

The Gradient Control Mat (GCM)



Installation Instructions

Overview

Most gradient control mats are designed and installed around above ground pipeline appurtenances to limit power frequency voltages. The DEI gradient control mat is designed to also limit potentially hazardous voltages due to lightning, a much more difficult task. Step potentials are inherently controlled by the design of the mat (grid wire size, grid spacing, etc.), but the touch potential that a worker may be subject to is determined both by the mat design and the installation; therefore, these installation guidelines must be followed to provide maximum protection from lightning-caused voltages.

Note: The most significant installation factor is to keep the conductor that connects the mat to the pipeline as short as possible, preferably 8" (200mm) or less, whether the mat is direct connected to the pipeline or connected through a DEI solid-state decoupler.

The reason for this is that conductors inherently have inductance and when a very fast rising current, such as from lightning, flows through the conductor from the pipeline to the mat a significant voltage per unit of conductor length is developed. This voltage drop adds directly to the touch potential for a worker standing on the mat. Therefore, keep conductor connections between the mat and pipeline as short as possible – as described above.

Materials Required for Installation

1. Gradient Control Mats (4' x 8'), GCM4-8
2. If more than one mat is required, then weld the mats together using the following mold and weld charge: MOLD-135 and WELD-135-15 (20/pack). The WELD-135-15 charge is an industry standard #15 cartridge and can be purchased from any industry source. Do not join mats with compression type or bolted type connections - thermit weld only.
3. Magnesium anodes per Table 2, Section 2.1 and 2.2 in the attached Correg Report, and backfill, if not provided with the anode.
4. To thermit weld the #6 AWG anode leads or the #6 decoupler leads to the mat (if the mat is decoupled) the following mold and weld charge is required: MOLD-6 and WELD-6-25 (20/pack). The WELD-6-25 charge is an industry standard #25 cartridge and can be purchased from any industry source. To thermit weld a #10 or #12 AWG lead, use MOLD-135 and WELD-135-15 (20/pack). Do not attach leads with compression type or bolted type connections - thermit weld only.
5. Wire cutters for 0.135" diameter steel wire (If necessary to cut out sections of the mat to fit around pipelines.)
6. A DEI solid state decoupler if used, typically Model SSD-A/B-C-D where A/B is the blocking voltage, C is the fault current rating at 30 cycles, and D

is the lighting current rating in kA. The most common rating is the SSD-2/2-1.2-75 for gradient control mat decoupling. Reference the DEI technical literature for model SSD for ratings and outline drawings.

7. Decoupler leads, 12" (300mm) or 36" (900mm) with factory installed terminals (one end only), order MTL-6-12 or MTL-6-36, with each kit containing two #6 AWG leads. It is recommended that two leads per decoupler terminal are used, but cut off all excess lead to make connections as short as possible.

8. Mounting of decoupler:

- By banding: Banding material to be selected/purchased by user
- By mounting to 8mm pin brazed studs. Equipment/studs/ceramic ferrules by user. Requires one Hex Coupling Nut from DEI, model #HCN-M8
- By securing to a post adjacent to the pipeline: User furnished.

The first two mounting methods are illustrated in Figures 2 and 3.

9. Sealant for all thermit welds: Denso LT tape (Available from DEI in 4"x33'rolls)

10. Crushed limestone to cover mat 6" (Use clean washed stone only if limestone is not available.)

Installation Procedure

Install mats and anodes as illustrated in the attached Correng Report. If a decoupler is used, refer to the attached decoupler Figures 1 – 3.

1.) Remove topsoil to a uniform depth of approximately 6" (150mm) in an area that extends beyond the lateral mat dimensions. At the anode locations, excavate an additional 36" (900mm) depth to the lateral dimensions of a horizontally oriented anode as depicted in the Correng Report. Apply backfill material around the anode (if the anode is not already bagged with backfill), and refill the hole with native soil, leaving the anode wire extended beyond the soil surface for later attachment to the mat.

2.) Orient adjacent mats as follows: Flip the adjacent mat over so that the top grid wires on one mat are oriented 90° with respect to the top grid wires on the adjacent mat. This will enable the outer grid wires on adjacent mats to be placed directly next to each other, a requirement for the grid wires to fit properly in the thermit welding mold.

3.) Locate the position of vertical pipe segments or other structures that will protrude through the mat, and using wire cutters, remove the unneeded portions of the mat so that the mat wires are no closer than 3" (75mm) to the pipe at any point, which will avoid contact and abrasion to the pipe coating.

4.) Place the mat segments in position around the structure, in the excavated area. When multiple mats are required for a given site, the adjoining mats should be thermit welded together approximately every 18" using the molds and weld charge recommended (MOLD-135 and WELD-135-15). Do not substitute or use any compression or bolted type connection.

