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GEN3 VIP

Gen3 Long Life High Performance Vacuum Insulation Panel

For Construction Applications

Innovations in Product Development

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GEN3 VIP Background

- Gen3 is a new VIP product with proven feasibility given the details presented herein
- Gen3 is based on the successful features of Owens Corning Aura® VIP with proprietary differences that make it better and less expensive.
- The Aura® VIP was conceived, developed, and produced by the author during his tenure at Owens Corning Science and Technology Center
- Aura® VIP were used in refrigerators sold by Whirlpool Corporation© from 1994 to 1996

GEN3 VIP Stage of Development

- Gen3 Production realization requires partnerships and financial backing
- Gen3 could be available within a year following completion of all agreements and confidentialities
- Gen3 has passed the concept and feasibility gates
- The next gate is Development – Release to Production
- Engineering through pilot build and production phase is available from the author
- A thin 0.1 U (SI) very long life VIP appears within striking distance

GEN3 VIP Construction Features

- High performance glass fiber core
- Stainless steel foil primary envelope
  - Foil can be 63 or 76 microns thick
  - Foil envelope is hermetic
  - Low conductivity foil reduces heat shunting
- Vacuum maintenance
  - Getter A Controls foil outgas
  - Getter B Controls core outgas
- Vacuum level is medium
- Secondary enclosure prevents punctures

GEN3 VIP Design Gates

- Provides an effective R56.8 (10 RSI or 0.10 USI) in a thickness about 2 inches (50mm) ? YES
- Provides R-value stability over the 50 to 100 year life of the building? YES
- Can survive construction and service environments? YES
- Achieves excellent value for the contractor and building owner at target £ 30/m² ($4.54/ft²)? YES
- Can produce VIP with the simplicity, speed, and 100% quality control to achieve the needed economy of scale and price? YES

GEN3 VIP Walk the Walk Agenda!

- Glass fiber COP Resistivity Physics
  - Model
  - Test data
- Estimates of Gen3 Effective R-value, R_e
  - 3D Model
  - Model output and extrapolations
  - Benefits of stainless steel foil
- Gen3 Predicted Life
  - Aged Aura® VIP and life factors
  - Enclosure concepts to survive the job site
- Value, Process, and Path Forward
- Acknowledgements and Questions

GEN3 VIP Physics

- Model of highly laminar pack structures from first principles
- Pressure range between 100 and 1000 milliTorr
- Response plot of Center of Panel (COP) R per inch (1/K)
- Plots showing comparison of model to data
- Test data

GEN3 VIP Physics

k_{rad} , Radiation heat transfer

k_{conv} , Convective heat transfer

k_{gas} , Gas conduction

k_{sol} , Solid conduction

k , Composite thermal conductivity of glass fiber core at 75 deg F

All thermal conductivity values are in Btu-in/hr-degF-ft^2

C_{sc} , Solid conduction coefficient, Btu-in/hr-degF-ft^2/ lb/ft^3

C_{rad} , radiation conductivity coefficient, Btu-in/hr-degF-ft^2- lb/ft^3

ρ_c , Core density, lb/ft^3

GEN3 VIP Physics

k_{gc} , Reduced conductivity of free gas by pore interference (kinetic theory)

k_f , Solid glass thermal conductivity

x_v , Void fraction, dimensionless

x_s , Solid fraction = $\frac{\rho_c}{\rho_g}$, dimensionless (5)

ρ_g , Bulk glass density, lb/ft^3

Note,

$$x_v = 1 - x_s \quad (6)$$

k_g , Thermal conductivity of air

L_f , Effective pore size of insulation core, HT

D_e , Effective core fiber diameter, HT

D , Is the mean fiber diameter and C_v is the coefficient of variation

L_g , Mean free path of air = $0.538T/P$, HT (10)

