Application of Configuration Management for Engineering Information Management in Pipeline Projects

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Abstract

Since April 2009, Korea has been importing 1.5 million tons of LNG(Liquefied Natural Gas) annually from the Sakhalin-II project, which is operated by Gazprom, Russia's largest state-run gas company. Also, it is expected that the cost of pipeline construction will reach $55 ~ 60 trillion by 2018 [1]. In this long-distance pipeline construction project, the importance of effective management of the vast amount of information generated throughout the life cycle stands out, and KOGAS(Korea Gas Corporation) has been cooperated with by Gazprom in a variety of fields such as natural gas supply and performing gas-related projects since the signing of the Gas Cooperation Agreement with Gazprom in December 2016. However, the level of related technology in Korea is still not competitive. Then, many experts sought to focus on the improvement of the life cycle process and efficient management [4], and it is very important to maintain up-to-date data and utilize it for work during long-term projects to reflect changes in pipeline projects [2]. Therefore, in this study, we propose a method to apply the Configuration Management to efficiently manage the changeable information generated during the engineering phase of the pipeline project. It is possible to systematically manage information that enables conformity and traceability of the design requirements and physical configuration of the changes in the engineering phase [13]. This study concentrates on Configuration Management which is one of the techniques applied to efficiently manage the information generated in the engineering phase [5]. So it is expected that efficient information change management would be achieved in the engineering phase by establishing data structure for each design requirement and physical configuration, and developing a model which facilitates linkage among the elements in the three areas of configuration management.

Keywords –

Configuration Management, Data Breakdown Structure, Pipeline, Engineering Information Management, Conformity, Traceability

1 Introduction

1.1 The Background and Purpose of Study

According to the decline in international exports and oil prices, plant orders have plummeted globally. At the same time, the number of obtained orders by overseas plant projects of Korean companies has also decreased. From 2011 until now (February, 2017), Korea's overseas plant orders have been steadily declining, as shown in Table 1, and costs have also recently dropped sharply [3].

On the other hand, Korea has been importing 1.5

Table 1. Trend of Investment Expenditures in overall Plant [3]

(Unit : $ 1,000,000)

Years	2011	2012	2013	2014	2015	2016	2017 (Jan-Feb)	Total
Cost of Orders	64,984	64,765	63,676	59,534	36,468	20,931	3,049	313,406

million tons of LNG(Liquefied Natural Gas) annually from the Sakhalin-II project, which is operated by Gazprom, Russia's largest state-run gas company, since April 2009. Also, it is expected that the cost of pipeline construction will reach $55 ~ 60 trillion by 2018 [1]. In this long-distance pipeline construction project, the importance of effective management of the vast amount of information generated throughout the life cycle stands out, and KOGAS(Korea Gas Corporation) has been cooperated with by Gazprom in a variety of fields such as natural gas supply and performing gas-related projects since the signing of the Gas Cooperation Agreement with Gazprom in December 2016. However, the level of related technology in Korea is still not overly competitive.

Therefore, the efficiency of the business conducted by domestic companies and their possessed technology should be enhanced in order to strengthen their competitive power. For this reason, many experts sought to focus on the improvement of the life cycle process and efficient management [4].

In addition, one of the major obstacles to the practical application and use of project management in pipeline projects is the occurrence of frequent changes. A typical example of such changes involves design change [5]. Thus, it is very important to maintain up-to-date data and utilize it for work during long-term projects to reflect changes in pipeline projects [2].

Therefore, in this study, the main objective is to propose a method to apply Configuration Management to efficiently manage the changeable information generated during the engineering phase of pipeline projects.

1.2 The Scope and Method of Study

The scope of this research was limited to data management in the engineering phase, which is very important for the successful execution of the project, by providing key information in later phases in the pipeline project [6], and the objective of this research is limited to the pipe itself which is the most important aspect of work in pipeline projects. Unlike other construction projects, plant projects are characterized by the fact that the process of installing pre-fabricated materials and facilities accounts for a large portion of the total project [7]. In particular, the pipe is the purpose of the plant facility and a vital work aspect on the process management side [8]. Therefore, this study focused on the pipes during the process in the engineering phase of pipeline projects.

