My message

- Most foam applications result in very high-performing building enclosures.
- Once in a while, things can go wrong.
- How can we as owners, designers, inspectors, contractors, installers, and administrators be sure that we get the best possible results?
  - Specify or require quality assurance in your projects
  - Perform quality assurance protocols during the work
  - Verify quality assurance after the work

Resources & information

Web site - *www.hcfennellconsulting.com*

- Resources (20+ pages of documents lists)
- Planning foam projects
  - How to select foam products
  - How to select foam contractors
  - Special foam applications
- Diagnostics and quality assurance techniques
- Technical resources by category - Building science, foam, safety, quality control, products, etc.
- Sample completed projects with details
- Foam industry commissioning services available

Four types of QA for foam plastic = causes

1. Design
   - Verify that the right type of foam is being used for the application
   - Verify that the design reflects good building science for the specific application
   - Verify the intent (product quality and application performance) of the design
2. Chemicals
3. Installation
   - ***Processing***
   - Technique
4. Installation follow-up
   - Maintain minimum cure requirements

Comment: In the old days, the contractor was responsible for all of these, plus training and education. Now, it is only #2 and #3.

Chemistry issues and QA

B. Concerns for the chemistry
    1. Prone to stratification when stored (requires mixing)
    2. Must be the right temperature
        a. When stored
        b. When processed
    3. The A-side requires a dry gas blanket
    4. Work-arounds for each
        a. *Specify processing to manufacturer's specs.*
        b. *Require process monitoring records as a submittal (monitor output)*

QA for Chemicals

Before the installation

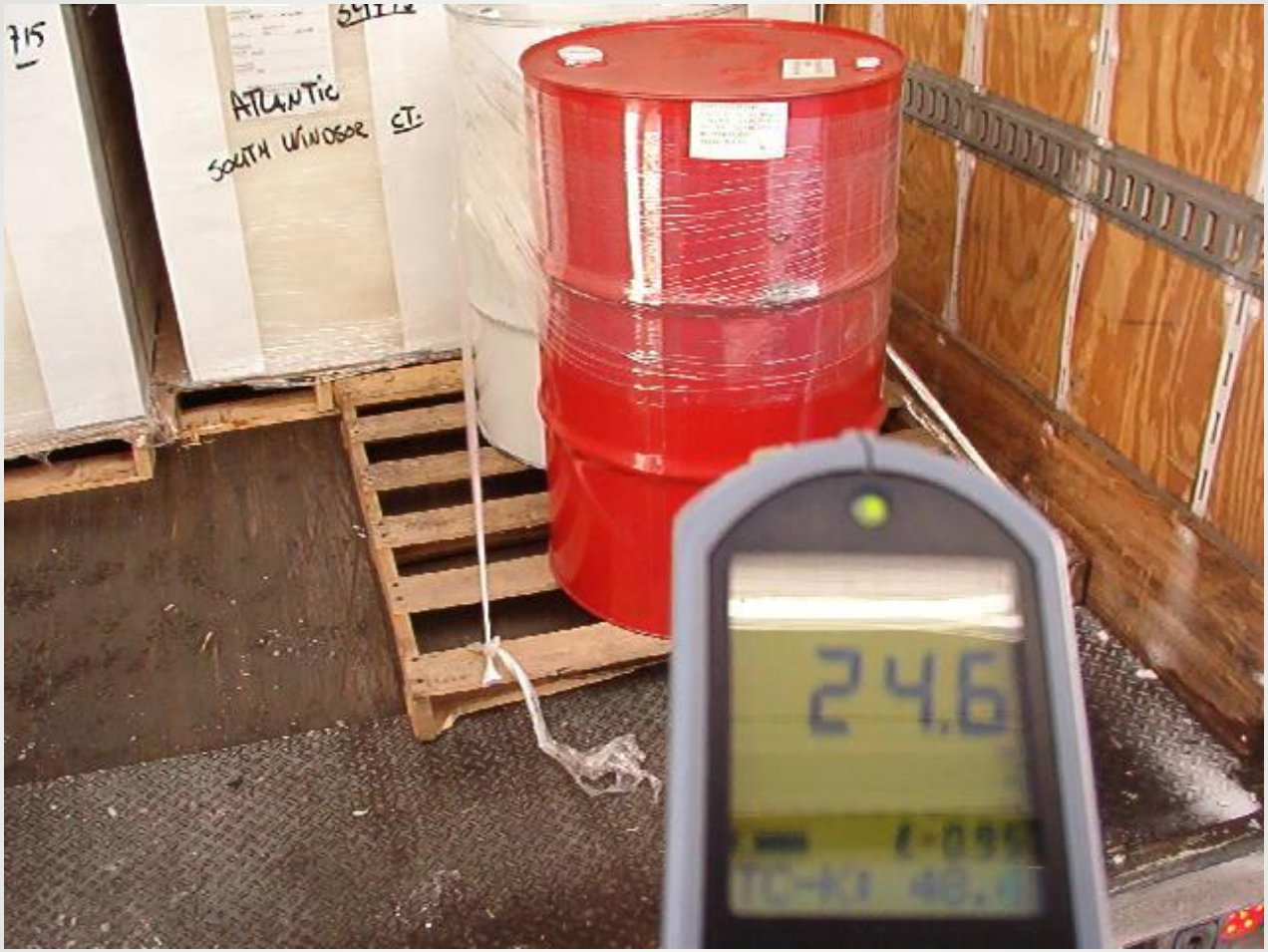
- Verify QA procedures at the factory – use proven products, ask for QA documentation
- Keep records of the lot numbers used for each project
- Maintain proper temperatures during storage or shipping - Do not store above 86F or below freezing

During the installation

- Maintain proper material temperatures
- Maintain proper ambient and substrate temperatures
- Maintain proper process-equipment temperatures – verify heaters are working properly (pump and gun)

Require process temperature and flow monitoring records as a submittal

Too cold



Foam rigs are normally insulated and heated to keep the
“A” and “B” components at their appropriate storage or feed temperatures.
(Rigs parked outside at the site overnight with no heaters)

QA for processing the chemicals

Processing

1. Verify pump is on ratio – monitors or scales
2. Maintain an adequate mix – regular test shots
3. Verify chemical, pump, and hose heat temperatures are properly set and maintained for the product – temperature monitors
4. Maintain proper ongoing quality assurance protocols to avoid changes after initial setup (Ideally use monitors with shut-down capability)

Hint: Require QA processing reports as submittals to assure product quality

SPFA AY 137 Guidance Document

SPFA AY 137

In order to properly spray polyurethane foam, the equipment must be capable of storing, pumping, heating, mixing, and spraying these two components at the material supplier's recommended temperature, viscosity, and material ratio.

