PIPE
INCREASE
OIL PRODUCTION

SIÃO PETRÓLEO

INTRODUCTION

It is the first equipment ever seen in the oil and gas industry that will be capable of thermal insulation in production columns where no other technology has ever been used due to operating restrictions, that is, after the Christmas tree at the bottom of the oceans. The thermal insulation technology in off-shore and on-shore production columns for oil extraction seeks to increase thermal efficiency, consequently the daily production gain (warmer oil flows faster) and reduce CO^2 emissions.

The figure side illustrates the PIOP installed right after the Christmas tree, which can be used for horizontal and vertical wells.

SIÃO PETRÓLEO

WHY PIOP ITS UNPUBLISHED?

A brief explanation of why PIOP technology is better than that of VIT and why PIOP can avoid the shortcomings of vacuum-based insulation technologies.

SIÃO PETRÓLEO

VACUUM INSULATION TECHNOLOGY

Disadvantages of vacuum-based technology for oil production:

- **Produced water, either in onshore or offshore wells, contains organic acids.**

- **In a water solution, acids produce H+ ions.**

- **H+ is a free hydrogen atom.**

- **Hydrogen is the smallest atom in nature (approximately 5 x 10-8 mm in diameter);**

- **Hydrogen atom passes through the steam pipe's metal walls and reacts with the "getters", causing it to lose its absorption potential.**

VACUUM INSULATION TECHNOLOGY

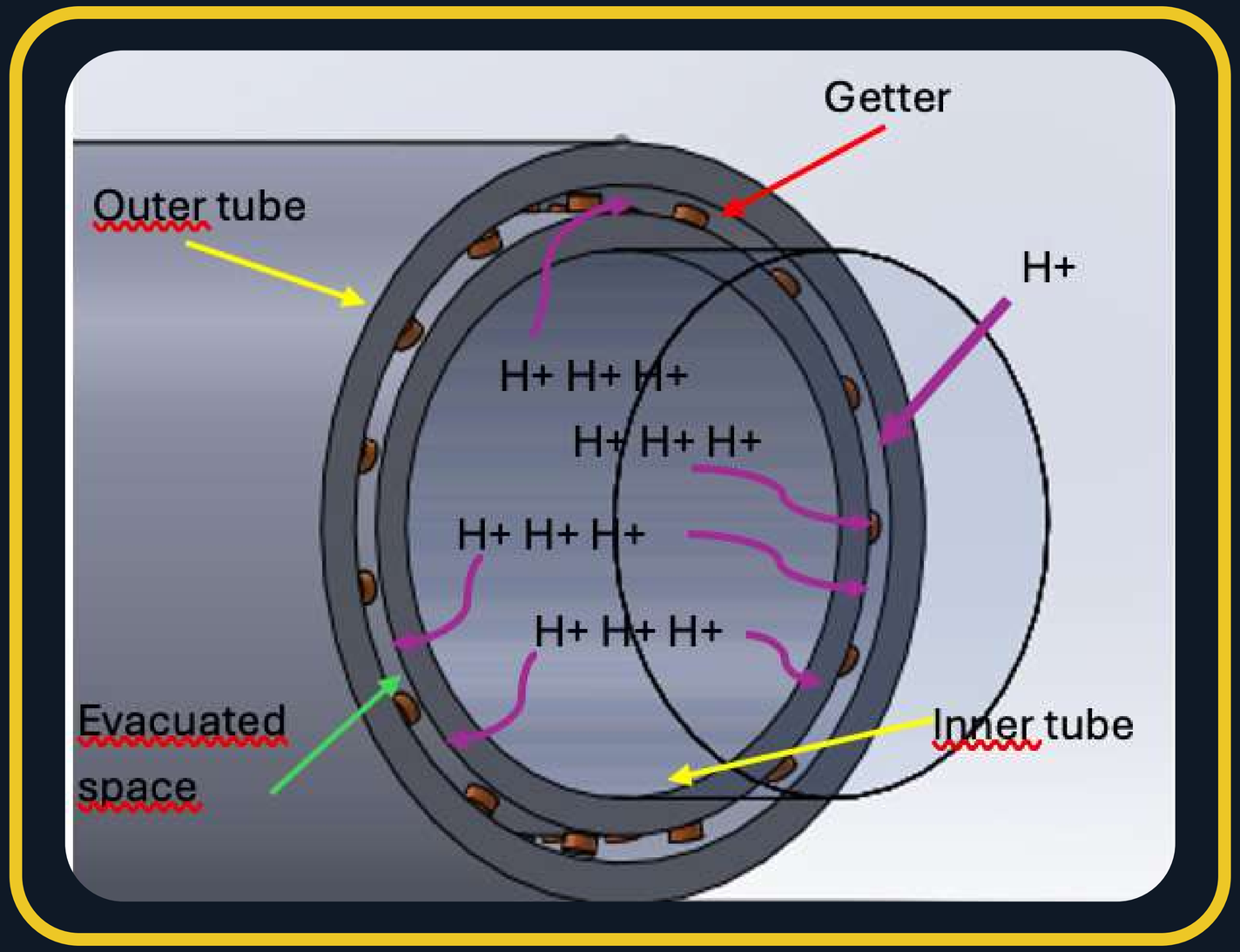
- Hydrogen’s thermal conductivity is higher than that of air. So, as far as thermal insulation is concerned, it is worse to have hydrogen in the evacuated space than to have air.