This research was conducted in the following sequence, as shown in Figure 1. First, the previous studies of configuration management for information management systems in the overall plant industry involving domestic and overseas literature review were investigated. Second, the meaning of configuration management was defined and analyzed. Following that, the information of three major elements concerning configuration management in pipeline projects were collected and analyzed. Once this was done, the data breakdown structures of each major element were derived, and each breakdown structure was verified through questionnaires by experts in pipeline projects. The final step is that the way of applying the concept of CM(configuration management) to each breakdown structure was proposed, and the work process of linkage among data from each breakdown structure was proven by using examples.

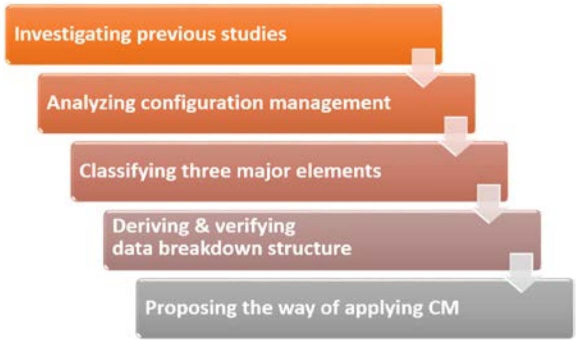

Figure 1. The sequence of this study

2 Literature Review

2.1 Previous Studies

2.1.1 Information Management in Pipeline Projects

The previous studies related to information management in pipeline projects are shown as Table 2.

Table 2. Major Research related to Information Management in Pipeline Projects

Author	Title	Main Content
Sunil (2016)	PIPEiD: Pipeline Infrastructure Database	Developing prioritization that can guide fundamental and applied research at institutions and entities funding research in water pipeline infrastructure.
Lee (2015)	Analysis of Data and Information Flow for Pipeline in Permafrost Area	Analyzing the data and information flow of pipeline projects in permafrost areas and developing the hierarchical structure of design and construction data for efficient administration of projects.
Won	Development of	Developing the process

(2015)	O&M Data Management System for Pipeline Project in Permafrost Area	and work breakdown structure of the design of the resource logistics network in extreme climate regions.

The studies of data and information flow analysis, derivation of hierarchical structure of design and construction data for project management, and identify the process and work breakdown structure in the design phase and use them to study the key factors for information management were conducted.

However, most of the studies attempted to adopt the information management technique in plant project to the technique in pipeline project. For this reason, in this study, it was derived to the main data management items for pipeline projects and proposed for adoption of the systematic management method.

2.1.2 Configuration Management

Research on configuration management that has been carried out in Korea and abroad were summarized in Table 3.

Table 3. Major Research related to Configuration Management

Author	Title	Main Content
Kang (2015)	Framework & Functions of Configuration Management (CM) in Nuclear Power Plants (NPP)	Seven industries (including defense, aerospace, software, engineering, architecture, civil engineering, nuclear power) that utilize the concept of configuration management (CM) were compared and analyzed based on the CM purpose, technique, and life-cycle perspectives.
Ko (2009)	A Study of Development of Change Process for Configuration Management in Construction Project Management	The review of the current systems now in use at worksites and are known to be efficient, and the introduction and application of configuration systems that are now a big issue.
Yoo (2008)	A Study on Developing Systems for Managing Information on Owner's Requirements in the Design Phase	The development of the efficient information system for managing owner's requirement throughout the design phases.
Schenk (1985)	Configuration management as applied to engineering projects	Configuration management is a management mechanism for handling changes by integrating technical and administrative decisions with respect to project goals and objectives.

The studies of development of the change process for configuration management in construction project management and developing systems for managing information on owner's requirements in the design phase were conducted. However, there was no research on configuration management in pipeline projects. In addition, most of the studies were focused on emphasizing the necessity of configuration management and proposing an abstract concept to apply configuration management to construction or plant projects. Therefore, this study was concentrated on the more concrete method of applying configuration management to information management in pipeline projects.

2.2 Introduction to Configuration Management

2.2.1 General Meaning of Configuration Management

Configuration Management(CM) was created by the US Department of Defense in the 1950s to improve weapon systems. According to the IEEE 610 standard, CM is principally applied to the change process in technical and management direction and supervision. Additionally, CM identifies the functional and physical characteristics of configuration items, and manages the changes in those characteristics. After that, it records and reports change procedures and implementation status to verify compliance with specified requirements.

