# THE HARTMAN LOOP

## ALL-VARIABLE SPEED CHILLER PLANT DESIGN AND OPERATING TECHNOLOGIES

# FREQUENTLY ASKED QUESTIONS

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# INTRODUCTION

Hartman "LOOP" all-variable speed chiller plant technologies offer revolutionary reductions in chiller plant energy use with only modest alterations in plant equipment configurations. This document is intended as a supplement to other technical information with answers to practical questions that arise when owners, operators and designers consider employing LOOP technologies in specific applications. If additional technical information is desired, please visit The Hartman Company website at http://www.hartmanco.com or contact Hartman by e-mail for the information you desire.

Hartman LOOP chiller plant design and operating technologies are straightforward to apply, but certain aspects of these technologies such as chiller loading and sequencing control are quite different from traditional chiller plant operating concepts. Owners, operators and designers contemplating the use of these exciting cost reducing technologies often have questions about whether their application is well suited to LOOP technologies.

As a part of developing LOOP technologies, Hartman has initiated testing of LOOP features, and has discussed aspects of LOOP operations with a wide range of industry experts that include owners, designers, and equipment manufacturers. LOOP technologies have been evaluated for many climate regions and facility types. Hartman has vigorously pursued all issues that have been raised in these tests and discussions such that an owner can be confident a LOOP plant implemented anywhere in the world will achieve the level of performance projected by the performance calculations without unanticipated costs or additional work.

It is our firm's intent to keep LOOP technologies completely open to all in the industry. This FAQ document is intended to provide information to answer questions being asked when LOOP technology is first considered for a project. Detailed design and operating information is also available. To recover our considerable development and support costs, LOOP technologies are patented and a low cost site license is required for each application. We have tried to make the licensing process as simple and easy to use as possible. We are always eager to hear our users' comments about improving the information and licensing procedures. If you have any ideas, I would like to hear from you!

I hope this information helps to answer your questions about the LOOP chiller plant technologies, and I trust you will not hesitate to contact us if you have additional questions or comments. Let us know if you have further questions or need more information so you can better evaluate the cost and energy impact of LOOP technologies on your chiller plant.

Tom Hartman

# GENERAL QUESTIONS

## 1. Why is this called "LOOP" technology?

ANSWER: 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 setpoints 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 primary/secondary systems.

## 2. What is new about LOOP technologies?

ANSWER: 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 0.6 kW/ton or less for most comfort cooling applications. This represents an annual energy reduction of 25% to 50% (depending on climate and application) below the most highly optimized conventional configurations of components of the same operating efficiencies. In LOOP chiller plants, all components are variable speed and chiller sequencing endeavors 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 in conventional plant operating strategies.

To achieve these higher levels of performance, an entirely new approach to operating the equipment in chiller plants has been developed. 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. It is how the equipment is sequenced and operated with simple, straightforward and stable network based controls that is really new.

## 3. In what applications are LOOP technologies most effective?

ANSWER: LOOP technologies have been developed specifically for chiller plants that serve comfort conditioning loads. Industrial process loads may be suitable for LOOP technologies if the process loads are variable because LOOP technologies reduce energy use only at part load 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 The Hartman Company with the plant's estimated load profile information.

# LOOP CHILLER PLANT ENERGY USE

## 1. How are the savings estimates calculated that are employed in the web site "Energy Savings Calculator" and how accurate are they?

ANSWER: A combination of hourly simulation and spreadsheet calculations are employed for this calculator and designers can see the comparison results for any application they wish to consider using the Savings Calculator at the Hartman website. This on-line program has been thoroughly tested and provides a good *first cut* estimate; savings are likely within 10% to 30% of the true value. Care has been taken to ensure the savings estimates in the savings calculator are not inflated. More accurate estimates can be easily developed when additional information about the load being served is available. The most useful additional information is the actual cooling load profile (e.g. the percent of time the plant spends operating at various loads) and/or total chiller plant operating hours for a typical year. At present, this additional information cannot be input directly into the on-line calculator, but if you have this information, you can e-mail it to us using the "contact us" page, and we will quickly send you back a corrected savings calculation that is adjusted by this additional information.

## 2. What efficiency equipment is used to calculate energy savings and what would be the effect on savings if chillers of different efficiencies or towers of different approaches were employed?

