ARMSTRONG

Water cooled central plant (CP/VS)

Design Envelope application guide

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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

9.561 – Water cooled chiller plant (all-variable)

9.562 – Water cooled chiller plant (CP/VS)

9.563 – Water cooled chiller plant with economizer

9.564 – Ground source heat pump system (VP)

HEATING

9.565 – Condensing boiler plant (VP)

9.566 – Condensing boiler plant (CP/VS)

9.567 – Closed circuit heat pump system (VP)

DISTRICT COOLING

9.568 – Water cooled central plant (all-variable)

This guide covers: 9.569 – Water cooled central plant (CP/VS)

9.570 – Water cooled central plant (VP/VS)

DATA CENTRES

COOLING

9.571 – Water cooled chiller plant with economizer (VP)

9.572 – Water cooled chiller plant (all-variable)

9.573 – 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

APPLICATION DETAILS

Equipment	Water-cooled chillers	3-12
Use	HVAC	▪
Configuration	Const. primary flow	▪
	Var. secondary flow	▪
	Const. condenser flow	▪

DESIGN ENVELOPE BENEFITS SUMMARY

Design Envelope benefit	Design Envelope savings over conventional plant
Lowest installed cost	35%
Lowest operating cost	6%
Lowest environmental cost/impact	Annual reduction in greenhouse gas emissions (tonnes): 216
Lowest project and operating risk	(See table on page 8)
Total Design Envelope 1st year savings	**22%**

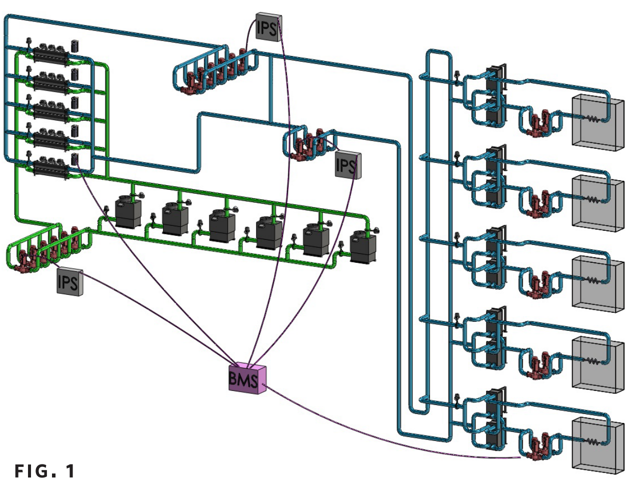


FIG. 1
DESIGN ENVELOPE PLANT LAYOUT.

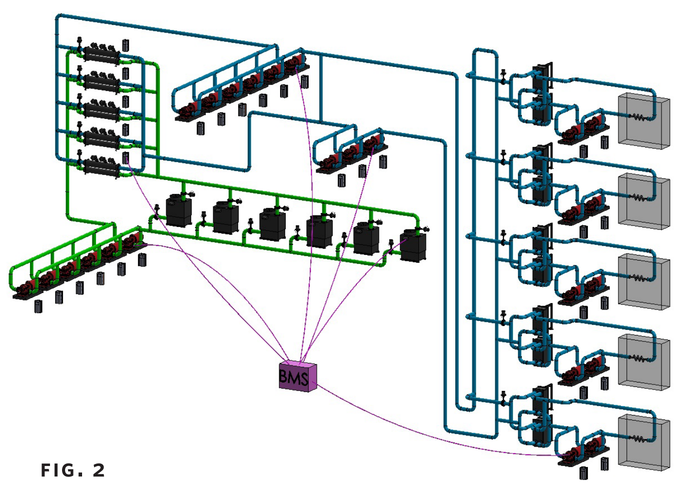


FIG. 2
CONVENTIONAL PLANT LAYOUT.