- For two reasons the presence of Hydrogen in the evacuated space jeopardises the pipe’s thermal insulation property.

- By losing its vacuum, VIT allows the oil/water mixture to exchange heat with the cold surroundings causing the mixture’s temperature to drop below crystallization of some of oil’s components, that adhere to the pipes inner wall, jeopardising production.

- Then, Vacuum insulated tubing, VIT, will have to be replaced, production will stop, operational costs (and risk) are incurred and so is loss of profit to the oil well operator!

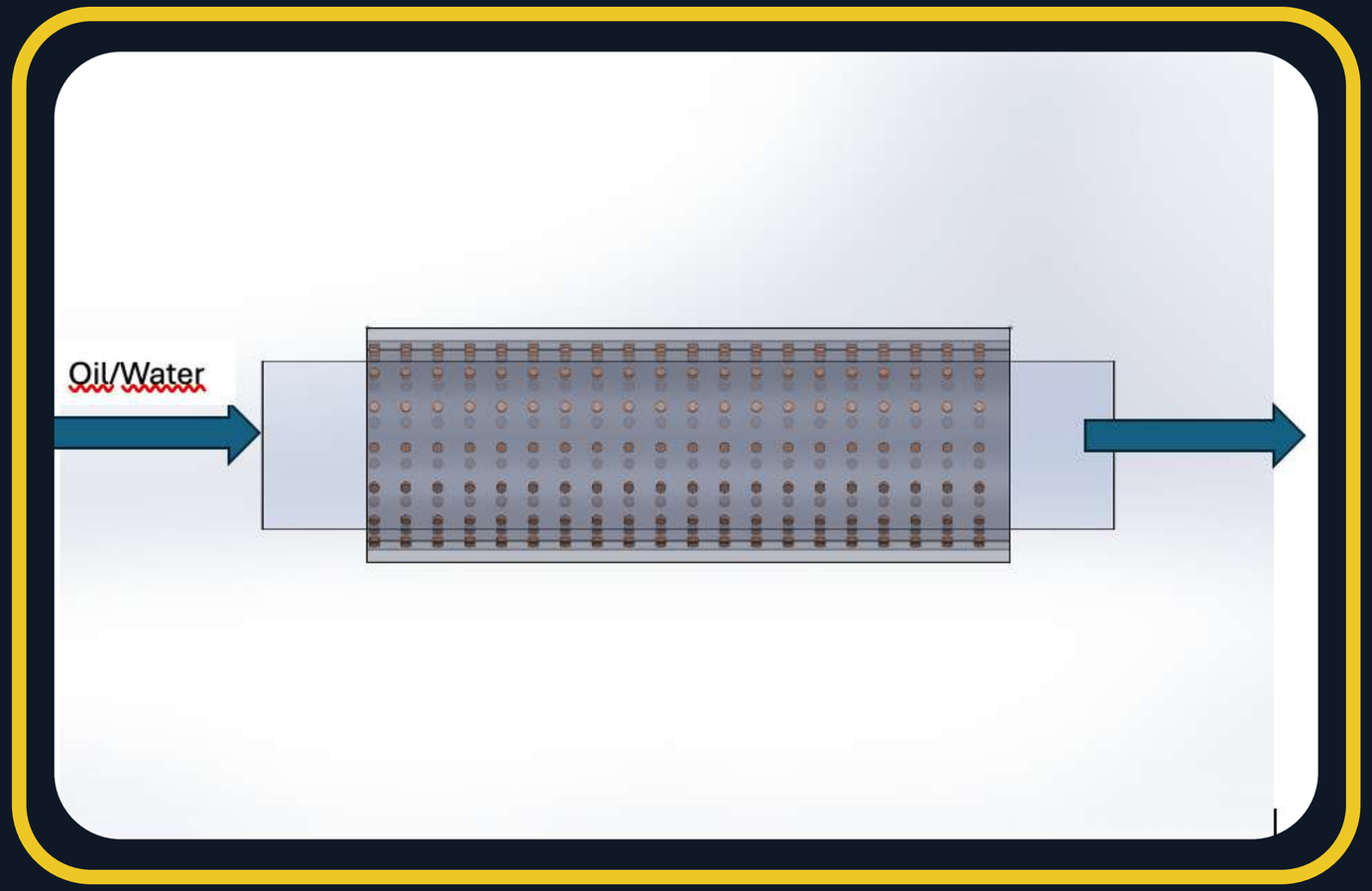
SIÃO PETRÓLEO



A SECTION OF VIT

A section of VIT showing outer and inner tubes and the getters, placed in the annular space between the two tubes. The drawing is on escale.

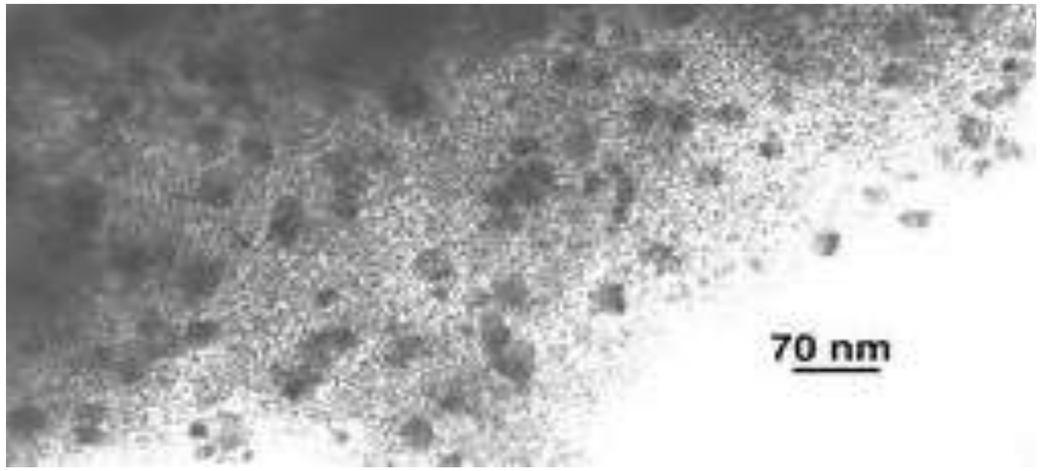
SIÃO PETRÓLEO



OUTER AND INNER TUBES BECAME TRANSPARENT TO ALLOW VISUALIZATION OF THE GETTERS.