ANSWER: Savings comparisons between LOOP plants and optimized conventional plants are calculated by simulating chillers with nominal full load ARI rated efficiency of 0.62 kW/ton and towers with 8 to 10°F approach. However, the *percentage* savings between LOOP and conventional plants is independent of chiller efficiency or tower approach temperatures. Thus, as efficiencies of chillers and related equipment are improved, LOOP configuration efficiencies will also improve offering approximately the same percentage of energy savings over the conventionally configured and controlled chiller plant.

## 3. Is water side economizing used in the LOOP system to achieve reduced energy use?

ANSWER: 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.

# LOOP PLANT DESIGN

## 1. How does a LOOP chiller plant layout differ from a conventional chiller plant?

ANSWER: 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.

## 2. How does LOOP chilled water distribution differ from standard Primary/Secondary systems?

ANSWER: 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 pump the chillers and distribution system (maintaining a neutral pressure in the distribution system), and "booster" pumps (that are connected in series with the primary pumps without decoupling lines) 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 efficiency improvements come from network optimization of the pumping, load flow control, and the elimination of direct mixing of supply and return chilled water.

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

ANSWER: No, LOOP chiller plant technologies are 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 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.

# CONSTRUCTION COST ISSUES FOR LOOP PLANTS

## 1. Are construction costs higher for LOOP plants?

ANSWER: No, not necessarily. It is sometimes 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, in many applications constructing a LOOP all-variable speed chiller plant in place of a constant speed plant of the same size and nominal efficiency costs about the same. Below about 80% loading, a LOOP all-variable speed chiller plant configuration incorporating variable speed chillers that are somewhat less efficient at full load, but cost the same as more efficient constant speed chiller of the same capacity will begin to operate more efficiently than a conventional plant with the more efficient constant speed chillers. This means that when chiller plants are sized with a 20% or greater margin of excess capacity, the operating efficiency of a LOOP all-variable speed chiller plant incorporating equipment of about the same cost will operate more efficiently even at peak load conditions than a conventional constant speed plant which loses efficiency when the equipment is oversized.

So, anytime a chiller plant is oversized for failure or standby protection the nominal efficiency of the chiller plant should be based on the actual peak load served by the plant rather than the total capacity of the plant. Doing so reduces the nominal full load efficiency requirements of variable speed plant components and therefore lowers their cost. This cost reduction, along with further reductions from effective network control connections offsets the extra cost for the variable speed drives and allows all-variable speed chiller plants to provide substantial annual energy savings while costing about the same to implement as an optimized constant speed alternative of the same capacity.

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

ANSWER: No. these controls are usually the same DDC controls that are employed in 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.

# LOOP RETROFITS OF EXISTING PLANTS

## 1. Is it cost-effective to retrofit an existing constant speed chiller plant to LOOP technologies, and if so, how is that accomplished?

ANSWER: Many existing chilled water plants can be cost-effectively retrofitted to LOOP plants. Chiller plants that are located in warm climates and do not employ effective tower optimization strategies are the very best candidates as they will provide the greatest annual energy savings. Because LOOP chiller plant technologies are modular, it is possible to upgrade a plant in stages, or to limit the upgrade to only certain elements of LOOP technologies. For example, applying LOOP technologies to the heat rejection circuits (condenser pumps and tower fans) is almost always a cost effective measure and therefore a good first step in an upgrade program. A heat rejection LOOP upgrade can be done without any configuration changes to the existing constant speed chillers. For chiller plants that serve large distribution systems, it is usually cost effective to convert the distribution system from primary/secondary to primary/booster and upgrade to LOOP low power pumping technologies. Whether or not it is beneficial to convert the existing constant speed chillers to variable speed chillers and apply LOOP operation technologies depends on the age, efficiency and configuration of the current chiller plant. The Hartman Company will gladly provide preliminary guidance on the costs and energy reductions associated with various upgrade options. Simply e-mail or mail the basic plant equipment schedule, configuration schematic, and load profile or description of loads served. You will receive a good first cut estimate of what the various upgrade options will cost and save.

## 2. Can any existing constant speed centrifugal chiller be upgraded to variable speed for LOOP operation?

ANSWER: Like all existing motors, those that drive centrifugal chillers can be retrofitted with variable speed drives. Like other motors, if the compressor motor is in good condition, many years of excellent operation can be expected. However, there are some limits that may make variable speed conversion uneconomical. Reasonably priced variable speed drives are generally not available for high voltage motors (over 600 volts), and for motor sizes on chillers rated at over 2000 tons. Furthermore, some constant speed chillers cannot be significantly slowed due to minimum refrigerant pressure requirements or certain mechanical limitation. Finally, chillers more than ten years old may employ refrigerants that are being phased out, and may operate at much lower efficiencies than modern chillers. Chiller plants with older, less efficient chillers may not be good candidates for variable speed upgrades. Because of low efficiency and lack of useful service life, it may be better to replace older chillers outright with new variable speed chillers, or focus immediate upgrade efforts on the heat rejection and distribution circuits. New variable speed chillers can then be retrofitted when the existing chillers reach the end of their useful life, or when scheduled as part of a refrigerant phase-out program.

