This presentation will provide an overview of the most common types of roofing systems in the commercial market place today. Along with a brief description, history and application of each of the systems, the advantages and disadvantages will also be reviewed.

We hope that this presentation will provide you with information you find useful. If you have any questions or need further information, please contact your local Garland representative or contact the Product Management Department at1-800-321-9336.

Types of Roof Systems

- Built-Up Roof (BUR)
- Single Ply
- Modified Bitumen Roofing
- Metal
- Inverted Roof Membrane Assembly (IRMA)
- Sprayed Polyurethane Foam (SPF)

There are the six (6) majors types of roofing systems used in the commercial roofing market place today. These six (6) systems account for 95% of all commercial and industrial roofing systems. Common applications include schools, hospitals, industrial facilities, office buildings and most other non-residential roofing application.

BUR

- 100+ Year History of Success
- Alternating Plies of Asphalt/Tar and Felts With Gravel
- Common And Acceptable Roofing System
- Many 20, 30, 40 Year Old BUR Still Sound

The Built Up Roof, also referred to as a B-U-R, has a storied history dating back well over 100 years. There are many buildings that have BUR's that are 40+ years old and are still working today. The BUR system originally consisted of cloth rags covered in tar. Over the years there has been many changes to the BUR system. The system now consists of three to five alternating plies of fiberglass felts and hot asphalt or coal tar with a gravel surface adhered in a coating of asphalt or coal tar. Variations with different ply sheets, specialty bitumens and smooth surface coatings are also available. This system is a common and accepted system and many roofing contractors are familiar with the application of the BUR system.

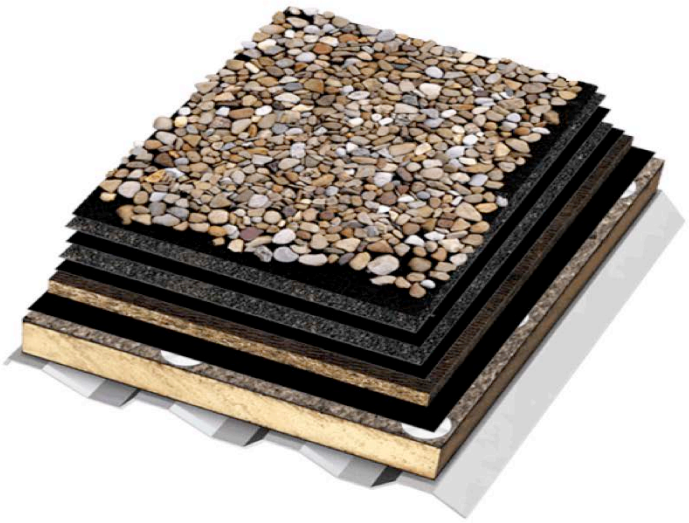
BUR - Components

- Bitumen (Asphalt/Tar)
- Felts (Reinforcement)
- Surfacing (Aggregate, Mineral, Liquid Coating)

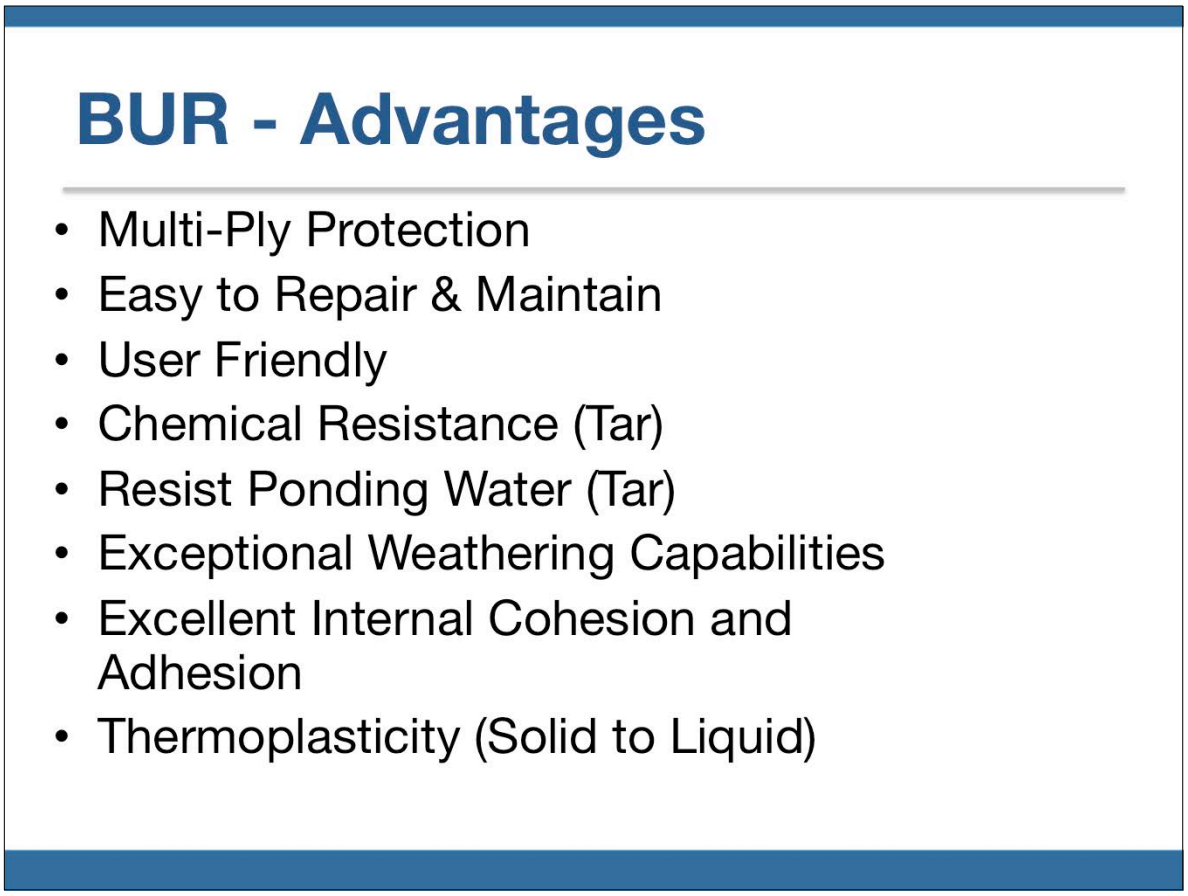
The BUR has three (3) major components, they are:

1. The bitumen is either asphalt or tar. This is the waterproofing agent as well as the adhesive that will hold the felts together. Specialty polymer modified asphalts and coal tar are also available.
2. The felts provide reinforcement and strength to the system. These felts are typically glass fibered reinforced. Polyester or combination polyester/ fiberglass ply sheets are also available.
3. The Surfacing is applied over top of the waterproofing felts. This can be a gravel surface adhered to the system using hot bitumen. Gravel provides excellent protection against fire, hail and UV damage from the sun. BUR systems can also be surfaced with a mineral cap sheet or liquid applied coatings.

BUR - Components



An illustration of the alternating plies of the BUR. BUR roofs start at the low point of the roof and are installed shingle fashion up the slope to prevent back water laps. Notice that throughout the BUR system there is is a consistent number of plies, these plies provide strength and redundancy to the roofing system.



The BUR has many advantages that make it a good roofing system. These advantages are:

1) The BUR has multi-ply protection. The redundancy in plies provides excellent weathering protection at the same time as adding strength to the roofing system. The built in redundancy of the multi-ply BUR minimizes the need for perfect workmanship from the contractor.
2) There are many repair and preventative maintenance products available from various manufacturers that are compatible with the BUR system.
3) Many contractors are very familiar and comfortable with applying the BUR system. Since the system has built in redundancy with alternating layers of asphalt (waterproofing) and felts (reinforcement), there is less chance of water entering the roof system.
4) When using tar, you are able to protect your roofs surface from chemical attack and ponding water.
5) The gravel surface provides exceptional weathering capabilities while the gravel protects the roof system from UV damage.
6) The system has great internal cohesion. The bitumen (asphalt/tar) provides a strong bond and holds the felt together to provide exceptional adhesion for the BUR system.
7) When using tar as the bitumen, it has a self-healing property. This means that as it is warmed up on the roof top it tends to soften and flow, allowing the tar to find voided areas that could cause potential leaks.

