International Journal of Education and Humanities
ISSN: 2770-6702 | Vol. 22, No. 1, 2026

Application of Weight Division in Progress Measurement of Oil and Gas Pipeline Projects

Li Zhou[1], Mingyi Han[2], Shiyao Wan[1], Hui Miao[1], Yimin Niu[2]

[1] China National Petroleum Corporation Pipeline Construction Project Management Branch. Langfang, Hebei, 065000, China
[2] Langfang Zhongyou Langwei Project Management Co., Ltd. Langfang, Hebei, 065000, China

Abstract: Oil and gas pipeline projects are characterized by linear construction, massive scale, complex processes, and long construction periods. The key to progress control lies in establishing an accurate and effective progress measurement system. Weight, as a quantitative indicator measuring the importance of activities or processes to the entire project, is a critical component of the progress measurement system. It determines whether the progress measurement system can accurately reflect the actual project progress. To accurately and reasonably allocate WBS weights, this study systematically investigates general principles and methods for weight division at various stages of oil and gas pipeline projects. A comprehensive method considering factors such as cost and duration is proposed for calculating WBS weights, which can effectively guide the setting of comprehensive progress weights for oil and gas pipeline projects.

Keywords: Pipeline, WBS Decomposition, Progress Measurement.

1. Introduction

According to the "Medium and Long-term Oil and Gas Pipeline Network Plan" by the National Development and Reform Commission and the National Energy Administration, by 2025, the total length of the national oil and gas pipeline network will increase to 240,000 kilometers. Due to the specific environmental conditions and complexity of construction processes, oil and gas pipeline projects often have lengthy construction periods [1-2]. Therefore, for pipeline projects, accurately reflecting actual project progress within the construction period is crucial for project schedule management. Establishing a robust and scientific progress measurement system forms the foundation for effective progress tracking and control. Once the project work breakdown structure is established, the key lies in creating an accurate work package weight allocation system. Weight division is pivotal in engineering progress measurement, particularly in complex projects like oil and gas pipelines. Scientifically dividing these weights systematically is a key focus and challenge in pipeline project progress management [4-6].

2. Principles of Weight Allocation

Weight division is a relative concept referring to the percentage set for measurement units. It is achieved and expressed through parameters such as cost, work hours, and project volume by progressively breaking down actual work content into direct and objective units. The accuracy of weight division is crucial for the practicality of the progress measurement system and directly impacts the rationality and accuracy of project decisions. In the allocation of progress weights for oil and gas pipeline projects, different project control engineers often assign weights differently due to varying levels of experience, habits, selected evaluation criteria, and familiarity with workloads [3-6]. When planning progress weight allocation for pipeline projects, it is adhered to the following principles.

2.1. Principle of Comprehensiveness

The progress measurement system must accurately and truthfully reflect the actual progress of the project. It is essential to quantitatively account for all activities and processes required for project completion. Based on the quantitative statistics of each activity's completion status, aggregate calculations should proceed from bottom to top according to the weights of each activity, ensuring every task holds its place in the project progress weight. This creates conditions for subsequent progress management based on quantified data, preventing discrepancies between aggregated project progress and actual progress. Additionally, an analysis of factors such as the importance, risk, and technical content of all individual project activities within the overall project is necessary to determine comprehensive coefficient assessments and achieve overall balance.

2.2. Principle of Hierarchical and Gradual Division

Progress measurement data accumulates from lower to upper levels of the Work Breakdown Structure (WBS). Data at one level is derived from weighted sums of data at the next lower level. Construction activities or processes are established under the lowest WBS level to ensure all work items are included in the progress measurement system. Based on this foundation, weight allocation progresses hierarchically and gradually, with the sum of weights at the lowest WBS level activities or processes totaling 100%. The sum of weights for lower WBS levels within higher WBS levels also totals 100%.

2.3. Principle of Systematic Optimization

Progress weights measure the comprehensive impact and effectiveness of each task on the entire project. They judge the relative importance of tasks under comprehensive consideration of various indicators. When determining WBS or process weights, decisions should not solely rely on individual indicators, nor should they evenly distribute weights or unilaterally emphasize a task's importance in

relation to a single indicator while disregarding others. Balancing relationships among evaluation indicators, following the principle of systematic optimization, and pursuing overall optimization are crucial. Establishing planning and monitoring benchmarks based on specific task nature and resource allocation facilitates clear determination of task weights to measure project progress.

