NUCAP – NSERC Engage
Characterization of NUCAP Enhanced Heat Exchangers

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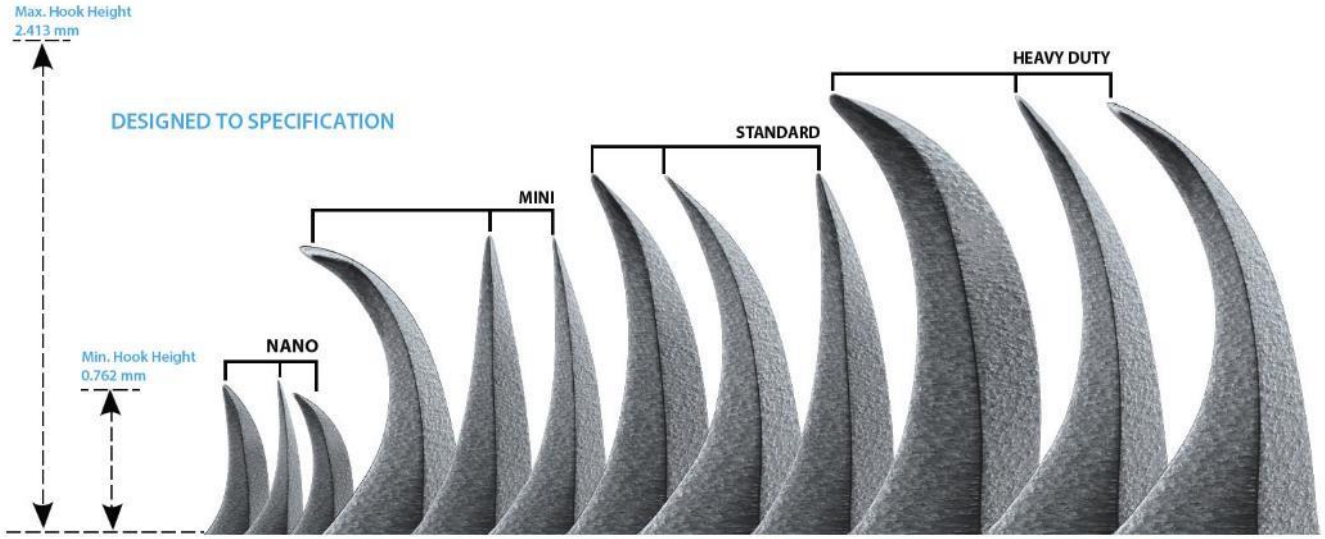
Background & Objective

Background:
NUCAP's proprietary surface structuring increases surface area and unique geometry could serve to promote increased mixing for convective heat transfer.



Objective:
To characterize the performance of heat exchangers fabricated using NUCAP's proprietary surface structuration.

Initial Test Methodology

"Dipstick" comparison testing between two kinds of heat exchangers:

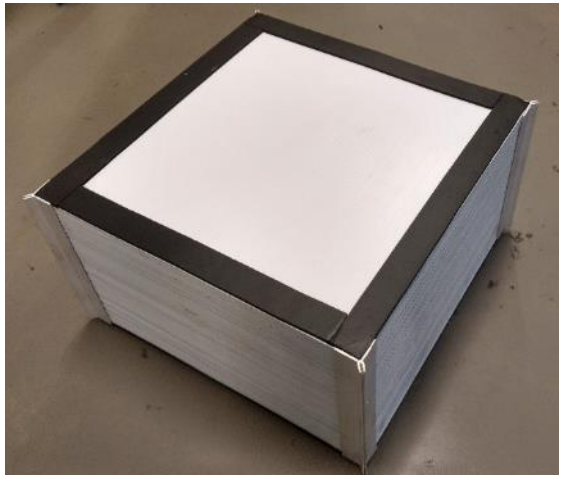
1. Water-to-air heat exchangers (natural & forced convection):

standard fins

Vs.

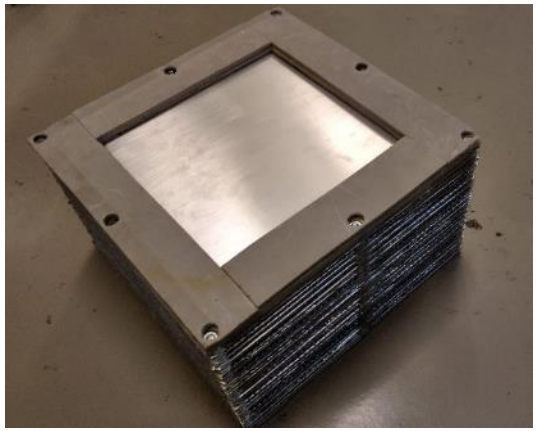
NUCAP enhanced fins

2. Air-to-air heat exchangers (forced convection):

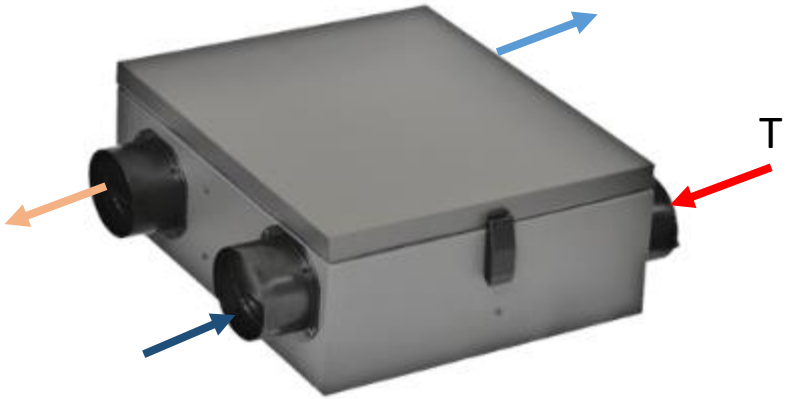


standard core

Vs.



