ARMSTRONG

Ground source heat pump system (VP)

Design Envelope application guide

File No: 9.564UK
Date: JANUARY 23, 2015
Supersedes: NEW
Date: NEW

DESIGN ENVELOPE APPLICATION GUIDES

Performance improvements are among the top priorities of many building professionals today. Whether you are a developer, design consultant, engineer, contractor, facility manager or owner, chances are that you face increasing demands to not only reduce costs, but also deliver performance improvements. Public awareness on multiple levels – from the individual all the way through to government bodies – has grown to the point that energy conservation, carbon reduction, tenant comfort, and other health and environment-driven practices are key objectives for any prominent, sizeable building project.

To support and sustain this paradigm shift, Armstrong has developed a suite of advanced fluid flow and HVAC offerings that we call 'Design Envelope solutions'. Design Envelope solutions integrating intelligent demand-based control to deliver optimal performance and the lowest possible cost, both at commissioning and throughout their full operating life.

This document is one of our Design Envelope Application Guides, a set of booklets that discuss a broad range of real-world HVAC scenarios. In each scenario the use of Design Envelope technology can result in tremendous improvements in performance of your HVAC installation (compared to standard industry practice) and ultimately your building - technically, financially, and environmentally.

The intent of this Application Guide is to present HVAC System designers with an alternative to standard practices for design layout, configuration, and design calculations and help you leverage the full potential of Armstrong Design Envelope solutions. Each Application Guide addresses a specific system configuration for HVAC or data center applications. The system configurations cover heating and cooling scenarios, including circuit configurations ranging from all constant flow, to full variable flow and variable speed plant configurations. The Application Guides will present piping arrangements, valving requirements, de-coupler configurations, instrumentation locations, control system options, and the associated impact on first cost and life-cycle costs. The full series of application guides is available for download from Armstrong's website at www.armstrongfluidtechnology.com

APPLICATION DIRECTORY

HVAC

COOLING

9.561UK – Water cooled chiller plant (all-variable)

9.562UK – Water cooled chiller plant (CP/VS)

9.563UK – Water cooled chiller plant with economiser

This guide covers: 9.564UK – Ground source heat pump system (VP)

HEATING

9.565UK – Condensing boiler plant (VP)

9.566UK – Condensing boiler plant (CP/VS)

9.567UK – Closed circuit heat pump system (VP)

DISTRICT COOLING

9.568UK – Water cooled central plant (all-variable)

9.569UK – Water cooled central plant (CP/VS)

9.570UK – Water cooled central plant (VP/VS)

DATA CENTRES

COOLING

9.571UK – Water cooled chiller plant with economiser (VP)

9.572UK – Water cooled chiller plant (all-variable)

9.573UK – Water cooled chiller plant (CP/VS)

VP = Variable primary flow

CP/VS = Constant primary flow / variable secondary flow

VP/VS = Variable primary flow / variable secondary flow

All-variable = All variable chiller plant, variable primary flow, variable secondary flow, variable condenser flow

Ground source heat pump system is a water-source heat pump system that provides heating and cooling throughout a building by using water circulating through a closed subsurface piping loop that functions as a heat exchanger with the surrounding earth. The ground heat exchanger is essentially an extension of the heat pump water loop, sized such that it will passively maintain the circulating loop water temperature within an acceptable temperature range of -1°C to 35°C (30°F to 95°F), and using variable speed pumps in a duty standby configuration.

On the load side, the system is a variable primary flow, with 2-way zone valves and auto bypass valve to maintain minimum flow through the heat pump. Variable speed pumps will optimise energy savings by supplying the right amount of conditioned water to match varying load demands throughout the year.

APPLICATION DETAILS

Equipment	Heat pumps	▪
Use	HVAC	▪
Configuration	Var. primary flow	▪
	Ground source	▪

DESIGN ENVELOPE BENEFITS SUMMARY

Design Envelope benefit	Design Envelope savings over conventional plant
Lowest installed cost	58%
Lowest operating cost	36%
Lowest environmental cost/impact	Annual reduction in greenhouse gas emissions (tonnes): 4.8
Lowest project and operating risk	(See table on page 8)
Total Design Envelope 1st year savings	**55%**

Tremendous benefits at all levels with Armstrong Design Envelope Solutions: consultants [reduced risks for equipment re-selection], contractors [lowest first installed cost] and owners [lowest life cycle cost]. The example presented in this guide shows overall savings of 55% of total installed cost. In Summary, lowest installed cost AND lowest life cycle cost can be now made a reality.

