DEVELOPMENT OF STANDARDS FOR THE TRANSPORTATION AND STORAGE OF HYDROGEN AS THE BASIS FOR THE SAFETY HYDROGEN'S USAGE

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Abstract

Today, the standardization of hydrogen is an important topic for increasing its production, while raising many questions. Hydrogen and its derivatives are central components of a decarbonized energy system. On the one hand, many countries are now establishing regulatory frameworks for renewable and low-carbon hydrogen, often accompanied by specific requirements for hydrogen. Similar processes are underway in Germany, Japan and the United States. The article discusses trends in the development of standards for the transportation of hydrogen through pipelines as the cheapest mode of transport and the prospects for creating a unified regulatory framework in this area, allowing the formation of a single world network for the transportation of hydrogen. Based on the results of the study, we came to the conclusion that at the present stage, the standardization of hydrogen is extremely underdeveloped, both on a global scale and at the national level. There are a number of regional initiatives that have not been widely adopted. Therefore, today it is extremely important to develop cooperation in this area at the international level. The Working Party on Regulatory Cooperation and Standardization Policies (WP.6) seems to be a good platform.

Keywords: standards, regulatory policy, hydrogen, certification, requirements

I. Introduction

Global standardization for the transportation of hydrogen fuels is becoming a cornerstone for the implementation of sustainable development goals, since hydrogen is the most promising and environmentally friendly of all possible energy sources today. The most promising in terms of cost is the transportation of hydrogen through existing pipelines, where the development of regulatory requirements for the transportation of hydrogen will make it possible to determine the possibility of using both existing networks and the principles of creating new hydrogen pipelines.

Today, the scientific community pays great attention to the standardization of hydrogen itself (Yang [1], Wurster [2]). However, there is no unified approach to the standardization of hydrogen at the international level. Although it should be noted that there are a large number of regulatory documents developed at the national level of different countries, as well as attempts to develop international standards in this area by the international organization for standardization - ISO. The lack of uniform approaches to the standardization of hydrogen makes it difficult to use, and more importantly, in our view, the development of both hydrogen infrastructure and hydrogen trade exchange.

The prospects for global standardization in the field of hydrogen technologies are very encouraging. States and companies recognize the importance of developing common standards to facilitate the use of hydrogen in various industries, including automotive, energy and industrial. The development of hydrogen transportation, distribution and storage is becoming a key element of hydrogen standardization. Therefore, today the standardization of hydrogen infrastructure is

being actively discussed at various venues. An important player in this field is the UNECE Working Party 6, where a project to harmonize different aspects of hydrogen pipelines has been implemented since 2023.

II. Methods

In this study, we relied on the scientific research of such experts in the field of hydrogen standardization as A. Ramensky [3], A. Shvarovsky [4], F. Gale, D. Goodwin, H. Lovell, H. Murphy-Gregory, K. Beasy, M. Schoen.

The methodological basis of our study was the national legislation of the EAEU countries, China, the USA, the European Union, international and regional strategies for the implementation of hydrogen energy, for example, the Roadmap on hydrogen standardization developed by the European Organization for Standardization (CEN/CENELEK) in 2023 [6].

Historically, the first attempts to standardize hydrogen date back to the beginning of the 20th century, when the scientific community first began to talk about standardization in hydrogen energy and, accordingly, about the need to create uniform requirements for hydrogen. Later, the Paris Climate Agreement 2015, aimed at decarbonizing the global economy, became an incentive for the development of hydrogen standardization. The development of alternative types of energy, including hydrogen, plays a key role in this process.

Today, the efforts of the international community are focused on the development of standards for hydrogen and its use, on the one hand, and attempts are being made to standardize hydrogen infrastructure on the other. An example is the flagship TransHyDE project, implemented since 2021 in Germany with the support of the German Federal Ministry of Education and Research, which aims to support the transportation, distribution and storage of hydrogen and other chemical energy carriers in practice.

III. Results

Within the framework of this study, it seems useful to look at who is involved in the development of standards for hydrogen and hydrogen infrastructure at the international and regional level. On a global scale, two major standardization organizations should be singled out here – the International Organization for Standardization (ISO) and the European Organization for Standardization (CENCENELEK). Statistics on the development of standards for hydrogen and hydrogen infrastructure at the international and regional level are presented in Table 1.

Table 1: *Development of hydrogen standards*

Organization	All Standard	Standards for Hydrogen pipeline
ISO	177 standards	1 standard
CEN	150 standards	1 standard

As can be seen from the analysis, a fairly broad regulatory framework for hydrogen energy has been developed on a global scale, but very little attention is paid to the standardization of hydrogen. Especially in terms of pipelines for hydrogen. The results in this direction have been achieved in Russia, where, in the course of the implementation of the national standardization program, new standards for steel pipes and cylinders for the transportation and storage of hydrogen were developed. The developer of a series of standards, consisting of three documents and establishing requirements for the transportation of hydrogen through steel and seamless pipes and for the storage of hydrogen in cylinders, is the technical committee TC 357 "Steel and cast iron pipes and cylinders". The standards are based on the results of research on overcoming hydrogen

embrittlement, the destruction of metals, in particular, high-strength steel, when interacting with hydrogen. Moreover, Russia has created a series of products for the creation of pipelines for hydrogen - Sputnik H, which includes pipes for the production and distribution, transportation and storage of hydrogen.

