TRS Group Taking Off with Thermal Conduction Heating

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TRS Group, Inc.

Started in 2000, TRS Group (TRS) has been the premier provider of electrical resistance heating. To better serve our customers, TRS now provides three heating technologies:

- **OptiFlux**® Electrical Resistance Heating (ERH) – using electrodes, TRS passes electricity through the subsurface, achieving temperatures up to the boiling point of water.
- **FlexHeater**® Thermal Conduction Heating (TCH) – TRS heats steel borings, transferring heat to the formation by conduction, reaching temperatures as high as 400°C among the borings.
- **EcoSteam**™ Steam Enhanced Extraction (SEE) – using injection and multiphase extraction wells, TRS injects steam into the formation and treats the collected fluids. Heating is limited to the temperature of steam.

Our research and development team has developed a patented TCH technology (Oberle et al. 2018) with targeted power delivery, reducing operating time and lowering costs.

TCH – what do you really need down-hole?

The steel casing reaches temperatures in the range of 300 to 800°C. When using electricity, it is important that the heater does not short to the casing. Therefore, the heater needs to be coated with a non-conductive material (silica, glass, ceramic) or centralized such that the metal part of the heater cannot touch the inside of the casing. As the heater wire is metal, TRS places ceramic spacers to prevent the wire from touching the casing, as shown in Figure 1. TRS offers multiple, patented and patent-pending **FlexHeater**® elements based on site conditions and goals. The TRS rod-style heater uses an alloy that is more flexible and sustainable than the systems others have used for decades. TRS uses this element in vertical, horizontal and angled boreholes, working around sensitive site infrastructure.

Figure 1. **FlexHeater**® *element which provides flexibility to control power input*

Heat movement is governed by matrix thermal diffusivity, which is the ratio of thermal conductivity to heat capacity. Thermal diffusivity varies with site stratigraphy and is based on water content, porosity and mineralogy. Even when these changes are modest (on the order of 1 to 3 times between a dry soil and wet clay), the ability of the formation to conduct heat away from the heater boring will vary.

The more uniform a site is heated, the less energy is used. A uniform heating profile requires different power inputs over depth. Therefore, it is desirable to control power delivery rates to different strata.

Some heaters accomplish this by varying the heater rod diameter, often with a boosted section at the top and bottom. TRS developed a heater with more flexibility in terms of power density over depth and time, allowing adjustment of the heat output as the collected data teaches us about the formation. The TRS design allows us to remove, adjust and re-insert the heaters, enabling precise heating with less energy use.

Full-scale TCH remedy in North Carolina

TRS completed a **FlexHeater®** TCH full-scale project in North Carolina in 2019. The site had 32 heaters, each approximately 60 feet deep. Figure 2 shows a heater connection and the well field. Learning much about optimizing heater operations, TRS met the contractual goals and objectives.

Figure 2. **FlexHeater®** *TCH Operations in North Carolina in 2019*

TCH Treatment in China

TRS China completed a large **FlexHeater®** TCH project in Nanjing, China. Operations with 420 heaters started in 2019. TRS China treated a 42,000 cubic meter source zone, concluding operations in 2020. The site was heavily contaminated with chlorophenols and other minimally volatile compounds. The value engineering designs for and lessons learned from this large, fast-paced project have been helpful for subsequent opportunities.

Figure 3. **FlexHeater®** *TCH Operations in Nanjing, China*

TCH at a Former Manufacturing Facility

TRS is implementing the **FlexHeater®** TCH technology under a large former manufacturing facility in Arkansas. TCH is well-suited to meet the challenging site conditions, which include limited access, dry vadose zone sediments, and interface to bedrock. TRS targeted three chlorinated volatile organic compounds (CVOCs) source zones with 154 vertical and angled heaters. TRS has removed over 4,000 pounds of CVOCs, achieved the remedial goals ahead of schedule in one of the areas and anticipates project completion by the Summer 2021.