# LOOP PLANT OPERATION

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

ANSWER: 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 head 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.

## 2. Is control of chiller capacity included with speed control in LOOP operation?

ANSWER: 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.

## 3. How are the condenser water pumps and tower fans controlled in a LOOP chiller plant?

ANSWER: 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.

## 4. How realistic are water flow, temperature values and power requirements that are employed in sample LOOP energy savings models?

ANSWER: The values for outdoor dry and wet bulb temperatures come for actual weather data for the specific location chosen. Operating flows and temperatures are all within manufacturers' limits for the chiller or tower to which they are applied. Pump flows and power requirements are calculated from standard manufacturers' pump performance curves. Chiller and tower operating temperatures and power requirements at each load condition come directly from the ARI and CTI performance data for the equipment involved. This data has been determined from testing at those specific flows, loads, and temperatures. Therefore the values and power requirements are considered to be very realistic.

## 5. If chillers run longer at lower loads in LOOP plants, does that mean chiller maintenance costs will rise?

ANSWER: 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 likely 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 in a LOOP plant, there is strong agreement among those expert in variable speed operations, including chiller manufacturers, that maintenance for wear and tear certainly does not increase 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.

## 6. Are there any new operating or maintenance issues that should be considered with a LOOP chiller plant?

ANSWER: 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 configurations. 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. Once the plant is operating, 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 now 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.

## 7. How does the owner know if LOOP technologies are performing as projected?

ANSWER: 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.

# LOOP EQUIPMENT REQUIREMENTS

## 1. What type of chiller and cooling tower are required by LOOP plants, and are these products readily available?

ANSWER: LOOP technologies are specifically developed for centrifugal chillers. Hartman has worked with the major chiller and cooling tower manufacturers during the development of the LOOP chiller plant technologies. Optimum LOOP plant configurations require that the centrifugal chiller be variable speed; 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 also be constructed such that the tower works effectively with a condenser water flow turndown ratio of approximately 2.5:1. Many US and international manufacturers of cooling towers make such towers that are suitable for LOOP plants.

## 2. Are manufacturers concerned about applying their equipment in LOOP plants, and does LOOP operation have any effect on equipment warranty?

ANSWER: 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.

## 3. What type of control system is required by LOOP plants to provide network control?

ANSWER: A LOOP chiller plant can be implemented with any of a number of direct digital control (DDC) systems to operate the chiller plant and/or distribution equipment. The fundamental requirements are that:

- The DDC system has a functional and flexible programming language that uses floating point math and allows multiple layers of custom mathematical calculations and logic statements. You can find more about this requirement by viewing our Operators' Control Language (OCL) guide to DDC manufacturers on our web site.
- The DDC system has extensive and automatic network management features such that each controller can employ point & variable data from any other controller in its control programs.
- The DDC system employs standard or gateway protocol features such that it can be connected to communicate with chiller and variable speed drive equipment.

Not all, but many of the existing DDC systems on the market today incorporate these features such that they are suitable for LOOP chiller plant control.

# SUPPORT FOR LOOP DESIGN & OPERATION

## 1. What is the history and present status of LOOP technologies?

ANSWER: Hartman first began investigating the benefits of all-variable speed chiller plants in 1992. At that time Hartman encouraged manufacturers and industry organizations to develop this promising technology. However, none elected to do so. Because even at that early date, the impact on plant energy use appeared to be very beneficial, Hartman determined to make the investment to develop the technologies internally. Along with the development, Hartman was encouraged by industry members to develop a mechanism for ongoing support since concerns arose that plant operators would not be able to tap their normal sources of operations information to keep all-variable speed plants operating at peak efficiency levels.

Since 1996 when development began in a large scale, Hartman has invested nearly a million dollars in the development of LOOP technologies and plans to continue to invest at this rate for ongoing development and support for LOOP plants that are now being implemented. LOOP technologies are protected by three patents (US Patent No. 5,946,926, US Patent No. 6,185,946, and US Patent No. 6,257,007) and one other pending.

