



U.S. Department  
of Transportation  
**Federal Highway  
Administration**

400 Seventh St., S.W.  
Washington, D.C. 20590

March 8, 2005

In Reply Refer To: HSA-10/CC-88

Mr. Kaddo Kothmann  
President  
Road Systems, Incorporated  
3616 Howard County Airport Road  
Big Spring, Texas 79720

Dear Mr. Kothmann:

On December 20, 2004, you requested Federal Highway Administration (FHWA) acceptance of modified versions of your original Sequential Kinking terminal (SKT), your reduced-length Sequential Kinking Terminal (SKT-LITE), and your Flared Energy Absorbing Terminal (FLEAT). The modifications were needed to match these terminals, which were originally tested as standard W-beam terminals, to the higher Midwest Guardrail System (MGS) which was formally accepted as an National Cooperative Highway Research Program (NCHRP) Report 350 test level 3 (TL-3) barrier on March 1, 2005 (acceptance letter B-133). To verify continued crashworthiness of the new designs, the Midwest Roadside Safety Facility (MwRSF) conducted the following four tests:

- Report 350 test 3-30 with the FLEAT-MGS terminal (Test FLEAT-8)
- Report 350 test 3-31 with the SKT-MGS terminal (Test SMG-1)
- Report 350 test 3-34 with the FLEAT-MGS terminal (Test FLEAT-6)
- Report 350 test 3-35 with the FLEAT-MGS terminal (Test FLEAT-5)

To match the MGS barrier design, similar modifications were made to the original SKT, SKT-LITE, and FLEAT designs. These were the following:

- The nominal height to the top of the rail increases from 700 mm (27-5/8 inches) to 787 mm (31 inches). For the anchor posts 1 and 2, the upright posts are increased to 804-mm (31.65 inches) and 842 mm (33.4 inches), respectively. The stub posts to which posts 1 and 2 are bolted are 1829-mm (72-inches) long and must be driven full-depth to provide adequate anchorage.
- All breakaway posts after posts 1 and 2 can be the same configuration as those originally tested, but are driven only 1019 mm (40 inches) deep to match the increased rail height noted above.



- The initial W-beam rail element is increased in length from 3.81 m (12.5 feet) to 4.79 m (15.625 feet) so all rail splices within the terminals fall at mid-span between adjacent posts as with the MGS barrier proper.
- Non-routed wood spacer blocks throughout the terminal are increased from 203 mm (8 inches) to 305 mm (12 inches), again to match the offset blocks used with the MGS barrier.

The NCHRP Report 350 requires up to seven crash tests to determine the adequacy of a traffic barrier terminal at TL-3. However, since the original designs for attachment to standard W-beam guardrail remain crashworthy, only those tests that are likely to be affected by the design changes noted above are considered necessary. You successfully completed test 3-31 (head-on into the SKT-MGS with the 2000-kg pickup truck) and test 3-35 (20-degree impact with the pickup truck at post 3 with a FLEAT terminal). Also with a FLEAT terminal, you conducted the small car head-on test and the Critical Impact Point (CIP) test. Summary sheets for each of these tests are shown in Enclosure 1 to this letter. English-unit drawings for steel-post versions of each of the tested applications are shown in Enclosure 2. I understand that corresponding drawings for wood-post designs are available from you upon request, as well as metric-unit drawings for each of the design configurations.

The modifications to the SKT and FLEAT terminals described above are acceptable and both terminals remain TL-3 designs that can be used on the National Highway System (NHS) when connected to the MGS barrier. While the barrier itself is non-proprietary, your terminals are proprietary and remain subject to the conditions stated in Title 23, Code of Federal Regulations, Section 635.411 when used on Federal-aid highway projects, except exempt, non-NHS projects.

Sincerely yours,

*/Original Signed by/*

John R. Baxter, P.E.  
Director, Office of Safety Design  
Office of Safety

2 Enclosures



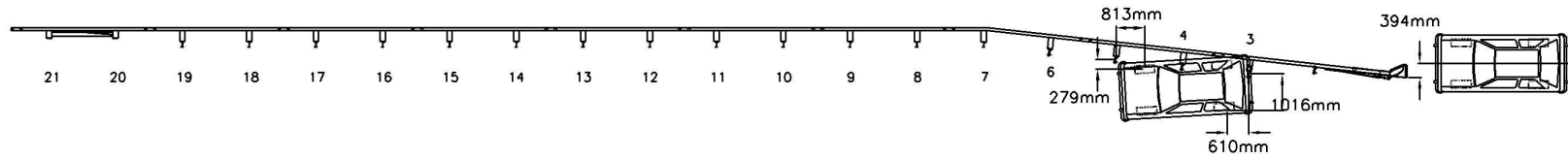
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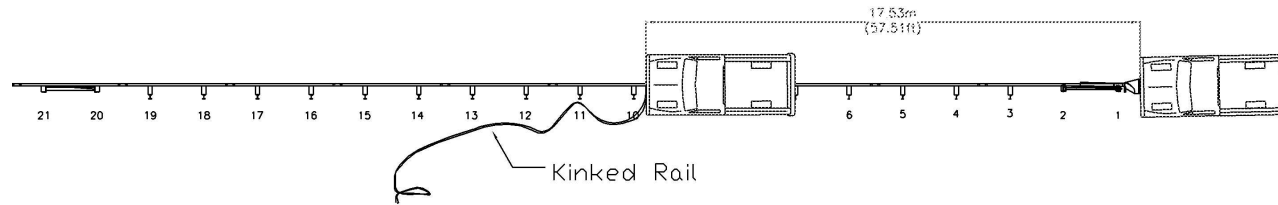
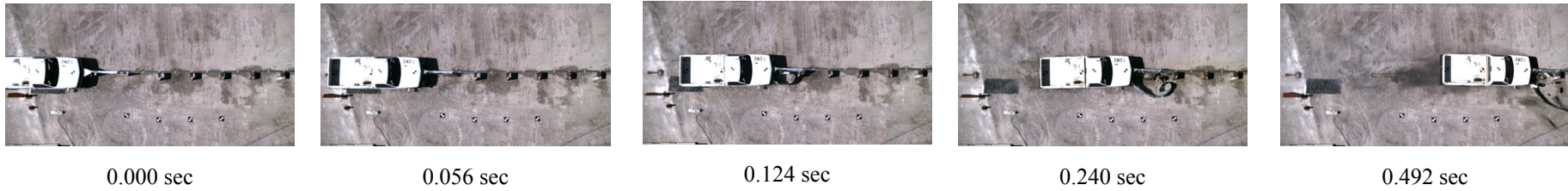
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41

