



Municipal Thermal Energy Network Accelerator



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*The New York
Community Trust*
of Westchester

A COLLABORATION BETWEEN:





Today's presentation ...

The latest GSHP standard: What you need to know for success

Jeff Hammond
Executive Director
International Ground Source
Heat Pump Association



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Learning Objectives

- Understand a “little bit of history” about IGSHPA and the standard
- Learn what’s new in the 2025 edition of the standard
- See why should you should care about the standard
- Look at impacts on applications / design / installation
- Understand how to obtain the new standard
- Q & A

A Little Bit of History ...



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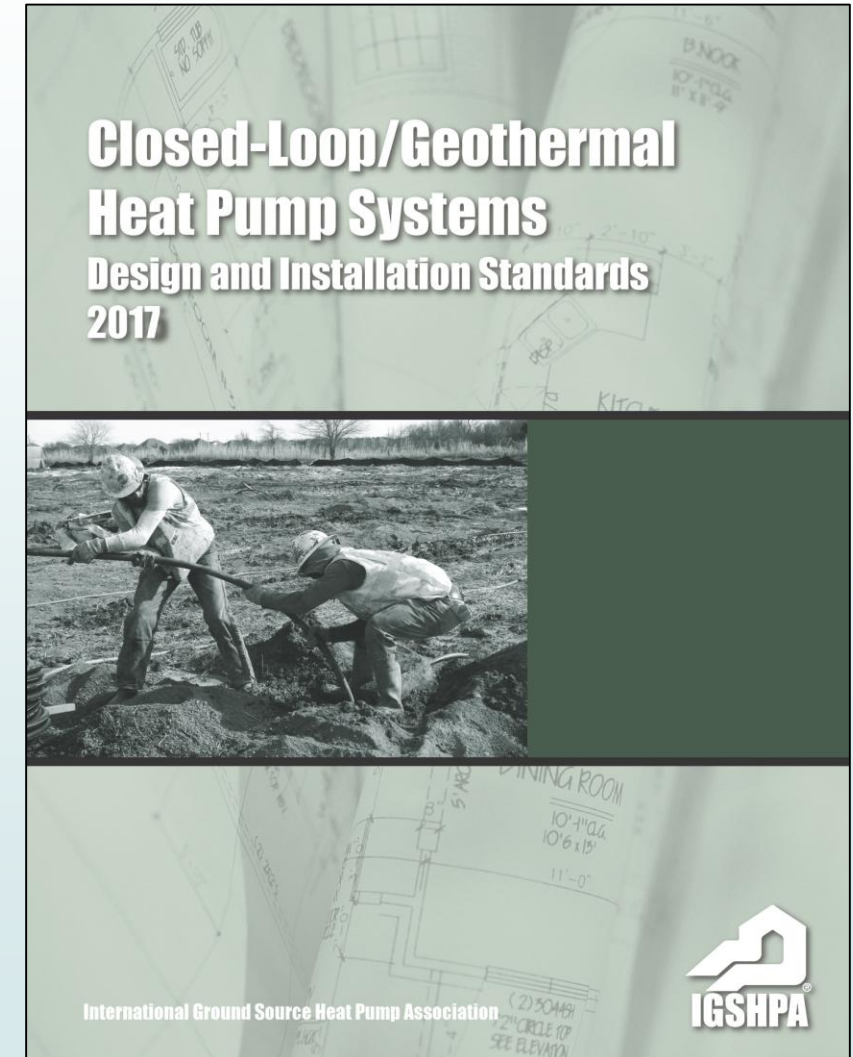
A Strong Foundation

- 1974: Oklahoma State Univ. research starts on ground source heat pumps
- 1987: Founding of IGSHPA
- 1988: First GSHP installation manual published (OSU/IGSHPA/NRECA)
- Late 1980s: GSHP training workshops started
- 1996: First IGSHPA design and installation standard
- And much more ...
- 2020: IGSHPA became an independent non-profit



2017 IGSHPA Standards

- IGSHPA Standards have guided the industry for years (original publishing date was 1996)
- Updated regularly by IGSHPA Standards Committee
 - Latest edition is 2017



C448 Standard History

- **1992:** First edition of C445 Design & Installation standard (Residential)
- **1994:** First edition of C447 Design & Installation standard (Commercial & Institutional)
- **2002:** C448 combined C445 & C447 into one standard (through 2013 edition)
- **2016:** CSA, ANSI, IGSHPA, PPI, NGWA, and many others updated C448 to a bi-national standard (Canada and U.S.) → **ANSI/CSA/IGSHPA Standard C448:16**



ANSI/CSA/IGSHPA C448 Series-16

Design and installation of ground source heat pump systems for commercial and residential buildings

*Until 2025, there were 2 standards:
2017 IGSHPA Standards & 2016
ANSI/CSA/IGSHPA C448 Standard*

REVISED AUGUST 2017

Endorsed by



International Ground Source Heat Pump Association

Why Change?



