H_2 Pipeline material

Hy2market-WP3.4 D3.1-pipe-line material testing campaign and deployment plan -2402

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Introduction and scope of work

1.1 Introduction

1.1.1 Hy_2Market

Europe needs a hydrogen market.

10 countries, 38 participants, investigate and develop a more mature hydrogen value chain across Europe on all market levels. The ultimate desire is to make Europe a resource-efficient and competitive green hydrogen economy. Hy2Market will step forward by creating interregional and international value chains by connecting regions in order to work on different innovations to boost the production, transport, and use of green hydrogen.

“Creating the hydrogen market for Europe”

1.1.2 WP3 hydrogen Transport

The main focus of this work package is to find innovative solutions for better, safer, affordable and efficient hydrogen transport between production and offtakers.

Different options for H2 transportation will be investigated and assessed for all regions, and tested in real life environments in Northern Netherlands. Lead for this WP3 is NEC with the partners Soluforce, HYE TS, HyET, EDP, CNR.

1.1.3 SoluForce product introduction

SoluForce® high pressure Flexible Composite Pipe (FCP) developed by SOLUFORCE has been fully certified for H2 transport. In contrast with steel pipes, it can be deployed from 400m spools greatly reducing cost for groundworks and welding, while being completely permeation-free for H2. Furthermore due to the use of the Soluforce pipe the CO_2 footprint is reduced to 30% compared to traditional solutions.

The Soluforce hydrogen certified pipe is available in 4 and 6” and can be used for hydrogen up to 52 bar and maximal 65°C. The pipes are packed in a 400 meter package which is easy to transport and is also used for uncoiling the pipe at the right of way.

The pipe consists of four layers: a PE100 liner pipe for leak free transport, an anti-permeation layer making sure the hydrogen permeation is nihil, an Aramid reinforcing layer to bear the strength for the high pressures and a cover layer to protect the pipe from environmental influences. The pipe system, pipe and fitting system, is fully non-metallic. The SoluForce pipes are inter connected by an electro fusion coupler system. First the liner pipe is butt-fused for a leak free connection and next the electro fusion sleeve is centrally placed over the butt-weld for the necessary strength. This connection is stronger than the pipe itself. For connecting the pipe to the hydrogen production and offtakers, an electro fusion end-fitting is used. The end-fitting is mechanically connected to steel parts with an ANSI flange or a weld stub. In order to connect different offtakers, producers or a connection to a large back-bone along the SoluForce pipeline also an electro fusion T-piece is being developed.

1.2 SoluForce scope

The SOLUFORCE scope in this WP3 work package for hydrogen transport has three main items:

1. Installation of a pilot for the SoluForce pipe line in Northern Netherlands ;
2. Find the optimal deployment plan, including regulatory affairs for the Rhone-Alpes region project of CNRhone in France near Lyon ;
3. Find the optimal deployment plan, including regulatory affairs for the EDP project in Asturias Spain.

All three items have in common that for the use of the SoluForce pipe the project and product need to comply to the local regulations and standards. There will be commonly used standards and available information and specific regional aspects which need to be recognised and being complied to.

1.2.1 Northern Netherlands installation

SOLUFORCE will install a pilot of their reinforced polymer pipeline (MS3.1, M33) in the Northern Netherlands connecting H2 production to H2 offtakers. One pipeline for Groningen sea ports and one pipeline for Firan in Deventer.

1.2.2 Rhone-Alpes region

The results of the Nothern Netherlands installation will be studied in detail for the Rhone-Alpes region where an electrolyser on an island in the river near Lyon needs a connection to the shore. CNRhone will work with SoluForce and local French SMEs (S3.6) to find the optimal deployment plan, including regulatory affairs, for the crossing and potential co-transport of O_2 and heat.

1.2.3 Asturias region

In Asturias, EDP will similarly work with Spanish SMEs (S3.5) to develop O_2 and heat co-transport in the context of the Spanish 100 MW electrolyser (see Task 2.4), where H_2 needs to cross Aboño river to reach the power plant.