In general, five equipment elements are necessary to spray polyurethane foam:

1. Material storage and handling system
2. Material feed system
3. Proportioner pumping/heating system
4. Material Delivery hose system
5. Spray gun. (this is the end of the process, where the material has to meet the mfg's processing requirements.)

SPFA AY 117

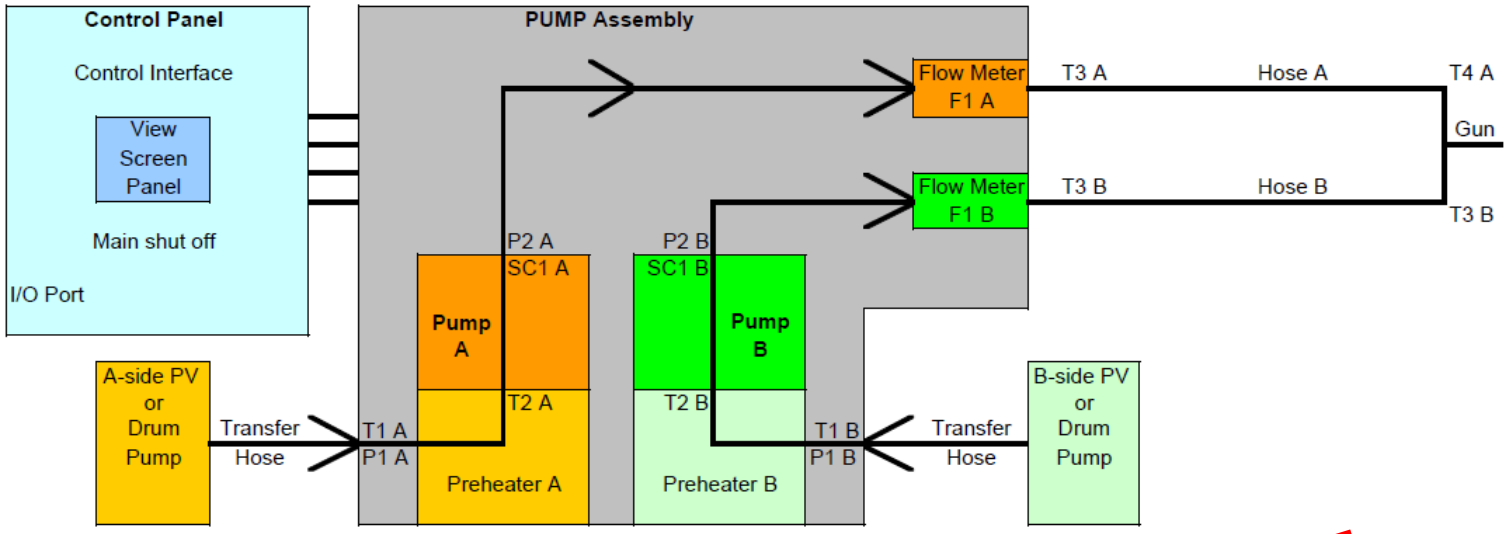
The proportioner commonly consists of two positive displacement, double acting piston pumps with a common drive system. This design assures that the “A” and “B” components will be delivered to the spray gun at constant ratio at high pressure.

A heating system is necessary to raise the temperature of the “A” and “B” components in order to lower their viscosities. Without lower viscosities, the materials would not mix properly at the spray gun resulting in poor foam quality. However, some proportioners do not have a primary heating system built into them.

Material heat is normally supplied in two stages: a primary heater (or pre-heater) and a heated hose. Generally, the primary heaters are responsible for heating the “A” and “B” components to their application temperatures while the heated hose is designed to maintain that temperature during application.

Complete QA system diagram

Pump Monitoring System Diagram



T1 A	Temperature at inlet from transfer hoses (A)	0 to 200 degrees F	Shut down if below set point
T1 B	Temperature at inlet from transfer hoses (B)	0 to 200 degrees F	Shut down if below set point
T2 A	Temperature at oulet from preheater (A side)	0 to 200 degrees F	Shut down if below set point
T2 B	Temperature at oulet from preheater (B side)	0 to 200 degrees F	Shut down if below set point
T3 A	Temperature in first section of hose (A side)	0 to 200 degrees F	Shut down if above high limit set point
T3 B	Temperature in first section of hose (B side)	0 to 200 degrees F	Shut down if above high limit set point
T4 A	Temperature at gun end of hoses (A side)	0 to 200 degrees F	Shut down if below set point
T4 B	Temperature at gun end of hoses (B side)	0 to 200 degrees F	Shut down if below set point
P1 A	Pressure at outlet of Transfer hose (A side)	0 to 500 psi	Shut down if below set point
P1 B	Pressure at outlet of Transfer hose (B side)	0 to 500 psi	Shut down if below set point
P2 A	Pressure at outlet of pump (A side)	0 to 3,000 psi	Shut down if below set point Alarm, then shut down if A - B difference exceeds preset limits
P2 B	Pressure at outlet of pump (B side)	0 to 3,000 psi	Shut down if below set point Alarm, then shut down if A - B difference exceeds preset limits
F1 A	Flow rate (A side)	0 to 5 GPM	Alarm, then shut down if A - B difference exceeds preset limits
F1 B	Flow rate (B side)	0 to 5 GPM	Alarm, then shut down if A - B difference exceeds preset limits
SC1 A	Stroke counter (A side)	0 to 100,000	Record only
SC1 B	Stroke counter (B side)	0 to 100,000	Record only
PV A	Pressure vessel (A - Side)		
PV B	Pressure vessel (B - Side)		

Product Data Sheet

PROCESSING CHARACTERISTICS AND RECOMMENDATIONS

RECOMMENDED PROCESSING TEMPERATURES	Preheater	Hose
Component A	100-130°F	100-130°F
Component B	110-130°F	100-130°F

These temperatures are typical of those required to produce acceptable product using conventional Gusmer or Grace equipment. Environmental conditions may dictate the use of other temperature ranges. However, under no circumstances should a temperature of 140°F be exceeded. It is the responsibility of the applicator to determine the specific temperature settings to match the environmental conditions and his own equipment.

