SIM20859:
Crank Up Your Volumes: Revit-Enabled CFD

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Introduction: Mandi Ebensperger

- M+W U.S., Inc.
- Interior Designer
- Architectural BIM Lead
- Sage College of Albany
  - BFA Interior Design
- Colorado State University Global
  - Masters Project Management
- Hobbies
  - Skydiving, hiking and traveling

Introduction: Michael Potts, PE, LEED AP, CxA

- M+W U.S., Inc.
- Mechanical Engineer
- Facilities Modeling Lead
- University of Central Oklahoma
  - B.S Engineering Physics
- Specializing in the design, modeling, construction, commissioning and operation of high-tech, clean manufacturing facilities

Introduction: M+W Group

1912
established
in Germany

Leading
Total Facility
Solution
Provider

$ 3.3 bn
order intake
and sales

Advanced Technology Facilities

Semiconductor
Photovoltaic
Displays
Batteries

Life Sciences & Chemicals

Pharmaceutical & Health
Food & Nutrition
Consumer Goods
Chemicals

Energy

Solar
Waste-to-Energy
Power Plants
Nuclear Systems

High Tech Infrastructure

Science & Research
Data Center
Space & Security

Cleanroom Technologies
& Controlled Environments

Cleanroom Products
Air Handling Units
Critical Subsystems
Analytical Laboratory

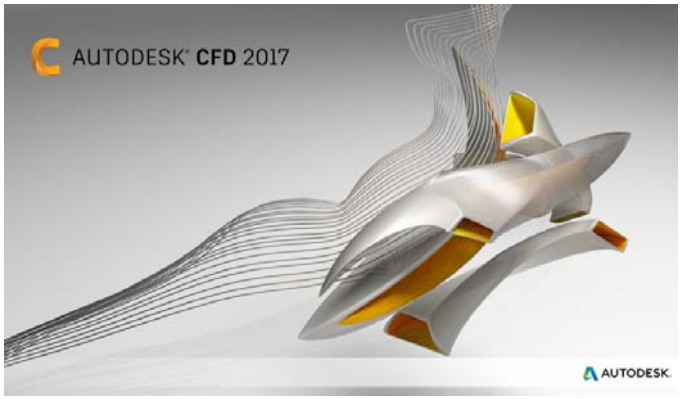
Class summary

- Autodesk Revit and Autodesk CFD Interoperability
- Revit design or construction models can contain
  - A high level of detail for construction
  - Gaps in geometry
  - Geometry clashes and conflicts
- Reuse or Replace Geometry
- Leverage Revit for
  - Design Coordination
  - Visualization
  - Management
  - Reporting

Key learning objectives

At the end of this class, you will be able to:

- Develop a Revit CFD model using industry best practices.
- Learn what Revit information translates to Autodesk CFD and how to leverage it
- See examples of Revit design geometry that can cause issues with CFD
- Leverage Revit data and parameters to manage the CFD project

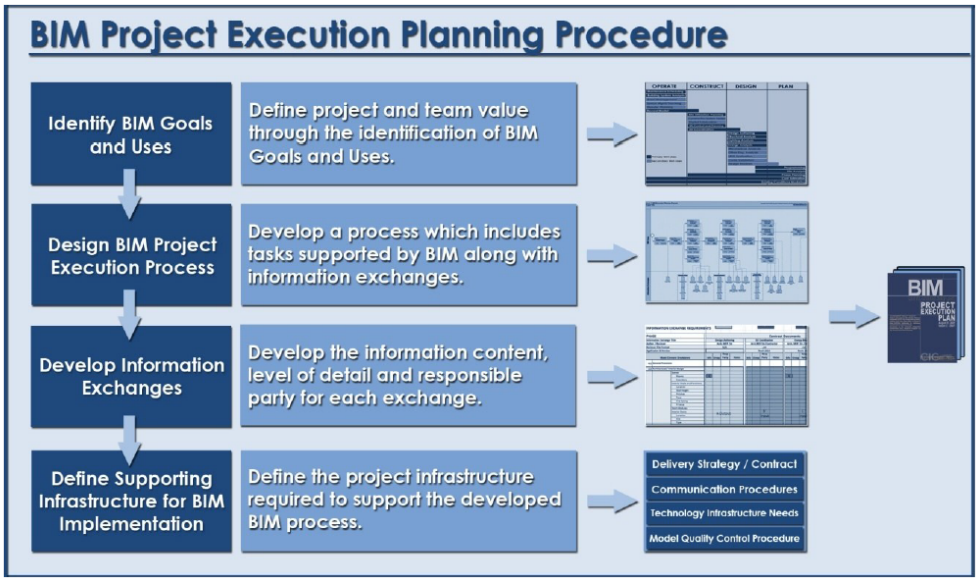


Class Poll

- Architectural / Engineering Firms?
- CFD Service Providers?
- Facility Owners/operators?
- A/E Firms Using CFD In-House?
- A/E Firms using 3rd Party CFD providers?

Understanding The Project Documents

- Project Execution Plans
- Project Basis of Design
- Project Engineering Narratives
- Project Engineering Calculations
- Systems Sequence of Operations
- Facility Operational Setpoints
- Industry Standards



1.5 Interior Conditions Basis of Design

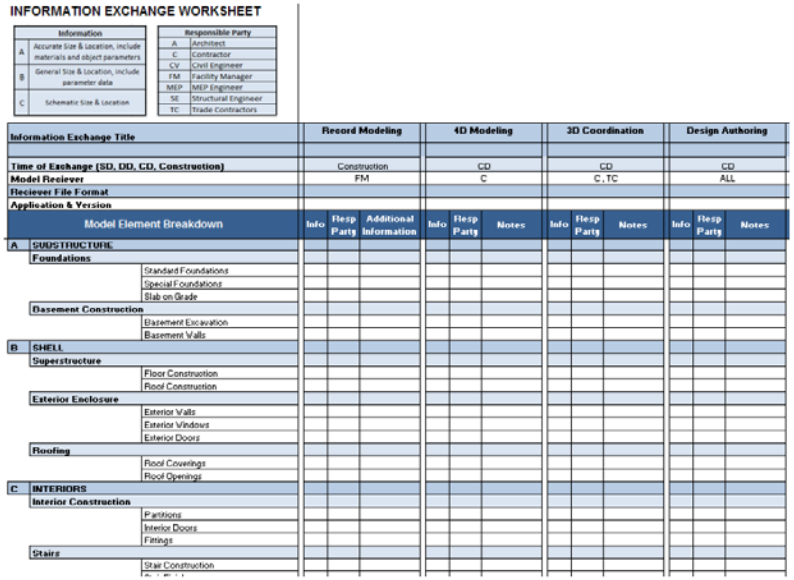
Table 1

Reception, records, conference room, closed offices, open offices, exercise room, lunch room, inventory, stock, etc.

Space	Use / Activity	Occupant Type	Num of Occs	Operating Hours per Day	Design Cooling DB	Design Cooling WB or RH	Design Heating DB OSAT	OSA CFM / Person or CO_2	Design Noise Level (NC)	Design Light Level (FC)

Understanding The Project Information

- Project Location and Site Information
- Project Staff Contacts
- Project Organizational Structure
- Staff Roles and Responsibilities
- BIM Usage Matrix
- Level of Development Matrix (LOD)
- Collaboration Procedures and Workflows
- Software/Technology Utilized
- File Naming Conventions & Legend



INFORMATION EXCHANGE WORKSHEET

Information	
A	Accurate Size & Location, include materials and object parameters
B	General Size & Location, include parameter data
C	Schematic Size & Location

Responsible Party	
A	Architect
C	Contractor
CV	Civil Engineer
FM	Facility Manager
MEP	MEP Engineer
SE	Structural Engineer
TC	Trade Contractors

Information Exchange Title			Record Modeling			4D Modeling			3D Coordination			Design Authoring		
Time of Exchange (SD, DD, CD, Construction)			Construction			CD			CD			CD		
Model Reciever			FM			C			C, TC			ALL		
Reciever File Format														
Application & Version														
Model Element Breakdown			Info	Resp Party	Additional Information	Info	Resp Party	Notes	Info	Resp Party	Notes	Info	Resp Party	Notes
A	SUBSTRUCTURE													
	Foundations													
		Standard Foundations												
		Special Foundations												
		Slab on Grade												
	Basement Construction													
		Basement Excavation												
		Basement Walls												
B	SHELL													
	Superstructure													
		Floor Construction												
		Roof Construction												
	Exterior Enclosure													
		Exterior Walls												
		Exterior Windows												
		Exterior Doors												
	Roofing													
		Roof Coverings												
		Roof Openings												
C	INTERIORS													
	Interior Construction													
		Partitions												
		Interior Doors												
		Fittings												
	Stairs													
		Stair Construction												

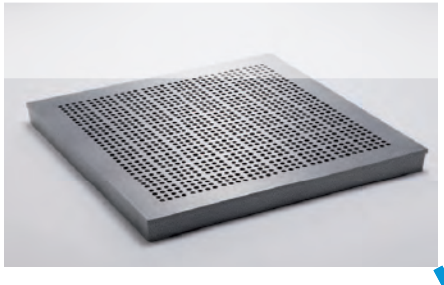
MODEL DELIVERY SCHEDULE OF INFORMATION EXCHANGE FOR SUBMISSION AND APPROVAL:

Document the information exchanges and file transfers that will occur on the project.

INFORMATION EXCHANGE	FILE SENDER	FILE RECEIVER	ONE-TIME or FREQUENCY	DUE DATE or START DATE	MODEL FILE	MODEL SOFTWARE	NATIVE FILE TYPE	FILE EXCHANGE TYPE
DESIGN AUTHORING - 3D COORDINATION	STRUCTURAL ENGINEER	(FTP POST) (COORDINATION LEAD)	WEEKLY	[DATE]	STRUCT	DESIGN APP	.XYZ	.XYZ .ABC
	MECHANICAL ENGINEER	(FTP POST) (COORDINATION LEAD)	WEEKLY	[DATE]	MECH	DESIGN APP	.XYZ	.XYZ .ABC

Basic Cleanroom Components

Perforated Panel



The perforated panel provides all the features and available options of our solid panel with the addition of either 1,296 or 1,024 chamfered holes to provide a nominal 18 ~ 38 % open area in a non-directional pattern for airflow requirements in both computer rooms and cleanrooms. Completely interchangeable with solid and grating panels.

