PART D - FIELD PRACTICES AND PROCEDURES

SECTION D1.00 – CONSTRUCTION INSPECTION

D1.01 General. A group of inspectors, headed by a Resident Engineer/Project Supervisor, is assigned to each Department project to administer it. **[105.02]** Administration of the Project includes inspection of the Contractor's work, preparation of daily reports of all Project activities, measurement and calculation of installed quantities, and rejection of materials and suspension of work, if necessary, until Specification compliance issues are resolved.

The inspection of the Work will consume the bulk of the Inspector's time. Inspectors must have a thorough knowledge of the Plans and maintain close contact with the Work in order to achieve their goals for the best possible project with the least possible inconvenience to the general public, utilities, and local industry. In order to accomplish these goals, the Inspectors must exercise what is known as "construction control." Construction control means using a combination of experience, training, judgment, and common sense in inspecting the project. These factors, in order to be effective, must be applied continuously and consistently from the beginning of the project to the end. The purpose is the translation of the Contract into a completed, effective highway facility.

The Contractor will establish a Schedule of Work that will indicate how and when it plans to take the necessary steps and advance the various stages to complete the Project, depending on its ability, work force, and equipment. The means and methods of construction that the Contractor elects to use, providing they do not violate the Plans, Specifications, other Contract provisions, and the various local codes and safety statutes, are the Contractor's prerogative. The responsibility for successfully completing the highway facility according to the Plans and Specifications is a joint effort of both the Department inspection force and the Contractor. To get the highest quality work possible, Inspectors and the Contractor must work together and aim for a single common goal. In addition to inspecting on-going construction activities, the Inspector must plan for upcoming construction activities. The Contractor and the Inspectors must discuss and agree on the work planned and the methods to be used for upcoming stages of construction so that both know what work will be done and what methods will be used to accomplish the work. The Inspector should not wait to see what the Contractor is going to do next and how it is going to be done before telling the Contractor that its plan is unacceptable. Working in this manner does not fulfill the Inspector's responsibilities to the State and does not advance the Project in a sound manner.

The Resident Engineer/Project Supervisor must be careful to exercise a very delicate degree of supervision, particularly with respect to the manner in which the work is to be performed. There is a very definite area of Contractor responsibility, and as long as the Contract is being followed, the Resident Engineer/Project Supervisor should not reject the Contractor 's planned means and methods unless they are clearly unsound or unsafe. By rejecting the Contractor's means or methods, the Resident Engineer/Project Supervisor will be assuming a greater responsibility for the work than the Contract intends. By interfering with the Contractor's means and methods, the Resident Engineer/Project Supervisor may become legally liable for the work.

D1.02 Inspector Qualifications. The Inspector must be a person of integrity and should have both practical experience and an understanding of the principles involved in the type of construction to which he or she is assigned. The Inspector should know both how the work is to be done and why it is to be done in a certain way. Even technically trained persons should serve for a period under the supervision of a more experienced person before working alone.

To be successful, an inspector must have the character and the personality to merit the respect and liking of the workers. Inspectors must be firm but fair in their dealings and faithful to their responsibility. They must be able to cooperate with the Contractor's superintendent and foremen to secure good work at the least cost. At the same time, the Inspector should keep in mind that being everyone's "good buddy" seldom makes a successful inspector.

The Inspector must be able to take the orders and decisions of superiors and carry them out faithfully, without resentment.

The Inspector must be observant and properly manage his or her time to be able to give greater attention to the more important construction activities.

D1.03 Responsibilities of the Resident Engineer/Project Supervisor and Inspectors. It is the responsibility of the Resident Engineer/Project Supervisor to obtain the results specified in the Contract. Field personnel should always assume that good and sufficient reasons exist for the Plans, Specifications, and all items included in the Contract for any project.

It is the Resident Engineer/Project Supervisor's job to spot-check all phases of the work periodically and check on the activities and performances of the other field personnel to the point that the Resident Engineer/Project Supervisor is assured that his or her directions are being satisfactorily followed. The Resident Engineer/Project Supervisor is to provide supervision over the inspection forces on the Project. This includes ensuring that knowledgeable project personnel are on duty at all required times and that sufficient work is being performed by this staff to promote the progress of the Contractor. The Resident Engineer/Project Supervisor is responsible for ensuring that all grades, layout, dimensions, and quantities of materials used are accurately checked by Project personnel.

The Resident Engineer/Project Supervisor should make sure all sick and annual leave slips, as well as time sheets and other administrative information, are turned in to the District Office on time for all subordinate personnel.

Unless field inspection is aggressively carried out, the completed project may be full of unknown quantities, a potentially high-maintenance facility, and/or a threat to the reputation and prestige of the Department.

The Inspector is responsible for ensuring that the work is executed in accordance with the Plans and Specifications. Negligence on the Inspector's part may lead to faulty construction and, in some cases, conditions endangering human life. The Inspector is responsible for thorough knowledge of the Specifications and for the exercise of good judgment. The Inspector's effort is often the deciding factor between a good project and an average or poor one.

A competent inspector is thoroughly conscious of the importance and scope of his or her work and is fully informed about the Plans and Specifications. Armed with this knowledge, and with the sound judgment that comes from experience, the Inspector will not only detect faulty construction but will also be in a position to avoid it by preventing the use of improper procedures.

Although the Inspector may require special instruction or advice from his or her supervisor concerning unusual problems or controversial matters, the Inspector's initiative is

continually required to detect problems, identify potential problems, and ensure the quality of the work being inspected. The Inspector is to be constantly on the lookout for conflicts between the Plans and Specifications and actual field conditions. All conflicts must be reported to the Engineer immediately.

The Resident Engineer/Project Supervisor should conduct a progress meeting every month during the Project. The progress meeting will be attended by the Contractor, the Resident Engineer/Project Supervisor, the Inspectors, and representatives from other Department offices that may be involved with the Project, such as Surveying, Materials and Research, and Traffic. The progress meeting will serve as an opportunity to review the Contractor's Schedule of Work, review the work planned for the following two weeks, and address any questions or concerns anyone may have about the Project. The Inspector should use the progress meeting as an opportunity to seek clarification from the Contractor on its work plans, inform the other Department representatives of the need for their presence on site, such as for layout or material inspections, and bring up any issues that may impact the quality of the completed Project.

