PHP SYSTEMS/DESIGN

BUILD IT RIGHT.

Applications in Sustainable Technology for Supporting Rooftop Piping & Equipment

START

Rooftop Pipe and Equipment Support Systems

Presented by: PHP Systems/Design
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Description: Provides an in-depth insight into the uses and benefits of pipe and equipment rooftop support applications. Includes discussions on safety issues, installation options, components and assembly, as well as the elements of design and engineering of the supports. Learn the positive benefits of these systems and avoid the pitfalls of wrong design and application. Identify the reasons that dictate a long term sustainable system, maximizing the longevity not only of the roofing system, but the equipment and components supported as well.

To ensure the accuracy of this program material, this course is valid only when listed on PHP Systems/Design Resource Center.

Purpose and Learning Objectives

Purpose: Provides an in-depth insight into the uses and benefits of pipe and equipment rooftop support applications. Includes discussions on safety issues, installation options, components and assembly, as well as the elements of design and engineering of the supports. Learn the positive benefits of these systems and avoid the pitfalls of wrong design and application. Identify the reasons that dictate a long term sustainable system, maximizing the longevity not only of the roofing system, but the equipment and components supported as well.

Learning Objectives:

At the end of this program, participants will be able to:

- Describe engineered pipe and equipment support systems, how they are constructed, and the advantages associated with using these systems
- Specify the preparation and installation of an engineered pipe and equipment support system in accordance with CSI 3-Part Master Specification - Section 07 72 00
- Identify the components of an engineered pipe and equipment support system, and explain the assembly and installation process
- Illustrate the mechanical benefits of an engineered pipe and equipment support system, and
- Discuss the design process and the options available during each stage of the process

Table of Contents

History of Pipe and Equipment Support Methods

History of Pipe and Equipment Support Methods

Managing Dead Weight on Rooftop Systems:

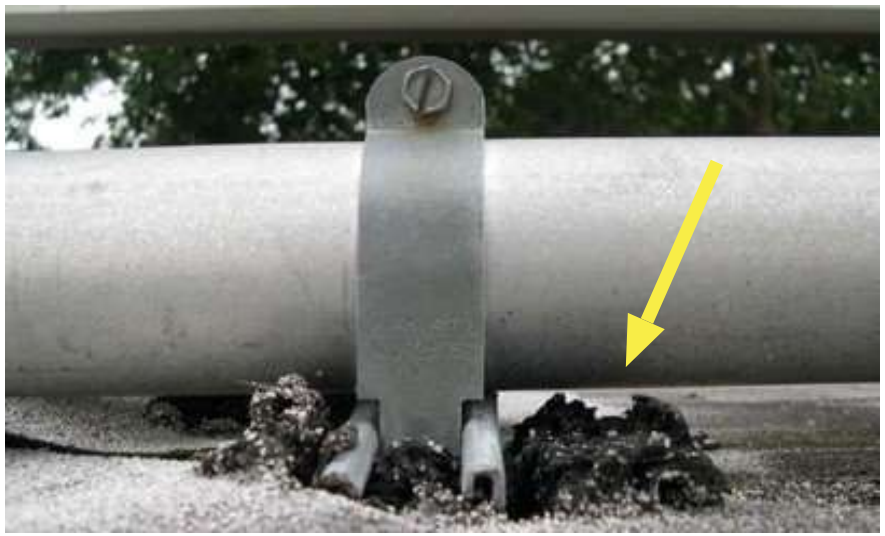
Any architect knows that proper selection of supports is critical to the overall performance of the roofing system. Rooftop support systems should never breach the existing roofing system, as support applications should eliminate almost all roof penetrations, except in the case of seismic or high-wind applications. Support systems must be a sustainable product, designed to meet each specific application.

There is a theory that should be applied to managing dead weight, especially on rooftop applications. As product and design methods have evolved, testing has been done making it possible to develop engineering tables to set the guidelines for the application of managing dead weight. These engineering tables also include wind resistance and seismic applications. Today, there is a tested and proven method for the management of dead weight on roofing systems that does not penetrate the roof, and allows for increased load distribution and flexibility.

History of Pipe and Equipment Support Methods

History shows several attempts to create and develop a means to manage dead weight on roofing systems, commercial and industrial. Most applications revert to prehistoric methods constructed of wood and metal, plastics, and some rubber products.

Sometimes a general contractor or contractor of specific applications would fabricate supports that penetrated the roofing system, thus giving way to failure and leakage. These prehistoric methods, so many still in use today, do not apply the theory of expansion and contraction, the movement associated with all pipe and some equipment.



History of Pipe and Equipment Support Methods

When designing rooftop supports, verify pipe support and roof load requirements with available engineering tables. Engineering tables also include wind resistance and seismic applications.
Individual manufacturers will also be able to supply information about proven methods for the management of dead weight on roofing systems that do not penetrate the roof and allow for increased load distribution and flexibility. The most important point is to design the system for the allowable loads for the building structure.

