ARMSTRONG

DESIGN ENVELOPE®

Intelligent Variable Speed Pumps

with cloud-based Active Performance Management®

All Design Envelope pumps substantially exceed USA/Canada pump energy index regulations

Natural Resources Canada
Canada

SOLUTION OUTLINE

FILE NO: 100.111
DATE: AUGUST 2021

SUPERSEDES: 100.111
DATE: MAY 2021

DESIGN ENVELOPE

ENGINEERED BEYOND THE OBVIOUS

Design Envelope technology is a demand-based, intelligent control solution that:

Models equipment and system behaviour

Monitors actual system conditions

Dynamically adjusts equipment operation to match system demand

Whether driven by social, environmental or fiscal responsibility, forward-thinking organizations must embrace energy-saving technologies and practices.

Armstrong Design Envelope pumps are a complete solution for heating, cooling and plumbing systems. The integration of a perfectly matched hydraulics, motive power and intelligent variable speed control creates the highest value pumping solution.

MAXIMUM ENERGY AND COST SAVINGS

1 Technology benefits

2 How it works

3 The solutions

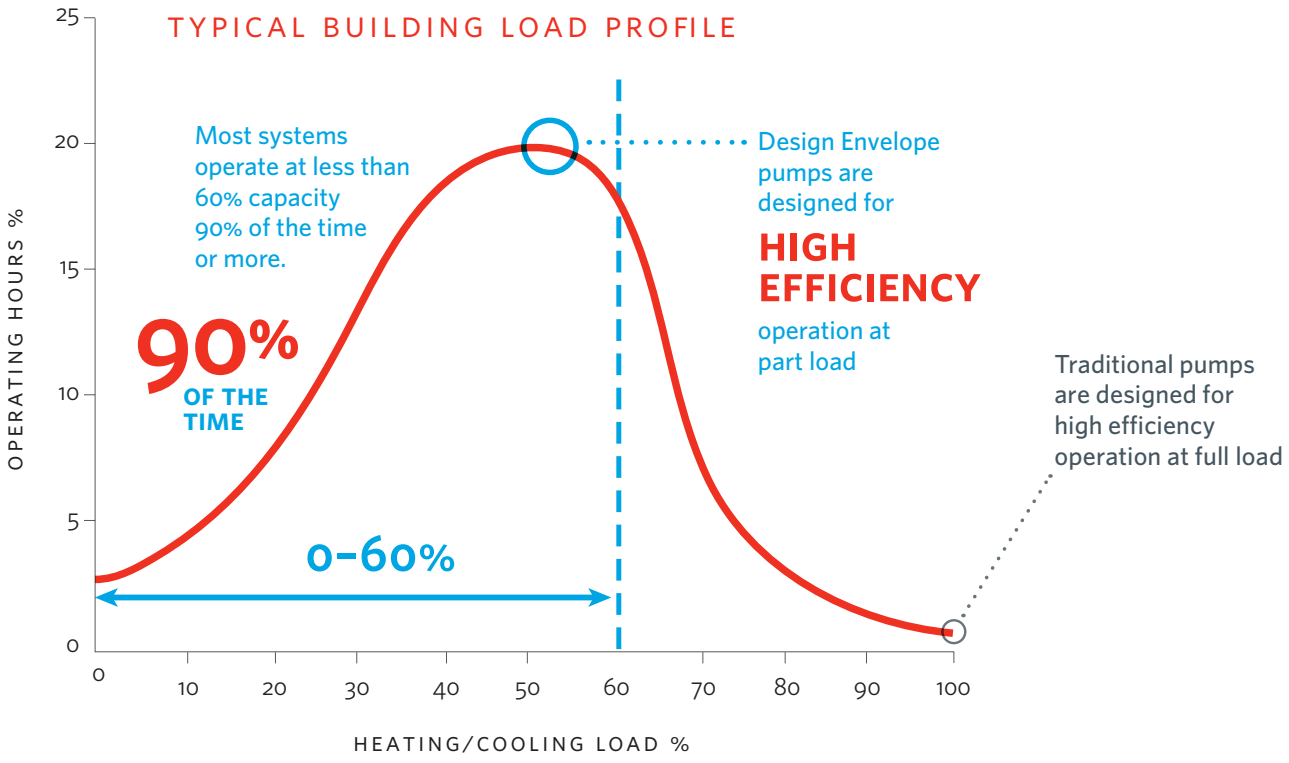
4 Solutions range

UP TO **65%**

INSTALLED COST SAVINGS*

UP TO **90%+**

ENERGY SAVINGS*



Sizing and selecting for efficiency

Design Envelope solutions reduce pumping costs through variable speed, demand-based operation — consuming only the energy required, based on current system demand. Design Envelope pumps use a combination of optimized impeller size and speed control for energy efficient operation within a given performance envelope. The performance envelopes are selected for the best pump efficiency where variable flow systems operate most often. This ensures a building's pumping system consumes as little energy as possible. It also helps to ensure that the installation meets or exceeds ASHRAE 90.1 guidelines requiring 70% energy savings at 50% of peak load.

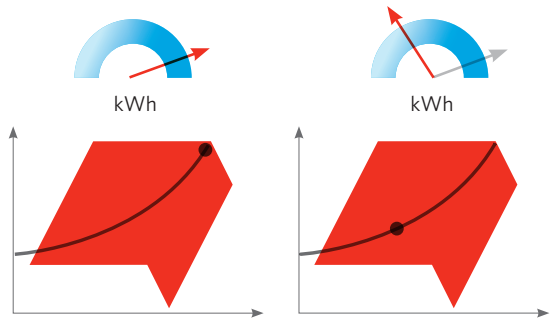
*Compared to a fixed speed system

1 THE TECHNOLOGY

THE EVOLUTION OF PUMPING

Energy Savings

Armstrong Design Envelope variable speed technology fundamentally changes the operation of a pump within the larger HVAC system. The variable speed intelligence embedded in the Armstrong Design Envelope controller adjusts the pump operation to meet the immediate demand. The pump responds instantaneously and draws only the power required to meet that demand.



Eliminate cost trade-offs

Through innovation, Armstrong's Design Envelope offers the lowest installed cost and lowest life cost of any pumping solution on the market.

CONSTANT SPEED PUMP
3-WAY VALVE

VARIABLE SPEED PUMP
WITH CONTROLS DISABLED (PUMP IN HAND)

> Constant speed operation
> Base case for pump energy usage
> Pump runs at design point, controlled by throttling

AVERAGE 15% ENERGY SAVINGS

VARIABLE SPEED PUMP
WALL-MOUNTED CONTROLLER/2-WAY VALVE

> Constant reduced speed
> Reduce motor speed in lieu of throttling flow

UP TO 50% ENERGY SAVINGS

VARIABLE SPEED PUMP
WALL-MOUNTED CONTROLLER/2-WAY VALVE

> Sensor in mechanical room
> Maintain constant design head
> No savings if sensor stops working

UP TO 65% ENERGY SAVINGS

VARIABLE SPEED PUMP/
WALL-MOUNTED CONTROLLER/2-WAY VALVE

> Inefficient induction motor operation
> Pump selected to design point
> Sensor located at remote load
> Maintain pressure at remote zone
> No savings if sensor stops working

