



Natural Resources Conservation Service
CONSERVATION PRACTICE STANDARD
ENERGY EFFICIENT BUILDING ENVELOPE
CODE 672
(no)

DEFINITION

A boundary between a conditioned space and an unconditioned space that meets or exceeds best practices for energy efficiency.

PURPOSE

This practice is used to accomplish the following purpose:

- Improve energy efficiency of an existing agricultural building envelope.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to any partially or fully conditioned agricultural building or space. A partially conditioned space is a building or space using both mechanical ventilation and natural ventilation. Ventilation systems can be used individually or at the same time. Examples include curtain-sided poultry broiler or swine finishing houses, and dairy milking parlors, among others. A fully conditioned space is a building or space using fans, heaters, or other mechanical devices for year-round conditioning of the space. Mechanically ventilated systems can be negative, positive, or neutral pressure. Examples include fully ventilated poultry layer houses or swine farrowing rooms, and milk storage rooms, among others.

A building envelope or boundary may include walls, doors, windows, roof or ceiling, and foundation or floor of a building.

This practice does not apply to residential spaces or buildings.

CRITERIA

General Criteria Applicable to All Purposes

Implement building envelope improvements based on the building tightness, insulation, and ventilation needs of the facility for the intended purposes of each area or space.

Provide an analysis of the impacts of energy efficiency improvements on the heating and ventilation needs.

Provide an analysis that demonstrates improved energy efficiency by documenting decreased energy consumption, estimated utility savings, and document the assessment methodology.

Plan, design, and implement the building envelope improvements to meet all Federal, State, Tribal, and local laws, codes, and regulations. Comply with all applicable building codes and National Fire Protection Association (NFPA) 150, "Fire and Life Safety in Animal Housing Facilities Code."

Prescriptive upgrades

Building envelope upgrades included on the State-approved prescriptive list improve energy efficiency, as such, design and implementation do not require additional specific computations for efficiency.

For building envelope improvements not included on the State-approved prescriptive list, utilize the following general criteria and the appropriate additional criteria sections below.

Air leakage through building envelope

Evaluate air leakage paths using one or more of the following methods:

- Building depressurization or pressurization with all windows and doors closed using approximately 1 cubic foot per minute (cfm) per square foot (sf) ventilation rate of floor space with smoke tracer or theatrical fog
- Visual inspection with smoke tracer or theatrical fog
- Other State-approved methods

Design an air barrier system based on the intended use of the space to seal air leakage paths identified during the evaluation.

Create air barriers in the building envelope or between spaces that have either significantly different temperature or humidity requirements. Use air barrier material that is durable or accessible for maintenance.

The air barrier must not displace under load or displace adjacent materials. Install air barriers in accordance with the manufacturer's recommendations.

Use flexible connections between roof air barrier, wall air barrier, window frames, door frames, foundations, floors over crawl spaces, ceilings under attics, and across building joints. The building joints must withstand building movements due to thermal changes, seismic activity, moisture content changes, and creep. The connection must support the same air pressures as the air barrier material without displacement.

After installation, verify leakage paths have been adequately sealed using one of the evaluation methods listed above.

Additional Criteria for Insulation

Select insulation and covering materials that are durable, moisture resistant, nontoxic to humans or livestock, and perform the intended function under the conditions the material is expected to encounter during normal use, including temperature extremes, moisture, ultraviolet (UV) light exposure, cleaning products, disinfectants, mildew, puncture by equipment, corrosion, and flammability. Where applicable, follow any U.S. Food and Drug Administration (FDA) regulations.

Install insulation according to manufacturer's recommendations. Ensure insulation fills all voids in the cavity uniformly and fits neatly and tightly around obstructions such as wiring.

Select insulation and covering material to discourage entrance and chewing by rodents, pecking by birds, infestation by insects, or damage by livestock. Choose installation techniques to reduce damage from displacement by livestock, rodents, birds, insects, equipment, wind, or air movement. Protect exposed flammable insulation with thermal barriers as defined in fire safety requirements below.

In Climate Zones 4 through 8, install insulation to at least 18 inches below ground level along the building exterior perimeter with minimum R-values shown in table 1, column "Walls, below grade" for the appropriate building type, except in instances such as an existing concrete slab is adjacent to the building that prevents excavation for installation.

