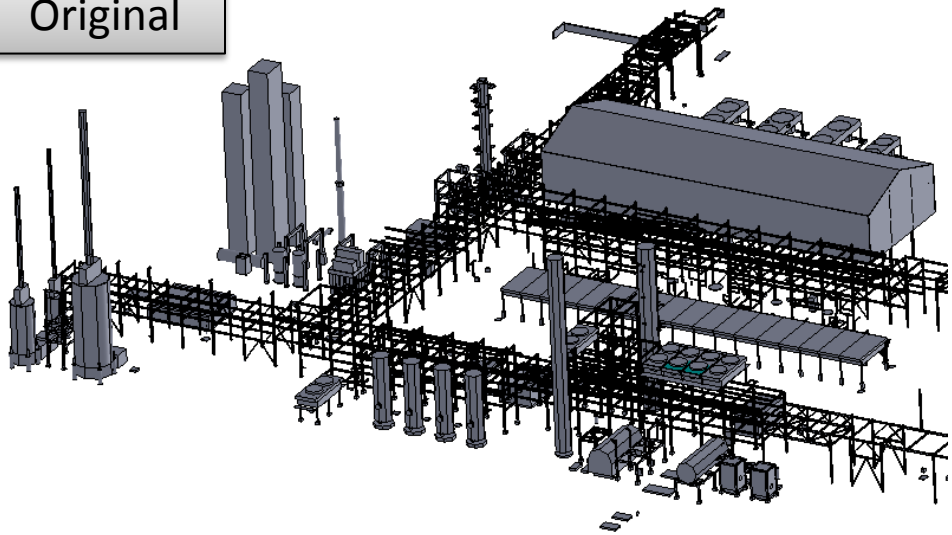
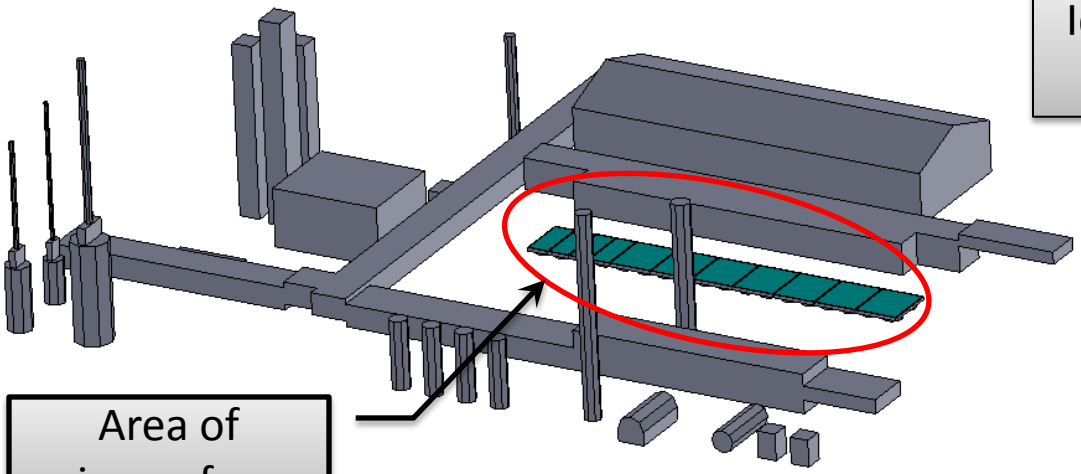
CAD Geometry

Original



The pipe rack structures were represented as solid obstructions; flow is still able to go beneath the lowest structural member. This is a conservative approach; some amount of air will go through the rack depending on the density of piping components.