UP TO 70%+ ENERGY SAVINGS

DESIGN ENVELOPE 3.1

> Pump speed control through Sensorless technology
> Detailed mapping of performance curve
> Smaller motor selection on 25% of projects
> Integrated controller — higher motor efficiency
> Flow measurement accuracy of ±5%
> Optimized selection against load profile

PERFORMANCE OF CONSTANT SPEED PUMP
3-WAY VALVE

UP TO
80%+
ENERGY SAVINGS

DESIGN ENVELOPE GENERATION 5

> Advanced digital controls
> Control tuned to specific motor
> DEPM motor: IE5 efficiency rating
> Advanced hydraulics

UP TO
90%+
ENERGY SAVINGS

DESIGN ENVELOPE GENERATION 5

> Multi-pump load sharing
> Best-efficiency staging (Parallel Sensorless)
> Onboard diagnostics and trending
> Real-time performance management

DESIGN ENVELOPE PERMANENT MAGNET (DEPM) MOTOR BENEFITS (up to 10hp/7.5kW)

> Higher efficiencies at full load and part-loads for lower lifecycle costs
> Higher stable operating speeds for smaller pumps, lower installed costs
> Reduced noise and vibration for quiet and stable operation
> Reduced weight and size for easier, faster installation
> Less heat generated for longer equipment life

NEXT LEVEL THINKING

ACTIVE PERFORMANCE MANAGEMENT SERVICES DELIVER:

- Ongoing tracking, analysis and benchmarking of HVAC performance
- Deeper insights into HVAC operation for informed decision making
- Data-driven optimization in response to system changes
- Long-term mechanical system efficiency
- Overall savings in HVAC energy and equipment maintenance costs

THE RESULTS

ENERGY SAVINGS UP TO **90%+**

HIGHEST ENERGY EFFICIENCY

1

Armstrong Design Envelope Pumps provide you with highest energy efficiency.

LOWEST INSTALLED COST

2

Design Envelope Pumps provide lowest installed equipment cost, plus savings in infrastructure such as transformers, switch gear, power cables, concrete and cabling.

LOWEST OPERATING COST

3

Design Envelope Pumps provide lowest operating and maintenance cost.

CASE STUDY | National Grid

ANNUAL ENERGY SAVINGS **70%**

Armstrong recently completed a project in the United Kingdom, retrofitting pumps in a commercial office building belonging to National Grid. The retrofit included new pump sets that reduced energy consumption by 70%, saving over £22,400 annually.

FACILITY TYPE
Commerical office

LOCATION
Solihull, Birmingham

SIZE
Three-storey building

ANNUAL ENERGY COST

BEFORE	AFTER
32,152 £ UK	9,752 £ UK
AVERAGE	AVERAGE

ANNUAL COST SAVINGS **£22,400** UK

CO_2 EMISSIONS

BEFORE	AFTER
82,309 kg CO_2	24,967 kg CO_2
AVERAGE	AVERAGE

ANNUAL CO_2 EMISSION REDUCTION **57,342** kg CO_2

LOWEST
CARBON
FOOTPRINT

LOWEST
PROJECT &
OPERATING
RISK

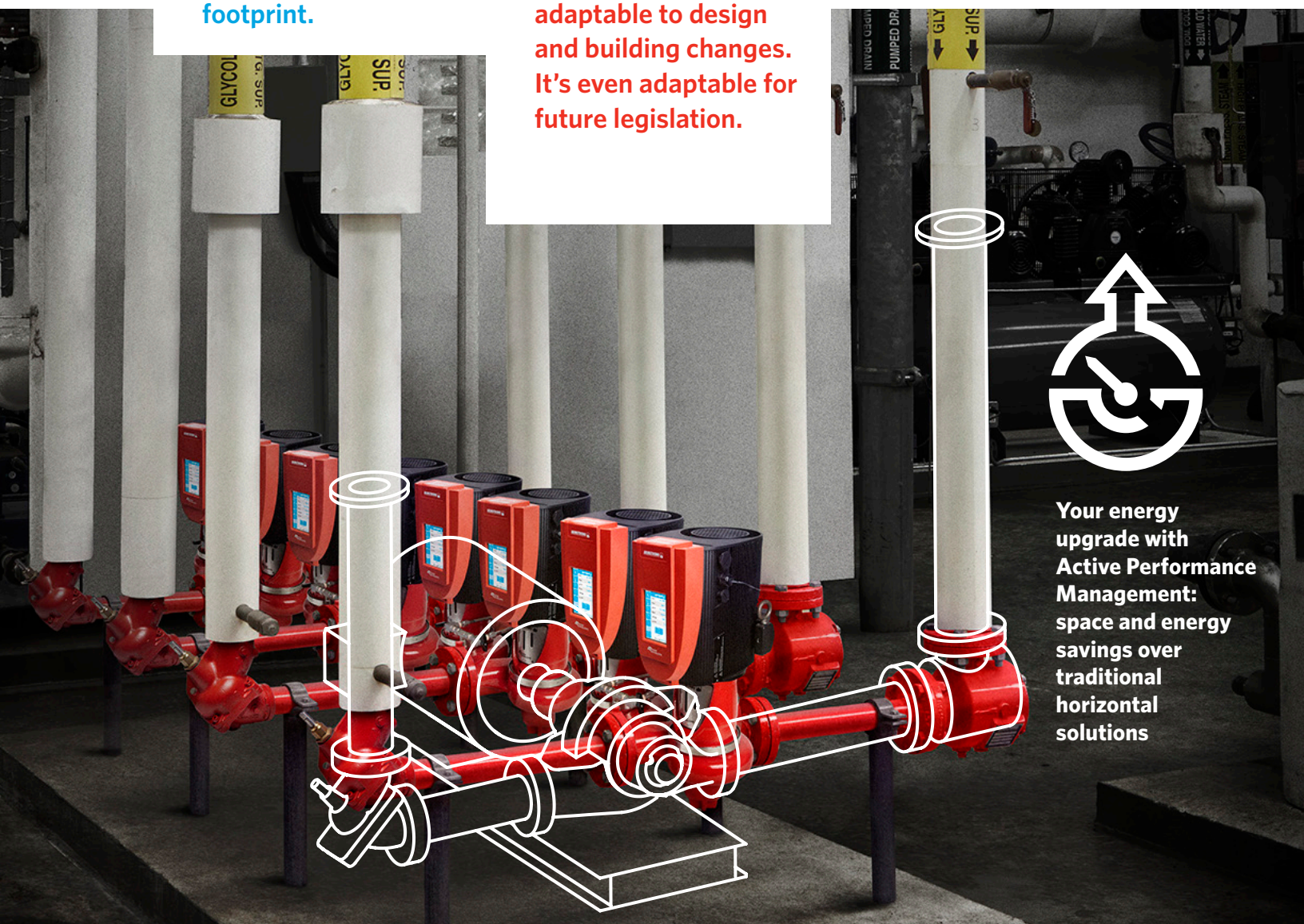
Together, these five key benefits of Design Envelope technology provide customer value far beyond alternative variable-speed or constant-speed solutions.

4

Design Envelope Pumps provide buildings with the lowest carbon footprint.