Lastly, the design bracing of the supports is determined by the type and size of the pipe, and should be in accordance with the given, allowable, maximum span.

PIPE DIAMETER (NOMINAL)	CONTENTS	WEIGHT (Pipe and contents)	SPACING OF PIPE SUPPORTS		
			5'	8'	10'
4"	GAS	10.79 plf	86 lb	86 lb	110 lb
	WATER	16.20 plf	98 lb	130 lb	160 lb
5"	GAS	14.62 plf	88 lb	117 lb	150 lb
	WATER	23.26 plf	140 lb	190 lb	230 lb
6"	GAS	18.96 plf	110 lb	150 lb	190 lb
	WATER	31.49 plf	190 lb	250 lb	310 lb
8"	GAS	28.56 plf	170 lb	230 lb	290 lb
	WATER	50.24 plf	300 lb	400 lb	500 lb
10"	GAS	40.50 plf	240 lb	320 lb	410 lb
	WATER	74.60 plf	450 lb	596 lb	750 lb
12"	GAS	49.60 plf	300 lb	408 lb	500 lb
	WATER	98.60 plf	590 lb	790 lb	990 lb

TEST NO.	FAILURE LOAD (lb)	BASE CROSS SECTION AREA (sq. inch)	PRESSURE (psi)	PRESSURE (psf)	LOAD TYPE
1	1,400	324	4.32	622.22	Uplift
2	1,450	324	4.48	644.44	Uplift
3	1,400	324	4.32	622.22	Uplift
4	1,300	324	4.01	577.78	Uplift
5	1,000	324	3.09	444.44	Uplift
6	1,450	324	4.48	644.44	Uplift

DECK INSULATION	STRESS	SMALL BASE	MEDIUM BASE	LARGE BASE
Expanded Polystyrene	5 psi	770 pounds	720 pounds	1,620 pounds
Glass/Mineral Fiber	5 psi	770 pounds	720 pounds	1,620 pounds
Polyisocyanurate	5 psi	770 pounds	720 pounds	1,620 pounds
Extruded Polystyrene	6 psi	924 pounds	864 pounds	1,944 pounds
Fiber Board	6 psi	924 pounds	864 pounds	1,944 pounds
Perlite	17.6 psi	2,696 pounds	2,520 pounds	5,670 pounds
Cellular Glass	50 psi	7,700 pounds	7,200 pounds	16,200 pounds

CHARACTERISTIC	TEST	RESULTS
Color	Visual	Black
Hardness (test averages) at -30° Fahrenheit at 73° Fahrenheit at 130° Fahrenheit	ASTM D2240-91 (See Table 4)	079.6 D03.5 D55.1
Ultimate Compressive Strength (test averages) at -30° Fahrenheit at 73° Fahrenheit at 130° Fahrenheit	ASTM D695-91 (See Table 5)	6867 psi 5505 psi 5311 psi
Ultimate Flexural Strength (Yield) (test averages) at -30° Fahrenheit at 73° Fahrenheit at 130° Fahrenheit	ASTM D790-86 (Procedure B)	4961 psi 4240 psi 2641 psi
Modulus of Elasticity (averages based on flexure) at -30° Fahrenheit at 73° Fahrenheit at 130° Fahrenheit		30.0×10^4 psi 20.0×10^4 psi 14.1×10^4 psi

History of Pipe and Equipment Support Methods

Proper Selection:

- In choosing support systems, it is paramount that the company provides engineering and design of the support on a per job application.
- Any support used on a roof should be made of a high grade, heavy duty channel and accessories that are hot-dipped galvanized, providing longer term sustainability.
- Ultimately, any support system used on a roof system should be set in a non-penetrating polypropylene base, designed specifically for correct weight disbursement and longevity under all weather conditions. The base design is important to correct weight distribution on the roofing system, guaranteeing lasting sustainability with no breach of the roofing system.

Consequences of Inadequate Support Apparatuses

Consequences of Inadequate Support Apparatuses

No matter how large or small the pipes or equipment are, improper support apparatuses and installation processes will inevitably lead to a breach in the roofing system.

Because secondary items added to the roofing system are not usually warranted by the roofing manufacturer, it is important that the support systems for piping and equipment on top of the roofing be engineered and designed to perform in a manner that will not adversely affect its weather tight integrity, thus voiding the roofing manufacturer's warranty.

As seen in the photos to the right, due to poor management of weight, thermal expansion and contraction of the pipes, the supports have penetrated the roof, ensuring leakage.

Consequences of Inadequate Support Apparatuses

Thermal expansion and contraction

Thermal expansion and contraction

Wind buffeting

Wind buffeting

Consequences of Inadequate Support Apparatuses

Thermal expansion and contraction

Inadequate design to manage weight

Inadequate design to manage thermal expansion & contraction

Inadequate walkway causing roof penetrations

Proper Support Components and Assemblies

Proper Support Components and Assemblies

The proper selection of supports is critical to the overall performance of the roofing system, the piping and equipment.

