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Military Standards and Spray Polyurethane Foam (SPF) Insulation

ENERGY EFFICIENCY AND THE ARMY

The Role of Buildings in U.S. Energy Demand

The federal government is the largest single user of energy in the United States, accounting for roughly 1.5 percent of the nation's annual energy consumption. Because of the rising costs of energy, the need for energy independence, climate change concerns, national security and shrinking natural resources, reducing energy consumption has consistently been a top priority for the federal government for the past 10 years. While programs like ENERGY STAR® initiated by the U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) are designed to curb energy use within the private sector, other standards and energy efficiency goals have been created to reduce the overall energy impact of the government.

The U.S. Department of Defense

According to the *Department of Defense Facilities Energy Conservation Policies and Spending*, the largest consumer of energy within the federal government is the U.S. Department of Defense (DoD), which uses 63 percent of the facility energy consumed. In 2008, the DoD used over 938 petajoules or roughly 980 trillion BTUs (British Thermal Units) of energy, which by comparison dwarfed the next largest consumer of energy in the federal government, the U.S. Postal Service, which consumed slightly more than 40 petajoules of energy. Accordingly, finding ways to reduce the amount of energy consumed by the DoD is a necessary step in achieving energy efficiency goals for the entire nation.

Several mechanisms have been used to improve energy efficient standards for the DoD. They include direct legislation by Congress, Presidential Executive Orders (E.O.), mandates from the Office of the Secretary of Defense (OSD) and internal policies within each organization that comprise the DoD. Most of these have been utilized in the past decade to reduce energy use by the DoD and the directives have prompted a whole new approach to building design and material use in both new construction and retrofits on military installations both at home and abroad.

Ft. Bliss, Texas

Energy Efficient Buildings – The Role of Air Infiltration

One of the most significant aspects of the new approach is a push to reduce unwanted air and moisture intrusion into structures by measurably improving the building envelope. According the U.S. Department of Energy, air infiltration accounts for a loss of 30 percent or more of heating and cooling costs. Spray polyurethane foam (SPF) insulation, more than any other insulating and air-sealing product, successfully addresses the three main challenges to improving the building envelope.

These challenges include:

- Uncontrolled air movement through the building's shell
- Moisture management
- Indoor air quality

Specifically, SPF is being used by the DoD in multiple applications both domestically and in overseas operations to increase insulation values in buildings, reduce air and moisture infiltration, improve indoor air quality, and create healthy and more energy-efficient structures for our service members.

ENERGY EFFICIENCY LEGISLATION

Two significant pieces of legislation enacted in 2005 and 2007 specifically called on the federal government to reduce energy consumption. The Energy Policy Act of 2005 (EPAct05) and Energy Independence and Security Act of 2007 (EISA07) set standards for all public buildings, including those utilized by the DoD.

Signed into law in August of 2005, EPAct05 required that federal building energy-efficiency performance standards be revised to aggressively reduce the amount of energy used by the federal government. Under this new law, the federal government was required to reduce energy consumption by at least 30 percent below the levels permitted by the then current applicable version of standards published by the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) 90.1-2004 or the 2006 International Energy Conservation Code (IECC) standards. In simple terms, this meant that new buildings built by the federal government must be tested and verified to be significantly more energy efficient than the traditional "code built" structures. Further, the law required that energy consumption must be reduced by two percent per year beginning in 2006, for a total reduction in annual energy consumption of 20 percent by the year 2015. To comply with this legislation, building materials, design elements and efficiency-improving strategies were required to ensure that new buildings met or exceeded the new standard.

The second major piece of legislation to mandate more energy-efficient building design and construction standards for the DoD was the Energy Independence and Security Act of 2007 (EISA07). Signed into law in December of 2007, EISA07 increased the energy saving requirements of EPAct05 and stipulated that all federal buildings, including military installations, reduce energy use by three percent per year up to a total of 30 percent by the year 2015. EISA07 also required that all new federal buildings and major renovations to federal buildings reduce fossil fuel-generated energy consumption by 100 percent by the year 2030 over a 2003 baseline.

This significant increase in energy conservation requirements further increased pressure on the DoD to improve and modernize new construction and renovation building projects.