D1.04 Authority of the Resident Engineer/Project Supervisor and Inspector. The authority of the Resident Engineer/Project Supervisor and the Inspectors is defined in Section 105 of the Specifications. The extent of their authority is clearly stated, and it can not be exceeded except when specifically permitted by other provisions of the Contract or when authorized by the District Construction Engineer. **[105.01] [105.02] [105.03]**

D1.05 Initial Duties of the Resident Engineer/Project Supervisor. The responsibilities of the Resident Engineer/Project Supervisor begin immediately after being assigned to a project. In most instances, this assignment is made well in advance of actual construction, and it should be the green light to begin the following preliminary work.

(a) Obtain sufficient copies of the Plans and Specifications and study them thoroughly.
(b) Review the District letter file and obtain copies of everything appropriate for the field office file, such as the tabulation of bid prices and the Award letter.
(c) Obtain a copy of all Right-of-Way Agreements. Review these with the Real Estate agent in the field.
(d) Walk through the Project area, comparing the area to the Plans to get a better feel for the Project.
(e) Assist in determining the location of and setting up the District field office.
(f) Obtain sufficient supplies and equipment to properly execute the forthcoming work, including the construction diary, Estimate Books, State and FHWA forms, and the required measurement tools.
(g) Attend the formal preconstruction meeting held with the Contractor and other interested persons.
(h) Review the Project personally in the field with the Contractor's superintendent.
(i) Set up a list of pertinent names, telephone numbers, and other important contact information for all project personnel and other important groups, such as the police department, fire department, and District office personnel.
(j) Arrange for initial signs, detours, and other traffic maintenance equipment that may be required.

(k) Prepare a progress chart to document actual work completed versus the Contractor's proposed schedule.

D1.06 Inspector's Duties during Construction. The Inspector is responsible for accomplishing the following during construction:

(a) Enforce all applicable Plans, Specifications, and other Contract provisions.

(b) Maintain an orderly file of all construction records, letters, test reports, and other pertinent Project information.

(c) Inspect the phase of the work in progress assigned by the Resident Engineer/Project Supervisor. The Resident Engineer/Project Supervisor will assign Inspectors so that all phases of active construction are inspected.

(d) Measure and record the quantities and progress of all work performed. All progress should be recorded daily, as should the work quantities whenever feasible. All tickets involving pay quantities should be collected and signed on the spot by the construction Inspector, labeled to indicate the item for which the material was used and the location used, and attached to the daily report to be filed for subsequent forwarding.

(e) Inspect the work up close. Inspection is personal, requiring initiative and effort, and must be firsthand.

(f) Keep abreast of the Contractor's rate of progress, and advise the Resident Engineer/Project Supervisor of any appreciable deviations from the proposed Schedule of Work. This should relate to both the rate of progress and the sequence of operations.

(g) Keep the Resident Engineer/Project Supervisor informed of all pertinent developments on the Project, such as unusual situations and Contractor requests.

(h) Understand the contractual responsibilities, authorities, and requirements for handling specification violations. **[105.02] [105.05]**

(i) Compile and record in the Estimate Books the required information for the progress, semi-final, and final estimates for payment. Include all appropriate records, tickets, and other required submissions.

(j) Ensure that the Contractor maintains safe conditions throughout the Project, including safety of traffic, the public, the Contractor's personnel, and State personnel. The Inspector should have a working knowledge of all safety precautions and provisions noted in the Specifications, as well as all applicable safety codes, including OSHA, State, county and city annotated codes. **[107.06] [107.07]**

(k) Inspectors who are sick or otherwise unable to report for work should telephone the Resident Engineer/Project Supervisor prior to the start of the workday to permit reassignment of personnel for adequate inspection coverage.

D1.07 Use of Photographs and Videotapes. The use of photography is encouraged. Photographs are useful for recording work progress, documenting work that was rejected, and keeping a record of work that will be concealed. For example, a photograph of a pile driven into a foundation, which is to be concealed, may be important for future record purposes. Photographing certain construction details prior to the placement of concrete may also be

important for future purposes. Similarly, the general cleaning-up of a structural site prior to final inspection is important to the acceptance decision, and should be documented with photographs.

In addition to photographs, videotapes may also be used for documentation of field conditions. The advantage of videotapes is that the Inspector can explain what is being recorded. For example, a videotape of painting that needs to be touched up is much easier to understand than a photograph, because the Inspector can explain conditions on the videotape that may not be apparent from a photograph. Videotapes or photos should be done prior to any work beginning. As well as other things, pavement markers can be properly located. Videotaping of underdrain and storm sewers will be required on most contracts. Inspector's supervision of this work is imperative.

SECTION D2.00 – TICKET CONTROL

D2.01 General. "Tickets," as the word is used here, should not be confused with Inspection Test Reports. Tickets are issued at a material source for each load of material prepared and transported to the Project site to be incorporated into the Project.

Tickets are issued to control quality, to indicate true weight for payment purposes, to control load count, or for any combination of these reasons. For example, portland cement concrete batch tickets are issued to control quality and load count. Hot-mix asphalt and similar tickets, in addition to the above, also indicate the true payable net weight of material.

Most tickets are originated by the company that produced the material or by the source of supply.

D2.02 Tickets Used for Payment. All progress estimates for payment of material by weight are to be supported by properly documented delivery tickets. All weight tickets must be signed by a Department Inspector upon receipt. **[109.01]**

The following information should appear on every ticket used for payment:

(a) description of the material
(b) source of the material (batch plant, quarry, or other source)
(c) date delivered to the Project
(d) destination (Contract number and name)
(e) source Inspector's signature
(f) serial number (if applicable)

Whenever a Contract Pay Item will be paid by the weight shown on a delivery ticket, the following information must be shown on the ticket:

(a) The legal licensed Gross Vehicle Weight (GVW) for the delivery vehicle. This must be computer generated, not written in by hand.
(b) Positive identification of the delivery vehicle, by license plate number or truck number.
(c) Signature or Seal of a Certified Weigh Master along with the Seal Number.