Most large commercial buildings rely on piping to transfer gas, water or electricity, for instance, from supply to distribution points. These pipes may also carry hazardous chemicals or substances at high temperatures and need to be installed and maintained correctly to avoid damage.

Effective piping supports hold the pipe up off the roof's surface to let the pipe expand and contract without damage to the pipe and the roof. Pipes that are not properly supported will sag, and weld joints may stress, leading to cracking and breaking of the pipe.

Proper Support Components and Assemblies

Proper supports and assemblies should always consist of components designed around the specific application. Supports are designed for single or multiple piping, ducting, and equipment at any specified height or width. Vertical and cross members and all accessories should be hot- dipped, galvanized steel, ensuring longevity and low maintenance. These bases are composed of lightweight, UV stable, high-density polypropylene and deliver the best overall sustainable product application. Variable base sizes and designs allow for a large range of weight management.

Proper Support Components and Assemblies

Low Profile Support Systems:

Low profile support systems are single base supports designed for a 3” or smaller pipe at a maximum elevation of up to 16” off the roof, and are available with a roller, band hanger or channel. Rollers or band hangers are for pipes in which thermal expansion and contraction is a factor, such as a gas or HVAC (heating, ventilation, air-conditioning) piping. Models with a channel are designed for electrical conduit, utility pipe, or condensate drain pipe, which can be secured to the support using a standard channel clamp.

Typical support spacing for low profile support systems is determined by pipe size, or a maximum recommended spacing of 10’ on center: the spacing may vary. Depending on the weight and design of the piping.

Proper Support Components and Assemblies

Low Profile Non-Adjustable Support Systems:

Low profile support models with channel are for electrical conduit, utility piping or condensate drain piping, which can be secured to the support using a standard channel clamp. The non-adjustable models are for pipe sizes up to 2’ x 2’ that can maintain a consistent elevation of 4’ off the roof. A typical base may weigh approximately 3 lbs., including the assembly.

Non-adjustable supports with channel and pipe guides

Non-adjustable support with channel

Proper Support Components and Assemblies

Low Profile Adjustable Support Systems:

Adjustable models are designed for pipes that are run at higher elevations or that need to maintain a consistent level independent of the roof slope. Similar to non-adjustable pipe support systems, these systems are for pipes up to 2½", but may weigh up to 4 lbs., including the assembly.

Height adjustable supports (adjustable to 10")

Height adjustable support with channel and copper clamp (adjustable to 10")

Proper Support Components and Assemblies

Height adjustable supports with rollers

Height adjustable supports with roller and pipe guide

Height adjustable support with channel and band hanger

Height adjustable support with channel and roller supporting conduit

Proper Support Components and Assemblies

Single Pipe Hanging Support Systems:

Single pipe hanging support systems for 3 1/2” and larger gas and HVAC piping utilize a roller or clevis hanger, and are designed to accommodate movement of the pipes during thermal expansion and contraction.

The supports are usually height adjustable with typical base sizes ranging from 12” x 12” to 18” x 18”. The larger base size is used when the pipe size is bigger than 8” or if the elevation is higher than 18” above the roof. Support spacing is determined by roof conditions, or a maximum recommended spacing of 10’ on center. Lateral bracing between supports may be required if pipe elevation exceeds 24” above the roof.

Proper Support Components and Assemblies

Multiple Pipe Hanging Support Systems:

Multiple pipe hanging support systems are for pipe sizes 3 1/2” and larger for gas, electrical, and HVAC (bare or insulated) piping. Custom supports can accommodate all multiple pipe runs.

Multiple hanging supports utilize a roller, band or clevis hanger, and are designed to accommodate movement of the pipes during thermal expansion and contraction. If the width of the support system increases, it may be necessary to incorporate a center leg to the support system in order to provide maximum stability and prevent defection of the horizontal beam.

The supports are usually height adjustable, and a typical base size is 18” x 18”. Support spacing is determined by the weight being supported, or a maximum recommended spacing of 10’ on center.

Lateral bracing between supports may be required if the top of the support frame horizontal beam exceeds 48” elevation above the roof, meaning it is an open or enclosed pipe support system.