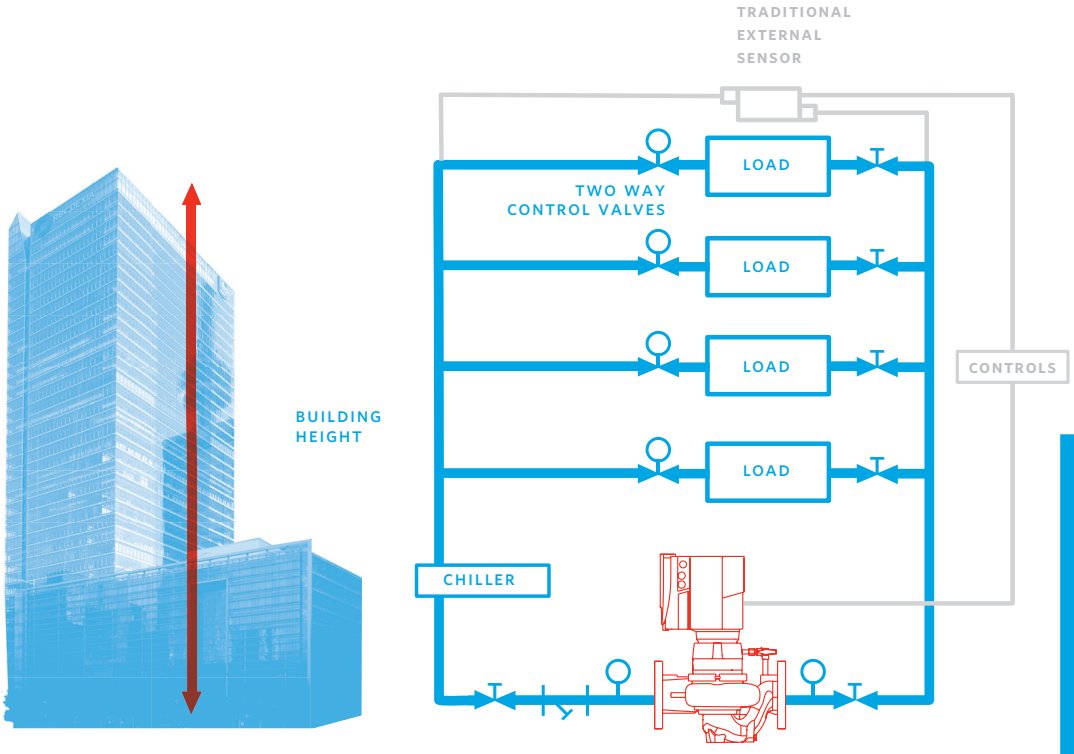
5

Design Envelope Pumps provide lowest project and operating risk, with solutions adaptable to design and building changes. It's even adaptable for future legislation.



Your energy upgrade with Active Performance Management: space and energy savings over traditional horizontal solutions

THE SENSOR WITHIN



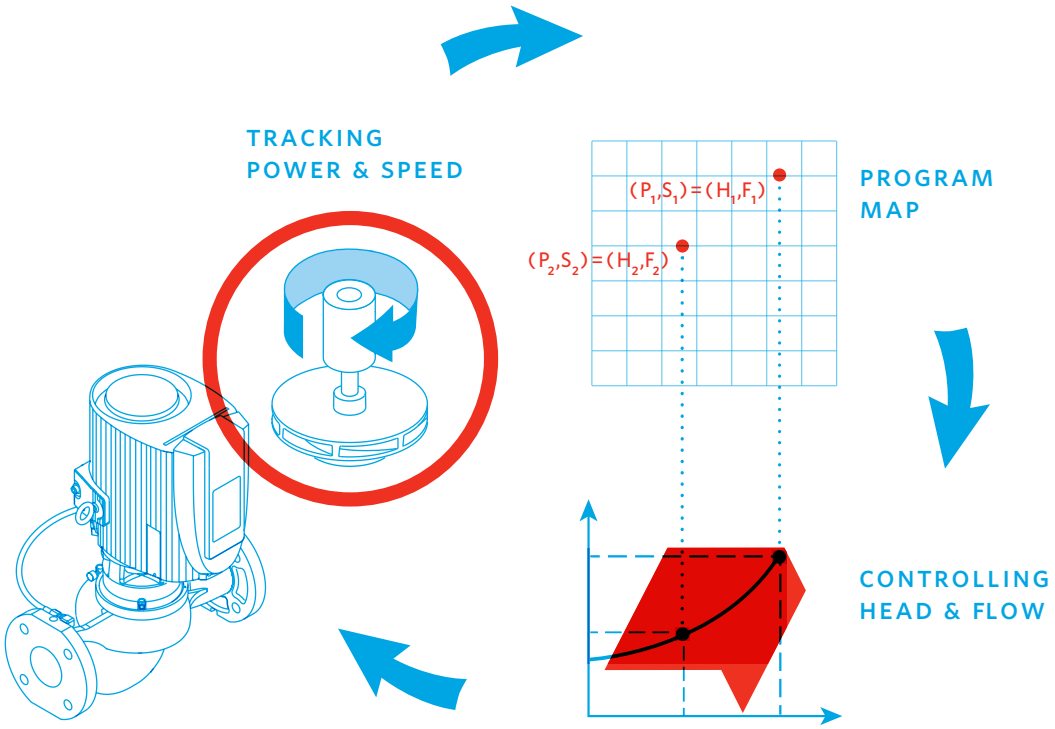
Equipped with Sensorless technology, Design Envelope solutions do not require an external sensor to monitor and control the HVAC load.

Using Sensorless technology, a Design Envelope pump's performance data (power draw and RPM) and operating curve are pre-programmed into the controller. During operation, the controller monitors the power draw and RPM of the pump and establishes the hydraulic performance and position of the pump's head-flow condition relative to the system requirements.

As the building's control valves open or close to regulate flow to the cooling coils and maintain building occupant comfort, the Sensorless controller automatically adjusts the pump speed to match the required system pressure and flow.

MONITOR POWER & SPEED

CONTROL HEAD & FLOW



Equipped with Sensorless technology, Design Envelope solutions do not require an external sensor to monitor and control the HVAC load.

In a chilled water system, a building's temperature controls influence the local flow of control valves that modulate the flow to the cooling coils (load). As the control valves open for more chilled water flow, the differential pressure across the valve decreases.

The controller reacts to this change by increasing the pump speed. If the control valves close to reduce the chilled water flow, the differential pressure across the valve increases and the controller reduces the pump speed.

PARALLEL SENSORLESS

SAVE UP TO 30%

ON OPERATING COSTS

Parallel Sensorless Pump Control (PSPC) is a patented technology that improves the efficiency of a multi-pump installation through optimized load sharing.

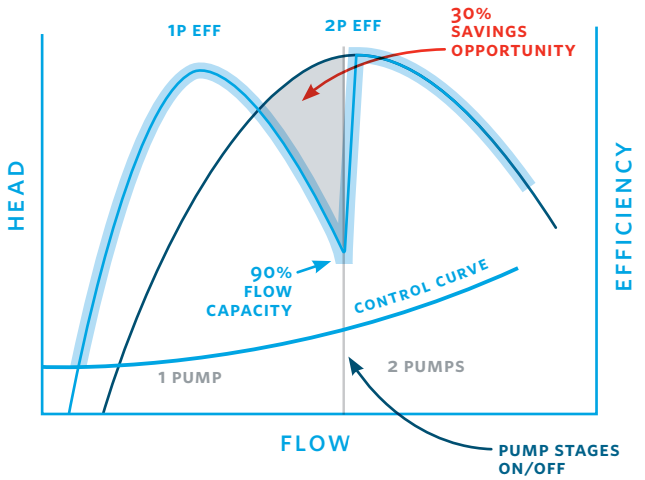
The traditional approach to control in a multi-pump installation involves staging pumps on the basis of motor speed. Parallel Sensorless Pump Control technology stages pumps based on operating efficiency rather than motor speed and improves the efficiency of the full pump array by up to 30% over traditional multi-pump installations.