As described in Section 105.12 of the Specifications, no payment will be made for any material weight above the licensed GVW shown on the weight ticket. If the weight tickets do not contain all of the above information, then no payment will be made for the entire load.

If the Inspector notices fluctuations greater than 400 lbs (180 kg) in the tare weight for a delivery vehicle, the Inspector should notify the Area Engineer, who should in turn notify the Materials and Research Section.

D2.03 Tickets Used for Quality Control. Some tickets are used for quality control (PCC ticket); therefore, each ticket must contain the following information:

(a) a description of the material
(b) source of the material (batch plant, quarry, or other source)
(c) date delivered to the Project
(d) destination (Contract number and name)
(e) source Inspector's signature
(f) all other pertinent and applicable facts such as temperature, additives, and batch-out time

D2.04 Other Ticket Preparation Instructions.

(a) Weigh tickets submitted by the originator must be correct.
(b) If errors inadvertently occur while being made up by the originator, the tickets are to be destroyed and prepared again.
(c) No weigh tickets will be accepted in the District Construction Office that have changes made to the scale reading entries.
(d) Audit corrections will be accepted only if they occur due to mathematical subtraction or addition error.

Originators of tickets must keep a record of all materials dispatched. This record should be recorded in a daily diary.

D2.05 Ticket Destination Instructions. Tickets are not to be defaced or mishandled, and should be protected as much as possible from soiling. All tickets must be received by the assigned Inspector in person at the time of the material delivery.

The receiving Inspector must examine each ticket before unloading to ascertain that the described material is in accordance with the specified material. If material does not appear to be in accordance with the Specifications, it must not be deposited until a decision is made by the Engineer. Rejected loads must be clearly marked on the ticket and recorded in the Project diary.

The receiving Inspector must sign each ticket at the time of delivery. Signed initials are sufficient if the full name is signed once on the first ticket of the day. If time of day is important, the Inspector must record the time of delivery. In the case of central mixed concrete, the Inspector should record the time that the concrete is deposited in place.

The receiving Inspector must check each truck after unloading to confirm that all material has been dumped from the truck's bed. If the Inspector notices that any material remains in the bed, he or she should immediately inform the truck driver, who must make an effort to remove the material. If the material is not removed, the Inspector will inform the Contractor's foreman that he or she will deduct the estimated weight of the material from the delivery ticket. The Inspector should explain the reason for the deduction on the back of the ticket.

The point of deposit of material, described in terms of the station, lane, footing, level, or similar feature, must be placed on every ticket, or if more appropriate, must be placed on each group of tickets.

If a periodic temperature check is appropriate, such as for concrete or hot-mix asphalt, it must be recorded on the tickets and in the Project diary.

If a surplus of material has been delivered and is not used, the oversupply is to be recorded on the tickets.

Running totals of quantities must be kept, and if not already provided for on the ticket face, are to be marked on the backs of the tickets.

The Contract Item for which the material is being used must be on the ticket.

SECTION D3.00 – DELDOT SAFETY REQUIREMENTS

D3.01 DelDOT Rules for Personnel Safety. The safety rules listed in this Section have been extracted from DelDOT directives. Employees may be subject to disciplinary action for violation of these rules.

D3.02 Water Work. Department employees are required to take adequate water safety precautions and wear a safety jacket approved by the United States Coast Guard when working over water, in a boat, on a float, or involved in any type of over-water bridge work. When work is being done on the water, the Resident Engineer/Project Supervisor should assign one or more people to be available on the shore to provide assistance in the event that individuals working off shore require help. The people on shore should be provided with adequate rope, a ring-type life preserver, and a mobile phone to use if assistance is required.

D3.03 Hard Hats. The hard hat is accepted by industry as a valuable safety tool. Hard hats are provided to Department personnel for the safety of the user and as an identifier on the Project site of a Department employee. The following hard hat requirements are from the Department's Personnel Safety Manual and more recent directives:

(a) Department personnel are required to wear hard harts at all times on construction projects or in materials plants.

(b) Hard hats are not required during semi-final and final inspections.

D3.04 Protective Clothing.

(a) *Clothes*. Department personnel working or otherwise located within the highway right-of-way are required to wear an approved vest, shirt, or jacket. Due to the nature and work climate of construction projects, Department personnel must be aware of and provide for protection against environmental and mechanical hazards such as scratches, lacerations, insect stings, and noxious and poisonous plants. Department personnel are to wear long trousers or slacks while on duty. Shorts, sleeveless shirts, and bare torsos are not permitted.

(b) *Ear Protection.* Ear protection devices can be furnished by the Department and are to be worn by employees whenever engaged in work operations where the noise level is suspected to be within damaging levels. Work that usually requires the use of ear protection includes blasting, jackhammers, and pile driving.

(c) *Foot Protection*. It is strongly recommended that shoes worn by employees conducting field or industrial type operations of any kind have hard soles. Soft-sole shoes such as tennis shoes are not recommended. If a non-slip sole surface is desired, it should have a hard sole base. "Safety toe" and foot protection devices are to be worn by employees whenever performing any work operation where individuals may be subject to having a heavy or penetrating object strike their feet.

(d) *Eye and Face Protection.* Protection devices are furnished by the Department and are to be worn under all circumstances where there is a possibility of eye or face injury from flying particles or objects. Examples of this type of work are sand blasting, jack hammering, welding, chipping, and rock crushing.

When in doubt, the Inspector should wear protective clothing and make sure that fellow employees and visitors protect themselves, too.

