

Discussion and re-evaluation of recent research on pressure ingress into a room from an opening

Appendices (Supplementary Material)

Appendix A - UFC Predictions for Codina & Ambrosini's Experiments

This appendix provides step-by-step calculations using the methods detailed in UFC 3-340-02 Section 2-15.4 to predict the interior side and back wall loading of the cubicle of Codina and Ambrosini's (2018, 2019) experiments as defined by Table_Apx A-1. Test 1 is detailed in section A.1 and Test 2 in A.2. Test 3 is excluded, as the charge was positioned off the building centre axis and is not covered by the UFC. As in the UFC, the calculations use imperial units but are converted to SI units for the paper body.

Table_Apx A-1 Building and Blast Parameters for Codina and Ambrosini experiment

	Test 1	Test 2
Building Parameters		
Width, W (ft)	8.66	
Height, H (ft)	7.28	
Length, L (ft)	8.66	
Opening area, A _o (ft ²)	6.89	
Facade area, A _w (ft ²)	63.09	
Blast Parameters		
TNT equivalent charge weight, W (lb).	2.20	11.02
Standoff distance, R (ft).	49.21	82.02
Scaled distance, Z (=R/W ^{0.33}) (ft/lb ^{0.33}).	37.81	36.85
Peak incident overpressure, P _{so} (psi).	1.25	1.30
Incident impulse, i _s (psi.ms).	3.06	5.34
Duration of positive phase, t ₀ (ms).	5.20	9.12
Time of arrival of blast wave, t _A (ms).	34.49	56.75
Shock front velocity, U (ft/ms).	1.15	1.15
Wavelength of positive phase, L _w (ft).	5.33	9.12
Therefore, for calculation purposes:		
W/H =	1.19	

$L/H =$	1.19	
$L_W/L =$	0.62	1.05
$A_o/A_w =$	0.11	

A.1 – Test 1

Parameters are $P_{so} = 1.25\text{psi}$, $A_o/A_w = 0.11$, $L_W/L = 0.62$, $L/H = 1.19$

Step 1. Calculate side wall peak overpressure P_{max} for $W/H = 1.5$ using UFC eq. (2-16) for $1.5 \leq W/H \leq 6$, with Test 1 parameters

$$A = [0.002 \cdot 1.5^{1.4467}] - 0.0213 = -0.0177 \quad \text{A.1-1}$$

$$B = 2.2075 - [1.902 \cdot 1.5^{-0.085}] = -0.3699 \quad \text{A.1-2}$$

$$C = 1.231 + [0.0008 \cdot 1.5^{2.678}] = 1.2334 \quad \text{A.1-3}$$

$$D = [2.573 \cdot 1.18^{-0.444}] - 0.3911 = 1.9996 \quad \text{A.1-4}$$

$$E = 0.4221 + [1.241 \cdot 0.11^{0.367}] = 0.9741 \quad \text{A.1-5}$$

$$K = [-0.0177 + (-0.3699 \cdot (0.62^{1.2334}))] \cdot 1.9996 \cdot 0.9741 \cdot 1.25^{1.025} \\ = 0.4846 \quad \text{A.1-6}$$

$$P_{max} = 0.4846/0.62 = 0.781\text{psi} \quad \text{A.1-7}$$

Step 2. Calculate side wall peak overpressure P_{max} for $W/H = 0.75$ using UFC eq. (2-22) for $W/H = 0.75$, with Test 1 parameters

$$A = [0.5422 \cdot 0.62^{1.2944}] - 0.001829 = 0.2902 \quad \text{A.1-8}$$

$$B = [0.654 + 2.616 \cdot 0.11 - 4.928 \cdot 0.11^2] \cdot [2.209 \cdot 1.18^{-0.3451} - 0.739] \\ = 1.1885 \quad \text{A.1-9}$$

$$C = 0.829 + 0.104 \cdot 0.62^{1.6} + [0.00124 + 0.00414 \cdot 0.62^{3.334}] \\ \cdot (1.18)^{2.5707} = 0.8806 \quad \text{A.1-10}$$

$$D = 2.579 - 0.0534 \cdot 0.62^{3.891} = 2.5656 \quad \text{A.1-11}$$

$$E = 999 \cdot 0.11^{9.964} = 0.00000028054 \quad \text{A.1-12}$$

$$F = 1.468 - 1.6627 \cdot (0.11)^{0.7801} + [1.8692 - 1.1735 \cdot (0.11)^{-0.2226}] \\ \cdot 0.62)^G = 1.1692 \quad \text{A.1-13}$$

$$G = 0.2979 \cdot 0.11^{-1.4872} - 0.8351 = 7.1029 \quad \text{A.1-14}$$

$$H = 5.425 \cdot 10^{-4} + 1.001 \cdot 10^{-9} \cdot 1.18^{9.965} = 0.00054251 \quad \text{A.1-15}$$

$$K = 0.2902 \cdot 2.1832 \cdot 0.8807^{0.0000002805} \cdot 1.1692^{0.00054} \cdot 1.25^{0.9718} \\ = 0.4285 \quad \text{A.1-16}$$

$$P_{max} = 0.4285/0.62 = 0.691\text{psi} \quad \text{A.1-17}$$

Step 3. Obtain P_{max} for $W/H = 1.18$ using linear interpolation of P_{max} from Steps 1 and 2

$$P_{max} = 0.691 + \frac{(1.18 - 0.75) \cdot (0.782 - 0.691)}{(1.5 - 0.75)} = 0.743 \text{psi} = 5.12 \text{kPa}$$

Step 4. Find the idealised interior side wall loading time parameters T_1 and T_2 using linear interpolation of UFC Figure 2-13 for $W/H = 1.18$ and $P_{so}=1.25\text{psi}$

For $W/H= 0.75$, $T_1=2.61\text{msec}$ and for $W/H= 1.5$, $T_1=6.73\text{msec}$, so for $W/H=1.18$:

$$T_1 = 2.61 + \frac{(1.18 - 0.75) \cdot (6.73 - 2.61)}{(1.5 - 0.75)} = 4.97 \text{s}$$

For $W/H= 0.75$, $T_2=4.37\text{msec}$, for $W/H= 1.5$, $T_2=8.51\text{msec}$, so for $W/H=1.18$:

$$T_2 = 4.37 + \frac{(1.18 - 0.75) \cdot (8.51 - 4.37)}{(1.5 - 0.75)} = 6.74 \text{s}$$

Step 5. Find the interior side wall loading time parameter T_3 for $L/H=1$, and $W/H=3/4$ using linear extrapolation of UFC Figure 214A, for $P_{so}=1.25\text{psi}$ as in Figure Apx A-1.

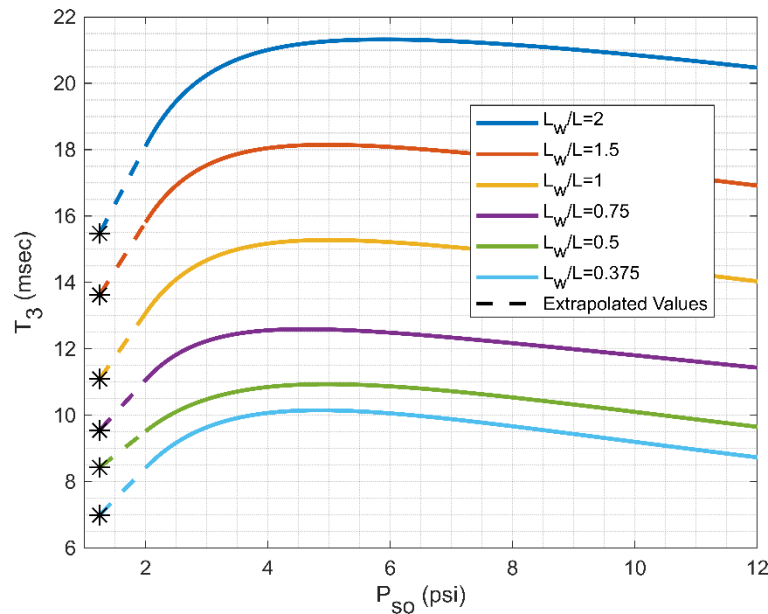


Figure Apx A-1 – T_3 , $P_{so}=1.25\text{psi}$ UFC extrapolated solutions for $L/H=1$, $W/H=3/4$

In this step, for $L_w/L = 0.5$, $T_3=8.43\text{msec}$ and for $L_w/L = 0.75$, $T_3=9.55\text{msec}$

Step 6 – Use linear extrapolation to find T_3 for $L/H=1$, $W/H=3/2$ from UFC Figure 215A, for $P_{so}=1.25\text{psi}$.

In this step, for $L_w/L = 0.5$, $T_3=10.64\text{msec}$ and for $L_w/L = 0.75$, $T_3=12.39\text{msec}$

Step 7 – Use linear extrapolation to find T_3 for $L/H=2$, $W/H=3/4$ from UFC Figure 218A, for $P_{so}=1.25\text{psi}$.

In this step, for $L_w/L = 0.5$, $T_3=10.37\text{msec}$ and for $L_w/L = 0.75$, $T_3=13.09\text{ msec}$

Step 7 – T_3 for $L/H=2$, $W/H=3/2$ from UFC Figure 219A, for $P_{so}=1.25\text{psi}$ using linear extrapolation.

In this step, for $L_w/L = 0.5$, $T_3=12.67\text{msec}$ and for $L_w/L = 0.75$, $T_3=16.53\text{ msec}$

Step 8 – T_3 for $L_w/L=0.63$, $L/H=1$, using linear interpolation.

In this step, for $W/H=0.75$ using T_3 from Step 5:

$$T_3 = 8.43 + \frac{(0.63 - 0.5) \cdot (9.55 - 8.43)}{(0.75 - 0.5)} = 9.01\text{msec}$$

And for $W/H=1.5$ using T_3 from Step 6:

$$T_3 = 10.64 + \frac{(0.63 - 0.5) \cdot (12.39 - 10.64)}{(0.75 - 0.5)} = 11.55\text{msec}$$

Step 9 – T_3 for $L_w/L=0.63$, $L/H=2$, using linear interpolation.

In this step, for $W/H=0.75$ using T_3 from Step 7:

$$T_3 = 10.37 + \frac{(0.63 - 0.5) \cdot (13.08 - 10.37)}{(0.75 - 0.5)} = 11.78\text{msec}$$

And for $W/H=1.5$ using T_3 from Step 8:

$$T_3 = 12.67 + \frac{(0.63 - 0.5) \cdot (16.53 - 12.67)}{(0.75 - 0.5)} = 14.68\text{msec}$$

Step 10 – T_3 for $W/H=1.18$, using linear interpolation.

In this step, for $L/H=1$ using T_3 from Step 8:

$$T_3 = 9.01 + \frac{(1.18 - 0.75) \cdot (11.55 - 9.01)}{(1.5 - 0.75)} = 10.47msec$$

And for $W/H=1.5$ using T_3 from Step 9:

$$T_3 = 11.78 + \frac{(1.18 - 0.75) \cdot (14.68 - 11.78)}{(1.5 - 0.75)} = 13.44msec$$

Step 11 – T_3 for $L/H=1.18$, using linear interpolation.

Therefore, using T_3 from Step 10:

$$T_3 = 10.47 + \frac{(1.18 - 1) \cdot (13.44 - 10.47)}{(2 - 1)} = 11.00msec$$

Step 12 – T_4 for $L/H=1$, $W/H=3/4$ from UFC Figure 214B, for $P_{so}=1.25psi$ using linear extrapolation.

In this step, for $L_w/L= 0.5$, , $T_3=21.53msec$ and for $L_w/L= 0.75$, $T_3=28.72msec$

Step 13 – T_4 for $L/H=1$, $W/H=3/2$ from UFC Figure 215A, for $P_{so}=1.25psi$ using linear extrapolation.

In this step, for $L_w/L= 0.5$, $T_3=25.93msec$ and for $L_w/L= 0.75$, $T_3=33.14msec$

Step 14 – T_4 for $L/H=2$, $W/H=3/4$ from UFC Figure 218A, for $P_{so}=1.25psi$ using linear extrapolation.