BUR

Typical application of the felts on a BUR system. Notice that throughout the system there will be felts layed in a multi-ply configuration, which provides built in redundancy. The lower roof is a two ply system installed over a nailed base sheet. Most two ply systems have a modified cap sheet installed as the top surfacing.

BUR - Disadvantages

- Difficult to Inspect (Gravel)
- Cannot Resist the High Movement of Modern Buildings
- Decreasing Quality of Products
- Old Antiquated Technology

Some of the disadvantages of the BUR system are:

1) They can be difficult to inspect if you have a gravel surface. All gravel must be spud back in order to properly repair the leak.
2) Today's building are built with lighter materials, such as metal decks. The coefficient of expansion and contraction are is much greater in metal than concrete. The movement created by these lighter construction materials can put a great amount of stress on the BUR system. A modified bitumen cap sheet over the BUR will provide strength to deal with the stresses of today's lighter weight building materials.
3) Asphalt is a by-product of the petroleum industry. It is more profitable for refineries to produce gas, jet fuel and oil rather than asphalt. Therefore, as the refineries became more efficient at manufacturing high end products, the asphalt began to loose some of its desirable characteristics.
4) The basic BUR system, which is alternating plies of bitumen and reinforcement, has not changed over the past 100 years. Some view this as a negative because of the numerous advances made in other trades in the construction industry.

BUR

Above are some typical problems that might occur on a BUR. These conditions are avoidable with yearly inspections and a maintenance program.

Upper Left: Exposed felts due to the gravel surface being removed. This is typically due to an insufficient amount of bitumen used or the bitumen wearing away. There are maintenance materials that can be applied to eliminate this problem and prolong the life of the roof.

Right: A split in the metal edge flashing. Typically caused by the movement in the metal edge, since it has a high coefficient of contraction and expansion with temperature differences. This is typically a maintenance item that can be avoided by implementing regular roof inspections with a maintenance program.

Lower Middle: Flashings cause 80 % of all off all roof leaks. Wall flashings are exposed to a great deal of physical abuse often more direct UV exposure. Fiberglass felts do not provide the strength necessary to accommodate this type of abuse. Therefore, most manufacturers now recommend a modified bitumen cap sheet installed around wall flashings and other penetrations to provide the additional protection necessary around these critical areas. This is typically a maintenance item that can be avoided by implementing regular roof inspections with a maintenance program.

Innovations In Roofing

- Tar is Phased Out (Limited Use)
- Asbestos Concerns
- Oil is More Refined

Investigating alternative roofing options and materials began as the following concerns arose.

- The increasing concern for tar having the potential to cause of cancer, the application of tar began to decline.
- Asbestos became outlawed for health reasons, and the use of asbestos felts was no longer allowed.
- With oil being more refined and and it's products being used more in high cost fuels, the quality of asphalt was starting to decline.
- The changes in the raw materials of the BUR and the oil crisis of the early 1970's opened the door for alternative types of systems for the commercial roofing industry.

Innovations in Roofing

- By 1970, Tire Companies Had Surplus Capacity Because Tires Last Longer
- An EPDM Price War Started With Prices at 25-30 Cents Per Square Foot
- Many Adhesive Problems Early On

With the introduction of the steel belted radial tire, tires began to last longer. There was then an excess of rubber and machines that were not being used to manufacture tires. Tire companies started to investigate using rubber in the roofing industry and soon began to manufacture roofing membranes made from this rubber. This lead to the introduction of single ply roofing systems that are in the market place today. Nearly every tire manufacture jumped into the roofing industry and a price war shortly followed with the rubber roof system costing as low as 25 cents per square foot. In the early years of rubber roofing, there were many problems associated with the adhesives used on these materials. Because these tire manufactures had very little roofing experience,these adhesive problems lead to many roof failures early on.

Single Ply - Classification

- Thermoplastic – Materials Whose Chemical and Physical Characteristics Allow Them to Soften When Heated and Harden When Cooled
- Thermoset – Materials Whose Polymers are Chemically Cross-Linked and Cannot Change Once the Sheet is Produced

Single ply membranes are composed of a single layer membrane, there is no multi-ply construction. Single Ply membranes can be classified in to two categories:

1. Thermoplastic – Materials that will soften when heated and harden when cooled. Thermoplastics are plastic-like materials.
2. Thermoset – Materials that are crossed linked when the sheet is formed and the characteristics can not be changed. Heat does not cause these sheets to change like the thermoplastic materials.

Single Ply - Thermoplastics

- Polyvinyl Chloride (PVC)
- Thermoplastic Polyolefin (TPO)

There are two main types of Thermoplastic membranes, they are:

1. Polyvinyl Chloride - more commonly referred to as PVC. These sheets are typically white and have a fabric reinforcement which the PVC is bonded to.
2. Thermoplastic Polyolefin – more commonly referred to as TPO. These sheets are also white and have a fabric reinforcement which a Polyolefin is bonded to. TPO membranes are relatively new to the North American roofing market and there are no set standards for the type of polyolefin that are used in manufacturing these membranes.

Single Ply - Thermoplastics

PVC Application

- Loose Laid with Ballast
- Fully Adhered
- Mechanically Attached
- Seams Heat/Solvent Welded

TPO Application

- Loose Laid with Ballast
- Fully Adhered
- Mechanically Attached
- Seams Heat Welded

Application of a PVC and TPO membrane can be done by any one of the following:

1. Ballasted systems are those systems that require weight above the waterproofing system to hold the roof in place. Most ballasted systems require 1000-1500 pounds per 100 square feet for sufficient ballast. The sheets is laid loose and only secured to the substrate at the edges, flashings and penetrations. Review all local building codes and uplift ratings because many ballasted systems do not meet all criteria. Ballasted systems are generally the least expensive application method and the most difficult to repair when leaks occur.
2. Fully adhered systems involves gluing the sheet to insulation. The insulation is most likely mechanically attached to the substrate. Glues and adhesives of today are far superior to those of even ten years ago. However, failures of the glue or fasteners backing out of the substrate and puncturing the single ply membrane are still somewhat common.
3. Mechanically attached systems vary from manufacturer to manufacturer. Most involve some proprietary type of bar being fastened through the the seam to attach the single ply membrane to the system. Proper engineering is required to determine uplift pressures, pull out strength of the fastener and fastener density. Mechanically attached system are generally the most expensive and least used method to install single ply membranes.
4. PVC and TPO membranes are often installed using a hot air welder. This high powered tool heats the membrane until it begins to melt. Once the thermoplastic material melts, the laps are rolled together to form a bond. Extreme skill of a qualified craftsmen is needed to ensure a proper bond. To much heat will burn the material and too little heat will result in an improper bond. Large roof areas can have miles of seams that need to be properly installed.
5. Chemical welds or bonds were once the primary method to seam thermoplastic single ply membranes. Environmental concerns about these harsh chemicals has reduced their use in recent years.

Single Ply - Thermosets

- Ethylene Propylene Diene Monomer (EPDM)
- Chlorosulfonated Polyethylene (CSPE) Dupont Trade Name - Hypalon

There are two types of Thermoset membranes, they are:

1. Ethylene Propylene Diene Monomer, commonly referred to as EPDM. EPDM is a rubber material that similar to a bicycle tire's inter-tube. These sheets are typically black and have no fabric reinforcement.
2. Hypalon, also referred to as Chlorosulfonated Polyethylene, is a trade name from Dupont. CSPE is manufactured as a thermoplastic; however, when it is exposed to UV it changes to a thermoset material. These sheets are typically white and may have a fabric reinforcement.

