Verizon – Montauk, NY Project

Executive Summary

September 2022

Preface

We would like to share an executive summary for Verizon Data Center project in Montauk, Long Island NY.

By this document, we will present the data and the related findings of Hydromx®'s perfomance compared to glycol.

We would also like to share a brief information regarding Hydromx®, its technology, the reports, certificates and the recent important developments.

For more details, please visit our website, www.hydromx.com or click here for our downloadable brochure.

Kind regards,

Hydromx® Team

Agenda

What is a Nanofluid?

Hydromx®

- How Hydromx® works?

Hydromx Reports and Certificates

- NSF - Toxicology
- EPD/LCA
- Corrosion Reports

Product Liability Insurance

Recent Developments

Global Projects

Verizon – Montauk Project

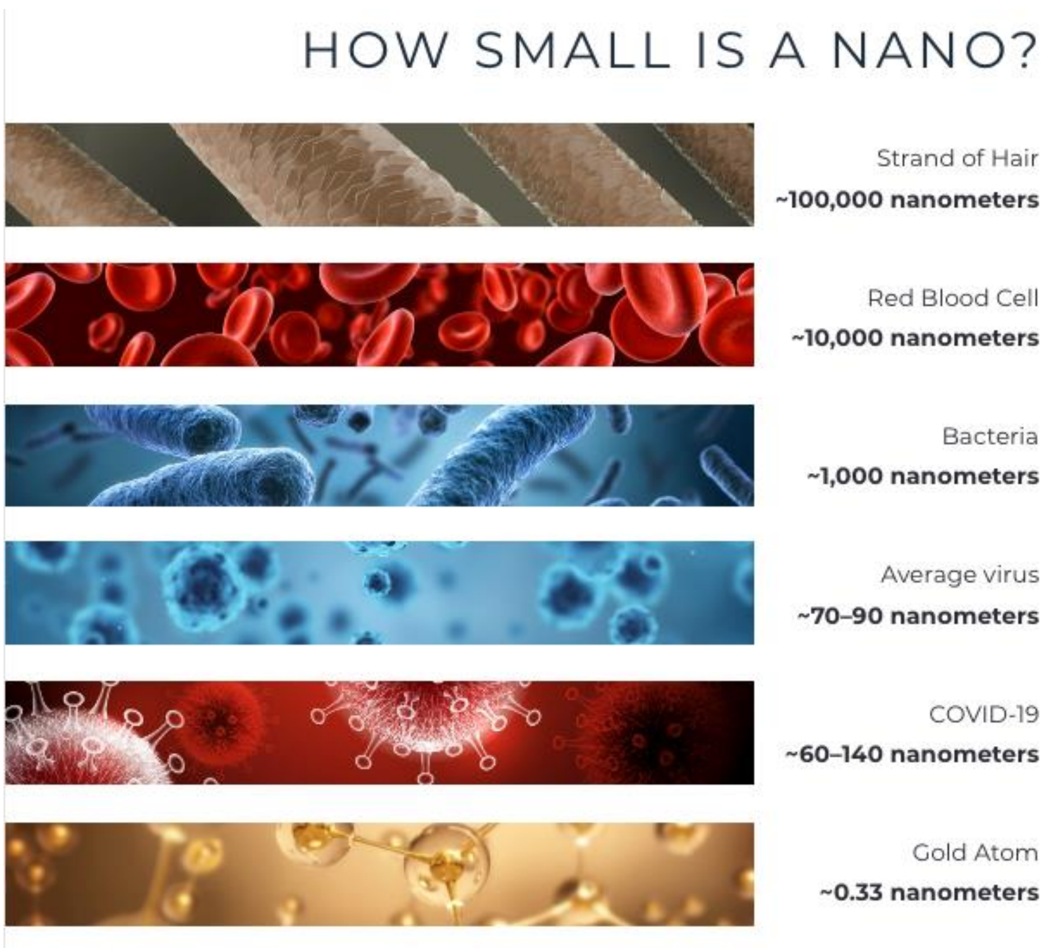
- System
- Drawings
- Results

Exhibits – Graphs & Sample Data

- – US Patent for Nanofluids
- Vertiv Glycol-Cooled Data for Upflow with Centrifugal (Forward-Curved) Fan(s), 60-HzModels – 20 Tons Fan Motor kW

What is a Nanofluid?

A nanofluid is a fluid containing nanometer-sized particles, called nanoparticles. Such fluids are engineered colloidal suspensions of nanoparticles in a base fluid. The nanoparticles used in nanofluids are typically made of metals, oxides, carbides, or carbon nanotubes. Common base fluids include water, ethylene & propylene glycol, and oil



Hydromx®

Hydromx® is the first commercially viable and academically recognized, complete, non-toxic Efficient Heat Transfer Nanofluid in the World for hydronic closed-loop cooling and heating systems. Hydromx® is a Trade Secret Protected & Certified innovative nano-technology product that enables 20-35% energy savings of the associated HVAC bills with a guaranteed maximum of 3-year ROI and is also backed by a full product liability insurance.

Hydromx® is one of the top measures for buildings to improve energy efficiency, offer opportunities to create local jobs, save on energy bills, and cost-effectively reduce greenhouse gas emissions and other harmful pollutants.

How Hydromx® works?

Hydromx® leverages the nanoparticles to increase the speed and the effectiveness of the overall heat transfer process. As a result, the required target temperature is satisfied (necessary BTU delivered) in a shorter amount of time, thereby the system consumes significantly less energy versus the conventional Newtonian heat transfer mediums including water.

Hydromx® Reports and Certificates

Hydromx® has been tested throughout the world and awarded by many industry standard-setting certifications such as NSF International, ASTM, BuildCert, and NACE hence proving its compatibility with the latest building and environmental standards.

NSF International/Nonfood Compounds Registration Program

Nonfood Compounds Program Listed

OFFICIAL LISTING

NSF International Certifies that the products appearing on this Listing conform to the requirements of the NSF Nonfood Compounds Registration Program

This is the Official Listing recorded on January 18, 2018.

Hydromx Inc.
58-75 57th Road
Maspeth, NY 11378
844-4HYDROMX
718-381-0351

Product Designation	Registration Number	Category Code
HYDROMX	151909	HT2
HYDROMX PG	156764	HT1

HT1 Heat transfer fluids with incidental contact.
HT2 Heat transfer fluids with no food contact.

CORROSION CERTIFICATION

System Protection
NSF APPROVAL FOR CHEMICAL INHIBITORS

NSF approval for nontoxicity is important. Also, Hydromx® is tested and approved by NSF for the closed-loop system's health and durability. Not only do we care for the environment by reducing energy consumption, but we also provide the best protection formula for the machinery.

Certificate No: NSF2102/0219
Sample No: NSF2102

21st February 2019

Mr Berkin Airkan
Hydromx Inc
5875 57th Road
Maspeth
New York
11738
USA

Dear Mr Berkin

Samples of the chemical inhibitor described below have been subjected to relevant tests as detailed in the "NSF standard specification for the performance of Chemical Inhibitors for use in Domestic Hot Water Central Heating Systems", and verified as complying with the Scheme's requirements for marking, instructions of use and quality system. After considering the test reports and supporting documentation, the Technical Assessment Panel (TAP) of the Chemical Inhibitor Approval Scheme (CIAS) finds that the chemical inhibitor so described complies with the requirements of the above standard, and its use when correctly installed/commissioned satisfies the minimum requirements for chemical inhibitors specified in Part L of the Building Regulations (England & Wales), and the supporting Domestic building services compliance guide (2013 edition).

