has been assembled based upon the selected site and the current definition of the proposed production process (together with proposed pollution control equipment and procedures). Key among the findings that substantiate the conclusion that the proposed site will meet any and all permitting requirements include the fact that the CerFab operation, owing to its projected emissions of Volatile Organic Compounds (VOCs) of only 1.8 metric tons/year with Hazardous Air Pollutants (HAPs) at 0.67 metric tons/year, will be considered a small (minor) source. Construction permits are not required, as no ground-disturbing construction will occur at the site. The site is in an existing Industrial Complex which is already zoned for Heavy Industrial use and is not in an environmentally sensitive area. The formal opinion of the environmental consultant is that the site will obtain approval under the Categorical Exclusion provision in NEPA.

Report Details

A. Introduction – Recovery Act Objectives and Decision Point 1

The objective of this project is to accelerate the adoption of ITM Oxygen technology by developing and constructing systems and infrastructure that will enable manufacturing of ITM membrane modules and the integration of the ITM technology toward deployment at industrial-energy plant scales. This objective includes the optimization of the materials processing technology and refinement of the module fabrication techniques to supply a conceptual 2000 ton per day (TPD) ITM oxygen facility (the "ITM Oxygen Development Facility"). The objective further includes the operation of the fabrication facility that demonstrates the capability of producing components and devices for separating oxygen from air and oxygen-containing streams. The key metrics for this effort include:

- Development of materials processing techniques and capacity to supply ceramic modules that meet specifications (each module capable of producing 1 TPD of oxygen) in support of the oxygen production goals for the ITM Oxygen Development Facility;
- Development of module designs and manufacturing techniques to enable reliability of constructed and individual modules that are capable of supplying the ITM Oxygen Development Facility;
- Development of integrated infrastructure, facilities, and quality control to enable constructed modules to be supplied to the ITM Oxygen Development Facility; and
- Development of a process design and appropriate budgetary cost for the ITM Oxygen Development Facility that meets scale-up and operational needs for a pre-commercial unit that supports the goals of the DOE NETL Gasification Program and Industrial Carbon Capture and Storage (ICCS) Program.

This development and construction effort will occur concurrently with the Phase III effort to construct and demonstrate a 100 TPD Intermediate Scale Test Unit (ISTU) of an Oxygen separation plant and pursuant to the objectives and provisions of the American Recovery and Reinvestment Act (the "ARRA").

The objective of this Topical Report is to address the requirements of Decision Point 1 (DP1) of the above referenced SOPO. The requirements of DP1 are referenced under Task 30.1.2.1 of the SOPO, entitled "Site Development (Air Products, Ceramatec)". For ease of reference, the entire text of Task 30.1.2.1 is referenced below.

"**30.1.2.1 Building Specification and Site Selection (Air Products, Ceramatec)** - Air Products will specify a building and required building infrastructure to house the ceramic manufacturing process equipment. Ceramatec will specify a preferred ceramic processing equipment layout in the building. Air Products will identify a suitable U.S. domestic site.

DECISION POINT 1 – Prior to Initiating Task 30.1.2.2
There shall be Decision Point prior to procuring the ceramic manufacturing site under task 30.1.2.2 based on the suitability of the site selected under task 30.1.2.2 and the preferred process scheme developed under 30.1.2.2. The Recipient shall submit a "Decision Point Application" directly to the DOE Project Officer and the DOE Contract Specialist no later than 30 days prior to the beginning task 30.1.2.2. The Decision Point Application shall include the following information:

1. A report on the preferred process scheme developed under Task 30.1.1 as it pertains to site selection; and
2. The suitability of the selected site to meet the needs of subsequent tasks and to meet requirements for NEPA approval.

The decision to proceed into task 30.1.2.2 will be based on the DOE's review of the technical accomplishments of tasks 30.1.1 and 30.1.2.1 programmatic changes and/or the availability of funding. If, at the time of the Decision Point, it is advantageous to the Government to continue the project, as determined by the sole discretion of the DOE, the DOE Contracting Officer shall decide whether or not to continue with Task 30.1.2.2 and shall notify the Recipient in writing in a timely notification. Work on Task 30.1.2.2 shall not begin in the absence of written approval by the Contracting Officer. In the event the DOE does not grant a favorable determination, the Contracting Officer shall notify the Recipient in writing of such decision. The DOE reserves the right to de-obligate any funds obligated to Phase V of the Cooperative Agreement pertaining to Task 30.1.2.2."