Single Ply - Thermosets

EPDM Application

- Loose Laid with Ballast
- Fully Adhered
- Mechanically Attached
- Seamed with Adhesives or Tape

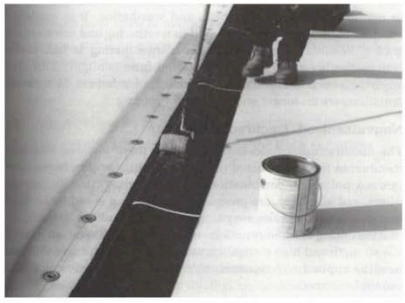
CSPE Application

- Loose Laid with Ballast
- Fully Adhered
- Mechanically Attached
- Seams Heat Welded

Application of an EPDM and CSPE membrane can be done by any one of the following:

1. Ballasted systems are those systems that require weight above the waterproofing system to hold the roof in place. Most ballasted systems require 1000-1500 pounds per 100 square feet for sufficient ballast. The sheets is laid loose and only secured to the substrate at the edges, flashings and penetrations. Review all local building codes and uplift ratings because many ballasted systems do not meet all criteria. Ballasted systems are generally the least expensive application method and the most difficult to repair when leaks occur.
2. Fully adhered systems involves gluing the sheet to insulation. The insulation is most likely mechanically attached to the substrate. Glues and adhesives of today are far superior to those of even ten years ago. However, failures of the glue or fasteners backing out of the substrate and puncturing the single ply membrane are still somewhat common.
3. Mechanically attached systems vary from manufacturer to manufacturer. Most involve some proprietary type of bar being fastened through the the seam to attach the single ply membrane to the system. Proper engineering is required to determine uplift pressures, pull out strength of the fastener and fastener density. Mechanically attached system are generally the most expensive and least used method to install single ply membranes.
4. EPDM membranes can wither be seamed using an adhesive or double side tape. Adhesive formulations will vary from manufacturer and have changed many times over the years. Currently, the most preferred method to seam EPDM is to tape the laps together.
5. CSPE laps are adhered by hot air welding similar to PVC.

Single Ply - Application



Clockwise from upper left:

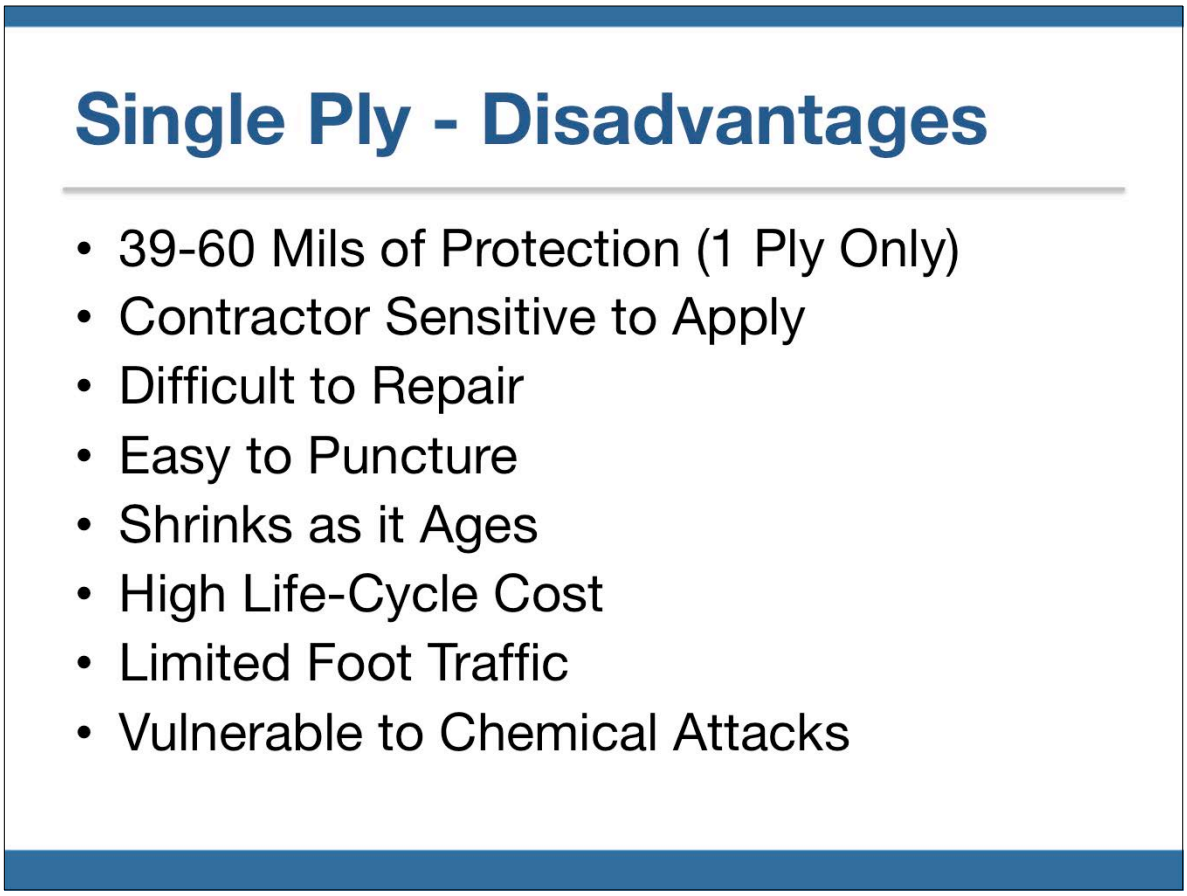
1. An EPDM membrane ballasted with river rock. The EPDM membrane is loose laid over the substrate, the river rock provides weight to hold the system in place.
2. An EPDM membrane that has been mechanically attached and the seams are being adhered using an adhesive.
3. Heat welding the seams of a PVC membrane. The machine being used generates hot air that helps soften the PVC and fuses the two membranes together. As the sheets cool, they are bonded together.
4. Fully adhering a single ply membrane with a solvent based adhesive.

Single Ply - Advantages

- Low Initial Cost
- Clean/Fast Application
- Lightweight (Except for Ballasted System)
- Excellent Elongation
- Easy to Inspect and Monitor

Some of the advantages and reasons single ply membranes are used:

1. Single ply membranes typically have a very low initial cost.
2. Typically the installation of a single ply membrane is fast and clean. These systems when installed require the use only a few tools or machines; there is little capital investment necessary for new contractors to install single ply membranes.
3. The roofing membrane consist of one (1) sheet that is 39-60 mils (.039-.060 inches) thick. This is extremely light weight, except when the system is loose laid and ballasted with rock.
4. Most single ply membranes have excellent elongation and flexibility.
5. The membranes can be inspected to identify leaks easily. However, this is not true with ballasted systems.



Although single ply membranes have some advantages, there are some disadvantages. These include:

1. The membrane thickness is only 39-60 mils (.039-.060 inches), which is about the thickness of a few sheets of paper. Membranes with a reinforcing scrim often offer only 10 mils (.010 inches) or less of waterproofing above the scrim. This is all that is protecting your buildings interior and assets.
2. Single ply membranes are extremely contractor sensitive to apply. The seaming integrity is critical to the waterproofing capability of the roof. If there is any area that has not been seamed properly, it will allow for a direct entrance of water in to the building's interior.
3. As single ply membranes age in the sun, they become more difficult to permanently repair.
4. Since the single ply membrane is 39-60 mils thick, it is easy to puncture Regular roof top traffic or workers dropping tools can easily damage the membrane, resulting in water entering the roof system.
5. Single ply membrane materials tend to shrink as they age, causing the seams to split and fail pre-maturely. The waterproofing integrity of a single ply system is dependent on the seams.
6. Although these membranes have a low initial cost, over a 30 year life cycle their cost become very high compared to other systems.
7. Some manufactures do not allow foot traffic on their membrane or the warranty will be voided.
8. Many common chemicals attach the membrane, weakening the systems seam integrity and waterproofing capabilities.