1.2.4 General

All regions will provide input on expected H_2 specs from their respective demo sites (T2.1-2.4, T4.1-4.2, T5.1-5.2, PMs included in T3.2), and an additional testing campaign for H_2 pipelines will be developed based on the specifications received (D3.1, M6).

Implementation of SoluForce Pipeline

2.1 General

In order to be allowed to use SoluForce pipe for Hydrogen transport, Authority approval will be necessary. The general items for approval are:

1. Synchronized pipe and project specifications ;
2. Pipeline routing (ROW) ;
3. Approval present pipe certification / qualification (API 15S and Kiwa) by local authority ;
4. Comply to local regulations for pipeline engineering and installation.

2.1.1 Synchronize pipe and project data

The SoluForce pipe portfolio consists of several fixed products. In order to be able to use the SoluForce pipe system in the project, the project specifications need to fall into the SoluForce pipe system specifications. The SoluForce datasheet lists the specifications of the SoluForce portfolio products. The first stap is the process is to see if one of the SoluForce products meets the project specifications.

2.1.2 Pipeline Routing

A first quick check of the pipeline routing (right of way (ROW)) is not a direct must, but can make already clear if the long length pipes can be applied in the project.

2.1.3 General certification of the product

The specific general used qualification standard for the SoluForce pipe (FCP pipes) is the API 15S. By using this standard the pipes can be qualified for certain operational parameters for specific fluids or fluid groups. The API15S certificate will need to be accompanied by the quality management system standard API Q1. API 15S does not specifically mention hydrogen and therefore an extra API15S assessment is needed to check the details for hydrogen application. For the SoluForce pipe system this is done by Kiwa in the Netherlands.

International Standards

API 15S
API Q1

In order to be allowed to use the SoluForce pipe the local authorities need to acknowledge these standards.

2.1.4 Comply to the local standards

This part is the biggest challenge for products and applications which are new. The local authorities are responsible for the local safety and therefore have to deal with risks. For the design, installation, and application of pipelines local regulations or standards are in place. Hydrogen is already used for decades but now gets the focus as new energy and therefore it is new for the local authorities. This means that regulators are extra keen on the risk assessments. The same yields for the SoluForce pipe which is already successfully used for 25 years in the oil and gas industry. The advantages of the SoluForce product are recognized by hydrogen or new energy customers, especially because SoluForce has already hydrogen certified products. Now the challenge is to comply to the local regulations which are very much focused on standard materials and the natural gas transport and distribution. The maximum allowed operating pressure is the large difference, where the distribution is typically set to 16 bar and allowed to be operated by local distribution network companies (DSO), while above that pressure the national operators operate the network (TSO). Also the allowed pressure levels for non-metallics are typically below 16 bar.

Typically the today's electrolysers produce 30 bar Hydrogen. This pressure level falls outside the typical TSO distribution production. Energetically it would be really unacceptable to first reduce the pressure below the 16 bar to allow the TSO to distribute the hydrogen, while the consumers or a possible backbone operates at 30 bar or higher. Furthermore any line packing or hydrogen storage in the pipeline will be drastically reduced.

In order to comply to the local standards it needs to be checked which standard apply and overcome the gap between these regulations and the project specifications and operation and very thing in between.

2.2 First Dutch hydrogen SoluForce pipe learnings

2.2.1 Qualification

The first step in the hydrogen journey was to qualify the SoluForce pipe for hydrogen. Kiwa assessed the SoluForce pipe system for hydrogen applications against API 15S. This resulted in several extra tests. The extra main items for the hydrogen application to check are:

1. Chemical compatibility of the used materials against hydrogen ;
2. Permeation of hydrogen ;
3. Rapid decompression of pipe system.