Advantages

- Existing solid panels can be refitted to perforated panels by applying ventilation openings with standard drilling equipment
- Manufactured with the highest precision
- Class A1 building material (non-combustible)
- Precisely drilled holes with chamfered edges

Filter Fan Unit SILENT *

FFU-S-EC (AC)-1212-T-AU

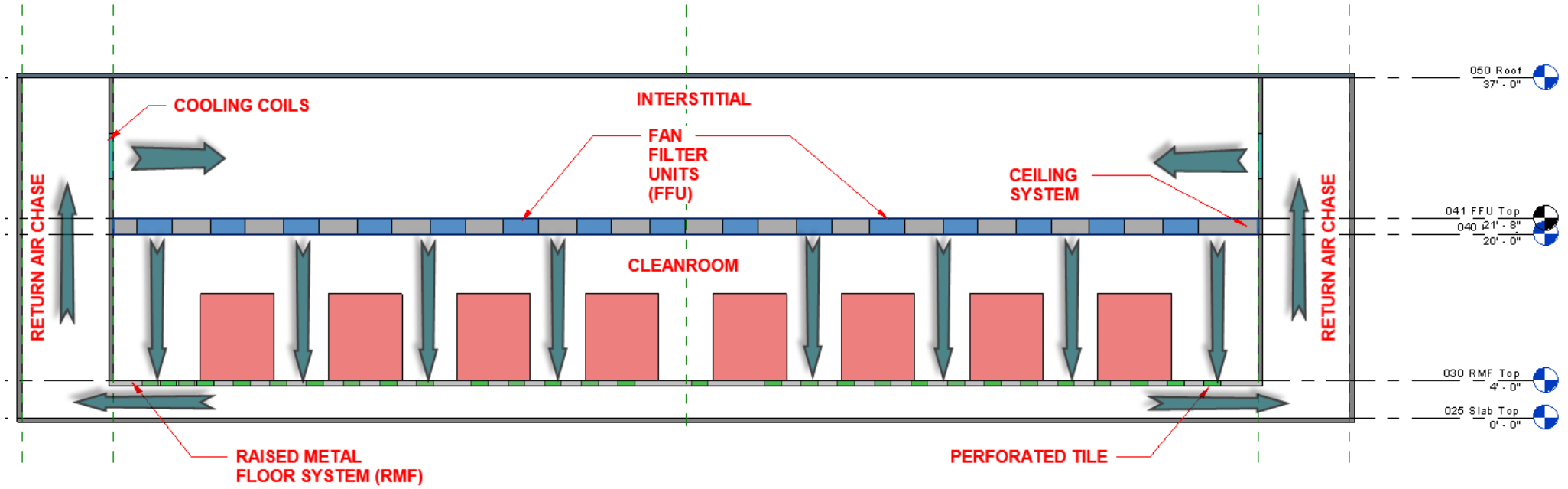
FFU optimized regarding sound power level and air flow.
Particularly suited for

- uni-directional airflow (laminar) cleanroom areas
- advanced requirements on the uniformity of the uni-directional air flow
- advanced sound pressure level requirements in the room
- cleanroom classes 1 – 8 according to ISO 14644-1

Applications

Electronics, Microelectronics
Life Sciences
High Tech Industries
New Technologies
Food Industry
Laboratories

Cleanroom Functionality



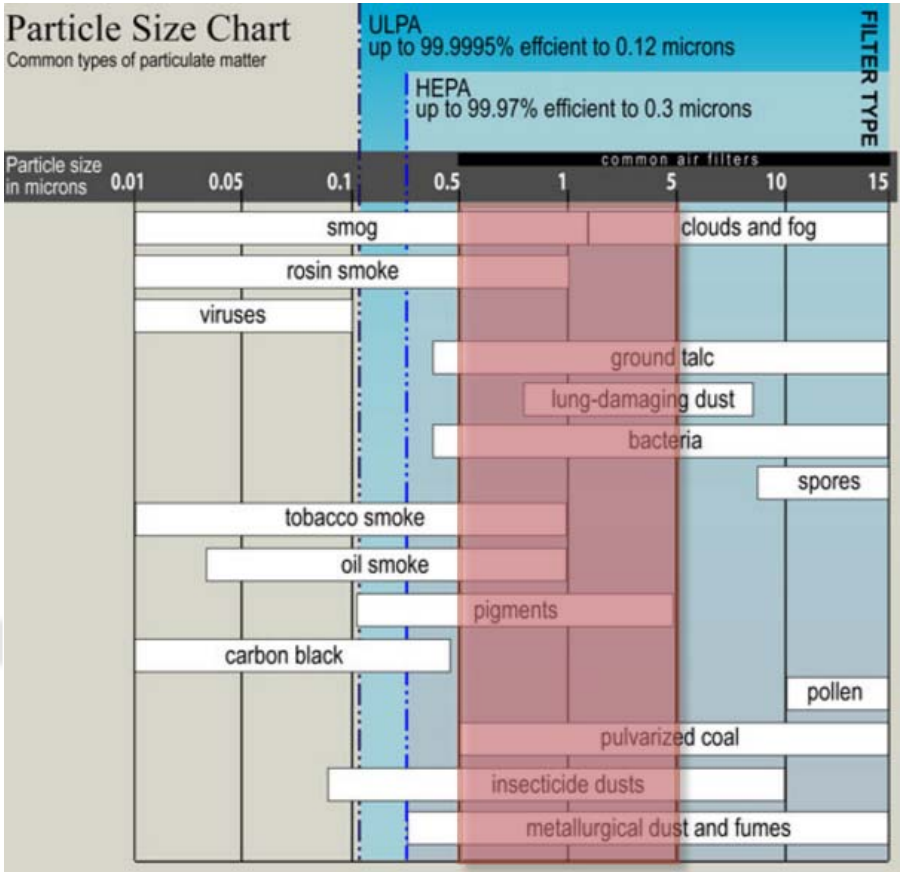
Collecting The Project Information - Standards

- Cleanrooms - ISO 14644 & FS209E

Airborne Particulate Cleanliness Classes (by cubic meter):

CLASS	Number of Particles per Cubic Meter by Micrometer Size					
	0.1 micron	0.2 micron	0.3 micron	0.5 micron	1 micron	5 microns
ISO1	10	2				
ISO2	100	24	10	4		
ISO3	1,000	237	102	35	8	
ISO4	10,000	2,370	1,020	352	83	
ISO5	100,000	23,700	10,200	3,520	832	29
ISO6	1,000,000	237,000	102,000	35,200	8,320	293
ISO7				352,000	83,200	2,930
ISO8				3,520,000	832,000	29,300
ISO9				35,200,000	8,320,000	293,000

Class ISO 146144-1 (Federal Standard 209E)	Average Airflow Velocity m/s (ft/min)	Air Changes Per Hour	Ceiling Coverage
ISO 8 (Class 100,000)	0.005 – 0.041 (1 – 8)	5 – 48	5 – 15%
ISO 7 (Class 10,000)	0.051 – 0.076 (10 -15)	60 – 90	15 – 20%
ISO 6 (Class 1,000)	0.127 – 0.203 (25 – 40)	150 – 240	25 – 40%
ISO 5 (Class 100)	0.203 – 0.406 (40 – 80)	240 – 480	35 – 70%
ISO 4 (Class 10)	0.254 – 0.457 (50 – 90)	300 – 540	50 – 90%
ISO 3 (Class 1)	0.305 – 0.457 (60 – 90)	360 – 540	60 – 100%
ISO 1 – 2	0.305 – 0.508 (60 – 100)	360 – 600	80 – 100%



Collecting The Project Information – Coils

Through-Flow Loss Coefficients

Values for loss coefficients are found in many fluids texts and the hydraulic resistance reference, Handbook of Hydraulic Resistance, 3rd Edition by I.E. Idelchik, published by CRC Press, 1994 (ISBN 0-8493-9908-4).

Alternatively, if measured data for pressure drop versus flow rate is available. Solve the equation,

$\Delta p = \zeta_i \rho \frac{u_i^2}{2}$, for ΔP, using the known values of pressure and velocity to determine the value of ζ

.

Enter this value for the **Through-Flow K.**

Item	Quantity	Units	Source	Comments
Coil Max Pressure Drop	0.1	in H2O	Mech Eng	
Coil Max Velocity	400	FPM	Mech Eng	
Coil K Factor	10.1	K Factor	Calc	

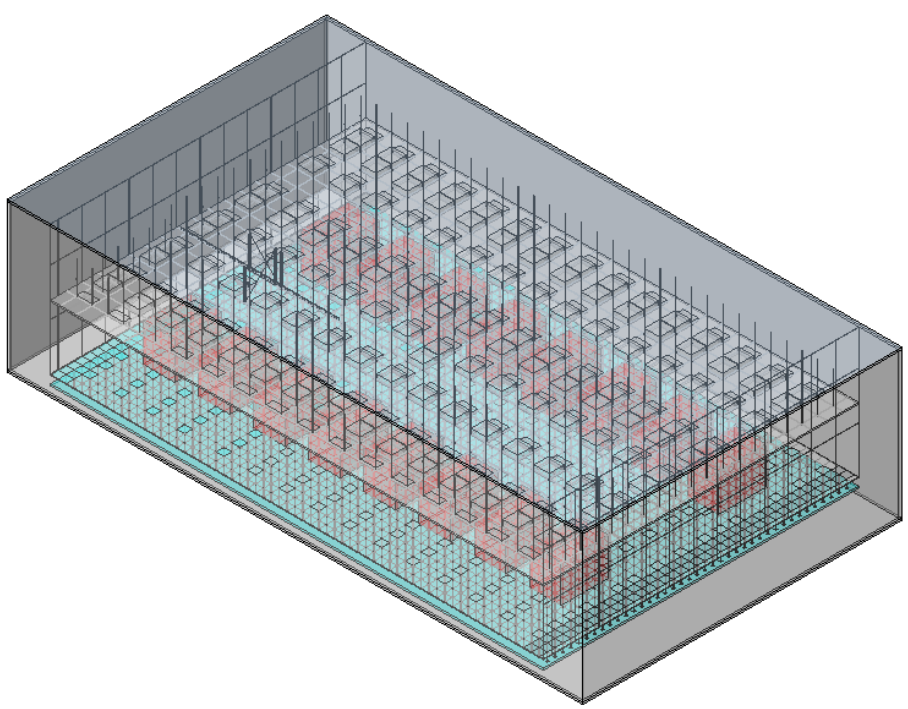
Organizing The Project Information - CFD

Item	Quantity	Units	Source	Comments
Site Elevation	500	ft	Site	
Site Barometric Pressure	99,507	Pa	Site	
Cleanroom Classification	ISO 7	-	Owner	Bay/Chase Configuration
Cleanroom Area	10,000	SF	Arch	
Cleanroom Length	120	FT	Arch	
Cleanroom Width	80	FT	Arch	
Cleanroom Height	16	FT	Arch	
Cleanroom Volume	160,000	CF	Calc	
Air Change Rate Min	60	ACH	ISO	ISO 7 Range 60-90 ACH
Air Change Min Airflow	160,000	CFM	Calc	Worst Case - Engr BOD
Space Velocity Avg	15	FPM	ISO	ISO 7 Range 10-15 FPM
Space Velocity Min Airflow	150,000	CFM	Calc	
Cleanroom Temperature	70	deg F	Owner	Range 70F +/- 2F
FFU Coverage Avg	20	%	ISO	ISO 7 Range 15-20%
FFU Area	16	SF	M+W Products	48" x 48" FFU
FFU Min. Quantity	125	Ea	Calc	
FFU Design Quantity	160	Ea	Mech Eng	
FFU Flow Ea.	1000	CFM	Mech Eng	MW Silent FFU
FFU Total Flow	160,000	CFM	Calc	

