CDOT PIPE MATERIAL SELECTION GUIDE Revised April 30, 2015

Implementation

The *CDOT Pipe Material Selection Policy* was initially developed by the Project Development Branch for approval by the Chief Engineer. However, this document is no longer required to be a separate policy document that requires the Chief Engineer's approval. Therefore, it will now be referred to as the *CDOT Pipe Material Selection Guide* and when the Drainage Design Manual is updated this guide will be incorporated as a design procedure in the Drainage Design Manual. Until such time it will continue to be "stored" on the Bulletins and Manuals webpage as a "stand alone" document (https://www.codot.gov/business/designsupport/bulletins_manuals).

These Procedures for Pipe Material Selection (as updated April 30, 2015) supersede and replace all previous procedures, guidelines, and policies regarding the selection of pipe materials used by CDOT.

These procedures also replace the CDOT Chief Engineer memo dated February 8, 1984, *Pipe to be Used in Storm Drains.*

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Introduction

This guide will enable Project Managers (PMs) to select the allowable pipe material options for each installation on a specific project. The Contractor will choose the final pipe material from the list of options provided in the Contract and as specified in applicable sections of the CDOT *Standard Specifications for Road and Bridge Construction.* Any pipe that meets the corrosion and abrasion criteria in this guide and is installed per the plans and specifications is assumed to have a 50-year service life.

Background

This policy/guide was originally developed to comply with the provisions of the Final Rule published in 23 CFR 635.411 (b) published in the Federal Register on November 15, 2006. On July 6, 2012 the Moving Ahead for Progress in the 21st Century Act (MAP-21) was signed into law, with the passage MAP-21 the federal requirement for this policy/guide was nullified. The Colorado Department of Transportation (CDOT) has determined the additional performance criteria outlined in the original policy (now guide) is beneficial to the state. Therefore this revised guide retains much of the original policy and is to be incorporated into all CDOT design projects. CDOT will follow its standard practices for the hydraulic and structural design of pipes. This guide replaces all previous policies regarding the selection of pipe material for Storm Drains, Cross Drains, and Side Drains.

Selection Considerations

CDOT will evaluate the risk associated with the performance of the pipe materials. Risk will be considered to the extent that it is influenced by the pipe, other materials, or installation techniques as they are used in construction.

The CDOT Pipe Material Selection Guide identifies the specific engineering and performance criteria used to evaluate the acceptability of alternative pipe materials. CDOT will allow alternative pipe materials where appropriate. A record of the determination of abrasion and corrosion levels will be documented and maintained in the project design files.

The following exemptions are not intended to be covered by this guide.

A. Subsurface Drains and Embankment Protector Type 3 (M-Standard 615).

B. Pipe extensions of existing pipes or systems shall be completed using similar material and sizes. Exceptions to this may be made when conditions and engineering justifications merit otherwise.

C. Local agencies and other organizations that will own and maintain the new pipe should be consulted for guidance on pipe material type selection. Only pipe material types that have been evaluated and approved for use by CDOT shall be used. In the event a local agency or organization will own and maintain the new pipe and the guidance provided differs from this guide, the guidance from the local agency or organization shall govern.

Definitions

Cross Drain –Pipes or culverts that convey flows from one side of the road to the other, and are typically open on each end. Also known as a Cross Culvert.

Side Drain – A pipe or culvert which is typically parallel to the roadway and under a driveway or a road approach to the mainline roadway.

Storm Drain – A network of pipes that connects inlets, manholes, and other drainage features to an outfall.

Subsurface Drain – A network of piping used to collect ground water, or relieve water pressure from a wall or structure, and transport it to a location where it will not harm the roadway features, or where it can be conveyed by another system, often a storm sewer. A common example is a French Drain.

Type III Embankment Protector – See M-Standard 615-1

Durability - A pipe or culverts ability to resist wear and tear or decay. Although structural condition is a very important element in the performance of pipes, durability problems are a common cause for replacement. Pipes are more likely to "wear away" than fail structurally. Durability is affected by two mechanisms: corrosion and abrasion. Each is discussed in the following sections.