GEN3 VIP Physics

$$k = k_{rad} + k_{conv} + k_{gas} + k_{sol}$$

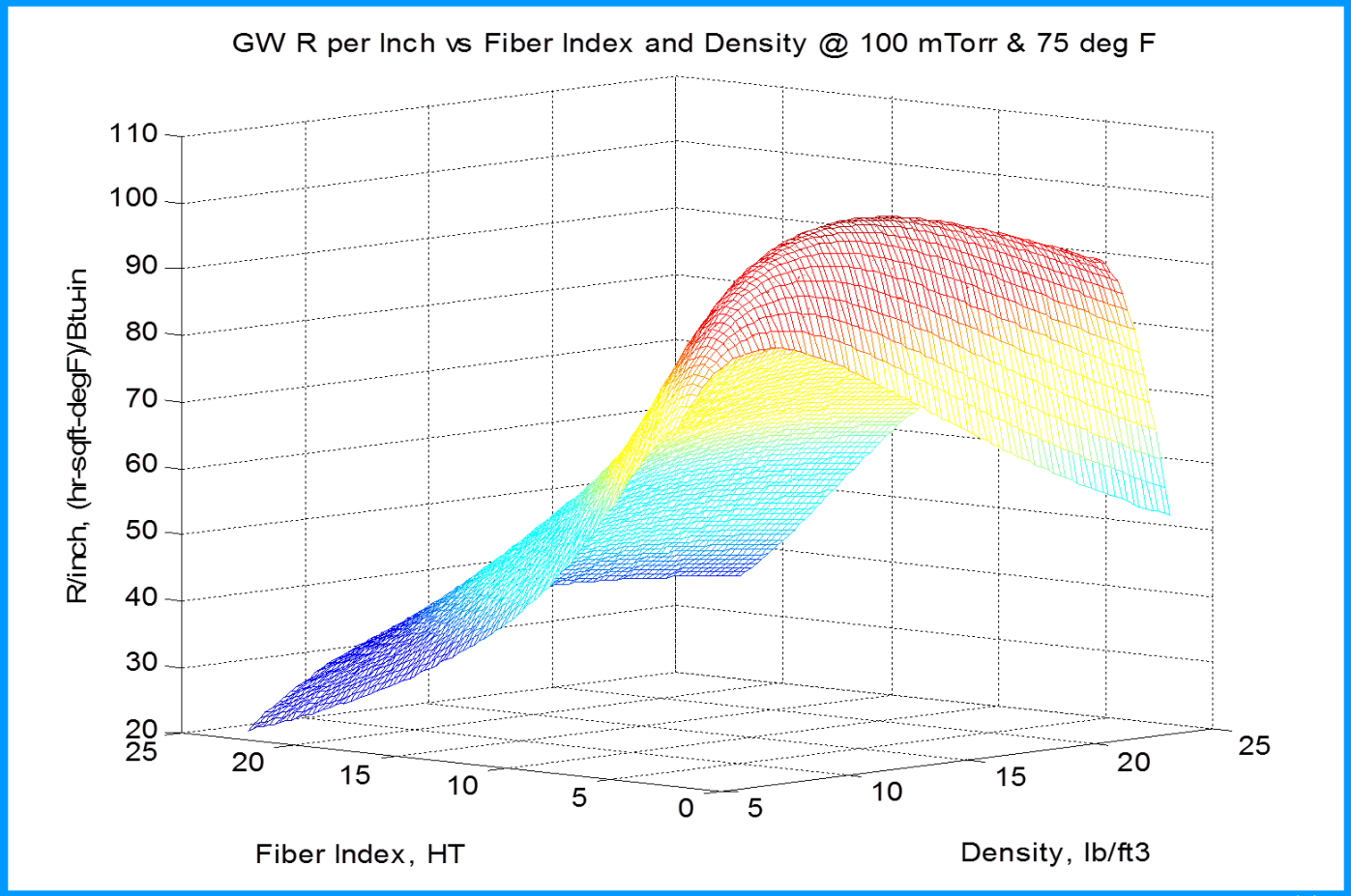
$$k = k_{sol} + k_{gas} + k_{rad}$$

$$k_{sol} = C_{sc}\rho_c \qquad k_{gas} = \frac{k_{gc}k_f}{k_f x_v + k_{gc} x_s} \qquad k_{rad} = \frac{C_{rad}}{\rho_c}$$