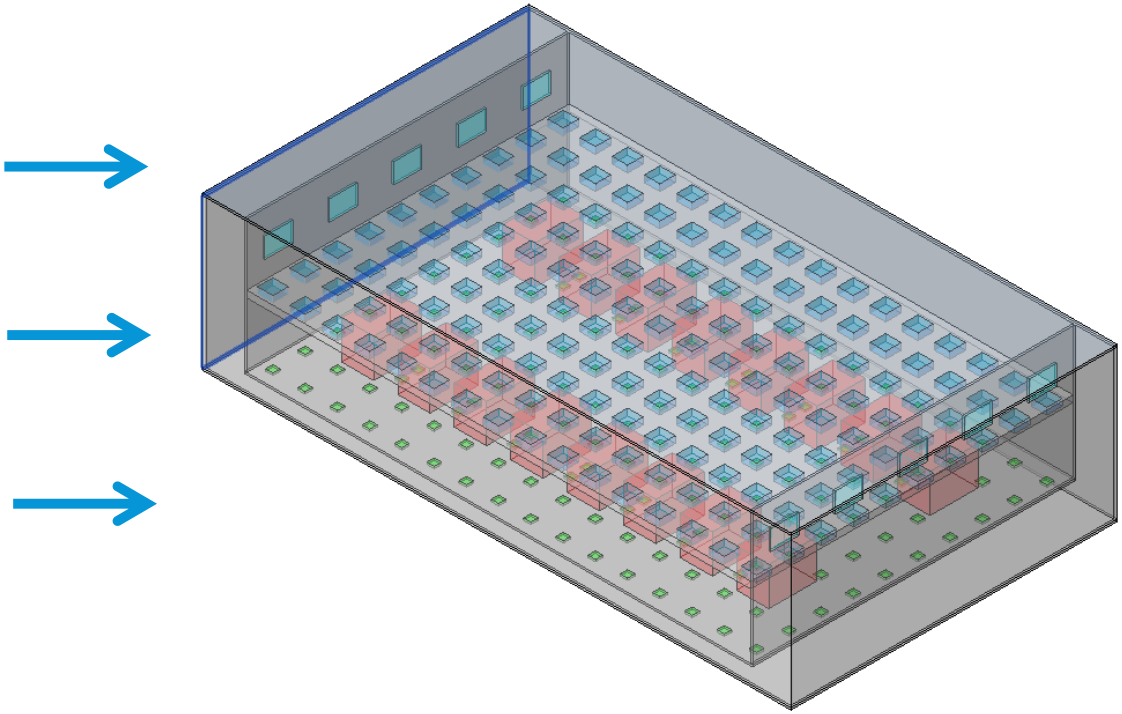
Organizing The Project Information - CFD

Item	Quantity	Units	Source	Comments
Perf Tile Size	4	SF	M+W Products	
Perf Tile Free Area	30	%	M+W Products	MW RMF Perforated Tile
Perf Tile Max Pressure Drop	0.06	in H2O	Mech Eng	
Perf Tile Max Velocity	200	FPM	Mech Eng	
Perf Tile Max Flow	800	CFM	Calc	
Perf Tile Min Qty	200	Ea	Calc	
Perf Coverage	8	%	Calc	
Equipment Quantity	16		Owner	
Coil Max Pressure Drop	0.1	in H2O	Mech Eng	
Coil Max Velocity	400	FPM	Mech Eng	
Coil K Factor	10.1	K Factor	Calc	
Coil Min Total Area	400	SF	Calc	
Coil Qty	10	EA	Mech Eng	5 coils per chase
Coil Min Area Each	40.0	SF	Calc	
Coil Selected Area Each	40.0	SF	Mech Eng	96" x 60" coils
Chase DesignVelocity	300	FPM	Mech Eng	
Chase Free Area	80%	%	Mech Eng	
Chase Qty	2	Ea	Arch	
Chase Min Area, Ea	667	SF	Calc	
Chase Min Width	8	FT	Calc	
Minimum CFD Object Dimension	6	in	CFD	

Migrating Revit Design Geometry To Revit CFD

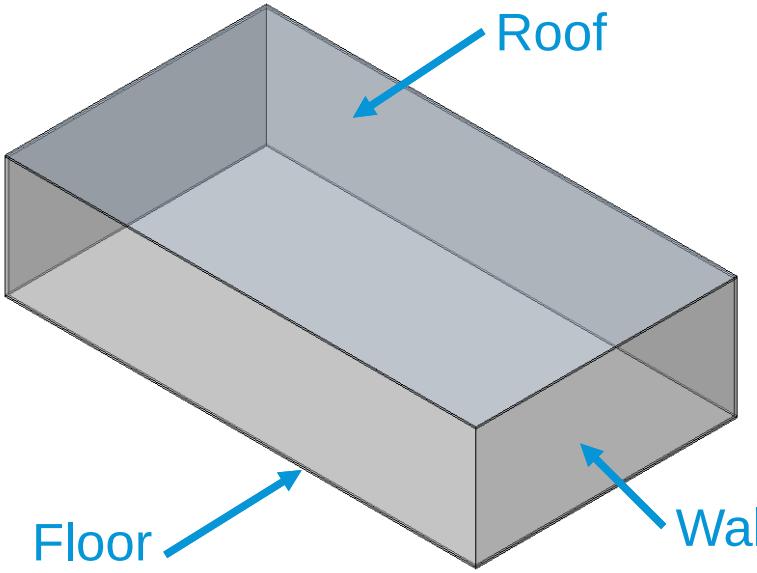


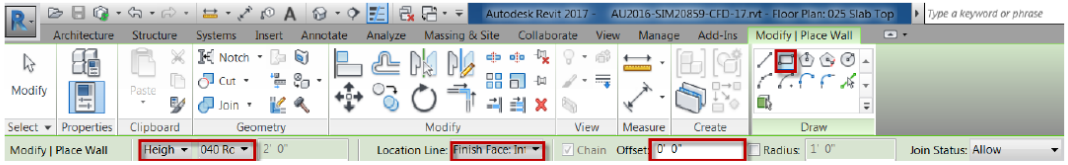
Design Model - Overall

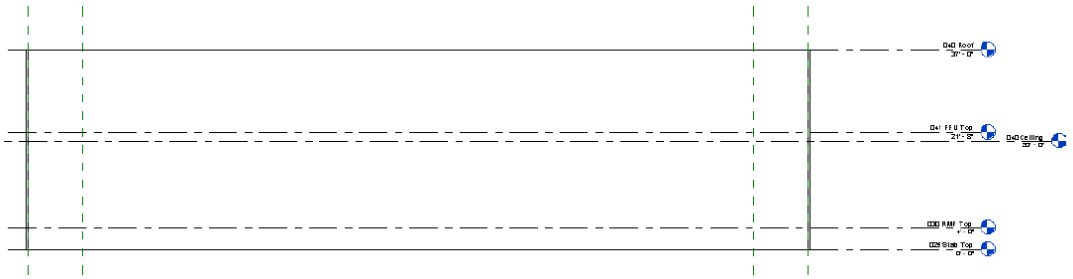


CFD Model -Overall

Create The Airtight CFD Envelope In Revit

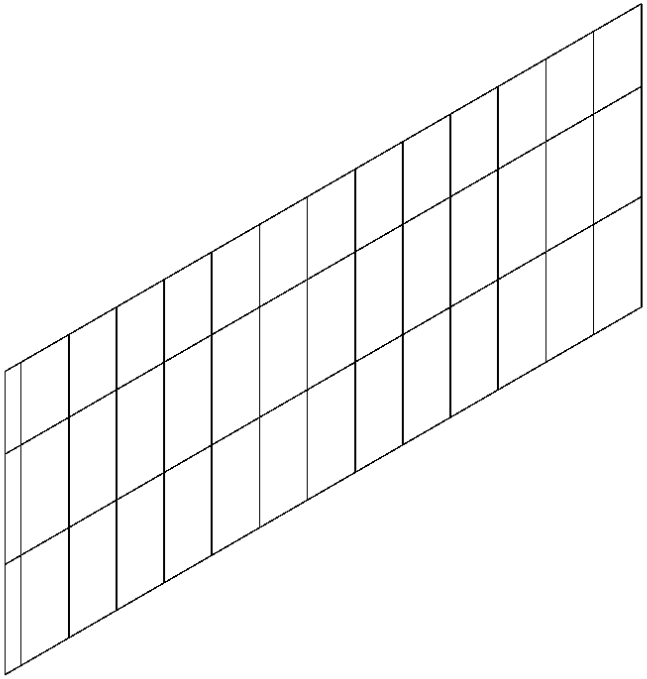






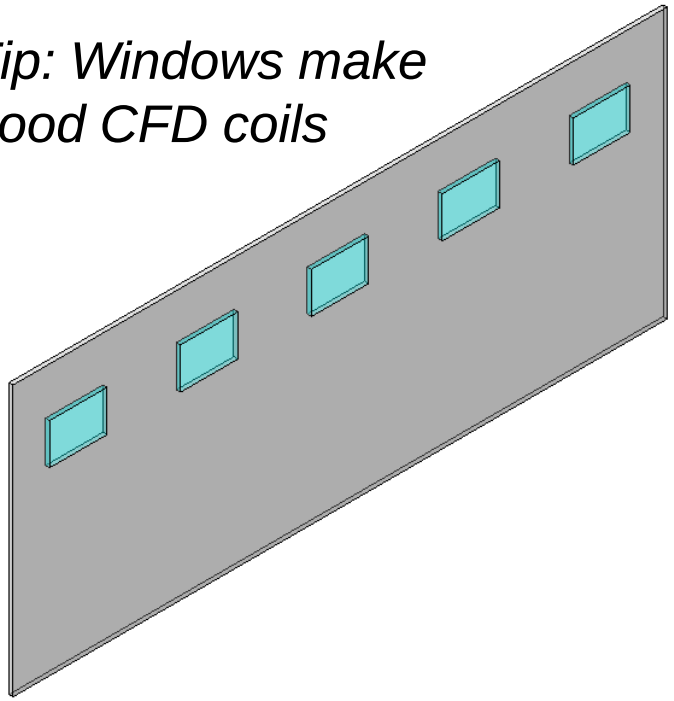
Tip: Use of reference planes and levels can add flexibility