- IGSHPA Standards language is not easy to adopt as code language in the current format
- Having one standard for the industry is much less confusing!
- IGSHPA Standards Committee completed a report in 2019 for sunseting the 2017 Standards in favor of ANSI/CSA/IGSHPA C448 bi-national standard
 - Included suggestions for changes to C448 next edition
- IGSHPA board of directors voted to sunset the 2017 Standards upon release of next bi-national standard

What's New?



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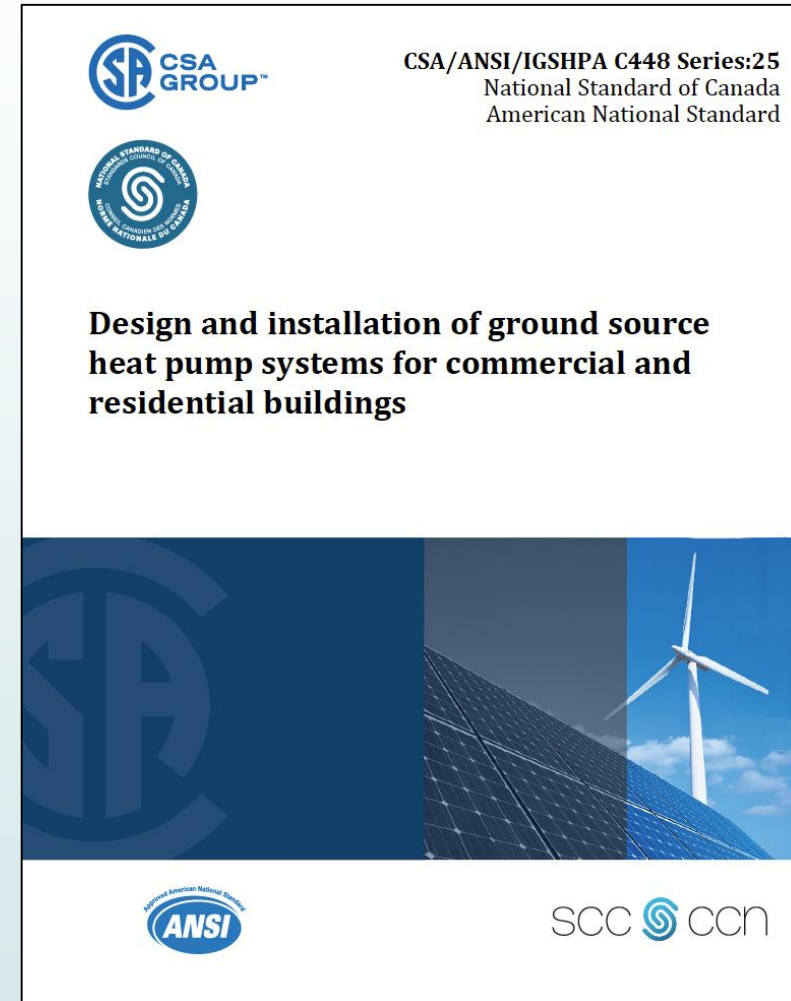
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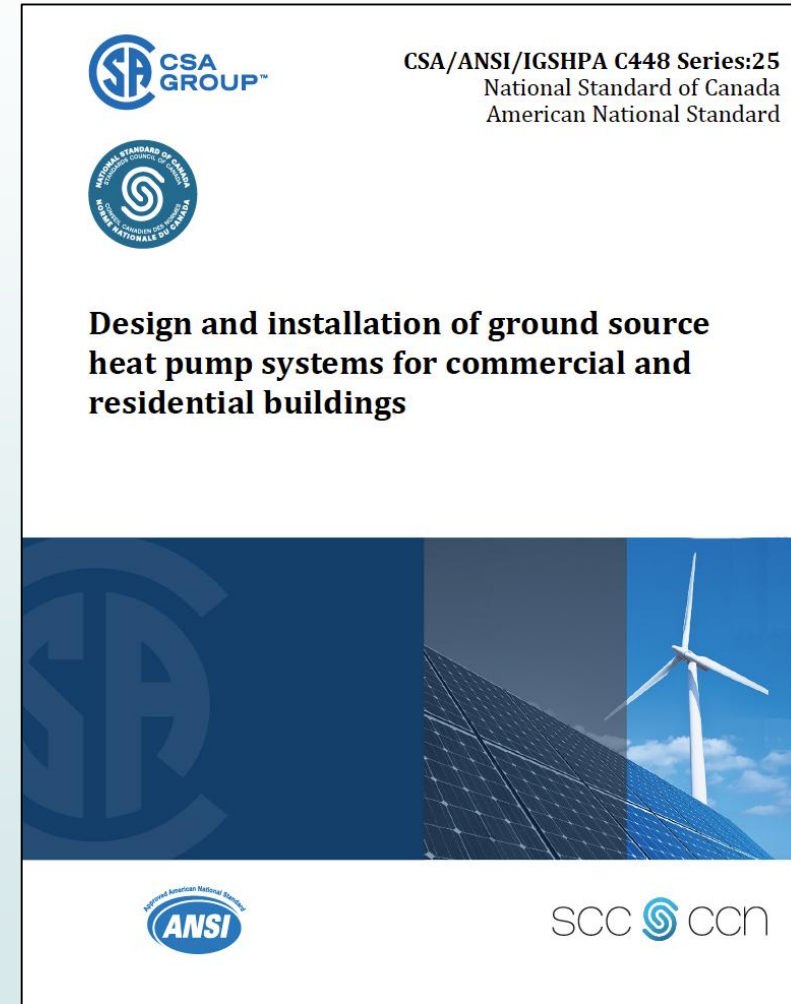
C448 Standard 2025 Edition

