



<p style="text-align: center;">SUPERSEDED BY <i>EI 99-016</i> EFFECTIVE 11/4/99</p>		<p style="text-align: center;">New York State Department of Transportation ENGINEERING INSTRUCTION</p>	<p style="font-size: 2em; font-weight: bold;">EI</p> <p style="font-size: 1.5em; font-weight: bold;">98-015</p>
<p>Title: END TERMINALS FOR HEAVY POST BLOCKED OUT CORRUGATED GUIDE RAIL-ET 2000, APPROACH ENDS</p>			
<p>Distribution:</p> <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/AGC(39) <input checked="" type="checkbox"/> Regions/Agencies (32) <input type="checkbox"/> _____ ()		<p>Approved:</p> <div style="text-align: center;">  _____ R. Dennison, Deputy Chief Engineer Design Division </div> <div style="text-align: right;"> <i>8/11/98</i> Date </div>	

ADMINISTRATIVE INFORMATION. No engineering instructions are superseded hereby. This instruction modifies §10.2.5.2 and §10.2.6.6.C. of the *Highway Design Manual*. It will become effective with the letting of September 10, 1998. 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 for the use of the ET2000 end terminal for use with heavy post blocked out corrugated guide rail (HPBO); and,
- issue specifications for these articles.

TRANSMITTED MATERIALS. This instruction transmits specifications for the ET2000. These will be main office inserts. They are proprietary specifications but, if used in accordance with this instruction, no justification need be made for their use. Materials details for these units will be transmitted under separate cover, as is customary for materials details. The transmitted specifications are:

ITEM 15606.34 (M) End Terminal for Heavy Post Blocked out Corrugated Guide Rail. ET 2000.

ITEM 15606.3450 (M) End Terminal for Heavy Post Blocked out Corrugated Guide Rail. ET 2000.
(RUSTIC)

NOTE: The (M) indicates that both U.S. Customary unit version and metric versions are indicated.

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. Note 5 of Standard Sheet M606-9R1 indicates that on highways with operating speeds in excess of 70 km/h that 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 that safety articles installed on the National Highway System (NHS) after July 1998¹ must be of a type that has passed National Cooperative Highway Research Program Report 350 (NCHRP 350) test criteria. The turned-down end terminal shown

¹ 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.

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on the standard sheet was presumed to be able to pass such crash testing at either the Test Level 1(31 mph) or Test Level 2 (45 mph.) Crash testing conducted for the FHWA, however, indicated this to be not so. The note on the above mentioned Standard Sheet must be changed accordingly, as these terminals are not in compliance with the federal requirements.

The ET2000, a guide rail end terminal for HPBO guide rail, is one of the safety articles, however, that did pass NCHRP 350 crash testing. This end terminal was developed at Texas Transportation Institute and is now marketed by Syro Steel Company. It is a Test Level 3 device, which means that it passed various crash tests prescribed by NCHRP 350, including a 100 km/h, 25° impact with a 2000 kg pickup truck. Test Level 3 devices may be used on all classes of highways and at all speeds.

The single working part of the ET 2000 is a guide rail extruder fabricated of steel. The guide rail extruder is located at the free end of the assembled ET 2000. During end on impact, the force of the impacting vehicle drives the guide rail extruder down the corrugated rail, flattening the rail, absorbing the energy of the impacting vehicle, and turning the flattened rail out of the way of the impacting vehicle. In end on impacts, the ET 2000 was able to stop the impacting vehicle imparting only approximately 6 Gs deceleration to the small car (810 kg.) and approximately 2.4 Gs deceleration to the large vehicle. In one test with the larger vehicle, up to 15.8 m (52 feet) of rail passed through the extruder.

There are nine posts in the ET 2000. They are spaced at 1905 mm (6'-3") center to center. Overall length of the ET 2000 is 15.8 m ± (52 feet ±) including the approximate 0.6 m (2 feet) that the guide rail extruder extends beyond the first post at the free end of the ET 2000. In the most maintainable of the ET 2000 designs, which is designated Option A by the manufacturer, the first eight posts from the free end are special, short posts weakened by 90 mm holes bored through them near the ground line. These short posts are 1143 mm long and are placed in metal foundation tubes. Ordinary timber guide rail posts, lacking these 90 mm holes, will not break away properly on impact and therefore must not be incorporated into the ET 2000 as any of the first eight posts. The ninth post is an ordinary HPBO guide rail post, and may be either steel or wood, depending upon the system to which the ET2000 is attached.

