Development of O&M Data Management System for Pipeline Project in Permafrost Area

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ABSTRACT

The securing of alternative energy is essential, since the Republic of Korea (hereafter, ROK) depends on 97% of its supply from overseas. Since G20 Summit Conference of 2011, it became possible to receive natural gas from Russia for 30 years starting from 2015 with mutual cooperative agreement for the procurement of natural gas/oil and minerals. It enabled Korea to advance to pioneering regions of extreme climate. However, it lacks the experience of design and construction of pipeline projects in permafrost area until now as well as the technique for the management of enormous information, which is generated from the project. This study aims to develop engineering data breakdown structure (DBS) and information flow of pipeline projects in permafrost area. The ultimate goal of this research is to develop a hierarchical structure of engineering/construction data for efficient project management in the extreme climate region. In order to achieve the research purpose, domestic and overseas literatures on this research topic are reviewed, and the business process of the design stage of pipeline projects in permafrost area as well as the characteristics of the important items are analyzed. Additionally, the result of this study will be used to build the comprehensive information management system for the entire process.

Keywords : Data Breakdown Structure, Process, Pipeline, Permafrost Area, Information Management

1 Introduction

1.1 The Purpose of Study

Recently, Russia concluded a $410 billion contract of natural gas transactions with China. In the past, Russia decided to supply natural gas amounting to 7.5 million tonnes/year for 30 years, beginning from 2015. Using this opportunity, Korea keeps watching for a chance to participate in approximately $55 billion to $60 billion worth of gas field and pipeline construction projects, including construction of a 4,000-kilometer pipeline connecting the eastern part of Siberia and Shandong Peninsula, which are extremely cold regions, to be conducted by 2018 [1].

Since this pipeline construction project for extremely cold regions is a large-scale project, it not only carries a big risk because of regional characteristics but also requires an enormous amount of information to be accumulated and generated in real time, according to work stage. In particular, O&M data which makes up a great part of LCC (Life Cycle Cost), should be efficiently managed for the success of the project. However, since Korea has no experience regarding pipeline construction in extremely cold regions, not much research on O&M information and data systems has been conducted.

Therefore, in this study, an efficient data system will be constructed for the maintenance of data generated during the pipeline construction project for extremely cold regions. The results of this study may be used as preliminary data for the establishment of data management systems and development of systems in the EPC (Engineering Procurement Construction) stage.

1.2 The Scope and Method of Study

The scope of the study is limited to data generated during the EPC and maintenance stage of the pipeline construction project for extremely cold regions.

As a study method, the concept of O&M data was established first and the PODS (Pipeline Open Data Standard), which is a pipeline O&M system and data model, was investigated/analyzed on overseas websites to establish comprehensive O&M data. In addition, the direction of O&M data system construction was

proposed in effort to make an efficient data association plan according to the work stage of the pipeline construction project for extremely cold regions.

2 Consideration of Precedent Studies

2.1 Definition of Extremely Cold Regions

Extremely cold regions refer to the areas with temperatures below 0° C during at least two continuous winters and one summer. The total area of extremely cold regions is approximately 13,050 thousand ㎢ (14% of the total land areas of the world), including the polar area adjacent to the Antarctic and Arctic. The ground of extremely cold regions is divided into the permafrost layer that maintains the frozen state (below 0° C) regardless of the change of temperature on the ground and active layer repeatedly freezing and thawing according to the change of seasons [2].

2.2 Risk Analysis of Pipeline Construction in Extremely Cold Regions

The risk of pipeline construction in extremely cold regions is evenly distributed throughout the life cycle. However, in this article, it was analyzed based on two distinct issues that can be discussed throughout the project.

First, the thickness of the active layer (surface layer) changes according to the changes of annual temperature and differential settlement occurs because of movements of the ground, which causes transformation of the foundation of pipelines.

Table 1 Differential settlement

Frost heaving	Thawing settlement
As temperature falls below cooling temperatures such as in winter, moisture contained in soil becomes frozen, ice lenses are formed, soil expands, and, as a result, the ground is locally elevated.	Contrast to frost heaving, as temperature rises above cooling temperature, ice lenses inside the soil of the frozen ground are melted, soil contracts, and the ground is locally settled.

Second, according to the Russia-East Asia Gas Transfer Network Plan announced by the Russian national natural gas company 'Gazprom' in 2012, a considerable number of pipelines involve long-distance pipelines and external influences such as extremely cold climates and seismic activity that places strain on designed/constructed pipes.

