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FREQUENTLY ASKED QUESTIONS

IPC 11550 SYSTEM
Ultra-Efficient Chilled Water Plant Control with Hartman LOOP^{TM} Technology

General Information

The IPC 11550 is an automated purpose duty control system designed specifically for energy efficient control of chilled water plants for comfort cooling (HVAC applications). The IPC 11550 manages the sequencing, operation, positioning, and/or speed control of the following chilled water plant devices:

- Chillers
- Chiller isolation valves
- Variable primary flow by-pass modulating valve(s)
- Building VPF pumps
- Condenser water pumps
- Cooling tower fans
- Chilled water supply temperature reset
- Emergency shut down and general recovery sequences

The IPC 11550 includes Hartman LOOP^{TM} control methodology for ultra-efficient all variable chilled water plant control.

FREQUENTLY ASKED QUESTIONS (FAQ)

1. **What is the relationship between Hartman and Armstrong?**
Armstrong has exclusive rights to 'productize' the Hartman LOOP^{TM} methodologies in a chilled water plant controller. Control companies and contractors continue to have access to the LOOP^{TM} methodologies through individual licensing agreements with Hartman directly. The Hartman LOOP^{TM} methodologies are patent protected.

2. **What is required for the Hartman LOOP^{TM} Methodology to work?**
Effectively, any all variable speed water cooled chilled water plant with 2 or more chillers can benefit from the Hartman LOOP^{TM} methodology of control. Best configuration includes: variable flow cooling tower, variable speed primary pumps, variable speed chiller, and adjustable chilled water supply temperature reset. The control method can be used on variable primary – variable secondary configurations also. The best energy savings are achieved in dry climates where the effects of lower entering condenser water temperature can be achieved. The control method can also work in parallel/conjunction with thermal energy storage, and or water side economizers (free cooling). Another important requirement is that the plant operator leave the control in automatic mode. The Hartman LOOP^{TM} methodology can be implemented in phases, for example, during cooling tower replacement a variable flow tower can be installed and natural curve sequencing can be applied to the existing constant speed chillers. Then at a later date the constant speed chillers can be upgraded to variable speed chillers.

3. **Is there any risk that this will void the chiller warranty because we are controlling the chiller?**
The IPC 11550, or the Hartman LOOP^{TM}, do not control the chiller, but sequence the chiller and provide the chilled water supply temperature set point (CHWST set point). The chiller control provided with the chiller from the chiller manufacturer continues to control the chiller and all traditional chiller protection, safety, and operating logic remains intact. Input of some critical data points, such as: minimum chiller flow, minimum chiller ECWT, minimum CHWST, minimum chiller flow acknowledge flow, delay to stop flow after chiller is disabled, or maximum chiller RLA is required for the IPC 11550 to properly sequence the chillers and other equipment.

4. **What do I do if I suspect someone is using the Hartman LOOP^{TM} and there isn't a licensing agreement with Hartman for the installation?**
Protecting the patented processes is of interest. Therefore, these situations should be reported to Armstrong Marketing or Sales to coordinate appropriate actions with the Hartman Company.

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5. **Does this really work? It seems too good to be true.**
   The Hartman Company has installed a number of all variable plant controllers that have operated for more than 5 years with success. This is a proven solution that is out there. Armstrong will be assembling a summary of those systems as testimonials to the efficiency levels that are being achieved with the Hartman LOOP™.

6. **Who do I need to focus on to get it on to a project?**
   The Hartman philosophy needs to be incorporated at the design stage. For Design Build work it should be incorporated in to the minds of all contractors prior to bid day as a competitive advantage, or part of the price of entry as others will be offering. In the Bid Spec world, upfront work with the design firm is required. At the design firm you will have to approach the controls team to get their buy in to releasing 'control' to the mechanical spec. A good approach would be to address the first meeting to the 'boss' of the mechanical and controls design team (not the boss of each). In all cases, if the final customer has influence, presenting the advantages to the final customer should be treated as a must.