- Test Number ..... FLEAT-8 (3-30)
- Date ..... 2/27/04
- Test Article
  - Type ..... FLEAT-MGS End Terminal
  - Key Elements ..... FLEAT impact head  
Hinged, breakaway steel posts  
Midwest Guardrail System
  - Orientation ..... 1/4 point offset to the center of post no.1
- Soil Type ..... Grading B - AASHTO M 147-65 (1990)
- Vehicle Model ..... 1998 Suzuki Swift
  - Curb ..... 799 kg (1,762 lbs)
  - Test Inertial ..... 821 kg (1,811 lbs)
  - Gross Static ..... 899 kg (1,977 lbs)
- Vehicle Speed
  - Impact ..... 98.7 km/h
  - Exit ..... 0.0 km/h
- Vehicle Angle
  - Impact (trajectory) ..... -0.83 deg
  - Exit (trajectory) ..... NA
- Vehicle Stability ..... Satisfactory
- Occupant Ridedown Deceleration (10 msec avg.)
  - Longitudinal ..... 12.24 g's < 20 g's
  - Lateral ..... 6.58 g's < 20 g's
- Occupant Impact Velocity
  - Longitudinal ..... 7.79 m/s < 12 m/s
  - Lateral ..... 0.27 m/s < 12 m/s
- Vehicle Damage ..... Moderate
  - TAD<sup>13</sup> ..... 12-FD-4
  - SAE<sup>14</sup> ..... 12FYEW2
- Vehicle Stopping Distance ..... 8.23 m downstream  
0.78 m to the left
- Test Article Damage ..... Moderate
- Maximum Deflection
  - Permanent Set ..... 7,659 mm
  - Dynamic ..... 7,676 mm
- Working Width ..... 8.5-m long by 2.14-m wide

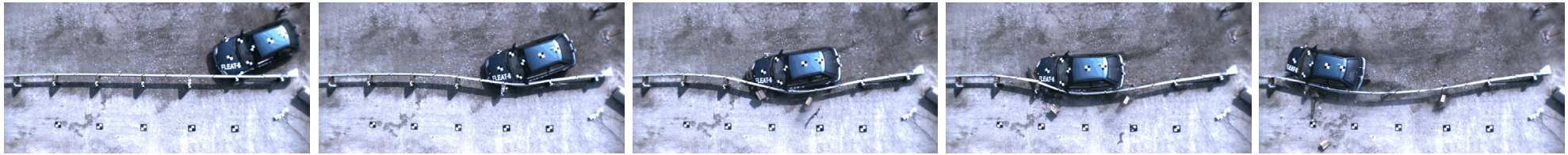
Figure 24. Summary of Test Results and Sequential Photographs, Test FLEAT-8



40

- Test Number . . . . . SMG-1 (3-31)
- Date . . . . . 9/23/03
- Test Article
  - Type . . . . . SKT-MGS End Terminal
  - Key Elements . . . . . SKT impact head
  - Breakaway steel posts
  - Midwest Guardrail System
  - Orientation . . . . . Centerline of truck with center of post no. 1
- Soil Type . . . . . Grading B - AASHTO M 147-65 (1990)
- Vehicle Model . . . . . 1997 GMC C2500 pickup truck
  - Curb . . . . . 1,988 kg
  - Test Inertial . . . . . 2,028 kg
  - Gross Static . . . . . 2,028 kg
- Vehicle Speed
  - Impact . . . . . 100.5 km/hr
  - Exit . . . . . 0.0 km/hr
- Vehicle Angle
  - Impact (trajectory) . . . . . 0.28 deg
  - Exit (trajectory) . . . . . NA
- Vehicle Stability . . . . . Satisfactory
- Occupant Ridedown Deceleration (10 msec avg.)
  - Longitudinal . . . . . 8.67 g's < 20 g's
  - Lateral . . . . . 4.11/-5.66 g's < 20 g's
- Occupant Impact Velocity
  - Longitudinal . . . . . 5.64 m/s < 12 m/s
  - Lateral . . . . . 0.28 m/s < 12 m/s
- Vehicle Damage . . . . . Minimal
  - TAD<sup>8</sup> . . . . . 12-FC-3
  - SAE<sup>9</sup> . . . . . 12FCEN2
- Vehicle Stopping Distance . . . . . 17.53 m downstream
- Test Article Damage . . . . . Extensive
- Maximum Deflection
  - Permanent Set . . . . . 17.53 m
  - Dynamic . . . . . NA
- Working Width . . . . . 26.87-m long by 4.23-m wide

Figure 24. Summary of Test Results and Sequential Photographs, Test SMG-1



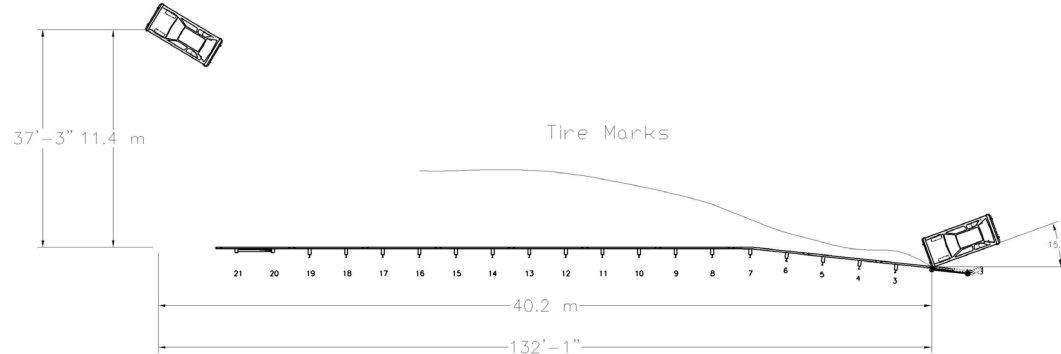
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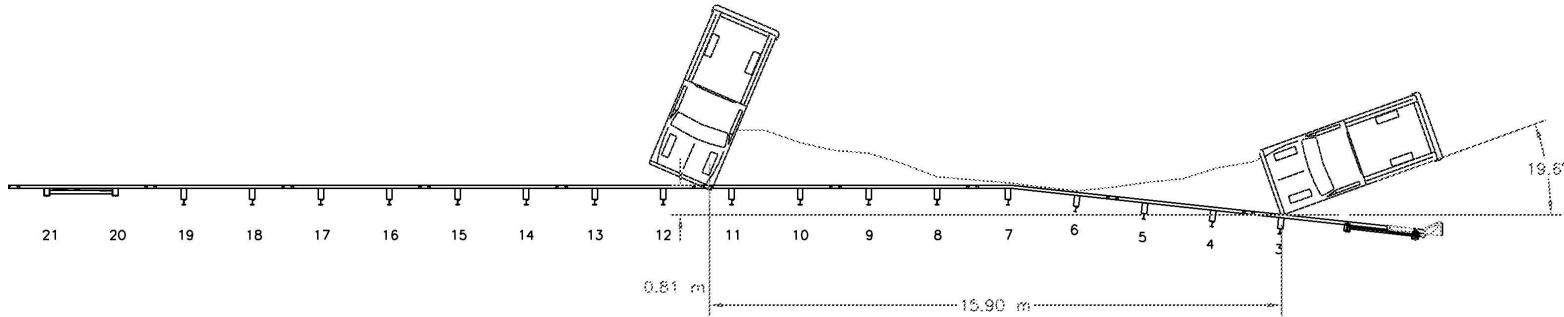
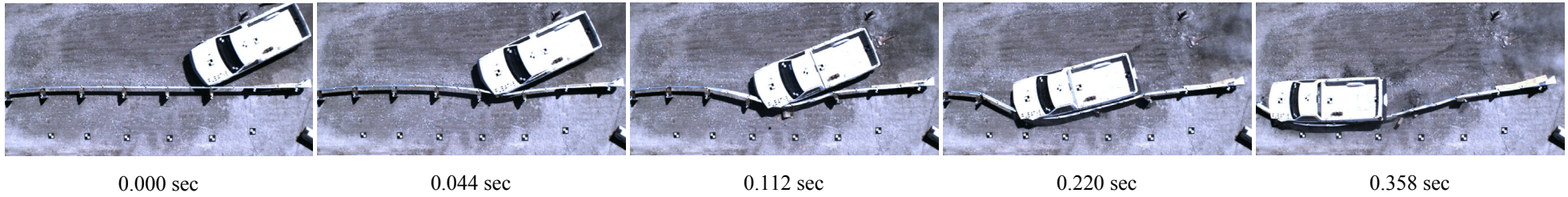