Single Ply

Here is a typical problem on single ply roofs. Notice the tent like profile of the sheet. This is the result of fasteners backing out through the membrane causing punctures were water can enter the building.

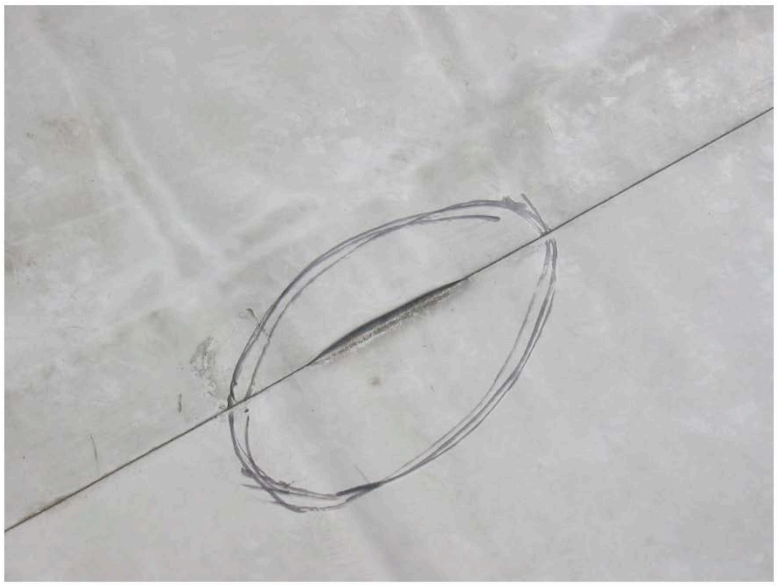
Single Ply

EPDM attacked by solvent causing it to swell.

Single Ply

An example of an eight year old EPDM membrane shrinking. This is caused from premature aging due to damage caused from UV and heat. Most EPDM membranes are black, which absorbs heat that helps accelerate the aging process.

Single Ply



A seam failure on a TPO roof. These seams are contractor sensitive and there is only on ply of protection. the seaming of the sheet is vital to the waterproofing capabilities of the system. This is an example of poor workmanship that may or may not be caught during the final inspection.

Single Ply

An example of a seam failure on a CSPE membrane. This seam failure allows for direct water entrance into the roofing system and the building.

Single Ply

With single ply membranes only being 39-60 mils thick, they can be punctured easily. This is an example of a split that could have been caused by dropping a tool onto the membrane.

Single Ply

Seam failure on a seven year old EPDM roof caused prematurely from the membrane shrinking. The black surface on EPDM membranes absorb heat and UV which cause the membrane to age prematurely and shrink. AS EPDM ages, it is very difficult to permanently repair.

Modified Bitumen Roofing

- Developed in Europe After World War II
- Brought to the U.S. in Early 1970s
- Modifier Added to Asphalt to Change Characteristics
- Popularity Has Increased Steadily for Past Two Decades
- Provides Time-Tested, High-Performance, Reliable Roof System

With innovations in the roofing industry taking place, the basic principles of the BUR were expanded to create the Modified Bitumen System (Mod Bit).

The Mod Bit system is similar to the BUR, since it has alternating plies of a bitumen and reinforcements. It differs by using a heavy duty reinforced cap sheet that has been polymer modified. Modification refers to adding a polymer (modifier) to the bitumen which improves many of the bitumen's waterproofing and aging characteristics. This system has steadily gained popularity since being introduced in the early 1970's and is time tested and reliable. There are many 25+ year old Mod Bit systems still performing well on buildings today.

Modified – Characteristics of Modifiers

- Modifier (Polymer) That Improves the Characteristics of the Bitumen
- Bitumen Takes on Characteristics of Modifier
- Improves Low-Temp Flexibility
- Improves Weatherability
- Increases Fatigue Resistance
- Superior UV Resistance
- Improved Fire Resistance

The modifier (polymer) is used to change the characteristics of the bitumen (asphalt). This helps improve certain qualities, which include:

1. Low temperature Flexibility – the ability of a membrane to remain flexible and prevent cracking when cooled to low temperatures.
2. Weatherability – resistance to degradation from UV and heat. Exposure to these elements are leading causes to premature roof system failures.
3. Fatigue Resistance – ability to not become weak with age, providing a long lasting roofing system.
4. UV Resistance – the sun damages and breaks down all organic matter. By adding a modifier to the bitumen, you greatly extend a roof's service life.
5. Fire Resistance – Asphalt is a by product of the petroleum industry and therefore will burn readily. Polymer and other chemicals can be added during the manufacturing process to dramatically improves fire resistance.

By improving on these characteristics, the Mod Bit is able to provide a more reliable and longer lasting system than the standard BUR.

Modified – Types of Modifiers

- Atactic Polypropylene (APP)
- Styrene Butadiene Styrene (SBS)
- Styrene-Isoprene-Styrene (SIS)
- Styrene-Ethylene-Butylene-Styrene (SEBS)

There are several types of modifiers used in the roofing industry. The modifier is added to the bitumen during manufacturing to produce a superior aging cap sheet. This cap sheet is installed over additional layers of felts and bitumen.

The two most common types of modifiers used in the roofing industry are Atatic Polypropylene (APP) and Styrene-Butadiene-Styrene (SBS).

- APP is a plastic modifier and produces plastic like characteristics. APP membranes have good resistance to heat but are more likely to crack in cooler climates. APP membranes are usually applied with an open flame torch. Some manufacturers provide a cold adhesive to install the APP membrane.
- SBS is a rubber modifier and produces rubber like characteristics. SBS membranes have very good resistance to UV, provide excellent low temperature flexibility and long term weatherability. Premium SBS membranes are often blended with secondary polymers such as SIS, SEBS and ES to provide an even longer service life. SBS membranes can be installed using hot asphalt, cold adhesives, torch applied or self-adhering adhesives.
- Three other rubber types of modifiers that are used today and are gaining more popularity are SIS and SEBS, which both have rubber characteristics. These modifiers are typically used in blends with SBS to provide increased life expectancy.
- SIS increases life expectancy by preventing chemical cross-linking.
- SEBS provides heat stability and UV resistance which helps prolong the waterproofing life of the membrane.
- ES provides additional UV resistance for superior long term aging.

Modified – Types of Reinforcements

- Polyester
- Fiberglass
- Fiberglass and Polyester Combinations

There are currently three common types of reinforcing scrims that are used to manufacture modified bitumen membranes. The scrim provides a carrier which is coated with the polymer modified compound. The scrim provides tensile strength, tear strength, rigidity and dimensional stability which gives the modified bitumen the necessary physical properties to last many years. The National Roofing Contractors Association, the Army Corps or Engineers ad many industry experts agree that one of the most significant attributes of a superior mod bit system, which is designed to last many years, is strength.