An ET 2000 design utilizing longer, directly embedded, breakaway posts is also available. Longer posts are 1830 mm long. This design option uses four of the short posts and foundation tubes for just the first four posts from the free end. The next four posts are the longer breakaway posts, directly embedded. The ninth post is the same as the ninth post used in Option A. The advantage to the long post design alternative is cost. Each of the steel foundation tubes adds \$75.00 to the cost of the ET 2000. The disadvantage of ET 2000 designs using longer directly embedded posts is it will be harder to repair these ET 2000s, especially when the ground is frozen.

USAGE POLICY. The approach ends of HPBO guide rail at all operating speeds that cannot reasonably be carried to a point outside the clear zone, shielded by another barrier, buried in the back slope or in a suitable berm, shall be terminated with an ET 2000, another approved end terminal,² or an approved crash cushion³. *The turned down end terminal shown on the standard sheets is not an approved end terminal at any speed within the clear zone at locations where they would be subject to head-on impacts.* Proper use of the ET 2000 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. For ease of maintenance, Option A will be the standard. This option uses only short (1143 mm), weakened, timber posts placed within steel foundation tubes for the first eight posts. Regions desiring to use other approved options are free to do so. Special specifications will be required.

APPLICABILITY. The usage policy included in this instruction is applicable to new installations of end terminals,

² The Slotted Rail Terminal (SRT), EI 98-016, is also an approved end terminal for use in NYS. There may also be others. See the Engineering Instructions or use the computer program EIB.

³ Sand Barrel Arrays on one-way roads, CAT, GREAT, BRAKE MASTER, REACT 350 are among the approved crash cushions. See also latest EIB program.

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 (ie. 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 the ET 2000. Number them starting with the post at the free end being post 1. Post spacing is 1905 mm (6'-3") throughout the length of the ET 2000. ET 2000s may be installed either parallel to the line of guide rail or flared from it. If flared, one of three options must be used: Option 1-The ET 2000 may be flared over the whole length 1:50 with respect to the line of guide rail, or, Option 2- it may be flared over half its length from post 5 to the free end 1:25 with respect to the line of the guide rail. Flare, by these options, is recommended, because it can easily be attained, and because flare will reduce the number of nuisance hits on the end and facilitate snow plowing. Greater flare rates, maximum 1:15, herein designated Option 3, are possible in accordance with details that will be shown on a future standard sheet.

The ET 2000 is a gating end terminal from its free end to post 3. From post 3 downstream, ET 2000s redirect and this length may be included in the length of need. Length of need should be determined as indicated in Engineering Instruction EI 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. ET 2000s are gating terminals upstream of post 3. An area approximately 6 m wide in back of the guide rail and 22.5 m along the guide rail should 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 desirable⁴ 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. Minor 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 or 2 meters for the ET 2000 because in the full scale crash test with the 4500 pound automobile at 60 mph, 15.8 m (52 feet) of rail passed through the extruder.

Reductions in the width of the obstacle free area are also permitted in projects 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 four meters (4 m) then the six meter width may be reduced to four meters.

Special Grading Requirements. Slopes between the road and the ET 2000 should be 1:10 or flatter. This slope should be carried underneath the ET 2000 to a slope break point located behind the back of the posts. Slopes may increase at 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 minimum behind the back of the post. Between post 8 and post 4, the distance to the slope break point increases to 1000 mm. Between post 4 and post 2, the slope break point is 1000 mm behind the back of the posts. This 1000 mm slope break point line is extended in line to a point opposite the front of the guide rail extruder unit. At that

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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.

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point, the slope break point transitions back to the normal slope break point given in the HDM in §10.2.3.5, Post Protection, 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. Until standard sheets are available⁵, 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 one meter (1 m) offset behind all eight of the posts would satisfy the federal desires, be simpler to layout than the federally proposed scheme, and would provide the same or better stability for the errant vehicle⁶.