Executive Orders and Energy Efficiency

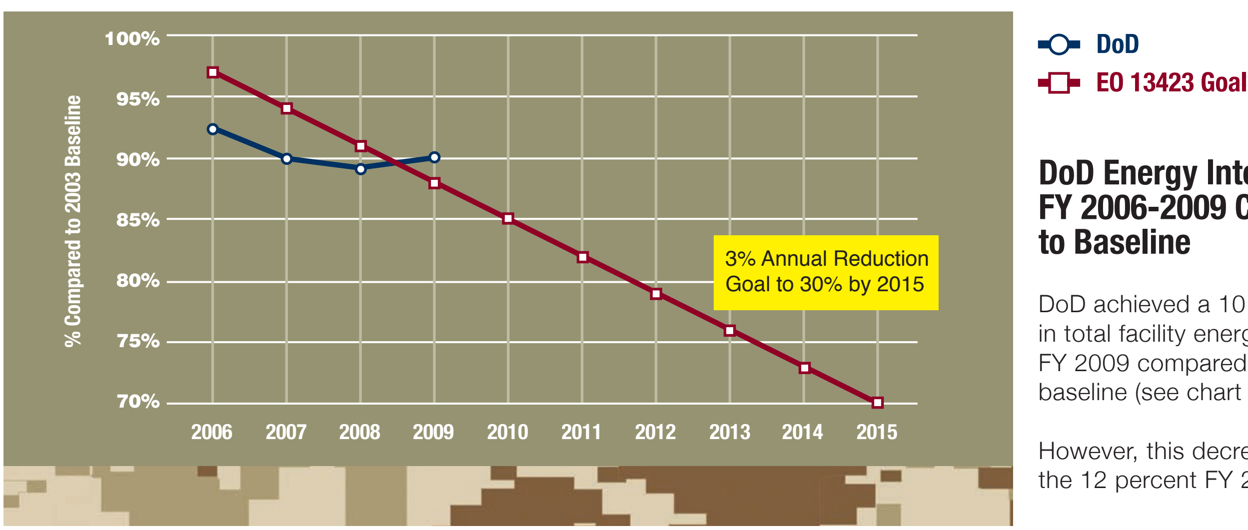
An Executive Order (E.O.) is a decree issued by the President of the United States usually meant to support, enforce or clarify acts of legislation. Two executive orders have been issued that relate to EPAct05 and EISA07, and each one expands on energy savings and sustainable building expectations within the federal government.

Executive Order 13423 was issued in 2007 and was the first Order to support EPAct05. This Order helped define exactly what new construction standards were expected in order to meet energy conservation goals. Specifically, E.O. 13423 required federal agencies pursuing new construction and major renovations to comply with the 2006 Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding.

The Sustainable Buildings Memorandum of Understanding (2006) defines sustainable building principles by incorporating common strategies for planning, acquiring, siting, designing, building, operating and maintaining a higher performing or energy-efficient building. Prior to construction, in order to follow established sustainable building guidelines, buildings must:

- Integrate building design to create a cohesive building strategy from planning to delivery to ultimate deconstruction, commonly referred to as a "holistic" or whole building approach to construction
- Optimize energy performance by establishing a whole building performance target that takes into account the intended use, occupancy, operations and all other energy demands on the building after construction is complete
- Protect and conserve water by including water reuse and recycling strategies
- Enhance the indoor environmental quality with improved ventilation, thermal comfort and moisture control
- Increase the use of recycled products in the construction process, reduce waste and eliminate the use of ozone depleting compounds during and after construction, where alternative environmentally preferable products are available

E.O. 13423 also required that all federal agencies reduce energy use by three percent each year, culminating in a 30 percent total reduction in energy usage by the year 2015.



Source: Department of Defense Annual Energy Management Report Fiscal Year 2009

DoD Energy Intensity FY 2006-2009 Compared to Baseline

DoD achieved a 10 percent decrease in total facility energy intensity in FY 2009 compared to the FY 2003 baseline (see chart at right).

However, this decrease did not meet the 12 percent FY 2009 Goal.

The second Executive Order to impact energy use was E.O. 13514, which expanded upon the energy reduction and environmental performance requirements of E.O. 13423. This Order also required that all new federal buildings entering the design phase in 2020 or later, be designed to achieve net-zero energy by the year 2030. By definition, net-zero energy in buildings means that the building generates as much energy as it uses over the course of a year. To accomplish this, buildings must employ extremely aggressive insulation, air sealing, mechanical systems and building performance standards. Additionally, in order to accomplish this goal, buildings must often incorporate renewable energy sources, such as solar photovoltaic arrays, windmills and solar water heaters.

