Qualified Pavement Markings Inspection Technician

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COURSE SCHEDULE

DAY 1

8:30-9:30am	INTRODUCTION AND WELCOME
	KM64-001 QUALIFICATION PROGRAM FOR TECHNICIANS
	SPECIFICATIONS
	DISTRICT WIDE STRIPING CONTRACTS
9:30-9:45am	**BREAK**
9:45-10:45am	MATERIALS HANDLING
	KENTUCKY METHODS
10:45-11:30am	LTL-X OVERVIEW
11:30-1:00pm	**LUNCH**
1:00-4:00pm	WORKSHOPS

DAY 2

8:30-9:00am	REVIEW
9:00-UNTIL	WRITTEN AND PRACTICAL EXAM

*****Between the written and practical exam, participants will have an opportunity to take a break and practice for the second part of the exam.

TABLE OF CONTENTS

WEBSITES

Kentucky Methods

http://transportation.ky.gov/Materials/Pages/Kentucky-Methods.aspx

2012 Specifications

http://transportation.ky.gov/Construction/Pages/Kentucky-Standard-Specifications.aspx

Sampling Manual

http://transportation.ky.gov/Materials/Pages/Sampling-Manual.aspx

Daily Striping Report/ KM202 Spreadsheet

http://transportation.ky.gov/materials/pages/Chemistry.aspx

QUALIFIED

PAVEMENT MARKING

TECHNICIAN

TRAINING

INTRODUCTION & WELCOME

1. Visitor Check-In & Out
2. Restrooms & Concessions

REASON FOR THE COURSE

KM 64-001

According to the Federal Highway Administration Policy all acceptance sampling and testing must be performed by "Qualified Personnel." In response to the federal policy, the state Qualification Program for Technicians was developed.

Kentucky Method 64-001-02 covers qualification and disqualification procedures for inspectors. This method states that to qualify you must attend training and pass both a written test and a practical test. Disqualification is the result of one of the following reasons:

1. Failure to pass re-qualification class
2. Found to be guilty of falsifying test results, records, and/or reports.
3. Improper performance of tests

OVERVIEW OF THE COURSE

DAY 1

We will begin by discussing **Kentucky Standard Specifications 713, 714 and 717**. Next we will review the new **district wide striping contracts**. After reviewing the contract requirements, we will discuss the materials requirements covered by **Kentucky Standard Specifications 831, 836, 837 and 842.** In the tab titled KY Methods we will cover **Kentucky Methods 201, 202 and 203**. A Flint Trading representative will finish the day by providing us with an **overview of the LTL-X** and then we will have **workshops that include hands-on practice with the LTL-X instrument**.

DAY 2

At the start of the day we will review any workshops that we did not review the day before and have a brief **question and answer session** followed by an open book exam. After the **written exam**, there is a **practical test.** For the practical the manuals are not allowed. Also, the practical will include written questions.

NO RETEST

TIPS

1. Follow along during the class so that you are familiar with your manual
2. Practice with the LTL-X until you are comfortable

Kentucky Method 64-001-08
Revised 04/02/08
Supersedes 64-001-05
Dated 01/28/05

KENTUCKY TRANSPORTATION CABINET
QUALIFICATION PROGRAM FOR TECHNICIANS

1. SCOPE:

   1.1. According to Title 23, Part 637, Code of Federal Regulations (23 CFR 637), FHWA's "Quality Assurance Procedures for Construction", all acceptance and verification sampling and testing must be performed by "qualified personnel".

   1.2. As defined in the Quality Assurance Program for Materials Testing and Acceptance, the Kentucky Department of Highways has established a Quality Assurance (QA) program to ensure that materials and workmanship incorporated into any highway construction project are in reasonable conformity with the requirements of the approved plans and specifications, including any approved changes. This QA program allows for the use of validated, contractor-performed, quality control (QC) test results as part of an acceptance decision. It also allows for the use of test results obtained by commercial laboratories in the Independent Assurance (IA) program as well as in acceptance decisions.

2. REFERENCED DOCUMENTS: Kentucky Department of Highways Quality Assurance Program for Materials Testing and Acceptance

3. QUALIFICATION PROGRAM STEERING COMMITTEE (QPSC): The Qualification Program is overseen by a Steering Committee consisting of the following representatives:

   State Highway Engineer

   Deputy State Highway Engineer for Project Delivery

   Director, Division of Construction

   Director, Division of Materials

   Director, Division of Employee Support

   Division of Materials Qualification Coordinator

   Representative, Federal Highway Administration

   Representative, Kentucky Ready Mixed Concrete Association (KRMCA)

   Representative, Kentucky Association of Highway Contractors (KAHC)

Representative, Kentucky Crushed Stone Association (KCSA)

Representative, Plantmix Asphalt Industry of Kentucky (PAIKY)

4. QUALIFICATION POLICIES:

4.1. Required qualifications are primarily: 1) sample and test oriented or 2) demonstration of knowledge or expertise for a specific discipline.

4.1.1. Qualifications required for sampling and testing as part of a QA program. These qualifications are required, as applicable, for the QC effort, acceptance, verification, or IAS program. To qualify, an individual must successfully perform the specific tests and necessary calculations required for each qualification type in the presence of an authorized evaluator. Successful performance is defined as demonstrating the ability to properly perform the key elements for each test method. If the individual fails to demonstrate the ability to perform a test, the individual may be allowed one retest per test method at the evaluator's discretion.

4.1.2. Qualifications required for demonstration of knowledge or expertise associated with items of work. These qualifications are required, as applicable, for project oversight when specific items of work are being performed.

4.2. The individual must pass a written examination administered by an authorized evaluator. An individual failing the written examination may request a retest. The individual may be allowed one retest at the evaluator's discretion. The retest must be requested, scheduled and administered within 30 days of the notification of failure. Failure to pass the second written examination shall be considered as failing the entire qualification.

4.3. Qualification of an individual is valid for not more than five years. After that time, the individual must qualify again. Under the requirements of the QA program, interim evaluations will be permitted when appropriately justified.

4.4. Test questions and other examination data used to administer this qualification program are subject to reuse and are considered confidential and exempt from public records inspection.

5. EXAMINATION METHODS AND POLICIES:

5.1. A standard set of examinations for each qualification will be used statewide. With the exception of national qualifications, the examinations will be developed by a committee composed of personnel from some or all of the following: Division of Materials, Division of Construction, and appropriate industry representatives.

5.2. In addition, the individual may be required to participate in proficiency sample testing administered by the qualification authority to validate the qualification. The result of the proficiency samples will be evaluated for compliance with acceptable tolerance limits. If the comparison of test results does not comply with the tolerances, an engineering review of the

test procedures and equipment shall be performed immediately to determine the source of the discrepancy. Corrective actions must be identified, and incorporated as appropriate, prior to the individual performing additional testing on that test method.

6. DISQUALIFICATION PROCEDURES: A qualified individual can be disqualified for any of the following reasons:

6.1. Failure to pass requalification requirements and/or provide payment of fees, initial or requalification.

6.2. Found to be guilty of falsifying test results, records, and/or reports or any willful departure from approved policy/procedure. Allegations of falsification or willful departure will be made to the QPSC in writing. The allegations will contain the name, address, and signature of the individual(s) making the allegation. The allegations will be investigated by the QPSC. The accused and the individual(s) making the allegation will be given the opportunity to appear before the QPSC. All involved parties will be notified in writing of the findings by the QPSC. Any warranted actions will be imposed according to the guidance contained herein. Decisions regarding allegations may be appealed in writing to the QPSC which will consider such written appeals and take such action considered appropriate.

6.2.1. First offense would result in a 12-month revocation of qualification status in all qualification types. Prior to reinstatement, the individual shall again successfully complete qualification classes.

6.2.2. Second offense would result in a permanent loss of qualification status in all qualification types.

6.3. Found to be guilty of improperly performing tests, failing to perform tests, or being incapable of performing tests and documented by a qualified technician. The documentation ("Report of Violation" form, copy attached) must include the date(s), time(s), location(s), occurrence(s) of non-conformance, and signature of the qualified technician reporting the incident.

6.3.1. First offense would result in a letter of reprimand from the QPSC.

6.3.2. Second offense would result in a 30-day revocation of qualification status.

6.3.3. Third offense would result in a revocation of qualification status. The individual may obtain qualification again after a six-month period and successfully completing the appropriate qualification class(es).

APPROVED _____

DIRECTOR
DIVISION OF MATERIALS

DATE 04/02/08

Kentucky Method 64-001-08
Revised 04/02/08
Supersedes 64-001-05
Dated 01/28/05

km00108.doc

KENTUCKY QUALIFICATION PROGRAM FOR TECHNICIANS
REPORT OF VIOLATION

The undersigned Kentucky Qualified Technician has witnessed and documented violation(s) of the Technician Qualification Program. These violations are outlined in Section 7 of KM 64-001, Kentucky Transportation Cabinet Qualification Program for Technicians. The qualified technician noted in violation is:

_____ _____
Name Certification No.

_____
Date(s) of Violation

_____
Time(s) of Violation

_____
Location(s) of Violation

Description of the violation (Attach additional sheets if necessary):

_____

_____

_____

_____

_____

_____

_____ _____ _____
Qualified Technician Inspector ID Number Date

_____
Signature

SPECIFICATIONS

Standard Specifications for Temporary Striping

- **Section 112.03.11: Temporary Striping with Paint or Tape**

Section 112.03.11: Temporary Striping

- **Striping expected to be in place less than 120 days**
  - Visual Acceptance
  - Maintained Retroreflectivity Readings
  - Manufacturer's Certification
  - Tape: Ensure the product is on the List of Approved Materials
- **Striping expected to be in place greater than 120 days**
  - Initial Retroreflectivity Readings
  - Maintained Retroreflectivity readings
  - Manufacturer's Certification
  - Paint: Collect a sample to be sent to Central Office Materials
  - Tape: Ensure the product is on the List of Approved Materials

Section 112.03.11: Initial Evaluation of Temporary Stripe

- **Less than 120 days**
  - Initial evaluation = Visual Evaluation
- **Greater than 120 days**
  - Initial Evaluation = Retroreflectivity within 5 days of application
    - White: 300 mcd/m²/lux
    - Yellow: 225 mcd/m²/lux

Readings taken in accordance with KM202 or KM203

Section 112.03.11: Minimum Maintained Retroreflectivity

- **Minimum retroreflectivity maintained as long as the temporary stripe is in place**
  - **Stripe in place less than 120 days**
    - Requested at any time by the Engineer
  - **Stripe in place greater than 120 days**
    - Requested any time after initial evaluation by the Engineer

White: 175 mcd/m²/lux
Yellow: 150 mcd/m²/lux

Readings taken in accordance with KM202 or KM203.

Section 112.03.11: Visual Acceptance Guidelines

- **Suitable and uniform color**
- **Crisp edges and clean cutoffs**
- **Adhere to pavement**
- **Sufficient retroreflectivity – visible daytime and nighttime**

Section 112.03.11: Corrective Work for Temporary Stripe

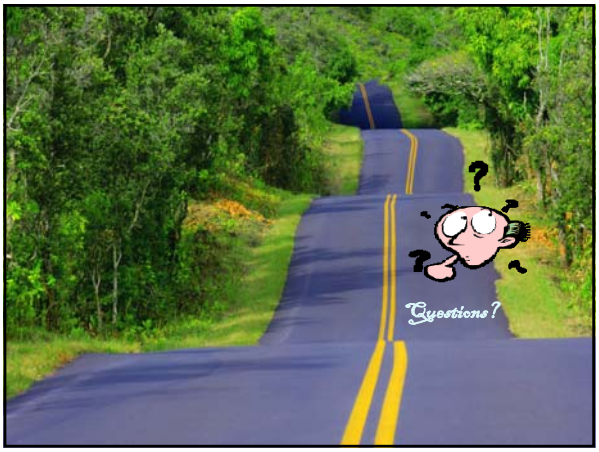
- **Unacceptable initial evaluation**
  - Corrective work completed within 24 hours
- **Damaged or missing stripe during the course of the contract**
  - Replace within 3 days

Section 112.03.11: Temporary Stripe Review Questions

- If the temporary stripe is only expected to be in place for two months, what type of initial evaluation do you need to perform?
- If the temporary stripe is expected to be in place for 6 months, what type of initial evaluation should you perform?

Section 112.03.11: Temporary Stripe Review Questions

- A temporary stripe has been in place for 90 days but at night the line is barely visible. What minimum values should the line be?
- If the line is below these values, how long does the contractor have to replace the temporary stripe?



Standard Specifications

- **Section 713: Permanent Pavement Striping**
- **Section 714: Durable Pavement Striping**
- **Section 717: Thermoplastic Intersection Markings**

Section 713

Permanent Pavement Marking Paints

On

Resurfacing, Restoration and Rehabilitation Contracts

Section 713: Materials

- **Waterborne Traffic Paint**
  - Conform to Section 842
- **Durable Waterborne Traffic Paint**
  - Conform to Section 846

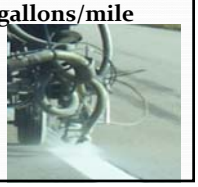
Section 713: Minimum Application Rates

4" Waterborne paint – 16.5 gallons/mile

6" Waterborne paint – 24.8 gallons/mile

6" Durable waterborne paint – 36 gallons/mile

Glass beads – 6 pounds/gallon



Section 713: Proving Period

- **Proving period – facility open to traffic**
- **Readings to be taken 30-60 days after prov period begins**

- **Minimum retroreflectivity requirements**

White: 300 mcd/m²/lux
Yellow: 225 mcd/m²/lux

Section 713: Pass/Fail Decisions

- **KM202**
  - 80% of the readings in each segment must pass
- **KM203**
  - 80% of the segments in each section must pass
- **Acceptance with Deduction**
  - Use if all other work is in conformity except retroreflectivity
  - Weather conditions prohibit corrective work
  - Sliding scale

Section 713: Acceptance Pay Schedule

Pay Value	White (mcd/m2/lux)	Yellow (mcd/m2/lux)
1.00	≥ 300	≥ 225
0.50	251-299	176-224
0.25	226-250	151-175
0.00	200-225	125-150
Remove & Replace	< 200	< 125

Section 713: Marking Removal

- Use ultra-high pressure water to remove markings
- Markings removal totaling less than 1,000 linear feet may be removed by an abrasive method
- Do not paint markings made in error or not in conformance with asphalt binder or other material
- Do not damage pavement in any way while removing markings and protect all joint seals

Section 714

Durable Striping

Type I Tape
&
Extruded Thermoplastic

Section 714: Type I Tape

- Use for markings on bridge decks, JPC pavement and JPC intersection
- Do not use thermoplastic on bridge decks, JPC pavement and JPC intersections

Section 714: Type I Tape

- **Materials Requirements (Section 836)**
  - **Manufacturer's Certification**
  - **Must meet the minimum retroreflectivity requirements**
    - White = 500 mcd/m²/lux
    - Yellow = 500 mcd/m²/lux
  - **List of Approved Materials**

Section 714: Proving Period for Type I Tape

- Blistering
- Excessive cracking
- Bleeding
- Staining
- Discoloration
- Oil content from pavement markings
- Chipping
- Spalling
- Loss of Retroreflectivity
- Vehicular damage

- Deterioration due:
  - Grease deposits
  - Oil
  - Diesel fuel
  - Gasoline

- Adequate bonding to the pavement

Section 714: Nighttime Visual Acceptance

- **Retroreflectivity readings are not necessary if**
  - Material shows no sign of failure
  - Adequately bonded to the pavement
- **Acceptance**
  - Nighttime visual evaluation
  - Manufacturer's certification

Section 714: Extruded Thermoplastic

- **Minimum application rate**
  - 90 mil line
- **1 foot gap every 20 feet**

Section 714: Equipment Requirements for Thermoplastic

- DO NOT use a spray or ribbon gun applicator
- Extrusion die deposits and shapes lines
- Maintain continuous and uniform heating between 400 and 440°F
- Kettle capable of continuous agitation
- Motorized and capable of applying line at a rate of 3 mph
- Cut off device to provide clean, square ends
- Automated bead dispenser

Section 714: Perform Bond Checks

- Check 60 to 120 seconds after application of stripe
- Cut 6 inch strip
- Bonding has successfully occurred if asphalt clings to the removed strip and the pavement surface is shiny and black

Section 714: Restrictions

- **DO NOT APPLY IF**
  - Air and Pavement Temperature < 50°F

Section 714: Thermoplastic Proving Period

- **180 Days**
- **Minimum retroreflectivity requirements**
  - White: 300 mcd/m²/lux
  - Yellow: 225 mcd/m²/lux
- **Readings taken 150-210 days after the start of the proving period**
  - KM202 – Portable readings (LTL-X)
  - KM203 – Mobile Readings (Mobile Van)

Section 714: Proving Period for Thermoplastic

- Blistering
- Excessive cracking
- Bleeding
- Staining
- Discoloration
- Oil content from pavement markings
- Smearing or spreading under heat
- Chipping
- Spalling
- Loss of retroreflectivity
- Vehicular damage
- Deterioration due:
  - Grease deposits
  - Oil
  - Diesel fuel
  - Gasoline

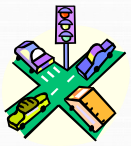
- Adequate bonding to the pavement

Section 714: Acceptance Pay Schedule

Pay Value	White (mcd/m²/lux)	Yellow (mcd/m²/lux)
1.00	≥ 300	≥ 225
0.50	251 – 299	176 – 224
0.25	226 – 250	151 – 175
0.00	200 – 225	125 – 150
Remove and Replace	< 200	< 125

Section 717

Intersection Markings



Section 717: Intersection Markings

- **Preformed Thermoplastic**
  - List of approved materials
  - 125 mil minimum thickness
- **Extruded Thermoplastic**
  - **90 mil line**

Section 717: Equipment Requirements

- DO NOT use a spray or ribbon gun applicator
- Extrusion die deposits and shapes lines
- Maintain continuous and uniform heating between 400 and 440°F
- Kettle capable of continuous agitation
- Motorized and capable of applying line at a rate of 3 mph
- Cut off device to provide clean, square ends
- Automated bead dispenser

Section 717: Restrictions

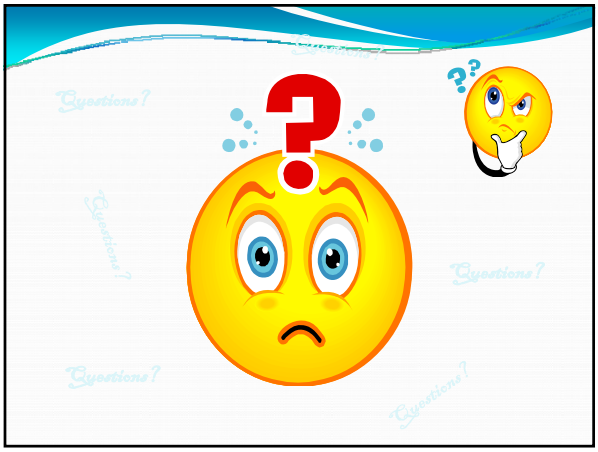
- **DO NOT APPLY IF**
  - Air and Pavement Temperature < 50°F

Section 717: Proving Period

- **Proving period – 180 days**
- **Minimum retroreflectivity requirements**
  - White = 300 mcd/m²/lux
  - Yellow = 225 mcd/m²/lux
- **Take readings 15-45 days after the start of the proving period**
  - Readings taken according to KM201

Section 717: Acceptance Pay Schedule for Intersection Markings

Pay Value	White (mcd/m²/lux)	Yellow (mcd/m²/lux)
1.00	≥ 300	≥ 225
0.50	251 – 299	176 – 224
0.25	226 – 250	151 – 175
0.00	200 – 225	125 – 150
Remove and Replace	< 200	< 125



EXCERPT FROM SECTION 112- MAINTENANCE AND CONTROL OF TRAFFIC DURING CONSTRUCTION

112.03.10 Removal of Permanent Pavement Markings. Remove all permanent markings and raised pavement markers that do not conform to the traffic operation in use. Remove striping according to Section 713.03.04. Remove raised pavement markers according to Subsection 403.03.02.

When the marker's casting will conform to the final marking scheme but does not conform to the current traffic operation, the Department may allow lens removal in place of removing the entire marker. Additionally, when weather would prohibit patching for marker removal within 24 hours, the Department may allow lens removal until such time weather permits patching.

112.03.11 Temporary Pavement Markings.

A) Placement and Removal of Temporary Raised Pavement Markers. Place and remove temporary raised pavement markers when the Contract specifies. Install temporary pavement markers according to the manufacturer's recommendations. Replace missing or damaged temporary markers within 3 calendar days. After completion of the work, remove the markers from the job site, including the primer and adhesive. Take ownership of the temporary markers at the end of the project.

B) Placement and Removal of Temporary Striping. Place temporary striping on new construction, resurfacing, pavement restoration, pavement rehabilitation and other projects that have existing pavement markings as the Contract specifies. On interstates and parkways, and other roadways approved by the State Highway Engineer, install pavement striping that is 6 inches in width. On other routes, install pavement striping that is 4 inches in width. Ensure that all lines have clean edges with a width tolerance of plus 1/2 inch.

Except on new construction or where markings do not exist, prepare and keep a written record of the existing pavement markings locations, and furnish a copy to the Engineer before removing or obliterating the markings.

Apply temporary striping when any course of a new pavement is to be driven over by the public, including patching, milling, leveling, and wedging courses, except when existing centerline markings are plainly visible and not obscured. Install the pavement marking material for centerlines and lane lines every day before sunset that day. The Department will defer installation of edgeline markings until all shoulder paving is complete, except on Interstate and Parkway roads or when the Contract specifies otherwise. When rain or other unavoidable occurrences prevent marking before sunset, mark the pavement as soon as conditions permit. Locate no passing zones as the Engineer directs.

1) Removable Striping. Use removable striping tape when different phases of construction will require the relocation of striping to different positions on the same pavement. Relocate lane lines, edgelines, and other pavement markings as the Standard Drawings and the Contract specify. Do not use removable material as a permanent marking unless the Engineer directs.
2) Non-removable striping material. Use either tape or paint where the striping is to be covered by subsequent paving courses and for temporary paved facilities which will be removed before completing the project. Apply paint according to Section 713.

Maintain the following minimum retroreflectivity requirements at all times:

White: 175 mcd/lux/square meter

Yellow: 150 mcd/lux/square meter

Additionally, when temporary striping that is to remain in use for more than 120 days, provide striping with the following minimum initial retroreflectivity readings:

White: 300 mcd/lux/square meter
Yellow: 225 mcd/lux/square meter

The Engineer may visually accept the markings intended for less than 120 days use but may obtain retroreflectivity readings at any time conformance to the minimum retroreflectivity readings are in doubt. When striping that is to remain in use for more than 120 days, the Department will obtain retroreflectivity readings within five days of application of temporary striping using an approved 30 meter geometry handheld or mobile retroreflectometer. The Department will determine acceptance of the temporary striping in accordance with KM-202 or KM-203 as applicable. When the Department determines the striping is not acceptable, complete corrective work within 24 hours.

Maintain all markings throughout the duration of the project. Replace missing or damaged stripes or tape within 3 days. Remove all markings placed in error or markings that do not conform to the traffic scheme in use.

SECTION 713 — PERMANENT PAVEMENT STRIPING

713.01 DESCRIPTION. Furnish and apply waterborne striping paint to provide lane lines, edgelines, and gore markings as specified in the Contract.

713.02 MATERIALS AND EQUIPMENT.

713.02.01 Paint. Conform to Section 842 and Section 846.

713.02.02 Drop On Glass Beads. Use beads that will ensure the pavement marking material will meet retroreflectivity requirements. The Department will evaluate the beads as part of the marking system through retroreflectivity readings.

713.02.03 Application Equipment. Use a self-propelled striper capable of heating the paint to provide uniform flow. Ensure that the striper has a guide boom or optical pointer to attain smooth and straight lines. Ensure that the equipment maintains proper application pressures for paint and beads at all times. Provide equipment capable of applying a single line or parallel lines of the specified width and in any combination of a skip line and a solid line in one pass.

Provide equipment with a paint cutoff device to provide clean, square marking ends of the paint lines.

Equip the paint pots or tanks with an agitator that will keep the paint thoroughly mixed.

Provide equipment with bead dispensers, minimum of one for each paint spray gun, placed such that the beads are applied to the paint almost instantly as the paint is being placed on the roadway surface. Design and align the bead dispensers so that beads are applied under air pressure uniformly to the entire surface of the paint lines. Equip the bead dispensers with cutoff controls synchronized with the cutoff controls for the paint spray guns.

713.03 CONSTRUCTION. Provide yellow centerline markings, which are defined as those separating traffic moving in opposite directions. Provide white lane line markings, which are defined as those separating traffic moving in the same direction. Ensure that these markings are skip lines and solid lines as required by Part 3 of the MUTCD. Ensure that edge lines are solid lines, and determine the color from Part 3 of the MUTCD.

On interstates and parkways, and other routes approved by the State Highway Engineer, install pavement striping that is 6 inches in width. On other routes, install pavement striping that is 4 inches in width. When centerline markings consist of a double yellow line (either a one-direction or two-direction no passing zone marking), the spacing between the two lines shall be the same as the width of one line marking. Ensure that all lines have clean edges with a width tolerance of plus 1/2 inch. The Engineer may waive the tolerances when deviations are caused by undulation in the pavement surface.

Construct skip lines with a stripe-to-gap ratio of a 10-foot paint stripe to a 30-foot gap. Ensure that the length of the stripe is between 10 and 10 1/2 feet. Ensure that the stripe-gap cycle is between 40 and 40 1/2 feet. Offset longitudinal lines at least 2 inches from longitudinal pavement construction joints. Offset longitudinal lane lines on multi-lane highways 2 inches towards the median.

On resurfacing, pavement restoration, and pavement rehabilitation projects, reinstall the recorded existing pavement markings as modified by the Engineer. On new construction, place the markings as the Contract specifies or as the Engineer directs.

713.03.01 Records. On resurfacing, pavement restoration, and pavement rehabilitation projects, prepare and keep a written record of the locations of existing pavement markings, and furnish a copy to the Engineer before removing or obliterating the markings.

713.03.02 Pavement Surface Preparation. Clean grease, oil, mud, dust, dirt, grass, loose gravel, or other deleterious material from the surface where pavement markings are to be applied. Use only Engineer approved cleaning methods.

713.03.03 Paint Application. Apply permanent striping to new pavements when the final surface course has been placed and subsequent paving operations will not adversely impact the permanent striping. When subsequent paving operations will adversely impact the permanent striping, apply temporary striping according to Section 112.03.11 and apply the permanent striping as soon as conditions permit. Apply striping before sunset on new pavement that is to be driven over by the public.

Comply with the following application rates.

Material	Paint Application Rate	Glass Bead Application Rate
4 inch waterborne paint	Min. of 16.5 gallons/mile	Min. of 6 pounds/gallon
6 in waterborne paint	Min. of 24.8 gallons/mile	Min. of 6 pounds/gallon
6 inch durable waterborne paint	Min. of 36 gallons/mile	Min. of 6 pounds/gallon

713.03.04 Marking Removal. Remove all markings made in error or not conforming to the traffic operation in use. Do not paint with asphalt binder or other material to obliterate the markings. Remove pavement striping, temporary or permanent, from asphalt or concrete pavement using ultra-high pressure water. Marking removal totaling 1,000 linear feet or less may be removed by an abrasive method to the satisfaction of the Engineer. Vacuum all marking material and removal debris concurrently with the marking removal operation.

Do not damage the pavement in any way and protect all joint seals. If damage is observed, stop the removal process until the operation can provide an acceptable marking removal. Repair any damage to the pavement as a result of the marking removal. Removal of marking will not be measured for payment.

Waterblast to remove temporary or permanent striping completely as the Engineer directs.

713.03.05 Proving Period. A proving period will follow the application of the permanent pavement striping. During this period, the Engineer will make such observations as are necessary to determine if the markings are acceptable. The proving period begins when the facility is opened to traffic.

A) Requirements. The minimum retroreflectivity requirements at the end of the proving period, as measured with a Department approved 30 meter geometry handheld or mobile retroreflectometer, are as follows:

White:	300 mcd/lux/square meter
Yellow:	225 mcd/lux/square meter

The Department will take these measurements between 30 and 60 days after the start of the proving period, with acceptance based on KM 202 or KM 203 as applicable. If the Department determines that the markings are acceptable, the installation of the markings will be considered complete.

B) Failure. For any one-mile section and each gore area during the proving period, the Department will consider the section defective when the retroreflectivity falls below the minimum required. The Department will consider each edge line, centerline, lane line and gore area marking separately.

C) Corrective Work. If a line is found to be defective, repair or remove and replace the line. Perform pavement marking replacement according to the

requirements specified in this subsection for the initial application. The corrective work will be subject to a proving period as listed above.

713.03.06 Acceptance of Non-Specification Markings. If weather conditions allow, perform corrective work to bring striping retroreflectivity into conformance. If corrective work has been performed and the work meets all requirements except for minimum retroreflectivity, the Department may accept the work according to Subsection 105.04. When the Engineer determines that the markings may be left in place, the Department will accept them at a reduction in the Contract unit bid price according to the Acceptance Pay Schedule. Additionally, the Engineer may remove the striping crew for the remainder of the project according to Subsection 108.06 Part A).

The Engineer may also apply this section when corrective work cannot be performed due to weather.

ACCEPTANCE PAY SCHEDULE FOR PERMANENT STRIPING		
Pay Value	White mcd/lux/square meter	Yellow mcd/lux/square meter
1.00	≥300	≥225
0.50	251-299	176-224
0.25	226-250	151-175
0.00	200-225	125-150
Remove and Replace	< 200	< 125

713.04 MEASUREMENT.

713.04.01 Pavement Striping. The Department will measure the quantity in linear feet. When a bid item is not included for gore markings, the Department will measure the quantity by converting the actual length and width of line installed to an equivalent length of the normal width line on that section of roadway. The Department will measure temporary striping according to 112.04.07 when subsequent paving operations will adversely impact the permanent striping.

713.05 PAYMENT. The Department will make payment for the completed and accepted quantities under the following:

Code	Pay Item	Pay Unit
06514-06517	Pavement Striping - Permanent Paint, Width	Linear Foot
24189ER	Durable Waterborne Marking – 6 IN W	Linear Foot
24190ER	Durable Waterborne Marking – 6 IN Y	Linear Foot
24191ER	Durable Waterborne Marking – 12 IN W	Linear Foot

The Department will consider payment as full compensation for all work required under this section.

SECTION 714 — DURABLE PAVEMENT STRIPING

714.01 DESCRIPTION. Furnish and install durable marking materials, thermoplastic or Type I tape, to provide lane lines, edgelines, and gore markings as specified in the Contract.

714.02 MATERIALS AND EQUIPMENT.

714.02.01 Thermoplastic. Conform to Section 837.

714.02.02 Type I Tape. Conform to Section 836.

714.02.03 Binder. Furnish a binder that the manufacturer of the pavement marking material recommends and the Engineer approves. Provide a binder that forms a continuous film that dries rapidly and adheres to the pavement. Provide a material that does not discolor or cause any noticeable change in the appearance of the pavement outside of the finished pavement marking. Submit the material and method of application to the Engineer and obtain written approval from the Engineer and the manufacturer of the pavement marking material before applying.

714.02.04 Drop On Glass Beads. Use beads that will ensure the pavement marking material will meet retroreflectivity requirements. The Department will evaluate the beads as part of the marking system through retroreflectivity readings.

714.02.05 Thermoplastic Application Equipment. Provide equipment with an extrusion die that simultaneously deposits and shapes lines at a minimum thickness of 90 mils on the pavement surface. Do not use spray and ribbon gun applicators.

Ensure the application equipment conforms to the following:

1) Capable of providing continuous and uniform heat to maintain the material between 400 and 440 °F throughout the mixing, conveying, and dispensing.
2) The kettle is capable of continuous agitation during mixing and heated storage and is equipped with an automatic thermostat control device and material thermometer.
3) Motorized and capable of applying a uniform line at a rate of 3 mph.
4) Equipped with a cutoff device that provides clean, square stripe ends.
5) Equipped with an automatic bead dispenser.

714.03 CONSTRUCTION. Provide yellow centerline markings, which are defined as those separating traffic moving in opposite directions. Provide white lane line markings, which are defined as those separating traffic moving in the same direction. Ensure that these markings are skip lines and solid lines as required by Part 3 of the MUTCD. Ensure that edge lines are solid lines, and determine the color from Part 3 of the MUTCD.

Install pavement striping at the width specified in the Contract. Ensure that all lines have clean edges with a width tolerance of plus 1/2 inch. The Engineer may waive the tolerances when deviations are caused by undulation in the pavement surface.

Construct skip lines with a stripe-to-gap ratio of a 10-foot stripe to a 30-foot gap. Ensure that the length of the stripe is between 10 and 10.5 feet. Ensure that the stripe-gap cycle is between 40 and 40.5 feet.

Use Type I Tape for markings on bridge decks, JPC pavement and JPC intersections. Do not use thermoplastic materials on bridge decks, JPC pavement and JPC intersections.

714.03.01 Layout. Install all pavement markings according to Part 3 of the MUTCD and the following requirements.

Make the width of lane lines and edgelines as specified in the Plans or as the Engineer directs. Make lines for gore area markings twice the normal width line for that section of roadway.

Unless striping plans are included in the proposal or otherwise directed by the Engineer, install gore area markings as shown in Figures 3B-8 and 3B-9 of the MUTCD. Do not use the optional markings shown (transverse lines in the neutral area and dotted extension of the right edgeline).

Due to the possibility that water may be retained on the roadway by the thermoplastic edgelines, place a one foot gap every 20 feet in all thermoplastic edgelines. Do not install gaps for taped edgelines.

Offset longitudinal lines at least 2 inches from longitudinal pavement construction joints. Offset longitudinal lane lines on multi-lane highways 2 inches towards the median.