Recommended offset. For maintenance purposes, the free end of the ET 2000 should be offset from the traveled way approximately 2.5-3 m minimum.

Where shoulders are narrow, ET 2000s should be flared back to the recommended offset or beyond, whenever practical to do so. Only 300 mm of flare is possible in the ET2000's 15.8 m length. Additional flare must be attained upstream of the ET 2000 in the rail itself. At short breaks in the run of guide rail, flaring back of the ET 2000 is not necessary, but the road side of the extruder unit should not project beyond the line of the guide rail.

Beginning length of need. ET 2000s redirected the test vehicle at post 3 (third post from the free end of the unit). Therefore, 11.43 m (37'6") of this end terminal is also an 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 ET 2000, when compared to the alternative Slotted Rail System, is that reduced grading is possible and lesser amounts of guide rail may be provided, if there is need to do so.

ESTIMATED COST. ET 2000s 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 ET 2000s installed per day by a good guide rail crew. Grading costs are not included in this estimate and would vary based on location and region. Rustic versions will be more expensive.

CONTACT PERSON. Larry Brown, Design Quality Assurance Bureau, M.O Bldg 5, Room 410, (518)-457-4093.

⁵ These are under preparation and will show layout, grading, and payment limits.

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

15606.34 M End Terminal For Heavy Post Blocked-out Corrugated Guide Rail, ET 2000

15606.3450 M End Terminal for Heavy Post Blocked-out Corrugated Guide Rail, ET 2000,
(Rustic)

DESCRIPTION.

Under this work, the Contractor shall furnish and install End Terminals for Heavy Post Blocked out Corrugated Guide Rail, ET 2000 and End Terminals for Heavy Post Blocked out Corrugated Guide Rail, ET2000, (Rustic), as indicated, at the locations indicated in the Contract Documents, or where directed by the Engineer in accordance with these specifications, manufacturer's directions, and the approved Materials Details. These end terminals will be abbreviated hereafter in these specifications as "ET 2000" and "ET 2000, (Rustic)."

MATERIALS.

The End Terminal shall be ET 2000, Option A (8 foundation tubes) as fabricated by the Syro Steel Company, Girard, Ohio (800-321-2755). All parts and the configuration of the ET 2000 corrugated beam guide rail energy absorbing end terminal shall be as indicated on the approved Materials Details.

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. Deep 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 Materials Details. All metal components 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.

ET2000, (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.

Basis of Acceptance. The Department requires the submission of Materials Details as defined in §101-34.1. The supplier shall prepare and submit the appropriate material in accordance with the procedural directives of the Design Quality Assurance Bureau (DQAB). Upon approval by DQAB, the name of the product and/or supplier, and the unique reference number assigned to the approved Materials Details by the supplier will be placed on the Approved List. Such products will then be accepted on the basis of their brand name and conformance to the approved Materials Details.

The supplier shall provide two copies of the approved Materials Details through the Contractor to the Engineer as part of the evidence of acceptability for the material at least ten (10) days prior to the use of the product.

ET 2000 and ET 2000, (Rustic) will be accepted at the project site on the basis of 1) Appearance of the manufacturer's name on the Approved List, 2) Compliance of the delivered articles with the approved materials details, 3) Manufacturer's certificate of compliance with these specifications.

15606.34 M End Terminal For Heavy Post Blocked-out Corrugated Guide Rail, ET 2000

15606.3450 M End Terminal for Heavy Post Blocked-out Corrugated Guide Rail, ET 2000,
(Rustic)

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 two copies of the approved Materials Details prior to installation of the ET2000 or ET 2000, (Rustic).

ET2000 or ET 2000, (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 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 ET 2000 or ET 2000, (Rustic) is damaged, the units shall be promptly repaired. Unless another period is indicated in the contract documents, promptly repaired shall mean fourteen (14) calendar days.