SECTION D4.00 – CONSTRUCTION SURVEYING AND LAYOUT

D4.01 General. The purpose of this Section is to provide basic information pertaining to Surveying and Layout appropriate to construction field personnel. This Section is not intended to replace a surveyor's manual. Material believed to be useful is included and should be used as a reference prior to starting, during, and after completing construction.

D4.02 Field Work and Staking. The "stake-out" is the work done by the Department to show the Contractor the exact location on the ground and to what dimensions the highway, its appurtenances, and structures are to be built. When there is not a Construction Engineering Pay Item in the Contract, stake-out is the responsibility of the Department. Staking responsibilities of the Department and the Contractor are clarified in Section 105.10 of the Standard Specifications. The stake-out work must be done carefully and accurately, as the Contractor is expected to base the location of its construction work on the Department stake-out. For this reason, the stake-out should be started well in advance of the beginning of the construction to avoid hurried work that may result in inaccuracies.

The work in the field should be discussed with the Contractor's representative. The staking procedures and markings should be carefully explained. If the Inspector has any doubt as to the Contractor's understanding of the staking procedures and markings, a written explanation should be given to the Contractor. A written record leaves little doubt and may prove to be a valuable record in the event the work is not built to proper lines and grades as staked in the field.

D4.03 Staking Centerline. In staking out a project for grading, the first operation is to stake the Project centerline. The Department will locate and reference the centerline in all cases. Where the centerline of the Project is the same as the baseline of the location survey, the centerline may already be staked.

D4.04 Slope Stakes. Slope stakes, which are flat marker stakes, are to be set at the computed actual top (cut) and toe (fill) of the side slopes. The slope stakes will be used by the Contractor to determine where and to what extent excavation and embankment work should be done. This, in turn, will determine the final lines and grades of the finished roadway and all ditches.

D4.05 Staking Right-of-Way and Easement Lines. After the centerline has been staked, the right-of-way lines should be staked on both sides of the centerline. Hubs should be set at right angles or radially to the centerline at all locations where the right-of-way and easement change width. Marker hubs must be driven flush with the ground. At the same time, guard stakes must be driven, the station number must be marked on the back of the guard stake, and the distance from the centerline must be marked on the other side facing the center line of the roadway.

D4.06 Cross Sections for Roadway. All crosssections are done by the Department. The original cross sections should indicate the elevations of the existing ground at the time of the survey. It is suggested that they be checked for accuracy prior to actual construction. If an unsatisfactory average variation is found, new "shots" should be requested and taken to be used in lieu of the Plan sections for computation of the excavation quantities.

When rock is encountered, the rock area should be cross-sectioned as soon as the overburden has been removed. These sections should be taken at the stations where the original cross sections were taken. Any additional sections that will be needed to arrive at the correct volume should also be taken. After the rock has been excavated, and before any backfill is placed, final cross sections must be taken to show the true lower limits of rock for quantity calculations. While this information applies specifically to roadway excavation, the principles apply to all excavation, such as structure, channel, and muck excavation. Where Plan quantities are estimated, complete pre-construction cross sections must be taken for accurate quantity calculations.

D4.07 Cross Sections for Borrow. Places from which borrow is to be obtained must be cross sectioned before and after borrow excavation in order to compute the quantity of material excavated. Where the site for a borrow pit is not close enough to the roadway, an independent baseline should be established that passes through the approximate center of the borrow pit, and sufficient cross sections should be referred to this baseline. If the pit is likely to be very large, two or more parallel lines should be referred to this baseline. The baseline should be referenced in such a manner that the references will not be disturbed so that the line and the stationing on it may be re-established for final sectioning.

A reference stake should be set at each limit of each cross section taken at a borrow pit. Such stakes should be marked to show the station number and distance from the baseline so that the Contractor will have some idea of the borrow pit limits.

D4.08 Staking Pavements. In staking out a pavement project, a single row of hubs is generally set on an offset line at one side of the centerline. If conditions are favorable, offset hubs should be set on the side of the road in which the first lane of paving is to be placed. This should be considered when it can be done without inconvenience or danger of loss of the hubs. The offset distance should be the same for all hubs.

D4.09 Staking Pipes. Generally, only a few stakes are needed by the Contractor to set a pipe culvert. Usually, a stake offset from the centerline of the pipe at each end of each run, and intermediate offset stakes are required. The offset distance should be adequate to place the stakes well out of the way of construction work, and should be marked on the face of each grade stake. Elevations to the flowline of the pipe can be placed on these stakes.

D4.10 Stakes for Box Culverts. In the case of a box culvert, more details and measurements for construction are required, and therefore, more stakes are necessary. Offset hubs that are well out of the way of the construction should be set on each side of the work. The inside face or other required working line of each of the main culvert walls should be located, and these lines similarly should be referenced by offset hubs. Offset hubs are set in a similar fashion for the wingwall lines.

All control points, whether on working lines or on offset lines, should be marked with tacks. To avoid confusion, a guard stake should be driven near each hub on an offset line and should be plainly marked to show the offset distance and the point on the structure to which the offset refers. Notes and sketches on the stake-out should be kept in a convenient stake-out book.

D4.11 Other Work for Box Culverts. Before excavation for a box culvert is begun, cross sections should be taken from the centerline established for the culvert. Sections should be located at enough points to make an accurate computation of the quantities of structural excavation and channel excavation.

D4.12 Staking Bridges. Because of the wide range of variations in Plans for bridges, standard methods for the stake-out of bridges cannot be established. In the stake-out for a bridge, especially one for crossing a large body of water, a highly precise horizontal control system is necessary. Such a system will make it possible to locate accurately and quickly various widely scattered piers and other component parts of the bridge. Because the staking system for a bridge may differ from that used for other bridges, the Inspector should be familiar with the particular staking system before any bridge work begins.

As a general procedure, the centerline of the bridge is carefully established and referenced. Points at the faces or other working lines of each abutment, and at the axis of each pier or row of footings, are located at the bridge centerline, and the angles corresponding to the skew of the bridge are turned at these points. Each line thus located is extended to reference points well beyond the work area. At each intersection of the face of an abutment and the face of a wingwall, the wingwall angle is turned, and the line thus located is referenced. As in any other stake-out, notes should be recorded, and the notebook retained by the District Office or the Inspector.