PROCESSING CHARACTERISTICS

Machine Mix at recommended temperatures*	Winter	Regular
Cream Time	1 second	2 seconds
Tack Free Time	On Rise	On Rise
Cure Time	4 Hours	4 Hours

Industry-standard requirements

1. Comply with the foam manufacturer's requirements
2. Follow the SPFA guidelines for equipment
3. Follow the SPFA guidelines for foam safety
4. Follow the OSHA guidelines for workplace safety
5. Follow the SPFA guidelines for foam processing

Transmittals:

- Require compliance with all of these in the Specifications or the Work Requirements for the project to assure product quality
- Prequalify installers to verify that they can comply with these requirements
- Require documentation of compliance in the submittals

Off ratio – B-rich

Infrared locates off-ratio material

Pattern analysis discovers off-ratio material

Standard OEM QA Equipment

MIXSYN EQUIPMENT

PLURAL COMPONENT SOLUTIONS

- Home
- Static Mix Models
- Low Pressure Sprayers
- Custom Built Machines
- PMC High Pressure
- Dynamic Mix Models
- Contact Us

MIXZEN M Series Dynamic Mix Machines

Dynamic mixing is required for harder to mix polyurethane's. Most high density rigid foams, flexible foams, and self-skinning foams require either a low pressure dynamic or high pressure RIM machine to process. RIM machines are very expensive, require more electrical power and are much tougher to service.

Experience the MIXZEN M Series advantage! Our helical mix blade turning at 6,900 RPM insures an incredible mix, precision pumps keep ratios within 0.5% and tempering controls maintain critical process parameters and reaction rates. The low pressure laminar flow exiting the mix chamber is ideal for dispensing into shallow open molds.

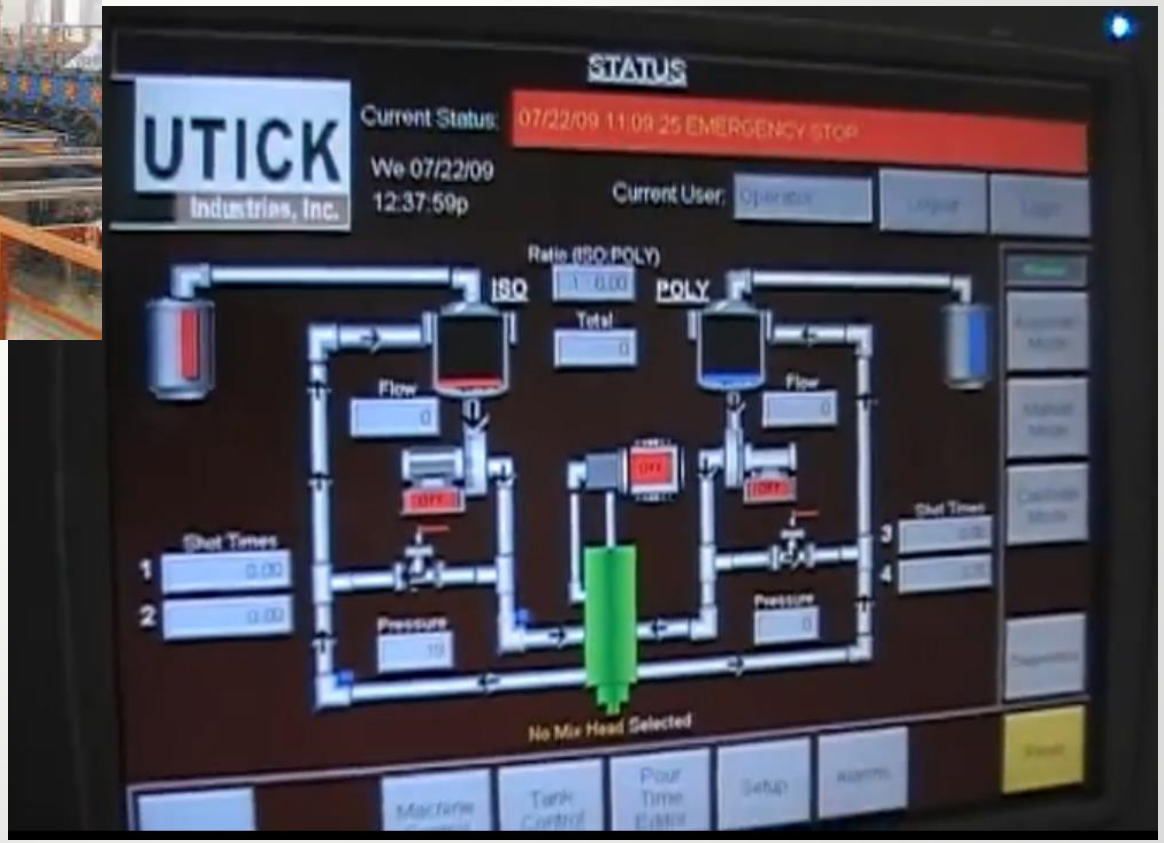
MIXZYN M40

Manufacturing Architectural Foam Trim

Specifications

Options

OEM PU Foam processing



Graco

GRACO

XP Pressure Monitor Kit

Provides Ratio Assurance for Graco XP70™ Sprayers

On-ratio spraying means peace of mind

- Provides assurance that your XP70 is spraying accurately and on-ratio
- Improved efficiency means you get it done right the first time and within the scheduled timeframe
- Reduced rework saves you labor and material costs
- Improved quality control – you have more confidence in end results
- Easily retrofits to any XP70 – can be installed in less than 20 minutes

Graco

Accurate, on-ratio dispense means less waste, more profits

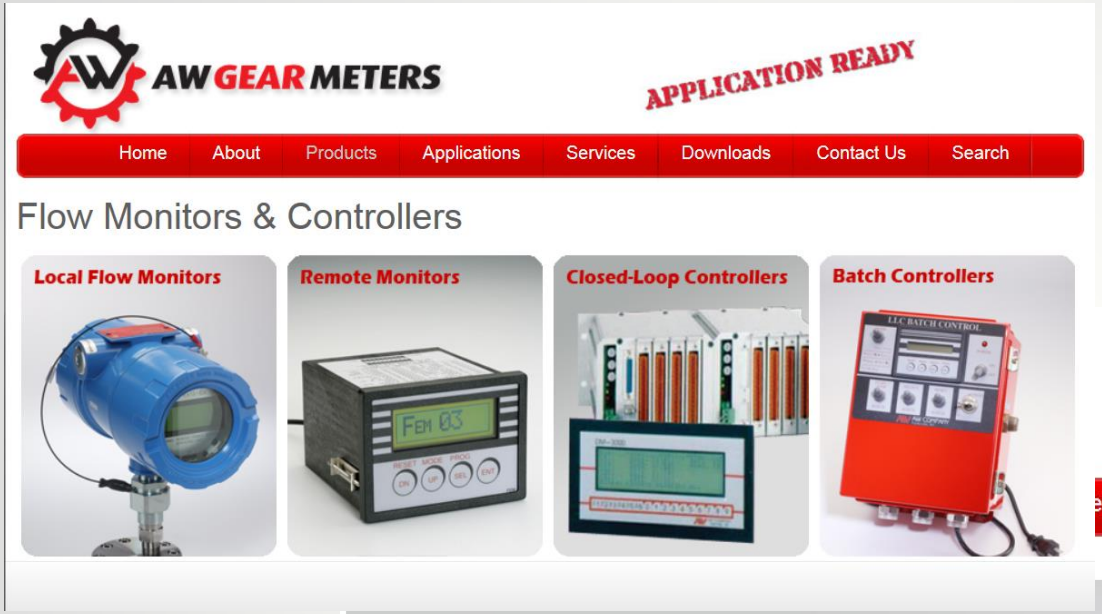
With the Graco HFR Metering System, you accurately mesure a specific ratio and volume – first time, every time. As the machine dispenses material, it automatically fine-tunes and adjusts to achieve a consistent material flow or pressure. With a ±1% ratio accuracy, you reduce scrap and rework with accurate, on-ratio dispensing.