- 2025 edition published in May
- Many new updates
- Consolidation of redundant clauses
- Nearly 250 pages!
- Significant price discount for IGSHPA members (licensed PDF version)
- Basis for all new IGSHPA training
- 2017 IGSHPA Standards have been sunset → C448 is the new IGSHPA Design & Installation Standard



What's New?

- **New section on District Systems**
- New section on Energy Foundations
- New Annex on Waste Water Energy Transfer Systems
- New PE-RT piping material added
- New glycerin-based and detoxified ethylene glycol added as acceptable heat transfer fluids
- Removal of PVC as an acceptable piping material for inside piping



C448 Layout

- 11 Sections
 - General Section: Applications for all systems, regardless of heat exchanger selection
 - Residential and other small buildings
 - Commercial and institutional buildings
 - **District Energy Systems**
 - Vertical Ground Heat Exchangers
 - Horizontal Ground Heat Exchangers
 - Surface Water Heat Exchangers
 - Groundwater Systems
 - Standing Column Well Systems
 - **Energy Foundations**
 - Direct Exchange Systems
- 6 Annexes
 - Electrical, environmental, and other guidelines
 - Installation checklist
 - Site survey / as-built worksheet
 - Annual energy requirements (ASHRAE bin hour method)
 - **Wastewater Energy Transfer**
 - Bibliography

Blue text = New sections, 2025 edition

General Section* (C448.0)

- MANY updates to definitions
 - Engineer → Designer
 - **Designer — the entity legally responsible for the ground source heat pump system design.** Note: This can be the engineer of record (P.E. or P.Eng.), a contractor who designs and installs ground source heat pump systems, or other entity acceptable to the AHJ
 - Geothermal → Ground Source Heat Pump (consistent with ASHRAE)
 - Clarity on “header” vs. “manifold”, including drawings
 - Consistency on terminology
 - e.g., Ground Heat Exchanger (vs. ground loop, earth coupled, etc.)
 - New terms for new sections/annex

General Section* (C448.0)

- Moved clauses that appeared in more than one section to General
- Setbacks: The designer shall be responsible for satisfying the requirements of the AHJ. No actual setback dimensions are provided.
- In situ (formation) conductivity test: Reviewed and updated language
 - 2016 edition was much more prescriptive; 2025 edition gives the designer the leeway needed to make the correct decision for the system they are designing.
- Underground piping: Added PE-RT & pipe installation procedure
- Interior piping: PE, PE-RT (new), PEX, steel, copper, PP-R, PP-RCT – *What's missing?*
- Locating and marking: Clauses expanded and addressed tracer wire

General Section* (C448.0)

- Heat transfer fluids: Completely rewritten by SMEs
 - Added glycerin-based & detoxified ethylene glycol
 - Added water quality specification
 - Added requirements for corrosion & scale inhibitors
- Added requirement for designer to specify minimum static pressure
- Added clarification to the grouting procedures
- Hydrostatic pressure testing: Based upon ASTM F2164; added GHX specific language and optional individual U-bend testing procedure