42

- Test Number . . . . . FLEAT-6 (3-34)
- Date . . . . . 7/23/03
- Test Article
  - Type . . . . . FLEAT-MGS End Terminal
  - Key Elements . . . . . FLEAT impact head  
Breakaway steel posts  
Midwest Guardrail System
  - Orientation . . . . . Impact at post no. 2
- Soil Type . . . . . Grading B - AASHTO M 147-65 (1990)
- Vehicle Model . . . . . 1997 Geo Metro
  - Curb . . . . . 755 kg (1,664 lbs)
  - Test Inertial . . . . . 822 kg (1,813 lbs)
  - Gross Static . . . . . 898 kg (1,979 lbs)
- Vehicle Speed
  - Impact . . . . . 102.6 km/h
  - Exit . . . . . 73.5 km/h
- Vehicle Angle
  - Impact (trajectory) . . . . . 15.8 deg
  - Exit (trajectory) . . . . . NA
- Vehicle Stability . . . . . Satisfactory
- Occupant Ridedown Deceleration (10 msec avg.)
  - Longitudinal . . . . . 7.34 g's < 20 g's
  - Lateral . . . . . 12.77 g's < 20 g's
- Occupant Impact Velocity
  - Longitudinal . . . . . 5.94 m/s < 12 m/s
  - Lateral . . . . . 4.98 m/s < 12 m/s
- Vehicle Damage . . . . . Moderate
  - TAD<sup>11</sup> . . . . . 11-LFQ-5
  - SAE<sup>12</sup> . . . . . 11FZEW2  
11LYES1
- Vehicle Stopping Distance . . . . . 40.2 m downstream  
11.4 m to the right
- Test Article Damage . . . . . Moderate
- Maximum Deflection
  - Permanent Set . . . . . 603 mm
  - Dynamic . . . . . 837 mm
- Working Width . . . . . 1,372 mm