To prevent such risks, advanced management using IT technologies such as measurement and monitoring for predictions is required. Furthermore, a data management plan should be established because the amount of data generated throughout the life cycle of the project is huge due to the application of IT technologies and data is accumulated and generated in real time [3].

3 Construction of O&M Data System for Pipelines in Extremely Cold Regions

3.1 The Establishment of Concept of O&M Data

O&M data is composed of final data collected in the EPC stage and field data for maintenance work based on as-built data submitted in the completion stage after commissioning.

First, O&M data refers to data required for daily and regular inspections and repairs required for maintaining the functions of architecture or facilities and preserving the value of assets. It is important to collect data required for each work stage because a party placing an order or facility manager may raise a complaint if O&M data is incomplete or unsuitable for work.

Second, final data referring to the data of the five major documents generated during the EPC stage including Engineering Deliverables, Fabrication Dossier, QC Documents, Commissioning Dossier, and Inspection & Test Dossier is regulated based on the advice of domestic experts.

Third, as-built data considering all potential variations during construction refers to final data provided to the party placing an order. This type of data is considered important when planning extensions of facilities because this data includes a variety of documents about elements rearranged due to design change, transportation systems, and distribution systems generated during the construction stage.

Finally, field data refers to various types of data created and collected during maintenance work, including on-site measurement data.

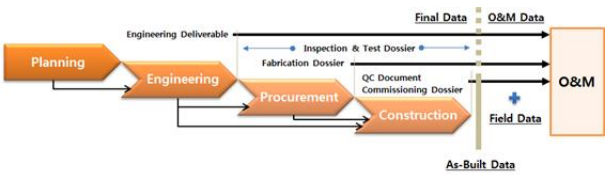

Figure 1. Conceptual Drawing of O&M Data

3.2 Base Analysis for Pipeline O&M Data Systemization

In order to establish comprehensive O&M data, existing pipeline O&M systems and PODSs were investigated and analyzed.

Pipeline O&M systems, which are currently developed or used by for companies, are surveyed and those companies include two-system development companies (SAP AG (Germany, SW company) and TCS (Indonesia, IT service company) and two maintenance companies (OMV (Austria, oil & gas company) and DOLPHIN ENERGY (UAE, gas company)).

O&M systems of the system development companies connect collected field data and history for the SCADA system and link them to enterprise resource planning (ERP). In addition, O&M systems of the maintenance companies spatially integrate each data based on work processes and GIS, and share information in the form of mobile, desktop, and web from the perspective of actual users. These systems realize various advantages including optimized decision-making by increasing the usability/sharing/reuse of data, improving data quality, and supporting the integration of work and risk management.

Figure 2. Holistic Pipeline Management [4].

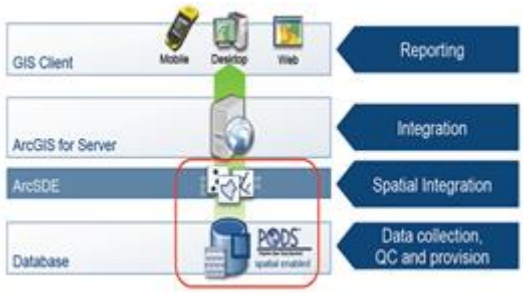

Figure 3. Integrated Pipeline Management System Conceptual Architecture [5]

In addition, most O&M systems are commonly using the PODS. The PODS is the integrated industrial pipeline data regulation established by relevant associations to continuously support data model development. A data model of the PODS is optimized for data integrity, improved safety, dependency, and compliance with regulations and composed of 31 kinds of categories and sub-items that are largely divided into facility/basic information/inspection and maintenance. It is considered that an O&M data model considering the characteristics of extremely cold regions can be developed based on the PODS in further studies.

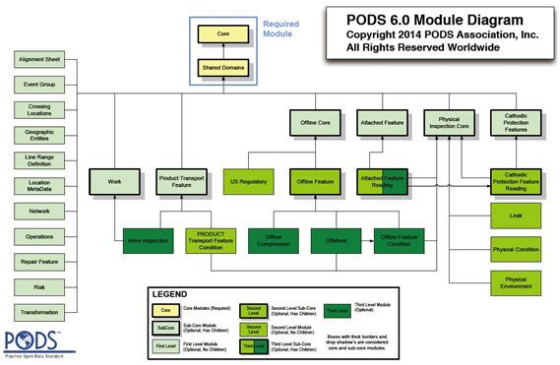

Figure 4. PODS Module Diagram [6]

3.3 Suggestion for Maintaining O&M Data System Construction Direction for Pipelines in Extremely Cold Regions

In order to construct an efficient O&M data system, an adequate data association plan should be established. O&M data established as above is composed of the final data of the EPC stage, as-built data of the completion stage, and field data of the maintenance stage. The connectivity with final data was preferentially considered for construction of a data system by reasons as below.

