SURVEY OF GEOTHERMAL HEAT PUMP REGULATIONS IN THE UNITED STATES

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ABSTRACT

Geothermal heat pump systems (GHPs) are becoming more common. As more of these systems are installed, and practitioners move into new operating areas, it is becoming increasingly important that designers and installers be aware of the pertinent environmental regulations which affect system design and installation.

To this end, a survey has been conducted of US Federal and State Regulations which govern the design and installation of both open and closed loop geothermal heat pump systems. The appropriate officials in the Federal and state governments were located, and copies of the regulations were obtained.

The regulations which affect GHPs show no uniformity across the nation. Most (but not all) states simply apply their water well regulations to open loop systems. The status of regulations for closed loop (borehole) systems is more disorganized. While a few states have adopted industry standard practice in their regulations, many have no specific regulations whatsoever, while others have adopted (or are in the process of adopting) regulations which are proscriptive, and likely to hamper the industry.

A summary of the regulations was written, and was approved by the governing officials. The summaries and copies of the regulations themselves are available on the World Wide Web at http://www.uidaho.edu/ghpc/. Contact information for governing officials, including addresses and phone numbers, is also available at the site.

1. INTRODUCTION

Geothermal heat pump systems (GHPs) are becoming more common. For example, the Geothermal Heat Pump Consortium (GHPC), has as its goal a ten-fold increase in the number of GHP systems installed by 2001. If more of these systems are to be installed, it will be necessary for both new practitioners to enter the field and for the experienced to move into new operating areas. As this occurs, it is essential that designers and installers are aware of the environmental regulations which affect system design and installation in their locale.

To this end, a survey has been conducted of the appropriate US Federal and State Regulations which govern the design and installation of both open and closed loop geothermal heat pump systems. The appropriate officials in the Federal and state governments were located, and a copy of the regulations was obtained. A summary of the regulations was written, and was approved by the governing officials. The summaries and copies of the regulations themselves are available on the World Wide Web at http://www.uidaho.edu/ghpc/. Information on the governing officials, and their addresses and phone numbers is also available at the site.

This work began as a part of the attempt to characterize existing grouting regulations (applicable to vertical boreholes). It was initially supported by the Electric Power Research Institute (EPRI) and the National Rural Electric Cooperatives Association (NRECA) as part of the effort to revise the International Ground-Source Heat Pump Association (IGSHPA) Grouting Manual. [Den Braven and Jensen, (1996)] This work was extended to include Canadian National, Provincial and Territorial regulations [Den Braven and Schiers, (1996)] but this work is not included on the US Regulations website.

The regulations survey was first extended with support from the Geothermal Heat Pump Consortium to include horizontal and open system regulations, and to place them on the World Wide Web. Later extensions to the work included gathering applicable building code regulations. This information is also available on our Website. Work in progress includes determining local codes and regulations, names and contact addresses of the local officials, and continuous updating of the existing information.

2. SUMMARY OF GEOTHERMAL HEAT PUMP REGULATIONS

2.1 Open Loop Geothermal Heat Pump Systems

Regulations governing open loop systems fall into the following five general governing categories:

-well driller licensing,
-pump installer licensing,
-water well construction standards,
-reinjection regulations, and,
-surface discharge.

While there is no nationwide consensus among regulators concerning appropriate regulations for drilling open loop geothermal heat pump systems, each state tends to apply its water well regulations to these systems. In addition, the National Ground Water Association disseminates information to its members on what is considered good well drilling practice. Forty six of the fifty states require licensing of well drillers, while about half also require separate licensing for pump installers.

On the discharge side, there are Federal regulations which govern both above-ground and below ground discharge. The Environmental Protection Agency's (EPA's) National Pollutant Discharge Elimination System (NPDES) regulations specifically govern surface discharge, unless a state has applied for and received "primacy" from EPA (the right to govern discharges at the state level). In addition, nothing in Federal statutes prevents a state or other governing body from adopting regulations which are more strict than the NPDES. Some states will prefer surface discharge for systems, while others will forbid it. Many are only worried about surface discharge if the change in the water temperature through the geothermal system is large, which is typically not the case for a geothermal heat pump system.