The current situation suggests the need to intensify efforts in this direction in order to really reduce the cost of transporting hydrogen and thereby increase trade in hydrogen.

The largest number of standards has been developed in the International Organization for Standardization, but this fact does not mean that the harmonization of standardization in this area at the global level has been achieved. The fact is that the regulations for the adoption of ISO standards at the national level provide for three options: standards identical to ISO, standards modified, standards not equivalent to ISO. An analysis of the distribution of ISO adoption of hydrogen standards in different countries is presented in table 2.

Table 2: *Types of adaptation of standards for hydrogen*

Country	Type of adopted standards		
	Identical (IDT)	Modified (MOD)	Nonequivalent (NEQ)
Europe	+		
China and Kazakhstan	+	+	+
Gulf countries	+	+	
USA	+	+	
Russia	+		

If the standard is accepted as identical, it means that no changes have been made to the text of the document. In the case of adopting a standard as a modified one, the structure of the international standard is retained in the national standard, but the text of the document contains technical deviations that must be explained and justified. A non-equivalent standard differs from a modified standard in that the technical changes to the text are not explained.

Thus, when adopting ISO International Standards, countries are left with the opportunity to make significant changes to the requirements contained in the document without justification. This practice is actively used by China, where 6 standards for hydrogen pipelines have been developed, based on ISO international standards [1].

IV. Discussion

I. Key standards at the global level have not been developed

A key obstacle faced by standards developers is the difficulty of developing global international standards that take into account the diverse technical and legal requirements that are present in national legislations of different countries. From the analysis of standards for transporting hydrogen through pipelines it is clear that foreign technology for transporting hydrogen through pipelines is actively developing. At the global level a number of standards or guidelines have been formed covering the design, construction, operation, and maintenance of hydrogen pipelines. However, the existing standards for hydrogen pipelines mainly apply to gas pipelines and industrial pipelines, but since the transportation through pipelines has different characteristics, it is not fully applicable to hydrogen pipelines. Therefore, the existing documents require a significant revision.

The positive effect of the development of standards for hydrogen pipelines at the global level is that the efforts of international organizations allow many countries to form their regulatory legal system taking into account the safety requirements established in the international arena, the criteria for assessing efficiency, and the features of the conceptual apparatus. The solution to the problem of the difference in requirements contained in regulatory documents is to organize a dialogue among all stakeholders in global standardization in the field of hydrogen pipelines. The platform for such dialogue is Working Party on Regulatory Cooperation and Standardization Policies (WP.6) of UNECE.

II. Standards as the basis for the safety of hydrogen pipelines

The creation of a safe hydrogen infrastructure consists of three essential elements: standards themselves, certification schemes and labeling. The interaction of these elements is shown in Figure 1.

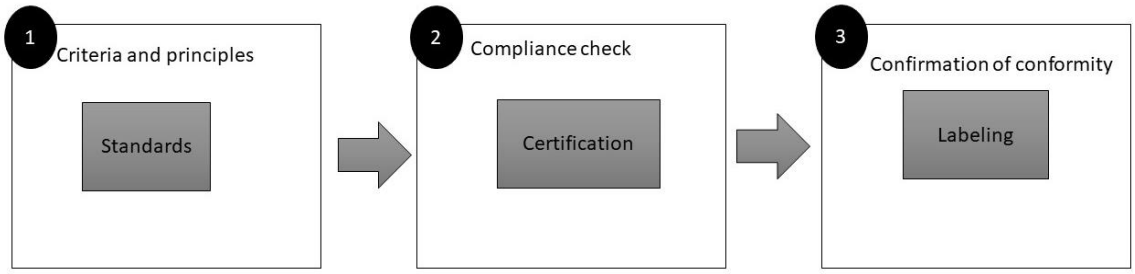

Figure 1: *Steps to ensure the safety of hydrogen pipelines*

Standards are therefore only the first step towards safety. The second important element is the certification of hydrogen pipelines - certification. Today, the difficulty lies in the fact that mainly developments in the field of certification relate to the reconstruction of existing networks for the transportation of hydrogen. An example of certification of existing pipelines for the transport of hydrogen is the program developed by the German certification body TUV-Sud entitled "Assessment of the suitability of new high-pressure gas pipelines for hydrogen operation (H2-ready certificate)", which aims to verify the suitability of existing pipelines. However, a comprehensive approach to the certification of hydrogen pipelines requires an analysis not only of existing networks, but also of the possibility of constructing new pipelines specifically for hydrogen. At the current stage, it is necessary to coordinate the efforts of the world community in this direction. The development of really working certification systems for hydrogen pipelines will make it possible to move on to the last step towards the creation of a safe hydrogen pipeline - the development of requirements for labeling hydrogen pipelines. The prospects for the implementation of this task in view of the great interest of both state bodies and the scientific community in the problem seem to be quite realizable.

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