In this step, for $L_w/L= 0.5$, $T_3=41.24msec$ and for $L_w/L= 0.75$, $T_3=53.32msec$

Step 15 – T_4 for $L/H=2$, $W/H=3/2$ from UFC Figure 219A, for $P_{so} = 1.25psi$ using linear extrapolation.

In this step, for $L_w/L= 0.5$, $T_3=59.83msec$ and for $L_w/L= 0.75$, $T_3=68.71msec$

Step 16 – T_4 for $L_w/L=0.63$, $L/H=1$ using linear interpolation.

In this step, for $W/H=0.75$ using T_4 from Step 12:

$$T_4 = 21.53 + \frac{(0.63 - 0.5) \cdot (28.72 - 21.53)}{(0.75 - 0.5)} = 25.27msec$$

And for W/H=1.5 using T_4 from Step 13:

$$T_4 = 25.93 + \frac{(0.63 - 0.5) \cdot (33.14 - 25.93)}{(0.75 - 0.5)} = 29.68msec$$

Step 17 – T_4 for $L_w/L=0.63$, $L/H=2$ using linear interpolation.

In this step, for W/H=0.75 using T_4 from Step 14:

$$T_4 = 41.24 + \frac{(0.63 - 0.5) \cdot (29.68 - 41.24)}{(0.75 - 0.5)} = 47.52msec$$

And for W/H=1.5 using T_4 from Step 15:

$$T_4 = 59.83 + \frac{(0.63 - 0.5) \cdot (68.71 - 59.83)}{(0.75 - 0.5)} = 64.45msec$$

Step 18 – T_4 for W/H=1.18, using linear interpolation.

In this step, for L/H=1 using T_4 from Step 16:

$$T_4 = 25.27 + \frac{(1.18 - 0.75) \cdot (29.39 - 25.27)}{(1.5 - 0.75)} = 27.80msec$$

And for L/H=2 using T_4 from Step 17:

$$T_4 = 47.52 + \frac{(1.18 - 0.75) \cdot (64.45 - 47.52)}{(1.5 - 0.75)} = 57.23msec$$

Step 19 – T_4 for L/H=1.18, using linear interpolation.

Therefore, using T_4 from Step 18:

$$T_4 = 27.80 + \frac{(1.18-1) \cdot (57.23-27.80)}{(2-1)} = 33.10s$$

Step 20 – Test 1 calculated side wall results are detailed in Table_Apx A-2

Table_Apx A-2 – Summary results for Test 1 side wall using the UFC method

Parameter	Value
$P_{\max}$	0.74 psi
T_1	4.97 msec
T_2	6.74 msec
T_3	11.00 msec
T_4	33.1 msec

Step 21 – P_{RIB}/P_{so} for $L/H=1$, from UFC Figure 230A, for $P_{so}=1.25$ psi using linear extrapolation.

In this step, for $A_o/A_w = 1/8$, $P_{RIB}/P_{so} = 0.76$ and for $A_o/A_w = 3/16$, $P_{RIB}/P_{so} = 0.88$

Step 22 – P_{RIB}/P_{so} for $L/H=2$, from UFC Figure 230B, for $P_{so}=1.25$ psi using linear extrapolation.

In this step, for $A_o/A_w = 1/8$, $P_{RIB}/P_{so} = 0.54$ for $A_o/A_w = 3/16$, $P_{RIB}/P_{so} = 0.66$

Step 23 – P_{RIB}/P_{so} for $A_o/A_w=0.11$, using linear extrapolation.

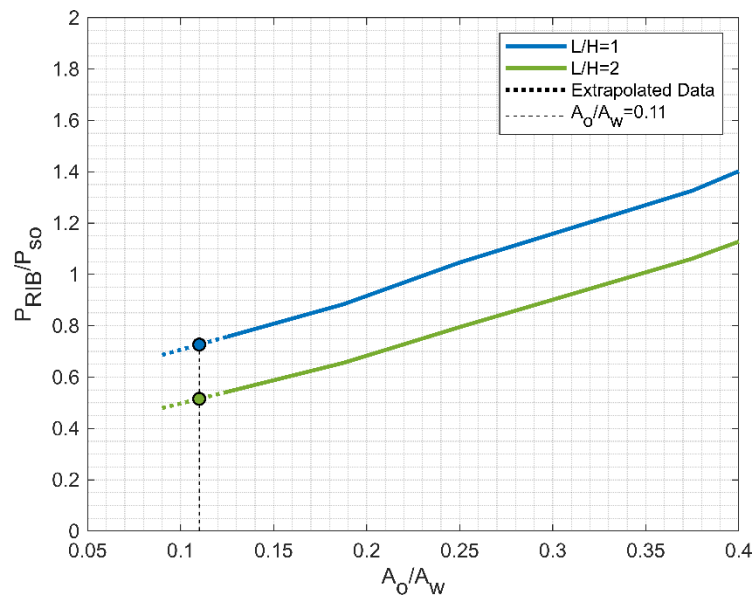


Figure Apx A-2 – P_{RIB}/P_{so} , extrapolated solutions of $A_o/A_w=0.11$ for $P_{so}=1.25$ psi, $L/H=1,2$

In this step, for $L/H=1$ using P_{RIB}/P_{so} from Step 21:

$$\frac{P_{RIB}}{P_{so}} = 0.76 + \frac{(0.11 - 0.125)}{(0.1875 - 0.125)} \cdot 0.11(0.88 - 0.76) = 0.76$$

And for L/H=2 using P_{RIB}/P_{so} from Step 22:

$$\frac{P_{RIB}}{P_{so}} = 0.54 + \frac{(0.11 - 0.125)}{(0.1875 - 0.125)} \cdot 0.11(0.66 - 0.54) = 0.54$$

Step 24 – P_{RIB}/P_{so} for L/H=1.18 using linear interpolation.

Therefore, T_4 using P_{RIB}/P_{so} from Step 23:

$$\frac{P_{RIB}}{P_{so}} = 0.76 + \frac{(1.18-1) \cdot (0.54-0.76)}{(2-1)} = 0.72$$

Thus $P_{RIB}=0.72 \cdot 1.25=0.90\text{psi}$

Step 25 – T_1 for L/H=1, W/H=3/4 from UFC Figure 232A, for $P_{so}=1.25\text{psi}$ using linear extrapolation.

In this step, for $A_o/A_w = 1/8$, $T_1 = 11.17\text{msec}$ and for $A_o/A_w = 3/16$, $T_1 = 11.12\text{msec}$

Step 26 – T_1 for L/H=2, W/H=3/4 from UFC Figure 232A, for $P_{so}=1.25\text{psi}$ using linear extrapolation.

In this step, for $A_o/A_w = 1/8$, $T_1 = 21.38\text{msec}$ and for $A_o/A_w = 3/16$, $T_1 = 21.30\text{msec}$

Step 27 – T_1 for $A_o/A_w=0.11$ using linear interpolation.

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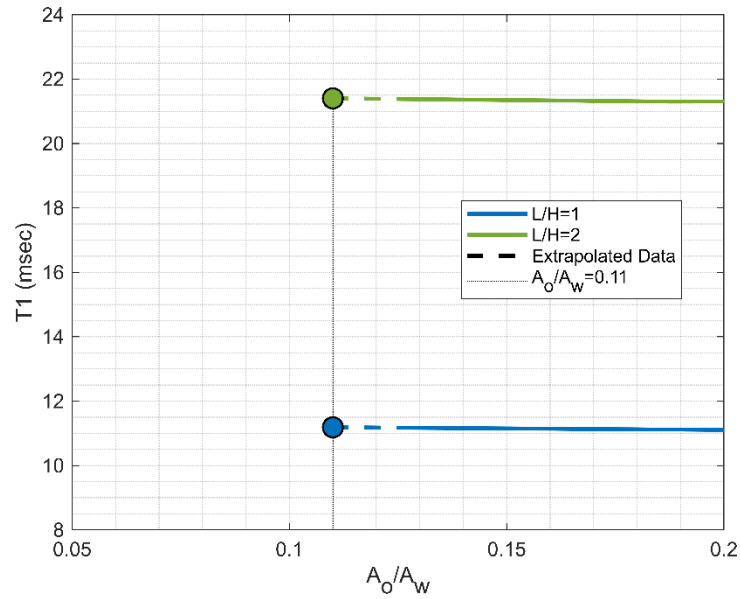


Figure Apx A-3 – Interpolated T_1 for $A_o/A_w=0.11$, $W/H=3/4$, $P_{so}=1.25\text{psi}$, $L/H=1,2$

In this step, for $L/H=1$ using T_1 from Step 25:

$$T_1 = 11.17 + \frac{(0.11 - 0.125)}{(0.1875 - 0.125)} \cdot 0.11(11.12 - 11.17) = 11.17\text{msec}$$

And for $L/H=2$ using T_1 from Step 26:

$$T_1 = 21.39 + \frac{(0.11 - 0.125)}{(0.1875 - 0.125)} \cdot 0.11(21.3 - 21.39) = 21.39\text{msec}$$

Step 28 – T_1 for $L/H=1.18$ using linear interpolation.

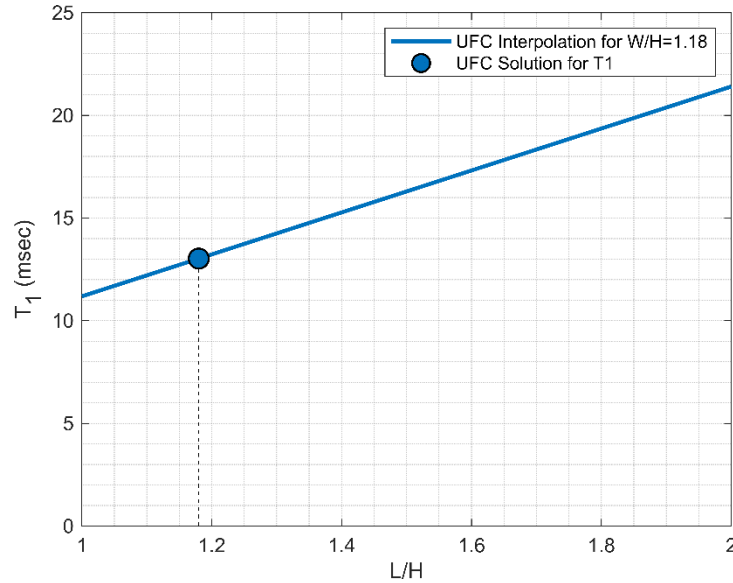


Figure Apx A-4 – Interpolated T_1 for $L/H=1.18$, $A_o/A_w=0.11$, $P_{so}=1.25$, $W/H=3/4$

Therefore, using T_1 from Step 27:

$$T_1 = 11.17 + \frac{(1.18-1) \cdot (21.39-11.17)}{(2-1)} = 13.01 \text{ msec}$$

Step 29 – T_1 for $L/H=1$, $W/H=3/2$ from UFC Figure 232B, for $P_{so}=1.25$ psi using linear extrapolation.

In this step, for $A_o/A_w = 1/8$, $T_1 = 13.09$ msec and for $A_o/A_w = 3/16$, $T_1 = 13.13$ msec

Step 30 – T_1 for $L/H=2$, $W/H=3/2$ from UFC Figure 232B, for $P_{so}=1.25$ psi using linear extrapolation.

In this step, for $A_o/A_w = 1/8$, $T_1 = 22.20$ msec and for $A_o/A_w = 3/16$, $T_1 = 22.60$ msec

Step 31 – T_1 for $A_o/A_w=0.11$ using linear interpolation.

In this step, for $L/H=1$ using T_1 from Step 29:

$$T_1 = 13.09 + \frac{(0.11 - 0.125)}{(0.1875 - 0.125)} \cdot 0.11(13.13 - 13.09) = 13.09 \text{ msec}$$

And for $L/H=2$ using T_1 from Step 30:

$$T_1 = 22.20 + \frac{(0.11 - 0.125)}{(0.1875 - 0.125)} \cdot 0.11(22.60 - 22.20) = 22.19 \text{ msec}$$

Step 32 – T_1 for $L/H=1.18$ using linear interpolation.

Therefore, using T_1 from Step 31:

$$T_1 = 13.09 + \frac{(1.18-1) \cdot (22.19-13.09)}{(2-1)} = 14.73 \text{ msec}$$

Step 33 – T_1 for $W/H=1.18$ using linear interpolation.