7. **What does the system comprise of?**
   The IPC 11550 system is available with 3 control panels, mounting rack w/wall mount superstructure, main disconnect switch and a single point power connection as standard. The following options are also available: DP sensors, temperature sensors, kW meter, flow meter, electrical disconnect circuit breaker for VFDs, power distribution step down transformer, condenser and chilled water pump VFDs, cooling tower fan VFDs, VFD line reactors, interpolating relays between terminal block and isolation valves and bypass valve.
   The master panel as a standalone device is not available. In all cases, the control panel will require project specific data entry by Armstrong (factory) including chiller and tower performance characteristics.

8. **What does web based control imply?**
   The IPC 11550 is 100% accessible and operable through internet protocol connection. Meaning, every function that can be performed on the touch screen interface at the master panel, can also be performed through an internet connection. Each IPC 11550 comes standard with 4 user seats for web access. In addition to operating through the web, the IPC 11550 can be set up to automatically email any number of address in response to any type of occurrence. Most commonly, emails are sent out for warnings, and/ or alarm occurrences to advise the responsible operator of the situation.

9. **Can this work with any chiller and any tower?**
   The IPC 11550 can control constant speed or variable speed devices, or any combination of. To gain the full efficiency advantages of the Hartman LOOP™ methodology the plant should be all variable speed. The greater the speed based turn down capability of each device, the greater the efficiency of the plant will be. Thus, a variable speed chiller with only 20% load turndown by variable speed would not render the same savings as a variable speed chiller with 70% load turndown. Variable flow towers are important to understand for the designer of an all variable speed plant. It is critical to select towers that operate with a 40% or greater flow turndown based on pump speed reduction, while maintaining 100% fill/coverage. Generally, the IPC 11550 controller will work with any variable speed chiller make that includes serial communication (Lonworks, BACnet, Modbus, or P Lan), and any chiller tower that can achieve 40% flow turndown.

10. **How can energy savings be achieved with little to no additional costs? Doesn't the IPC 11550 cost anything?**
    If a constant speed chiller plant is being considered, the sizing of the chiller hardware (evaporator and condenser) will be sized for optimal heat transfer at full flow design, and also have to perform for the design day with the same flows (or water and refrigerant). A comparable variable speed/flow chiller will be selected with smaller condenser and evaporator barrels taking advantage of the opportunity of matching the ideal tube velocities to the load, and achieving better overall IPLV with a small machine. This will save money on the chiller barrels, money that instead can be directed to the electronic/VSD costs of making the compressor variable speed. If the base case is a constant speed plant, a Hartman LOOP™ based system will likely cost a little less. If the base case is using a variable speed/flow chiller there will be a small incremental cost to implementing the Hartman LOOP™ in the IPC 11550.

11. **Why is this called 'LOOP' technology?**
    During the development process Hartman named these 'LOOP' technologies because they employ integrated 'closed LOOP' controls for the entire plant whereby the operation of all chillers, pumps and towers is coordinated in order to optimize total plant efficiency under all conditions. Most equipment in conventional plants operates in

stand alone fashion, responding only to certain temperature set points rather than operating in coordination with related equipment.

'LOOP' is also used to describe the chilled water distribution system in this technology which involves a fully determinant, single circuit chilled water loop instead of the common but less efficient indeterminate bypass or primary/secondary systems.

12. What is new about LOOP technologies?
The most significant improvement of LOOP all-variable speed chiller plant and distribution systems over conventional plants is the significantly reduced energy use in comfort conditioning applications. Under LOOP operation, the entire chiller plant annual energy use usually averages about 0.5 kW/ton or less for most comfort cooling applications. This represents an annual energy reduction of 25% to 60% (depending on climate and application) below the most highly optimized conventional configurations of components of the same initial cost.

From an operational standpoint, LOOP chiller plants are very different. To achieve these higher levels of performance, an entirely new approach to operating the equipment in chiller plants has been developed based on the 'Equal Marginal Performance Principle.' Aside from the use of variable speed drives for all pumps, chillers and tower fans, LOOP plant configurations are very similar to conventional chiller plants. However, in a Hartman LOOP plant, components are sequenced to keep chillers and towers operating at lower loads and flows rather than shedding them to keep the on-line equipment at high loading as is done in conventional plants. It is this method of component speed control and sequencing with simple, straightforward and stable network based controls that is really new.