Although CM has been important for all the manufacturing and production industries since the industrial revolution, very few theoretical frameworks for CM are available in the literature. Based on knowledge and work experience in the production industry, it was found that three sub-domains, or three types of formal descriptions, are fundamental for CM [16].

In the case of general large-scale plant construction projects, CM methodology is applied to efficient change management for systematic project management. It is required to maintain 'Design Requirements – Physical Configuration – Facility Configuration Information' consistently within the project period [2].

The strongest property of CM is that it enables information conformity and traceability. Through these two critical properties, the most important process among various standards for CM is change management [13].

2.2.2 Three Major Elements of CM

Basically, CM consists of three elements: Design Requirements, Physical Configuration, and Facility Configuration Information. As shown in Figure 2, the information contained in the three elements must be linked with each other and always matched. This is called CM Equilibrium, which is the basic concept of CM.

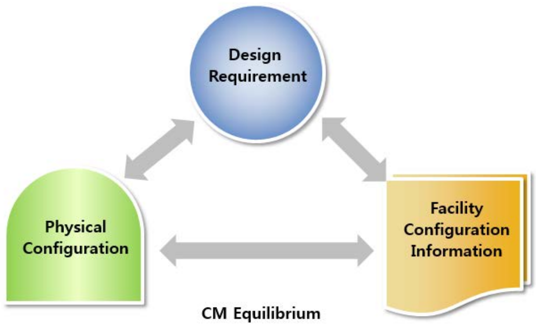

Figure 2. Three Major Elements of CM [2]

'Design Requirements' pertains to information related to design requirements, including design criteria, regulatory requirements, and other design components. 'Physical Configuration' is the facility(functional location) information, including its design result and construction result. Lastly, 'Facility Configuration Information' pertains to basic/detailed design information, including purchase specifications, drawings and procedure documentation.

3 Application of CM

3.1 Three Elements of CM Applying to Pipeline Projects

Design requirements management is an activity that establishes, documents, maintains and utilizes the design requirements for the CM objects(structure, equipment, etc.) of facilities. Also, establishment of a proper management system for pipeline design requirements and design is an important management factor during the lifecycle of the pipeline project.

3.1.1 Breakdown Structure of Design Requirements

The design requirements for the pipeline project in this study are referenced in the Design Basis Document of Application for Approval by several major pipeline projects such as Mackenzie Valley Pipeline. The breakdown structure of design requirements related to piping is shown in Figure 3.

Piping is rooted from a sub-class called piping equipment, which is rooted from a class called mechanical equipment. The design requirements of piping are largely divided into seven categories: Codes and Standards, Piping Joints, Loading Conditions, Environmental Factors, Materials-related Considerations, Thermal Insulations, and Sizing of Piping Systems. Each of those categories has their own components.

1	mechanical equipment class
1.1	piping equipment
1.1.1	Piping
1.1.1.1	Codes and Standards
1.1.1.1.1	Differentiation between Codes and Standards
1.1.1.1.2	The ASME Pressure Classification System
1.1.1.1.3	Reference Codes and Standards
1.1.1.2	Piping Joints
1.1.1.2.1	Butt-welded Joints
1.1.1.2.2	Socket-welded Joints
1.1.1.2.3	Brazed and Soldered Joints
1.1.1.2.4	Threaded or Screwed Joints
1.1.1.2.5	Grooved Joints
1.1.1.2.6	Flanged Joints
1.1.1.2.7	Compression Joints
1.1.1.3	Loading Conditions
1.1.1.3.1	Design Pressure
1.1.1.3.2	Design Temperature
1.1.1.3.3	Deadweight
1.1.1.3.4	Wind Load
1.1.1.3.5	Snow and Ice Loads
1.1.1.3.6	Seismic (Earthquake) Loads
1.1.1.3.7	Hydraulic Transient Loads
1.1.1.3.8	Acoustically Induced Vibration Loads
1.1.1.3.9	Relative Anchor Movements
1.1.1.4	Environmental Factors
1.1.1.4.1	Corrosion
1.1.1.4.2	Erosion
1.1.1.4.3	Physical Damage
1.1.1.4.4	Erosion-Corrosion (Flow-Assisted Corrosion)
1.1.1.5	Materials-Related Considerations
1.1.1.5.1	Strength
1.1.1.5.2	Toughness
1.1.1.5.3	Corrosion Resistance
1.1.1.6	Thermal Insulation
1.1.1.7	Sizing of a Piping System
1.1.1.7.1	System Fluid Flow Design
1.1.1.7.2	Pressure-Integrity Design
1.1.1.7.3	Determination of Pipe Wall Thickness
1.1.1.7.4	Determining the Pressure Class for In-Line Components
1.1.1.7.5	Determining the Design Conditions and Pressure Class of a Piping System
1.1.1.7.6	Design of Piping for Internal and External Pressure
1.1.2	flange
1.1.3	manifold
1.1.4	seal
...	...

