

Seismic Forces & Curb Mounted Equipment

Introduction:

The newer building codes such as **2000 IBC, TI-809-04, 2003 IBC, and NFPA 5000** have mandated design seismic forces that are much larger in magnitude than were previously specified in the older model building codes. These new codes have written the design horizontal seismic force equation to account for the amplification of the accelerations due to increasing flexibility as you go up in a building. Therefore, equipment that is mounted on the roof of a building will have design seismic forces that are three times larger than a similar piece of equipment that is mounted on grade. Great care must be taken in the design, selection, and installation of supports and restraints for roof top curb mounted equipment.

Basic Curb Types:

The roof curbs may be broken down into **isolated** and **non-isolated** types. The **isolated** roof curbs may be further broken down into **sheet metal** and **structural** types. The discussion will start with the **isolated** curb types.

Sheet Metal Seismic Isolation Curbs:

Kinetics Noise Control provides two products for isolation with sheet metal roof curbs. First is the Kinetics Noise Control model **KSR Isolation Rail**. The **KSR-1** and **KSR-2** are seismically restrained steel coil spring isolation systems that are built to be installed on third party sheet metal roof curbs. Figure D6.1-1 shows a typical cross-section through the springs of a **KSR** installation. Figure D6.1-2 is a typical cross-section through the seismic/wind restraints of the **KSR**. **KSR-1** systems are designed to operate with a system **Static Deflection** of **1"** when loaded, which gives a system **Natural Frequency** of **3.13 Hz**. The **KSR-2** systems are intended to operate with a loaded system **Static Deflection** of **2"**, which produces a system **Natural Frequency** of **2.21 Hz**. The **Static Deflection** of the **KSR** systems is adjustable by adding or removing the spring coils, which are easily accessible and compressed for insertion or withdrawal.

The seismic/wind restraints consist of stainless steel leaf horizontal restraints, and reinforced neoprene strap vertical restraints. Each **KSR** installation requires a minimum of one horizontal restraint per curb side. The vertical restraints are required only if uplift will occur at any of the equipment corners. The leaves and straps, when required are attached to the extruded aluminum top rail and the curb side wall through the nailer as shown in Figure D6.1-2. The locations for the restraints are specified by the by Kinetics Noise Control. The required number of restraints, horizontal and vertical, is determined by analysis using the Kinetics Noise Control Seismic/Wind Certification Program.

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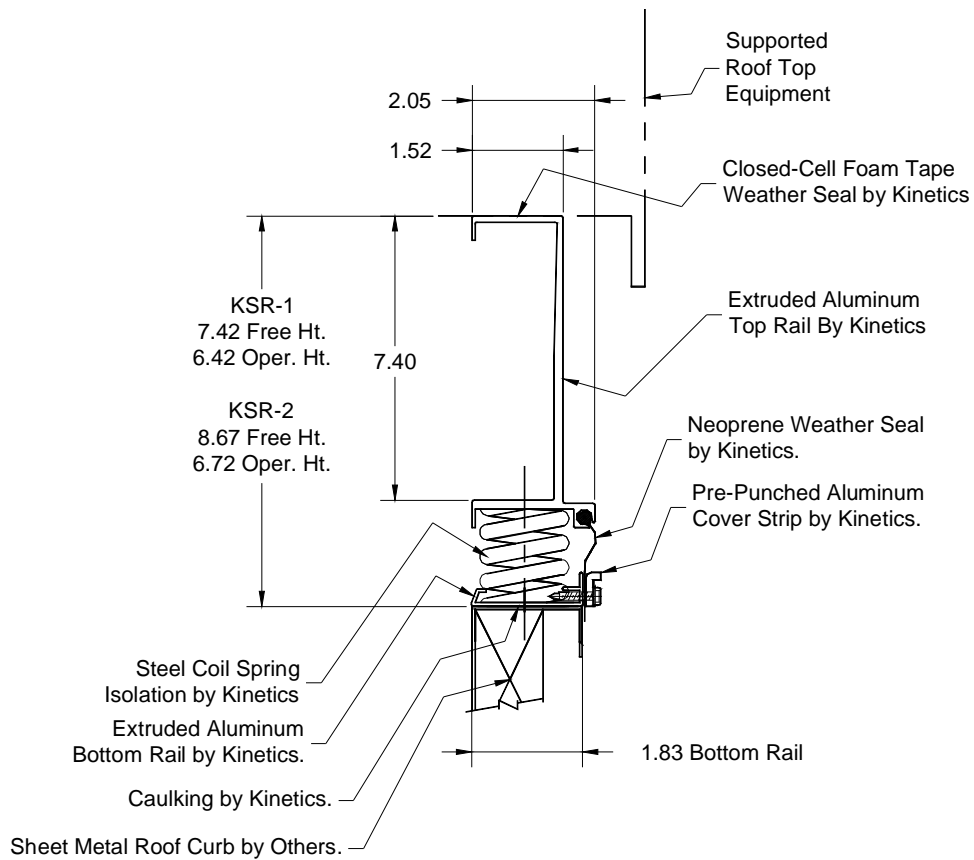