METHOD OF MEASUREMENT

The work will be measured as the number of Corrugated Beam Guide Rail Energy Absorbing End Terminal ET2000 or Corrugated Beam Guide Rail Energy Absorbing End Terminal ET2000 (Rustic) satisfactorily furnished and installed in accordance with these specifications. The payment limits for these units 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 Corrugated Beam Guide Rail Energy Absorbing End Treatments or Corrugated Beam Guide Rail Energy Absorbing End Treatments(Rustic) shall include the cost of 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 ET 2000s or ET 2000s, (Rustic) damaged by public travel will be borne by the Contractor or the by State in accordance with the provisions of §107-09 Damage.

15606.34 End Terminal For Heavy Post Blocked-out Corrugated Guide Rail, ET 2000

15606.3450 End Terminal for Heavy Post Blocked-out Corrugated Guide Rail, ET 2000,
(Rustic)

DESCRIPTION.

Under this work, the Contractor shall furnish and install End Terminals for Heavy Post Blocked out Corrugated Guide Rail, ET 2000 and End Terminals for Heavy Post Blocked out Corrugated Guide Rail, ET 2000, (Rustic), as indicated, at the locations indicated in the Contract Documents, or where directed by the Engineer in accordance with these specifications, manufacturer's directions, and the approved Materials Details. These end terminals will be abbreviated hereafter in these specifications as "ET 2000" and "ET 2000, (Rustic)."

MATERIALS.

The End Terminal shall be ET 2000, Option A (8 foundation tubes) as fabricated by the Syro Steel Company, Girard, Ohio (800-321-2755). All parts and the configuration of the ET 2000 corrugated beam guide rail energy absorbing end terminal shall be as indicated on the approved Materials Details.

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 (45 inch) 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. Deep 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 A36. Fasteners shall be as indicated on the Materials Details. All metal components 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 four inch (4") yellow and non-reflectorized 4½ inch 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.

ET 2000, (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.

Basis of Acceptance. The Department requires the submission of Materials Details as defined in §101-34.1. The supplier shall prepare and submit the appropriate material in accordance with the procedural directives of the Design Quality Assurance Bureau (DQAB). Upon approval by DQAB, the name of the product and/or supplier, and the unique reference number assigned to the approved Materials Details by the supplier will be placed on the Approved List. Such products will then be accepted on the basis of their brand name and conformance to the approved Materials Details.

The supplier shall provide two copies of the approved Materials Details through the Contractor to the Engineer as part of the evidence of acceptability for the material at least ten (10) days prior to the use of the product.

ET 2000 and ET 2000, (Rustic) will be accepted at the project site on the basis of 1) Appearance of the manufacturer's name on the Approved List, 2) Compliance of the delivered articles with the approved materials details, 3) Manufacturer's certificate of compliance with these specifications.

15606.34 End Terminal For Heavy Post Blocked-out Corrugated Guide Rail, ET 2000

15606.3450 End Terminal for Heavy Post Blocked-out Corrugated Guide Rail, ET 2000,
(Rustic)

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 two copies of the approved Materials Details prior to installation of the ET2000 or ET 2000, (Rustic).

ET 2000 or ET 2000, (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 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 ET 2000 or ET 2000, (Rustic) is damaged, the units shall be promptly repaired. Unless another period is indicated in the contract documents, promptly repaired shall mean fourteen (14) calendar days.

METHOD OF MEASUREMENT

The work will be measured as the number of Corrugated Beam Guide Rail Energy Absorbing End Terminal ET 2000 or Corrugated Beam Guide Rail Energy Absorbing End Terminal ET 2000 (Rustic) satisfactorily furnished and installed in accordance with these specifications. The payment limits for these units extend from the front of the guide rail extruder to the center of the ninth guide rail post which is located approximately 52 feet distant from the front of the guide rail extruder.

BASIS OF PAYMENT.

The unit bid price per Corrugated Beam Guide Rail Energy Absorbing End Treatments or Corrugated Beam Guide Rail Energy Absorbing End Treatments (Rustic) shall include the cost of 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 ET 2000s or ET 2000s, (Rustic) damaged by public travel will be borne by the Contractor or the by State in accordance with the provisions of §107-09 Damage.