On resurfacing, pavement restoration, and pavement rehabilitation projects, prepare and keep a written record of the locations of existing pavement markings, and furnish a copy to the Engineer before removing or obliterating the markings. The Engineer will notify you of any changes to the existing markings.

Before applying the pavement marking material, pre-mark the pavement surface and obtain the Engineer's approval of the proposed location, alignment, and control guides.

714.03.02 Surface Preparation.

1) Remove existing pavement markings and clean grease, oil, mud, dust, dirt, grass, loose gravel, or other deleterious material from the surface where pavement markings are to be applied, as directed by, and by methods acceptable to, the Engineer.
2) Remove the existing pavement markings until a minimum of 90 percent of the pavement surface is uniformly exposed throughout. Ensure that the pavement surface is in proper condition for successful bonding of the pavement markings and provides a neat appearance. Do not leave any loose or flaking existing pavement markings.
3) When removing the existing pavement markings, ensure that the finished pavement surface is not damaged or left in a condition that may mislead or misdirect the motorist. Repair any damage to the pavement, pavement joint materials, or the pavement surface caused by the removal of the existing pavement markings in a manner acceptable to the Engineer. After completing these operations, use compressed air to blow clean the pavement surface of residue and debris resulting from the removal of existing pavement markings.
4) When removal of existing pavement markings and objectionable materials obscures existing pavement markings of a lane occupied by public traffic, immediately remove the residue, including dust, from the surface being treated. Obtain the Engineer's approval of the removal methods.
5) Place the final pavement markings on the same day that the existing pavement markings are removed.
6) On concrete surfaces and as the Engineer directs on older asphalt pavements, apply binder to the area where placing pavement marking material.
7) On new concrete pavement surfaces, remove the curing compound from the pavement surface before applying the binder and the pavement marking material.

714.03.03 Application.

A) Type I Tape. Apply according to the manufacturer's recommendations. When applied to concrete, cut the tape at all joints.

B) Thermoplastic. Rather than installing thermoplastic pavement markings on fresh asphalt, the Department will allow temporary striping with paint. When choosing this option, cover the temporary striping with the thermoplastic pavement markings within 30 calendar days. The Department will not require

removal of the interim pavement marking paint before applying the thermoplastic pavement markings.

Install the thermoplastic material at a minimum thickness of 90 mils on the pavement surface in a melted state at a temperature from 400 and 440 °F.

Apply additional glass beads by drop-on or pressure spray methods in sufficient quantities to obtain the retroreflectivity requirements specified in Subsection 714.03.06.

Verify the adhesion of the thermoplastic to asphalt pavements by performing bond checks, at least 4 per mile of line, as follows. Approximately 60 to 120 seconds after applying a thermoplastic line to the roadway surface, cut and lift approximately a 6-inch section of thermoplastic. The thermoplastic is successfully bonding to the pavement surface if a layer of asphalt clings to the removed thermoplastic stripe and the pavement surface under the removed stripe is shiny and black.

Provide finished markings that are continuous and uniform in shape, having clear and sharp dimensions. Ensure that all lines have well-defined edges.

714.03.04 Restrictions. Do not apply the pavement marking material when air and pavement temperatures are below 50 °F.

Do not apply the pavement marking material when the surface of the pavement contains evidence of moisture in amounts significant enough to prevent the pavement marking material from bonding to the pavement. Significant amounts of moisture can be caused by heavy dew or very humid nights as well as from rainfall.

If encountering significant amounts of moisture while applying the thermoplastic, the Contractor, at his own risk, may attempt to apply thermoplastic subject to the following restrictions. Heat the thermoplastic material to the upper temperature limit specified by the manufacturer, and apply a test line on the pavement. Perform a bond check according to Subsection 714.03.03. If the thermoplastic successfully bonds to the pavement continue to apply thermoplastic lines, provided there is evidence that the moisture is escaping through the surface of the line, as indicated by very small pin holes. If there is excessive moisture, as indicated by larger sized holes or bubbles on the surface of the line, do not apply thermoplastic until the moisture can be effectively dealt with. Perform a sufficient number of bond checks to ensure that the thermoplastic is bonding to the pavement.

714.03.05 Project Conflicts. When other construction projects are in progress within the limits of the designated work areas, install no pavement markings that will be removed or damaged by immediate subsequent construction. The Engineer will give notification of all conflicting construction projects. Schedule the installation of pavement markings after completion of the conflicting construction. When scheduling is impossible or creates an undue hardship, the Engineer will delete the intersection from this project.

714.03.06 Proving Period for Durable Markings. A 180 day proving period will follow the application of the durable markings. During this period, the Engineer will make such observations as are necessary to determine if the markings are acceptable. The proving period begins when the facility is opened to traffic.

A) Requirements.

1) Type I Tape. During the proving period, ensure that the pavement marking material shows no signs of failure due to blistering, excessive cracking, bleeding, staining, discoloration, oil content of the pavement materials, deterioration due to contact with grease deposits, oil, diesel fuel, or gasoline drippings, chipping, spalling, poor adhesion to the pavement, loss of retroreflectivity, vehicular damage, and normal wear. Type I Tape is manufactured off site and warranted by the manufacturer to meet certain retroreflective requirements. As long as the material is adequately bonded to the surface and shows no sign of failure due to the other items listed in

Subsection 714.03.06 A) 1), retroreflectivity readings will not be required. In the absence of readings, the Department will accept tape based on a nighttime visual observation.

2) Thermoplastic. During the proving period, ensure that the thermoplastic pavement marking material shows no signs of failure due to blistering, excessive cracking, bleeding, staining, discoloration, oil content of the pavement materials, smearing or spreading under heat, deterioration due to contact with grease deposits, oil, diesel fuel, or gasoline drippings, chipping, spalling, poor adhesion to the pavement materials, loss of retroreflectivity, vehicular damage and normal wear.

The minimum retroreflectivity requirements at the end of the proving period, as measured with a Department approved 30 meter geometry handheld or mobile retroreflectometer, are as follows:

White:	300 mcd/lux/square meter
Yellow:	225 mcd/lux/square meter

The Department will take these measurements between 150 and 210 days after the start of the proving period, with acceptance based on KM 202 or KM 203 as applicable. If the Department determines that the markings are acceptable, the installation of the markings will be considered complete.

B) Failure. During the proving period, the Department will consider markings defective when the retroreflectivity falls below the minimum required or the material fails to meet the other requirements of A) above. Additionally, when more than 10 percent of any one-mile section or individual gore area is defective, the Department will consider the entire section defective. The Department will consider each edge line, centerline, lane line and gore area marking separately.

C) Corrective Work. If a line is found to be defective, repair or remove and replace the line. Perform pavement marking replacement according to the requirements specified in this subsection for the initial application. The corrective work will be subject to a proving period as listed above.

714.03.07 Marking Removal. Remove all markings made in error or not conforming to the traffic operation in use. Do not paint with asphalt binder or other material to obliterate the markings. Remove pavement striping, temporary or permanent, from asphalt or concrete pavement using ultra-high pressure water. Marking removal totaling 1,000 linear feet or less may be removed by an abrasive method to the satisfaction of the Engineer. Vacuum all marking material and removal debris concurrently with the marking removal operation.

Do not damage the pavement in any way and protect all joint seals. If damage is observed, stop the removal process until the operation can provide an acceptable marking removal. Repair any damage to the pavement as a result of the marking removal. Removal of marking will not be measured for payment.

714.03.08 Acceptance of Non-Specification Thermoplastic Markings. When reasonably acceptable work has been produced but retroreflectivity requirements are not met, the Department may accept the work according to Subsection 105.04. When the Engineer determines that the markings may be left in place, the Department will accept them at a reduction in the Contract unit bid price according to Acceptance Pay Schedule for Thermoplastic.

714.04 MEASUREMENT. When a bid item is not included for gore markings, the Department will measure the quantity by converting the actual length and width of line installed to an equivalent length of the normal width line on that section of roadway.

714.04.01 Thermoplastic Pavement Markings. The Department will measure for payment by the units listed in the Quantity Summary. The Department will not measure sampling, testing, surface preparation, pre-marking, interim marking, and binder application for payment and will consider them incidental to the thermoplastic bid items. The Department will not measure corrective work for payment.

714.04.02 Durable Pavement Markings, Type I. The Department will measure for payment by the units listed in the Quantity Summary. The Department will not measure sampling, testing, surface preparation, pre-marking, and binder application for payment and will consider them incidental to the pavement marking bid items. Corrective work will not be measured for payment.

714.04.03 Pavement Striping Removal. When listed as a bid item, the Department will measure for payment by the units listed in the Quantity Summary. The Department will not measure for payment the removal of existing pavement markings that have not been authorized by the Engineer. When the Contract does not list a bid item, the Department will consider existing pavement marking removal incidental to the other pavement marking bid items. The Department will not measure for payment any corrective work required due to the removal work.

714.05 PAYMENT. The Department will make payment upon completion of the work. If after the proving period the markings do not meet minimum retroreflectivity requirements, the Department will adjust the payment or require corrective work according to the following:

ACCEPTANCE PAY SCHEDULE FOR THERMOPLASTIC		
Pay Value	White mcd/lux/square meter	Yellow mcd/lux/square meter
1.00	≥300	≥225
0.50	251-299	176-224
0.25	226-250	151-175
0.00	200-225	125-150
Remove and Replace	< 200	< 125

Code	Pay Item	Pay Unit
06540-06547	Pavement Striping - Thermoplastic, width, color	Linear Foot
06554-06561	Pavement Striping - Durable Type I Tape, width, color	Linear Foot

The Department will consider payment as full compensation for all work required under this section.

SECTION 717 — INTERSECTION MARKINGS

717.01 DESCRIPTION. Furnish and install thermoplastic or Type I tape intersection markings (Stop Bars, Crosswalks, Turn Arrows, etc.) by either a machine applied, screed extrusion process or by applying preformed thermoplastic intersection marking material.

717.02 MATERIALS AND EQUIPMENT.

717.02.01 Preformed Thermoplastic Intersection Marking Material. Select from the Department's List of Approved Materials.

717.02.02 Extruded Thermoplastic Pavement Marking Material. Conform to Section 837.

717.02.03 Binder. Conform to Subsection 714.02.03

717.02.04 Drop On Glass Beads. Use beads that will ensure the pavement marking material will meet retroreflectivity requirements. The Department will evaluate the beads as part of the marking system through retroreflectivity readings.

717.02.05 Extruded Thermoplastic Application Equipment. Provide equipment with a shaping die that simultaneously deposits and shapes lines at a minimum thickness of 90 mils on the pavement surface. Do not use spray and ribbon gun applicators.

Ensure the application equipment conforms to the following:

1) Capable of providing continuous and uniform heat to maintain the material between 400 and 440 °F throughout the mixing, conveying, and dispensing.
2) The kettle is capable of continuous agitation during mixing and heated storage and is equipped with an automatic thermostat control device and material thermometer.
3) Equipped with a cutoff device that provides clean, square stripe ends.
4) Equipped with an automatic bead dispenser.

717.02.06 Type I Tape. Conform to Section 836.

717.03 CONSTRUCTION.

717.03.01 Layout. On resurfacing, pavement restoration, and pavement rehabilitation projects, prepare and keep a written record of the locations of existing pavement markings, and furnish a copy to the Engineer before removing or obliterating the markings. The Engineer will notify you of any changes to the existing markings.

On new construction, the Department will provide more detailed information for each intersection prior to beginning work. This information will consist of plans, a drawing of each intersection, or an inspector to work with each crew to layout the markings in the field.

Before applying the pavement marking material, pre-mark the pavement surface and obtain the Engineer's approval of the proposed location, alignment, and control guides.

717.03.02 Surface Preparation. Clean all grease, oil, mud, dust, dirt, grass, loose gravel, or other deleterious material from the surface where pavement markings are to be applied as directed by, and by methods acceptable to, the Engineer.

On concrete surfaces and as the Engineer directs on older asphalt pavements, apply binder to the area where placing pavement marking material. Ensure that all solvents have evaporated from the binder before applying the marking material. On new concrete pavement surfaces, remove the curing compound from the pavement surface before applying the binder and the pavement marking material.

717.03.03 Application.

A) Thermoplastic. Install extruded thermoplastic at a minimum thickness of 90 mils on the pavement surface in a melted state at a temperature from 400 and 440 °F. Install preformed thermoplastic according to manufacturer's instructions at a minimum thickness of 125 mils. Apply additional glass beads by a drop-on method at a rate that satisfies the retroreflectivity requirements of Subsection 717.03.05.

When installing symbols and legends (turn arrows, the word "ONLY" etc.) by the extrusion process, ensure that the finished markings conform to the standard size and shape in the Manual on Uniform Traffic Control Devices.

Verify the adhesion of the thermoplastic to asphalt pavements by performing bond checks as follows. Approximately 60 to 120 seconds after applying the thermoplastic material cut and lift approximately a 6-inch section. The thermoplastic is successfully bonding to the pavement surface if a layer of asphalt clings to the removed thermoplastic and the pavement surface under the removed section is shiny and black.

Ensure that finished markings are continuous and uniform in shape having clear and sharp edges with uniform bead distribution across the entire width and length of the line, symbol, or legend.

B) Type I Tape. Apply according to the manufacturer's recommendations. Cut all tape at pavement joints when applied to concrete surfaces.

717.03.04 Restrictions. Do not apply the pavement marking material when air and pavement temperatures are below 50 °F.

Do not apply the pavement marking material when the surface of the pavement contains evidence of moisture in amounts significant enough to prevent the pavement marking material from bonding to the pavement. Significant amounts of moisture can be caused by heavy dew or very humid nights as well as from rainfall.

If encountering significant amounts of moisture while applying the thermoplastic, the Contractor, at his own risk, may attempt to apply the thermoplastic material subject to the following restrictions. Heat the thermoplastic material to the upper temperature limit specified by the manufacturer, and apply a test line on the pavement. Perform a bond check according to Subsection 717.03.03. If the thermoplastic successfully bonds to the pavement continue to apply thermoplastic material, provided there is evidence that the moisture is escaping through the surface of the material, as indicated by very small pinholes. If there is excessive moisture, as indicated by larger sized holes or bubbles on the surface of the material, do not apply thermoplastic until the moisture can be effectively dealt with. Perform a sufficient number of bond checks to ensure that the thermoplastic is bonding to the pavement.

717.03.05 Proving Period. A proving period of 180 days will follow the application of the durable markings. During this period, the Engineer will make such observations as are necessary to determine if the markings are acceptable. The proving period begins when the facility is opened to traffic.

A) Requirements.

1) Thermoplastic. During the proving period, ensure that the material shows no signs of failure due to blistering, excessive cracking, bleeding, staining, discoloration, oil content of the pavement materials, smearing or spreading under heat, deterioration due to contact with grease deposits, oil, diesel fuel, or gasoline drippings, chipping, spalling, poor adhesion to the pavement materials, loss of retroreflectivity, vehicular damage and normal wear.

The minimum retroreflectivity requirements at the end of the proving period, as measured with a Department approved 30 meter geometry handheld retroreflectometer, are as follows:

White: 300 mcd/lux/square meter
Yellow: 225 mcd/lux/square meter

The Department will take these measurements between 15 and 45 days after the start of the proving period, with acceptance based on KM 201. If the Department determines that the markings are acceptable, the installation of the markings will be considered complete.

2) Type I Tape. During the proving period, ensure that the pavement marking material shows no signs of failure due to blistering, excessive cracking, bleeding, staining, discoloration, oil content of the pavement materials, drippings, chipping, spalling, poor adhesion to the pavement, loss of retroreflectivity, vehicular damage, and normal wear. Type I Tape is manufactured off site and warranted by the manufacturer to meet certain retroreflective requirements. As long as the material is adequately bonded to the surface and shows no signs of failure due to the other items listed in Subsection 714.03.06 A) 1), retroreflectivity readings will not be required. In the absence of readings, the Department will accept tape based on a nighttime visual observation.

B) Failure. The Department will consider any marking defective when the readings for that marking do not satisfy the retroreflectivity requirements or more than 10 percent of the material fails to meet the other requirements of A) above. The Department will consider each marking separately.

C) Corrective Work. If any marking is found to be defective, repair or remove and replace the marking. Perform pavement marking replacement according to the requirements specified in this subsection for the initial application. The corrective work will be subject to a proving period as listed above.

717.03.06 Marking Removal. Remove all markings made in error or not conforming to the traffic operation in use. Remove markings by water blasting process to the satisfaction of the Engineer. Vacuum all marking material and removal debris concurrently with the removal operation. Do not paint with asphalt binder or other material to obliterate the markings.

A) Waterblast Stripe Removal. Conform to subsection 713.03.04.

717.03.07 Acceptance of Non-Specification Markings. When reasonably acceptable work has been produced but retroreflectivity requirements are not met, the Department may accept the work according to Subsection 105.04. When the Engineer determines that the markings may be left in place, the Department will accept them at a reduction in the Contract unit bid price according to Acceptance Pay Schedule for Thermoplastic. The Department will not consider these procedures a means to continue accepting non-specification markings.

717.04 MEASUREMENT. The Department will measure the intersection markings on a per unit basis for items listed in the Quantity Summary.

The Department will not measure the removal of existing markings, layout, surface preparation, binder, glass beads, or testing for payment and will consider them incidental to the installation of the new marking. The Department will exclude the gaps when measuring dotted lane line extensions.

717.05 PAYMENT. The Department will make payment for the completed and accepted quantities under the following:

ACCEPTANCE PAY SCHEDULE FOR THERMOPLASTIC		
Pay Value	White mcd/lux/square meter	Yellow mcd/lux/square meter
1.00	≥300	≥225
0.50	251-299	176-224
0.25	226-250	151-175
0.00	200-225	125-150
Remove and Replace	< 200	< 125

Code	Pay Item	Pay Unit
06565, 06566	Pavement Marking, Thermoplastic X-Walk, Size	Linear Foot
06567, 06568	Pavement Marking, Thermoplastic Stop Bar, Size	Linear Foot
06569	Pavement Marking, Thermoplastic Cross Hatch	Square Foot
06572	Pavement Marking, Dotted Lane Extension	Linear Foot
06573-06575, 06578	Pavement Marking, Thermoplastic Arrow, Type	Each
06576	Pavement Marking, Thermoplastic “ONLY”	Each
06577	Pavement Marking, Thermoplastic “SCHOOL”	Each
06563	Pave Marking – R/R X Bucks 16 IN	Linear Foot
20782NS714	Pave Marking Thermo – Bike	Each
23251ES717	Pave Mark TY I Tape X-Walk, Size	Linear Foot
23264ES717		
23252ES717	Pave Mark TY I Tape Stop Bar, Size	Linear Foot
23265ES717		
23253ES717	Pave Mark TY I Tape Cross Hatch	Square Foot
23254ES717	Pave Mark TY I Tape Dotted Lane Extension	Linear Foot
23255ES717	Pave Mark TY I Tape Arrow, Type	Each
23268ES717-23270ES717		
23256ES717	Pave Mark TY I Tape- ONLY	Each
23257ES717	Pave Mark TY I Tape- SCHOOL	Each
23266ES717	Pave Mark TY 1 Tape R/R X Bucks-16 IN	Linear Foot
23267ES717	Pave Mark TY 1 Tape-Bike	Each

The Department will consider payment as full compensation for all work required under this section.

DISTRICT WIDE STRIPING CONTRACTS

Waterborne Traffic paint

District Wide Striping

- Maintenance striping – one contractor stripes routes for the entire district as specified in the pre-construction meeting

District Wide Striping

- Materials will be covered in another section
- Equipment and Surface Preparation
- Quality Control/Quality Assurance
- Dispute Resolution
- Application of Striping
- Marking Removal
- Retroreflectivity Requirements
- Scheduling
- Measurement and Payment

District Wide Striping Topics

- **Electrical counter**
  - Tabulate the amount of footage applied by each striping gun
- **Data logger system – recorded in 1 mile increments**
  - Gallons of paint per mile
  - Average wet film thickness
  - Pounds of beads per gallon of paint
  - Ambient temperature
  - Pavement temperature
  - Paint temperature
  - Store the calibration parameters
  - Remote cab mounted display indicating parameters in real time

Equipment and Surface Preparation

- **Sweeping Unit**
  - Remove dirt and debris
  - Shall not be a part of the striper
  - Broom must maintain contact with the roadway

Equipment and Surface Preparation

- KM 64-267
  - Stripers available at a central location for inspection
  - Stripers pre-approved prior to striping
  - Random field verifications

Equipment and Surface Preparation

QC/QA Requirements

- **Quality Control Coordinator (QC)**
  - Designated by the contractor
  - Performs QC Inspection
- **Quality Control Plan**
  - Furnished and approved prior to the start of work
- **Quality Assurance Inspector (QA)**
  - Designated by the state
  - Performs QA Inspection

QC Coordinator

- Hold qualification as a Pavement Marking Inspection Technician
- Oversee contractor's evaluation of applied lines
- Submit electronic Daily Striping Reports and Data Logger Spreadsheets within 24 hours of the application of striping
- Notify Engineer of changes to the striping application process

QC Coordinator (cont.)

- Inform/mobilize crews to complete restriping or corrective work
- Supply certifications at the time of sampling
- Track quantities of materials
- Meet with the Engineer to conduct field reviews
- Coordinate and review/perform KM202 and provide electronic test reports to the Engineer

Quality Control Plan

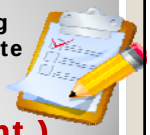
- **Identifies QC Coordinator and other Pavement Marking Inspection Technicians**
  - Names and addresses
  - Phone and fax numbers
- **Work Plan**
  - Starting and completion dates
  - Number of crews
  - General description of how the project will be completed

Quality Control Plan (cont.)

- **Description of striping equipment**
  - Make and model of each striper
  - Minimum and maximum operating speeds
  - Instruments used to calibrated flow of paint and beads
- **Frequency and method of monitoring application rates and quality of line**
- **Materials list**
  - List of paint and beads
  - Manufacturer's recommendations for application

Quality Control Plan (cont.)

- **Contact person for paint on vehicle claims**
  - Email
  - Phone and fax numbers
- **Description and product literature for reflectometers to be used on the project**
- **Submit manufacturer's sampling procedure for sampling from tote**



- **Perform testing on at least one segment of each section for verification of QC testing**
  - Randomly select at least one segment
  - Test in accordance with KM202
  - Perform testing within two weeks of receiving QC report

QA Inspector

- **Base payment on QC results if QC and QA mean values differ by less than 10%**

Dispute Resolution

1. **Do the QC and QA results differ by more than 10% within a segment and indicate a change in pay?**
   - Additional readings are required
   - Discard original QC and QA test results for the section
   - QA will randomly establish 3 new zones in each segment of the section
   - QC and QA will jointly evaluate each new zone within the section
   - ➢ Accept QC test results if the mean values differ by less than 10%

Dispute Resolution

2. **Do the QC and QA results differ by more than 10 % but there is no change in pay?**
   - Additional Readings will not be required
   - Accept the QC test results
   - Determine the cause of the discrepancy
   - Document resolution to the discrepancy

Dispute Resolution

Dispute Resolution

- 3. **Can a resolution not be achieved by the QC and QA?**
  - Additional testing within 2 weeks of written request
  - Three (3) new zones in each segment of the section
  - Calibrate QC, QA and CO instruments
  - Accept QC: QC < 10% to CO
  - Accept QA:QC > 10% to CO and QA < 10% to CO
  - Accept CO:QC and QA > 10% to CO

- Contractor will incur all costs associated with dispute resolution that does not results in use of QC test data for payment
- Department reserves the right to take over the QC portion of testing; the contractor will incur the cost of testing performed by the Department

Dispute Resolution

- **Vendor evaluating markings by KM203 must demonstrate compliance to quality control procedures**
  - Department will select test site
  - Joint evaluations conducted for both white and yellow markings
  - Vendor deemed compliant if mean averages differ by less than 10% for each marking
  - ➢Payment for evaluation by KM203 will be based solely on the Department's approved vendor

Dispute Resolution

- Paint must be applied in a single pass at an application rate in accordance with Section 713.03.03
- No bead application rate
- Contractor responsible for protecting paint line

Application of Striping

- Engineer may stop the striping operation for unsatisfactory quality including but not limited to
  - Retroreflectivity
  - Bead distribution
  - Paint thickness
  - Overspray
  - Accuracy of retracing
  - Line width
  - Consistency
  - Tracking

Application of Striping

Cleaning of Applied Stripe

- May clean prior to QC testing
- Cleaning – single pass using a broom truck
- Notify the Engineer 48 hours prior to performing cleaning operations

Marking Removal

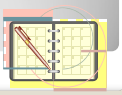
- Water blasting only
- Begin corrective within 5 working days and work continuously

Retroreflectivity Requirements

- **Section 713**
  - White: 300 mcd/m²/lux
  - Yellow: 225 mcd/m²/lux

Scheduling Deadlines

- Derby routes (District 5)
- Priority routes– June 1, 2013
- Additional routes added by– July 1, 2013
- Scheduled routes– September 1, 2013
- Re-Striping– October 15, 2013



Re-Stripe

- Re-stripe -completed within 15 calendar days of notification by the Engineer
- If a section is not accepted, the entire section must be re-striped

Additional Testing Costs

- Cost of re-testing by KM203 shall be reimbursed to the Department by the contractor
- Costs associated with additional testing for dispute resolution shall be incurred by the contractor if the QC results are not used for payment

Measurement and Payment

- Initial payment
  - 70% upon application of stripe
- Final payment
  - Section is accepted – 30%
  - Section is not accepted – required restripe

SPECIAL NOTES FOR WATERBORNE PAINT STRIPING
AND DURABLE WATERBORNE STRIPING
DISTRICT WIDE CONTRACTS

DESCRIPTION

Work performed under this contract shall be in conformance with Commonwealth of Kentucky, Transportation Cabinet, Department of Highways' Standard Specifications for Road and Bridge Construction, 2012 Edition, applicable Special Provisions, Kentucky Methods, general notes, specifications included in this proposal and the Standard Drawings, 2012 Edition.

SCOPE OF WORK

The work performed under this contract shall consist of furnishing and applying waterborne striping paint for 4 inch lines and durable waterborne striping paint for 6 inch lines reflectorized with glass beads, to the sections of roadway provided in this contract with an updated listing provided at the pre-construction meeting. This contract is for the installation of centerlines, lane lines, edgelines, ramp lines, dotted lines and gore markings only. Gore marking materials shall be the same as the mainline of the roadway. Special markings such as stop bars, crosswalks, cross-hatching, railroad markings, etc. are not to be installed under this contract.

Intersection approach markings such as the edgelines of large painted islands or edgelines on mountable medians may be included at the discretion of the Engineer provided they can be painted by the striping truck. Markings that would require application by equipment other than the striping truck are not to be installed under this contract.

The vast majority of the work performed under this contract will consist of retracing existing lines. The Department will be responsible for pre-marking any section of roadway where the old markings are no longer visible or where the existing markings are to be changed. Edgelines shall not be installed on any section of roadway where edgelines do not currently exist without written authorization from the Chief District Engineer.

MATERIALS FOR WATERBORNE AND DURABLE WATERBORNE PAINT STRIPING

Select Materials for this project to meet the performance requirements detailed in **Section 842 and 846 of the Standard Specifications**. Initial samples for each formulation must be submitted for approval prior to initiation of the striping operation. The initial sample may be sent directly to the Department from the manufacturer of the paint.

Samples of paint will be obtained by the Department in accordance with the Materials Field Sampling Manual when striping operations are in progress. A minimum of one sample will be obtained per color, per truck, per week and shall represent the quantity of striping applied per week. Deductions for application of non-specification paint shall be assessed to the quantity of striping represented by the sample.

BEADS: The Department will evaluate beads as part of the installed pavement marking in accordance with Kentucky Method 202 or 203 as applicable. Testing of the coatings, gradation and quality of the product applied shall be the responsibility of the contractor.

MATERIALS SAMPLING AND ACCEPTANCE

If two or more random samples obtained during striping operations fail to meet minimum compositional requirements, striping operations shall be discontinued at the discretion of the Engineer. In the event striping operations are discontinued, the Department will randomly sample and test each batch of paint the contractor has in stock at the storage location.

For batches of paint that fail to meet the minimum compositional criteria, the stock material will be rejected. The contractor will be required to remove all failing paint from his central storage location. Batches that are tested and found to be in compliance with the compositional requirements may be used. After the Department has sampled all of the material at the central storage area, sampling and testing will resume according to the Materials Field Sampling Manual as soon as striping operations resume.

A deduction in payment will be made for any paint that fails to meet the material requirements of **Section 842 and 846 of the Standard Specifications**.

EQUIPMENT

Each striper shall be equipped with electrical foot counters. The counters shall individually tabulate the amount of footage applied by each striping gun on the carriage, whether solid or dashed. The counters shall be capable of measuring up to six digits and shall have a reset feature. The counters shall be calibrated in the presence of the Engineer to insure an accurate measurement of the paint applied.

Each striper shall be equipped with an accurate dashing mechanism, capable of being adjusted to retrace existing lane line, dotted lines or centerline markings as directed by the Engineer. The striper shall also be equipped with a detection device that will automatically cutoff the paint guns when a raised pavement marker is detected in the pavement. The Contractor, at his own expense, shall replace or adequately clean any pavement marker lens that is painted.

The Contractor's **striper shall be equipped** with a **Data Logger System**. The Data Logger shall monitor and report the quantities of paint and beads consumed in line. The data logger shall calculate, in real time, the gallons of paint per mile, average wet film thickness, and pounds of beads per gallon of paint for each line application. The Data Logger shall monitor and report the ambient temperature, pavement temperature, and paint temperature. The data shall be recorded at the beginning of each line application and at a minimum of 1 mile increments during application. The Data Logger shall be capable of storing and supplying the necessary scaling and calibration parameters to the flow meters, and shall provide a means of adjusting the scaling factor as

necessary. The Data Logger shall include a remote cab mounted display, which shall indicate in real time, pavement temperature, application rate of paint in gallons per mile, paint film thickness in mils, and application rate of beads in pounds per gallon. In addition the Contractor's striper shall also be equipped with a calibrated measuring device for monitoring quantities of paint and beads consumed in line. A data logger report, as an Excel spreadsheet, shall be submitted to the engineer with each Daily Striping Report (DSR) containing the following information; route, line type, line width, line color, direction of application, weight of paint applied in pounds or number of strokes counted, appropriate scaling factors, paint film thickness in mils, paint application rate in gallons per mile, bead application rate in pounds per gallon, paint temperature obtained immediately after the heat exchanger, ambient temperature, pavement temperature, and vehicle speed in miles per hour. Application and temperature data shall be reported in one-mile increments for each line applied. **The Department reserves the right to obtain any and all raw data recorded by the Data Logger at any time during this contract.**

Prior to starting striping operations, all stripers shall be made available at a central location within Kentucky for inspection by the Department for compliance to Kentucky Method 64-267. Striping trucks that can fulfill the requirements of this method and these notes will be approved for use on this contract. Striping trucks that have not been approved for use by Department personnel will not be allowed to stripe as part of this contract. The Department reserves the right to perform random field verifications of striping equipment during this contract.

The Contractor shall provide a separate sweeping unit powerful enough to remove normal highway dirt and debris. This unit shall not be a part of the striper.

The Engineer may require the Contractor to provide detailed operating instructions from the manufacturer of the striping equipment if quality issues arise at any time during the contract. The Contractor shall then be required to operate the striping equipment within the suggested operating guidelines of the manufacturer, with particular emphasis on the speed of the striping operation, or make other adjustments until the quality of the striping is satisfactory to the Engineer.

CONSTRUCTION

SURFACE PREPARATION

Prepare the pavement surface for the striping operation in accordance with **Section 713.03.02 of the Standard Specifications**. All pavement surfaces shall be swept prior to striping and the cleaning operation shall be far enough in advance of the striping operation to prevent any dust from the cleaning operation from mixing with the paint. The sweeper must maintain contact with the roadway. When the Engineer determines abnormal amounts of debris or other material have accumulated beyond the capability of the required sweeping unit which will require shoveling or other means to remove, the Engineer will make arrangements, prior to painting, to have the material removed by the Department or that section of roadway will be deleted from the contract.

QUALITY CONTROL/QUALITY ASSURANCE

The Contractor shall designate a Quality Control Coordinator (QC) for the project who will be the contact person for any questions or concerns regarding the quality of the work performed under this contract. The Quality Control Coordinator shall:

- Hold current qualification from the Department as a Pavement Marking Inspection Technician
- Plan and oversee the Contractor's evaluation of the lines applied on the project
- Complete and submit Daily Striping Reports and Data Logger spreadsheets (electronic copies) to the Engineer within 24 hours of completion of that days striping
- Coordinate and review or Perform KM-202, for each section of striping and provide completed test reports (electronic copy) along with printouts from the handheld retroreflectometer to the Engineer within one (1) working day of completion
- Document all adjustments made to the application process to consistently produce the quality of line desired
- Notify the Engineer of any changes in the striping work plan that are determined necessary
- Inform and mobilize crews to complete restriping or corrective work (after notification by the Department)
- Supply the appropriate certifications for paint to the Engineer assigned to the particular project at the time of sampling
- Track the quantities of materials supplied by the vendors and applied by the painting crew
- Meet with the Engineer to discuss and/or conduct field reviews on the project throughout the execution of the contract.

Quality control testing in accordance with KM-202 will be performed for each section of striping on zones selected by the Department based on KM-64-113.