In early 2000, the LOOP technologies were released to the public for use in new chiller plant designs as well as retrofits of existing plants. Projects incorporating LOOP technologies are now under design and construction.

## 2. What is The Hartman Company's role in LOOP projects?

ANSWER: Hartman continues to be an advanced technology engineering firm and does not represent any manufacturer or sell any equipment. Nor does Hartman specifically recommend any one manufacturer for chillers, towers, pumps or DDC systems. While Hartman can act as the design engineer when desired by the owner, the firm's main focus is on providing implementation support of LOOP technologies to design and contracting teams and ongoing operations support as required to the plant's operations staff.

## 3. How are LOOP technologies implemented and what is the cost?

ANSWER: Although LOOP technologies are protected by patents, Hartman endeavors to make them all open technologies subject to industry discussion and testing as any other new technology. There is no need to employ "black box" controls or other secretive devices or products in a LOOP chiller plant. LOOP technologies are implemented with standard mechanical systems and controls through standard plan/spec or design-build contract procedures. To recover development costs, Hartman issues a "***Site License***" for each installation. The fee for each site license is a one-time payment of $5.00 per installed ton of the chiller plant employing LOOP technologies. The site license entitles the licensee to employ all Hartman LOOP technologies at the site.

For additional support, a "***Support License***" provides the site license; an updated "Hartman LOOP Design Guide," and a two year Ongoing Operations Support Agreement. The Hartman LOOP Design Guide includes suggested plant configurations, equipment specifications, LOOP control sequences and other important design considerations and guides. The Ongoing Support Agreement provides support for plant operations staff with on-line information, Q&A resources, and membership in the Internet based LOOP users group. The ongoing support services also include direct contact channels to LOOP operations specialists for assistance in troubleshooting for an initial two year period which can be easily extended to the entire life of the plant if desired. The cost for the Support License option is a one-time payment of $10.00 per installed ton.

However, experienced designers know that in order for a newly developed technology to be implemented effectively, the design team should have access to special expertise in that technology throughout the design and implementation process. In LOOP projects, this can be accomplished with a LOOP "***Engineering Agreement***" which includes all the features of the site and support Licenses plus direct engineering support from The Hartman Company to the design and construction team. In Engineering Agreements, Hartman acts as a LOOP technology specialist to the design and construction team(s) and provides one or more of the following as deemed necessary by the design and construction team:

A. Engineering and peer review services to the Owner, designer or contractor to assist in developing the configuration of chillers, towers, pumps, piping and controls that is most suitable for the plant needs and ensures optimal LOOP plant operation.

B. Specifications for critical elements of the plant that include the chillers, towers, and DDC system, along with procurement services in order to ensure that the purchase of major equipment employs value analysis principles in a "pre-purchase" or similar process that fits the needs of the Owner's organization.

C. Construction services to review and support the DDC control contractor's software and hardware design, and assistance to the startup, test and balance, or commissioning agencies in order to ensure that LOOP hardware and control sequences are implemented correctly and that optimum operational efficiency of the plant is achieved.

The cost of an Engineering Agreement varies depending on the amount and areas of support that are identified as necessary. However, an Engineering Agreement option which includes site license, design guide and ongoing support in addition to this direct engineering support will cost approximately $20.00 per installed ton. Such an agreement is adequate to fully support a design team new to LOOP technologies but otherwise experienced in chiller plant design. The annual energy reduction achieved by employing LOOP technologies usually makes the payback for this one-time fee less than a year.

## 4. How do I start evaluating LOOP technologies to see if they fit my application?

To start the process of implementing LOOP technologies into a chiller plant project, the first step is to see if LOOP technologies energy savings can meet the financial threshold required for your specific application. The ***Savings Calculator*** on The Hartman Company web site - http://www.hartmanco.com/innovate/savecalc/index.htm - be employed for this purpose by giving a quick first cut estimate of the savings that can be achieved by implementing the LOOP technologies in a specific application. The savings calculator also provides a range of first cost differentials for implementing a LOOP plant in place of a conventional plant for new, upgrade, or retrofit applications. These broad ranges can be refined by your design team or with our help.

If the decision is made to employ LOOP technologies, the project engineer or owner should contact Hartman to purchase a ***Site License***, ***Support License***, or an ***Engineering Agreement*** depending on the level of support required. With the license or agreement in place, any change in plant capacity requirement that may be made during the design process can be easily accommodated by a simple adjustment to the license or agreement. Such flexibility for plant size adjustments is built into all licenses and agreements.