Flow meters

AW FLOW METERS

EMO-500
Two Component Ratio Monitor

Flow meters


AW GEAR METERS
APPLICATION READY
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Search
Flow Monitors & Controllers
Local Flow Monitors
Remote Monitors
Closed-Loop Controllers
Batch Controllers


APPLICATION READY
ervices
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Search
Dependable flow measurement technology geared to your specific application
Flow meters designed for those tight spaces or robotic applications

Ratio Check

Because the cost of failure is too high!

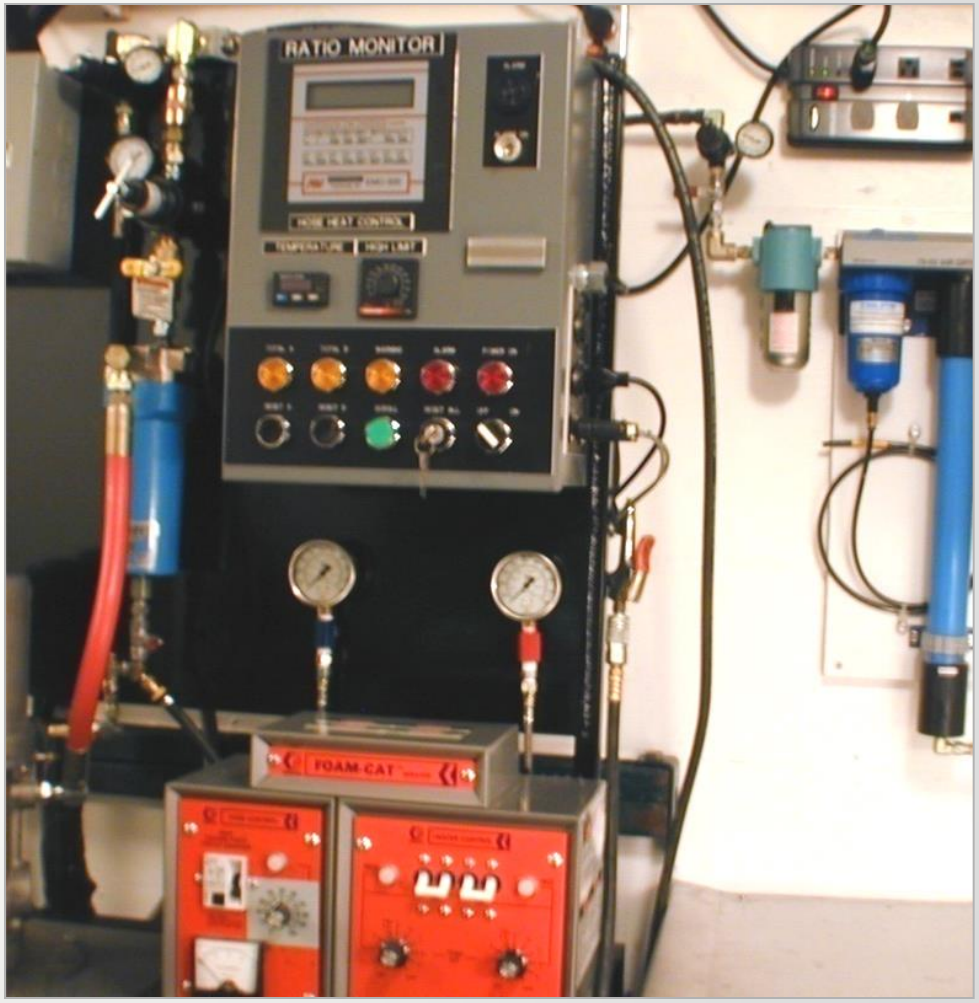
Features

Ratio Check

1. Shuts down pumps when it detects an off-ratio scenario, sounding an alarm horn with red flashing light.
2. Complete shtut-down at any off-ratio percentage the customer desires (can be set to alarm, but not shut down your equipment at a set percentage as well)
3. Easy reset for the operators should an alarm occur.
4. Monitors ratio by volume on Graco Reactors, Graco/Gusmer H-20/35 and other plural-component pumps.
5. Continuous monitoring with LED readout of both A & B components
6. Totals of both A & B per part or job
7. System is completely installed at the pump controls for operator convenience(not remote-mounted)
8. Runs on 110-volt circuit
9. Meters attached directly to the pump system, making the whole system more compact.
10. Hands-on start-up and training by trained field technicians available.

Mobile Spray Rig (Bulk foam)

Ratio, use, and temperature monitor



Complete Monitoring System

1. Primary heaters
2. Hose heaters
3. Hose high limit
4. Flow – batch and total
5. Flow – ratio A to B
6. Digital outputs
7. Alarm and shut off set points for all monitored systems

1. Thermistors
2. Air valve
3. Wiring

1. Pressure
2. Ambient temp. & humidity

EMO-500/E Industrial Enclosure

Dual Flow Meter Support

Warning and Alarm Lights

Alarm Siren and Silencer

External Reset

RS-232/485 Communications

NEMA 12 Enclosure

Industrial Push Button Control

Pre-wired, ready to go

QA for installations

1. Verify substrate material compatibility for adhesion
2. Establish and maintain temperature requirements
    a. Ambient
    b. Substrate
4. Substrate conditions – clean and dry
5. Monitor pass thickness
6. Take periodic test shots and verify product quality