Figure 25. Summary of Test Results and Sequential Photographs, Test FLEAT-6

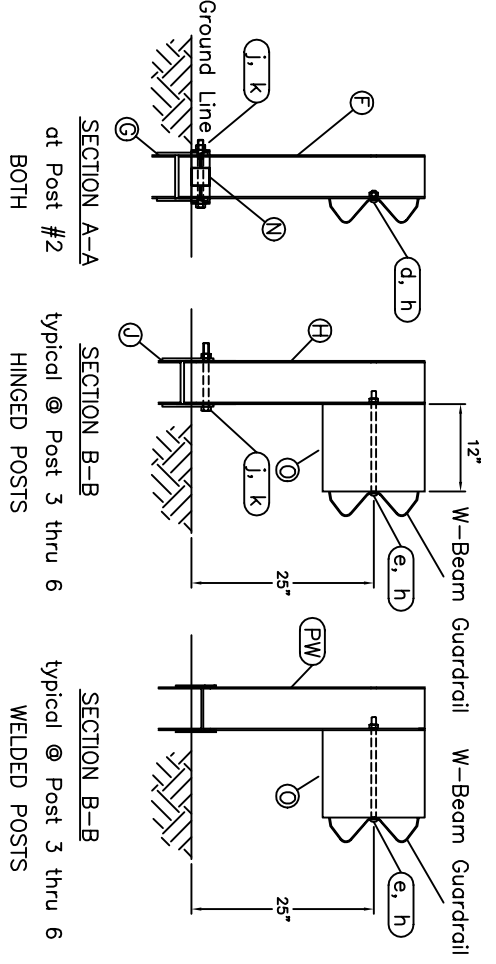
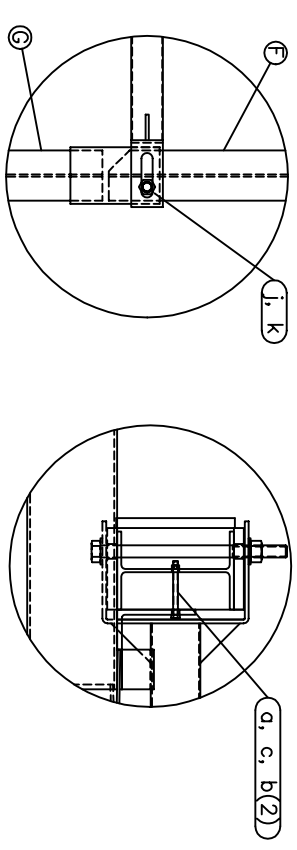
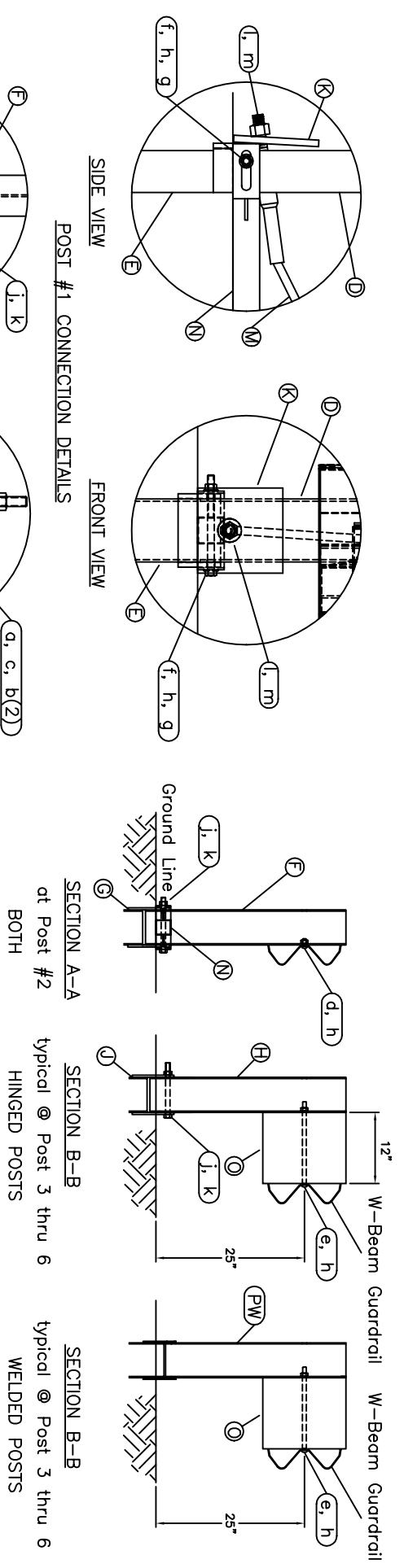
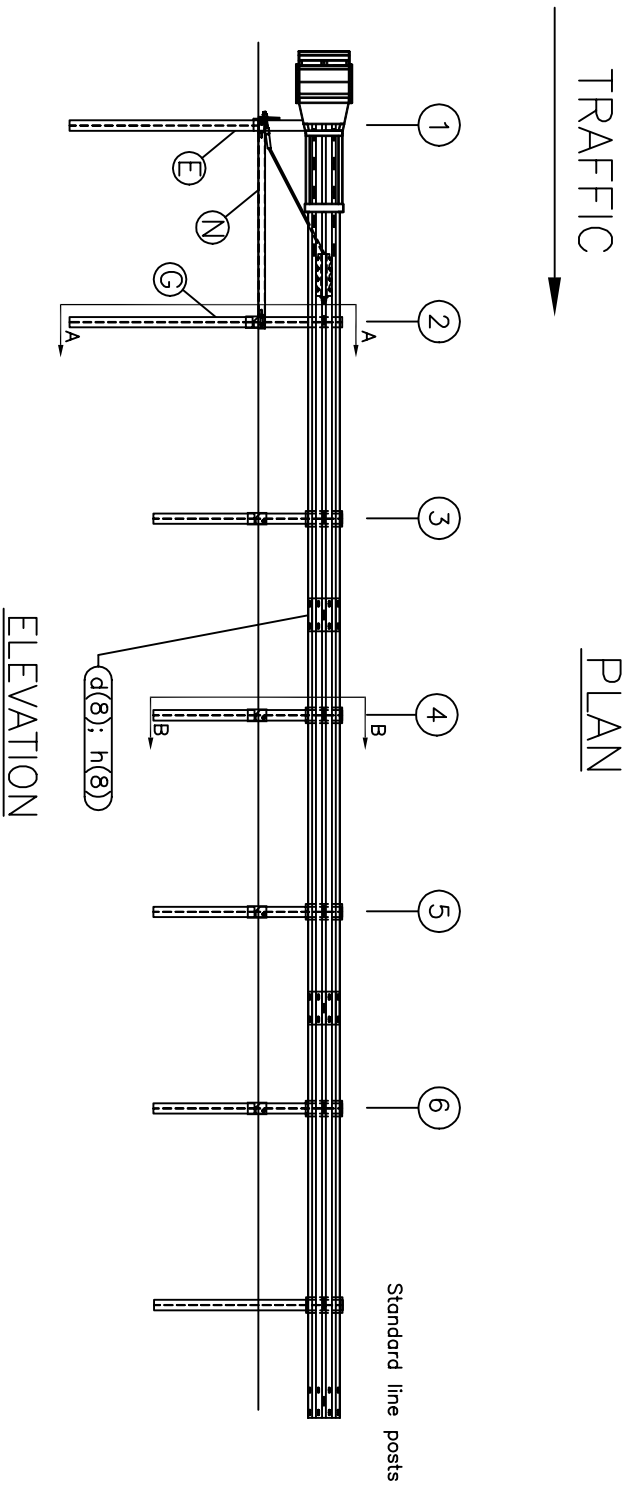
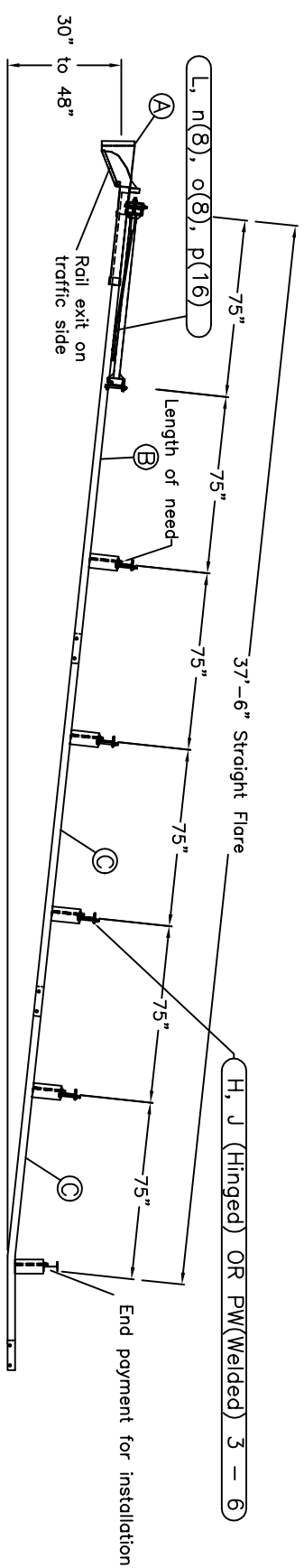




41


- Test Number . . . . . FLEAT-5 (3-35)
- Date . . . . . 7/23/03
- Test Article
  - Type . . . . . FLEAT-MGS End Terminal
  - Key Elements . . . . . FLEAT impact head
  - Breakaway steel posts
  - Midwest Guardrail System
  - Orientation . . . . . Impact at post no. 3
- Soil Type . . . . . Grading B - AASHTO M 147-65 (1990)
- Vehicle Model . . . . . 1997 GMC C2500 pickup truck
  - Curb . . . . . 1,880 kg
  - Test Inertial . . . . . 1,999 kg
  - Gross Static . . . . . 1,999 kg
- Vehicle Speed
  - Impact . . . . . 98.2 km/h
  - Exit . . . . . NA
- Vehicle Angle
  - Impact (trajectory) . . . . . 19.6 deg
  - Exit (trajectory) . . . . . NA
- Vehicle Stability . . . . . Satisfactory
- Occupant Ridedown Deceleration (10 msec avg.)
  - Longitudinal . . . . . 6.17 g's < 20 g's
  - Lateral (not required) . . . . . 6.39 g's
- Occupant Impact Velocity
  - Longitudinal . . . . . 3.90 m/s < 12 m/s
  - Lateral (not required) . . . . . 3.57 m/s
- Vehicle Damage . . . . . Minimal
  - TAD<sup>11</sup> . . . . . 11-LFQ-3
  - SAE<sup>12</sup> . . . . . 11FZEW2
  - 11LFES2
- Vehicle Stopping Distance . . . . . 15.90 m downstream
- 0.81 m to the right
- Test Article Damage . . . . . Moderate
- Maximum Deflection
  - Permanent Set . . . . . 1,314 mm
  - Dynamic . . . . . 1,787 mm
- Working Width . . . . . 1,838 mm