Firstly, omissions and errors due to data transfer can be minimized when data is properly managed from the starting point of major contracts and works according to EPC stage for long-term projects. Secondly, each system is separately operated since work entities are separated according to each EPC stage and efficient data management is difficult because the consistency of collected data is poor. Thirdly, historical information not mentioned in construction drawings and precise information of facilities/equipment/components for maintenance is required as O&M data.

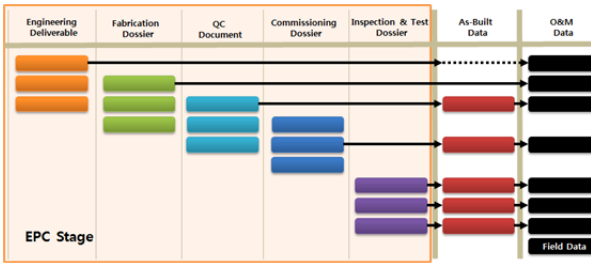

Figure 5. O&M Data Relationship Diagram [7]

Final data collected thus far includes one document of the plant sector (Engineering Deliverable), two documents of the construction sector (Fabrication Dossier and Commissioning Dossier), and three documents of the pipeline sectors (Fabrication Dossier, QC Documents, and Inspection & Test Dossier). Final data of the pipeline sector will be additionally collected and analyzed by connecting with pre-analyzed PODS data systems and items. In addition, the concordance rate of subordinate contents of final data and O&M data will be analyzed through one-to-one matching of identical terms, similar expressions, and contexts. For highly connected data, a system will be constructed for data management according to EPC stage.

Table 2. Final Data Collected by Project Sector and Stage

	Pipeline	Construction	Plant (SSO, off-shore)
Engineering Deliverable			· Geotechnical investigation · Topographic survey · Conveyance design · Pump station design · Right of way map / Real Estate
Fabrication Dossier	· Completed piping system · Process module · Pressure vessel · Heat exchanger · Construction of industrial application	· Approval · Materials · Shop fabrication · Inspection & Test · Final test · Delivery · Records	
QC Documents	· Visual inspection of structural steel and piping · Non-destructive examinations · Leak / Hydrostatic testing · Inspection of surface treatment · Dimensional control		
Commissioning Dossier		· Objective · Description · Lists of temporary equipment and consumables · Health/Environment/Safety · Preservation · Scope · Planning · Handover	
Final (As-built) Documents		· Architectural · Mechanical services · Electrical Services · Closed-circuit Television (CCTV) · Hydraulic services · Fire services	· General · Electrical equipment · Mechanical equipment · Panels & panel equipment · Instruments · Valves · HVAC · Safety equipment · Piping · Structural – topside, jacket · Miscellaneous
O&M Documents		· Building/Architectural/Structural/Mechanical services · Electrical/Security/Communication services · Hydraulic/Fire services · Vertical transport · Document register	

