
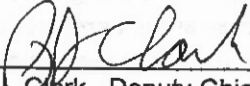


<p>MODIFIED BY EI 99-032 EFFECTIVE 5/4/00</p> <p><b>SUPERSEDED</b> BY EFFECTIVE 5/3/01 <i>EI 00-034</i></p>		<p>New York State Department of Transportation</p> <p><b>ENGINEERING INSTRUCTION</b></p>	<p><b>EI</b></p> <p><b>99-016</b></p>								
<p><b>Title: END TERMINALS FOR HEAVY POST BLOCKED-OUT CORRUGATED GUIDE RAIL- ET 2000 &amp; SKT 350</b></p>											
<p>Distribution:</p> <table border="0"> <tr> <td><input type="checkbox"/> Manufacturers (18)</td> <td><input type="checkbox"/> Surveyors (33)</td> </tr> <tr> <td><input checked="" type="checkbox"/> Main Office (30)</td> <td><input checked="" type="checkbox"/> Consultants (34)</td> </tr> <tr> <td><input type="checkbox"/> Local Govt. (31)</td> <td><input type="checkbox"/> Contractors (39)</td> </tr> <tr> <td><input checked="" type="checkbox"/> Regions/Agencies (32)</td> <td><input type="checkbox"/> _____ ( )</td> </tr> </table>	<input type="checkbox"/> Manufacturers (18)	<input type="checkbox"/> Surveyors (33)	<input checked="" type="checkbox"/> Main Office (30)	<input checked="" type="checkbox"/> Consultants (34)	<input type="checkbox"/> Local Govt. (31)	<input type="checkbox"/> Contractors (39)	<input checked="" type="checkbox"/> Regions/Agencies (32)	<input type="checkbox"/> _____ ( )	<p>Approved:</p> <p> P. J. Clark, Deputy Chief Engineer Design Division</p> <p style="text-align: right;"><i>5/7/99</i> Date</p>		
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**ADMINISTRATIVE INFORMATION.** This instruction supersedes EI 98-015. This instruction modifies §10.2.5.2 and §10.2.6.6.C. of the *Highway Design Manual*. It will become effective with projects submitted for letting on or after 11/4/99. The contents of this instruction ultimately will be incorporated into the *HDM*. The specifications may be used earlier.

**PURPOSES.** The purposes of this instruction are to:

- Issue a usage and selection policy and specifications for the use of the ET 2000 and the SKT 350 end terminals for use with Heavy Post Blocked-Out Corrugated Guide Rail (HPBO);
- Provide an optional specification under which either the ET 2000 or the SKT 350 may be used.
- Provide guidelines for the continued use of turned-down end terminals in lower speed urban areas.

**TRANSMITTED MATERIALS.** This instruction transmits information and specifications for the ET 2000 and the SKT 350 end terminals and the optional specifications mentioned above. All these will be Main Office inserts. All are proprietary specifications, including the optional specifications, but if used in accordance with this instruction, no justification need be made for their use.

The transmitted specifications are:

<u>ITEM 15606.34 M</u>	<u>End Terminal for HPBO Corrugated Guide Rail, ET 2000</u>
<u>ITEM 15606.3450 M</u>	<u>End Terminal for HPBO Corrugated Guide Rail, ET 2000, (Rustic)</u>
<u>ITEM 15606.35 M</u>	<u>End Terminal for HPBO Corrugated Guide Rail, SKT 350</u>
<u>ITEM 15606.3550 M</u>	<u>End Terminal for HPBO Corrugated Guide Rail, SKT 350, (Rustic)</u>
<u>ITEM 15606.36 M</u>	<u>Optional Enc Terminal for HPBO Corrugated Guide Rail, ET 2000 or SKT 350</u>
<u>ITEM 15606.3650 M</u>	<u>Optional End Terminal for HPBO Corrugated Guide Rail, ET 2000 or SKT 350, (Rustic)</u>

**BACKGROUND.** §10.2.5.2 W-Beam Anchorages of the *HDM* indicates that HPBO Guide Rail is so unyielding that its terminal section is to be flared away from the highway. It also references Standard Sheet M606-9R1, which was issued under EI 97-016. Remark 5 of Standard Sheet M606-9R1 indicated that on highways with operating speeds in excess of 70 km/h (45 mph) the approach ends of the HPBO guide rail shall either be anchored outside the clear zone and converge with the highway at a flare rate not to exceed 1:15, or alternatively, be preceded or replaced by properly designed crash cushions.