At the Pre-construction Conference, the Contractor shall furnish the Department a quality control plan that covers in detail the following items:

- The name, address, phone and fax numbers for the Quality Control Coordinator
- The names of individuals other than the Quality Control Coordinator taking readings in accordance with KM202 (these people shall hold qualification from the Department as Pavement Marking Inspection Technicians)
- An overall work plan which states the estimated starting and completion dates for the entire project, the number of crews to be used on the project and a general description of how the project will be completed
- A description of the striping equipment to be used on the project, including make and model of each striper, minimum and maximum operating speeds, and type of instruments to be used to calibrate the flow of paint and beads
- The frequency and method to be used to monitor application rates and quality of the line (specifically with regard to retroreflectivity, width, thickness, bead distribution, tracing accuracy, etc.)
- A list of paint(s) and bead(s) to be used in this contract along with a statement from the paint

manufacturer that indicates the recommended minimum and maximum application temperatures for ambient temperature, pavement temperature, paint temperature, and guidelines for any other environmental factors that would adversely affect the successful performance of the paint

- The contact person, phone, e-mail and fax numbers for reporting claims for paint on vehicles
- Submit the description and product literature of the reflectometer to be used to the Engineer assigned to the project for approval
- Submit a manufacturer's sampling procedure for sampling from tote

Acceptance of the Contractor's quality control plan is required prior to the start of work. The Department reserves the right to require the Contractor to make changes in the quality control plan and operations to obtain the quality specified in the contract.

After acceptance by the Department, the Contractor shall notify the Engineer in writing of any proposed change. Proposed changes are subject to acceptance by the Department.

The Department will provide the locations of randomly selected zones for QC testing for each section of striping within two weeks of receipt of the Daily Striping Report.

The Department will perform Quality Assurance (QA) testing on (at least) one segment of each section of striping completed by the Contractor. QA testing is intended to verify the Contractor's QC test data. Upon receipt of the Contractor's test report for each section, the QA Inspector will randomly select (at least) one segment for evaluation and test in accordance with KM202 with the exception that QA testing will be conducted within 2 weeks of receipt of the QC report.

The Department will base payment for each section evaluated in accordance with KM-202 on the Contractor's QC test results if the QC and QA mean values for each segment selected for QA testing differ by less than 10% of the QA mean value.

If a dispute should arise regarding the acceptability of the Contractor's QC test results the dispute resolution shall be conducted as follows:

1. If the retroreflectivity values obtained during the QA testing within a segment indicate a change in pay quantities (i.e. QC readings are passing and QA readings are failing) and the mean values differ by more than 10 % of the QA mean value; additional testing will be required. Discard the original QC and QA test results for the section in question. The QA will randomly establish three new zones, in accordance with KM-113, in each segment within the section in question. The QC and QA will jointly evaluate each new zone within the section in accordance with KM-202 (with the exception of the evaluation period if greater than 60 days). The QC test results for each segment will be used for evaluation of the section if the QC and QA mean values for each segment differ by less than 10% of the QA mean value.

2. If the variance between QC and QA testing does not indicate a change in the pay quantities for the section (i.e. QC and QA readings are both passing) however, the QC mean values differ by more than 10% of the QA mean value: additional readings will not be required.

Accept the QC test results for evaluation of the section. However, additional testing within the section in question should be conducted as soon as possible to determine the cause of the discrepancy. Resolution to the discrepancy should be documented.

3. If resolution to a dispute or variance of QC and QA test results cannot be achieved by the QC and QA, additional testing will be required. Discard the QC and QA test results for the section in question. Additional testing will be conducted by the QC, QA, and representatives of Central Office Division of Materials. Additional testing will be conducted within two weeks of receipt of a written request from the Engineer to the Division of Materials for each section in question. Three new zones, randomly selected in accordance with KM-113, will be established by the QA for each segment of the section in question. Each instrument to be used for testing will be calibrated in the presence of Central Office representatives prior to initiation of testing. The QC, QA and Central Office representatives will obtain readings for each new zone in accordance with KM-202 (with the exception of the evaluation period if greater than 60 days). The QC test results for each segment will be used for evaluation of the section if the QC mean values for each segment differ by less than 10% to the mean value obtained by Central Office. The QA test results for each segment will be used for evaluation of the section if the QC mean values differ by more than 10% to the mean value obtained by Central Office and the QA mean value differs by less than 10% to the Central Office mean value. If neither the QC nor QA mean values meet these requirements, the Central Office mean value for each segment will be used to evaluate the section in question. These results will be final and the basis of payment for the section in question.

The Contractor will incur all costs associated with additional testing performed by Department personnel for dispute resolution that does not result in the use of QC test data as the basis of payment. These costs will include the cost of maintenance and control of traffic.

The Department reserves the right to take over the QC portion of testing. In the event that the Department exercises this option, the Contractor will incur the cost of testing performed by the Department.

The Department reserves the right to evaluate designated routes, in whole or in part, in accordance with KM-203. The Department will identify routes or portions of routes to be evaluated in accordance with KM-203 at the Pre-construction Conference. Any section of striping which includes a designated route, in whole or in part, will be evaluated in accordance with KM-203. The evaluation of a section in accordance with KM-203 will be conducted at the Departments expense.

The Department will require the approved vendor performing retroflectivity evaluation in accordance with KM-203 to successfully demonstrate compliance to his/her quality control procedures prior to collection of data for this contract. The Department will select an appropriate test site for demonstration purposes and conduct joint evaluations of both yellow and white longitudinal markings within the test site using approved 30M geometry handheld instruments. The demonstration will be deemed successful if the mean average obtained by the approved vendor differs by less than 10% to the mean average obtained by the Department for each marking evaluated within the test site.

The Department will base payment for each section evaluated in accordance with KM-203 solely on the test results obtained by the Department's approved vendor. Completed test results submitted by the Department's approved vendor will be considered final and are not subject to dispute.

The Department will furnish the Contractor with a blank electronic copy of the Contractors Daily Striping Report (DSR). The Contractor shall complete and furnish this standard DSR to the Engineer's office daily for each crew for each color and width of line applied. The information on the DSR shall reflect the milepoints and quantities for striping completed for that day and for that crew. The Contractor shall also include with the DSR the certification for the paint used on that day's striping. (Sample attached)

APPLICATION OF STRIPING

Roadways shall be marked with 4", 6", 8" and 12" lines as indicated in the plans. The four-inch line shall not be less than four inches nor more than five inches in width. The six-inch line shall not be less than six inches nor more than seven inches in width. The centerline of all newly applied lines shall be within one inch of the centerline of the existing stripe. All of the Interstate and Parkway system shall be marked with six-inch lines using Durable Waterborne paint. Gore area markings shall be installed at twice the width of the normal line width on that portion of roadway. All lines shall have distinct, clean edges with proper bead distribution across the entire width and length of the line.

Passing zones and lane lines shall be installed as a 10' segment of paint with a 30' gap. The length of the 10' segment shall not be less than 10' nor longer than 10 feet 6 inches. The stripe-gap cycle shall not be less than 39 feet 6 inches and no longer than 40 feet 6 inches.

Apply paint, in a single pass, at an application rate in accordance with the application rate in Supplemental Specification 713.03.03. Bead application rate is at the discretion of the contractor and must meet retroreflectivity requirements.

The Contractor shall be responsible for protecting the painted line from traffic until dry in order to eliminate tracking. Retroreflectivity readings will be taken on zones with substantial amounts of tracking and the readings will be used in the calculation of payment. If the contractor elects to use additional traffic control devices beyond what is specified in the TRAFFIC CONTROL PLAN, the additional cost shall be incidental to the bid item "Maintain and Control Traffic. "

If the Engineer determines that the quality of the striping applied by the Contractor is unsatisfactory with regard to retroreflectivity, bead distribution, paint thickness, overspray, accuracy of retracing, line width, consistency, tracking, etc., the Engineer may stop the striping operation immediately until the Contractor can demonstrate that the problem has been corrected. **If it is determined by the Engineer that the striping is not applied at the specified application rate, restriping will be required.** Striping errors shall be handled as below.

CLEANING OF APPLIED STRIPING

The contractor has the option to clean accumulated debris from affected route prior to performing QC testing. Cleaning is defined as a single pass using the broom truck to remove accumulated debris from the affected striping. Notify the Engineer 48 hours prior to performing the cleaning operations.

MARKING REMOVAL

Any striping error (including tracking) that requires removal of a line applied by the Contractor shall be removed, at the Contractor's expense, by water blasting only. This removal process shall be done in a manner that shall not be detrimental to the pavement. Upon notification of a striping error by the Engineer, the Contractor shall be required to begin the process of correcting the striping error within five working days and shall work continuously to complete the corrective work prior to striping any other section of roadway included in this contract. Liquidated damages, as outlined in **Section 108.09 of the Standard Specifications**, shall apply for each day beyond the five working days that the Contractor has not begun to correct the striping error or continuously worked to complete the corrective work. The Contractor shall be responsible for all necessary cleanup of any paint or other material that is spilled onto the pavement or elsewhere as a result of his operations.

The Engineer will notify the Contractor if existing striping errors need to be removed. Contrary to the Standard Specifications, striping removal shall be done by water blasting only (see attached notes) and will be paid in linear feet.

PAINT ON VEHICLES

The Contractor shall be responsible for addressing disputes with the public regarding paint on vehicles that occur as a result of his operations. All complaints from the public shall be addressed in a timely manner and the Contractor must demonstrate a “good faith” attempt to resolve disputes to the satisfaction of the citizen. However, the Contractor shall have the right to dispute fault and refuse settlement in cases where the Contractor feels that paint on the vehicle was a result of negligence on the part of the citizen. Unresolved disputes involving paint on vehicles shall be handled through the legal system. The Department shall not be held responsible for paint on vehicles under any circumstances.

RETROREFLECTIVITY REQUIREMENTS

The minimum retroreflectivity requirements shall be in accordance with **Section 713.03.05A of the Standard Specifications**.

Restriping will be required for striping that fails to meet the minimum retroreflectivity requirements. The provisions for restriping are described in the section of this contract entitled MEASUREMENT AND PAYMENT. Complete restriping within 15 calendar days after notification by the Engineer except that no striping will be performed after **October 15, 2013**. All aspects of this specification shall apply to lines that are repainted due to failure to meet the requirements of this specification including the retroreflectivity requirements.

Liquidated damages, as outlined in **Section 108.09 of the Standard Specifications**, shall be assessed for each day beyond the 15 calendar days that repainting is not completed and shall accrue until the **October 15, 2013** deadline. At that point, no additional striping will be performed and payment will be based upon the Payment Schedule.

SCHEDULING

At the Pre-construction conference, the Engineer shall provide the contractor with a list of priority routes (not to exceed 10 percent of the total project estimate) which are to be striped prior to **June 1, 2013**. The painting of all scheduled routes shall be completed by **September 1, 2013.** The Contractor shall be assessed liquidated damages as outlined in **Section 108.09 of the Standard Specifications** for each calendar day that any of the scheduled routes are not striped with all lines.

The Contractor shall coordinate the daily striping schedule, one week in advance, with the Engineer. **The Contractor shall ensure that once striping begins on a section that ALL striping on that section must be completed within two weeks.** Failure to comply with this requirement will result in withholding of pay estimates.

The Engineer may eliminate any route from the schedule if it is determined that the route does not require retracing. Also, the Engineer may add additional routes to be striped. The Contractor shall be notified of these routes prior to July 1, 2013. Contrary to Section 104.02.02 of the Standard Specification, the overrun and underrun formula shall not apply to this contract.

CONTRACT COMPLETION AND LIQUIDATED DAMAGES

All routes that are required to be striped under this contract shall be completed by September 1, 2013. Contrary to specifications, no time extension will be granted. Liquidated damages will apply in accordance with **Section 108.09 of the Standard Specifications** for failure to complete the striping by September 1,2013. Liquidated damages will accrue until October 15, 2013; no striping shall be performed after this date.

All priority routes shall be striped by June 1, 2013. Contrary to specifications, no time extension will be granted for failure to complete striping of these priority routes by the June 1, 2013

milestone completion date. Liquidated damages will apply in accordance with **Section 108.09 of the Standard Specifications**.

Sections that are required to be re-striped must be completed within 15 calendar days after notification by the Engineer. All re-striping must be complete by October 15, 2013. Failure to complete all necessary corrective work by the October 15, 2013 deadline will result in no additional payment for the stripe beyond the 70% that was initially paid for the installation of the stripe.

RE-TESTING OF FAILURES

Costs associated with re-testing of striping failures for Kentucky Method 203 shall be reimbursed to the Department by the contractor. The reimbursement shall include mobilization of the mobile testing machine as well as the current per mile rate for the mobile striping contractor in accordance with the Cabinet's master agreement.

MEASUREMENT AND PAYMENT

The Department will measure the quantity in linear miles. When a bid item is not included for 8-inch or 12-inch lines, the Department will measure the quantity at twice the rate for a 4-inch line when an 8-inch line is applied or twice the rate for a 6-inch line when a 12-inch line is applied.

Full payment to the Contractor for each bid item 4" and 6" PAVE STRIPING WB (COLOR) will be based upon successful compliance with the retroreflectivity requirements outlined in this contract. The Contractor will be paid 70% of the payment for the bid item after application of striping to a particular section of roadway. The remaining payment will be made based upon the following procedure and the Payment Schedule:

Each section of striping will be evaluated in accordance with KM 202 or KM 203, as applicable, for the purpose of evaluating retroreflectivity.

1. Section is accepted in accordance with the appropriate Kentucky Method.

2. If a section is not accepted, the contractor will be required to restripe the entire section at no additional cost to the Department. The restriping will be subject to the same requirements as the original striping.

- If time does not allow for the section to be restriped, accept deduction in payment for the section that has been determined to be unacceptable.

Payment Schedule

	Initial Payment	Final Payment	Total Payment
Section is Accepted	70%	30%	100%
Section is Not Accepted	70%	0%	70%

MAINTAIN AND CONTROL TRAFFIC

See special note for Maintain and Control Traffic.

Items not listed as a bid item shall be considered incidental to other items of work.

Supplemental Specifications to the
Standard Specifications for Road and Bridge Construction, 2012 Edition
Effective with the December 14, 2012 Letting

Subsection: **Revision:**	206.04.01 Embankment-in-Place. Replace the fourth paragraph with the following: The Department will not measure **suitable** excavation included in the original plans that is disposed of for payment and will consider it incidental to Embankment-in-Place.
Subsection: **Revision:**	213.03.02 Progress Requirements. Replace the last sentence of the third paragraph with the following: Additionally, the Department will apply a penalty equal to the liquated damages when all aspects of the work are not coordinated in an acceptable manner within 7 calendar days after written notification.
Subsection: **Part:** **Number:** **Revision:**	402.03.02 Contractor Quality Control and Department Acceptance. D) Testing Responsibilities. 4) Density. Replace the second sentence of the Option A paragraph with the following: Perform coring by the end of the following work day.
Subsection: **Revision:**	403.02.10 Material Transfer Vehicle (MTV). Replace the first sentence with the following: In addition to the equipment specified above, provide a MTV with the following minimum characteristics:
Subsection: **Revision:**	412.02.09 Material Transfer Vehicle (MTV). Replace the paragraph with the following: Provide and utilize a MTV with the minimum characteristics outlined in section 403.02.10.
Subsection: **Revision:**	412.03.07 Placement and Compaction. Replace the first paragraph with the following: Use a MTV when placing SMA mixture in the driving lanes. The MTV is not required on ramps and/or shoulders unless specified in the contract. When the Engineer determines the use of the MTV is not practical for a portion of the project, the Engineer may waive its requirement for that portion of pavement by a letter documenting the waiver.
Subsection: **Revision:**	412.04 MEASUREMENT. Add the following subsection: 412.04.03. Material Transfer Vehicle (MTV). The Department will not measure the MTV for payment and will consider its use incidental to the asphalt mixture.
Subsection: **Part:** **Number:** **Revision:**	606.03.17 Special Requirements for Latex Concrete Overlays. A) Existing Bridges and New Structures. 1) Prewetting and Grout-Bond Coat. Add the following sentence to the last paragraph: Do not apply a grout-bond coat on bridge decks prepared by hydrodemolition.

Subsection: **Revision:**	609.03 Construction. Replace Subsection 609.03.01 with the following: 609.03.01 A) Swinging the Spans. Before placing concrete slabs on steel spans or precast concrete release the temporary erection supports under the bridge and swing the span free on its supports. 609.03.01 B) Lift Loops. Cut all lift loops flush with the top of the precast beam once the beam is placed in the final location and prior to placing steel reinforcement. At locations where lift loops are cut, paint the top of the beam with galvanized or epoxy paint.
Subsection: **Number:** **Revision:**	613.03.01 Design. 2) Replace "AASHTO Standard Specifications for Highway Bridges" with "AASHTO LRFD Bridge Design Specifications"
Subsection: **Revision:**	615.06.02 Add the following sentence to the end of the subsection. The ends of units shall be normal to walls and centerline except exposed edges shall be beveled ¾ inch.
Subsection: **Revision:**	615.06.03 Placement of Reinforcement in Precast 3-Sided Units. Replace the reference of 6.6 in the section to 615.06.06.
Subsection: **Revision:**	615.06.04 Placement of Reinforcement for Precast Endwalls. Replace the reference of 6.7 in the section to 615.06.07.
Subsection: **Revision:**	615.06.06 Laps, Welds, and Spacing for Precast 3-Sided Units. Replace the subsection with the following: Tension splices in the circumferential reinforcement shall be made by lapping. Laps may not be tack welded together for assembly purposes. For smooth welded wire fabric, the overlap shall meet the requirements of AASHTO 2012 Bridge Design Guide Section 5.11.2.5.2 and AASHTO 2012 Bridge Design Guide Section 5.11.6.3. For deformed welded wire fabric, the overlap shall meet the requirements of AASHTO 2012 Bridge Design Guide Section 5.11.2.5.1 and AASHTO 2012 Bridge Design Guide Section 5.11.6.2. The overlap of welded wire fabric shall be measured between the outer most longitudinal wires of each fabric sheet. For deformed billet-steel bars, the overlap shall meet the requirements of AASHTO 2012 Bridge Design Guide Section 5.11.2.1. For splices other than tension splices, the overlap shall be a minimum of 12" for welded wire fabric or deformed billet-steel bars. The spacing center to center of the circumferential wires in a wire fabric sheet shall be no less than 2 inches and no more than 4 inches. The spacing center to center of the longitudinal wires shall not be more than 8 inches. The spacing center to center of the longitudinal distribution steel for either line of reinforcing in the top slab shall be not more than 16 inches.

Subsection: **Revision:**	615.06.07 Laps, Welds, and Spacing for Precast Endwalls. Replace the subsection with the following: Splices in the reinforcement shall be made by lapping. Laps may not be tack welded together for assembly purposes. For smooth welded wire fabric, the overlap shall meet the requirements of AASHTO 2012 Bridge Design Guide Section 5.11.2.5.2 and AASHTO 2012 Bridge Design Guide Section 5.11.6.3. For deformed welded wire fabric, the overlap shall meet the requirements of AASHTO 2012 Bridge Design Guide Section 5.11.2.5.1 and AASHTO 2012 Bridge Design Guide Section 5.11.6.2. For deformed billet-steel bars, the overlap shall meet the requirements of AASHTO 2012 Bridge Design Guide Section 5.11.2.1. The spacing center-to-center of the wire fabric sheet shall not be less than 2 inches or more than 8 inches.
Subsection: **Revision:**	615.08.01 Type of Test Specimen. Replace the subsection with the following: Start-up slump, air content, unit weight, and temperature tests will be performed each day on the first batch of concrete. Acceptable start-up results are required for production of the first unit. After the first unit has been established, random acceptance testing is performed daily for each 50 yd^3 (or fraction thereof). In addition to the slump, air content, unit weight, and temperature tests, a minimum of one set of cylinders shall be required each time plastic property testing is performed.
Subsection: **Revision:**	615.08.02 Compression Testing. Delete the second sentence.
Subsection: **Revision:**	615.08.04 Acceptability of Core Tests. Delete the entire subsection.
Subsection: **Revision:**	615.12 Inspection. Add the following sentences to the end of the subsection: Units will arrive at jobsite with the "Kentucky Oval" stamped on the unit which is an indication of acceptable inspection at the production facility. Units shall be inspected upon arrival for any evidence of damage resulting from transport to the jobsite.

MATERIALS HANDLING

Materials Handling

- Temporary Striping Materials
- Permanent Striping Materials
  - Resurfacing, rehabilitation & restoration
  - District wide striping

Temporary Striping

- Temporary Paint
- Temporary Tape

Temporary Paint Materials Requirement

- **Less than 120 days – no sample**
- **Greater than 120 Days – send samples**
  - Conform to Section 842 and 846
  - Manufacturer's Certification
  - Do not sample glass beads

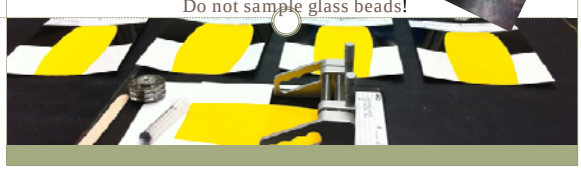
Temporary Tape Materials Requirement

- Conform to Section 831: Construction Zone Temporary Marking Tapes
- Manufacturer's Certification
- List of Approved Materials

Resurfacing, Rehabilitation and Restoration Contracts

- Waterborne and Durable Waterborne Traffic Paint
- Extruded Thermoplastic
- Type I Tape

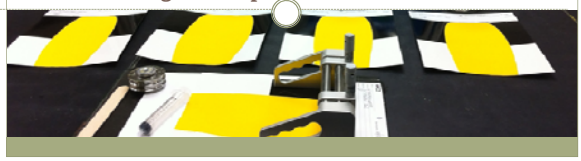
Do not sample glass beads!



Waterborne & Durable Waterborne Paint

(Resurfacing, Rehabilitation & Restoration Contracts)

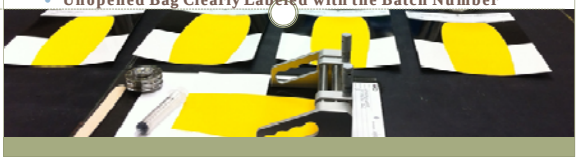
- **Conform to Section 842 & 846**
- **Manufacturer's Certification**
- **Randomly sample paint from striper**
  - Minimum of one per color per project
  - Paint samples should be taken from the striper
- **Site Manager Sample Record Form**



Extruded Thermoplastic

(Resurfacing, Rehabilitation & Restoration Contracts)

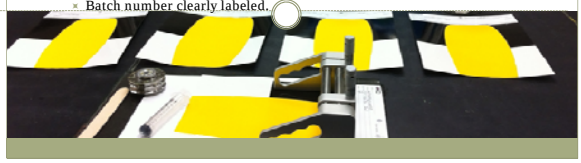
- **Thermoplastic must meet the requirements of Section 837**
- **Manufacturer's certification**
- **Site Manager Sample Record Form**
- **Unopened Bag Clearly Labeled with the Batch Number**



Sampling Extruded Thermoplastic

(Resurfacing, Rehabilitation & Restoration Contracts)

- **Small Quantities < 250 pounds**
  - Manufacturer's Certification
- **Quantities > 250 pounds**
  - Manufacturer's Certification
  - Provide one unopened bag of thermoplastic per batch per color of material delivered to the contract
    - Batch number clearly labeled.



Type I Tape

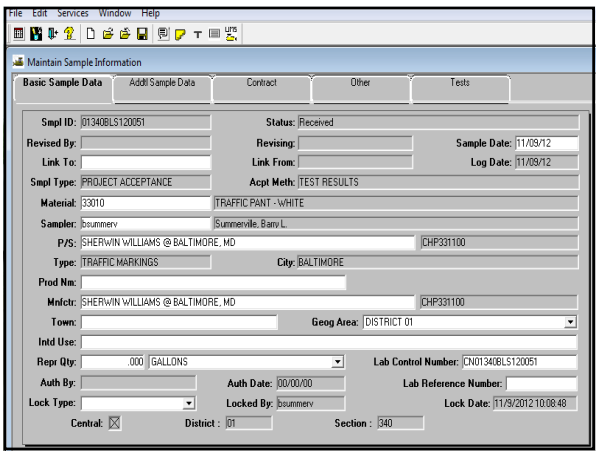
(Resurfacing, Rehabilitation & Restoration Contracts)

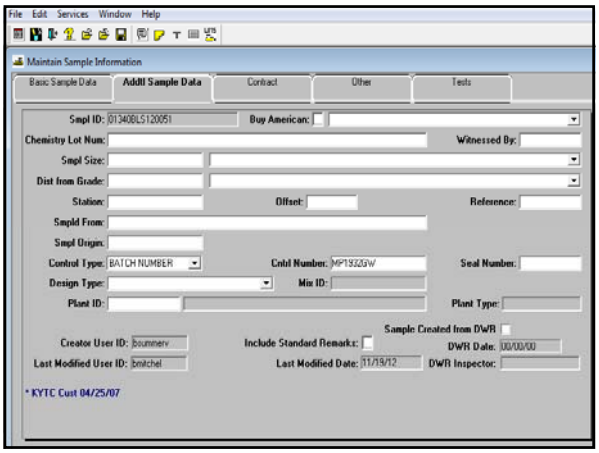
- **Meet the requirements of Section 836 of the Standard Specifications**
  - **Manufacturer's Certification**
  - **Minimum retroreflectivity requirements**
    White: 500 mcd/m²/lux
    Yellow: 500 mcd/m²/lux
  - **List of Approved Materials**

Waterborne & Durable Waterborne Paint

(District Wide Striping Contracts)

- **Conform to Section 842 & 846**
  - **Deduction shall apply to color from 4.1 to 6.0**
  - **No paint accepted with color deviation > 6.0**
- **Manufacturer's Certification**
- **Samples**
  - Minimum of one per color per truck per week
  - Paint samples should be taken from the striper
- **Site Manager Sample Record Form**

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Witnessed By:
Smpl Size:
Dist from Grade:
Station:
Offset:
Reference:
Smpld From:
Smpl Origin:
Control Type: BATCH NUMBER
Cntrl Number: MP1932GW
Seal Number:
Design Type:
Mix ID:
Plant ID:
Plant Type:
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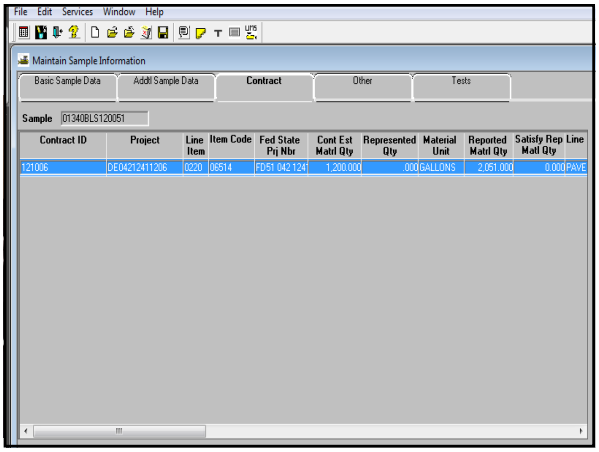
Creator User ID: bsumnerv
Include Standard Remark:
DWR Date: 00/00/00
Last Modified User ID: bmitchel
Last Modified Date: 11/19/12
DWR Inspector:
* KYTC Cust 04/25/07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Fed State Prj Nbr
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Represented Qty
Material Unit
Reported Matl Qty
Satisfy Rep Line Matl Qty
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GALLONS
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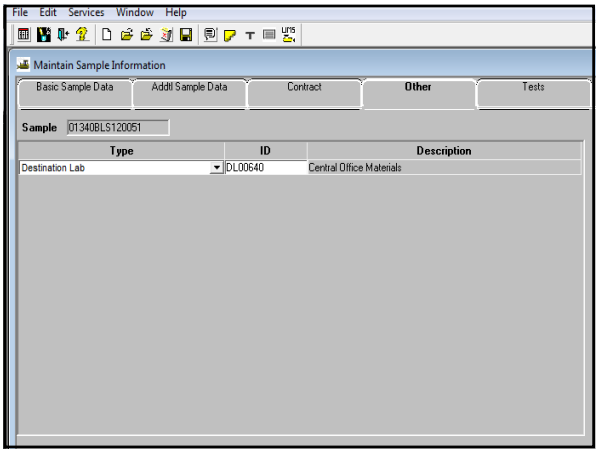
0.000
PAVE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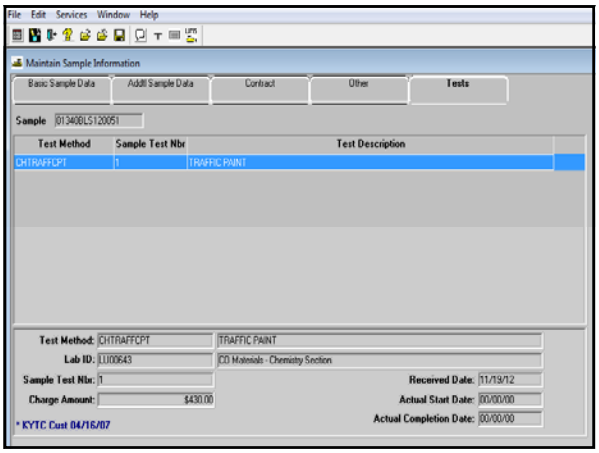
ID
Description
Destination Lab
DL00640
Central Office Materials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Maintain Sample Information
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Contract
Other
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Sample 013408LS120051
Test Method
Sample Test Nbr
Test Description
CHTRAFFCPT
1
TRAFFIC PAINT
Test Method: CHTRAFFCPT
TRAFFIC PAINT
Lab ID: LL000643
CO Materials - Chemistry Section
Sample Test Nbr: 1
Received Date: 11/19/12
Charge Amount: $430.00
Actual Start Date: 00/00/00
Actual Completion Date: 00/00/00
* KYTC Cust 04/16/07

SECTION 831 — CONSTRUCTION ZONE TEMPORARY MARKING TAPES

831.01 DESCRIPTION. This section covers pavement marking material designed to provide reflective delineation in construction zones. This section covers the following types of marking material:

A) Type A. Non-removable Pavement Marking Tape.
B) Type B. Removable Pavement Marking Tape.

831.02 GENERAL.

831.02.01 Manufacture. Use a material consisting of a weather and traffic-resistant reflective film on a backing precoated with a pressure-sensitive adhesive.

831.02.02 Adhesive. Use a precoated pressure-sensitive adhesive that does not require a liner or activation.

831.02.03 Application Properties. Ensure that the material adheres to asphalt and concrete surfaces, when applied according to the manufacturer's recommendations, at or above surface temperatures of 40 °F. Ensure that the material does not require any protective devices such as traffic cones or barricades after application. Do not allow re-use of previously installed material.

831.02.04 Conformability and Thickness. Use material that is thin, flexible, formable, and remains conformed to the texture of the pavement surface following application. Ensure that the thickness of the material furnished is within 2 mils of the thickness of the material submitted for approval. Use tape with a minimum width of 4 inches.

831.02.05 Miscellaneous Requirements. Ensure that the supplied material is of good appearance, free from cracks, with edges true, straight, and unbroken. Make the material available in rolls with no more than 3 splices per 50 yards of length. Package the material according to accepted commercial standards. Ensure that the supplied material is capable of being stored at temperatures up to 100 °F for a period of one year after purchase without adversely affecting the physical properties stated in this section.

831.03 APPROVAL. The Department will approve temporary marking tapes based on conformance to KM 64-207 and the requirements of this section. The Department may remove temporary marking tapes from the Department's List of Approved Materials for poor field performance in Kentucky.

831.04 CERTIFICATION. Submit manufacturer's certification stating conformance to the requirements of this section for each shipment of approved temporary marking tapes delivered for use on projects. Clearly state the manufacturer, product name, product code and color as listed in the Department's List of Approved Materials. Identify the lot number(s), expiration date and quantity delivered.

831.05 ACCEPTANCE. The Department will accept temporary marking tapes based on verification of inclusion on the Department's List of Approved Materials, compliance of the manufacturer's certification, verification the expiration date will not be exceeded, and visual inspection of the temporary marking tape installation. The Department reserves the right to sample and test temporary marking tape, at the discretion of the Engineer, in

accordance with the Department's Field Sampling and Testing Manual.

SECTION 836 — DURABLE PREFORMED PAVEMENT MARKINGS TYPE I TAPE

836.01 GENERAL. Use preformed pavement marking material consisting of white or yellow films with retroreflective optics incorporated to provide immediate and continuing retroreflection.

Use preformed pavement marking material capable of adhering to new dense and open graded asphalt surfaces, during the paving operation, or portland cement concrete by a pre-coated pressure sensitive adhesive. The Engineer may require a primer to precondition the pavement surface. Ensure that the markings conform to pavement contours by the action of traffic. Ensure that, after application, the markings are immediately ready for traffic.

Ensure that these markings provide long term reflectivity, as determined in the following performance requirements, when applied according to the manufacturer's instructions.

Ensure that the preformed markings are suitable for use one year after the date of receipt when stored according to the manufacturer's recommendations.

836.02 REQUIREMENTS.

836.02.01 Composition. Use retroreflective preformed pavement markings consisting of a mixture of high quality polymeric materials, pigments, and retroreflective optics distributed throughout its base cross sectional area.

836.02.02 Reflectance. Ensure that the white and yellow markings have the following minimum reflectance values as measured according to the testing procedures of ASTME 1701. Measure the coefficient of retroreflected luminance and express the value as millicandelas per square meter per lux [$(mcd/m^2)lx^{-1}$].

MINIMUM REFLECTANCE			
Color	Entrance Angle	Observation Angle	Minimum Reflectance
White	88.76º	1.05º	500 minimum
Yellow	88.76º	1.05º	500 minimum

836.02.03 Skid Resistance. Ensure that the surface of the retroreflective material provides an initial minimum skid resistance value of 45 BPN when tested according to ASTM E 303.

836.02.04 Patchability. Ensure that the pavement marking material is capable of use for patching worn areas of the same type according to the manufacturer's recommendations.

836.02.05 Material Quality. Replace any material used as longitudinal or intersection markings that fails minimum reflectivity values or fails due to loss of adhesion or complete wear through. Minimum replacement zone is 300 feet of roadway

length or one intersection marking.

836.03 APPROVAL. The Department will approve Type I pavement marking tape based on conformance to KM 64-207 and this section.