Proper Support Components and Assemblies

Multiple hanging HVAC piping

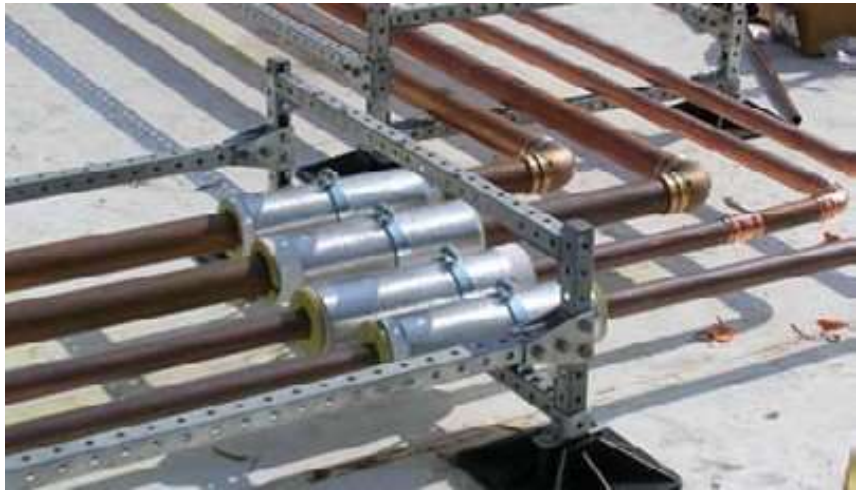
Multiple hanging gas piping

Multiple hanging gas piping

Multiple hanging gas piping with center leg support

Proper Support Components and Assemblies

Open pipe support system with straight bracing



Enclosed pipe support system with straight bracing

Open & Enclosed pipe support system with straight bracing

Enclosed pipe support system with k-bracing

Proper Support Components and Assemblies

Duct Support Systems:

Duct support systems can be designed for rectangular, spiral, round, and oval ducting in a variety of sizes, in almost any configuration.

The open “goal post” model is designed to cradle the duct which can then be strapped or fastened to the support. The “enclosed” model encapsulates the duct for a greater measure of restraint.

Both models are height adjustable, and a typical base size is 18” x 18”. Support spacing is normally 10’, except when state and local codes dictate otherwise. Lateral bracing between supports may be required if pipe elevation exceeds 60”, except when state and local codes dictate otherwise.

Proper Support Components and Assemblies

Duct and pipe support system with straight bracing

Open duct supports

Enclosed duct supports

Open duct supports with straight bracing and crossover system

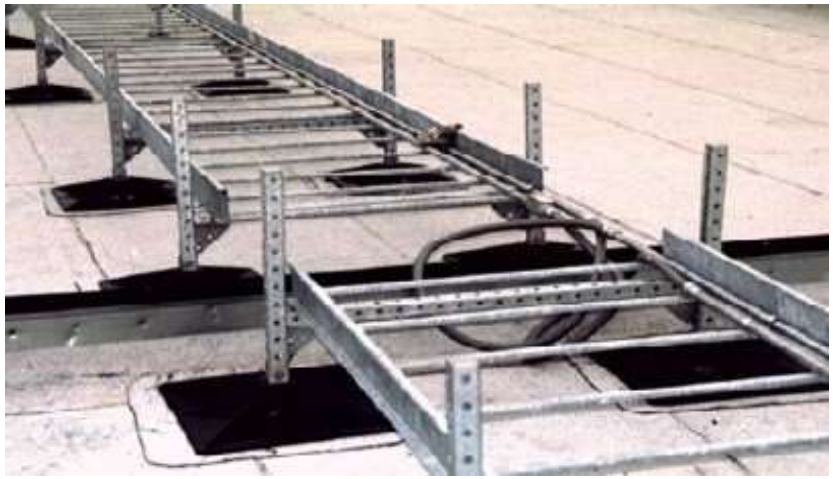
Proper Support Components and Assemblies

Cable Tray Support Systems:

Available in a variety of tray sizes, cable tray support systems can be used for any specified height or width, with any roofing system. Similar to pipe and duct support systems, the supports are height adjustable with typical base sizes of 18” x 18”. Support spacing is determined by conditions, or a maximum recommended spacing of 10’ on center.

Proper Support Components and Assemblies

Over 3,000 lineal feet of cable tray ranging from 12” to 36” wide and 36” above finished roof



48” wide cable tray at 12” off roof

Cable tray raised 12” off roof

Proper Support Components and Assemblies

Equipment Support Systems:

Equipment supports are designed to support air handlers, HVAC, blowers and exhaust fans. These supports offer a more efficient operation of all equipment, including noise reduction, operational savings and longevity. Proper weight distribution is critical for reduced maintenance of the equipment.

10 and 15-ton rooftop units with corner equipment supports raised 10” above roof

Multiple 10 and 15-ton rooftop units with center and corner equipment supports raised 10” above roof

Proper Support Components and Assemblies

There are typically four equipment supports, one at each corner, to accommodate multiple equipment applications including air handlers, HVAC, blowers and exhaust fans.

Center supports can be included for longer units over 60” or for heavier units exceeding 450 lbs. A maximum elevation of 16” is recommended, and lengths of threaded rods may be used to fasten the supports to the unit or to brace the supports together.

Rooftop blowers with corner supports and AC disconnect supports

HVAC with corner and center supports and with electrical and gas supports

Proper Support Components and Assemblies

Solar Panel Support Systems:

This same system can be used to support a variety of solar panels to meet any unique design and installation specification.

Solar panel supports affect roof system performance, in regard to increased heat and moisture impact.

The supports can be configured and adjusted to meet the required angle for optimum panel efficiency, supporting single or multiple panels at various elevations.