Residential* (C448.1)

- Added maximum cooling design EWT to GHX system design (previously included only minimum EWT for heating)
- Many clauses moved to General section that were duplicated in other sections

*Design and installation of ground source heat pumps for residential and other small buildings

Commercial* (C448.2)

- Reviewed the IGSHPA Standards Committee recommendations and comments
- Aligned terminology in the clauses with definitions to provide greater clarity.
- Clauses were rewritten to be more performance based rather than prescriptive.
- Clauses for design and commissioning were rewritten to align with ASHRAE requirements.
- Many clauses moved to General section that were duplicated in other sections

*Design and installation of ground source heat pump systems for commercial and institutional buildings

District Energy Systems* (C448.3)

- New section in the standard
- Includes
 - Project planning
 - Site survey
 - Suitability assessment
 - Piping materials / components
 - System design
 - Heat transfer fluid
 - Controls
 - Startup/commissioning & decommissioning/abandonment
- References ASHRAE District Heating & District Cooling design manuals

District energy system - A system characterized by one or more central plants distributing ambient water, hot water, water-based solutions, steam, and/or chilled water, which then flows through a network of pipes to provide hot water, space heating, and/or air-conditioning for multiple buildings. Central plants are inclusive of pumping stations or plants which can be employed as part of a district energy system using the earth, groundwater, and/or surface water as a source or a sink in the distribution system.

*Planning, design, installation, and commissioning of district energy systems

Surface Water Systems* (C448.6)

- Standard section title was updated**
- Structure was aligned with the general section
- Plate heat exchangers were incorporated into the section and a requirement for certification of cleaning and pressure testing
- Language for survey, design, installation and as-builts reviewed and updated
- Clauses moved to General section that were duplicated in other sections

*Design and installation of surface water heat pump systems

**Previously: Installation of surface water (including submerged exchangers) heat pump systems

Groundwater Systems* (C448.7)

- Standard section title was updated**
- Updates were made to make the section more detailed and less generic
 - Approximately 90 per-cent of this section is new content that includes site specific emphasis
 - Added investigation framework and design aspects to minimize underperforming outcomes
 - Includes more design aspects specific to groundwater
 - Emphasis on the importance of water quality and its effect on systems.
 - Design approaches that can promote robust operation with regard to system fouling
- Decommissioning of groundwater systems now follows local water well decommissioning regulations
- Great participation from NGWA

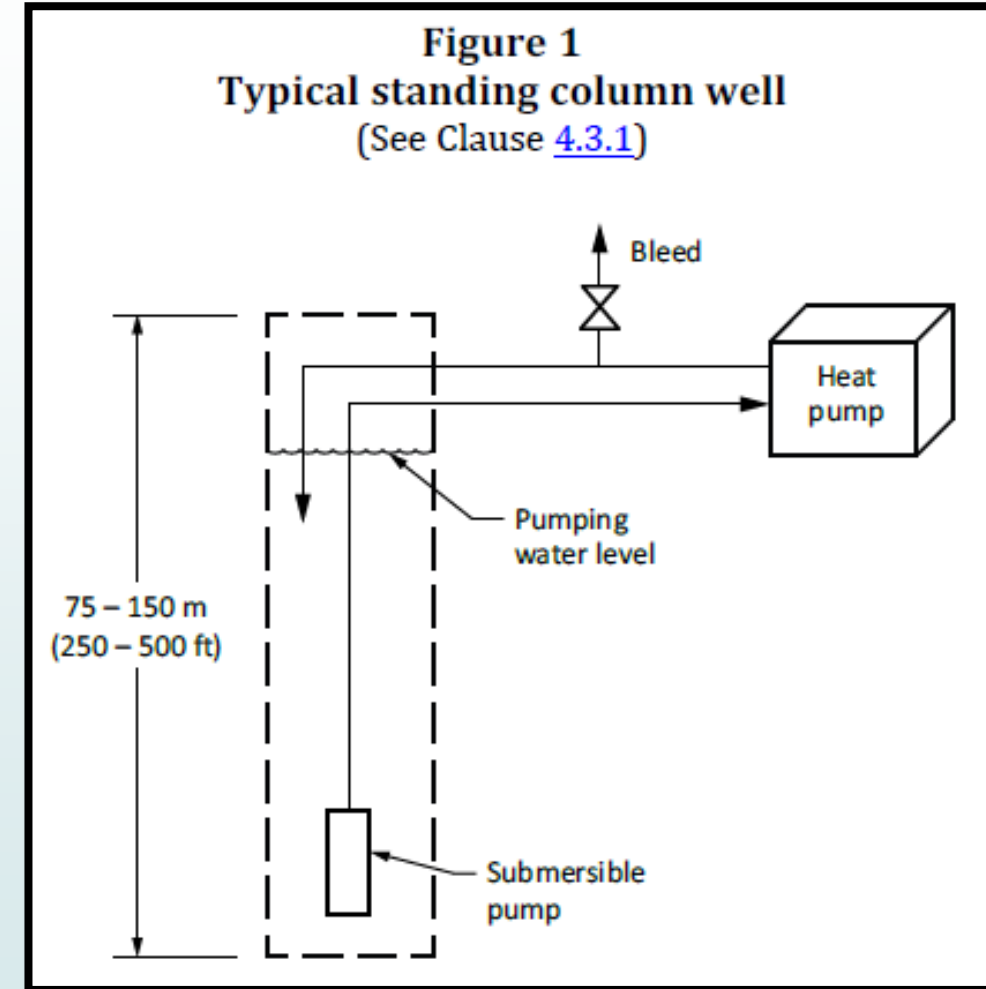
*Design and installation of groundwater systems