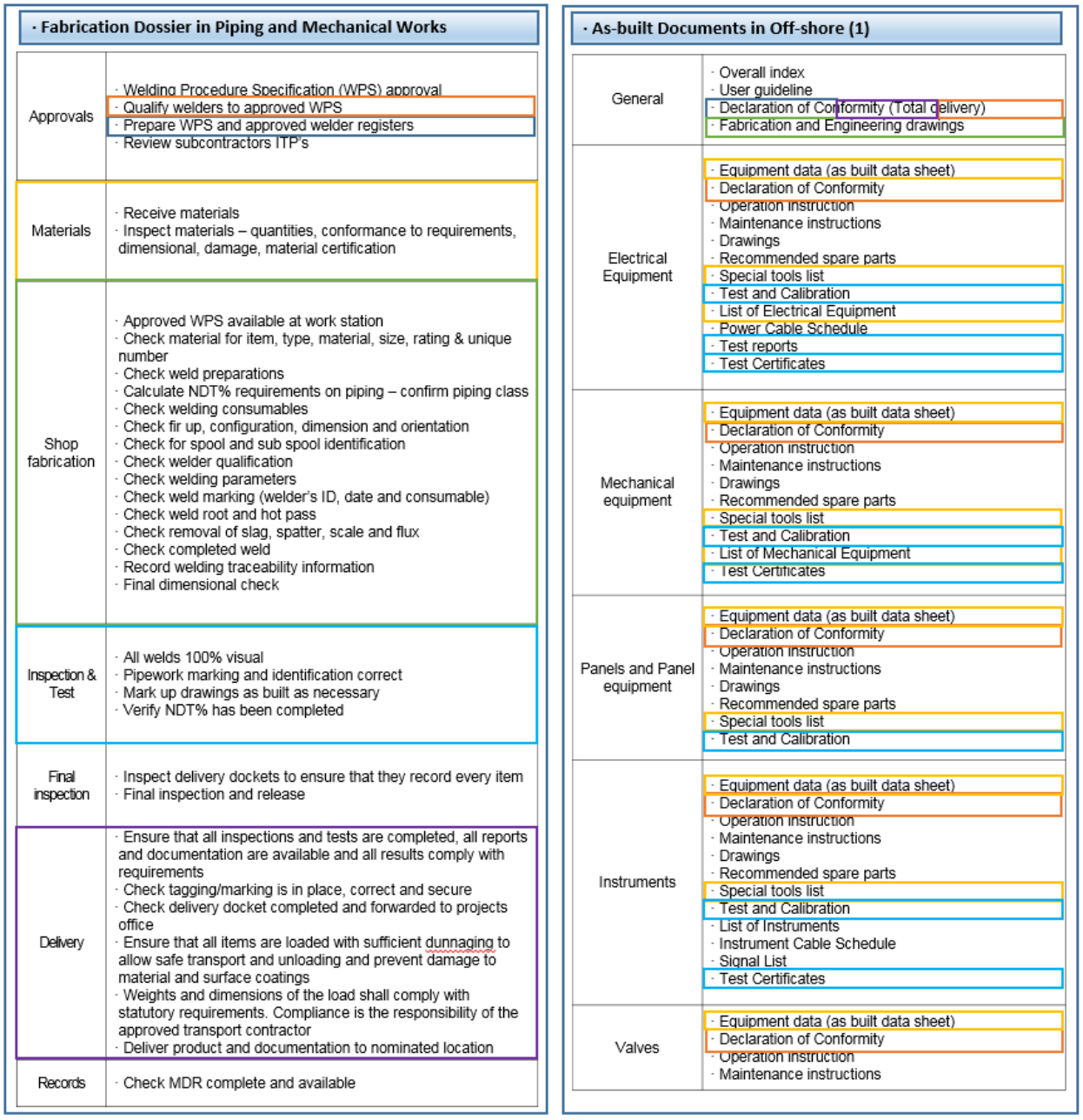

Figure 6. Data Association Diagram of Final Data and O&M Data

4 Conclusion

According to a natural gas supply agreement with Russia, Korea has continued to monitor for an opportunity to participate in approximately $55 billion to $60 billion worth of gas field and pipeline construction projects, including construction of a 4,000-kilometer pipeline by 2018. Not only does it carry a big risk because of regional characteristics of extremely cold regions but also an enormous amount of data will be generated resulting from this large-scale project. Since O&M data, which makes up a great part of LCC (Life Cycle Cost), should be efficiently managed for the success of the project, this study was conducted to construct an efficient data system for maintenance work of data generated during the pipeline construction project for extremely cold regions.

First of all, the concepts of final data of the EPC stage, as-built data of the completion stage, and field data of the maintenance stage were established as O&M data. In order to establish comprehensive O&M data, pipeline

O&M systems which are currently developed or used by four companies (System development companies: AP AG and TCS, Maintenance companies: OMV and DOLPHIN ENERGY) were investigated and analyzed. It was found that most O&M systems are commonly using the PODS (Pipeline Open Data Standard) and it is considered that an O&M data model, after considering the characteristics of extremely cold regions, can be developed based on the PODS through further studies. Lastly, in the direction of O&M data systems, construction was proposed to make an efficient data association plan according to the work stage of the pipeline construction project for extremely cold regions. In particular, data should be properly managed from the starting point of major contracts and works according to EPC stage, the consistence of data should be improved with a separate entity, and history and precise data which is difficult to obtain from construction drawings should be considered first. Final data of the pipeline sector will be continuously collected and analyzed in connection with PODS data systems and items of the PODS shall be continuously collected and analyzed. The results of this study may be used as preliminary data for establishment of data management systems and development of systems in the EPC stage.

Acknowledgements

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