13. In what applications are LOOP technologies most effective?
LOOP technologies have been developed specifically for chiller plants that serve comfort conditioning loads. Industrial process loads may be suitable for LOOP technologies depending on the application. LOOP technologies reduce energy use most at part load and reduced wet bulb conditions. Warm, dry climates usually offer the best savings opportunities, but LOOP technologies offer huge savings in comfort conditioning applications all over the world. The energy savings calculator at The Hartman Company website can estimate energy savings for a chiller plant that is employed for comfort conditioning in any of more than 200 different climates worldwide. To estimate the potential reduction for an industrial process cooling plant, contact Armstrong with the plant's estimated load profile information.

14. Is water side economizing used in the LOOP system to achieve reduced energy use?
No, the savings estimates do not consider water side economizing but a direct tower cooling cycle could be incorporated into a LOOP chiller plant just as it can into conventional plants. However, the energy saving comparisons for LOOP plants are not based on varying equipment configurations or equipment efficiencies, but on straight-across comparisons employing identical equipment efficiencies, approach temperatures, and weather and load data. The only change made to compare LOOP performance with conventional plants is that the equipment in the LOOP plant is operated by variable speed drives and employs network based LOOP control technologies for sequencing and equipment speed control.

15. How does a LOOP chiller plant layout differ from a conventional chiller plant?
On the chilled water generating side, there is usually little or no difference in layout between a conventional chiller plant and LOOP chiller plant. Designers may decide to employ common headers or dedicated chilled and condenser water pumps with either system, although LOOP control considerations may influence which approach to choose. Though LOOP plant layouts are the same or very similar to conventional plants, for LOOP configurations employing multiple chillers, it is recommended that all chillers be the same in size and have the same operating characteristics, and it is helpful, though not necessary, to have the same number of towers or tower cells as chillers.

16. How does LOOP chilled water distribution differ from standard Primary/Secondary systems?
LOOP chilled water distribution technologies employ a single circuit chilled water distribution system based on 'Low Power Pumping' technologies that are a subset of the LOOP chiller plant technologies. In these recommended distribution systems, there are no decoupler lines. For single building and small distribution systems Hartman recommends that the same set of pumps that pump the chillers also pump the distribution system and the loads. In large systems, primary pumps are employed to pump the chillers and to work in concert

with direct coupled 'booster' pumps (that are connected in series with the primary pumps without decoupling lines) in order to pump each load, major aggregate of loads, or building.

Note that instead of a primary/secondary pumping system, LOOP plants employ primary only or primary/booster arrangements with the booster pumps in series with the primary pumps. A bypass valve may be installed at the end of each main to ensure a minimum flow is maintained at all times. Operation of this simple configuration is optimized with network based control sequences. Enormous pumping efficiency improvements result from network optimization of the pumping, load flow control, and the elimination of direct mixing of supply and return chilled water.

17. How can LOOP technologies be applied; must the chiller plant and distribution system both employ LOOP technologies for proper operation?

No, LOOP chiller plant technologies are completely modular. The two major parts are the LOOP chilled water generation technology and the LOOP chilled water distribution technology. LOOP technologies can be applied to each independent of the other. It is also possible to further modularize LOOP technologies such that only the heat rejection circuits employ LOOP technologies. This is being done cost-effectively for existing chilled water plants that employ constant speed chillers and cannot justify the expense of changing them at this time. However, energy reduction opportunities are substantially increased by implementing a complete 'LOOP' network based system to the entire chilled water plant and distribution systems.

18. Are construction costs higher for LOOP plants?

No, there is a misconception that variable speed always requires a cost premium over constant speed equipment. It is assumed that a cost premium equal to the cost of the variable speed drives less the cost of the across-the-line starters for the chillers, pumps and fans will be necessary. However, by carefully selecting the variable speed chillers, pumps, towers and controls, it is usually possible to attain the ultra-efficient operations of a LOOP all-variable speed chiller plant for about the same budget as a conventional constant speed plant. Furthermore, when plants are purposely oversized to provide some degree of backup or redundancy additional cost and energy performance advantages may be obtained by configuring the plant as an all-variable speed LOOP plant rather than a conventional constant speed plant. This is possible because in oversized plants, the peak operating efficiency of the variable speed equipment is less critical. The equipment will operate at peak load only in the event of a failure at design load conditions. At part load conditions, less expensive variable speed equipment can significantly outperform more costly conventional constant speed equipment.