Fire safety requirements

All insulation applied under this standard must meet the following.

- Flame spread index of 75 or less (ASTM E84, “Standard Test Method for Surface Burning Characteristics of Building Materials”).
- Smoke development index of 450 or less (ASTM E84) or UL 723, “Standard for Test for Surface Burning Characteristics of Building Materials.”
- Include a thermal barrier that meets one of the following:
 - Prescriptive Thermal Barriers.—Either of the following materials applied between the insulation and the interior of the building space serves as acceptable thermal barrier:
 - 1/2 inch (13 mm) fire-rated gypsum board
 - 23/32 inch (18.2 mm) wood structural panel
 - Tested Thermal Barrier Materials.—A material that is tested in accordance with and meets the acceptance criteria of both tests of National Fire Protection Association (NFPA) 275, “Standard Method of Fire Tests for the Evaluation of Thermal Barriers.” Thermal barrier materials typically tested under NFPA 275 include spray-applied cementitious materials, spray-applied cellulosic materials, Portland cement plaster, and other various proprietary materials. The standard method of fire tests for the evaluation of thermal barriers includes both of the following:
 - Temperature Transmission Fire Test (Part I).—The temperature rise of the unexposed surface of the barrier material is limited within the test standard.
 - Integrity Fire Test (Part II).—To establish that the barrier material will sufficiently remain in place during a fire scenario by complying with one of the 15-minute, large-scale fire test standards listed immediately below, or tested to meet the acceptance criteria in Annex C of NFPA 286, “Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth.”
 - UL 1715, “Standard for Safety Fire Test of Interior Finish Material”
 - FM 4880, “Class 1 Fire Rating of Building Panels or Interior Finish Materials”
 - UL 1040, “Standard for Fire Test of Insulated Wall Construction”.
 - Alternative Thermal Barrier Assemblies.—Many assemblies without thermal barriers have earned various building code acceptances as an alternative to the use of thermal barriers over insulation based on large-scale fire testing. An acceptable assembly, consisting of either the exposed foam plastic, the foam plastic, or other insulation with a fire-protective product, meets the following requirements:
 - The assembly must pass either UL 1715, FM 4880, or UL 1040 large-scale fire test standards, or be tested to meet the acceptance criteria in annex C of NFPA 286.
 - The insulation material must be installed at a thickness equal to or less than the thickness tested in the previous paragraph.
 - The tested assembly is consistent with planned use for installation in walls, ceilings, or both.
- Specific conditions where a thermal barrier is not required.
 - Masonry or Concrete Installations.—A thermal barrier is not required in a masonry or concrete wall, floor, or roof system where the insulation is covered on each face by not less than 1-inch (25-mm) thickness of masonry or concrete.
 - Sill Plate, Joist Header, and Rim Joist Installations.—A thermal barrier is not required for these installations when all of the following requirements are met:
 - The maximum thickness of the foam plastic is 3.25 inches (82.6 mm).
 - The density of the foam plastic is 1.5 to 2.0 pounds per cubic foot (pcf) (24 to 32 kg/m³).
 - Flame spread index of 25 or less (ASTM E84).
 - Smoke development index of 450 or less (ASTM E84)

- Attic Insulation.—A thermal barrier is not required when fiberglass loose fill or unfaced batt insulation is installed to retrofit the unoccupied attic area of agricultural structures.

Vapor retarders

Complete a hygrothermal (movement of heat and moisture through buildings) evaluation to determine the need, location, and selection of a vapor retarder. Perform analysis in accordance with the latest edition of American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) “Handbook of Fundamentals”; “Midwest Plan Service, Structures and Environment Handbook” (MWPS-1); or other State-approved locally-accepted procedure. Use analysis of typical installations for the climatic region and expected moisture production (such as animals, heaters, etc.).

When needed, select a vapor retarder that meets the level identified by the hygrothermal analysis. Install required vapor retarders in accordance with the manufacturer’s recommendations.