Substrate compatibility

Substrate material compatibility for foamed-in-place polyurethanes

Substrate Materials - General Description	Product/Brand name	Adhesion rating	Preparation	Maximum moisture content allowed
Wood products				
Construction grade spruce	Many	Good	Clean and dry*	< 11%
Pressure treated lumber	Many	Varies	Clean and dry*, free of preservative buildup	< 11%
Wood boards	Rough-sawn and planed			
Glue-laminated beams & joists				< 11%
Natural wood face layer	Many	Good	Clean and dry*	< 11%
Waxed finish	Many	Poor	Apply bonding material	< 11%
Plywood				< 11%
Standard wood	Many	Good	Clean and dry*	< 11%
Pressure treated	Many	Varies	Clean and dry*, free of preservative buildup	< 11%
OSB				< 11%
Smooth side	Many	Moderate	Sand and/or prime	< 11%
Rough side	Many	Good	Clean and dry*	< 11%
High and medium-density composite wood panels				< 11%
MDO	Many	Moderate	Sand and/or prime	< 11%
Particle board	Many			< 11%

Substrate compatibility

Substrate material compatibility for foamed-in-place polyurethanes

Substrate Materials - General Description			Product/Brand name	Adhesion rating	Preparation	Maximum moisture content allowed
Metals						
	Steel					
		Mill-finish cold rolled sections	Many	Moderate	Clean and apply etching agent/primer	
		Mill-finish coil stock	Many	Poor	Clean and apply etching agent/primer	
		Primed and/or painted	Many	Good	Clean and dry	
		Galvanized steel - Spangled	Many	Poor	Apply etching agent	
		Galvanized steel - Hot dipped	Many	Moderate	Prime	
		Galvanized steel - Cold coated	Many	Moderate	Prime	
		Galvanized steel - with paint-prep. galvanization process	Galvalume	Good	Clean, dry, free of oil and grease, or uncured solvent-based materials	
	Aluminum					
		Mill-finish		Poor	Etching & prime	
		Primed and/or painted		Good	Clean and dry*	
		Galvanized - Galvalume		Moderate	Clean and dry*	
		Aluminum foil facers on RFB		Moderate	Clean and dry*	
Coatings						
		Bituminous coatings	Tar, foundation coatings, vapor barrier coatings	Poor	May delaminate from heat of reaction	
		Water-based coatings	Foundation coatings, vapor barrier coatings	Varies by product - verify with manufacturer	As directed by manufacturer	
		Polyurea	Many	Good	Clean and dry	
		Oil and water-based paints	Many	Good	Clean and dry	

Substrate temperature

Product Data Sheet

RECOMMENDED SUBSTRATE TEMPERATURES

At time of application	RT2045 Winter	RT2045 Regular
Minimum	40°F	60°F
Maximum	80°F	120°F

For applications below 40°F, the installer's personnel should be consulted. At the lower end of the indicated temperature ranges, flash passes should be avoided.

Hot roof and pass thickness issue

Thermal shock

Technical Issues

Pass frequency and thickness

1. Verify core temperature before installing new passes
2. Requires QA tests for pass and total insulation thickness

Submittals: Require Work and QA reports, including these measurements, to verify product quality

Pass thickness test

Too hot - burnout

Hot roof and pass thickness issue

Thermal shock

Technical Issues

Pass frequency and thickness

1. Verify core temperature before installing new passes
2. Requires QA tests for pass and total insulation thickness

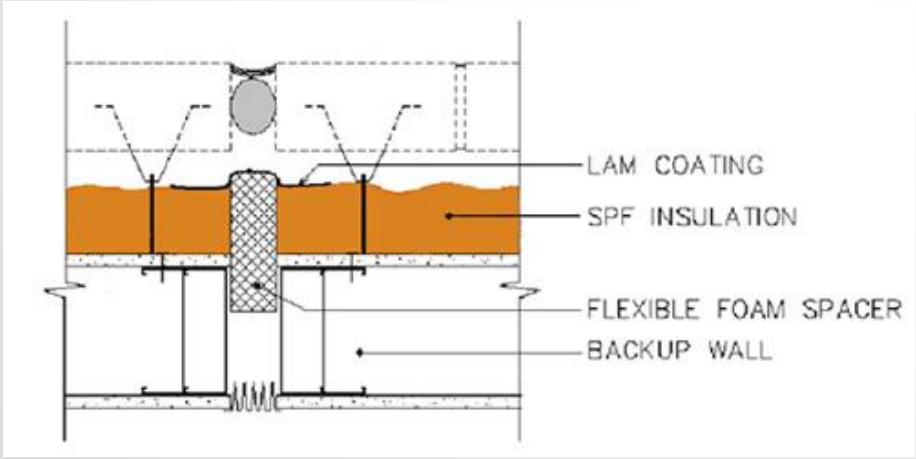
Submittals: Require Work and QA reports, including these measurements, to verify product quality

How can we verify long-term performance?

Anticipate building movement in the design and installation

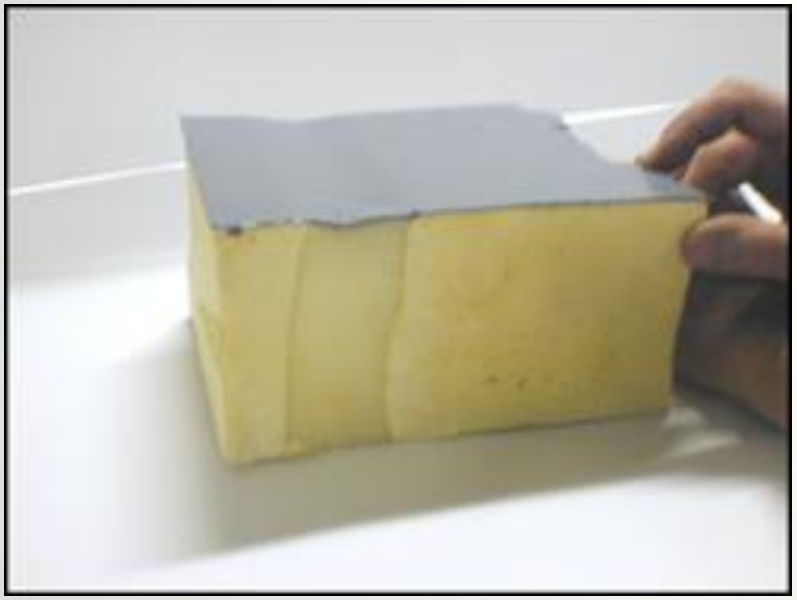
- Provide control joints where necessary
- Relieve stresses with surface cuts or bond breakers where necessary

Control Joints



Control Joints

Allow movement to relieve stress, while maintaining air barrier continuity and water management

