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# Tenaris solutions for Geothermal

A photograph of a geothermal power plant. In the foreground, several large, parallel pipes run across a grassy field. In the middle ground, there is a complex of pipes and machinery, including a large cylindrical tank. A large plume of white steam rises from a structure on the right side of the plant. The background consists of a dense forest of evergreen trees under a clear blue sky with some light clouds.

# Tenaris: Global leader in pipes and related services for the world's energy industry



Serving the world's energy industry and other industrial applications.

**6.5**

US\$ billion

Annual net sales  
(2021)

**16**

Countries

Manufacturing  
facilities

**3**

R&D Centers

Worldwide

**3**

Stock exchanges

New York, Italy,  
Mexico

**23,000**

Employees (approx.)

(2021)

**25**

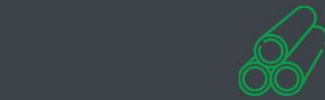
Countries

Services and  
distribution network

# Tenaris expertise in geothermal developments



Providing customers with specific products, proprietary steel grades and all-round support, from well design up to on-site installation.



+8

Million meters sold for geothermal applications



13

Involved in geothermal projects in 13 countries

## Our portfolio includes

Proprietary steel grades

TenarisHydril premium connections

Proprietary coatings

Rig Direct® services

# Our decarbonization strategy

**30%**  
Target 2030

Reduction in CO<sub>2</sub> intensity per ton of steel (Scopes 1, 2 & 3) vs 2018 values



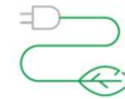
Collaboration with partners to minimize CO<sub>2</sub> footprint

**80 USD**

per ton CO<sub>2</sub>  
Internal carbon price



Increase scrap use



Clean electricity



Energy efficiency



Green H<sub>2</sub>

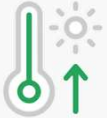
















Waste energy recovery



Carbon capture and utilization

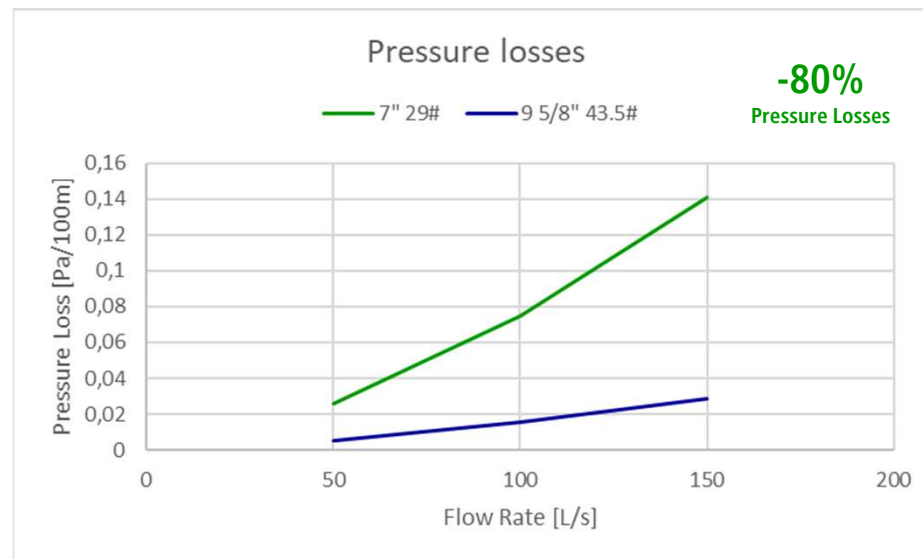
# Challenges for Geothermal well design

		Direct Use	Power Generation
 <p><b>High temperature:</b></p> <ul style="list-style-type: none"> <li>• Heated fluids in the annular lead to high external pressures.</li> <li>• Tension-compression cycles impact on the connections.</li> </ul>			
 <p><b>Corrosive environment</b></p> <p>The presence of liquid water together with CO<sub>2</sub> / H<sub>2</sub>S, forces corrosion and cracking tendency to be understood.</p>			
 <p><b>Highly fractured formations</b></p> <p>Mud is often circulated with little to no returns making the casing subject to significant collapse loads.</p>			
 <p><b>Elevated flow rates</b></p> <p>Flow regime conditions and well design can lead to pressure loses, erosion/corrosion and potentially sealability issues.</p>			
 <p><b>Environmental footprint</b></p> <p>Wells located in urban areas may need special considerations in terms of pollution and social impact.</p>			

# Challenges for Geothermal well design – Elevated flow rates

## Production optimization

As pressure losses play a major role, geothermal wells normally produce through the casing. Larger OD's help minimizing pressure losses, increasing the well productivity.