Access Systems

Access Systems

Walkway and Crossover Systems:

Walkways are used to prevent and direct traffic on the roofing system for safety, convenience, and maintenance support.

Crossovers provide access to areas that may be obstructed by piping, ducting, or equipment. Walkways and crossovers are typically 36” to 48” wide and are often available in custom lengths and elevations, with handrails and optional kick plate (consult individual manufacturers).

The systems may be constructed from galvanized steel channel with 1/4” steel connectors, steel planking, or bar grated walk surfaces. The systems are set on the roof surface without penetrations, using high-density polypropylene bases.

Access Systems

Walkway system, 4’ wide, raised 30” off roof

Walkway system with OSHA railing and stairs

Crossover span 36” high by 42” wide

Crossover, spanning duct supports and 6’ retaining wall

Access Systems

Stairs and Ramp Systems:

Stairs and ramps are used to access different roof levels and equipment that may be out of reach. Systems may range from 36” to 48” wide and be available in custom lengths and elevations, with handrails and an optional kick plate. The systems are constructed from galvanized steel channel with 1/4” steel connectors, steel planking or bar grated walk surfaces.

Access stairs with handrails

Ramp and walkway system with handrails

Access Systems

Roof-to-roof access stairs with handrails

Roof-to-roof access stairs with handrails

Ramp system with roof helipad access

Ramp system with stair access

Access Systems

Platform Systems:

Platforms are available for uses ranging from rooftop media, service and smoking areas, to platforms for AHUs (air handling units) and small chillers.

Platforms are available in custom sizes and elevations, with and without handrails and access stairs. The systems are constructed from galvanized steel channel with ¼” steel connectors, steel planking or bar grated walk surfaces, and are set on the roof surface using non-penetrating, high-density polypropylene bases.

Access Systems

Access platform with stairs

Equipment platform supports for blowers

Tower access platform

Access platform with stairs

High-Wind Applications

High-Wind Applications

Traditionally, the Atlantic and Gulf Coast regions are considered high-wind zones due to hurricane susceptibility. However, many other areas of the country have adopted more stringent building codes with regards to wind safety; this must be a factor to consider in the design of rooftop pipe and equipment systems. An engineer must determine if wind loads are sufficient to warrant any attachments for specific applications.

In high-wind situations, non-penetrating, high-density, polypropylene rooftop support bases will need to be fastened through the roof. Through evaluation and testing, the round support bases have a three-phase approach. Drawing designs include three different roof deck types: concrete deck, steel deck and wood deck. Each deck has its own method of attachment.

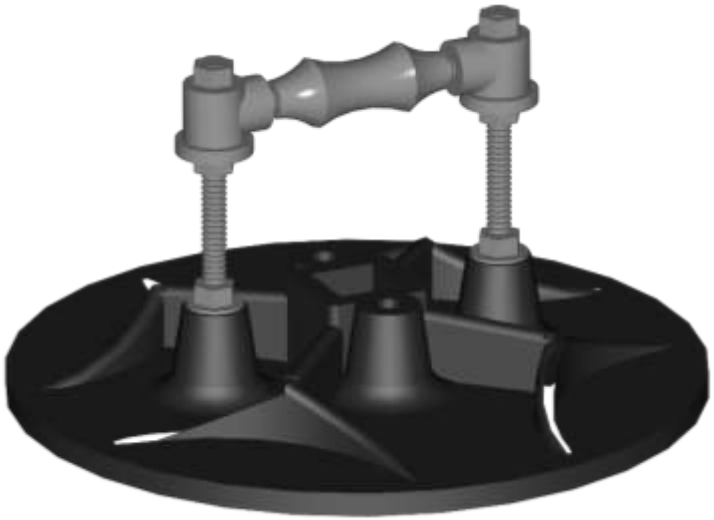
A typical application for the support bases is to provide the “footings” for roof-mounted equipment frames, typically constructed of galvanized steel.

High-Wind Applications

Round Bases and Methods of Attachment:

A high-density polypropylene base for high-wind situations will have holes for fastening to the roof deck. A high-wind application base is 18” in diameter, and 5/8” thick, with stiffening ribs distributed over its top surface for added strength to the base. The fastener holes are stiffened and extend approximately 3” above the bottom of the base to allow for sealant and attachment bolts. Fastener holes have an injection port for the purpose of injecting sealant into the underside of the base to ensure a watertight seal.