B. Supporting Information

1. A report on the preferred process scheme developed under Task 30.1.1 as it pertains to site selection

1.1 Design Basis Analysis

i. Current capabilities

Air Products is currently carrying out Phase III of the Cooperative Agreement in which Air Products, through the efforts of its subcontractor Ceramatec, Inc., has established and is operating a prototype manufacturing process development facility (PDF) for the production of ceramic membrane components and modules in support of a major Phase III objective, operation of the 100 TPD ISTU. The PDF is comprised of industrial ceramic processing equipment in a range of equipment scales appropriate to the Phase III tasks of process development for the purposes of establishing process scale-up information and for supplying the various test apparatus including the ISTU with membrane modules. The PDF is operated as a production line and is currently sized for production rates consistent with supplying the ISTU during the course of Phase III, which concludes in March 2013. The PDF is also intensively used for research and development related to ceramic processing of ITM components. On-going tasks under Phase III include yield improvement of various steps and studying scale-up of thermal processing equipment, select powder processing steps, and ceramic tape featuring equipment.

ii. Phase V Supporting Tasks

As part of the Phase V SOPO, Air Products, Ceramatec, and Penn State are carrying out materials development tasks in support of the Phase V objectives listed above. These include Task 28.2, Advanced Module Development, and Task 28.3, Manufacturing Process Development and Scale-up, both of which seek to improve ceramic manufacturing by improving the design of the ceramic articles and improving the manufacturing processes, respectively. As developments from these tasks emerge and are qualified, they will be introduced into the fabrication facility project in a controlled manner.

1.2 Preferred Process Scheme

Ceramatec developed a scaled up process for the CerFab based on the development work completed in Phase III. The CerFab process represents an approximately ten-fold scale-up of

the pilot-scale module fabrication line developed under Phase III.

As shown in Figure 1, the proposed process consists of 12 sequential batch or semi-batch processing steps to transform the raw ITM powders into completed membrane modules ready for shipment.

1. The first 3 steps are Powder Processing operations performed upon the raw ITM powder materials only, including the key Calcining step required to obtain the desired membrane powder composition.
2. Steps 4-6 are Slip Preparation steps, during which the membrane powder is mixed with solvents, organic binders and plasticizers to form a pourable slip of the correct viscosity and composition.
3. Batches of slip are cast in step 7 to form continuous thin sheets of "green" tape which is formed on a moving-belt tape casting machine, during which much of the solvents are extracted to leave a dried tape which can be handled in downstream processing steps.
4. Tape Featuring (Step 8) utilizes mechanical-press and laser-etching processes to form components of the ITM wafer structure, which are subsequently assembled in the following lamination step into complete wafers.
5. The final 3 steps of the process are the Thermal Processing steps carried out in high-temperature furnaces where the assembled wafers are first sintered to densify the ceramic materials, and subsequently assembled into sub-modules and then finally completed modules ready for packaging.