Figure 3. Breakdown Structure of Design Requirements related to Piping

3.1.2 Breakdown Structure of Physical Configuration

Physical configuration involves information about real facilities and its components. There are two results which include its design and construction results. The design results of physical configuration were analyzed and only the piping part is shown in Figure 4 because of the excessive amount of data.

Piping is inherited by a sub-class called piping equipment, which is inherited by a class called mechanical equipment. It is easily noticed that classification of high levels consists same as the breakdown structure of design requirements. This infers the possibility of linkage between design requirements and physical configuration, and this is illustrated with chapter 3.2. The piping of physical configuration is largely divided into four categories: Pipe, Valve, Control and Monitoring, and Miscellaneous. Each of those categories has their own components.

1	mechanical equipment class			
	1.1	piping equipment		
		1.1.1	Piping	
			1.1.1.1	Pipe
				1.1.1.1.1 Fastener/ bolts
				1.1.1.1.2 Joints
				1.1.1.1.3 Flange
				1.1.1.1.4 Header
				1.1.1.1.5 Lining
				1.1.1.1.6 Pipe element
				1.1.1.1.7 Plug
			1.1.1.2	Valve
				1.1.1.2.1 Valve
				1.1.1.2.2 Actuator
				1.1.1.2.3 Control and monitoring
			1.1.1.3	Control and monitoring
				1.1.1.3.1 Actuating device
				1.1.1.3.2 Control unit
				1.1.1.3.3 Internal power supply
				1.1.1.3.4 Monitoring
				1.1.1.3.5 Sensors
				1.1.1.3.6 Valves
				1.1.1.3.7 Wiring
				1.1.1.3.8 Piping
				1.1.1.3.9 Seals
				1.1.1.4.1 Pipe support
				1.1.1.4.2 Others
			1.1.1.4	Miscellaneous
		1.1.2	flange	
		1.1.3	manifold	
		1.1.4	seal	
		...	...	

Figure 4. Breakdown Structure of Physical Configuration related to Piping

3.1.3 The components of Facility Configuration Information

Facility configuration information in the engineering phase includes most of the engineering information except information for design requirements and physical configuration. The main elements of facility CM include basic and detailed design information. There are so many types of information in basic and detailed design, but the three major components are purchase specifications, drawings and procedure documentation. The example of facility CM for pipe is shown in Figure 5.

Even though there isn't any standardized breakdown structure of facility configuration information since it is just information of basic/detailed design like property data, all information should be linked with proper components of design requirements and physical configuration.

