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Applications of corrosion free tubulars: the choice for GRE. Case history: Melun l'Almont, France

by *Wilfried Haarman & Laura van Strien

STAR Fiber Glass Systems BV, PO Box 310, 7570 AH Oldenzaal, The Netherlands

ABSTRACT

Glassfiber Reinforced Epoxy (GRE) is becoming the material of choice for corrosion control related to geothermal energy exploration. Applications extend to all facets of waterproduction, from low to high pressure flow lines, tubing and casing, including cemented liners and slotted production liners. GRE pipes have numerous advantages over steel or coated steel pipes. Dominant among the advantages is the corrosion resistance against i.a. CO_2- and/or H_2S-gas and salty water. Another specific advantage of GRE in comparison with steel is the light weight and the easy handling and installation.

In order to show the suitability of GRE-tubulars in a geothermal application, the geothermal energy-exploration site in Melun l'Almont, France, makes a perfect example. A "new generation" geothermal well has been successfully completed at Melun l'Almont, 50 km south of Paris, on March 2 1995. This well is the fourth to be drilled at this site where, in 1969, the doublet technique (a production well associated with an injection well) was developed using the initial two geothermal boreholes. The third well was drilled in 1989 to replace the injection well that had become slightly damaged after twenty years of service.

KEYWORDS

Corrosion-free, pipe-systems, geothermal applications

1. Introduction

This presentation will deal with the following subjects: first, you will get (further) acquainted with the company STAR Fiber Glass Systems. Then, you will get an overview of the various products that form it's product range. In this part, we will provide you with not only the "sec" data and figures; we will also indicate the main applications and the specific application-methodsper product. Although GRE, as an alternative to steel, is already quite commonly used by many of you and your companies, there are still many varieties of GRE.

We would like to take this opportunity to tell you something about the production process and the specific qualities of STAR GRE-tubulars. One important aspect of the process of choosing GRE and, after that, of selecting the producer of the GRE is the total of the costs during the project-lifetime. This is also a matter tbat will be discussed during this presentation. Although we can tell you all kinds of beautiful stories about the quality of our production process, the resulting products and the supplied service, you will probably be more convinced by the international quality approvals that we obtained for all the applications that we supplied our products for. Finally, when we will have given all the theoretical data on STAR Fiber Glass and it's products and services, we will go into the day-to-day practice of the application of GRE tubulars by means of a detailed case-history

2. Company profile

STAR Fiber Glass Systems BV, located in Oldenzaal, The Netherlands, is the exclusive distributor of Fiber Glass Systems Inc. for Europe and North Africa. The production facilities of FGS Inc. are located in San Antonio and Big Spring, Texas, **US.**

STAR Fiber Glass is part of the Dutch holding company Vos Groep BV, headquartered in Oldenzaal as well. The Vos Groep consists of many companies with various specialisations in i.a. the oil- and gas-production sector. The companies can benefit from each other's know-how, and, depending on the characteristics of a project, act individually or complement each other when acting as a group.

From the Oldenzaal business location, various activities take place. First, it is the central sales-office of STAR products for Europe and North Africa. With the assistance of our representatives in several countries, our sales staff serves the customers throughout this area of distribution. Also located in Oldenzaal is the workshop. In this workshop, the pipes imported from the United States are worked on and finished to serve the customer's demands. STAR Fiber Glass also has excellent storage facilities, including a bonded warehouse, so customers can be served very fast, if needed. After-sales service is provided by our very well equipped technical staff. Finally, our customer service department will make sure that all phases of the process, from the first inquiry through the production, delivery and installation process to the final payment, will be arranged effectively and efficiently according to the customer's wishes.

3. Products and joining methods

The product-range of STAR Fiber Glass consists basically of three groups of fiberglass epoxy (GRE) pipes:

1. Line pipe and fittings
2. Tubing
3. Casing

These groups on their turn consist of several products, varying by diameter and pressure rating. For the various kinds of applications, these products require various joining methods, which will be dealt with in detail. Finally, a few of the most common applications were selected and will be discussed during this presentation.

Line pipe

Line pipe is available in sizes ranging from 1" to 12". This group of products can be divided in two pressure classes: low pressure and high pressure. Low pressure according to API-standard, all pressures up to 500 psi. For this **type** of line pipe, three different joining methods can be offered:

1. Adhesive Bond Connection (ABC)
2. STAR Super Seal **(SSS),** O-ring seal connection with thread
3. Threaded connection, API 8rd

High pressure line pipe is available in a pressure rating from 500 to 4,000 psi. For this type of line pipe, the best available joining method is another API 8rd connection: Advanced Composite Thread. ACT is a molded thread, with an excellent performance in high pressure applications.

For both **types** of line pipe, the connection will preferably be made by an integral joint, meaning that one end of the pipe has a conical shape with a female thread and the other end has a male thread so the pipes can be easy connected with a thread compound for a leakfree joint.