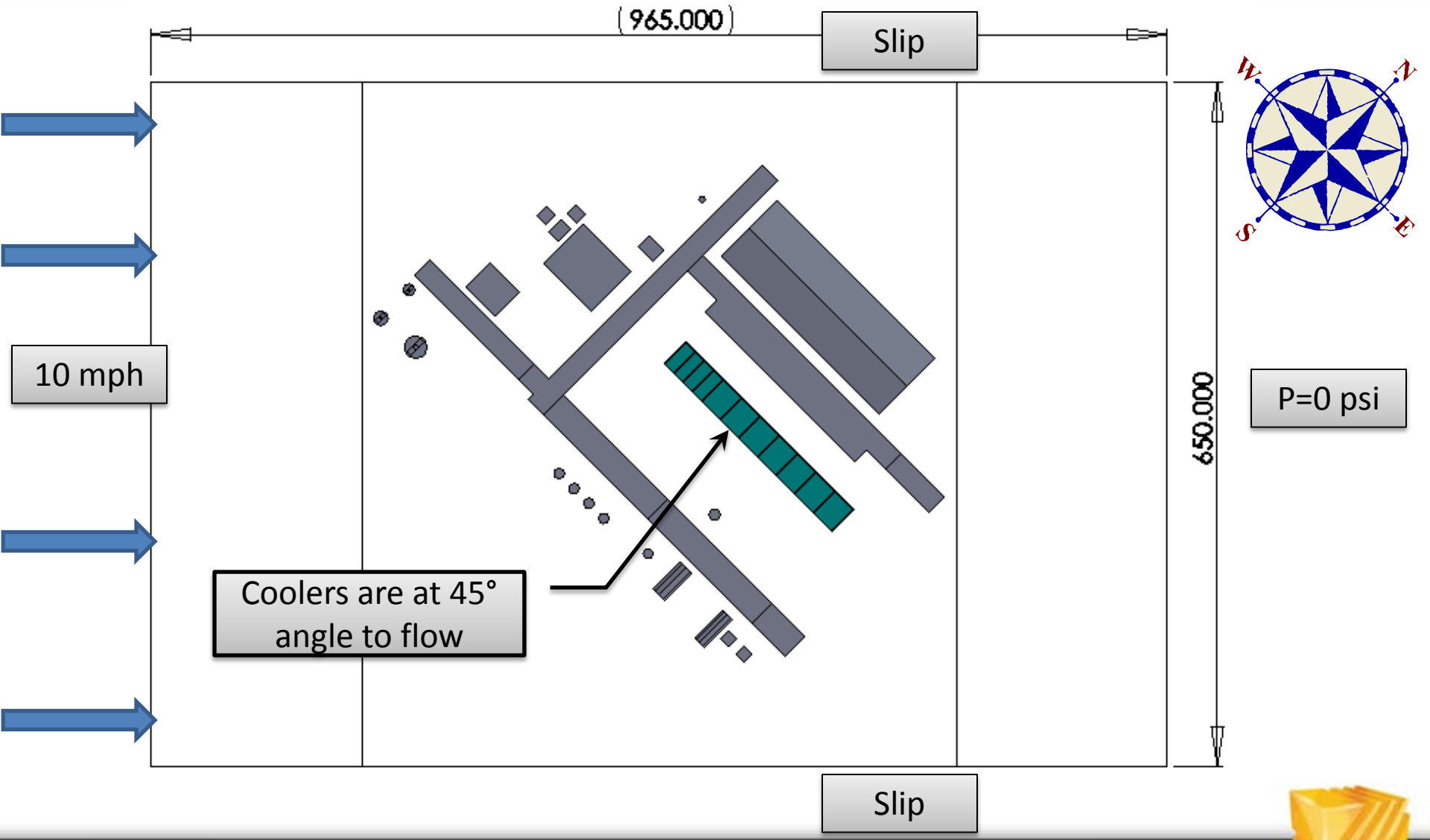
Idealized for CFD



Area of primary focus

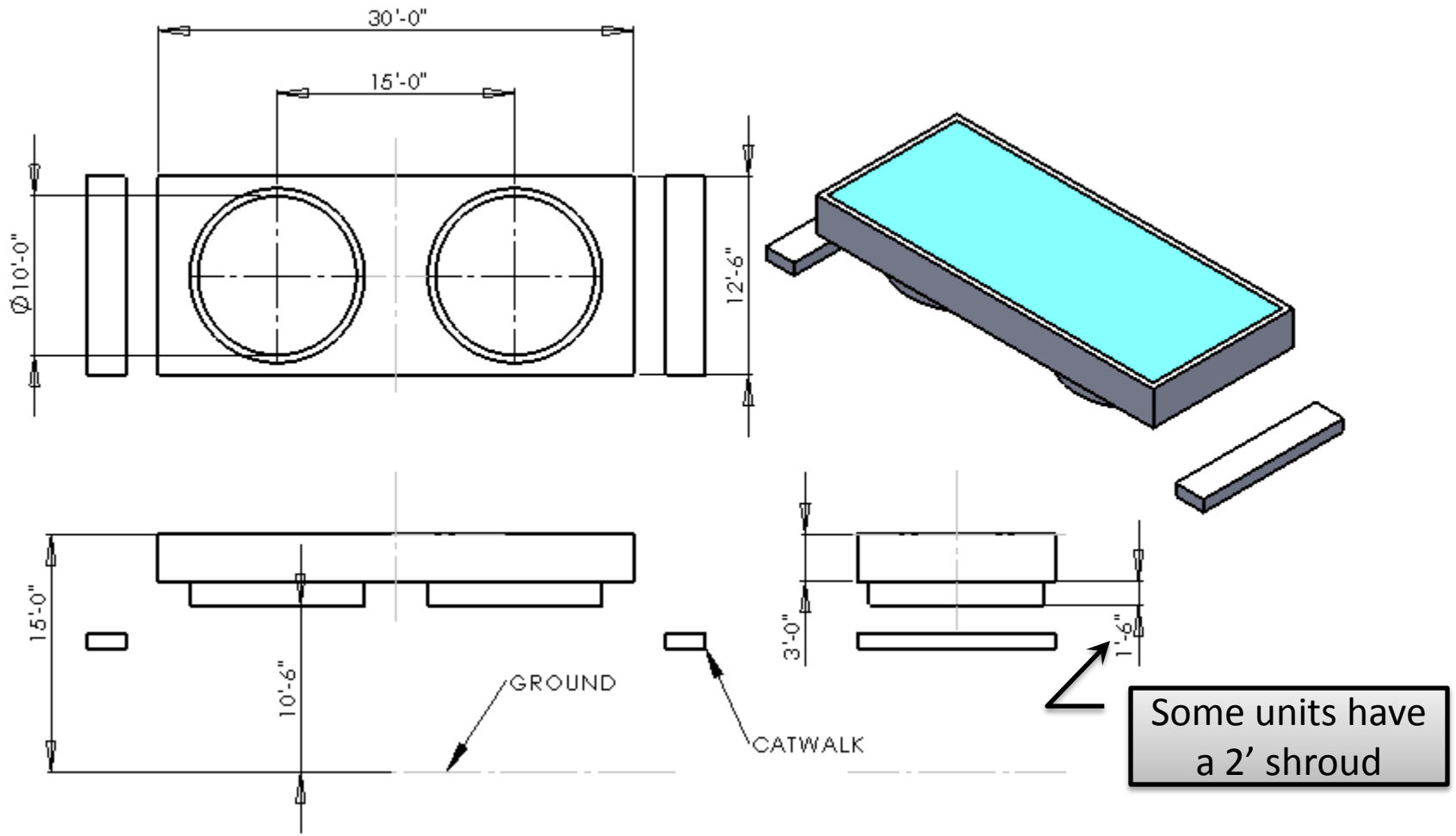
All CAD work performed in SolidWorks

Simulation Flow Domain and Conditions



Air is at STP conditions

Cooler Unit Dimensions (typical, unit 3040 shown)



Air is at STP conditions

Cooler Unit Flows and Velocities

Unit	ACFM/Fan	# Fans	V_{inlet} (fpm)	V_{outlet}(fpm)
3037	80,874	2	1030	480
3038	126,473	2	1610	772
3039	115,919	2	1476	725
3040	124,629	2	1587	746
3021	110,863	4	1412	657
3020	110,833	4	1411	703
3019	62,233	4	792	357
3307	130,689	4	1664	732
3306	140,054	4	1783	737
3916	126,628	4	1612	743
3917	129,685	4	1651	715