Convert The Revit Design To CFD Geometry



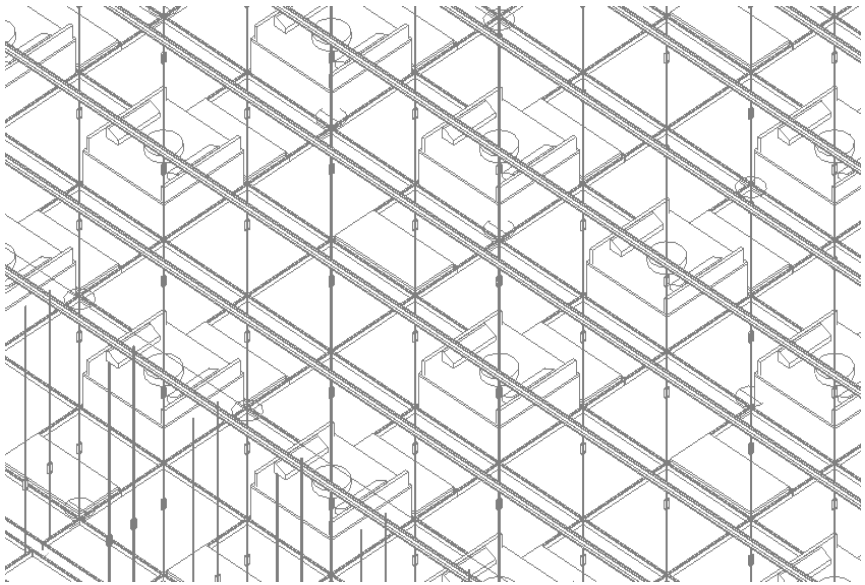
Architectural Model Cleanroom Wall

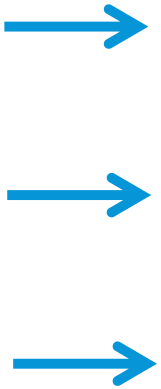
Tip: Windows make good CFD coils

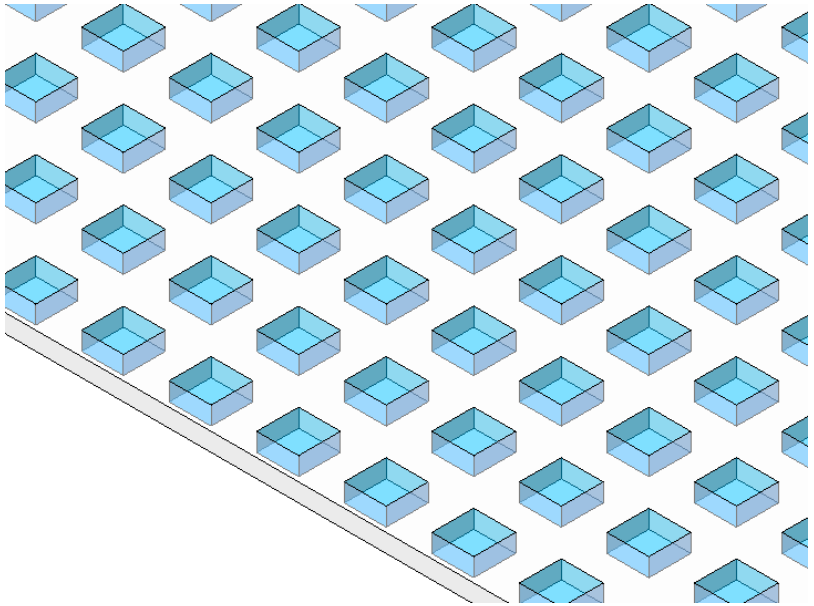


CFD Model Cleanroom Wall

Convert The Revit Design To CFD Geometry



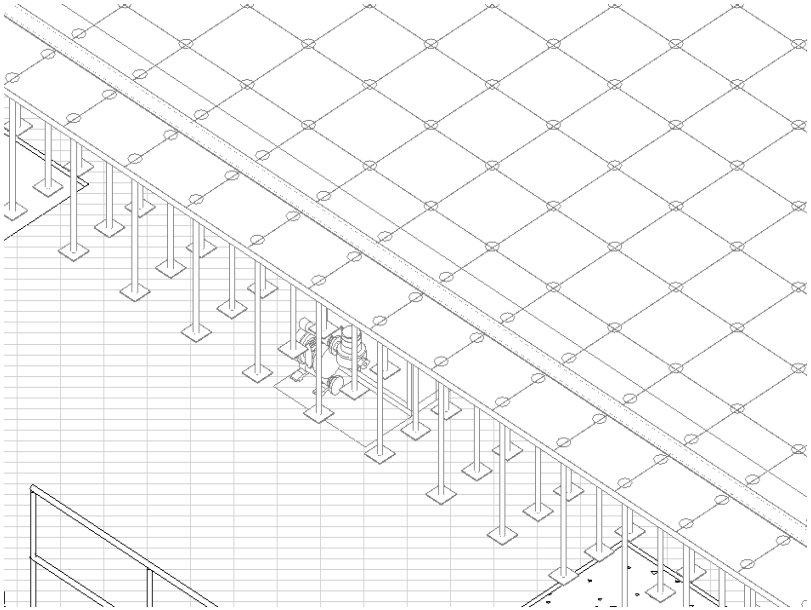


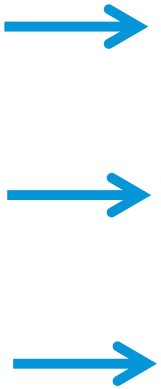


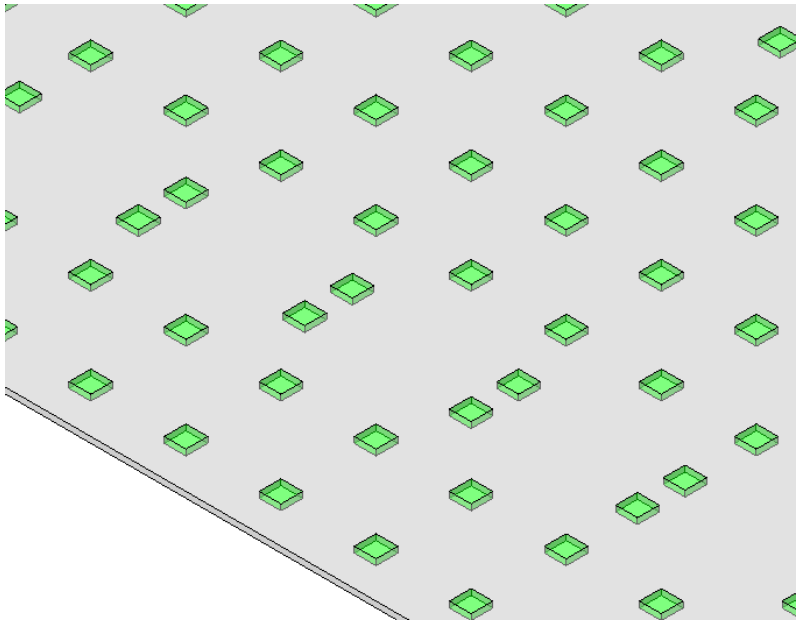
Architectural Model Ceiling & FFU’s

CFD Model Ceiling & FFU’s

Convert The Revit Design To CFD Geometry



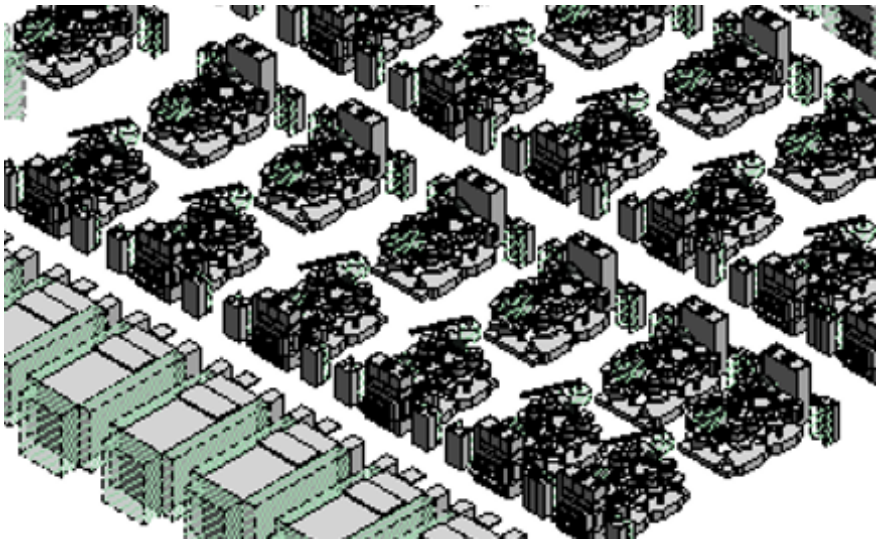