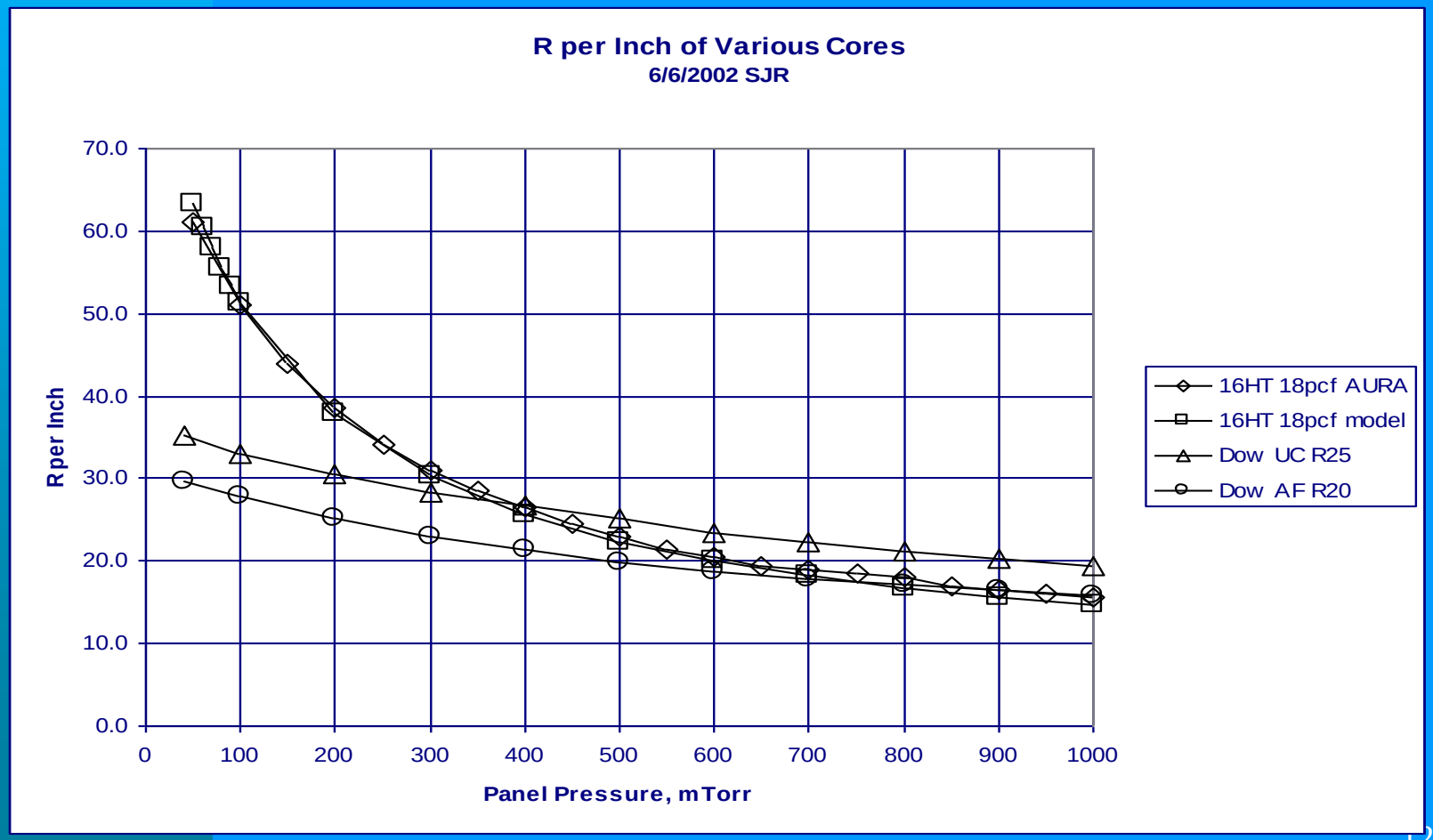
$$k_{gc} = \frac{k_g L_f}{L_f + L_g} \qquad L_f = \frac{\pi D_e}{4 x_s}$$