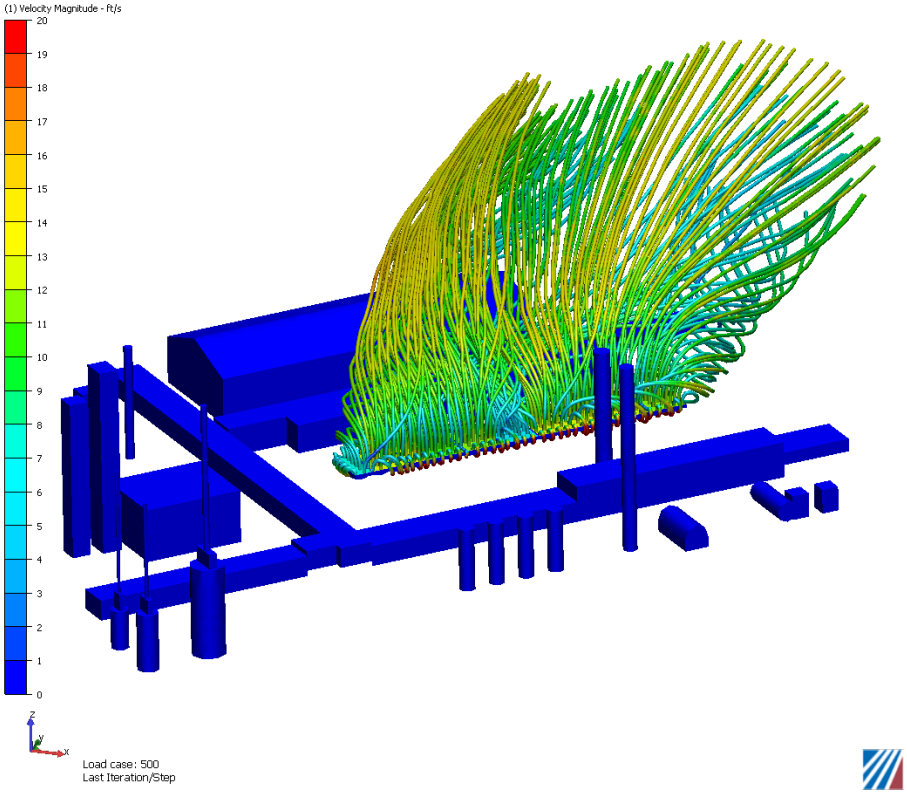
Inlet velocities are calculated at the fan inlet.

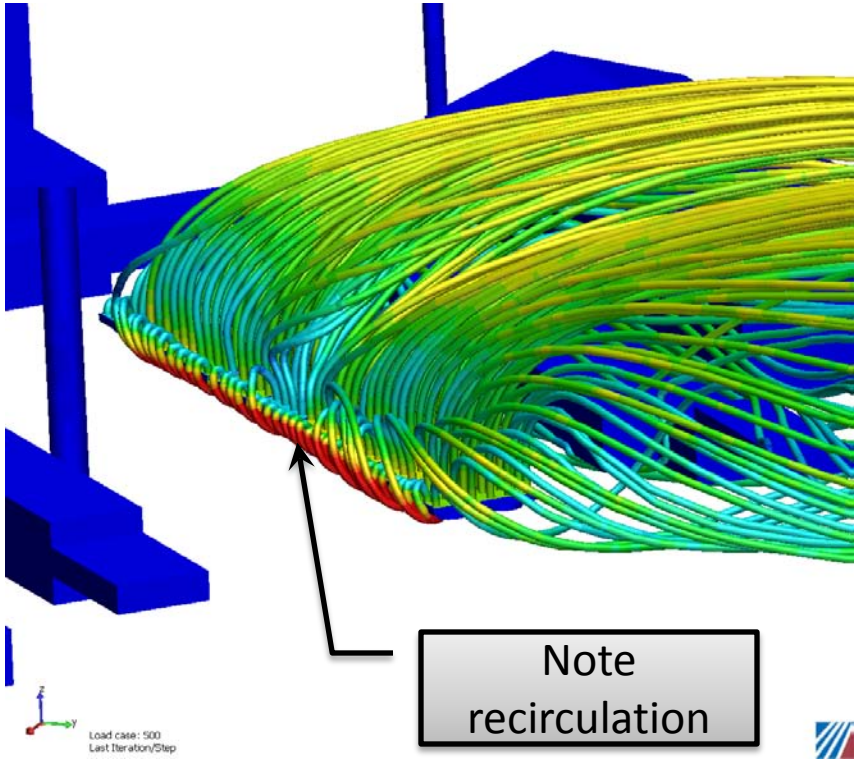
Simulation Assumptions

- Incompressible, homogenous air used as the fluid medium.
- Air is at standard temperature and pressure (STP) with constant density and viscosity.
- Adiabatic conditions; heat transfer not considered.
- Steady-state flow results; no transient effects.
- Constant velocity conditions across the cooler inlets and outlets.
- Ambient wind speed of 10 mph from SW.
  - Typical speed for site confirmed from the National Climatic Data Center

    www.ncdc.noaa.gov/oa/ncdc.html

Overall Particle Traces

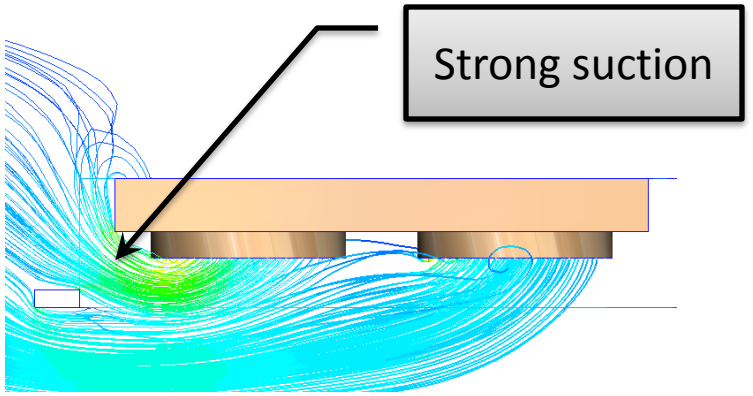


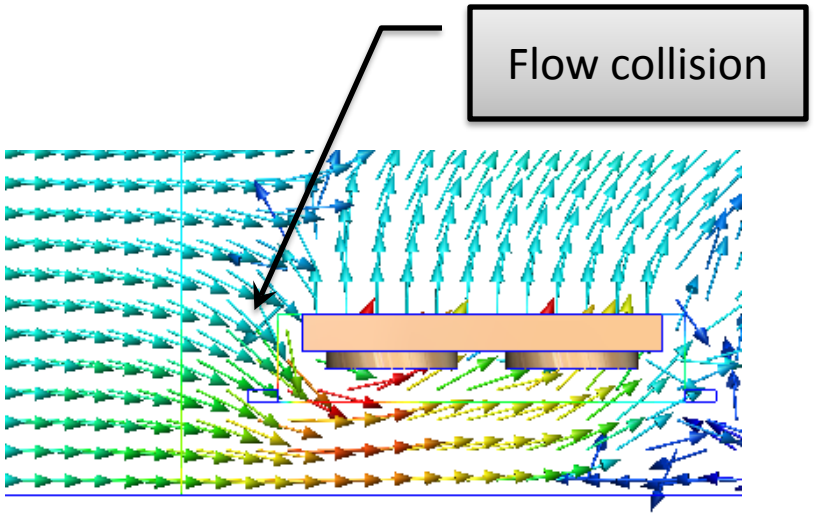


Traces are seeded from cooler outlets.

