Utilizing the Total Cost Equation When Selecting Pipeline Material

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Abstract

When Request for Proposals go out to construct a pipeline project, usually there are several if not many line items that eventually determine the project cost. However, when bid documents are received by the owner or engineer, many times the per foot bid for the pipeline material is all that is considered. The scope of this paper will focus upon "The Total Cost Equation" which looks at other factors which should be taken into account before the bid analysis is finalized. When utilizing the "Total Cost Equation" to analyze bid proposals for differing pipeline materials, it has been found from actual field data the cost differential between those materials can be much different than the initial per foot bid of the material when taking into account respective factors that are directly related to installation. Using the "Total Cost Equation", one can determine final project costs related to differing materials. This approach has shown the initial per foot cost of the respective materials is often deceiving, but unfortunately used by many owners and engineers to select pipeline material. In order to best serve a utility owner in the selection of pipeline material for a specific project, several if not many factors relating to the successful installation of that pipeline should be taken into account. Beyond the initial per foot cost of the pipeline material, some other immediate costs exist such as bedding, tapping saddles, line locator wire, corrosion protection and materials to prevent leakage. Additionally, longer term present worth costs such as energy and life cycle should be considered. Prior to a final decision on the selection of pipeline material for a particular project, the "Total Cost Equation" should be applied and the components of the equation incorporated into the final material selection process.

INTRODUCTION

The proper selection of pipeline material for a certain project many times requires that other factors in addition to the initial bid price be analyzed. Some of these additional factors can affect the cost of constructing the project in the same direct manner as the initial bid price of the material. There may also exist certain other factors in this selection process that may have longer term financial effect on the utility.

BACKGROUND

When serving as a lead executive for the nation's largest privately owned water utility, one of my responsibilities was to grow the company customer base through acquisition of water utilities, many of which were rural systems .Frequently when systems were evaluated, sub-standard construction of the distribution system was found. When water utility personnel were asked why facilities were installed improperly wherein, for example, many times either no or little bedding was used when proper design called for a type 4 or type 5 trench, the answer would be that the utility wanted new customers, it had no money to fund the installation on its own, it had no personnel to inspect the construction, and so a developer installed the facility and transferred it to the utility. Thus the developer, contending they had to use the least cost material in order to make the development economically viable, installed the pipeline and "turned the keys over" to the utility in twelve months time. In discussing the differences of pipeline material with numerous utilities and engineering firms in my current position, it appears the same scenario not only exists, but has gotten more prolific in light of recent economic times where developers insist to the utility they must use the least expensive material in order for their development to be viable. There is nothing wrong with this model used by the developer IF the material used is installed to proper engineering standards acceptable to the utility. Unfortunately, as to be highlighted in this paper, many small utilities are accepting facilities that are installed with little or no inspection, ignoring proper design criteria such as bedding requirements for certain pipeline material. This document is meant to highlight cost factors, both short and long term, that many times are not taken into account and to many small utilities not even known beyond the initial bid price of the pipeline material. These additional cost factors are just as much a part of the project cost and the utility's budget as the initial unit price of the pipeline material alone. More importantly, the failure to install facilities to proper engineering standards may limit sustainability and increase operational and maintenance expense to the utility.

INTERVIEW WITH A CONTRACTOR

I have managed water utilities (some having waste water facilities as well) ranging in population base from 21,000 to 350,000. During those opportunities to lead system operations, I found it invaluable to listen to field personnel who were boots on the ground in developing operational criteria for the company. When considering how I should approach developing this paper, I decided the best approach was to talk with the boots on the ground--someone who made their living installing water pipelines. Thus, components of the *Total Cost Equation* with the exception of energy costs were developed by conducting a four (4) hour interview with a pipeline contractor in Lexington, Kentucky (TFH Underground Utilities Contractor; Tom Friley, P.E., 2014). During this interview, specific material cost components were examined, and market prices representing distributors' quotes at that time were assigned to each of these components. A model was then developed which was also representative of a typical subdivision in the Lexington, Kentucky region. It should be noted these costs are respective only to the Lexington, Kentucky region. However, the components of the *Total Cost Equation* may be relevant to all proposed pipeline projects, with pricing attached to each component dependent on the region where the pipeline will be constructed.