836.04 CERTFICATION. Submit manufacturer's certification stating conformance to the requirements of this section for each shipment of approved Type I pavement marking tape for use on projects. Clearly stat the manufacturer, product name and product code and color as listed in the Department's List of Approved Materials. Identify the lot number(s), expiration date, and quantity delivered.

836.05 ACCEPTANCE. The Department will accept Type I pavement marking tape based on verification of inclusion on the Department's List of Approved Materials, compliance of the manufacturer's certification, and visual inspection of the installation of the Type I pavement marking tape.

SECTION 837 — EXTRUDED THERMOPLASTIC PAVEMENT MARKING MATERIALS

837.01 GENERAL. This section covers extruded thermoplastic pavement marking materials for permanent applications.

837.02 DROP ON BEADS. Use beads that will ensure the pavement marking material will meet retroreflectivity requirements. The Department will evaluate the beads as part of the marking system through retroreflectivity readings.

837.03 APPROVAL. Select materials that conform to the composition and physical characteristic requirements below when evaluated in accordance with AASHTO T-250 or other test methods as cited. The Department will sample and evaluate for approval each lot of thermoplastic material delivered for use per contract prior to installation of the thermoplastic material. Do not allow the installation of thermoplastic material until it has been approved by the Division of Materials. Allow the Department a minimum of 10 working days to evaluate and approve thermoplastic material from the date received by the Division of Materials.

837.03.01 Composition. Use a maleic-modified glycerol ester resin (alkyd binder) to formulate the thermoplastic material. Ensure the pigment, pre-mix beads, and filler are uniformly dispersed in the resin. Use material that is free from all dirt and foreign material. Provide independent analysis data and certification for each formulation stating the total concentration of each heavy metal present, the test method used for each determination, and compliance to 40 CFR 261 for leachable heavy metals content.

COMPOSITION (Percentage by Weight)		
Component	White	Yellow
Binder, [(1)]	18.0 min.	18.0 min.
Glass Beads (Premixed)	30 - 40	30 - 40
Titanium Dioxide	10.0 min.	—
Calcium Carbonate & Inert Fillers [(2)]	42.0 max.	50.0 max.
Heavy Metals Content	Comply with 40 CFR 261	Comply with 40 CFR 261

[(1)] Use a binder that consists of a mixture of synthetic resins, at least one being solid at room temperature, and high boiling point plasticizers. Ensure that at least one-third of the binder composition is solid maleic-modified glycerol ester resin and is not less than 8 percent by weight of the entire material formulation. Do not use alkyd binder that contains petroleum based hydrocarbon resins.

[(2)] The manufacturer may choose the amount of calcium carbonate and inert fillers, providing all other requirements of this section are met.

837.03.02 Physical Characteristics. For thermoplastic material heated for 4 hours at 425ºF under agitation, conform to the following requirements.

A) Color. As determined with a spectrophotometer using D65 illuminant with a 45 degree entrance angle and 0 degree observation angle geometry.

CIELAB Color Coordinates		
	Yellow	White
Daytime Color (CIELAB) Spectrophotometer using illuminant D65 at 45º illumination and 0º viewing with a 2º observer	L* 81.76 a* 19.79 b* 89.89 Maximum allowable variation 6.0ΔE*	L* 93.51 a* -1.01 b* 0.70 Maximum allowable variation 6.0ΔE*
Nighttime Color (CIELAB) Spectrophotometer using illuminant A at 45º illumination and 0º viewing with a 2º observer	L* 86.90 a* 24.80 b* 95.45 Maximum allowable variation 6.0ΔE*	L* 93.45 a* -0.79 b* 0.43 Maximum allowable variation 6.0ΔE*

B) Flowability. Ensure that the white thermoplastic material has a maximum residue of 18 percent and the yellow thermoplastic material has a maximum residue of 21 percent.

C) Set Time. Use material that, when applied at a temperature range of 415 ± 15 ºF and thickness of 40 to 120 mils, sets to bear traffic in not more than 2 minutes when the air and road surface temperature is approximately ≥ 50 ± 3 ºF, and not more than 10 minutes when the air and road surface temperature is approximately < 50 ± 3 ºF.

D) Softening Point. Ensure that the thermoplastic material has a softening point of 215 ± 15 ºF.

E) Bond Strength. Ensure that the bond strength of the thermoplastic material to concrete exceeds 180 psi.

F) Cracking Resistance at Low Temperature. Ensure that the thermoplastic material shows no cracks when observed from a distance exceeding one foot.

G) Impact Resistance. Ensure the impact resistance of the thermoplastic material is a minimum of 1.13 joules.

H) Flash Point. Use thermoplastic material that has a flash point not less than 475 °F.

837.04 PACKAGING. Package thermoplastic material in suitable 50 pound containers to which the material shall not adhere during shipment or storage. Include a label stating that the thermoplastic material is to be maintained with a temperature range of 400 – 440ºF during application. Provide the thermoplastic material in either block or granular form.

837.05 SHELF LIFE. Ensure that the thermoplastic material conforms to this section for a period of one year. Replace any thermoplastic material not conforming to the above requirements.

837.06 MANUFACTURER'S TESTING. Perform testing in accordance with AASHTO T-250 on a minimum of one composite sample per 10,000 pounds, or portion thereof, per lot of thermoplastic produced.

837.07 CERTIFICATION. Submit manufacturer's certification stating conformance to the requirements of this section for each lot of extruded thermoplastic delivered for use on projects. Clearly state the manufacture, formulation identification, product name, color, date of manufacturer, lot number (s), expiration date, total quantity of lot produced, actual quantity of thermoplastic material represented, sampling method utilized to obtain the samples, and required manufacturer's testing data for each composite sample tested to represent each lot produced.

837.08 ACCEPTANCE. The Department will accept extruded thermoplastic based on compliance of the manufacturer's certification and conformance of test results obtained by the Department to the requirements of this section.

SECTION 842 — PAVEMENT STRIPING PAINT

842.01 DESCRIPTION. This section covers quick-drying waterborne acrylic pavement striping paint for permanent applications.

842.02 GENERAL. Select waterborne acrylic paint that conforms to the composition requirements below. Provide independent analysis data and certification for each formulation stating the total concentration of each heavy metal present, the test method used for each determination, and compliance to 40 CFR 261 for leachable heavy metals content.

PAINT COMPOSITION		
Property and Test Method	Yellow	White
Daytime Color (CIELAB) Spectrophotometer using illuminant D65 at 45º illumination and 0º viewing with a 2º observer	L* 81.76 a* 19.79 b* 89.89 Maximum allowable variation 4.0ΔE*	L* 93.51 a* -1.01 b* 0.70 Maximum allowable variation 4.0ΔE*
Nighttime Color (CIELAB) Spectrophotometer using illuminant A at 45º illumination and 0º viewing with a 2º observer	L* 86.90 a* 24.80 b* 95.45 Maximum allowable variation 4.0ΔE*	L* 93.45 a* -0.79 b* 0.43 Maximum allowable variation 4.0ΔE*
Heavy Metals Content	Comply with 40 CFR 261	Comply with 40 CFR 261
TiO_2 ASTM D 4764	NA	10% by wt. of pigment min.
VOC ASTM D 2369 and D 4017	1.25-lb/gal max.	1.25-lb/gal max.
Contrast Ratio (at 15 mils wft.)	0.97	0.99

842.03 MANUFACTURER'S TESTING. Perform testing for Daytime and Nighttime Color, Contrast Ratio, Titanium Dioxide (white paints) and Volatile Organic Content (VOC) on each lot of waterborne acrylic paint to be delivered for use on projects.

842.04 SAMPLING. The Department will obtain samples of waterborne acrylic paint for compliance testing to the requirements of this section in accordance with the Department's Materials Field Sampling Manual.

842.05 CERTIFICATION. Submit manufacturer's certification stating conformance to the requirements of this section for each shipment of waterborne acrylic paint delivered for use on projects. Clearly state the manufacturer, product name, product code, lot number(s), expiration date, color, sampling method, test results of manufacturer required testing, and quantity delivered.

842.06 ACCEPTANCE. The Department will accept waterborne acrylic paint based on compliance of the manufacturer's certification and conformance of test results obtained by the Department to the requirements of this section.

842.07 ACCEPTANCE PROCEDURES FOR NON-SPECIFICATION PAVEMENT STRIPING PAINT. When non-specification paint is inadvertently

incorporated into the work the Department will accept the material with a reduction in pay. The percentage deduction is cumulative based on its compositional properties, but will not exceed 60 percent. The Department will calculate the payment reduction on the unit bid price for the routes where the non-specification paint was used. Do not accept waterborne acrylic paint with a Daytime or Nighttime color variation greater than 6.0ΔE* or if the cumulative deduction exceeds 60 percent.

PAVEMENT STRIPING PAINT REDUCTION SCHEDULE					
Non-conforming Property	Color 4.1ΔE* to 6.0ΔE*	Heavy Metals	TiO_2	VOC	Contrast
Reduction Rate	10%	60%	10 %	60%	10%

SECTION 846 - DURABLE WATERBORNE PAINT

846.01 DESCRIPTION. This section covers quick-drying durable waterborne acrylic pavement striping paint for permanent applications. The paint shall be ready-mixed, one-component, 100% waterborne acrylic striping paint suitable for application on such traffic-bearing surfaces as Portland cement concrete, bituminous cement concrete, asphalt, tar, and previously painted areas of these surfaces.

846.02 GENERAL. Select durable waterborne acrylic paint that conforms to the composition requirements below. Provide independent analysis data and certification for each formulation stating the total concentration of each heavy metal present, the test method used for each determination, and compliance to 40 CFR 261 for leachable heavy metals content.

The non-volatile portion of the vehicle shall be composed of a 100% acrylic polymer as determined by infrared spectral analysis. The acrylic resin used shall be a 100% cross-linking acrylic as evidenced by infrared peaks at wavelengths 1568, 1624, and 1672 cm-1 with intensities equal to those produced by an acrylic resin known to be 100% cross-linking.

PAINT COMPOSITION		
Property and Test Method	Yellow	White
Daytime Color (CIELAB) Spectrophotometer using illuminant D65 at 45º illumination and 0º viewing with a 2º observer	L* 81.76 a* 19.79 b* 89.89 Maximum allowable variation 4.0ΔE*	L* 93.51 a* -1.01 b* 0.70 Maximum allowable variation 4.0ΔE*
Nighttime Color (CIELAB) Spectrophotometer using illuminant A at 45º illumination and 0º viewing with a 2º observer	L* 86.90 a* 24.80 b* 95.45 Maximum allowable variation 4.0ΔE*	L* 93.45 a* -0.79 b* 0.43 Maximum allowable variation 4.0ΔE*
Heavy Metals Content	Comply with 40 CFR 261	Comply with 40 CFR 261
Titanium Dioxide ASTM D 4764	NA	10% by weight of pigment min.
VOC ASTM D 2369 and D 4017	1.25 lb/gal max.	1.25 lb/gal max.
Contrast Ratio (at 15 mils wft)	0.97	0.99

846.03 MANUFACTURER'S TESTING. Perform testing for Daytime and Nighttime Color, Contrast Ratio, Titanium Dioxide (white paints) and Volatile Organic Content (VOC) on each lot of durable waterborne acrylic paint to be delivered for use on projects.

846.04 SAMPLING. The Department will obtain samples of durable waterborne acrylic paint for compliance testing to the requirements of this section in accordance with the Department's Field Sampling and Testing Manual.

846.05 CERTIFICATION. Submit manufacturer's certification stating conformance

to the requirements of this section for each shipment of durable waterborne acrylic paint deliverer for use on projects. Clearly state the manufacturer, product name, product code, color, sampling method, test results of manufacturer required testing, and quantity delivered.

846.06 ACCEPTANCE. The Department will accept durable waterborne acrylic paint based on compliance of the manufacturer's certification and conformance of test results obtained by the Department to the requirements of this section.

846.07 ACCEPTANCE PROCEDURES FOR NON-SPECIFICATION DURABLE WATERBORNE PAVEMENT STRIPING PAINT. When non-specification paint is inadvertently incorporated into the work the Department will accept the material with a reduction in pay. The percentage deduction is cumulative based on its compositional properties, but will not exceed 60 percent. The Department will calculate the payment reduction on the unit bid price for the routes where the non-specification paint was used. Do not accept waterborne acrylic paint with a Daytime or Nighttime color variation greater than 6.0ΔE*.

DURABLE WATERBORNE PAVEMENT STRIPING PAINT REDUCTION SCHEDULE						
Non-conforming Property	Resin	Color 4.1ΔE* to 6.0ΔE*	Contrast	TiO_2	VOC	Heavy Metals Content
Reduction Rate	60%	10%	10%	10%	60%	60%

KENTUCKY METHODS

KENTUCKY METHOD

KM201: Handheld Inspection of Intersection Markings

KM202: Handheld Inspection of Pavement Markings

KM203: Mobile Inspection of Pavement Markings

Kentucky Method 201

Evaluation of Retroreflectivity on
Intersection Markings Using
Portable Hand-Operation Instruments

KM201: Evaluation of Intersections

- 180 day proving period
- Evaluate between 15 and 45 days after the date the material is applied for retroreflectivity

KM201: Inspection of Intersection Markings

- Perform visual inspections and bond checks
- Perform retroreflectivity tests at each intersection
- Each marking is considered separately
  - Evaluate two markings per intersection
    - Take two readings on each marking

KM201: Performance Requirements

- If all readings meet or exceed the minimum requirements markings are accepted

White = 300 mcd/m²/lux
Yellow = 225 mcd/m²/lux

- If any reading fails to meet the minimum requirements additional readings will be taken

KM201: Additional Readings

Additional readings are taken to assess which markings need to be repaired or replace.

KM201: Reporting

- Include
  - Hand-operated instrument printout of the readings (date & time of test, zero reading, calibration, retroreflectivity measurements)
  - Date and time of application of the pavement markings
    - From contractor's DSR
  - Location
    - County, intersection and marking tested

Kentucky Method 202

Evaluation of Retroreflectivity on Pavement Markings Using Portable Hand-Operated Instruments

KM202: Definitions

- **Section**
  - Portion of striping completed for a single color per line width by one crew in one shift
- **Segment**
  - Portion equal to one fifth (or more) of a section
- **Zone**
  - Location within a segment where one begins taking readings

KM202: Definitions Cont.

- Crew
  - Group of two or more people identified by the striper and the driver
- Shift
  - Period of time where a single crew works continuously stopping only for legally required breaks

KM202: Divide Each Section According to the Striping Completed

Section	Number of Segments Required
≥ 30 miles	5 segments
≥ 10 miles and < 30 miles	3 segments
< 10 miles	1 segment

KM202: Establishing the Zone

- **Randomly generate the starting point of a zone within each segment**
  - Mark the beginning of each zone with spray paint
- **Start each zone for the section at the same distance into each segment**
- **The starting point of the first zone is used to establish the location of the next zone within the next segment**

KM202: Retroreflectivity Readings

Retroreflectivity readings are to be taken in the direction the striper applied the line.

Take readings in both directions.

Which ever direction gives you the higher reading is the way the striper was headed when the line was applied.

KM202: Reading Within the Zone

- Obtain 20 readings in each zone
  - Take the first reading at the beginning of the zone
  - Take subsequent readings at 15 foot intervals (5 paces)
  - For centerlines, alternate readings between the solid lines or on the combination of solid and skip lines
    - Measure each skip at two evenly spaced locations

KM202: Moving the Zone

- Move the zone if any portion is unsafe
- Change in starting point of one zone should not change the starting point for the next zone
- Move ahead within the zone if readings cannot be taken due to

-Pothole s -Grass -Break in pavement -Debris

KM202: Pass/Fail Segments

- IF:
  - 80% or more of the readings within a zone pass, the segment passes
- IF:
  - Less than 80% of the readings pass, additional readings must be taken

KM202: Additional Readings

- Establish two additional zones within the segment
- Take twenty readings in each of the two additional zones
- If 80% or more of <u>all</u> readings in the segment pass, the segment passes

KM202: Exception…

- If 13 or more of the readings in the first zone in a segment fail, additional readings are unnecessary
  - The segment fails

KM202: Pass/Fail Section

- 3 segments fail (section > 30 miles)
  - The section is not accepted
- 1 segment fails (section < 30 miles)
  - The section is not accepted

KM202: Reporting

- Include
  - Hand-operated instrument printout of the readings taken
  - Date and time of application
  - Location of test

KM203

Evaluation of Retroreflectivity on Permanent Pavement Markings Using Mobile 30 Meter Geometry Instruments

KM203: Definitions

- Section
  - Portion of striping completed for a single color per line width by one striping crew in one shift
- Segment
  - Portion equal to one-tenth of a mile of a section
    - Segment is 528 feet

KM203: Definitions Cont.

- Crew
  - Two or more people identified by the truck and driver applying pavement markings
- Shift
  - Period of time where a single crew works continuously

KM203: Mobile Evaluation

- At least 50% of all segments in each section will be evaluated by the mobile
- The mobile will pass/fail sections
- Readings will be taken in the direction the striper applied the line

KM203: Pass/Fail Criteria

- If
  - 80% or more of the segments for a section pass, the section passes
- If
  - Less than 80% of the segments pass, the section will not be accepted

KM203: Reporting

- Include
  - Mobile readings
    - Date and time of test
    - Calibration information
    - % Passing
  - Date and time of application
    - From mobile request form
  - Location of test

Kentucky Method 64-201-08
Dated 2/4/08
Supersedes KM 64-201-03
Dated 2/5/03

EVALUATION OF RETROREFLECTIVITY ON INTERSECTION PAVEMENT MARKINGS USING PORTABLE HAND-OPERATED INSTRUMENTS

1. SCOPE:

   1.1. This method covers the evaluation of retroreflectivity on pavement markings using portable hand-operated instruments.

   1.2. It is intended to provide standards of intersection pavement markings to assure that adequate retroreflectivity for the driver is provided by newly applied markings.

   1.3. Thermoplastic intersection pavement markings will be evaluated in a period of not less than 15 to no more than 45 days after the date the materials are applied.

2. TERMINOLOGY: Retroreflectivity: a standard of measure for pavement markings. The units for these readings are millicandelas per square meter per lux ($mcd/m^2/lx$).

3. SUMMARY OF SPECIFICATION:

   3.1. Perform a visual inspection and bond checks for each marking.

   3.2. Perform retroreflectivity tests at each intersection on at least 2 markings.

   3.3. For the purpose of evaluating retroreflectivity, each marking will be considered separately with 2 readings taken on each marking evaluated. Readings will not be taken on portions of the marking that are in the wheel track or where build up of road debris such as oil, grease, etc. would provide readings not representative of the quality of the work.

4. PERFORMANCE REQUIREMENTS:

   4.1. Retroreflectivity: The pavement marking will be evaluated for acceptance within the time period detailed in section 1.3.

   4.2. If all four readings taken in an intersection meet or exceed the required minimum retroreflectivity values established for the materials that are being measured, the intersection markings that are being evaluated will be accepted.

   4.3. If any of the readings taken in an intersection are below the required minimum retroreflectivity values established for the materials that are being measured, additional readings will be taken within the intersection that is being evaluated.

4.4. Taking additional readings: At the discretion of the engineer, additional readings may be taken to assess which markings within an intersection need to be replaced or repaired.

5. REPORTING:

5.1. Include the following in the inspection report:

5.1.1. Printout of the readings taken with the hand-operated instrument (which should show date and time of test and zero reading and calibration).

5.1.2. Date and time of application of the pavement marking from the Contractors Daily Report.

5.1.3. Location (County, intersection, marking tested and any special information).

5.2. Readings shall be recorded in millicandelas per square meter per lux ($mcd/m^2/lx$).

5.3. Measurement shall be reported for each intersection of markings per day.

APPROVED _____
Director
DIVISION OF MATERIALS

DATE 2/4/08

Kentucky Method 64-201-08
Dated 2/4/08
Supersedes KM 64-201-03
Dated 2/5/03

Kentucky Method 64-202-12
Revised 1/20/12
Supersedes KM 64-202-10
Dated 1/15/10

EVALUATION OF RETROREFLECTIVITY ON PAVEMENT MARKINGS USING PORTABLE HAND-OPERATED INSTRUMENTS

1. SCOPE:

1.1. This method covers the evaluation of retroreflectivity on pavement markings using portable hand-operated 30-meter geometry instruments.

1.2. It is intended to provide standards of horizontal pavement markings to assure that adequate retroreflectivity for the driver is provided by newly applied markings.

1.3. Waterborne and durable waterborne pavement markings will be evaluated in a period of not less than 30 to no more than 60 days after the date the materials are applied.

1.4. Durable pavement markings such as Thermoplastic, Permanent Pavement Tapes, and Epoxies will be evaluated in a period of time not less than 150 days to no more than 210 days after the date the materials are applied.

2. TERMINOLOGY:

2.1. Section: a portion of striping completed for a single color per line width by one striping crew in one shift.

2.2. Segment: a portion equal to one fifth (or more) of a section.

2.3. Zone: a location in each segment where one begins taking retroreflectivity readings.

2.4. Retroreflectivity: a standard of measure for pavement markings. The units for these readings are millicandelas per square meter per lux ($mcd/m^2/lx$).

2.5 Crew: a group of two or more people identified by the striper and the driver of the striper applying pavement markings.

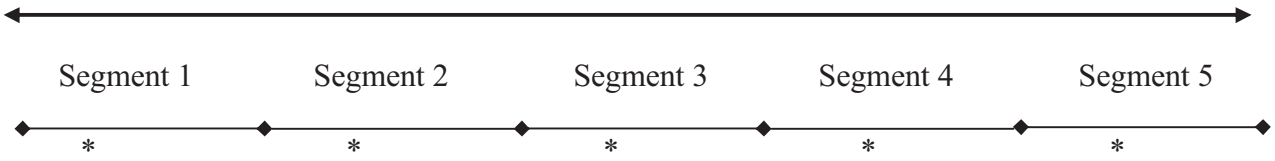
2.6 Shift: a period of time whereby a single crew works continuously stopping only for legally required breaks

3. SUMMARY OF SPECIFICATION:

3.1. For the purpose of evaluating retroreflectivity, each section will be evaluated separately. Divide each section into segments containing a zone (as shown in Figure 1A, Figure 1B, Figure 1C, and as described in Step 3.2). Establish five segments to collect readings to

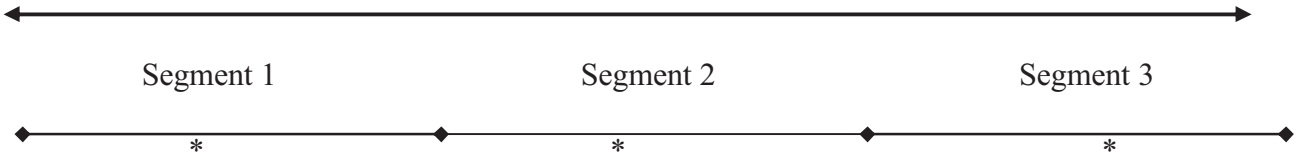
represent a day's striping if the total day's striping is ≥ 30 miles. Establish three segments to collect readings to represent a day's striping if the total day's striping is ≥10 miles and <30 miles. If the total day's striping is <10 miles the day will be considered one segment.

Figure 1A. Striping Day (≥ 30 miles)



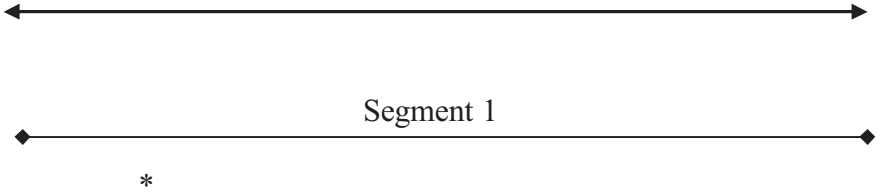
*Marks beginning of the Zone in each Segment

Figure 1B. Striping Day (≥ 10 miles and < 30 miles)



*Marks beginning of the Zone in each Segment

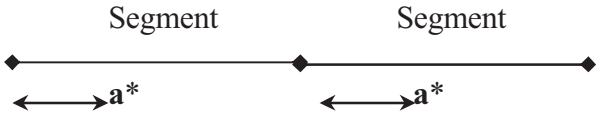
Figure 1C. Striping Day (< 10 miles)



*Marks beginning of Zone in the Segment

3.2. As stated in Step 3.1, divide the number of miles striped in a day to establish the length of each segment. In the first segment, randomly generate a milepoint (to the nearest tenth of a mile) to begin taking readings in the first zone. The distance from the beginning of the segment to the beginning of the zone (distance **a***), in the first zone, will be used to establish the location of each successive zone within successive segments (See Figure 2).

Figure 2.



NOTE: **a*=**distance each time, from beginning of each segment, to beginning of zone.

3.3. Mark the beginning and ending point of each zone with spray paint. Make sure the calibration transfer is not more than one week old. Perform a daily calibration on the hand-operated instrument according to the manufacturer's instructions. Print the calibration readings at the beginning of each days work. Recalibrate the instrument every 2 hours when taking continuous readings or before taking readings if the instrument has not been used for 30 minutes or more. Print the calibration readings each time these operations are performed.

3.4. Take 20 readings in each of the zones in the direction the striper applied the traffic markings. Take the first reading exactly at the beginning of the zone. Take subsequent readings at approximately 15-foot intervals (5 paces). If any portion of the zone is unsafe for taking readings, move forward to the first point which can be inspected safely and begin the zone there. Do not move the zone simply for convenience. A change in the starting point of one zone should not change the starting points of any subsequent zones. Also, if a valid reading is not attainable at a location within the zone due to a pothole, grass, occasional tracking, etc., move forward in the zone to the first available location for a valid reading, then resume the subsequent readings within that zone in the incremental procedure described above. However, readings will be taken in areas with substantial amounts of tracking.

3.5. For readings taken on centerlines, take alternating readings between solid lines or on the combination of solid and skip lines.

3.6. When a zone contains only skip lines for evaluation, measure each skip line at two evenly spaced locations on the line. Continue measuring within the established zone in this manner until 20 readings are obtained.

3.7 When a zone contains multiple line types of the same color and width, i.e. edgeline and lane line, obtain measurements representative of the quantities of line types.

4. PERFORMANCE REQUIREMENTS:

4.1. Retroreflectivity: The pavement marking will be evaluated for acceptance within the time period detailed in sections 1.3 and 1.4.

4.2. If 80% (16 or more) of the readings in a zone meet or exceed the required minimum retroreflectivity values established for the materials that are being measured, the segment that is being evaluated will be accepted.

4.3. If less than 80% (less than 16) of the readings in a zone meet the required minimum retroreflectivity values established for the materials that are being measured, additional readings will be taken within the segment that is being evaluated.

4.4. Taking additional readings - Randomly establish two (2) new zones within the segment in question using the procedure detailed in section 3.2. Obtain readings for each of these zones as described in 3.2 –3.4. These readings will be combined with the initial readings for evaluation of the segment. If less than 80% of the 60 readings (20 in each of three zones) taken within a segment meet the minimum retroreflectivity requirements established for the materials that are being measured, the segment is not accepted. Alternatively, if 13 or more of the first 20 readings taken within a segment fail to meet the minimum retroreflectivity requirements established for the materials that are being measured, the segment is not accepted and additional testing within that segment is not required.

4.5. If three of five segments are not accepted on a section of striping that is ≥ 30 miles in length, the entire section of striping will not be accepted. If one segment is not accepted on a section of striping that is <30 miles in length, the entire section of striping will not be accepted.

5. REPORTING:

5.1. Include the following in the inspection report:

5.1.1. Printout of the readings taken with the hand-operated instrument (which should show date and time of test and zero reading and calibration)

5.1.2. Date and time of application of the pavement marking from the Contractors Daily Striping Report

5.1.3. Location (County, route, milepoint, intersection, direction of travel, color of line, line type and any special information)

5.2. Record readings in millicandelas per square meter per lux ($mcd/m^2/lx$).

5.3. Report measurements for each section of striping per color per line width per shift.

APPROVED _____

DIRECTOR
DIVISION OF MATERIALS

DATE 01/24/12

Kentucky Method 64-202-12
Revised 1/20/12
Supersedes KM 64-202-10
Dated 1/15/10

Km20212.doc

Kentucky Method 64-203-12
Revised 1/20/12
Supersedes 64-203-10
Dated 1/15/10

EVALUATION OF RETROREFLECTIVITY ON PERMANENT PAVEMENT MARKINGS USING MOBILE 30 METER GEOMETRY INSTRUMENTS

1. SCOPE:

1.1. This method covers the evaluation of retroreflectivity on permanent pavement markings using mobile 30-meter geometry instruments.

1.2. It is intended to provide standards of horizontal pavement markings to assure that adequate retroreflectivity for the driver is provided by newly applied markings.

1.3. Waterborne and durable waterborne pavement markings will be evaluated in a period of not less than 30 to no more than 60 days after the date the materials are applied.

1.4. Durable pavement markings such as Thermoplastic, Permanent Pavement Tapes, and Epoxies will be evaluated in a period of time not less than 150 days to no more than 210 days after the date the materials are applied.

2. TERMINOLOGY:

2.1. Section: a portion of striping completed for a single color per line width by one striping crew in one shift.

2.2. Segment: a portion equal to one-tenth of a mile of a section.

2.3. Retroreflectivity: a standard of measure for pavement markings. The units for these readings are millicandelas per square meter per lux ($mcd/m^2/lx$).

2.4. Crew: a group of two or more people identified by the striper and the driver of the striper applying pavement markings.

2.5. Shift: a period of time whereby a single crew works continuously stopping only for legally required breaks.

3. SUMMARY OF SPECIFICATION:

3.1. For the purpose of evaluating retroreflectivity, data obtained through evaluation according to KM 64-203 will be collected and evaluated separately for each section.

3.2. Calibrate the mobile instrument. Record calibration measurements at the beginning of the day's work. Recalibrate the instrument as necessary when taking readings. Provide the

calibration measurements in the retroreflectivity report, each time these operations are performed.

3.3. The Department will provide the Contractor operating the mobile retroreflectometer with routes for evaluation. The routes evaluated will represent at least 50% of the segments completed in a section of striping. Data shall be collected in the direction the striper applied the traffic markings.

4. PERFORMANCE REQUIREMENTS:

4.1. Retroreflectivity: The pavement marking will be evaluated for acceptance within the time periods detailed in sections 1.3. and 1.4.

4.2. If 80% or more of the segments evaluated in a section meet or exceed the required minimum retroreflectivity values established for the materials that are being measured, the section will be accepted.

4.3. If less than 80% of the segments evaluated in a section meet the required minimum retroreflectivity values established for the materials that are being measured, the section will not be accepted.

5. REPORTING:

5.1. Include the following in the inspection report:

5.1.1. Calibration information for the mobile retroreflectometer.

5.1.2. Average of the readings taken for each segment evaluated by the mobile retroreflectometer (which should show date of test, total number of segments, passing segments, % passing segments, failing segments and % failing segments).

5.1.3. Date of application of the pavement marking.

5.1.4. Location (District, county, route, starting milepoint, ending milepoint, line type, direction of travel, color of line, and any special information).

5.2. Readings shall be recorded in millicandelas per square meter per lux ($mcd/m^2/lx$).

5.3. Measurement shall be reported for each section of striping per color per line width per shift.

APPROVED _____

DIRECTOR
DIVISION OF MATERIALS

DATE 01/24/12

Kentucky Method 64-203-12
Revised 1/20/12
Supersedes 64-203-10
Dated 1/15/10

LTL-X OVERVIEW

AND

HANDS ON

DEMONSTRATION

Retroreflectivity

Measuring visibility of pavement markings with the handheld

LTL-X

Retroreflectometer

Flint TRADING INC.

DELTA

Nighttime Visibility

"Inadequate and poorly maintained signs and markings are often sited as the contributing factor to accidents.

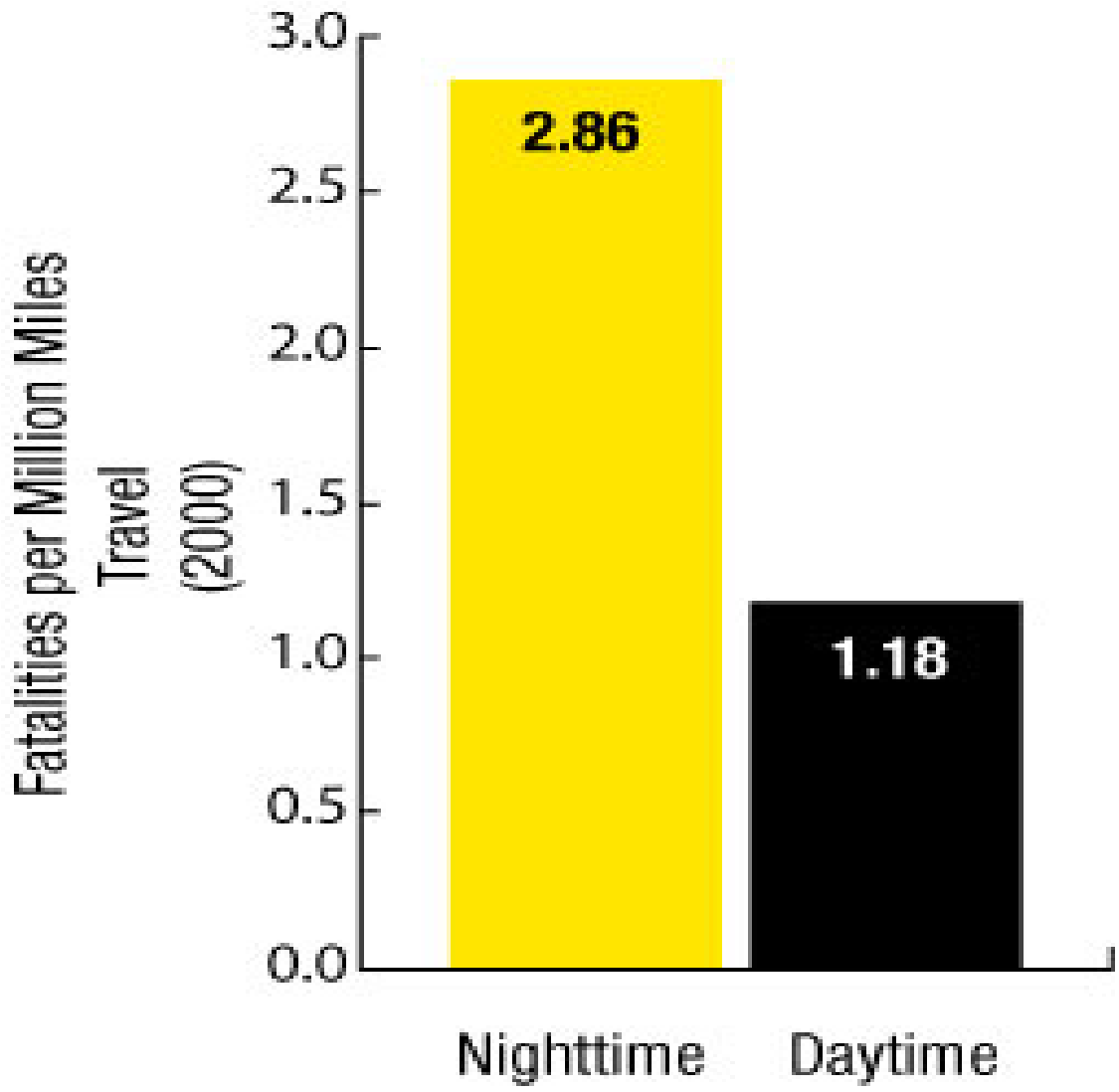
While only 25 percent of travel occurs at night, about 55 percent of the fatal accidents occur then."