PLANT LAYOUT
DESIGN ENVELOPE VS. CONVENTIONAL

	Design Envelope plant	Conventional plant
Primary loop	5-Duty + 1-standby DE 4300 Pumps Model 0810-040.0 flow balancing to ASHRAE 90.1.	5-Duty + 1-standby horizontal end suction pumps with remote variable frequency drive for flow balancing to ASHRAE 90.1, poured concrete base, inertia base and springs, two line size flexible connectors, wall mounted VFD and power wiring.
Secondary loop	2-Duty + 1-standby DE 4300 Pumps Model 1217-250.0	2–duty + 1-standby horizontal end suction pumps with remote variable frequency drive, poured concrete base, inertia base and springs, two line size flexible connectors, wall mounted VFD and power wiring.
Tertiary loop	1-Duty + 1-standby DE 4300 Pumps Model 0810-040.0, 1-duty + 1-standby heat exchanger	1-Duty + 1-standby horizontal end suction pumps with remote variable frequency drive, and 1-duty + 1-standby heat exchanger, poured concrete base, inertia base and springs, two line size flexible connectors, wall mounted VFD and power wiring.
Condenser loop	5-Duty + 1-standby DE 4300 Pumps Model 1013-100.0 flow balancing to ASHRAE 90.1	5-Duty + 1-standby horizontal end suction pumps with remote variable frequency drive for flow balancing to ASHRAE 90.1, poured concrete base, inertia base and springs, two line size flexible connectors, wall mounted VFD and power wiring.
Cooling towers	Single cell cooling towers where each fan motor is driven by a variable frequency drive	Single cell cooling towers where each motor is driven by a variable frequency drive.

PLANT AUTOMATION / CONTROL STRATEGY DESIGN ENVELOPE VS. CONVENTIONAL

Design Envelope plant		Conventional plant	
Primary loop	• Primary pump staging is constant flow where the number of pumps matches the number of chillers • Staging of chillers is capacity based.	Primary loop-BMS controls	• Primary Pump staging is constant flow where the number of pumps matches the number of chillers • Staging of chillers is capacity based.
Secondary loop	• Pumps are controlled by the IPS4000 controller where it receives the tertiary loop valve positions from each tertiary IPS4000 controller.	Secondary loop-BMS controls	Pump speed / alternation to maintain differential pressure
Tertiary loop-IPS 4000	• Pumps are controlled by the IPS4000 controller and the IPS4000 also controls the return water valve temperature on the secondary loop. Communicates valve position to the IPS4000.	Tertiary loop-BMS controls	• Pump speed / alternation to maintain differential pressure building loop • Valve on heat exchanger controls secondary return loop temperature back to chilled water plant
Condenser loop	• Condenser pump staging is constant flow where the number of pumps matches the number of chillers.	Condenser loop-BMS controls	Condenser pump staging is constant flow where number of pumps matches number of chillers
Tower loop	• Fans controlled by variable speed drive to maintain leaving tower set point • Tower staging is constant flow where the number of towers matches the number of chillers	Tower loop-BMS controls	• Fans controlled by variable speed drive to maintain leaving tower set point • Tower staging is constant flow where the number of towers matches the number of chillers
Remote plant energy efficiency monitoring	Remote Monitoring – BMS controls	Remote plant monitoring	Remote Monitoring-BMS controls.

LARGE CHILLED WATER PLANT BASE CASE INSTALLATION

University complex: Cairo, Egypt

Technical details:

5,000 ton load; 6 chillers @1,000 ton each; 6 towers; 7 condenser pumps, 6 VP pumps & 3 VS pumps, 5 buildings 1,000 tons each served by 2 tertiary pumps and 2 HX

Design conditions (without redundancy):

- 5,000 Ton Plant Load, 39F supply, 51F return
- 5 Buildings, 1,000 Ton each with Tertiary Flow 2,000gpm @ 50' with HX
- Primary Flow 10,000gpm @ 50' without flow redundancy
- Secondary Flow 10,000gpm @ 150' without flow redundancy
- Condenser Flow 15,000gpm @ 70' without flow redundancy
- Outdoor Ambient Design 100F Dry Bulb, 78F Wet Bulb
- Cooling tower fan 75hp per cell
- Design entering condenser water temperature of 85F, 0.642 kW/ton full load power draw per chiller.