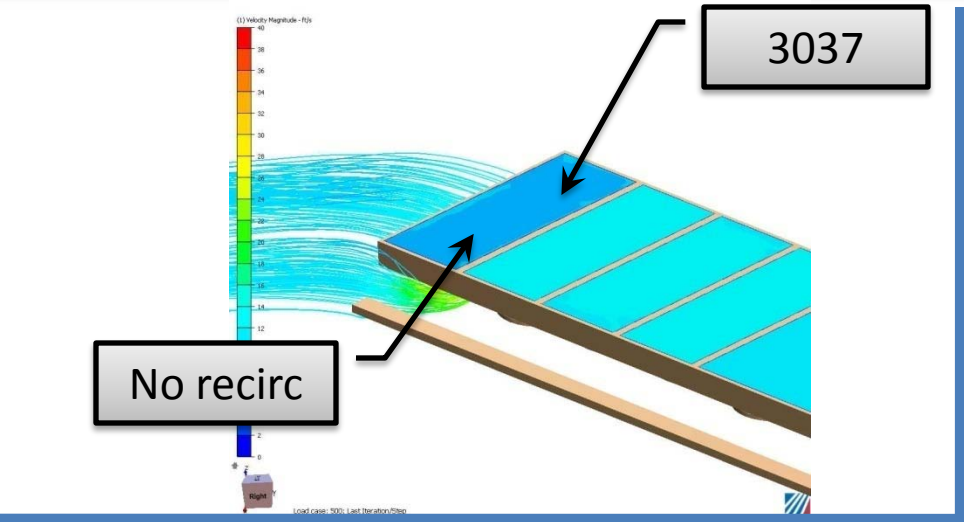
Why are some units showing slight recirculation?

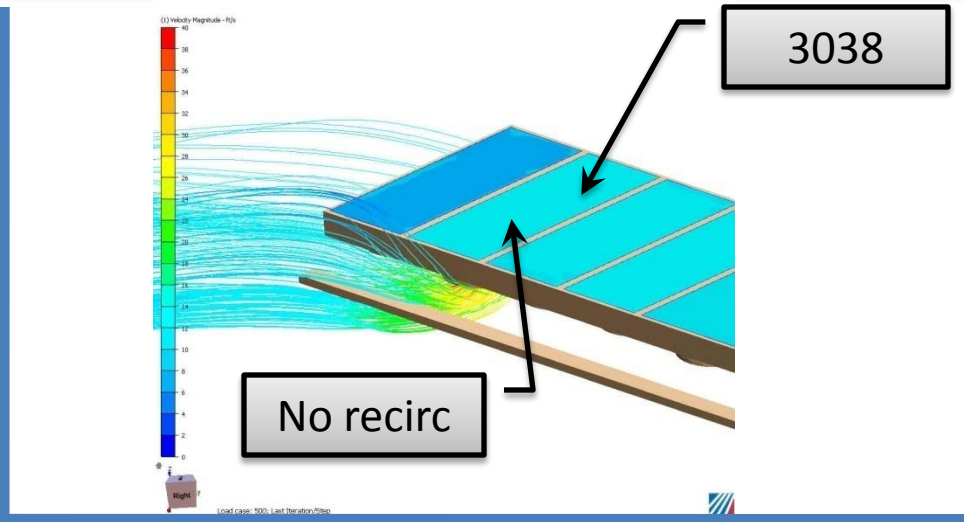
- Strong suction at the inlet is in close proximity to the leading edge of the outlet.
- A short circuit path exists between the inlets and outlets between the catwalk.
- The ambient horizontal air is colliding with the strong vertical air column from the fan exhaust.
- The combination of these factors provides the opportunity for a small percentage of recirculation to occur.

