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COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN PIPELINE TRANSPORATION INFRASTRUCTURE PROJECTS
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COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN PIPELINE TRANSPORTATION INFRASTRUCTURE PROJECTS

TCM Framework: 7.3 – Cost Estimating and Budgeting

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Disclaimer: The opinions expressed by the contributors to this recommended practice are their own and do not necessarily reflect those of their employers, unless otherwise stated.

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PURPOSE

As a recommended practice (RP) of AACE International, the Cost Estimate Classification System provides guidelines for applying the general principles of estimate classification to project cost estimates (i.e., cost estimates that are used to evaluate, approve, and/or fund projects). The Cost Estimate Classification System maps the phases and stages of project cost estimating together with the generic project scope definition maturity and quality matrix, which can be applied across a wide variety of industries and scope content.

This recommended practice provides guidelines for applying the principles of estimate classification specifically to project estimates for engineering, procurement, and construction (EPC) work for pipeline transportation infrastructure. This document supplements the generic cost estimate classification RP (17R-97 [1]) by providing:

- A section that further defines classification concepts as they apply to pipeline transportation
- A chart that maps the extent and maturity of estimate input information (project definition deliverables) against the class of estimate.

As with the generic RP, an intent of this document is to improve communications among all the stakeholders involved with preparing, evaluating, and using project cost estimates specifically for pipeline transportation infrastructure.

The overall purpose of this recommended practice is to provide the pipeline transportation infrastructure definition deliverable maturity matrix which is not provided in 17R-97. It also provides an approximate representation of the relationship of specific design input data and design deliverable maturity to the estimate accuracy and methodology used to produce the cost estimate. The estimate accuracy range is driven by many other variables and risks, so the maturity and quality of the scope definition available at the time of the estimate is not the sole determinate of accuracy; risk analysis is required for that purpose.

This document is intended to provide a guideline, not a standard. It is understood that each enterprise may have its own project and estimating processes and terminology and may classify estimates in particular ways. This guideline provides a generic and generally acceptable classification system for pipeline transportation projects that can be used as a basis to compare against. This recommended practice should allow each user to better assess, define, and communicate their own processes and standards in the light of generally-accepted cost engineering practice.
INTRODUCTION

The term pipeline transportation includes onshore and offshore pipelines for transportation of gas and liquids in the infrastructure industries. The gas and liquids can be of any type including but not limited to hydrocarbons, chemicals and water. This primarily covers pipelines under pressure (e.g., steel, composite, etc.) and not gravity drainage (e.g., concrete). This excludes piping within a process plant, mining facility, utilities plant or other facility site. It also excludes pumping and compression stations and storage and shipping terminals. The defining deliverables of those excluded process (e.g., plant piping) and civil (e.g., drainage) project scopes are covered in other RPs (e.g., 18R-97 for process plants [2] and 56R-08 [3] for general construction).

Pipeline transportation is considered an element of the infrastructure industry. The Construction Industry Institute has provided a good definition of infrastructure in its Project Definition Rating Index for Infrastructure Projects as follows [4]:

“A capital project that provides transportation, transmission, distribution, collection or other capabilities supporting commerce or interaction of goods, services, or people. Infrastructure projects generally impact multiple jurisdictions, stakeholder groups and/or a wide area. They are characterized as projects with a primary purpose that is integral to the effective operation of a system. These collective capabilities provide a service that is made up of nodes and vectors into a grid or system.”

Using this definition, pipeline transportation is a vector or linear scope element that connects pumping or compression facilities or storage or shipping terminal nodes at terminations or intermediate points. The pumping and compression facility nodes are integral elements of a pipeline project scope; however, because their design and execution differ greatly from the pipeline itself, they are excluded here. Likewise, terminals (e.g., tank farms) are often associated with pipeline projects, but are excluded. However, incidental valve, monitoring or pigging stations may be included. In any case, pipeline projects are often executed as part of a program that also involves node project scope or facility operational changes, or at least considerations for integrated system commissioning and startup. A key element of defining scope is by system hydraulics and while station estimate classification is excluded in this RP, the design of pipeline and stations (which can vary in number and placement) are done iteratively [5]. As the definition states, a distinguishing feature of these projects is that they often traverse wide areas, cross country or subsea, which in turn has emphasis on the definition of routing, land ownership and conditions, and establishing right-of-way (ROW). Associated scope definition challenges include defining stakeholder, permitting and regulatory requirements (pipeline transportation is usually a regulated industry if not government owned).

The main physical pipeline transportation scope elements are the pipe, fittings, valves and controls as well as associated items for road, rail, water and other crossings including horizontal drilled borings (tunneling is excluded). Surface pipelines also include structural supports. Main installation elements include land clearing if over land (including forestry if applicable), foundation and structure erection if on the surface, or trenching and backfill if buried, and pipe transport and handling, joining (i.e., welding), coating, cathodic protection, insulation and placement. Special scope elements are involved with crossings of water, road, rail and so on and at the pipeline terminations. Environmental, safety and health concerns are paramount with pipelines under pressure, and may carry hazardous materials, therefore, monitoring and control systems are key scope elements as well as inspection and maintenance considerations (e.g., pigging).

In general, the more developed the route, the more complex the installation will be. For urban areas, obstructions are frequent. In remote locations and/or difficult or environmentally sensitive terrain, installation has its own challenges. Before any installation work can begin in an area, appropriate land and ROW must be acquired which creates unique scheduling as well as cost challenges.
For the purpose of estimate classification then, the main scope definition deliverables are associated with hydraulic design, defining the throughput capacity (volume/time), pipeline, fitting and control materials, and the routing including its elevation profiles, crossings and other elements. Pipelines materials can vary widely (e.g., steel, plastic, composite, etc.) as do coatings and insulation (if applicable). The pipeline material costs may be 20 to 40% of the total pipeline costs, making these projects highly susceptible to escalation and currency uncertainty. The route’s land or subsea characteristics and the nature of developments drive the need for special design features and execution strategies. For each scope definition decision, stakeholder requirements need to be considered.