Qualification

Chemical compatibility
Permeation of hydrogen
Rapid decompression

The Kiwa assessment was finalized with a certificate for the application of hydrogen laid down in a Kiwa covenant (K101779-02). The SoluForce datasheet for hydrogen application lists all the specifications.

2.2.2 Project versus Pipe system specifications

Due to the innovative drive of multiple Dutch companies a project for a local industrial hydrogen backbone was made. In the Groningen-seaport different companies are clustered where already hydrogen is a side product. Together with a hydrogen production the industries on the area will use the hydrogen for their activities.
The project specifications, including the performance of the electrolyser, were compared with the pipe system specifications and showed to be inline.

2.2.3 Risk assessment

In order to be allowed to perform a project a quantitative risk assessment (QRS) needs to be performed for the project. In case well known fluids are used with standard materials such a risk assessment is a straight forward job. In case of this situation, where hydrogen and a not commonly used pipe material is applied, such a risk assessment is quite extensive. The SoluForce certification for the German gas standard DVGW VP642 gave a big advantage here, for this certification already a risk assessment was made.

Risk management

QRA
BEVB / REVB regulation
SAFETI calculation

In a project team supported by the Dutch authorities RIVM (RijksInstitute voor Volksgezondheid en Milieu, Governmental institute for health and environment) a full risk assessment was

performed. The base for the risk assessment are the BEVB (besluit externe veiligheid buisleidingen, decision external safety pipelines) and REVB (regeling externe veiligheid, regulation external safety pipelines). A list of risks are analysed and given a probability number according to specific rules and next are put in the risk assessment calculation program SAFETI (P010319/2020.00724). The conclusion was that the SoluForce pipe could be installed for this Hydrogen project.

This risk assessment document is available. It can be used helping to make such a risk assessment for a specific project more easy to complete. For the projects in this Hy2market project it will be necessary to identify local pipeline safety regulations.

2.2.4 Local engineering regulations

Engineering

NEN3650
NEN3651
PLE calculation protocall

To be allowed to construct a pipeline in the Netherlands it is mandatory to comply to the Dutch local regulations / standards NEN3650 and NEN3651 and associated documents. NEN3650 is the general standard and the NEN3651 is a special regulation for waterways. The NEN3650 consists of several parts, starting with a general part and parts for specific pipeline materials:

- NEN3650-1 General
- NEN3650-2 Steel pipes
- NEN3650-3 Non-metallics and GRE pipes (solid wall)
- NEN3650-6 FCP pipes (being worked on)

This standard describes how to design a pipeline and which issues have to be taken care of. The standard takes into account the transportable fluid and divides the application is classes. All kind off issues have to be taken into account and the designed pipeline needs to be modelled in a software program. Typically the PLE program is used for this modelling. In the Dutch case for the Groningen-seaport project the NEN3650-3 was used. The SoluForce pipe has the same properties as a standard HDPE pipe when there is no pressure, but behaves like a composite when under pressure. In NEN3650-3 both are described. The standard HDPE pipe part is used for the situation where there is no pressure and for the situation with pressure the GRE part is used. This is possible because GRE pipes also have different specifications for axial and radial direction. An engineering company has designed the Groningen-seaport pipeline and made the procedure for calculating the SoluForce pipeline according to NEN3650-3. This calculation was checked and approved by Lloyds. This means that for this project the pipe design with the SoluForce pipe complied to the local engineering regulations.

When looking into the standards it shows that many NEN regulations are also EN NEN regulations and applicable for other European countries. It seems that the NEN3650 and NEN3651 are Dutch regulations and not European. Other countries most probably have less stringent regulations. The Dutch regulations are tight because of the large risk of soil deformation resulting from the high water tables and different weak soils. Most probably these Dutch standard might be accepted by other local European authorities. For the Hy2market projects this means that it is necessary to identify such design regulations are get the Dutch ones acknowledged.