Round base designed for mechanical attachment and for flashing into roofing system

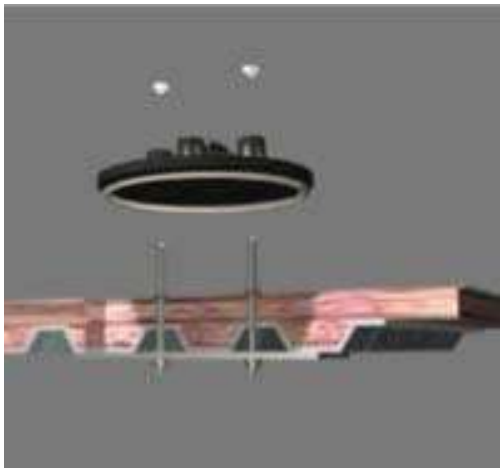


Round base with roller for gas lines up to 6” (base can be mechanically fastened if required)

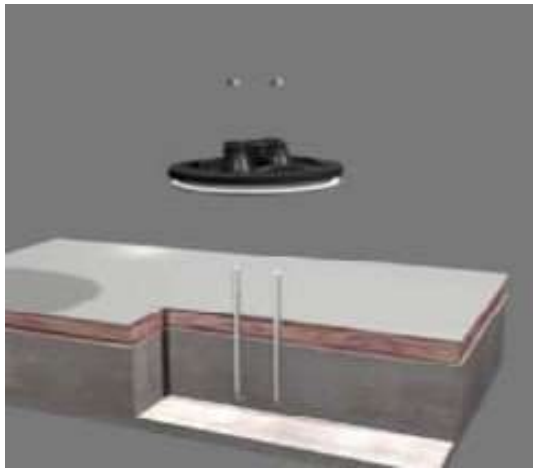
High-Wind Applications

Wood Deck
Base Attachment

Metal Deck
Base Attachment



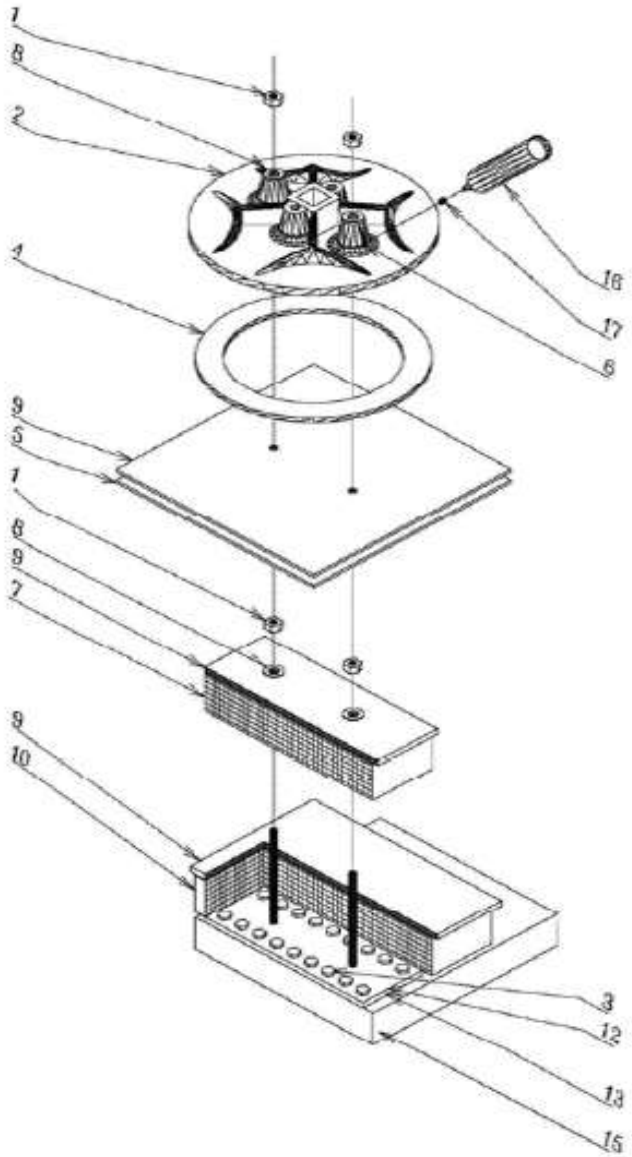
Concrete Deck
Base Attachment



High-Wind Applications

Round Bases and Method for Wood:

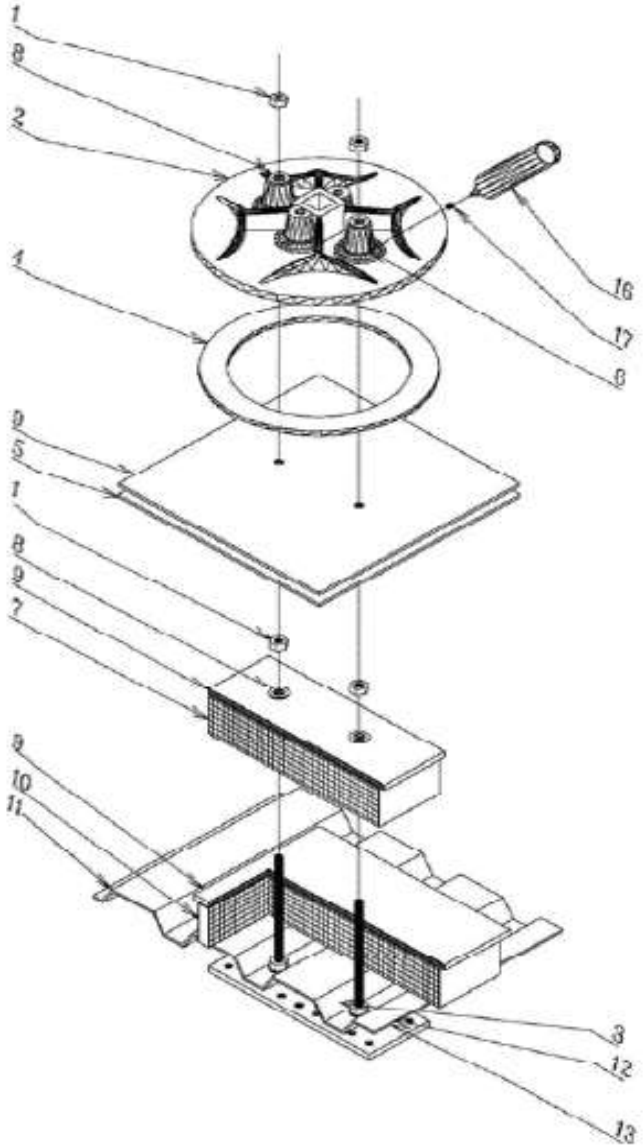
1 Nut
2 RB-18
4 3/8” Compressible Gasket
5 20” x 20” Floor Cover Sheet
6 Injection Port
7 Insulation Cut
8 Washers
9 Roof Membrane
10 Rigid Insulation
12 Sealing Mastic (after fastening base)
13 Seismic Base
15 Wood Deck
16 Urethane Deck
17 Injection Port Cap



High-Wind Applications

Round Bases and Method for Metal:

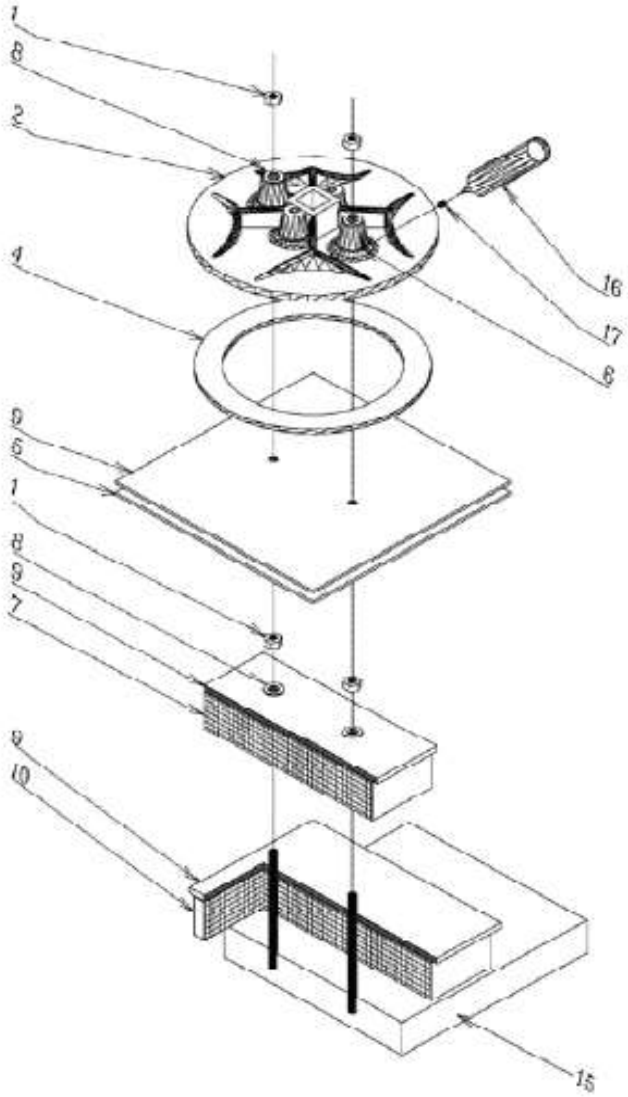
1 Nut
2 RB-18
4 3/8” Compressible Gasket
5 20” x 20” Floor Cover Sheet
6 Injection Port
7 Insulation Cut
8 Washers
9 Roof Membrane
10 Rigid Insulation
11 Steel Deck
12 Sealing Mastic (after fastening base)
13 Attachment Plate
16 Urethane Caulking
17 Injection Port Cap



High-Wind Applications

Round Bases and Method for Concrete:

1 Nut
2 RB-18
3 Bolts
4 3/8” Compressible Gasket
5 20” x 20” Floor Cover Sheet
6 Injection Port
7 Insulation Cut
8 Washers
9 Roof Membrane
10 Rigid Insulation
15 Concrete Deck
16 Urethane Caulking
17 Injection Port Cap