## Optimized OD clearance– Semi Flush connection

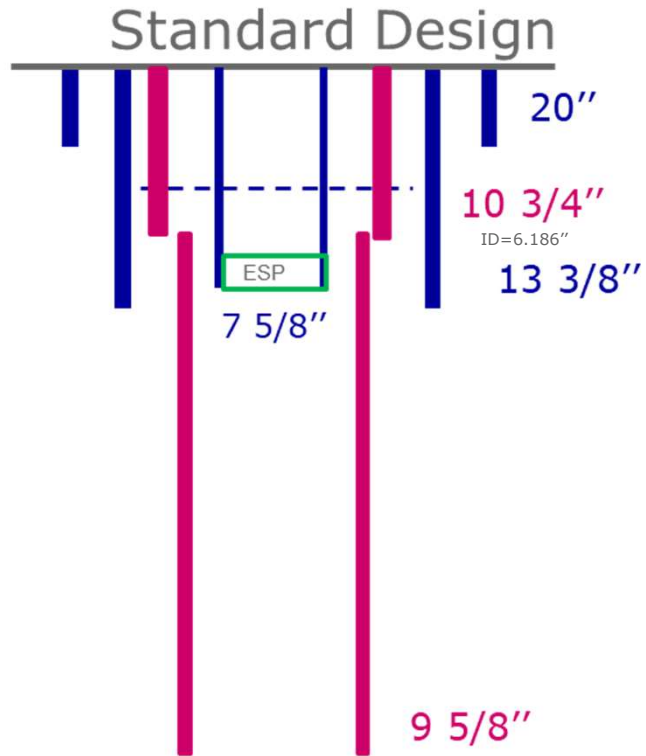


### TSH 521 Semi Flush Connection

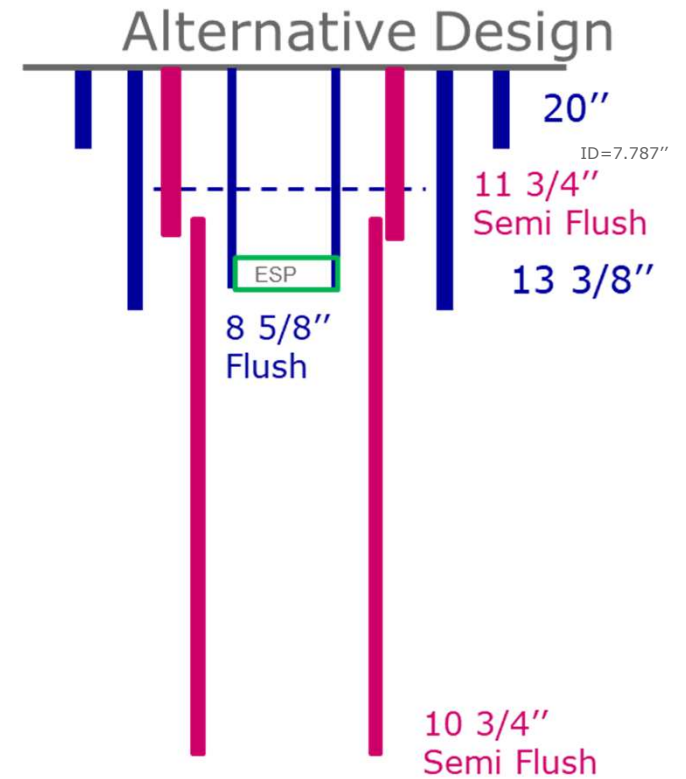
- An integral **semi-flush** connection suitable for a range of functional applications where high **clearance** is required.
- High **compression rating** provided by the reverse angle stab flank of the dovetail threads makes the Wedge 521® suitable for the more severe compression applications.