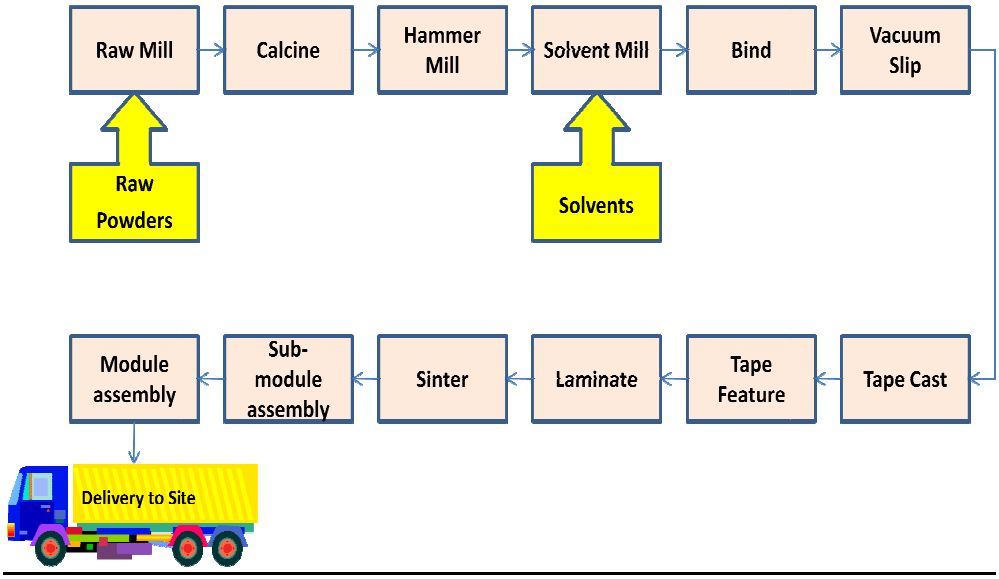

Figure 1. Schematic of a ceramic-processing scheme proposed for the CerFab.

Based upon a provisional simulation of the proposed manufacturing process for the ceramic membrane manufacturing facility ("CerFab"), Ceramatec developed a preliminary facility layout in order to determine the manufacturing floor-space required by CerFab. This layout was based on quotations received for specific machinery selected for the proposed fabrication processes. Office and support space requirements were also developed based on manning requirements (both technical

and production staff) developed to support the fabrication process. Overlayed on the preliminary facility layout were utility requirements (positions and routings) needed to support the fabrication process equipment, including electrical, natural gas, chilled water, nitrogen, compressed air and exhaust/ventilation requirements.

In addition, a detailed Building Project Definition was drawn-up to act as a general document to specify all aspects of the required building needed to house the proposed fabrication process. The Building Project Definition was formulated in part based on experience with similar facilities that Air Products has out-fitted for its polymeric membrane fabrication business in the St. Louis, Missouri, region. Key criteria in the following areas include:

- **Location**
  Sites near ceramic processing subcontractor, Ceramatec, Inc., Salt Lake City, Utah, were given highest consideration. Ceramatec provides the ceramic processing expertise for which easy access to the site is critical for smooth project execution. Ceramatec is also carrying out critical Phase III activities from its Salt Lake City location.

- **General Building Description**
  Building code was specified, as were specific requirements in terms of square footage, expected occupancy rates, utility requirements including back-up power infrastructure, roof characteristics, flooring, and HVAC.

- **Space Allocations**
  Space allocations were generated for the various functional areas of the ceramic processing line including specific area requirements.

- **Engineering Requirements**
  Requirements for building structure, flooring, HVAC, roofing, plumbing, fire protection, electrical, telecommunications, and security were generated that are specific to the needs of the intended ceramic processing line.

- **Suggested building Layout/Plot Plan**
  A representative schematic of the fabrication facility floor plan including major equipment was generated to help assess building fit.

Based upon the above information, Engineer/Procure/Construct contracting companies (EPC's) in the Salt Lake City area were asked to bid on the facility based on two options: a new building construction and rehabilitation of an existing generic leased building.

Results of the bid process confirmed a cost penalty for new construction and bidders provided valuable feedback for APCI to optimize facility layouts to minimize overall cost. Following APCI internal review and driven by the budgetary constraints of completing the overall Phase V project, the decision was made to proceed to identify an existing facility that would meet CerFab needs and that could be leased within the available budget.

APCI then worked with a commercial property realtor to identify suitable properties available for leasing in the general Salt Lake City area. The realtor was given a list of

selection criteria based upon area and utility requirements for the CerFab. Some 20 properties were initially identified by the realtor and these were narrowed down to 5 facilities for detailed review.

Based upon tours conducted of these 5 facilities, a property within 40 minutes' drive of Salt Lake City was selected as the most suitable.

2 The suitability of the selected site to meet the needs of subsequent tasks and to meet the requirements for NEPA approval.