Therefore, using T_1 from Step 28 and 32:

$$T_1 = 13.01 + \frac{(1.18-0.75) \cdot (14.73-13.01)}{(1.5-0.75)} = 14.00 \text{ msec}$$

Step 34 – Scaled ($T_2 - T_1$) from UFC Figure 234, for $P_{so}=1.25$ psi using linear extrapolation.

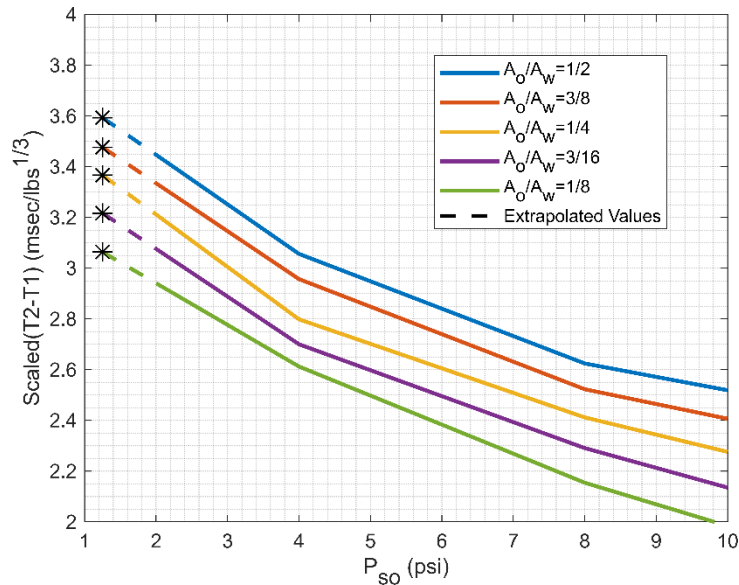


Figure Apx A-5 – Scaled($T_2 - T_1$), UFC extrapolated solutions for $P_{so}=1.25$ psi

In this step, for $A_o/A_w = 1/8$, $T_1 = 3.06$ msec and for $A_o/A_w = 3/16$, $T_1 = 3.22$ msec

Step 35 – Scaled($T_2 - T_1$) for $A_o/A_w=0.11$ using linear extrapolation used.

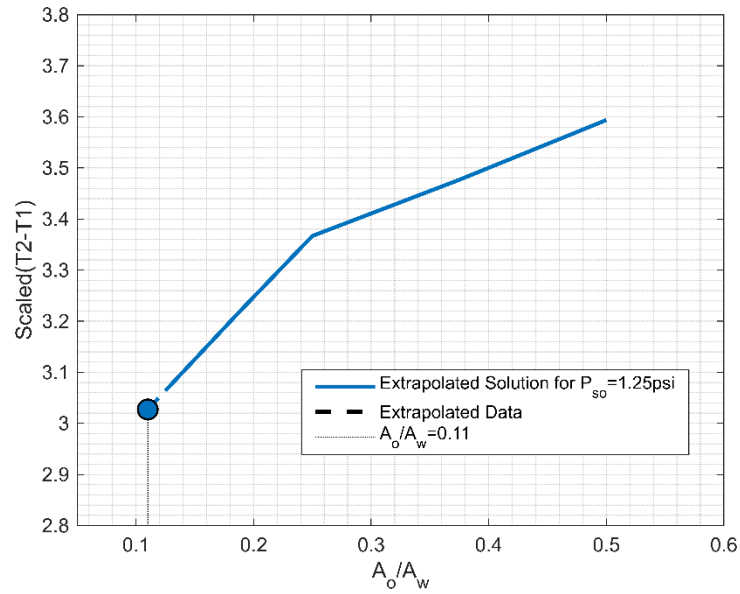


Figure Apx A-6 – Interpolated Scaled(T_2-T_1) for $A_o/A_w=0.11$, $P_{so}=1.25\text{psi}$

Therefore, using values from Step 34:

$$\frac{T_2-T_1}{W^{\frac{1}{3}}} = 3.06 + \frac{(0.11-0.125)}{(0.1875-0.125)} \cdot 0.11(3.22 - 3.06) = 3.06 \frac{\text{msec}}{\text{lbs}^{\frac{1}{3}}}$$

And

$$T_2 - T_1 = 3.06 \cdot 2.2^{\frac{1}{3}} = 3.98\text{msec}$$

Thus

$$T_2 = 14.00 + 3.98 = 17.98\text{msec}$$

Step 36 – Test 1 back wall calculated results are detailed in Table_Apx A-3

Table_Apx A-3 – Summary results for Test 1 back wall using the UFC method

Parameter	Value
P_{RIB}	5.90psi
T_1	14.00msec
T_2	17.98msec

A.2 – Test 2

Step 1. Side Wall Peak Overpressure using UFC eq. (2-16) for $1.5 \leq W/H \leq 6$, with $P_{so} = 1.3$, $A_o/A_w = 0.11$, $L_w/L = 1.05$, $L/H = 1.19$ solve for P_{max} for $W/H = 1.5$.

$$A = [0.002 \cdot 1.5^{1.4467}] - 0.0213 = -0.0177 \quad \text{A.2-18}$$

$$B = 2.2075 - [1.902 \cdot 1.5^{-0.085}] = -0.3699 \quad \text{A.2-19}$$

$$C = 1.231 + [0.0008 \cdot 1.5^{2.678}] = 1.2334 \quad \text{A.2-20}$$

$$D = [2.573 \cdot 1.18^{-0.444}] - 0.3911 = 1.9996 \quad \text{A.2-21}$$

$$E = 0.4221 + [1.241 \cdot 0.11^{0.367}] = 0.9349 \quad \text{A.2-22}$$

$$K = [-0.0177 + (-0.3699 \cdot (1.05^{1.2334}))] \cdot 1.9996 \cdot 0.9349 \cdot 1.3^{1.025} \\ = 0.9434 \quad \text{A.2-23}$$

$$P_{max} = 0.9434/1.05 = 0.898 \text{psi} \quad \text{A.2-24}$$

Step 2. Side Wall Peak Overpressure using UFC eq. (2-22) for $W/H = 0.75$, with $P_{so} = 1.3$, $A_o/A_w = 0.11$, $L_w/L = 1.05$, $L/H = 1.18$, solve for P_{max} for $W/H = 0.75$.

$$A = [0.5422 \cdot 1.05^{1.2944}] - 0.001829 = 0.5757 \quad \text{A.2-25}$$

$$B = [0.654 + 2.616 \cdot 0.11 - 4.928 \cdot 0.11^2] \cdot [2.209 \cdot 1.18^{-0.3451} - 0.739] \\ = 1.1885 \quad \text{A.2-26}$$

$$C = 0.829 + 0.104 \cdot 1.05^{1.6} + [0.00124 + 0.00414 \cdot 1.05^{3.334}] \\ \cdot (1.18)^{2.51754} = 0.9507 \quad \text{A.2-27}$$

$$D = 2.579 - 0.0534 \cdot 1.05^{3.891} = 2.5175 \quad \text{A.2-28}$$

$$E = 999 \cdot 0.11^{9.964} = 0.00000028054 \quad \text{A.2-29}$$

$$F = 1.468 - 1.6627 \cdot (0.11)^{0.7801} + [1.8692 - 1.1735 \cdot (0.11)^{-0.2226}] \\ \cdot 1.05^{7.1029} = 1.1017 \quad \text{A.2-30}$$

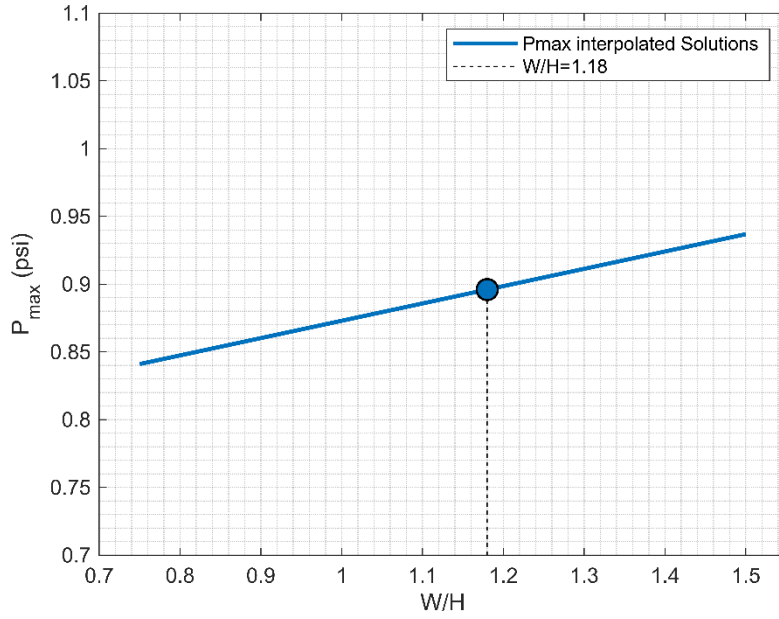
$$G = 0.2979 \cdot 0.11^{-1.4872} - 0.8351 = 7.1029 \quad \text{A.2-31}$$

$$H = 5.425 \cdot 10^{-4} + 1.001 \cdot 10^{-9} \cdot 1.18^{9.965} = 0.00054251 \quad \text{A.2-32}$$

$$K = 0.5757 \cdot 1.1885 \cdot 0.9507^{0.00000028054} \cdot 1.1017^{0.00054251} \cdot 1.3^{0.9718} \\ = 0.8831 \quad \text{A.2-33}$$

$$P_{max} = 0.8831/1.05 = 0.841 \text{psi} \quad \text{A.2-34}$$

Step 3. Using the calculated values of P_{max} vs. W/H , linear interpolation to obtain the value for $W/H = 1.18$



Figure_Apx A-7 – Step 3 Linear Interpolation of P_{max} for $W/H = 1.18$

$$P_{max} = 0.841 + \frac{(1.18 - 0.75) \cdot (0.898 - 0.841)}{(1.5 - 0.75)} = 0.87psi$$

Step 4. – Idealised interior side wall overpressure-time parameter – T_1 , T_2 .

Using UFC Figure 2-13, linear interpolation for $W/H=1.18$, $P_{so}=1.3psi$

For $W/H= 0.75$, $T_1=2.60msec$ and for $W/H= 1.5$, $T_1=6.73msec$. Therefore, for $W/H=1.18$:

$$T_1 = 2.60 + \frac{(1.18 - 0.75) \cdot (6.73 - 2.60)}{(1.5 - 0.75)} = 4.97s$$

For $W/H= 0.75$, $T_2=4.36msec$ and for $W/H= 1.5$, $T_2=8.49msec$. Therefore, for $W/H=1.18$:

$$T_2 = 4.36 + \frac{(1.18 - 0.75) \cdot (8.49 - 4.36)}{(1.5 - 0.75)} = 6.73s$$

Step 5 – T_3 for $L/H=1$, $W/H=3/4$ from UFC Figure 214A, for $P_{so}=1.3psi$ using linear extrapolation.

In this step, for $L_w/L= 1$, $T_3=11.22msec$ and for $L_w/L= 1.5$, $T_3=13.77msec$

Step 6 – T_3 for $L/H=1$, $W/H=3/2$ from UFC Figure 215A, for $P_{so}=1.3\text{psi}$ using linear extrapolation.

In this step, for $L_w/L=1$, $T_3=13.92\text{msec}$ and for $L_w/L=1.5$, $T_3=15.82\text{msec}$

Step 7 – T_3 for $L/H=2$, $W/H=3/4$ from UFC Figure 218A, for $P_{so}=1.3\text{psi}$ using linear extrapolation.

In this step, for $L_w/L=1$, $T_3=17.34\text{msec}$ and for $L_w/L=1.5$, $T_3=23.16\text{ msec}$

Step 8 – T_3 for $L/H=2$, $W/H=3/2$ from UFC Figure 219A, for $P_{so}=1.3\text{psi}$ using linear extrapolation.

In this step, for $L_w/L=1$, $T_3=18.31\text{msec}$ and for $L_w/L=1.5$, $T_3=22.28\text{ msec}$

Step 9 – T_3 for $L_w/L=0.63$, $L/H=1$ using linear interpolation.