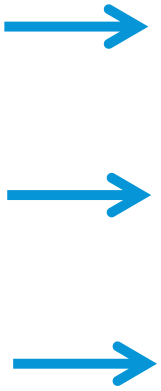


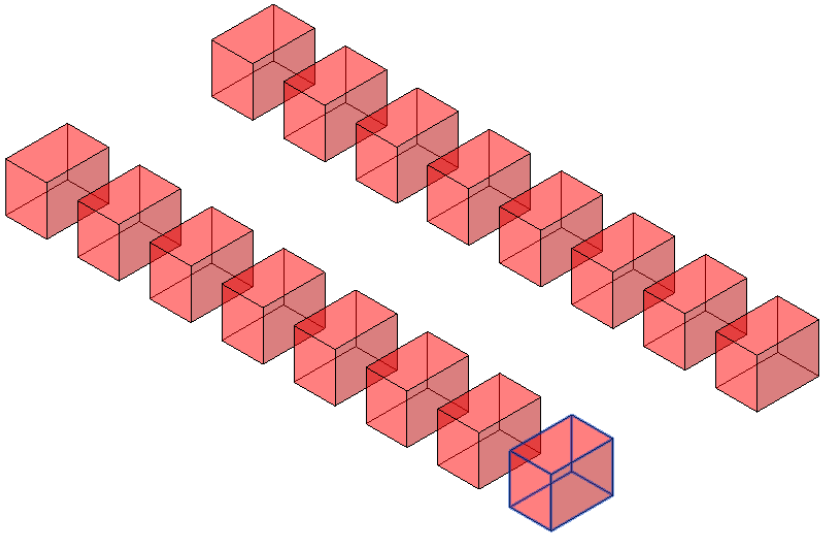
Architectural Model RMF

CFD Model RMF

Convert The Revit Design To CFD Geometry



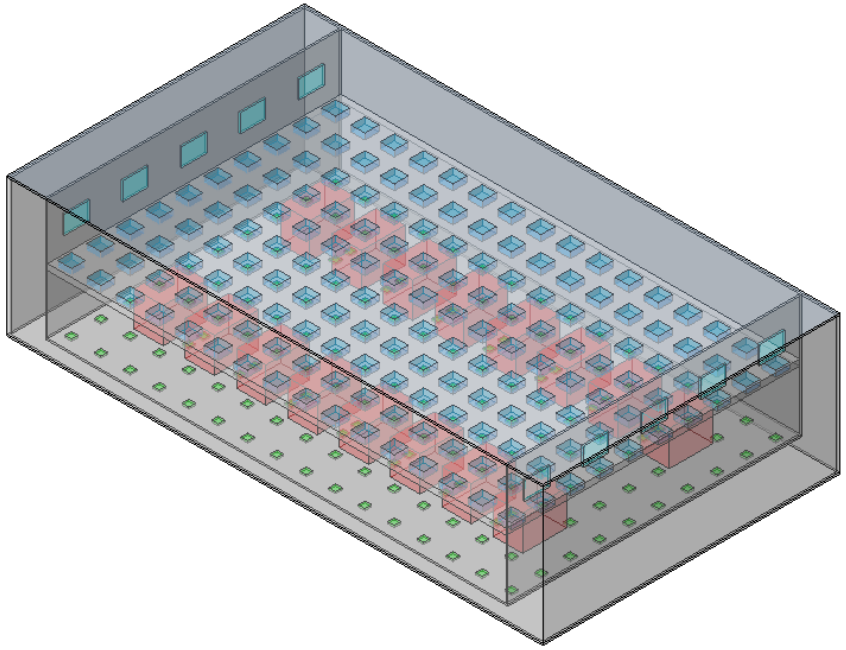


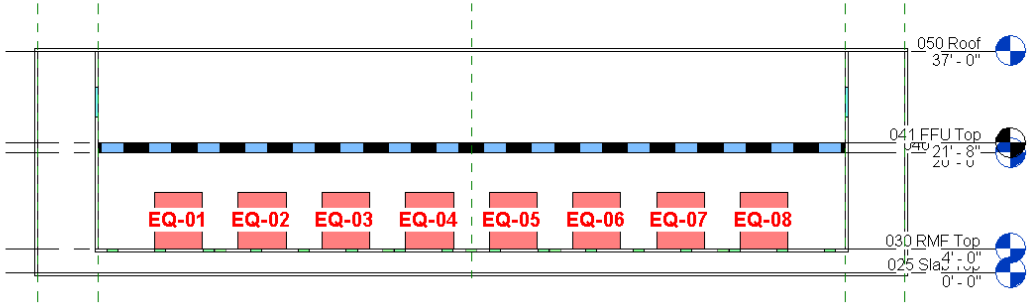


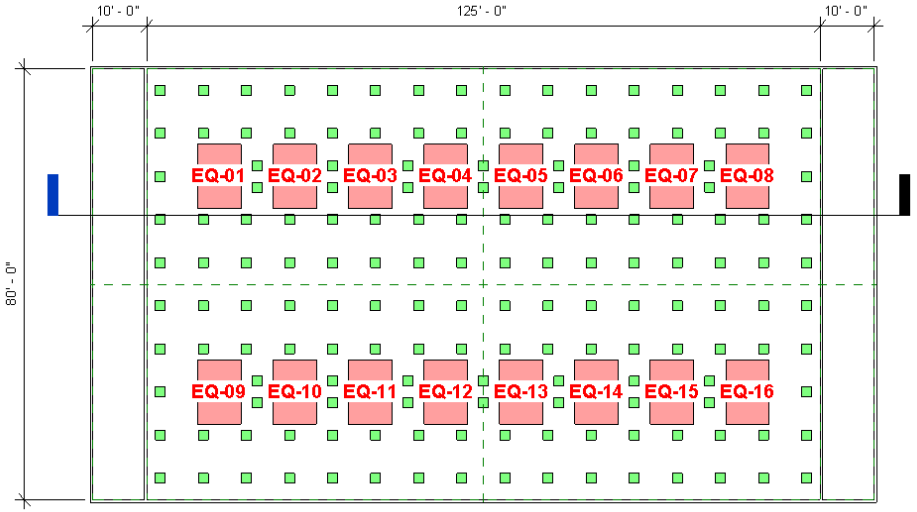
Process Model Equipment

CFD Model Equipment

Check The Revit CFD Model - Visual

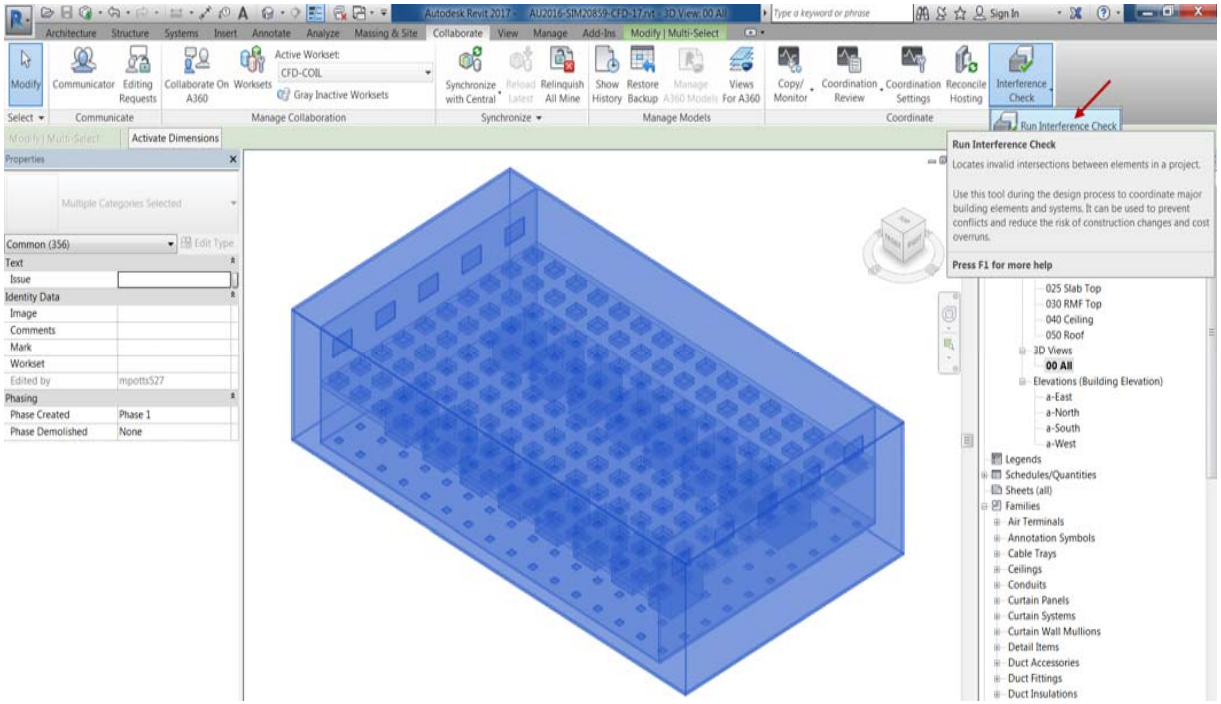


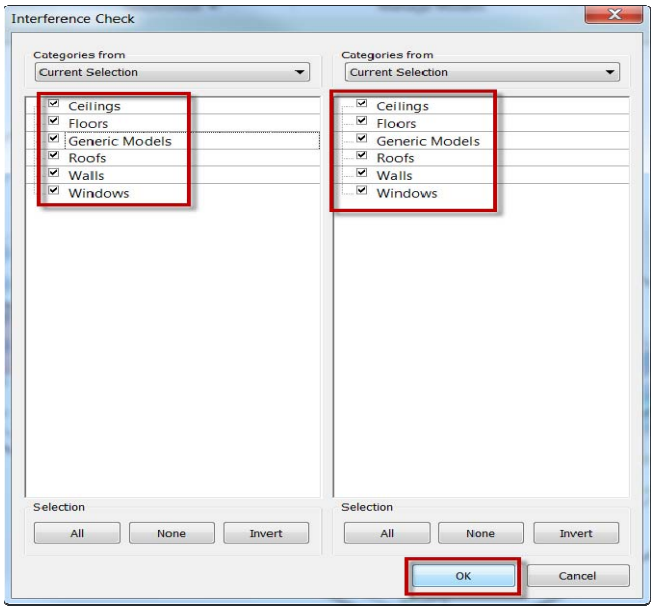


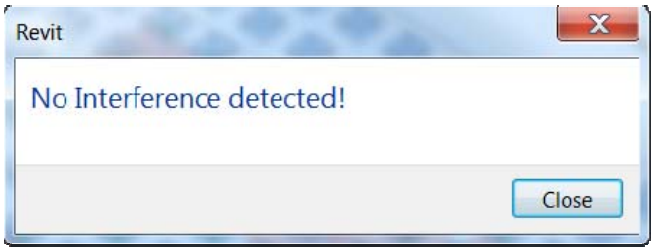


Tip: Use Revit plans, sections and 3D views along with graphics control to visualize the model.