5.) Weld the #6 AWG anode leads to the mat as illustrated in the Correng Report using the mold and weld charge made for this purpose (MOLD-6 and WELD-6-25). For anodes with #10 or

#12 AWG leads, use MOLD-135 and charge WELD-135-15. Do not substitute or use any compression or bolted type connection.

6.) If the mat is to connect to the pipe through a decoupler, mount the decoupler as close to the mat as feasible, taking into account that the mat is to be covered with 6" of crushed limestone. The mounting method for the decoupler should have been pre-determined by the user and may consist of banding to the pipe wall, mounting by using 8mm studs pin brazed to the pipe, or by mounting to a post adjacent to the pipe that is to be connected to the mat. All mounting is to be user furnished, except, if 8mm studs are pin brazed to the pipe, a hex coupling nut kit is required from DEI (#HCN-M8) to make the connection from one decoupler terminal directly to the pipe wall. See the attached figures for various decoupler mounting methods.

7.) Make lead connections from the appropriate decoupler terminal to the closest section of mat with the shortest lead that will still allow welding of the lead to the mat using the mold provided for this purpose (use MOLD-6 for #6 AWG). Two #6 lead connections are recommended from each decoupler terminal as this also helps to minimize lead inductance, with one lead set to the pipe and the other set to the mat, each preferably less than 8" (200mm) long. Of the two DEI decoupler lead lengths available, the 36" (900mm) long leads are never recommended when limiting touch potentials due to lightning is of concern, but this length is acceptable for power frequency voltages. When connections are made to adjacent mats as illustrated in Figure 1 (bottom view) of the Correng Report it is desirable to mount the decoupler so one lead goes to each mat with the shortest possible lead length.

8.) After all welding is complete (i.e., all mat to mat and lead to mat welds), seal around and beyond the end of each weld with two or more layers of Denso LT petrolatum tape or other user

approved sealant. When the Denso tape is used, a 2" to 3" long piece of the 4" wide tape is required to seal each weld.

9.) Cover the entire gradient control mat with 6" of crushed limestone (alternatively, use clean washed stone, but only if crushed limestone is not available). Extend the covering at least several feet beyond the outer edges of the mat on all sides.