NUCAP enhanced core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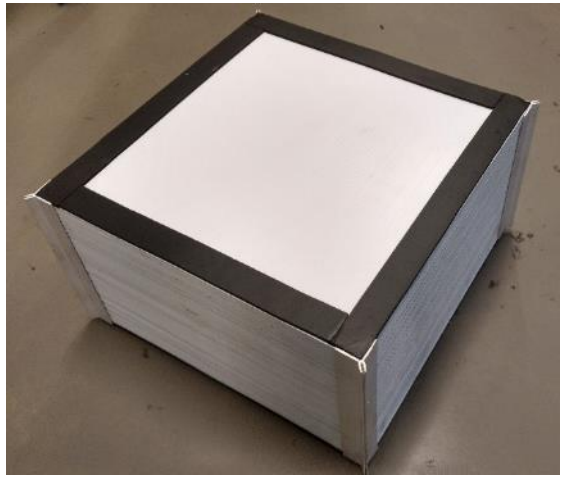
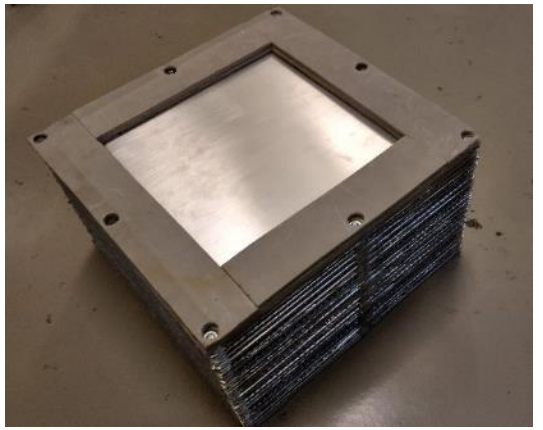
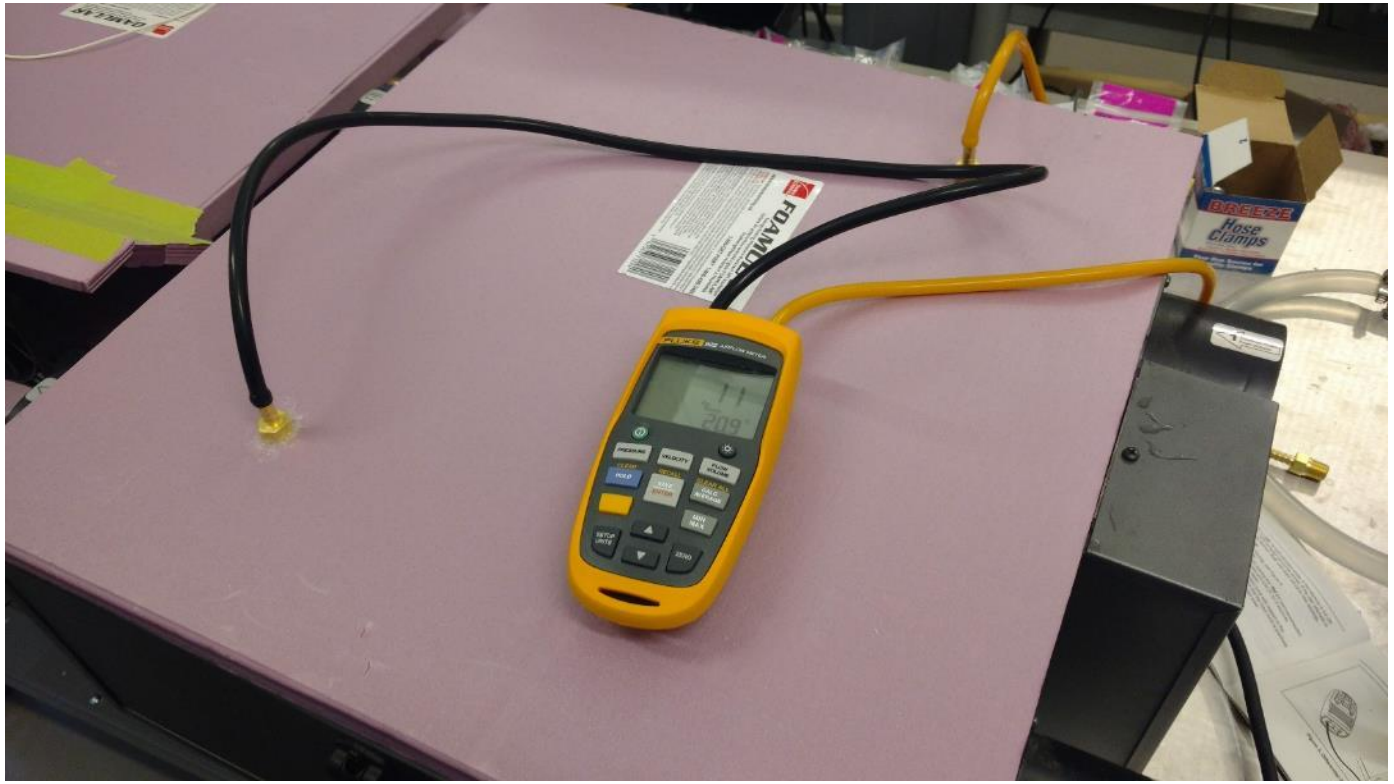
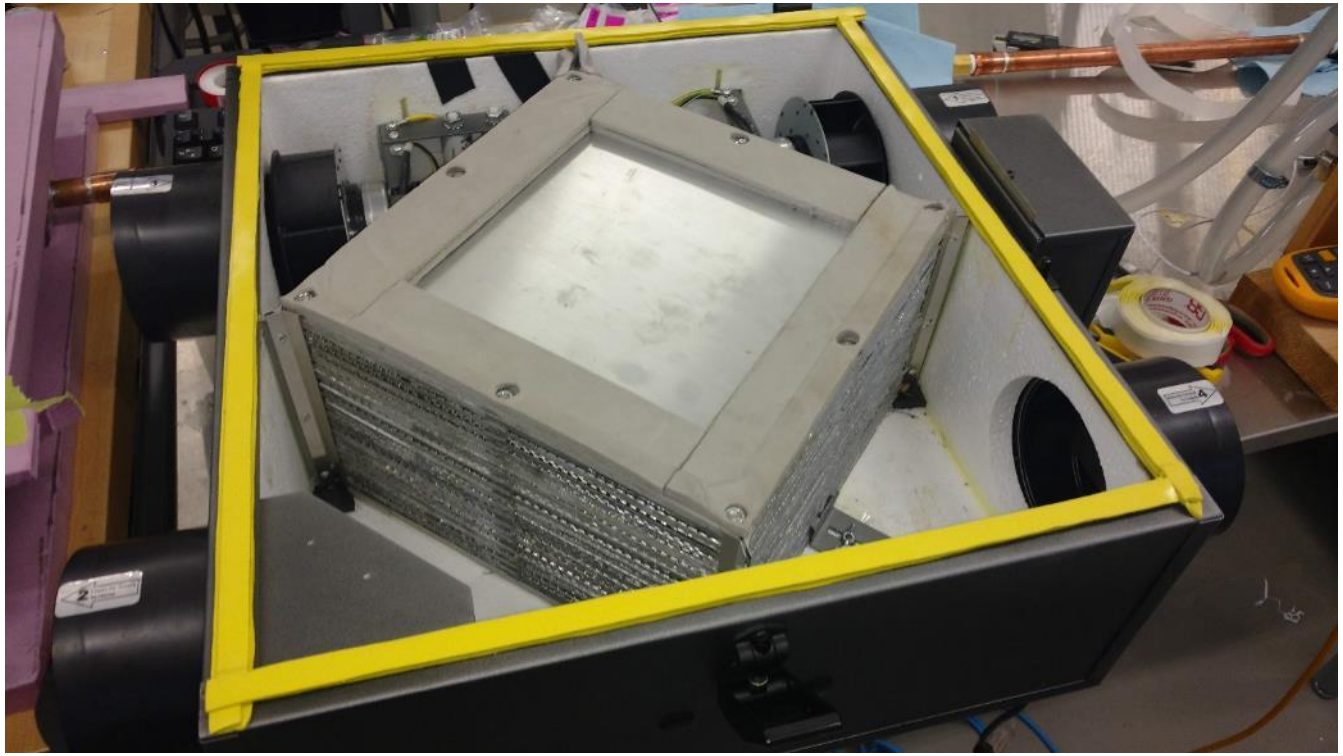
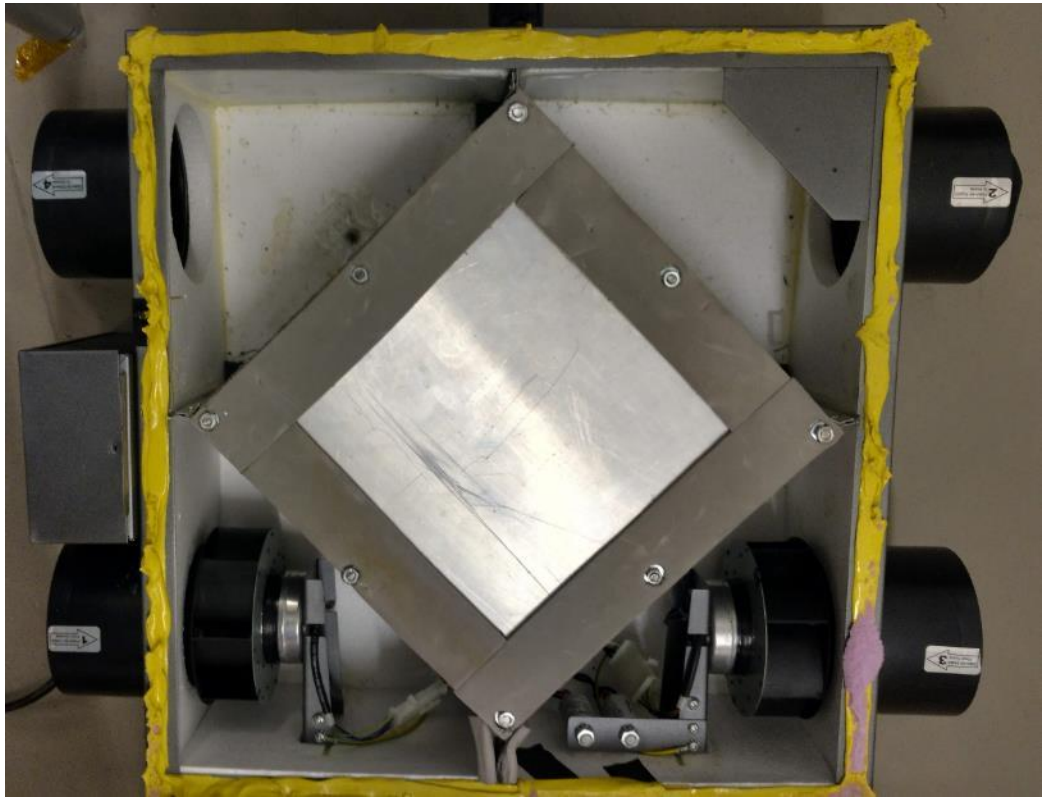




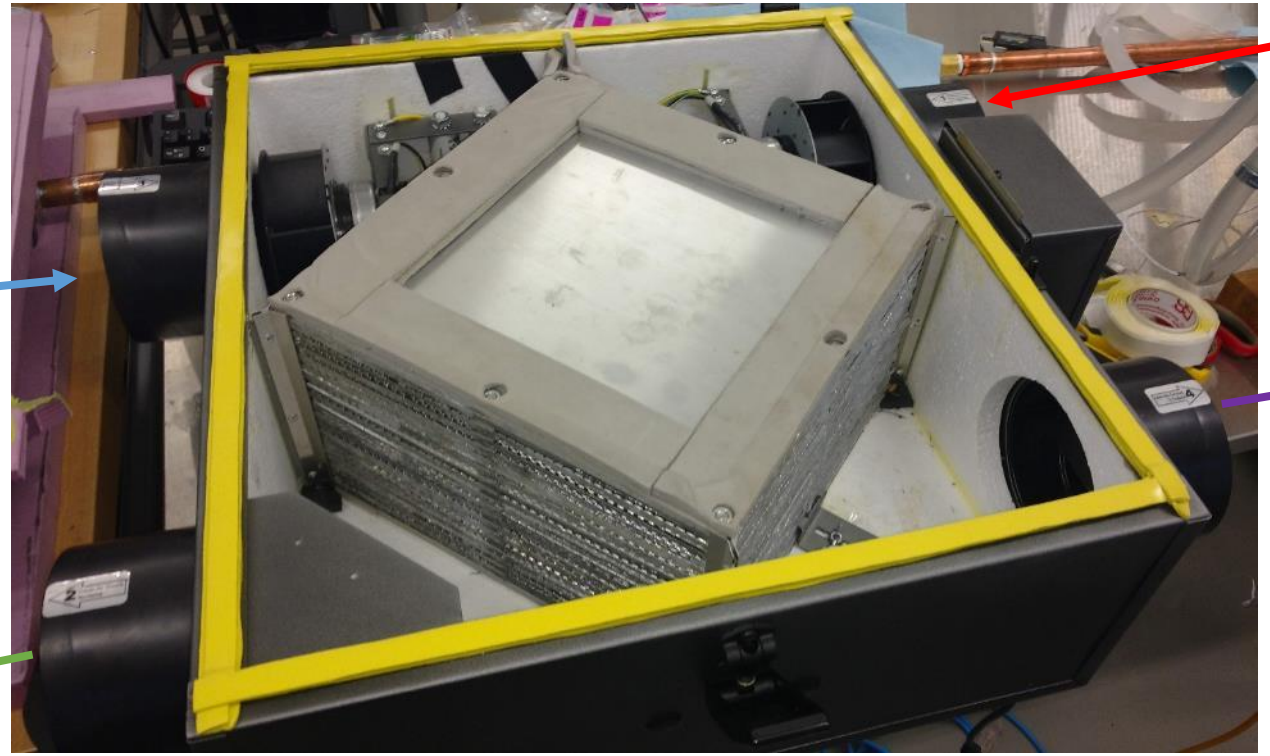

FOAMULAR
DIBEEZE
Hose Clamps





1. Fresh air intake from outside
2. Fresh air supply to home
3. Stale air intake from home
4. Stale air exhaust to outside