Both of these Executive Orders included the entire federal government in their application and helped define for the DoD what standards and requirements were necessary within the military to meet and or exceed the energy efficiency expectations of the President.

MILITARY ENERGY EFFICIENCY REQUIREMENTS

Conserving energy and investing in energy reduction measures makes good business sense for the DoD, because the DoD operates on a limited annual budget. Reducing the amount of energy consumed in facilities produces monetary gains that can be applied to other DoD budget line items.

Because dramatic fluctuations in the cost of energy significantly impact operating budgets, a significantly lowered demand for energy provides an even greater opportunity to fulfill the DoD's mission today, and in the future.

In order to further the mission of energy conservation, the DoD also follows mandates from the Office of Secretary of Defense (OSD). With reference to energy conservation, OSD Policy DODI 4170.11 was issued first in 2005 and then updated in 2009 to include provisions of E.O. 13423 discussed above.

When issued, OSD Policy DODI 4170.11 affirmed many of the energy efficiency goals set forth in the previous Executive Orders and legislation that has been highlighted above. It also stipulated that new DoD buildings shall obtain at least U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED®) rating system silver level of performance or equivalent, based on LEED 2.2. This provision requires that new buildings follow specific design and construction guidelines, especially when addressing indoor air quality, water mitigation and air barriers.

The final major mandate for energy improvements in U.S. Army buildings was issued in 2008 as Army Regulation (AR) 420-1 and the Army Energy and Water Campaign Plan. AR 420-1 sets goals for the management of buildings under U.S. Army control that are meant to ensure that the essential energy needs of all residents are provided without waste. Per AR 420-1, equipment and facilities are required to be operated and maintained in an energy efficient manner, and new techniques and building science technologies are to be applied when designing, building, modernizing, operating, maintaining, repairing and furnishing its housing facilities. The policy also stipulates that the Army must continually evaluate existing building stock and determine where excessive energy consumption occurs and develop corresponding remediation plans.

For the DoD to achieve the increased energy efficiency standards required, facilities built and managed by the DoD must address and overcome fundamental building science challenges. These requirements are most simply expressed by the Sustainable Buildings Memorandum of Understanding (2006), which required the DoD to enhance indoor environmental quality with improved ventilation, thermal comfort and moisture control. In basic terms, this meant that the DoD had to address three key aspects of new construction and major renovations:

- Reduce uncontrolled air movement
- Improve moisture management
- Improve insulation

Only by adequately addressing these three issues in new construction or major renovations, can the DoD effectively reduce energy consumption in facilities and successfully achieve the required energy savings.

Ft. Drum, New York

Uncontrolled Air Movement

According to the Air Barrier Association of America (ABAA), uncontrolled air leakage in a building accounts for approximately 40 percent of heating and cooling energy usage. Even small gaps or holes in a building will allow unconditioned outside air to move freely through the building, making the space uncomfortable and increasing the load on the HVAC system. An air barrier system in the building envelope, or shell of the structure, is the primary mechanism used to control unwanted air movement into and out of the building. Simply put, an air barrier is used to control the flow of air between the outside and inside. An air barrier can be made from many different types of materials, but to be effective it must be installed properly and provide a complete shield around all sides of the building (i.e., the building envelope). When installed in a building, the air barrier material becomes part of an air barrier system, which is the combination of the air barrier material and all other components in the building – windows, doors and design features. The primary objective of the air barrier system is to block the random movement of air through building cavities.

There are three key attributes to a well-designed and successfully-installed air barrier system. An air barrier must:

- Be impermeable to air flow
- Have sufficient durability over the expected lifetime of the building and not easily be damaged or compromised during the construction process
- Provide continuous coverage around the entire building from the roofing system to the below-grade structure

An improperly-installed, poorly-sealed or incomplete air barrier can effectively negate insulation and other energy saving devices in the building.