Optional Accessories

Optional Accessories

Roller Hanger
For use with gas and other bare pipes

Band Hanger
For use with HVAC and other insulated pipes

Clevis Hanger
For use with HVAC and other insulated pipes

J-Clamp
For 2” and smaller conduit line

Accessory Bar
For use with conduit or cable under 2 1/2” in diameter

Pipe Guide
For use with units with roller assembly

Swivel
For use on supports for sloped and tapered roof systems equal to or exceeding 1/2” per foot

Leveling Assembly
Adjustable assembly for leveling of platforms and equipment supports

Optional Accessories

Straight Bracing
Straight bracing for pipes 24” above the roof surface and higher

K-Bracing
K-bracing for pipes 24” above the roof surface and higher

Optional Accessories

Pipe supports with clevis hangers

Swivel assembly

Leveling assembly attached to platform

Pipe guide

System Design and Installation

System Design and Installation

Pipe and equipment supports are engineered and designed to support pipe, duct, cable tray, equipment, solar panel, platform and access systems directly on the roof surface without causing a breach in the existing roofing system. These systems successfully manage loads, as well as thermal movement and vibration, eliminating roof penetrations.

The support systems are constructed from carbon steel components for maximum strength and durability. All steel is hot-dipped galvanized for excellent weather durability.

The bases are injection molded in a non-penetrating polyurethane base, designed specifically for correct weight disbursement and longevity under all weather conditions, and a UV package added to stand up to the rigors of UV rays.

Designing a rooftop pipe or equipment support system involves considering spacing constraints, roof finishes, wind loads, and access requirements for servicing and maintenance. Each design must be based on the needs of the application.

System Design and Installation

4 key steps in designing and installing a pipe support system:

- **Take-off** - (From plans or site take-off in a retrofit) Take your digital plans from an architect and determine the amount of pipe and equipment to be supported

- **Design** - Determine the proper support system for pipes, ducts, cable trays, and equipment based on size, type, content, weight and height off roof. For access systems, determine the proper system for walkways, crossovers, stairs, ramps or platforms based on placement location and conditions. Next, determine proper support spacing based on pipe span or load to roof.

- **Layout** - Provide layout of pipe supports, equipment, platforms and access systems to CAD format on project plans. Also provide CAD detail drawings of pipe supports, equipment, platforms and access systems to CAD format on project plans.

- **Tech Support** - Provide onsite tech support as needed.

System Design and Installation

Depending on the manufacturer, support systems may be delivered to the site with pre-assembled sub-structures; pre-cut and pre-fitted pieces, all designed to be assembled without any field cutting or specialized tools. Individual stairs, as well as crossovers with stairs, may arrive pre-assembled. Manufacturers will provide a diagram and detailed assembly instructions.

The sub-structures are positioned according to the layout of the diagram and adjusted to level. The intermediate handrails are installed first, then the top handrails, and finally the walk surface planks or grating.

System Design and Installation

Case Study:

Tyson-Noel Case History
February 13, 2009

Situation:

Tyson Foods couldn't take any chances with rooftop refrigeration pipelines that chilled a 28,000-square-foot, high-volume chicken processing facility in Noel, Missouri. For this job, the chosen support system required durable stability for three reasons:

- Sections of the building had to remain between +50 degrees to -40 degrees for processing
- Pipelines carried ammonia, a key element in refrigeration, but one that can be hazardous if a line ruptures
- The roof had a 2-in-12 slope. Adding complexity to the job were gas pipelines, electrical lines, glycol lines (also for refrigeration), and ACHR ductwork

System Design and Installation

Case Study:

Tyson-Noel Case History
February 13, 2009

Solution:

The engineers designed a free, detailed rooftop support plan using CAD drawings to pinpoint the location of each support. The plan illustrated each support, spaced at 10-foot intervals throughout the 4,800-foot job, enabling Tyson engineers to see the entire system before the bid process began.

Proprietary supports with adjustable legs and swivel attachments were specified because the bases, or “feet,” of these structures match the roof slope while the support legs remain plumb. Crossover parts were also specified with the same swivel attachments, for crossing over rooftop piping at intersections.

System Design and Installation

Case Study:

Tyson-Noel Case History
February 13, 2009

The support system was designed for easy installation, with minimum roof penetrations which can make a roof vulnerable. The pipe support bases used were made of high-density polypropylene with additives that provide UV protection. This reduces deterioration when bases expand in the 140-degree rooftop heat of summer, and contract in the sub-freezing temperatures of winter.

Results:

Tyson Foods has used professional engineered and designed roof supports with polypropylene bases and hot dipped galvanized channels on about 25% of their facilities. They like the added benefit that these supports are reusable in a variety of configurations, which over time, means less cost and less waste in landfills.

System Design and Installation – Tyson Foods

Open duct supports with swivel assembly, adjustable supports and pipe guides on sloped roof

Enclosed pipe supports and custom hanging supports with clevis hanger and swivel assembly

Leveling assembly attached to crossover and custom hanging supports with accessory bars on a sloped roof

Open pipe supports with adjustable supports, channels and pipe guides

Conclusion

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