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Standard Practice for Life-Cycle Cost Analysis of Corrugated Metal Pipe Used for Culverts, Storm Sewers, and Other Buried Conduits[1]

This standard is issued under the fixed designation A 930; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers a procedure for using life-cycle cost (LCC) analysis techniques to evaluate alternative drainage system designs using corrugated metal pipe that satisfies the same functional requirements.

1.2 The LCC technique measures the present value of all relevant costs of installing, operating, and maintaining alternative drainage systems, such as engineering, construction, maintenance, rehabilitation, or replacement, over a specified period of time. The practice also accommodates any remaining residual or salvage value.

1.3 Using the results of the LCC analysis, the decision maker can then identify the alternative(s) with the lowest estimated total cost based on the present value of all costs.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 917 Practice for Measuring Life-Cycle Costs of Buildings and Building Systems[2]

2.2 *Other Documents:*

TM-5-802-1 Economic Studies for Military Construction Design—Applications (12/86)

Circular No. A-94 Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *common costs*, *n*—costs common to all alternatives in nature and amounts such as initial planning fees or future annual inspection costs.

3.1.2 *discount rate*, *n*—the investor's time value of money, expressed as a percent, used to convert the costs occurring at different times to equivalent costs at a common point in time.

3.1.3 *drainage project*, *n*—a project having a definable, functional drainage requirement that can be satisfied by two or more design or construction alternatives.

3.1.4 *future costs*, *n*—costs required to keep the system operating that are incurred after the project is placed in service, such as operation, maintenance, rehabilitation, or replacement costs.

3.1.5 *inflation*, *n*—the general trend or rising prices that result in reduction of the purchasing power of the dollar from year to year over time.

3.1.6 *initial cost*, *n*—the total of all costs, such as design costs, material purchase costs, and construction and installation costs, that are specific to each alternative and are incurred to bring each alternative to a point of functional readiness.

3.1.7 *maintenance cost*, *n*—the annual or periodic costs, such as inspection and cleaning, to keep a drainage structure functioning for the project design life but that do not extend the material service life.

3.1.8 *material service life*, *n*— the number of years of service that a particular material, system, or structure will provide before rehabilitation or replacement is necessary.

3.1.9 *project design life*, *n*—the planning horizon for the project, expressed as the number of years of useful life required of the drainage structure.

3.1.10 *rehabilitation cost*, *n*—the total of all costs incurred to extend the material service life of a specific alternative.

3.1.11 *replacement cost*, *n*—the total of all costs incurred to replace a material before the end of the project design life.

3.1.12 *terminal value*, *n*—the remaining value of the drainage structure in place at the end of the project design life.

4. Summary of Practice

4.1 This practice outlines a procedure for conducting an LCC analysis of two or more drainage pipe alternatives using corrugated metal pipe over a specified project design life. It identifies the project data and general assumptions necessary for the analysis and the method of computation.

5. Significance and Use

5.1 LCC analysis is an economic method for evaluating

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[2] *Annual Book of ASTM Standards*, Vol 04.11.

[3] Available from Office of Management and Budget, Washington, D.C.

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alternatives that are characterized by differing cash flows over the designated project design life. The method entails calculating the LCC of each alternate capable of satisfying the functional requirement of the project and comparing them to determine which has (have) the lowest estimated LCC over the project design life.

5.2 The LCC method is particularly suitable for determining whether the higher initial cost of an alternative is economically justified by reductions in future costs (for example, operating maintenance, rehabilitation, or replacement) when compared to an alternative with lower initial costs but higher future costs. If a design alternative has both a lower initial cost and lower future costs than other alternatives, an LCC analysis is not necessary to show that the former is the economically preferable choice.

6. Procedures

6.1 The procedure for performing an LCC analysis for drainage pipe applications is summarized in the following steps:

6.1.1 Identify the project objectives, alternatives, and constraints (6.2).

6.1.2 Establish the basic assumptions (6.3).

6.1.3 Compile data (6.4).

6.1.4 Compute the LCC for each alternative (6.5).

6.1.5 Evaluate the results (6.6).

6.2 *Project Objectives, Alternatives, and Constraints*:

6.2.1 Specify the design objective that is to be accomplished, identify alternative systems or designs that accomplish that objective, and identify any constraints that may limit the options to be considered.