Marine Corps Support Facility Blount Island, Florida

To ensure that the high-energy efficiency and indoor air quality standards were met, the U.S. Army Corps of Engineers instituted a stringent validation process for new and retrofit construction projects that includes a blower door test and thermographic testing for air leakage. Also part of the validation process is the requirement that the building enclosure have a continuous air barrier system to control air leakage into or out of the conditioned space. Specifically, the U.S. Army Corps of Engineers directed that an acceptable air barrier system have the following characteristics:

- It must be continuous with all joints sealed
- It must be structurally supported to withstand positive and negative air pressures applied to the building enclosure
- Connection shall be made between:
  - Foundation and walls
  - Walls and windows
  - Walls and doors
  - Different wall systems
  - Walls and roof
  - Walls and roof over unconditioned space
  - Walls, floors, and roofs across construction, control and expansion joints
  - Walls, floors, and roofs to utility, pipe and duct penetrations

To help drive the usage of robust air barrier systems, the U.S. Army Corps of Engineers require a whole building test for air leakage with a maximum building envelope air leakage rate of 0.25/CFM/sq.ft.[2] at a pressure differential of 0.3 iwg (75 Pa). This testing is required by the Engineering and Construction Bulletin No. 2009-29 issued by the U.S. Army Corps of Engineers on building air tightness requirements.

Uncontrolled air leakage in buildings, account for approximately 40 percent of heating and cooling energy usage.

Conducting whole building performance for air tightness.
Photo courtesy of Retrotec www.retrotec.com

Selecting air barrier materials that will stop the flow of air from the outside into the structure and the flow of conditioned air from inside the structure to the outside is critical in order to reduce energy consumption. While traditional air barrier materials – house wrap, polyethylene and rigid sheathing materials, including gypsum and plywood – were once acceptable to use, the more stringent requirements for air barriers renders many of these materials troublesome, if the final goal is to significantly reduce energy consumption. Creating a complete and unbroken air barrier system using traditional air barrier materials is difficult and often impossible in structures that are of a unique design or shape.

SPF as an Air Barrier

As an air barrier material, SPF offers many advantages over traditional insulations. Air barrier materials and assemblies are tested for their air permeance, or the volume of air that passes through the test specimen. Testing for permeance is done to standards established by the American Society for Testing and Materials (ASTM). Based upon the results of the test, air barrier materials and assemblies are assigned an air leakage rating.

The baseline for an effective air barrier material is not to exceed $0.02L/(s \bullet m^2)$ @ 75Pa. ($0.004\ cfm/ft^2$ @ 1.57 psf) per E2178 ASTM. When evaluated for air permeability, both open and closed cell SPF have permeability ratings that are far lower than traditional insulation materials, making either SPF type an ideal air barrier material. The number of inches of foam necessary to create and air barrier is dependent on the foam type. Closed cell SPF is typically an air barrier at 1 inch. Open cell SPF is typically an air barrier at 5.5 inches or more.

Furthermore, SPF meets or exceeds all expectations for creating a rigid, continuous air barrier that can withstand the maximum positive and negative air pressures placed on the building. Because of its ease of application, SPF is consistently helping military buildings perform to U.S. Army Corps of Engineer's air tightness standards. Installation is quick, saving labor costs, as the SPF is produced on-site, and minimizes the chance of failing the air tightness test, a very expensive proposition.

SPRAY POLYURETHANE FOAM (SPF)

SPF is an insulating foam plastic that is used as a water, vapor and air barrier material in the building assembly. When applied between framing members, over substrate material on the exterior or as roof material, SPF immediately adheres to the surface and then expands 20 to 120 times its original size.

There are two kinds of SPF used in construction today, open cell (.5 lb.) SPF and closed cell (2-3 lb.) SPF. To create spray foam insulation, liquid polyurethane precursors are combined with a blowing agent to produce a foamed material structurally composed of small bubbles or cells. Two liquid components are joined under pressure in a spray nozzle where they are applied directly onto wall, roof or foundation building assemblies. As the mixture expands and dries the tiny cells either burst (open cell SPF) or remain intact (closed cell SPF).

Once cured, SPF hardens into a seamless and monolithic piece. Closed cell SPF sprayed into the walls enhances overall building stability and reduces "rack and sheer," while providing the highest insulation R-value per inch available today. Unlike other building materials, SPF does not require mechanical fasteners or supporting structures and will not sag over time. Also, SPF is an effective sound insulation material.