SIÃO PETRÓLEO

PIOP USES A SPECIAL CERAMIC DUST

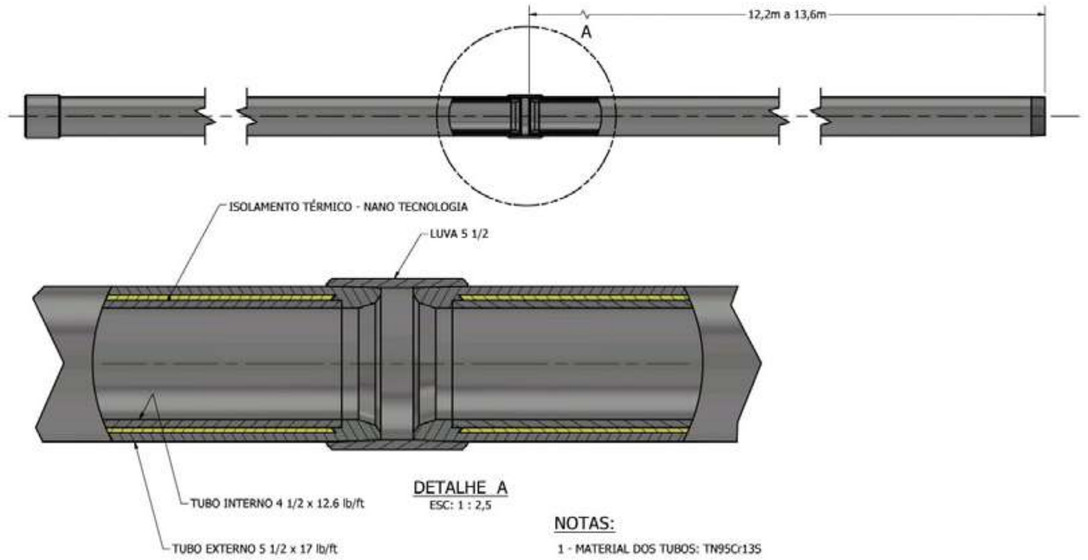


Nano-particle's size

PIOP uses a special Ceramic Dust derived from Nano Technology. This is the same technology utilised in NASA's space programmes to thermally insulate their satellites in space.

Silica is a poor conductor of heat. Silica aerogels or fumed silica are composed of silica nanoparticles interspersed with nanopores filled with nano vacuums. As a result, this substance is mostly made up of vacuum as no atom or particle fits inside its pores. These properties make nano aerogels or fumed silica the best thermal insulators known to man, maintaining and invariable production column thermal efficiency for more than 30 years.

THE ASSEMBLY OF THE INDIVIDUAL PIOP'S



The figure demonstrates the assembly of the individual PIOP'S. The diameters that form the set are varied, depending on the configuration of each well. On 6 5/8" production columns, we use the 8" OD with an insulation thickness compatible with a 9 5/8" casing.

SIÃO PETRÓLEO

RESULTS OF A TYPICAL SIMULATION OF PIOP EFFICIENCY

This presentation aims at showing and analyzing the results of a deep-water computer simulation of a homogeneous mixture of oil and water, flowing through PIOP tubing, from the oil reservoir to the sea floor, according to the following data.

SIÃO PETRÓLEO

SIMULATION DATA

1. Vertical Well;
2. Sea water depth - 2.000 meters;
3. Water temperature at sea floor - 3.5°C;
4. Soil temperature varies linearly from sea floor to the oil reservoir.
5. Oil reservoir temperature – 85 °C;
6. Soil composition - Sand;
7. Completion fluid – Sea Water;
8. Production tubing - Range 3;
9. Casing OD 9 5/8, weight 53.5 lb/ft;
10. Well bore diameter = OD Casing + 4 in;
11. Well depth, bellow sea floor – 1,500 meters.
12. Oil pressure in the reservoir – 4,985 psi;
13. Produced fluid considered as a homogeneous mixture of oil and water.

PIOP CONFIGURATION

- **External tube OD 5 1/2 in**
- **Weight - 17 lb/ft;**
- **Wall thickness – 0.304 in;**
- **Internal tube OD 4 1/2 in**
- **Weight - 12.6 lb/ft;**
- **Wall thickness – 0.271 in;**
- **Tube length - 13.6 meters, range 3**

Insulating material based on nano technology and located in the annular space between the concentric internal and external tubes

PRODUCTION DATA

- **Flow rate: 300 cubic meters per day**
- **Water produced: 150 cubic meters per day**
- **Percentage of water: 50%**

Minimum Temperature required at sea floor: 63 ºC.