In this step, for $W/H=0.75$ using T_3 from Step 5:

$$T_3 = 11.22 + \frac{(1.05 - 1) \cdot (13.77 - 11.22)}{(1.5 - 1)} = 11.48\text{msec}$$

And for $W/H=1.5$ using T_3 from Step 6:

$$T_3 = 13.92 + \frac{(1.05 - 1) \cdot (15.82 - 13.92)}{(1.5 - 1)} = 14.11\text{msec}$$

Step 10 – T_3 for $L_w/L=1.05$, $L/H=2$ fusing linear interpolation.

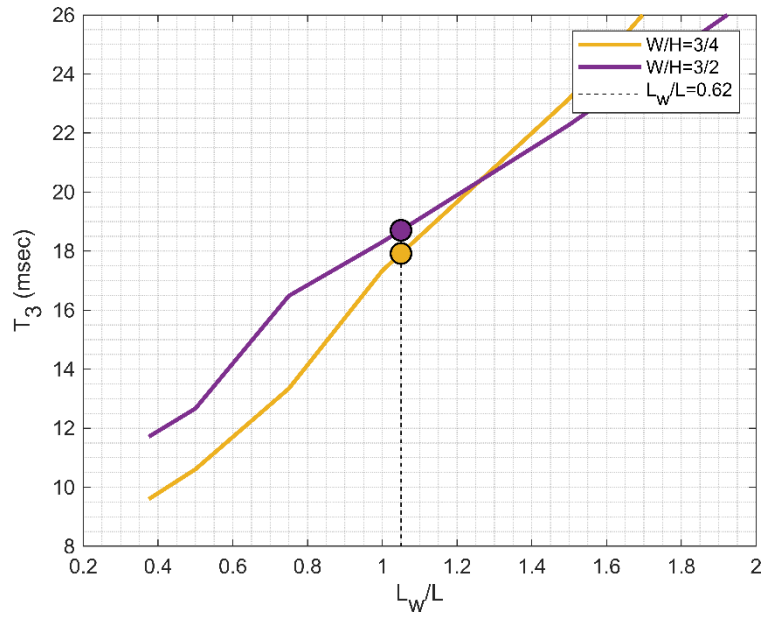


Figure Apx A-8 –Interpolated T_3 for $L_w/L=0.63$, $L/H=2$, $P_{so}=1.3\text{psi}$ for $W/H=3/4, 3/2$

In this step, for $W/H=0.75$ using T_3 from Step 7:

$$T_3 = 17.34 + \frac{(1.05 - 1) \cdot (23.16 - 17.34)}{(1.5 - 1)} = 17.92\text{msec}$$

And for $W/H=1.5$ using T_3 from Step 8:

$$T_3 = 18.31 + \frac{(1.05 - 1) \cdot (22.28 - 18.31)}{(1.5 - 1)} = 18.71\text{msec}$$

Step 11 – T_3 for $W/H=1.18$, using linear interpolation.

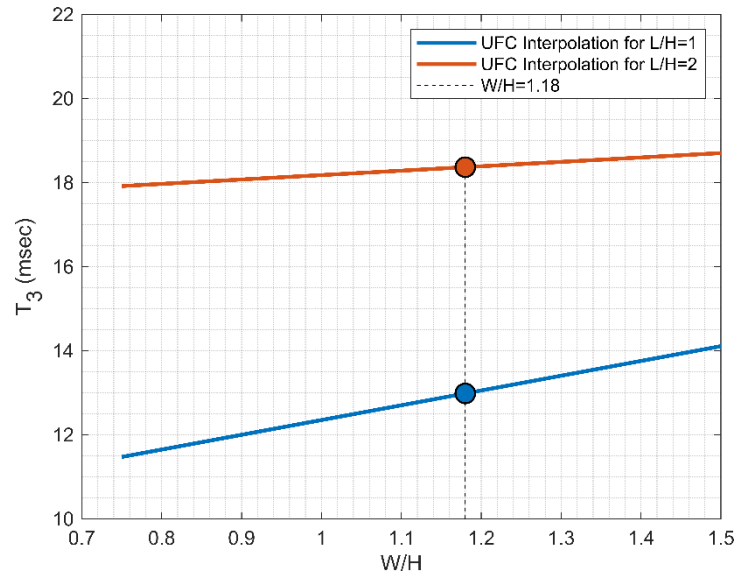


Figure Apx A-9 –Interpolated T_3 for $W/H=1.18$, $L_w/L=0.63$, $P_{so}=1.3\text{psi}$ for $L/H=1, 2$

In this step, for $L/H=1$ using T_3 from Step 9:

$$T_3 = 11.48 + \frac{(1.18 - 0.75) \cdot (14.11 - 11.48)}{(1.5 - 0.75)} = 12.99\text{msec}$$

And for $W/H=1.5$ using T_3 from Step 10:

$$T_3 = 17.92 + \frac{(1.18 - 0.75) \cdot (18.71 - 17.92)}{(1.5 - 0.75)} = 18.71\text{msec}$$

Step 11 – T_3 for $L/H=1.18$, fusing linear interpolation.

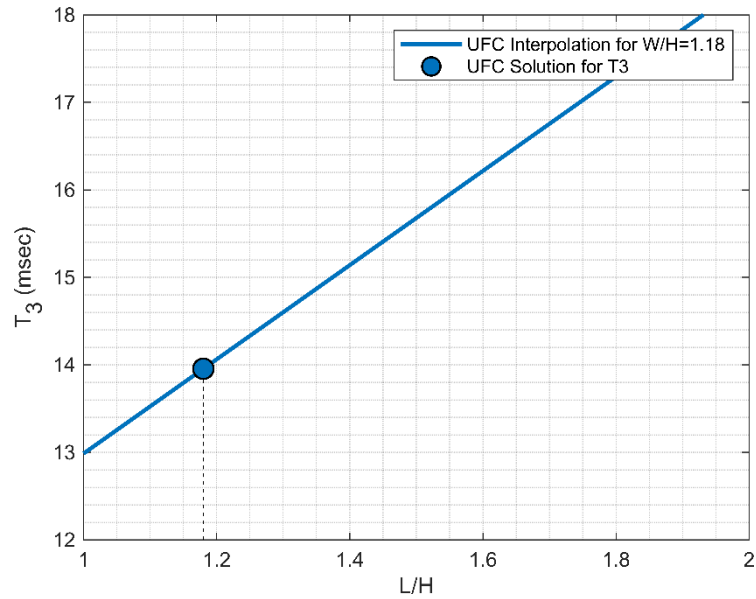


Figure Apx A-10 –Interpolated T_3 for $L/H=1.18$, $W/H=1.18$, $L_w/L=0.63$, $P_{so}=1.3\text{psi}$

Therefore, $T_3 = 13.96\text{msec}$

Step 12 – T_4 for $L/H=1$, $W/H=3/4$ from UFC Figure 214B, for $P_{so}=1.3\text{psi}$ using linear extrapolation .

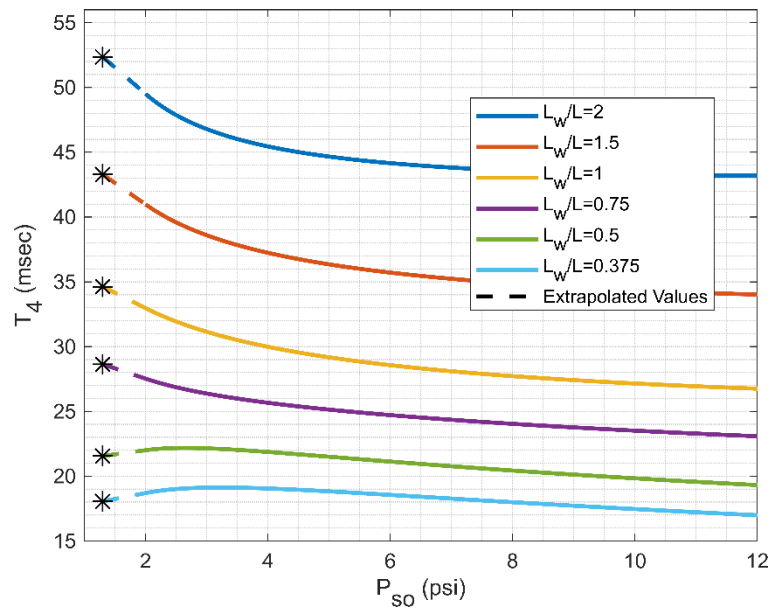


Figure Apx A-11 – T_4 , $P_{so}=1.3\text{psi}$ UFC extrapolated solutions for $L/H=1$, $W/H=3/4$

Step 13 – T_4 for $L/H=1$, $W/H=3/2$ from UFC Figure 215A, for $P_{so}=1.3\text{psi}$ using linear extrapolation.

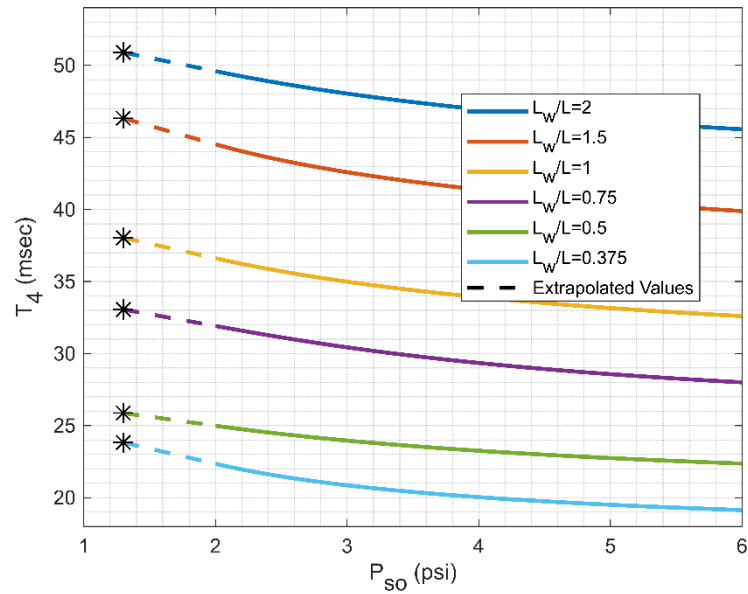


Figure Apx A-12 – T_4 , $P_{so}=1.3$ psi UFC extrapolated solutions for $L/H=1$, $W/H=3/2$

Step 14 – T_4 for $L/H=2$, $W/H=3/4$ from UFC Figure 218A, for $P_{so}=1.3$ psi using linear extrapolation.

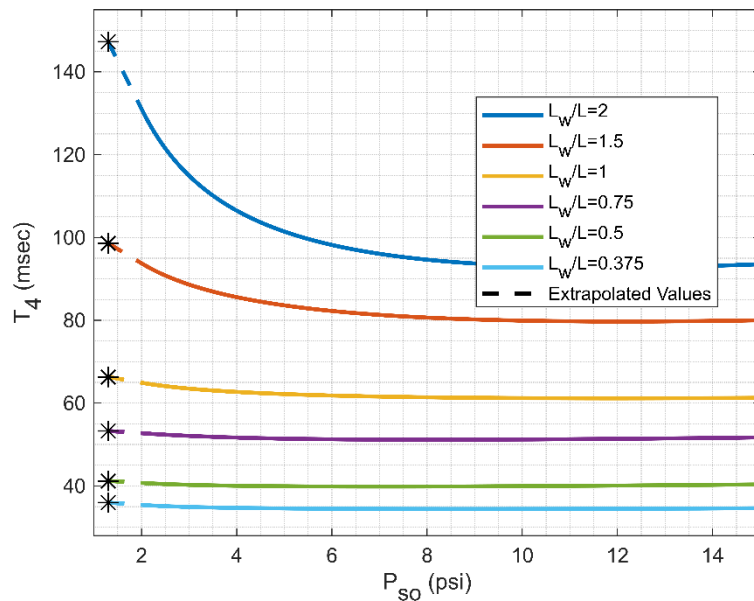


Figure Apx A-13 – T_4 , $P_{so}=1.3$ psi UFC extrapolated solutions for $L/H=2$, $W/H=3/4$

Step 15 – T_4 for $L/H=2$, $W/H=3/2$ from UFC Figure 219A, for $P_{so}=1.3$ psi using linear extrapolation.