Insulation for agricultural buildings except for greenhouses

Meet the minimum R-values of the wall and attic components provided in table 1 or provide a building energy analysis that demonstrates that the whole building assembly will meet or exceed the energy efficiency of the R-values. Meet the R-values provided in ASHRAE 90.1-2016, “Energy Standard for Buildings Except Low-Rise Residential Buildings,” tables 5.5-1 through 5.5-8, for additional types of building envelope components not shown in table 1 below. As an alternative to minimum R-values, install insulation that provides an equivalent assembly U-factor (time rate of heat flow through a unit area induced by a unit temperature difference between two defined surfaces of material or construction under steady-state conditions ($\text{h} \cdot \text{ft}^2 \cdot ^\circ\text{F}/\text{Btu}$)).

Table 1. Minimum Insulation R-values for Opaque Building Envelope Components ⁽¹⁾

Minimum R-values ($\text{Btu}/(\text{h} \cdot \text{ft}^2 \cdot ^\circ\text{F})$) ⁽²⁾⁽³⁾						
Partially Conditioned Space				Fully Conditioned Space		
Climatic zone ⁽⁴⁾	Attic	Wood framed walls, above grade	Walls, below grade	Attic	Wood framed walls, above grade	Walls, below grade
1	R-13	NR ⁽⁵⁾	NR	R-38	R-13	NR
2	R-19	R-13	NR	R-38	R-13	NR
3	R-19	R-13	NR	R-38	R-13	NR
4	R-30	R-13	NR	R-49	R-13+3.8 c.i. ⁽⁶⁾ or R-20	R-7.5 c.i.
5	R-30	R-13	NR	R-49	R-13+7.5 c.i. or R-19+5 c.i.	R-7.5 c.i.
6	R-30	R-13	R-7.5	R-49	R-13+7.5 c.i. or R-19+5 c.i.	R-10 c.i.
7	R-38	R-13+3.8 c.i.	R-7.5 c.i.	R-60	R-13+7.5 c.i. or R-19+5 c.i.	R-15 c.i.
8	R-38	R-13+7.5 c.i.	R-7.5 c.i.	R-60	R-13+18.8 c.i.	R-15 c.i.

(1) Data Source: Reference ANSI/ASHRAE/IES Standard 90.1-2016, “Energy Standard for Buildings Except Low-Rise Residential Buildings,” Tables 5.5-1 through 5.5-8. The R-values provided in this table for Partially Conditioned Space and Fully Conditioned Space correspond with the semi-heated and

nonresidential R-values, respectively, in the referenced ASHRAE 90.1-2016 tables. Refer to ASHRAE 90.1-2016 for additional building component types such as other roof types, wall types, floors, slab-on-grade.

(2) The values shown do not represent the values necessary to provide a heat balance between heat produced by products or animals and the heat transferred through the building. The minimum R-values may be reduced if the latent heat analysis demonstrates a need for less insulation to maintain the target temperature and humidity in the building under allweather conditions.