Recent Engineering Instructions, including EI 97-016, have discussed an FHWA policy that requires safety

articles installed on the National Highway System (NHS) after September 1998<sup>1</sup> have passed National Cooperative Highway Research Program Report 350 (NCHRP 350) test criteria. The turned-down end terminal depicted on Standard Sheet M606-9R1 has not been so tested, and therefore should not be used within the clear zones of most roads at locations where the turned down end terminals are subject to end-on or near end-on impacts. However, in view of the slower speeds common in the urban setting, and the high number of property damage only urban area brush hits that occur there, an exception is in order. The rationale for the exception is that it is better to have a fully functional second best end terminal than a damaged crashworthy end terminal. Accordingly, retention and continued installation of sloped end terminals, such as those depicted on M 606-9R1 and M 606-10R1 remain the overall best and most logical end terminals for use in the urban area, where design speeds will be predominantly 70 km/h (45 mph) or less. This has been discussed with the FHWA and they are in agreement. Therefore, the remark on the above mentioned Standard Sheets will be changed accordingly. This will be done in a separate Engineering Instruction.

The ET 2000 and the Sequential Kinking Terminal 350 (SKT 350) are guide rail end terminals for HPBO guide rail that have passed NCHRP 350 Test Level 3 crash testing. Test Level 3 involves testing at 100 km/h (62 mph), and articles qualified at that test level may be used on all classes of highways and at all speeds. As mentioned above, however, because of the considerable maintenance they will require, and because they offer only slightly better performance than turned down end terminals at very slow speeds, they are not the best choice for some urban situations where speeds are slow and numerous minor impacts may be expected.

The SKT 350 is very similar to the ET 2000, which was issued under EI 98-015. Like the ET 2000, the single working part of the SKT 350 is a guide rail extruder (impact head) fabricated of steel. The guide rail extruder is located at the free end of the assembled ET 2000 or SKT 350. During end on impact, the force of the impacting vehicle drives the SKT 350 guide rail extruder down the corrugated rail, putting a series of kinks into the rail. The ET 2000 operates similarly, except it flattens the rail. A certain amount of energy is required to flatten the rail or to kink the rail, thereby absorbing the energy of the impacting vehicle. The extruder head also turns the kinked rail out of the way of the impacting vehicle. In one test with the larger vehicle at 100 km/h (62 mph), up to 15.8 m (52'-0") of rail passed through the extruder/impact head.

The ET 2000 and the SKT 350 are "parallel type" end terminals. This means they may be installed more or less parallel to the line of guide rail. In actuality, up to 600 mm (2'-0") of flare, or offset from the line of guide rail, may be tolerated. The whole amount of the flare may be introduced over the whole length of these end terminals or half the flare over half the length of these end terminals. Standard Sheet M 606-12, issued separately under EB 99-019, shows this.

There are nine posts in the ET 2000 and the SKT 350. They are spaced at 1905 mm (6'-3") center to center. Overall length of the ET 2000 and the SKT 350 is 15.8 m  $\pm$  (52'-0"  $\pm$ ) including the approximate 0.6 m (2'-0") that the guide rail extruder/ impact head extends beyond the first post at the free end of the ET 2000 or the SKT 350. The most maintainable of the SKT 350 designs is designated "SKT 350 Assembly with 8 Foundation Tubes" by its manufacturer. The most maintainable of the ET 2000 designs is designated "Option A" by its manufacturer. In these most maintainable configurations, the first eight posts from the free end of either end terminal are special, short posts weakened by 90 mm (3½") holes bored through them near the ground line. These short posts are 1143 mm (3'-9") long and are placed in metal foundation tubes. Ordinary timber guide rail posts, lacking these 90 mm (3½") holes, will not break away properly on impact and therefore must not be incorporated into either the SKT 350 or the ET 2000 as any of the first eight posts. The ninth post of either end terminal is an ordinary HPBO guide rail post, and may be either steel or wood, depending upon the system to which the ET 2000 or SKT 350 is attached.