2.4. Principle of Combined Methods

For engineering projects, combining multiple allocation methods may be necessary when dividing WBS and process weights, depending on specific project conditions. For instance, second-level WBS (project implementation phases) weight allocation might combine estimated experience with cost-based methods. Detailed design specialization weight allocation could use proportional distribution based on the proportion of specialized norm input hours to total norm input hours. Similarly, construction process weight allocation could combine time and cost factors.

3. Method for Determining Project Progress Weights

The key to establishing a weight system lies in assigning weights to tasks, whether it's WBS weights or process weights. These are comprehensive measures of the importance of various evaluation criteria, and different weight allocations lead to significant differences between projected and actual project progress statistics. In actual oil and gas pipeline engineering projects, visual progress weights based on the engineering representation are commonly used to reflect the actual progress of the project. The division of engineering visual progress weights is based on the WBS, which involves breaking down project deliverables and tasks into smaller, more manageable components. By progressively aggregating all tasks from the bottom layers of the breakdown structure upwards, the process ensures there are no omissions or additions. The weight of a particular activity within the scope of consideration can be calculated based on cost or duration [7-10].

4. Principles of Project Progress Weight Measurement

4.1. General Principles of Comprehensive Progress Calculation

Based on the WBS breakdown of oil and gas pipelines, the overall project progress is calculated by multiplying the total progress of each level of WBS work package by its respective weight and summing them up, represented by the formula:

Project overall progress $P=\sum_i^n P_i * W_i$ (where "n" is the number of WBS levels)

P_i is the progress percentage of the i-th work package (WBS), W_i is the progress weight of the i-th work package (WBS), and $\sum_i^n W_i = 1$.

4.2. Principles of WBS Weight Calculation at Various Levels

$W_i=N_1 C_i+N_2 T_i$

C_i is the cost coefficient, T_i is the duration coefficient, C_i represents the basic weight, and T_i is the adjusts parameters. When the basic weight calculation appears significantly unreasonable, additional duration adjustment parameters are added. N1 and N2 represent the proportion of cost and duration weights respectively, where N1 + N2 = 1.

Cost coefficient = Individual WBS cost / Total cost of higher-level WBS;

Duration coefficient = Individual WBS standard duration / Total duration of higher-level WBS;

For same-level WBS where it is inconvenient to determine weights based on cost and duration, empirical weight coefficients are used.

Weight determination principles are as follows:

(1) Top-down calculation at each level.

(2) Same-level WBS are calculated concurrently; different levels are calculated separately.

(3) If a single coefficient is zero, the corresponding "n" needs to be reduced by 1.

5. Project Phase Progress Measurement

5.1. Determination of Project First-order Weights

For typical oil and gas pipeline projects, the second-level WBS is generally divided into phases including preliminary, definition, implementation, and acceptance. The weight division of these phases constitutes the level 1 weights of the project. Directly assigning specific weight values is challenging; in actual projects, empirically determined weights are often inaccurate and fail to consider project-specific characteristics. Project first-order weights can be determined based on estimated proportions. The preliminary phase spans from project initiation to approval, the implementation phase spans from approval to preliminary design approval, and the acceptance phase spans from preliminary design approval to commissioning completion.

5.2. Determination of Project Secondary Weights

5.2.1. Preliminary Phase

The third-level WBS segments include feasibility study and approval stages (Level-3 WBS). Their weights are calculated based on estimated costs.

Table 1. Division of Work Weight in the Early Stage of the Project

Implementation stage of engineering construction	Estimated costs	Weigh ts
Project feasibility study	C1	C1/C
Project approval	C2	C2/C
Total	C	1

5.2.2. Definition Phase

The third-level WBS segments encompass specialized evaluations and preliminary designs, with weights determined through estimated cost calculations.

Table 2. Division of Work Weight in Project Definition Stage

Implementation stage of engineering construction	Estimated costs	Weigh ts
Special evaluation	C1	C1/C
Preliminary design	C2	C2/C
Total	C	1

5.2.3. Implementation Phase

The third-level WBS segments include construction

documents design, procurement, outsourcing, construction, and commissioning. Their weights are determined through estimated cost calculations.