Figure 24. Summary of Test Results and Sequential Photographs, Test FLEAT-5



ITEM	QTY	BILL OF MATERIALS	ITEM NO.
A	1	IMPACT HEAD	F3000
B	1	W-BEAM GUARDRAIL END SECTION, 12 Ga.	F1303 MGS
C	2	W-BEAM GUARDRAIL, 12 Ga.	G1203 MGS
D	1	FIRST POST ASSEMBLY TOP	HP1A MGS
E	1	FIRST POST ASSEMBLY BOTTOM	HP1B
F	1	SECOND POST ASSEMBLY TOP	HP2A MGS
G	1	SECOND POST ASSEMBLY BOTTOM	HP2B
*H	4	BREAKAWAY LINE POST TOP	HP3A MGS
*J	4	BREAKAWAY LINE POST BOTTOM	HP3B MGS
K	1	BEARING PLATE	E750
L	1	CABLE ANCHOR BOX	S760
M	1	BCT CABLE ANCHOR ASSEMBLY	E770
N	1	GROUND STRUT HINGED POST	S785
O	4	MGS TIMBER BLOCKOUT OR RECYC. EQUIV.	P618
HARDWARE (ALL DIMENSIONS IN INCHES)			
a	2	1/4 x 4 HEX BOLT	B140404
b	4	1/4 WASHER	W014
c	2	1/4 HEX NUT	N014
d	17	5/8 Dia. x 1 1/4 SPLICE BOLT (POST #2)	B580122
e	4	5/8 Dia. x 14 H.G.R. BOLT (POSTS 3 THRU 6)	B581402
f	1	5/8 Dia. x 9 HEX BOLT GRD 5	B580904A
g	1	5/8 WASHER	W050
h	22	5/8 Dia. H.G.R NUT	N050
*j	5	3/4 Dia. x 8 1/2 HEX BOLT GRD A449	B340854A
*k	5	3/4 Dia. HEX NUT	N030
l	2	1 ANCHOR CABLE HEX NUT	N100
m	2	1 ANCHOR CABLE WASHER	W100
n	8	CABLE ANCHOR BOX SHOULDER BOLT	SB58A
o	8	1/2 A325 STRUCTURAL NUT	N055A
p	16	1 1/16 OD x 9/16 ID A325 STR. WASHER	W050A
WELDED POST QUANTITIES			
*PW	4	STEEL BREAKAWAY POST	PB621
*j	1	3/4 Dia. x 8 1/2 HEX BOLT GRD A449	B340854A
*k	1	3/4 Dia. HEX NUT	N030

- GENERAL NOTES:**
1. Breakaway posts are required with the FLEAT.
  2. All bolts, nuts, cable assemblies, cable anchors and bearing plates shall be galvanized.
  3. The lower sections of the posts shall not protrude more than 4 in above the ground (measured along a 5' cord). Site grading may be necessary to meet this requirement.
  4. The lower sections of the hinged posts should not be driven with the upper post attached. If the post is placed in a drilled hole, the backfill material must be satisfactorily compacted to prevent settlement.
  5. When rock is encountered, a 10" Ø post hole, 20 in into the rock surface may be used if approved by the engineer. Granular material will be placed in the bottom of the hole, approximately 2.5" deep to provide drainage. The first two posts can be field cut to length, placed in the hole and backfilled with adequately compacted material excavated from the hole.
  6. The breakaway cable assembly must be taut. A locking device (vice grips or channel lock pliers) should be used to prevent the cable from twisting when tightening nuts.



**Road Systems, Inc.**  
Big Spring, TX  
Phone: 432-263-2435  
or Phone: 330-346-0721

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Flared Energy Absorbing Terminal - FLEAT Assembly  
Midwest Guardrail System

Steel Post System  
Hinged and Welded Options

Sheet: **A1**

Date: 12/01/2004

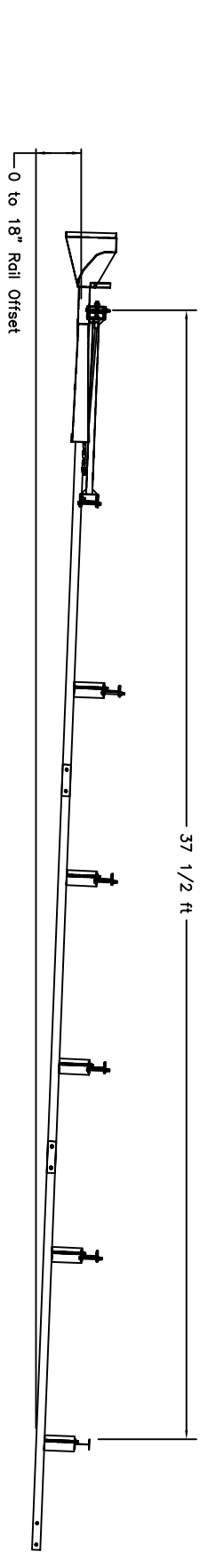
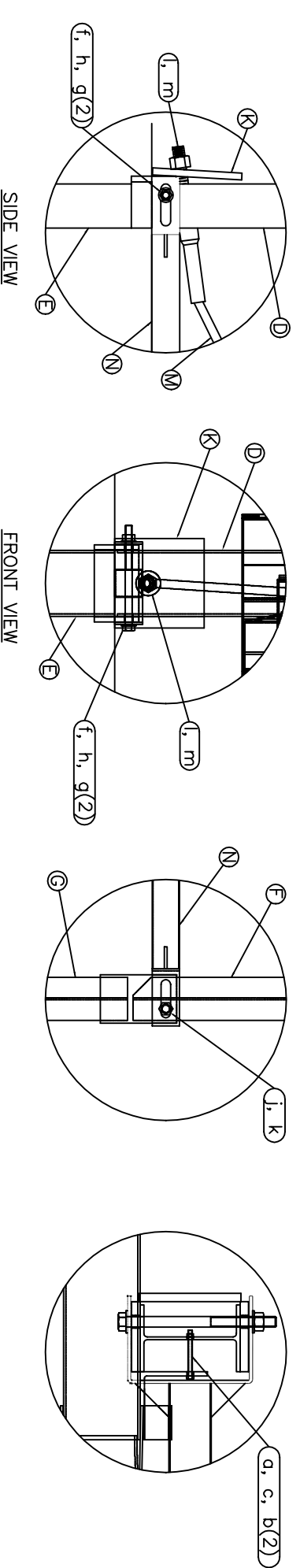
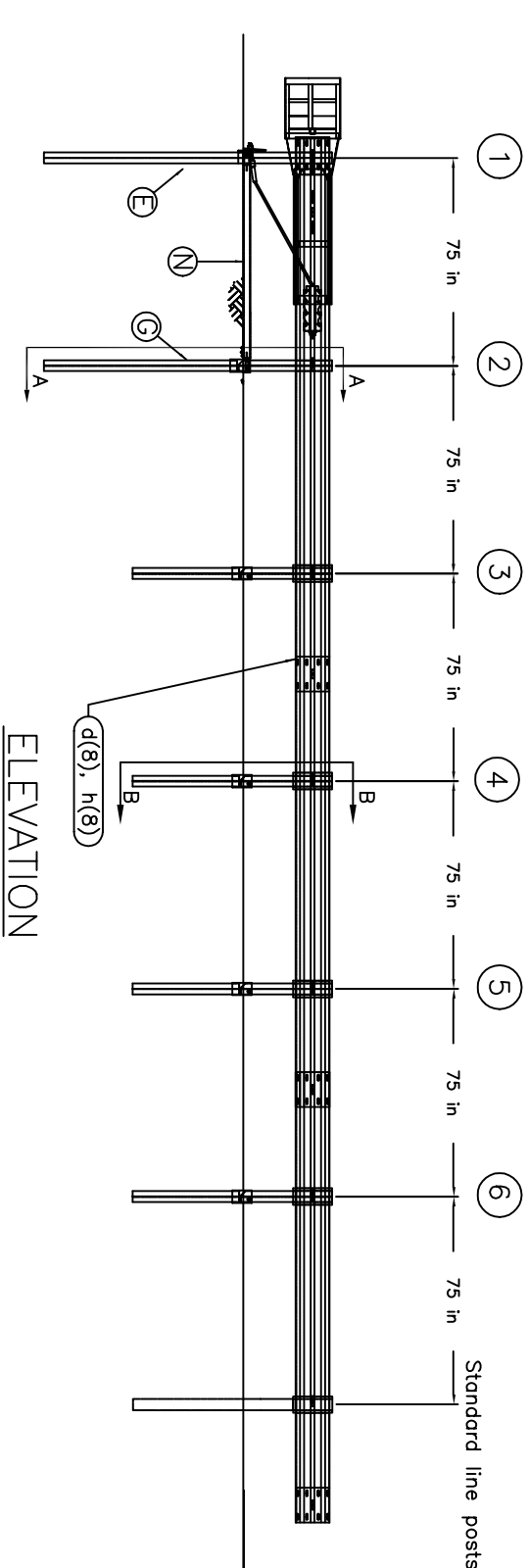
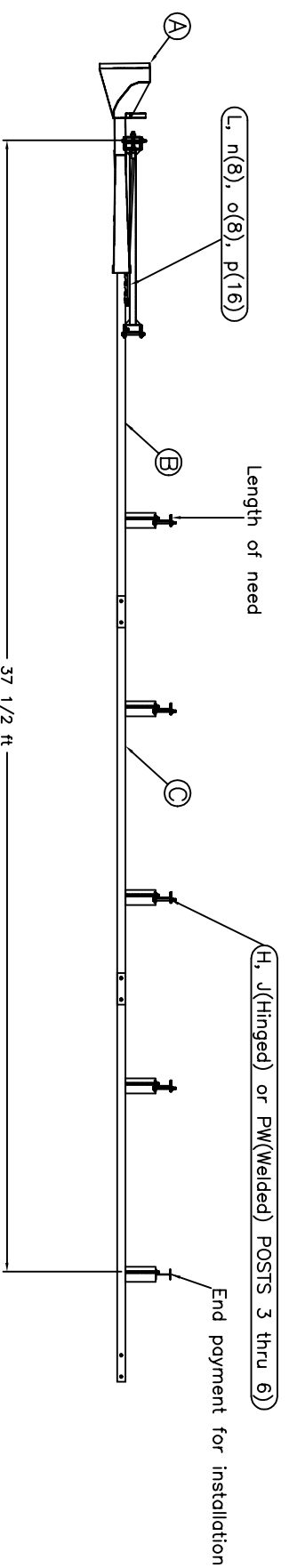
By: **JRR**