# Well Design Alternatives

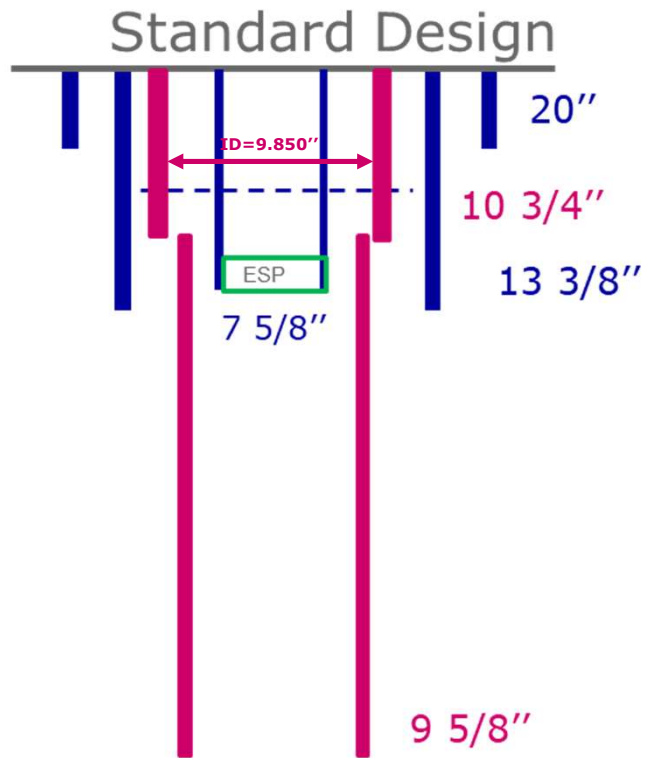


25% ID increase

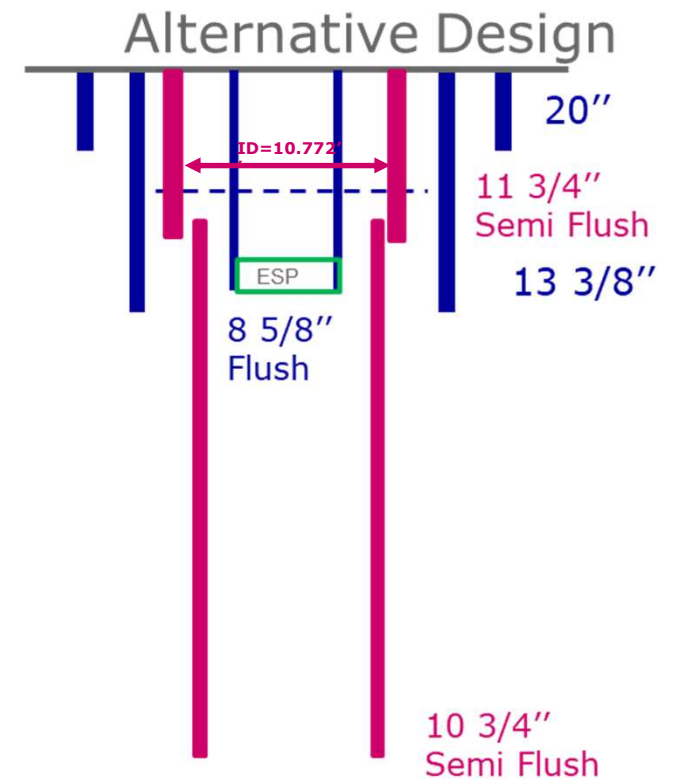




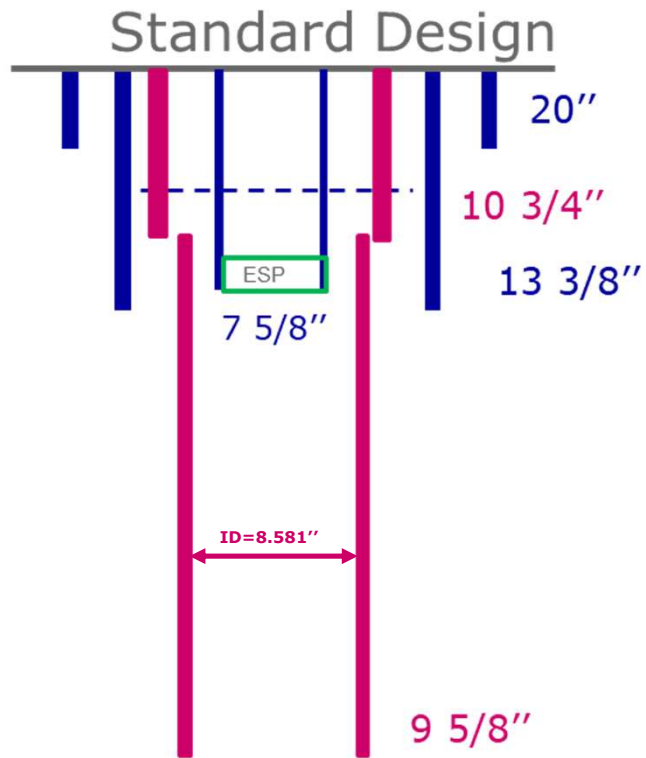
# Well Design Alternatives



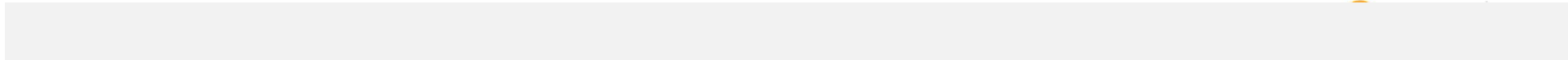
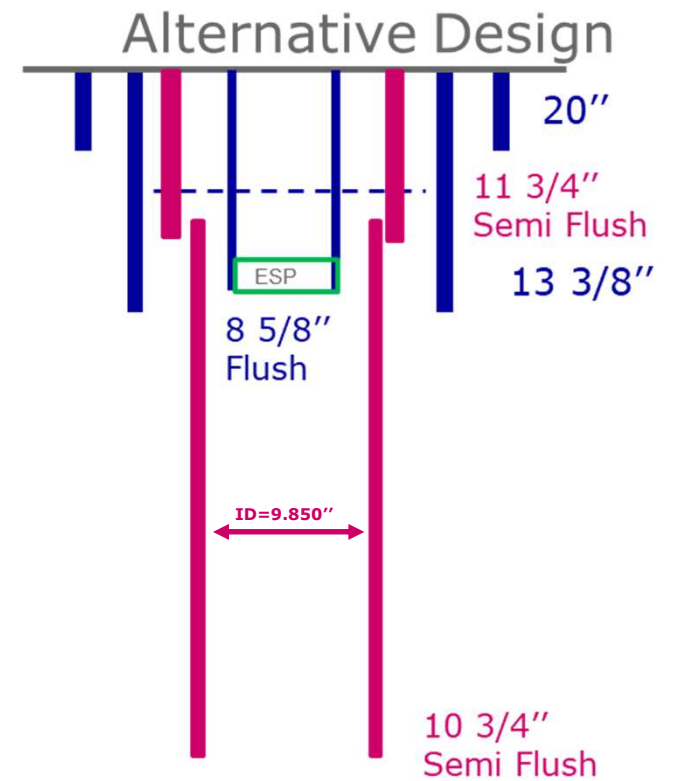
9% ID increase