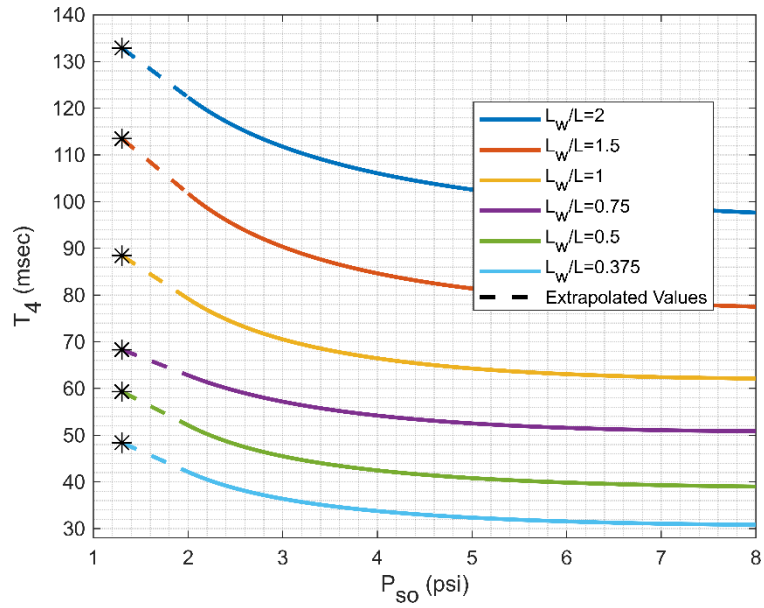


Figure Apx A-14 – T_4 , $P_{so}=1.3\text{psi}$ UFC extrapolated solutions for $L/H=2$, $W/H=3/2$

Step 16 – T_4 for $L_w/L=0.63$, $L/H=1$ with linear interpolation used as per Figure Apx **A-15**.

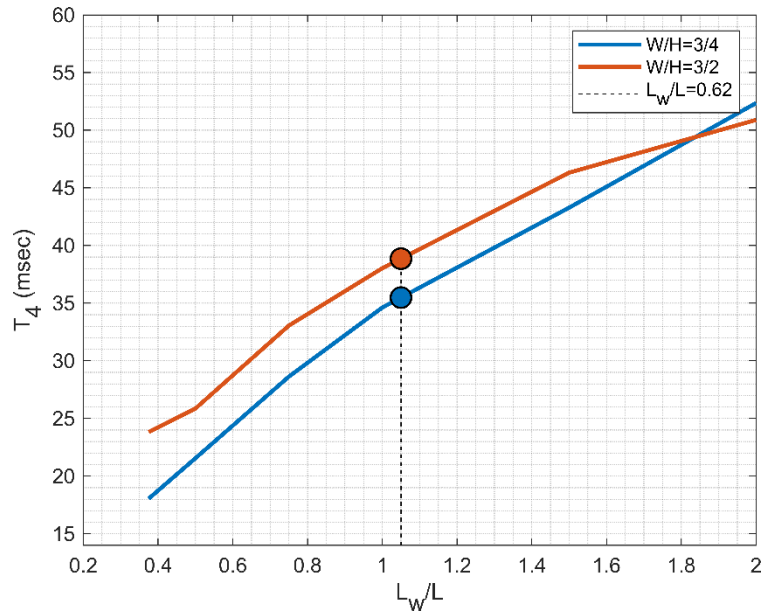


Figure Apx A-15 – Interpolated T_4 for $L_w/L=0.63$, $L/H=1$, $P_{so}=1.3\text{psi}$ for $W/H=3/4$, $3/2$

Step 17 – T_4 for $L_w/L=0.63$, $L/H=2$ with linear interpolation used as per Figure Apx **A-16**.

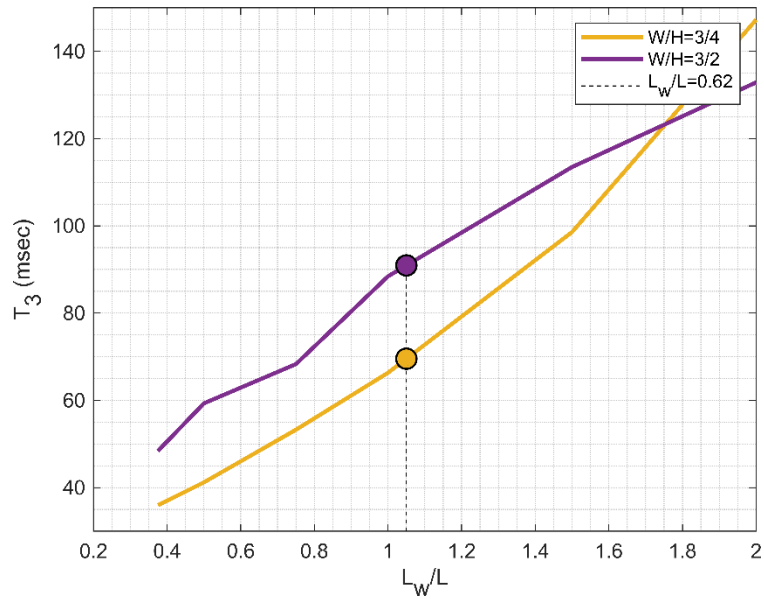


Figure Apx A-16 –Interpolated T_4 for $L_w/L=0.63$, $L/H=2$, $P_{so}=1.3\text{psi}$ for $W/H=3/4$, $3/2$

Step 18 – T_4 for $W/H=1.18$, with linear interpolation used as per Figure Apx A-17.

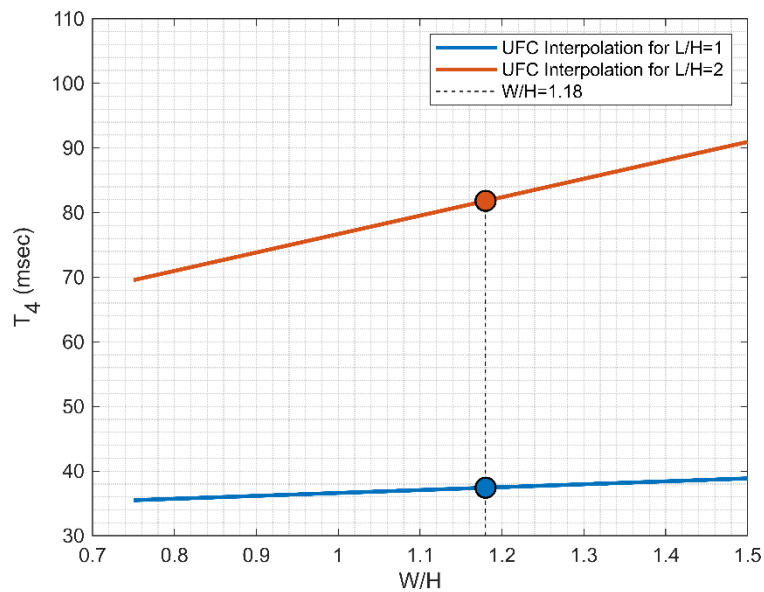


Figure Apx A-17 –Interpolated T_4 for $W/H=1.18$, $L_w/L=0.63$, $P_{so}=1.3\text{psi}$ for $L/H=1$, 2

Step 19 – T_4 for $L/H=1.18$, with linear interpolation used as per Figure Apx A-18.

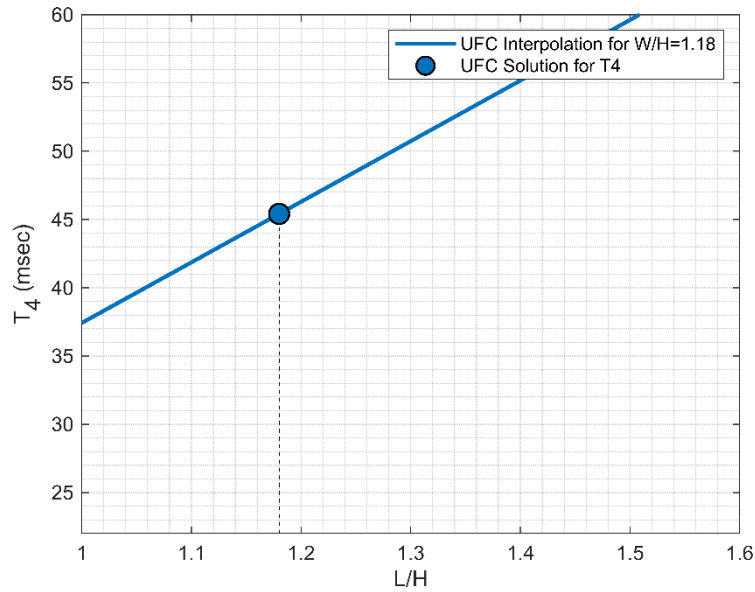


Figure Apx A-18 –Interpolated T_4 for $L/H=1.18$, $W/H=1.18$, $L_w/L=0.63$, $P_{so}=1.3\text{psi}$

Therefore, $T_4 = 45.41\text{msec}$

Step 20 – Test 1 calculated side wall results are detailed in Table_Apx A-2

Table_Apx A-4 – Summary results for Test 1 side wall using the UFC method

Parameter	Value
$P_{\max}$	0.90psi
T_1	4.97msec
T_2	6.73msec
T_3	13.95msec
T_4	45.41msec

Step 21 – P_{RIB}/P_{so} for $L/H=1$, from UFC Figure 230A, for $P_{so}=1.3\text{psi}$ with linear extrapolation used as per Figure Apx A-19.

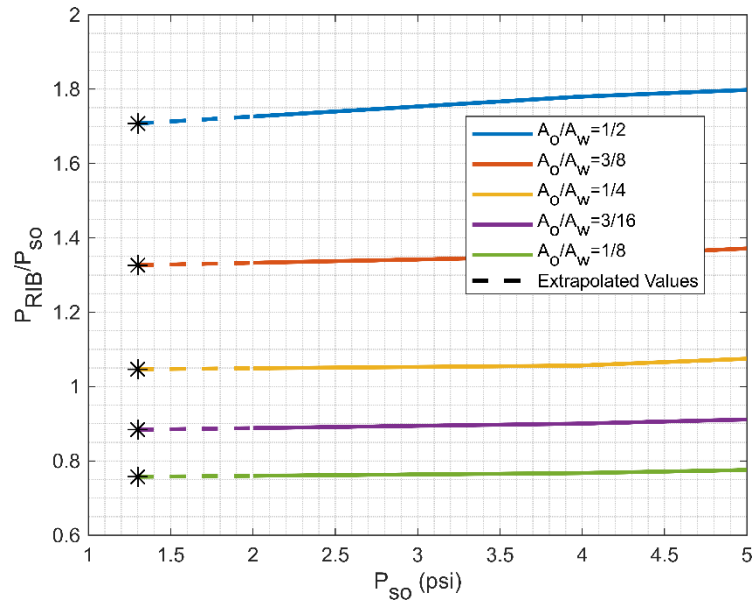


Figure Apx A-19 – P_{RIB}/P_{so} , $P_{so}=1.3$ psi UFC extrapolated solutions for $L/H=1$

Step 22 – P_{RIB}/P_{so} for $L/H=2$, from UFC Figure 230B, for $P_{so}=1.3$ psi with linear extrapolation used as per Figure Apx A-20.

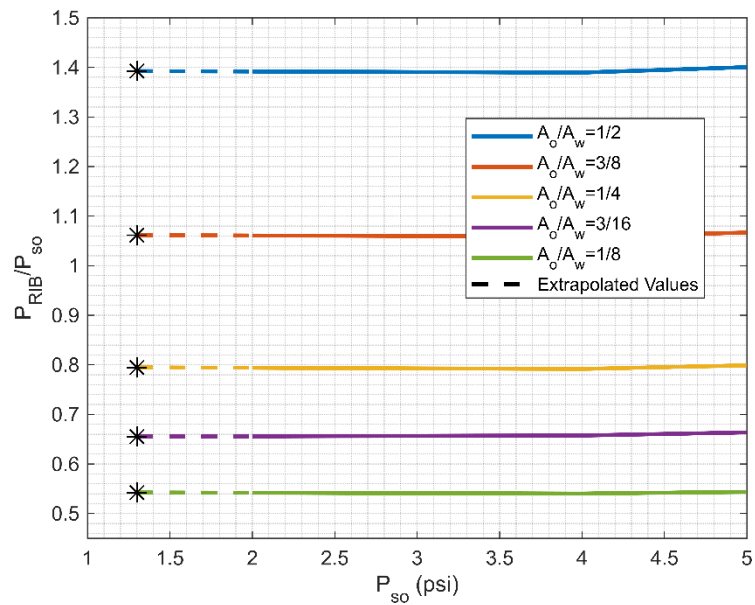


Figure Apx A-20 – P_{RIB}/P_{so} , $P_{so}=1.3$ UFC extrapolated solutions for $L/H=2$

Step 23 – P_{RIB}/P_{so} for $A_o/A_w=0.11$, from Figure Apx A-19 and Figure Apx A-20, an extrapolation is required as per Figure Apx A-21.