Toxicology

Nanotechnology is a known science and nanofluids have the capability and potential to revolutionize industries such as HVAC, automobiles, warm sea ships, plastic injection molding etc... The United States has a patent on nanofluids. In the Patent, it reads *"Various nanofluids that may find widespread acceptance for industrial use should preferably be, as a minimum, stable Suspensions with little or no particle settling, available in large quantities at affordable cost, environmentally neutral, and* ***non-toxic****."* Furthermore, there are thousands of research papers scientifically proving the fact that nanofluids do dramatically enhance the thermal transfer process.

Picture 1 (Please see the Exhibit)

EPD / LCA

US Green Building Council (USGBC) Recognized

Hydromx®'s Comparative LCA and EPD are verified and certified by a panel put together by NSF, which is headed by Thomas P. Gloria, Ph.D., Director of Harvard University's Sustainability Department. NSF International certified and verified EPDs are type III environmental product declarations and will help new building or retrofit projects qualify for points through the Leadership in Energy and Environmental Design (LEED) US Green Building Rating System (LEED V4).

A Climate Declaration describes the emissions of greenhouse gases, expressed as carbon dioxide (CO_2) equivalents for a product's life cycle. This indicator is often referred to as "carbon footprint", which makes Hydromx® end-users automatically qualify to reduce their CO_2 emissions hence meeting the new stringent government requirements.

Carbon Effect | LCA/EPD

Corrosion Reports

Total System Protection

- CORROSION PROTECTION

Corrosion is a common problem that may cause your system to destroy zone valves, tanks, ball and check valves, etc.

- SCALING PROTECTION

Hydromx provides complete protection against scaling without decreasing the efficiency of your system.

- FREEZING & BURST PROTECTION

Glycol is the most common anti-freezing agent used in the industry.

- BACTERIA PROTECTION

Hydromx protects your system from the occurrence of pseudomonas and legionella bacteria.

NSF Corrosion Report

NSF / Buildcert Corrosion Certificate

Nace-RP0775 (Corrosion Station Performance)

Corrosion Report – Holland

Product Liability Insurance

Closed-loop systems are covered by a full product liability insurance against all damages that may arise from Hydromx. Hydromx has been renewing this insurance policy every year since 2013. No claims have been made so far.

THE CINCINNATI SPECIALTY UNDERWRITERS INSURANCE COMPANY

The Cincinnati Specialty Underwriters Insurance Company
A Stock Insurance Company

Headquarters: 6200 S. Gilmore Road, Fairfield, OH 45014-5141
Mailing address: P.O. Box 145496, Cincinnati, OH 45250-5496
www.cinfin.com ■ 513-870-2000

COMMON POLICY DECLARATIONS

POLICY NUMBER: CSU0153445 **PREVIOUS POLICY NUMBER:** CSU0153445

NAMED INSURED AND MAILING ADDRESS:
Hydromx Inc

Refer to Named Insured Schedule CSIA409
5875 57TH RD
MASPETH NY 11378

PRODUCER - Your contact for matters pertaining to this policy: 32-006
Marsh & McLennan Agency LLC
1400 EASTCHESTER DR STE 200
HIGH POINT NC 27265

Surplus Lines Broker:
EX-1081092-R
CSU Producer Resources, Inc.
6200 South Gilmore Road
Fairfield, OH 45014-5141
Scott Hintze

Policy Period: From 07/09/2022 **To** 07/09/2023 AT 12:01 A.M. STANDARD TIME AT YOUR MAILING ADDRESS SHOWN ABOVE.

Form of Business:
☐ Individual ☐ Partnership ☒ Corporation ☐ Joint Venture ☐ Limited Liability Company ☐ Other

Click here to download the Insurance Policy

HYDROMX®
Energy Saving Solution

Recent Developments

- Hydromx® had been installed in 20 different loops at The Empire State Building. Syska Hennessy specified Hydromx® for the Observatory renovation project at the Empire State Building.

- The Empire State Realty Trust has approved Hydromx® to be installed in the entire Chilled Water Loop of another iconic building at 1350 Broadway. Completed in December 2021.

- Skanska in the UK completed a case study in a heat recovery loop at London Royal Hospital in March 2021. Skanska has chosen Hydromx® to be installed 13 more major run-around loops in one of the largest London NHS Hospitals in the Fall of 2022 as the second step forward for a major launch throughout Skanska facilities.

- Xcel Energy, a grid company in Minnesota, issued our first rebate for their end-users that installed Hydromx® in their run-around loops; the rebate is 25% cash of the cost of the installation.

- CTC Case Study - Brainerd Public Utilities issued our second Rebate

- The manufacturing facility is completed at Queens Village in NY, making Hydromx® "Made in USA".

HYDROMX®
Energy Saving Solution

Hydromx comply with the NYC DOB

In 2020, the NYC Department of Buildings launched the Carbon Neutrality Innovation Challenge competition. The competition sought ideas for increasing energy efficiency and cutting emissions among NYC's buildings. Hydromx® won this competition for nanofluids. Following that NYC DOB announced a bulletin.

This Bulletin describes how heat transfer nanofluids, that comply with the description and acceptance criteria of this Bulletin, can be utilized in building mechanical systems in compliance with the NYC Construction Codes.

The Technical Bulletin dated October 1, 2021, NYC Department of Buildings (DOB) defined heat transfer nanofluids under the code MC 1207. In addition, regarding the toxicity limits, NYC DOB dictates that the nanofluids must acquire HT1 and HT2 NSF certification. NSF International's HT1 and HT2 categories are specifically designed by Food & Drug Administration and structured under FDA CFR 21.

Hydromx fulfils acceptance criteria, installation, and maintenance requirements for heat transfer nanofluids used in hydronic closed-loop HVAC systems by MC 1207.

Bulletins

BUILDINGS
2021-017
BULLETIN
TECHNICAL

ISSUANCE DATE
October 1, 2021

NYC Buildings

ISSUER: **Alan Price, P.E.**
Director, Office of Technical Certification and Research

PURPOSE: This document establishes acceptance criteria, installation, and maintenance requirements for heat transfer nanofluids used in hydronic closed-loop HVAC systems.

SUBJECT(S): Innovation Challenge, Heat Transfer Nanofluid, Hydronic Close-Loop HVAC System

RELATED CODE SECTIONS: AC 28-113, MC 1207

Proud Recognition from UK GREEN BUILDING COUNCIL

The UK Green Building Council is on a mission to "radically improve the sustainability of the built environment" across the United Kingdom. As a part of this mission, they call on members to submit sustainability challenges and invite the entire building industry to source solutions.

In January and February of 2022, they posed a challenge called "Retrofitting Resilience" with the question, "How can existing buildings be made more resilient to climate change, with as little disruption to their occupants as possible, by 2030?"

The UKGBC acknowledges that retrofitting existing buildings will play a huge role in limiting carbon emissions. They also stress the need to make buildings ready to handle the effects of climate change that will inevitably occur, regardless of what actions society takes in the near term.

Buildings in the future will have to deal with heat stress and more significant temperature variability, along with the increased cost and scarcity of heating fuel, making energy-saving solutions of paramount importance. Among the proposed solutions, the UKGBC judging panel highlighted a handful of technologies that best respond to this challenge, and Hydromx was among them.

The UKGBC noted the product's effectiveness "in a wide range of applications globally, including hospital space heating, commercial space heating and cooling, hospital cooling, heat recovery and space heating in social housing. Hydromx is a retrofit solution for existing systems with no modifications required."

https://www.ukgbc.org/solutions/hydromx/

NYC Accelerator Accepted Hydromx as a Service Provider to Fight CO^2 Emission in New York City

In 2012, New York City launched the NYC Accelerator program. The mayor's office of climate and sustainability is working with building owners across its five boroughs to lower carbon emissions. Their goal is to make New York City carbon-neutral by 2050, and buildings account for 68% of the city's carbon emissions.

