

# Kaldera Roller Cone Increases On-Bottom Drilling Hours by 37% in Italian Geothermal Application

Advanced seals and grease extend bearing life in high-temperature environments

## CHALLENGE

Drill hard and abrasive igneous/meta-morphic formations at elevated down-hole temperatures of up to 570 degF to tap a superheated steam reservoir for a geothermal project with a narrow margin.

## SOLUTION

Undertake the development of new seal and grease materials that will advance the durability of bit bearings in high temperature environments. Launch new Kaldera roller cone drill bit technology specifically designed for the world's most demanding geothermal and hot hole applications.

## RESULT

On-bottom drilling hours increased by 37% compared to offsets resulting in longer bit runs and fewer trips to complete the well. This set a new Larderello field record for on-bottom drilling hours.

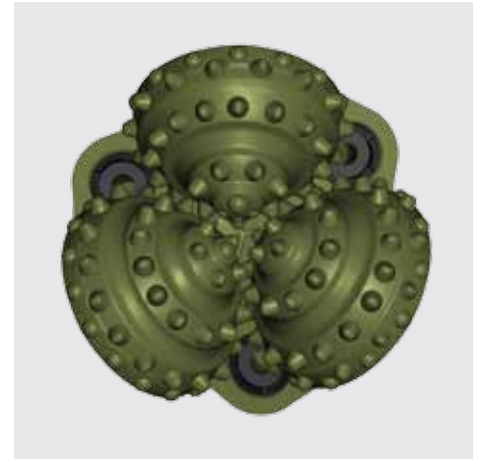


## Advances/legislation make geothermal legitimate contender

The worldwide energy industry is focusing more effort on developing geothermal resources. The leading countries producing geothermal power include the United States, Philippines, Indonesia, Mexico, and Italy. Experiments with hot hole drilling have also been conducted in Japan, Iceland, and other geologically active areas. Over the last 20 years, technical innovation has significantly reduced the amount of capital expenditure required to build geothermal power generating systems making it a more cost effective method for producing electricity than natural gas or clean coal. Additional momentum is being generated by government support mechanisms and the liberalization of electricity markets. Approximately 60 countries now have support policies in place that encourage the production and sale of electricity produced from geothermal and other alternative energy sources.

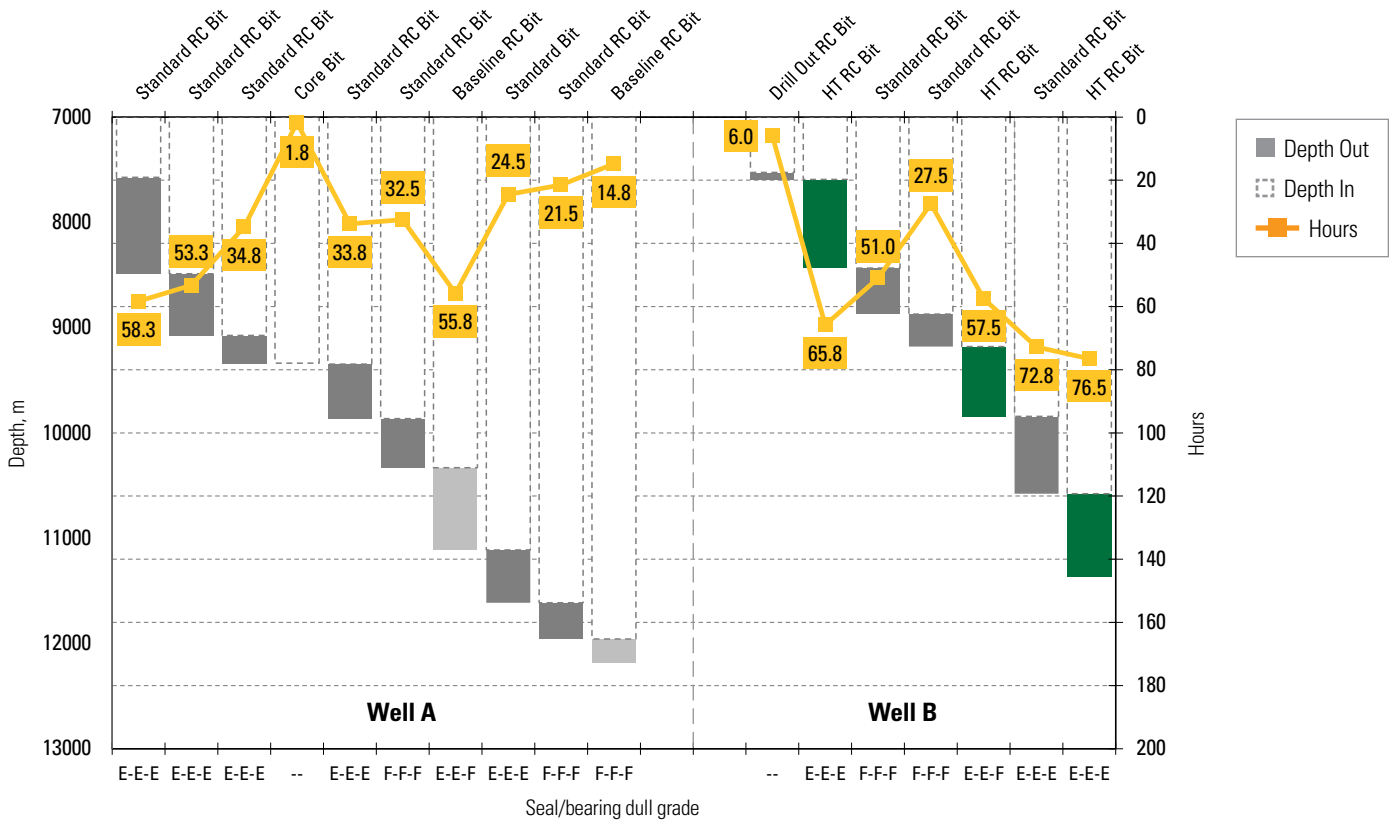
## Temperature tolerant downhole tools required