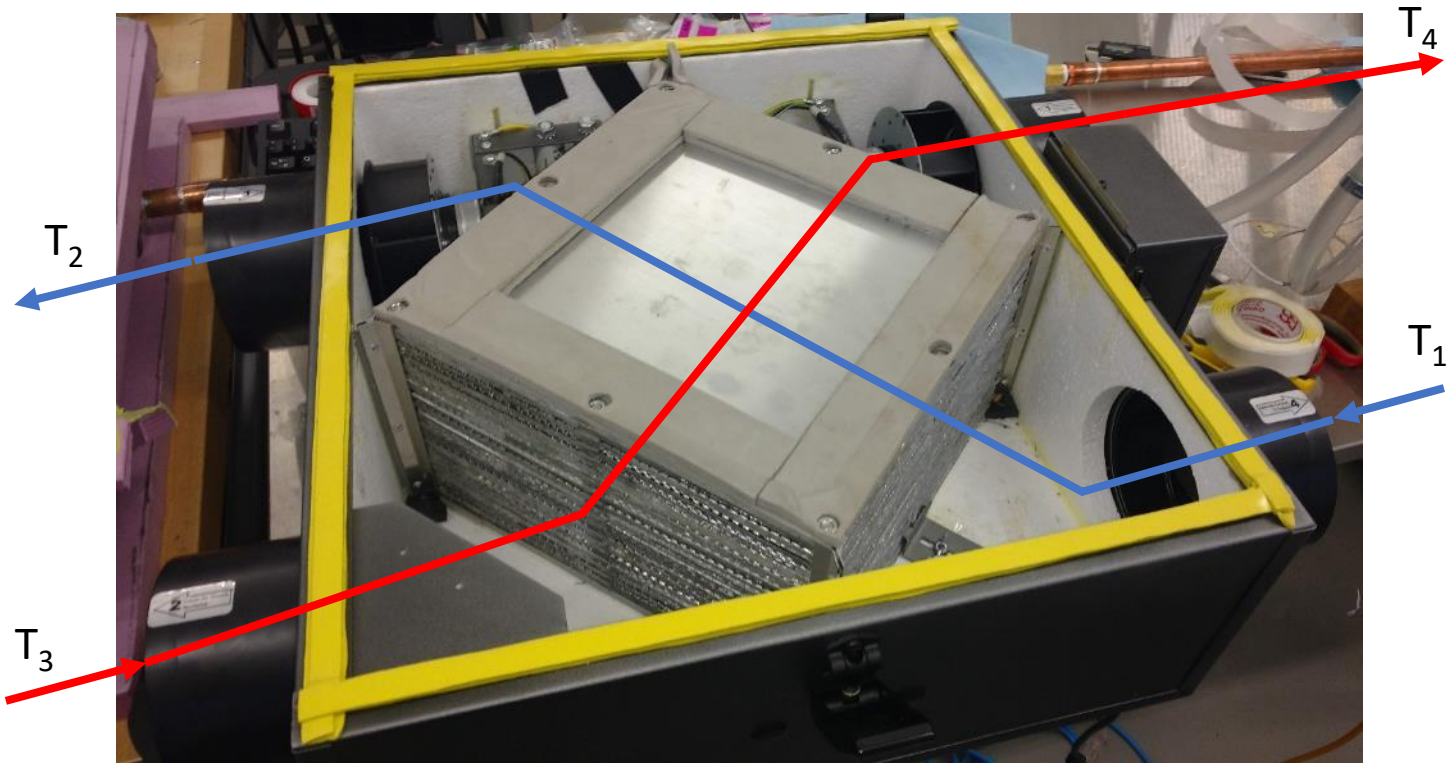
1. Fresh air intake from outside



3. Stale air intake from home

4. Stale air exhaust to outside

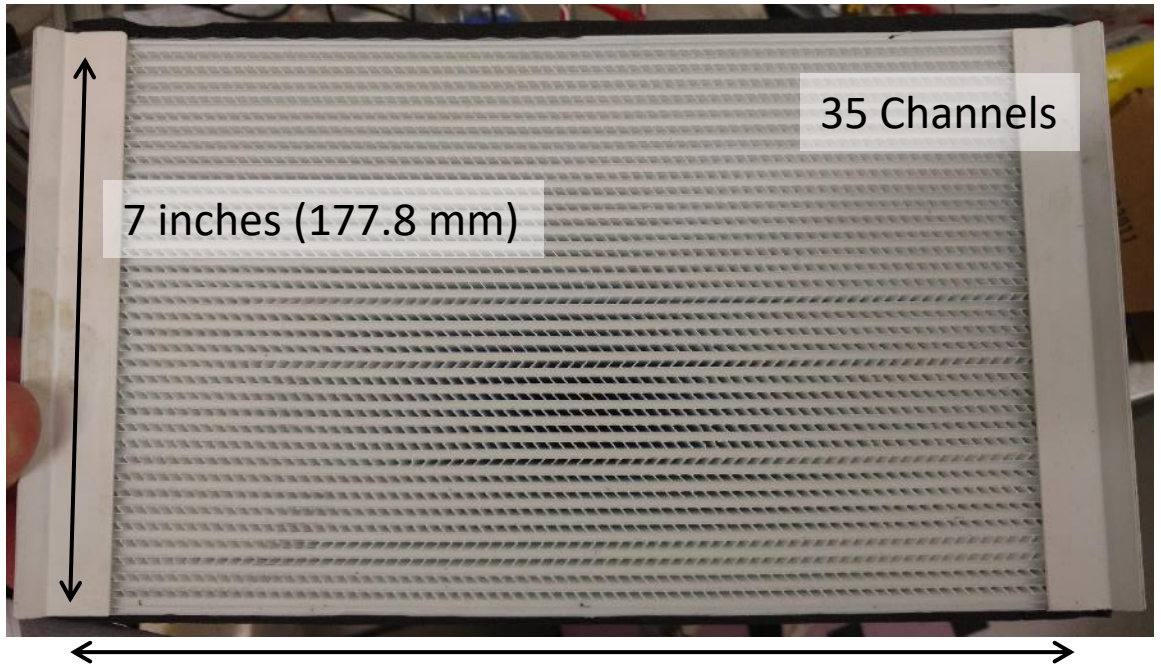
2. Fresh air supply to home


T4
T2
T1
T3

ssure taps
for delta P
asurement

3D printed ducts
for air pre-heater
and anemometers

Vane anemometer

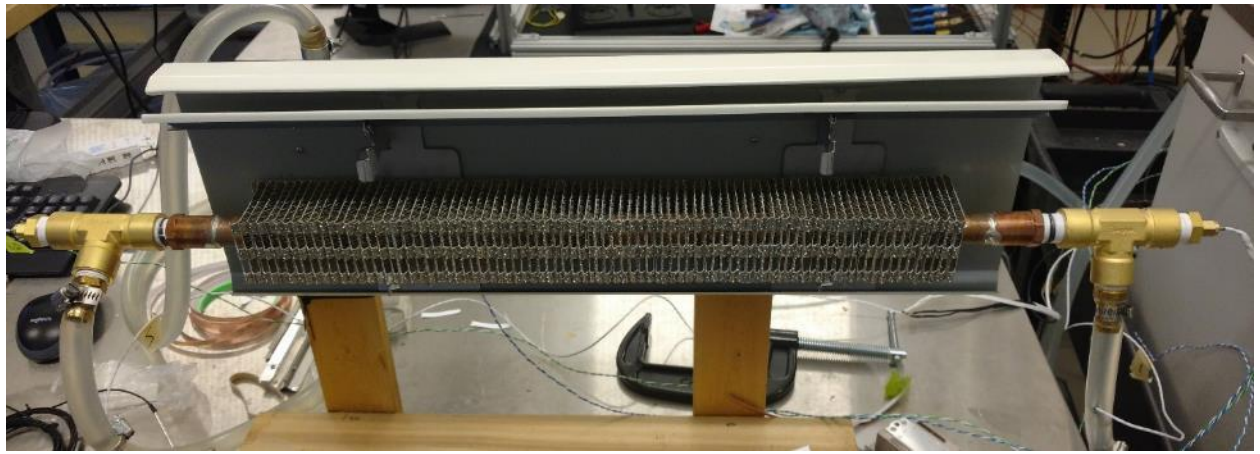

35 Channels
7 inches (177.8 mm)
12 inches (304.8 mm)


18 Channels
7 inches (177.8 mm)
12 inches (304.8 mm)

Water-to-air Heat Exchanger: Test Setup

- Water inlet temperature (70 deg C) maintained using water circulator
- Heat dissipation quantified by measuring water flowrate and temperature drop through heat exchangers:

$$Q = \dot{m} c_p \left(T_{inlet} - T_{outlet} \right)$$

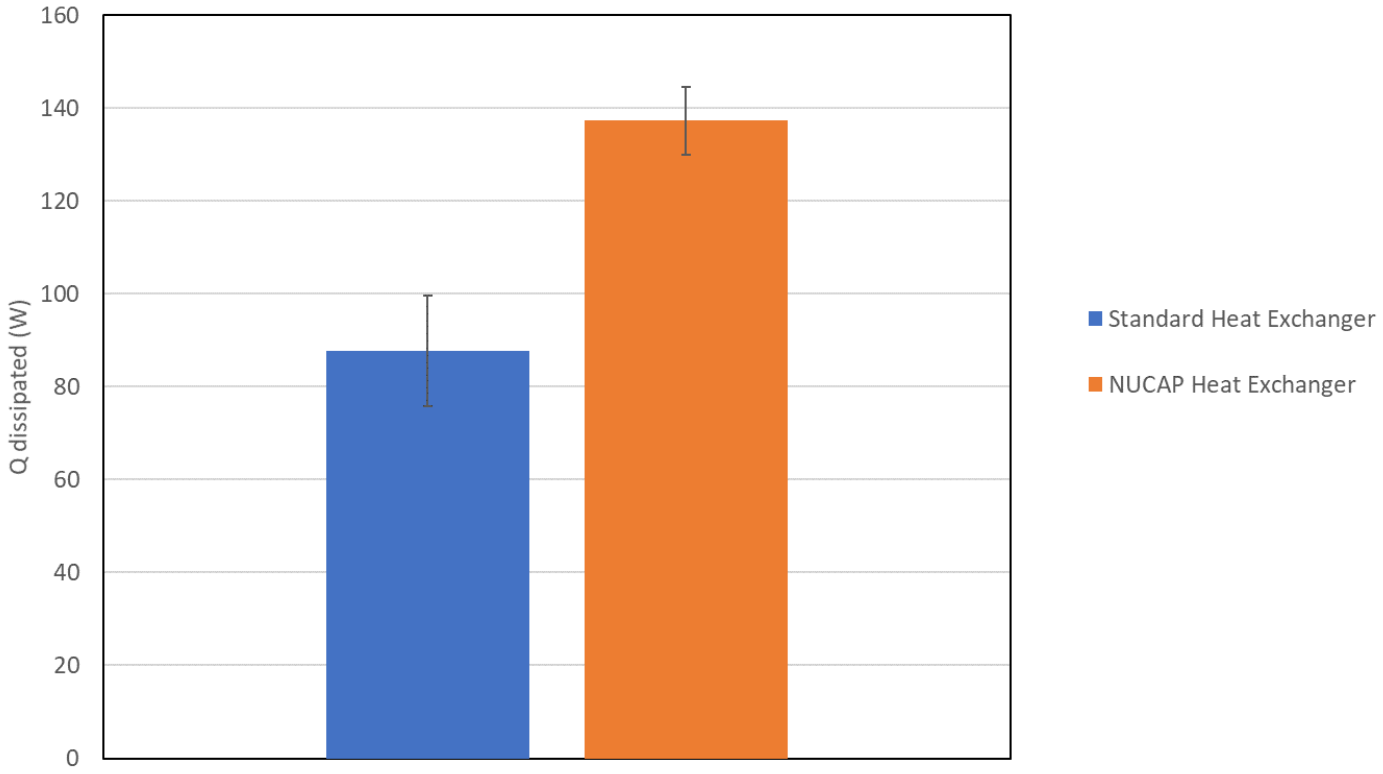


Temperature drop measured using high-accuracy RTDs calibrated to +/- 0.01 K

Flow rate measured using rotameter (initial setup) and high-accuracy turbine flowmeter (subsequent tests)