Figure 1 Typical Procedure For Decoupling A Gradient Control Mat

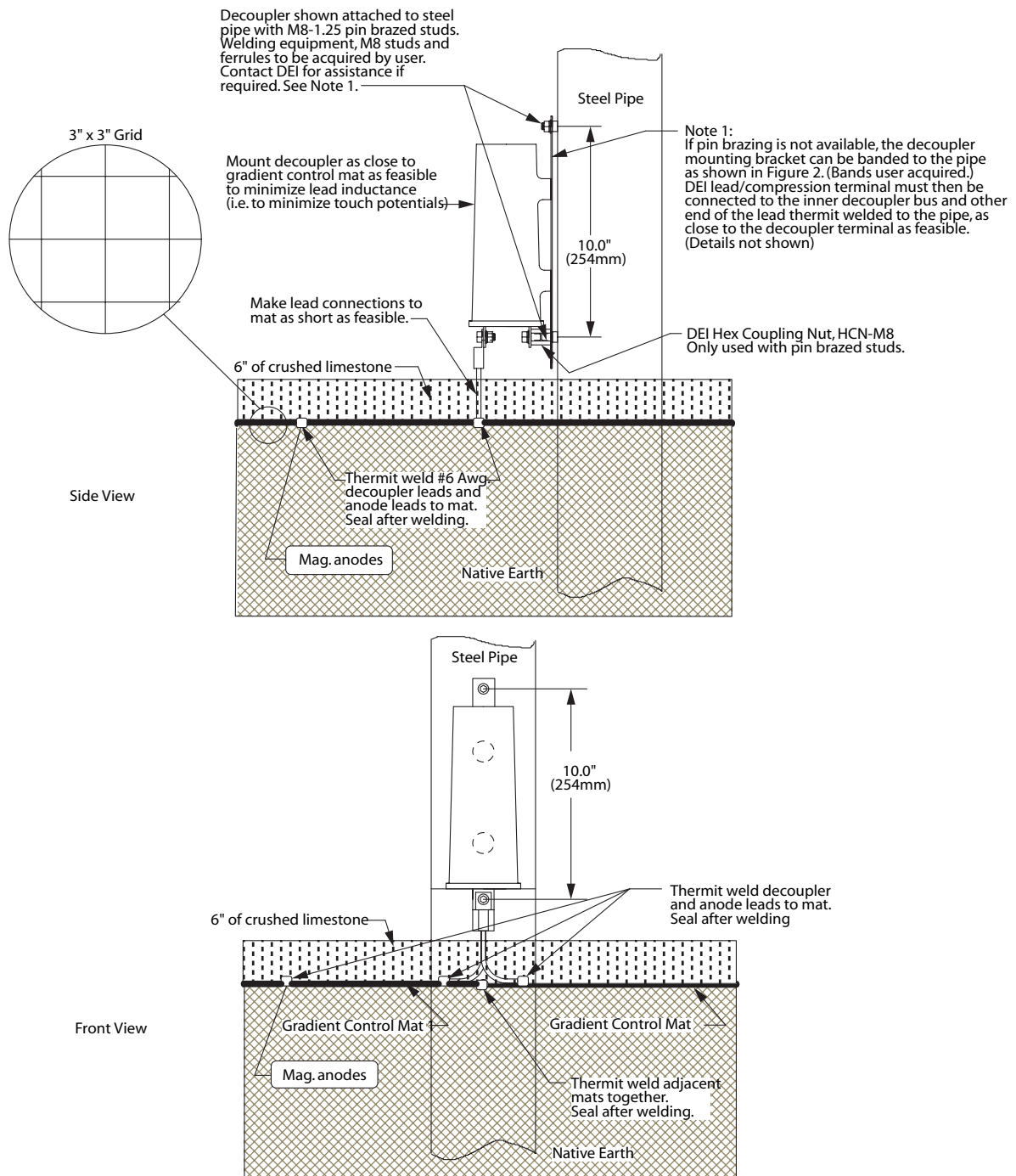


Figure 2 Banding SSD to a Test Station or Pipe Wall

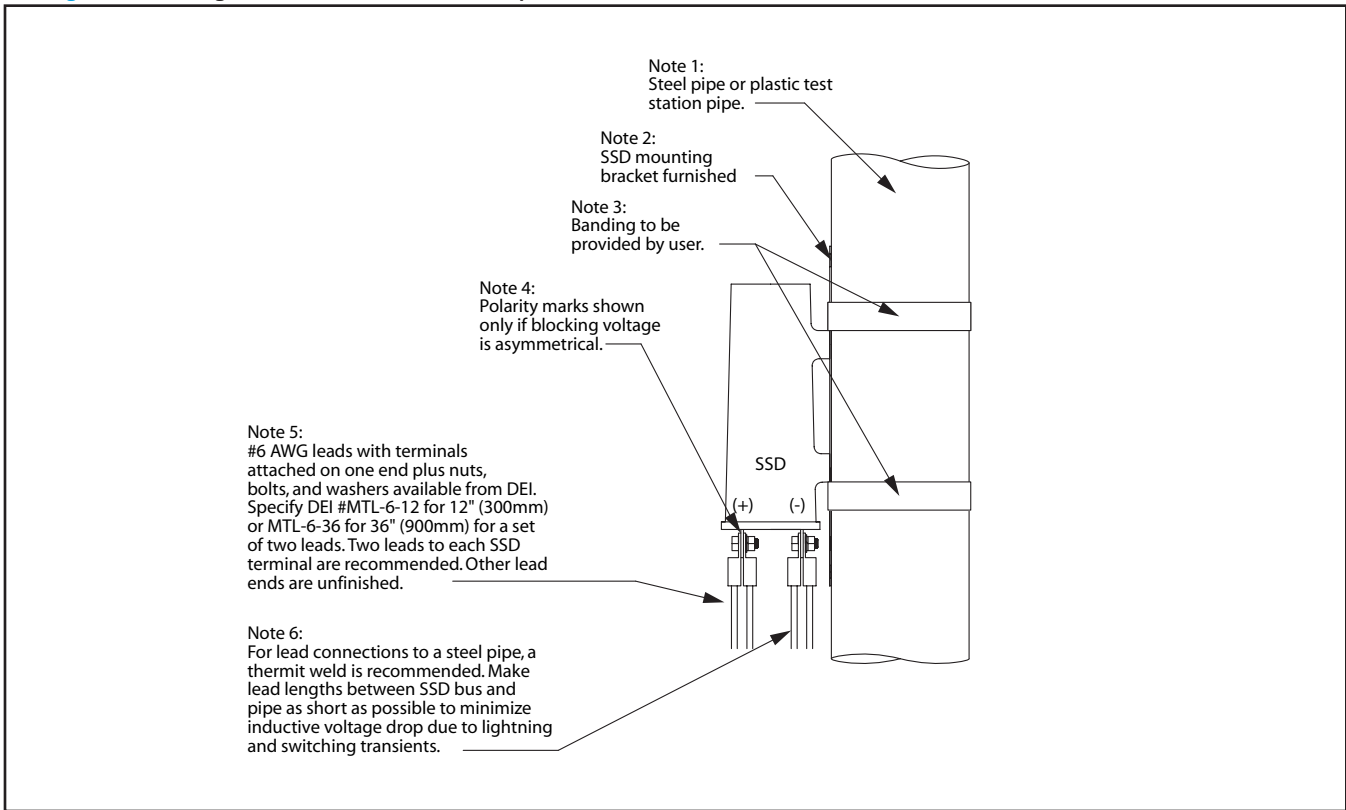
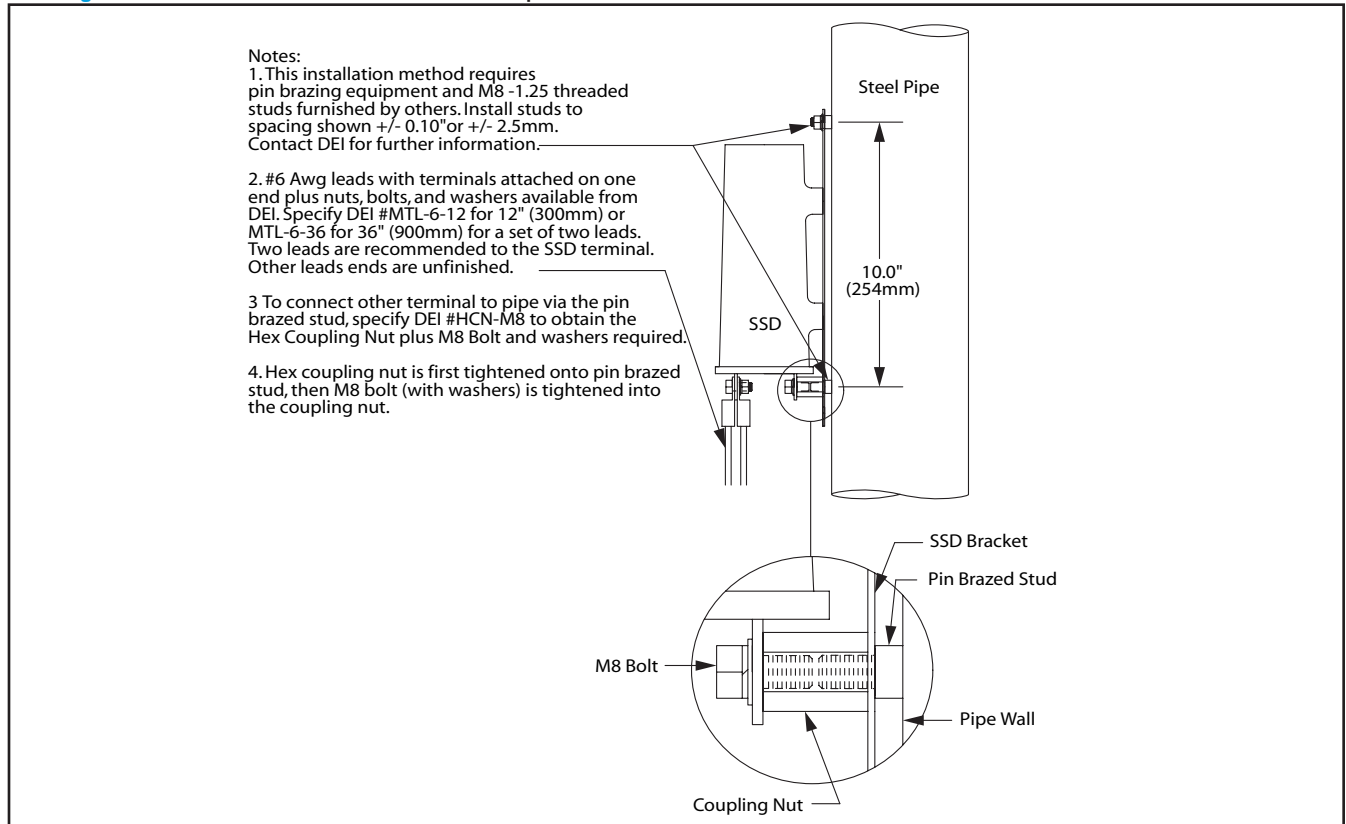


Figure 3 Pin Brazed Stud Connection to a Pipe Wall





GUIDELINES FOR CATHODIC PROTECTION OF GALVANIZED STEEL GRADIENT CONTROL MATS

1.0 APPLICABILITY

- 1.1 These guidelines apply to cathodic protection of galvanized steel gradient control mats installed at pipeline appurtenances to reduce electrical step and touch potentials in areas where persons could come into contact with a pipeline appurtenance subject to hazardous potentials.
- 1.2 These guidelines do not apply when the gradient mat is connected to other grounding systems, either directly or indirectly through the pipeline appurtenance. These applications require consultation with a cathodic protection specialist.
- 1.3 If the pipeline is not cathodically protected, the galvanized steel mat should be connected only via a decoupling device, or provision should be made to protect both the pipe and the mat in consultation with a cathodic protection specialist.

2.0 ANODES

- 2.1 The magnesium anodes used to protect the mats should be either high potential packaged magnesium anodes (Alloy M1C) or H1-Alloy (Standard) packaged magnesium anodes, as indicated in Table 1.