Table 3. Division of Work Weight in Project Implementation Stage

Implementation stage of engineering construction	Estimated costs	Weighs
Construction documents desig	C1	C1/C
Purchase	C2	C2/C
Outsourcing	C3	C3/C
Construct	C4	C4/C
Trial operation and production	C5	C5/C
Total	C	1

5.2.4. Acceptance Phase

The third-level WBS segments cover pre-commissioning, completion documentation, specialized inspections, and final acceptance. Their weights are determined based on empirical values.

Table 4. Weight Division of Project Closing Stage

Serial number	Job content	Weights
1	Pre-transfer capital	0.1
2	Completion data	0.2
3	Special acceptance	0.5
4	Final acceptance of construction	0.2
Total		1

5.3. Determination of Project Level 3 Weights

5.3.1. Preliminary Phase

(1) Feasibility study includes segments such as feasibility study report commissioning, report preparation, specialized evaluation initiation, report review, report approval, and site and route approval. Their weights are determined using empirical values.

Table 5. Weight Division of Project Feasibility Study

Serial number	Work Items	Weights
1	Commissioning of Project Feasibility Study Report	10%
2	Preparation of Project Feasibility Study Report	40%
3	Review of Project Feasibility Study Report	10%
4	Approval of Project Feasibility Study Report	20%
5	Initiation of Special Evaluation	10%
6	Approval of Site and Route Selection	10%
Total		100%

(2) WBS at the next level of project approval mainly includes: planning and site selection, land use pre-trial opinions, social stability evaluation, project application report and project approval, and its weight is determined by empirical values.

Table 6. Weight Division of Project Approval Work

Serial number	Work item	Weights
1	Planning and site selection	20%
2	Pre-examination opinions on land use	20%
3	Social stability evaluation	20%
4	Project application report	10%
5	Project approval	30%
Total		100%

5.3.2. Definition Phase

(1) Specialized evaluations include environmental impact assessment, seismic safety evaluation, overlying mineral assessment, geological hazard assessment, soil and water conservation assessment, safety assessment, occupational hazard assessment, energy conservation assessment, cultural relic survey, flood control assessment, and forestry survey. Their weights are determined through a comprehensive consideration of estimated costs and durations, with cost accounting for 0.5 and duration for 0.5.

(2) Preliminary design includes segments such as design commissioning, design preparation, initial design review and modification, preliminary design and estimated budget approval, safety facility design review, and preliminary design change adjustment. Their weights are determined based on given empirical values.

Table 7. Weight division of project initial design work

Preliminary Design	Weights	Remarks
Commissioning of Preliminary Design	10%	
Preparation of Preliminary Design Documents	40%	
Review and Modification of Preliminary Design	10%	
Submission for Approval of Preliminary Design and Cost Estimate	20%	
Review of Safety Facility Design	10%	
Changes in Preliminary Design	10%	
Total	100%	

5.3.3. Implementation Phase

(1) Construction documents design

Construction documents design includes detailed survey, geology, drilling, process, piping, general layout, architecture, structure, anti-corrosion and insulation, instrumentation and automation, communication, machinery, plumbing, fire protection, heating, ventilation and air conditioning, electrical, and external power supply. Their weights are determined based on design hours.

(2) Procurement

Procurement includes service procurement and material procurement. Their weights are calculated based on estimated procurement costs.

Service procurement include PMC service providers, design consulting (supervision) services, construction supervision services, construction contractors (PC contractors), non-destructive testing contractors, environmental supervision, water conservation supervision, quality supervision, fourth-party monitoring re-evaluation, welding process certification, anti-corrosion process certification, resident factory supervision, and transit station service providers. Their weights are determined based on bidding and contract signing periods, typically around 51 days.

Material procurement include initial materials for

construction, pipeline steel, long-cycle equipment (valves, gas injection pressure regulating valve assemblies, gas pressure regulating valve assemblies, filtration separation assemblies), and other equipment. Their weights are determined through a comprehensive consideration of estimated procurement costs and durations, with cost accounting for 0.5 and duration for 0.5.