**Previously: Installation of open ground water systems

Standing Column Wells* (C448.8)

- Major updates/revisions to section, including:
 - Periodic maintenance
 - Inspection guidance
- New drawings illustrating system design
- New monitoring/maintenance table
- Separate commercial & residential sections

*Installation of standing column well systems

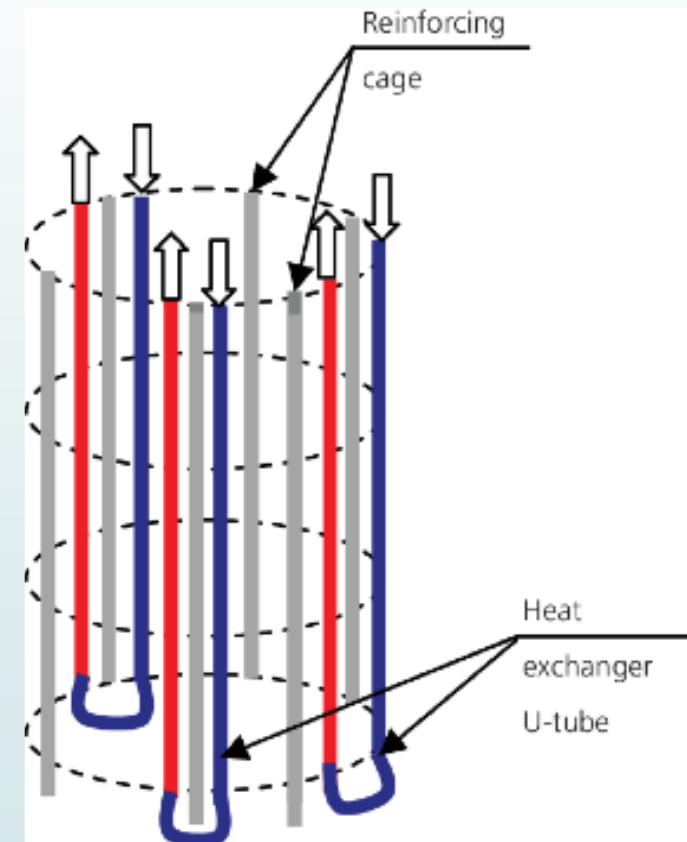


Energy Foundations* (C448.9)

- New section in the standard
- Includes
 - Piling/foundation, MEP, and GSHP designer responsibilities
 - Thermal conductivity testing
 - Design considerations
 - Installation
 - Monitoring & controls
 - System startup
 - Decommissioning & abandonment

*Design and installation of ground source heat pump systems connected to energy foundations

Energy foundation - The utilization of a concrete pile, caisson, slurry wall, diaphragm wall, underground structures, tunnel lining, or a combination of any of these items, constructed as part of a new building or infrastructure, that has incorporated heat exchange loops for the purpose of delivering heating and/or cooling to building(s).



DX Systems* (C448.10)

- New DX technology added
- Guidance on new refrigerants
- Clauses moved to General section that were duplicated in other sections

*Installation of direct expansion heat pump systems



Wastewater Energy Transfer*

- Annex E (informative)

- New Annex in the standard
- Guidance from German Association for Water Management (DWA) Set of Rules: Wastewater and Waste, DWA-M 114, April 2020
- Added as an annex in C448 as a placeholder until it becomes its own section in C448 or has its own standard

*Wastewater energy transfer systems design and installation

Why Should I Care?