Figure D6.1-1; Typical Cross-Section Through KSR Showing Isolation Springs.

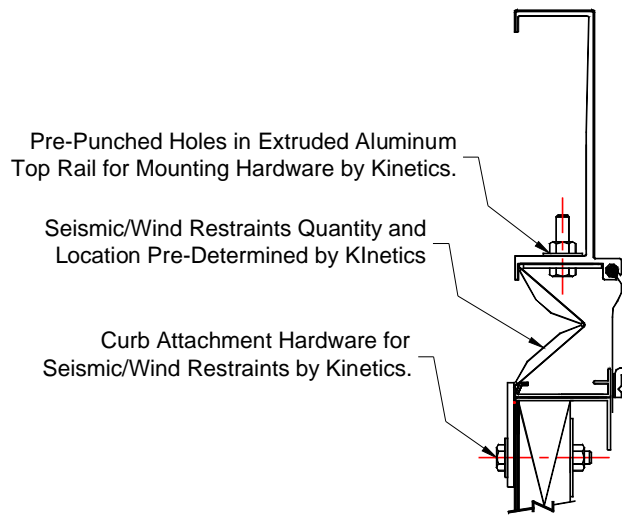


Figure D6.1-2; Typical Cross-Section Through KSR Showing Restraints.

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Kinetics Noise Control also provides two complete seismically rated sheet metal curb and isolation rail systems, the model **KSCR-1** and **KSCR-2**. A typical cross-section through the **KSCR** is shown in Figure D6.1-3.