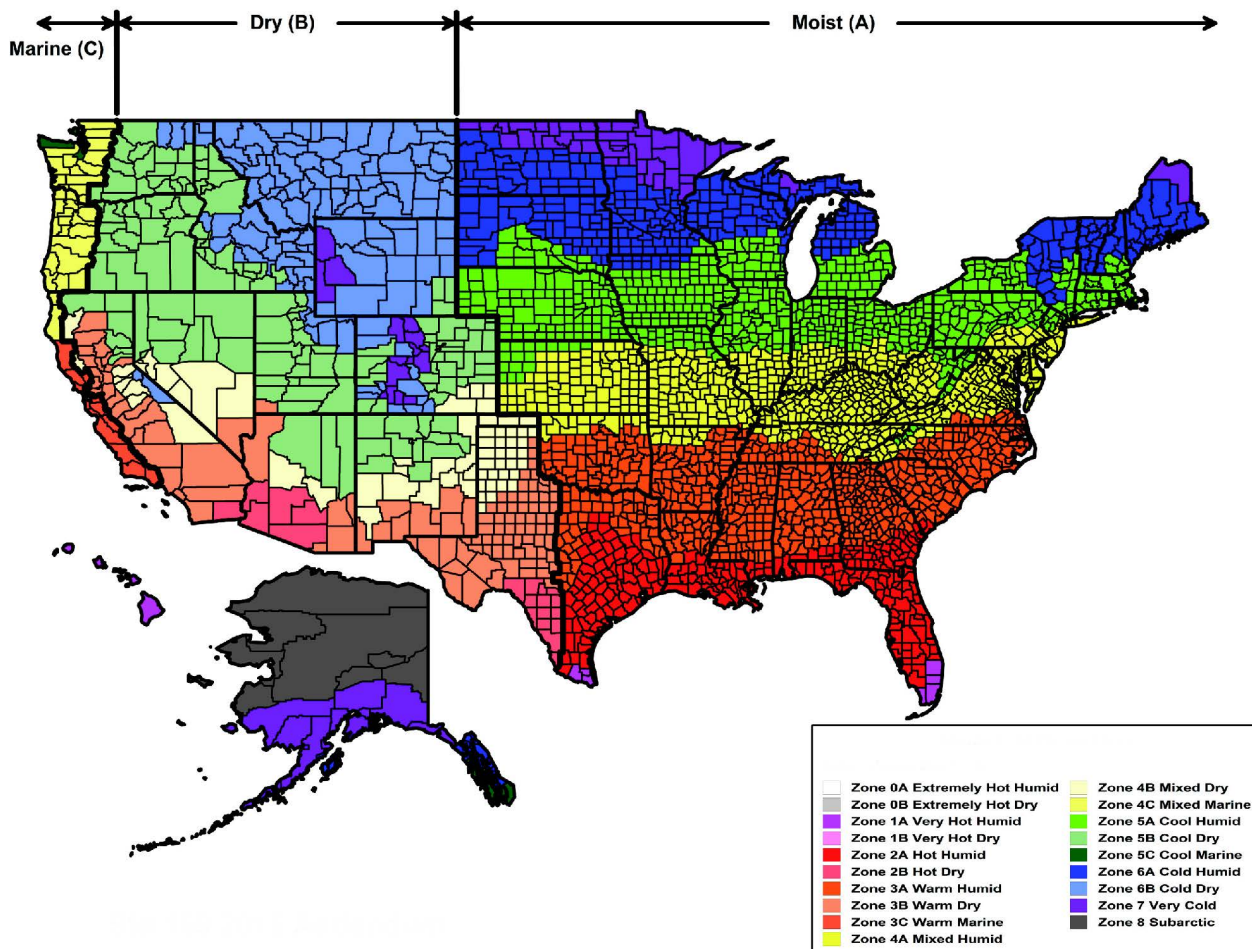
(3) For poultry grow-out buildings, Climate Zones 1 through 4 use minimum R-values (Btu/(h ft² °F)) of R-19 in the roof/ceiling and R-7 in the walls.

(4) Refer to figure 1. ASHRAE 90.1-2016, Annex 1, Table Annex 1-1 provides a listing of U.S. Climate Zones by State and County.

(5) NR = No insulation requirement.

(6) c.i. = continuous insulation. Insulation that is uncompressed and continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope (ASHRAE 90.1-2016). Continuous insulation has an R value associated with it. For example, R-13+7.5 c.i. is wall cavity insulation of R-13 plus a continuous insulation wrap of R-7.5.

Figure 1: Climate zones for United States counties.



Insulation for greenhouses

Insulate greenhouse perimeter walls where light transmission will not be adversely affected.

For vertical perimeter walls, install rigid insulation with a minimum insulation value of R-5 above the interior floor elevation to the top of the knee walls, but no higher than bench height.

For curved perimeter surfaces or similar areas where flexibility is required, use insulated material faced with foil on both sides with a minimum insulation value of R-1.5 with a minimum nominal thickness of 3/16 inches to a minimum height of 3 feet above the interior floor elevation, but no higher than bench height.

State-approved alternative greenhouse insulating methods and materials may be used.