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Why Should You Care?

- Standard provides unified / consistent requirements
 - Minimizes / removes differences
 - Provides / simplifies referencing for regulators → improves enforcement
 - Provides framework for practitioners in the industry to adhere to
 - Provides confidence for consumers
 - With each new edition, validation and inclusion of new advancements
 - Helps industry to explain the benefits of GSHPs to policy makers and the public
- Gives the industry a single resource for training development / personnel certification
- Bi-National (Canada/U.S.) provides consistency of design/installation in North America*
- An accredited process provides further legitimacy to the GSHP industry
- Sets the course for real growth of the GSHP Industry via a performance-based standard that delivers true end-user value with all market stakeholders

*Referenced in building code in Canada / IMC and IRC in U.S.

What if We Don't Have a Universally Accepted Industry Standard?

- As the industry grows, we could see new requirements that may contradict best practices or restrict installations due to lack of a common industry document
 - e.g.,:
 - Grouting requirements are different from jurisdiction to jurisdiction
 - Vertical loops are restricted in a jurisdiction due to lack of understanding of design/installation
 - Terminology could cause the AHJ to apply codes incorrectly (“well” vs. “bore”)
 - Engineers specify components/products that are not designed for GSHP operation

How Does the Standard Impact New York Codes / Regulations?

- New York is a LOT farther along than most states with codes and regulations. However ...
 - Codes and regulations can't cover all aspects of design and installation
- **Codes** specify the minimum requirements and **standards** for protection of public health, safety and welfare
- **Codes** are not intended as “installation guides” or best practices”
- **Codes** refer to **standards** or other specifications

How Does the Standard Impact New York Codes / Regulations?

- ***Standards*** are defined as a set of technical definitions and requirements
- Product manufacturers are responsible to determine which ***standards*** apply to their products (heat pumps, pipe, accessories, etc.)
- Designers and installers benefit from using a standard for reference ...
 - Demonstrates compliance (can help with legal liability)
 - Provides evidence of due diligence
 - Can help establish norms when working with subcontractors

How Does the Standard Impact New York Codes / Regulations?

- New York uses ICC (International Code Council) for IMC (International Mechanical Code) and IRC (International Residential Code)
 - References C448
- IAPMO (International Association of Plumbing and Mechanical Officials) is another code body
 - USHGC (Uniform Solar, Hydronics, and Geothermal Code)
 - Model code (i.e., code language)
 - References C448
- 48 states are ICC states for mechanical codes
- IGSHPA works with ICC and IAPMO

Look at Impacts on Applications / Design / Installation



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Impacts on Applications / Design / Installation

- Definitions
- Heat Transfer Fluids
- Piping Materials for Inside Piping
- GHX Piping Materials
- EWTs
- Flushing & Purging
- Locating & Marking
- District Energy Systems

Definitions

- 11 pages of definitions!
- Objective was to increase consistency and align with ASHRAE handbooks
- Examples:
 - Geothermal, Ground Coupled → Ground Source Heat Pump or GSHP
 - Ground Loop → Ground Heat Exchanger or GHX
 - Engineer → Designer (not all jobs have an engineer involved)
 - Well or Loop → Bore (super important for codes and regulations!)
 - Open Loop → Groundwater System
 - Pond/Lake Loop → Surface Water System

-- Continues --

Definitions

- Examples (con'd)
 - Manifold vs. Header (illustrations included)
 - Header is “field header” (buried) or “inside header” (non-pressurized system)
 - Manifold joins multiple GHXs (inside the building)
 - Definitions of small and large commercial
 - District Energy System defined
- More consistency = less confusion

Heat Transfer Fluids

- 2016 edition of C448 did not allow ethylene glycol and did not recognize new glycerin-based antifreeze
- 2025 edition includes both
- What has changed?
 - ***Detoxified*** ethylene glycol is chemically treated to render it non-toxic (UK company Hydratech pioneered the chemistry)
 - Ethylene glycol has been used for years in boiler/tower WSHP applications, but was not been allowed for use in GHX (Ground Heat Exchanger) piping
 - Glycerin-based antifreeze (developed by Kilfrost in the UK)
 - Has become available in the U.S. through Corechem as Corefrost™

-- Continues --

Heat Transfer Fluids

- What has changed (con'd)?
 - Both detoxified ethylene glycol and glycerin based (glycerin-potassium formate) antifreezes are non-toxic and non-flammable
 - Both have higher conductivity and lower viscosity than propylene glycol
 - More choices but the designer will still need to consider the economics for the best fit heat transfer fluid for the application
- Acceptable fluids are now ...

