Three-Phase Heating? Six-Phase Heating? Which is Better?

First off, both "three-phase heating" and "six-phase heating" are varieties of Electrical Resistance Heating (ERH) – there really isn't that much difference between them. The skill of the electrode designers and the experience of the operators are far more important to the success of your project than is the number of electrical phases. Thermal Remediation Services uses the best phasing technique for each particular application.

History

Three-phase heating ERH was invented as an oilfield enhancement technique. Bill Pritchett of ARCO patented three-phase ERH in 1976; the patent has subsequently expired and is now in the public domain.

Six-phase heating was developed and patented by the Department of Energy at government expense. As such, the patent is majority-owned by the federal government and the government has full rights to use the technology in any way it sees fit at its facilities, using any ERH vendor to complete the work. Battelle is a minority owner of the six-phase heating patents and can issue usage licenses as desired for commercial applications.

Description

Six-phase heating is marvelously optimized for the application of ERH to a single circular area of less than about 65-ft (20-m) diameter. For almost any other application area or shape, six-phase heating suffers from inherent flaws due to uneven heating between arrays that make it impractical. Three-phase heating is the ideal electrical phasing method for large and non-circular remediation areas. An example site is illustrated below, showing the optimum phasing for three-phase heating and for six-phase heating:

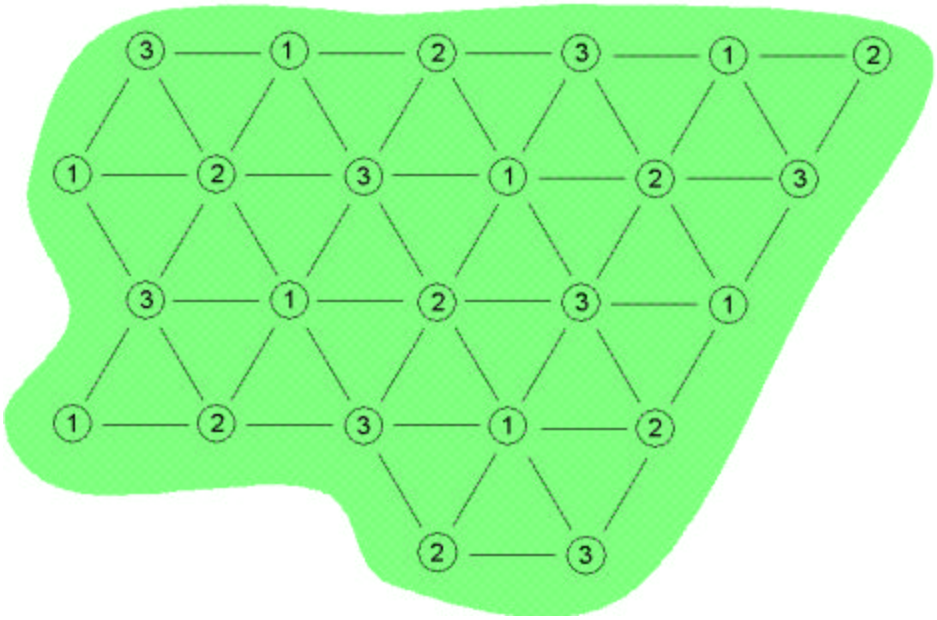

Figure 1 - Three-Phase Heating Pattern

When using three-phase heating, the current flow and heating pattern (simplified as thin black lines above) is very simple, uniform and regular. The electrodes can be easily "mapped" over the region of contamination. Three-phase heating is naturally balanced electrically, with similar numbers of electrodes connected to all three phases.