2.2.5 Horizontal directional drilling (HDD)

Already several projects are active in the Netherlands for the transport of hydrocarbons. In several of these projects HDD is considered. Moreover in one project already the HDD is being engineered. For HDD also the NEN3650 and NEN3651 are applicable. HDD is an installation process and therefor the pipe is not under pressure of the transport fluid. The pipe is pulled into a drilled hole and will see several forces resulting in axial pulling force, bending force and external compression forces. For NEN there is a modelling is performed by using the Sigma calculation program. For this program specific material properties need to be filled in. The properties of the SoluForce pipe has been checked and compared to the standard HDPE material properties at the right temperature and time scale. It has been shown that the SoluForce pipe can modelled as a full wall HDPE pipe with the same material properties as for HDPE. These parameters can be found in the SoluForce datasheet.

HDD

NEN3650
NEN3651
Sigma calculations

For the Hy2market projects this means that also this program and these standard could be used to design the HDD which are planned for these project. The outcome

2.2.6 Hy2market Dutch projects

2.2.6.1 SoluForce project

In the Hy2market a Dutch project will be realized where SoluForce is in the lead. In first instance a project in Emmen was selected, however this project could not be realized. A new project is selected in Deventer, building the first part of a hydrogen backbone together with gas company Firan. The location of the hydrogen production is known and the different present and future offtakers. Presently the ROW is checked and in order to increase the success factor for this project it is checked if an abandoned pipe can be used as casing, reducing the need for civil works.

2.2.6.2 HyE TS project

The other pipeline realization is led by Hey TS. In this case a pipeline will connect the Nobian electrolyser to the compression station through a HDD crossing a waterway. The project is already approved by the local authorities and engineering is performed.

Hy2market projects

3.1 General

For supporting the Hy2market projects in Frans and Portugal first an extended excel filling form was send. The requested data are about the operational parameters, the local area conditions, possible installation techniques, ROW details and local regulations. With these details a gap analyses can be made to understand open issues and to start a detailed deployment plan.
In the next paragraphs the present information about the projects is shown and where possible already a gap analyses made.

3.2 France Rhone-Alpes region (CNRhone)

3.2.1 General

This project handles about a hydrogen pipeline in the Rhone-Alpes region where an electrolyser on an island in the river near Lyon needs a connection to the shore. The pipeline can be a DN100 pipe which is intrinsically operating at 40 bar and a max pressure of 50 bar. In the future the pressure shall be increased to possibly 100 bar to enable injection onto a planned European hydrogen backbone. Preferably the later compression to 100 bar is done at the electrolyser area where here is power and room. It handles about a pipeline of about 700 meters which needs to be installed using HDD. The HDD crosses for a large part the waterway and also a high way and a local road. The hydrogen will be 99.995% pure. The impurities will be less then 50 ppm of O_2, N_2, H_2O.
The project shall be commissioned by end of 2026. Works start in 2025.

3.2.2 Regulations

Next to the local regulations which still need to be checked already several issues are set:

1. Lifetime >50 years (SoluForce at least 50 years) ;
2. Inspections every 10 years (possible for SoluForce, maybe insert spool piece) ;
3. Piggable (SoluForce piggable with PUR foam pig) ;

3.2.3 Location

Below the picture shows the location of the pipeline.

3.2.4 Frans preliminary standards and regulations list

For the SoluForce qualification and certification for the Frans authorities, a preliminary list is made of assossiated standards and regulations. For the Rohne project at least the same will be applicable. Table 1 lists the documents

Table 1: List of assossiated standards and regulations (France)