Designs for the ET 2000 and the SKT 350 utilizing longer, directly embedded, breakaway posts are also available. Longer posts are 1830 mm (6'-0") long and also have the 90 mm (3½") holes near the ground line. These design options use two or four of the short posts and foundation tubes for just the first two or four posts from the free end. The next six or four posts are the longer breakaway posts, directly embedded. The ninth post is the same as the ninth post used in the option having eight foundation tubes. The advantage to these options using the longer directly

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<sup>1</sup> On 7-25-97 the FHWA changed the date to September 30, 1998 and indicated that the requirement applied to contracts advertised after that date and to work undertaken under force account after that date.

embedded breakaway posts is initial cost. Each of the steel foundation tubes adds approximately \$75.00 to the cost of either the ET 2000 or the SKT 350. The disadvantage of the designs using the longer directly embedded posts is that it will be harder to repair them, especially when the ground is frozen.

**USAGE POLICY.** Except for the Urban roads with speeds 70 km/h (45 mph) or less, the approach ends of HPBO guide rail that cannot reasonably be carried to, the clear zone, shielded by another barrier, buried in the back slope or in a suitable berm, shall be terminated with the appropriate of the above end terminals; one of the flared end terminals, such as, SRT 350, FLEAT, ROSS 350 and REGENT, or an approved crash cushion<sup>2</sup>. On Urban roads with speeds 70 km/h (45 mph) and under, standard, turned down end terminals may continue to be used inside or outside the clear zone and shall converge with the highway at a flare rate of 1:8<sup>3</sup> or less. Proper use of the crashworthy end terminals requires that the point-of-need for the run of guide rail be located in accordance the EI 98-004 Point of Need Determination for Guide Rail Runs That Use Gating End Terminals. Point of need for the turned down end terminals may continue to be determined as indicated in §10.2.2.1 Point of Need, given in the *Highway Design Manual*.

For ease of maintenance, the design option using eight foundation tubes will be the standard for the "parallel type" end terminals. These are the ET 2000 and the SKT 350 end terminals. Each of these end terminals are available in various options. Options standard in NYS will use only short 1143 mm (3'-9"), weakened, timber posts placed within steel foundation tubes for the first eight posts. Each of the manufacturers offers this design and other designs that use longer directly embedded breakaway posts. Regions desiring to use these other tested designs are free to do so. Special specifications will be required.

**Optional Items Preferred.** The optional items are the preferred items because they will increase competition and lower prices if used. The specifications requiring either the ET 2000 or the SKT 350 may be specified by Regions if they desire to use them in order to obtain either device for research purposes; or upon the directions of the Regional Director, with the concurrence of the Deputy Chief Engineer, Design Division. They may also be used during construction as part of the value engineering process or in Orders-on Contract.

**APPLICABILITY.** The usage policy included in this instruction is applicable to new installations of end terminals, whether on new construction projects, reconstruction projects, or on 3R projects. It also requires replacements of non-conforming end terminals on reconstruction projects, but does not require replacement of (i.e., is silent on) non-conforming end terminals on 3R projects. That matter will be separately addressed in a future engineering instruction which will be entitled "Replacement of Guide Rail (and Median Barrier) End Terminals on 3R Projects."