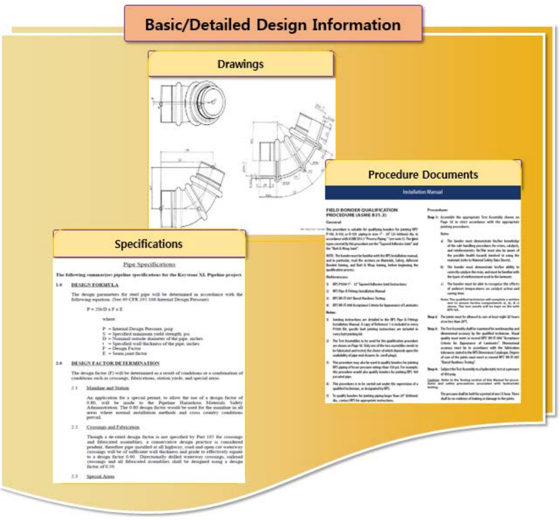

Figure 5. The Components of Facility Configuration Information related to Piping

3.2 The Method of Applying CM to Engineering Information

3.2.1 Application of Tag System

Unique Number	Tag Class Name	Unique Number	Property
5247	pipe	6164	lower limit design temperature
5247	pipe	6189	lower limit operating temperature
5247	pipe	6392	normal operating flow velocity
5247	pipe	6395	normal operating pressure
5247	pipe	6396	normal operating pressure drop
5247	pipe	6398	normal operating temperature
5247	pipe	6887	test pressure
5247	pipe	7004	upper limit design pressure
5247	pipe	7005	upper limit design temperature
5247	pipe	7033	upper limit operating pressure
5247	pipe	7034	upper limit operating temperature
5247	pipe	40000007	anti corrosion coating thickness
5247	pipe	40000008	anti corrosion coating type
5247	pipe	40000030	buried
5247	pipe	40000071	critical pipeline
5247	pipe	40000126	flow line type
5247	pipe	40000132	fluid name
5247	pipe	40000133	fluid phase
5247	pipe	40000227	maximum burial depth
5247	pipe	40000230	minimum burial depth
5247	pipe	40000246	nominal pipe diameter
5247	pipe	40000249	nominal wall thickness
5247	pipe	40000250	non destructive testing methods
5247	pipe	40000259	normal operating gas density
5247	pipe	40000273	normal operating liquid density
5247	pipe	40000275	normal operating mass flow rate
5247	pipe	40000276	normal operating mixed liquid and vapour density
5247	pipe	40000289	normal operating volume flow rate
5247	pipe	40000315	pipeline colour code
5247	pipe	40000316	pipeline material and grade
5247	pipe	40000337	remarks
5247	pipe	40000372	special service
5247	pipe	40000413	thermal insulation coating thickness
5247	pipe	40000414	thermal insulation coating type
5247	pipe	40000472	upper limit operating mass flow rate
5247	pipe	40000482	weight coating density
5247	pipe	40000483	weight coating thickness

Figure 6. A portion of pipe tag list

The definition of 'tag' means a word or keyword that is given for use in searching for information. In essence, a tag system is a system that collects necessary information by using these tags as data.

In this study, the tag system was used to be linked to each of the correlated data by tagging all piping data of engineering phase in pipeline projects. In addition, each of the inquired data has two properties which are basic file attributes and registrants. A name, a format, a location, a size, a creation date and a modified date are included as basic file attributes. Also, there exists a registrant ID and a company code as registrants. A portion of the pipe tag list in our research is shown in Figure 6.

3.2.2 Applying CM to Pipe Information in Engineering phase

In this study, CM enables to link all engineering information assigned tags in three main elements. The most basic method of application of CM involves establishing one among three major elements as a standard, and managing to link information of other elements based on tags. Specifically, based on the physical configuration, related information generated in design requirements and facility configuration information are linked. Starting from this process, the information generated in the subsequent process steps(procurement, construction, and maintenance) are included in the related category, so that the changeable information can be efficiently managed.

To facilitate easier understanding, an example of a part of the piping work which is the scope of this study is shown in Figure 7. Among the large amount of data, only a portion of piping data is extracted from each element, and information such as 'Physical Configuration for Pipe', 'Design Basis Document for Piping / Code & Standards for Piping', 'Drawing for Pipe / Procedure Document for Pipe / Specification for Pipe' are extracted. All information is managed through linkage with each other due to connections from the tag system. From the design stage to the maintenance stage, newly generated pipe-related information are added to the corresponding elements so that information can be continuously traced and conformed.

3.3 The Expected Result of Applying CM to Real Design Changes

In order to demonstrate real world design changes and how the proposed method handle the changes appropriately, the comparison of work procedures in design change between existing information system and the system applied by CM.

A prior condition is that public employer requests a design change due to reduction in the budget of pilot test in pipeline construction project. This can affect the work of both engineer(architect) and contractors such as main contractor and vendors in the aspects of three major elements of CM which are design requirement, physical configuration and facility configuration information. There are two alternatives which are reducing the diameter of pipe from 32 inch to 30 inch and the length of pipe from 100m to 60m. The comparison of each procedure is shown in Table 4.