Water-to-air Heat Exchanger: Initial Results

Natural Convection: Water T_{inlet}=70 °C and Air $T_{ambient}$ = 22 °C



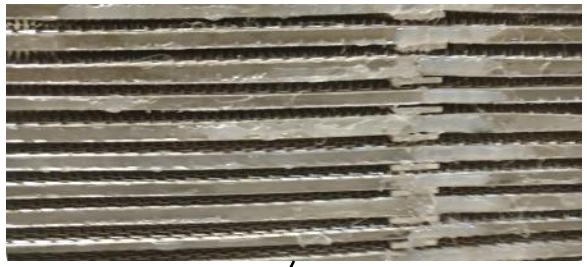
→NUCAP Heat Exchanger dissipates significantly more heat for the same conditions

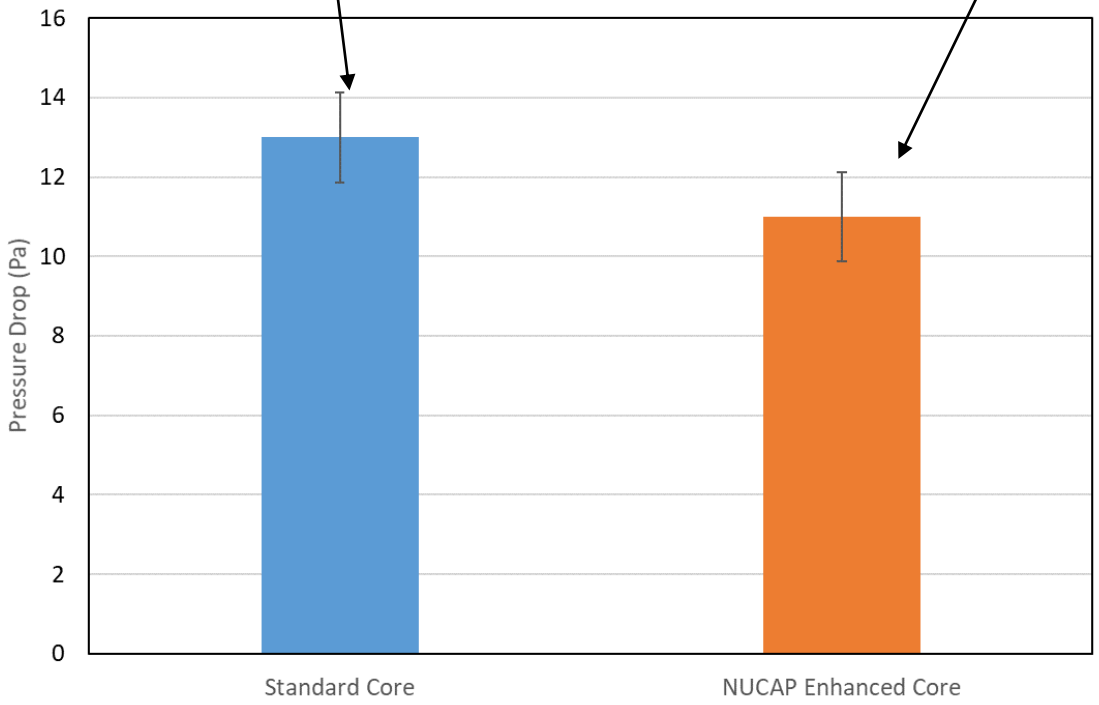
Next steps:

- Refinement of results by improving flow rate measurement (turbine flow meter)
- Characterization of heat exchangers under forced convection tests

Air-to-air Heat Exchanger: Initial Test Results

Pressure drop penalty of heat exchanger cores measured first to evaluate initial NUCAP design:





Slightly lower pleasure drop measured for NUCAP core due to slightly larger channel cross-sectional area

Next steps:

- Setup heated and chilled air supplies for thermal effectiveness testing
- Instrumentation for air temperature and air flow rates to quantify and compare effectiveness

Summary

- NUCAP enhanced air-to-water heat exchanger has demonstrated clear performance improvement over standard finned model
- Further tests need to be performed to reduced measurement uncertainties and quantify performance under forced convection cases

- NUCAP enhanced air-to-air core does not demonstrate pressure drop penalty vs. standard polymer core
- Testing to be performed to quantify thermal effectiveness

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Characterization of Enhanced Heat Exchangers

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2018-08-03

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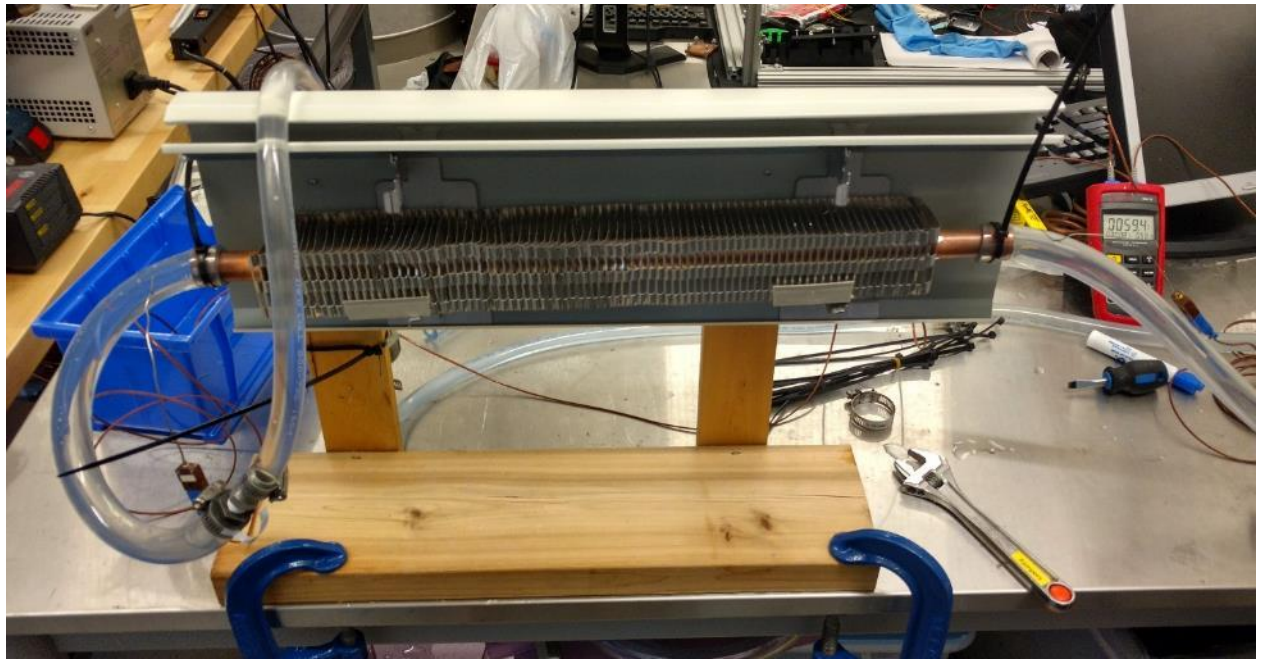
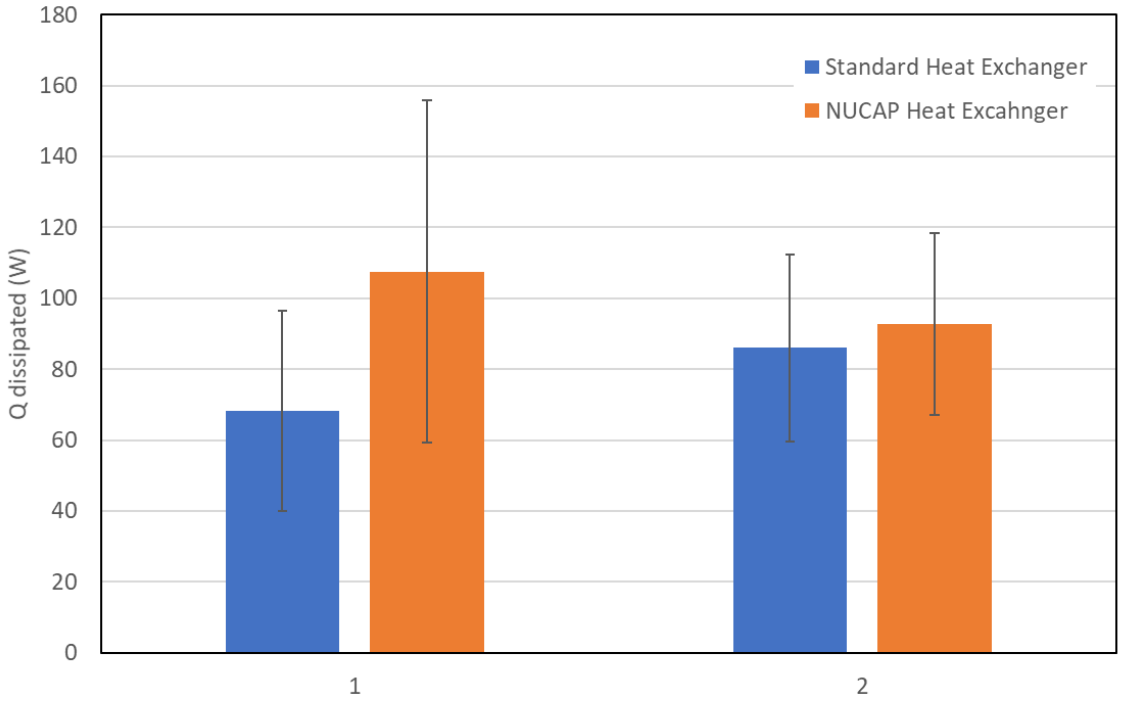
Initial Test Setup – Natural Convection