#### LAYOUT INFORMATION.

There are nine posts in either the SKT 350 or the ET 2000. Number the posts starting with the post at the free end being post 1. Post spacing is 1905 mm (6'-3") throughout the length of either end terminal. The end terminal may be installed either parallel to the line of guide rail or moderately flared from the theoretical line of the guide rail to 600 mm (2'-0") or less. The term 'moderately flared' is being used since we have a number of generic flared end terminals that have higher flare than is allowed here and a separate EI is being issued regarding 'flared end terminals'. If moderately flared, one of two options must be used: Option 1-The SKT 350 or ET 2000 shall be flared over the whole 15.2 m (50'-0") length 1:25, or less, with respect to the line of guide rail; or, Option 2- they shall be flared over half their 15.2 m (50'-0") length from post 5 back to the free end 1:25 or less with respect to the line of the guide rail. Flare is recommended because flare will reduce the number of nuisance hits on the end, and facilitate snow plowing. The manufacturers do not recommend any other means of attaining flare. These two options are detailed by the manufacturer in their drawings,

<sup>2</sup> Sand Barrel Arrays for approach ends on one-way roads, CAT, QUADGUARD, BRAKE MASTER, REACT 350 are among the approved crash cushions. See also latest EIB program.

<sup>3</sup> The note on Standard Sheet M606-9R2 will be changed to this flare rate, which is consistent with the HDM.

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and will be shown on a Standard Sheet (M 606-12.)

Both of the above end terminals "gate" from their free ends to post 3. From post 3 downstream, both end terminals redirect, and this length may be included in the length of need. For the ET 2000 and the SKT 350, the distance from Post 3 to the end is 11.43 m (37'-6").

Length of need should be determined as indicated in Engineering Instruction 98-004 on "Point of Need and Runout Length Determination for Guide Rail Runs That Use Gating End Terminals." Ideally, the amount of guide rail indicated by the formulas should be provided. If there is not enough room available to provide this much, then lesser amounts may be provided. The lower bound on the length of guide rail to install in advance of a shielded object is suggested below under "Obstacle free area."

### MISCELLANEOUS INFORMATION.

**Obstacle Free Area.** As indicated above, both of the end terminals discussed herein "gate" upstream of post 3. An area approximately 6 m (20'-0") wide in back of the guide rail and 23 m (75'-6") along the guide rail is recommended by the FHWA to be made clear of obstacles and reasonably traversable. Such an area is referred to as an "Obstacle Free Area." Grading within this area should be as indicated below under "Special Grading Requirements."

As indicated in the above mentioned instruction (EI 98-004), additional lengths of guide rail upstream of the shielded object beyond the amount provided by the obstacle free area are desirable<sup>4</sup>, and should be provided if reasonable to do so. The amount of guide rail provided by the obstacle free area is a good working minimum. Reductions in the length of the obstacle free area are, however, permissible in special instance. These reductions in the length should be limited to 1 m (3'-3") or 2 m (6'-6") for the end terminals in high speed situations because, in full scale crash tests with the full size pickup truck at 100 km/h (62 mph), all 15.8 m (52'-0") of rail passed through the extruder. At lesser speeds, the length could be reduced proportionate to the squared ratio of the speeds.

Reductions in the width of the obstacle free area are also permitted where the design clear zone is reduced. Reduction in width, however, should not be so great as to provide less room behind the terminal than the width of the design clear zone. For example, if the design clear zone width is 4 m (13'-0") then the 6 m (20'-0") width may be reduced to 4 m (13'-0").

**Special Grading Requirements.** Grading is shown on Standard Sheet M606-12. Slopes between the road and the ET 2000 or the SKT 350 should not be steeper than 1:10. Ordinary shoulder slopes, which are generally not steeper than 1:16, are excellent. These relatively flat slopes should be carried underneath the ET 2000 or SKT 350 to a slope break point located behind the back of the posts. Slopes may increase outboard of the slope break point to 1:4 slope preferred; 1:3 maximum. At post 8, the distance to the slope break point should be 600 mm (2'-0") minimum behind the back of the post. Between post 8 and post 4, the distance to the slope break increases to 1000 mm (3'-3"). Between post 4 and post 2, the slope break point is 1000 mm (3'-3") behind the back of the posts. This 1000 mm (3'-3") slope break point line is extended in line to a point opposite the front of the guide rail extruder unit. At that point, the slope break point transitions back to the normal slope break point given in the HDM in §10.2.3.5, Post Systems, Table 10-4. Transition length longitudinally should be 15 times the difference in widths between the slope break points opposite the guide rail extruder and the normal width to the slope break point shown on the plans. This distance is usually taken from Table 10-4. These requirements are shown on Standard Sheet M 606-12 Parallel Type End Terminal