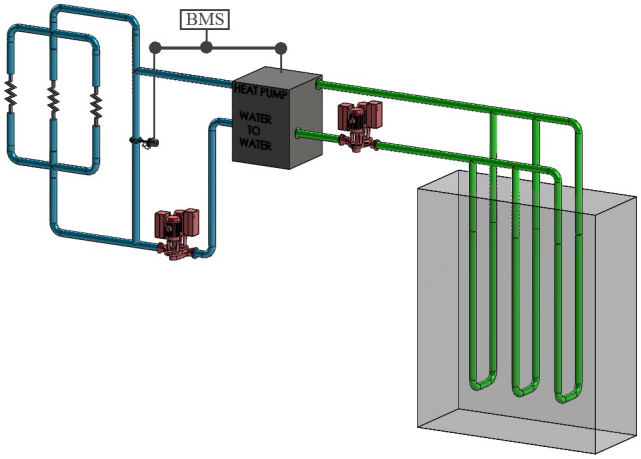


FIG. 1
DESIGN ENVELOPE LAYOUT

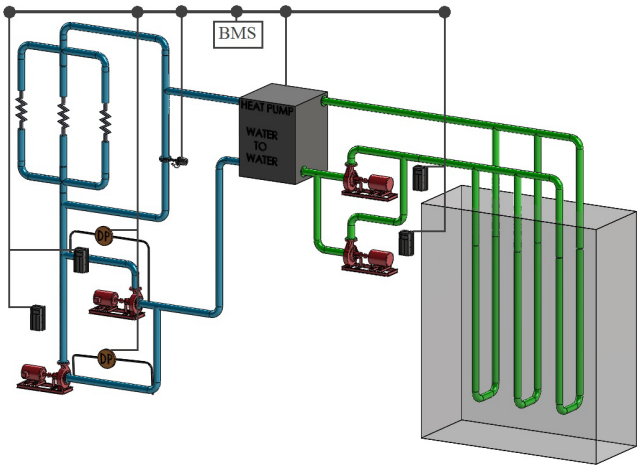


FIG. 2
CONVENTIONAL LAYOUT

PLANT LAYOUT
DESIGN ENVELOPE VS. CONVENTIONAL

	Design Envelope plant	Conventional plant
Building loop Variable Primary	• Design Envelope 4312 Vertical Twin Pump split coupled with integrated variable speed controls • Suction Guide • Flo-Trex Valve • 2-way zone valves (not shown) • 2-way bypass valve Other considerations • If design is specified with 50% redundancy then use Design Envelope 4302 Vertical DualArm Pump split coupled with integrated controls using Parallel Sensorless Technology • For multiple diverse zones or Critical zones where DP sensor across zone is needed - use Armstrong IPS 4000 controller with integrated controls using Parallel Sensorless technology	• 1 Duty + 1-standby horizontal end suction pumps • Concrete inertia base • Flexible connectors • Variable Frequency Drives remotely mounted on the wall • VFDs installation and wiring to remote pumps and BMS • Differential pressure sensors, installation and wiring to BMS • Suction Guides • Flo-Trex Valves • 2-way Zone valves (not shown) • 2-way bypass valve
Ground source loop	• Design Envelope 4312 Vertical Twin Pump split coupled with integrated variable speed controls • Suction Guide • Flo-Trex Valve	• 1 Duty + 1 – standby horizontal end suction pumps • Concrete inertia base • Flexible connectors • Variable Frequency Drives remotely mounted on the wall • VFDs installation and wiring to remote pumps and BMS • Suction Guide • Flo-Trex Valve

With the Design Envelope (DE) solution, DE pumps are self-controlled using Sensorless technology to adjust pump speed to match system demands, with pump alternation algorithms to drastically improve system efficiency and save energy. The Building Management System [BMS] does not control the DE pumps, thus saving on wiring from BMS to both DE pumps and DP sensors as well as saving on Input/Outputs required by the BMS.

The BMS will also start/stop the pumps (via the heat pump) and controls auto bypass valve to maintain minimum flow through heat pump recommended by manufacturer

Design Envelope pumps provides tremendous benefits at all levels: consultants (reduced risks for equipment re-selection), contractors (lowest first installed cost) and owners (lowest life cycle cost).