$$D_e = D\left(1 + \left(\frac{Cv}{100}\right)^2\right)$$

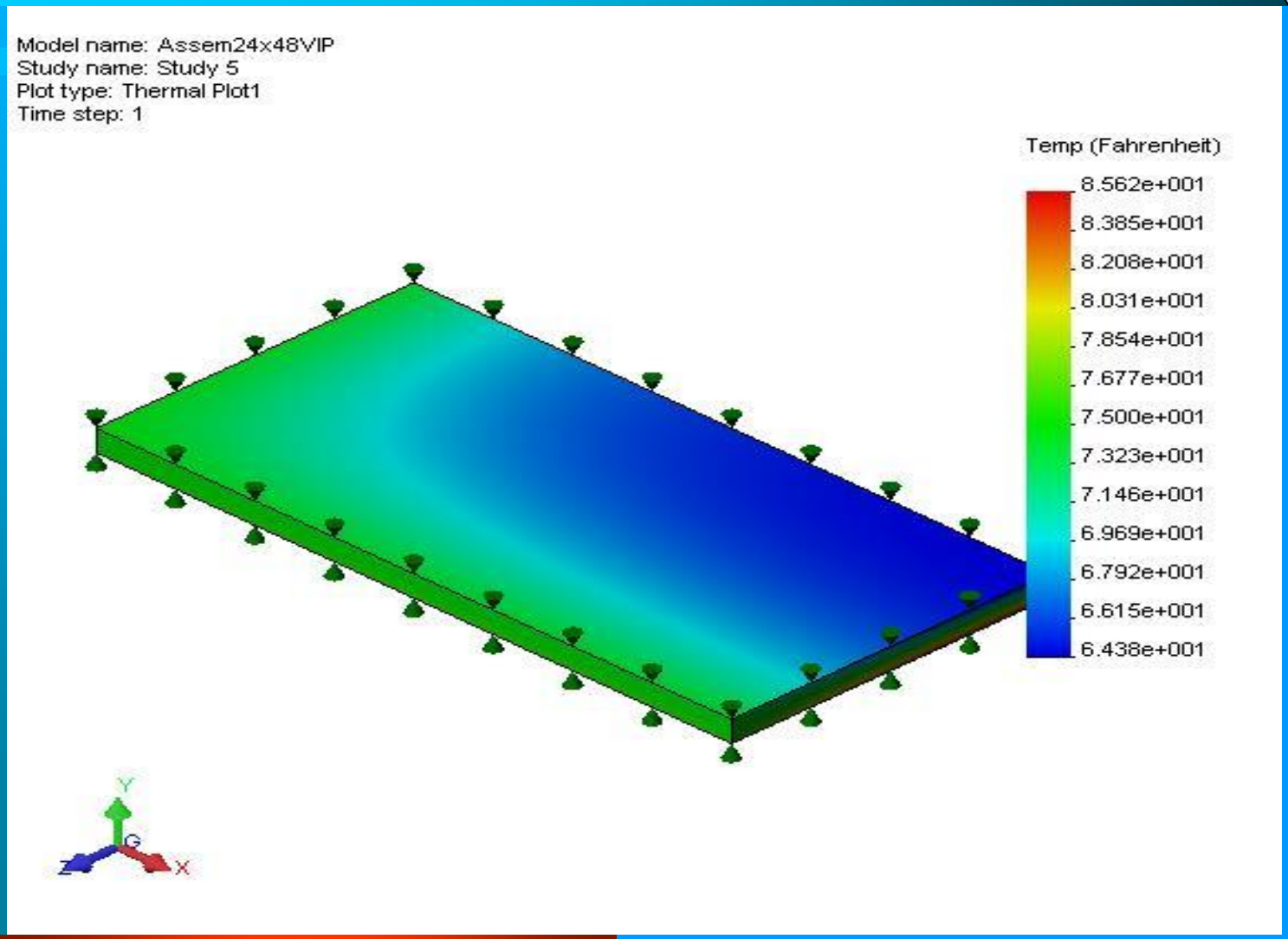
GEN3 VIP Physics COP R per Inch



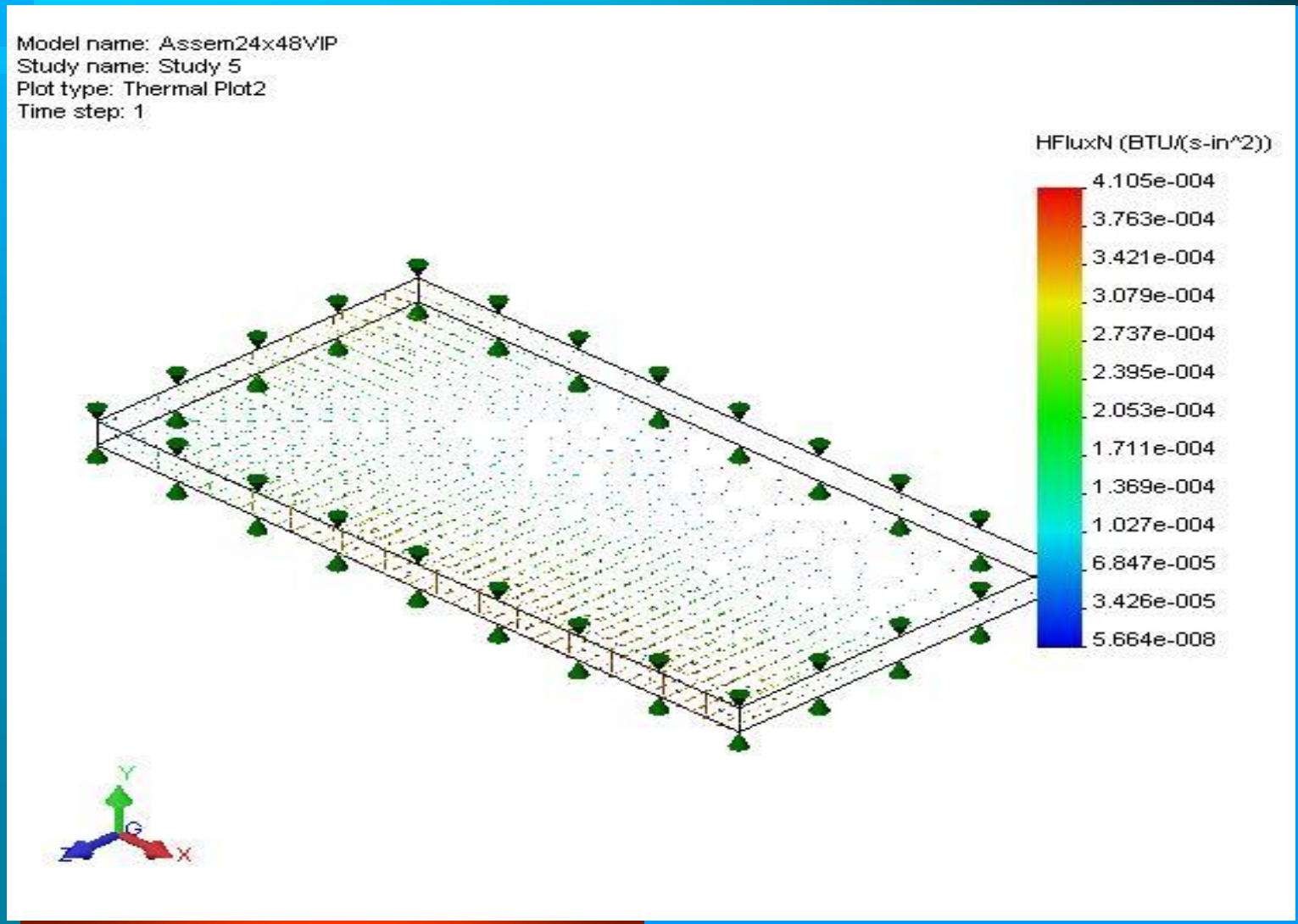
GEN3 VIP Core Performance vs. Model



GEN3 VIP 3D Temperature Output



GEN3 VIP 3D Heat Flux Output



GEN3 VIP Effective R_e (US) Calculation

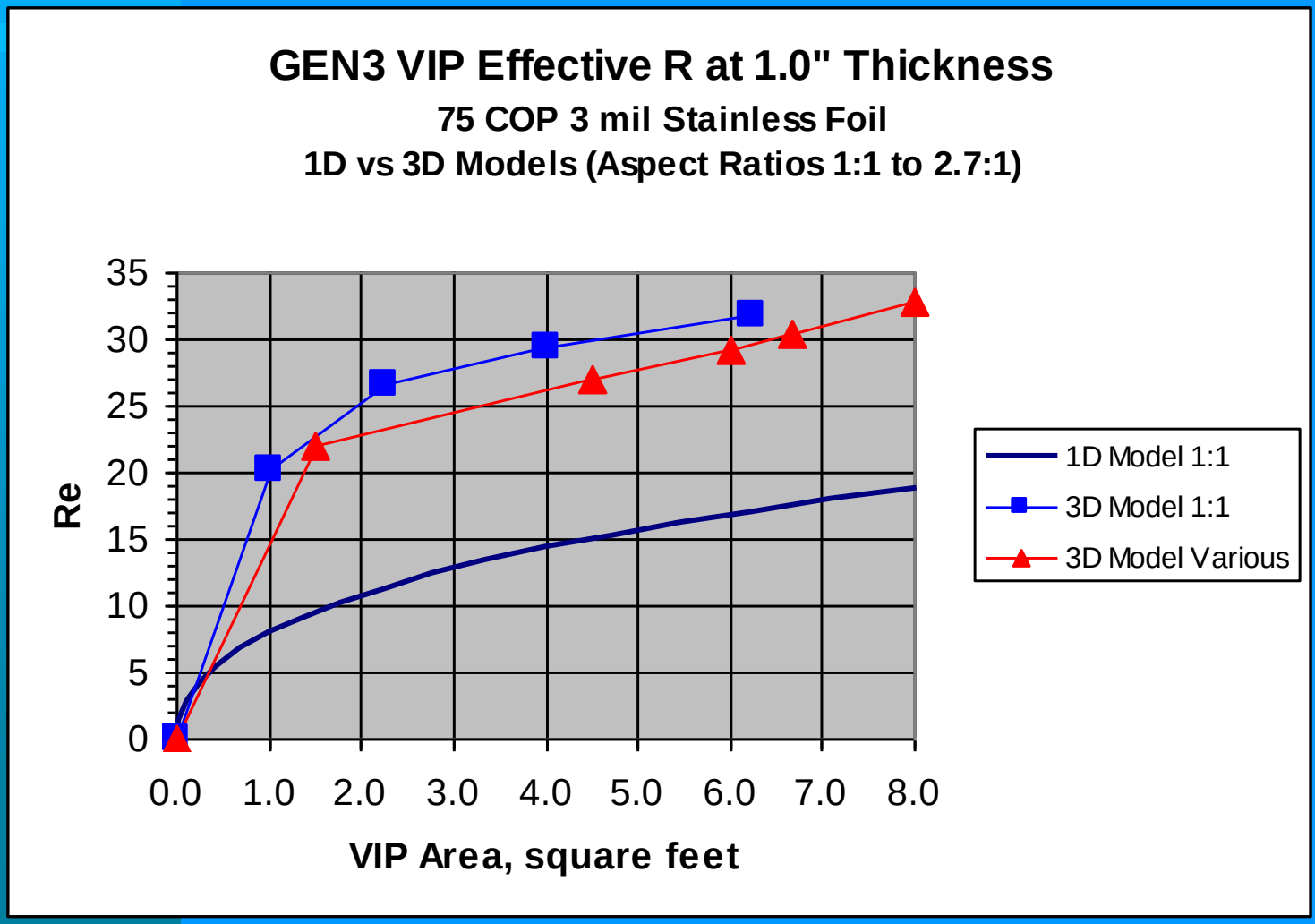
$R_e = (AREA) \times (\Delta T)/Q$

56.8 R (US) is the goal

GEN3 VIP 3D Cases R_e (US) Model 1.0”

Aspect Ratio	Side, in	Side, in	Area,Ft2	Re