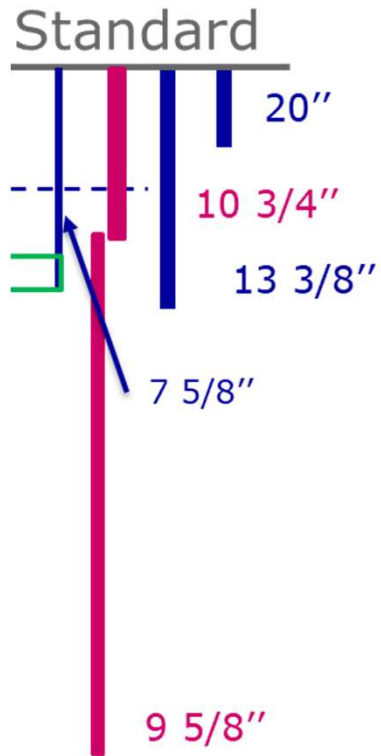
# Well Design Alternatives



14% ID increase

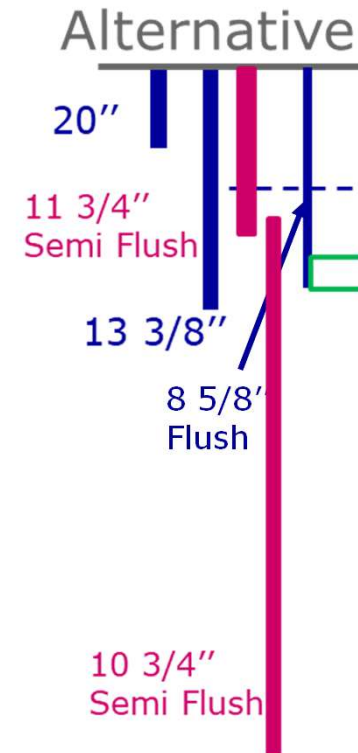


# Well Design Alternatives

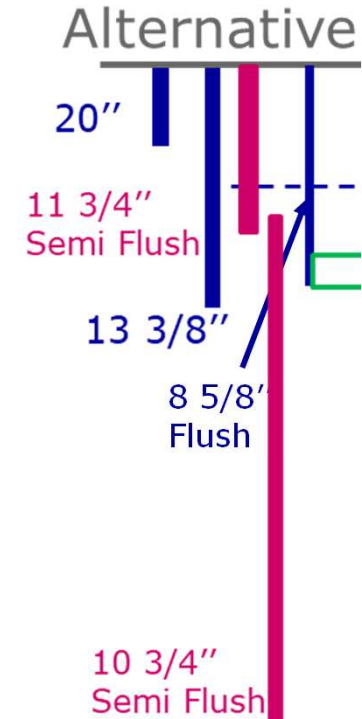
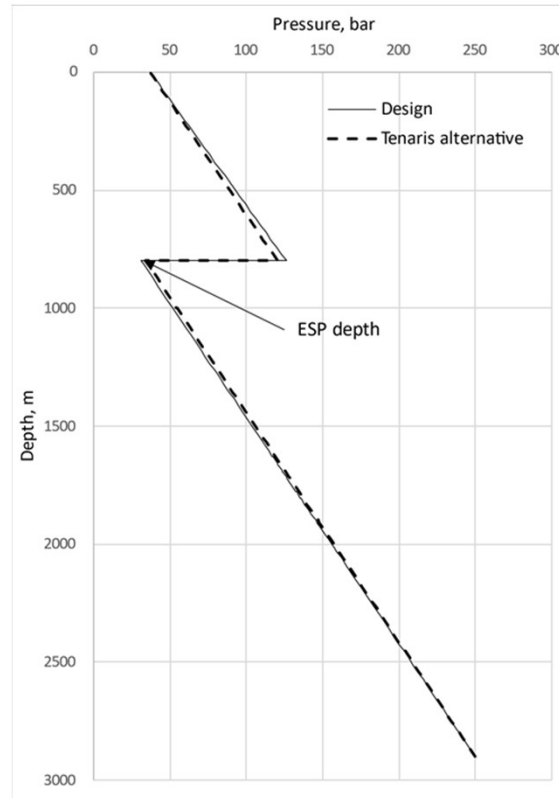
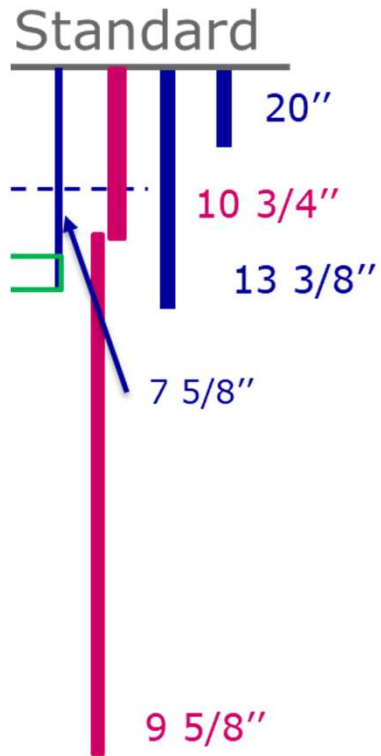


## Input

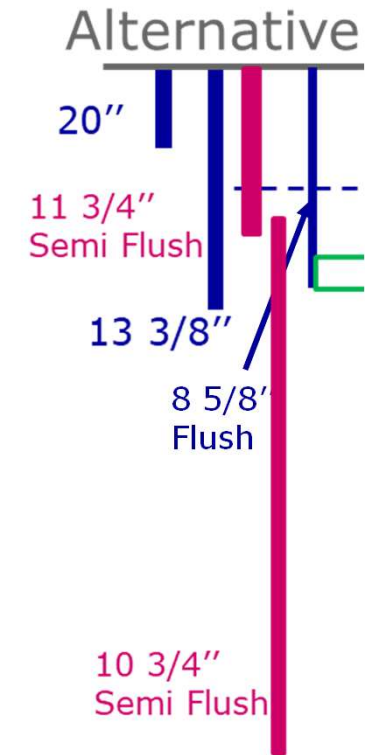
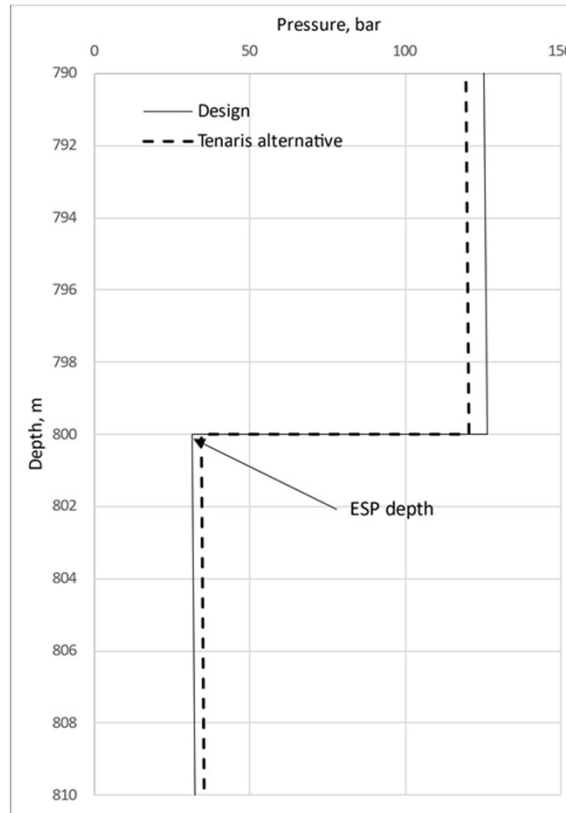
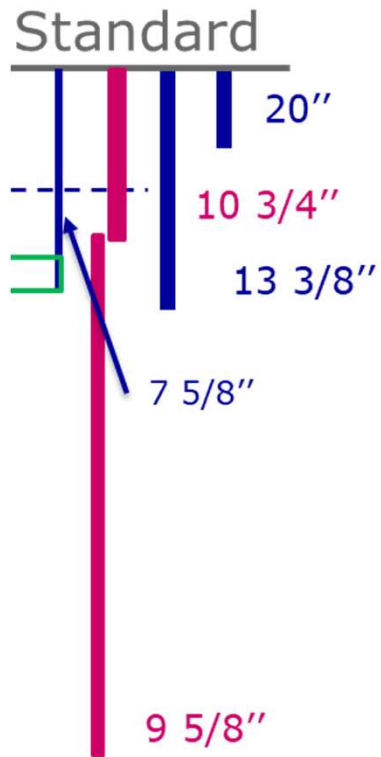
- Bottom Hole dynamic pressure of 250 bar.
- Pump efficiency of 70%
- Wellhead pressure of 37 bar.
- Geothermal fluid above bubble point.
- Comparison of ESP pump power in standard casing design vs alternative.