The situation is similar for reinjection. Since water is being reinjected underground, these wells are covered by the Underground Injection Control (UIC) regulations. Many states have regulations governing spacing of wells, allowable depths, etc.

2.2 Closed Loop Geothermal Heat Pump Systems

Closed loop geothermal heat pump systems are unlike any technology which has been used before. While it makes some sense to apply water well regulations to open loop supply wells, there is no existing body of regulations which are immediately appropriate for closed loop systems.

As the number of systems increases, environmental concerns are also coming to the forefront. Responsibility for groundwater quality can come under the purview of Federal, state, and local or regional governmental entities.

The Federal UIC and NPDES regulations were designed to prevent contamination of groundwater, aquifer, and surface water. However, the UIC portion of the Safe Water Drinking Act (40 CFR, Parts 144-147) precludes a closed-loop ground source system from being defined as an injection well as it is not used for the emplacement of fluids underground. Similarly, the NPDES portion of the Clean Water Act (40 CFR, Parts 122-124) which covers surface discharge of fluids, does not include ground-coupled heat pump systems under the definition it uses for "waters of the United States", which specifically limits its influence to such water bodies as wetlands, ponds, streams, sloughs, and navigable waterways. However, nothing in either the UIC or NPDES regulations precludes any state, county, parish, water district, municipality, etc. from adopting more stringent regulations. The majority of regulatory activity concerning closed loop ground-coupled heat pump systems has occurred at the state level.

The primary concern of the states is protection of groundwater quality, and all are at least concerned about the potential for groundwater contamination due to these systems. However, the reaction of the various states to this concern has varied greatly. The resulting action ranges from benign neglect to proscriptive policies which dictate materials and methods of design and installation very precisely. The recent increase in the number of installed systems has improved awareness, but has not necessarily increased understanding and knowledge among those who are responsible for promulgating and enforcing environmental regulations. The current status of regulatory requirements is a mish-mash, with little rhyme or reason. All wish to protect groundwater, but do not agree on how this is best accomplished.

In some cases, regulators have consulted with the practitioners in a particular state or region, and have worked out acceptable statutes which the industry accepts as sensible. In other cases, regulators have been hostile to concerns from industry practitioners, and have enacted debilitating legislation despite technical and scientific arguments to the contrary. Yet again, others have acted out of a sense of protective duty, but with ignorance of the technology and a lack of understanding of various options and their environmental impact.

Existing regulations for closed-loop systems tend to fall into the following categories:

-horizontal loop construction,
-vertical borehole and loop construction,
-grouting or backfill methods and materials,
-antifreeze specifications, and
-direct expansion specifications.

(A very few will also mention such lesser used systems as mains-connected systems, and standing columns wells.)

A typical example of the type of regulatory chaos that one will find is shown by looking at antifreeze specifications in the different states.

Closed-loop heat pump systems installed in most locations in the United States require the use of an antifreeze within the ground loop piping in order to prevent damage due to freezing. While approximately half of the states do not have specific regulations, all are at least somewhat concerned about the potential for groundwater contamination due to ground-coupled heat pump systems. Numerous antifreeze solutions have been tried over the years, with varying success.

The perfect antifreeze has not yet been invented. It would be:

- non-toxic,
- non-flammable,
- stable,
- compatible with other system materials,
- non-polluting (with respect to such characteristics as biological oxygen demand (BOD),
- non-corrosive,
- cheap, *and*
- would have excellent heat transfer and low viscosity characteristics.

Every antifreeze in use represents a compromise in the above characteristics. The most commonly used fluids to this point in time have been aqueous mixtures of:

- ethylene glycol,
- propylene glycol,
- methanol,
- ethanol,
- sodium chloride,
- calcium chloride, and
- potassium acetate.