1.0	0	0	0.0	0.0
1.0	12	12	1.0	20.2
1.0	18	18	2.3	26.6
1.0	24	24	4.0	29.5
1.0	30	30	6.3	31.9
6.0	0	0	0.0	0.0
6.0	6	36	1.5	22.1
2.0	18	36	4.5	27.0
2.7	18	48	6.0	29.2
2.4	20	48	6.7	30.5
2.0	24	48	8.0	32.9

GEN3 VIP Plot of 3D Cases



GEN3 VIP Estimates for 56.8 R (US)

Width, in	Length, in	Re/inch	Inches for 56.8	Area, ft2
18.00	36.00	27.00	2.10	4.50
18.00	48.00	29.20	1.95	6.00
20.00	48.00	30.50	1.86	6.67
24.00	48.00	32.90	1.73	8.00
24.00	54.00	34.56	1.64	9.00
24.00	60.00	36.22	1.57	10.00
24.00	66.00	37.88	1.50	11.00
24.00	72.00	39.55	1.44	12.00
24.00	78.00	41.21	1.38	13.00
24.00	84.00	42.87	1.32	14.00
24.00	90.00	44.53	1.28	15.00
24.00	96.00	46.19	1.23	16.00

GEN3 VIP Stainless Foil Benefits

- Type 201L Stainless
  - Available in 2.5 and 3.0 mils thicknesses (63 and 76 µ)
  - Pinhole free
  - Low thermal conductivity
  - Cost effective, tough, and it works
- Aluminum vs. Stainless K x T Discussion
  - Minimum edge heat requires minimum K x T
  - K = thermal conductivity; T = foil thickness
  - Pinhole free Al foil must be >= 1.0 mils thick (25 µ)
  - K x T for 3 mil 201L Stainless = 339
  - K x T for 1 mil Al foil = 1629 or 5X higher!
  - The 1D Calculator appears at the end of this presentation

GEN3 VIP Aura® at Age 14+

TR#: 90550
Date: 7/2/2009
Tester: Mark Mantonya
Method: ASTM C518
Equipment: Fox 1,2,3 LaserComp
Meter Area: 10"x10"
Material: **Aura Panels from 1995**
No.Layers Tested: 1

OWENS CORNING SCIENCE & TECHNOLOGY CENTER
2790 Columbus Road
Granville, Ohio 43023-1200
740.321.5000