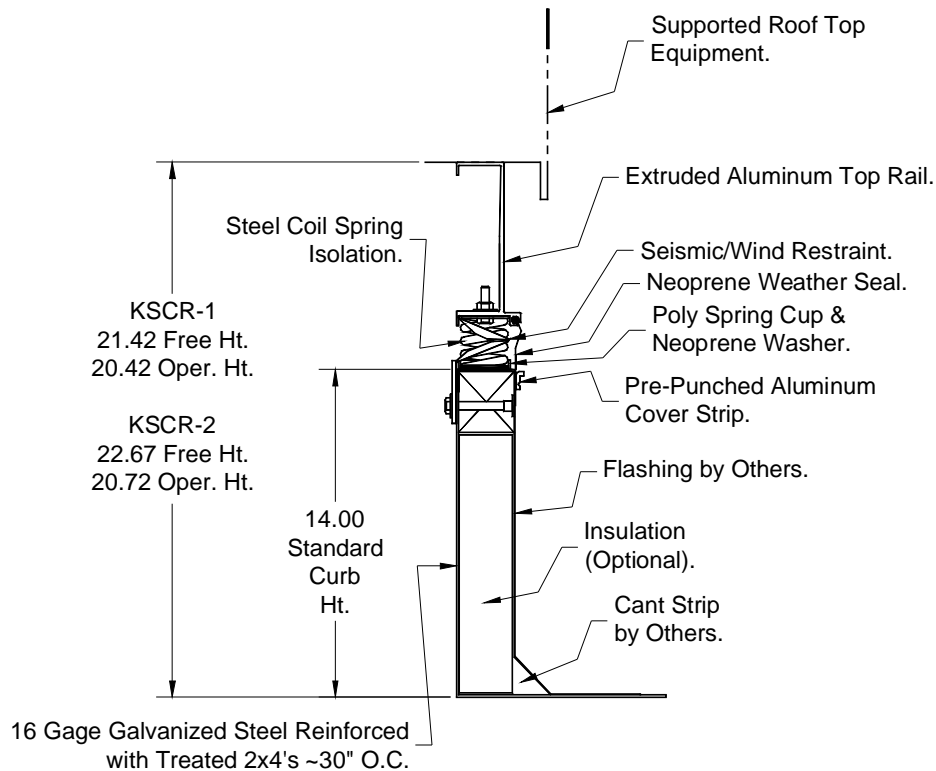


Figure D6.1-3; Typical Cross-Section Through a KSCR.

As with the **KSR-1 & -2**, The **KSCR-1** is a **1" Static Deflection** isolation system, and the **KSCR-2** is a **2" Static Deflection** isolation system. The horizontal and vertical restraints used for the **KSCR** are the same ones used on the **KSR**. At least one horizontal restraint per curb side wall is required, and more are added as indicated by analysis through the Kinetics Noise Control Seismic/Wind Certification Program. The vertical restraints are added where indicated by the analysis. Typically the curb itself is **16 Gage** Galvanized steel reinforced with treated wood **2x4's** at **30"** On Center. Curb heights greater may require the use of heavier gage sheet steel in order to carry the seismic and wind loads without danger of buckling failure.

Structural Seismic Isolation Curb:

Kinetics Noise Control provides the model **ESR-1**, **ESR-2**, and **ESR-4** structural seismic isolation curb systems. They are, respectively, **1"**, **2"**, and **4" Static Deflection** isolation systems. The intended system **Natural Frequencies** are **3.13 Hz**, **2.12 Hz**, and **1.56 Hz** respectively.

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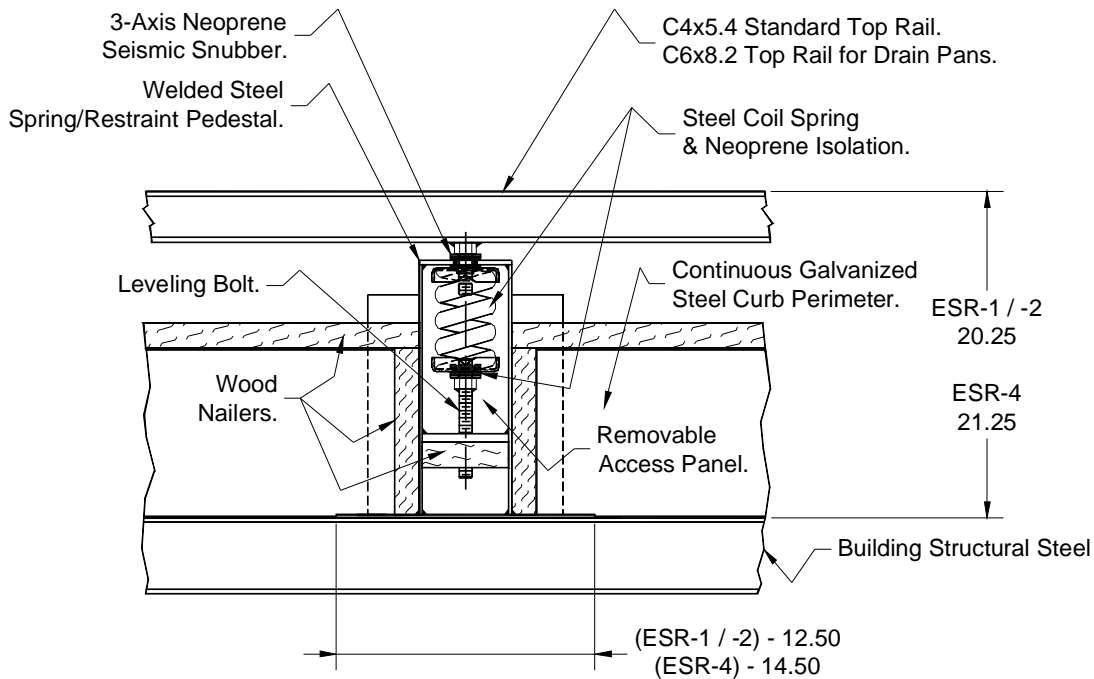


Figure D6.1-4; Typical ESR Pedestal Installation.