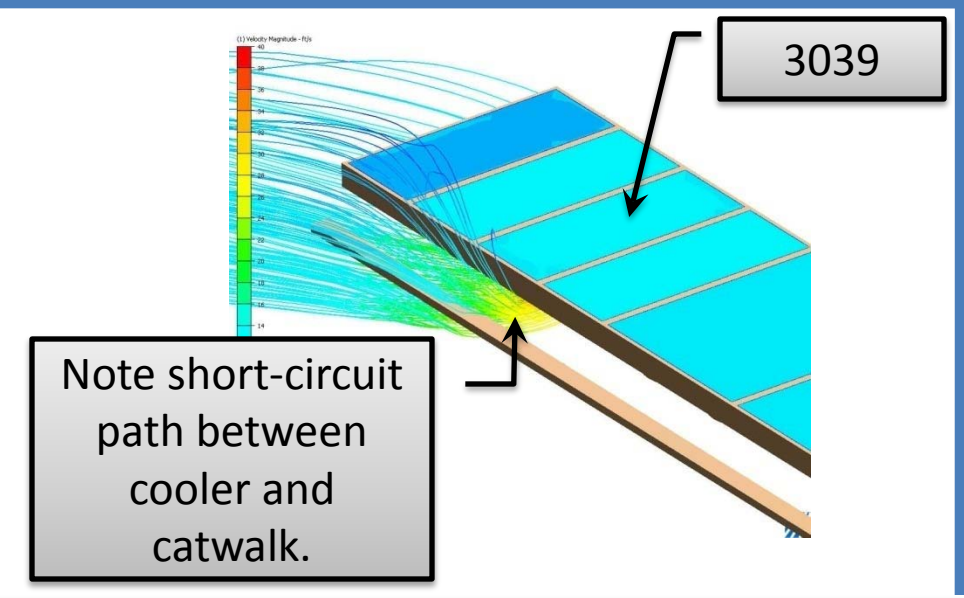


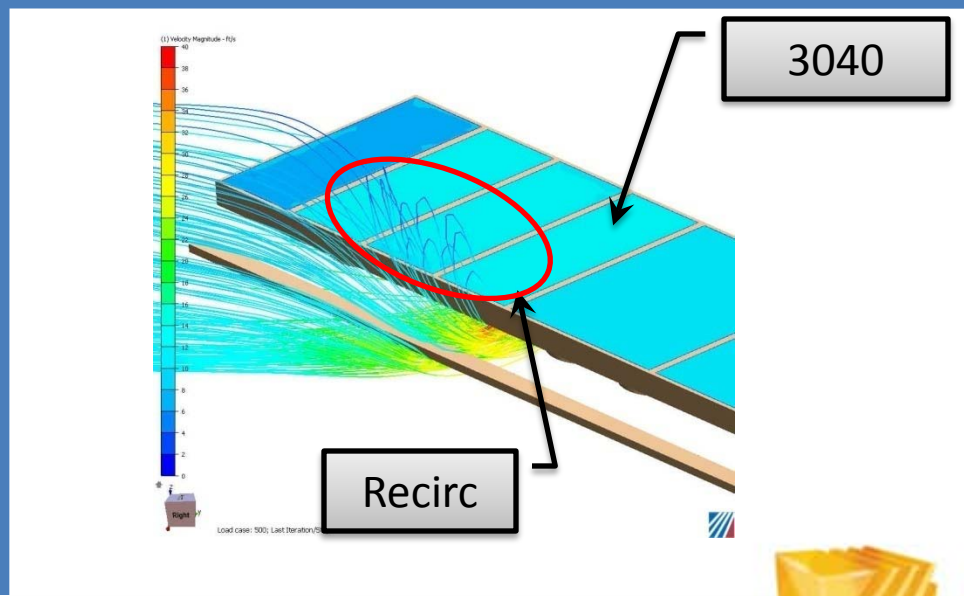


Unit Recirculation Details: 1 of 3



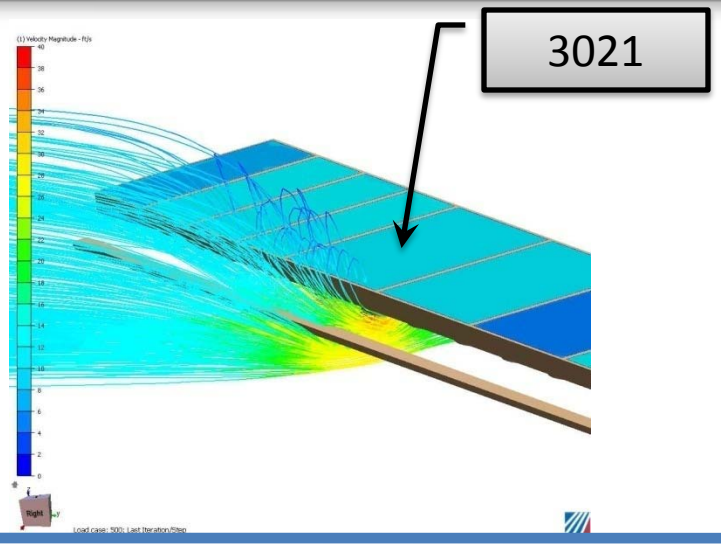


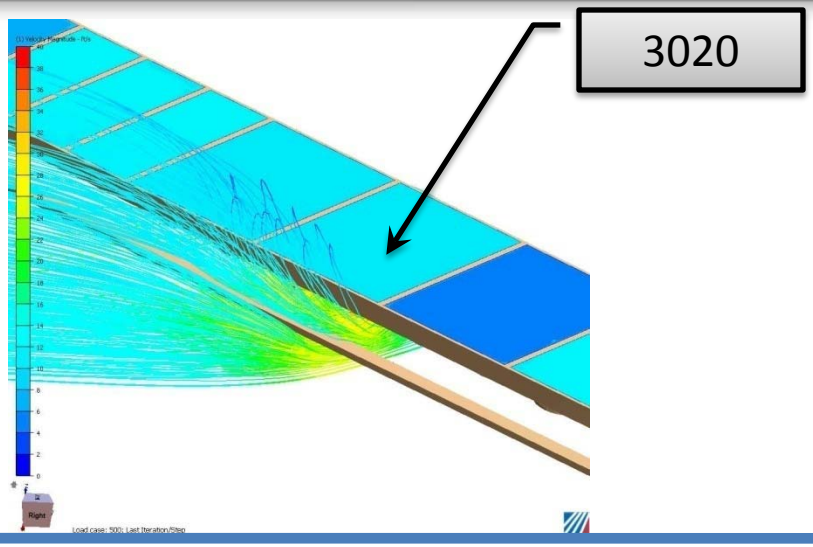


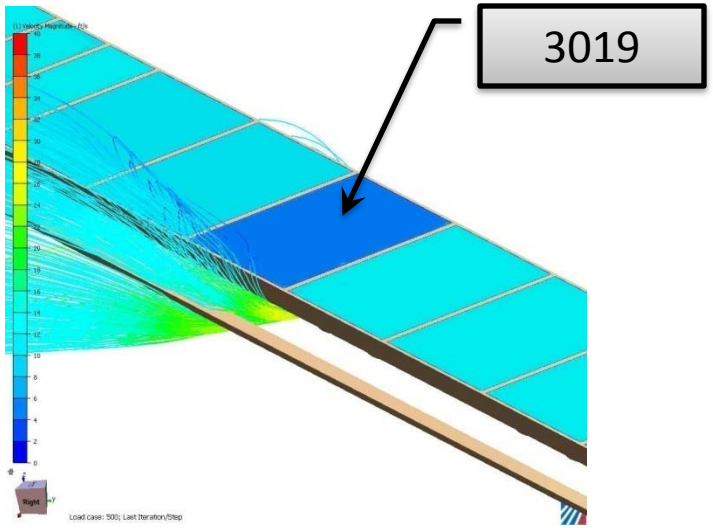


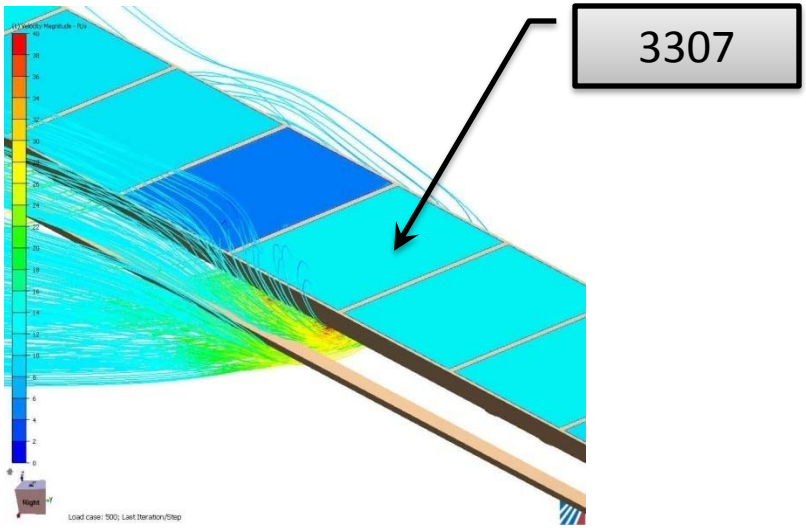
Traces are seeded from the fan inlets.