MOISTURE MANAGEMENT

When considering moisture management strategies, air movement is the most important variable to be concerned with. Controlling how water enters and leaves the building envelope is a necessary step in order to maintain a healthy, energy-efficient and durable building, as 80 to 90 percent of a building's issues are moisture-related.

Water can enter the building in two ways:

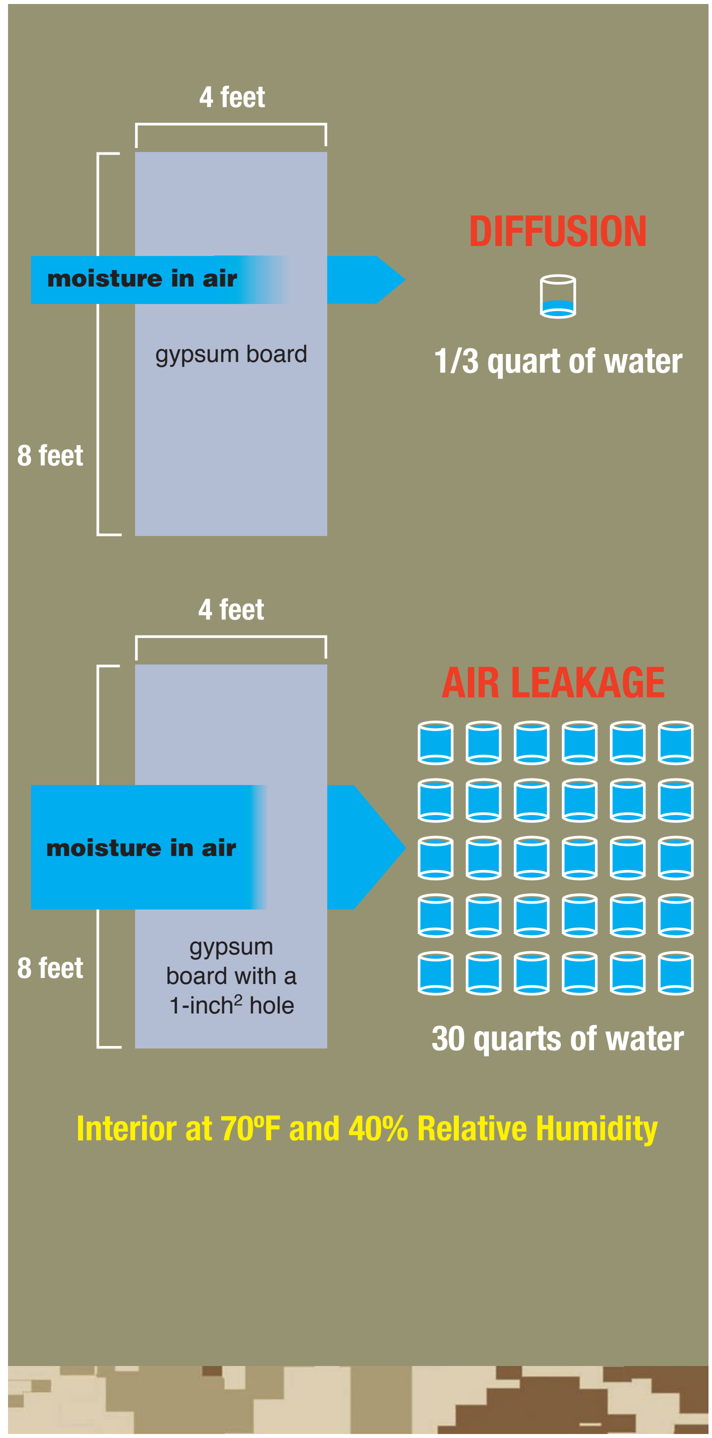
- As a liquid
- As a vapor

In liquid form, water often enters the building envelope through rain, snow or the ground. Although older buildings have some sort of water management strategy in place, poorly designed or aging water management systems can allow wind-driven rain, ice dams from poor insulation, or leaks in the foundation to allow water to flow into the structure.

Water vapor is closely linked to air movement in the building and the effectiveness of the air barrier system installed in the structure. In cooling climates, warm and humid air from the outside can enter the building and come in contact with a relatively cool surface of the interior wall. Conditions may cause the moisture to condense to liquid form. In cooler, northern climates, warm interior air, often more humid than the cold exterior air, can pass through a wall assembly where it can condense on the inside-face of the exterior walls. If the condensed moisture is unable to dry out quickly, damage can occur in the wall assembly.