Downhole tubulars

Downhole products can be divided in tubing, with a nominal diameter of 1" to 4" and casing, ranging from 5 _ to 9⁵/8". Tubing is available in pressure rating from 1,000 to 4,000 psi; casing from 1,000 to 2,000 psi. For both products, the best available joining method is the patent Advanced Composite Thread (ACT). For downhole applications, a Threaded and Coupled (T&C) connection is preferred, mainly because of the easy handling with the standard rig tools and equipment; these connections can be screwed and unscrewed several times without any thread damage or break out problems of the tubing. The maximum depth for STAR downhole tubing is 3,000 m, depending on the static fluid level.

4. Typical applications

Although STAR tubulars can be applied in a wide variety of industries and situations, there are some typical applications for which the **use** of GRE is becoming more and more common. For these applications of STAR **GRE,** the field experience is more than **30** years and exceeds 50 million feet. The product is used i.a. in the exploration of geothermal energy and in oil- and gasproduction. **In** table 1, some examples of common applications are shown.

Table 1: Applications of GRE tubulars

Line Pipe Applications	Tubing Applications	Casing Applications
Flow Lines	Water Injection Tubing	Corrosive Zone Casing
Geothermal Water	Disposal Wells	Water Well Casing
High Pressure Injection Lines	Oil Production, ESP – Suckerrod	Cemented Casing/Liners
Tank Battery Hook Up	Gas Lift Production	Slotted Liners
Water Condensate Lines	UGS Tubing	
Natural Gas Pipe Line	Cement Stinger	

5. Production process

In order to explain the qualities of STAR GRE products, some of the characteristics of producing the tubulars will be mentioned here. All pipes are manufactured to the so called filament winding process, with e-glass and epoxy resin cured with aliphatic amine curing agent to give the product high performance in pressure and temperature.

STAR supplies GRE tubulars for the extraction of hot water and for oil- and gas-exploration, mainly as an alternative for steel. GRE is already quite commonly used in other sectors of the economy; usually it regards very low pressure applications. When a higher pressure-rating is needed (up to 4,000 psi or 280 bar), the pipe has a relatively thin wall due to the high allowable hoopstress. This is accomplished by the production of a very compact laminate, with up to 80% e-glass and 20% resin. The twistless glassfibers are filament wound on a polished steel mandrel into very thin compact layers. This process makes sure that, though the walls remain relatively thin, the allowable pressure can be very high.

In the application of traditional (steel) tubulars, the joining methods would always form the weak point in the system. In the case of GRE, the connections are prefabricated during the production of the pipes. Therefore, all work that remains to be done in the field is to screw or glue the pipes together. STAR Fiber Glass offers a mechanical connection, of which the most important are the API 8rd threads; Precision Ground Thread for low and medium pressure line pipe; Advanced Composite Thread for high pressure line pipe and for casing and tubing. For low pressure line pipe, the O-ring connection (STAR Super Seal) and the Adhesive Bond Connection are also available.

One more distinction between STAR GRE and other GRE products is the fact that STAR products have a non reinforced liner. This aspect contributes to the cost-effectiveness of STAR products.

6. Major qualities

The most particular quality of GRE as opposed to carbonsteel is it's resistance against corrosion. GRE tubulars are corrosion **free** against all fluids with traces of CO_2 and H_2S, hydrocarbons, production of water and natural gas (HOSSEIN ARIAN 1996), which make them very suitable for i.a. the geothermal applications mentioned earlier. This means that, taking into consideration the limits regarding temperature (maximum 200°F) and pressure (4,000 psi), they will often make a perfect substitute for steel, because using GRE removes the need for additional protection like plastic lining, cathodic protection and inhibition systems; also GRE material requires little or **no** maintenance.

The flow characteristics of STAR GRE products are excellent (and remain so due to the resistance against corrosion). The very smooth interior gives GRE approximately 30% better flow characteristics than steel because of the very low effective roughness of the material (0.00006") and the Hazen Williams (C=150) . The excellent flow characteristics cause an increase in the flow capacity and the pump-efficiency and diminish the scale build-up and the paraffin build-up.

For downhole applications, STAR provides the STARWELL computer program for stress/strain analysis of the well concerned, so the most suitable type of tubing can he selected.

7. Economics

One specific quality that **needs** extra attention is the economics of STAR GRE tubulars. Although people are convinced of the importance of the advantages of GRE, the price is still an important issue. Usually, the issue will be related to the choice between GRE and steel of some kind. **In** a corrosive environment the expected life time of the system should be taken in consideration when making a statement about the comparison of the costs, when choosing between these materials. The best alternative price-wise will always depend **on** the characteristics **of** the application. E.g. what is the medium, what is the nature of the corrosion-problem (if existing), what is the expected life-time of the application, what will be the operating pressure and temperature, all kinds of details that together will determine the best alternative.