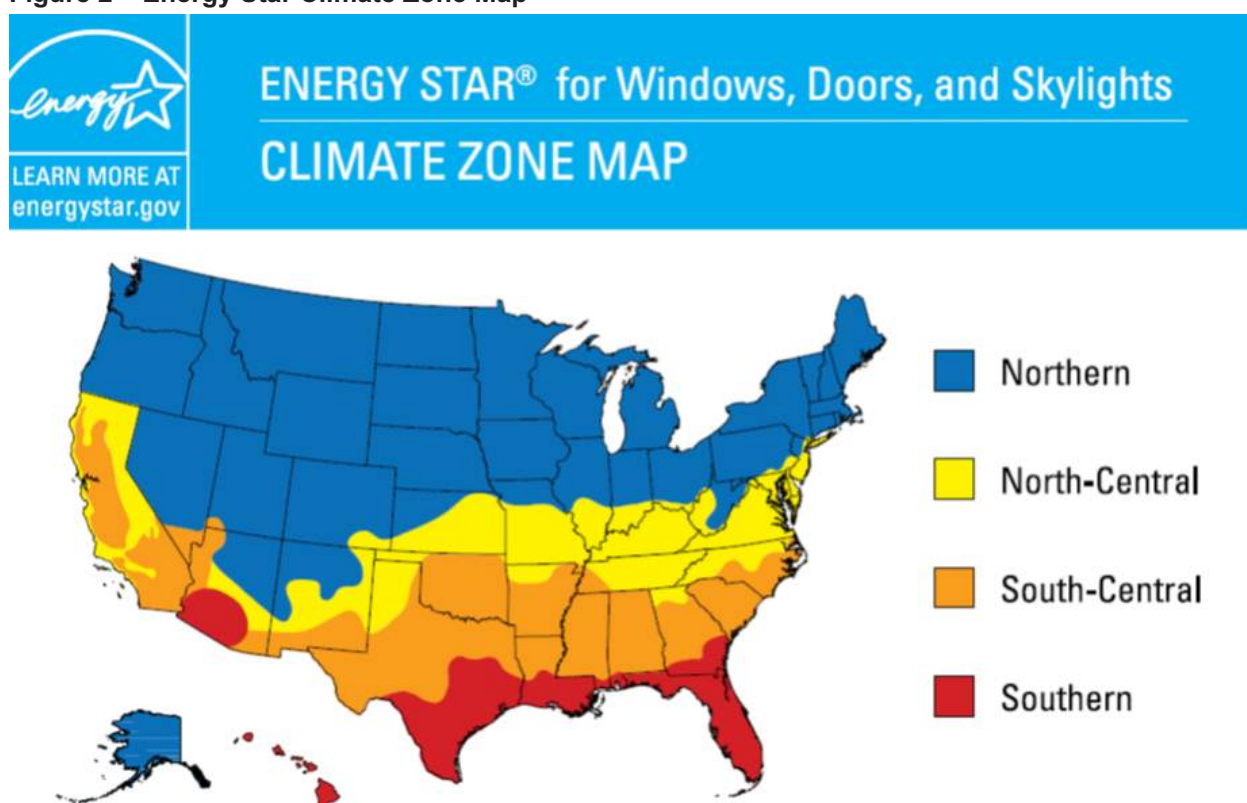
Additional Criteria for Commercial Doors and Windows

The insulation values of the building envelope will meet or exceed the R-values in table 1 above.

Select door and window materials based on temperature extremes, moisture conditions in the building, and expected UV light exposure. Install doors and windows in an airtight manner in accordance with local building codes and manufacturer's recommendations.

Use windows and doors labeled to meet U.S. Environmental Protection Agency (EPA) Energy Star minimum rating associated with the facility's climate zone shown in figure 2, or ASHRAE 90.1-2016, Tables 5.5-1 through 5.5-8 and Section 5.8.2, "Fenestration and Doors," or provide an energy analysis that demonstrates that the door and window assembly will meet or exceed the energy efficiency of the R-values, as applicable.

Figure 2 – Energy Star Climate Zone Map



Additional Criteria for Energy Screens

Select screens with a warranty life of 5 years or greater on strength and flexibility.

Use screen materials that are flame retardant. Use firebreaks where needed to limit screen-to-screen fire spread. Materials and installation must meet all local fire codes.

Use single strand smooth plastic or metal support lines (not cable).

When screens are in the closed position, screens must fit tightly where the screen meets the sidewalls, framing, or gutters.

Greenhouse screens (curtains)

Select greenhouse screens based on intended use such as heat retention, daytime shading, or both.

Select screens according to the energy savings as determined by the transmissivity, emissivity, and reflectivity of heat radiation; the air permeability of the material; and the humidity transport through the material.

