ARMSTRONG

THIS PRODUCT EMPLOYS
Hartman LOOP™
TECHNOLOGIES

Patented under one or more of U.S. Patent
Nos. 5,946,926 6,185,946 6,257,007B1

INTEGRATED PLANT CONTROLLER 11550
HARTMAN LOOP™ TECHNOLOGY
Ultra-Efficient All Variable Speed Chilled Water Plant Control

The IPC 11550 System is an automated purpose-duty control system designed specifically for energy efficient operation of chilled water plants for comfort cooling (HVAC applications).

The IPC 11550 incorporates the Hartman LOOP™ control methodology for ultra-efficient all variable chilled water plant control.

The Hartman LOOP™ control methodology is a control method for chilled water plants that employs three patented techniques:

- "Natural Curve" sequencing
- "Equal Marginal Performance Principle" for speed optimization
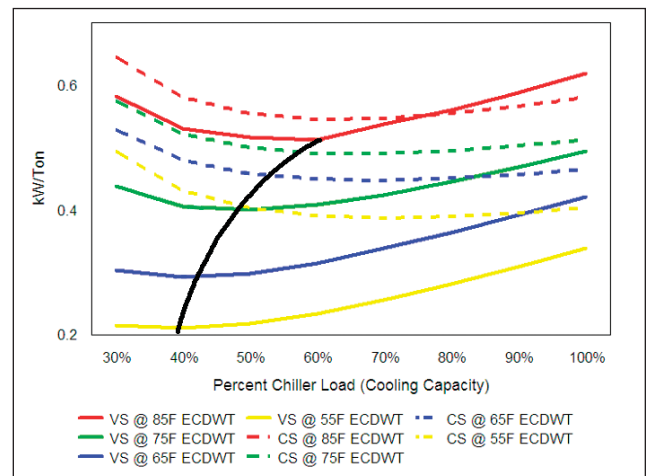- Demand Based control for stable operations

These patented control methodologies are available in Armstrong's IPC 11550 System, and continue to be available under license from The Hartman Company.

The all variable speed plant includes:
- Variable speed chillers with variable flow on condenser and evaporator (variable speed compressor)
- Variable speed primary pumps (and variable speed secondary pumps if included)
- Variable speed cooling tower fans
- Variable speed condenser water pumps

Natural Curve

The Hartman LOOP™ optimizes the plant efficiency by considering the performance curve of the equipment at different loading scenarios and attempts to sequence/stage parallel devices to minimize energy consumption. The illustration below shows two sets of curves, a dotted set for a constant speed chiller, and a solid line set for a variable speed chiller. By connecting the highest efficiency points on the variable speed chiller's efficiency curves for the four entering condenser water temperatures we have created the Natural Curve for the Chiller. The staging methodology for the patented Natural Curve technique that states that you operate the variable speed device as close as possible to the Natural Curve by staging on or off parallel equipment. This runs contrary to traditional equipment sequencing methods that recommends operating the lead devices to 95-100% load before sequencing on the first lag piece of equipment.

Legend:
— VS @ 85F ECDWT   — VS @ 55F ECDWT   - - CS @ 65F ECDWT
— VS @ 75F ECDWT   - - CS @ 85F ECDWT   - - CS @ 55F ECDWT
— VS @ 65F ECDWT   - - CS @ 75F ECDWT

The "Natural Curve" of a variable speed centrifugal chiller is shown as the black line. The Natural Curve is the locus of load points at various condenser and evaporator conditions at which the highest operating efficiency is achieved. To achieve optimum performance, chillers should be sequenced such that the on-line chillers operate as close as possible to their Natural Curve.