Corrosion – Corrosion is the deterioration of material due to chemical or electrochemical reaction with the environment. Corrosion of pipe materials may occur in many different types of soils and waters. Corrosive types of soil and water may contain acids, alkalis, dissolved salts, organics, industrial wastes or chemicals, mine drainage, sanitary effluents, and dissolved or free gases. Pipe corrosion is generally related to water and the chemicals that have reacted to, become dissolved in, or been transported by the water.

Abrasion – Abrasion is the process of wearing down or grinding away the surface material of pipes, as water laden with sand, gravel, or stones flow through a pipe. The abrasive force increases with rising pipe velocity.

Alternative Materials – Alternative materials are the various pipe materials that will meet the project requirements. The alternative materials will be identified in the Contract, and the Contractor may select any one of them for use on the project.

Selection Process/Responsibility – All decisions regarding pipe material type will be based on best engineering practices and judgments. The PM is responsible for all aspects of the design of the project and for ensuring timely completion of tasks associated with project advertisement. The PM will schedule work associated with this procedure to ensure compliance with the project schedule. The PM will consider such factors as durability, environmental considerations, soil conditions, fill heights, need for water tight joints, pipe minimum and maximum slope (i.e. pipe velocity), hydraulic characteristics of pipe material inside surfaces, and other factors relevant to the project and or specific pipe location.

The PM will specify on the plans or in the special provisions when water tight joints are required. Siphons, irrigation systems, and storm drain systems require water tight joints.

In some cases the results of the material type selection process may produce alternative materials types in differing pipe diameters. In such cases the PM may specify the appropriate diameter for each material type or specify only the largest pipe diameter (produced by the selection process regardless of the material type) in the plans.

When a specific manning's "n" value is critical to the pipe's performance, the maximum/minimum value shall be shown on the plans. If the larger diameter will not meet the minimum cover requirements, or the material will not meet the Manning's "n" value range, then that material type shall be disqualified at those location(s). Any Material type disqualified at a location during design should be stated as such on the plans.

Step I: Determine Application – The PM will use the latest version of CDOT's *Drainage Design Manual* and CDOT's *Project Development Manual.* The pipe selection process begins when the PM determines the location of the new pipe. The PM will then determine and document the specific use of the pipe:

- Cross Drain
- Side Drain
- Storm Drain

Step II: Determine Abrasion Level – An estimate of the potential for abrasion is required to determine acceptable pipe types and whether there is a need for invert protection.

The PM with concurrence of the project hydraulics engineer will estimate and document the abrasive forces that will have an effect on the pipe material; and document the following items:

- Measure or estimate the velocity of the water based upon 2-year flow and less.
- Estimate the bed-loading as:
    - No bed load
    - Minor bed load – silt and sand
    - Moderate bed load – silt, sand, and gravel
    - Heavy bed load – silt, sand, gravel, and rock
- Determine whether the abrasion level is 1, 2, 3, or 4 as defined below.
    - Abrasion Level 1 – This level applies where the conditions are nonabrasive. Nonabrasive conditions exist in areas of no bed load and very low velocities. This is the level assumed for the soil side of drainage pipes. This is also the level assumed for the inverts of cross drains and side drains installed in typically dry drainages.
    - Abrasion Level 2 – This level applies where low abrasive conditions exist. Low abrasive conditions exist in areas of minor bed loads of sand and velocities of 5 fps or less.
    - Abrasion Level 3 – This level applies where moderately abrasive conditions exist. Moderately abrasive conditions exist in areas of moderate bed loads of sand and gravel and velocities between 5 fps and 15 fps.
    - Abrasion Level 4 – This level applies where severely abrasive conditions exist. Severely abrasive conditions exist in areas of heavy bed loads of sand, gravel, and rock and velocities exceeding 15 fps.

Abrasion levels are intended to help the PM consider the impacts of bed-load wear on the invert of pipe materials. The PM will determine the expected level of abrasion through visual examination and documentation of the size of the materials in the stream bed and the average slope of the channel. In some case sampling of the streambed material may be required to assist the PM in determining the level of abrasion.

