The Chilldyne Cool-Flo® System is a direct-to-chip liquid cooling system that delivers coolant under negative pressure. Chilldyne’s technologies were designed specifically to eliminate the risks associated with liquid cooling while keeping deployment and operating costs low. The Chilldyne system mitigates risk with its patented leak-proof design.

**Negative Pressure Cooling Without Risk of Leaks**

- **Retains Air Cooling**
  Utilizing standard finned heat sinks modified for liquid cooling, the Chilldyne system can retain the ability to air cool servers and can operate as a standard air-cooled system to minimize down-time.

- **Leak-Proof System**
  Cool-Flo® uses negative pressure on both supply and return so if a leak occurs anywhere air will flow into the system instead of coolant leaking out.

- **Failure Tolerant**
  The system will maintain cooling even with one server open to air. Leaks are a maintenance issue, they do not reduce uptime.

- **Increased Density**
  With liquid cooling, the power density is only limited by the electricity that can be delivered to the chip. This means shorter connections between servers and higher speed data transfer.

- **Low Cost and Easy Installation**
  The Chilldyne system has no hidden installation costs or delays. Plumbing is only required for the CDU while the racks and servers can be installed by data center technicians.

- **Automatic Coolant Evacuation**
  The Cool-Flo No-Drip/Hot Swap Connector automatically evacuates coolant from a server when it is disconnected from a system. The racks can also be drained automatically.

- **Low Cost, High Volume**
  The system utilizes low cost plastic tubing and simple connections, minimizing cost and allows data center technicians, not plumbers, to reconfigure racks.

- **Reduced Setup Time**
  The CDU automatically fills and drains the system, monitors the coolant and adds or drains coolant as needed. Air purging is automatic to reduce setup time and maintenance effort.
INNOVATIVE TECHNOLOGIES

• No Drip Hot Swap Connector
  The No-Drip/Hot Swap Connector automatically evacuates coolant from a server when it is disconnected allowing for ease of maintenance and no down time. The connector fits into a standard PCI slot, or it can be built in.

• Liquid and Air Cooled Heat Sinks
  The Chillyne system uses standard finned heat sinks modified for liquid cooling for air cooled backup, free rear door cooling, easy deployment and server resale. We add liquid cooling capability to the server, so it can still go through the standard manufacturing and test process.

• GPU Cooling Capabilities
  The Chillyne system has the ability to efficiently cool high power GPU Cards with direct cold plate technology. The Chillyne system interfaces with stock liquid cooled GPU cards or a custom GPU cold plate can be designed.

• Pistonless Pump Technology
  The Chillyne pistonless pump will last 12 years or more with annual maintenance due to the slow moving valves and low speed liquid ring vacuum pump.

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**Before:** Four CRAC (Computer Room Air Conditioner) units cost $4/watt to install and computing density is constrained.

**After:** One CRAC units @ $1/watt + $1/watt for liquid cooling and then opex reduced 20-50% per year. Option to increase density.
Liquid Cooling Power Savings

Chilldyne’s Cool-Flo System is an efficient and low cost liquid cooling system that reduces data center power consumption 3 ways:

- 75-100% reduction in HVAC power
- 75% reduction in server fan power
- 5-10% reduction in CPU power

This example shows a legacy data center power reduction of 45% with the Cool-Flo System. Any data center can bring their Power Usage Efficiency (PUE) down to 1.2 or less plus additional power savings at the server.

Liquid Cooling Payback Case Study

**SDSC Comet, 1984 Nodes, 551 kW avg 1MW peak, Efficient System**

<table>
<thead>
<tr>
<th>CAPEX 1 MW Cooling (300 tons)</th>
<th>OPEX (Less HVAC, Fan and CPU power)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air</strong></td>
<td><strong>Power Consumption (kW)</strong></td>
</tr>
<tr>
<td>Air Handler plus installation</td>
<td><strong>Category Description</strong></td>
</tr>
<tr>
<td>$500,000</td>
<td><strong>Power Reduction (%)</strong></td>
</tr>
<tr>
<td>Chilled water supply</td>
<td><strong>Savings ($/yr)</strong></td>
</tr>
<tr>
<td>$720,000</td>
<td>CoolFlo</td>
</tr>
<tr>
<td><strong>Total (air)</strong></td>
<td>HVAC Power</td>
</tr>
<tr>
<td>$1,220,000</td>
<td>13.8%</td>
</tr>
<tr>
<td><strong>Liquid</strong></td>
<td>$65,623</td>
</tr>
<tr>
<td>Cooling tower plus installation</td>
<td>(Rear Door HX Effect)</td>
</tr>
<tr>
<td>$110,000</td>
<td>1.6%</td>
</tr>
<tr>
<td>CDUs (4 +1 spare @$60K)</td>
<td>Server Fan Power</td>
</tr>
<tr>
<td>$300,000</td>
<td>4.7%</td>
</tr>
<tr>
<td>Plumbing &amp; connectors (28 racks*1200)</td>
<td>CPU Power</td>
</tr>
<tr>
<td>$60,000</td>
<td>3.3%</td>
</tr>
<tr>
<td>Server side parts (1984*60 each)</td>
<td>Other Server Power</td>
</tr>
<tr>
<td>$120,000</td>
<td>0.0%</td>
</tr>
<tr>
<td>Server Side Plumbing Installation</td>
<td>$0</td>
</tr>
<tr>
<td>$50,000</td>
<td>13.6%</td>
</tr>
<tr>
<td>Heat Sink offset. ((1984<em>15</em>2)</td>
<td>Cooling tower and CDU power</td>
</tr>
<tr>
<td>-$60,000</td>
<td>-1.6%</td>
</tr>
<tr>
<td><strong>Total (liquid )</strong></td>
<td><strong>Total</strong></td>
</tr>
<tr>
<td>$580,000</td>
<td>20.3%</td>
</tr>
</tbody>
</table>