Equal Marginal Performance Principle

When the chilled water plant is operating at its most efficient configuration of equipment speeds, it will be processing a defined load (tonnage) for the lowest power (kW) input. If an operator were able to manually adjust the speeds of the tower fan, condenser pumps, compressor, and distribution pumps for a given load and ambient condition the system could likely achieve this combination of speed, such that altering the speed of any one device downward, and the others upward, would increase the total kW. Hartman has termed this process operating point as the Equal Marginal Performance Principle - balance equipment loading such that the kW per ton is optimized for the system by the loading of each "sub-component". The illustration below shows how an operator might fine tune the speed of all the equipment in the all variable speed plant to optimize kW for a specific building load and ambient condition. Realistically, the ambient conditions are always changing, and the load rarely stays level for longer than a few minutes. Although, with today's micro-processor technology it might seem possible to control plant equipment speed through continuous adjustment it is by definition suspect to instability through reaction of the system component to alteration of each of the other system component speeds. To approach the ideal technique of the equal marginal performance principle we employ Demand Based Control.
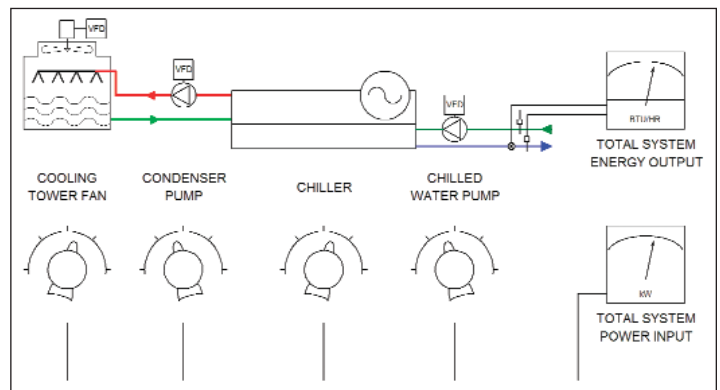
Demand Based Control

Demand Based Control is a means of applying the Equal Marginal Performance Principle in which the operation of the all-variable speed chiller plant is optimized based on the actual demand for cooling, and is satisfied by managing the power (kW) demand of each piece of equipment. Demand response and management is achieved through the use of very simple network management services, similar to those applied in IT networks.

Equipment is connected via an integrated network and operation is coordinated to maintain lowest overall energy use at all load conditions, using demand based control and natural curve sequencing of equipment. Unless incorporated as design criteria, temperature and pressure setpoints are not employed except as operating limits.

With demand-based control, operators adjust the speed of the plant equipment to a pre-calculated setpoint for each plant load scenario for the combination of staged equipment.
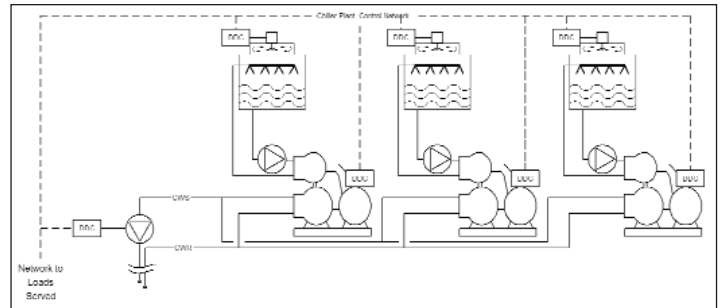

Benefits of Hartman LOOP™ Control

The Hartman LOOP™ brings a number of features the modern day chilled water plant including:

1. Simple Direct Control Relationships between Chillers, Pumps and Tower Fans
2. "Natural Curve" Sequencing of chillers
3. Ultra-Efficient Plant Operation
4. Simpler and More Stable Plant Operation
5. Longer Life for Equipment and Lower Maintenance Costs

Determine how much energy can your project can save relative to the existing plant control options by considering the performance chart below:
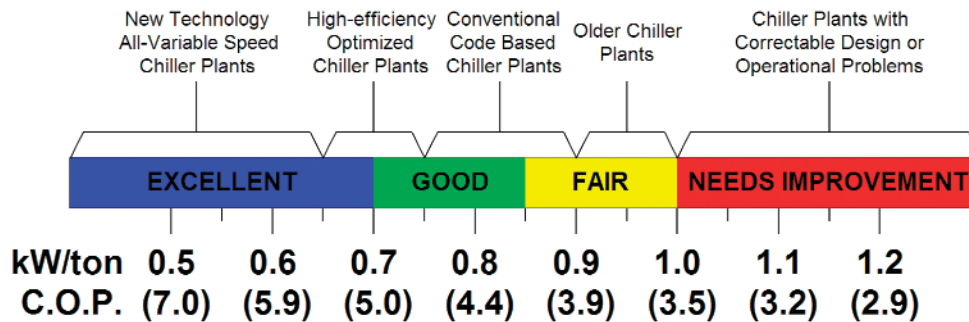
Average annual chiller plant efficiency in kW/Ton (C.O.P.)
(Input energy includes chillers, condenser pumps, primary distribution pumps and tower fans)

The chart above is based on electricity driven centrifugal chiller plants in comfort conditioning applications with 42°F (5.6°C) nominal chilled water supply temperature and open cooling towers sized for 85°F (29.4°C) maximum entering condenser water temperature. Local climate adjustment for North American climates is ± 0.05 kW/ton.