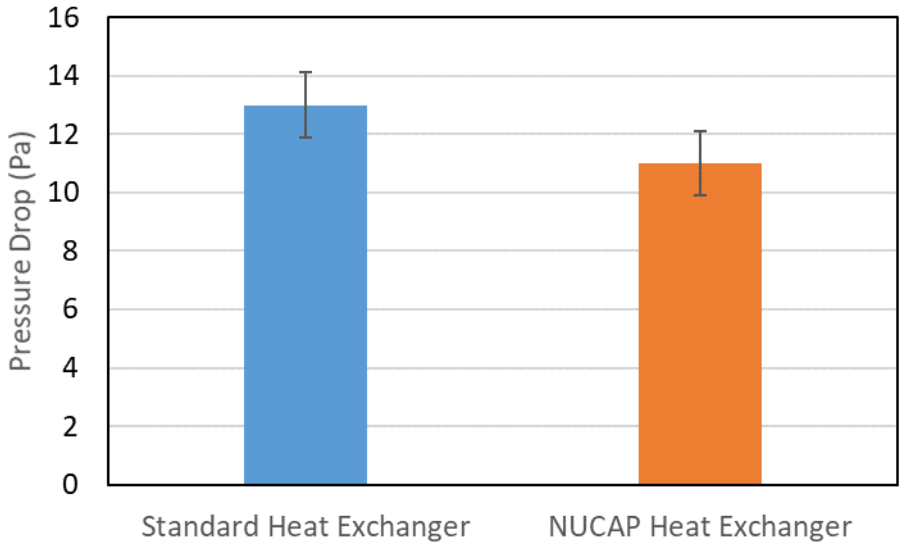
- Water inlet temperature (70 deg C) maintained using water circulator
- Thermal dissipation measured using water flowrate and temperature drop across the heat exchangers

Large Experimental uncertainties:

- Water temperature drop using thermocouples
- Low flow rate used to in order to achieve measurable temperature drop
  - Large uncertainty in flow rate (measured using a simple rotameter)
  - Poor mixing and temperature stratification at outlet

Air-to-Air Heat Exchanger

Initial Pressure Drop Measurement



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2018-12-04

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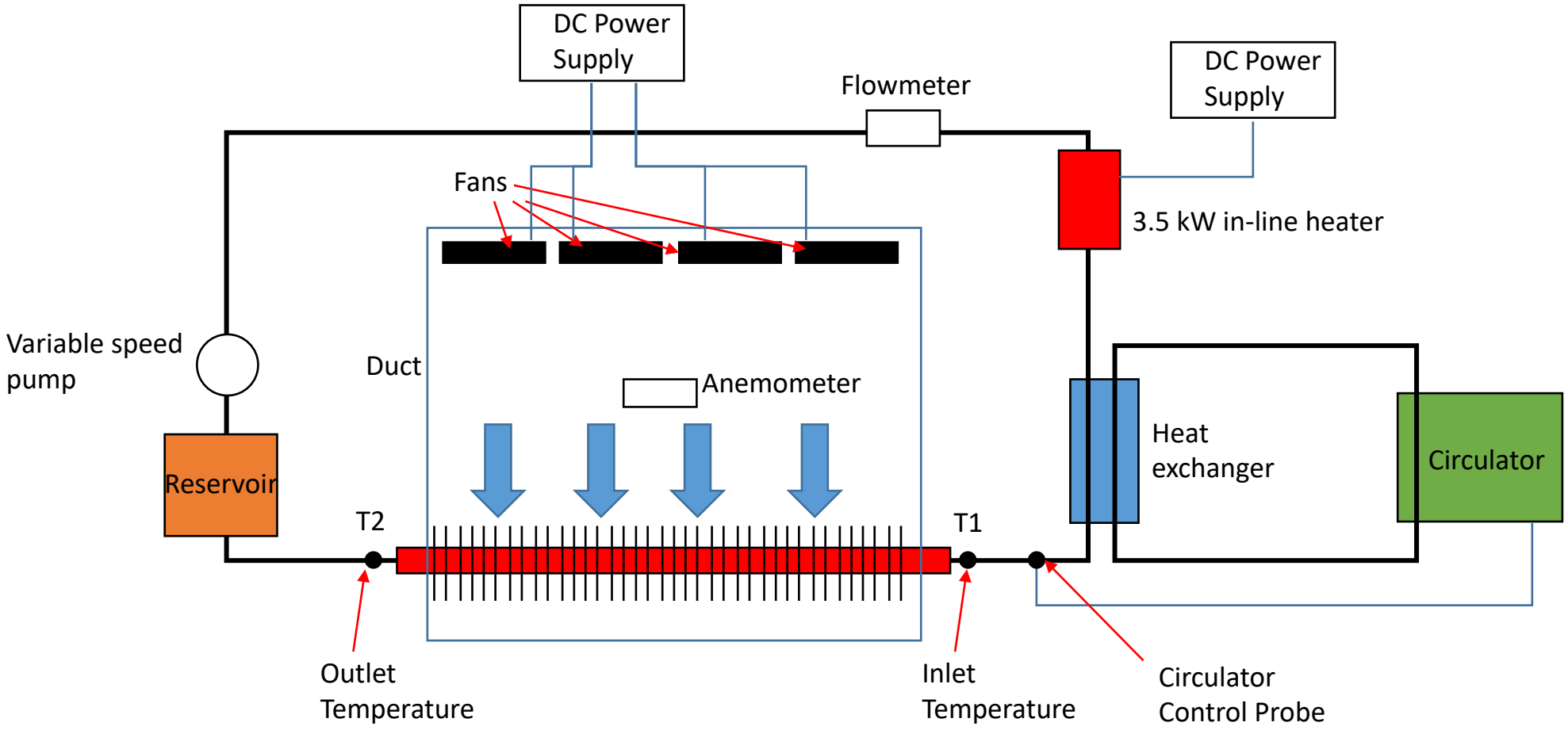
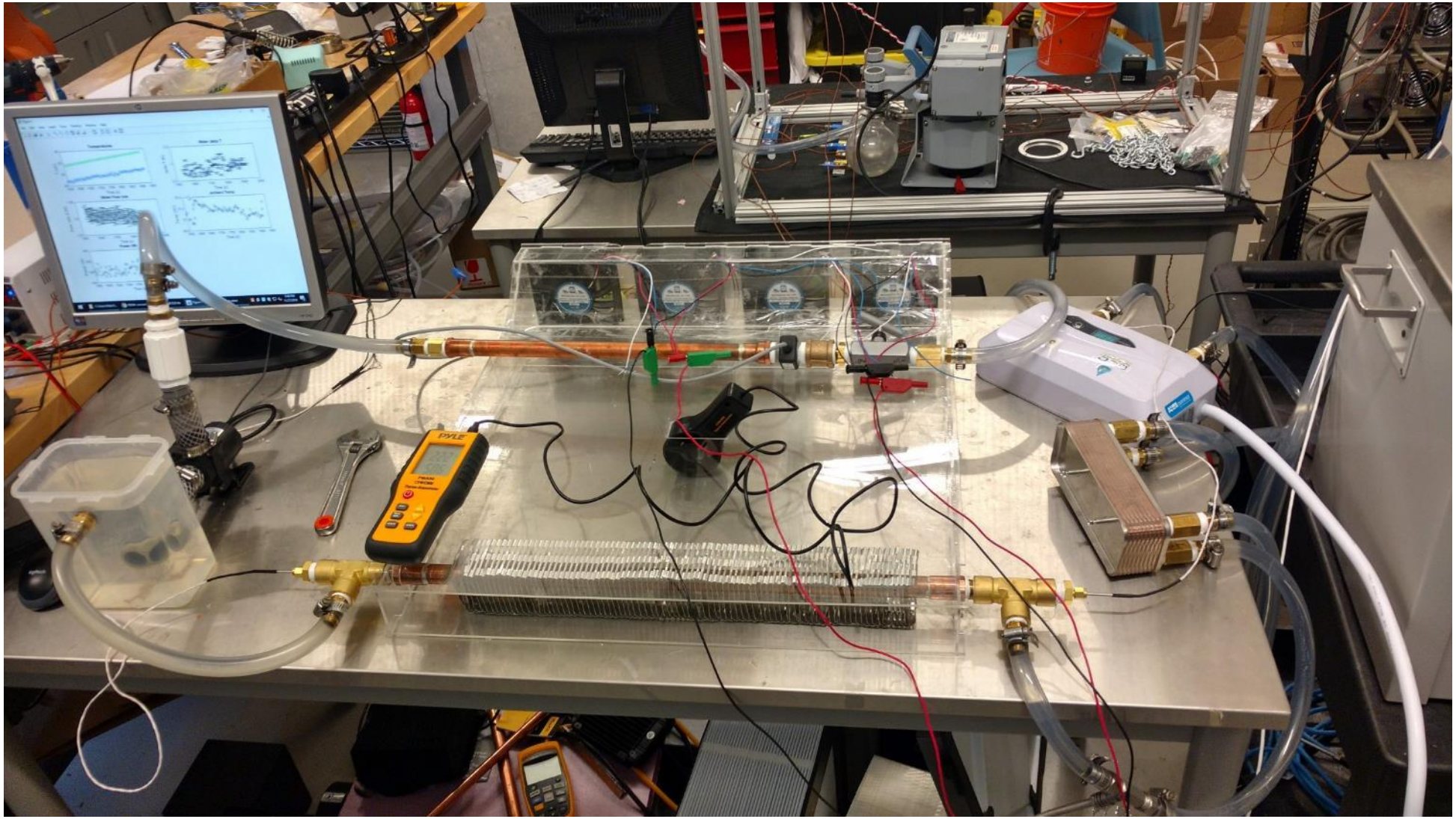
Forced Convection Heat Exchanger Test Setup