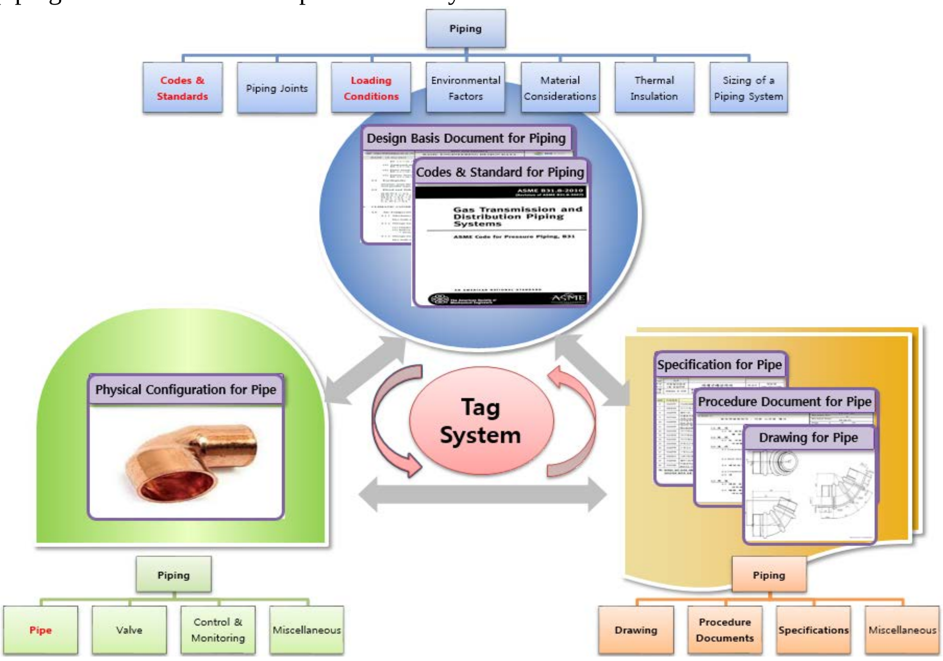

Figure 7. Application of CM for Piping related Engineering Information

Table 4. Comparison of work procedures in design change between existing information system and the system

As-Is			To-Be		
Object	Work	Effect	Object	Work	Effect
Public Employer	Request for design change due to reduction in the budget ↓ Notify the architect or engineer		Public Employer	Request for design change due to reduction in the budget ↓ Notify the architect or engineer	
Architect or Engineer	Review 'Design Requirements' such as Code & Standard and Design Basis Document	Increase the probability of human errors occurrence since the review of design requirements proceeds manually	Architect or Engineer & Vendors	Review 'Design requirements' such as Code & Standard and Design Basis Document in a short period of time through the change management system applied by CM	Reduce the time and make a high accuracy of the works
	↓ Change 'Facility Configuration Information' such as design drawings and specifications	Increase the probability of problems occurrence due to the inefficient communication Ex) Occur the errors producing pipe due to the notifications of incorrect Revision number		Recognize and identify design changes without additional communication by participants in the system	Find definitive design changes in the final Rev. and increase communication efficiency by all participants
	↓ Notify the vendors of design changes			Produce the pipes according to design change without any problem caused by information error	Detect information immediately when searching for relevant information in the future
Vendors	Produce real pipes and change the information of 'Physical Configuration' based on changed design information	Overall, require extra time due to unnecessary works			

4 Conclusion

In this study, research was carried out to solve the frequent changing occurrences which are one of the main obstacles of information management of the engineering phase in pipeline projects. Since these changes occur frequently in the actual construction, top managers who manage the construction are satisfied with utilizing the time schedule of work as promotional purposes and avoid performance management due to concerns about additional process management costs in actual construction management. The new approach that this study suggests to solve this problem is applying configuration management(CM). Therefore, the basic concept of CM, which is one of the information change management techniques, was explained. In addition, according to the three major elements of CM, all data breakdown structures were classified. Following that, the application of CM to the pipeline project is presented through an example of piping which is the main work type of the pipeline.

The results of this study will lead to a study on the automatic linkage method of detailed information in three major elements of the CM in the future. The final goal of this research involves reducing the occurrence of changes in the plant project by creating the CM management system in order to ensure efficient change management.

Acknowledgements

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