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Drawing Name: **FLT-MGS-S-US**

Scale: **None**

Rev: **0**



**OPTIONAL FLARED INSTALLATION**

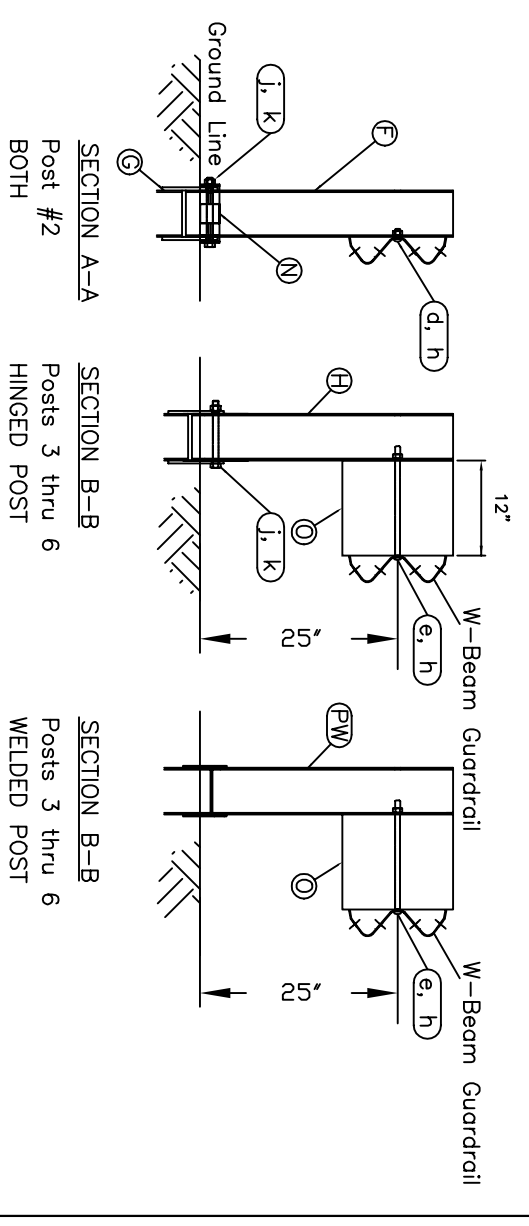
25:1 maximum flare rate


- GENERAL NOTES:**
1. Breakaway posts are required with the SKT.
  2. All bolts, nuts, cable assemblies, cable anchors and bearing plates shall be galvanized.
  3. The SKT can be flared at a rate of up to 25:1 to prevent the impact head from encroaching on the shoulder.
  4. The lower sections of the posts shall not protrude more than 4" above the ground (measured along a 5' cord). Site grading may be necessary to meet this requirement.
  5. The lower section of the hinged posts should not be driven with the upper post attached. If the post is placed in a drilled hole, the backfill material must be satisfactorily compacted to prevent settlement.
  6. When rock is encountered, a 10" Ø post hole, 20" into the rock surface may be used if approved by the engineer. Granular material will be placed in the bottom of the hole, approximately 2.5" deep to provide drainage. Posts 1 & 2 can be field cut to length, placed in the hole and backfilled with adequately compacted material excavated from the hole.
  7. The breakaway cable assembly must be taut. A locking device (vice grips or channel lock pliers) should be used to prevent the cable from twisting when tightening nuts.
  8. A site evaluation should be considered if there is less than 25' between the outlet side of the terminal and any adjacent driving lane.