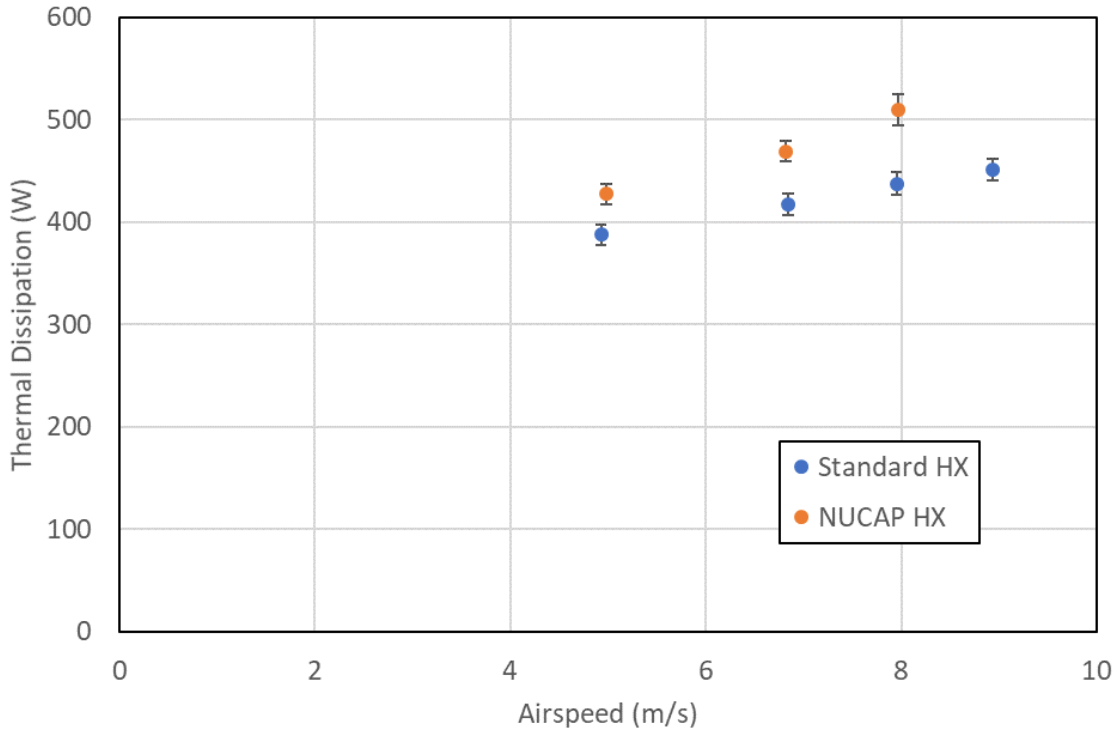


Forced Convection Heat Exchanger Test Setup



Initial Results

Case	T1		T2		delta T		Tamb		water flowrate		airspeed	Q_diss			% improve
	°C		°C		K		°C		LPM		m/s	W			
Standard HX	59.99645	0.02268	58.6194	0.04186	1.377049		20.70585	0.066113	4.042148	0.008268	4.93	387.7803	10.23859		
	60.00198	0.013424	58.52042	0.037628	1.481557		20.81562	0.087664	4.042458	0.010193	6.84	417.2432	10.36794		
	60.00044	0.013895	58.43444	0.042498	1.566		20.86074	0.094736	4.012498	0.007096	7.95	437.7557	11.25934		
	59.99953	0.011388	58.38243	0.03902	1.617106		20.96686	0.071952	4.005286	0.007245	8.935	451.2296	10.7224		
NUCAP HX	60.00089	0.012734	58.48366	0.036976	1.517231		21.10666	0.087104	4.046529	0.012556	4.98	427.7202	10.12673		10.29963
	59.99843	0.012755	58.33738	0.034704	1.661054		20.91675	0.091369	4.054844	0.00918	6.82	469.2256	9.643015		12.45855
	60.00032	0.014717	58.19751	0.052895	1.80281		20.81625	0.091886	4.059022	0.009098	7.97	509.7993	14.91021		16.45748



Characterization of Enhanced Heat Exchangers

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2019-05-27

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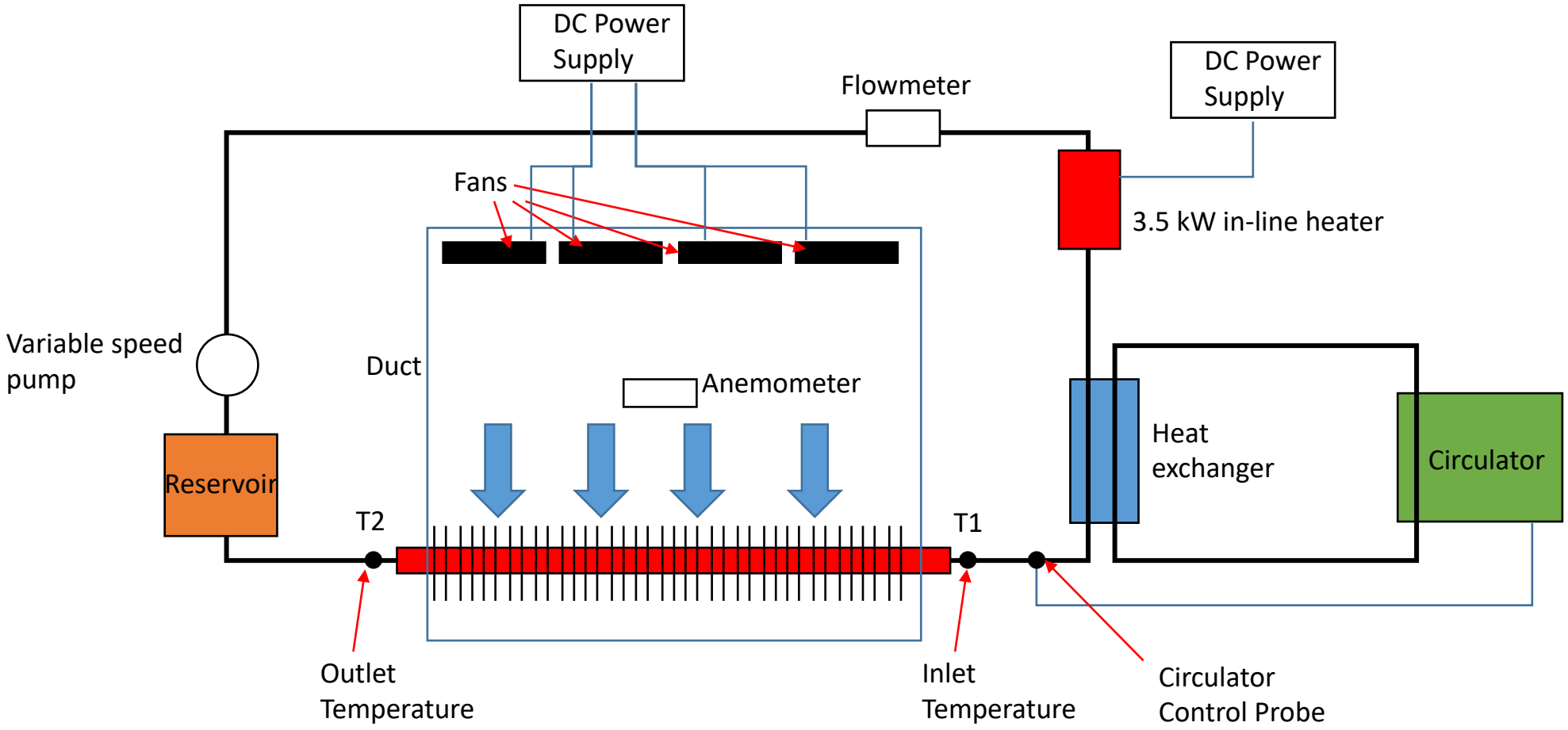
Forced Convection Heat Exchanger Test Setup