THE MODEL SUBDIVISION

Parameters representing a typical subdivision in the Lexington, Kentucky region are as follows:

- Assumed length of pipeline installed: 5,280 feet
- Houses located on both sides of the street
- Lot frontage: 65 foot lots
- Pipeline facilities to be installed behind the curb

- One-one inch corporation stop serving two 5/8 x ¾ meters
- Native soil conditions are non-corrosive, allowing for direct backfill for type one or type two trench when warranted

FACTORS TO BE CONSIDERED

Factors that will be considered in the *Total Cost Equation* include: 1) The initial bid price of the material, 2) the cost of bedding respectively needed for each pipeline to be installed, 3) the material cost to connect each customer to the water main, 4) the material cost to provide line locating ability after the waterline is buried and 5) the energy savings derived by using pipeline material with a larger hydraulic diameter. In addition to these costs, two other construction components and another long term cost to the utility associated with this respective pipeline model will be identified and discussed.

THE INITIAL BID PRICE

This component of the selection model is one of the most simple to analyze, and unfortunately the place where many stop when selecting pipeline material for a project. In Table 1 below, the price quote by a distributor at the time of the interview is shown. These quoted prices represent relative market costs for these respective materials. Although these costs consistently change with time, the relative differential should basically remain in place.

Material	Unit Bid Price	Total Ft. of Pipe	Total Cost to Project	Cost Difference
8” Ductile Iron	$14.90	5,280	$78,672	+ $31,627
8” PVC	$ 8.91	5,280	$47,045	

Table 1

COST OF BEDDING MATERIAL

The cost of bedding requirements for a particular project can be very significant, and should be looked at carefully from an engineering standpoint. Because of this cost factor, it does the utility a disservice when a belt and suspenders approach is utilized. If pipeline materials are selected wherein less (or no) bedding is required due to superior strength, then the reduction of cost needed for select backfill material, and the cost to haul away the spoil material coming out of the ditch should be considered when selecting the type of pipe to be used.

Ductile Iron pipe resists up to eight (8) times the crushing load of PVC pipe, and has up to thirteen (13) times the impact strength (DIPRA ,2008-“ Ductile Iron Pipe Vs. PVC”). Because of this inherent strength advantage of Ductile Iron pipe, less soil support is needed to protect the pipe from external loading. The most supportive trench for PVC pipe is a type 5 trench (AWWA C605), developing sidewall support with an E’ value of 2,000 psi which is many times unrealistic. A similar trench for Ductile Iron pipe only requires an E’ value of 700psi, one-third that required for PVC (DIPRA, 2008-“ Ductile Iron Pipe Vs. PVC). Because of this strength component of Ductile Iron pipe, type 1 (flat bottom, loose backfill) and type 2 (flat bottom, lightly consolidated backfill) trench conditions in accordance with ANSI/AWWA C150/21.50 are adequate for the vast majority of applications (DIPRA,2008-"Ductile Iron Pipe Vs. PVC).

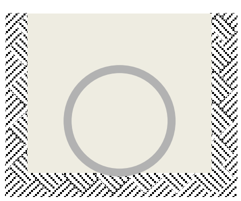
In the model assumed for this analysis utilizing actual soil conditions for installing an 8 inch pipeline behind the curb in a new subdivision in Lexington, Kentucky, Table 2 below shows the respective bedding costs required for Ductile Iron and PVC pipe.

Material	Cost/LF for Bedding	Total Project Cost	Cost Difference
8" Ductile Iron	$0	$0	
* 8" PVC	$ 3.95	$ 20,856	+ $ 20,856

Table 2

(*The cost of $ 3.95/LF was the actual cost incurred to establish the necessary trench condition for PVC pipe in the Central Kentucky area. Native soil conditions allowed for the installation of Ductile Iron pipe with no select backfill required.)

It should be noted the differential of bedding materials required as shown above is applicable in this model because the pipeline location behind the curb and respective soil conditions for this installation allow for a type 1 or type 2 trench to be utilized with Ductile Iron pipe. If the pipeline were to be installed under a street or roadway, a type 4 or type 5 trench would be designed to accommodate the support of the traffic surface regardless of the type pipeline material utilized, thus eliminating this added cost needed for bedding for PVC pipe. However, under the premise of installing waterlines for a new subdivision, utilities desire pipes to be installed in a location wherein lower costs for maintenance can be effected.



Type 1 Trench- A flat bottom trench with loose backfill can be utilized with Ductile Iron pipe

Figure 1

COST TO RECONNECT CUSTOMERS

This model assumes that houses will be constructed on both sides of the street, and the frontage of each lot is 65 feet. In this model, one service line serves two meter settings, a conservative approach in regard to the number of tapping saddles required. A total of 82 one-inch tapping saddles will be needed.