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The lengths of guide rail provided by the formulas given in EI 98-004 are regarded the ideal since they theoretically minimize accident cost. If there are practical reasons at the site to lengthen the run beyond the formula length, for example, to place the free end at a place where there is more clear area behind the terminal, it is permitted to increase the formula length. If there are practical reasons to reduce the run below the formula length, for example, to allow driveway access or access for maintenance purposes, the formula lengths may also be shortened.

Grading, Pavement, & Layout Details. Until these Standard Sheets are available<sup>5</sup>, the grading details should be included in the Contract Plans.

The above grading scheme has been proposed by the FHWA. Regions wishing to simplify it may do so. For example, a constant 1 m (3'-3") offset behind all eight of the posts would satisfy the Federal intent, be simpler to layout than the federally proposed scheme, and would provide the same or better stability for the errant vehicle<sup>6</sup>.

**Recommended Offset At The First Post.** For maintenance purposes, the free end of the ET 2000 or the SKT 350 should be offset from the traveled way approximately 2.5 m minimum. Larger offsets are preferred.

Where shoulders are narrow, ET-2000s or SKT 350s should be flared back to the recommended offset or beyond, whenever practical to do so. Up to 600 mm (2'-0") of flare from the theoretical line of guide rail is possible within the SKT 350's or the ET 2000's 15.2 m (50'-0") length.

**Beginning Length Of Need.** Both of these end terminals redirected the test vehicle at post 3 (third post from the free end of the unit.) Therefore, the 1143 mm (3'-9") of the ET 2000 or the SKT 350 end terminals downstream of the third post are also effective barrier and may be included within the length of need.

**Selection Guidelines.** There are several types of end terminals that have passed crash testing and could be used at the approach end of heavy post blocked-out guide rail. See the Highway Design Manual and Engineering Bulletin 98-021 Selection Guidelines for End Terminals for Heavy Post Blocked-Out Guide Rail. The principal advantages of the SKT 350 or the ET 2000, when compared to the alternative systems, is that reduced grading is possible and lesser amounts of guide rail may be provided, if there is need to do so.

**IMPLEMENTATION.** DQAB will insert the specifications into the proposals. EIC shall give one copy each of manufacturers directions and drawings to the Transportation Maintenance Division and the Resident Engineer.

**ESTIMATED COST.** ET 2000's and SKT 350's are expected to cost \$2500 installed in the upstate regions and perhaps somewhat more in the downstate regions. This estimate is based on \$1,900 parts cost and an installation rate of four SKT 350's or ET 2000's installed per day by a good guide rail crew.

**CONTACT PERSON.** Larry Brown, Design Quality Assurance Bureau, M.O Bldg 5, Room 410, (518)-457-4093, or Arvind Salgam of the Design Quality Assurance Bureau at (518) 457-5855.

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<sup>5</sup> These are under preparation and will show layout, grading, and payment limits.

<sup>6</sup> Both grading schemes will be shown on the standard sheets for grading, layout, and payment details.

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<u>ITEM 15606.3450 M</u>	<u>End Terminal for HPBO Corrugated Guide Rail, ET 2000, (Rustic)</u>
<u>ITEM 15606.35 M</u>	<u>End Terminal for HPBO Corrugated Guide Rail, SKT 350</u>
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**DESCRIPTION.**

Under this work, the Contractor shall furnish and install End Terminals for Heavy Post Blocked-Out Corrugated Guide Rail of the type indicated at the locations indicated in the Contract Documents, or where directed by the Engineer, in accordance with these specifications, applicable Standard Sheets, and the manufacturer's directions and drawings. The Engineer will be sole determiner in the event there are differences between specifications, standard sheets, manufacturers directions and drawings.