The experts at NYC Accelerator have outlined several strategies to retrofit older buildings (and equip new construction) with green technologies. They offer building owners a free energy summary report to identify opportunities for energy conservation.

Hydromx, the revolutionary heat-transfer nanofluid, has been shown to increase the efficiency of closed-loop heating and cooling systems by up to 40%. It has a proven track record of decreasing energy consumption and greenhouse gas emissions for many kinds of buildings, from offices and schools to healthcare facilities and data centers. Hydromx guarantees a maximum return on investment of three years — and several case studies point to even faster recuperation of costs.

Hydromx has aligned its goals as a company with those set forth by COP26, the recent UN Climate Change Conference, and offers clients the least-intrusive way to upgrade existing heating and cooling systems to meet those goals.

https://www.hydromx.com/nyc-accelerator-award-hydromx/

Hydromx is an official service provider for the NYC Accelerator program.

Global Projects

- 1350 Broadway
- Ajit Bahawan
- BAS Surgical
- Blue Star Chiller Manufacturer
- BPS Electricity Production Plant
- Camp Ripley
- Carrefour Shopping Mall
- Cass County Data Center
- CIPET
- Club Mahindra Hotel
- CNC Stone
- Colonial Church
- CTC Data Center
- Cuyuna Regional Medical Center
- Dubai Ice Arena
- Empire State Building
- Equinix Atlanta Site
- Erzurum Air Base
- Forest Green Rovers Football Club
- General Directorate of Mining Affairs
- Hamworthy Boiler Manufacturer
- Hayat Kimya
- HBO Data Center
- Hennepin County Forensic Science
- Holiday Inn
- Honda Motorcycle Factory
- Hotkovice
- ITC Maurya
- Jezenice Electricity Production Plant
- Lalit Hotel
- Liben Electricity Production Plant
- Luna Fluid Tech
- Madison School
- Mahindra Tractors
- MBA Engineering
- Mechanical and Chemical Industries Association
- Microlab
- Minneapolis-St. Paul Airport (MSP)
- Montana State University
- Nestle Chocolate Factory
- Northwestern College
- Radion Building
- RedFox Hotel
- Residential Care Home
- Ridgeview Medical Center
- Royal Bank of Scotland
- Royal Orthopedic Hospital
- Samsung Electronics
- SL Green
- Student Accommodation
- Sujan Rajmahal Palace
- SV Development
- Temple Israel
- The Roseate
- Tierpoint Data Center
- University of North Dakota
- University of St. Thomas
- Virginia Tech University Data Center
- Voets & Donkers

Verizon – Montauk, NY Project

System

Verizon Data Center Montauk, Long Island, NY

Two identical Vertiv DS series, CRAC units with model no DSVS070KD.

Water cooled compressors, by dry coolers with model no DDO498Y64 Quiet line.