Here we will address:

- A summary of the attributes of the selected facility
- Why the selected facility will meet the needs of CerFab
- Cost of leasing the facility to the Phase V project
- Why we believe the selected site will be permitted
- The NEPA application for the selected site
- Employment in the region of the selected site

2.1 A summary of the attributes of the selected facility

The selected facility was a former furniture manufacturing facility, purpose-built recently to the owner's requirements. It operated for a little more than a year before curtailing operations starting in 2008 due to poor business conditions; the plant was ultimately closed in December 2010. The building is currently unoccupied and offered for sale or lease by the current owner

In comparison with the other 4 facilities on the shortlist that were toured, the selected facility was a clear winner in meeting all requirements for the CerFab. It was very close to the compiled Building Project Definition although larger in production floor-space than strictly required.

Favorable attributes of this property are:

- A modern well-planned and constructed facility that will meet existing building codes with minimum modifications
- Sufficient installed power with installed step-down transformers and switch-gear
- Good heavy-duty HVAC system with humidity control
- Open, useable factory layout with sufficient ceiling heights and column spacing
- Appended offices, reception, lunchroom, Server Room and Maintenance Workshop are all appropriately sized and located.
- Installed air compressors and distribution pipe-work
- Modern sprinkler and fire detection system
- Installed LAN for machine locations and installed PA system
- All drawings for the original building project are available electronically for re-use
- Located in an area with fewest barriers for permitting
- Located within a 40 minute drive of the existing Ceramatec facility

Overall, the selected property is an excellent choice for CerFab as its original intended use was also as a fabrication facility with high power and HVAC demands. The numbers of planned personnel for the owner's operation were also similar to that intended for CerFab and consequently the office and support facilities closely match our CerFab requirements. Although the current production floor-space is approximately twice that required for CerFab, there is room for both unexpected changes to the final process layout and for supporting R&D under Tasks 28.2-3. Air Products estimates that the facility will reduce the cost of the CerFab because of lower building refurbishment costs than was assumed in the project budget. .

2.2 Why the selected facility will meet the needs of CerFab

Using the Building Project Definition (referred to above) as a template for reviewing all properties, it was clear that the selected property met nearly all requirements of the ideal, purpose built facility and would be by far the lowest cost to rehabilitate for CerFab use.

We will see the biggest savings (relative to other potential facilities) in 2 main areas: Electrical Installation and HVAC Installation - both of which are unusually high demand requirements driven by the CerFab process requirements (the kilns consume large electrical loads and the HVAC has to handle the high heat output of these same kilns).

The significant planned upgrades to meet CerFab needs are:

- We will need to install power-cabling for the planned kilns and upgrade the power feed above its current rating. Emergency back-up generators will also be installed.
- We will need to modify the existing HVAC system to exactly meet our process requirements
- We will need to install the remainder of the utilities required (Nitrogen, Chilled Water, and Natural Gas)
- We will need to install clean rooms for selected parts of the production process
- Floors are currently excellent but lack any installed drainage for equipment wash-down. We will install trench and drains to a central sump for analysis prior to discharge to local sewage treatment

Air Products will modify the current Building Project Definition to reflect all of the required modifications needed for the selected facility to meet the requirements of CerFab. As soon as we have a lease agreement in place, we intend to engage the original facility contractors to cost the needed changes; at this stage we are confident that this can be accomplished within the current budget allowance.

2.3 Cost of leasing the facility to the Phase V project

During the Definitization process, Air Products estimated the direct and associated cost for leasing the CerFab facility over the 36 month Period of Performance during Phase V. Our intent is to secure a lease of the selected site at or below that 36-month estimated cost.

Negotiations with the owners are currently underway on the lease rate, term of the lease, and various terms pertaining to the condition of the building prior to taking occupancy, the condition of the building upon termination of the lease, and options to secure the building following the lease term should Air Products have an on-going interest in the property. The lease rate at this point in negotiations is near the estimated project cost. Property taxes, which are the tenant's responsibility, are based on an assessed (2010) value of the property,

resulting in annual taxes of approximately $90,000. Accordingly, at this point the cost to lease the facility during the Period of Performance is within the estimated Phase V budget. Lease rate negotiations are continuing and may alter these numbers somewhat, but are not expected to result in a significant variance with respect to the Phase V budget. Separately, Air Products has applied for tax relief on some aspects of the costs of the CerFab through the state of Utah that will benefit the overall project through lowered state and local taxes.