SIMULATION DATA

To ensure the reliability of the results, the simulation was carried out using two different numerical methods, Finite Volumes and Finite Elements, addressing two situations:

1. Production tubing without thermal insulation - Bare tubing.

2. Production tubing with thermal insulation – PIOP
The results obtained by the two numerical methods showed a difference of less than 0.3%, which guarantees their reliability.

The main result of the Bare tubing simulation was the oil pressure at sea floor.

The main result of the PIOP simulation was the oil temperature at sea floor.

SIÃO PETRÓLEO

BARE TUBING SIMULATION RESULTS

Mixture (oil/water) flow rate: 300.00 m3/day

Water flow rate: 150.00 m3/day

Percentage of water: 50.00 %

Well depth: 1,500 m

Oil Temperature in the reservoir: 85.000 ºC

Oil Temperature at sea floor: 60.190 ºC

Oil pressure in the reservoir: 4,984.853 psi

Oil pressure at sea floor: 2,944.835 psi

Pressure drop: 2,040.017 psi

Pressure drop due to viscosity: 59.434 psi

Pressure drop due to gravity: 1,980.703 psi

Total heat lost by tubing: 239,904.500 W

PIOP TUBING SIMULATION RESULTS

Mixture (oil/water) flow rate: 300.00 m3/day

Water flow rate: 150.00 m3/day

Percentage of water: 50.00 %

Well depth: 1,500 m

Oil Temperature in the reservoir: 85.000 ºC

Oil Temperature at sea floor: 77.349 ºC

Oil pressure in the reservoir: 4,984.853 psi

Oil pressure at sea floor: 2,949.906 psi

Pressure drop: 2,034.947 psi

Pressure drop due to viscosity: 54.382 psi

Pressure drop due to gravity: 1,980.703 psi

Total heat lost by tubing: 73,858.836 W

Heat lost by couplings: 7,798.057 W

ANALYSIS

Bare tubings do not attend the minimum required temperature at sea floor.

PIOP tubing not only meet the minimum required temperature at sea floor but exceeds it by more than 7 °C.

Another important observation is that PIOP's pressure drop, from reservoir to sea floor, is lower than that of Bare tubing.

If Bare tubing pressure drop is OK as far as oil production is concerned, then PIOP's oil production can be increased to match Bare tubing pressure drop.

Considering the situation, which was simulated, oil production could be increased in almost 10%!
This was exactly the purpose of SIÃO's novel development. PIOP was designed with two goals in mind: keep the oil temperature high, by avoiding heat exchange with the surroundings; and, the most important goal, enhance oil productivity.

CONCLUSION

PIOP technology is long-lasting, spanning more than 30 years.

PIOP maintains the oil warm so that its temperature at sea floor exceeds the minimum required.

PIOP increases oil production in up to 7%.

SIÃO PETRÓLEO

AN IMMEASURABLE ECONOMIC GAIN FOR OPERATORS

In addition to the savings on installation, the payback on the investment is extremely profitable for the investor, as it is short-lived, between 3 and 4 years after installation. For example, a well that produces 20,000 barrels per day, considering a production increase of up to 7%, with an accumulated 20-year profitability of more than $730 million more with the use of the new technology. “In this example, we have an initial investment of around 35 million dollars, that is, less than 5% of the result of the operation, plus a success fee that will be agreed with each operator for the 20 years of production. So, we will have an investment payback that is always four years, or less.”

OUR FOCUS

As our company already has a 25-year history in this industry, with 2 successful patents and more than 80 contracts equipping over 600 wells in the last 20 years, the objective at this moment is to identify producing partners to start pilot projects in production wells, with an estimated increase in production already informed by simulation soon after receiving the well data.

SIÃO PETRÓLEO

SIÃO PETRÓLEO