#	Document	SF Comply
1	NF EN ISO 9001: 2015 “Quality Management System – Requirements”	yes
2	API SPEC Q1: 2019 + Errata 1 to 3 + ADD 1 & 2 “Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry”	yes
3	API 17B: 2014 “Recommended Practice for Flexible Pipe”	partly
4	API 17J: 2017 + Errata 1 & 2 + ADD 1 “Specification for Unbonded Flexible Pipe”	partly
5	API 15S: 2019 + Errata 1 + ADD 1 “Spoolable Reinforced Plastic Line Pipe”	yes
6	NF EN 1594 « Système d’alimentation en gaz – Canalisations pour pression maximale de service à 16 bars – Prescriptions fonctionnelles »	project
7	ISO TS 18226 « Tubes et raccords en matières plastiques – Composition »	yes
8	NF EN ISO 13628-10 : 2010 “ Industries du pétrole et du gaz naturel - Conception et exploitation des systèmes de production immergés - Partie 10 : spécification pour canalisations flexibles composites »	Partly / offshore
9	French Ministerial decree on the 03/07/2020 modifying the 03/05/2014 version (“Multifluids ministerial decree”)	To be checked

3.2.5 First project analyses

When all present details are overseen the following can be mentioned:

1. Initial operating parameter can be met with the SoluForce M480 H2T pipe ;
2. The regulations of 3.2.2 can be met with the SoluForce pipe ;
3. The present SoluForce pipe will not be capable to run at 100 bar. If the compression will be at the electrolyser site the pipe will need to be capable of operating at 100 bar ;
4. SoluForce will have a hydrogen pipe available beginning of 2025 for over 100 bar. This pipe can be used for this project. Both schedules are inline ;
5. HDD can be designed according to the NEN3650 regulations, if allowed ;
6. Up to now there is no list of applicable regulations give, only a copy of the standards which were listed for the SoluForce Frans certification. It will need to be checked if more regulations apply. Probably the NEN3650 and NEN3651 may help ;

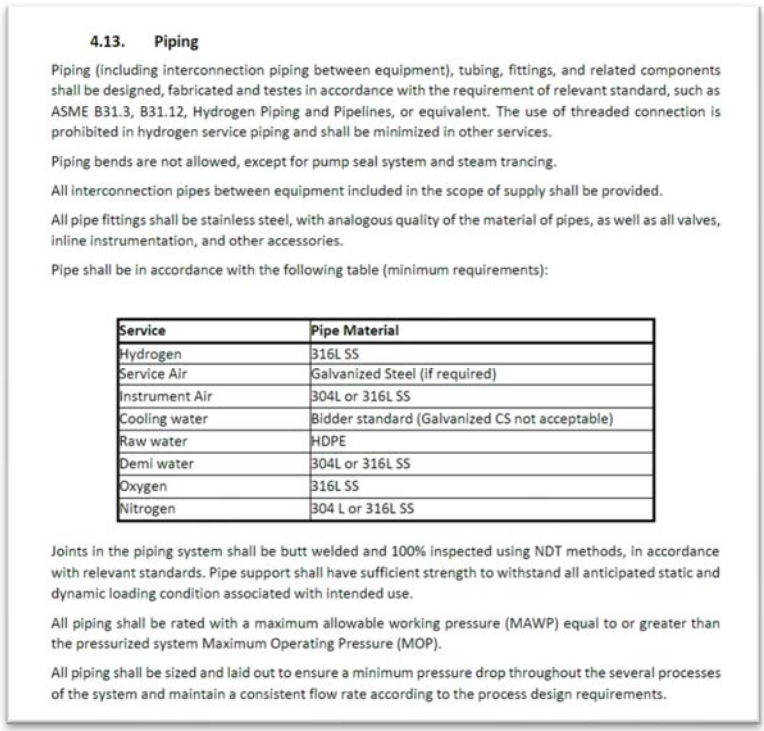
3.3 Spain Asturias region (EDP/SMEs)

3.3.1 General

This project handles about a hydrogen pipeline in the Asturias region where an 100 MW electrolyser needs to be connection to a the power plant across Aboño river. Most probably the pipeline must be 6” to 12” pipe. The pipe needs to handle 1800 kg H_2 per hour at approximately 30 bar. The exact components in the fluid are not known yet.