The three common types or reinforcing scrims are:

- Polyester – Polyester reinforced modified membranes are used in many commodity Mod Bit membranes. Polyester has very good elongation characteristics and is easy to conform, around irregular projections. In general, polyester reinforced modified membranes are less expensive; however, many polyester sheets experience shrinkage and shortened life cycles.
- Fiberglass – Fiberglass is inherently stronger than polyester and is therefore used by many manufacturers to produce premium modified bitumen membranes. Fiberglass experiences much less shrinkage than polyester, but it is somewhat more difficult to apply because of the strength of the fiberglass scrim.
- Fiberglass and Polyester combinations – Many manufacturers offer the best of both worlds by offering combination reinforcements which provide the tensile strength of fiberglass which will help the roof system resist thermal movement and polyester which is easy to install. Most fiberglass and polyester combinations are

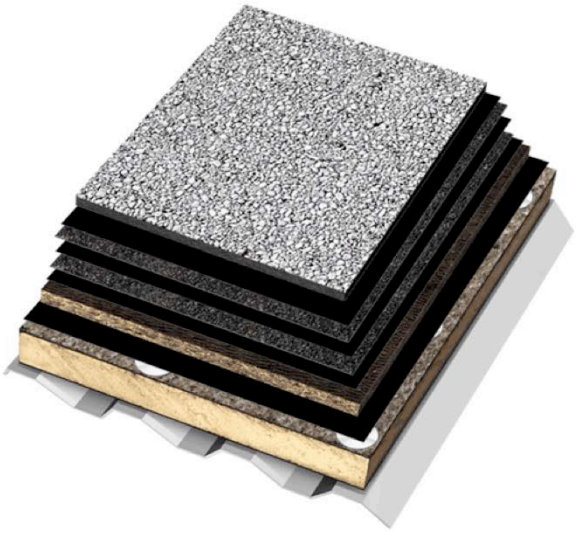
Modified - Components

- Bitumen (Asphalt/Tar)
- Ply Sheets
- Modified Bitumen Cap Sheet
- Surfacing

The components of the modified bitumen roof system are similar to the BUR.

- The bitumen is the waterproofing material and the adhesive that holds the reinforcements together. Most Mod Bits use asphalt as the bitumen. In BUR systems, the bitumen is the waterproofing agent. Mod Bits use the bitumen more as an adhesive that bonds the plies together. The primary waterproofing is the Mod Bit cap sheet.
- The modified cap sheet is the layer that differentiates the Mod Bit system from the traditional BUR. A Modified cap sheet is a reinforced sheet that provides added strength and durability to the roofing system.
- Surfacing which provides UV protection and impact resistance to the roofing system.
- Many manufacturers offer multi-ply Mod Bit systems which incorporate one or more sheets adhered in bitumen. These additional layers provide additional redundancy and protection.

Modified - Components



Above is a detailed drawing of a cross section of a mod bit system. Notice the redundancy of plies throughout the Modified system. This is similar to the BUR but the modified cap sheet provides added strength and protection to this high performance roof system.

Modified – Surfacing Types

- Aggregate (Gravel)
- Mineral Cap Sheet
- Smooth (Liquid Applied)

The surfacing options for the sheet include:

- A gravel surface which is applied in a flood coating of bitumen (asphalt or tar).
- A liquid applied coating (which is typically a white or aluminum reflective coating).
- The sheet may have a factory applied granulated surface.
- By applying a surfacing you are protecting the cap sheet from UV, physical abuse, hail, fire and foot traffic. All of these can lead to premature failure.

Modified - Surfacing

Left - A Mod Bit roof coated with an aluminum coating. This provides excellent reflectivity which protects the system from UV degradation and lowers roof top temperature and cooling cost.

Right – A gravel surfaced Mod Bit. The gravel surface looks similar to the BUR, but the addition of the modified cap sheet as a ply adds greater strength and longer life to this system. The gravel surface provides protection from UV, hail damage and roof top traffic as well as fire resistance.

The modified roof has several advantages.

- By using the cap sheet you have added tensile strength as well as excellent low temperature flexibility and puncture resistance compared to traditional BUR's. The high tensile strength prevents the membrane from splitting or punctures caused by movement in the building or roof top traffic. The low temperature flexibility protects the membrane from splits or cracks caused from thermal expansion and contraction.
- There are many manufacturers of repair and maintenance materials for modified bitumen roof systems. These materials an easily extend the life of aging Mod Bit systems.
- The Modified system has multi-ply protection for added protection. There is not just a single membrane protecting the building assets.
- The Modified system can be applied in various ways which include hot asphalt, torching, cold adhesives or even self adhering.

Modified - Disadvantages

- Sold in Niche Market
- Higher Initial Cost
- Poor Distribution of Polymer if Not Mixed Correctly
- Craze Cracking on APP

The modified does have some disadvantages.

- It is sold in a niche market. Not every building owner wants a modified roof because of it's higher initial cost, even though it has a very low life cycle cost because it outlast most other commercial roofing systems.
- The manufacturer must ensure proper distribution of the polymer (modifier). This is critical to the long term performance of the membrane.
- APP sheets, which have plastic characteristics, can have some slight cracking on the sheet similar to a piece of plastic that has aged in the sun.

Modified

A typical application of the felts that will be beneath the modified cap sheet. The lapping of the felts results in multi-ply redundancy being built into the system.

Modified

Application of the felts. Notice the overlapping of the sheets to ensure that there is more than one layer of protection trough out the system.

Modified

On top of the inter-ply felts, a modified cap sheet is installed. This sheet will be surfaced with either gravel or a liquid applied coating. This reinforced sheet provides added strength and protection to the system.

Modified

Some problems that can occur if the system is not properly installed. Here is a lap that is not adhered, typically due to an inadequate amount of bitumen being applied. Many manufacturers offer jobsite inspectors which can significantly reduce application errors such as this. This problem can easily be corrected with the use standard repair materials.

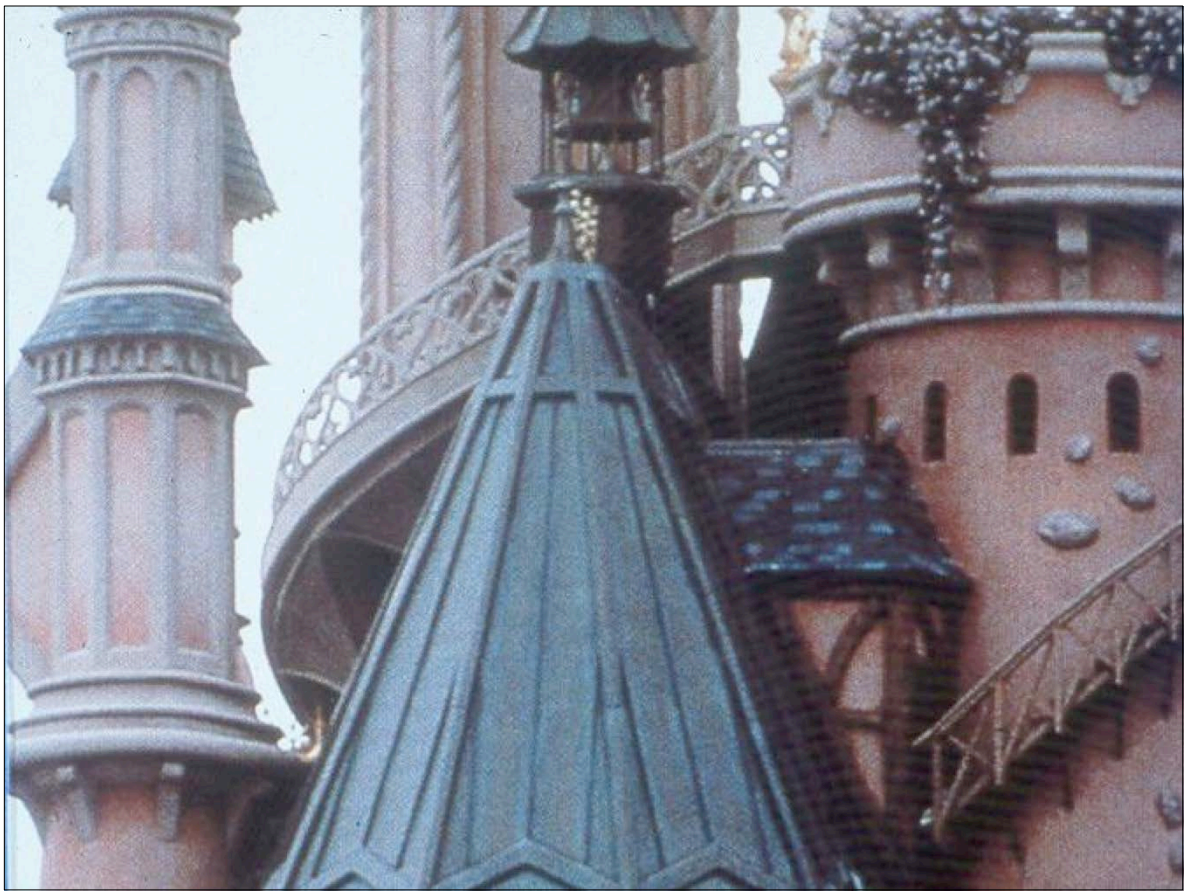
Modified

Another example of a problem that can occur if the system is not properly installed. Here is a lap that is not adhered, typically due to an inadequate amount of bitumen being applied. Many manufacturers offer jobsite inspectors which can significantly reduce application errors such as this. This problem can easily be corrected with the use standard repair materials.