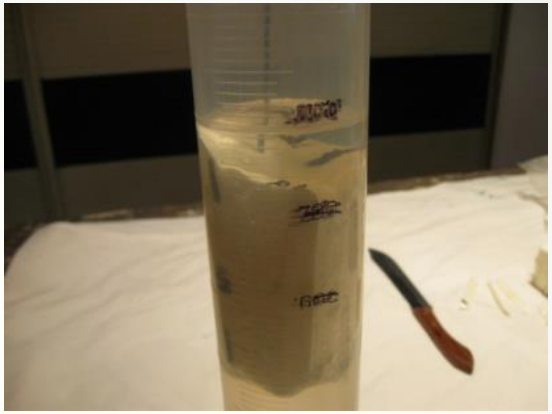


Tools of the QA trade

1. Pull / adhesion test tool
2. Density check kit
3. Compressive strength gauge
4. Temperature meter
5. Relative humidity meter
6. Slit test knife
7. Theatrical fog machine
8. IR camera
9. Blower door

Testing foam properties

Foam inspections – Installation quality

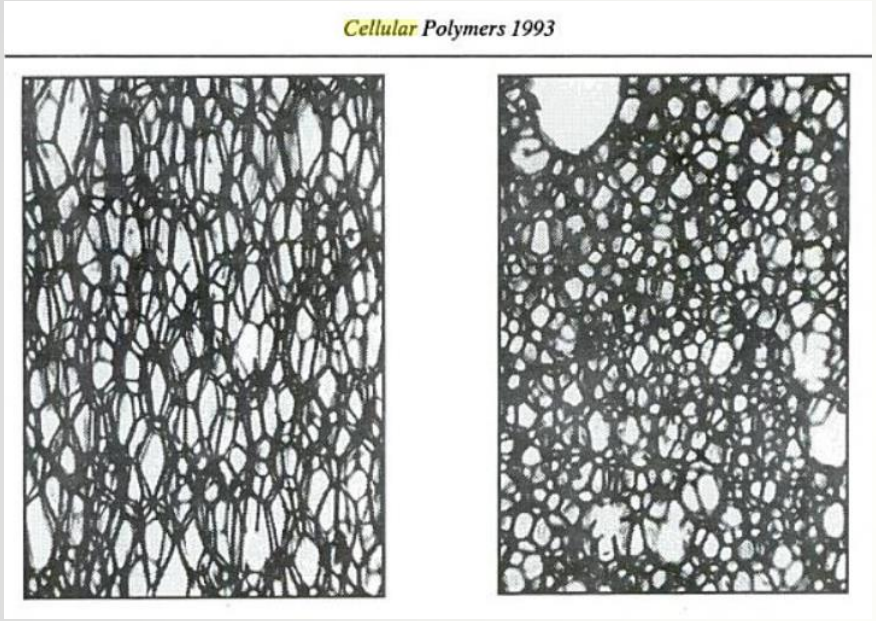


Installation quality assurance

Graduated beaker displacement density test

Courtesy: Air Barrier Association of America