Unit Recirculation Details: 2 of 3



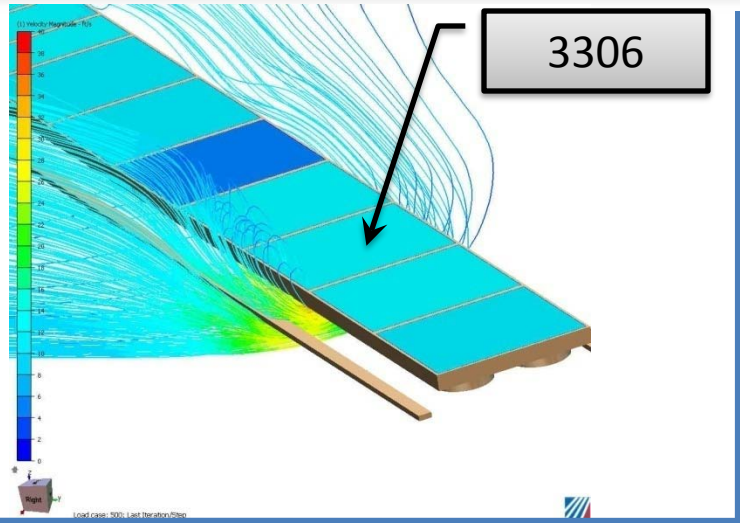


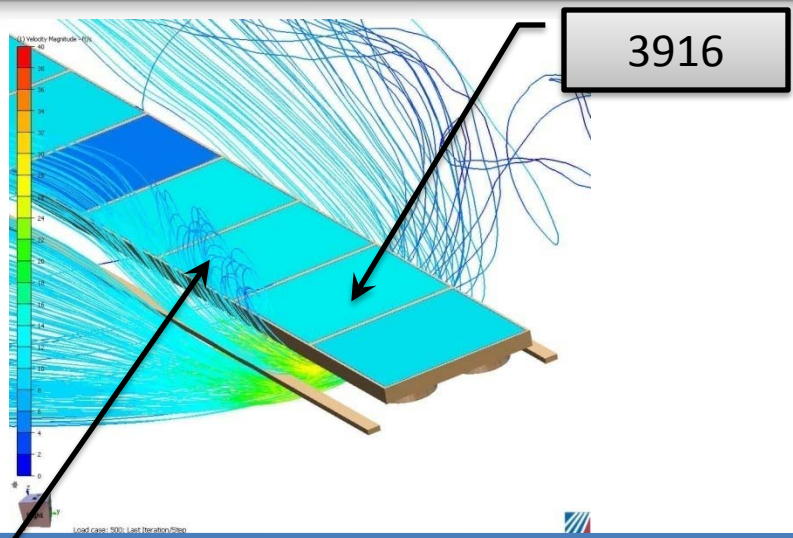


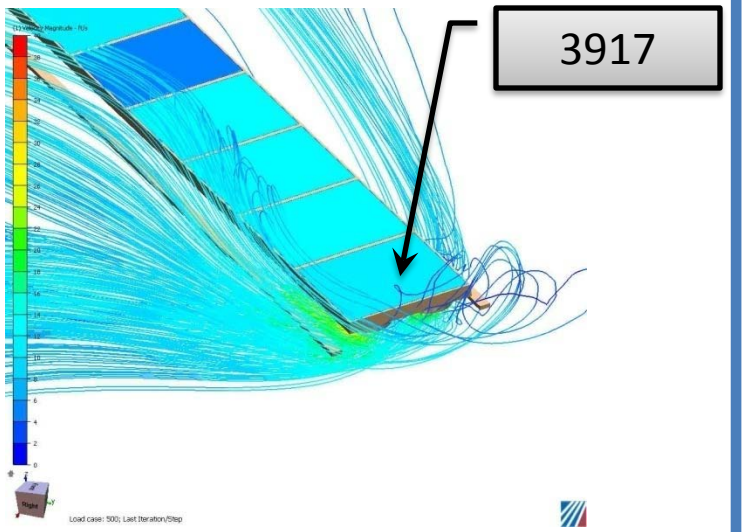


Traces are seeded from the fan inlets.

Unit Recirculation Details: 3 of 3







Note that since the units are at a 45 degree angle to the ambient flow, the recirculation into a unit mostly comes from the units upstream

Traces are seeded from the fan inlets.

Cooler Unit Recirculation Estimates

- Estimates made by seeding 100 traces from each fan inlet and then counting number of traces with come from the fan outlets.

Unit	% Recirculation
3037	0
3038	0
3039	1
3040	5
3021	5
3020	2.5
3019	2.5
3307	2.5
3306	7
3916	8
3917	3.5

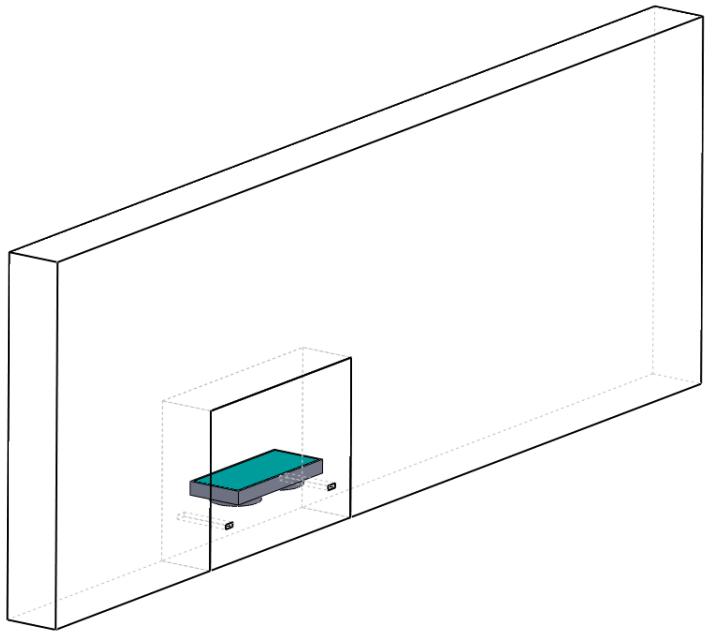
Summary

- Some amount of recirculation observed at leading edge of units due to interaction between ambient and exhaust air streams.
- A short-circuit path exists between the cooler and the catwalk; eliminating or extending this path could prevent any recirculation
- Possible solutions:
  - Adding a kick plate from the catwalk to the cooler to eliminate the short-circuit path.
  - Adding a skirt above the cooler unit which extends to short-circuit path

Results may vary for other wind speeds and directions.