Use screens with a minimum energy savings potential of 40 percent according to the manufacturer.

Install screens either gutter-to-gutter (screen pulled flat across the structure at gutter height) or truss-to-truss (screen pulled between adjacent trusses). In some wide greenhouse bays with peaked roofs, screens can be installed that follow the roof line up from the gutter before crossing over horizontally.

Livestock housing curtains

Use curtains that have a minimum R-value of 4.

CONSIDERATIONS

Consider using the American Society of Agricultural and Biological Engineers (ASABE) S612, "Performing On-farm Energy Audits," or equivalent, to prioritize energy conservation opportunities and estimate potential energy savings of improvements.

To reduce energy imported on a farm, consider developing and using on-farm solar, wind, or other renewable energy resources. Energy conservation and energy efficiency improvements should also consider greenhouse gas emission and ambient air pollutants.

Consider the need to move or modify electrical wiring, water pipes, fuel supply pipes, light fixtures, or other infrastructure for installation of the practice.

To increase energy efficiency consider the following enhancements:

- To control solar heat gain, use windows that meet climate zone-specific Energy Star ratings or ASHRAE 90.1-2016, Tables 5.5-1 through 5.5-8, and Section 5.5.4.4, "Fenestration Solar Heat Gain Coefficient (SHGC)."
- Insulate and seal the ventilation fan or other openings when not in use for an extended period.
- Replace roofs with a cool roof meeting ASHRAE Standard 90.1-2016, Section 5.5.3.1.1 in climate zones 1 through 3.

Where relative humidity is maintained above 85 percent within the agricultural building, refer to the latest edition of American National Standards Institute (ANSI)/American Society of Agricultural Engineers (ASAE) EP475, "Design and Management of Storages for Bulk, Fall-Crop, Irish Potatoes," or other appropriate guidelines for additional design features.

Consider long-term cost savings and associated life cycle costs to increase long-term profitability.

Consider the following greenhouse energy efficiency enhancements:

- Install multiple independently operated screens in greenhouses to increase heat retention and shading options for improved control and energy savings.

- Improve the efficiency of moveable greenhouse screens with temperature and moisture sensors, and automated controls.
- Install inlet and exhaust opening insulation in a manner that allows for removal during the warmer months of the year in greenhouses that use sidewalls for ventilation. When using removable insulation, consider the durability of the materials used.
- Install perimeter insulation that extends 1 to 2 feet below grade level to prevent thermal bridging between the internal greenhouse perimeter and the outdoor soil.
- Use energy efficient glazing materials (e.g., double-layered and inflated polyethylene films or twin-walled rigid plastic panels). Reduce opportunities for condensation between the layers.
- When expanding an existing greenhouse, consider gutter-connected additions that minimize the external surface area and therefore the resulting heat loss.
- Install a heat sink to absorb and retain heat.
- Consider ability to fold compactly, durability, and functionality when selecting screen materials.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for building envelope improvements that describe the requirements for applying the practice to achieve the intended purpose. As a minimum, include—

- Plan view and cross section drawings and description of the existing and modified or retrofitted building envelope and related components or devices, if applicable.
- Description and characteristics of materials to be applied or installed in the building envelope.
- Installation details associated with the practice.
- Estimated quantities.
- Requirements for disposal of replaced materials, if applicable.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operator. Requirements may include but are not limited to—

- Annual inspection and testing of building envelope components, including as appropriate, but not limited to—
 - Building envelope.—Check for leaks (e.g., visual inspection, fogger, or pressure test).
 - Insulation.—Depth in ceiling, gaps, shrinkage, adhesion, tears.
 - Vapor barriers.—Tears or other holes.
 - Energy screen.—Visual inspection along screen edges where it meets sidewalls, framing, or gutters; look for gaps, tears, holes, or other damage while the screen is fully extended.
 - Control systems.
- Maintaining records of annual inspections and finding.
- Implementing a vector (insects, rodents, etc.) control program to minimize damage to building envelope.
- Repairing or replacing within 30 days of finding any items identified during the annual inspection. Repair as needed to maintain energy efficiency.
- Energy screen replacement within the life span of the practice.

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