History of Metal Roofing

- Over 200 Year Track Record in North America
- Prior to 1900, Most Public Buildings Were Built With Metal Roofs
- Metal Roofing Industry in North America Developed Primarily in the 19th Century
- Mid 1900's Metal Manufacturing and Paint Coatings Significantly Improved

- Metal roofing has been successfully utilized throughout North America for many years.
- The longevity of metal roofing has been tested by time.
- Significant improvements have been made over the past 30 to 40 years primarily in the manufacturing process and in the coatings offered.

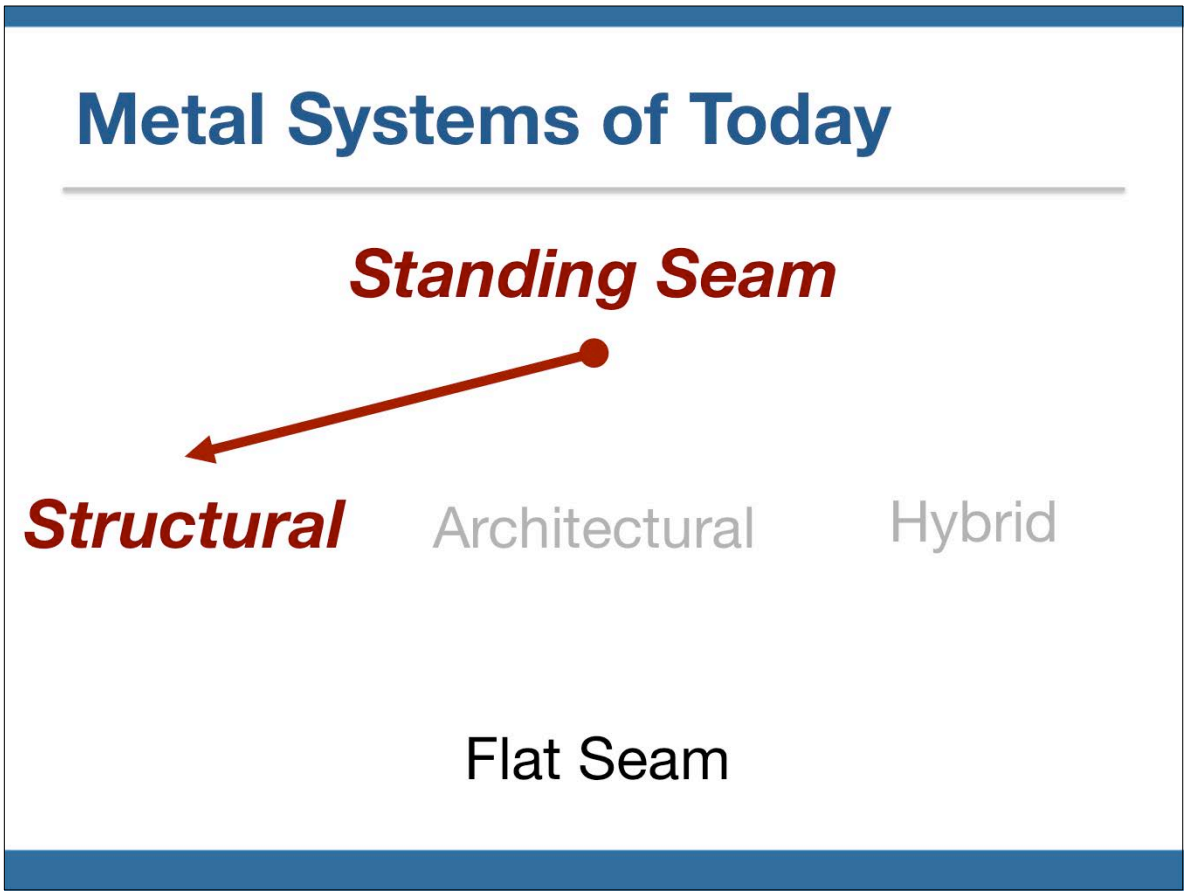


- Many metal systems that were installed centuries ago are still performing today.
- These systems were very costly due to the materials that were utilized (copper in this example) and the craftsmanship that was necessary to install these hand seamed systems.

Why Metal?

- Longevity (Low Life-Cycle Cost)
- Aesthetics
- Low Maintenance
- Environmentally Friendly

- The four main reasons why metal is increasing in popularity are stated here.
- Each of these topics will be elaborated upon in the following slides.



- Metal Systems are broken down into two major families of products…… standing seam and flat seam.
- The seaming details define these two families.
- Standing seam metal panels are joined at vertical seams.
- Flat seam metal panels are joined with overlapped horizontal seams.
- We will start with standing seam - structural panel systems.

Standing Seam Structural Panel

- High Seams; Normally 1-1/2” to 3” High
- Hydrostatic (Panels Are Watertight); Does Not Require Solid Substrate or Underlayment
- Low Slopes; Down to a 1/4” Per Foot
- Spanning Capability up to 7’ O.C.
- Larger, Stronger Clips
- Unlimited Panel Length

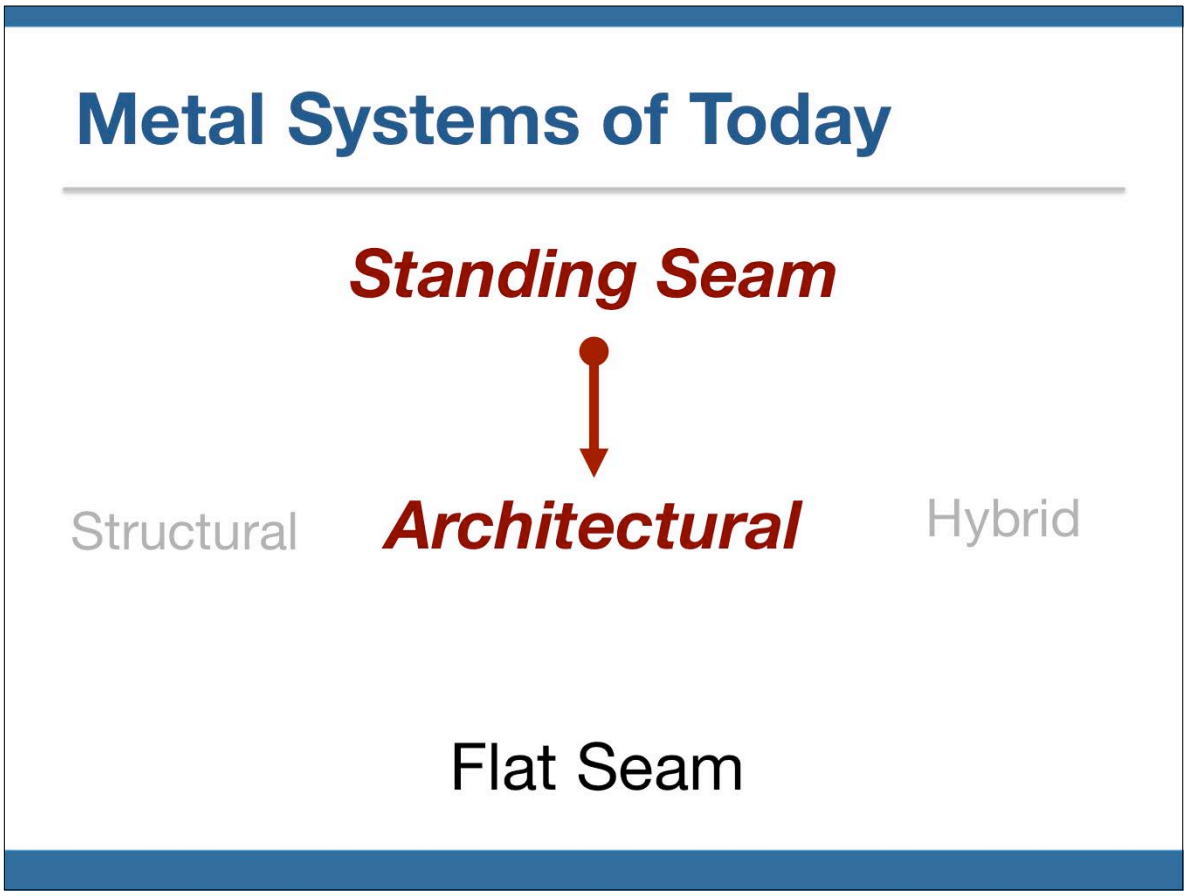
- It is important to understand the performance characteristics of the different panels.
- Structural standing seam panel systems have high seams which generally keeps the seam above the flow of water.
- These systems are water tight, not requiring an underlayment, and can therefore be installed at low slopes.
- The strength of these systems means long spanning capabilities with strong clips.
- Some manufacturers have the ability to fabricate structural panels in virtually unlimited lengths.