Appendix – Validation Overview

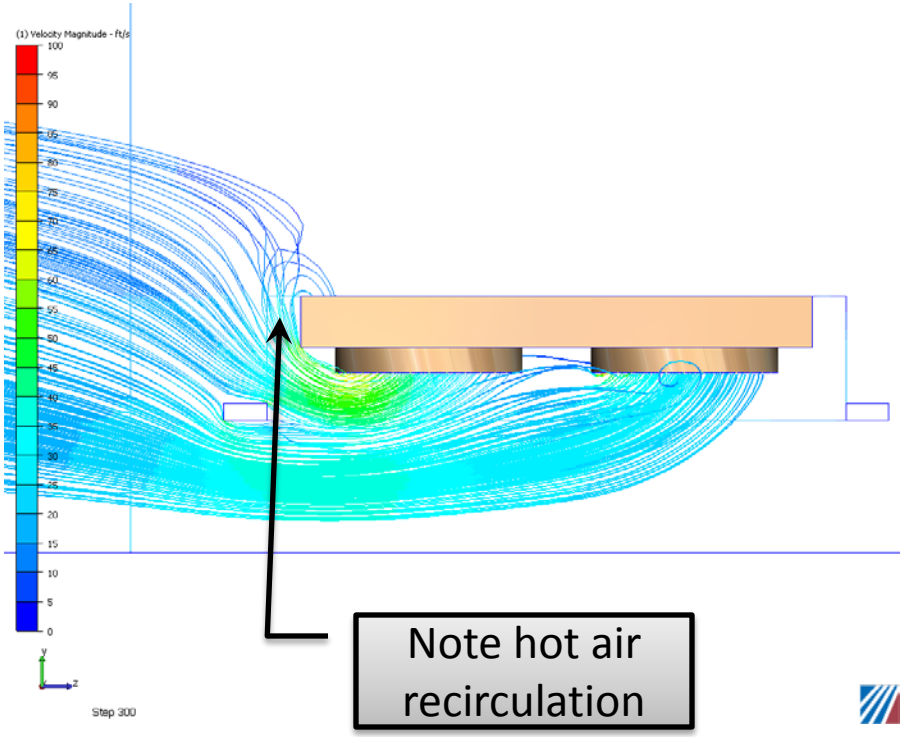
- Used to prove that this application is dominated by forced convection and that buoyancy (air density change due to temperature variation) has little to no impact on results.
- Test isolated to unit 3040
- Temperatures:
  - Ambient: 110 °F
  - Discharge: 128.2 °F
- External air flow: 10mph
- An 18°F rise in air temperature only results in a 3% reduction in air density.



Results reveal minimal difference between constant and buoyant air.