In general, one might say that the initial procurement costs of GRE are higher than carbon steel; lower than stainless steel. But there are more elements of the Capital Expenditure (CAPEX) that already change this relation, not to mention the fact that the final Operational Expenditure (OPEX) is usually lower for GRE than for any kind of steel. Therefore, depending **on** the length of the lifecycle, the total Life Cycle Costs of GRE are considerably lower than for many alternatives (DE LEEUW 1997).

A big but often made mistake would be to only consider the purchasing price of the material. Although GRE might seem a bit expensive compared to steel, this price difference will probably be nullified or even reversed during the installation (PATERSON 1998).

Because of the light weight and easy handling of the material, the installation can be significantly faster than would be the case when using steel. Then, one also has to consider the often very high price of maintenance, of cleaning the pipe, of corrosion protection, etcetera. Leaving exceptions aside, also economically **GRE** will often be the material of choice.

8. International quality approvals

Fiber Glass Systems Inc. possesses the API Q1 quality rate, assuring the consistent manufacturing standards and product performance. The San Antonio and Big Spring production locations both have the ISO 9001 certificate, while the Oldenzaal office has the ISO 9002. STAR is an API 15 HR and API 15 LR approved manufacturer, furthermore the products have many other international quality approvals like the TUV quality and manufacturing contract and the German Hygiene Institut approval for drinking water applications.

9. Case history Melun l'Almont

A "new generation" geothermal well has been successfully completed at Melun l'Amont, 50 km south of Paris, on 2 March 1995. This well is the fourth to be drilled at this site where, in 1969, the doublet technique (a production well associated with an injection well) was developed using the initial two geothermal boreholes. The third well was drilled in 1989 to replace the injection well that had become slightly damaged after twenty years of service. The novel geothermal production well design is based on a patent-no. 9002206 (France), 919005542 (Europe), and 5,228,509 (USA)-that was conceived to reduce corrosion and scaling phenomena that severely affect the integrity and lifetime of wells exploiting the mid-Jurassic (Dogger) carbonate formations of the Paris basin for district heating purposes. Under this new concept, the wells are completed by combining cemented steel casings and fiberglass liners, while the annulus is kept free.

The casings provide mechanical strength (propping function), while the liners furnish chemical resistance (corrosion and scaling protection). The free annular space allows 1) circulating corrosion/scaling inhibitors and/or biocides, which otherwise would need to be circulated using a downhole chemical injection line, and 2) removing and, if necessary, replacing the fiberglass column whenever damaged. It is noteworthy that this design can accommodate a submersible pump set, in which case the upper fiberglass lining is placed under compression and the lower part, of smaller diameter, under tension, i.e., it is freely suspended under its own weight. Vertical displacement of the fiberglass lining is elsewhere eased by an upper expansion spool and fiberglass centralizers (not by couplings as often contemplated in other centralizing designs). At Melun, due to exceptional reservoir performance, artificial lift is no longer required and, instead, self-flowing at high production rates prevails-a fact which led to a simplified design.

The project was commissioned by STHAL in late 1994 and the contract awarded, on a turnkey basis, to a Sedco Forex/Geoproduction Consultants (GPC) joint venture. Owing to its innovative design, the project was granted financial support from the European Union (DG XVII, Thermie program) and the French Ministry of Environment (ADEME). Well drilling/completion/testing operations lasted a total of fifty-two days and were completed in February 1995. An electric drilling rig, with a 350-tonne capacity hook load rating, was used in the project, as well a state-of-the-arttechnologies-e.g., MWD (measurements while drilling), PDC (polycrystalline diamond compact) bits, steerable BHA (bottom-hole drilling assembly), modified design tongs. All these were required by the large dia-meter (44.5 cm), 2,000 m long, deviated (35°) section of the well and the need to run a 24.5 cm diameter, 2,000 m long centralised fiberglass string into the hole. Furthermore, drilling in this densely populated area called for improved environmental measures, like soundproofing, gas abatement and waste processing/disposal, etc.

The well, put online on 21 March 1995, shows high productivity, producing about 70°C fluids at a rate of 200 m^3/h at 2.5 bars wellhead overpressure. It is connected to two existing wells (one producer and one injector); the whole system operates according to a triplet array (two producers, one injector). It will supply geothermal heat (heating proper and domestic hot tap water) to about three thousand dwellings.

The concept of using wells with steel casing and removable fiberglass liners is being seriously considered as an alternative in order to extend the lifetime and improve the reliability of existing installations (over thirty doublets are presently being operated in the Paris area). The following strategy would be used; a new production well would be drilled and completed; the two existing wells would be reconditioned/modified into injectors. Exploitation would resume under a triplet configuration (one producer, two injectors). Total projects costs, including workover, are estimated to be about US$ 3 million. The geothermal operation at Melun l'Almont is now set for at least the next twenty years and will supply 35,000 MWh per year to a group of approximately 3,000 dwellings. This "new generation" well opens up prospects not only for the continuation of existing operations but also for new ones, since they will no longer be affected by corrosion and scaling problems.

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