Sample I.D.	Total Test Thick. in.	Test Temp Hot, °F	Test Temp Cold, °F	Test Temp Mean, °F	K-Value BTU·in / hr·ft^2·°F	R-Value hr·ft^2·°F/ BTU	Machine	R/in
Aura Panel 1	1.10	95.03	55.03	75.03	0.01551	70.92	Fox 1	64.47453
Aura Panel 2	1.11	95.03	55.03	75.03	0.009909	112.02	Fox 3	100.9184
Aura Panel 3	1.09	95.03	55.03	75.03	0.009765	111.21	Fox 4	102.4066
Aura Panel 2	1.10	95.03	55.03	75.03	0.01197	91.81	Fox 1	83.54219
Aura Panel 1	1.10	95.03	55.03	75.03	0.01039	105.77	Fox 3	96.24639

AVERAGE 89.5176
AGE 14 years+

GEN3 VIP Protective Enclosures

- Cons
  - Pr
  - Us
  - Fo
- How

GEN3 VIP Aura® Photo

GEN3 VIP SUMMARY

- **Value Proposition**
  - The Architect gets a system that provides design flexibility and simplicity
  - The Contractor gets a dependable consistent product that installs correctly every time using minimum SKUS
  - The Customer gets long life high performance at a reasonable price
  - Low energy buildings improve the environment
- **Process Details**
  - Author's expertise in VIP is a key to success of Gen3
  - Process and materials are proprietary
- **Path Forward Requires a Solid Partnership**

GEN3 VIP Acknowledgements

- Owens Corning Science and Technology Center
  - Neil Hettler; Building Systems Leader
  - Jerry Parks; HVAC Systems Engineer
  - Mark Montonya; Thermal Testing Lab Services
  - James Dottavio; Intellectual Property Counsel
- Mary Christine Rusek
  - The author is currently the R&D Leader at Quietflex Goodman Global Amana in Houston, Texas developing new products for the HVAC industry
  - MS in Chemical Engineering U of Dayton, Ohio, USA
  - BChe in Chemical Engineering U of Dayton, Ohio, USA
  - 25 years of service at the Owens Corning Science and Technology Center, Granville, Ohio, USA
  - Holds 14 US Patents, 8 of these on the Aura® VIP
  - R&D 100 Award Winner

GEN3 VIP Questions?

- Thank you for your attention!
- What is your interest in Gen3?
- Please take a business card and contact me if you have more questions or need more information.

GEN3 VIP Effective R One D Model Calculator

1 D parallel flow model calculator for foil edge panels						SJR	8/7/2009		
MATERIALS								k	Btu-in
barrier type		201L Stainless Steel						201L Stai	113.02
barrier thickness		0.0030	in	76.2	mic	3.00	mils	Al Foil Co	1629.4
barrier R		0.0088	R					Al Pure	1525.39
barrier k		113.02	µ-in	16.30	w/mK				
insulation type									
insulation thickness		2.00	in	50.8	mm			Thick	in
insulation COP R/in		75.00	R/in	520.11	mK/w			SS foil	0.003000
insulation k		0.0133	Btu-in	1.9227	milli-w/mK			SS foil	0.002500
PANEL SIZE								SS foil	0.002000
Length		24	in	0.61	m			Al foil	0.001000
Width		24	in	0.61	m			Al foil	0.000750
								Al foil	0.000500
								Al foil	0.000350
PARALLEL HEAT FLOW CALCULATOR								Al foil	0.000285
DELTA T =		40	degF					Al met 2L	0.000014
Re = DELTA T * TOTAL AREA / TOTAL HEAT FLOW								Al met 3L	0.000020
Ai	4.00000E+00	sqft							
Af	2.00025E-03	sqft	At	4.00200E+00	sqft				
Q i	1.07	Btu/hr							
Qf	4.52	Btu/hr							
Q sum	5.59	Btu/hr							
R_e	28.65	R							
R_e	5.04	RSI							
U_e	0.198	USI							
TARGET IS 56.8 R or 10 RSI