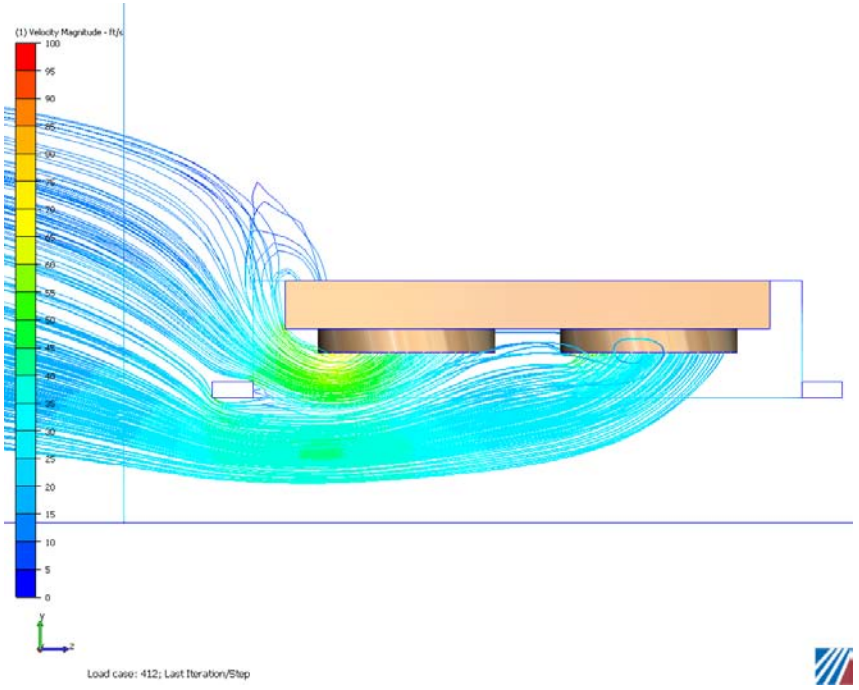
Appendix – Validation Particle Traces

Constant



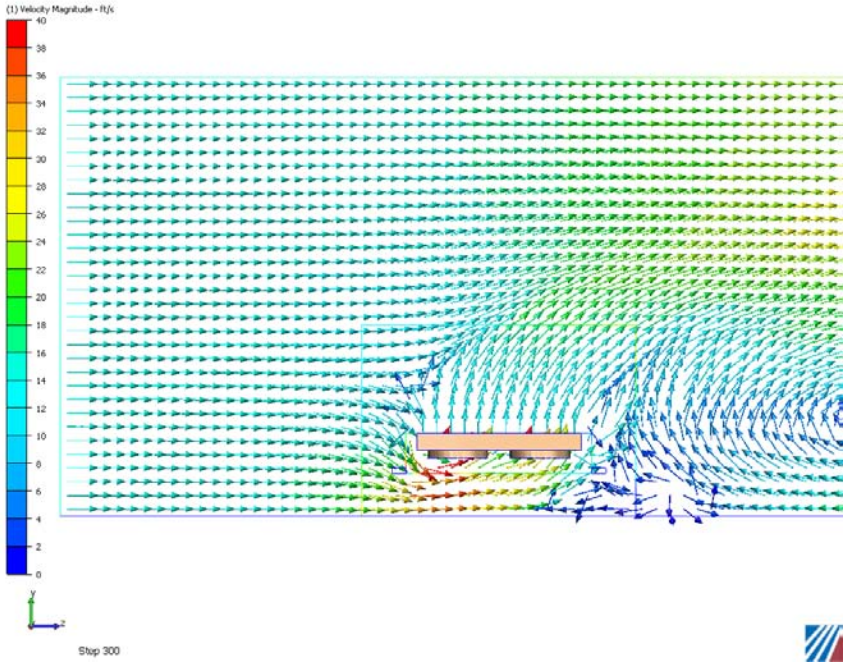
Note hot air recirculation

Buoyant

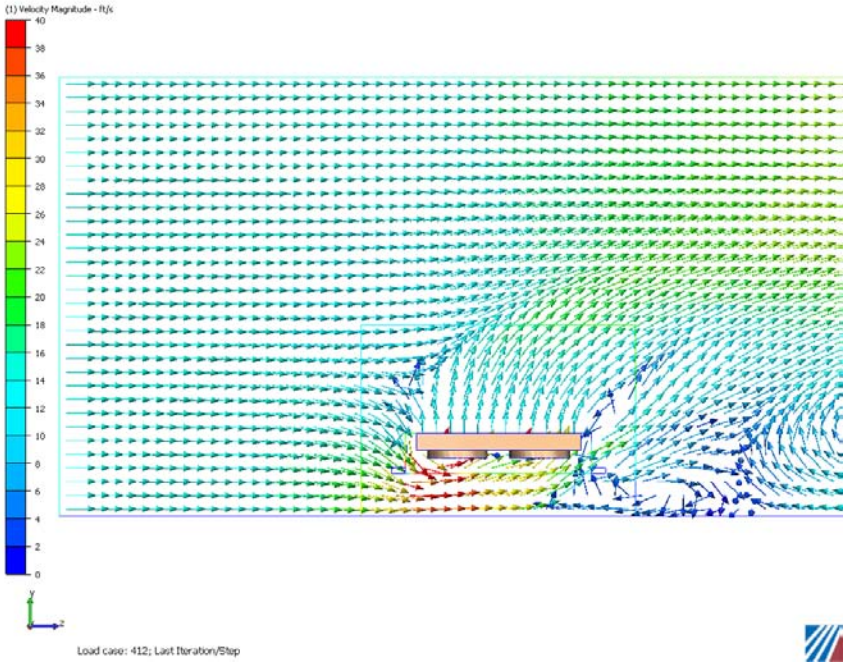


Appendix – Validation Flow Vectors

Constant

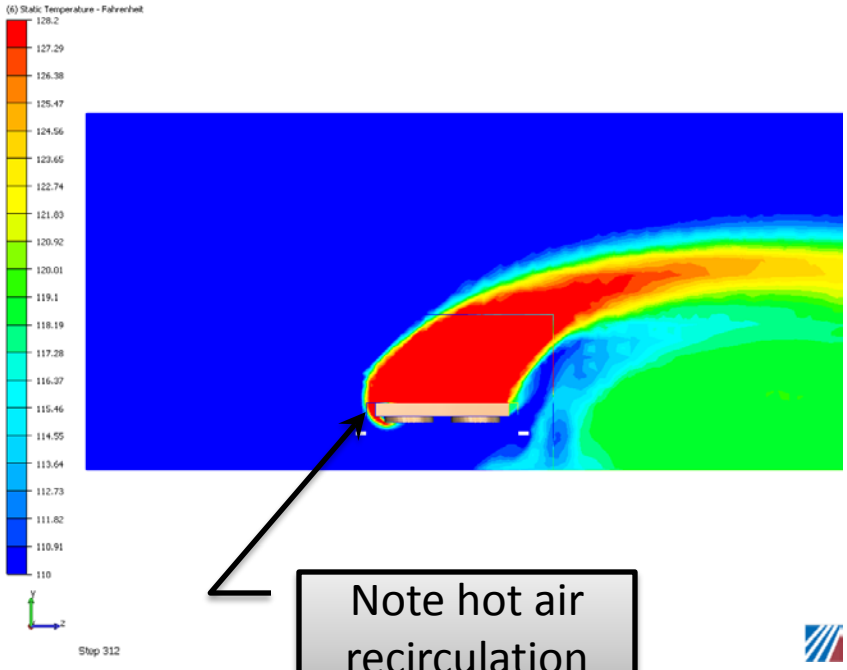


Buoyant



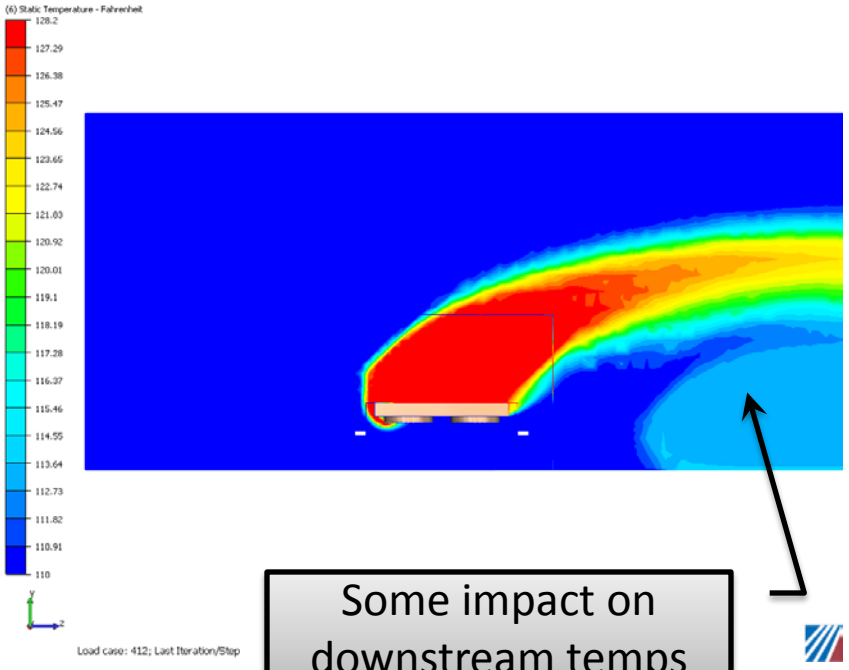
Appendix – Validation Temperature Profile

Constant



Note hot air recirculation

Buoyant



Some impact on downstream temps