The term of the lease is still under negotiation, but is expected to be approximately 60 months.. The 60 month term exceeds the Period of Performance under Phase V. Air Products is aware that costs incurred after the Period of Performance are not subject to cost-share under the Phase V contract with the DOE and is prepared to pay lease costs incurred after the Period of Performance up to and including the full amount.

2.4 Why we believe the selected site will be permitted

Any selected site will need to be approved under the National Environmental Policy Act (NEPA) and also be permitted to operate under the Environmental Protection Act (EPA). To date, all of the data required to complete the NEPA questionnaire has been assembled based upon the selected site and the current definition of the proposed production process (together with proposed pollution control equipment and procedures). The completed NEPA questionnaire has been internally reviewed by knowledgeable personnel from both APCI and Ceramatec. In addition, we have had the questionnaire reviewed in detail by APCI's national environmental consultant. Overall conclusions from these reviews were as follows:

- The air pollution resulting from CerFab operation will be considered a small (minor) source. An air permit will be required for operation. However, a construction permit from Utah EPA will not be required as we do not plan any construction at the site.
- The solid and liquid waste-stream permitting should be straightforward if handled as currently proposed.
- The small (minor) source determination is driven by the calculated 1.8 metric ton/year of VOC emissions and 0.67 metric ton/year of Hazardous Air Pollutants (HAPs) (as toluene).
- The environmental consultant's formal opinion is that the selected site will obtain approval under the Categorical Exclusion provisions in NEPA. Their main arguments for this opinion are:
    - The new process is a small (minor) source of VOC's but that the selected site is not in a non-attainment zone for VOC emissions, which is not the case for most of the other properties considered.
    - The selected site is in an existing operating Industrial Complex which is already zoned for Heavy Industrial use.
    - No ground-disturbing construction is planned at the selected site, only internal modifications and upgrades to the existing building interior to meet Cerfab needs.
    - The selected site is not in an environmentally sensitive area.

2.5 The NEPA application for the selected site

The NEPA questionnaire was completed based upon the selected facility site and representing the current process definition for CerFab. The NEPA questionnaire was submitted to the DOE along with the Decision Point 1 report.

2.6 Employment in the region of the selected site

Because one of the goals of the American Recovery and Reinvestment Act (ARRA) is to re-invigorate the American economy, an analysis of the impact of this project on the local employment is pertinent.

It should be stated from the outset that the former furniture production plant housed at the preferred site for the CerFab had ceased operations directly as a result of the poor economic conditions in the nation in the 2008-9 timeframe. The workforce from that facility has since been laid off. The CerFab at full operating rates will require 50-60 full time personnel. While it is not certain how many of the furniture manufacturer's former workers have found new employment, the CerFab will pull from the same local workforce for many of its positions, and will require a similar number of workers as had been employed by the furniture manufacturer (based on the office and floor space available in the facility). Furthermore, should Air Products choose to expand the operations subsequent to the Phase V Period of Performance, personnel requirements will increase. The existing building could house a significantly larger production line if desired; the site (at 20 acres) could support building expansions of fivefold or more.

The local economy in the region of the preferred site has undergone a significant decline since the nationwide recession began in 2008. This is illustrated in Figure 2 below, which shows unemployment rate in the region since 2004. The current unemployment rate is approaching 9%. In addition to the potential to add permanent employment to the region, the Phase V project offers approximately 50 local construction and skilled labor positions during the 15 month period in which the CerFab is built.

Figure 2. Unemployment Rate in the county of the preferred CerFab site

Air Products also considered other sites outside of the Utah region. These include the St. Louis, Missouri, area, in which Air Products has a manufacturing operation, and the Allentown, Pennsylvania, area, in proximity to Air Products' headquarters. Both are less desirable than the preferred site listed above, mainly because of impact that supporting such sites would have on the productivity of the Ceramatec workforce. Ceramatec is an integral part of the on-going Phase III work to supply the 100 Intermediate Scale Test Unit (ISTU) with ceramic modules, and could not efficiently support both the production of modules for the ISTU and the research, design, engineering, and procurement activities associated with Phase V and the CerFab. Moreover, the unemployment situations in the St. Louis and Allentown regions are similar to that of the preferred site (see Figure 3).