The conventional approach for both the load and heat pump side pumps is base mounted pumps with concrete inertia bases and flex connectors to isolate the vibrating pumps from building piping. The pumps operate in a 100% duty/standby configuration, and Variable Frequency Drives remotely mounted on the wall. Note the extra-long wires required for this type of installation.

The Building Management System (BMS) controls all equipment; start/stop pumps, control bypass valve to maintain minimum flow, adjust load side pump speed based on DP sensor across pump [over pumping] with duty/standby alternation, and adjust geothermal pump speed based on return temperature.

GROUND SOURCE HEAT PUMP SYSTEM BASE CASE INSTALLATION

School Building: Raleigh, North Carolina

Details:

- School building
- 140 kW geothermal heat pump
- 3000 hrs/year operation

Load side:

- Variable primary flow piping system
- 2-way zone valves
- 2-way auto bypass valve
- 18 m^3/h @ 27 m
- 4 kW Motor & Controls (compared to 5.5 kW for conventional system)

Source side:

- Variable primary flow piping system
- 2-way zone valves
- 2-way auto bypass valve
- 41 m^3/h @ 24 m
- 5.5 kW Motor & Controls

The Design Envelope approach for both the building and ground source circuits is Armstrong Design Envelope Vertical Twin pump with integrated controls using Sensorless control algorithms that adjusts the speed of the operating pumps to match system demands and alternates the standby pump when required. The load side pumps are sized at 18 m^3/h each with 100% standby (select Design Envelope 4312 5015-004.0), whereas the ground source pumps are sized for 41 m^3/h (select Design Envelope 4312 5015-005.5). The result is smaller motors (4kW vs. 5.5kW), smaller size controls infrastructure (wiring, conduits, fittings, MCC…) [for load pump only], eliminating 2 DP sensors w/ wiring from the building loop, and much higher efficiency operation using Sensorless technology.

Design Envelope pump saves energy operating at higher efficiency levels during part load demands vs. conventional systems operating at higher speeds most of the time to maintain constant DP across the pumps.

Specified redundancy is maintained, discussed in details later in this guide.

DESIGN ENVELOPE BENEFITS SUMMARY

Design Envelope benefit	Design Envelope savings over conventional plant
Lowest installed cost	£10,243
Lowest operating cost	Annual £1,050
Lowest environmental cost/impact	Annual reduction in greenhouse gas emissions (tonnes): 21.7
Lowest project and operating risk	(See table on page 8)
Total Design Envelope 1st year savings	**£11,293 (55%)**

By incorporating Design Envelope pumps we are able to provide a lower carbon footprint, more efficient and more economical first cost solution whilst maintaining flexibility and lower life cycle costs.

With Armstrong Design Envelope solutions, customers will enjoy major savings on all levels: lowest installed and operating costs, lowest environmental impact and lowest project risks. In this example the savings amounts to a staggering **£11,290 which represents 55% savings over the conventional solution**;

A breakdown of the total savings is explained in detail in the following pages.

LOWEST INSTALLED COST

Savings area	Design Envelope plant installed savings
Material & installation	£3,810
Time (labour)	£394
Power infrastructure	£1,641
Space	£3,938
Civil structure	£66
Commissioning & call backs	£394
Total installed savings	**£10,243 (58%)**

Through optimised Design Envelope pump selections, we are able to select equipment for the same flow and head duty, but with smaller floor space requirement where we are able to integrate the control/vfd into the pump.

The table above summarises the achieved savings for the example installation for the total lowest installed cost. We are converting from horizontal base mounted pumps with the VFDs mounted on an adjacent wall to Armstrong Design Envelope pumps.

The benefits of Armstrong Design Envelope pumps:

- Free up wall space by fully integrating pumps and controls
- Wiring savings (material and labour) between wall-mounted VFDs and pumps
- A smaller sized pump motor for the same design conditions
- Electric infrastructure savings; includes smaller size MCC's [4kW vs. 5.5kW]
- Elimination of DP sensors, installation and wiring to BMS
- Eliminate the inertia base, concrete, coupling alignment, housekeeping pad, and flexible connections for the conventional pumps
- Design flow can be balanced and verified on the pump controls as they now function as an integrated flow meter
- Reduction in mechanical floor space, 3.7 m^2 saved or 74% less space required for DE pumps
- Commissioning savings (no dp sensors or VFDs on wall)

LOWEST OPERATING COST

Savings area		Design Envelope plant operating savings (annually)
Energy		£459
Maintenance	(£50/hour)	£591
Total operating savings		**£1,050 (36%)**

Energy savings in this example installation stem from the unique Design Envelope pumping system solution. The savings result from operating the Design Envelope pumps at optimum system efficiency at all times using Sensorless technology (instead of controlling pump speed based on dp sensors across the pumps).