Savings over 4 years ($M)

$1.024 = 1.22 — 0.58 + 4(0.096)
CAPEX(air+liquid) OPEX (4 yr)
The Chilldyne Cooling Distribution Unit (CDU) is a negative pressure system that uses liquid to cool up to 300kW of server heat. The Cooling Distribution Unit (CDU) can use cooling tower water at 15-30°C (59-86°F) to remove up to 300 kW of server heat (15°C Rise). Its innovative design and energy efficiency allow for effective cooling of servers in high density applications.

**Key Features**

- Touchscreen Controls
- Data logging of key performance parameters
- Remote monitoring via webpage
- 6 cooling loops for easy hose routing
- 300 lpm cooling flow at .5 bar
- Monitors water temperature and quality, fills, drains, and tests for leaks
- Measures heat removed and facility water flow
- Automatic control of anti-corrosion fluid
- (N+1) Redundancy: Back up CDU stays in active idle mode with minimal power and wear

**CDU Standard Components**

1. **Pump Chamber**
   The Chamber is where coolant is stored, supplied to the servers and received from the servers. The system cycles through the main and auxiliary chambers allowing for a steady flow.

2. **Heat Exchanger (2x)**
   Transfers the heat created by the servers to the cooling tower or chiller. The HX are connected in series to minimize the processor temperature on hot humid days with warm facility water.

3. **Liquid Ring Pump (LRP)**
   LRP uses water as a seal to provide the required vacuum necessary to propel the coolant. The water seal does not wear out.

4. **Microprocessor Control**
   The temperature in the fluid reservoir is controlled to maintain the coolant temperature above the dew point in the data center.

5. **Water Quality Control**
   The water quality is monitored and controlled to maintain corrosion and bacterial protection. Automatic fill, drain, air purge and leak test are included and coolant additive is stored on board.
Liquid and Air Cooled Heat Sinks

The Chilldyne hybrid air-liquid heat sinks are designed for maximum direct-to-chip liquid cooling while retaining air-cooling capability. Chilldyne can modify existing hardware or design and develop custom hybrid heat sinks to provide a unique liquid cooling solution.

- Leak-Proof, failure tolerant Liquid Cooling.
- Fins provide additional cooling to the data center while liquid cooled.
- Provides backup air cooling when liquid cooling is off or during test and setup.
- Low cost tubing and plumbing because of negative pressure technology.
- Easy to add to any server-fits in existing PCI slot, tall or short, or chassis can be punched for 2x6mm holes.

Dual Xeon Kit
Liquid and air cold plate/heat sink and no drip hot swap connector. Standard 90mm heat sink design

GPU Cold Plate

Chilldyne GPU Cold Plate removes heat from the GPU, RAM and voltage regulators. Chilldyne uses turbulators within drilled holes to adjust heat transfer for each customer’s requirements.

Also works with OEM sealed low pressure cold plates.

GPU Cold Plate
Custom Cold plate for 300 watt Fury X GPU, uses OEM VRM cooler
No Drip Hot Swap Connector

The patented No Drip Hot Swap Connector automatically drains the server upon disconnection and automatically purges the air. Its low cost design has no valves on the server side and it fits into a standard PCI slot.

Internal Server Manifold

- Internal Server Manifold Distributes flow to all heat sinks and GPU Cards.
- Individual Servers/Cards may be removed for service.
- Design doesn’t need expensive connectors or hose clamps.

Servers and Rack Manifold

- Rack mounted manifolds distribute coolant for all the servers.
- The negative pressure system allows the servers to be connected and disconnected while the system is in operation.
- The hoses which are not connected have automatic shut off valves.
- Broken fittings will leak air into the system, not water onto the servers.
- Minor leaks do not result in downtime.
- Low flow resistance connectors, manifolds and tubing provides consistent cooling flow for distant racks 30 ft (10m) or more from CDU.