Pumping, compression, terminal and well site projects are usually associated with pipeline transportation projects. However, these facilities are equipment-centric and located on facility sites that have physical and defining characteristics similar to process plant projects (e.g., reliance on equipment lists, piping and instrumentation diagrams (P&IDs), plot plans, etc.). Therefore, RP 18R-97 for process plants is recommended for classifying those estimates [2]. Pipelines projects may also share right-of-ways with power transmission line projects that are covered in RP 96R-18 [6].

This guideline reflects generally-accepted cost engineering practices. This addendum was based upon the practices of multiple pipeline companies as well as published references and standards. Company and public standards were solicited and reviewed, and the practices were found to have significant commonalities. These classifications are also supported by empirical industry research of systemic risks and their correlation with cost growth and schedule slippage [7].

**COST ESTIMATE CLASSIFICATION MATRIX FOR PIPELINE TRANSPORTATION INFRASTRUCTURE**

A purpose of cost estimate classification is to align the estimating process with project stage-gate scope development and decision-making processes.

Table 1 provides a summary of the characteristics of the five estimate classes. The maturity level of definition is the sole determining (i.e., primary) characteristic of Class. In Table 1, the maturity is roughly indicated by a % of complete definition; however, it is the maturity of the defining deliverables that is the determinant, not the percent. The specific deliverables, and their maturity or status are provided in Table 3. The other characteristics are secondary and are generally correlated with the maturity level of project definition deliverables, as discussed in the generic RP 17R-97 [1]. The characteristics are typical for pipeline transportation projects but may vary depending on the specific type and size of work.
This matrix and guideline outline an estimate classification system that is specific to pipeline transportation in the infrastructure industry. Refer to the generic estimate classification RP [1] for a general matrix that is non-industry specific, or to other cost estimate classification RPs that will provide more detailed information for application in other specific industries (e.g., 18R-97 for pumping, compression and terminal facilities [2]). These will provide additional information, particularly the project definition deliverable maturity matrix which determines the class in those particular industries.

Table 1 illustrates typical ranges of accuracy ranges that are associated with the pipeline projects. The +/- value represents typical percentage variation at an 80% confidence interval of actual costs from the cost estimate after application of appropriate contingency (typically to achieve a 50% probability of project cost underrun versus overrun) for given scope. Depending on the technical and project deliverables (and other variables) and risks associated with each estimate, the accuracy range for any particular estimate is expected to fall into the ranges identified (although extreme risks can lead to wider ranges).

In addition to the degree of project definition, estimate accuracy is also driven by other systemic risks such as:
- Level of familiarity with technology and hydraulic conditions.
- Unique/remote nature of route locations and conditions and the availability of reference data for those.
- Complexity of the project and its execution.
- Regulatory, community, land owner and political risks.
- Quality of reference cost estimating data.
- Quality of assumptions used in preparing the estimate.
- Experience and skill level of the estimator.
- Estimating techniques employed.
- Time and level of effort budgeted to prepare the estimate.

Systemic risks such as these are often the primary driver of accuracy, especially during the early stages of project definition. As project definition progresses, project-specific risks (e.g. risk events and conditions) become more prevalent and also drive the accuracy range. Another concern in estimates is potential pressure for a predetermined
value that may result in a biased estimate. The goal should be to always have an unbiased and objective estimate, including for contingency. The stated estimate ranges are dependent on this premise and a realistic view of the project. Failure to appropriately address systemic risks (e.g. technical complexity) during risk analysis impacts the resulting probability distribution of the estimate costs, and therefore the interpretation of estimate accuracy.

Figure 1 illustrates the general relationship trend between estimate accuracy and the estimate classes (corresponding with the maturity level of project definition). Depending upon the technical complexity of the project, the availability of appropriate cost reference information, the degree of project definition, and the inclusion of appropriate contingency determination, a typical Class 5 estimate for a pipeline transportation project may have an accuracy range as broad as -50% to +100%, or as narrow as -20% to +30%. However, note that this is dependent upon the contingency included in the estimate appropriately quantifying the uncertainty and risks associated with the cost estimate. Environmental and political risk are increasing that becomes a particular concern when regulators require reporting of maximum costs or similar dictates related to accuracy. Refer to Table 1 for the generalized accuracy ranges illustrated in Figure 1.

Figure 1 also illustrates that the estimating accuracy ranges overlap the estimate classes. There are cases where a Class 5 estimate for a particular project may be as accurate as a Class 3 estimate for a different project. For example, similar accuracy ranges may occur if the Class 5 estimate of one project that is based on a repeat project with good cost history and data and, whereas the Class 3 estimate for another is for a project involving new technology. It is for this reason that Table 1 provides ranges of accuracy range values. This allows application of the specific circumstances inherent in a project, and an industry sector, to provide realistic estimate class accuracy range percentages. While a target range may be expected of a particular estimate, the accuracy range should always be determined through risk analysis of the specific project, and should never be pre-determined. AACE has recommended practices that address contingency determination and risk analysis methods.

If contingency has been addressed appropriately, approximately 80% of projects should fall within the ranges shown in Figure 1. However, this does not preclude a specific actual project result from falling inside or outside of the indicated range of ranges identified in Table 1. In fact, research indicates that for weak project systems and complex of otherwise risky projects, the high ranges may be two to three times the high range indicated in Table 1.