AACE INTERNATIONAL RECOMMENDED PRACTICE

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COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PIPELINE TRANSPORTATION INFRASTRUCTURE INDUSTRIES

AACE INTERNATIONAL

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TCM Framework: 7.3 – Cost Estimating and Budgeting

Rev. August 7, 2020

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Any terms found in AACE Recommended Practice 10S-90, *Cost Engineering Terminology*, supersede terms defined in other AACE work products, including but not limited to, other recommended practices, the *Total Cost Management Framework*, and *Skills & Knowledge of Cost Engineering*.

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TABLE OF CONTENTS

1. 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 a 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 the pipeline transportation infrastructure industries. It supplements the generic cost estimate classification RP 17R-97 [1] by providing:

- A section that further defines classification concepts as they apply to the pipeline transportation infrastructure industries.
- 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, the intent of this document is to improve communications among all the stakeholders involved with preparing, evaluating, and using project cost estimates specifically for the pipeline transportation infrastructure industries.

The overall purpose of this recommended practice is to provide the pipeline transportation infrastructure industries with a project definition deliverable maturity matrix that 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, terminology, and may classify estimates in other ways. This guideline provides a generic and generally acceptable classification system for the pipeline transportation infrastructure industries 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.

2. INTRODUCTION

For the purposes of this document, the term *pipeline transportation* is assumed to include 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 its terminations or intermediate points. The pumping and compression facility nodes are integral elements of 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 to study 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 puts an 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

August 7, 2020

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 with utilities are frequent requiring existing condition studies, coordination with utilities and sometimes relocations. 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 recommended practice 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].

This RP applies to a variety of project delivery methods such as traditional design-bid-build (DBB), design-build (DB), construction management for fee (CM-fee), construction management at risk (CM-at risk), and private-public partnerships (PPP) contracting methods.

3. COST ESTIMATE CLASSIFICATION MATRIX FOR PIPELINE TRANSPORTATION INFRASTRUCTURE INDUSTRIES

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 project definition is the sole determining (i.e., primary) characteristic of class. In Table 1, the maturity is roughly indicated by a percentage 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. [1] Again, the characteristics are typical but may vary depending on the circumstances.

August 7, 2020

	Primary Characteristic	***Secondary Characteristic***		
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges at an 80% confidence interval
Class 5	0% to 2%	Concept screening	Cost/length factors, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Cost/length, factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

Table 1 – Cost Estimate Classification Matrix for the Pipeline Transportation Infrastructure Industries

This matrix and guideline outline an estimate classification system that is specific to the pipeline transportation infrastructure industries. Refer to the Recommended Practice 17R-97 [1] for a general matrix that is non-industry specific, or to other cost estimate classification RPs or guidelines 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 *Estimate Input Checklist and Maturity Matrix* which determines the class in those industries. See Professional Guidance Document 01, *Guide to Cost Estimate Classification.* [8]

Table 1 illustrates typical ranges of accuracy ranges that are associated with the pipeline transportation infrastructure industries. 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 overrun versus underrun) 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 within the ranges identified. However, this does not preclude a specific actual project result from falling outside of the indicated range of ranges identified in Table 1. In fact, research indicates that for weak project systems and complex or otherwise risky projects, the high ranges may be two to three times the high range indicated in Table 1. [9]

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 project locations and conditions and the availability of reference data for those.
- Complexity of the project and its execution.
- 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.
- Market and pricing conditions.
- Currency exchange.

- Regulatory, community, landowner, and political risks.

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 (or better known) and also drive the accuracy range.

Another concern in estimates is potential organizational pressure for a predetermined value that may result in a biased estimate. The goal should be to have an unbiased and objective estimate both for the base cost and 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 the risk analysis process, impacts the resulting probability distribution of the estimated 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 industry 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. Refer to Table 1 for the accuracy ranges conceptually illustrated in Figure 1. [10]

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 values. This allows consideration 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 for 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. [11]

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. As previously mentioned, research indicates that for weak project systems, and/or complex or otherwise risky projects, the high ranges may be two to three times the high range indicated in Table 1.