HVAC loads and flow requirements change throughout the day. In the graphs to the right, the grey dotted line intersecting the pump efficiency curves represents the flow level at which one pump in the array should be staged on or off. The solid grey line, however, indicates where staging often occurs with speed-based control, which forces the pump array to operate at efficiency levels that are less than optimal.

In an installation of (up to four pumps) Parallel Sensorless Pump Control monitors pump speed and stages pumps at the correct flow levels to optimize efficiency, as shown in the bottom-right graph.

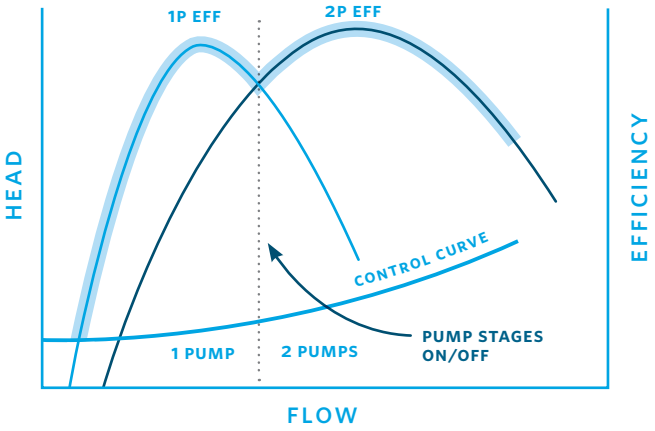
TRADITIONAL

SPEED-BASED STAGING



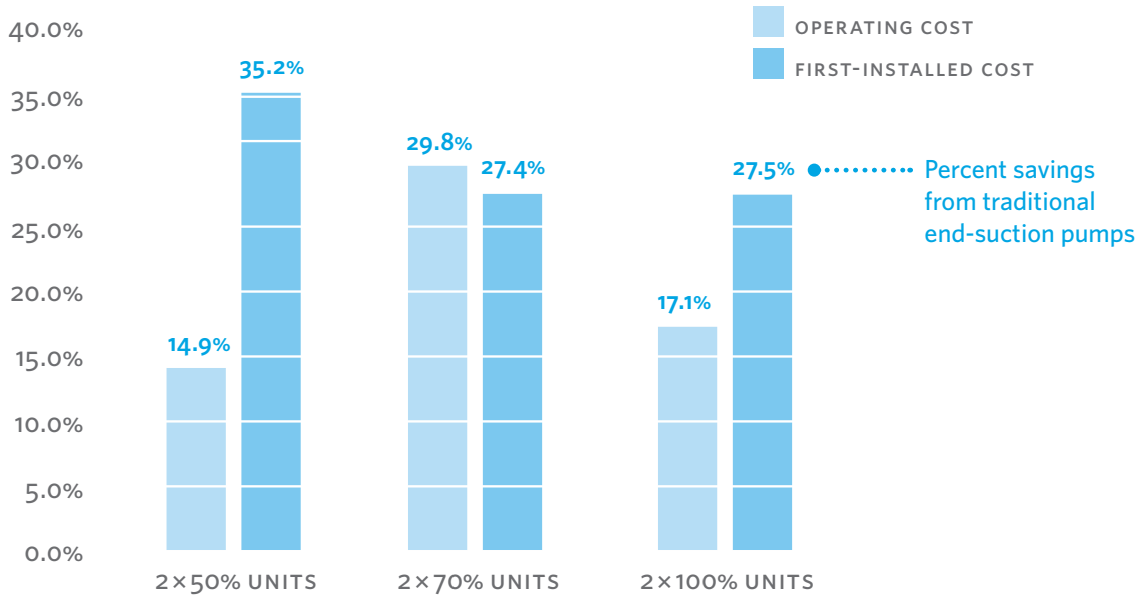
PARALLEL SENSORLESS PUMP CONTROL

BEST-EFFICIENCY STAGING

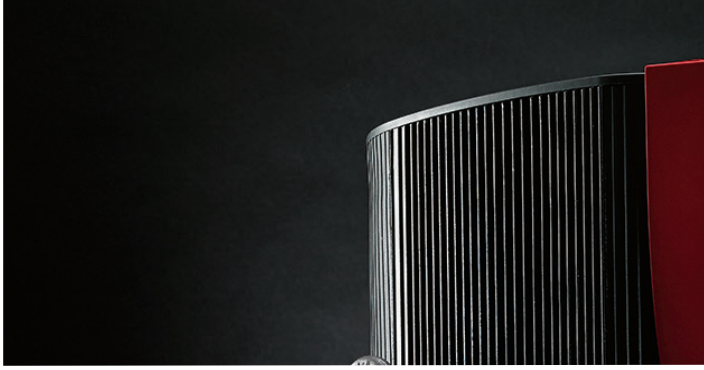


Because HVAC pumping systems mostly operate at part-load, a design using two or more smaller pumps is more efficient than one larger pump. In a two-pump system, if one pump fails, the remaining pump can serve the system requirements with up to 70% flow redundancy. The capacity split can be adjusted based on the building type and duty requirement.

REDUNDANCY AND SAVINGS WITH PARALLEL PUMPING



CAPACITY SPLIT	FLOW REDUNDANCY	DUTY REQUIREMENT	TYPICAL BUILDING EXAMPLES
Two pumps running at **50%**	If one pump fails, the other will operate at **70%**	Generic duty	Schools Apartments Condos
Two pumps running at **70%**	If one pump fails, the other will operate at **85%**	High comfort sensitivity	Hotels Offices Outpatient clinics
Two pumps running at **100%**	If one pump fails, the other will operate at **100%**	Mission critical	Blood banks Hospitals Data centers



FLOW INFORMS

The rate of fluid flow in an HVAC system is crucial to understanding how the different components are operating. Without information on system flow, it's difficult to diagnose and optimize performance. With accurate flow information, the picture changes entirely. Armstrong can optimize each component and the overall system.

Design Envelope Pumps monitor flow so accurately they function as a flow meter. Industry standards recommend balancing system flows to ±5% accuracy. Design Envelope pumps deliver accuracy of ±5%.

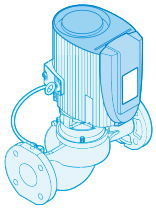
Highly accurate and reliable: no issues with fouling, so no need to service or re-calibrate.

Low installation cost: easy installation for retrofits.

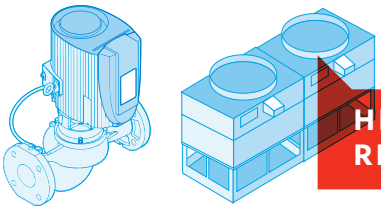
Integral to pump: no additional space or wiring required.

Energy savings: accurate flow data informs optimization of an entire HVAC system.

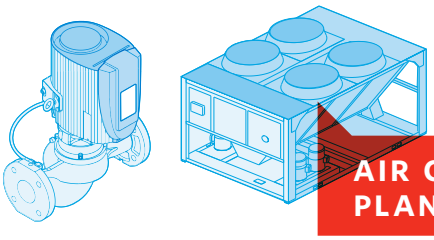
For evaluating an HVAC system, just two flow values and four temperature points provides all the data needed to understand flow rates, heat loads and operating efficiency.