Cell Geometry



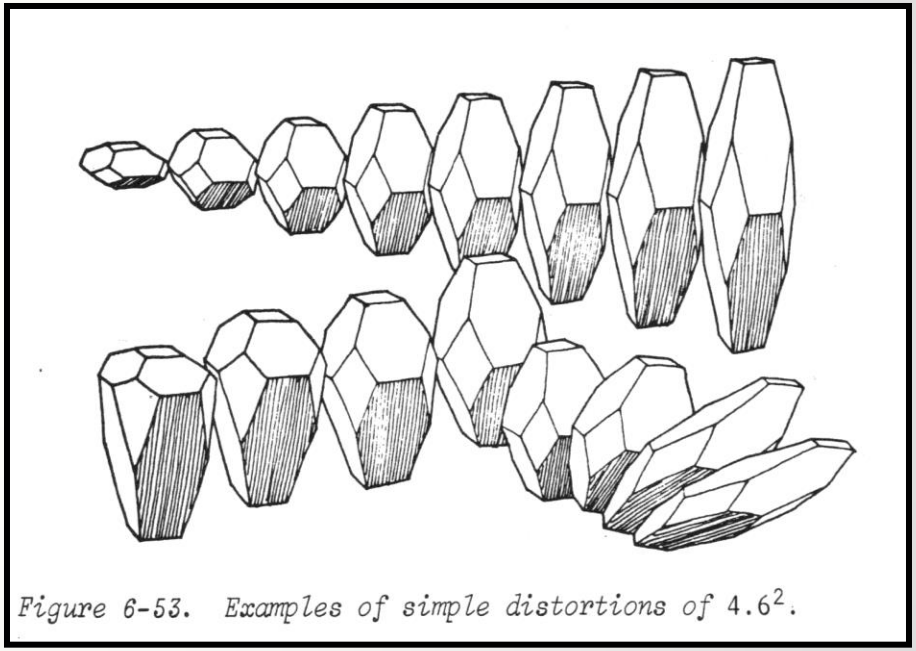


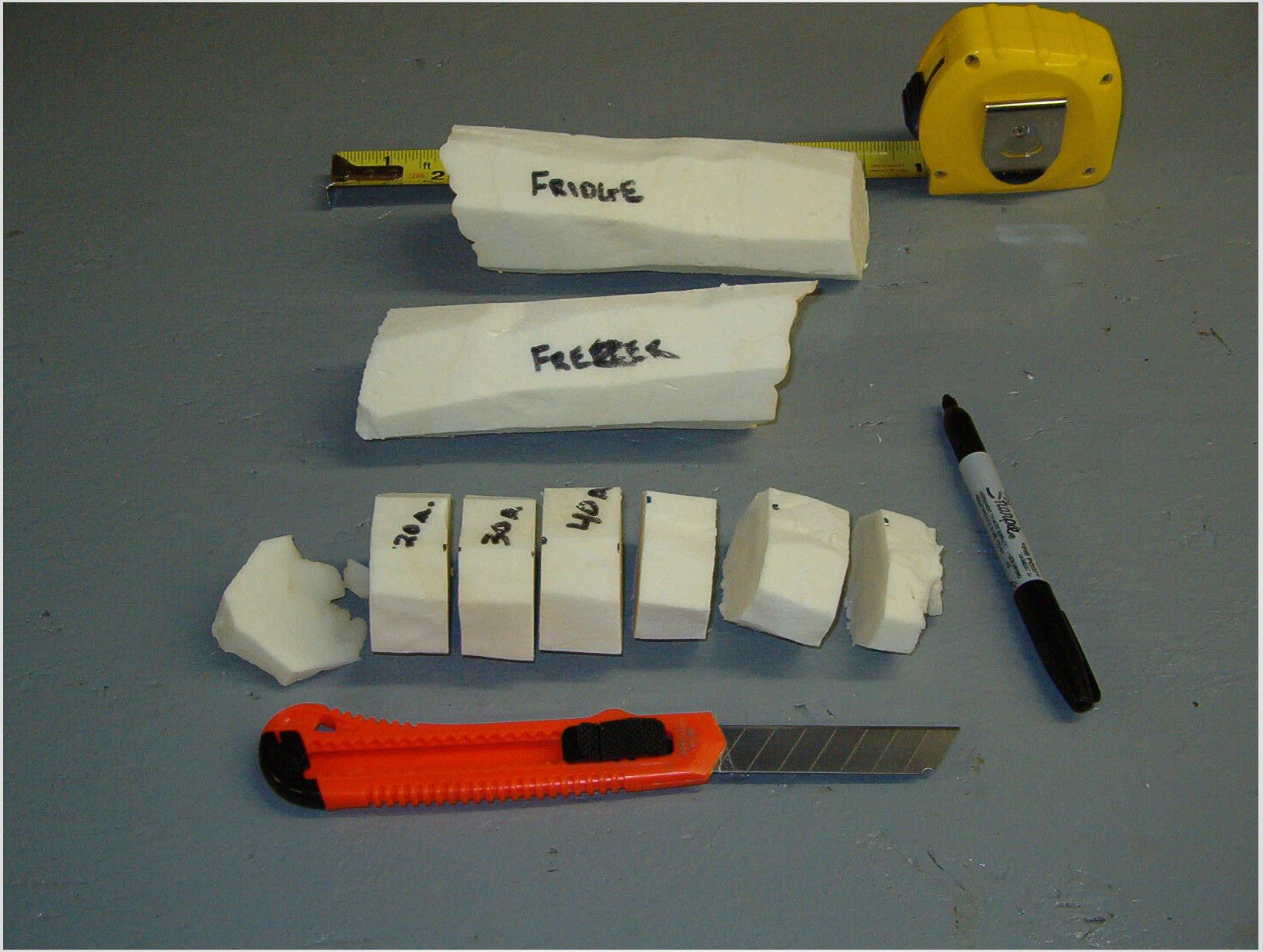
Figure 6-53. Examples of simple distortions of 4.6^2.

- Elongated cells are stronger parallel to the long axis than perpendicular to it (similar to the grain in wood).
- Elongated cells usually mean improper application technique.

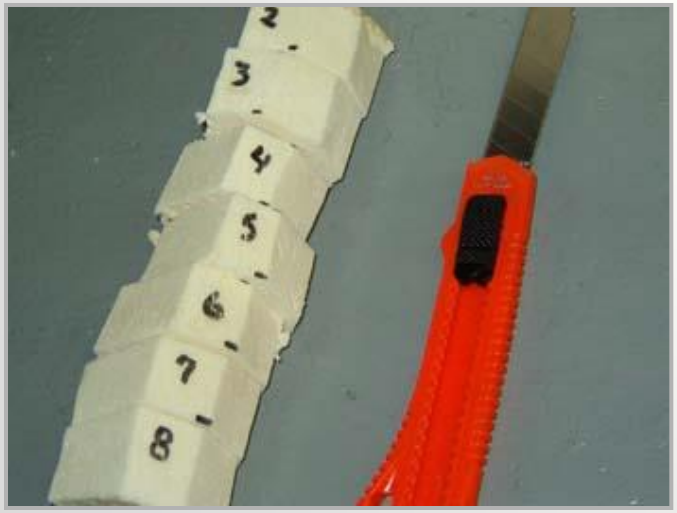
Cellular density

Elongated cells are weaker perpendicular to the grain and thermal shock causes the material to shrink laterally.