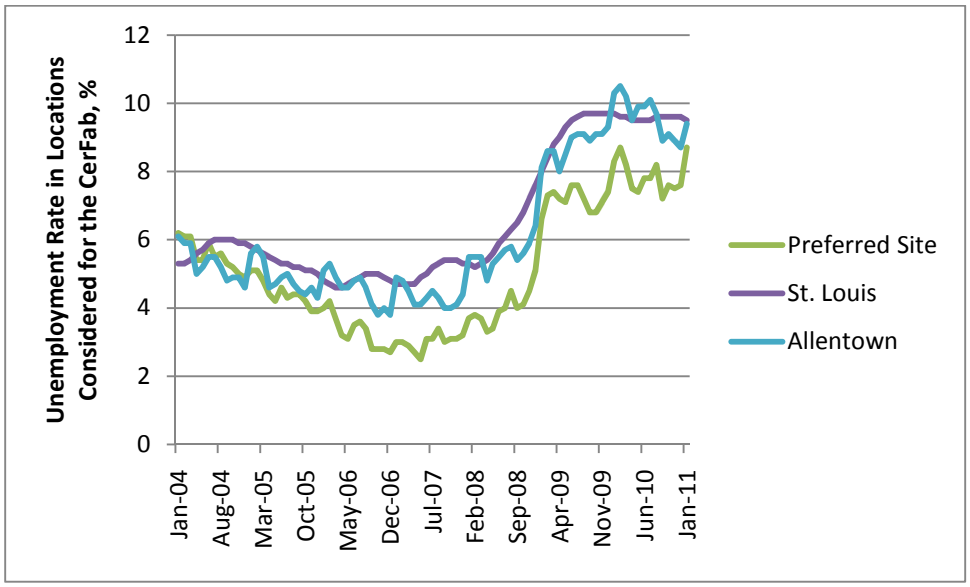

Figure 3. Unemployment rate by region for sites considered for the CerFab.
Source: U.S. Bureau of Labor Statistics

C. Conclusion

Air Products has identified a site for location of the CerFab, a ceramic membrane module manufacturing facility to be designed, constructed, and commissioned as part of Task 30.1 in Phase V of the Cooperative Agreement. The site was chosen from a selection of twenty available properties in the Salt Lake City region; the site includes a building with some existing required manufacturing infrastructure, office space, and various supporting utilities. The site was judged based on criteria determined for the facility through an assessment of the ceramic manufacturing process requirements, including required floor space, power, heating, ventilation and cooling. Air Products also assessed the expected ease of obtaining the required environmental permits. The selected site meets or exceeds all of the CerFab requirements; costs for the facility will meet the CerFab project cost allocation. Moreover, the site once housed a facility that was shut down because of the poor economic conditions during the economic recession in 2008-9; re-starting manufacturing at the selected site is therefore consistent with the intent of the American Recovery and Reinvestment Act which funds this Phase of the Cooperative Agreement. Air Products recommends proceeding under Task 30.1 to procure the selected site.

GRAPHICAL MATERIALS LIST

Figures

ACRONYMS AND ABBREVIATIONS

APCI = Air Products and Chemicals, Inc.

ARRA = American Recovery and Reinvestment Act

CerFab = ceramic module fabrication facility

DP1= Decision Point 1

EPA=environmental protection agency

EPC= engineering/procurement/construction

HVAC = heating, ventilating and air conditioning

HAP = hazardous air pollutant

ITM = ion transport membrane

ICCS = industrial carbon capture and storage

ISTU = intermediate scale test unit

LAN=local area network

NEPA = National Environmental Policy Act

PDF = process development facility

PA=public address or Pennsylvania

VOC = volatile organic compound

TPD = tons per day

SOPO = Statement of Project Objectives