When it comes to maintenance, seal changes on Design Envelope pumps are considerably faster than on conventional base mounted pumps. In addition, Armstrong Design Envelope pumps eliminate the need for shaft alignments – which are necessary after seal changes on base mounted pumps.

LOWEST ENVIRONMENTAL COST

Savings area	Design Envelope plant environmental savings	
Carbon footprint (energy)	(ton GHG [90% NG, 10% hydro])	4.8

Above carbon savings were calculated using the Armstrong carbon footprint calculator. The tool accounts for the actual amount of electricity saved as well as the fuel mix for generation used by the local power utility.

There are also savings in concrete [not shown] and are based on conventional pump infrastructure not needed for Design Envelope pumps, such as inertia bases and housekeeping pads.

LOWEST PROJECT AND OPERATING RISK

Risk to	Risk source	Design Envelope plant risk reduction	% of total mechanical project
General contractor	Commissioning delay and payment delay of hold back amounts	£399	0.45%
Owner (capital projects)	Inevitable design changes by different stakeholders	£138	0.16%
Owner (operations and maintenance)	Energy and operational savings not achieved	£1,050	1.19%
Engineer	Reputation deterioration and losing new business	£660	0.75%
Mechanical contractor	Commissioning delay and payment delay of hold back	£173	0.20%

Reduced project risks were estimated based on avoided labor (when using Design Envelope technology over conventional practices) by contractors and engineers for:

- Concrete foundation, pad and coupling alignment
- More parts introduce more complexity for design, purchasing, and coordination for installation
- Components must be synchronised vs Design Envelope is fully factory tested
- Installing and troubleshooting remote differential pressure sensors,
- Wiring pump motors to their corresponding VFDs, and
- Manually balancing system flow.

Overall benefits offered by Design Envelope Solutions

Armstrong Design Envelope Solutions offer these value added benefits:

Design Engineers:

- Design Envelope selection reduces risk and cost
- Reduces risks on Future Changes to the load and requirement
- Savings on re-selections
- Use the Integrated Controls as an energy meter for energy measurement verification
- Hydronic systems can be conveniently balanced through speed control rather than trimming impellers or throttling. This also results in lower pressure drops

Contractors:

- Impeller trim is optimised to the motor power
- Ability for digital flow readout and communication to BMS – Ease while commissioning
- Potential wiring savings —with 30 kW motor and controls, the savings is estimated to be £223 per pump.
- Design Envelope IVS pump controls include built-in DC line reactors (equivalent to 5% AC line reactors)
- Design Envelope IVS pumping unit controls include RFI filters to ensure compliance to low emission and immunity requirements EN61800-3 to the 1st environment class CI (EN55011 unrestricted sales class B).
- No room on wall for multiple VFDs
- Superior control (eliminate DP sensor)
- Pipe savings
- Wiring savings
- Motor control savings
- Reduces installation time & cost