SCADA system to record the KPI

1.T_{air} Supply to Server room

2.T_{air} Return from Server room

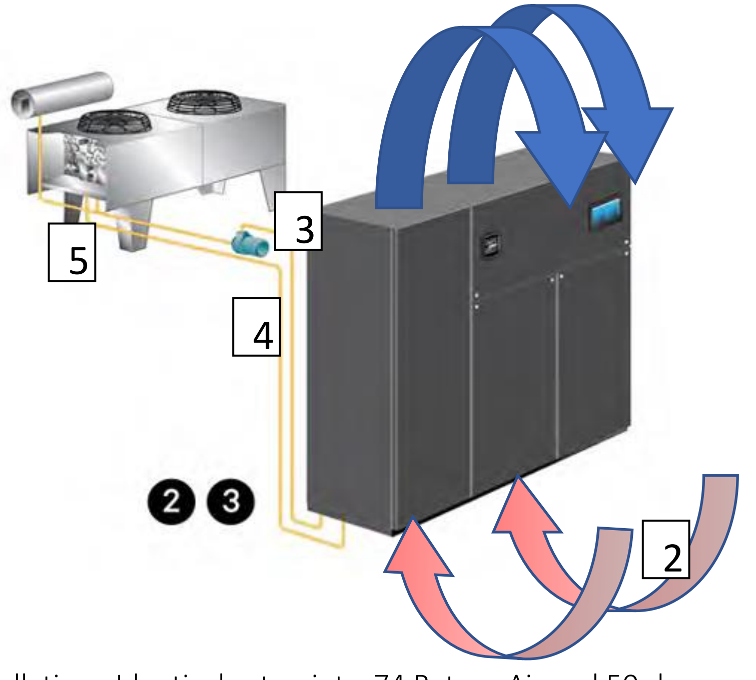
3.T_{fluid} supply to Condenser

4.T_{fluid} return from Condenser

5.$T_{outdoor}$ at Dry coolers

6.Kw of CRAC

7.Kwh of CRAC

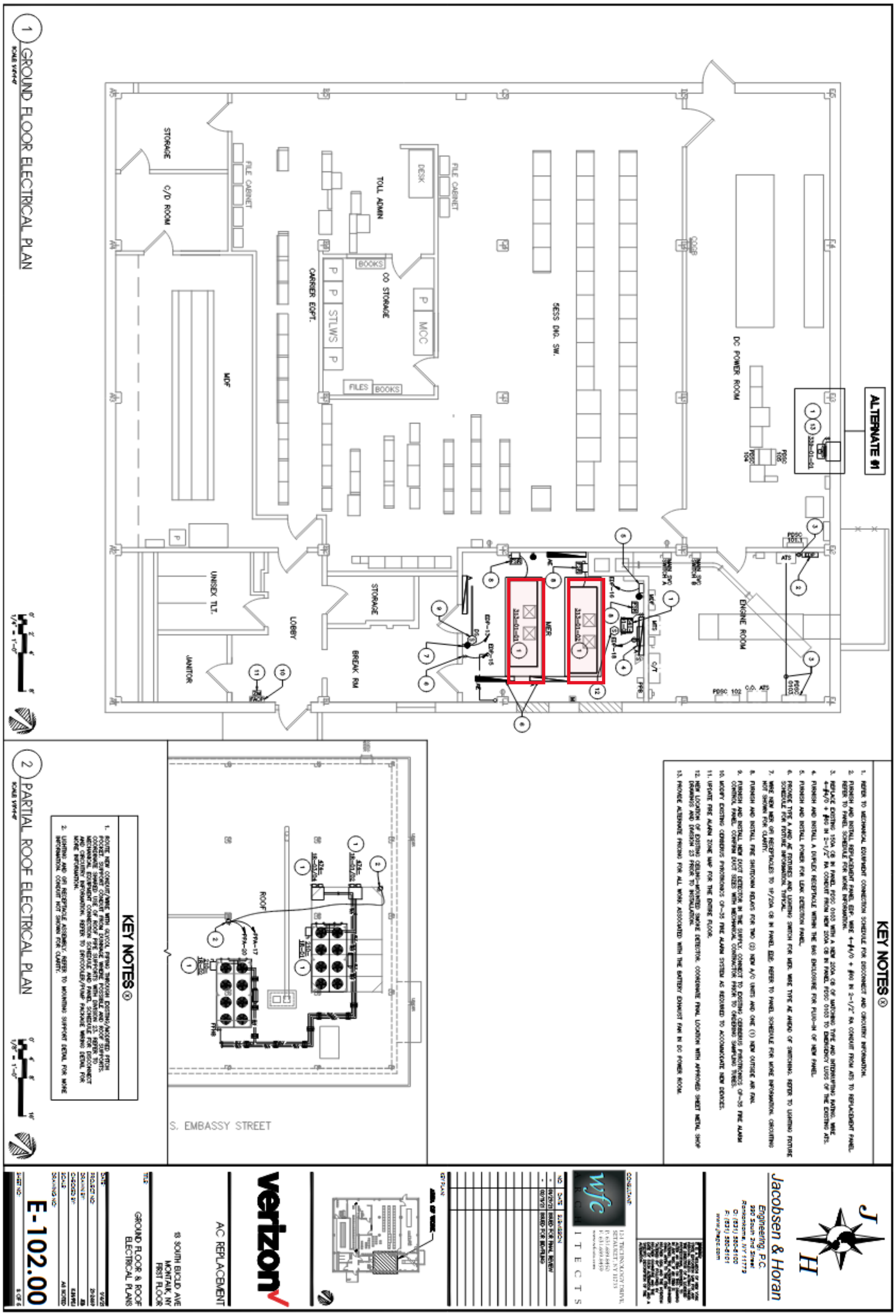


Identical two units are both brand new installation. Identical set points: 74 Return Air and 50 rh. The only difference is the cooling liquid that circulates in between condenser & dry coolers.

One unit runs with glycol-water mixture 35%, the other one runs with Hydromx-water mixture at 44%. The independent CRAC units are run alternately per week. The kWh values are compared for the weeks that they are active.

The data and results shared in this summary are based on the raw data that has been recorded by the SCADA software, which is available for online connection upon request.

Drawing



Results:

For the period from July14th to September 13th, the kW data collected from the SCADA system. *(Please see a sample of the data at the Exhibit. Full dataset can be downloaded from the Cloud).*

The hourly averages of Total kW consumptions of the Vertiv Units along with total kWh Data have continuously been recorded along with other pertinent data points. Units have been alternating on a weekly basis.

Furthermore, the outside temperatures are downloaded from wunderground.com for Montauk and included into the spreadsheet. As seen below, for different temperature ranges, Hydromx® performs significantly better compared to glycol. The higher OAT temperatures allow Hydromx®'s performance to get better, due to increased load in the space. Higher load demand in the building is directly correlated to the outside temperature increases. Since Hydromx® saves on the compressor kWh, higher loads unequivocally impact Hydromx's performance.

The identical Vertiv Units at the site have continuously been running single stage a Fan Motor, which draws 3.7 kW. In order to quantify the percentage impact of Hydromx on the compressor consumption, hence, to be able to determine the precise efficiency, Fan Motor's consumption must be adjusted. (please see the final Exhibit's highlighted areas)

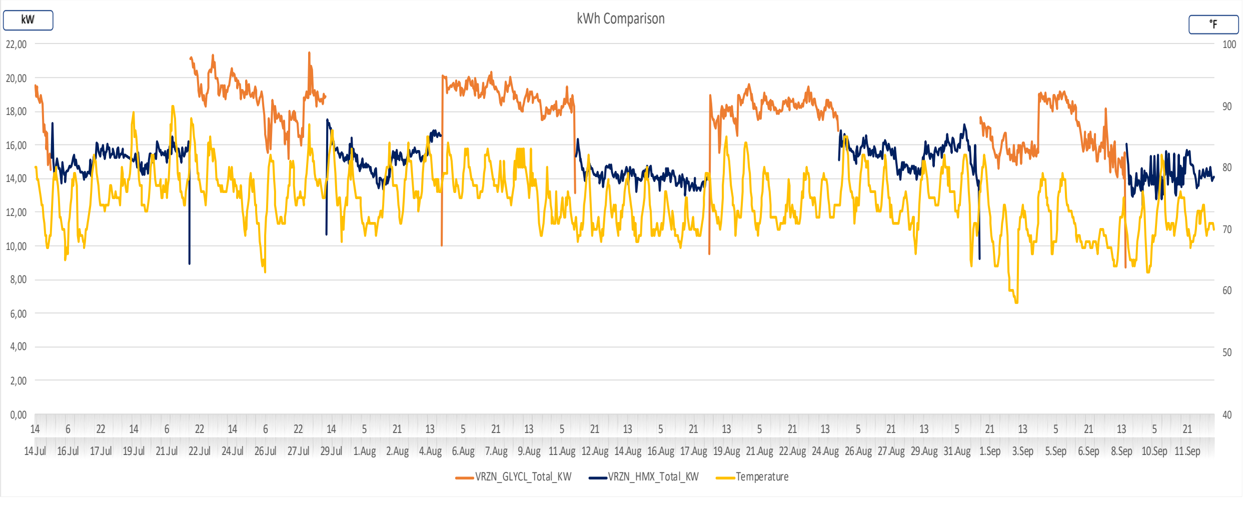
Below tables show both Glycol and Hydromx Units' kWh consumptions broken down by 5 F OAT incremental:

UNITS' TOTAL kWh - OUTSIDE AIR TEMPERATURE RANGES

OAT	GLYCOL (avg kWh)	HYDROMX (avg kWh)	Efficiency %
60 t0 65 °F	15.82	13.93	**11.98%**
66 to 70 °F	16.51	14.28	**13.50%**
71 to 75 °F	17.90	14.73	**17.70%**
76 to 80 °F	18.81	15.29	**18.73%**
81 to 85 °F	19.18	15.58	**18.79%**
+ 86 °F	21.08	15.70	**25.50%**
OVERALL OAT AVG	74.42 F	74.56 F	For the period
FAN MOTOR KWH	3.70	**ADJUSTED**	

OAT	GLYCOL (avg kWh)	HYDROMX (avg kWh)	Efficiency %
60 t0 65 °F	12.12	10.23	**15.64%**
66 to 70 °F	12.81	10.58	**17.40%**
71 to 75 °F	14.20	11.03	**22.32%**
76 to 80 °F	15.11	11.59	**23.32%**
81 to 85 °F	15.48	11.88	**23.28%**
+ 86 °F	17.38	12.00	**30.93%**

Total kWh Avg of both Units vs OAT



Total kWh Comparison & Expected ROI Analyses

The SCADA energy analyzer recorded all 3 phases from both Units to calculate the Total kWh, which was a requirement of the Verizon Sustainability Team. On July 31st, there was a 23 hours of "hourly" missing data, yet total kWh data continued to record.. Therefore, a missing total number of hours had to be added.

If the both Units would run about **4 months** on Montauk, the ROI calculation would be as follows. Clearly, we cannot quantify the Glycol pump efficiency due to longer hours of free cooling. To clarify, the Fan Motor adjustment is not part of this ROI analysis. Below analysis is based solely on kWh savings resulted from Hydromx.

And the reason that the starting kWh's are different is due to the PLC's previous recorded data, which has no impact on the data except a starting point difference.