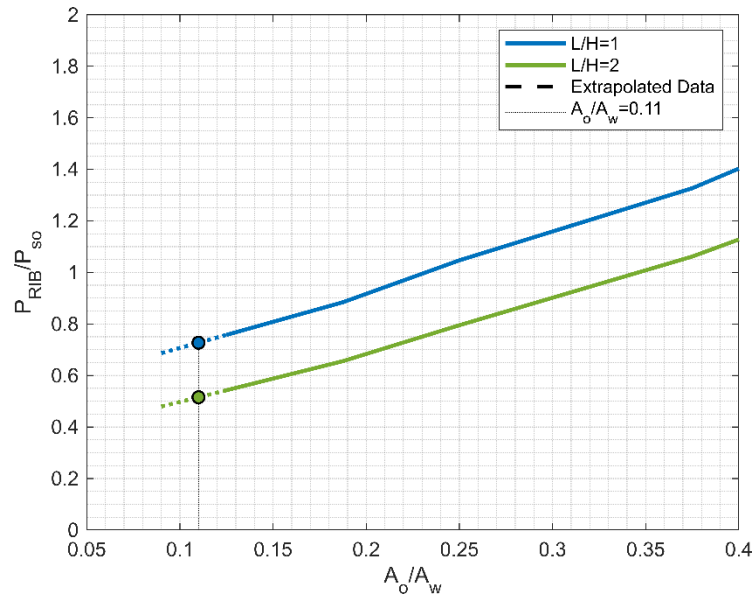


Figure Apx A-21 – P_{RIB}/P_{so} , extrapolated solutions of $A_o/A_w=0.11$ for $P_{so}=1.3$, $L/H=1,2$

Step 24 – P_{RIB}/P_{so} for $L/H=1.18$ from Figure Apx A-2 with linear interpolation used as per Figure Apx **A-22**.

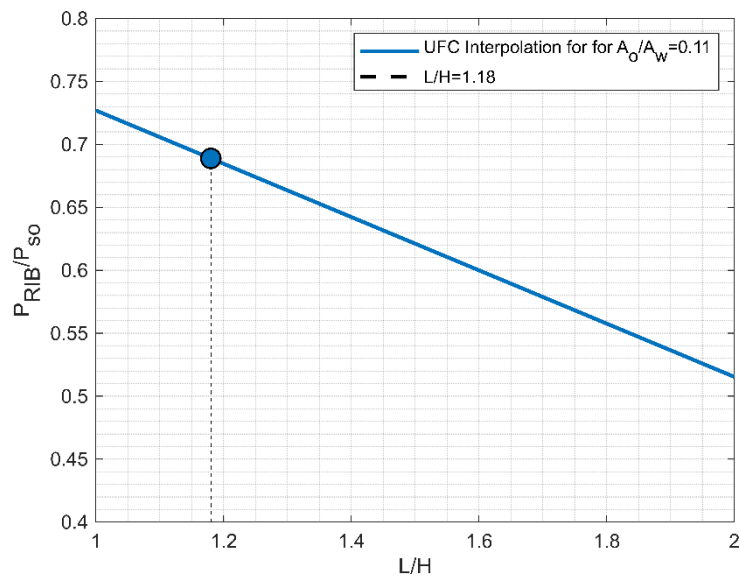


Figure Apx A-22 – P_{RIB}/P_{so} , interpolated solution for $L/H=1.18$, $A_o/A_w=0.11$, $P_{so}=1.3$ psi

Therefore, $P_{RIB}/P_{so}=0.69$, Thus $P_{RIB}=0.69*1.3=0.86$ psi

Step 25 – T_1 for $L/H=1$, $W/H=3/4$ from UFC Figure 232A, for $P_{so}=1.3$ psi with linear extrapolation used as per Figure Apx **A-23**.

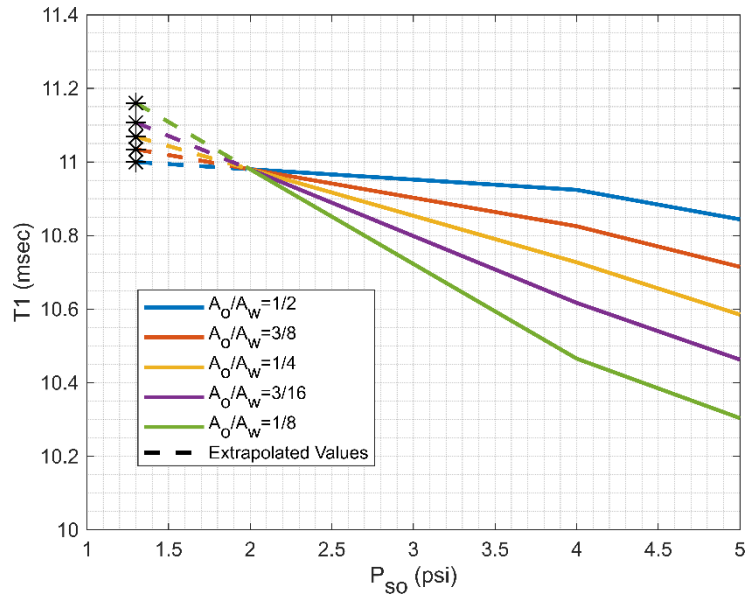


Figure Apx A-23 – T_1 , $P_{so}=1.3$ psi UFC extrapolated solutions for $L/H=1$, $W/H=3/4$

Step 26 – T_1 for $L/H=2$, $W/H=3/4$ from UFC Figure 232A, for $P_{so}=1.3$ psi with linear extrapolation used as per Figure Apx **A-24**.

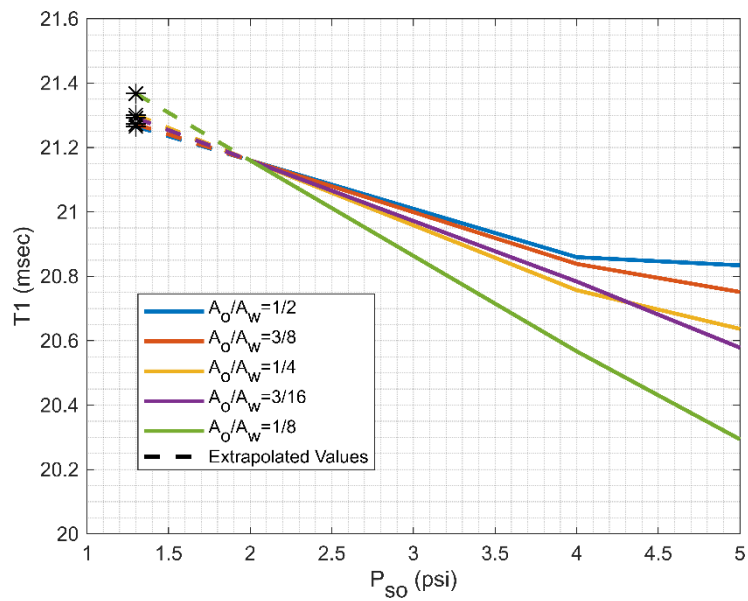


Figure Apx A-24 – T_1 , $P_{so}=1.3$ psi UFC extrapolated solutions for $L/H=2$, $W/H=3/4$

Step 27 – T_1 for $A_o/A_w=0.11$ from Figure Apx **A-23** and Figure Apx **A-24** with linear extrapolation used as per Figure Apx **A-25**.

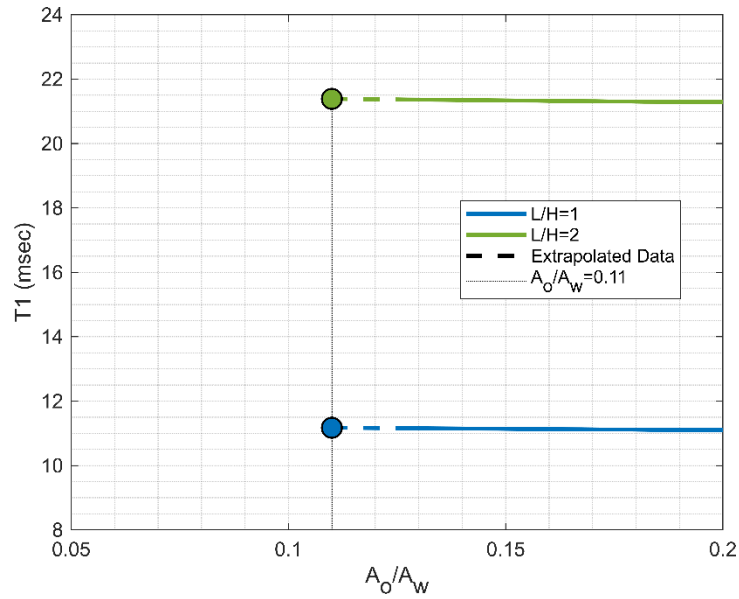


Figure Apx A-25 – Interpolated T_1 for $A_o/A_w=0.11$, $W/H=3/4$, $P_{so}=1.3\text{psi}$, $L/H=1,2$

Step 28 – T_1 for $L/H=1.18$ with linear extrapolation used as per Figure Apx **A-26**.

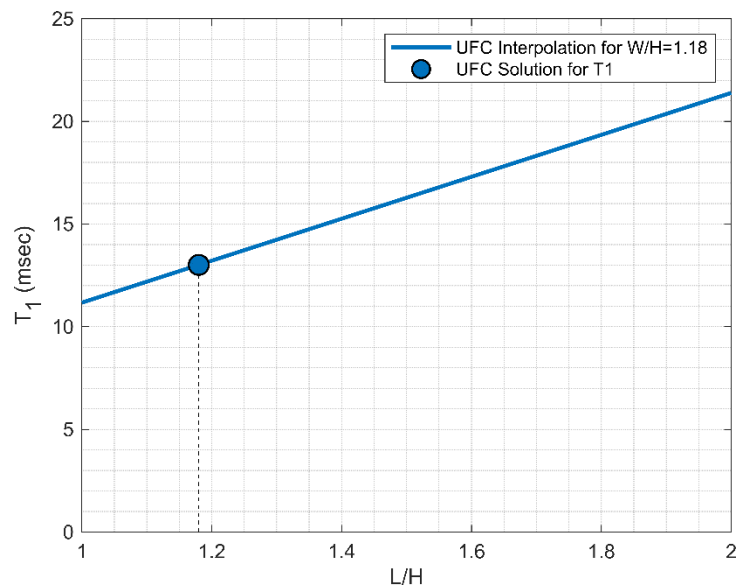


Figure Apx A-26 – Interpolated T_1 for $L/H=1.18$, $A_o/A_w=0.11$, $P_{so}=1.3\text{psi}$, $W/H=3/4$

Step 29 – T_1 for $L/H=1$, $W/H=3/2$ from UFC Figure 232B, for $P_{so}=1.3\text{psi}$ with linear extrapolation as per Figure Apx **A-27**.