Check The Revit CFD Model – Interferences

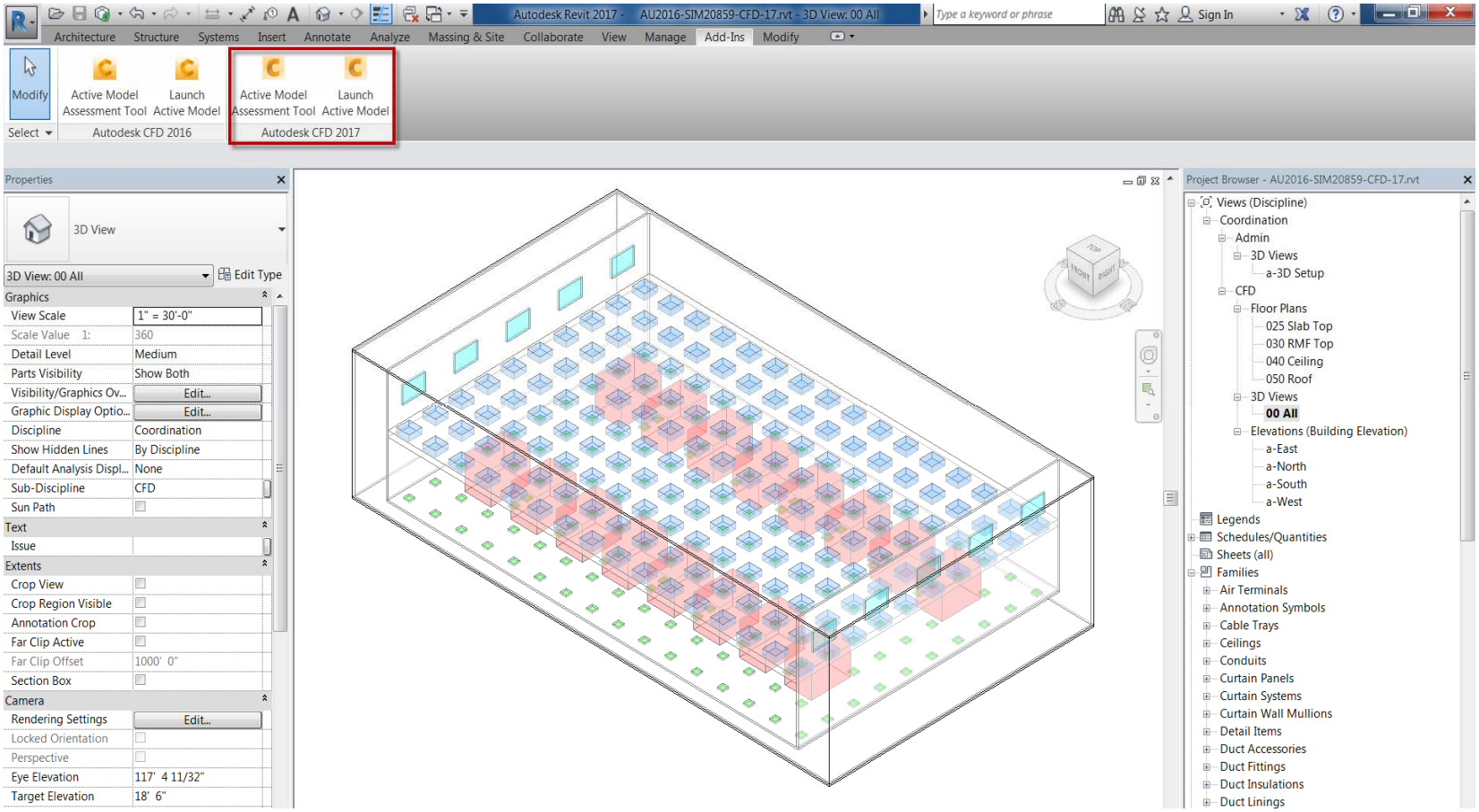




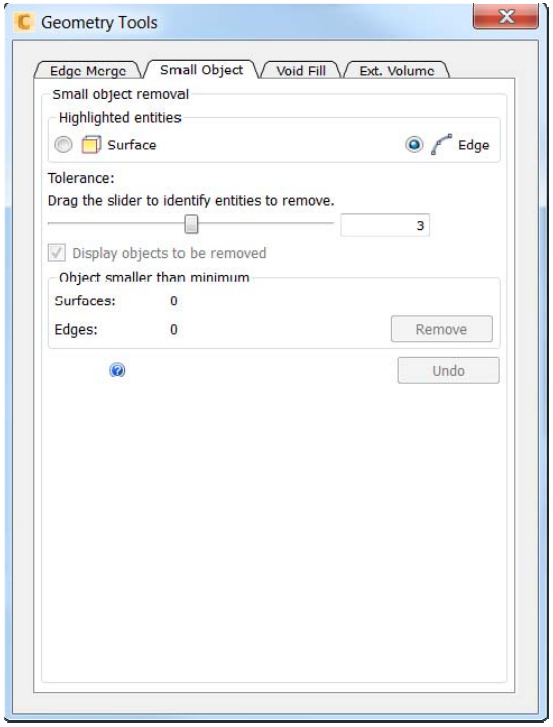


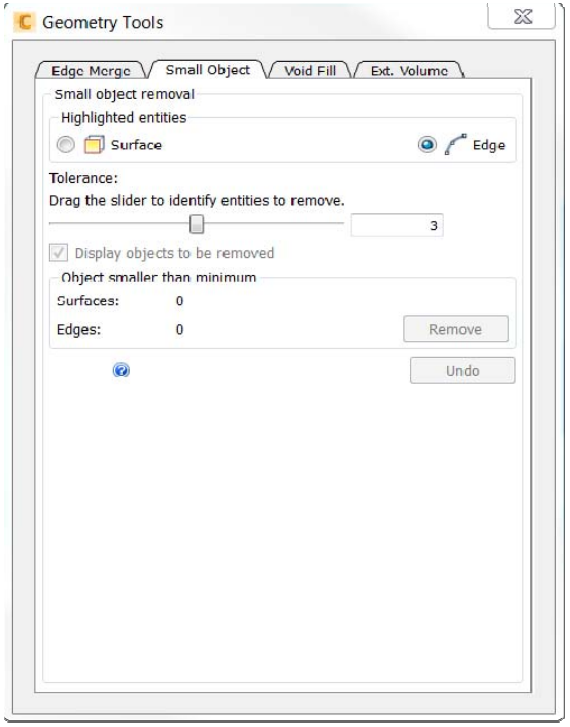
Tip: Revit Interference Checker to help further identify geometric clashes.

Launch Revit CFD Model Into Autodesk CFD



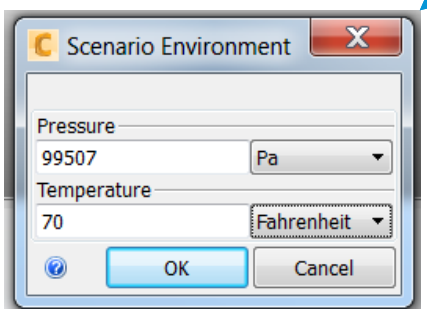
Review CFD Geometry Tools On CFD Launch





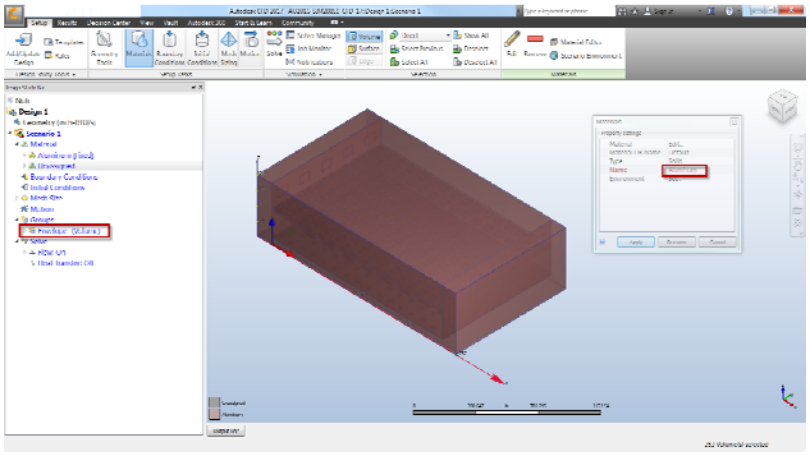
Tip: *Benefit limiting the CFD Revit model minimum element dimension to 6" and keeping it free of interferences is that there are no Small Object or Edge Merge issues.*

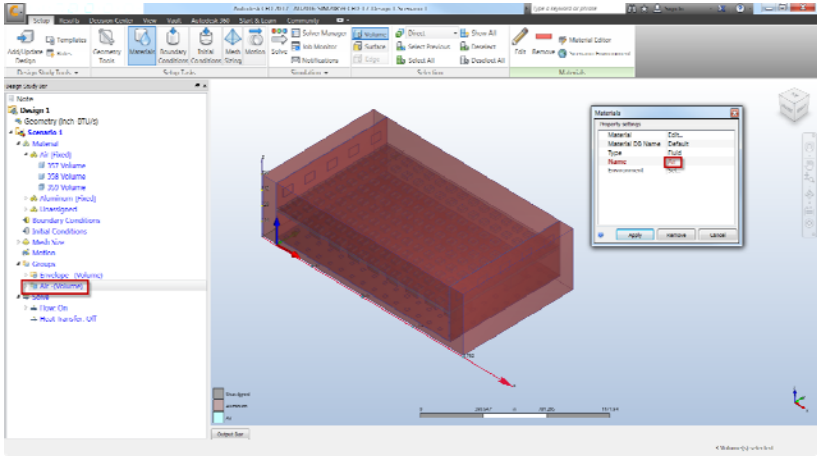
Setup The CFD Model & Scenario Environment

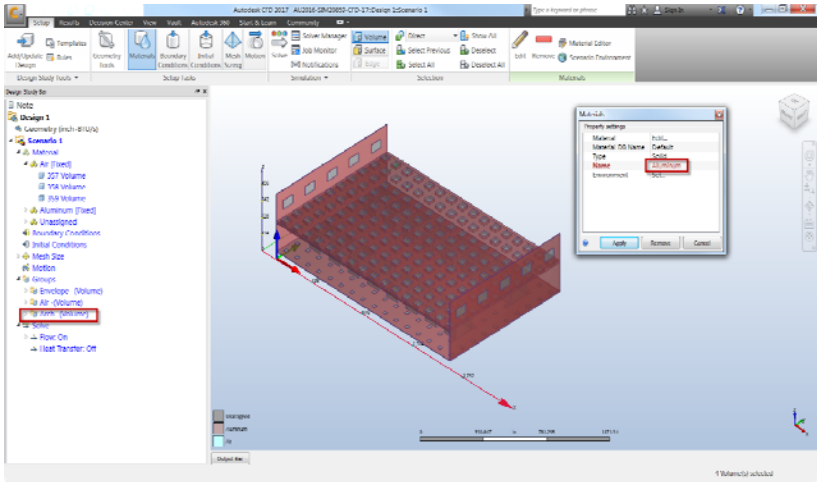


Tip: *The Setup Tasks in the Autodesk CFD Setup Ribbon are arranged in progressive order from left to right.*

Group Objects & Assign Materials

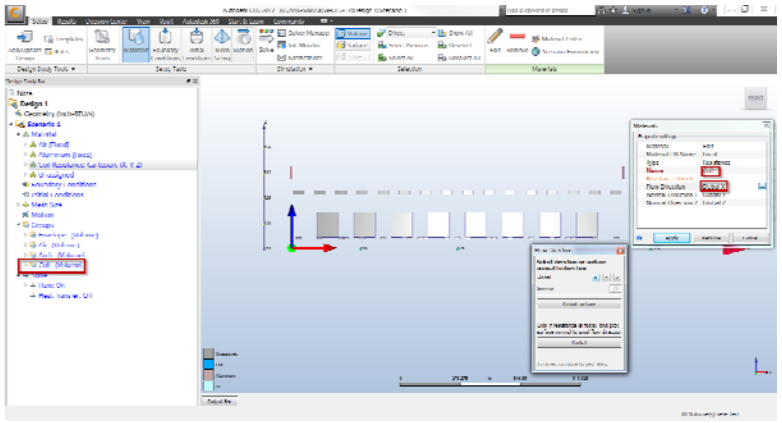


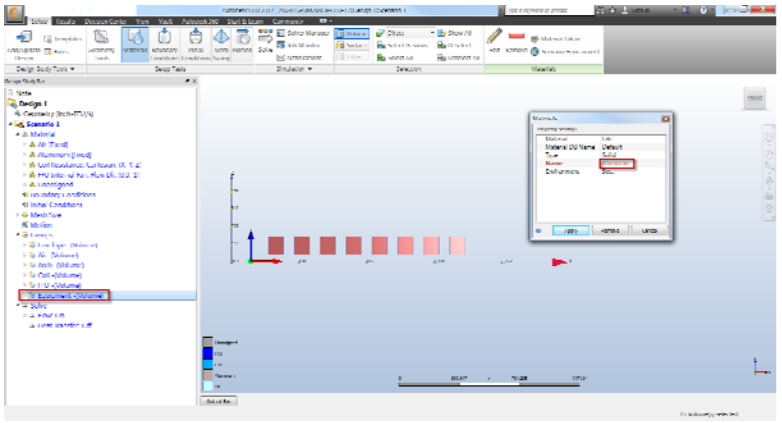


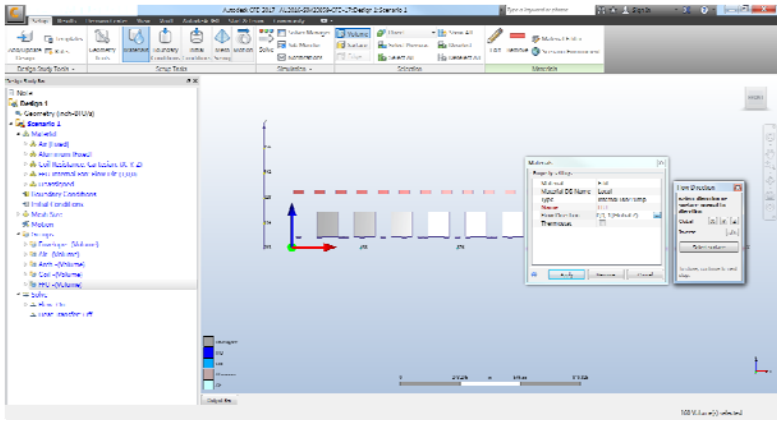


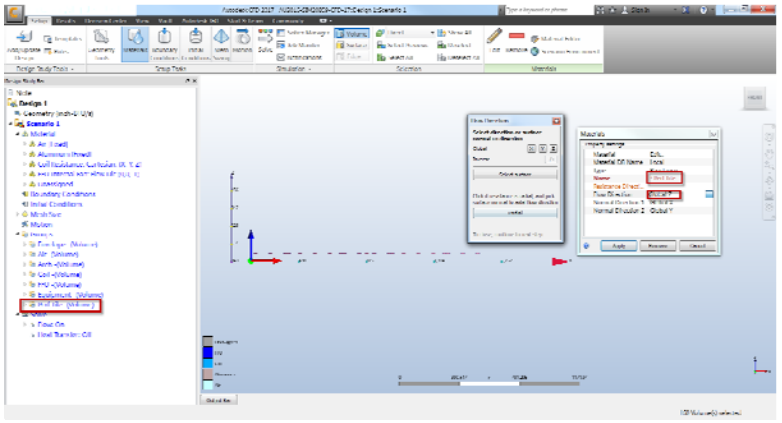
Tip: *Hide objects that have been assigned as you drill down through the model objects.*