Excessive water in framing members can lead to rot and compromise the structural integrity of the building. Standing water or water-damaged framing members and insulation also quickly results in the growth of mold, bacteria and promotes insect infestation. Mold growth is of special concern because mold spores in the air can result in headaches, breathing difficulties, allergic reactions and aggravate asthma symptoms.

Because of these concerns, **buildings must have an effective air barrier installed to keep moisture from migrating through the wall assemblies via uncontrolled air movement.** In colder climates, the potential for moisture condensation is higher. In this case, a vapor retarder is also needed to prevent moisture from entering the walls through diffusion. Diffusion is the migration of moisture at a molecular level through the building material itself.



Source: *Energy & Environmental Building Alliance (EEBA)*

The above diagram highlights water transport via diffusion and air leakage.

SPF and Moisture Management

SPF is able to assist in moisture management in several ways. Most importantly, SPF is an air barrier and will prevent moisture from entering wall assemblies via air infiltration. When applied between framing members as an insulation material, SPF expands to fully seal the space, eliminating gaps and spaces that allow for uncontrolled air infiltration. By controlling air infiltration, both types of SPF effectively stop water vapor movement due to air movement within the building envelope, thus reducing condensation issues.

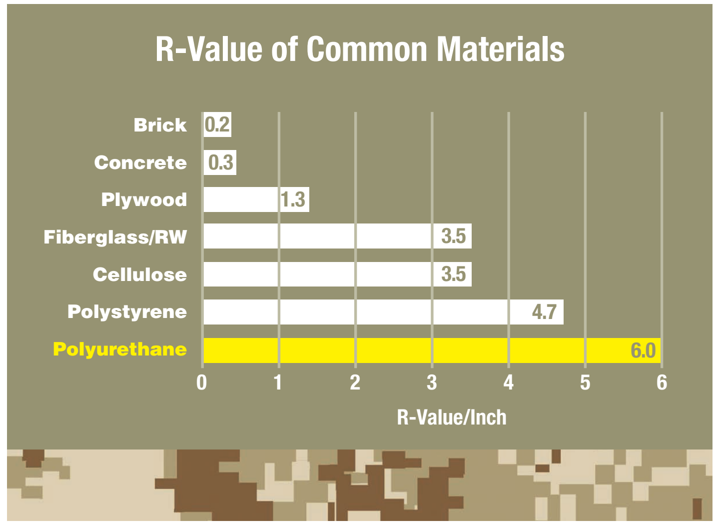
Closed cell SPF can also serve as a moisture vapor retarder, to address diffusion, in conditions and climates where it is needed. In addition, closed cell SPF can be used as a bulk water barrier to protection against intrusion from liquid water, such as rain and snow. Open cell foam may need additional protection from moisture vapor diffusion depending on climate.

If designed to account for bulk water intrusion and moisture vapor diffusion, wall designs using both types of SPF can be effective in controlling moisture across all climates. The air tightness of SPF wall assemblies then minimizes the possibility for air infiltration-related moisture transfer, the primary cause of condensation problems in walls. With all three moisture sources addressed, the risk for condensation, mold, structural rot and insect infestation is greatly reduced.

IMPROVED INSULATION

Insulation provides a thermal boundary in the building envelope to reduce energy usage and keep the occupants comfortable. Insulation material is rated on its resistance to heat transfer or R-value. The higher the R-value, the more effective the material is in stopping heat transfer. From an energy efficiency standpoint, the importance of increasing insulation in buildings is two-fold. First, the better the thermal boundary, the slower the rate of heat or cooling lost from the interior to the exterior of the building. This lowers the money spent on utility costs. Second, with improved thermal performance, a smaller heating and cooling system can be installed, which helps reduce the overall cost of construction.

The primary way that traditional insulation types – fiberglass batts and blown-in cellulose – work is to stop conductive heat transfer through the use of small pockets of air that limit conductive heat flow. In fiberglass batt insulation, the spun glass fibers create a web of air pockets. However,



The above chart shows the R-value of common insulation materials.

the material is prone to compression, which reduces the amount of air pockets and lowers the R-rating. Fiberglass often is installed with gaps around it, which can reduce the effectiveness of the material by up to 20 percent lower. This means that unless installed correctly, fully-lofted and properly-sized, the R-value of fiberglass insulation can be compromised.