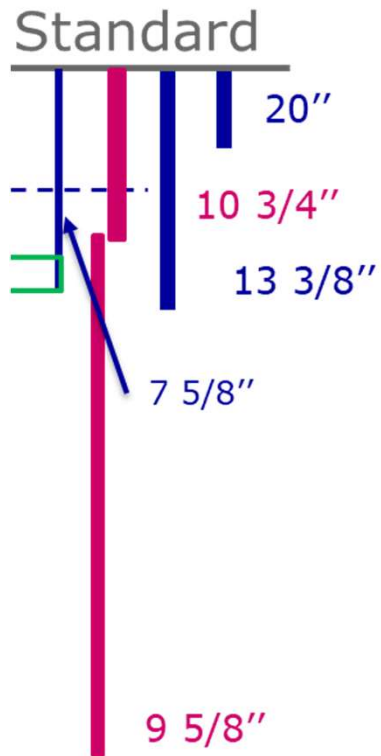
# Well Design Alternatives



# Well Design Alternatives

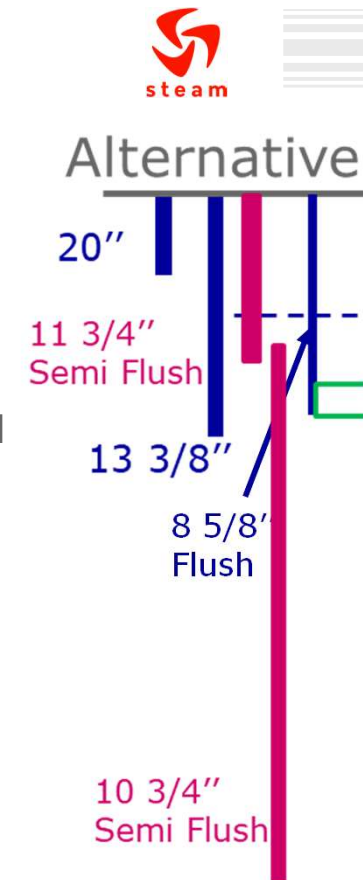


# Conclusion

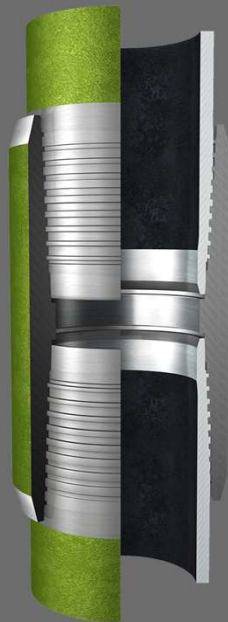


## Results

- Pump power for standard case is 1286 kW
- Pump power for alternative case is 1165 kW
- Saving of approx 10% of consumed power expected for alternative case with a reduction in OPEX.
- Proposed well design modification does not impact on drilling sequence or drill bit diameter.
- Case study proposed show a significant impact of well design on production optimization.
- Further analysis to be performed for medium/high enthalpy wells.



# TenarisHydril Wedge 563<sup>®</sup> 2 3/8" to 13 5/8"



 Tenaris

## Enhanced alternative for large diameters and high temperatures

- Available with Corrosion Barrier (CB<sup>®</sup>) option for use together with internal coating
- 100% ratings in tension and compression
- Recess Free Bore (RFB) option to maintain flow stream continuity

### + 30 years in O&G applications

**+30**

MM METERS  
SOLD AROUND  
THE GLOBE

**+2**

MM METERS  
INSTALLED WITH  
DOPELESS<sup>®</sup>  
TECHNOLOGY

INSTALLED IN  
**+85**  
COUNTRIES

CHOSEN BY  
**+700**  
OPERATORS

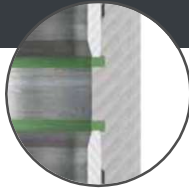


CONFIDENTIAL

25

# TenarisHydril Wedge 563<sup>®</sup> 2 3/8" to 13 5/8"

## CB<sup>®</sup> Ring Option



- Corrosion Barrier (CB<sup>®</sup>) Ring available.
- Corrosion protection and ID coating possibility without reduction of performance.

## Gas Tight

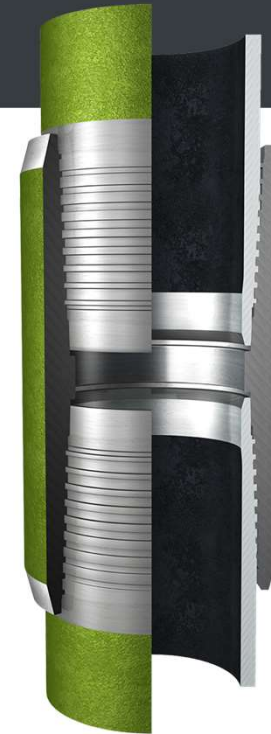


- 100% internal pressure rated metal seal maintains gas sealing capability under high axial loads.

## Simple & fast make-up



- Roller-stenciled make-up confirmation band.