Foam inspections – Project identification


FRIDGE
FREEZER
20A
30A
40A

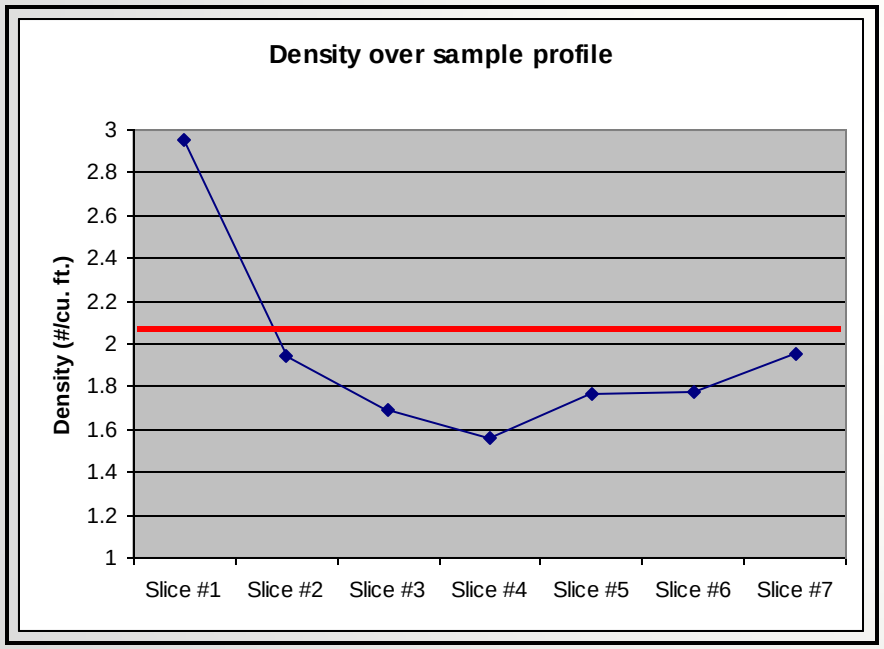
Density Profiles

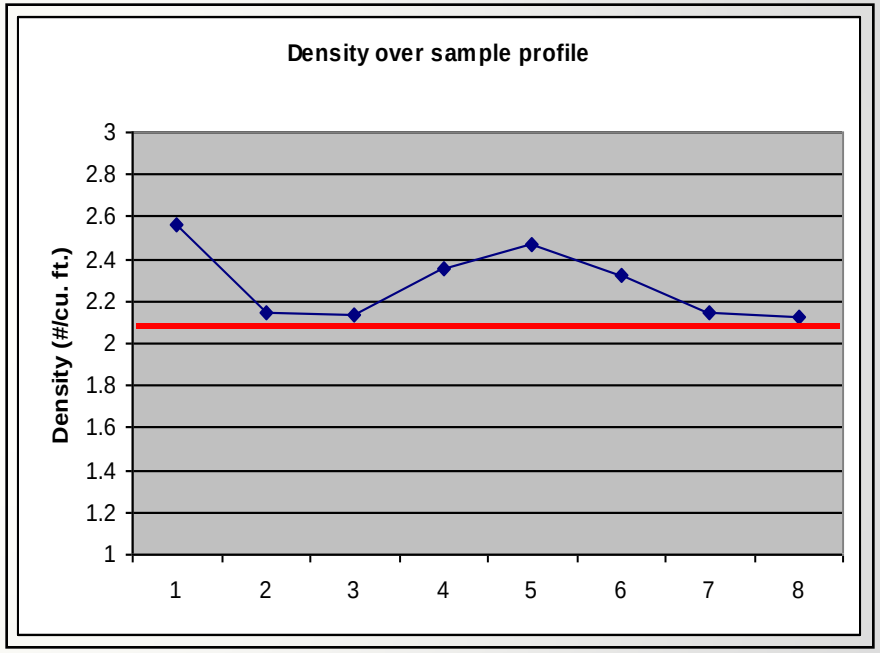


	Sample 10A	Sample 5B
Pass thicknesses	1.5" - 7"	1.5" - 2"
Percent change	6%	25%
Average density for entire sample	~1.8	~2.2
Slice #1	2.95	2.56
Slice #2	1.94	2.15
Slice #3	1.69	2.14
Slice #4	1.56	2.35
Slice #5	1.77	2.47
Slice #6	1.78	2.32
Slice #7	1.95	2.15
Slice #8	-	2.13

Density Profiles

Blue line: Incorrect pass thickness

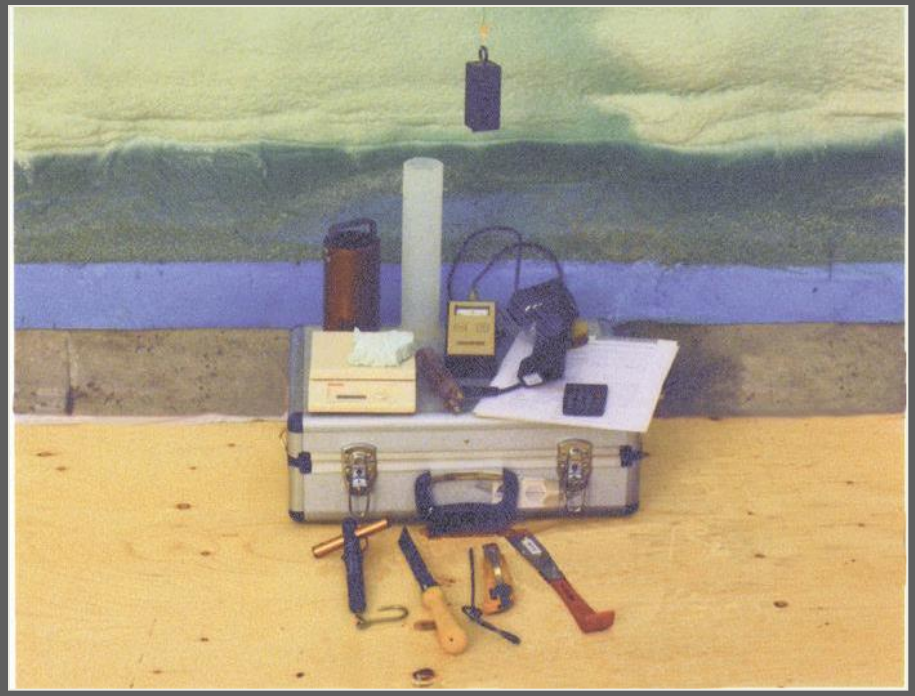




Correct pass thickness

Red line indicates minimum density (2.1#/cu. ft.) for good dimensional stability

On-site testing



Adhesion test

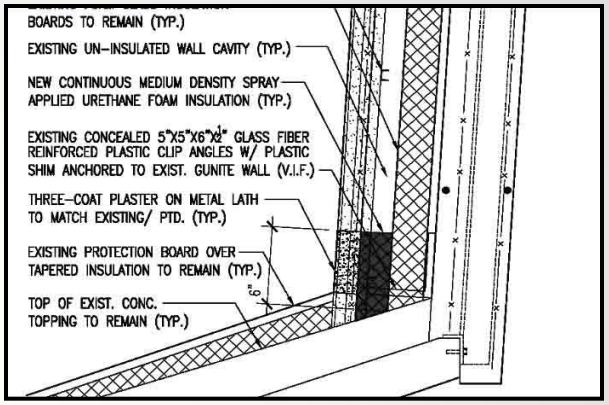
Adhesion test

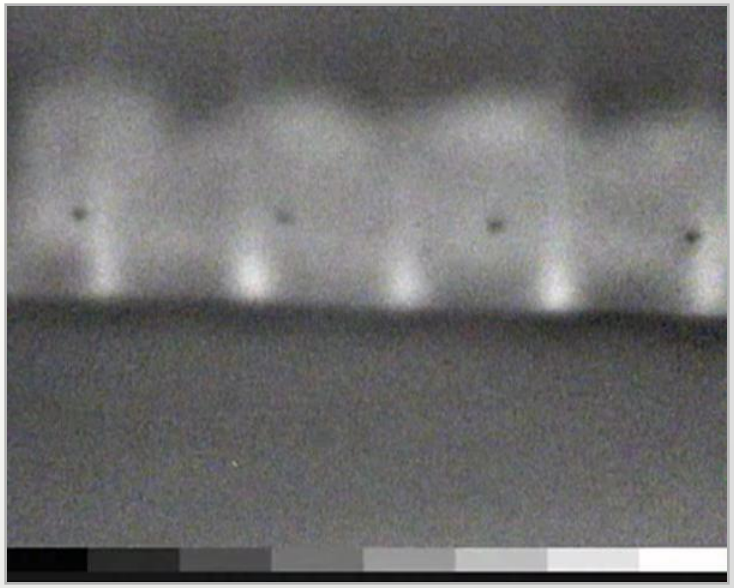
Adhesion test

IPF – Bulk foam

Infrared QA of foamed-in-place insulation –
effective year-round (240F)

IPF – Bulk foam





Infrared QA of foamed-in-place insulation behind 1” plaster – effective year-round (240F)

Good technique

Good technique also saves material ($)

Technique

Better depth control

Self supporting

Technique

Below grade application

Technique

Unvented roof application

Technique

Drainage plane application

Bad technique

Uneven installation - voids

Bad technique

Lack of over-spray protection

Post installation problems

1. Failure to maintain minimum cure requirements
2. Inadequate quality assurance protocols
3. Lack of protection against damage by related trades

Note: Product Data sheets and ESRs report cure requirements – verify compliance with the manufacturer's requirements