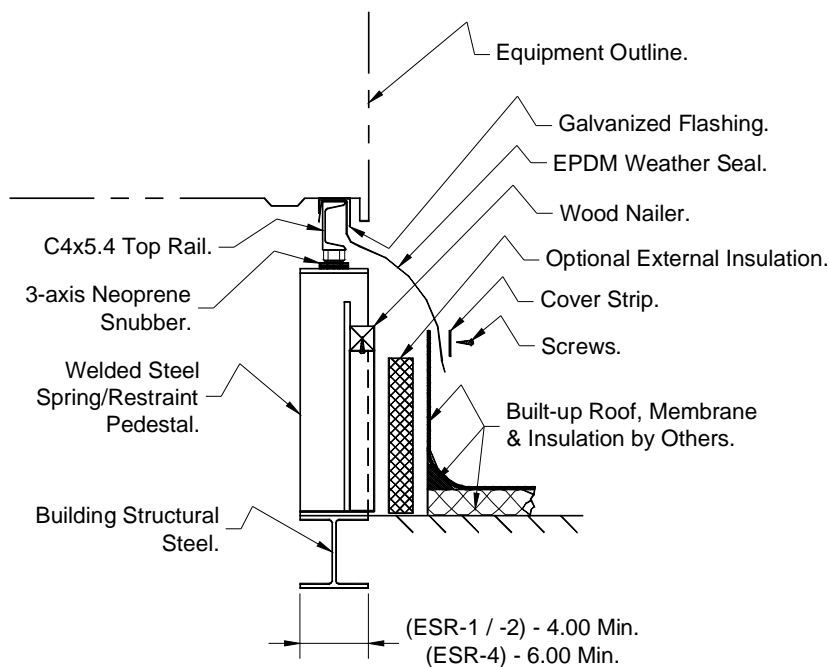


Figure D6.1-5; Typical Cross-Section Through an ESR Pedestal Installation.

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The seismic forces are transferred from the equipment to the top rail through fasteners or welds at each pedestal location. The size and number of the fasteners, and the size and length of weld required at each pedestal is specified by the Kinetics Noise Control Seismic/Wind Certification Program. The loads are transferred to the welded steel spring restraint pedestal through the 3-axis neoprene snubber assembly. The loads then are transferred from the pedestal to the building structure. The **ESR** is normally to be intended to be attached directly to the building structural steel either by bolting or welding. Mounting holes are provided for three (3) 5/8" Bolts/Anchors in the base plate of each pedestal. An equivalent amount of weld is specified by Kinetics Noise Control for each pedestal. Attachment of the **ESR** to the building structural steel will maximize the seismic capacity of the system. If the **ESR** is to be attached to concrete or some type of wooden structure, special analysis and additional components will be required to make an adequate attachment, and the full capacity of the **ESR** may not be realized.

Application of Isolated Roof Curbs:

The **KSR & KSCR** are generally used for small to medium sized pieces of equipment, and in low to medium seismic areas. For instance, they may work well for equipment weights up to **8,000 lbs – 10,000 lbs** in areas like Central Ohio, Western Pennsylvania, Northwestern New York, Chicago, etc. However, they may not be at all suitable for equipment weights of **2,000 lbs – 5,000 lbs** in high seismic areas like Memphis, Tennessee; Los Angeles, California; Salt Lake City, Utah; or Charleston, South Carolina. Also, the building type may determine the usefulness of the **KSR & KSCR**. For instance, they may not work well for the smaller units on the roof of a hospital in New York City.

The **ESR** is used for the larger pieces of equipment **10,000 lbs** and up. Also, it will be used for small to medium pieces of equipment in the high seismic areas. The **ESR** is used when a structural curb is specified, when adjustment of the springs is an issue, and when a low system **Natural Frequency, 4" Static Deflection**, is required for sensitive applications.