FHWA

Retroreflectivity: Raising the Nighttime Brightness Of Traffic Signs and Markings

Flint TRADING INC.

Nighttime Visibility: The Real Problem



Flint TRADING INC.

LTL-X Wet Night

- **ASTM E 2176**
  "…Standard Condition of Continuous Wetness"
- **ASTM E 2177**
  "…Standard Condition of Wetness"

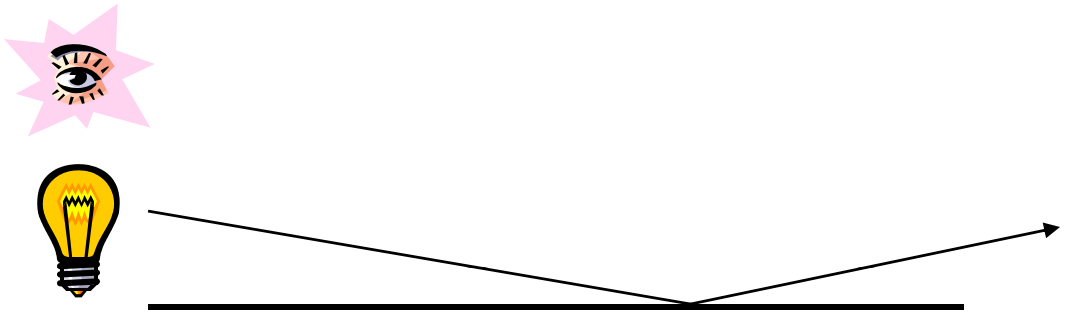
Flint TRADING INC.

LTL-X Depth Ability

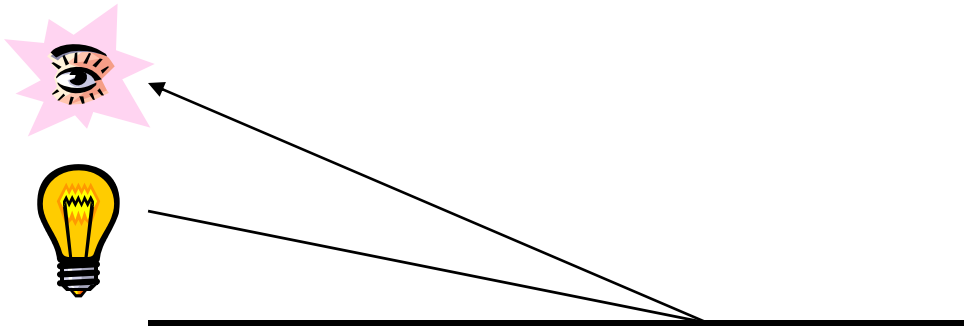
The LTL-X is able to reliably measure profile pavement markings in accordance with ASTM E 1710 with a profile height/depth of up to 0.55 in. (14 mm).

Flint TRADING INC.

Retroreflection -
Light Comes Back Towards the Source



Mirror reflection



Retro reflection

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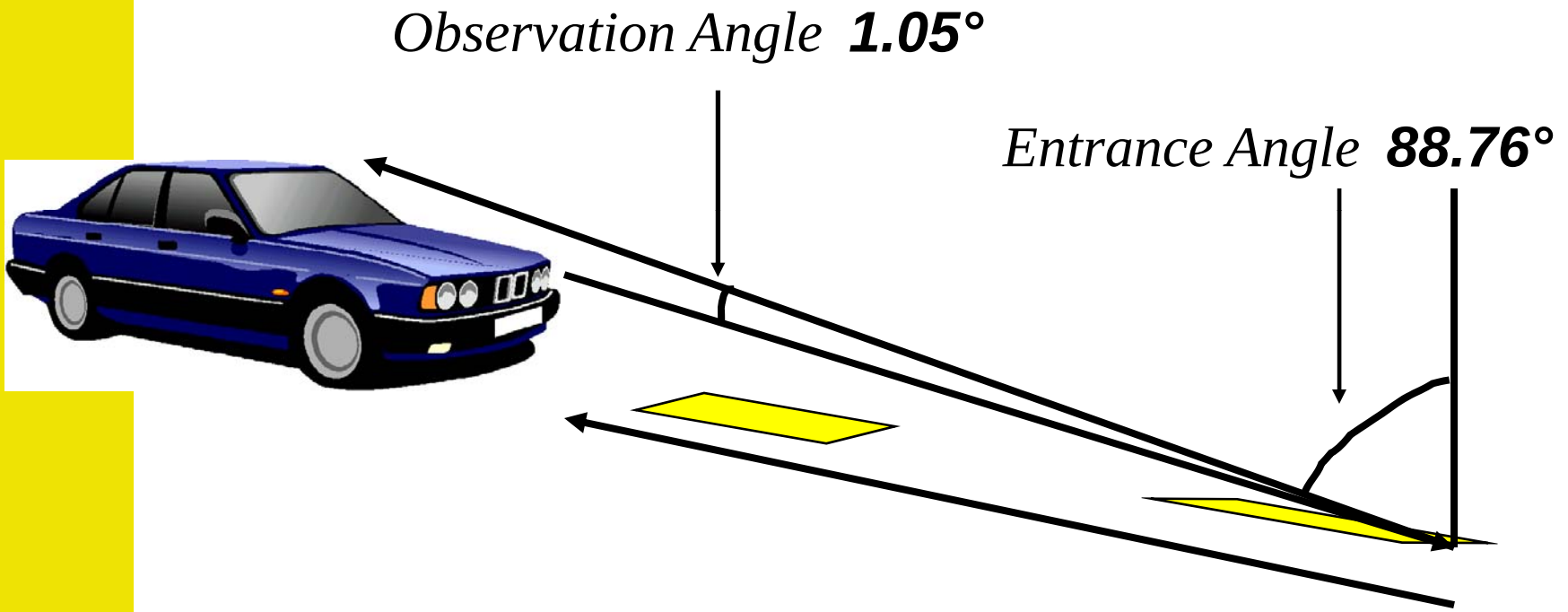
30-Meter Geometry



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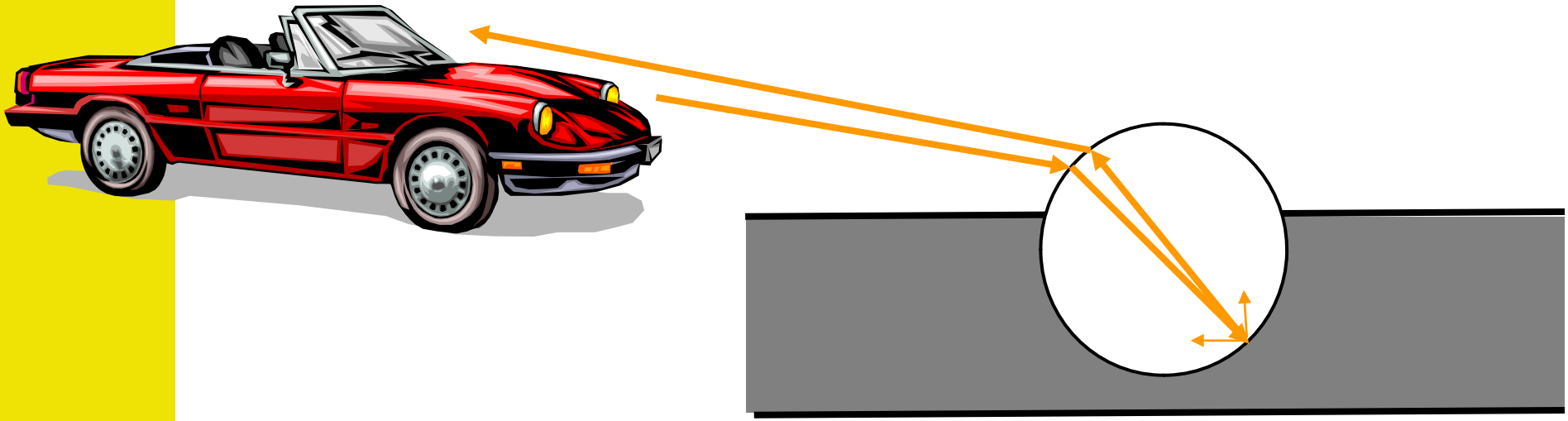
Pavement Marking Retroreflectivity: How does it work?



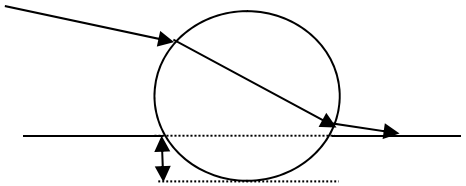
Flint TRADING INC.

Glass Beads
What affects performance?

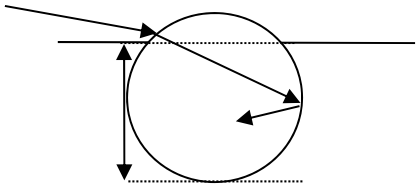
- Material
  - Roundness
  - Clarity
  - Index of Refraction
  - Size
- Application
  - Embedment
  - Coverage (Density)

Flint TRADING INC.

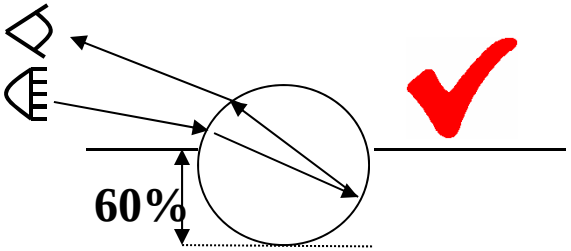
Glass Beads - Embedment



High Embedment (<40%), Poor



Low Embedment (>60%), Poor



60% Embedment, Good

Flint TRADING INC.

LTL-X Retroreflectometer

- Repeatability: With any instrument, repeated readings on the same spot should be within ±2% of each other
- Reproducibility: With any two instruments, readings taken with each instrument on the same spot should be within ±5% of each other
- Traceability: Black calibration standard

Flint TRADING INC.

LTL-X Retroreflectometer

- Portable self-contained instrument
- Small dimensions / low weight
- Ergonomic operation height
- Fast measurement (approx. 1 sec)
- Measure dry and wet surfaces
- Plane & profiled markings
- Built-in thermal printer

Continues…

Flint TRADING INC.

LTL-X Retroreflectometer

- Data storage, user identification and Series ID
- RSC PC software
- Easy calibration procedure
- Traceable and accredited calibrated reflection standard
- User-replaceable NiMH battery, charging time approx 1 hour
- Average, Fixed or Moving
- Multiple languages
- Wheel unit

Flint TRADING INC.

LTL-X Parts and Accessories

- LTL-X unit
- Black Calibration Block and Red Field Calibration Block
- LTL-X Manual
- RSC2 Program CD
- Extra Rolls of Paper
- Communication Cable
- Calibration Labels
- Fuses & Tools
- Wheel Unit
- Wet Night Measurement Kit

Flint TRADING INC.

Keyboard Layout

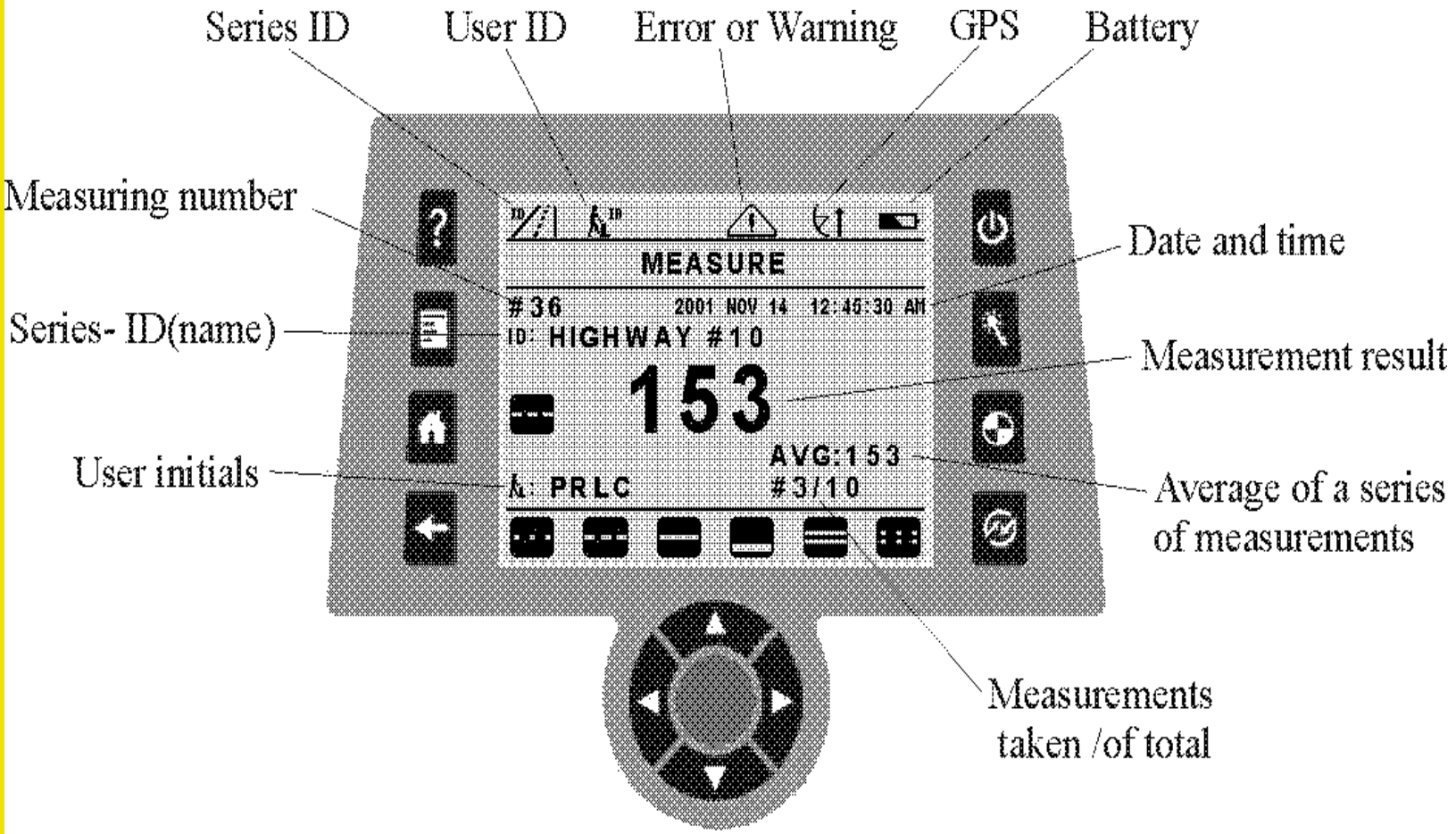
HELP			On/Off
Menu			Smart
Home			Calibrate
Back			Print/Out

Center Green button allow you to take measurements & select options

Arrow buttons allows you to move thru the menu system and highlight options

Flint TRADING INC.

Home Screen



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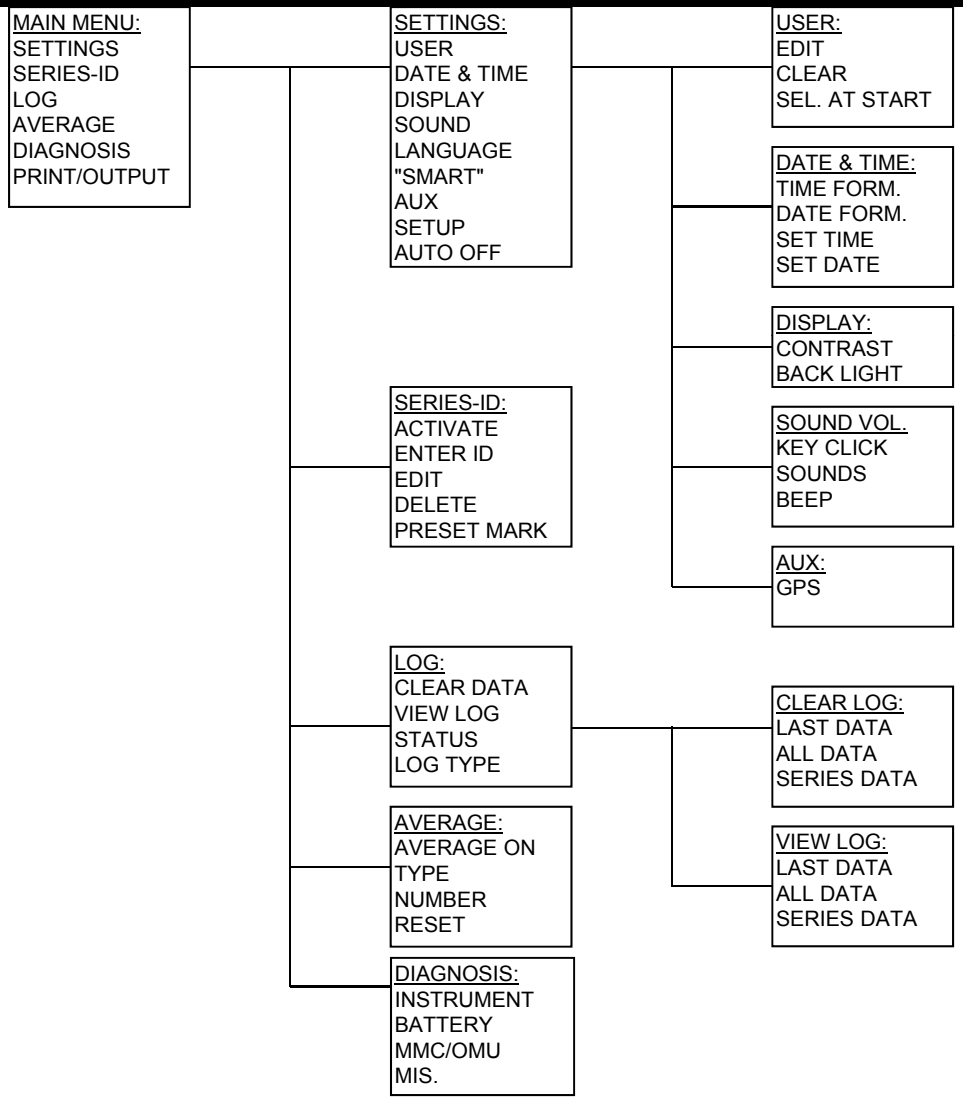
Menu Tree



Flint TRADING INC.

Main Menu Screen

When the user selects the Main Menu they have access to view information & edit options in the Instrument.

- Settings
- Series-ID
- Log
- Average
- Diagnosis
- Print/Output

Flint TRADING INC.

Settings Menu

Allows the user to setup the LTL-X defaults settings.

- User
- Date & Time
- Display (Contrast/Back Light)
- Sound
- Language
- Smart
- Aux (turn GPS on/off)
- Setup
- Auto Off (Setting 60-300 sec)

Flint TRADING INC.

User ID

The user ID is used to identify the operator and is saved in the log together with each measurement. It consists of up to four letters, If enabled, it can be seen at the lower left side of the measurement display. Measurements can also be taken without a user ID. 8 predefined user ID's can be setup.

Flint TRADING INC.

Language

Flint TRADING INC.

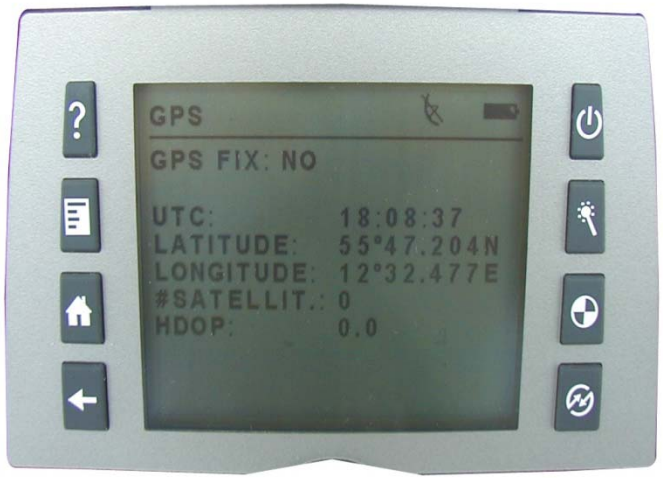
Smart Key

The Smart Key is programmable to one of several functions.

- Select Series
- Clear Last Measurement
- Reset Average
- Series ID ON/OFF

Flint TRADING INC.

Aux: GPS Option



The GPS receiver is mounted inside the instrument and is supplied by the internal battery. It is used to supply positional data (latitude and longitude) to the log together with the measurement data. If enabled, a GPS icon is shown in the upper icon row.

Flint TRADING INC.

Series ID Screen

Series ID's can be activated

Enter new ID

Edit preset ID's

Delete preset ID's

The User can preset up to 250 ID's

Preset 6 road marking icon for each Series ID

Flint TRADING INC.

Icon Presets Display

The LTL-X comes with 24 Icons of which 6 can be preset to display on the last line of the display.

Flint TRADING INC.

Log Screen

This menu gives you the ability to:

- Clear Data
- View Log
- Status (of the log)
- Type (of storing data)

Flint TRADING INC.

Log Screen (Cont.)

The data log can store up to 1500 measurements.

Information stored in the Log:

- Measurement data
- Date & Time
- Series ID
- Road marking icon
- User ID
- GPS data

View entire log on screen

Flint TRADING INC.

Status Screen

Flint TRADING INC.

Average

The Average function can be activated showing the average of the measured R_L value calculated over a selectable number of measurements (2 to 99). The average mode can be **fixed** or **moving.**

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Diagnosis Screen

This screen shows the status of these options:

- Instrument
- Battery
- Boards
- Miscellaneous

Tech Support will guide you through these options

Flint TRADING INC.

Battery Status

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Help System

Press the HELP button to show the help page for the current function. Pressing HELP once more will present a general help menu in which you can highlight a subject by using the UP or DOWN button and then pressing the OK button to show the help text.

Flint TRADING INC.

Errors and Warnings

When a measurement is taken, a status number is generated and saved in the log together with the measurement. The status number reflects various conditions concerning the measurement. If a certain problem has arisen, a warning icon or an error icon is shown above the measure display and an audible alarm is sounded (if enabled).

Flint TRADING INC.

Operation Overview

- Instrument Considerations
- Pavement Marking Considerations
- Environmental Considerations
- Calibration Considerations
- Calibration Procedures
- Taking Measurements
- Cleaning

Flint TRADING INC.

Operation Overview: Instrument Considerations

- Check the calibration date (date is not > 1 week old)
- Make sure the frame and instrument are clean
- Make sure the battery is charged (~ 1 hour)

Flint TRADING INC.

Operation Overview: Pavement Marking Considerations

Do

- Make sure the markings are dry from application
- Make sure the markings are dry from moisture

Don't

- Take measurements on wet or damp markings
- Take measurements on markings with loose glass beads or debris on them

Flint TRADING INC.

Operation Overview: Environment Considerations

Do

- Make sure the operating temperature is between 32 ºF and 113 ºF
- Make sure the humidity should be between 0 and 90% and non-condensing
- Transport the instrument in a non-air-conditioned or non-heated area of your vehicle

Don't

- Use the instrument when moisture is condensing out of the air, such as early morning dew
- Use the instrument too soon after moving it from place to place where the temperature or humidity are very different without letting the instrument acclimate for 15 minutes out of its case

Flint TRADING INC.

Operation Overview: Calibration Considerations

Do

- Store the black block properly inside its case within the office
- Store the red field block properly inside its case when not in use

Don't

- Touch the white ceramic area of the calibration blocks
- Bump edges of the calibration blocks, this could cause damage to the ceramic face
- Take the black block outside of the office

Flint TRADING INC.

Operation Overview: Calibration

Figure A:
Zero Calibration Position

Figure B:
Reference Calibration Position

During the calibration procedure

- The LTL-X handle should be in the down position
- The Wheels should not be installed
- The LTL-X should be on a flat surface

Flint TRADING INC.

Operation Overview:
When to Perform a Field Calibration

- Before the start of work each day at the work site
- If the LTL-X has not been used for 30 minutes or more
- Once every 2 hours if the LTL-X is being used continuously all day
- Calibrate the LTL in the field using the Red field block
- Keep the traceable calibration block (black block) at the office

Flint TRADING INC.

Operation Overview: Field Calibration Procedure

Zero calibration

Press the CALIBRATION button . Mount the red calibration unit underneath the front end of the instrument. This is done by tilting the instrument slightly backward and then placing the calibration block. Make sure that the pins on the side of the unit fit into the holes in the LTL-X. Press the GREEN button to start zero calibration. During calibration the lamp will flash a number of times.

Reference calibration

Now the instrument is ready for the next step and the display will tell you to rotate the calibration unit. Again it is important that the pins on the side of the unit fit into the holes in the LTL-X. Check and if necessary update the calibration value shown in the display so it matches the value stamped on the calibration unit. Press the GREEN button to finish the calibration.

Flint TRADING INC.

Operation Overview: When to Perform a Calibration Transfer

- Minimum of once per week
- If you have to clean the ceramic face of the Red Field Calibration block (even if it has not been a full week since the last calibration transfer)

Flint TRADING INC.

Operation Overview: Calibration Transfer Procedure

Zero calibration

Press the CALIBRATION button . Mount the black calibration unit underneath the front end of the instrument. This is done by tilting the instrument slightly backward and then placing the calibration block. Make sure that the pins on the side of the unit fit into the holes in the LTL-X. Press the GREEN button to start zero calibration. During calibration the lamp will flash a number of times.

Reference calibration

Now the instrument is ready for the next step and the display will tell you to rotate the calibration unit. Again it is important that the pins on the side of the unit fit into the holes in the LTL-X. Check and if necessary update the calibration value shown in the display so it matches the value stamped on the calibration unit. Press the GREEN button to finish the calibration.

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Operation Overview: Calibration Transfer Procedure (Cont.)

Red field block verification

Mount the red calibration unit underneath the front end of the instrument with the ceramic face towards the tower. This is done by tilting the instrument slightly backward and then placing the calibration block. Make sure that the pins on the side of the unit fit into the holes in the LTL-X. Press the GREEN button to take a reading of the red field block. On the red field block there is a label that needs to be updated. Please write the new value from the display on the label with the date it was done.

Calibration Transfer should be done once a week or if the Red field block looks dirty. If the Red field block is cleaned a calibration transfer needs to be performed.

Flint TRADING INC.

Operation Overview: Taking Measurements

- Place the LTL-X on the marking straight down making sure that the LTL-X covers the marking as much as possible
- Moving the LTL-X is done by lifting the unit straight up and moving it to the next position to take a reading. Do not slide unit, this can cause damage to the optic window
- Press the Operater (Green) button to take a reading

Wheels can be installed on the LTL-X for taking readings

Flint TRADING INC.

Operation Overview:
Built-in Printer

```
--------------------------------
LTL-X S/N: #109
Rl: 525 (mcd/m²)/lx
#3 MAPLE AVE
MAR 10 2003  11:52:00 AM
Status: 0
--------------------------------
LTL-X S/N: #109
Rl: 420 (mcd/m²)/lx
#5 MAPLE AVE
LATI: 35°53.218N HDOP:2.3
LONG: 80°03.518W #SAT:5
MAR 10 2003  11:56:43 AM
Status: 0
--------------------------------
```

JOHN

JOHN

Flint TRADING INC.

Operation Overview: Cleaning

- **Do not clean the black block it is your traceable standard. It can only be certified by Delta Light & Optics.**
- Clean the Red Field block with Windex & a lint free cloth. After cleaning a calibration transfer needs to be performed.
- Clean the optic window with Windex & a lint free cloth.

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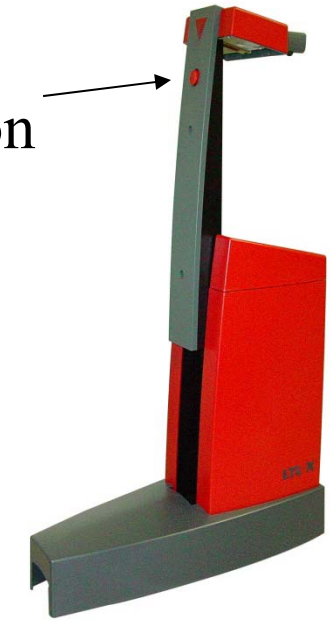
Handle Extension

Extension
Red Button



The operating panel can be adjusted in height for ergonomic considerations. The height is adjusted by pressing the red button on the front of the instrument and at the same time lifting the handle on the operating panel. Release the button and continue lifting until the handle locks.

Flint TRADING INC.