DESIGN ENVELOPE BENEFITS SUMMARY

Design Envelope benefit	Design Envelope savings over conventional plant
Lowest installed cost	$574,215
Lowest operating cost	Annual $126,214
Lowest environmental cost/impact	Annual reduction in greenhouse gas emissions (tonnes): 216
Lowest project and operating risk	(See table on page 8)
Total Design Envelope 1st year savings	**$700,429 (23%)**

LOWEST INSTALLED COST

Savings area	Design Envelope plant installed savings
Material & installation	$479,415
Time (labour)	included in material &installation
Power infrastructure	150 hp (110 Kw)
Space	$90,000
Civil structure	included in material &installation
Utility rebates	Not applicable in Egypt
Commissioning & call backs	$4,800
Total installed savings	**$574,215 (35%)**

LOWEST OPERATING COST

Savings area	Design Envelope plant operating savings (annually)	
Energy	(706,672 KWH @$.0.10/KWH)	$70,672
Maintenance	($75/hour)	$8,400
Reliability	(increased availability)	0%
Water	(414,840 US gal @ $0.05/gal)	$20,742
Operator labour	($75/hour)	$8,400
Target Mtce avoids failure (E*P)		$18,000
Total operating savings		**$126,214 (7%)**

LOWEST ENVIRONMENTAL COST

Savings area	Design Envelope plant environmental savings	
Carbon footprint (energy)	(ton GHG [90% NG, 10% hydro])	216
Waste material reduction on construction	(cubic yards of concrete)	50

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	$122,000	1.5%
Owner (capital projects)	Inevitable design changes by different stakeholders	$44,000	0.5%
Owner (operations and maintenance)	Energy and operational savings not achieved	$347,000	4.2%
Engineer	Reputation deterioration and losing new business	$124,000	1.5%
Mechanical contractor	Commissioning delay and payment delay of hold back	$46,000	0.6%

SUMMARY:

By incorporating Design Envelope and Integrated Plant Control 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.

Every pump we are converting from horizontal base mounted pumps with the VFDs mounted on an adjacent wall to Armstrong Design Envelope Intelligent Variable Speed pumps. Resulting in the following:

- Free up wall space by integrating the VFD onto the motor.
- In many selections, a smaller sized pump motor for the same design conditions.
- Eliminate the inertia base, concrete, housekeeping pad, and flexible connections for the traditional pumps.
- Design flow can be balanced and verified right on the pump controller as it is now an integrated flow meter.
- For secondary and tertiary pumping, the differential pressure sensors can be removed for additional first installed cost reduction.
- Reduction in mechanical floor space

For controls, this application is for buildings that are looking to meet the minimum energy requirements of ASHRAE 90.1-2013, and there doesn't appear to be any driving forces to go beyond the ASHRAE minimum efficiencies.

However, there are still control opportunities that will reduce the first installed cost, save energy, and make the building commissioning easier.

We are recommending the IPS4000 controller on all of the variable secondary and tertiary pumping to provide parallel sensorless pumping. Each building's 2-way valve position will be communicated by the IPS4000 controller back to the secondary IPS4000 to minimize secondary pumping energy to keep the valves as open as possible (reference ASHRAE 90.1-2013 section 6.5.4.2).

The difference in the installation cost comes from not having to install the bases with concrete, flexible couplings, VFD wiring, horizontal alignment labor, and additional piping that would be required to install the traditional horizontal base mounted pumps.

For the controls, this is the difference in cost for providing the IPS4000 controls on both the secondary and the tertiary pumping. Traditional BMS controls would have to hard-wire differential pressure sensors in each building where we are utilizing parallel sensorless control to reduce the installed cost.