**MATERIALS.**

Steel foundation tubes shall meet the requirements of §710-21 Box Beam Guide Railing and Median Barrier. The break away wooden posts shall be short 1143 mm posts of the dimensions indicated on the approved materials details and they and the blockouts shall meet the requirements of §710-13, Wood and Timber Posts and Timber Blockouts. Corrugated Beam Guide Rail shall meet the requirements of §710-20. Soil plates, struts, bearing plates, and the guide rail extruder shall meet the requirements of ASTM A36 or ASTM A36M. Fasteners shall be as indicated on the manufacturer's drawings. All metal components, except those of end terminals designated as Rustic, shall be hot dip galvanized in accordance with §719-01.

Reflective sheeting mounted on a frangible material shall be provided by the manufacturer for the free end of the terminal. The reflectorization shall consist of alternating reflectorized 100 mm yellow and non-reflectorized 115 mm black stripes oriented at a 45 degree angle, with the lower edge of the stripes near the traveled way. The reflective material shall meet the requirements of §730-05, Reflective Sheeting, Class B.

End terminal designated as rustic shall comply with the above requirements except metal parts exposed to view shall meet the requirements of §710-25 Guide Rail and Median Barrier Systems (Rustic.)

**Silicone Sealant.** Silicone sealant shall be commercially available silicone sealant which will adhere to wood and galvanized steel.

**ET 2000.** The End Terminal shall be ET 2000, Option A (8.foundation tubes) as fabricated by the Syro Steel Company, Girard, Ohio (800-321-2755).

**SKT 350.** The SKT 350 shall be the "SKT 350 Assembly with Eight Foundation Tubes" as fabricated by Road Systems, Inc., Big Springs, Texas, (915) 263-2435 or (815) 464-5917.

**CONSTRUCTION DETAILS.**

§606-3.01 General of the Standard Specifications shall apply. Foundation tubes shall be driven unless otherwise approved by the Engineer. The manufacturer shall provide written installation instructions and three copies of their manufacturers drawings, maintenance manuals, and parts lists prior to installation of the ET 2000 or SKT 350, (Rustic.)

SKT 350 or SKT 350, (Rustic) shall be installed after grading is completed at the locations indicated in the Plans, or where directed by the Engineer. They shall be installed in accordance with the manufacturer's instructions and the directions of the Engineer.

The work, including the necessary grading work, shall be coordinated with the installation of the guide rail or

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Optional End Terminal for HPBO Corrugated Guide Rail, ET 2000 or SKT 350  
Optional End Terminal for HPBO Corrugated Guide Rail, ET 2000 or SKT 350, (Rustic)

removal of existing anchorage units to minimize the time the traveling public is exposed to unanchored runs of guide rail. This period shall not exceed fourteen calendar days. During periods when the public is exposed to unanchored guide rail, plastic drums or other devices approved by the Engineer, shall be placed in advance of the unanchored run and in advance of the ends of the rail. In addition, the ends of the rail shall be brought to the ground level, twisted over to lay flat, and be pinned to the ground.

The space between the wooden post and the top of the foundation tube shall be sealed with commercially available silicone sealant which is compatible with both wood and galvanized steel.

In the event the end terminals become damaged, the units shall be promptly repaired. Unless another period is indicated in the contract documents, promptly repaired shall mean repaired within fourteen (14) calendar days.

### METHOD OF MEASUREMENT

The work will be measured as the number of End Terminals for Heavy Post Blocked-Out Corrugated Beam Guide Rail of the indicated type satisfactorily furnished and installed in accordance with these specifications. The payment limits for these units shall extend from the front of the guide rail extruder to the center of the ninth guide rail post, which is located approximately 15.8 m distant from the front of the guide rail extruder.

### BASIS OF PAYMENT

The unit bid price per End Terminal for Heavy Post Blocked-Out Corrugated Beam Guide Rail of the indicated type shall include the cost of all labor, materials, and equipment necessary to satisfactorily furnish and install the units between the above described payment limits. The cost of earthwork, grading, top soiling, and seeding shall be measured and paid for separately. The cost to repair units damaged by public travel will be borne by the Contractor, or the by State, in accordance with the provisions of §107-09 Damage.