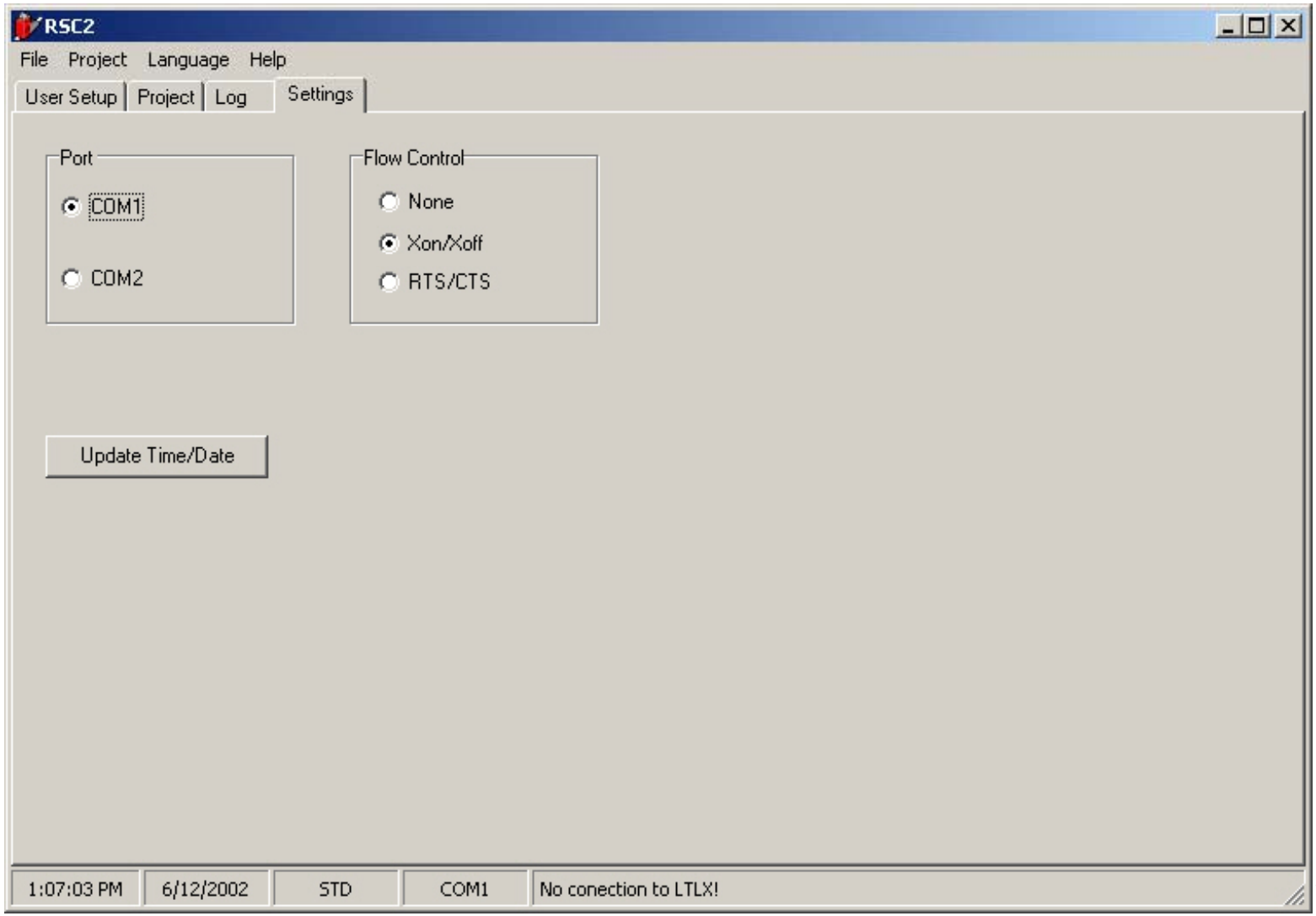
Communications with the LTL-X

The LTL-X downloads its data to a computer by means of the RSC program.(Road Sensor Control program)

Projects Developed
User Settings
Log Download

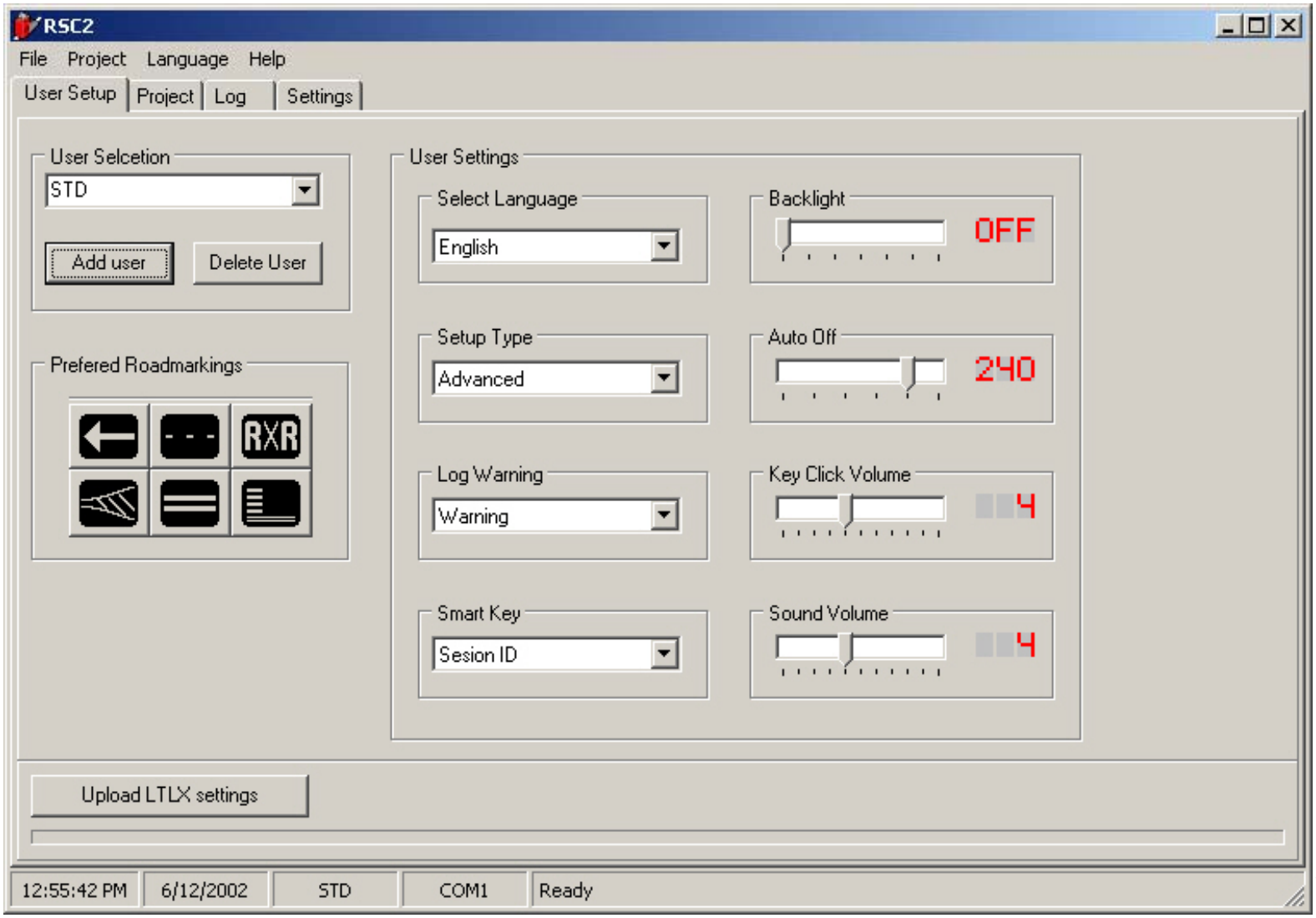
Flint TRADING INC.

LTL- X RSC Program / Settings



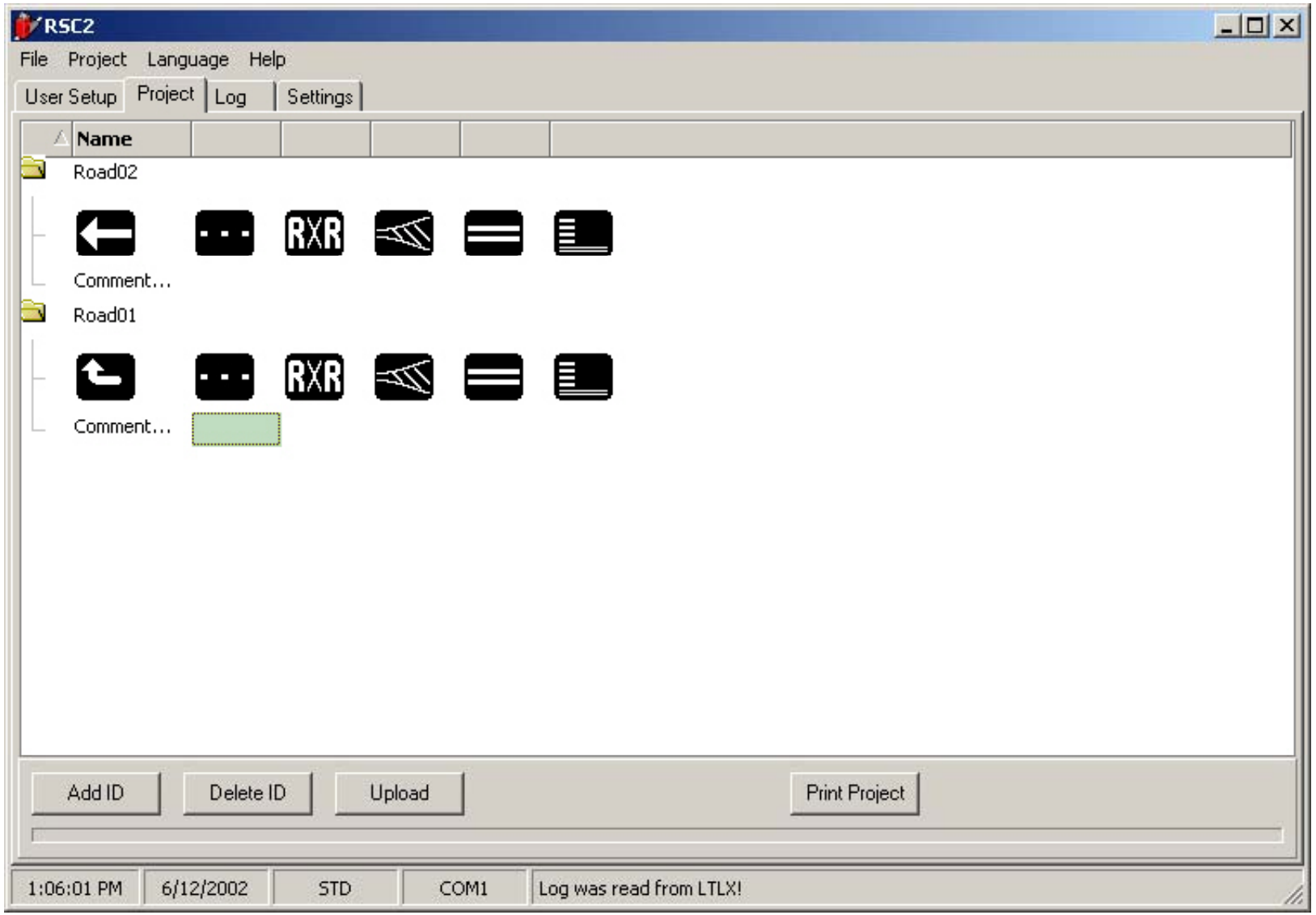
Flint TRADING INC.

LTL-X RSC Program / User Setup



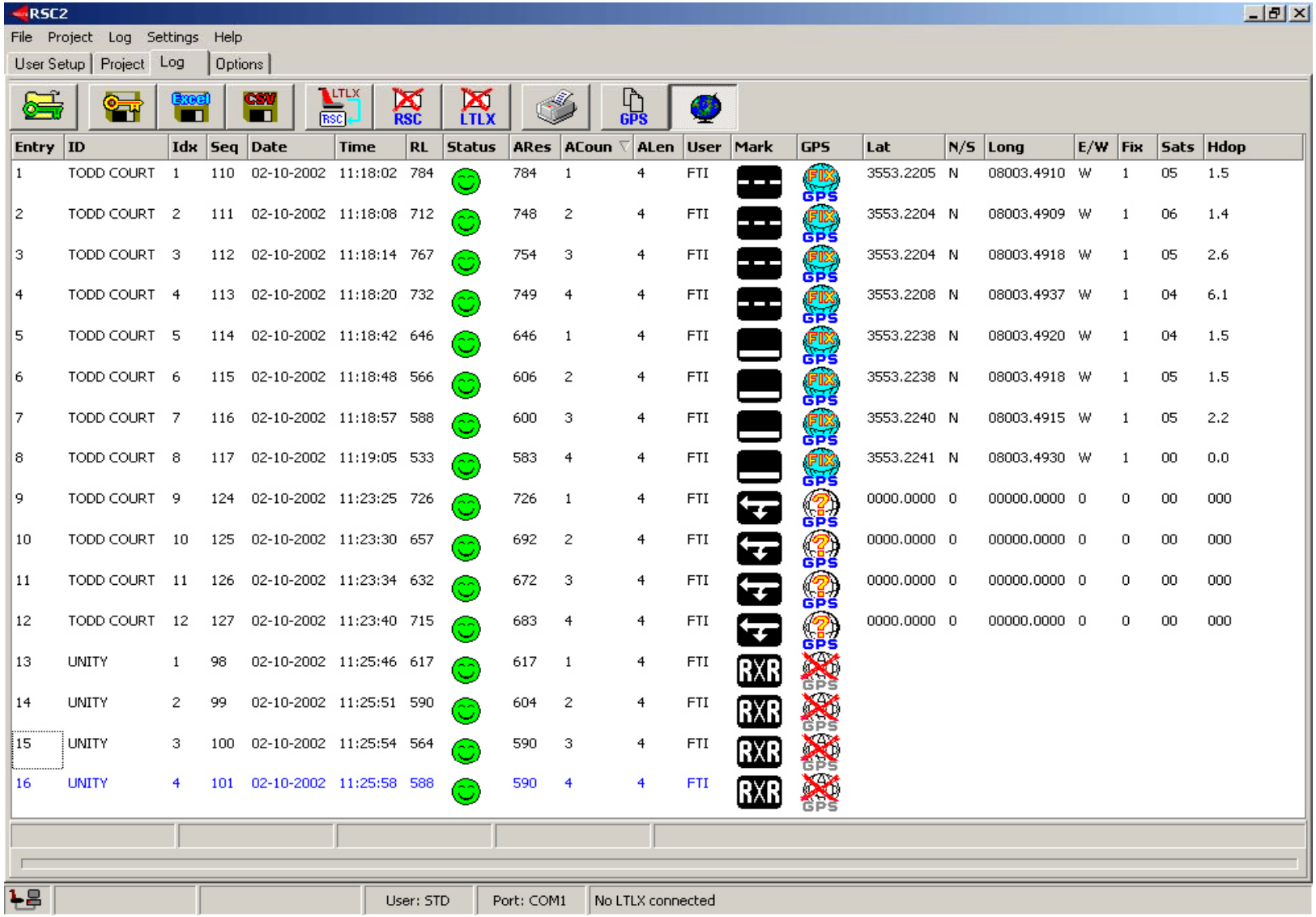
Flint TRADING INC.

LTL-X RSC Program / Project



Flint TRADING INC.

LTL-X RSC Program / Log



Entry	ID	Idx	Seq	Date	Time	RL	Status	ARes	ACoun	ALen	User	Mark	GPS	Lat	N/S	Long	E/W	Fix	Sats	Hdop
1	TODD COURT	1	110	02-10-2002	11:18:02	784		784	1	4	FTI		FIX GPS	3553.2205	N	08003.4910	W	1	05	1.5
2	TODD COURT	2	111	02-10-2002	11:18:08	712		748	2	4	FTI		FIX GPS	3553.2204	N	08003.4909	W	1	06	1.4
3	TODD COURT	3	112	02-10-2002	11:18:14	767		754	3	4	FTI		FIX GPS	3553.2204	N	08003.4918	W	1	05	2.6
4	TODD COURT	4	113	02-10-2002	11:18:20	732		749	4	4	FTI		FIX GPS	3553.2208	N	08003.4937	W	1	04	6.1
5	TODD COURT	5	114	02-10-2002	11:18:42	646		646	1	4	FTI		FIX GPS	3553.2238	N	08003.4920	W	1	04	1.5
6	TODD COURT	6	115	02-10-2002	11:18:48	566		606	2	4	FTI		FIX GPS	3553.2238	N	08003.4918	W	1	05	1.5
7	TODD COURT	7	116	02-10-2002	11:18:57	588		600	3	4	FTI		FIX GPS	3553.2240	N	08003.4915	W	1	05	2.2
8	TODD COURT	8	117	02-10-2002	11:19:05	533		583	4	4	FTI		FIX GPS	3553.2241	N	08003.4930	W	1	00	0.0
9	TODD COURT	9	124	02-10-2002	11:23:25	726		726	1	4	FTI		? GPS	0000.0000	0	00000.0000	0	0	00	000
10	TODD COURT	10	125	02-10-2002	11:23:30	657		692	2	4	FTI		? GPS	0000.0000	0	00000.0000	0	0	00	000
11	TODD COURT	11	126	02-10-2002	11:23:34	632		672	3	4	FTI		? GPS	0000.0000	0	00000.0000	0	0	00	000
12	TODD COURT	12	127	02-10-2002	11:23:40	715		683	4	4	FTI		? GPS	0000.0000	0	00000.0000	0	0	00	000
13	UNITY	1	98	02-10-2002	11:25:46	617		617	1	4	FTI	RXR	GPS							
14	UNITY	2	99	02-10-2002	11:25:51	590		604	2	4	FTI	RXR	GPS							
15	UNITY	3	100	02-10-2002	11:25:54	564		590	3	4	FTI	RXR	GPS							
16	UNITY	4	101	02-10-2002	11:25:58	588		590	4	4	FTI	RXR	GPS							

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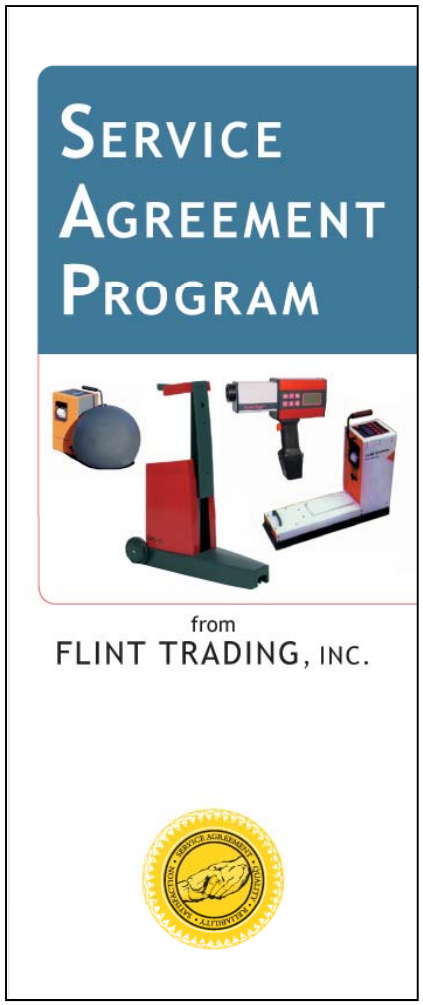
Annual Maintenance



Through Flint Trading Inc.'s Annual Maintenance Program, factory trained and authorized personnel will thoroughly check, adjust and/or repair your instrument if it fails to meet the high quality standards set by DELTA during the original manufacture.

Flint TRADING INC.

Contact Us For More Information

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Thomasville, NC 27360
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www.flinttrading.com

Flint TRADING INC.

LTL-X MANUAL

LTL-X RETROMETER
Manual

On site quality control of road markings & road surfaces in accordance with CEN / ASTM specifications.

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Rev. 25. January 2005
SW ver: (MMC V3.04 up)

TABLE OF CONTENTS

SECTION 1

OPERATING INFORMATION

LTL-X introduction

The LTL-X retrometer is a portable field instrument intended for measuring the retroreflection properties of road markings in car headlight illumination, the value Rl (coefficient of retroreflected luminance) is used. Rl is a measure of the lightness of the road marking as seen by drivers of motorized vehicles in car headlight illumination. The road is illuminated at an angle of 1.24° and the reflected light is measured at an angle of 2.29°, which corresponds, to an observation distance of 30 meters. This is relevant for a motorist's viewing situation under normal conditions.

Rl is an important factor in the **ON-SITE** quality control of road markings.

The operation of the retrometer is very simple and requires minimal instruction.

The LTL-X measures the retroreflectivity and calculates Rl according to international agreements. Results are presented in plain text on a large graphic display. Error messages or warnings are shown in the display in case of any problems during use.

The built-in printer and memory provides registration of measurements with corresponding date and time and other important data. The following data is also registered (if enabled):

- Name of measuring series (road name).
- Profile (icon) for road marking.
- User initials.
- GPS data (if installed).

Communication with a PC using the RSC-program (**see pg. 38**) allows for data exchange with other PC programs, extended command, calibration, diagnostics and other facilities.

A rechargeable NiMH battery powers the LTL-X, giving hours of measurement capacity. A mains powered battery charger power supply is supplied as standard. The instrument can also be charged from a 12-18V source such as a car battery using an adapter.

LTL-X retrometer features

- Portable self-contained instrument
- Small dimensions / low weight
- Ergonomic operation height
- Fast measurement (completed in less than 1 sec)
- Measuring on dry and wet surfaces (or the continuous wetting measurement method)
- Will measure flat, textured & profiled markings
- Built-in thermal printer
- Fully documented measurements with automatic data storage, user and series identification for labeling and grouping measurements
- Audible signals during use
- RSC PC software for data exchange, extended control, etc. Log data can be exported to applications such as Microsoft Excel
- Easy calibration procedure
- Traceable and accredited calibrated reflection standard
- User replaceable battery
- Fast charging (approx. 1 hour)
- Rechargeable from power adapter or a car battery using an adapter
- Average (2-25 readings)
- Multiple languages
- Wheel unit

Options

- GPS, for precise logging of measuring location
- Large battery pack with more capacity for extended use between charges

Buttons:

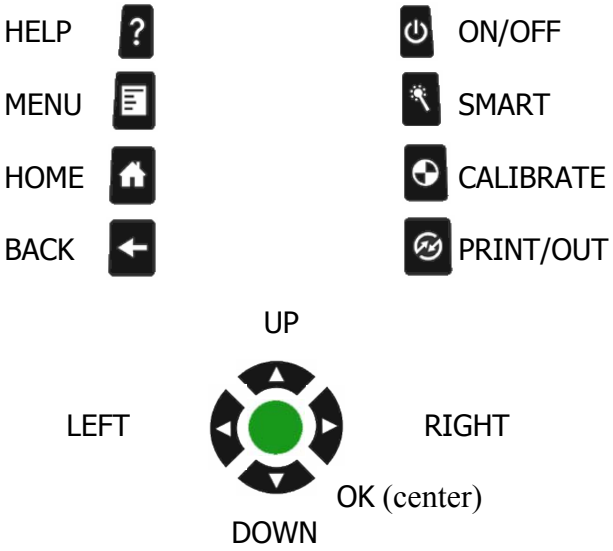


Figure 1. Buttons

Height adjustment
Before using the LTL-X, notice that the operating panel can be adjusted in height for ergonomic considerations. The height is adjusted by pressing the red knob on the front of the instrument and at the same time lifting the handle on the operating panel. Release the knob and continue lifting until the handle locks.

Measuring

Turn on the LTL-X by pressing and holding the ON/OFF button until the welcome message appears. The display will then change to the measure mode. (An exception is when the instrument is set to ask for user identification, see **User select** in this section).

Calibrate the instrument if necessary. See **Calibration** in this section**.**

Place the instrument on the road marking.

Press the green OK-button to take a measurement. A measurement will be finished in approx. 1 sec.

When the measurement is complete, the Rl value will be displayed. Data is automatically transferred to the data log. If there is a problem with the measurement a warning icon or an error icon will pop up (see **Warnings and errors, see pg. 37**)) and an audible alarm will sound (if enabled, see **Sound settings**).
Measurements taken with a battery voltage that is too low are rejected or marked in the log and an error icon appears.

To print the last measurement data, press the PRINT/OUT button . The Print/Output function must be set to **Int**. (See **pg. 37**). Printing can be stopped by pressing the PRINT/OUT button or the ON/OFF button for approximately 0.5 sec.

User select (user initials)

If a user icon  is displayed in the upper icon row on the measuring display, press the UP button ▲and if necessary ◄ or ► to mark the user icon. Press the OK button to enter the user select menu. For further information see **Selecting a user id**, **pg. 19**

Series ID select (name)

From the HOME screen (measure display) press the UP button ▲to mark the road icon . Press the OK button to enter the series ID select menu. Select a name from the list using UP or DOWN and accept with OK.

Calibration

The instrument is supplied with two calibration units, a reference calibration unit (black) and a field calibration unit (red). The reference calibration unit is factory calibrated and traceable to PTB. The field calibration unit must be calibrated against the reference calibration unit by the user at suitable intervals. The reference calibration unit is stored in the black protection box, and the field calibration unit in the grey protection box.

Two steps are required for a complete calibration, *zero calibration* and *reference calibration*. The instrument will guide you through the procedure.

Calibration procedure

• *Zero calibration*

Press the CALIBRATION button  once. Mount the calibration unit underneath the front end of the instrument by tilting the instrument slightly backward. Make sure that the end pins on the side of the calibration unit fit into the slots in the LTL-X.
It is important that the calibration unit faces with the dark opening toward the instrument tower. The display will show the correct orientation of the calibration unit. Make sure that the calibration unit and the light trap is clean. Press the OK button to start *zero calibration (black calibration)*. During calibration the lamp will flash a number of times.

• *Reference calibration*

After zero calibration, the instrument is ready for the reference calibration (white calibration). The display will tell you to turn the calibration unit so that the white face is facing the instrument tower. Again, it is important that the pins on the side of the unit fit into the slots in the LTL-X. Press the OK button to start reference calibration. Check the value displayed, and if necessary, adjust the calibration value shown in the display so it matches the value stamped on the calibration unit.
Press the OK button to perform the calibration.

The calibration procedure is now complete. Remove the calibration unit and store it properly. Press OK to return to the measurement display. For further details see **pg. 43**.

Control Calibration.

Use in case of doubt during on site measurement. Follow the traceable calibration procedure using the red control calibration unit. Use the Rl value from the control calibration unit label.

Transfer of calibration value.

At regular intervals the traceable calibration value must be transferred from the reference calibration unit to the control calibration unit.
Mount the reference calibration unit and perform a complete traceable calibration. Replace the reference calibration unit with the control calibration unit and make a normal Rl measurement. Label the Control Calibration unit with the value and the date.

Warnings and errors
An error or warning icon will appear in the upper row of the display if the LTL-X detects a problem. Press the UP button ▲ to get a description of the most serious error or warning. Now press the OK button to display a total list of all errors or warnings related to the measurement.

Sound setting

Press the MENU button  and select **SETTINGS / SOUND**. Select **KEY CLICK** or **SOUNDS** to set the individual sound levels for key click and warning/error sounds. Use the UP ▲ or DOWN ▼ button to set the level. Accept the setting by pressing the OK button. A loud additional beep can be selected by pressing the OK button when **BEEP** is highlighted.

Miscellaneous

The HOME screen can be activated at any time by pressing the HOME button  .

Reset log: Press the MENU button  and select **LOG / CLEAR DATA .** Now select from the menu: **LAST**, **ALL** or **SERIES**.

Date and time: Press the MENU button and select **SETTINGS / DATE & TIME**. Use the UP ▲ and DOWN ▼ buttons to set the time and date. Accept the setting by pressing the OK button.

Power save: Press the MENU button and select **SETTINGS / AUTO OFF**. Use ▲and ▼ to edit the auto turn off time.

Data exchange / communication
The RSC program, developed by DELTA for use on a PC, allows data to be exchanged between the LTL-X and a PC. See **RSC-program, pg. 38.**

Important guide lines for the correct use of the LTL-X

Positioning of the instrument on the road marking
Select an area of the pavement marking that is level when taking readings. The red dot on the side of the base cover indicates the centre of the measurement field on flat markings. The measurement field is appr. 45 mm wide and 200 mm long. Ensure the pavement marking to be measured is free of debris before taking measurements. Make sure that the instrument is stable positioned.
Reason: The LTL-X has three support pads, each with a small footprint. An uneven marking or a small piece of gravel trapped under one of the pads will move the measurement field and affect the reading.

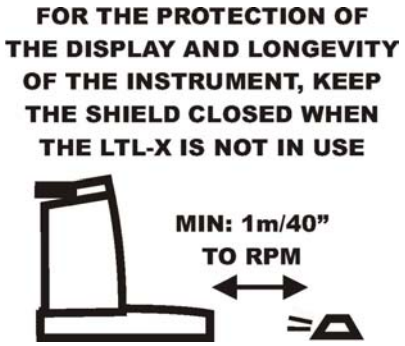
Taking the measurement
Press the green OK button to take a single reading. Do not put pressure on the handle when taking a measurement.
Reason: Pressure on the handle can affect the measurement geometry and thus influence the reading.

Number of measurements.
For accurate readings, do not take just one reading of a road marking. Three readings will give a more accurate result than one reading. Five readings will give a more accurate result than three readings, etc. Take the readings in adjacent areas of the marking. Let the instrument calculate the average of the readings (fixed- or moving average options).
Reason: A road marking's retroreflectivity varies from area to area. It is not unusual to see variations of 5% - 20% when the instrument is moved even less than 10 mm/ ½" in either direction.

Obstructions in front of the LTL-X
Ensure the pavement marking to be measured is clear of any obstructions at least 1 meter/ 40 inches in front of the LTL-X. For example, do not stand in front of the instrument when taking the reading, and do not have anyone else standing in front of the instrument while taking the reading.
Reason: The observation field of the LTL-X extends beyond the front opening of the instrument.

RPM's/retroreflective materials in front of the LTL-X
Recommended Procedure: Ensure there are no retroreflective materials not belonging to the marking at least 1 meter / 40 inches in front of the LTL-X. For wet road markings this distance is 2 meters/ 80 inches. Examples of such materials are raised pavement markers, high visibility clothing and shoes with retroreflective properties. Whenever the user suspects that materials ahead affect the reading the material should be covered with a dark cloth.
Reason: The observation field of the LTL-X extends beyond the front opening of the instrument, and such retroreflective materials can cause false readings.

Protection of the display/display shield.
For the protection of the display and longevity of the instruments keep the display shield closed when the instrument is not used. For further information please see section 2.



Remember:

- LTL-X is an optical precision instrument, handle with care.
- Keep the protection window and calibration unit clean.
- Store in a clean and dry environment.

SECTION 2

GENERAL INFORMATION

The measurement

The LTL-X retrometer measures the Rl (coefficient of retroreflected luminance) parameter. The Rl parameter represents the brightness of road markings seen by drivers of motor vehicles by headlight illumination.

In the LTL-X the illumination angle is 1.24 degrees and the observation angle is 2.29 degrees. According to both ASTM and CEN standards this angle simulates a driver's viewing distance of 30 meters. The instrument's illumination field is approximately 200 mm x 45 mm and the observation field is approximately 610 mm x 60 mm. The dimensions are given for plane surfaces. **For real non-planar road markings the fields are elongated**. The measurement field is identical with the illumination field.

The figure below shows the placement of the fields for normal and continuous wetting operations. For continuous wetting measurements the instrument is raised 7 mm by mounting the wet night base plate and two feet (See **pg 46**).

In this operation the illumination/measurement field is placed just in front of the horizontal base cover allowing the continuous wetting.

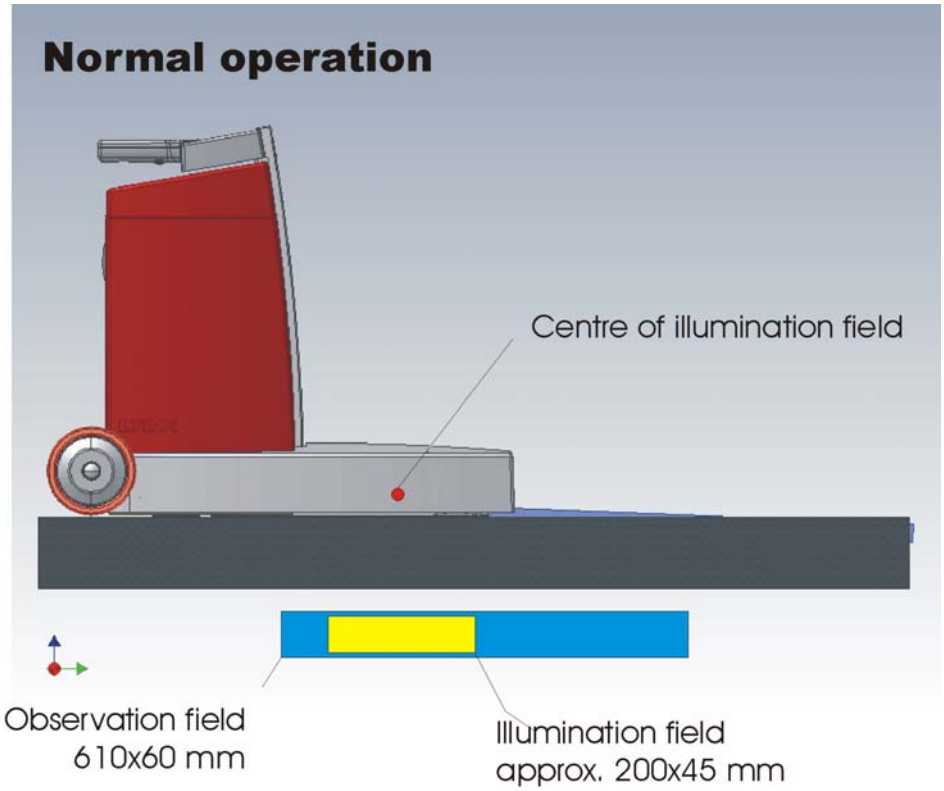


Figure: 2 – Measurement field

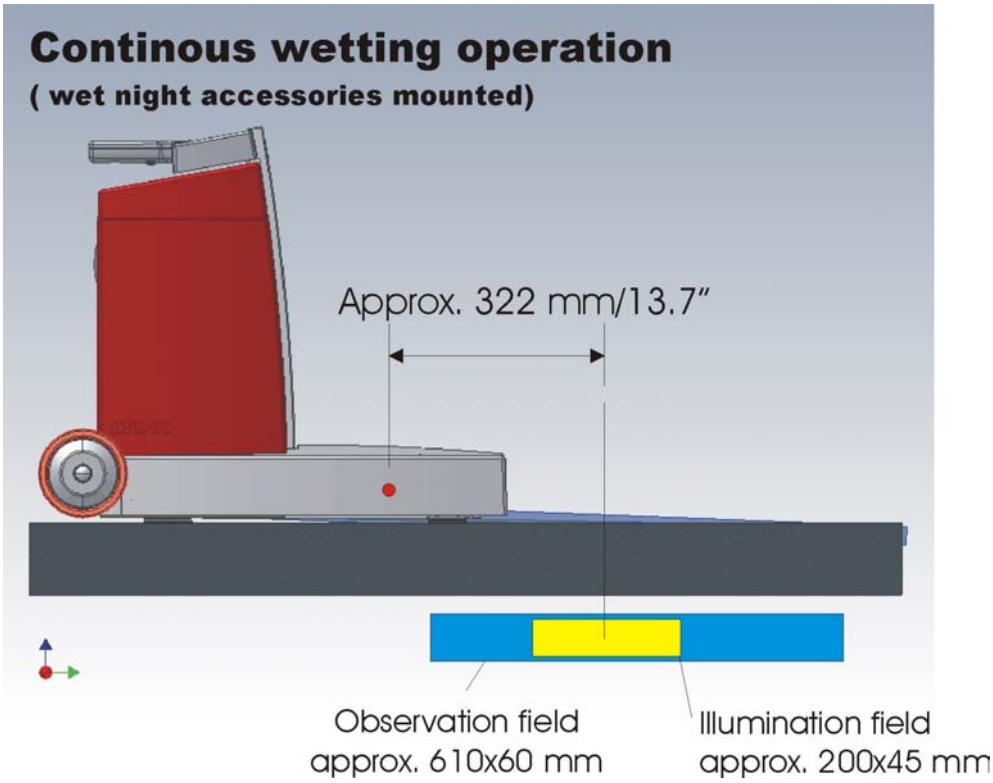


Figure: 3. Measurement field with wet night accessories mounted.

The tower of the LTL-X contains the illuminating and observation system and the control electronics. At the bottom of the tower an optical system, with mirror, directs a beam of light toward the road surface through a dust-protection window. A polymer shielding covers the measuring area for normal operation (see above).

The LTL-X is controlled by multiple microprocessors. It is operated with an extractable key-board located at the top of the retrometer. It executes the measurement automatically by push of a button and presents the result on a display. The result is automatically transferred to the internal memory. The measurement, along with its corresponding time, date, and other data can be printed using the built-in printer.

Optical principle

The optical system in the LTL-X is covered by a patent pending. A long life xenon lamp in the top of the tower generates the light for the measurements. After a field stop the light is collimated by a lens and deflected through a mirror toward the road.

The reflected light from the road uses the same mirror and lens. Between the lens and the photo detector field aperture, stops define the observation area. The illumination field is inside in the observation field. This is important to assure correct measurement on profiled markings.

