10 YEARS VDI 4640
German Guidelines for Ground Coupled Heat Pumps, UTES and Direct Thermal Use of the Underground

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General Principles of VDI Guidelines

VDI guidelines are generally recognized as engineering standards

Objectives:

• Description of current and future state-of-the-art developments
• perspective working papers and decision support
• drawing up appraisal and evaluation criteria
• promoting the exchange of experience and the transfer of technology
• gaining a special legal recognition (e.g. by laws, decrees and regulations or through inclusion in terms and conditions of business and contracts)
• integrating in harmonized European and international rule making (e.g. basis documents and as national perspective in the drawing up of European or international rules)
History of VDI 4640

Members:
- Science: representatives from universities and research institutes
- Industry: heat pump industry, drilling companies, design engineers
- Legal entities: mining and water authorities

Working started July 19 in 1995 (constitutional session)

Objectives:
Design and installation procedure of the different techniques of thermal use of the underground – heat extraction, heat injection and heat storage
History of VDI 4640

Publishing:

- Part 1 – ‘Fundamentals, Approvals, Environmental Aspects’
- Part 2 – ‘Ground Source Heat Pump Systems’
  - 1st draft: Feb. 1998
  - 1st draft: Mar. 2000
- Part 4 – ‘Direct Use’
  - 1st draft: Mar. 2002
  - final version: Dec. 2004
Contents of the Guidelines
Part 1 – ‘Fundamentals, Approvals, Environmental Aspects’

1 Scope
2 Abbreviations and definitions
3 Principles
4 Legal aspects, approvals required
   - water rights – heat pumps with groundwater wells, horizontal loops, BHE’s, UTES
   - mining law – geothermal as licensed mineral resource, depth => 100 m, below 100 m
5 Safety aspects of heat pumps
Contents of the Guidelines
Part 1 – ‘Fundamentals, Approvals, Environmental Aspects’

6 Site assessment – above ground, underground

7 Environmental aspects
  - primary energy
  - CO₂-Emission, refrigerants
  - potential influence – thermal impact, pollution by antifreezes and refrigerants due to leaks

8 Environmentally friendly materials for underground installation
  - materials for wells, horizontal loops and borehole heat exchangers
  - antifreeze in horizontal loops and borehole heat exchangers
  - refrigerants in direct evaporation systems
Contents of the Guidelines
Part 2 – ‘Ground Source Heat Pump Systems’

1. Scope

2. Abbreviations

3. Use of groundwater with wells
   - design and installation – hydraulics, hydrochemistry, drilling and well construction

4. Use of the shallow underground with horizontal loops
   - design, installation – loop depth and distance, material properties, commissioning
Contents of the Guidelines
Part 2 – ‘Ground Source Heat Pump Systems’

5 Use of the underground with borehole heat exchangers
   - design – small systems < 30 kW, big systems > 30 kW
   - installation – drilling, manufacturing and testing of BHE’s, installation and grouting, pressure test, filling, purging, commissioning

6 Special features of direct evaporation heat pumps

7 Characteristics of other heat sources
   - foundation piles; trench collectors, spiral collectors; coaxial wells; mines, tunnels

8 System integration (manifolds, dimensioning of piping and pumps)

9 Heating system and buffer storage

10 Dismantling of ground source heat pumps (groundwater wells, horizontal loops, BHE’s)
Contents of the Guidelines

Based on ECES IEA Annex VIII, XII, XIII work!

1 Scope

2 Abbreviations, symbols and indices

3 General
   ➢ definitions,
   ➢ environmental aspects of UTES,
   ➢ materials for higher temperatures

4 Integration in energy supply systems
   ➢ energy balance,
   ➢ temperature levels,
   ➢ performance ratio,
   ➢ uses – heat, cold and heat/cold storage with or without a heat pump,
     solar energy storage, heat and power co-generation, waste heat, etc.
Contents of the Guidelines


5 Aquifer storage
- description of system;
- site exploration – collecting & interpretation of parameters;
- design of system and wells;
- licensing of ATES;
- potential operating problems – precipitation of calcium carbonate in high-temperature heat storage systems, precipitation of iron and manganese, degassing phenomena, contaminated sites.

6 Storage systems using borehole heat exchangers (BHE)
- general;
- geometry of the storage system;
- layout – general procedure, rough layout, numerical simulation;
- construction – boreholes, BHE materials, heat transfer fluid, antifreeze, installation and grouting of BHE’s, hydraulics.

7 Other underground thermal storage systems
- cavern storage;
- abandoned mines;
- gravel/water pits, soil/water pits.
Contents of the Guidelines

Part 4 – ‘Direct Uses’

1 Scope

2 Abbreviations and definitions

3 Direct thermal use of ground water
   - system description;
   - environmental influence and water management and water legislation – environmental effects, water management objectives, water legislation aspects;
   - design – hydraulic and hydro-chemical parameters, installation, dismantling
Contents of the Guidelines
Part 4 – ‘Direct Uses’

4 Direct thermal use of the underground with borehole heat exchangers, energy piles, etc.
- system description;
- environmental aspects and questions relating to water legislation;
- construction and installation including dismantling

5 Air heating or cooling in the underground
- description of system;
- environmental aspects;
- air hygiene
- design – fundamentals of design, design of small and large plants;
- installation, selection of materials, dismantling;
- control strategy;
- economic efficiency – economic calculations, operational costs, capital costs and investment costs, maintenance costs
Conclusion
VDI 4640 guideline ‘Thermal Use of the Underground’

Objectives are compilation of
- environmental aspects,
- basic requirements of components and installation techniques in a legally binding guideline

It covers
- fundamental aspects,
- ground source heat pumps,
- underground thermal energy storage and
- direct use of the underground
Conclusion
VDI 4640 guideline ‘Thermal Use of the Underground’

Part 1 & 2 – fundamentals & ground source heat pumps:
- high quality of components and
- construction of ground source heat pump systems
  - to the advantage of users and environment
  - well recognized by the licensing authorities

Part 3 and 4 cover UTES and ‘Direct Uses’
- high potential in terms of energy conservation and efficient use of energy
- but not yet penetrated the market like ground source heat pumps.

Actual market development and advances of technology require a revision of the guidelines (start 2004)