ITEM QTY	BILL OF MATERIALS	ITEM NO.
A	1 IMPACT HEAD	S3000
B	1 W-BEAM GUARDRAIL END SECTION, 12 Ga.	S1303 MGS
C	2 W-BEAM GUARDRAIL, 12 Ga.	G1203 MGS
D	1 FIRST POST ASSEMBLY TOP	HP1A MGS
E	1 FIRST POST ASSEMBLY BOTTOM	HP1B MGS
F	1 SECOND POST ASSEMBLY TOP	HP2A MGS
G	1 SECOND POST ASSEMBLY BOTTOM	HP2B MGS
H	4 BREAKAWAY LINE POST TOP	HP3A MGS
J	4 BREAKAWAY LINE POST BOTTOM	HP3B MGS
K	1 BEARING PLATE	E750
L	1 CABLE ANCHOR BOX	S760
M	1 BCT CABLE ANCHOR ASSEMBLY	E770
N	1 GROUND STRUT HINGED POST	S785
O	4 MGS TIMBER BLOCKOUT OR RECYC. EQUIV.	P618
HARDWARE (ALL DIMENSIONS IN INCHES)		
Q	2 1/4 x 4 HEX BOLT	B140404
B	4 1/4 WASHER	W014
C	2 1/4 HEX NUT	N014
D	17 5/8 Dia. x 1 1/4 SPLICE BOLT, POST #2	B580122
E	4 5/8 Dia. x 14 H.G.R. BOLT (POSTS 3 THRU 6)	B581402
F	1 5/8 Dia. x 9 HEX BOLT GRD 5	B580904A
G	2 5/8 WASHER	W050
H	22 5/8 Dia. H.G.R NUT	N050
J	5 3/4 Dia. x 8 1/2 HEX BOLT GRD A449	B340854A
K	5 3/4 Dia. HEX NUT	N030
L	2 1 ANCHOR CABLE HEX NUT	N100
M	2 1 ANCHOR CABLE WASHER	W100
N	8 CABLE ANCHOR BOX SHOULDER BOLT	SB58A
O	8 1/2 A325 STRUCTURAL NUT	N055A
P	16 1 1/16 OD x 9/16 ID A325 STR. WASHER	W050A

**WELDED POST QUANTITIES**

*PW	4 WELDED BREAKAWAY POST	PB621
*J	1 3/4 Dia. x 8 1/2 HEX BOLT GRD A449	B340854A
*K	1 3/4 Dia. HEX NUT	N030





**Road Systems, Inc.**  
Big Spring, TX  
Phone: 432-263-2435  
or Phone: 330-346-0721

Sequential Kinking Terminal  
SKT-LITE Assembly

Midwest Guardrail System  
Steel Post System  
Hinged and Welded Options

Sheet: **A1**

Date: **12/01/04**

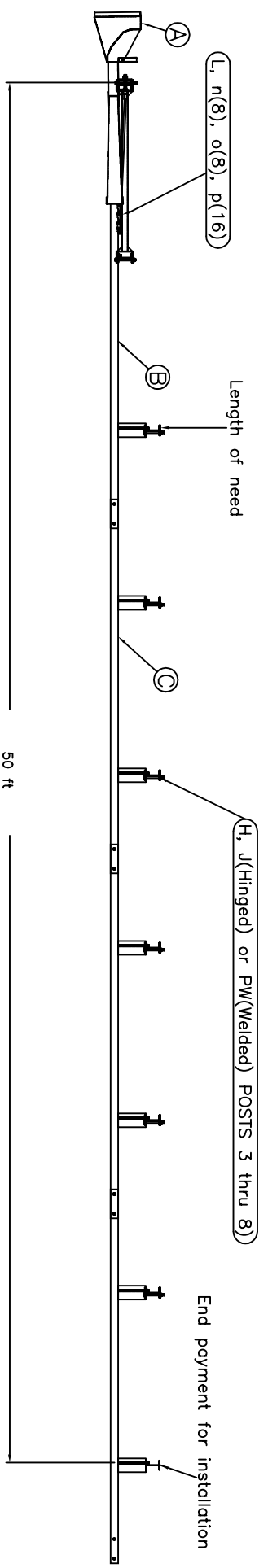
By: **JRR**

Rev: **0**

Drawing Name: **SKT-MGS-LITE-S-US**

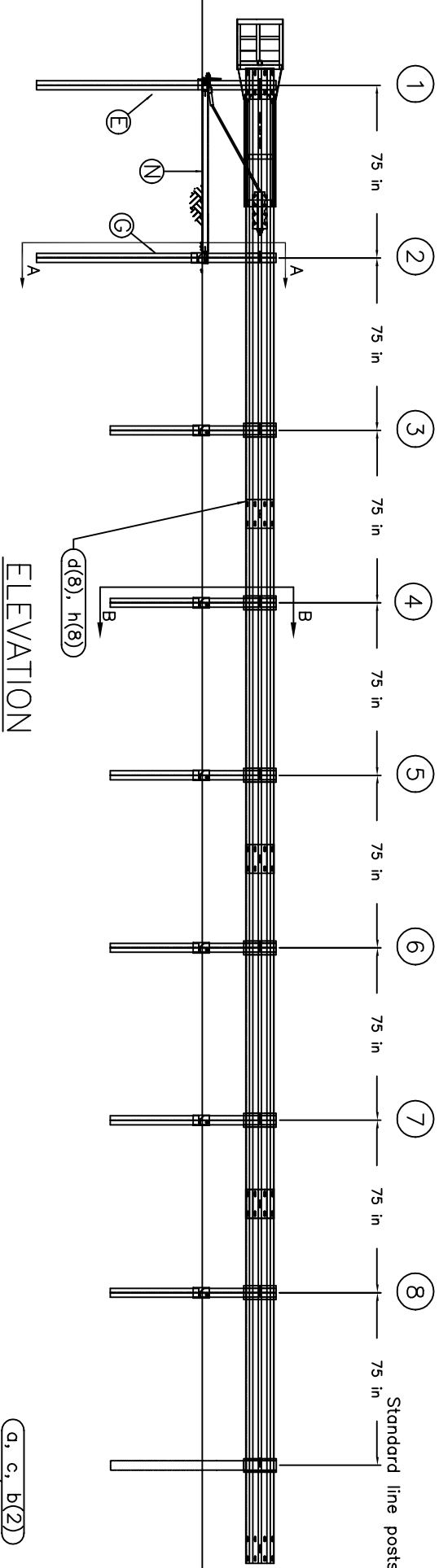
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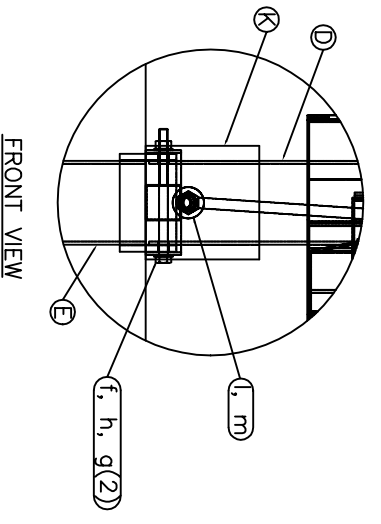
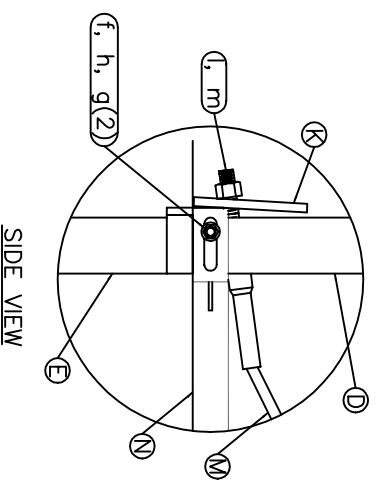