5.7.3.2 Acceptable fluids

Acceptable heat transfer fluids include, but are not limited to, formulations based on propylene glycol, ethylene glycol, glycerin-based, ethanol, and methanol solutions and shall be permitted by the AHJ.

Heat Transfer Fluids

- New additions
 - Water quality specification (if not provided by heat pump manufacturer)

5.7.2.1.2 Water quality specification

Water quality shall meet the equipment manufacturer and heat transfer fluid manufacturer recommendations. If no recommendation is available, then the following values for water quality shall be used:

- a) pH: 6.5 – 8.5;
- b) chlorides: less than 125 ppm;
- c) sulfates: less than 125 ppm;
- d) iron: less than 1 ppm;
- e) copper: less than 3 ppm;
- f) ammonium: less than 2 ppm;
- g) turbidity: less than 15 NTU; and
- h) any other recommendations from a water treatment specialist.

Heat Transfer Fluids

- New additions (con'd)
 - Inhibitors are required

5.7.3.4 Chemical inhibitors

Where applicable, and permitted by the AHJ, the heat transfer fluid shall contain chemical inhibitors to protect the biological and chemical integrity of the solution to prevent corrosion of system pipes, etc., as required to produce a product meeting the requirements of Clauses [5.7.2.2](#) and [5.7.3.5](#).

- C448 also includes Table 2, “Properties of Common Commercial Heat Transfer Fluids” to allow comparisons to various choices

Inside Piping Materials

- PVC and CPVC was removed from acceptable inside piping materials in 2025
 - Letters from one PVC/CPVC manufacturer in the U.S. and one in Canada recommended against using their products for GSHP systems
 - Incompatibility with methanol and higher percentages of propylene glycol
 - Incompatibility with systems that use POE oil in refrigeration system
 - Flow centers with PVC material could be replaced (considered a system component) but PVC/CPVC piping may be run in wall cavities or above ceilings and could be inaccessible in a potential failure

Inside Piping Materials

- Allowed materials in 2025 edition

5.6.3.1 General

Interior piping systems shall be comprised of

- a) PE pipe and fitting materials per Clause [5.4.2](#);
- b) PE-RT pipe and fitting materials per Clause [5.4.3](#);
- c) PEX pipe and fitting materials per Clause [5.4.4](#);
- d) steel piping (schedule 10 and 40) per Clause [5.6.3.2](#);
- e) copper tubing (Type K and L) per Clause [5.6.3.3](#); or
- f) polypropylene pipe (PP-R and PP-RCT) per Clause [5.6.3.4](#).

- Each piping materials includes reference ASTM requirements
 - As the industry grows, there may be temptation to use similar materials (e.g., HDPE water pipe ≠ HDPE GSHP pipe)

GHX Piping (Buried Portion)

- PE, PE-RT, or PEX only

5.4.1.1 Piping materials

Acceptable plastic pipe and fitting materials for the underground or underwater portion of a ground heat exchanger (i.e., the ground loop) include PE, PE-RT, and PEX, as specified in this Standard.

- Fittings for PE – socket, butt, or electrofusion only

5.4.2.2 Fittings for PE pipe and tubing

Fittings for use with the PE pipe and tubing shall

- a) comply with the requirements of
 - i) ASTM D2683 for PE socket-type heat fusion fittings;
 - ii) ASTM D3261 for PE butt-type heat fusion fittings, including saddle fittings; or
 - iii) ASTM F1055 for PE electrofusion-type fittings, including saddle fittings;

EWTs (Residential Systems*)

- Heating minimum EWTs were in 2016 edition but not cooling maximum EWTs – 2025 edition includes both

Mean ground temperature, °C (°F)*	12 (53.6)	11 (51.8)	9, 10 (48.2, 50)	7, 8 (44.6, 46.4)	6 or lower (42.8)
Minimum entering water temperature, °C (°F)	0 (32)	-1 (30.2)	-2 (28.4)	-3 (26.6)	-4 (24.8)

Mean ground temperature, °C (°F)*	10 or lower (50)	12 (53.6)	15 (59)	20 (68)	25 or higher (77)
Maximum entering water temperature, °C (°F)	40 (104)	38 (100.4)	36 (96.8)	35 (95)	35 (95)

Note: "Entering water temperature" refers to the heat transfer fluid.