R-values also suffer when there is air infiltration that passes through the insulation or when the insulation gets wet from condensation. Other traditional fibrous insulation types – cellulose – have similar performance considerations.

Traditional building materials and methods are unlikely to successfully address these three main energy efficiency issues facing existing buildings and new construction projects. However, for each of these three issues, air movement, moisture movement, and increased insulation, SPF is a highly effective and successful solution.

SPF AND INDOOR AIR QUALITY

Indoor air quality is a critical part of the overall indoor environmental quality, and SPF is an ideal solution to help meet this objective. Uncontrolled air movement between unconditioned and conditioned building cavities can lead to serious and potentially health threatening indoor air quality issues. As air moves from unconditioned spaces like attics, crawlspaces, utility rooms, attached garages and the outside of the building, it can transfer dust, allergens, pollutants, exhaust fumes and chemicals directly into the interior environment.

In both new and retrofit construction, SPF creates a monolithic air barrier protecting indoor air from pollutants and airborne particulates that could enter the conditioned air space. The use of SPF to create a tight building envelope eliminates unwanted air infiltration and encourages the use of controlled mechanical ventilation, which introduces clean, conditioned air into the building in an efficient manner.

SPF AS A ROOFING MATERIAL

When addressing major renovations in existing building stock, roofs are often a major concern. **Roof failure is a primary cause for water intrusion into the building, and traditional methods of removing and replacing roofing material can be expensive and expose the structure to additional damage.** SPF can be used as a re-roofing material applied directly on the existing roof structure. It provides two important benefits to a building through waterproofing and increased insulation value.

Further, the application of SPF to an existing roof structure is simple and fast. The expanding foam is simply applied directly over the existing metal, wood, concrete, membrane, or built-up roofing material. Once the SPF has been applied to the proper thickness, a protective layer of elastomeric coating or gravel is applied as a protective layer over the insulation. This combination of foam insulation and protective layer produces a durable, weather-resistant surface that is strong enough to walk on.

Some of the benefits of using SPF for roof repair include:

- Increased insulation value
- Waterproofing and existing leak sealing
- Lightweight
- Less building material hauled to site
- Less demolition and waste through old-roof removal
- Extended service life of more than 30 years
- Reduction in thermal bridging
- Reduction in air filtration from fastners

Additionally, as a roofing material, SPF also increases the structural strength of the building by providing wind uplift resistance.

Camp Patriot, Kuwait

CASE STUDIES OF THE DOD AND SPF

The DoD has successfully been using SPF in domestic installations and forward operating bases (FOBs) for several years to reduce energy use, improve indoor environmental conditions, reduce mold, and increase the durability of barracks, tents and operational structures.

One strikingly successful and innovative use of SPF was in FOBs in Iraq, Kuwait and Afghanistan. Every day, hundreds of trucks transport fuel for hundreds of miles, exposing drivers and soldiers to attack and improvised explosive devices. After assessing fuel usage, the U.S. Army determined that most of the fuel delivered to FOBs was being used for use in electrical generators. With daily temperatures rising up to 130 degrees Fahrenheit, air conditioning units in tents and temporary structures consumed almost all of the electricity generated.

Bagram Airfield, Afghanistan

SPF on Temporary Structures

Tents and temporary structures were sprayed with closed cell SPF and topped with a weather-resistant elastomeric coating. **After applying SPF directly to the outside of tents and structures, the average thermal load of the structures was significantly reduced, allowing for an 85 percent total reduction in the amount of energy needed to maintain a comfortable living environment.**

In the summer of 2009, the Army Deputy Chief of Staff for Logistics commissioned the U.S. Army Material Systems Analysis Activity (AMSAA) to conduct a study in order to quantify the overall benefit of applying SPF to tents and other temporary structures. The study found that **due to the increased energy efficiency produced by the use of SPF, the U.S. Army was realizing a savings of over $1 billion annually in fuel costs,** and thousands of trucks were no longer required to transport fuel to FOBs, thereby greatly reducing the risk to soldiers and convoy operators. **Using the fully-burdened cost of fuel, the payback on spray foaming the tents was found to be 75 days.**

Additionally, applying SPF to tents and temporary buildings increased structural stability and improved indoor air quality, especially in conditions prone to dust and sand storms. SPF also created a significant sound barrier in barracks to allow troops a reprieve from the almost constant noise of generators, trucks, tanks and aircraft.