Where existing pipes are in place in the same drainage, the conditions of their inverts should be documented and used as guidance. The expected stream velocity should be based upon 2-year flow and less.

Step III: Determine Corrosion Level – The station of each proposed pipe will be determined by the PM. The PM will schedule the soil and water testing to ensure compliance with the project advertisement date. Resistivity, PH, and moisture levels will be determined in the field by the Region as these tests are most efficiently and effectively conducted at the time of sampling. The CDOT Materials and Geotechnical group is available to perform sulfate and chloride testing, however, the PM will schedule this work appropriately to avoid project delays. The Region should develop their ability to perform these simple tests in the Region to expedite project design. The resulting sample testing information will be used in flow charts (Figures 1 and 2) to select appropriate material.

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The PM will document the following properties of the soil and water using the designated test procedure:

- Sulfate Levels - **CPL 2103**
- Chloride Levels - **CPL 2104**
- Resistivity - **ASTM G57**
- pH - **ASTM G51**
- Moisture Levels

This information will be obtained at all pipe locations supplied by the PM and documented in the project records by the PM. If the alluvium of the area is sufficiently homogeneous, a reduced sampling schedule will be acceptable. This determination should only be made with input from the Region Materials Engineers (or Staff Materials) and the Region Hydraulics Engineer.

Table 1

Guidelines for selection of corrosion resistance levels

	SOIL			WATER		
CR Level	Sulfate	Chloride		Sulfate	Chloride	
	(SO_4)	(Cl)	pH	(SO_4)	(Cl)	pH
	% max	% max		ppm (max)	ppm (max)	
*CR 0	0.05	0.05	6.0-8.5	50	50	6.0-8.5
CR 1	0.10	0.10	6.0-8.5	150	150	6.0-8.5
CR 2	0.20	0.20	6.0-8.5	1,500	1,500	6.0-8.5
CR 3	0.50	0.50	6.0-8.5	5,000	5,000	6.0-8.5
CR 4	1.00	1.00	5.0-9.0	7,500	7,500	5.0-9.0
CR 5	2.00	2.00	5.0-9.0	10,000	10,000	5.0-9.0
CR 6	>2.00	>2.00	<5** or >9	>10,000	>10,000	<5** or >9

*No special corrosion protection recommended when values are within these limits. **Concrete pipe used when the pH of either the soil or water is less than 5 shall be coated in accordance with subsection 706.07. When needed, specify the coating in a special provision or plan note.

Table 2

Minimum Pipe Thickness for Metal Pipes Based on the Resistivity and pH of the Adjacent Soil

SOIL SIDE		MINIMUM REQUIRED GAUGE THICKNESS FOR METAL PIPE MATERIAL
Resistivity, R (Ohm – cm)	pH	
≥1,500	5.0-9.0	0.052 in (18 Gauge) Aluminized Type 2
≥250	3.0-12.0	0.052 in (18 Gauge) Polymer Coated

For Storm Drains use Standard Specification 603, and write a Project Special Provision stating the required corrosion classification as determined by this guide. (i.e., sulfate class). Use appropriate pay items in these cases.