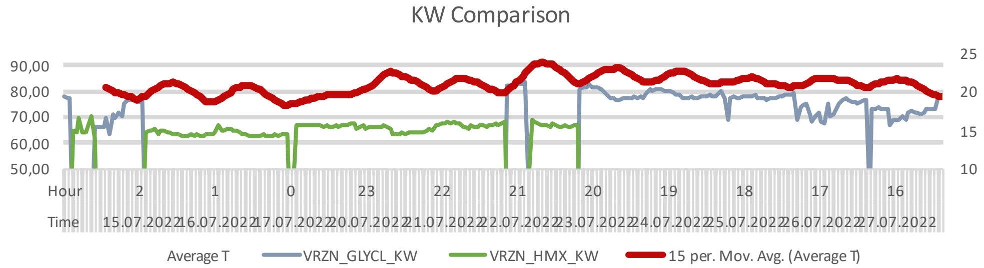
TOTAL kWh of the Units	GLYCOL (total kWh)	HYDROMX (total kWh)	
14.07.2022	10761.03	5881.68	
13.09.2022	23,105.36	17,758.21	
Total kWH Consumption	12,344.33	11,876.53	
Total Hours	675	781	
Due to missing data on Jul31st	12,210.75	11,566.61	kWh Difference
Average Consumption/Hr	18.09	14.81	3.3
HMX Performance	22.1%		
If both Units had Hydromx			
Summer kWh rate (Avg)	19 cents		
Expected Savings (4 months)	$1,794.82		
Hydromx Installed (gal) x 2	240		
Hydromx Cost / gal	$40.00		
ROI (months)	20	Excluding pump efficiency	

Supporting Findings:

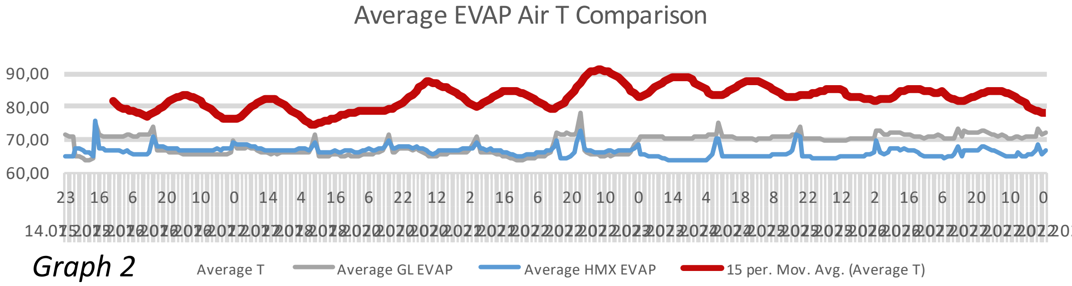
One may rightfully wonder the effects of an efficient heat transfer nanofluid on the operating temperatures which in return would lead to significant savings.

During the Hydromx period "Evaporator Supply Air temp" was 67˚F whereas it was 71˚F at the glycol period. If the system should have been configured to have the same supply temps, Hydromx period could have saved significantly more.

Vertiv technical team agreed on the fact due to complex algorithms on the Units, a 74F setpoint do not necessarily mean that the space will run at 74F sharp.

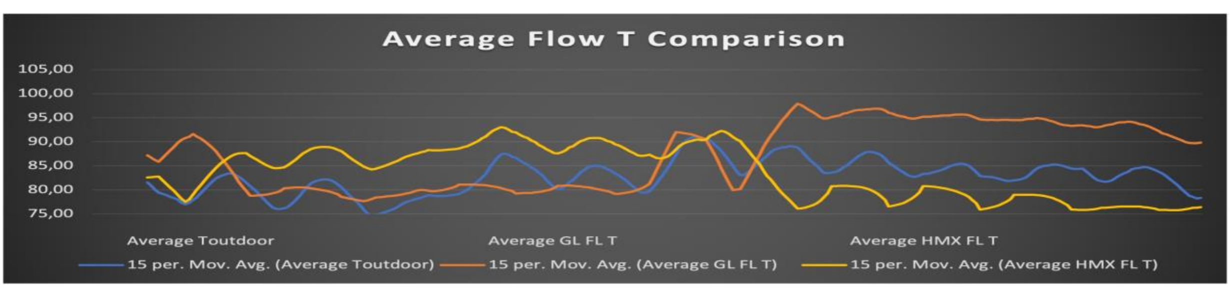


Graph 1



Graph 2

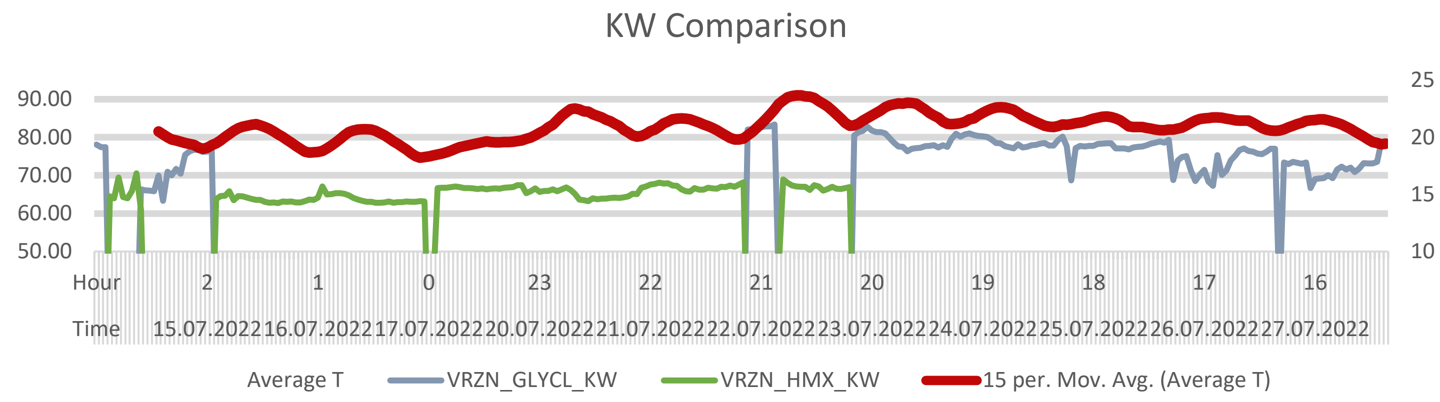
The operating fluid temps have been reflecting the same. Hydromx's average fluid temp is 84˚F, whereas it is 90˚F at glycol for the period.