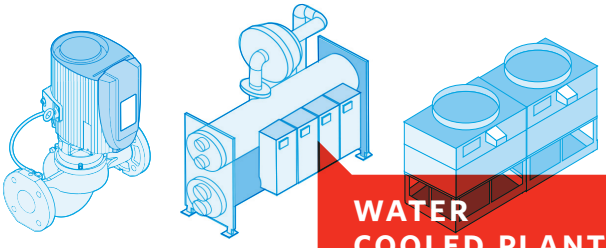
PUMPING SYSTEMS



HEAT REJECTION



AIR COOLED PLANT



WATER COOLED PLANT

±5%

FLOW MEASUREMENT ACCURACY

ARMSTRONG

Flow 550 GPM

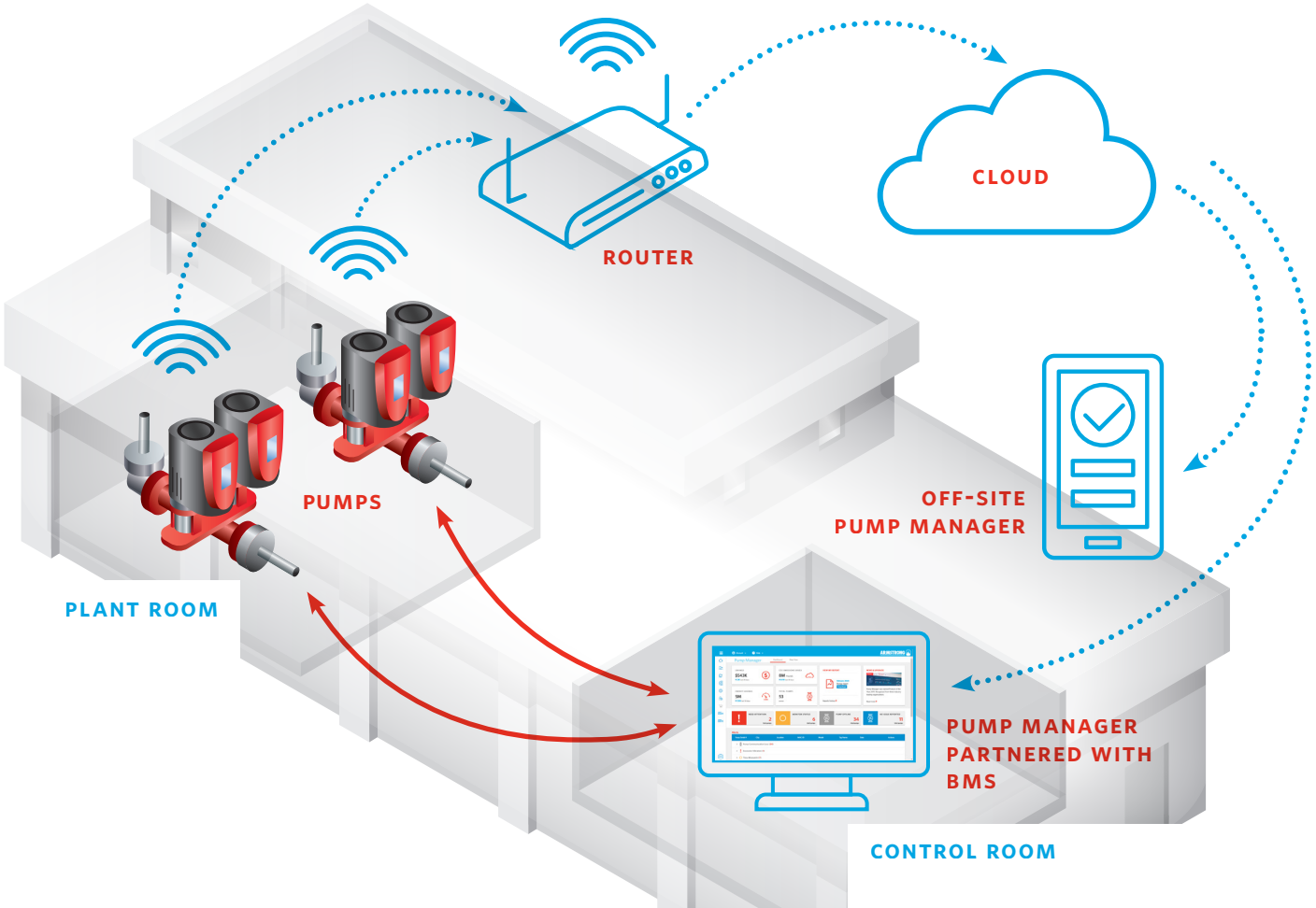
ACTIVE PERFORMANCE MANAGEMENT™

Active Performance Management is a systems management approach that optimizes HVAC systems at any stage of a building's life-cycle by continually learning from a broad network of installations and responding to changing HVAC requirements.

The combination of smart commissioning with real-time alerts and system transparency addresses performance drift and maintains occupant comfort.

Bring performance drift under control

With Active Performance Management at the plant level, you can save up to **40%** Annual cost savings



3 THE SOLUTIONS

TANGO

DESIGN ENVELOPE | TECHNOLOGY

Available for outdoor operation

UNMATCHED ENERGY EFFICIENCY

Advanced hydraulic design supports industry-leading flow efficiency

Built-in Parallel Sensorless pump control saves up to 30% more energy

Armstrong DEPM motor technology delivers an additional 6-20% efficiency, meeting IE5 efficiency standards

Control algorithm constantly reviews operating conditions and adjusts output to meet immediate flow requirements at minimum energy consumption

ALWAYS AVAILABLE

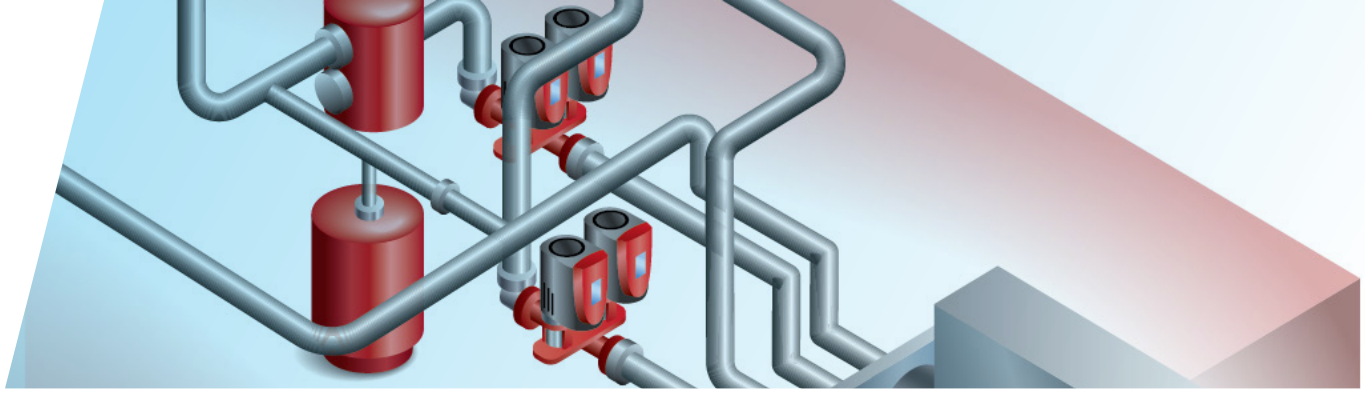
Most building HVAC systems operate at the design point (100% load) less than 1% of the time. Traditional system design applies 100% redundancy and duplication of components to ensure that the design point can always be met. This creates huge over capacity and higher costs.