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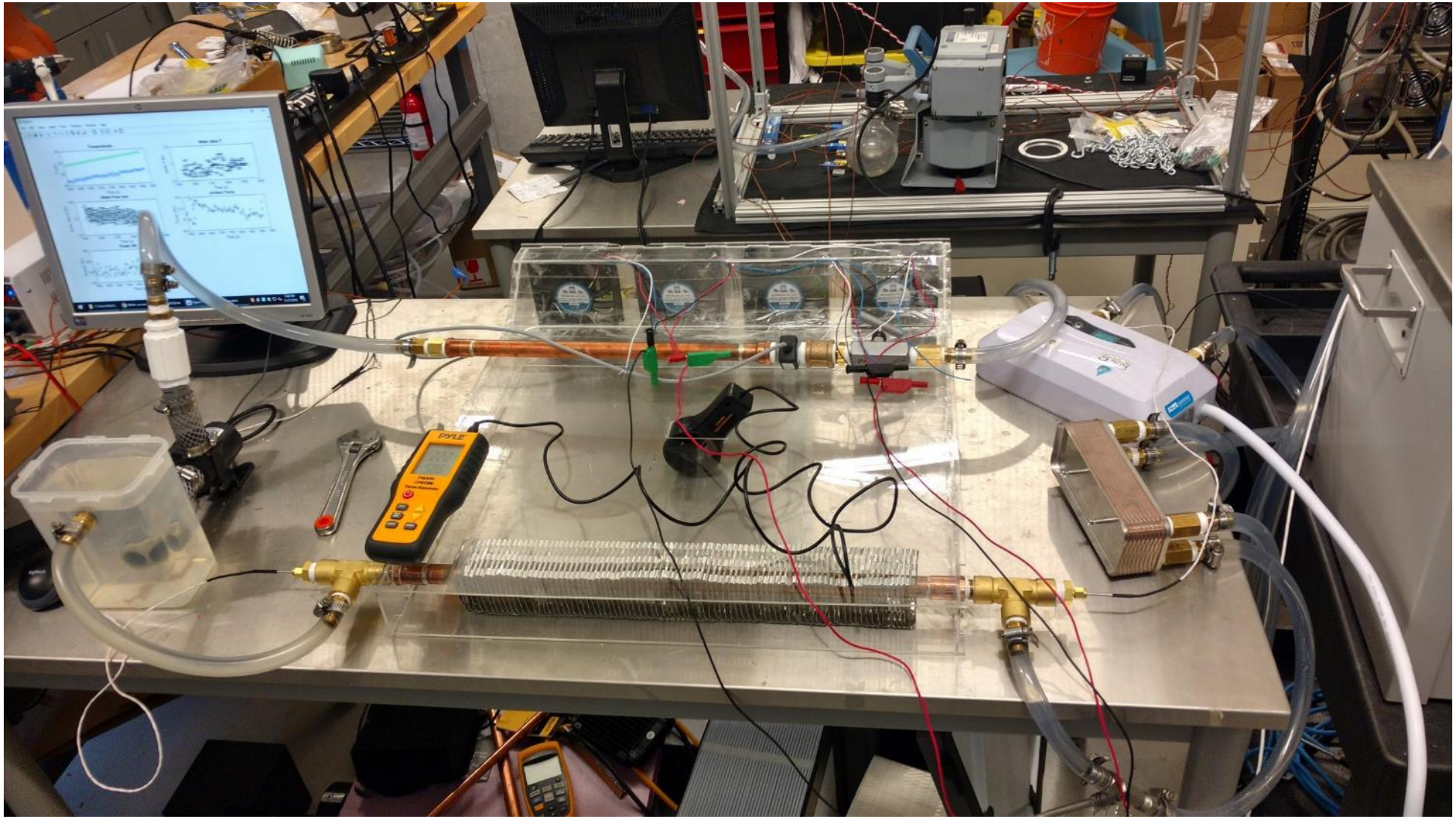
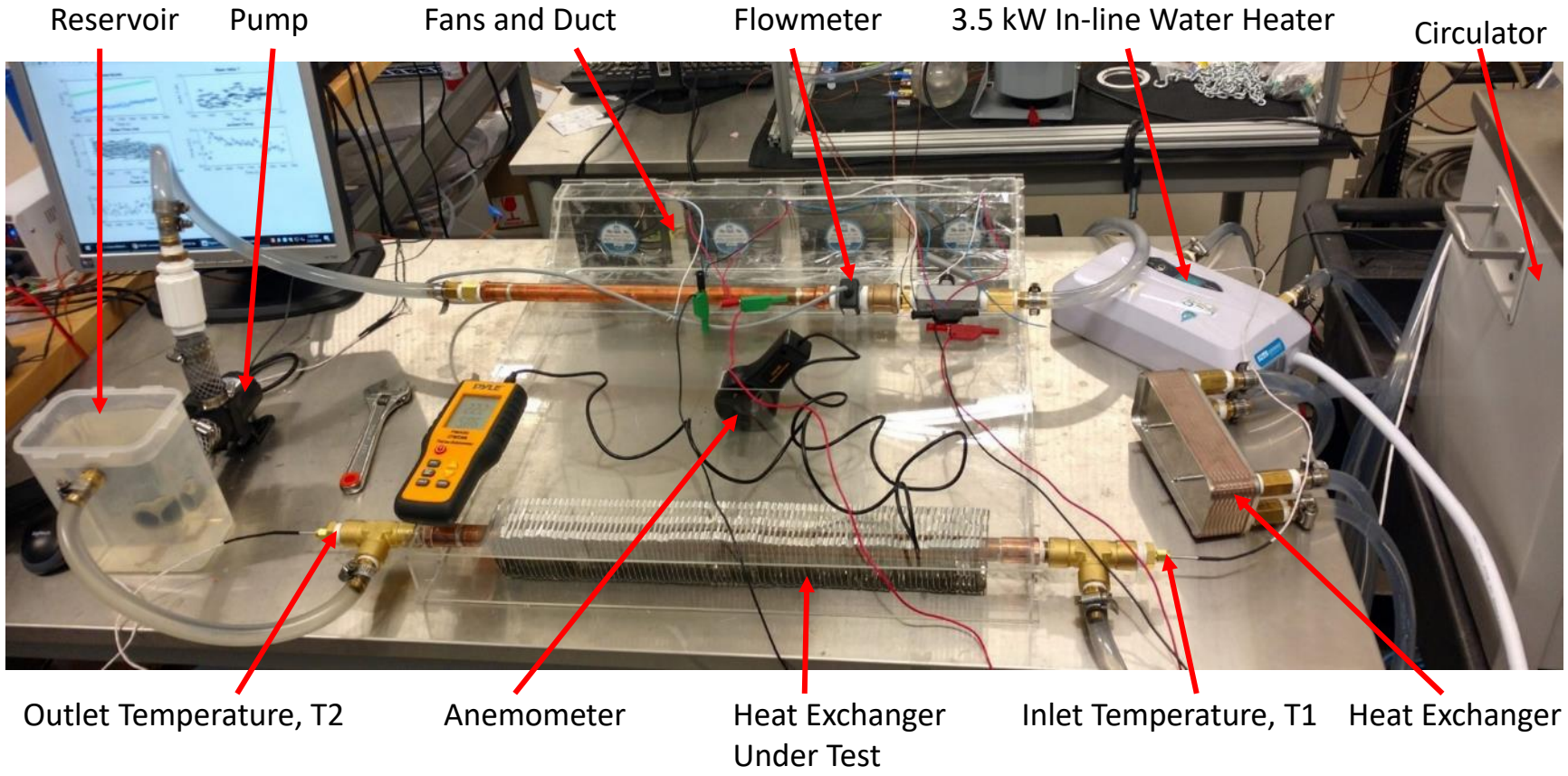
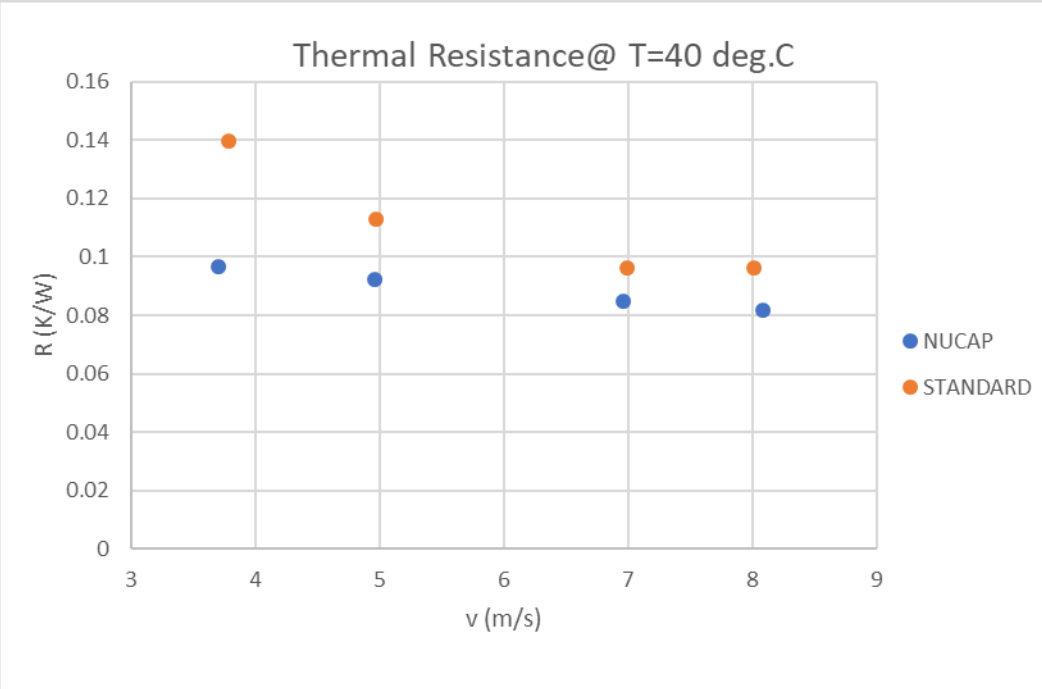


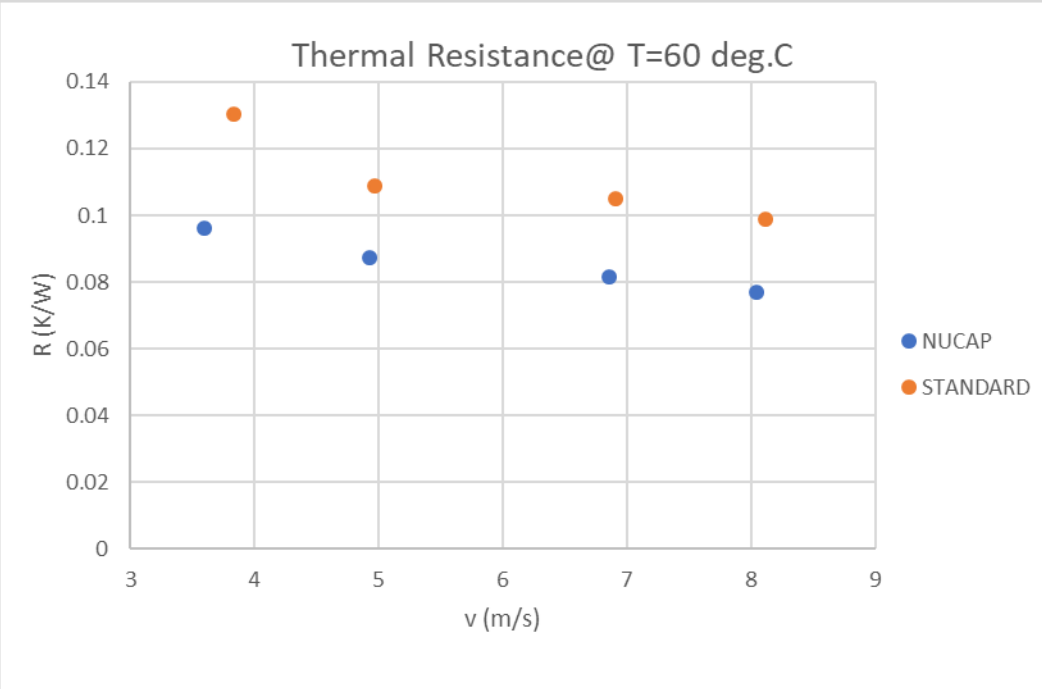
Forced Convection Heat Exchanger Test Setup