D4.13 Final Surveys. The purpose of the final survey on a project is to determine the quantities of the various items of work for which the Contractor is to receive payment in the final settlement of the Contract. The method of calculating the quantity of each individual item is always made a part of the Specifications for the item under the subsection "Method of Measurement". For the determination of the final quantities of excavation, borrow, and similar items for which payment is made per cubic yard (meter), it is necessary that final cross sections be taken. The important step in the procedure for taking final sections is to reset the centerline of the road or the baseline from which the original sections were taken.

> The final sections must be taken from the same stations on the reference line as the originals. This means that a final section must be taken from every station on the line from which an original section was taken.

D4.14 Useful References and Conversion Tables. The following pages contain tables and other information that the Inspector may find useful when performing or inspecting survey work.

Table D-1: Temperature Corrections per Foot for Steel Tapes

The following table is used to determine the correct length of a steel tape at different temperatures. To determine the correct tape length, multiply the nominal tape length by the correction factor for the ambient temperature at the time measurements were taken, and add the correction factor to the tape length.

Temp. (°F)	Correction Factor	Temp. (°F)	Correction Factor	Temp. (°F)	Correction Factor
-10	-0.00050310	36	-0.00020640	82	0.00009030
-9	-0.00049665	37	-0.00019995	83	0.00009675
-8	-0.00049020	38	-0.00019350	84	0.00010320
-7	-0.00048375	39	-0.00018705	85	0.00010965
-6	-0.00047730	40	-0.00018060	86	0.00011610
-5	-0.00047085	41	-0.00017415	87	0.00012255
-4	-0.00046440	42	-0.00016770	88	0.00012900
-3	-0.00045795	43	-0.00016125	89	0.00013545
-2	-0.00045150	44	-0.00015480	90	0.00014190
-1	-0.00044505	45	-0.00014835	91	0.00014835
0	-0.00043860	46	-0.00014190	92	0.00015480
1	-0.00043215	47	-0.00013545	93	0.00016125
2	-0.00042570	48	-0.00012900	94	0.00016770
3	-0.00041925	49	-0.00012255	95	0.00017415
4	-0.00041280	50	-0.00011610	96	0.00018060
5	-0.00040635	51	-0.00010965	97	0.00018705
6	-0.00039990	52	-0.00010320	98	0.00019350
7	-0.00039345	53	-0.00009675	99	0.00019995
8	-0.00038700	54	-0.00009030	100	0.00020640
9	-0.00038055	55	-0.00008385	101	0.00021285
10	-0.00037410	56	-0.00007740	102	0.00021930
11	-0.00036765	57	-0.00007095	103	0.00022575
12	-0.00036120	58	-0.00006450	104	0.00023220
13	-0.00035475	59	-0.00005805	105	0.00023865
14	-0.00034830	60	-0.00005160	106	0.00024510
15	-0.00034185	61	-0.00004515	107	0.00025155
16	-0.00033540	62	-0.00003870	108	0.00025800
17	-0.00032895	63	-0.00003225	109	0.00026445
18	-0.00032250	64	-0.00002580	110	0.00027090
19	-0.00031605	65	-0.00001935	111	0.00027735
20	-0.00030960	66	-0.00001290	112	0.00028380
21	-0.00030315	67	-0.00000645	113	0.00029025
22	-0.00029670	68	0.00000000	114	0.00029670
23	-0.00029025	69	0.00000645	115	0.00030315
24	-0.00028380	70	0.00001290	116	0.00030960
25	-0.00027735	71	0.00001935	117	0.00031605
26	-0.00027090	72	0.00002580	118	0.00032250
27	-0.00026445	73	0.00003225	119	0.00032895
28	-0.00025800	74	0.00003870	120	0.00033540
29	-0.00025155	75	0.00004515	121	0.00034185
30	-0.00024510	76	0.00005160	122	0.00034830
31	-0.00023865	77	0.00005805	123	0.00035475
32	-0.00023220	78	0.00006450	124	0.00036120
33	-0.00022575	79	0.00007095	125	0.00036765
34	-0.00021930	80	0.00007740	126	0.00037410
35	-0.00021285	81	0.00008385	127	0.00038055

Table D-1M: Temperature Corrections per Meter for Steel Tapes

The following table is used to determine the correct length of a steel tape at different temperatures. To determine the correct tape length, multiply the nominal tape length by the correction factor for the ambient temperature at the time measurements were taken, and add the correction factor to the tape length.

Temp. (°C)	Correction Factor	Temp. (°C)	Correction Factor	Temp. (°C)	Correction Factor
-30	-0.0005800	-3	-0.0002668	24	0.0000464
-29	-0.0005684	-2	-0.0002552	25	0.0000580
-28	-0.0005568	-1	-0.0002436	26	0.0000696
-27	-0.0005452	0	-0.0002320	27	0.0000812
-26	-0.0005336	1	-0.0002204	28	0.0000928
-25	-0.0005220	2	-0.0002088	29	0.0001044
-24	-0.0005104	3	-0.0001972	30	0.0001160
-23	-0.0004988	4	-0.0001856	31	0.0001276
-22	-0.0004872	5	-0.0001740	32	0.0001392
-21	-0.0004756	6	-0.0001624	33	0.0001508
-20	-0.0004640	7	-0.0001508	34	0.0001624
-19	-0.0004524	8	-0.0001392	35	0.0001740
-18	-0.0004408	9	-0.0001276	36	0.0001856
-17	-0.0004292	10	-0.0001160	37	0.0001972
-16	-0.0004176	11	-0.0001044	38	0.0002088
-15	-0.0004060	12	-0.0000928	39	0.0002204
-14	-0.0003944	13	-0.0000812	40	0.0002320
-13	-0.0003828	14	-0.0000696	41	0.0002436
-12	-0.0003712	15	-0.0000580	42	0.0002552
-11	-0.0003596	16	-0.0000464	43	0.0002668
-10	-0.0003480	17	-0.0000348	44	0.0002784
-9	-0.0003364	18	-0.0000232	45	0.0002900
-8	-0.0003248	19	-0.0000116	46	0.0003016
-7	-0.0003132	20	0.0000000	47	0.0003132
-6	-0.0003016	21	0.0000116	48	0.0003248
-5	-0.0002900	22	0.0000232	49	0.0003364
-4	-0.0002784	23	0.0000348	50	0.0003480