V_λ spectral correction is achieved by use of advanced optical filters.

Notes on error sources

Stray light can occasionally enter the instrument but will be insignificant under normal measurement conditions. Before each measurement, the LTL-X automatically evaluates the leakage and compensates for it before the readout. In case of a significant leakage level, a warning or error message is given and special precautions may be necessary.

Instrument leak, drift and offset errors are compensated by means of data obtained during the calibration procedure. It is very important to keep the light trap, the dust-protection window and the ceramic on the calibration unit clean.

The LTL-X illumination angle is 1.24° relative to the road surface. Because of this small angle accurate placement on the road is important. Avoid pebbles and abnormal irregularities. The LTL-X must be parallel and in contact with the marking surface.

The LTL-X retrometer is a rugged instrument, but it is an optical instrument and must be handled as such.

The LTL-X is factory calibrated. Nevertheless start measurements with a calibration. Study the display for any warning or error icons. See **also Section 4 - Maintenance**

Note

Keep the light trap, dust-protection window and ceramics on the calibration unit clean.

Keep the battery fully charged. A well charged battery is more resistant to aging and damage.

High temperature conditions.

Display

If the display is exposed to intense direct sunlight during a longer period of time the display could become overheated.
To reduce heat an IR-reflecting filter is mounted on the display. It is recommended to close the protective display shield. The shield also protects against damages and scratches.
"Daylight readable" displays are vulnerable to high temperatures. High temperature will decrease the display service life.

When the display temperature exceeds 50°C / 122°F an audible alarm will sound. The alarm will sound for 20 second and then pauses for one minute. This sequence continues until the temperature is lowered or the instrument is turned off. The alarm can be suspended for one minute by pressing any key.

Battery

The battery is rated to maximum 45°C / 113°F operating temperature.

SECTION 3

THE USER INTERFACE

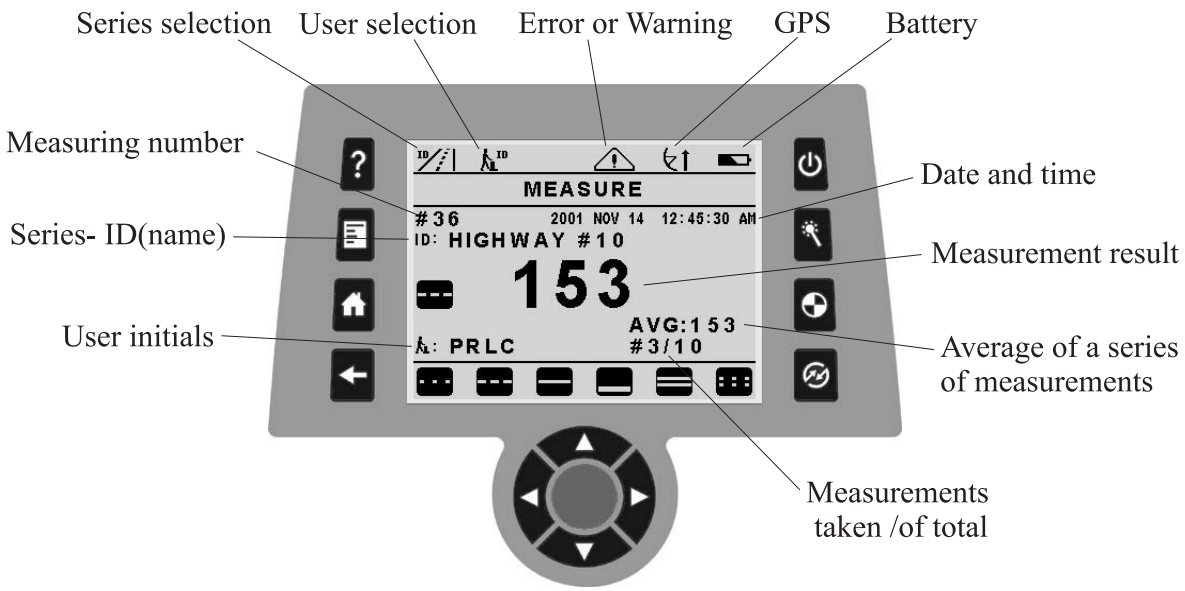


Figure: 4 – Display

Display and keyboard layout

The user interface consists of a rectangular display surrounded by push buttons.
The display has two main modes: the *measurement display* (HOME screen) and the *menu display*.
The instrument will start up with the measurement display shown. The display area is divided into four areas: a large main display in the middle, an icon row at the top, a message or caption field underneath and an icon row at the bottom.

Measurement display

Here the last measured Rl value is presented with large digits together with other information. On the graphic above, all possible information is shown in the display. If a function is deactivated, it will not be shown. The actual date and time is always shown.

Upper icon row

The upper row of icons is accessed by pressing the UP button ▲. One of the icons is then highlighted (inverted) and can then be activated by pressing the OK button. The other icons in the row can be accessed by using the LEFT ◄ or RIGHT ►buttons. The meanings of the icons are (from left to right):

- Series ID (name) selection.
- User ID (initials) selection. Can be switched off (see **pg. 19**).
- Error/warning alarm. Will be shown in case of an error/warning (see **pg. 37**).
- GPS indication (see **pg. 24**).

- Battery status (see **pg. 41**).

Lower icon row

- From the lower icon row you can select a road marking icon that will be saved together with the measurement in the log (see **pg. 19**) for future measurement identification. Access the icons by pressing the DOWN button ▼. Use the LEFT or RIGHT button to mark the preferred icon. Pressing DOWN again shows more icon rows from a roll stack of four rows. One row, marked with a *"PR" for "Preset"* can be preset by the user (see **pg. 29**) and is saved separately for each measuring series. It will be the active icon row, ready for selection, when a measuring series is selected. The measuring schedule upload (see **pg. 38**) includes series ID and the six preset icons for each series.

- Activate the marked icon with the OK button or exit with the HOME  or UP ▲ button. The selected icon is now shown in the left side of the HOME screen and the instrument is again ready for measuring.

- Other functionality regarding the lower icon row:
  Activating an already selected icon will cancel the activation and remove the icon from the main display (and no icon will be saved by the next measurement). When the measurement display is selected (with the MENU button or the BACK button) the lower icon row will be the same as when the measurement display was last shown. Pressing DOWN and then UP in the HOME screen will show the row with the currently selected icon marked.

Pushbuttons

OK 
When the message row shows MEASURE, press the OK button to take a measurement. In most other cases pressing the OK button will activate a highlighted selection.

ON/OFF 
Turn the instrument *ON* or *OFF*. Press the button to turn *ON* the instrument. To turn it *OFF* hold down the button for about half a second until the display shows a farewell message. When the instrument is on, a short press on the button will turn on the display backlight (if enabled, see **pg. 23**).

HOME 
Bring you back to the measurement display.

BACK 
Backward one step in the menu, canceling new settings which has not yet been confirmed by the OK button. In most cases the LEFT button has the same function.

HELP 

Present a context sensitive help text. Another press on the button will open up a general help menu.

Menu 

Selects the top level of the menu tree, the main menu. Use the UP and the DOWN buttons to scroll through the menu items. Press OK to select the highlighted item. In some cases it opens up future submenu levels.

SMART 

This button is user programmable to one out of several functions, e.g. to clear the last measurement, see **pg. 23**.

CALIBRATE 

Starts the calibration wizard, see **pg. 43**.

PRINT/OUT 

Print out the last measurement or selected parts of the log to the internal printer or send data to the communication port, see **pg. 37**.

The menu tree

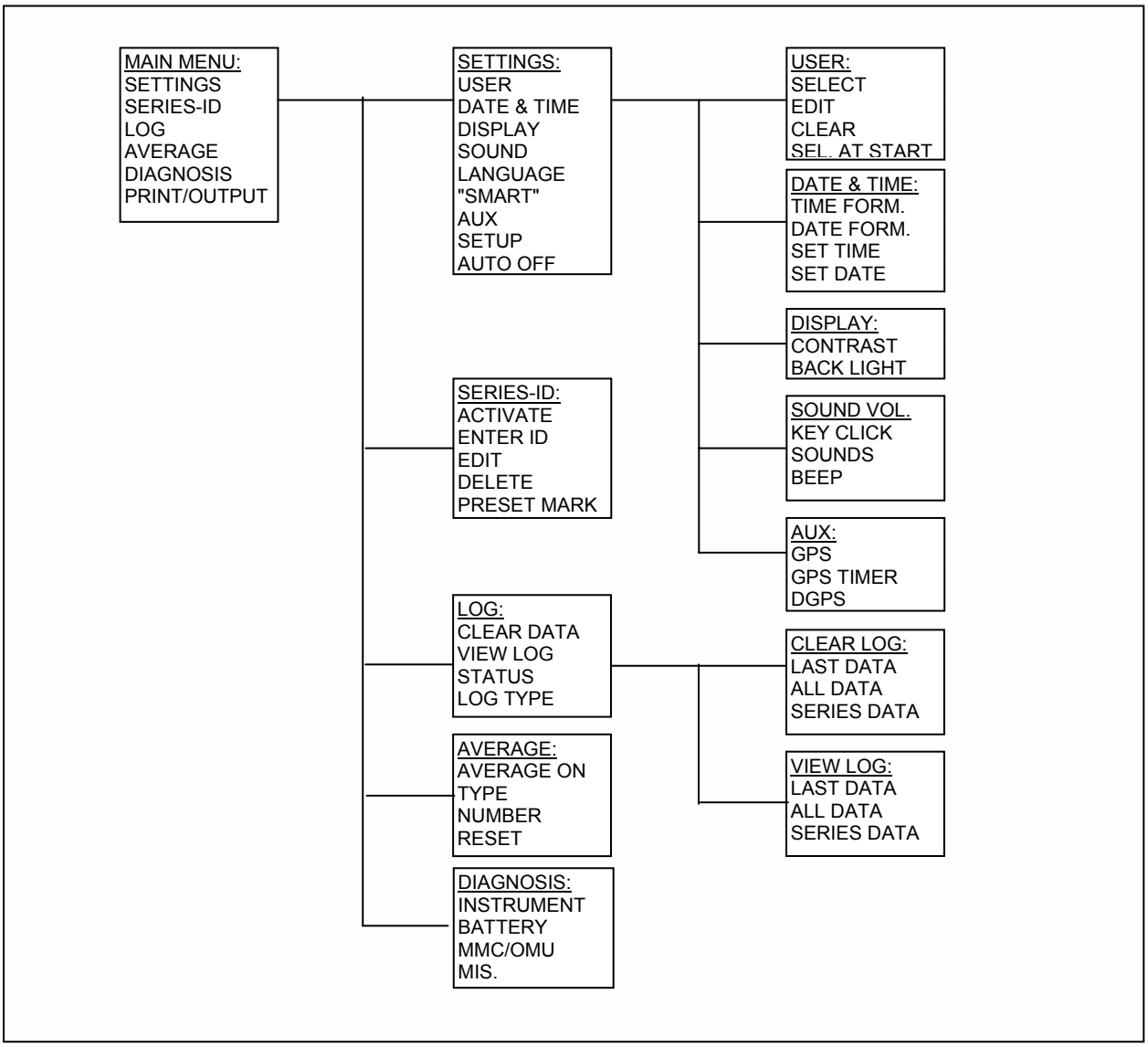


Figure: 5 – Menu tree

SETTING UP FOR MEASUREMENTS

Selecting a user ID

The user ID (user profile) is used to identify the operator and is saved in the log together with each measurement. It consists of up to four characters, for instance initials of the operator's name. If enabled, it can be seen at the lower left side of the measurement display. Measurements can also be taken without a user ID.
Eight user ID's can be stored in the instrument.

Certain instrument settings are stored individually for each user. Selecting a user will restore these settings.
Following settings are stored:

- All sound settings
- SMART key
- Back light timer
- Instrument auto off timer
- Advanced / basic menu setup

The select procedure.

1. *If a user select icon*  *is not seen in the upper icon row*:
   Press the MENU button and select **SETTINGS / USER / SELECT** to display **the SELECT USER** menu.

2. *If a user select icon is seen in the upper icon row*:
   Press the UP button. Then, if necessary use the LEFT or RIGHT button to highlight the user icon. Press the OK button. The **SELECT USER** menu is shown:

SELECT USER: ▲▼**OK**
Off
KFP
HEN
JOHN
U4
U5
U6
U7
U8

Now use the UP or DOWN button to highlight a user name.
Press the OK button to accept the name.
In case 1 press the HOME button to return to the HOME screen.
In case 2 the apparatus will automatically return to the HOME screen.

Changes made to the above mentioned individual instrument settings are automatically stored in the selected user ID.

User names can be edited from the menu **SETTINGS / USER / EDIT** (see **editing pg. 36**).

Selecting *OFF* will deactivate the user function and set all individual instrument settings to default.

Clear user

USER: HEN ▲▼OK
SELECT
EDIT
CLEAR
SEL. AT START NO

Clearing the user id will rename the user name to its default name (U1 to U8) and all individual instrument settings are set to default.

SELECT USER: ▲▼OK
Off
KFP
U2
JOHN
U4
U5
U6
U7
U8

Select at start

USER: JOHN ▲▼OK
SELECT
EDIT
CLEAR
SEL. AT START YES

Enabling *SEL. AT START* will force the user to select a user ID each time the LTL-X is turned on. The last used user ID is automatically highlighted.

Press the MENU button and select SEL. AT START. Press OK to toggle between YES and NO

Selecting a road marking icon

The purpose of a road marking icon.
The road marking icons are used as labels for the individual measurement corresponding to the measured road marking and will be saved in the log together with the measuring result. The icon will then be presented together with the corresponding measurement when viewing the log (**see pg. 32**) or by using the RSC program (**see pg. 38**).
There are 24 icons to select from. Six of the icons can be programmed as individual presets

for each series (**see pg. 29**) and will be ready for selection when a series is selected.

The procedure.
From the HOME screen press the DOWN button.
Then use the LEFT or RIGHT button to highlight the wanted icon. Pressing DOWN steps through and displays the four icon rows. Pressing UP will return to the HOME screen without selecting a new icon.
Pressing the OK button will activate the selected icon. The selected icon is now shown in the left side of the measuring field and the instrument is again ready for measuring.

Deactivating the profile icon.
Activating an already selected marking icon will cancel the activation and remove the icon from the main display.

Setting the date and time

Date and time is always shown in the display. Every measurement taken is marked with the date and time, so it is essential that the settings are correct.

Press the MENU button and select **SETTINGS / DATE & TIME**. Press OK and the time format sub menu is shown.

Setting the time format

DATE & TIME ▲▼OK
TIME FORM.: 12 HR
DATE FORM.: Y/MMM/D
SET TIME: 02:34:56 PM
SET DATE: 2001 NOV 24

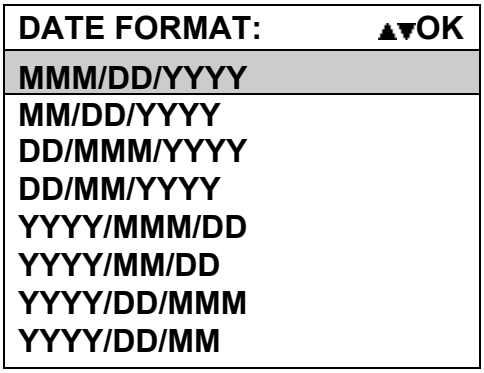
Press OK when **TIME FORM** is highlighted. The time format menu is shown.

TIME FORMAT: ▲▼OK
24 HR
12 HR

Highlight the preferred time format by using UP or DOWN. Press OK to accept.

Setting the date format

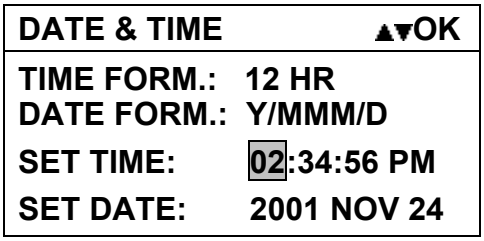
Use UP or DOWN until **DATE FORM** is highlighted. Press OK and the date format menu is shown.



Highlight the preferred date format using UP or DOWN. Press OK to accept.

Setting the time

Use UP or DOWN until **SET TIME** is highlighted. Press OK and the time menu is shown.



Now use UP or DOWN to set the hour. Press the RIGHT button to select the minutes and repeat the procedure for minutes and seconds. Press OK to accept the setting. Note: the time in this menu is not live, but it will synchronize the time shown in the HOME screen.

Setting the date

Use UP or DOWN until **SET DATE** is highlighted. Press OK and the date menu is shown. Now use the same procedure as for setting the time.

Note:

Settings are first valid when OK is pressed. Until then you can abandon your changes with BACK or HOME.

Setting the display, contrast and back light

The backlight time display shows how long the display backlight will be turned on. To turn on the light briefly, press .

DISPLAY :	▲▼OK
CONTRAST	5
BACK LIGHT:	60s

Press the MENU button and select **SETTINGS / DISPLAY**. Select **CONTRAST** and press the OK button. The figure will be highlighted

DISPLAY :	▲▼OK
CONTRAST	5
BACK LIGHT:	60s

Now use the UP or DOWN button to change the contrast. Accept by pressing the OK button or leave unchanged by pressing BACK, LEFT or HOME.

The **BACK LIGHT** time is changed in a similar way.
WARNING: Using the backlight will drain the battery faster!

Setting the sound level

Press the MENU button and select **SETTINGS / SOUND**. Select **KEY CLICK** or **SOUNDS** to set the individual sound levels for key click and warning and error sounds. Use the UP or DOWN button to set the level. Accept the setting by pressing the OK button or leave unchanged by pressing BACK, LEFT or HOME.
A loud additional beep can be selected by pressing the OK button when **BEEP** is highlighted. This beep will be heard when a measurement cycle is completed. It lets the user know that it is ok to lift the instrument and move it to a new location.

Setting the language

Press the MENU button and select **SETTINGS / LANGUAGE**. Use the UP or DOWN button to select a language. Accept by pressing the OK button or leave unchanged by pressing BACK or LEFT.
English can always be selected at power-up by pressing and holding the HELP key before ON is pressed. This will override any language selection.

Setting the SMART key function

This button is user programmable to one of several functions, e.g. to clear the last measurement
Press the MENU button and select **SETTINGS / SMART KEY**:

SMART KEY:	▲▼OK
SELECT SERIES	
CLEAR LAST MEAS.	
RESET AVERAGE	
SER. ID ON/OFF	

Use the UP or DOWN button to select the SMART key function. Accept by pressing the OK button.

The selected function is now accessed every time  is pressed

Setting the aux functions

The Aux function is used to control auxiliary built-in equipment, e.g. a GPS receiver.

AUX:		▲▼OK
GPS	ON	
GPS TIMER	OFF	
DGPS	WAAS	

Using GPS (optional)

The GPS receiver is mounted inside the instrument, drawing its power from the internal battery. The GPS system is used to supply position data (latitude and longitude) to the log together with the measurement data.

If activated a GPS icon is shown in the upper icon row (see **picture pg. 15**). The icon will display the quality (reliability) of the GPS signal. If DGPS (Differential GPS) is selected, and a valid DGPS satellite is recognized, a "**D**" is added to the icon. This is illustrated in the FAIR reception icon below.

In order to minimize the time required to get a GPS position fix after the LTL-X has been turned on, a "GPS TIMER" can be activated. This timer will keep the GPS unit powered up for 30 minutes after the instrument has shut off. If the instrument is turned back on within 30 minutes, the GPS will acquire a valid fix quickly.

Below is an explanation of the GPS icon states.

GOOD:  The GPS HDOP (Horizontal Dilution Of Precision) value is below 5.

FAIR:  The GPS HDOP value is larger than 5, but the GPS can FIX.

NO:  The GPS cannot FIX (weak or no signal).

The GPS position data, HDOP value, and the number of satellites used in the position calculation are saved in the log together with the R_L data.

Activating the GPS

Press the MENU button and select **SETTINGS / AUX**, highlight the GPS line and press the OK button to toggle the GPS ON or OFF. Press the HOME button to return to the HOME screen.

The GPS data can be viewed from the HOME screen by pressing the UP button and then highlighting the GPS icon by using LEFT or RIGHT buttons. Press the OK button to display the GPS data. When the GPS data changes the display is updated.

If the GPS does not fix and a measurement is taken a warning menu appears. You will be presented with the following options:

- Measure anyway
- Skip measurement
- Turn off GPS

GPS delayed off timer
Press the MENU button and select **SETTINGS / AUX**, highlight GPS TIMER and press the OK button to toggle the timer ON or OFF. Press the HOME button to return to the HOME screen. If the timer is activated a message showing the delayed off time is shown in the display when the LTL-X is turned off.

DGPS (WAAS / EGNOS) – optional.
DGPS (Differential GPS) can improve the basic GPS accuracy. If DGPS is used, the GPS unit will receive correction data from the geostationary satellites such as WAAS, EGNOS and others. WAAS / EGNOS reception does not require additional receiving equipment.

Currently, WAAS satellite coverage is only available in North America. Even though GPS users outside North America can receive WAAS, the signal has not been corrected and thus would not improve the accuracy of the position data. In some regions in the northern parts of the continent, the position of the satellites over the equator can make it difficult to receive the signals when trees or mountains obstruct the view of the horizon.

EGNOS is the European counterpart of the WAAS satellite and the same limitations apply.

Press the MENU button and select **SETTINGS / AUX**, highlight DGPS and press the OK button and the DGPS sub menu is shown.

DGPS ▲▼OK
OFF
WAAS
EGNOS
AUTO

AUTO will automatically search for a DGPS satellite.

When DGPS correction is selected the data is not necessary corrected immediately, it can take time to receive and process the correction signal.

LTL-X will show if the correction data is used. The GPS icon in the upper row of the display will include a "**D**".
If the GPS icon is selected, a line in the GPS screen will show the DGPS system used. If no correction system is selected, "**N/A**" will be displayed.
The log data will also record the status of the correction system. When saving the log using

the RSC2 program, the column "**FIX**" will show the value 2 if the DGPS correction was used. It is not possible to see which correction system was used.

For further information about the GPS system and WAAS / EGNOS webpages can be found that describe the systems and how they function.

Map datum.
The default map datum system is WGS84. There are more than 200 different map datums that can be selected. The selected datum can be seen in the GPS menu.
The datum information is also stored in the log.

Warning: Selecting the wrong map datum can result is substantial position errors!

For further information on selecting the correct map datum system, please contact your local mapping software distributor.

Contact your local distributor for futher information on changing the map datum in LTL-X.

More about the GPS
The GPS unit will typically acquire satellite signals and process a position fix in 5-40 seconds. If the GPS receiver has been turned off for a long period of time, the time to first fix will take longer.

The GPS engine used have a navigation performance of 2.5 m CEP[1)]
The precision of the GPS receiver in the LTL-X is determined by many factors. A few are listed below:

- Signal obstruction. The GPS receiver requires a clear view of the sky. Trees, buildings and other environmental objects can affect the satellite signals.
- Satellite constellation and geometry.
- Multi path (reflection of signal from buildings etc.).

The HDOP (Horizontal Dilution of Precision) is a number that indicates the quality and precision of the received GPS data (low values are better than high).

When the GPS is used, the operating time for the LTL-X will be decreased and you must charge the battery more often.

[1)] CEP (Circular Error Probable):
A statistical measure of the horizontal precision. The CEP value is defined as a circle's radius, when centered at the true position, encloses 50% of the data points in a horizontal scatter plot. Thus, half the data points are within a 2-D CEP circle and half are outside the circle.

Setup

Setup is used to separate between advanced or basic users. The basic settings reduce the number of menus available to the user. For example, in basic menu operation, users cannot clear the log.
The following menu points can be selected in basic mode:

Settings: user, date & time, display, sound, setup.
Log: status.

Diagnosis.
Print/output.

To change the setup, press MENU and select **SETTINGS / SETUP**. Pressing OK will toggle between *ADVANCED* and *BASIC*.
To return from setup press BACK, LEFT or HOME.

Auto off

To save power, the instrument can be programmed to automatically shut off if not used.
When communicating with RSC program the instrument will not power down automatically.

Press the MENU button and select **SETTINGS / AUTO OFF**. Use UP and DOWN to edit the auto turn off time.
The off time can be set from 60-300 sec. in intervals of 60 sec. or it can be deactivated (*OFF*)

SERIES ID

Working with series ID (name)

The purpose of a series ID.
The series ID is a label. For example, it could be the name of the road.
Although measurements can be performed without selecting a series ID, it is convenient to group (name) the measurements for each geographical spot, road or part of a road for easier recognition of each measurement.
The series ID for such a group of measurements will be saved in the log together with the measuring results. The ID must be selected prior to the measurement.

The individual measurements in a group can further be labeled by selecting a road marking icon (see **pg. 29**) corresponding to the actual road. Measurements taken with the same series ID are automatically marked with a unique number.

The instrument can store 250 series ID's.

The series ID can be entered manually but it is far more convenient to enter the series ID's in the RSC program (see **pg. 38**) and transfer them to LTL-X.

Activate

To use the series ID it must be activated. Press the MENU button and select: **SERIES ID / ACTIVATE**. By pressing OK you can toggle between *ON* and *OFF*, to activate or deactivate the series ID function. Press the HOME button to return to the HOME screen. When the series ID is off no ID is shown in the display and ID's in the log marked: "No name".

Selecting a series ID

From the HOME screen press UP. If necessary, use the LEFT or RIGHT button to highlight the road icon  . Press the OK button. The **SELECT SERIES** menu is shown:

SELECT SERIES: ▲▼**OK**
NEW
ROAD #2
HIGHWAY #1
HIGHWAY #2
HIGHWAY #3

Now use the UP or DOWN button to highlight a series name. If the symbol ">" is displayed in the top right corner then more series can be accessed by pressing the RIGHT button.
Press the OK button to accept the name. The instrument will now return to the HOME screen.

Enter a new series ID

Do the same as above but select **NEW** from the series list (or select **MENU / SERIES ID /**

ENTER ID). Proceed by spelling the series name (see **Editing pg. 36**).

Removing a series ID

This will remove the series ID from the selection list.
Press the MENU button and select **SERIES-ID / DELETE**:

DELETE SERIES-ID ▲▼OK
ROAD #1
ROAD #2 HIGHWAY #1 HIGHWAY #2 HIGHWAY #3
1 11 04 2001 - 11 04 2001

Use UP or DOWN to select the series that should be deleted. Accept by pressing the OK button. A confirm menu is shown:

DELETE SERIES?
NO
YES, ALSO IN LOG

Select with UP or DOWN and accept with OK.

Note! All measurements in the selected series will be erased from the log!

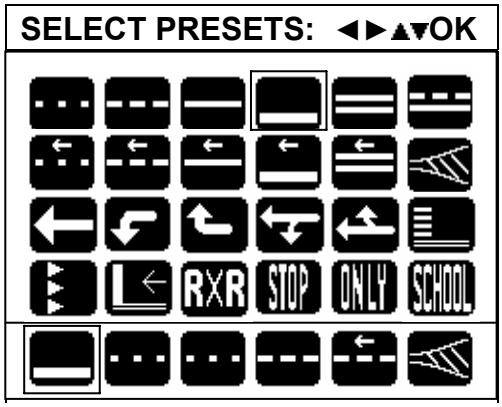
Setting the road marking icon

Six of the 24 icons symbolizing road markings can be programmed as individual presets for each series ID and will be ready for selection when a series ID is selected.
Press the MENU button and select **SERIES-ID** to enter the **SERIES ID** menu:

SERIES-ID ▲▼OK
ACTIVATE: OFF ENTER ID EDIT DELETE
PRESET ROAD MARKINGS
HIGHWAY #10 used: 6/200 

This menu shows in the bottom of the display the name of the actual series, the number of used series out of the total and the current preset row of markings for the actual series.

To edit the preset marking icons, highlight the **PRESET ROAD MARKINGS** and press the OK button to show **THE SELECT PRESETS** menu:



The bottom line shows the present six preset icons.
Use the LEFT, RIGHT, UP and DOWN buttons to choose a new icon for the first position, accept by pressing the OK button and the cursor (frame) will move to the second icon. Repeat for all six icons and the programming is done. You can amend at any point by pressing the BACK button and start over again.

THE LOG

Each time a measurement is taken data is stored to the log. The following data are saved, if enabled:

- Measurement result incl. average
- Date and time.
- Name of measuring series (road name) and sequence number.
- Road marking icon
- User initials.
- GPS data (if installed).
- Status

The instrument can store 1500 measurements in the log.

Clearing data in the log

Press the MENU button and select **LOG / CLEAR DATA**:

CLEAR LOG: ▲▼OK
LAST DATA
ALL DATA
SERIES DATA

This menu gives the option to clear data, either the last measurement, all measurements or one of the measuring series stored in the log. By pressing the OK button you will be asked to confirm the erasure of the data:

CLEAR ALL DATA
NO
YES

If you selected **SERIES**, you may select the series you wish to delete from the log from the list shown. Only the log entries will be erased. The series will still be available in the series select list.

Amending clear data.

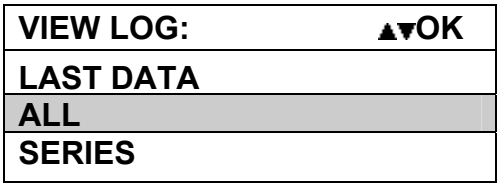
The clear all option can be amended, but **only until a new measurement is taken**. To amend clearing all data, again choose **LOG / CLEAR DATA / ALL DATA**. If you have not taken a measurement after having deleted ALL DATA, the menu will now look like this:

CLEAR ALL DATA
NO EMPTY
YES UNDO

Simply choose UNDO and OK to restore the log.

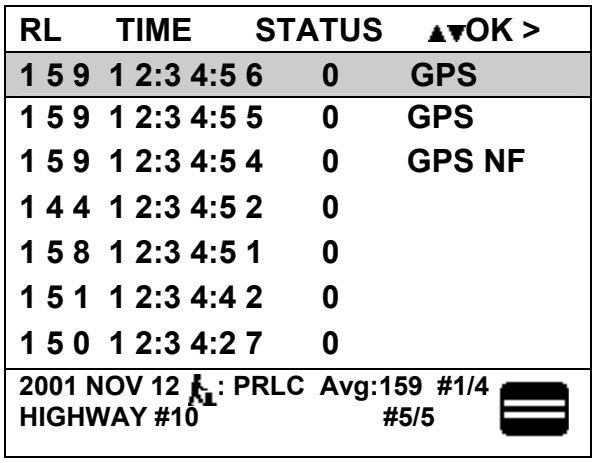
Viewing the log

Press the MENU button and select **LOG / VIEW LOG**:



This menu gives the possibility to view or print data from either the last measurement, from all measurements or from one of the measure series stored in the log.

The figure below shows the ALL menu.



In each line, the menu shows the Rl value, the time and the status, starting with the most recent measurement. To view a list of the individual errors/warnings in the status, print out the measurement (see below).
By pressing the DOWN or UP button, the individual measurements are highlighted and corresponding data are shown in the bottom of the display. These data are: date, users initials, average information, series ID, number of measurement / total measurements in that series and finally the marking icon selected (if any).

Each time a measurement is taken, a status information is generated. If any error occurs the information can be interpreted by the warning/error icon in the top line of the display. The information is available until a new measurement is taken.
The status information is also stored in the log. The status is a coded number, where 0 (zero) indicates that every thing is ok.
GPS indicates that valid GPS data was stored with the measurement. **GPS NF** indicates that the GPS had no fix during the measurement.

To get further information about the measurement the status number can be interpreted by the RSC program.

The arrow > in the top indicates that there are more entries (another page) to view, by either pressing the RIGHT button or using the DOWN button to roll the bar past the bottom.
Also, if a left arrow < appears in the top, left corner, you can access a previous page by press-

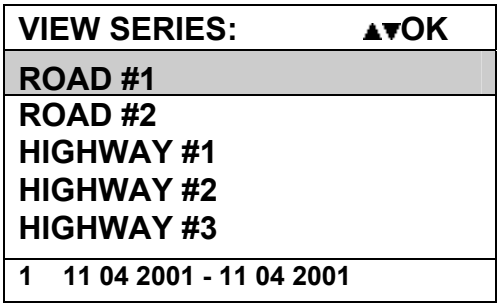
ing the LEFT button or rolling the bar out of the top by pressing the UP button.

To return to the log menu, press OK or BACK

Printing.
Press the PRINT / OUT button to print the log from the highlighted measurement to the end of (newest data) the log.
The printing can be aborted at any time by pressing and holding the PRINT / OUT button or the ON / OFF button for about 0.5 sec. Release the button as soon as the printing stops.

View series data.

In the log menu, select **SERIES** to view the list of series:



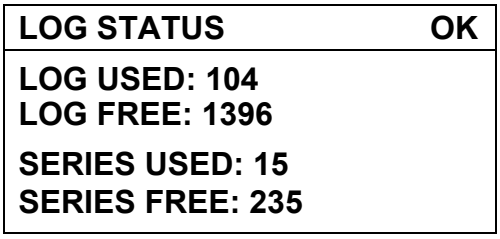
The menu shows a series ID in each line. By pressing DOWN or UP, the individual series are highlighted and corresponding number of measurements taken and the date interval for the measurement are shown in the bottom of the display. These data are: the number and the date interval for the measurement taken in the series.
Highlight a series and press the OK button to view the individual measurements.

To return to the **VIEW SERIES** menu, press the OK or the BACK button.

Printing.
Highlight a series name and press the PRINT / OUT button to print all the series data from the highlighted measurement to the end (newest data) of the log.
Highlight a measurement in the individual display and press the PRINT / OUT button to print the log from the highlighted measurement to the end of the series.
The printing can be aborted at any time by pressing and holding the PRINT / OUT button or the ON / OFF button for about 0.5 sec. Release the button as soon as the printing stops.