Group Objects & Assign Materials

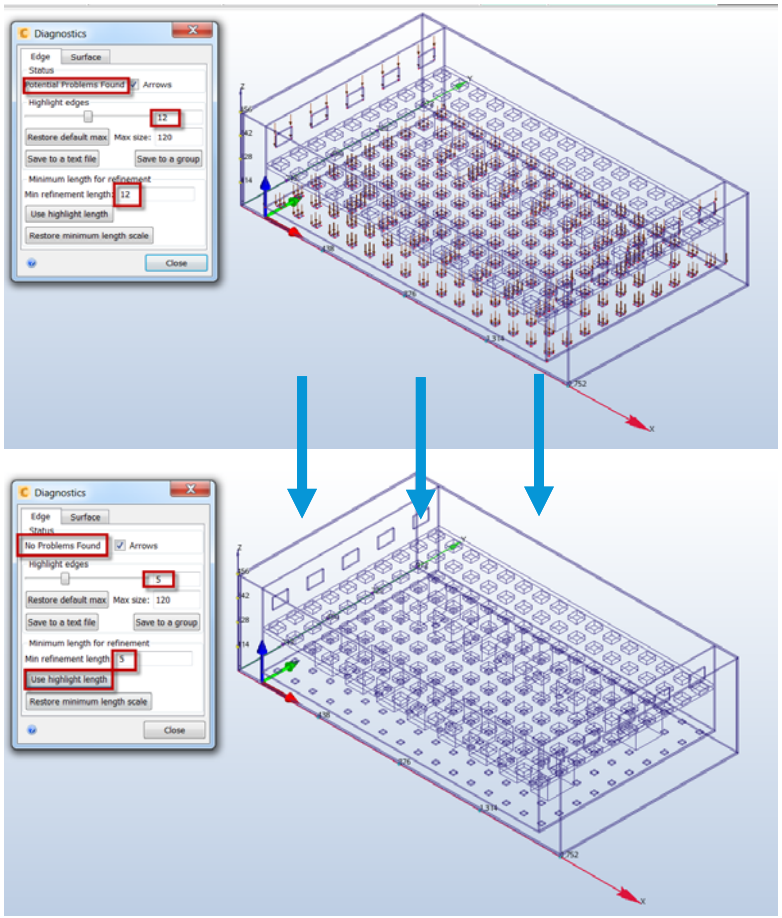




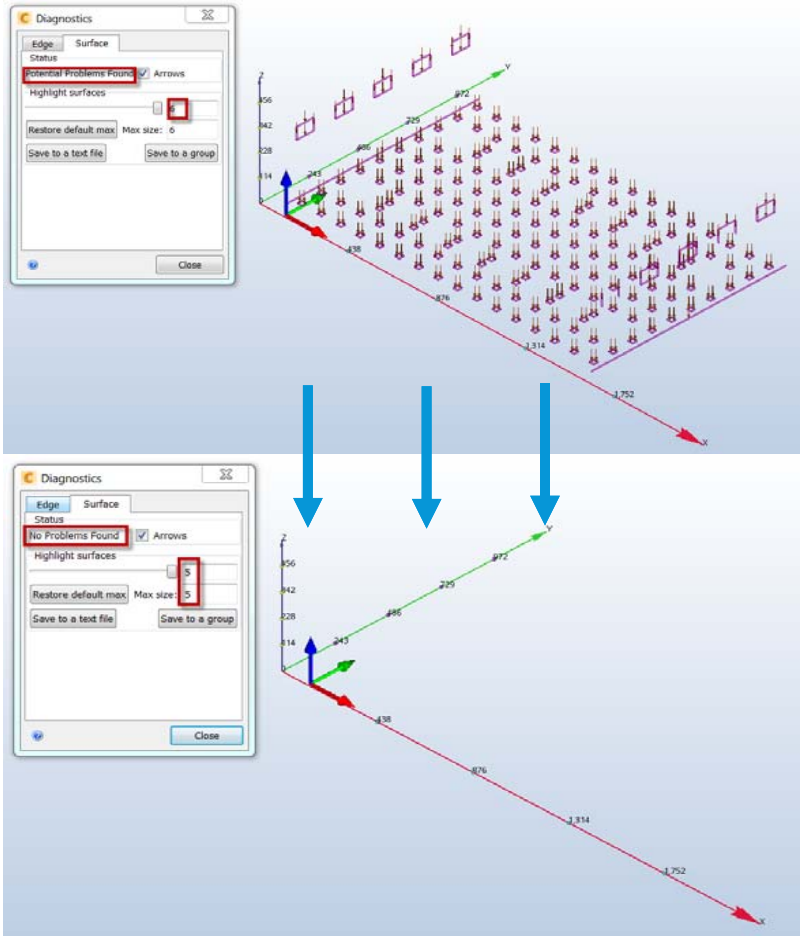




Group Objects & Assign Materials

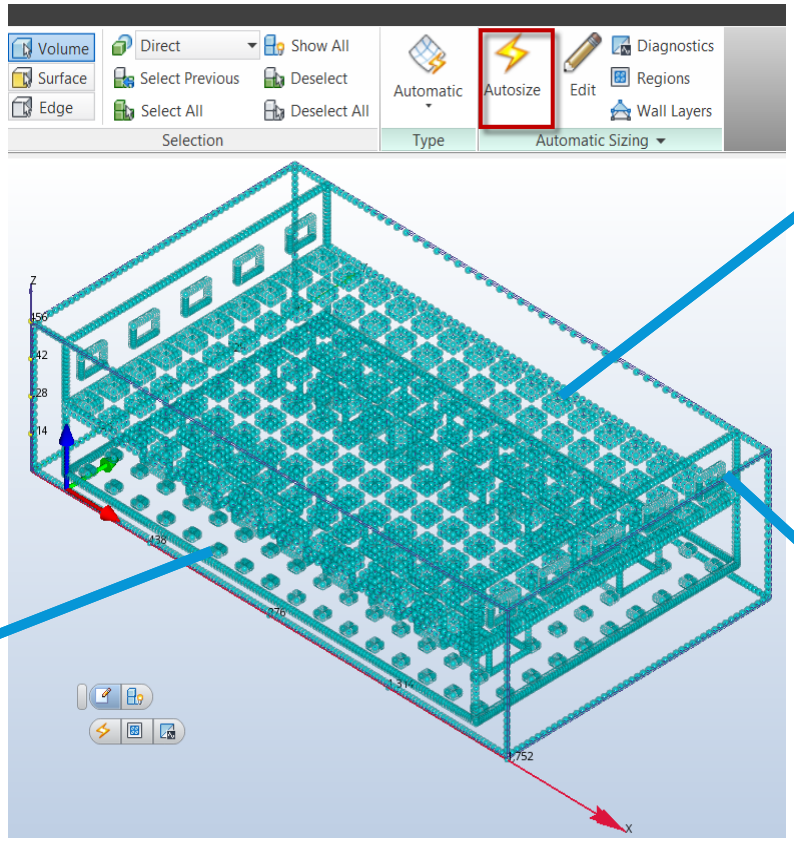


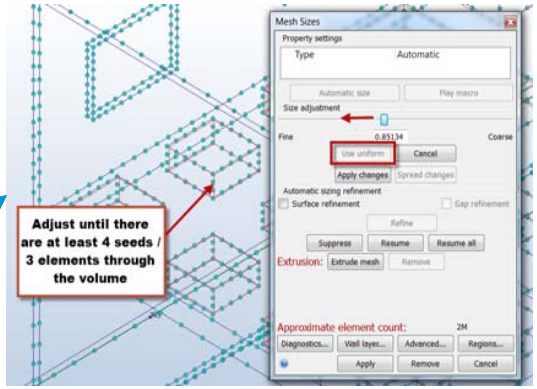
Adjust Mesh Settings Below Model Minimum Dimension