Table D-2: Degrees-Minutes-Seconds Conversion Table

Minutes and Seconds (expressed as decimals of 1E)

Min.	Seconds						Min.	Seconds					
	0	10	20	30	40	50		0	10	20	30	40	50
0	.0000	.0028	.0056	.0083	.0111	.0130	30	.5000	.5028	.5056	.5083	.5111	.5139
1	.0167	.0195	.0223	.0250	.0278	.0306	31	.5167	.5195	.5223	.5250	.5278	.5306
2	.0333	.0361	.0389	.0417	.0444	.0472	2	.5333	.5361	.5389	.5417	.5444	.5472
3	.0500	.0528	.0556	.0583	.0611	.0639	33	.5500	.5528	.5556	.5583	.5611	.5639
4	.0667	.0695	.0723	.0750	.0778	.0806	34	.5667	.5695	.5723	.5750	.5778	.5806
5	.0833	.0861	.0889	.0917	.0944	.0972	35	.5833	.5861	.5889	.5917	.5944	.5972
6	.1000	.1028	.1056	.1083	.1111	.1139	36	.6000	.6028	.6056	.6083	.6111	.6139
7	.1167	.1195	.1223	.1250	.1278	.1306	37	.6167	.6195	.6223	.6250	.6278	.6306
8	.1333	.1361	.1389	.1417	.1444	.1472	38	.6333	.6361	.6389	.6417	.6444	.6472
9	.1500	.1528	.1556	.1583	.1611	.1639	39	.6500	.6528	.6556	.6583	.6611	.6639
10	.1667	.1695	.1723	.1750	.1778	.1806	40	.6667	.6695	.6723	.6750	.6778	.6806
11	.1833	.1681	.1889	.1917	.1944	.1972	41	.6833	.6861	.6389	.6417	.6444	.6472
12	.2000	.2028	.2056	.2083	.2111	.2139	42	.7000	.7028	.7056	.7083	.7111	.7130
13	.2167	.2195	.2223	.2250	.2278	.2306	43	.7167	.7195	.7223	.7250	.7278	.7306
14	.2333	.2361	.2389	.2417	.2444	.2472	44	.7333	.7361	.7389	.7417	.7444	.7472
15	.2500	.2528	.2556	.2583	.2611	.2639	45	.7500	.7528	.7556	.7583	.7611	.7639
16	.2667	.2695	.2723	.2750	.2778	.2806	46	.7667	.7695	.7723	.7750	.7778	.7806
17	.2833	.2861	.2889	.2917	.3944	.2972	47	.7833	.7861	.7889	.7917	.7944	.7972
18	.3000	.3028	.3056	.3083	.3111	.3139	48	.8000	.8028	.8056	.8083	.8111	.8139
19	.3167	.3195	.3223	.3250	.3278	.3306	49	.8167	.8195	.8223	.8250	.8278	.8306
20	.3333	.3361	.3389	.3417	.3444	.3472	50	.8333	.8361	.8389	.8417	.8444	.8472
21	.3500	.3528	.3556	.3583	.3611	.3639	51	.8500	.8528	.8556	.8583	.8611	.8639
22	.3667	.3695	.3723	.3750	.3778	.3806	52	.8667	.8695	.8723	.8750	.8778	.8806
23	3833	3861	.3889	.3917	.3944	.3972	53	.8833	.8861	.8889	.8917	.8944	.8972
24	.4000	.4028	.4056	.4083	.4111	.4139	54	.9000	.9028	.9056	.9083	.9111	.9139
25	.4167	.4195	.4223	.4250	.4278	.4306	55	.9167	.9495	.9223	.9250	.9278	.9306
26	.4333	.4361	.4389	.4417	.4444	.4472	56	.9333	.9361	.9389	.9417	.9444	.9472
27	.4500	.4528	.4556	.4583	.4611	.4639	57	.9500	.9528	.9556	.9583	.9611	.9639
28	.4667	.4695	.4723	.4750	.4778	.4806	58	.9667	.9695	.9723	.9750	.9778	.9806
29	.4833	.4861	.4889	.4917	.4944	.4972	59	.9833	.9861	.9889	.9917	.9944	.9972
30	.5000	.5028	.5056	.5083	.5111	.5139	60	1.0000	1.0028	1.0056	1.0083	1.0111	1.1139

Table D-3: Decimal Degrees Conversion Table

Decimals of One Degree (expressed as minutes and seconds)										
Degrees	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0.0	0' 00"	0' 36"	1' 12"	1' 48"	2' 24"	3' 00"	3' 36"	4' 12"	4' 48"	5' 24"
0.1	6' 00"	6' 36"	7' 12"	7' 48"	8' 24"	9' 00"	9' 36"	10' 12"	10' 48"	11' 24"
0.2	12' 00"	12' 36"	13' 12"	13' 48"	14' 24"	15' 00"	15' 36"	16' 12"	16' 48"	17' 24"
0.3	18' 00"	18' 36"	19' 12"	19' 48"	20' 24"	21' 00"	21' 36"	22' 12"	22' 48"	23' 24"
0.4	24' 00"	24' 36"	25' 12"	25' 48"	26' 24"	27' 00"	27' 36"	28+' 12"	28' 48"	29' 24"
0.5	30' 00"	30' 36"	31' 12"	31' 48"	32' 24"	33' 00"	33' 36"	34' 12"	34' 48"	35' 24"
0.6	36' 00"	36' 36"	37' 12"	37' 48"	38' 24"	39' 00"	39' 36"	40' 12"	10' 48"	41' 24"
0.7	42' 00"	42' 36"	43' 12"	43' 48"	44' 24"	45' 00"	45' 36"	46' 12"	46' 48"	47' 24"
0.8	48' 00"	48' 36"	49' 12"	49' 48"	50' 24"	51' 00"	51' 36"	52' 12"	52' 48"	53' 24"
0.9	54' 00"	54' 36"	55' 12"	55' 48"	56' 24"	57' 00"	57' 36"	58' 12"	58' 48"	59' 24"