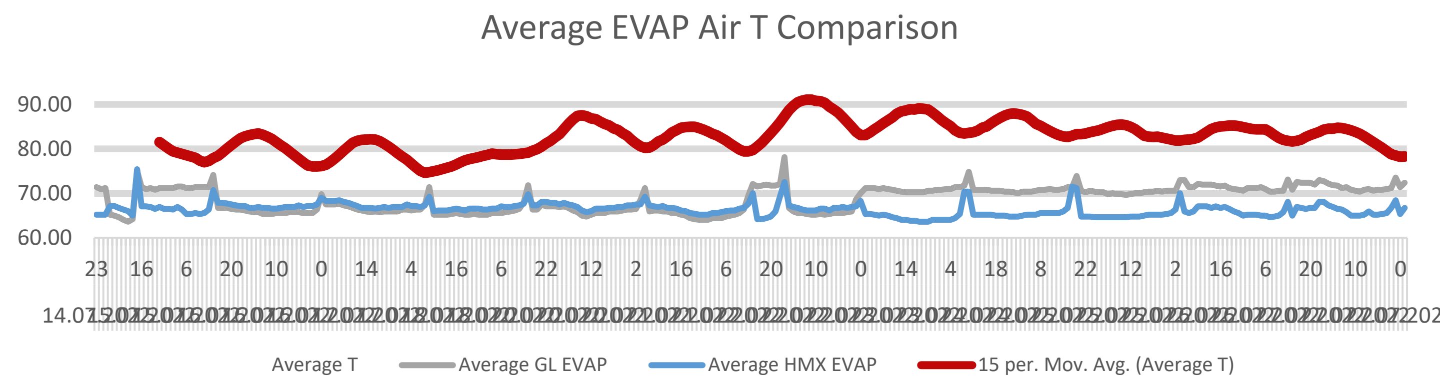
Graph 3

Please see the Exhibit for the full scale graphs

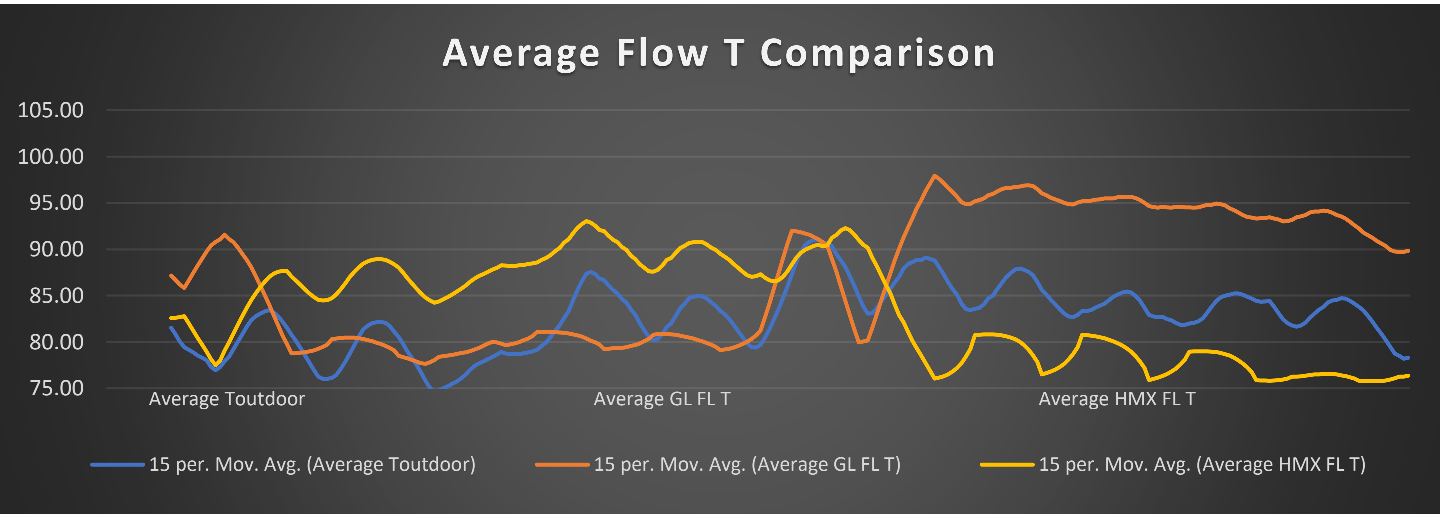
Exhibits



Graph 1

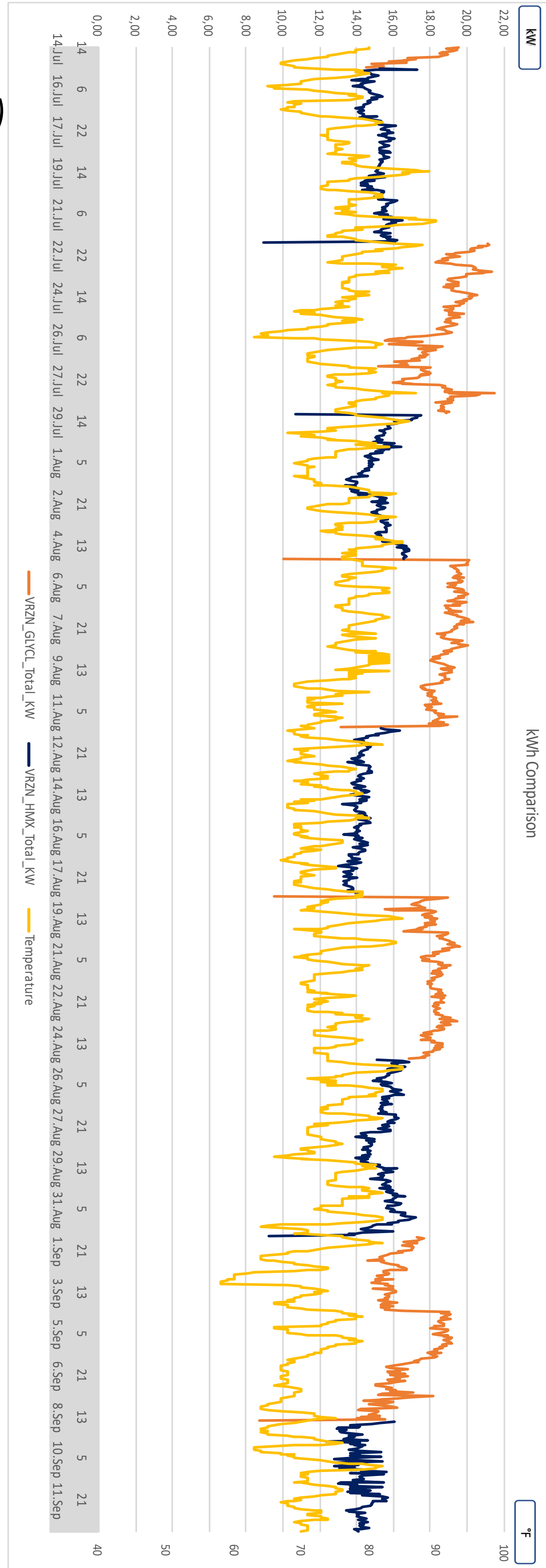


Graph 2



Graph 3

Exhibits – *(continued)*



Exhibits – *(continued)*

Sample Data Spreadsheet

Date	Hour	Time EST	Time TR	Glycl/HMX	VRZN_GLYCL_Total_KW	VRZN_HMX_Total_KW	Temperature	VRZN_GLYCL_Total_kwh	VRZN_HMX_Total_kwh
14.Jul	14	14:00:00	21:00:00	GLYCL	19,56		80	10.761,03	5.881,68
14.Jul	15	15:00:00	22:00:00	GLYCL	18,89		80	10.780,11	5.881,82
14.Jul	16	16:00:00	23:00:00	GLYCL	19,45		78	10.799,49	5.881,98
14.Jul	17	17:00:00	00:00:00	GLYCL	19,23		78	10.818,58	5.882,12
14.Jul	18	18:00:00	01:00:00	GLYCL	18,80		78	10.837,38	5.882,27
14.Jul	19	19:00:00	02:00:00	GLYCL	18,69		77	10.856,07	5.882,42
14.Jul	20	20:00:00	03:00:00	GLYCL	18,51		76	10.874,94	5.882,56
14.Jul	21	21:00:00	04:00:00	GLYCL	18,96		75	10.893,91	5.882,72
14.Jul	22	22:00:00	05:00:00	GLYCL	18,70		74	10.912,69	5.882,87
14.Jul	23	23:00:00	06:00:00	GLYCL	18,46		74	10.931,19	5.883,01
15.Jul	0	00:00:00	07:00:00	GLYCL	16,76		72	10.947,88	5.883,17
15.Jul	1	01:00:00	08:00:00	GLYCL	17,19		71	10.965,17	5.883,31
15.Jul	2	02:00:00	09:00:00	GLYCL	16,59		69	10.981,81	5.883,46
15.Jul	3	03:00:00	10:00:00	GLYCL	16,77		69	10.998,89	5.883,61
15.Jul	4	04:00:00	11:00:00	GLYCL	15,80		68	11.014,54	5.883,76
15.Jul	5	05:00:00	12:00:00	GLYCL	16,67		67	11.031,17	5.883,91
15.Jul	6	06:00:00	13:00:00	GLYCL	14,81		67	11.046,49	5.884,06
15.Jul	7	07:00:00	14:00:00	GLYCL	15,21		68	11.061,81	5.884,20
15.Jul	8	08:00:00	15:00:00	GLYCL	15,49		69	11.077,19	5.884,35
15.Jul	9	09:00:00	16:00:00	GLYCL	14,52		69	11.091,96	5.884,61
15.Jul	10	10:00:00	17:00:00	HMX		15,25	72	11.092,13	5.900,09
15.Jul	11	11:00:00	18:00:00	HMX		17,27	75	11.092,30	5.916,98
15.Jul	12	12:00:00	19:00:00	HMX		15,06	78	11.092,47	5.932,00
15.Jul	13	13:00:00	20:00:00	HMX		14,31	79	11.092,64	5.946,70
15.Jul	14	14:00:00	21:00:00	HMX		14,39	78	11.092,81	5.961,47
15.Jul	15	15:00:00	22:00:00	HMX		14,78	80	11.092,97	5.976,25
15.Jul	16	16:00:00	23:00:00	HMX		14,81	79	11.093,14	5.990,93
15.Jul	17	17:00:00	00:00:00	HMX		15,19	78	11.093,31	6.005,77
15.Jul	18	18:00:00	01:00:00	HMX		14,89	77	11.093,48	6.020,49
15.Jul	19	19:00:00	02:00:00	HMX		14,57	75	11.093,65	6.035,02
15.Jul	20	20:00:00	03:00:00	HMX		14,58	72	11.093,82	6.049,57
15.Jul	21	21:00:00	04:00:00	HMX		14,28	72	11.093,99	6.063,98
15.Jul	22	22:00:00	05:00:00	HMX		13,72	71	11.094,17	6.078,28
15.Jul	23	23:00:00	06:00:00	HMX		14,95	70	11.094,34	6.092,57
16.Jul	0	00:00:00	07:00:00	HMX		14,54	70	11.094,51	6.106,94
16.Jul	1	01:00:00	08:00:00	HMX		14,24	70	11.094,68	6.121,29
16.Jul	2	02:00:00	09:00:00	HMX		14,35	68	11.094,85	6.135,67
16.Jul	3	03:00:00	10:00:00	HMX		13,84	65	11.095,02	6.149,93
16.Jul	4	04:00:00	11:00:00	HMX		14,40	66	11.095,19	6.164,23
16.Jul	5	05:00:00	12:00:00	HMX		14,45	67	11.095,36	6.178,51
16.Jul	6	06:00:00	13:00:00	HMX		14,44	66	11.095,53	6.192,86

Exhibits – *(continued)*

THE PATENT BEHIND THE TECHNOLOGY

United States Patent for Nanofluids


US009340720B2

(12) **United States Patent**
Singh et al.

(10) **Patent No.:** **US 9,340,720 B2**
(45) **Date of Patent:** **May 17, 2016**

(54) **HEAT TRANSFER FLUIDS CONTAINING NANOPARTICLES**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 404 days.

(21) Appl. No.: **12/828,025**

(22) Filed: **Jun. 30, 2010**

(65) **Prior Publication Data**
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Related U.S. Application Data