# Internal Coatings in geothermal wells

## Cost-effective solution for corrosive environments

Tested in O&G applications and suitable for temperatures up to 200°C

### TenCoat™

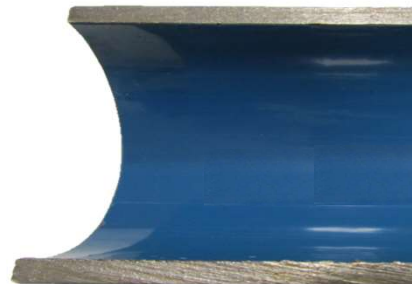
Epoxy-phenolic internal coating applied over phenolic primer proven to protect against:

- Corrosion
- Abrasion

### Additional advantage

Low roughness reducing pressure losses that grant a flow improvement and mitigates the adhesion of scaling

TenCoat™ 8000



TenCoat™ product line has been tested with specific equipment to withstand the **wear resistance**

# GRE liners in geothermal wells

## Cost-effective solution for corrosive environments

Typically suitable for temperatures up to 120°C

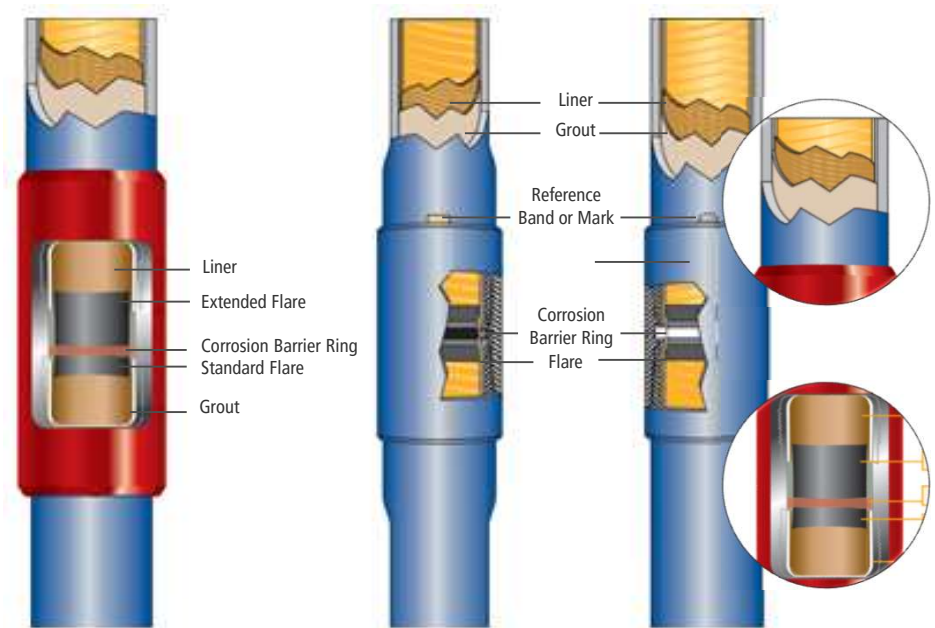
### GRE Liner

Glass reinforced epoxy liner is used as an internal protection.

Its principal function is to prevent corrosion of tubular products by providing a resistant barrier that isolate steel from corrosive fluids.

Materials used are:

- Epoxy resin (matrix).
- Fiberglass (reinforcement).
- Center of coupling is covered with rubber ring (CBR).



# Dopeless® technology

## Dry, multifunctional coating applied in the mill

- Makes thread compounds obsolete
- Qualified in accordance with the industry's highest standards
- Minimizes environmental footprint
- Many advantages for Geothermal applications:
  - Proven in high temperatures environments
  - Anticorrosion protection
  - Improve the make up reliability
  - Reduces running times