Log status

To see how much of the memory is used, press the MENU button and select **LOG / STATUS**:

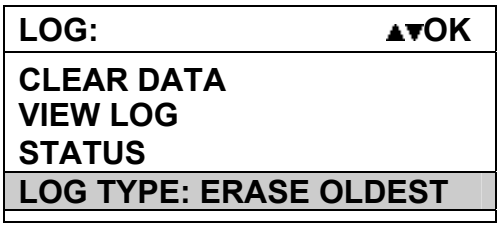


In the case shown above, there are 104 measurements in the log, leaving room for 1396 more. There are 15 measuring series in the log, leaving room for 235 more.

Setting the log type

You can choose between two different log types:
Erase oldest: The oldest measurement will be overwritten by the newest measurement.
Warn At Full: A warning will be issued when the log is full and the measurement will **not** be saved.

Press the MENU button and select log. Highlight the line **LOG TYPE** by using the DOWN button:



By pressing the OK button you can change the type of response when the log is full.

OTHER SETTINGS

Average function

An average function can be activated showing the average of the measured Rl value calculated over a selectable number of measurements (2 to 25). The average mode can be **fixed** or **moving**. In **moving** mode the average is always calculated from the last N measurements where N is the selected number of measurements. In **fixed** mode the averaging will start over again when N measurements has been taken. The average data is shown in the HOME screen at the lower right corner (see **picture pg. 15**).
The average value is **not** stored in memory.

Press the MENU button and select AVERAGE:

AVERAGE	▲▼OK
AVERAGE:	ON
TYPE:	MOVING
NUMBER:	10
RESET	

AVERAGE:
Use the UP or DOWN button to highlight the first line. Press the OK button to toggle between AVERAGE *ON* and AVERAGE *OFF*.

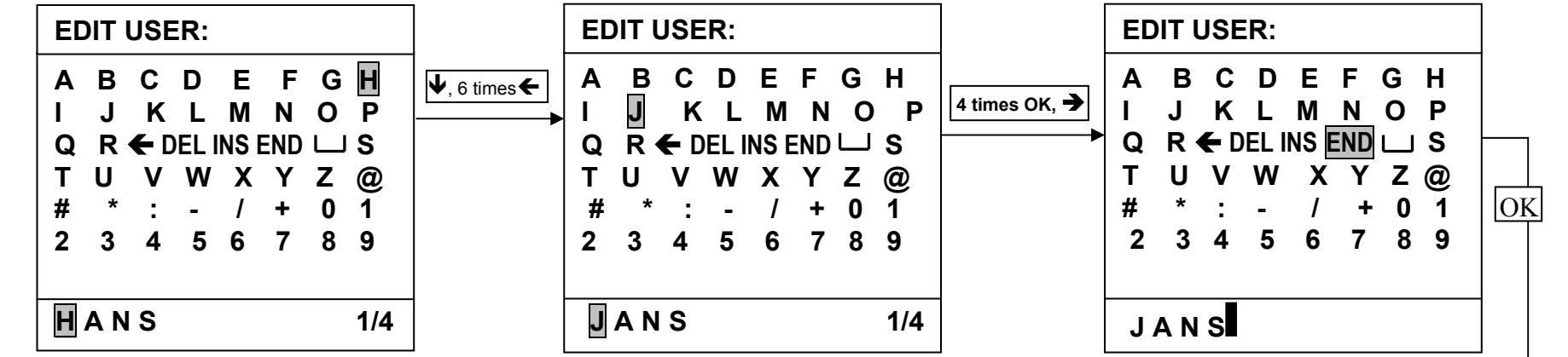
TYPE:
Highlight the second line and press the OK button to toggle between type: MOVING and type: FIXED.

NUMBER:
Highlight the third line and press the OK button to focus on the NUMBER digits. Then use the UP or DOWN button to change the value between 2 and 25. Finally press the OK button to confirm the new value (or you can amend changes by pressing LEFT or BACK). The default setting is 4.

RESET:
Highlight the fourth line and press the OK button to reset the calculated average value and reset the number of measurements included in the average to zero.

Editing names

From certain points you arrive to the EDIT menu e.g. by choosing NEW from the series list.



1. Accept the highlighted letter with **OK** or select a new letter with ←,→,↑,↓.
   To delete the marked letter: select **DEL**.
   To insert before the marked letter, select **INS** (insert).
2. Press the OK button to accept. The cursor moves one place to the right and the next letter is highlighted.
3. Repeat 1-2 to correct or add new letters.
   To move backwards, select ← and press the OK button the required no. of times. This mode is cancelled by using ←, →, ↑ or ↓.

Example: change HANS to JANS.

1. Use ↓ and ← to place the upper cursor on **J** . Press the OK button to accept 'J' and further 3 times to accept the following letters.
This places the lower cursor after the end of the name. The upper cursor will now stay on **INS** .

Use → to select **END** and press OK to finish editing.

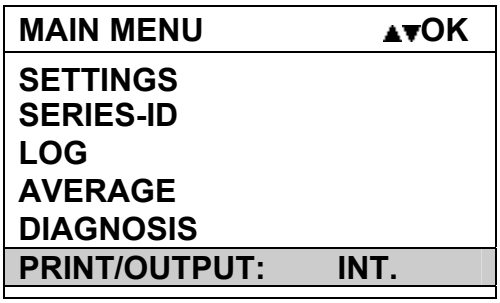
Diagnosis

Press the MENU button. Highlight the line **DIAGNOSIS**. Press the OK button, and the menu showing**: INSTRUMENTS, BATTERY**, **BOARDS** and **MISCELLANEOUS** will be seen.

Each gives information aimed at extended service and factory use. All the information will be printed out if you press the PRINT button.

Choosing output device

Press the MENU button. Highlight the line **PRINT / OUTPUT** by pressing the UP button once:



By pressing the OK button you can change the output device:
The two possibilities are:
Int: The built-in printer will be used for output.
Ser: The communication port will be used for output.

The help system

Press the HELP button to show a context dependent help page. Pressing HELP once more will present a general help menu in which you can highlight a subject by using the UP or DOWN button and the press the OK button to show the help text.

Errors and warnings

When a measurement is taken, a status number is generated and saved in the log together with the measurement. The status number reflects various conditions concerning the measurement. If a problem occurs, a warning icon ⚠ or an error icon ⚡ is show above the HOME screen and an audible alarm is sounded (if enabled) and error is stored in the log.

To view the nature of the problem, press the UP button and the warning/error icon will be highlighted and the most severe problem will be stated in the message line underneath.
Then press the OK button to view a total list of problems starting with the most severe.
Press the OK button (alternatively BACK or LEFT) to return to the HOME screen.
If the problem did not hinder the completion of the measurement, the erroneous Rl value will be saved in the log together with a status number, which can identify the problems when the log is evaluated using the RSC program.

Default settings / user reset

At power up a combination of buttons can be pressed to reset the active instrument setting and restoring the default settings.

Forced English menu and standard contrast:
If the instrument is set to a foreign language and you can not find the language select menu, do the following:

Turn off the instrument.
Press and hold the HOME button while turning on the instrument.

Now you can find the language select menu and select the language you want. If you do not set a language the foreign language will return at the next start-up.

Small factory reset:
This non destructive reset can be used to set parameters to factory standards but will **not** erase the log, the series list, the user list or the preferred markings:

Turn off the instrument.
Press and hold the HELP button while turning on the instrument.

Factory reset:
This will set all parameters to factory standards **and will also erase the log, the series list and the user list:**

Turn off the instrument.
Press and hold the HELP and HOME buttons while turning on the instrument.

RSC program

Main features of the RSC program delivered together with the LTL-X:

- Transfer of log data to a pc
- Export of log data to other programs e.g. spread sheets
- Printing reports of the log data
- Easy entry of series-ID to make your measurement task efficient and reliable
- Programmable user setup

For more details see the separate user's manual for the RSC program, found on the installation CD.

SECTION 4

MAINTENANCE

General care

The retrometer is constructed for outdoor use in ordinary good weather conditions. It will stand moist weather with wet roads, but caution must be taken against heavy rain and dirt. The LTL-X retrometer is an optical instrument and shall be handled as such. Avoid shock and vibration if possible.

CAUTION!

To reduce the risk of electrical shock, do not remove the cover.

Protection window

The protection window is accessible from underneath of the instrument. The protection window is coated with a high-efficiency anti-reflection coating. Take care not to damage this coating when cleaning. Compressed air or a fine brush can be used for removing loose particles/dust. If this is not sufficient the window should by cleaned using a soft paper tissue or cloth and some window cleaning liquid.

Battery

The LTL-X retrometer is powered by a 12V/1.3Ah NiMH battery. Under normal use, this battery requires no maintenance. However it is recommended to keep the battery fully charged. A fully charged battery is more capable of withstanding degeneration.

A battery charger power supply is provided as a standard accessory for charging the battery from mains. The output cable of the charger is equipped with a connector matching the connector in the instrument. Connect the charger to an outlet and the instrument.
If the instrument was turned off the display will now show a moving text that explains the charging state (Charging/Trickle charging/Charging done/Is Charged and Charge Error). The battery icon in the upper right corner will also indicate the charging state.

No harm will result from leaving the charger connected after the charging process. However, the instrument must be disconnected from the charger when disconnecting the battery from the wall outlet.
In addition, the battery can be charged using any DC supply from 12-18 V. such as a car battery by using an inverter.

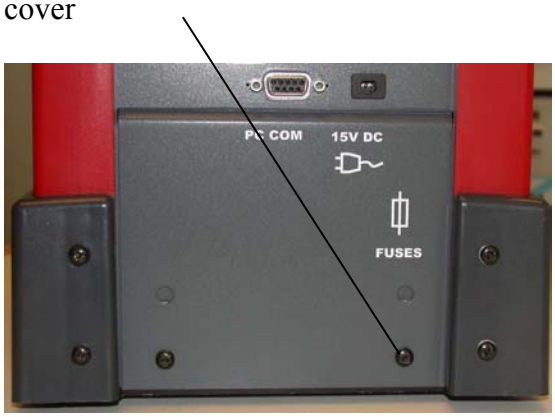
When storing the instrument for a long period of time fully charge the battery.

It is possible to install a larger battery pack to increase the operating time for the instrument. This is also recommended when using a GPS.

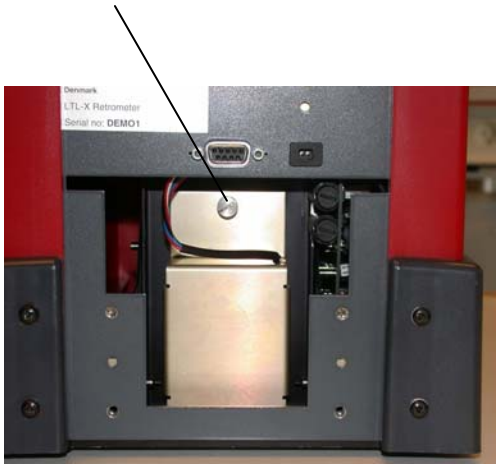
Replacing the battery

A worn out battery will not hold a charge very long. When the battery is worn out it must be replaced. The user can do this.

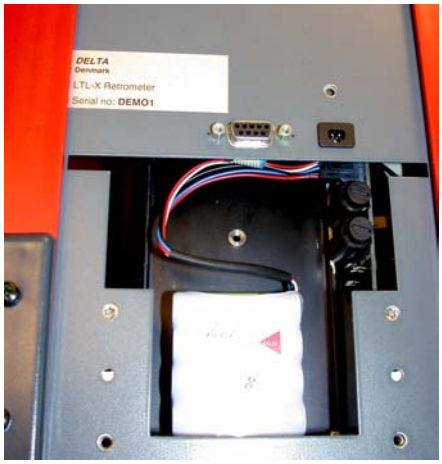
The battery is located in a compartment at the rear of the tower. To replace the battery, remove the screws from the back cover, and remove the cover



Loosen the big screw at the battery cover. Your can now remove the cover.



Lift out the battery of the compartment



Press the snap-on clip on the connector and carefully withdraw it from the printed circuit board

The battery can now be removed and replaced. Refit in reverse order.
Please check your local regulations for disposal of the battery.

Battery status
The capacity of the battery can be seen from the icon in the upper icon row.

Indicates that the battery is fully charged.

Indicates that the capacity of the battery is high to fair

The capacity is low. You should recharge the battery.

The battery is almost empty.

The battery voltage is shown as it was **at the last measurement** in idle (when the instrument is on but not taking a reading) and in loaded mode (when xenon lamp is charging). Select the battery icon (with UP, LEFT and OK). The display will then show the voltages.

Fuses

Two fuses are located in the battery compartment. The charging fuse protects the battery against short circuit and other errors in the charging connector, charger or charging system.
The battery fuse protects the battery and electronics against short circuit and other errors in the electronic system.

Always replace a blown fuse with one of equal rating **See Electrical Characteristics pg. 51** . To change the fuses you need access to the battery compartment. **See replacing battery pg. 40**. Carefully unscrew the plastic cap fuse holder by using e.g. a coin. Pull out the fuse from the cap and insert the new one and reassemble

Lamp

The lamp is a long life xenon type and requires no maintenance. Only trained personnel should replace the lamp when replacement is required.

Calibration unit

Reference
The road marking is simulated by a piece of white ceramic (the reference) mounted on an aluminum profile. Ceramics have very stable optical properties because of the smooth surface.

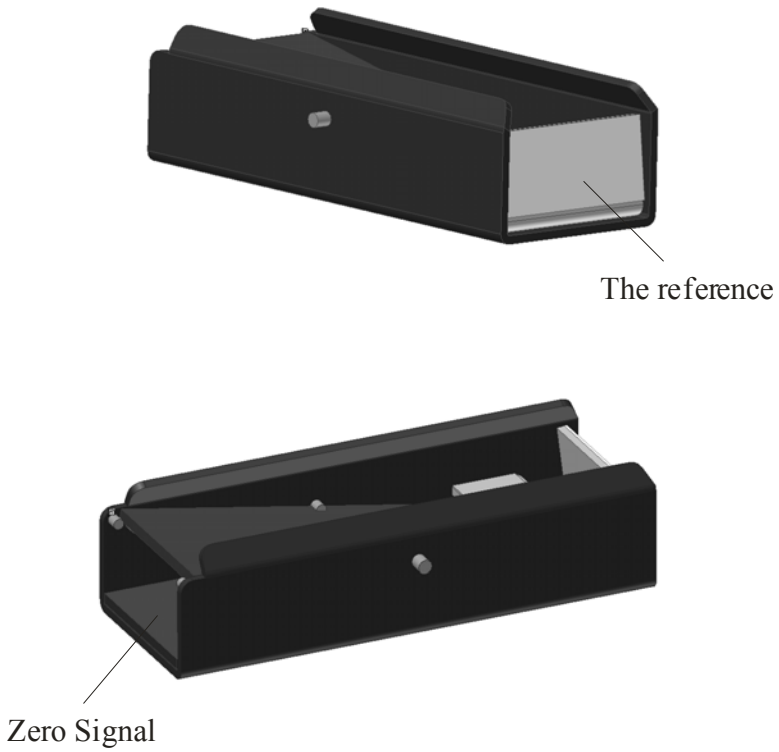


Figure: 5 - Calibration normal

To make sure that calibration of the retrometer is correct it is important that the ceramics and light trap on the calibration unit is clean and undamaged. Always keep the calibration unit well protected.

If the ceramic is stained, scratched or broken, the calibration unit has to be replaced and calibrated. In case of dust on the ceramics surface of the traceable reference, the use of compressed air is recommended for removal. To clean the ceramic reference on the field calibration unit, the use of a soft damp cloth is recommended if compressed air fails to remove the dirt. If necessary, use a mild household detergent. A calibration transfer must always be completed after the field reference is cleaned. It is necessary to have the traceable reference available to perform the transfer prior to cleaning the field reference.

To ensure reliable measurements, it is recommended that the calibration unit be periodically recalibrated to a traceable standard. DELTA Light & Optics offers calibration traceable to PTB (Physikalsich-Technishe Bundesanstalt). For information contact your distributor or DELTA.

Light trap
The zero signal is simulated by a light trap mounted in the calibration unit in the opposite end of the reference. It is made of two glossy and black plastic sheets mounted at an acute angle. If clean this will provide very efficient light absorbing device.

It is necessary to disassemble the light trap to clean it efficiently. Using a fine brush, clean pressurized air or a soft paper tissue/cloth and some window cleaning liquid can do the cleaning.

Calibration

The LTL-X is factory calibrated and very stable but a calibration should always be carried out before starting a new series of measurements.

The instrument is supplied with two calibration units, a reference calibration unit (black) and a field calibration unit (red). The reference calibration unit is factory calibrated and traceable to PTB. The field calibration unit must be calibrated against the reference calibration unit by the user at suitable intervals. The reference calibration unit is stored in the black protection box, and the field calibration unit in the gray protection box.

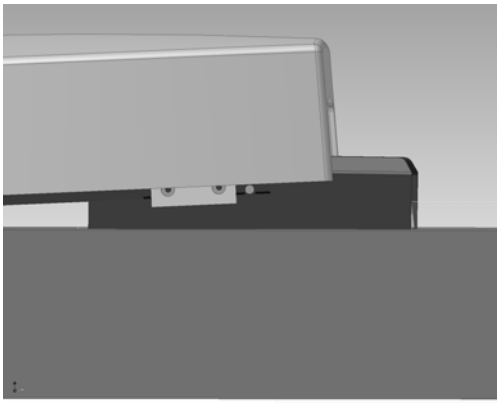


Figure: 6 – Calibration

Calibration
Two steps are required for a complete calibration, *zero calibration* and *reference calibration*. The instrument will guide you through the procedure.

Calibration procedure

- *Zero calibration*

  Press the CALIBRATION button once. Mount the instrument upon the calibration unit. This is done by tilting the instrument slightly backward and then insert the unit underneath the front end of the instrument. Make sure that the pins on the side of the unit fit into the slots in the LTL-X.
  It is important that the calibration unit faces with the dark opening towards the instrument tower. The display will show the correct orientation of the calibration unit.
  Make sure that the calibration unit and the light trap are clean.
  Press the OK button to start *zero calibration*. During calibration the lamp will flash a number of times.

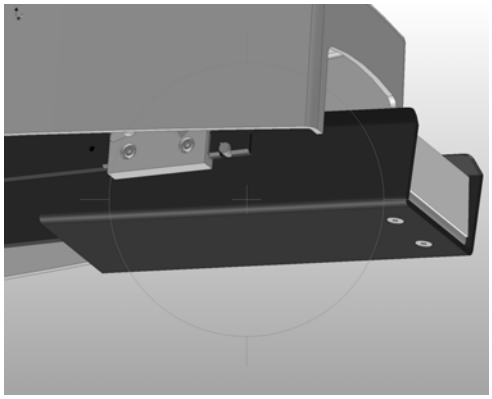


Figure: 7 – Placing the calibration normal.

- *Reference calibration*
  Now the instrument is ready for the next step and the display will tell you to rotate the calibration unit so that the white face is facing the instrument tower. Again it is important that the pins on the side of the unit fit into the slots in the LTL-X. Press OK to begin the reference calibration. Check the value displayed and if necessary adjust the calibration value shown in the display so it matches the value stamped on the calibration unit.
  Press the OK button to perform the calibration.

  The calibration procedure is now complete. Remove the calibration unit and store it properly. Press OK to return to the measurement display.

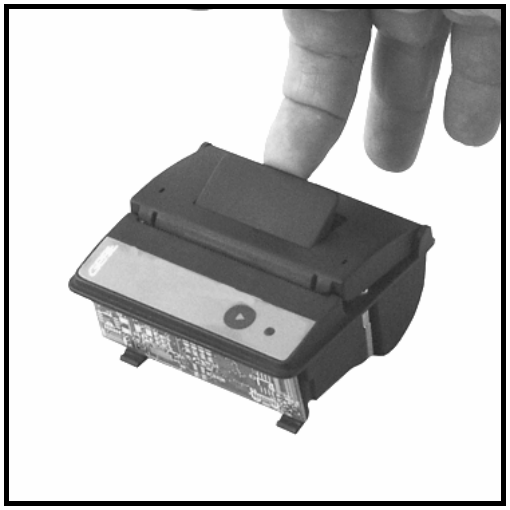
The instrument automatically compensates for zero signal, leakage and other known errors, and calculates a calibration factor. This process is fully automatic. If the calibration routine is followed precisely the retrometer will now display **'true'** Rl.

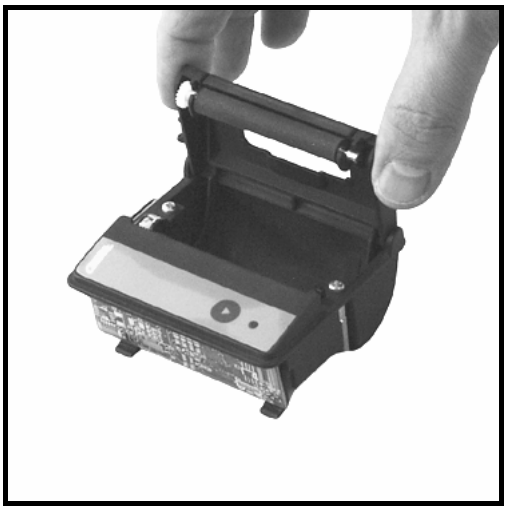
Always store the reference calibration unit in a dry and clean environment.

Printer

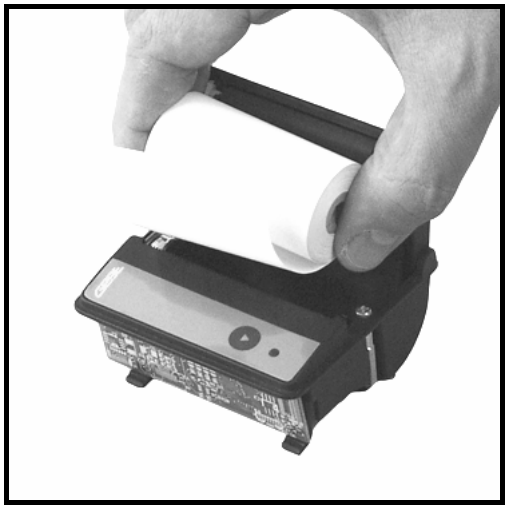
The printer is a high-speed high quality mini thermal printer. It has only a few moving parts and does not require any special or periodic maintenance.
It uses a thermal paper roll, width: 57.5±0.5 mm (2.26 in), diameter: max. 31 mm (1.22 in)

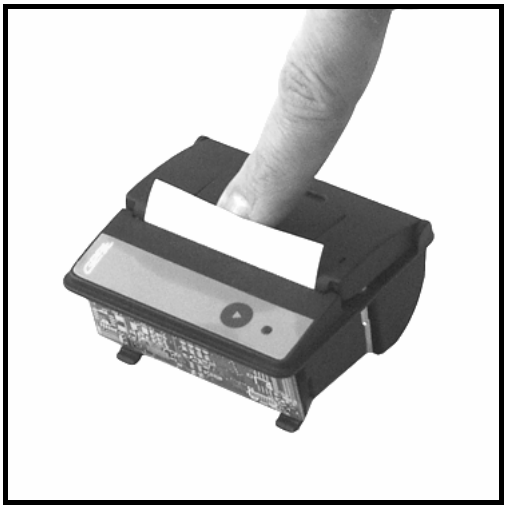
Replacing paper
Replacing the paper is simple. First, pull the little lever out with your finger and the cover will open into the paper roll compartment.





Insert the new paper roll and let a short paper tail hanging out at the top. Close the cover with a firm push and with some of the paper sticking out.





Mounting the plate feet for rain measurements

In order to move the measurement field outside the horizontal base cover as shown on figure 3, page **13** the wet night base plate and the two wet night feet should be mounted.

Mount the wet night plate by removing the four M3x3 slotted set screw in the base plate. Then mount the wet night base plate with the four slotted countersunk M3 screws as shown in figure 8.

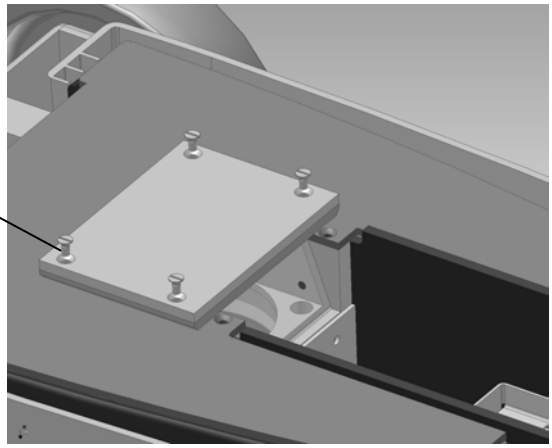


Figure: 8 - Wet night plate

The wet night feet are mounted as shown in the figure 9 with spring washer's wing nuts.

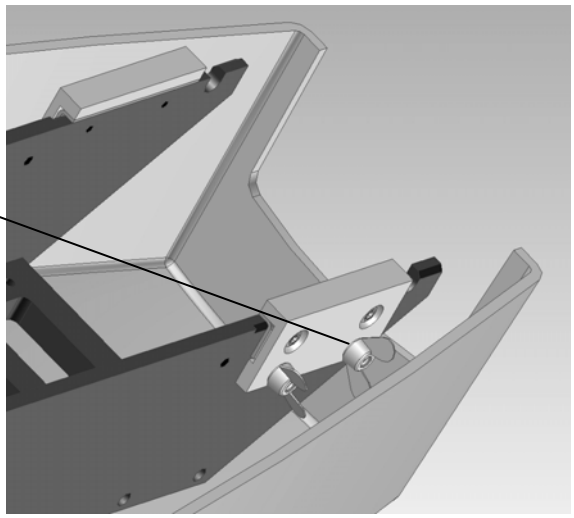


Figure: 9 – wet night feet's

Important: Make sure that the wet night feet are in full contact with the existing feet. Dismount the feet by reversing these operations.

Mounting the wheel unit (option)

A wheel unit can be mounted in the rear of the instrument for easy transportation during heavy use.

The wheels are mounted easily to the rear by fastening the two nuts mounted on the wheel block.

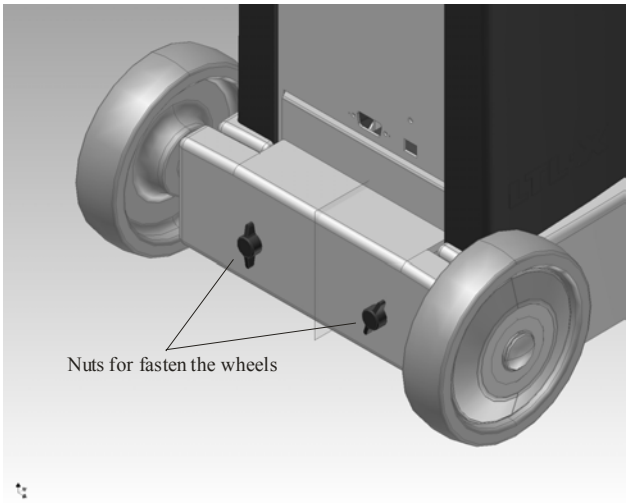


Figure: 10 – Mounting the wheels

APPENDIX A

COMMUNICATION FACILITIES

Communication specification

The LTL-X is equipped with a communication port that enables the use of a PC for extended control and data exchange.

The electrical connections meet the EIA/TIA-232E and CCITT V.28 specifications. e.g. it can be connected to any standard RS232 serial communication port with the below wiring.

Connection example #1. PC with 25-pin D-Sub communication port.

Cable connections:

PC Port DTE	pin name		LTL DTE
1	FG	X	
2	TxD	---	3
3	RxD	---	2
4	RTS	X	
5	CTS	---	8
6	DSR	X	
7	SG	---	5
8	DCD	X	
20	DTR	---	4

25-pin female D-SUB

9-pin male D-SUB

Connection example #2. PC with 9 pin D-Sub communication port.

Cable connections:

PC Port DTE	pin name		LTL DTE
1	CD	X	
2	RxD	---	2
3	TxD	---	3
4	DTR	---	4
5	SG	---	5
6	DSR	X	
7	RTS	X	
8	CTS	---	8
9	RI	X	

9-pin female D-SUB

9-pin male D-SUB

Interconnections have been held to an absolute minimum. In rare situations additional connections will have to be established on the PC side. Please refer to your PC manual for further information.

Data protocol

The communication between the LTL-X and the PC uses the following settings:

Baud Rate ..... 19200 bit/sec.
Number of data bits 8
Parity..... none
Stop bit 1
Hand Shake ..... Xon/Xoff

APPENDIX B

SPECIFICATION

General characteristics

Illumination angle 1.24º
Observation angle 2.29º
Equivalent observer distance ..... 30 m

Observation angular spread ..... ±0.17º
Type 30m CEN
Illumination angular spread horizontal 0.33º
Illumination angular spread vertical 0.17º

Field of measurement:
Width ..... 50 mm (2.0 inch)
Length (typ.) ..... 200 mm (7.9 inch)

Min. reading ($mcd \cdot m^2 \cdot lx^{-1}$) 0
Max. reading ($mcd \cdot m^2 \cdot lx^{-1}$) ..... Typ. 2000

Electrical characteristics

EMC:
Emission ..... EN 55022 Class A
Immunity ..... EN 61000-6-1:2001
IEC 61000-6-1

Power supply:
Battery ..... Built in 12 volt / 1.3Ah NiMH
External charger power supply ..... 100-240 VAC / 12VDC
Charging time ..... Approx. 1 hour 15 min

Charger fuse (5*20 mm) T3.15A
Power supply fuse (5*20 mm) T3.15A

Data memory ..... 1500 measurements
Data retention (from purchase) ..... Typ. 5 years

Serial communication mode 19200,N,8,1
Data flow control ..... Xon/Xoff
Interface ..... Modified RS 232

Environmental characteristics

Temperature:

Operating	0ºC to + 45ºC (32ºF to +113º F)
Storage*)	-15ºC to + 55ºC (5º F to +131º F)
Humidity	Max. 40°C, 93 % RH, non-condensing

*) Battery must be fully charged

Mechanical characteristics

Max. length	573 mm/ 22.56 inch
Max. width	222 mm/ 8.74 inch
Max. height	538 mm/ 21.18 inch
Weight	9 kg/ 20 lbs
Shipping weight	20 kg/ 45 lbs

Construction:

Structural parts	Aluminum
Housing	Polymer
Keyboard	Silicone rubber
Circuit boards	Epoxy glass

Printer:

Thermal paper	width/dia. 57.5 ±0.5 mm/31mm (2.26 in/1.22in)

INDEX

LTL-X

QUICK REFERENCE SHEET

LTL-X Quick Reference Sheet

Start of day / End of day Check Out

- Check the optic window for any dust or dirt, clean with lint free cloth and window cleaner
- Check that the calibration date on the Red field block is not more than 1 week old – if so, do a calibration transfer
- Make sure the battery is charged

Calibration Block Safety

- Always store the calibration blocks in their specific holders when not in use
- Do not touch the white ceramic area of the calibration blocks
- Store the black calibration block in the office, it should never go into the field
- The ceramic face of the black calibration block should never be cleaned

LTL-X Use Overview

- Turn on the LTL-X
- Select User ID
- Select Series ID
- Zero the instrument
- Perform a transfer calibration or a field calibration
- Take Readings

Turn on Instrument

- Press and hold the ON/OFF button,  , until the welcome display starts to show (unless the instrument is set to ask for user identification, see User select)

User Select

- Press the Up arrow to access the top line of the display
- Press the Back and Forward arrows to move between icons until the User icon is highlighted (the word User will appear in the second line of the display)
- Press the OK button to enter the user select menu

OR

- Press the Menu button, 
- Select Settings/User/Select
- Select a user and press OK

Series ID Select

- Press the Up arrow to access the top line of the display
- Press the Back and Forward arrows to move between icons until the Series ID icon is highlighted (the word Series-ID will appear in the second line of the display)
- Press the OK button to enter the series id select menu

OR

- Press the Menu button, 
- Select Series ID
- Select Enter ID, Edit or Delete (note: pre-set road markings may be accessed in this screen)

Zeroing Procedure

- Press the Calibration button 
- Mount the unit underneath the front end of the instrument with the ceramic face pointing away from the tower (tilt the instrument slightly backward and then place the pins on the sides of the unit into the holes on the bottom of the LTL-X)
- Press the OK button to start zero calibration (the calibration lamp will flash a number of times)

Transfer Calibration Procedure

- After performing a zero calibration, mount the black calibration unit underneath the front end of the instrument with the ceramic face pointing towards the tower (make sure the pins on the sides of the unit are in the holes on the LTL-X)
- Check the calibration value and correct if necessary (must be the same value as stamped on the calibration unit)
- Press the OK button
- Place the red calibration unit underneath the front end of the instrument with the ceramic face pointing towards the tower and take a reading
- Write the new Rl value and date on the label of the red calibration unit

Field Calibration Procedure

- After performing a zero calibration, mount the red calibration unit underneath the front end of the instrument with the ceramic face pointing towards the tower (make sure the pins on the sides of the unit are in the holes on the LTL-X)
- Check the calibration value and correct if necessary (must be the same value as written on the calibration unit)
- Press the OK button

Take Readings

- Place the instrument on the road marking
- Press the OK button

Miscellaneous

Reset Log

- Press the Menu button and select Log/Clear Data/All

Date and Time

- Press the Menu button
- Select Settings/Date & Time
- Use the up and down arrows to set the time and date
- Press OK to accept the settings

Power Save

- Press the Menu button
- Select Settings/Auto Off
- Use the up and down arrows to edit the auto turn off time
- Press OK to accept the settings

Sound

- Press the Menu button
- Select Settings/Sound
- Select Key Click or Sounds to set the individual sound levels for key click and warning/error sounds
- Use the up and down arrows to set the levels
- Press OK to accept the settings

Warnings and Errors

- An error icon (bolt of lightning in a rectangle) or a warning icon (an exclamation mark in a triangle) will be displayed in the top line of the display if a problem is detected
- Press the up arrow to get a description of the most severe error or warning
- Press the OK button to display a list of all errors or warnings related to the measurement