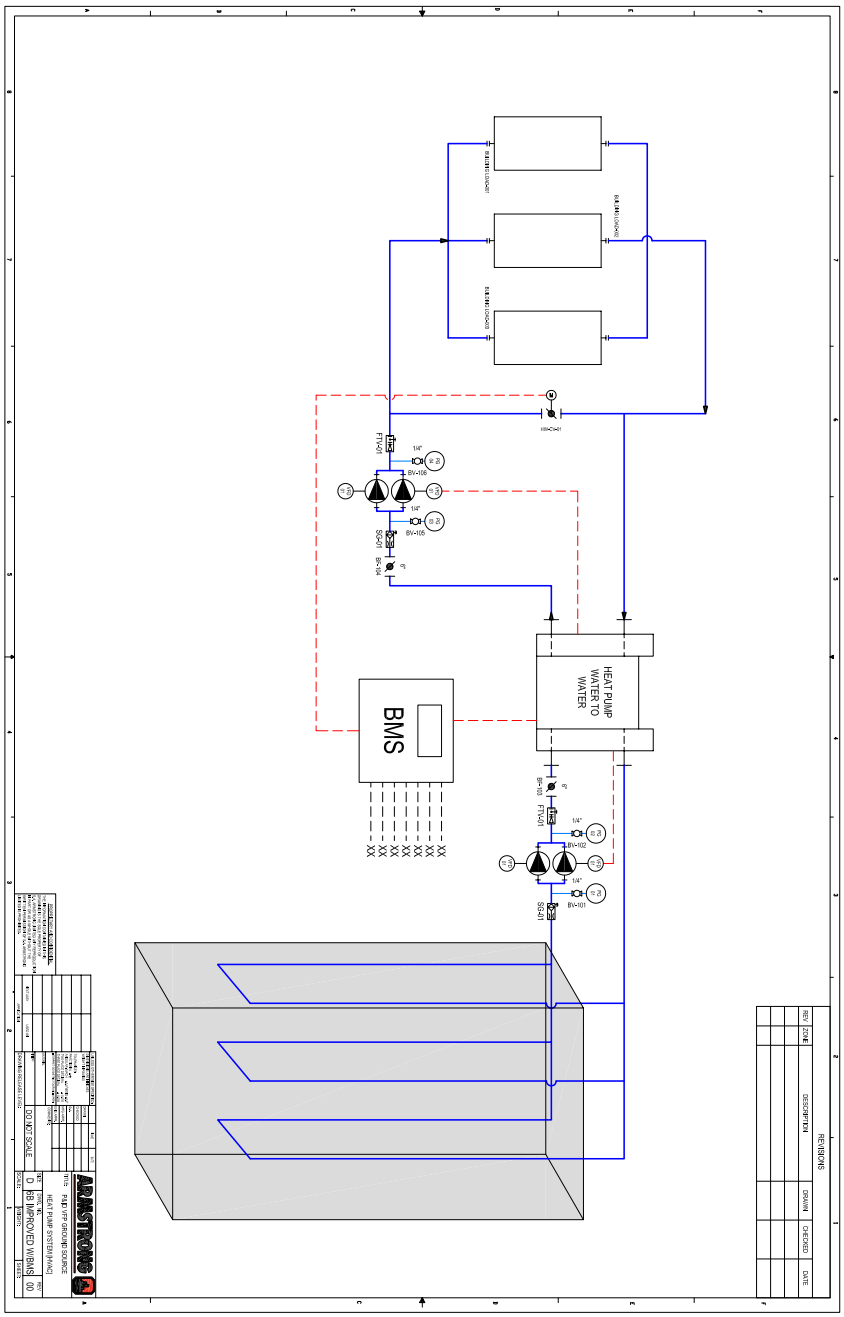
Owners:

- Floor space savings
- Lowest pump operating costs
- Plug & play – Easy to maintain
- Electronic load limiting
- Design Envelope Pumps advantageous on constant speed applications
- Digital flow readout in all control modes
- Provides a gentle ramp up or down in speed to eliminate the surges, mechanically, electrically, and hydraulically, caused by starting a motor
- Monitors and protects the motor
- Smaller size motor and control
- Reflected wave voltage
- Emission and immunity requirements
- Energy savings of 49% over mechanical room sensor
- Saves wall space
- First cost savings
- Maintenance savings

OTHER CONSIDERATIONS

- If design is specified with 50% redundancy then use Design Envelope 4302 Vertical DualArm Pump split coupled with integrated controls using Parallel Sensorless Technology.
- For multiple diverse zones or Critical zones where DP sensor across zone is needed - use Armstrong IPS 4000 controller with integrated controls using Parallel Sensor-less technology

PROCESS & INSTRUMENTATION DIAGRAM



TORONTO

23 BERTRAND AVENUE
TORONTO, ONTARIO
CANADA
M1L 2P3
+1 416 755 2291

BUFFALO

93 EAST AVENUE
NORTH TONAWANDA, NEW YORK
U.S.A.
14120-6594
+1 716 693 8813

BIRMINGHAM

HEYWOOD WHARF, MUCKLOW HILL
HALESOWEN, WEST MIDLANDS
UNITED KINGDOM
B62 8DJ
+44 (0) 8444 145 145

MANCHESTER

WOLVERTON STREET
MANCHESTER
UNITED KINGDOM
M11 2ET
+44 (0) 8444 145 145

BANGALORE

#59, FIRST FLOOR, 3RD MAIN
MARGOSA ROAD, MALLESWARAM
BANGALORE, INDIA
560 003
+91 (0) 80 4906 3555

SHANGHAI

NO. 1619 HU HANG ROAD, XI DU TOWNSHIP
FENG XIAN DISTRICT, SHANGHAI
P.R.C.
201401
+86 21 3756 6696

MAKING ENERGY MAKE SENSE™