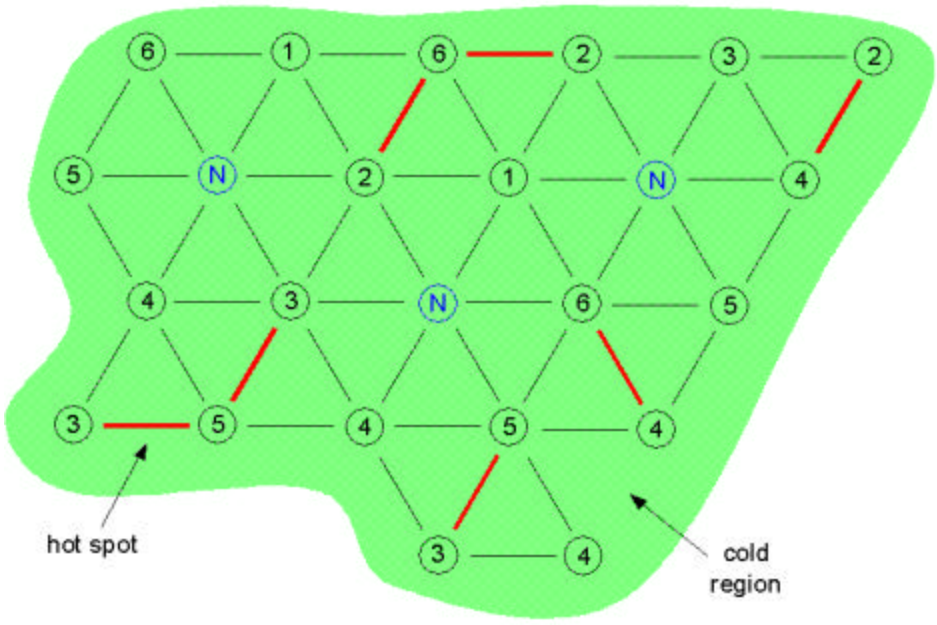

Figure 2 - Six-Phase Heating Pattern

The optimum configuration of six-phase heating to treat the same region is shown above, consisting of three complete arrays and seven peripheral electrodes. If an electrode is

adjacent to an electrode that is one different in phase number, normal electrical current and heating will occur. If an electrode is adjacent to a neutral electrode (labeled "N" above), normal electrical current and heating will occur. If adjacent electrodes differ by more than one phase number, excess current will flow and a hot spot will develop as shown between the electrodes labeled as phases "3" and "5" above. Similarly, if adjacent electrodes are the same phase, no current flow or heating will occur as shown in the "cold region" above. The problems depicted above are common in any large-scale application of six-phase heating, and tend to become worse as the area of treatment expands.

In addition to uneven heating problems, six-phase heating is not as naturally balanced as three-phase heating. In the example depicted above, the number of electrodes connected to each electrical phase is:

Phase	**1**	**2**	**3**	**4**	**5**	**6**	**N**
# of electrodes	2	3	4	5	4	3	3

As can be seen from the above table, the Power Control Unit must apply over twice as much power to Phase 4 as it applies to Phase 1 to achieve even heating. Finally, notice there are no Phase 1 or Phase 2 electrodes located in the southern half of the region shown in Figure 2; such geometric distortion results in further heating problems.

For the above reasons, no ERH vendor has ever used only six-phase heating to successfully remediate a full-scale site. All successful full-scale ERH remediations have been performed using three-phase heating or a combination of three-phase heating and six-phase heating. A project example history (arranged by date of completion from 1997-2001) is shown below:

Site	**Type**	**Phases Used**
Savannah River Site	single array pilot	six-phase
Niagara Falls AFB	single array pilot	six-phase
Dover AFB	single array pilot	six-phase
Chicago, IL	full-scale (failure)	six-phase
Fort Richardson Pilot	single array pilots	six-phase
Fort Wainwright	single array pilot	six-phase
Petroleum Refinery	single array pilot	six-phase
Skokie, IL	full-scale	six-phase, then three-phase
Western Washington	full-scale	three-phase
Fort Richardson Full Scale	full-scale	three-phase
Georgia Manufacturer	full-scale	three-phase
Pesticide Manufacturer	single array pilot	six-phase
Launch Complex 34	rectangular pilot	mostly three-phase
USAF Plant Four	single array pilot	six-phase
Waukegan, IL	full-scale	three-phase
Portland, OR	full-scale	three-phase

As can be seen from the table above, six-phase heating has been used on a larger number of projects than has three-phase heating. However, three-phase heating is has been used on the larger projects and therefore has treated far greater cubic yards than has six-phase heating.

In the future, it is likely that six-phase heating will be used only for single-array pilot tests. Furthermore, the need for pilot tests is expected to decline as the marketplace becomes more comfortable with ERH.

For more information contact David Fleming 425-603-9036, dfleming@thermalrs.com, and visit our website, www.thermalrs.com.

Upcoming ERH Projects 2001-2002

Site	Type	Phases Used
NAS Dallas	single array pilot	six-phase
NAS Alameda	single array pilot	six-phase
Navy Charleston	full-scale	three-phase
Lowry Landfill	full-scale	three-phase
Air Force Plant Four	full-scale	three-phase
DOE Pinellas	full-scale	three-phase
DOE Paducah	single array pilot	six-phase