Water-to-Air HX: Forced Convection

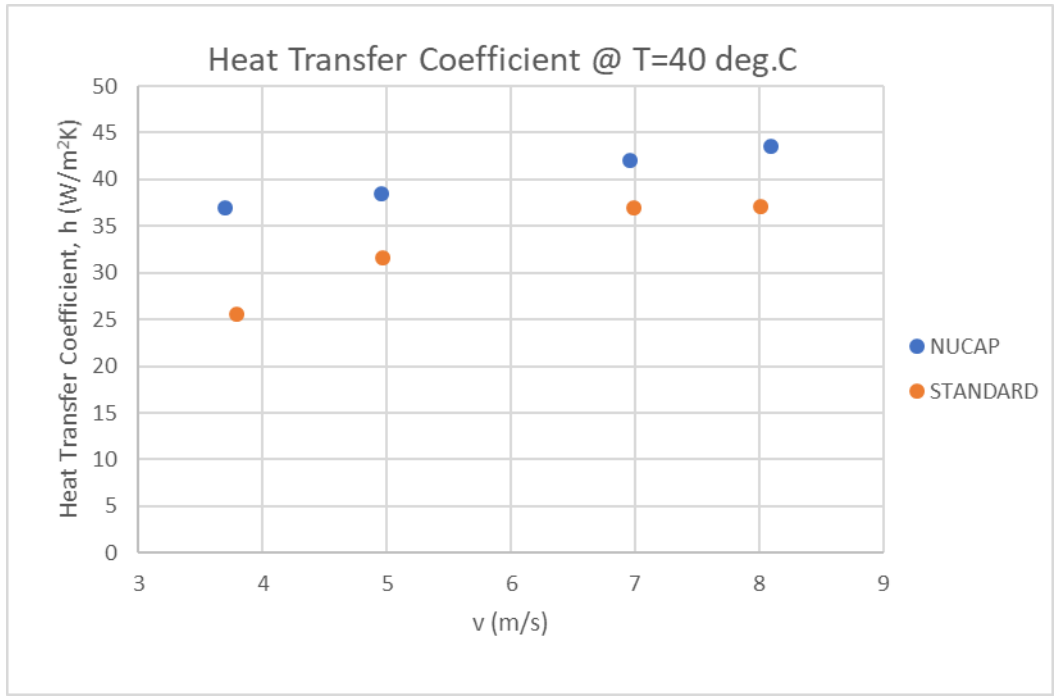
Thermal Resistance vs. Air Speed

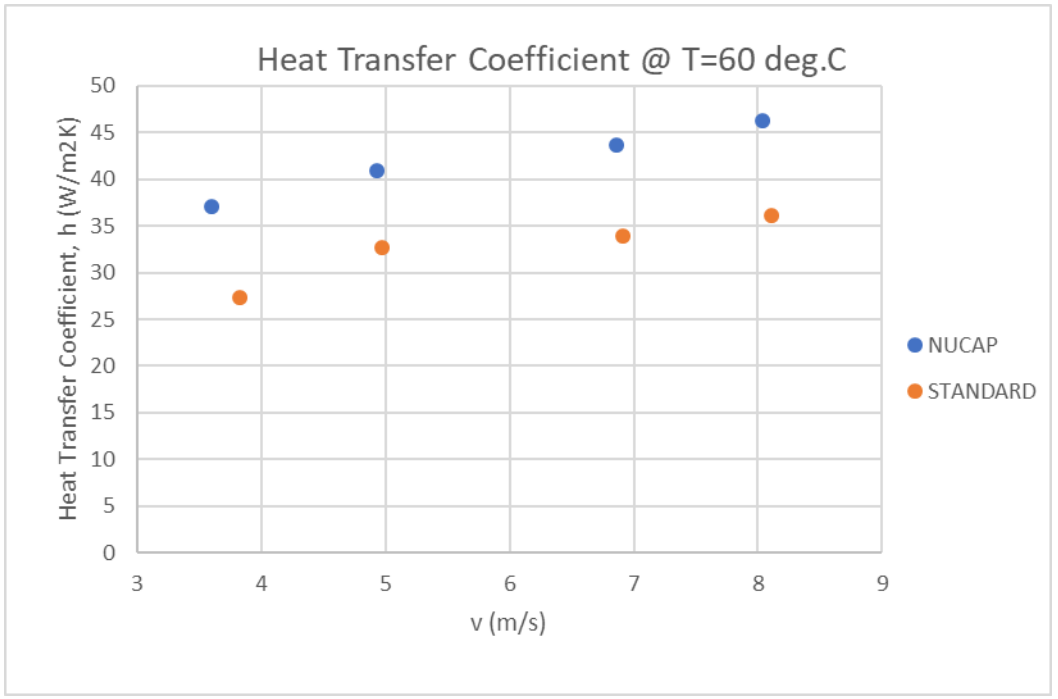




Water-to-Air HX: Forced Convection

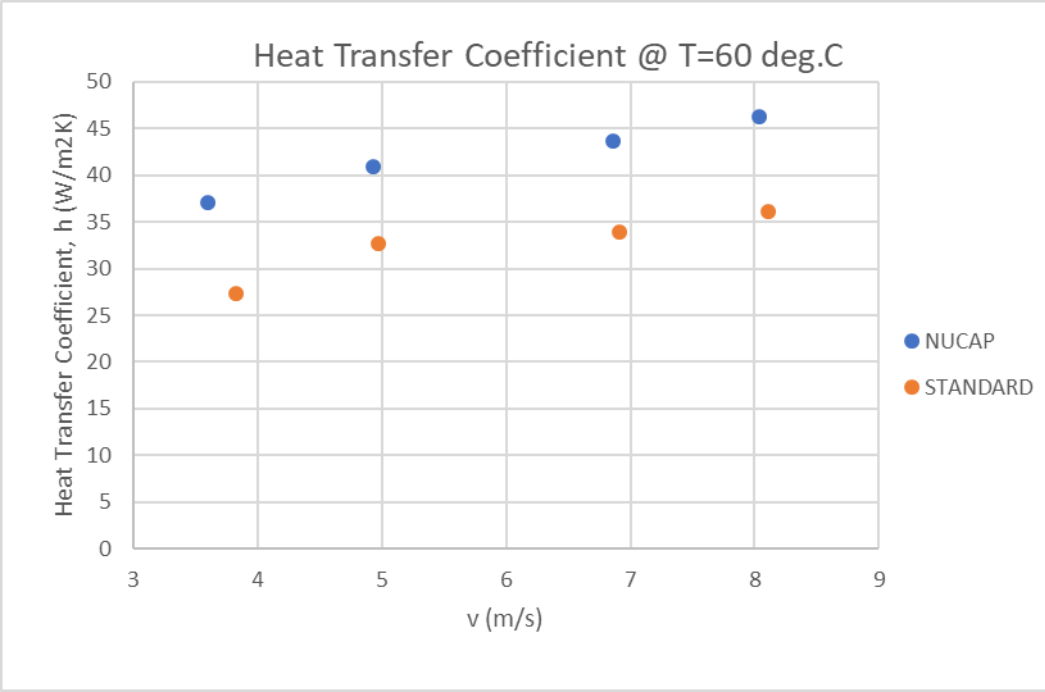
Estimated Heat Transfer Coefficient vs. Air Speed

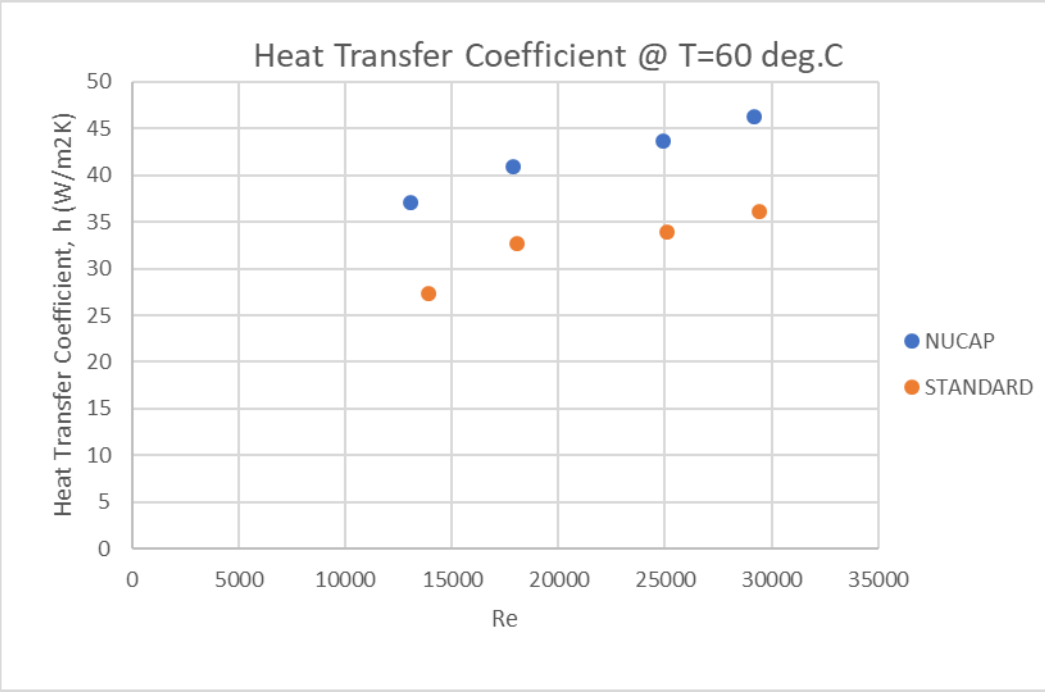




Water-to-Air HX: Forced Convection

Estimated Heat Transfer Coefficient vs. Air Speed

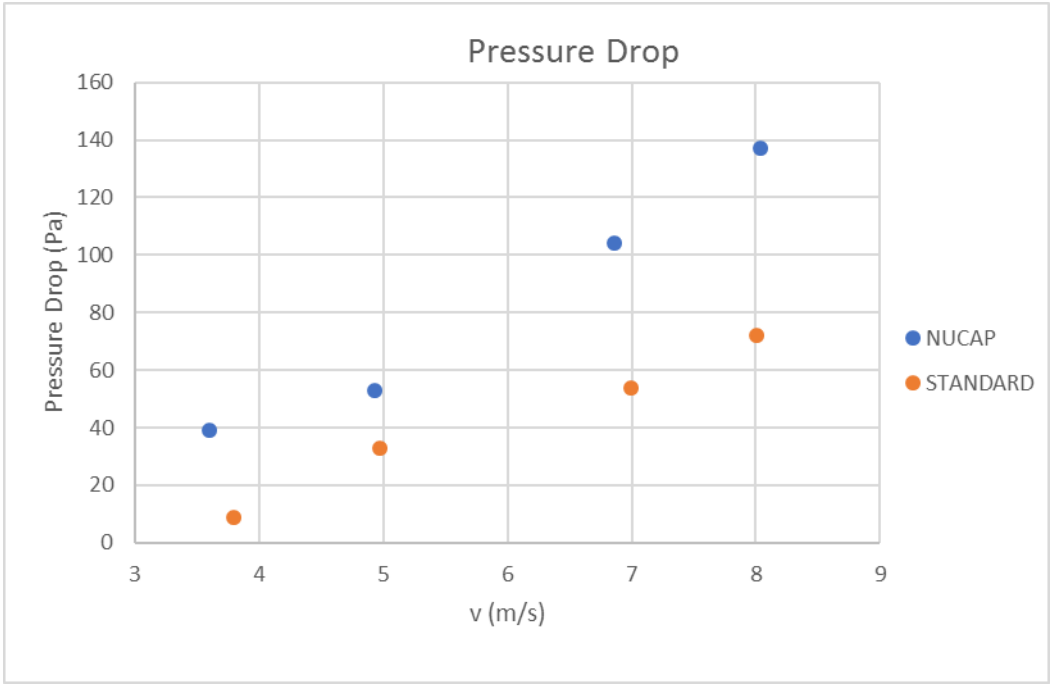




NUCAP fins increase convective heat transfer coefficient by approximately 30% over standard fins

Water-to-Air HX: Forced Convection

Pressure Drop vs. Air Speed



Water-to-Air HX: Natural Convection