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(51) **Int. Cl.**
C09K 5/00 (2006.01)
C09K 5/10 (2006.01)
C09K 5/08 (2006.01)
C09K 5/14 (2006.01)

(52) **U.S. Cl.**
CPC ... *C09K 5/10* (2013.01); *C09K 5/08* (2013.01); *C09K 5/14* (2013.01)

(58) **Field of Classification Search**
CPC C09K 5/00; C09K 5/08; C09K 5/14; C09K 5/20
USPC 252/73, 70, 71, 78.1, 74, 75, 67; 361/697, 698, 699; 62/122; 165/164, 4
See application file for complete search history.

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(Continued)

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(74) *Attorney, Agent, or Firm* — Foley & Lardner LLP

(57) **ABSTRACT**

A nanofluid of a base heat transfer fluid and a plurality of ceramic nanoparticles suspended throughout the base heat transfer fluid applicable to commercial and industrial heat transfer applications. The nanofluid is stable, non-reactive and exhibits enhanced heat transfer properties relative to the base heat transfer fluid, with only minimal increases in pumping power required relative to the base heat transfer fluid. In a particular embodiment, the plurality of ceramic nanoparticles comprise silicon carbide and the base heat transfer fluid comprises water and water and ethylene glycol mixtures.

18 Claims, 24 Drawing Sheets

US 9,340,720 B2

HEAT TRANSFER FLUIDS CONTAINING NANOPARTICLES

SUMMARY OF THE INVENTION

Industrial applications for nanofluid technology are in an embryonic stage. However, today, the nanofluid field has developed to the point where it is appropriate to look to the next level, i.e., nanofluids that show substantial heat transfer enhancement over their base fluids and are candidates for use in industrial/commercial systems. For example, potential use of nanofluids for cooling systems such as radiators in vehicles will require not only enhanced thermal properties, but also minimal negative mechanical effects of the nanofluid in a closed system. In this regard, viscosity of the nanofluid for instance is a contributing factor to pumping power needed for the circulation of the nanofluid.

Further, any erosive and clogging effects of the nanofluids on the fluid transmission lines or radiator can have an adverse effect on its use. Various nanofluids that may find widespread acceptance for industrial use should preferably be, as a minimum, stable suspensions with little or no particle settling, available in large quantities at affordable cost, environmentally neutral, and non-toxic. In addition, such applications would generally prefer that there be little change in particle agglomeration over time and that the nanofluid not be susceptible to adverse surface adhesion.

A favorable combination of desirable nanofluid characteristics can be achieved with, for example, ceramic nanoparticles disposed in a base fluid. Ceramic nanoparticles are not susceptible to surface oxidation, and enjoy significantly better chemical stability over longer periods of time than metals.

Since the discussion for the nanofluids' acceptance ends with the published US Patent, the only viable, feasible, commericially available and nontoxic product is now Hydromx®.

As stated in the US Patents a viable commercial nanofluid must be:

- **AFFORDABLE** ⟶ Hydromx guarantees 3-year ROI
- **ABUNDANT** ⟶ Hydromx is "Made in USA"
- **NON-TOXIC** ⟶ Hydromx has been approved by NSF for HT1 and HT2 certificates as a nontoxic product.