Material	Unit Cost per Tapping Saddle	No. of Saddles required	Total Cost to the Project	Cost Difference
8”Ductile Iron	$0	0	$0	$0
8” PVC	$75.00	82	$ 6,150	+ $ 6,150

Table 3

Ductile Iron pipe CL 350 can be directly tapped for a new customer service without the use of a tapping saddle (DIPRA, 2008-“Tapping Ductile Iron Pipe Vs. Polyvinyl Chloride Pipe”). However, in tapping PVC DR 14 pipe, the contractor utilizes a tapping saddle for each one inch tap. Table 3 above shows the cost to be incurred on the project in regard to this tapping saddle requirement. It should be noted that costs shown in Table 3 are for material only, and does not include the labor cost to install the saddle on the PVC main itself. The corporation stop average load to failure in a pull-out test shows 9,644 pounds for Ductile Iron pipe versus 4,558 pounds for PVC pipe. The moment inch-pounds respectively shows 4721 inch-pounds for Ductile Iron versus 3269 inch- pounds for PVC.(DIPRA 2015-“Tapping Ductile Iron Pipe vs. Polyvinyl Chloride Pipe”). In the UniBell PVC Pipe Association publication, it is noted that PVC becomes less resistant to impact at very low temperatures, that PVC becomes more flexible and thus susceptible to over tightening of the tapping machine, and that feed rates should be less in cold weather (UniBell, 2007). This coupled with the fact that no direct tap should be installed on PVC pipe that has external wall stress due to bending of the pipe during installation causes this contractor to use tapping saddles on all residential taps on PVC pipelines. Some contractors may not choose this conservative approach. It should also be noted that some pipeline designs for subdivisions as outlined in this paper have service tees installed during construction.

COSTS FOR LINE LOCATOR WIRE

The location of Ductile Iron pipe after it has been buried can be performed using conventional pipe locating equipment without the necessity of including a buried metallic wire. However, the installation of PVC pipe should include a buried metallic wire or some metallic material. Although the cost of this wire is somewhat nominal, it is a cost just the same. It should also be noted the cost listed in Table 4 below does not include any labor to install the locator wire.

Material	Unit Locator Wire Cost	Length of Wire Required-Ft.	Cost Difference
8” Ductile Iron	$.26/LF	0	$0
8” PVC	$.26/LF	5,280	+ $ 1,373

Table 4

Many utilities bury with all pipeline installations warning tape with wire edges to alert third party excavators of the pipeline below. This has been substituted for the use of locator wire with PVC installations. However, the disturbance by a third party of either line locator wire or warning tape will create a non-continuous segment for pipeline locating ability. Seldom, if ever, do third parties replace the wire or tape they have excavated.

BELL PROTECTION

Potential leaks on PVC pipe can occur from “over belling” of the pipe. The PVC industry has developed a bell protection coupling to prevent this fallacy during construction. Ductile Iron pipe cannot be “over belled”, and thus does not need such a device to be installed during construction. The number of bell protection devices that would have been needed if using PVC pipe for this installation is 264 equating to a material cost of $18,480.00. However, this contractor as do many other contractors, chooses no tot utilize these couplings, thus the respective cost HAS NOT been included in this analysis.

CORROSION PROTECTION

Ductile Iron pipe possesses good resistance to corrosion and needs no additional protection in most soils. (DIPRA, 2012-“Polyethylene Encasement”) . The soils in the Lexington, Kentucky region do not require corrosion protection for Ductile Iron pipe, thus this expense HAS NOT been included.. However, similar to the previous section, I will note that if corrosion protection were required for Ductile Iron pipe using V-Bio polyethylene encasement, that cost would equate to $3,485.00 wherein no cost in this regard would be incurred using PVC pipe.

LONG TERM COST COMPONENTS

There exist two long term cost components that should be considered when evaluating pipeline material to be utilized. The Present Worth of ENERGY and ESTIMATED SERVICE LIFE are very important financial considerations to the utility in future years.

ENERGY COSTS

The hydraulic diameter of a pipeline is directly related to the head loss experienced in that pipeline. This head loss must be overcome by utilizing pumped energy in order to get a certain amount of water from one end of a pipe to the other. The larger the inside diameter of the pipeline, the smaller the head loss that must be overcome. The inside diameter of 8” Ductile Iron pipe CL 350 is 8.43 inches.(DIPRA, 2015-“Hydraulic Analysis of Ductile Iron Pipe”). The inside diameter of 8” PVC DR-14 is 7.68 inches (JM Eagle- “ Blue Brute Brochure- JME-02A”) This hypothetical model has utilized the following assumptions in determining the Present Worth of Energy Savings to the utility recognizing the differential in the inside diameters of these two pipe materials. These assumptions are of course subjective, and can be changed to accommodate those values respective of any particular utility.