15 minutes to replace the mechanical seal — no need for realignment; saves up to $700

The traditional duty/standby approach to redundancy in HVAC systems inflates the installed costs for equipment and labor, and adds to the carbon footprint of the building. Tango's dual-pumping configuration modernizes the approach to redundancy. Pumps and motors are selected from a range of sizes to achieve a level of redundancy that matches the requirements of the application.

With the proper approach to redundancy, HVAC requirements can be met for all but the most extreme days of the year; and for those few days, variation in temperature will be minimal.

For pumps larger than 10hp/7.5kW use dualArm pumps for lowest installed cost, lowest life cyle operating cost achieved with Parallel Sensorless, and increased serviceability with built-in isolation valves.



ENERGY EFFICIENT PRODUCT OF THE YEAR

CIBSE BUILDING PERFORMANCE AWARDS 2019

"Armstrong has made significant commitments to reduce its own carbon emissions in its manufacturing locations. Donating the proceeds from recycling aged pumps, via their sustainability initiative Planet Proposition, to charitable causes also impressed us greatly."

JUDGE'S COMMENTS

CASE STUDY | Delta Hotel

ANNUAL ENERGY SAVINGS

40%

The Delta Hotel commissioned an upgrade of one of their existing pumps to a new Tango. New control algorithms and performance management of the Tango pump proved that the upgrade was the right choice. The total annual energy cost savings amounted to over $2,295 with a total kWh savings of 22,957 kWh: a 40% savings overall.

FACILITY TYPE
Hotel

LOCATION
Toronto, Canada

SIZE
300,000 ft²

ANNUAL ENERGY COST

BEFORE	AFTER
5,659 $ CAD	3,364 $ CAD
AVERAGE	AVERAGE

ANNUAL COST SAVINGS **$2,295 CAD**

CO_2 EMISSIONS

BEFORE	AFTER
7,923 kg CO_2	4,709 kg CO_2
AVERAGE	AVERAGE

ANNUAL CO_2 EMISSION REDUCTION **3,214 kg CO_2**

VERTICAL IN-LINE PUMPS (VIL)

DESIGN ENVELOPE TECHNOLOGY

Available for outdoor operation

For a 10 hp/7.5 kW pump, save $2,000 with pipe mounting and no inertia base

THE HEART OF YOUR BUILDING

Mechanical room space savings

Pumps require minimal floor space or can be installed overhead

Reduced vibration

Dynamically balanced impeller and shaft assembly operates with minimum vibration

Lowest installed cost

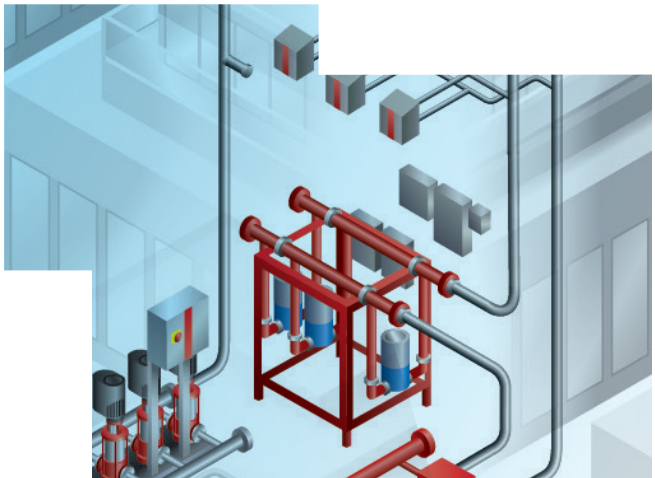
Component, Material and Labor savings — fewer fittings and no housekeeping pad required

Reliability

Vertical In-Line design requires less maintenance, at a lower cost, than any other pump configuration

Easy maintenance

15 minutes to replace the mechanical seal — no need for realignment; saves up to $700



FOR ALL DESIGN ENVELOPE SOLUTIONS

Advanced performance control

Armstrong has reinvented and redesigned pumping solutions to include connectivity and performance management services. Design Envelope Pumps provide optimal lifetime efficiency through:

- Expanded performance range (and options)
- One-touch auto-flow balancing
- Pump speed modulation based on an adjustable quadratic control curve for better part-load efficiency
- Flow monitoring accuracy (+/- 5%)
- Operating data and notifications to support diagnostics and service
- Advanced onboard control functions

PERFORMANCE PACKAGES	FUNCTIONS INCLUDED
Sensorless Bundle (standard)	• Sensorless control • Flow meter • Constant flow • Constant pressure
Parallel Sensorless (standard on Tango and dualArm)	• Parallel Sensorless control
Energy Performance Bundle	• Auto-flow balancing • Maximum flow control
Protection Bundle	• Minimum flow control • Bypass valve control
Zone optimization	• Accept up to two dP sensor control signals
Dual-season setup	• Pre-set heating and cooling parameters for two-pipe systems

CASE STUDY | Carlson Court

ANNUAL ENERGY SAVINGS
87%

Armstrong replaced six constant speed pumps with new Vertical In-Line pumps. Combining Design Envelope technology and Pump Manager, Armstrong optimized pump operations for annual energy savings of 87%.

FACILITY TYPE
Large Office Complex

LOCATION
Toronto, Canada

SIZE
300,000 ft²

ANNUAL ENERGY COST

BEFORE	AFTER
$140,072 CAD	$18,380 CAD
AVERAGE	AVERAGE

ANNUAL COST SAVINGS **$121,692 CAD**

CO_2 EMISSIONS

BEFORE	AFTER
150,847 kg CO_2	19,794 kg CO_2
AVERAGE	AVERAGE

ANNUAL CO_2 EMISSION REDUCTION **131,053 kg CO_2**

END SUCTION

DESIGN ENVELOPE | TECHNOLOGY

NO INERTIA BASE NEEDED* =SAVINGS OF

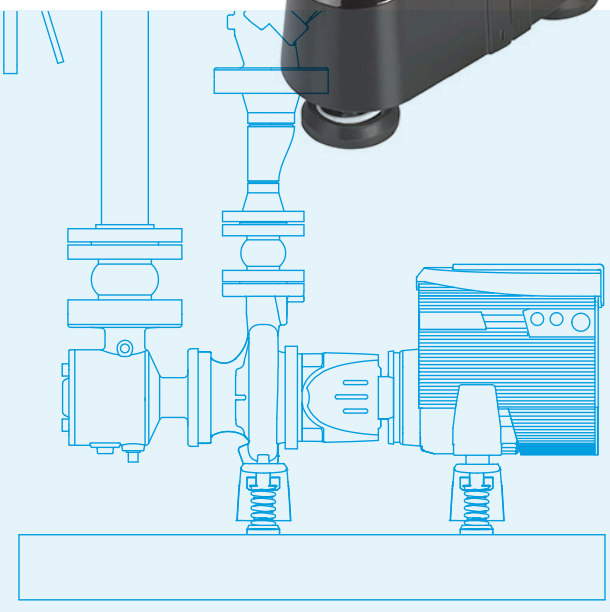
$2,000 *10hp / 7.5kW or smaller

HVAC pumping systems are expected to operate smoothly and quietly.