Standing Seam Structural Panel

- This photo illustrates the high seam height of a structural standing seam system.
- The mechanical finish (mesa's) in this system do an excellent job of minimizing the effects of "oil canning".
- Also the long panel runs are evident in this photo.
- This photo is a manufacturing facility.

Standing Seam Structural Panel

This photo illustrates the ability to create not only curved panels but also reverse curves.



Architectural metal systems have entirely different performance characteristics than structural systems.

Standing Seam Architectural Panel

- Low Seams; Normally 1/2” to 1-1/2” High
- Hydrokinetic (Water Shedder); Is Not Watertight - Requires an Underlayment
- Minimum Slope of 3:12
- Clip Spacing is Typically 2’ O.C.
- Less Metal Per Square Foot
- No Spanning Capability (Requires a Solid Substrate)

- Architectural systems have typically lower seam heights.
- These systems are not designed to be watertight and therefore require an underlayment to shed any water that might get through the seams.
- Because these systems are not watertight, they are required to be at high slopes to shed water rapidly.
- These systems are not as strong as structural systems and require a tighter clip spacing and have no spanning capability.
- Due to lower seam height, these systems have less metal per square foot and therefore lower cost.

Standing Seam Architectural Panel

- This is a photo of a typical architectural metal roof system application.
- This photo is a retail facility in New England.

Standing Seam Architectural Panel

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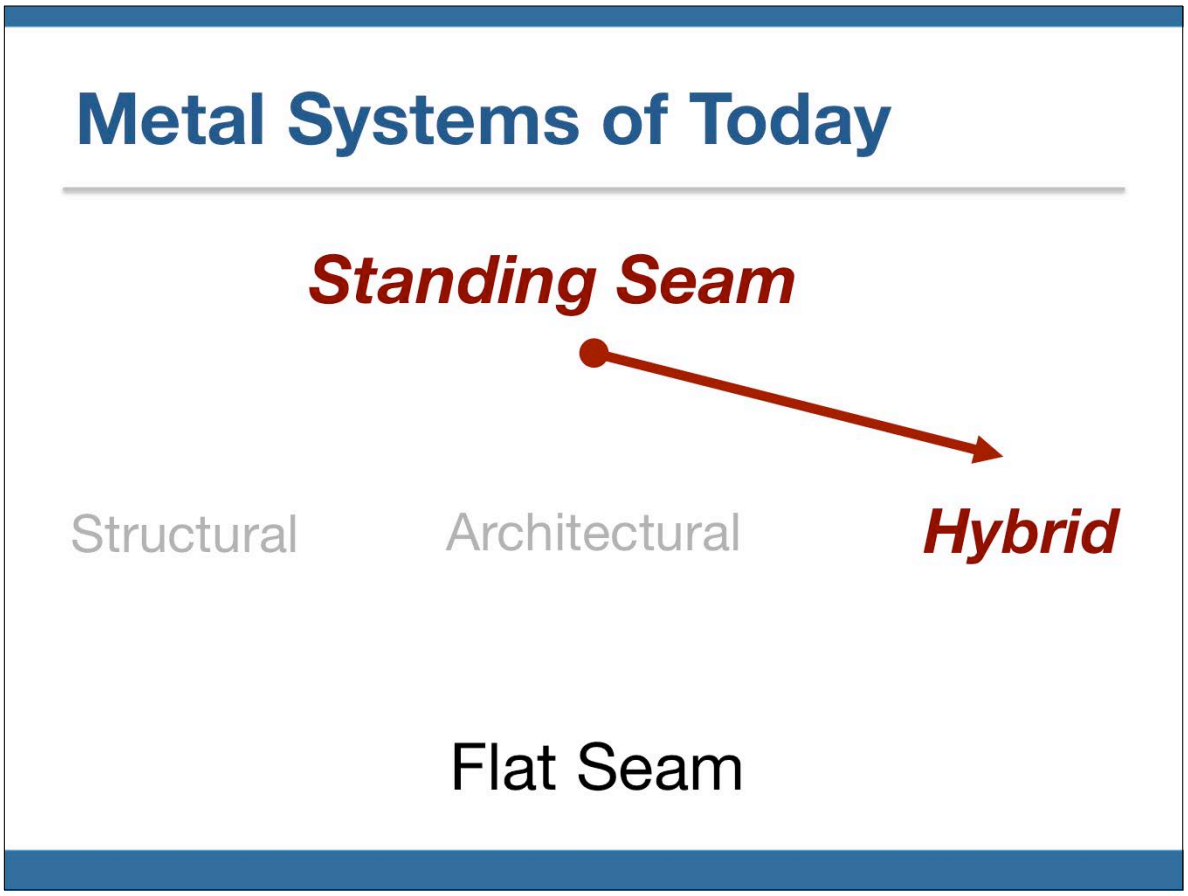


- The final member of the standing seam family are the hybrid systems.
- Hybrid systems are those that don't fall within the standard definitions of structural or architectural.

Standing Seam Hybrid Panels

- Moderate Seams; Normally 11/4” to 2” High
- Minimum Slope Will Depend on Panel Profile
- Either Hydrokinetic or Hydrostatic (Slope Dependent)
- May Require a Solid Substrate System And/or Slope Dependent
- Clip Spacing Is Typically 2’ to 4’ o.c.

- The performance characteristics of hybrid systems are typically between the characteristics of a structural system and an architectural system.
- These systems have moderate seam heights and have different slope constraints.
- These systems may be water tight or they may not be….depending on slope.
- Because these systems may or may not be watertight, they may require an underlayment.