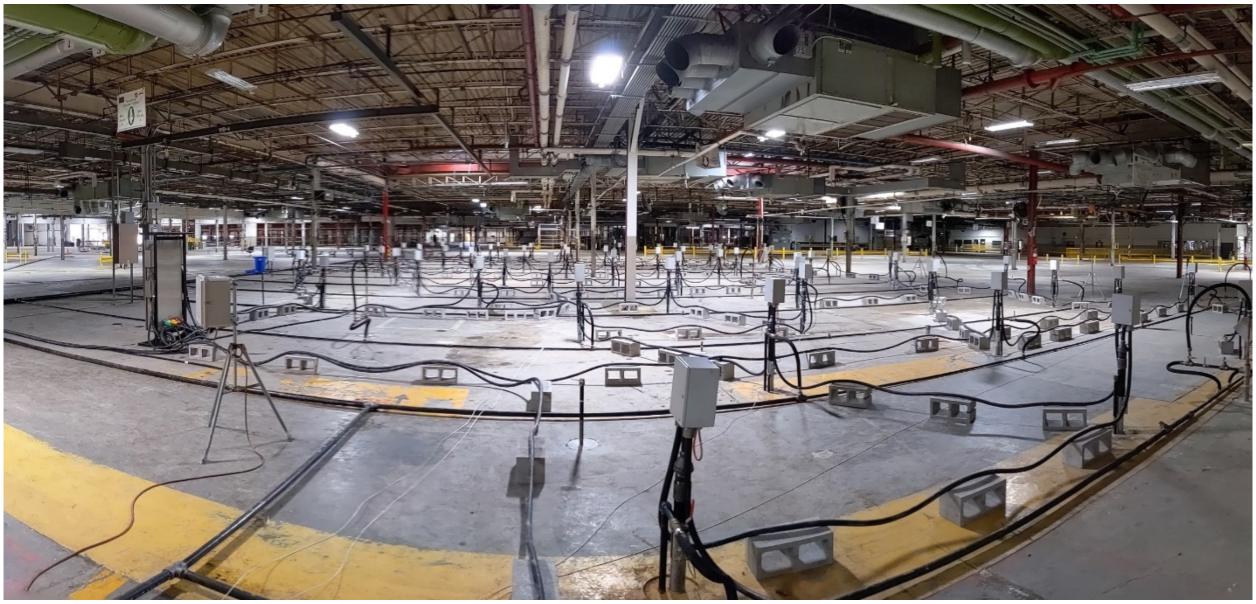

Figure 3. An operating **FlexHeater®** *TCH site in Arkansas*

Challenging TCH project under a large building in New Jersey

A commercial client approached TRS to apply TCH at a manufacturing facility in New Jersey. We are performing thermal treatment at depths of 50 to 120 feet below grade and installing more than four miles of heaters. Because much of the TCE source zone is located below the active facility, which must remain clean, TRS cannot drill from those rooms; instead, we are accessing the treatment zone from a separate room using angle drilling methods. To minimize costs, TRS designed, developed and tested a novel 200-foot long heater. We can install it at any angle and deliver depth-specific optimized power that allows for virtually no heating over the first 50 feet. The patent-pending design will keep the building cool, while heating the target zone to boiling temperatures. Installation started in 2020 and operations will start in 2021.

TCH treatment in Brazil

A TRS Doxor TCH project is in the design phase for implementation at a site in Sao Paulo, Brazil. The site is heavily contaminated by diesel range organics and has relatively stringent cleanup criteria for soil and groundwater. Using 113 **FlexHeater®** wells to deliver 500 kW or power to three source zones, TRS Doxor will complete the project in 2021.