Non-Isolated Sheet Metal Seismic Roof Curbs:

Kinetics Noise Control does not produce a **non-isolated** roof curb. However, Kinetics Noise Control does make a set of kits to attach the supported piece of equipment to a roof curb that is built by others, or the building structure. The attachment of equipment to third party curbs is an issue that has not been well addressed by either the equipment manufacturers or the curb manufacturers. The kits produced by Kinetics Noise Control provide enough parts and hardware to connect a wide range of equipment types and makes to sheet metal curbs.

The horizontal seismic /wind restraint kits provided by Kinetics Noise Control are the models **KSMF**, Figure D6.1-6; **KSCM-1**, Figure D6.1-7; and **KSCM-2**, Figure D6.1-8. A minimum of four (4) kits are required for each curb. One (1) kit for each curb side wall.

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Additional kits may be required based on an analysis by Kinetics Noise Control. The required number and location of each kit are specified by Kinetics Noise Control.

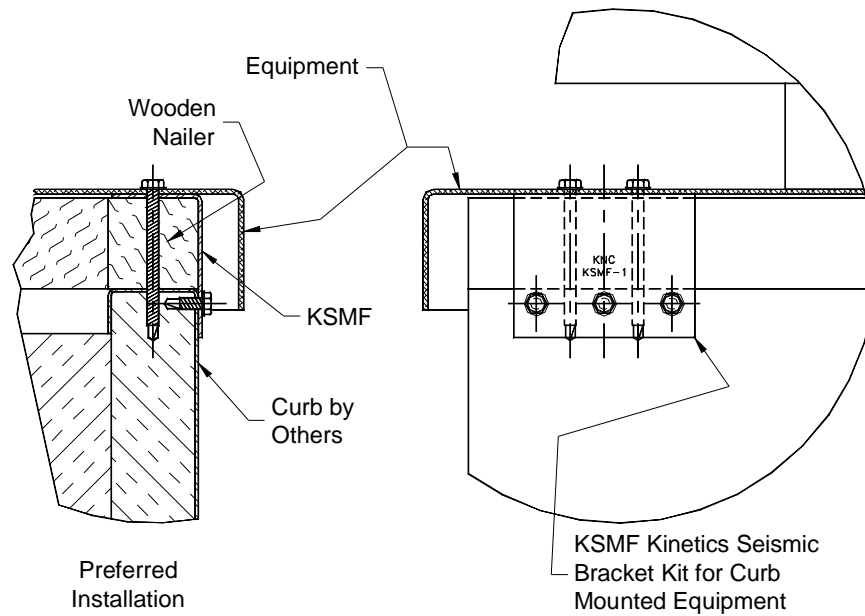


Figure D6.1-6: Typical KSMF Seismic Attachment Kit Installation.

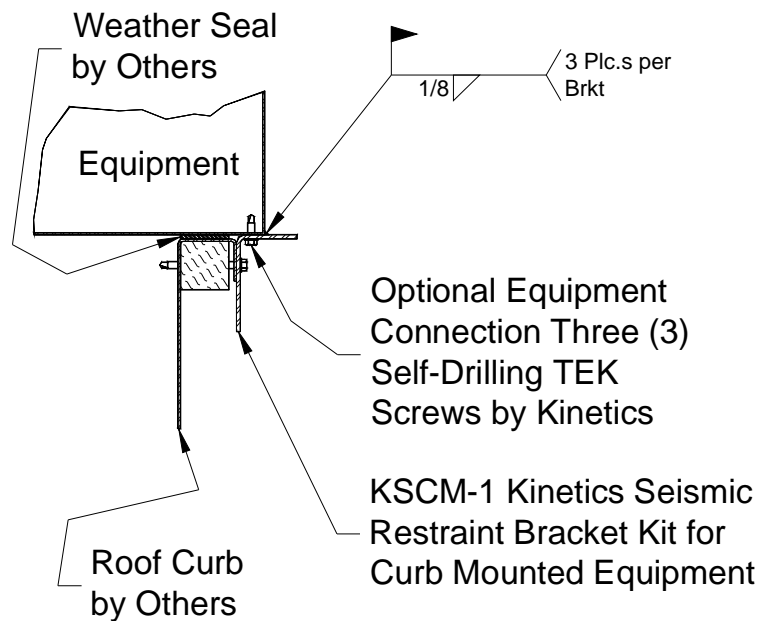


Figure D6.1-7; Typical KSCM-1 Horizontal Seismic Attachment Kit Installation.