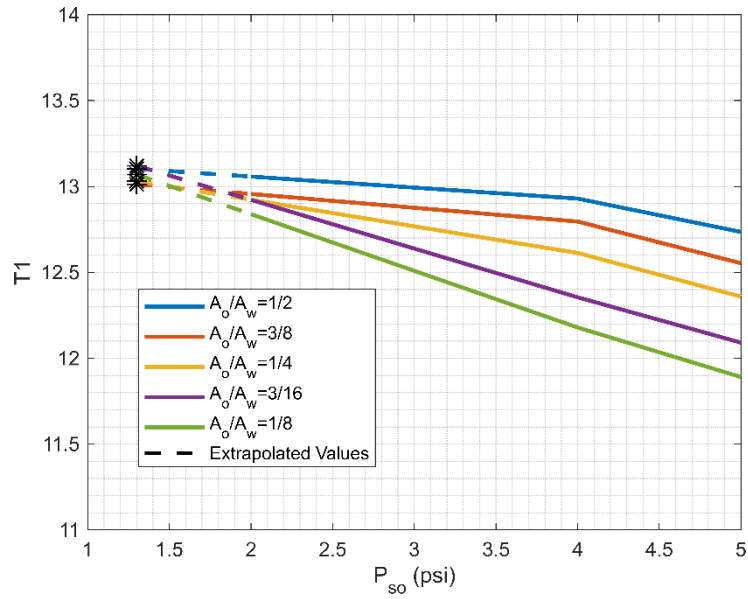


Figure Apx A-27 – T_1 , $P_{so}=1.3$ psi UFC extrapolated solutions for $L/H=1$, $W/H=3/2$

Step 30 – T_1 for $L/H=2$, $W/H=3/2$ from UFC Figure 232B, for $P_{so}=1.3$ psi with linear extrapolation used as per Figure Apx **A-28**.

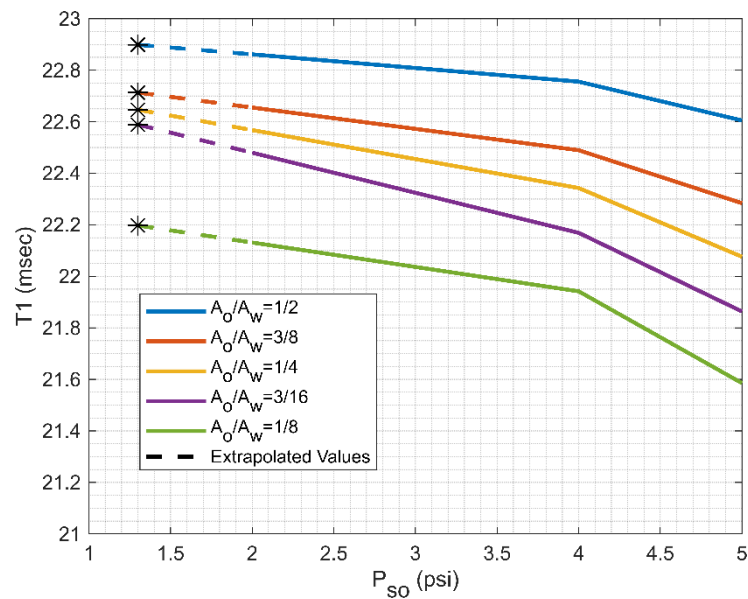


Figure Apx A-28 – T_1 , $P_{so}=1.3$ psi UFC extrapolated solutions for $L/H=2$, $W/H=3/2$

Step 31 – T_1 for $A_o/A_w=0.11$ from Figure Apx **A-27** and Figure Apx **A-28** with linear extrapolation used as per Figure Apx **A-29**.

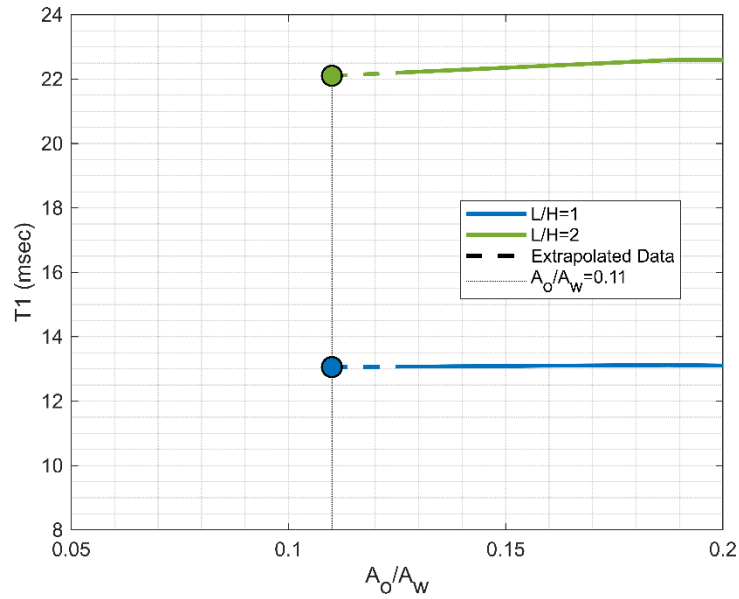


Figure Apx A-29 – Interpolated T_1 for $A_o/A_w=0.11$, $P_{so}=1.3\text{psi}$, $L/H=1,2$, $W/H=3/2$

Step 32 – T_1 for $L/H=1.18$ from with linear interpolation used as per Figure Apx **A-30**.

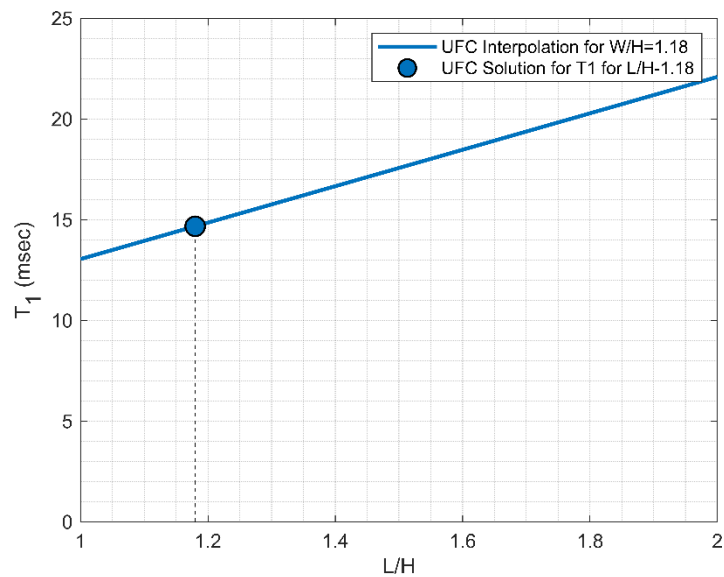


Figure Apx A-30 – Interpolated T_1 for $L/H=1.18$, $A_o/A_w=0.11$, $W/H=3/2$, $P_{so}=1.3\text{psi}$

Step 33 – T_1 for $W/H=1.18$ from Figure Apx **A-26** and Figure Apx **A-30** with linear interpolation used as per Figure Apx **A-31**.

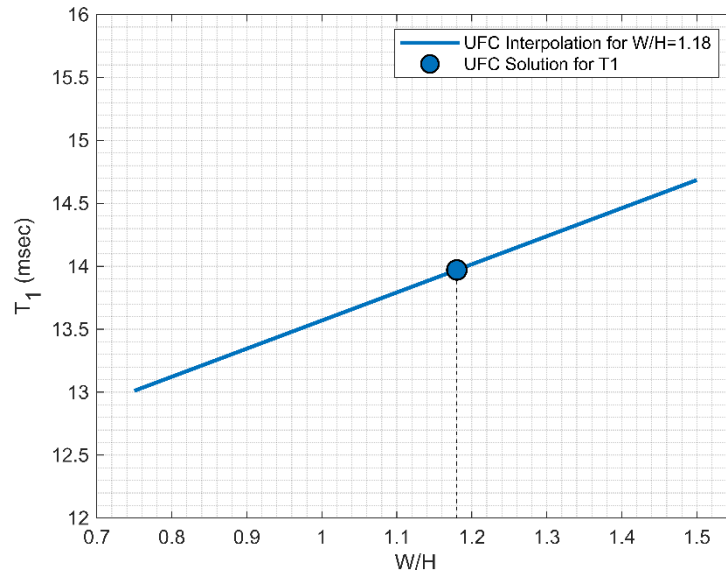


Figure Apx A-31 – Interpolated T_1 for $W/H=1.18$, $L/H=1.18$, $A_o/A_w=0.11$, $P_{so}=1.3\text{psi}$

Therefore $T_1 = 13.99\text{msec}$

Step 34 – Scaled($T_2 - T_1$) from UFC Figure 234, for $P_{so}=1.3\text{psi}$ with linear extrapolation used as per Figure Apx A-32.

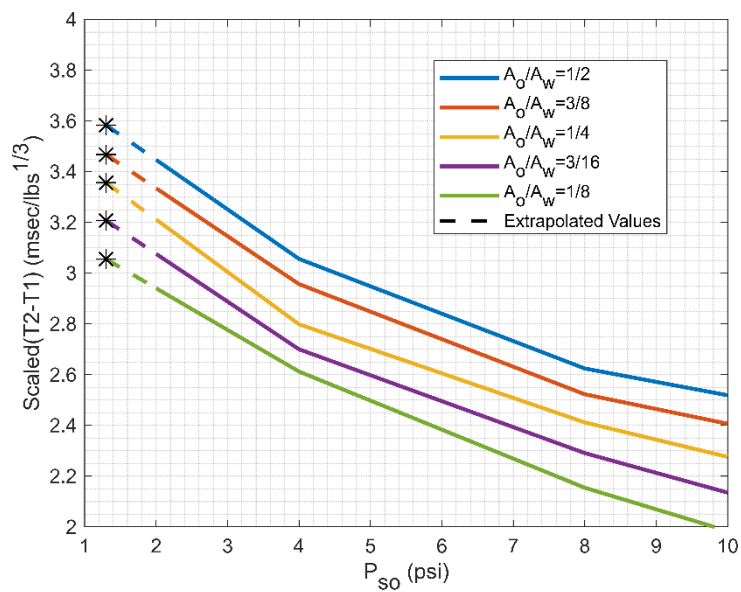


Figure Apx A-32 – Scaled ($T_2 - T_1$), UFC extrapolated solutions for $P_{so}=1.3\text{psi}$

Step 35 – Scaled($T_2 - T_1$) for $A_o/A_w=0.11$ from Figure Apx A-32 with linear extrapolation used as per Figure Apx A-33.

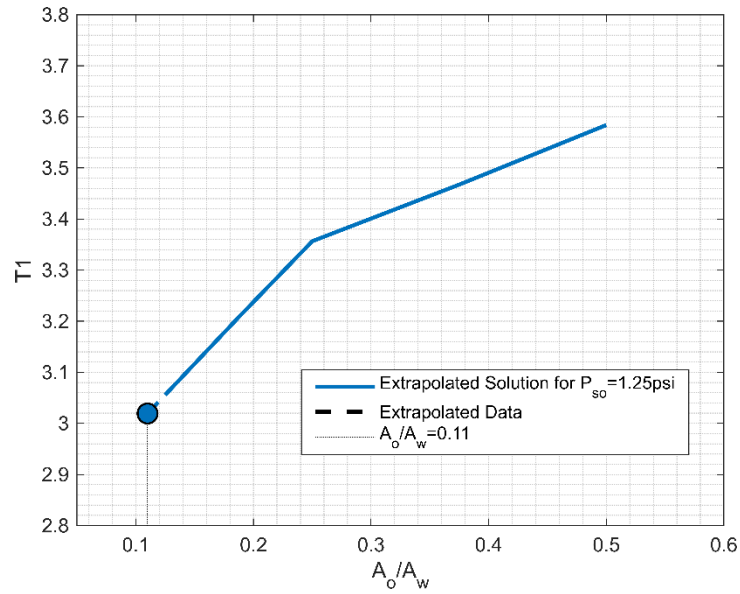


Figure Apx A-33 – Interpolated Scaled($T_2 - T_1$) for $A_o/A_w=0.11$, $P_{so}=1.3\text{psi}$

Therefore, Scaled ($T_2 - T_1$) = 3.02, thus $T_2 - T_1 = 3.02 \cdot 11.02^{(1/3)} = 6.72$ and $T_2 = 20.69\text{msec}$

Step 36 – Test 1 back wall calculated results are detailed in Table_Apx A-3

Table_Apx A-5 – Summary results for Test 1 back wall using the UFC method

Parameter	Value
P_{RIB}	6.17psi
T_1	13.97msec
T_2	20.69msec

Appendix B – Detailed Gauge Comparisons

This appendix provides timeseries plots and peak overpressure and impulse summary tables for all gauges and methods.