Table 1. Magnesium Anode Data

Anode Type	Alloy (ASTM B843-93)	Weight (Lbs.)	Standard Package Dimensions
17S4	H-1 Alloy Grade A	17	6.5" x 19"
17D4	M1C (High Potential)	17	6.5" x 19"
32S5	H-1 Alloy Grade A	32	8" x 30"
32D5	M1C (High Potential)	32	8" x 30"

- 2.2 The packaged anodes should be provided with 10 ft. of AWG 6/7 RWU 90 cable. The backfill should be a mix of 75% hydrated gypsum, 15% bentonite, and 5% sodium sulphate.



CP of Galvanized Steel Gradient Control Mats

2.3 The type and quantity of the packaged anodes should be in accordance with Table 2. Contact DEI if the size of the mat exceeds 16' x 16'.

Table 2. Required Type and Number of Magnesium Anodes

Mat Size	Soil Resistivity (Ω -cm) ^[1]	Anode Type	Required No. of Anodes	Calculated Anode Service Life		Layout
				Decoupled GCM	Directly Connected GCM ^[2]	
4' x 8'	Low (1000 to 2000)	32S5	1	>20 years	>18 years	Figure 3
	Moderate (Over 2000)	17S4	1	>20 years	>20 years	Figure 3
8' x 8'	Low (1000 to 2000)	32S5	1	>20 years	>17 years	Figure 1
	Moderate (Over 2000)	17D4	1	>20 years	>20 years	Figure 1
8' x 16'	Low (1000 to 2000)	17S4	2	>20 years	>19 years	Figure 4
	Moderate (Over 2000)	32D5	1	>20 years	>20 years	Figure 3
12' x 16'	Low (1000 to 2000)	32S5	2	>20 years	>20 years	Figure 4
	Moderate (Over 2000)	32D5	2	>20 years	>20 years	Figure 4
16' x 16'	Low (1000 to 2000)	32S5	2	>20 years	>19 years	Figure 2
	Moderate (Over 2000)	32D5	2	>20 years	>20 years	Figure 2

^[1] The cathodic protection system was designed to provide an anode life in excess of 20 years in soil resistivities as low as 1000 Ω -cm and to provide the required protection current at soil resistivities up to 15,000 Ω -cm. Soils with resistivities higher than 15,000 Ω -cm are not considered corrosive.

^[2] If the gradient control mat is directly connected to a pipe appurtenance, then the polarized potential of the protected structure is expected to drop from -1100mV_{CSE} to -850 mV_{CSE} and the service life of the anode would be reduced by 28% for high potential anodes and by 36% for H1-Alloy anodes.



3.0 ANODE INSTALLATION

- 3.1 The anodes should be installed horizontally approximately 3 ft. below the mat, as indicated in Figures 1 to 4.
- 3.2 The anode wire should be run to a close mat wire. The radius of bends should be at least 8".
- 3.3 The #6 AWG anode wire connections to the 0.135" diameter galvanized steel wire of the gradient control mat and the mechanical/electrical bonding of the galvanized steel wires in adjacent gradient control mats should be done by thermit welding. Custom molds and the weld metal for each case are available from DEI (Dairyland Electrical Industries, Inc.) All thermit welded connections should be sealed with two or more layers of Denso LT tape.