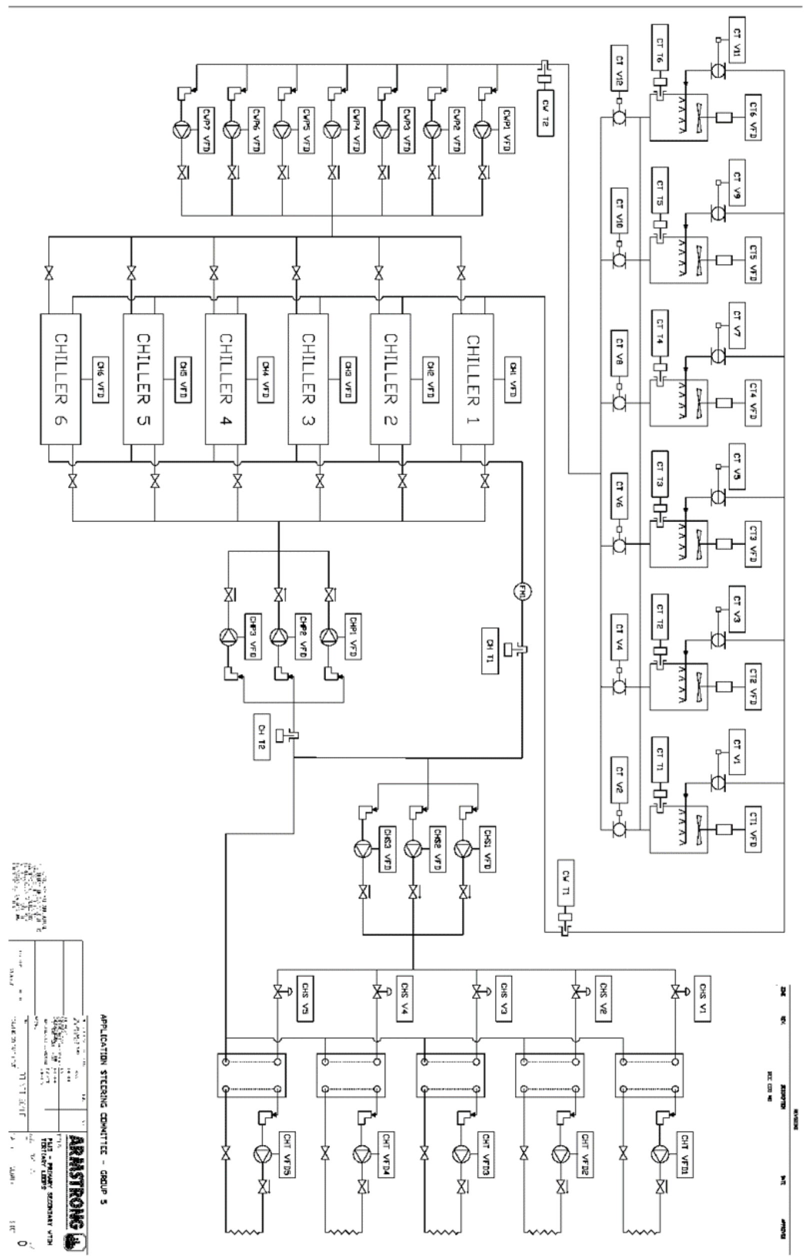
Energy savings would be comparable between the two systems, with a small amount associated with parallel sensorless pumping.

The Design Envelope Pumps reduces the maintenance spending as it takes less time to change a seal in a Design Envelope Pump compared to a traditional based mounted pump. Additionally, Armstrong Design Envelope Pumps eliminate shaft alignment that would be required for a traditional base mounted pump after a seal change.

For the waste material reduction, this is an estimated savings of the concrete that would have had to have been used for the traditional horizontal pump bases as well as their corresponding housekeeping pads.

The project risk has been approximated on the amount of time that the general contractor and engineer would have to spend on installing and troubleshooting remote differential pressure sensors, co-ordinating the electrical installation of the VFDs to the traditional horizontal pump motors, time spent as risk in balancing the system flow traditionally verses utilizing the Design Envelope pumps to measure and balance the design flow at the pump

PROCESS & INSTRUMENTATION DIAGRAM



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