Although it's practical to mount pumps on the floor, this practice can also transmit noise or vibration to the rest of the building. Concrete and inertia bases have traditionally been used to mitigate vibration, but this adds excess weight and cost to the installation.

The new Design Envelope End Suction pump with integrated vibration isolation:

- Eliminates the need for inertia bases
- Reduces installed costs and operating cost
- Adds more value than any other horizontal pump



EQUIPMENT AND MATERIAL SAVINGS

- No inertia base, concrete and curing time required
- Rigid pump design needs no steel baseplate
- No differential pressure sensors required
- Less concrete means a lower carbon footprint

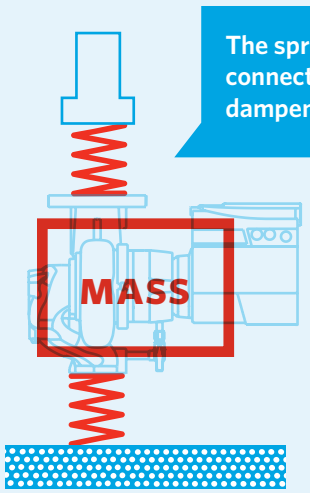
Integral vibration isolation eliminates the need for inertia bases or baseplates. The following features minimize the transmission of vibration:

Balanced rotor design

Soft start controls

Direct coupling to motor

Reduced overall weight

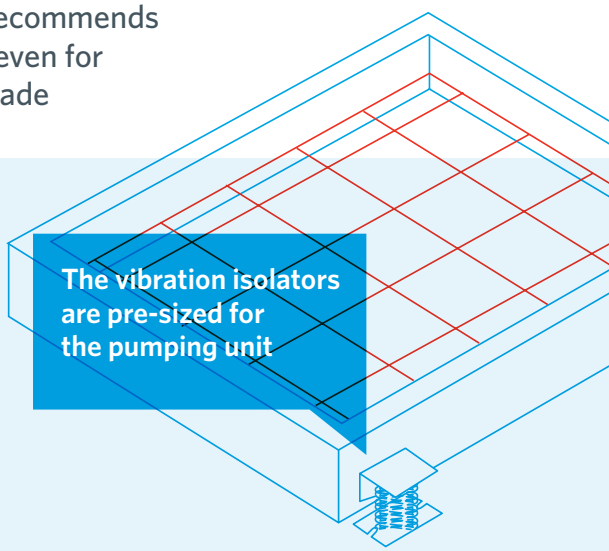


The springs and flex connectors act to dampen vibration.

With flex connectors separating the pump from the piping, and vibration isolators between the pump and the ground, the pump floats in an isolated spring system.

The ASHRAE handbook recommends the use of inertia bases even for pump installations on grade

In pumps over 10 hp the integrated design with baseplate has a lower installed cost than a traditional pump with a wall-mounted drive

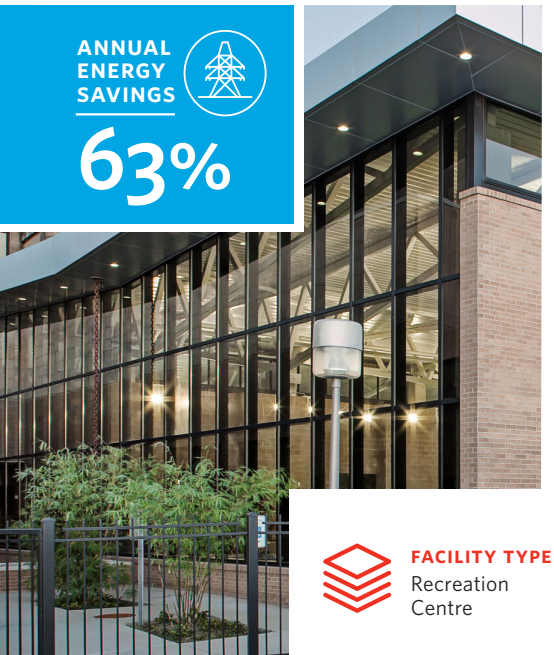


The vibration isolators are pre-sized for the pumping unit

CASE STUDY | Texas Christian University

ANNUAL ENERGY SAVINGS

63%



In 2018 Armstrong upgraded three constant-speed pumps in the Recreation Center. As a result of the retrofit project, TCU is saving over $7,500 per year.