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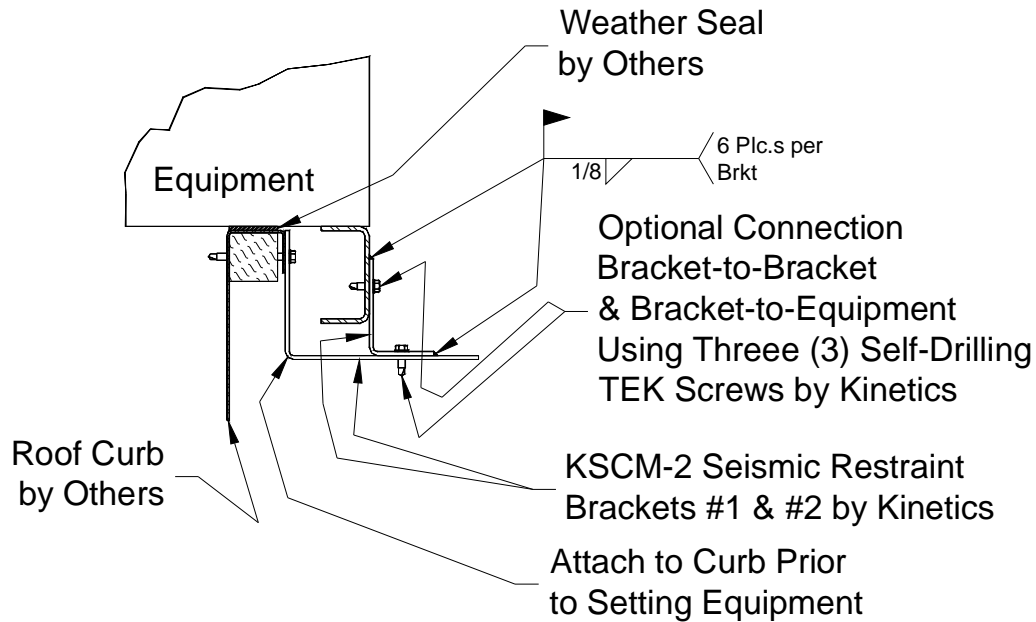


Figure D6.1-8; Typical KSCM-2 Horizontal Seismic Attachment Kit Installation.

The analysis performed by Kinetics Noise Control will indicate if uplift occurs at any of the corners of the equipment. If uplift is present, Kinetics Noise Control will recommend the use of model **KSCV**, Figure D6.1-9, vertical equipment restraint kits that restrain the equipment directly to the building. A minimum of one (1) **KSCV** kit will be required at each corner of the equipment. The analysis performed by Kinetics Noise Control will show exactly how many kits are required for an application. The reason Kinetics Noise Control recommends the use of the **KSCV** kits rather than taking the vertical loads through the curb, is that we do not control the construction of the curb, and can not guarantee that the curb side walls will be able to carry both horizontal and vertical loads generated by a seismic or wind event.

The analysis performed by Kinetics Noise Control also looks at the curb side walls if enough information is provided in the submittal sent to Kinetics. If the curb side walls do not appear to be able to carry the design seismic or wind loads, Kinetics Noise Control will make recommendations that reinforcements are to be used for the curb side walls and/or that heavier gage steel is to be used in the curb side walls in order to meet the design load requirements. If reinforcements are indicated by the analysis, Kinetics Noise Control can provide the model **KSVR**, Figure D6.1-10, curb side wall reinforcement kit. The **KSVR** kit is intended to carry the vertical loads generated by the equipment and leave the curb side walls to carry the horizontal seismic loads. The analysis performed by Kinetics Noise Control will recommend the number and spacing for the reinforcements.