3.0 ANODE INSTALLATION CONT'D

3.3 Cont'd

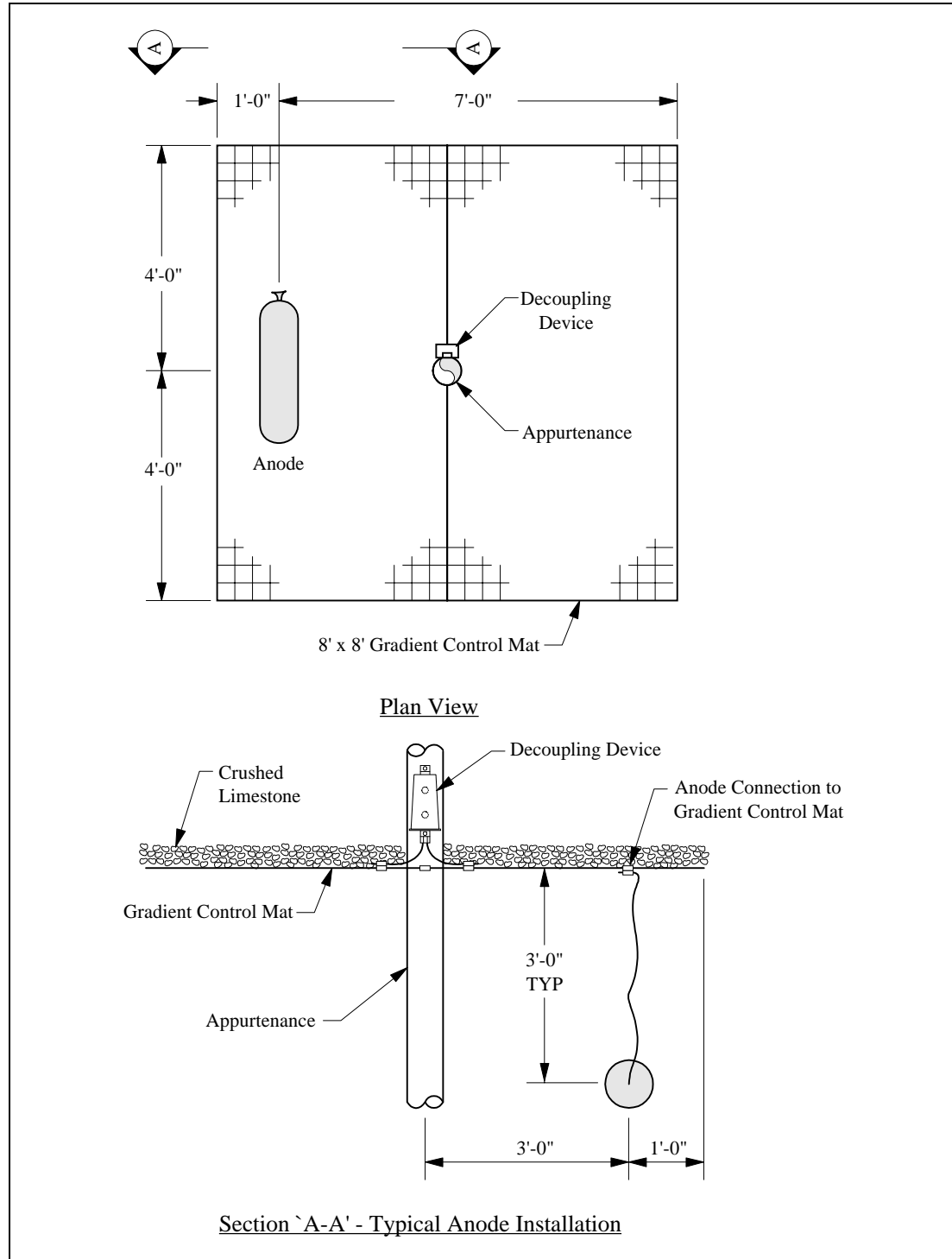


FIGURE 1 • Square Gradient Control Mat with One Anode

3.0 ANODE INSTALLATION CONT'D

3.3 Cont'd

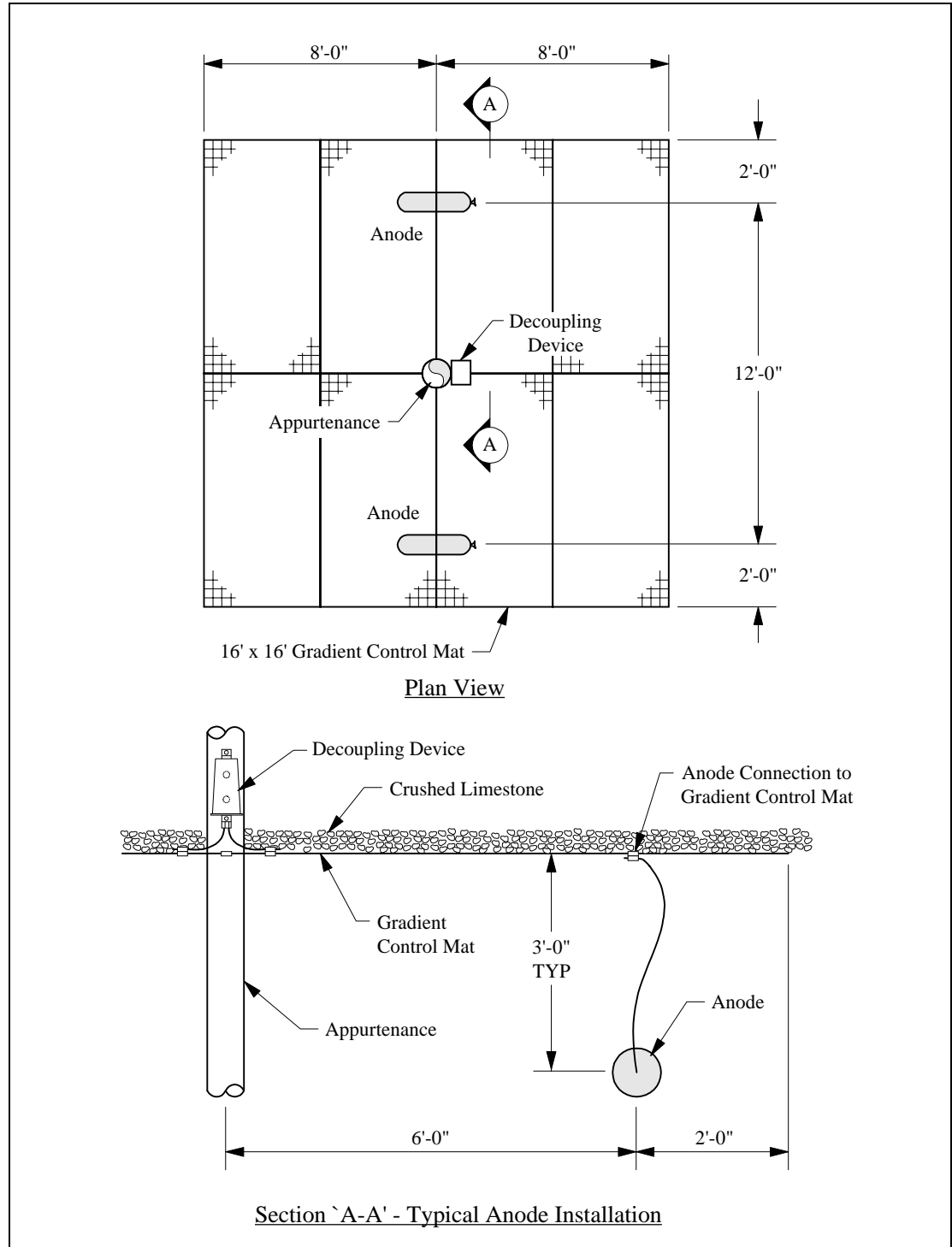


FIGURE 2 • Square Gradient Control Mat with Two Anodes