Each of these has benefits and drawbacks. Each is acceptable in some locations in the United States, while at the same time being unacceptable in others. Ethylene glycol is the most common automotive antifreeze. However, it is toxic, and is not commonly used in ground-coupled heat pump systems, except in Europe [Heinonen, Tapscott, Wildin, and Beall, (1997)]. The salt solutions are non-toxic and non-flammable, but present potentially serious corrosion problems. Methanol is common, but is toxic, and is flammable in high concentrations. Ethanol is also common, and is less toxic than methanol, but can also be flammable, requiring care in handling. Potassium acetate is non-toxic and non-flammable, but its use can cause leakage and consequent corrosive problems which have resulted in litigation. Propylene glycol is non-toxic, and if food- or pharmaceutical-grade, is acceptable as a food additive. However, propylene glycol is more viscous than the other fluids, resulting in higher energy usage for the system. This higher viscosity also makes it more difficult to handle in cold weather. Three fluids have been recommended for use by the International Ground Source Heat Pump Association (IGSHPA) (a ground source heat pump industry association) in their standards. These are potable water, water plus potassium acetate, and water plus propylene glycol.

A detailed study of the relative advantages and disadvantages of numerous antifreeze solutions was recently completed by Heinonen, Tapscott, Wildin, and Beall, (1997), which is summarized in [Heinonen, Wildin, Beall, and Tapscott, (1997)]. Their conclusions detail:

- life cycle costs,
- corrosive risks,
- leakage risks,
- health, fire and environmental concerns, and
- regulatory risks (termed concern for future risk).

They also identified two other potential antifreezes which may be worth considering due to their characteristics and use in similar applications: calcium magnesium acetate (CMA), and urea ($CO(NH_2)_2$). They note CMA has high leakage potential and high long-term costs, while urea is also prone to leakage and is also corrosive. In general, the authors agree with IGSHPA, which recommended potable water, water plus potassium acetate, or water plus propylene glycol.

At present, twenty-six (26) of the fifty (50) states have no specific regulations or recommendations about what fluids are acceptable for use in ground-coupled heat pump ground

loop piping. Most of these also have no specific regulations regarding the construction or grouting of boreholes either.

Most of the rest of the states that have considered the issue have taken what may be referred to as a "belt-and-suspenders" approach to groundwater protection. That is, they will not only dictate proper construction of the ground loop to prevent joint leakage, they also require proper grouting of the borehole to minimize damage should leakage occur, and then also specify use of a non-toxic fluid for the loop to prevent any damage should construction and grouting measures both fail.

Of the remaining twenty-four (24) states, six (6) do not have specific regulations (or in some cases, regulatory authority) but do have "recommendations" or "policies" which in some cases are optional, but may be made part of a drilling permit. Some of these do recommend specific fluids. Another six (6) states merely have a requirement that any fluid used be "non-toxic". As was mentioned previously, in two states jurisdiction over closed-loop fluids lies with regional or local authorities; the state does not have jurisdiction. In the remaining ten (10) states, detailed directives have been written concerning acceptable fluids (and usually other aspects of ground-coupled heat pump system construction as well). The roster of fluids that are or are not acceptable varies widely from state to state.

The only fluid which is always acceptable is potable water. Other than that, there is no universal agreement, and no universally acceptable fluid. In Table 1, the number of states listed as accepting each of the following fluids will include both those of the six states who make "recommendations" and those of the ten states which have specific requirements. They will not include those who merely require a "non-toxic" fluid.

Several fluids acceptable to some of the states, as shown in Table 1, have not yet been mentioned. HCFC-22 is a chlorofluorocarbon refrigerant most commonly used in refrigeration systems. Its use as a heat transfer fluid in ground source heat pump systems is primarily limited to what are known as direct expansion systems, in which the evaporator/condenser piping itself is buried as the ground loop without the use of an intermediary heat exchanger. This type of system is not yet common. Glycerin, dipotassium phosphate, and calcium carbonate have also seen limited use in ground source heat pump systems.