(3) Outsourcing

Outsourcing includes temporary land acquisition, permanent land acquisition, and compensation costs. Their weights are calculated through a comprehensive consideration of estimated costs and durations.

(4) Construction

Construction includes line engineering, large and medium-sized crossing engineering, valve chamber engineering, and station engineering. Their weights are determined through a comprehensive consideration of estimated construction costs and durations, with cost accounting for 0.5 and duration for 0.5.

(5) Trial operation and production

Trial operation and production includes segments such as preparation for commissioning (technical, material, and personnel preparation), compliance procedure handling (fire acceptance, lightning protection and electrostatic protection acceptance, pressure vessel registration, safety valve verification, water and electricity usage agreements), commissioning condition inspection, 72-hour trial production, and management transfer. Their weights are determined based on empirical values.

Table 8. Weight division of project trial operation and production

Trial operation and production	Weights	Remarks
Production preparation	0.3	
Processing of compliance procedures	0.4	
Production conditions inspection	0.1	
72-hour trial production	0.1	
Transfer of management rights	0.1	
Total	1	

6. Project Integrated Progress Measurement Curve

By establishing a progress measurement system, weights of various levels of WBS such as design, procurement, construction, and commissioning are weighted. Time is used as the horizontal axis, and comprehensive weights as the vertical axis. The cumulative value of comprehensive weights is described against the time coordinate, thereby deriving the project measurement curve.

(1) Progress control of engineering projects first involves describing the visual progress of project construction. Then, the actual progress of project construction is compared with the project schedule to identify deviations and their causes. Measures are then taken to correct these deviations, ultimately achieving control over the project schedule.

(2) To measure actual progress using the engineering progress measurement system, it is necessary to quantify the visual progress of completed project construction according to weight allocation rules. By comparing this with planned values, quantitative management of the project schedule is achieved, accurately and visually monitoring the progress of engineering activities.

7. Conclusion

(1) WBS division forms the basis for setting project progress weights. It decomposes project deliverables and work into smaller, more manageable processes, following a top-down approach.

(2) Weight systems play a crucial role in project progress management, particularly in overall schedule control. These systems convert progress into monitorable indicators, allowing each WBS to be converted into a ratio of a certain level WBS, thereby facilitating process monitoring of the overall project progress.

(3) This study has researched methods and approaches for integrated progress measurement of oil and gas pipeline projects. Weights at various WBS levels are primarily determined based on comprehensive consideration of estimated costs and durations, with cost being the primary factor and duration factors adjusted according to actual WBS activities.

References

[1] Huang Weihe, Zheng Honglong, Li Mingfei.Development history and prospect of China's oil and gas storage and transportation industry[J]. Oil & Gas Storage and Transportation, 2019,38(01):1-11.

[2] JIN J, ZHU X S, LIU Y Y, LI N, ZOU B. Research on integration technology method of oil and gas long distance pipeline big data[J]. Oil-Gasfield Surface Engineering, 2020, 39(2): 77-81

[3] Chen Shibo.Construction plan and schedule management of pipeline[J].Petrochemical construction,2021,43(01):17-19.

[4] LIN D M, TONG W. Application of pipeline construction schedule control system in pipeline EPC project management[J]. Science & Technology Information, 2009(23): 35.

[5] XUE J X.Research and Application of Long-distance Pipeline Construction Project Schedule Control Based on Hall 3D Model[J].Petrochemical Industry Technology,2022(1):142-144.

[6] YAN Z Y.Analysis of the Schedule Management in the Long-distance Natural Gas Pipeline Project[J].Chemical Engineering Management,2021(9):56-57.

[7] WANG G C. Research on Schedule Management of Long Distance Pipeline Project[J].Shan Dong Chemical Industry,2017(46):159-160.

[8] YU F P,LIU Z P,CUI X.Establishment of progress measurement system for FPSO hull project[J]. Ship Engineering,2007,1(29):53-56.

[9] JING H Y,JIA X,HUANG J.Optimization of subsea gas pipeline maintenance schedule[J].Oil & Gas Storage and Transportation，2015,34(10):1131-1134.

[10] Arahanm Shtub,Jonathan F.Bard,Shlomo Globerson.Project Management Processes,Methodologies and Economics, 3rd[M].pearson Education South Asia Pte Ltd,2010.