FACILITY TYPE
Recreation Centre

LOCATION
Fort Worth, Texas

SIZE
179,831 ft²

ANNUAL ENERGY COST

BEFORE	AFTER
$12,106 USD	$4,525 USD
AVERAGE	AVERAGE

ANNUAL COST SAVINGS **$7,581 USD**

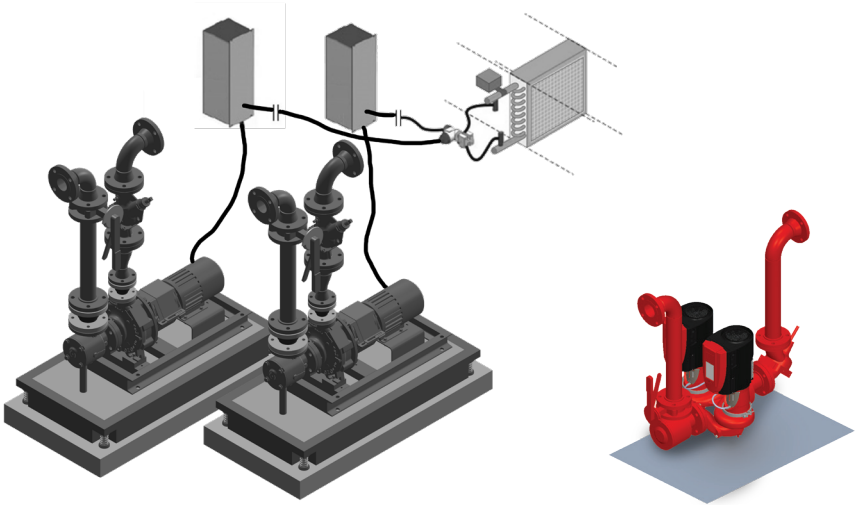
CO_2 EMISSIONS

BEFORE	AFTER
80,792 kg CO_2	30,193 kg CO_2
AVERAGE	AVERAGE

ANNUAL CO_2 EMISSION REDUCTION **30,193 kg CO_2**

CHOOSE YOUR CONFIGURATION

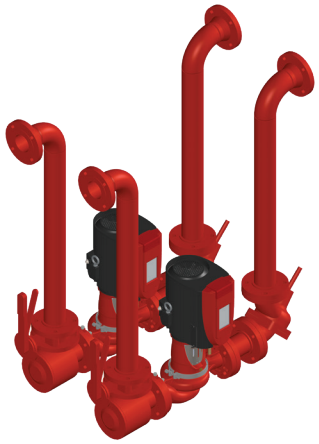
INSTALLATION COST COMPARISON

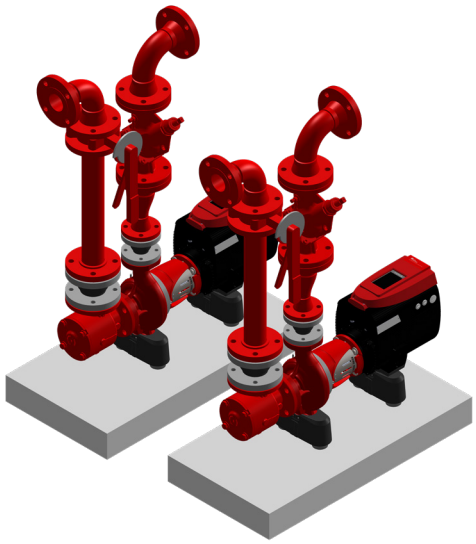


	2 × End Suction with drive on wall and remote pressure sensor 100% duty/standby	1 Tango pump with sensorless and parallel sensorless control 2 × 50% capacity split, parallel operation
Total pump weight	682 lbs	91 lbs 87% savings
Installation weight	2,221 lbs	521 lbs 76% savings
Installation footprint	26.6 sf	5.8 sf 78% savings
Installation cost	$9,004	$1,829 80% savings
	• Legacy design • Base case for comparison • Time-intensive seal change	• Managed redundancy and parallel operation replaces duty/standby • Smaller units are easier to handle • Two rotating devices sharing one casing • Reporting and proactive management • Optimized lifetime performance

Complete integrated solutions offer the lowest installed cost and add value in lifetime energy and maintenance savings

DESIGN ENVELOPE CONFIGURATION OPTIONS

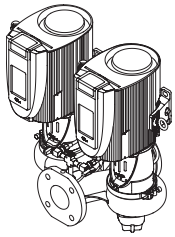
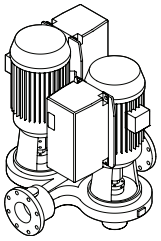
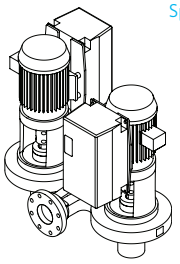
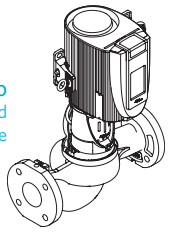
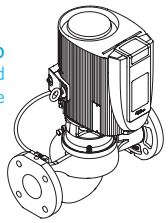
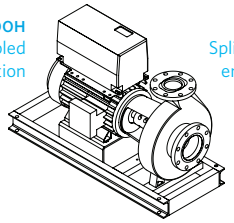
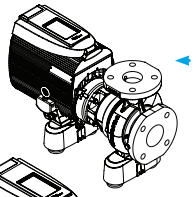
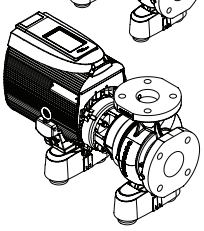




2 × Design Envelope Vertical Inline with sensorless control 100% duty/standby*	2 × Design Envelope End Suction with sensorless control 100% duty/standby*
216 lbs 68% savings	198 lbs 71% savings
748 lbs 66% savings	961 lbs 57% savings
12.3 sf 54% savings	18.1 sf 32% savings
$4,163 54% savings	$4,906 46% savings
Eliminates the need for: housekeeping pads, inertia base, flex connections, grouting and alignment • Reduced installation labor costs • Smaller mechanical room footprint (50–75%)	**Eliminates the need for:** housekeeping pads, inertia base, flex connections, grouting and alignment • Reduced installation labor costs • Smaller mechanical room footprint (50–75%)

*May also be sized 2 × 50% parallel

4 DESIGN ENVELOPE PUMP RANGE

	INDOOR	OUTDOOR
4322/4372 Split and close-coupled Tango 	0.33–10 hp	0.33–10 hp
4302 Split-coupled dualArm 	15–100 hp	15–100 hp
4312 Split-coupled Twin 	15–40 hp	1–40 hp
4300 Split-coupled vertical in-line 	0.33 –450 hp	0.33 –125 hp
	450 –1250 hp with Standalone control	N/A
4380 Close-coupled vertical in-line 	0.33 –10 hp	0.33 –10 hp
	1 –2 hp in Stainless steel	N/A
4200H Split-coupled end suction 	1–10 hp with integrated vibration isolators	N/A
4200H Split-coupled end suction 	15–125 hp	
4280 Close-coupled end suction 	1–10 hp with integrated vibration isolators	N/A

DEPM SINGLE PHASE PUMPS

ALL RANGES AVAILABLE IN 3 PHASE 200-230V, 380-480V AND 575V SINGLE PHASE 200-230V UP TO 2HP

PUMP MODELS DESIGNED AND ENGINEERED FOR OUTDOOR OPERATION

Controls enclosure rated for UL Type 4X

Equipped with overhead weather shield to prevent pump from icing in cold weather conditions and overheating when exposed to direct sunlight

OUR SERVICE TO THE PLANET

PLANET PROPOSITION

Through our Planet Proposition charter, Armstrong has committed to minimizing our impact on the environment. Around the world, Armstrong's Planet Proposition teams have taken on projects that are helping us meet our targets. Two examples of ongoing projects are:

2 BY 22

Armstrong is committed to helping existing customers reduce green house gas emissions of installed equipment by 2 million tons by the year 2022. Under this initiative, Armstrong works with customers to upgrade existing installations and continues to develop new energy-savings solutions.

NET ZERO CARBON BUILDINGS COMMITMENT

The Net Zero Commitment positions energy efficiency as a central component to achieving decarbonization globally. In signing the Net Zero Carbon Buildings Commitment, Armstrong has pledged to ensure our entire portfolio of buildings operates at net zero carbon by the year 2030.

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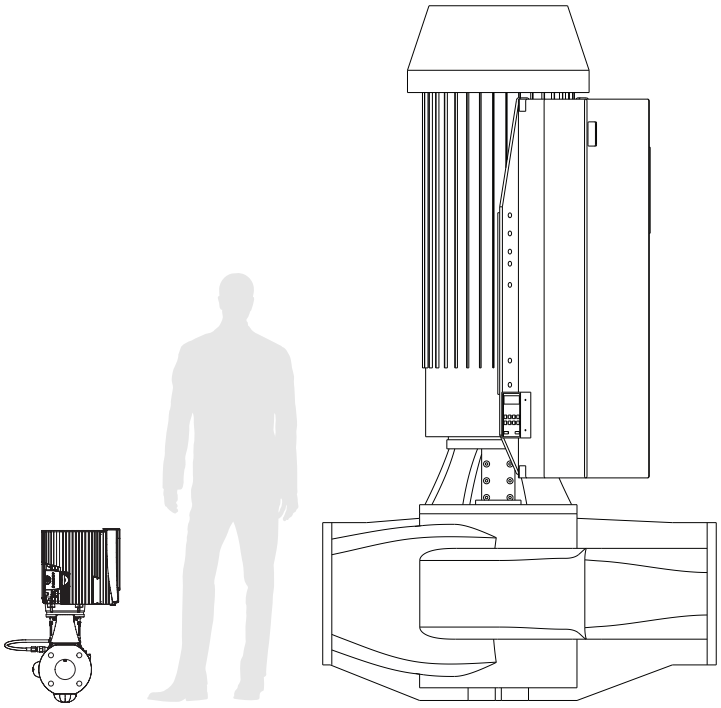

0.33 hp **1250 hp**

SELECT & CONFIGURE

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