Finding cost effective technologies to drill production wells in high temperature environments will require improving current tools and conducting research to develop next generation products. In many geothermal applications the hard/abrasive igneous formations are drilled with roller cone (RC) bits but the 350 degF to 550 degF temperatures can reduce bit life, which leads to multiple runs that drive up field development costs. To economically exploit a number of Italy's current geothermal projects, operators required improved roller cone technology: capable of enduring high-temperature environments to increase run lengths and on-bottom drilling hours while reducing trip time and total bit consumption.



The 8½-in Kaldera drill bit set a new field record of 76.5 hours on-bottom drilling.

## CASE STUDY: New BHA design produces a significant improvement in drilling performance



Kaldera drilled more footage and reduced bit consumption by 30% compared to an offset drilled with baseline roller cone products. The performance improvement reduced operator drilling costs and shortened time to production.

### Engineered roller cone bit solution

A focused initiative was launched to develop roller cone technology specifically tailored for geothermal drilling. The project started with an application analysis that explored the complexities of downhole temperature and pressure variations. Armed with the knowledge gains, engineers worked to develop a specialized fluorocarbon seal compound and proprietary grease formula that could withstand elevated temperature. The research was successful and a new seal was developed that contains fabric reinforced composites that provide excellent thermal stability and wear resistance. A high-temperature grease compound was formulated with a precise mixture of synthetic lubricants, lithium and various additives to increase load capacity at high temperature. Using a custom-designed apparatus that accurately simulates RPM, temperature/pressure, and fluids chemistry to test the seal has confirmed that it is well suited for high-temperature drilling. Additional laboratory testing revealed the new grease can maintain consistent load capacity up to 500 degF. This compares favorably to standard grease which experiences a dramatic loss of viscosity at 350 degF. The advances in seal compounds and lubricating capabilities

have significantly improved bearing reliability at elevated temperatures. These new technologies are incorporated into Kaldera, a new line of roller cone bits for geothermal applications.

### Kaldera advantage

Operator Enel Italy recently field tested Kaldera RC bits in a Larderello geothermal production well with outstanding results. Three 8½-in Kaldera bits were used to drill hard and abrasive granite/metamorphic formations with average temperature of 320 degF to 350 degF with spikes up to 570 degF. The new seal and grease formula had a positive impact on run length and increased in on-bottom drilling hours by 37% when compared to an offset well drilled with a standard roller cone. The last Kaldera run set a new field record by logging 76.5 on-bottom drilling hours while compiling high total bit revolutions (300,000 revs). All three bits came out of the hole in good dull condition with eight of the nine seals still effective. The new Kaldera roller cone line will improve drilling efficiency in geothermal applications resulting in longer bit runs and reduced trip times, which will lower drilling costs while shorting time to production.

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