3.3.2 Regulations

A list of regulation was give which needs to be complied to. Part is giving the properties of the pipe and part is the design of the pipeline. A gap analyses is being made to see if the SoluForce pipe and the pipeline can comply to it. Table 2 shown the list of the documents.
Additional as small list of the material was given where it shows that for the fitting system SS 316L shall be used and some extra pipeline settings.



4.13. Piping

Piping (including interconnection piping between equipment), tubing, fittings, and related components shall be designed, fabricated and testes in accordance with the requirement of relevant standard, such as ASME B31.3, B31.12, Hydrogen Piping and Pipelines, or equivalent. The use of threaded connection is prohibited in hydrogen service piping and shall be minimized in other services.

Piping bends are not allowed, except for pump seal system and steam trancing.

All interconnection pipes between equipment included in the scope of supply shall be provided.

All pipe fittings shall be stainless steel, with analogous quality of the material of pipes, as well as all valves, inline instrumentation, and other accessories.

Pipe shall be in accordance with the following table (minimum requirements):

Service	Pipe Material
Hydrogen	316L SS
Service Air	Galvanized Steel (if required)
Instrument Air	304L or 316L SS
Cooling water	Bidder standard (Galvanized CS not acceptable)
Raw water	HDPE
Demi water	304L or 316L SS
Oxygen	316L SS
Nitrogen	304 L or 316L SS

Joints in the piping system shall be butt welded and 100% inspected using NDT methods, in accordance with relevant standards. Pipe support shall have sufficient strength to withstand all anticipated static and dynamic loading condition associated with intended use.

All piping shall be rated with a maximum allowable working pressure (MAWP) equal to or greater than the pressurized system Maximum Operating Pressure (MOP).

All piping shall be sized and laid out to ensure a minimum pressure drop throughout the several processes of the system and maintain a consistent flow rate according to the process design requirements.

Table 2: List of assossiated standards and regulations (Portugal)

#	Document	SF Comply
1	ASME B31.12-2019. Tuberías y oleoductos de hidrógeno.	check
2	ASME B31.8-2020. Sistemas de Tuberías de Transmisión y Distribución de Gas.	check
3	CGA G-5. Hidrógeno.	check
4	ISO/TR 15916:2015. Consideraciones básicas para la seguridad de los sistemas de hidrógeno.	check
5	NCSE-02. Norma de construcción resistente a terremotos NFPA 2 Código de tecnologías de hidrógeno	check
6	NFPA 2. Código de Tecnologías del Hidrógeno.	check
7	UNE 60302:2015. Tuberías para combustibles gaseosos. Emplazamiento.	check
8	UNE 60305:2015. Tuberías de acero para combustibles gaseosos. Zonas de seguridad y coeficientes de diseño según su emplazamiento.	check
9	UNE-EN 1594:2014. Infraestructura de gas. Tuberías para una presión máxima de funcionamiento superior a 16 bar. Requisitos funcionales.	check
10	CGA G-5.3. Especificación de productos básicos para el hidrógeno.	check
11	CGA G-5.4. Estándar para sistemas de tuberías de hidrógeno en las ubicaciones de los usuarios.	check
12	CGA G-5.5. Estándar para sistemas de ventilación de hidrógeno.	check
13	CGA G-5.6. Sistemas de tuberías de hidrógeno.	check
14	NFPA 55. Código de Gases Comprimidos y Fluidos Criogénicos.	check
15	IGC 13/12/E Oxygen pipeline and piping systems	N.A.
16	ISO 11114-1:2020 Cilindros de gas. Compatibilidad de los materiales del cilindro y la válvula con el contenido de gas. Parte 1: Materiales metálicos.	N.A.
17	Norma ISO 22734:2019. Generadores de hidrógeno que utilizan electrólisis de agua: aplicaciones industriales, comerciales y residenciales.	N.A.
18	Norma ISO 26142:2010. Aparato de detección de hidrógeno. Aplicaciones estacionarias.	N.A.
19	ISO/TS 19883:2017. Seguridad de los sistemas de adsorción por cambio de presión para la separación y purificación de hidrógeno.	N.A.
20	UNE-EN 10028. Productos planos de acero para uso a presión.	N.A.