* As specified in CSA F280 for Canada or IGSHPA Residential/Light Commercial Design and Installation Guide for the U.S.

*Commercial systems EWT at the discretion of the designer

Flushing and Purging

- Hydrostatic flushing and purging section completely rewritten
 - 2016 edition only had a few clauses without much detail
 - 2025 edition includes completely rewritten section
 - Started with ASTM F2164
 - Committee worked with pipe manufacturers to adapt for GSHP systems (original is primarily for gas piping)
 - Includes provisions for multiple contractors (e.g., contractors for bore field, headering and supply/return, inside piping)
 - Optional individual U-bend assembly test (for testing prior to connecting to lateral piping and headers)

Locating and Marking

- Updated locating and marking requirements
 - Added tracer wire (including type and color)
 - Based upon APWA (American Public Works Association) requirements
 - Added radio frequency markers
 - Included metallic detectable tape specifications from previous edition
 - Added details on placement of location and marketing (1 – 2 ft above horizontal piping)

District Energy Systems

- Also called thermal energy networks (TENs), utility thermal energy networks (UTENs), community heat pump systems, etc.
- Many utilities (even gas utilities) are interested in district systems for ...
 - New infrastructure (in areas where fossil fuels are being phased out)
 - New revenue streams (i.e., leasing or on-bill financing)
 - Decreasing peak demand on the grid
 - Meeting mandated state goals

-- Continues --

District Energy Systems

- New section includes guidelines for ...
 - Pre-planning
 - Site survey
 - Sustainability assessment
 - Preliminary concept plan
 - Confirmatory investigations
 - Refined concept plan
 - Detailed engineering design
- Includes considerations for connected load diversification, heat exchange options, piping materials, system components, operating temperature range, evaluation of heat sources, and consideration of future expansion

How Can I Get It?



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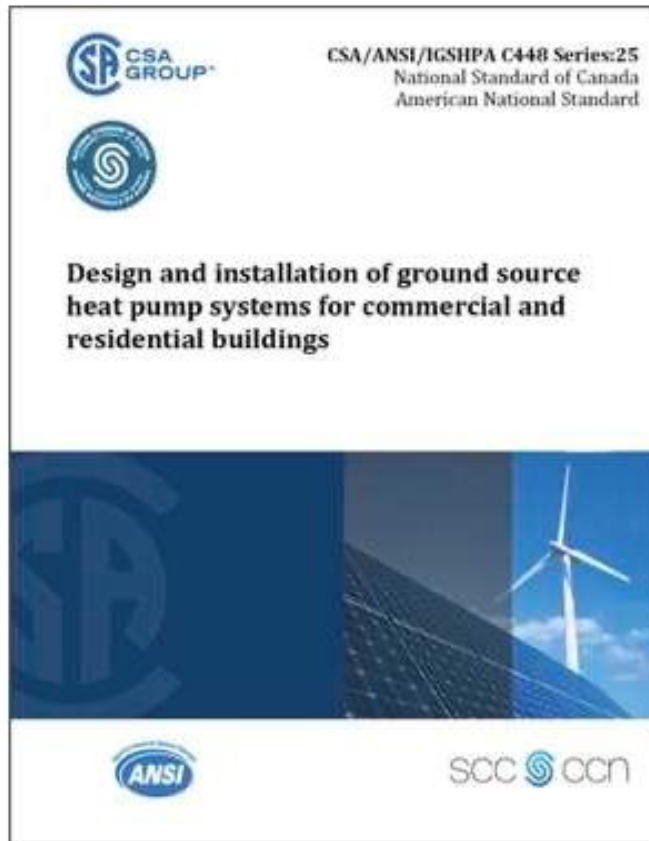


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How Do You Get the New Standard?



Purchase C448 as an IGSHPA Member**

Purchase C448 at the CSA Store

Purchase C448 at the ANSI Store

\$250 for paper edition
or licensed PDF

\$175 for licensed PDF
(igshpa.org/standards)

Next Up: ***IGSHPA – Training Opportunities for Municipal Staff***



February 23rd
11am - 12pm

Session #9: Training Opportunities for Municipal Staff

- Part 2 of IGSHPA's guest sessions
- Relevant *self-paced* opportunities include:
 - System Verification & Inspection
 - Selecting a Ground Source Heat Pump

Upcoming:

- Final session in March
- Resources & recommendation packets





Questions???

The latest GSHP standard: What you need to know for success

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