19. Are the network controls required for LOOP plants more expensive or complicated to operate than standard controls?

No. these controls are usually the same DDC controls that are employed in conventional plants. In most LOOP configurations, the controls instrumentation and configurations are actually simpler and less costly than what is required for optimized conventional plants. Most modern DDC systems have the capacity for network control, but it is seldom employed. See the section on LOOP equipment requirements for more information on LOOP control system requirements.

20. How are the chillers staged in a LOOP chiller plant?

Hartman has developed an entirely new method of chiller sequencing called the 'Natural Curve' method of sequencing. The 'Natural Curve' is a term coined to describe the most efficient operating load point of a chiller at various head (condenser and evaporator temperature) conditions. Typically, the Natural Curve for a constant speed chiller is at or very near full load at all head conditions, but for a variable speed chiller the most efficient operating point is at much lower loads and varies with the head conditions. Thus, a curve can be developed for variable speed chillers that plots their most efficient operating point at various load conditions, and this curve is called the 'Natural Curve' of the variable speed chiller.

In this easily applied Natural Curve sequencing method, chillers (and towers) are staged in LOOP chiller plants such that chillers operate at all times closest to their Natural Curve. Typically, LOOP plant chiller shedding occurs at much lower loads than in conventionally operated plants. As the load falls from full load, all equipment is operated at reduced speed until the Natural Curve algorithm calculates that the plant can operate more closely to the remaining chillers' Natural Curves if a chiller is shed. The same is true when a chiller is staged on. The exact points of this staged operation depend on the characteristics of the variable speed chillers and towers employed, as well as the current characteristics of the load served and the chiller head conditions.

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21. Is control of chiller capacity included with speed control in LOOP operation?
Yes. Currently, a DDC controller is configured and programmed to operate chillers in a LOOP plant just as DDC controllers typically operate chillers in a conventional plant. Thus, the operation of variable speed chillers in LOOP chiller plants is very similar to the operation of conventional plants. A LOOP DDC controller controls both chiller sequencing (on/off control) as well as the amount of capacity (demand limit) of each chiller. All factory built variable speed chillers include internal logic that is intended to continuously optimize vane and speed control to meet current conditions and variable speed chillers can also be configured to accept ‘demand’ commands from the LOOP plant controller. Thus it is not difficult to establish LOOP plant operations with any variable speed chillers. In plants that are retrofit from constant speed chillers, the speed/vane control logic may be externally applied in some circumstances.

22. How are the condenser water pumps and tower fans controlled in a LOOP chiller plant?
In LOOP chiller plants, the condenser water pumps and tower fans are variable speed as are all other components. LOOP control of these components is accomplished with very simple algorithms that tie the pump and fan operation directly to the power input to the chiller(s). Some special care must be taken in the choice of the towers for LOOP operation such that each tower is able to handle a range of flows and still achieve full coverage of its fill and provide efficient air/water surface exposure. It is also important that the fixed head requirement of the tower be considered when selecting the condenser pump(s). There are, however, many tower and condenser pump configurations that easily provide the variations in flow required for efficient LOOP operation. While condenser pump speed and tower fan speed are both adjusted in accordance with chiller loading, the control also employs limits on this preset relationship to ensure that maximum efficiency for the plant as a whole is achieved, and that certain temperature and flow operating limits are not exceeded.

23. If chillers run longer at lower loads in LOOP plants, does that mean chiller maintenance costs will increase?
No, but this is a very important point. This question was first raised when the LOOP technology was being developed. We have discussed maintenance issues with chiller manufacturers and others who agree that chiller maintenance based on component wear will be reduced from the application of LOOP operation. The reason for reduced maintenance despite the longer operating hours of each chiller are 1) fewer starts, 2) softer starts, and 3) lower average loading on each machine. While there is not yet sufficient data to show conclusively that maintenance costs are reduced enough to make decreased maintenance cost a tangible benefit for LOOP plants, there is strong agreement among those expert in variable speed operations, including chiller manufacturers, that maintenance for wear and tear certainly does decrease in LOOP plants.