Domestically, SPF has been a critical component for the DoD in improving the energy efficiency, indoor air quality, and comfort at a number of installations. Applications range from barracks to hospitals to hangars to single-family housing. Peterson Air Force Base used SPF in on-base family housing in between the stud cavities reducing noise levels, allowing for smaller HVAC systems, and saving energy dollars. At Fort Drum, transition barracks utilized closed cell foam on the exterior of the sheathing as continuous insulation, an air barrier and a weather resistant barrier. In this way, the SPF eliminates thermal bridging through studs and takes advantage of the thermal storage capacity of the concrete masonry walls.

Ft. Carson, Colorado

At Tinker Air Force Base, SPF was used to re-cover an existing roof to be not only more energy efficient but to fix the leaks as well.

For projects subject to the U.S. Army Corps air tightness standards, SPF is an excellent choice for an insulation and air barrier system. Spray foam buildings consistently deliver excellent performance in air tightness testing, when designed and installed properly. Achieving good air tightness results with other systems is often more difficult because of its reliance on difficult, time-consuming detailing work. Regardless of the reason, SPF will consistently achieve a tight building envelope leading to reduced energy loads and improved indoor air quality while minimizing the potential for moisture problems.

CONCLUSION

Because SPF works as a water barrier, vapor barrier and air barrier, while providing significant R-value insulation and structural strength, SPF provides the DoD with a unique system that meets or exceeds performance standards associated with the key components of an energy efficient building. Considering the tremendous challenge in front of the DoD to improve energy efficiency levels in buildings, while also reducing the overall amount of energy used, SPF is a superior option in new construction and major renovation projects.

Military Installations Currently Using SPF

- Ft. Belvoir
- Ft. Bliss
- Ft. Bragg
- Ft. Carson
- Ft. Drum
- Ft. Eustis
- Ft. Hood
- Ft. Irwin
- Ft. Jackson
- Ft. Knox
- Ft. Leavenworth
- Ft. Lee
- Ft. Leonard Wood
- Ft. Polk
- Ft. Riley
- Ft. Stewart
- Ft. Wainwright
- Marine Corps Base Hawaii
- Marine Corps Support Facility Blount Island
- Muscatatuck Urban Training Center
- Parris Island
- Peterson Air Force Base
- Schriever Air Force Base
- Tinker Air Force Base

Forward Operating Bases Currently Using SPF

- Afghanistan
- Djibouti
- Iraq
- Kuwait

Links and Resources:

Army Energy Program, Army Energy and Water Management Program
army-energy.hqda.pentagon.mil/

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www.wbdg.org/ccb/ARMYCOE/COEECB/ecb_2009_29.pdf

Engineering and Construction Bulletin: External Spray-Applied Polyurethane Foam (SPF) Insulation on Tents and Temporary Structures in Contingency Locations (U.S. Army Corps of Engineers 2010)
www.wbdg.org/ccb/ARMYCOE/COEECB/ecb_2010_11.pdf

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www.wbdg.org/pdfs/usace_ewcdr_execsummary.pdf

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Executive Order 13423, Strengthening Federal Environmental, Energy and Transportation Management (Jan 2007)
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Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance
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Spray Foam use at Fort Bragg
www.sprayfoam.com/npps/story.cfm?nppage=436

HUNTSMAN

Enriching lives through innovation

American headquarters
Huntsman
10003 Woodloch Forest Drive
The Woodlands
Texas 77380
USA
Telephone +1 281 719 4914
Fax +1 281 719 4953

Asian headquarters
Huntsman
No. 452 Wen Jing Road
Minhang Development Zone
Shanghai 200245
Telephone +86 21 6462 6868
Fax +86 21 6462 1234

European headquarters
Huntsman
Everslaan 45
B-3078 Everberg
Belgium
Telephone +32 2 758 9952
Fax +32 2 758 7268

www.huntsman.com/sprayfoam