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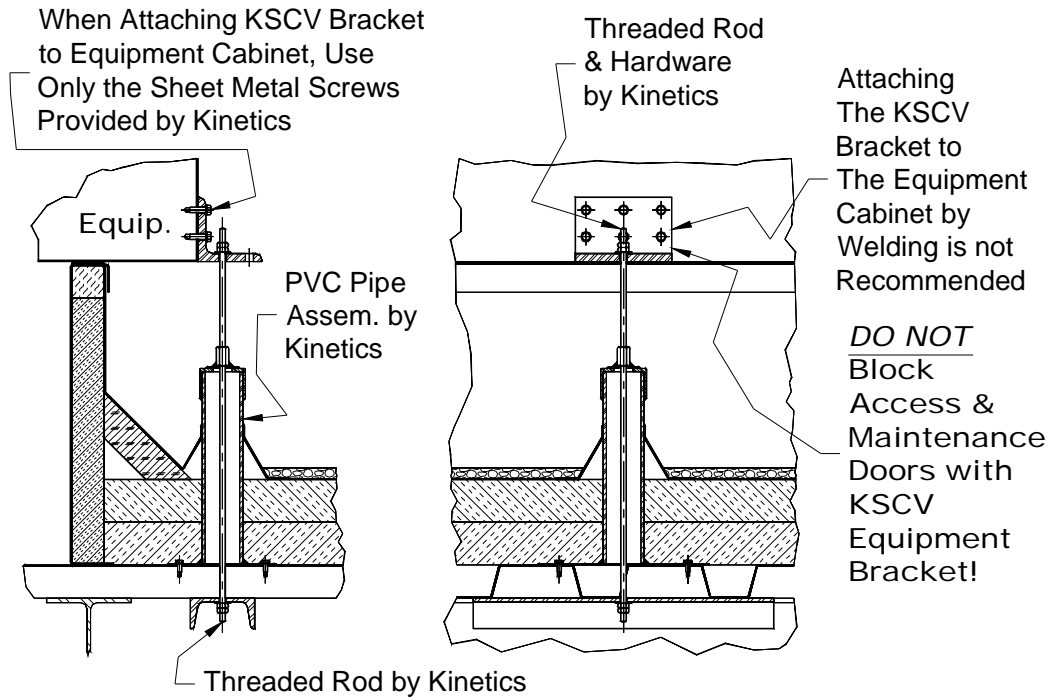


Figure D6.1-9; Typical KSCV Vertical Seismic Restraint Kit Installation.

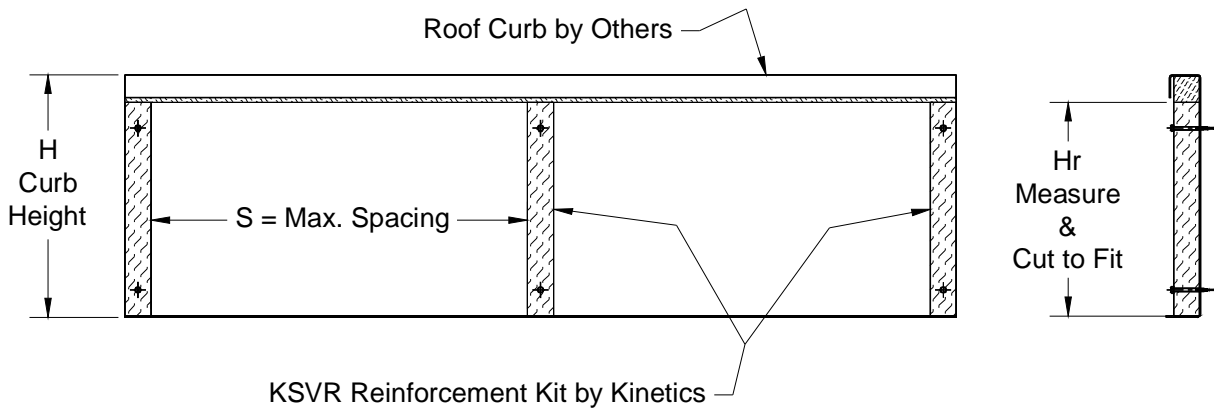


Figure D6.1-10; Typical KSVR Reinforcement Kit Installation.

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Summary:

For roof top curb mounted equipment on a job requiring seismic restraint it is important to perform a seismic analysis. If isolated, the analysis will indicate whether a KSR & KSCR would be suitable for the application with the proper number of restraints, or whether an ESR with the proper number of pedestals would be required. If non-isolated, the analysis will show the correct number of horizontal and/or vertical restraint kits needed for the application. It will also show if the curb side walls require reinforcement, or if they need to be made of a heavier gage steel.

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