6.2.2 An example is the design of a storm water drainage system for a residential development project. The system must satisfy mandated drainage system objectives such as specified rainfall intensities and storm water runoff limits. Available alternatives, such as different pipe materials and varying configurations of catch basins, ponds, or underground detention chambers, may have different initial costs as well as expected future costs. The system design may be constrained by structural and hydraulic limits such as minimum and maximum slopes and depth of burial, limits on surface flows on streets, etc.

6.3 *Basic Assumptions*:

6.3.1 Establish the uniform assumptions to be made in the LCC analysis of all alternatives. These assumptions include the selection of discount rate, treatment of inflation, general inflation rate, project design life, and desired comprehensiveness of the analysis.

6.3.2 *Discount Rate*—The discount rate selected should reflect the owner's time value of money. That is, the discount rate should reflect the interest rate that makes the owner indifferent about paying or receiving a dollar now or at some future time. The discount rate is used to convert the costs occurring at different times to equivalent costs at a common point in time.

6.3.2.1 No single correct discount rate exists for all owners. Selection of the discount rate should be guided by the rate of return on alternative investment opportunities of comparable risk (that is, the opportunity costs of capital) or, in the case of some public organizations, on mandated or legislated requirements such as that contained in OMB Circular No. A-94.

6.3.2.2 The discount rate may include general price inflation over the study period. This discount rate is referred to as the nominal discount rate in this practice. The discount rate may also be expressed as the real earning power of money over and above general price inflation, referred to as the real discount rate.

6.3.2.3 A nominal discount rate (d_n) and its corresponding real discount rate (d_r) are related as follows:

$$d_r = \frac{1 + d_n}{1 + I} - 1 \text{ or } d_n = (1 + d_r)(1 + I) - 1 \quad (1)$$

where:

I = rate of general price inflation.

6.3.2.4 The same discount rate should be used when evaluating each design alternative. Table 1 contains a procedure to follow when developing the discount rate. This procedure can be applied by those who wish to select their own values as well as those required to follow mandated or legislated requirements.

6.3.3 *Inflation*—This practice is designed to accommodate only a uniform rate of general inflation. The LCC can be calculated in constant dollar terms (not including general inflation) or current dollar terms (including general inflation). If the latter is used, a consistent projection of general price inflation must be used throughout the LCC analysis, including adjustment of the discount rate to incorporate the general inflation (6.3.2.2). The percentage change in the GNP deflator and producers price index are two broad indicators of general inflation.

6.3.3.1 If the user desires or is required to treat inflation on an incremental (differential) basis, or uniquely to each individual cost component (for example, energy costs), he or she should consult either TM-5-802-1 or Practice E 917, respectively.

TABLE 1 Discount Rate Procedure

1.0	*General*—This procedure is intended to guide the user in developing a real discount rate, that is, the long-term rate of return over and above the general inflation rate. This procedure can be used by those required to use rates specified by mandate or legislated requirement, as well as those desiring to select their own values. This procedure does not recommend any specific rates; that selection is up to the user and should be made based on the considerations described in 6.3.2.1.
1.1	Is there a discounted rate that must be used by policy, mandate, or legislated requirements? (check one):
1.1.1	____ Yes. If yes, the discount rate is ____ %
1.1.2	____ No. Proceed to 2.
1.2	____ Does the discount rate in 1.1.1 include inflation? (check one):
1.2.1	____ Yes. If yes, the inflation rate is ____ % (proceed to 2.1.4)
1.2.2	____ No. The rate shown in 1.1.1 is the real discount rate (excludes general inflation) and can be used as d_r in (Eq 3) and (4).
2.	If no discount rate is mandated, two approaches are possible:
2.1	Select a long-term percentage rate of return on invested money, over and above the general inflation rate. This value can be used as d_r in (Eq 3) and (4).
2.2	Select a nominal discount rate (including general inflation): ____ % = (d_n).
2.3	Select a long-term rate of general inflation: ____% = (I).
2.4	Calculate the real discount rate (d_r) for use in (Eq 3) and (Eq 4). $d_r = \frac{1 + d_n}{1 + I} - 1$

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