Award of Two ESTCP Projects for PFAS Treatment using TCH

The remediation of per- and polyfluoroalkyl substances, also known as PFAS, is becoming increasingly important. The environmental industry is recognizing the challenges of developing analytical methods for

PFAS in water, vapor and soil. At many U.S. Department of Defense (DOD) sites, stockpiles of untreated soil are growing, with no good or economical solution in sight. Source areas continue to leach PFAS to groundwater, impacting drinking water aquifers.

In 2020, DOD funded four PFAS treatment projects, for which TRS is a co-performer. The Environmental Security Technology Certification Program (ESTCP) funded two projects focused on thermal desorption of PFAS from soil using the **FlexHeater®** TCH technology. One of the 2021 field demonstration projects is focused on *in situ* PFAS removal from vadose zone soils; the other on *ex situ* removal from soil stockpiles.

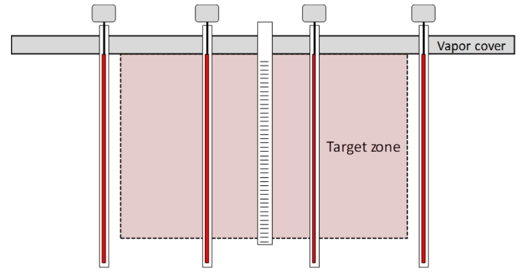

Figure 4. In Situ TCH of PFAS in Vadose Zone

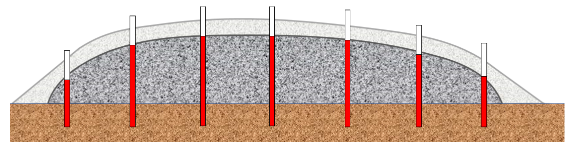

Figure 5. Ex Situ TCH of PFAS

How TCH allows TRS to treat more compounds

Because TCH can achieve far higher temperatures than ERH, TRS can treat semi-volatile compounds such as PFAS, PCBs, PAHs and dioxins in the vadose zone or above-grade in pile structures. Applying the **FlexHeater®** technology, TRS can provide more economical options for sites with minimal drilling access or deep treatment zones.

Additionally, TCH is effective in some materials where ERH is challenging, such as crystalline bedrock with little water, dry sediments, and highly saline environments. For example, the Arkansas site mentioned above has dry bedrock under the building, making ERH more difficult.

Further, TRS heaters are smaller and simpler than the heaters used in the past. Table 1 below compares various TCH approaches.

Table 1. Differences among TCH Heater Solutions

	FlexHeater® Elements (patented and patent pending)	**Stainless steel rod heaters**	**Electromagnetic induction heaters**	**Gas burners**
Heater type	Electrical resistive wire coil or rod	Electrical resistive rod with nickel cold pin	Large copper coil using high frequency power	Gas burner at well-head
Cold section heat output	Less than 5% of heated section output	40-60 watts/foot or 15-20% of heated section output	Modest (cables to the heater assembly)	High – gas must flow down and up
Boosting ratio at top and bottom	100% or higher, as needed (coil density can be varied)	25-40% (rods with modest diameter differences welded together)	Only via multiple heaters in each boring	No adjustment possible
Supplemental renewable energy for power	Yes – wind and solar	Yes – wind and solar	Yes – wind and solar	No – burning fossil fuel
Energy source	Electricity	Electricity	Electricity – requires frequency conversion	Natural gas or propane
Cost of well and heater materials	Low (wire and ceramic disks)	Medium (solid rods and insulators)	Very high – complex assembly	High (gas burners on top of the heaters)

While gas energy may appear to be lower cost than electricity, it turns out that using electricity is generally the less expensive option, due to the actual useful power and energy delivered to the formation.

We would be happy to discuss energy delivery options in detail with you. TRS continually strives to provide improved, less costly and robust TCH solutions.

References

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Stegemeier, G.L. and H.J. Vinegar. 2001. Thermal Conduction Heating for In Situ Desorption of Soils. Hazardous & Radioactive Waste Treatment Technologies Handbook. Boca Raton, FL: CRC Press.

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