Picture 1

Exhibits – *(continued)*

20 Tons

Model Size - Upflow Configuration		VS035	VS042	VS053	VS070	VS077	VS105
DX Evaporator - Net Capacity Data with 104°F Entering and 115°F Leaving 40% Propylene Glycol Temperatures							
	Compressor Type	Digital Scroll				Semi-Hermetic (Four-Step Cooling)	
85°F DB[1], 64.4°F WB, 52°F DP, 32% RH (29.4°C DB, 18°C WB)	Total, kW (BTUH)	37.6 (128,000)	42.2 (144,000)	59.5 (203,000)	71.1 (243,000)	76.9 (262,000)	95.1 (324,000)
	Sensible, kW (BTUH)	37.6 (128,000)	42.2 (144,000)	59.5 (203,000)	70.7 (241,000)	76.7 (262,000)	94.3 (322,000)
	Flow Rate, GPM (lps)	36.1 (2.3)	40.8 (2.6)	52.8 (3.3)	65.6 (4.1)	72.2 (4.5)	89.6 (5.6)
	Unit Pressure Drop, ft of Water (kPa)	16.6 (49.6)	20.8 (62.2)	18.8 (56.2)	28.4 (84.9)	33.9 (101.4)	45.3 (135.4)
	Heat Rejection, kW (BTUH)	53.9 (184,000)	61.0 (208,000)	78.8 (269,000)	97.9 (334,000)	107.6 (367,000)	133.7 (456,000)
	External Static Pressure, in.w.g. (Pa)	0.4[1] (100)	0.4[1] (100)	0.4[1] (100)	0.5[1] (125)	0.5[1] (125)	0.5[1] (125)
80°F DB, 62.7°F WB, 52°F DP, 38% RH (26.7°C DB, 17.1°C WB)	Total, kW (BTUH)	35.0 (119,000)	39.2 (134,000)	55.9 (191,000)	67.4 (230,000)	72.5 (247,000)	89.6 (306,000)
	Sensible, kW (BTUH)	35.0 (119,000)	39.2 (134,000)	54.5 (186,000)	64.9 (221,000)	70.3 (240,000)	86.8 (296,000)
	Flow Rate, GPM (lps)	34.3 (2.2)	38.8 (2.4)	50.6 (3.2)	63.1 (4.0)	69.1 (4.4)	85.7 (5.4)
	Unit Pressure Drop, ft of Water (kPa)	14.9 (44.6)	18.9 (56.5)	17.3 (51.7)	26.4 (78.9)	31.2 (93.3)	41.6 (124.4)
	Heat Rejection, kW (BTUH)	51.1 (174,000)	57.9 (198,000)	75.5 (258,000)	94.2 (321,000)	103.1 (352,000)	127.8 (436,000)
	External Static Pressure, in.w.g. (Pa)	0.5 (125)	0.5 (125)	0.5 (125)	0.5 (125)	0.5 (125)	0.5 (125)
75°F DB[2], 61°F WB, 52°F DP, 44% RH (23.9°C DB, 16.1°C WB)	Total, kW (BTUH)	32.6 (111,000)	36.1 (123,000)	52.1 (178,000)	63.3 (216,000)	68.0 (232,000)[2a]	84.0 (287,000)[2a]
	Sensible, kW (BTUH)	31.3 (107,000)	35.3 (120,000)	47.9 (163,000)	56.9 (194,000)	59.0 (201,000)[2a]	75.1 (256,000)[2a]
	Flow Rate, GPM (lps)	32.6 (2.1)	37.0 (2.3)	48.6 (3.1)	61.0 (3.8)	65.0 (4.1)[2a]	81.2 (5.1)[2a]
	Unit Pressure Drop, ft of Water (kPa)	13.6 (40.7)	17.2 (51.4)	16.1 (48.1)	24.7 (73.9)	28.0 (83.7)[2a]	38.0 (113.6)[2a]
	Heat Rejection, kW (BTUH)	48.7 (166,000)	55.2 (188,000)	72.6 (248,000)	91.0 (311,000)	97.0 (331,000)[2a]	121.1 (413,000)[2a]
	External Static Pressure, in.w.g. (Pa)	1.0[2] (250)	1.0[2] (250)	1.0[2] (250)	1.0[2] (250)	1.0[2] (250)	1.0[2] (250)
	Compressor Type	Scroll (Two-Step Cooling)					
85°F DB[1], 64.4°F WB, 52°F DP, 32% RH (29.4°C DB, 18°C WB)	Total, kW (BTUH)	36.5 (125,000)	42.4 (145,000)	60.1 (205,000)	72.9 (249,000)		
	Sensible, kW (BTUH)	36.5 (125,000)	42.4 (145,000)	60.0 (205,000)	72.1 (246,000)		
	Flow Rate, GPM (lps)	34.4 (2.2)	40.1 (2.5)	53.2 (3.4)	66.7 (4.2)		
	Unit Pressure Drop, ft of Water (kPa)	15.0 (44.8)	20.1 (60.1)	19.1 (57.1)	29.4 (87.8)		
	Heat Rejection, kW (BTUH)	51.3 (175,000)	59.9 (204,000)	79.5 (271,000)	99.5 (340,000)		
	External Static Pressure, in.w.g. (Pa)	0.4[1] (100)	0.4[1] (100)	0.4[1] (100)	0.5[1] (125)		
80°F DB, 62.7°F WB, 52°F DP, 38% RH (26.7°C DB, 17.1°C WB)	Total, kW (BTUH)	33.9 (116,000)	39.4 (134,000)	56.7 (193,000)	69.4 (237,000)		
	Sensible, kW (BTUH)	33.9 (116,000)	39.4 (134,000)	55.1 (188,000)	66.1 (226,000)		
	Flow Rate, GPM (lps)	32.7 (2.1)	38.2 (2.4)	51.2 (3.2)	64.4 (4.1)		
	Unit Pressure Drop, ft of Water (kPa)	13.6 (40.7)	18.3 (54.7)	17.7 (52.9)	27.4 (81.9)		
	Heat Rejection, kW (BTUH)	48.8 (167,000)	57.1 (195,000)	76.4 (261,000)	96.1 (328,000)		
	External Static Pressure, in.w.g. (Pa)	0.5 (125)	0.5 (125)	0.5 (125)	0.5 (125)		
75°F DB[2], 61°F WB, 52°F DP, 44% RH (23.9°C DB, 16.1°C WB)	Total, kW (BTUH)	31.1 (106,000)	36.7 (125,000)[2a]	53.1 (181,000)	65.5 (223,000)		
	Sensible, kW (BTUH)	30.5 (104,000)	34.4 (117,000)[2a]	48.5 (165,000)	58.0 (198,000)		
	Flow Rate, GPM (lps)	31.1 (2.0)	35.9 (2.3)[2a]	49.4 (3.1)	62.4 (3.9)		
	Unit Pressure Drop, ft of Water (kPa)	12.4 (37.1)	16.0 (47.8)[2a]	16.6 (49.6)	25.8 (77.1)		
	Heat Rejection, kW (BTUH)	46.4 (158,000)	53.6 (183,000)[2a]	73.7 (251,000)	93.0 (317,000)		
	External Static Pressure, in.w.g. (Pa)	1.0[2] (250)	1.0[2] (250)	1.0[2] (250)	1.0[2] (250)		
FAN SECTION - Centrifugal (Forward-Curved)							
	Return Air Volume - ACFM (ACMH)	5,500 (9,345)	6,600 (11,213)	8,000 (13,592)	9,800 ([illegible])	11,000 (18,689)	14,600 (24,805)
	Standard Fan Motor, hp (kW)	3.0 (2.2)	5.0 (3.7)	3.0 (2.2)	5.0 (3.7)	7.5 (5.6)	10.0 (7.5)
	Optional Fan Motor, hp (kW)	5.0 (3.7)	7.5 (5.6)	5.0 (3.7)	7.5 (5.6)	10.0 (7.5)	15.0 (11.2)
	Number of Fans	1	1	2	2	2	3

1. Rated in accordance with the AHRI Datacom Cooling Certification Program at AHRI Standard 1360 (I-P) Standard Rating Conditions.
2. Certified in accordance with the ASHRAE Standard 127-2007 Standard Rating Conditions. Certified units may be found in the Compliance Certification Database at www.regulations.doe.gov.

2a. Performance data derived from Return ACFM required to be listed in Compliance Certification Database.. (VS042=5,800; VS077=9,500; VS105=13,400)

3. Some options or combinations of options may result in reduced air flow. Consult factory for recommendations.
4. Net capacity data has fan motor heat factored in for all ratings.
5. Consult factory for alternate performance outputs.. Performance data generated in LRS Update Version 02-11-2019.
6. See Table 2.15 for Optional Dual Cool Performance.

Picture 2