## 18MM

Meters run worldwide

## 20 YEARS

Of tests in Tenaris' and  
3rd Parties' Laboratories

## 60 CAL IV

Test protocols



### TIME

↓ 25%  
Running Times



### RELIABILITY

> 99%  
1st Time Make-Up



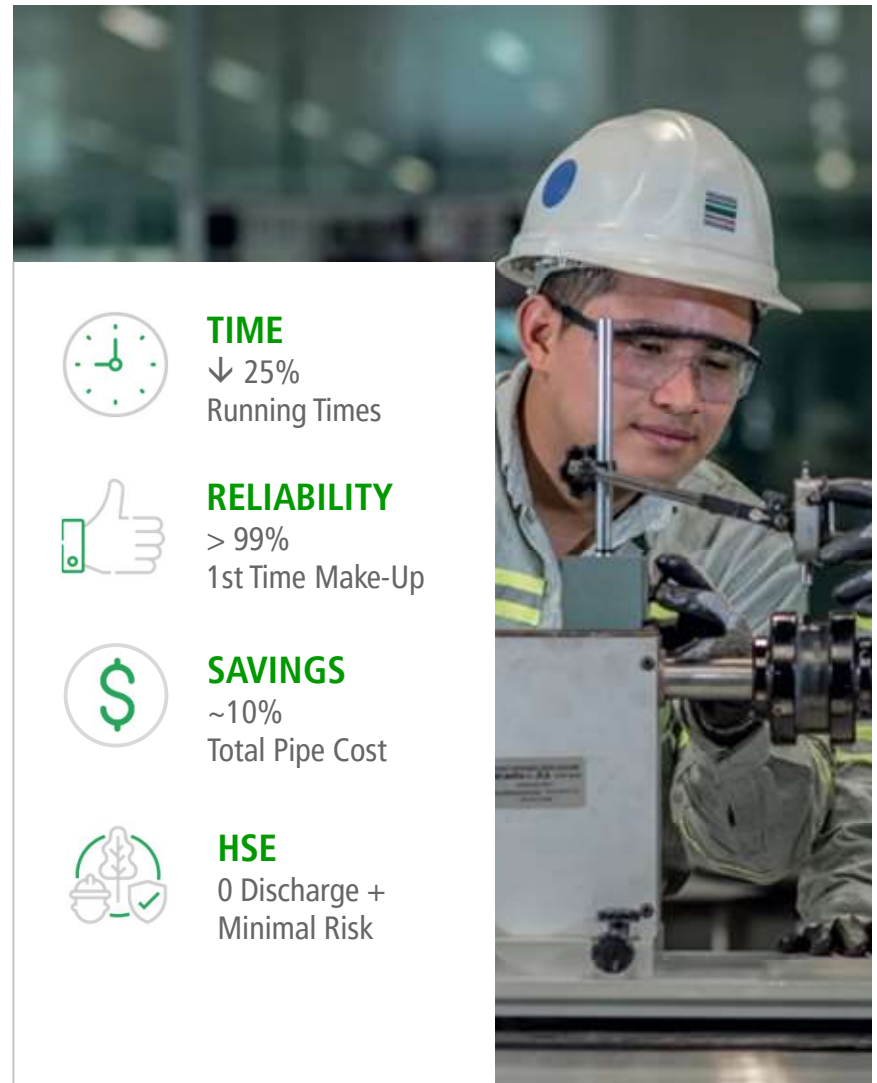
### SAVINGS

~10%  
Total Pipe Cost

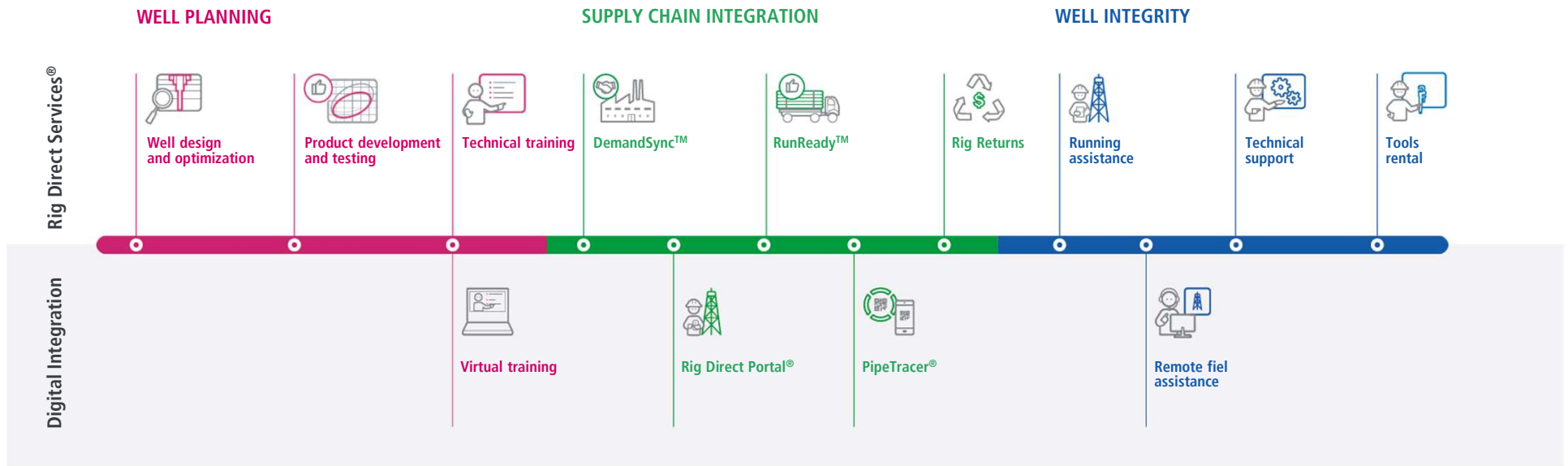


### HSE

0 Discharge +  
Minimal Risk



# Rig Direct®



# Our Experience | ENEL Green Power



## Project description

Exploratory, energy rich, geothermal well located in a small Tuscan village.

## Main challenges

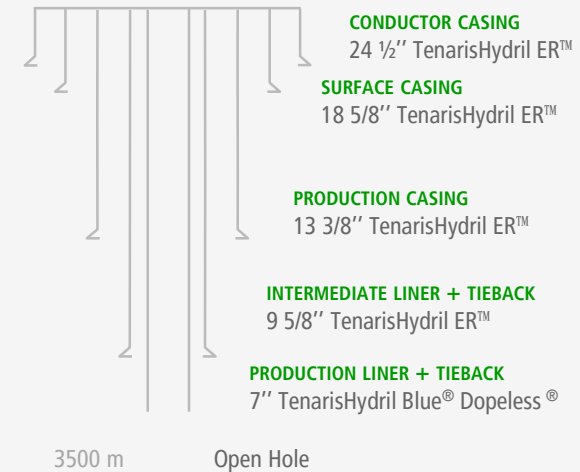
Formation located at around 3,000m TVD, with an expected temperature above 450 °C and a pore pressure of 300 bars.

## Tenaris solution

TenarisHydril ER™ connection has been selected for the 9 5/8" casing. To be ready to face corrosive conditions and promote high structural resistance, ENEL chose Tenaris proprietary sour service steel grade TN 125SS.

## Project status

ENEL Green Power led and coordinated the implementation of this project, while Tenaris supplied its customer with the products selected for the well profile, providing the assistance of Tenaris Field Service Specialists.



# Our Experience | Iceland Deep Drilling Project

## Project description

Three groundbreaking wells drilled in Iceland by a consortium of local energy companies and the Icelandic government.