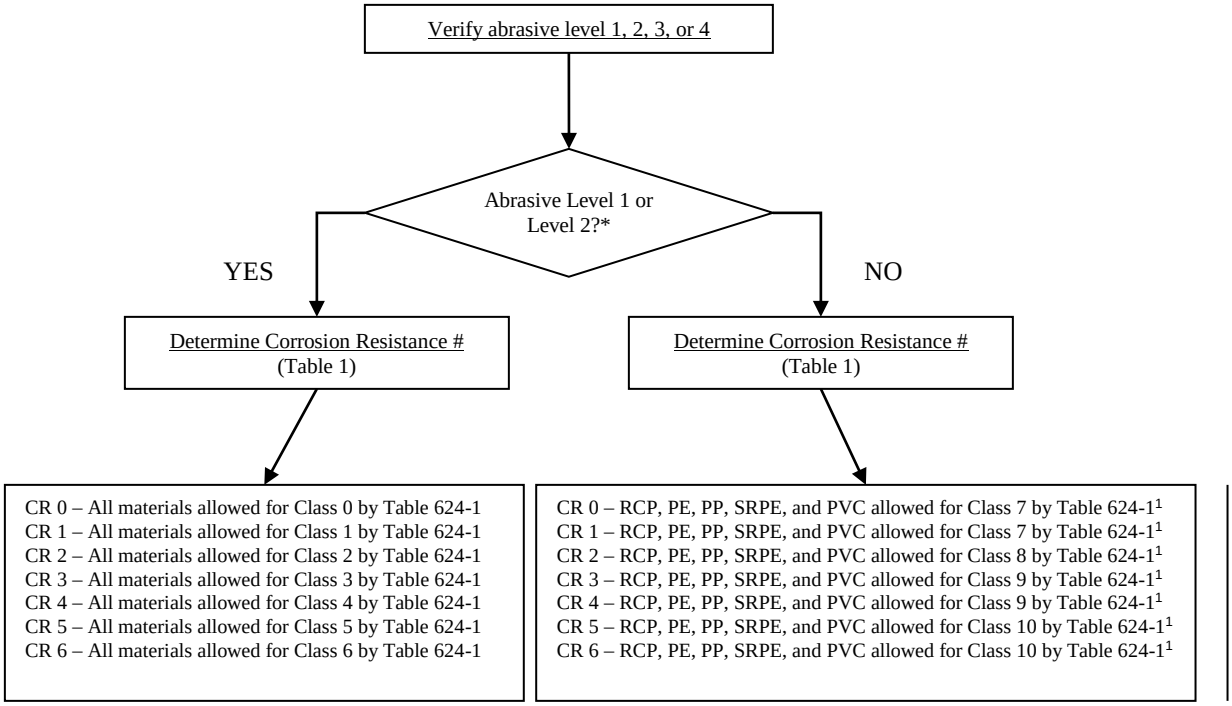
Step IV: Selection of Pipe Material Type – Use the flowcharts in this document to identify acceptable pipe material types. Use Figure 1 to determine if metal pipe is an allowable material type, and then use, Table 2 to determine whether there are additional requirements for metal pipes.

Step V: Verify Fill Height – Check Fill Height tables in the Standard Plans. Determine if Project Special Provisions are required and/or if any other Standard Special Provisions are applicable. Use the latest versions of these specifications, found at: http://www.coloradodot.info/business/designsupport/construction-specifications/2011-Specs

Step VI: Address Exceptions to CDOT Pipe Materials Selection Guide – When sound engineering judgment justifies an exception to this guide, the PM shall document this in a justification letter. All justification letters shall be approved by the Region Program Engineer (PE III) or their designee prior to final design.

Step VII: Documentation – All design decisions regarding pipe material type selection must be documented and a letter placed in the project file. Copies of all selection letters are to be sent to the Region Program Engineer or their designee prior to final design decisions being made, for guidance and to verify consistency.

Figure 1
CROSS – DRAINS and SIDE – DRAINS



*Aluminum alloy pipe not allowed in environments with an Abrasion Level higher than 1.

[1] ***When concrete pipe is selected the sulfate content dictates the CR level***. Cementitious requirements for Sulfate Protection Classes are listed in 601.04. A higher level of protection may be used. Concrete shall have a minimum compressive strength of 4,500 psi and maximum water to cementitious ratio (w/cm) listed in 601.04. Concrete may be used when the pH and chlorides exceed the levels listed in Table 1

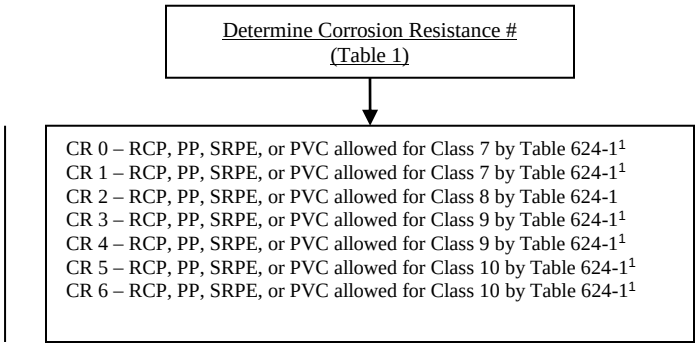
For Metal pipes, see "Minimum Pipe Thickness for Metal Pipes Based on the Resistivity and pH Of the Adjacent Soil" (Table 2) in this document.