Figure D-1: Tape Corrections for Slope Measurements

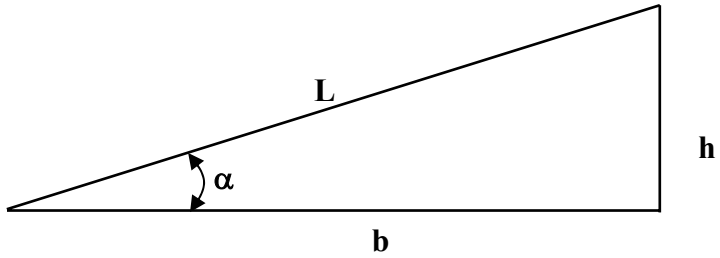
For known elevation differences:

$$C_h = \frac{h^2}{2L}$$

where:
C_h = slope correction
h = difference in height of two ends
L = length recorded

Note: This formula is good for small values of h; as h increases, C_h becomes increasingly in error

For known angular slopes:



C_h = L vers α
where:
C_h = slope correction
L = length recorded
vers = versine = 1 - cosine (Versine table in *Highway Curves*, by Ives and Kissam)

Note: Slope correction is to be subtracted from field measurement.

SECTION D5.00 – MOBILE RADIOS

D5.01 Communications. Communications play an important role in expediting the daily activities of the Department. The effective use of the equipment is dependent on the training employees receive, operating techniques used by individuals, and policies implemented by the Department. Radio equipment used by the Department is maintained by the State Police. The Federal Communications Commission (FCC) regulates the radio systems and provides the laws for their use.

D5.02 Radio. Radio transmissions may be received by both Department personnel and those outside the Department that may be tuned into the same frequency. It is important that conversations focus on the business at hand. Communications are to be clear, spoken distinctly, concise, and to the point. It is good practice to think out a message prior to putting it on the air. Prior to delivering the message, consider the content and the intent of the message and the impact on the receiver. Verbal messages should not contain inappropriate phrases.

> The use of profanity or obscene language is never to be used during transmission of messages.

D5.03 Construction of Messages. As stated in the previous section, communications are to be clear, spoken distinctly, concise, and to the point. The message to be transmitted is to be carefully thought out to deliver the meaning without having to repeat the message. The choice of words used on the air should be such that the receiver does not need the message repeated because it was not spoken slowly, clearly or directly into the microphone. Pauses during transmissions may lead the receiver to think the communication is completed before the full message has been delivered.

The choice of words should be carefully selected when constructing a message. Many words have similar or double meanings or may be mistaken for other words during a “mumbled” transmission. Effective communications will improve the use of radio transmissions.

D5.04 Transmission of Messages. When transmitting radio messages, the sender should clearly identify for whom the transmission is intended by approved designation, code name, or vehicle identification number. Sentences and statements should not be broken; the words should be pronounced distinctly, spoken slowly, and at a rate of approximately forty to sixty words a minute. Messages should be transmitted at the normal conversational tone, without the use of dramatics. Emotion should never be voiced on the air, regardless of the circumstances. Private or personal communication is not the intent of the radio system, and is in direct conflict with Department policy.

The sender should be approximately 6" (15 cm) from the microphone and speak directly into the instrument at a normal, “room” conversation level. The sender should always try to transmit from a quiet area with no surrounding distracting noises. Long transmissions should be avoided. Transmissions should be in approximately thirty-second intervals, and the sender should wait a few seconds before resuming the transmission. The purpose is to allow the receiver to “Copy” the message or ask the sender to “say again” the message. Pausing also allows anyone with an emergency to “break-in” or go ahead of your transmission without waiting.

When transmitting a message that includes numbers, the numbers should first be spoken individually, and then repeated as a whole number. For example, 12,357 would be spoken as one, two, three, five, seven, and then repeated as twelve thousand three hundred fifty seven.

People inexperienced in using radios should consider practicing by speaking into a microphone connected to a tape recorder and then playing back the transmission. This should be done a few times to better understand how the transmission may sound to others.

D5.05 Systems of Standards. In order to clarify radio communications, the phonetic alphabet was developed. When a transmission contains letters spoken individually, such as from a license plate, or the sender is spelling a word, the phonetic alphabet should be used. For example, if a license plate were "ABC-123", the sender would say "Alpha-Bravo-Charlie-One-Two-Three". Table 1 lists the 26 words to be used in the phonetic alphabet.

Table D-4: Phonetic Alphabet

A = Alpha	J = Juliet	S = Sierra
B = Bravo	K = Kilo	T = Tango
C = Charlie	L = Lima	U = Uniform
D = Delta	M = Mike	V = Victor
E = Echo	N = November	W = Whiskey
F = Foxtrot	O = Oscar	X = X-ray
G = Golf	P = Papa	Y = Yankee
H = Hotel	Q = Quebec	Z = Zulu
I = India	R = Romeo	

Number pronunciations are generally emphasized as listed below to avoid a misunderstanding of the numbers communicated. The number "0" is stated as "zero" not "naught".

D5.06 Two-Way Signals. The following list of commonly used signals (known as ten signals) is used in radio communications within the Department as abbreviations for specific meanings. (The numeral "10" was selected from the FCC Rules and Regulations under which a radio system is licensed and operates.) By proper use of these signals, specific transmissions may be more easily and correctly interpreted by Department personnel and individual radio time may be reduced.