The Present Worth Cost of Energy Savings

- 8” DI Pipe vs. 8” PVC Pipe
- Pipeline Length: 5,280 ft.
- C Factor: 140 (DI); 150 (PVC)
- Flow Rate: 695 GPM
- Unit Power Cost: 0.06 $/kWh
- Pump Rate: 24 Hr/Day
- Pump Efficiency: 70%
- Design Life: 100 Years
- Rate of Return: 5%
- Inflation Rate: 4%

Table 5 below illustrates the energy cost savings to the utility by using Ductile Iron pipe which has a larger inside diameter. A progression of standard hydraulic formulas including the Hazen-Williams formula, the standard formula for determining Pumping Cost after the head loss has been determined, and the formula for Present Worth utilizing these values has determined the energy savings below. The “Hydraulic Analysis of Ductile Iron Pipe Calculator” found on the DIPRA website (www.dipra.org) incorporates these formulas to determine energy savings by inserting respective values into the calculator data request.

Material	Expected Life	Energy Savings	Cost Difference
Ductile Iron	100 Yrs.	$79,940	
PVC	55 Yrs.		+ $79,940

Table 5

ESTIMATED SERVICE LIFE

The American Water Works Association published a research report entitled “BURIED NO LONGER-Confronting America’s Water Infrastructure Challenge” (AWWA, 2012). This report has served as a report card on the nation’s water infrastructure. Contained in this report was an estimated service life for various pipeline materials using the Nessie Model. The estimated service life for Ductile Iron pipe for the Kentucky region of the U.S. was estimated to be 100 years, while that of PVC pipe was 55 years. An equivalent of almost two PVC pipes would have to be installed over the estimated life of one Ductile Iron pipeline. Thus, the annual depreciation cost to a private water utility using a longer depreciable life is reduced, and public utilities could argue that longer term bonds would be appropriate in funding longer lasting facilities.

Depreciation Cost Advantage for the Private Water Utility

Depreciation is a direct expense in calculating net income to the private water utility. A long term benefit can be derived with extending the depreciable life of an asset if the value doesn’t increase. In essence, extending depreciable life reduces the recorded expense required to operate in any given year. Even considering the loss of some tax benefit, a longer depreciation life on an asset is beneficial. Utilizing the Buried No Longer Report prepared by a notable, third party entity showing the significant difference in estimated service life between Ductile Iron and PVC pipe should provide a compelling argument to a regulatory commission when considering the respective depreciation rates for the utility.

Financial Advantages to the Public Water Utility by Installing Material With An Extended Service Life

The capital needs of a water system, be it pipelines, water treatment plants, boosters, tanks, office facilities, etc. are very significant. There seems to always be more projects than money to fund them. If, however, a utility strategically selects products with a proven extended service life, then the capital that would have been required to be spent on replacing a product with a shorter service life can be re-directed to other pressing capital needs of the utility. The proven extended service life of a product may also provide a compelling argument to financial institutions to extend bonding terms, thus reducing the rate impact on customers.

THE *TOTAL COST EQUATION SUMMARY*

Costs shown in Table 6 below summarizes the cost *differential* associated in constructing the waterlines in this hypothetical model of installing one mile of 8 inch waterline in a new residential sub-division.

Element of Cost	8" Ductile Iron CL 350	8" PVC DR-14
Unit Bid Price	+ 31,627	
Cost of Bedding		+ $20,856
Cost to Tap New Services		+ $6,150
Line Locator Wire		+ $1,373
Addn. Energy Cost		+ $ 79,940

Table 6

We see in Table 6 above, the use of Ductile Iron pipe *could* possibly effect a cost savings both immediate and long term to the utility of $76,692.00.This chart *does not include* the previously described potential financial benefits of a greater estimated service life of the material. Would this be the cost savings to every utility constructing a similar waterline? The answer is of course NO. Each utility must determine which of these components are applicable to their particular situation. The purpose of this paper is only to highlight that more elements of cost than merely the initial bid price of the material should be taken into account before a final decision is ultimately made to select a certain pipeline material., emphasizing that proper engineering design should be in place and construction parameters complimenting that design should be adhered to regardless of the entity constructing the facility.

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