When extending an existing pipe, the same size and type of material must be specified. If conditions are Abrasive level 1 or 2 **and** CR 0, specify material type from Section 603 pay items.

Figure 2

STORM-DRAINS

CDOT will only allow the use of reinforced concrete pipe (RCP), Polypropylene (PP), Steel Reinforced Polyethylene (SRPE), or Polyvinyl Chloride Pipe (PVC) in accordance with Standard Plans M-603-2 and M-603-5 for storm drains



[1] – If abrasion level is 3 or 4, concrete shall have a minimum compressive strength of 4,500 psi. Cementitious requirements for Sulfate Protection Classes are listed in 601.04. A higher level of protection may be used.

When extending an existing pipe, the same size and type of material must be specified. If conditions are Abrasive level 1 or 2 **and** CR 0, specify material type from Section 603 pay items.

TRIAL INSTALLATIONS & EVALUATION PROCESS FOR NEW PIPE MATERIAL

At any time, Manufacturers may request in writing to have materials not approved herein evaluated for a specific application. Requests for trial installations shall follow the requirements of P.D. 1401.1. Contact information for that procedure is given below:

Product Evaluation Coordinator
Colorado Department of Transportation
Materials and Geotechnical Branch
4670 Holly Street, Unit A
Denver, CO 80216
303-398-6500

- Manufacturers will provide all of the materials, equipment, and labor required for the pipe material to be evaluated at no cost to CDOT.
- The pipe material to be evaluated must meet applicable AASHTO and ASTM design and material standards.
- Manufacturers will be responsible for all coordination with the Contractor, and any additional cost incurred by the Contractor as a result of the trial installation.
- CDOT will determine a suitable location for the trial installation.
- During installation, the manufacturer shall have a representative at the installation site. The manufacturer will provide documentation to CDOT that the pipe material was designed and installed per all current and applicable AASHTO and CDOT design and installation standards.
- Trial installations shall perform satisfactorily for at least one year before conclusions regarding product performance are made.

- During the one year evaluation period, at a time chosen by CDOT, the manufacturer shall provide laser video inspection services on the trial installation utilizing an inspection contractor approved by CDOT.
- The results of the laser video inspection shall be used to evaluate trial installations. The results shall demonstrate compliance with CDOT and AASHTO deflection, joint separation, buckling, tearing, sagging, and cracking standards.
- Monitoring may include research of the trial material in use in other states.
- If further evaluation is required beyond one year, the supplier will be notified of the justification for this evaluation extension.
- An independent evaluation performed by a local agency or other organization may be substituted for this trial installation and evaluation process if all of the following are true.
    - The local agency or other organization owns and maintains the material being evaluated.
    - A representative with the local agency or organization can be contacted to verify the information supplied.
    - The installation specifications are available for CDOT to review.
    - A trial installation was performed in Colorado on site applications similar to CDOT projects.
    - A laser video inspection was performed (or can be performed) a minimum of 1 year after installation that produced satisfactory results.
- Upon successful completion of the monitoring period, CDOT's Drainage Advisory Committee will review the performance and determine the acceptability of the material for future inclusion into the *CDOT Pipe Material Selection Guide*.
- If changes to this guide, including the introduction of new materials or drainage products, are requested, they will be evaluated through the following process:
    - The Drainage Advisory Committee will evaluate documentation concerning changes to the guide.
    - Documentation supporting the proposed change shall be submitted by the supplier to the Product Evaluation Coordinator (PEC) at the address above.
    - The PEC will compile all submitted documentation and submit it to the chair and secretary of the Drainage Advisory Committee.
    - The Drainage Advisory Committee will determine the future acceptability of the material for inclusion into the CDOT Pipe Material Selection Guide. The Drainage Advisory Committee will forward recommendations to the Chief Engineer for signature.