Currently, much periodic chiller maintenance is triggered by runtime hours. It is generally agreed that for a LOOP plant these should be adjusted or replaced with new PM guides that recognize the reduced wear per operating hour that LOOP plants achieve. Also, the newer studies that show mechanical failures are not generally reduced by periodic maintenance based only on run time, but only when maintenance is triggered by vibration, power or other operating anomalies. The implementation of a LOOP plant should be accompanied with a new more enlightened review of maintenance procedures for the plant equipment.

24. Are there any new operating or maintenance issues that should be considered with a LOOP chiller plant?
Yes. Because LOOP plants operate at reduced condenser water flows at low loads, there is the possibility of a greater rate of condenser tube fouling with a LOOP plant than with a conventional plant in some applications. Because the flow is variable, it is difficult to precisely plan the frequency of required tube cleaning of a LOOP plant. However, if specific tube cleaning intervals are essential, there is a great deal of flexibility in LOOP plant design and operations that should be considered by the designer or plant operations manager. To reduce the frequency of tube cleaning, the designer may decide to employ a three pass condenser bundle. This design can raise the flow rate in the chiller and eliminate any potential problem altogether. Also, the minimum condenser flow can be adjusted by the plant operators at any time to establish any tube cleaning intervals that are required. These steps may have a small effect on construction or operating costs for a LOOP plant, but they can keep the tube cleaning at present levels, or even reduce the frequency of cleaning. Furthermore, there are several different approaches to automatic tube cleaning that can be implemented to ensure that chillers operate at all times with the highest possible condenser heat transfer.

25. How does the owner know if LOOP technologies are performing as projected?
The Hartman LOOP™ Design Guide outlines a simple and low cost means of integrating real-time chiller plant efficiency monitoring into the plant controls. This added feature costs very little, but it is of enormous assistance in operating the plant and managing maintenance activities. The energy performance instrumentation provides a

continuous readout of the current total chiller plant operation effectiveness in kW/ton and also accumulates data that can be compared with previous periods during which the plant operated under similar load and weather conditions. This information helps operations staff and management know very quickly when the plant operations stray from projected and historic energy use patterns, and it helps provide direction for getting the operation back on track.

26. **What type of chiller and cooling tower are required by LOOP plants, and are these products readily available?**
LOOP technologies are specifically developed for variable speed centrifugal chillers. Hartman has worked with the major chiller and cooling tower manufacturers during the development of the LOOP chiller plant technologies. All major chiller manufacturers make such variable speed chillers suitable for LOOP operation. LOOP plants also require that the cooling tower be a low head type with gravity or rotating sprinkler hot water distribution. Towers must be constructed such that the tower works effectively, providing complete coverage of the fill, with a condenser water flow turndown ratio of approximately 2:1 or greater. Many US and international manufacturers of cooling towers make such towers that are suitable for LOOP plants.

27. **Are manufacturers concerned about applying their equipment in LOOP plants, and does LOOP operation have any effect on equipment warranty?**
No. LOOP designs never exceed the operating limits for the equipment selected. There is no effect on warranty, and manufacturers are generally pleased to have their equipment chosen for this ultra-efficient application. While in some locations the local manufacturers' representatives for chillers and cooling towers may not fully understand LOOP technologies or envision widespread applications, the major manufacturers are supportive of LOOP configurations for their equipment.

28. **How do I start evaluating LOOP technologies to see if they fit my application?**
There are many supporting documents, on the Armstrong Partners website, designed to provide information and assist you in your evaluation process. The 'Energy Analysis Input' web site has been designed to collect all the required information for a plant energy savings analysis and submit it to Armstrong. The 'IPC 11550 Inquiry Form' should be used to collect the chilled water plant information for submission to the Armstrong quotations group for project evaluation and IPC 11550 pricing.

If the decision is made to employ LOOP technologies, the project engineer or owner should contact the local Armstrong Sales Representative for further assistance.

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