21	UNE-EN 16726:2016+A1:2019. Infraestructuras gasistas - Calidad del gas - Grupo H.	N.A.
22	UNE 60309:2015. Tuberías para combustibles gaseosos. Espesor mínimo de pared para tuberías de acero.	check
23	UNE 181001:2010. Tecnologías del hidrógeno - Terminología.	check
24	UNE-EN 1127. Atmósferas explosivas.	check
25	UNE-EN 12186:2015. Infraestructura gasista - Estaciones reguladoras de presión de gas para transporte y distribución - Requisitos funcionales.	check
26	UNE-EN IEC 60079. Atmósferas explosivas.	check
27	UNE-EN ISO/IEC 80079. Explosive atmospheres.	check

The first analyses show that a large part is about the engineering of the pipeline which just needs to be followed. No obstacles for SoluForce are found yet. Non-metallics are not always mentioned, but at least it is also no excluded. The material properties for steel pipes are mentioned. With the datasheet of the SoluForce pipe, the API 15S qualification and the Kiwa covenant a large part can be covered.

3.3.3 Location

Up to now the exact location is not known. This will become more clear at the next meeting in Portugal.

3.3.4 Operational conditions

Details are given about the pipeline. There are two parts, one of 400 meter and one of 14 km, both having a capacity of 1800 kg H_2 per hour. Suggested are 6” or 12” pipe. SoluForce has already a Hydrogen pipe available and will also develop a 6” and a 8” hydrogen pipe. Indicational calculations are made to get a view in which pipe dimensions are necessary for this project. In table 3 and 4 the results of the calculation are listed. For the calculation the SoluForce gas calculation is used (GPC6). From the calculations it can be concluded that for purely the transport of the hydrogen in the 400 meter case SoluForce M570 H2T is more than enough and maybe even a M480 H2T. For the long 14 km length the SoluForce M5570 H2T pipe can do the job, but a pipe of 6 or 8” would be preferable. A 12” pipe is overdone. In this calculation the line packing is not taken into account for possible storage of hydrogen.

Table 3: 400 m pipe section, calculated parameters

Parameter	units	SF M570 H2T	SF 6”	SF 8”	Steel 6”	Steel 12”
Internal diameter	[mm]	122	133	194	146	299
Capacity	[kg/hr]	4024	5066	>10000	6496	>43000
Outlet pressure	[bar]	29	29	29	29	29
400 m, Inlet 30 bar, 25°C, target 1800 kg/hr H_2						

Table 4: 14 km pipe section, calculated parameters

Parameter	units	SF M570 H2T	SF 6”	SF 8”	Steel 6”	Steel 12”
Internal diameter	[mm]	122	133	194	146	299
Capacity	[kg/hr]	1800	1800	>2340	1800	>7400
Outlet pressure	[bar]	22	25	29	27.2	29
14 km, Inlet 30 bar, 25°C, target 1800 kg/hr H_2						

3.3.5 First project analyses

When all present details are overseen the following can be mentioned:

1. In principle SoluForce can do the job with the M570 H2T pipe ;
2. Depending on the time line also new larger SoluForce pipes in the portfolio will be able to perform the long length job, with possible extra capacity ;
3. The SoluForce pipe will give advantages in easy installation and lower OPEX, equal to the Rhone project ;
4. The regulations will need to be checked, an gap analyses is being made. The English versions of the documents are used ;
5. The first analyses show that a large part is about the engineering of the pipeline which just needs to be followed. No obstacles for SoluForce are found yet ;
6. Most probably the NEN3650 and NEN3561 may be used as well ;
7. The small regulation sheet details can be met by the SoluForce products.