## Main challenges

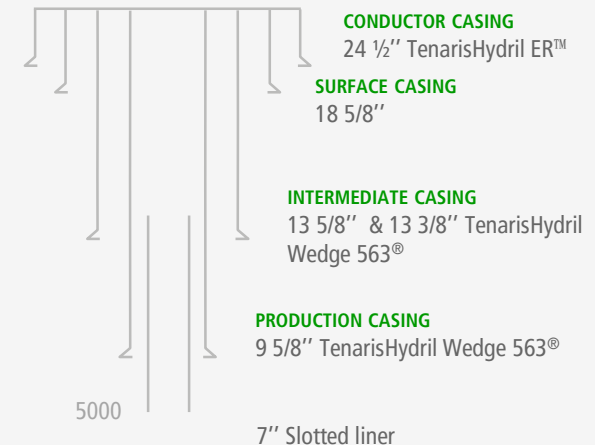
Boreholes around 5km deep together with reservoirs holding hydrothermal fluids at supercritical conditions (450 °C to 600 °C).

## Tenaris solution

For the lower sections of the well, the operator chose to deploy TenarisHydril Wedge 563®. For the 24 1/2" first intermediate casing, Landsvirkjun decided to run TenarisHydril ER™.

## Project status

A magma body with a temperature of around 1000° C was encountered and unintentionally penetrate. Fortunately, the 9 5/8" production casing had been previously cemented, which allowed for the well to be successfully and safely completed with a slotted liner.



# Our Experience | Thermal bath in Loipersdorf, Austria

## Project description

Geothermal well providing heat to Loipersdorf thermal area.

## Main challenges

Cost effective solution for corrosion management avoiding work over operations through the design life of the facilities.

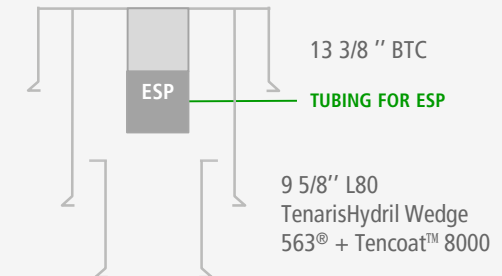
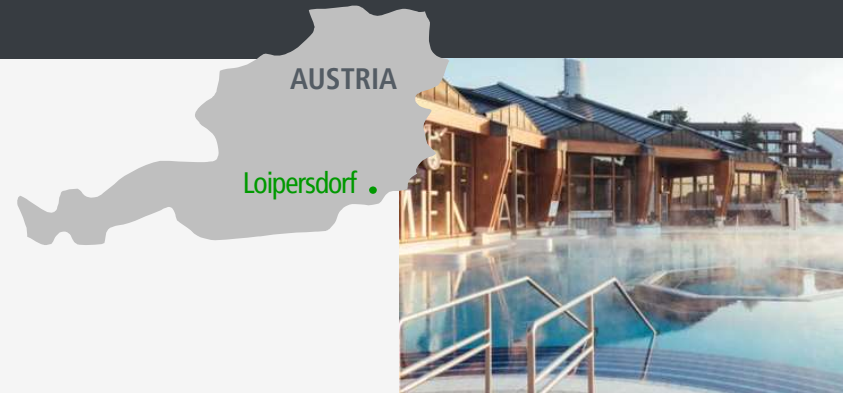
## Tenaris solution

TenCoat™ 8000 internal coating plus TenarisHydril Wedge 563® Corrosion Barrier premium connection.

TenCoat™ 8000 internal coating is proven to protect against corrosion, high temperature, and abrasion. TenarisHydril Wedge 563® Corrosion Barrier counts with an elastomeric ring placed between PIN and BOX ensuring coating continuity.

## Project status

Running successfully performed witnessed by Tenaris Field Service experts. Well currently in operation.



# Our Experience | District Heating in Romania

## Project description

District heating of Beius in Northwest Romania.

## Main challenges

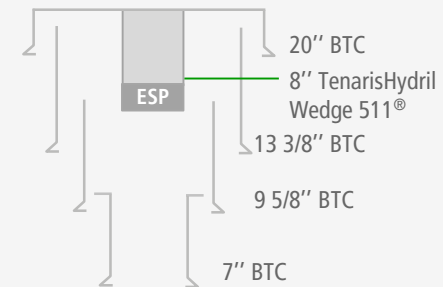
Cost effective solution to optimize production flow from ESP.

## Tenaris solution

A pump is inserted in the well to increase the production rate. To increase the size of the pump, and thus the production flow, Tenaris supplied the tubing string with TenarisHydril Wedge 511<sup>®</sup>, an integral connection that minimizes the outside dimension of the connection.

## Project status

Running successfully performed witnessed by Tenaris Field Service experts. Well currently in operation.





# Our Experience | Greenhouse heating in Italy

## Project description

Drilling of 4 doublets to provide geothermal power and heat to hydroponic tomatoes greenhouse in Northern Italy.

## Main challenges

Complex drilling with target depth of 3600 m. High thermal loads and collapse loads in a particularly challenging geological formation.

## Tenaris solution

TenarisHydril ER™ rely on decades of use in Geothermal fields and ensures easy stabbing and fast make-up while maintaining 100% compression efficiency.  
Improved Collapse Yield (ICY) steel grade in order to obtain enhanced collapse and burst performances required for 13 5/8" string.

## Project status

Running successfully performed witnessed by Tenaris Field Service experts. Well currently in operation.





# Summary

- As an industry leader, Tenaris is **committed to reduce its carbon footprint**. Aiming towards carbon neutrality, we pledged a 30% reduction in our CO<sub>2</sub> emissions intensity rate by 2030.
- In areas with peculiar geological environments, geothermal energy is well known and extensively used for power generation and district heating.
- Drilling wells to extract heat from underground poses **several challenges for well design**. These challenges include high temperatures and aggressive conditions.
- Each geothermal field and reservoir is unique, having different temperatures and fluid compositions. Tenaris is the **sole supplier able to provide the full range of materials**: from CLAS to corrosion resistant alloys (CRA).
- Tenaris offers its customers a comprehensive portfolio of premium connections. For every operation we can supply a compliant solution.
- Our **Dopeless® technology** is a perfect match for this application, with important benefits in environmental impact and tested in high temperature conditions.
- Under our **Rig Direct® services** model, we are able to support you during the well planning process, including well design and optimization, product development and testing and technical trainings.