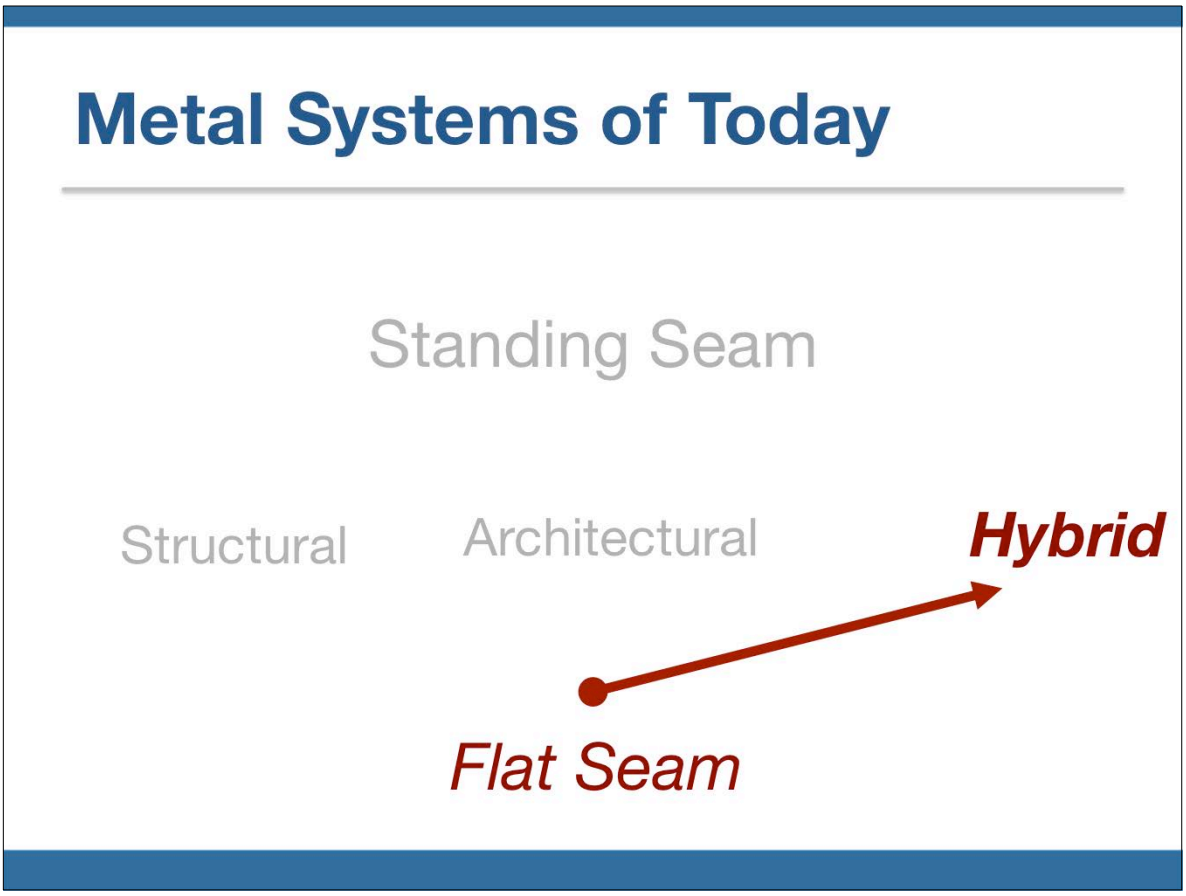
Standing Seam Hybrid Panels

- It is difficult by appearance alone to determine whether a standing seam system is structural, architectural, or hybrid.
- The versatility of metal allows specifiers and owners to utilize metal for many different applications.
- This photo is a school in New Jersey.

Standing Seam Hybrid Panels

- When installing slope into an existing flat roof, it is optimal to use a system with spanning capabilities to eliminate the requirements of a deck. The slope can be added through the use of a framing system.
- This photo is a school in the Philadelphia area.

Metal Systems of Today



- Flat seam systems have a totally different design.
- These systems must be engineered to restrain all expansion and contraction movement at the seams.
- The effects of thermal movement must be accommodated in the panels because the seams are restrained.
- As in any metal system, the engineering of these types of systems is critical for long term performance.

Flat Seam Hybrid Panels

- Minimum Slope Will Depend on Panel Profile
- Either Hydrokinetic or Hydrostatic (System Dependent)
- Usually Requires a Solid Substrate
- System And/or Slope Dependent
- Hat Channel Spacing Is Typically 10’ to 12’ o.c.

- These types of metal systems can have very different performance characteristics.
- Different panels have different minimum slopes and might be watertight systems or water shedding systems.

- With these types of systems, the metal panels are overlapped and horizontally seamed as opposed to vertically seamed as in standing seam metal systems.
- This photo is a school in Texas.

- Some flat seamed metal systems due to their flexibility have curving capabilities. Light gauge metal systems depending on their seaming characteristics can conform to the shape of a barrel roof due to their design.
- This is a photo of a university building in Washington.

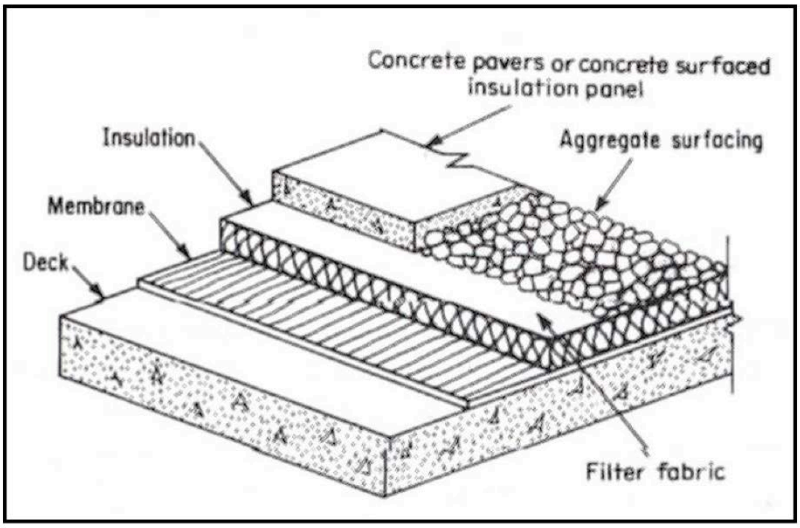
Inverted Roof Membrane Assembly (IRMA)

- Dow Chemical Patented This System in the Early 1970s
- Can Be Used With Single Ply, BUR, Modified Bitumen Configuration
- Roof Membrane is Below Insulation
- Extruded Polystyrene is the Only Acceptable Insulation Because it Does Not Absorb Moisture

The Inverted Roof Membrane Assembly (IRMA) is a trade name from Dow Chemical. This system is also referred to as a Protected Membrane Roof (PMR).

- This can be used in conjunction with any single ply, BUR or mod bit system.
- In this application the insulation is installed on top of the roofing membrane. The roofing membrane is applied above the deck followed by the insulation.
- There is only one type of insulation board that can be used with this system: extruded polystyrene. The insulation is covered with either gravel, walk way pavers or a combination of the two to ballast the insulation to the structural deck.
- This system is typically used on plaza deck or walk out terraces. Most IRMA systems are installed over a structural concrete deck due to the excessive weight loads of these systems.
- Since the roof system has the insulation and a ballast or paver system on top, the membrane is protected from both UV and foot traffic.

IRMA Mock-Up



Above is a detailed drawing of the cross section of an IRMA system. Notice the attachment of the roof system directly to the deck followed by the insulation.

Sprayed Polyurethane Foam (SPF)

- Insulation With High Thermal Resistance
- Expands 20-30 Times Original State
- Seamless Construction
- Used for Crickets or Slope
- Must be Coated to Protect from UV

Sprayed Polyurethane Foam is a two component spray that expands 20-30 times the original state when applied to a substrate. SPF currently accounts for approximately 2% of the commercial roofing industry. SPF provides seamless insulation with excellent uplift resistance and good thermal resistance properties. There needs to be a waterproof coating installed over the insulation, which is typically 10-20 mils (0.010-0.020 inches) thick. SPF works best on roofs with good slope and little foot traffic or penetrations. To provide watertight integrity and to maintain warranties, many manufacturers recommend recoating the surface every 3-5 years.

Sprayed Polyurethane Foam

Upper Right -The application of the two part SPF is delivered to the roof in heated lines. Temperature, moisture and humidity will effect the ratios of the two materials. A trained and experienced foam crew is required for proper installation.

Lower left – A foam roof with the coating worn off. Notice the dark orange color of the foam, this damage was caused by UV. Repair of foam is difficult because often moisture has already penetrated the system.

Thank You