TRAFFIC

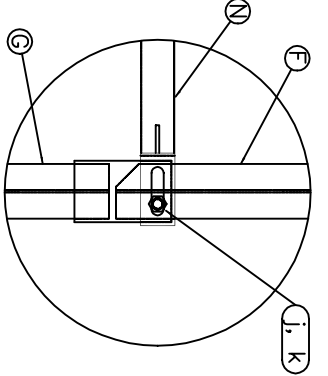
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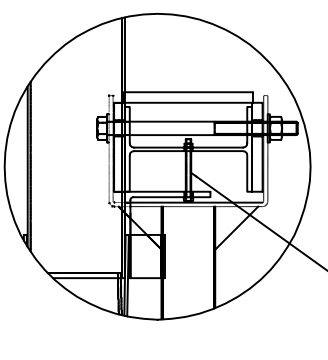
ELEVATION



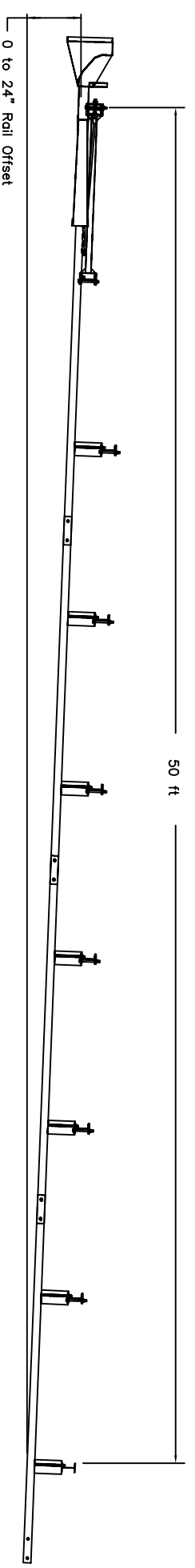
POST #1 CONNECTION DETAILS



Side View Detail of Post #2



Impact Head Connection Detail



OPTIONAL FLARED INSTALLATION

25:1 maximum flare rate

GENERAL NOTES:

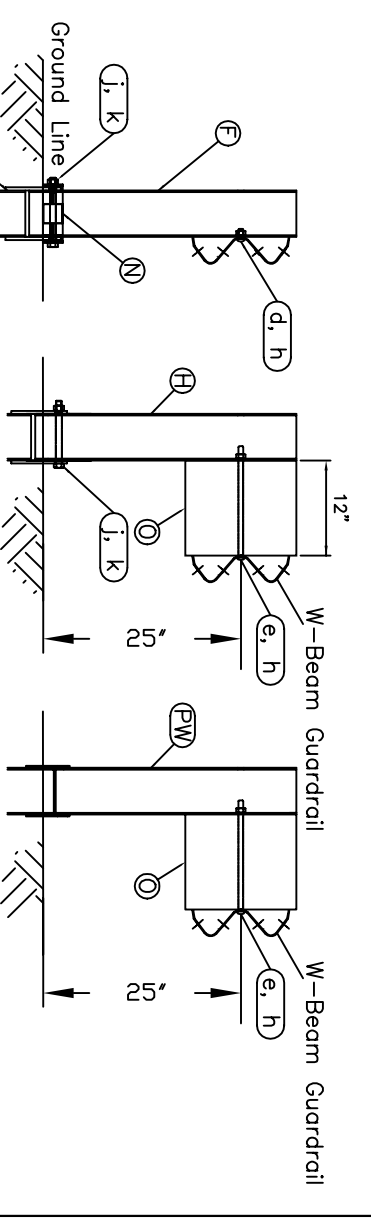
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5. The lower section of the hinged posts should not be driven with the upper post attached. If the post is placed in a drilled hole, the backfill material must be satisfactorily compacted to prevent settlement.
6. When rock is encountered, a 10" Ø post hole, 20" into the rock surface may be used if approved by the engineer. Granular material will be placed in the bottom of the hole, approximately 2.5" deep to provide drainage. Posts 1 & 2 can be field cut to length, placed in the hole and backfilled with adequately compacted material excavated from the hole.
7. The breakaway cable assembly must be taut. A locking device (vice grips or channel lock pliers) should be used to prevent the cable from twisting when tightening nuts.
8. A site evaluation should be considered if there is less than 25' between the outlet side of the terminal and any adjacent driving lane.

ITEM QTY BILL OF MATERIALS ITEM NO.

A	1	IMPACT HEAD	S3000
B	1	W-BEAM GUARDRAIL END SECTION, 12 Ga.	S1303 MGS
C	3	W-BEAM GUARDRAIL, 12 Ga.	G1203 MGS
D	1	FIRST POST ASSEMBLY TOP	HP1A MGS
E	1	FIRST POST ASSEMBLY BOTTOM	HP1B MGS
F	1	SECOND POST ASSEMBLY TOP	HP2A MGS
G	1	SECOND POST ASSEMBLY BOTTOM	HP2B MGS
H	6	BREAKAWAY LINE POST TOP	HP3A MGS
J	6	BREAKAWAY LINE POST BOTTOM	HP3B MGS
K	1	BEARING PLATE	E750
L	1	CABLE ANCHOR BOX	S760
M	1	BCT CABLE ANCHOR ASSEMBLY	E770
N	1	GROUND STRUT HINGED POST	S785
O	6	MGS TIMBER BLOCKOUT OR RECYC. EQUIV.	P618
HARDWARE (ALL DIMENSIONS IN INCHES)			
Q	2	1/4 x 4 HEX BOLT	B140404
B	4	1/4 WASHER	W014
C	2	1/4 HEX NUT	N014
D	25	5/8 Dia. x 1 1/4 SPLICE BOLT, POST #2	B580122
E	6	5/8 Dia. x 14 H.G.R. BOLT (POSTS 3 THRU 8)	B581402
F	1	5/8 Dia. x 9 HEX BOLT GRD 5	B580904A
G	2	5/8 WASHER	W050
H	32	5/8 Dia. H.G.R NUT	N050
J	7	3/4 Dia. x 8 1/2 HEX BOLT GRD A449	B340854A
K	7	3/4 Dia. HEX NUT	N030
I	2	1 ANCHOR CABLE HEX NUT	N100
M	2	1 ANCHOR CABLE WASHER	W100
N	8	CABLE ANCHOR BOX SHOULDER BOLT	SB58A
O	8	1/2 A325 STRUCTURAL NUT	N055A
P	16	1 1/16 OD x 9/16 ID A325 STR. WASHER	W050A

WELDED POST QUANTITIES


*PW	6	WELDED BREAKAWAY POST	PB621
*J	1	3/4 Dia. x 8 1/2 HEX BOLT GRD A449	B340854A
*K	1	3/4 Dia. HEX NUT	N030



SECTION A-A  
Post #2  
BOTH

SECTION B-B  
Posts 3 thru 8  
HINGED POST

SECTION B-B  
Posts 3 thru 8  
WELDED POST



**Road Systems, Inc.**  
Big Spring, TX  
Phone: 432-263-2435  
or Phone: 330-346-0721

Sequential Kinking Terminal  
SKT Assembly

Midwest Guardrail System  
Steel Post System  
Hinged and Welded Options

Sheet: **A1**

Date: **12/01/04**

By: **JRR**

Rev: **0**

Drawing Name: **SKT-MGS-S-US**

Scale: **NONE**