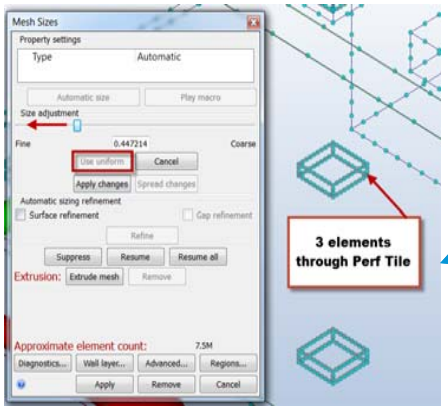


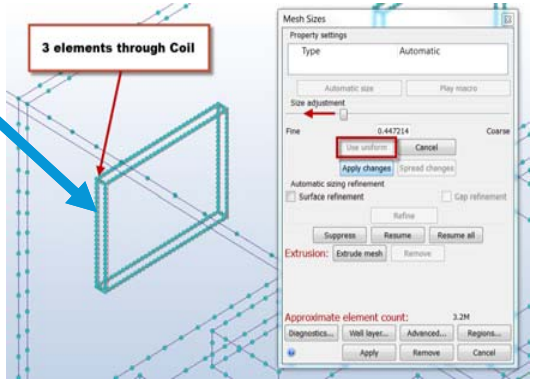
Autosize & Refine The Mesh

***Tip**: Refine the mesh on resistance volumes and internal fans to get at least 3-4 mesh elements minimum.*



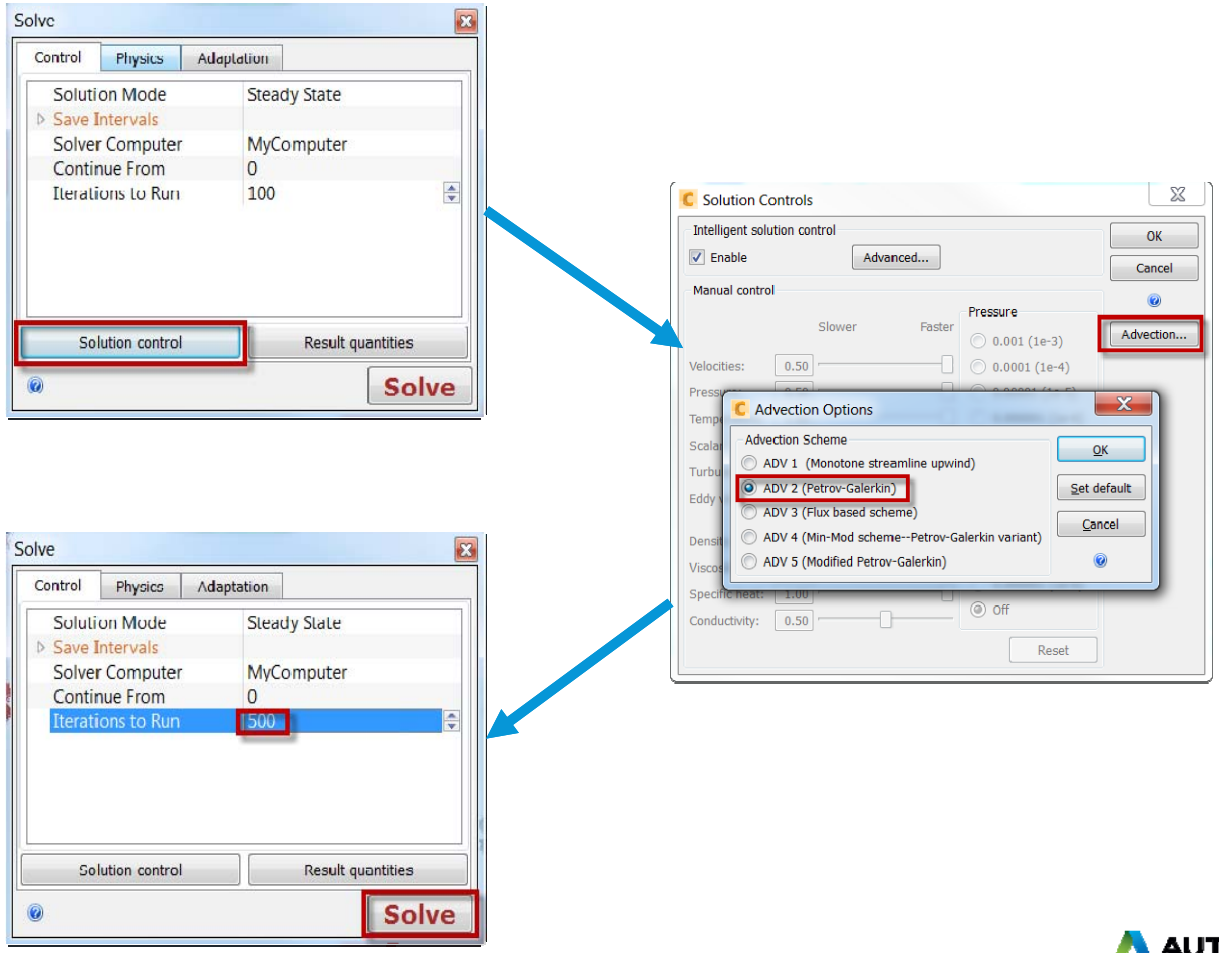




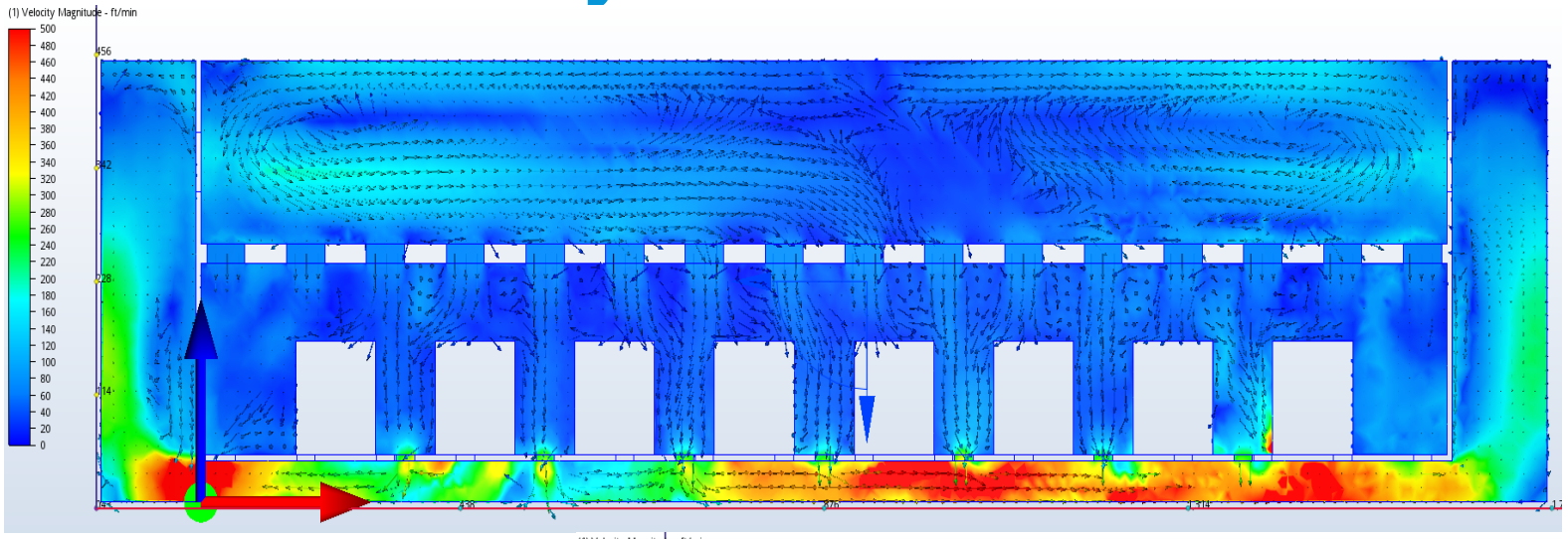


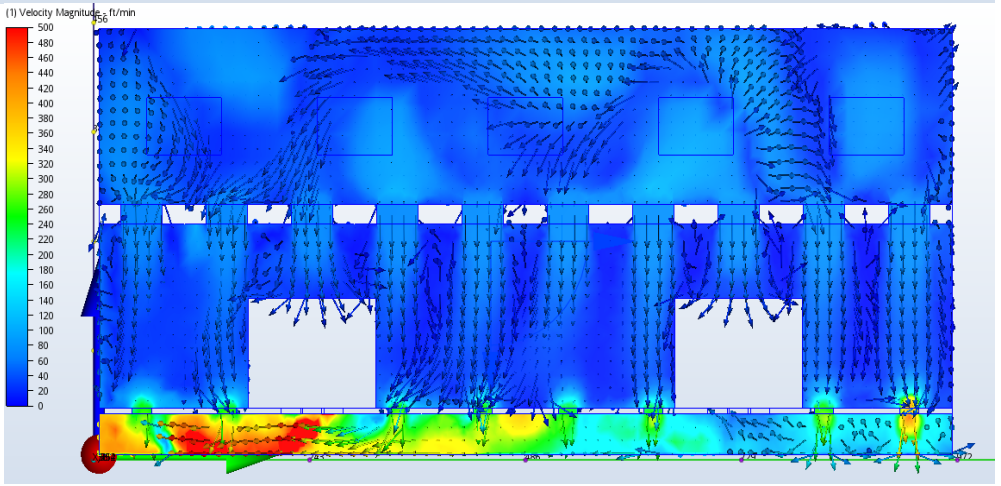
Solve The CFD Analysis Flow Model

Tip: *Preliminarily run for only a couple of iterations to check for errors and flow direction.*



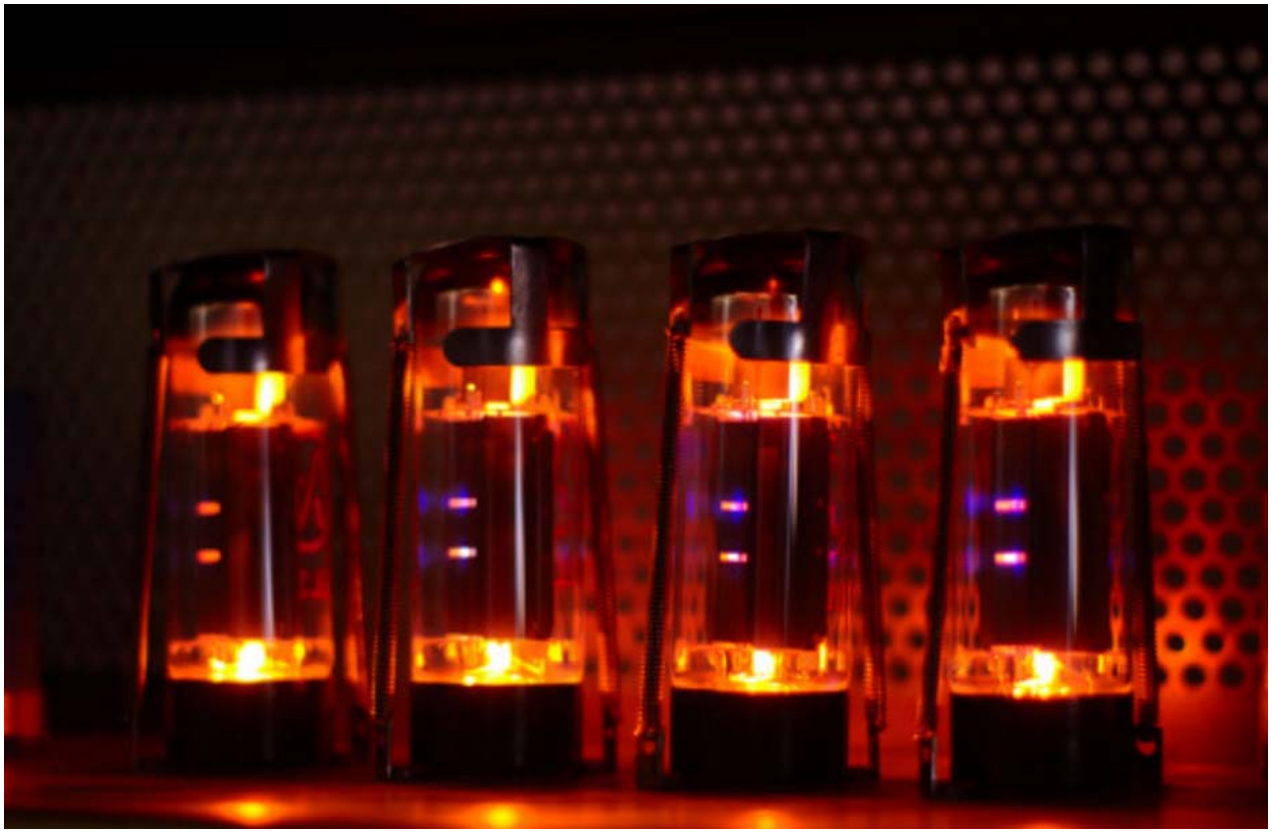
View the CFD Analysis Results





Tip: *Results Planes are a simple and powerful visualization tools.*

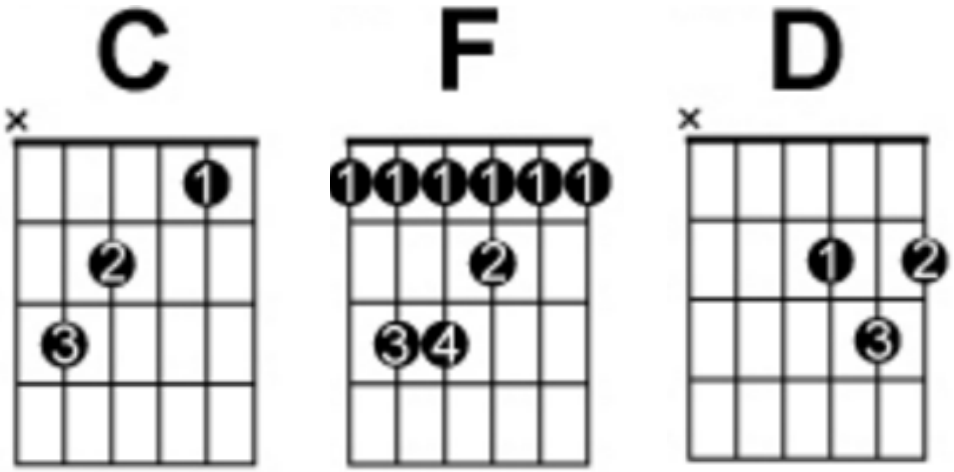
Time To Rock The Demo…



Quiz

- What does FFU and RMF stand for?
- What was the minimum CFD Revit model dimension?
- What is the recommended CFD mesh element quantity through a resistance volume or internal fan?
- What is the amp manufacturer model basis for the Autodesk wall of rock on the Key Learning Objectives slide?

Questions



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