Additional testing campaign

4.1 General

For the Hy2market projects it shows that already the majority of the SoluForce pipe system tests have been performed in order to comply to the regulations and engineering rules.

Two items are still remaining:

1. Effect of linerpipe material on the purity of the hydrogen ;
2. Engineering and handling of SoluForce pipes on pipe racks ;

These tests will be performed under the WP3.C.3 budget for other services. Request for offers has been send out and probably beginning of April work can be started.

4.2 Hydrogen purity

The hydrogen purity is very much important for the offtakers. When the hydrogen is leaving the production site it is fully cleaned and dried and in perfect condition for the offtakers. Especially for the fuel cells the high purity is of importance.
The SoluForce liner pipe is made of HDPE100 Ineos TUB121 which has a drinking water certificate, meaning that the drinking water is not affected by the material. Still to be sure a simple test has been designed to check if the material will effect the purity of the hydrogen. For this a piece of the material will be put in an autoclave and cycled several times with hydrogen with a period of 52 bar H_2 pressure and a period with no pressure. The periods will be long enough to give the gas the possibility to ab-sorb and dis-sorb. After 20 cycles the gas content will be checked for impurities. The test will be performed by a third party.

4.3 SoluForce on pipe racks

Typically SoluForce is installed on the ground or buried. In the case that the pipe is used in an industrial area it may be necessary for the pipe to run on a pipeline rack. For this the pipe will need to be fixed and supported. Fixing the pipe will give forces on the pipe and the pipeline rack. For several standard set ups an engineering company will calculate the forces and see if any special attention needs to be made. It will give advice about the maximum support spacing, catenary and clamp conditions. The modelling will be performed by an engineering company. Furthermore a SoluForce pipe document needs to be written for the handling, design and pipe rack working procedure on such pipe racks. The document will need to be written by SoluForce.

Actions

The following actions will need to be performed:

1. Add regulation and standard list for France and Spain project (CNRhone , EDP) ;
2. GAP analyses of the regulations and standards (SoluForce, CNRhone , EDP) ;
3. More ROW information for the Spain project (EDP);
4. Check possibility to deploy SoluForce for the France and Spain projects (SoluForce, CNRhone , EDP) ;
5. ROW Deventer project and installation plan (SoluForce, Firan) ;
6. Hydrogen purity test (SoluForce) ;
7. SoluForce pipe rack modelling (SoluForce) ;

References

5.1 Reference list

Ref	Document
[1]	**SoluForce - T-D-003 - Technical Datasheet for SoluForce Classic H2T- 003.1**
[2]	**API - API 15S - April 2022 - Spoolable reinforced plastic line pipe**
[3]	**API - API Q1 - June 2018 - specification for quality management system requirements for manufacturing organizations for the petroleum and natural gas industry**
[4]	**Kiwa - K101779-02 - Hydrogen Covenant Soluforce**
[5]	**BEVB - 2020.00724 - QRA for plastic pipe system hydrogen backbone Groningen seaports**
[6]	**NEN - NEN3650 - Requirements for pipeline systems part (1 &3)**
[7]	**NEN - NEN3651 - Additional requirements for pipelines in or nearby important public works**
[8]	**EDP - SoluForce Excel project information filling forms EDP**
[9]	**CNR - SoluForce Excel project information filling forms CNR Rhone**
[10]	**SoluForce - GPC6 - Gas pipeline capacity calculation sheet**

5.2 Standards and regulations

Many standards and regulations are not open source and are bought for explicit use by the buyer only, therefore the listed standards and regulations cannot be shared.
These standards and regulations can be found at the document originated organizations.
The following links can be used:

List of all Codes and Standards - ASME	Shop By Publisher (techstreet.com)
ISO - Standards	API Webstore
CGA Publications (cganet.com)	The List of 300+ Codes and Standards (nfpa.org)

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