3.0 ANODE INSTALLATION CONT'D

3.3 Cont'd

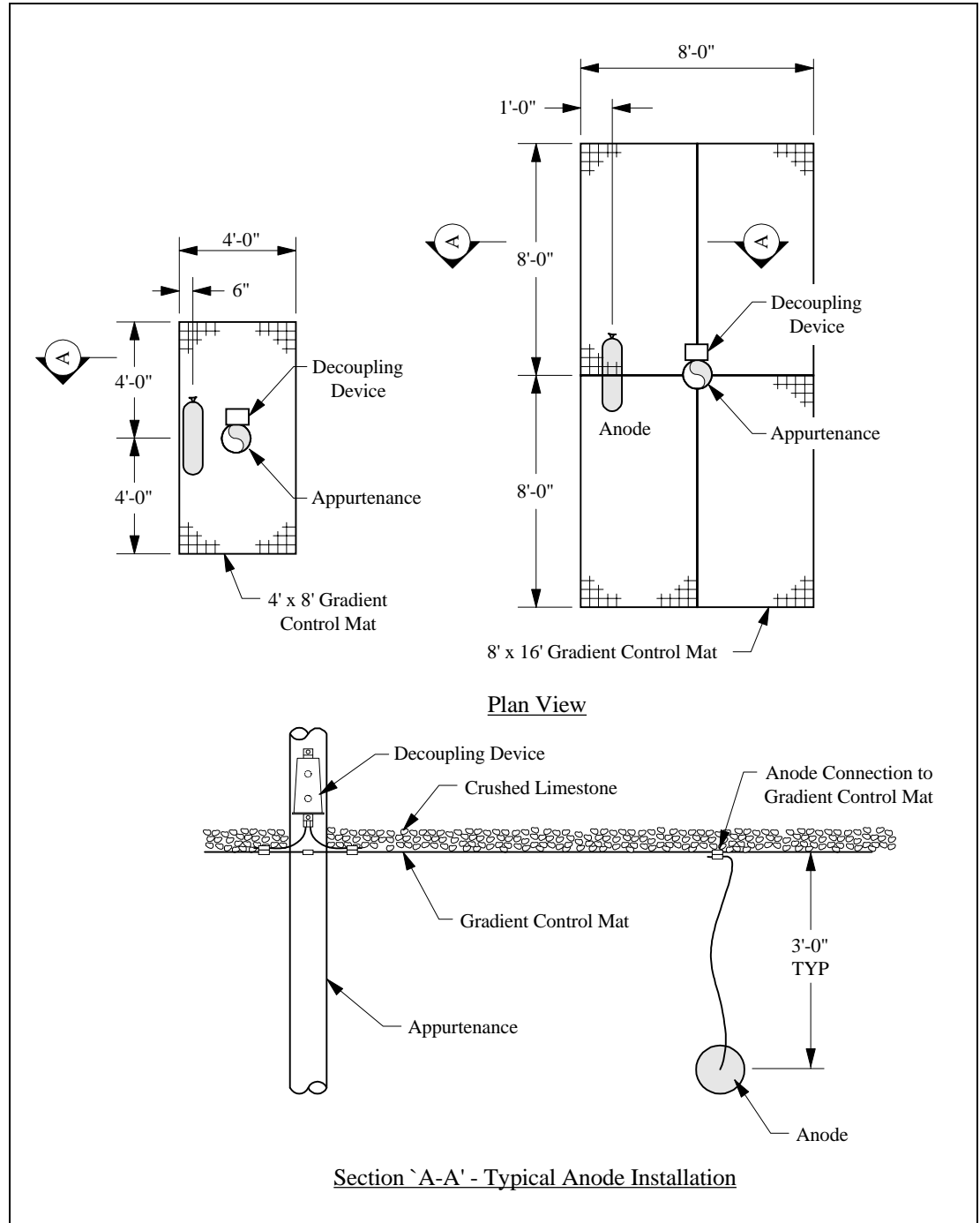


FIGURE 3 • Rectangular Gradient Control Mat with One Anode

3.0 ANODE INSTALLATION CONT'D

3.3 Cont'd

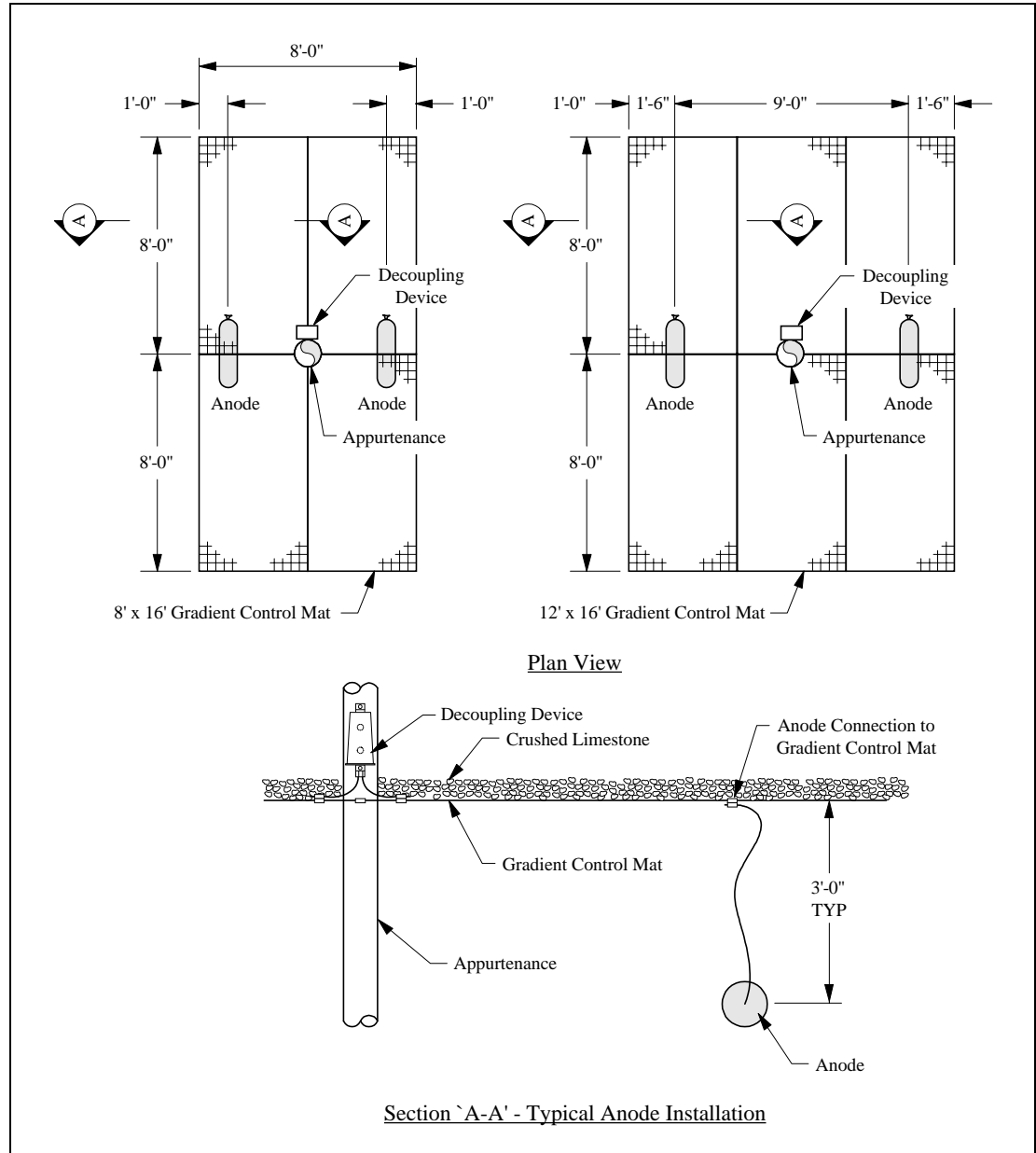


FIGURE 4 • Rectangular Gradient Control Mat with Two Anodes



4.0 ADDITIONAL RECOMMENDATIONS

- 4.1 It is recommended to use crushed limestone as the high resistivity layer to be installed on top of the safety mat, in order to minimize the attack of acid rain on the galvanized steel.