As can be seen from Table 1, a majority of those states which specify fluids prefer potable water, propylene glycol, and potassium acetate. It is no accident that these fluids are the ones recommended by IGSHPA, as a number of states looked to them for industry input as they constructed their regulations.

A detailed list of the fluids which are approved by each state is given in [Den Braven, (1998)].

It is strongly recommended that the reader contact the pertinent regulatory officials within each state or other regulatory body to determine in detail the current application of regulations, as these do evolve and change over time.

TABLE 1: *FLUIDS ACCEPTABLE TO THE STATES*
(of the sixteen states who specify fluids)

FLUID	**NUMBER WHICH ACCEPT THE FLUID**
Potable Water	All
Aqueous propylene glycol	13
Aqueous potassium acetate	10
Aqueous calcium chloride	6
Aqueous sodium chloride	3
Aqueous ethanol	3
HCFC-22	2
Glycerin (Pharmaceutical grade)	2
Dipotassium phosphate	2
Aqueous methanol	2
Calcium carbonate	1
Aqueous ethylene glycol	1
Salt water	1
"Others on approval"	1

2.3 Local Regulations

In addition to the state regulations, a number of localities have adopted regulations concerning geothermal heat pump systems. We are in the process of collecting local regulations. Once again there is no systematic agreement on the part of local officials on appropriate regulations for this technology. Local regulations often exist due to the efforts (for good or ill) of only one or a few individuals. The situation is even more variable than on the state level.

By way of example, we have discovered the following:

-In Washington, thirteen counties have authority to expand on the state's water well construction standards as they see fit.

-Several counties in Montana have the authority to regulate water wells and driller licensing.

-All counties in Minnesota have the authority to expand upon state reinjection well standards.
-Several townships in Pennsylvania forbid the construction of open loop systems.

These regulations typically exist on the county or town (or city) level. Again, it is again strongly recommended that the practitioner contact officials in his or her location to determine whether there are any applicable regulations *before* commencing activities in a new location.

3. REGULATORY CLIMATE CHANGE

In addition to the regulations listed above, a number of states also have regulatory changes in progress, including Wyoming, Illinois, Iowa, Kansas, Washington, Ohio, and Maryland. The majority of these involve open loop systems. However, a few are developing detailed regulations. These include California and New Jersey. Still others with no regulatory authority have developed detailed "guidelines" to encourage proper construction of geothermal heat pump systems (Pennsylvania).

To assist in the development of appropriate construction practices, the National Ground Water Association in 1997 gathered together regulators, scientists, installers and other interested parties in an effort to develop industry supported guidelines for the construction of vertical boreholes for closed loop systems. This resulted in the publication in July, 1997 of "Guidelines for the Construction of Vertical Boreholes for Closed Loop Heat Pump Systems" [McCray, Ed., (1997)]. Their primary concern is that the subsurface environment is protected, and that industry practice be consistent with that concern. In this document, they address such issues as drilling , sanitary protection, control of drilling fluids, grouts, grout placement techniques, piping, pipe joining, heat transfer fluids, decommissioning, and many other topics. It should be noted that many of their suggestions, such as recommendations on acceptable piping materials, refer to that accepted by IGSHPA.

4. SUMMARY AND CONCLUSIONS

The regulations which presently govern the design and construction of open and closed loop geothermal heat pump systems across the US are a patchwork of appropriate and inappropriate responses to potential environmental problems. As these systems become more common, fear of environmental degradation can cause the passage of proscriptive legislation.

It is imperative that GHP system designers and installers recognize and acknowledge the concerns of regulatory officials. It is also imperative that they help educate officials in current and suggested industry practice. The existence of the Website which summarizes the existing regulations can be useful, as many states or other governing locales will study the response of other regulators to the technology, or even contact them for input.

The totality of state regulations in the US is so broad that is impossible to cover them thoroughly in this short paper. It is recommended that the reader consult the Web site mentioned before and their state regulators for complete information.

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