Table D-5: Radio Call Signals

Signal	Interpretation		Signal	Interpretation
10-1	Situation under control		10-48	Alarm at location
10-2	Arriving at scene		10-49	Civil Disturbance-Police Action Required
10-3	Go ahead with message		10-50	Accident involving DOT vehicle
10-4	OK, received message		10-52	Permission to leave sector
10-5	Relay message to		10-53	Obstruction in roadway
10-6	Busy, call later		10-54	Road blocked or closed at_____
10-7	Out of service (not available by radio)		10-55	Pick up _____
10-8	In service (available by radio)		10-58	Traffic light not functioning
10-9	Repeat message		10-59	Release standby personnel
10-10	Accident PD,PI,H&R		10-61	Property Check
10-12	Request assistance at headquarters or fire station		10-62	Clear on property check
10-13	Advise weather and road conditions		10-63	Advise where ____can be contacted
10-14	Convoy or escort		10-66	Radio Tower lights checked
10-17	Meal stops or send coffee & sandwiches to scene		10-67	Permission to transmit car to car
10-18	Complete assignment ASAP		10-69	En route to _____
10-19	Return to _____		10-70	Report to _____
10-20	What is your location		10-71	Alert for Major Emergency
10-21	Contact by telephone		10-70	Mobilize for Major Emergency
10-22	Disregard		10-87	Police action (caution)
10-23	Direct traffic at _____		10-90	Possible cardiac arrest (external heart massage)
10-24	Send assistance to scene		10-91	D.O.A.
10-24A	Assist _____at_____		10-92	Possible internal injury
10-25	E.T.A.		10-93	Fractured limb
10-27	Notify appropriate Police Agency		10-99	Heart Attack
10-30	Does not conform to rules and regulations		10-100	Clear the Air Emergency Message
10-31	Meet complainant at _____			
10-32	Complaint (to be suffixed alphabetically)			
10-33	Disabled vehicle (location)			
10-34	Prepare to make copy			
10-35	Confidential information			
10-36	Time check			
10-37A	Not open			
10-39	Use caution			
10-40	Officer in trouble			
10-41	Checking MV or Pedestrian at location			
10-43	Wrecker needed			
10-44	Ambulance needed			
10-45	Rescue equipment needed			
10-46	Fire apparatus needed for washdown			
10-47	Dispatch tank truck			

D5.07 Equipment Maintenance. In the event of equipment failure, the items listed below should be attempted prior to requesting repair service:

(a) Be sure the user is familiar with the equipment and knows the operation.

(b) In the event of receiver or transmitter failure, have at least two other knowledgeable employees check the unit for operation. At times, the problem may lie with the original operator due to a minor oversight.
(c) A determination should be made as to whether the fuses have blown.
(d) If possible, attempt to determine if the problem is with the receiver or transmitter.
(e) Determine if the battery is in good order and fully charged.
(f) If possible, a determination should be made if it is the base unit that is inoperative or the radio unit in the vehicle.

D5.08 Operating Procedures. Each operator is required to be familiar with and abide by the regulations initiated by the FCC and the Department.

(a) *Personal Messages.* Title 47 CFR Part 90 prohibits the use of the Department radio system for purposes of transmitting any personal messages. The network is restricted to official Department communications.
(b) *Lengthy or Conversation Type Messages*. Title 47 CFR Part 90 prohibits the use of the radio system for lengthy or two-way conversations. Highway communications are to be restricted to the minimum transmission time necessary to communicate official messages.
(c) *Improper Use of Ten (10) Signals.*
    (1) The 10-4 signal is to be used as an acknowledgment only by the receiving operator. The 10-4 signal is not to be used as a question.
    (2) The 10-9 signal is to be used for only the portion of the transmission not understood (such as route numbers, street names, or hard to understand words).

D5.09 Improper Use of the Radio System. The Telecommunications Act of 1934 underwent major revisions in 1996. The new Act is officially known as the Telecommunications Act of 1996, Pub. LA. No 104-104, 110 Stat.56 (1996) and authorizes the FCC to impose fines of up to $500.00 for willful or repeated violations of communications regulations. The information provided in this section is extracted from "situations" that would fall under the purview of the FCC regulations:

(a) Operated by a person not holding a valid operators license or permit of the class required, where a permit is required.
(b) Fails to identify at the time and in the manner set forth in the rules covering that particular type of station.
(c) Transmits any false call signals contrary to FCC rules.
(d) Transmits improper communications on a distress or calling frequency.
(e) Interferes with a distress call contrary to rules.
(f) Renders a communication service not authorized by the Commission for the particular station.
(g) Profane, obscene, or indecent language.

D5.10 Federal Regulations.

(a) The Federal Regulations that apply to the use of mobile radios and base stations on construction sites are located in Title 47 CFR Part 90.

(b) *Title 47 CFR Part 90.425, Paragraph a.* Section 425 states in part that "Except as provided for in paragraphs (d) and (e) of this section, each station or system shall be identified by the transmission of the assigned call sign during each transmission or exchange of transmissions, or once each 15 minutes (30 minutes in the Public Safety Pool) during periods of continuous operation. The call sign shall be transmitted by voice in the English language or by International Morse Code…" Department operators of Base Stations are required to end each message or exchange of messages with the call signs. Section 425 further states "…a single mobile unit in the licensee's authorized geographic area of operation may transmit station identification on behalf of any other operating mobile units in the fleet." The phrase "each general geographic area" means an area not smaller than a city or county and not larger than a single district of a State where the district is administratively established for the service in which the radio system operates. Department operators of mobile stations are to give the mobile call sign at the end of each message or exchange of messages. This section applies to the Division of Highway Operations.

D5.11 Preparedness for Inspection. This section provides information regarding the data to be available when FCC inspections of Public Safety Services Communication Networks are initiated:

(a) *Station License.* This document is to be framed and placed in a highly visible location at the control point.

(b) *A Record of the Frequency and Modulation Deviation Measurements.* This record is to be established when the transmitter is initially installed and up-dated not less than at twelve-month intervals. The Department policy is to have the measurements made every six months.

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