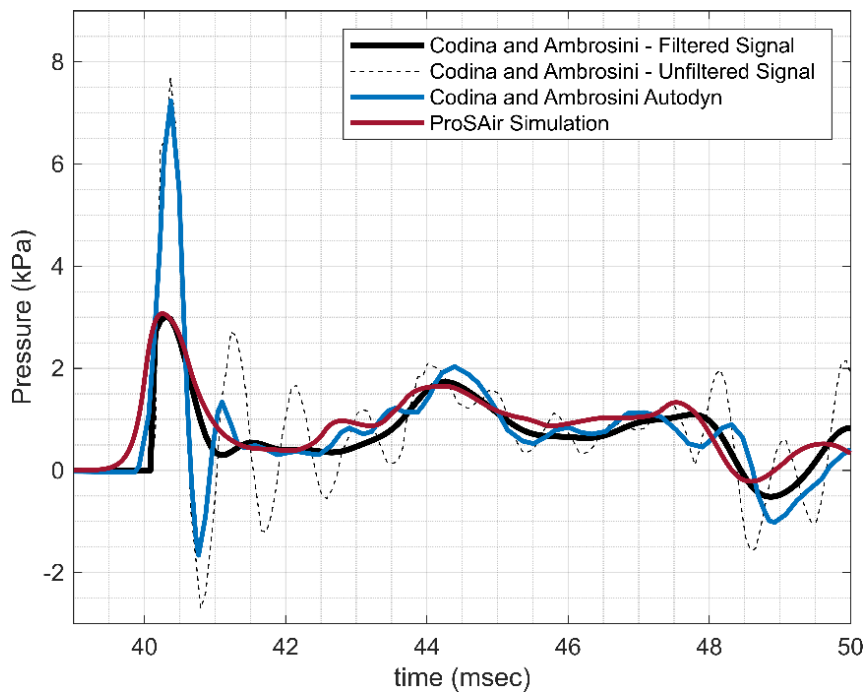


Figure Apx B-1 – Test 1 Gauge 1 Comparative Results - Overpressure

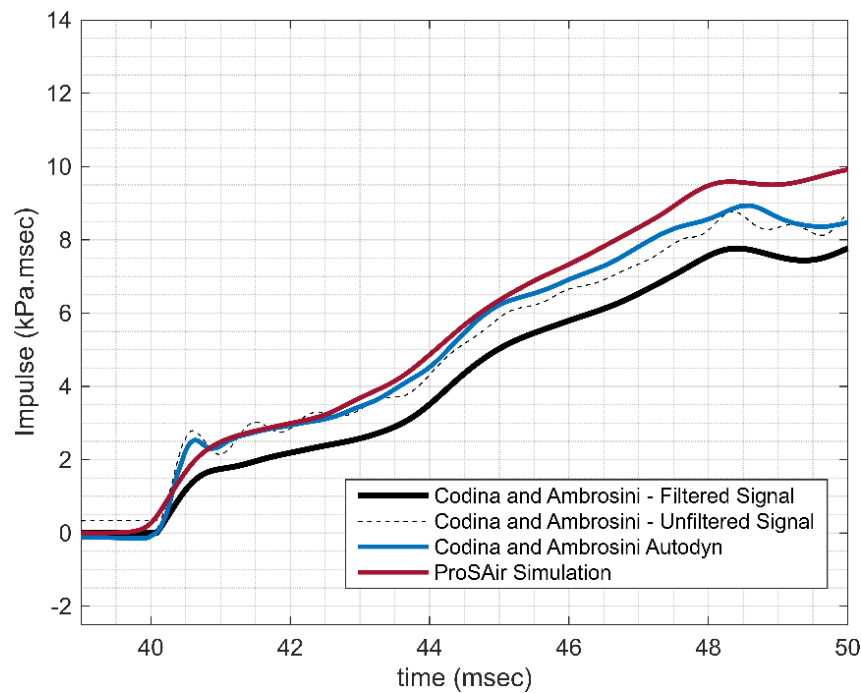


Figure Apx B-2 – Test 1 Gauge 1 Comparative Results - Impulse

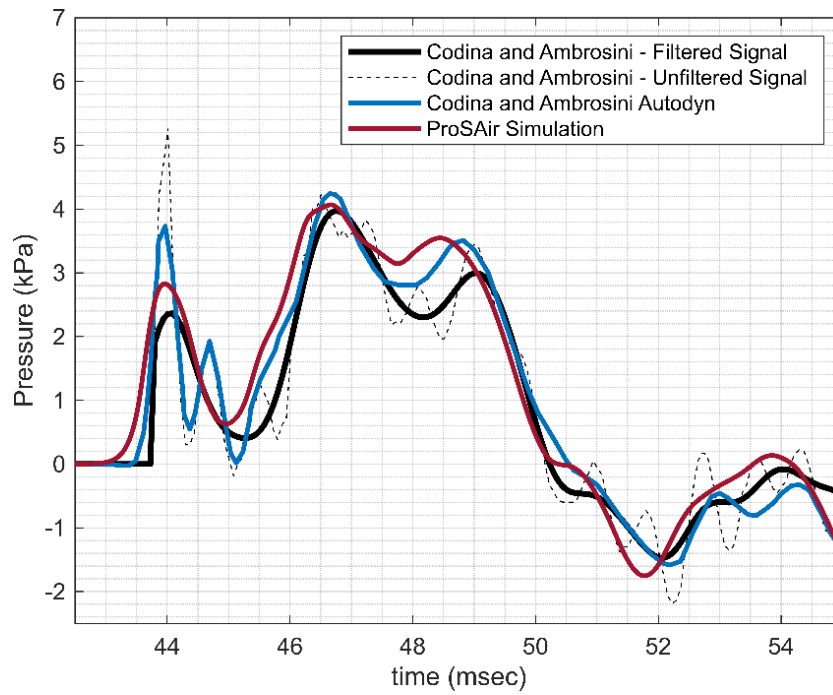


Figure Apx B-3 – Test 1 Gauge 2 Comparative Results - Overpressure

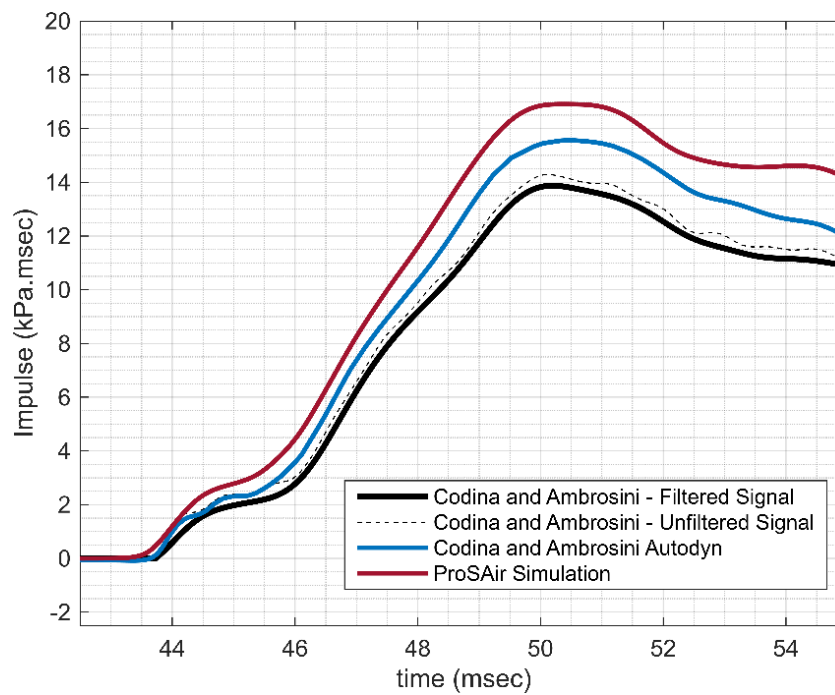


Figure Apx B-4 – Test 1 Gauge 2 Comparative Results - Impulse

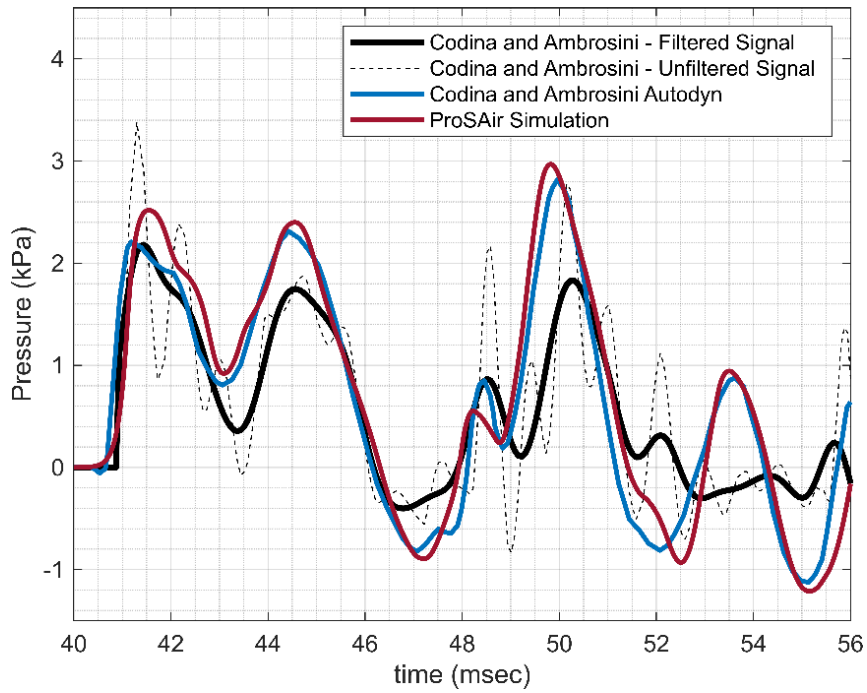


Figure Apx B-5 – Test 1 Gauge 4 Comparative Results – Overpressure-Time History

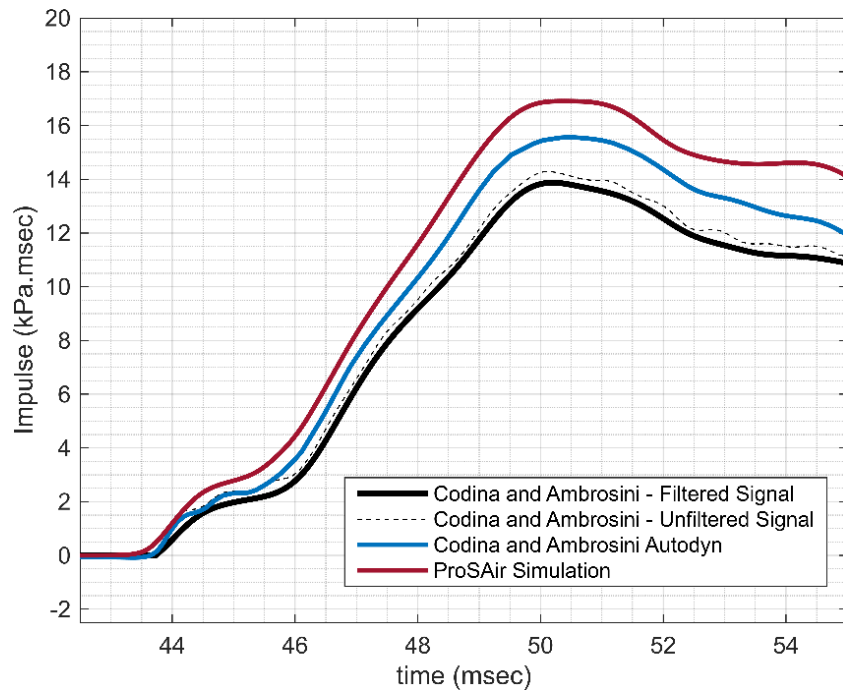


Figure Apx B-6 – Test 1 Gauge 4 Comparative Results – Overall Impulse vs. Time

Table Apx B-1 – Test 1 Result Comparison

		Gauge Number		
		1	2	4
First Overpressure Peak (kPa)	Codina and Ambrosini Unfiltered	7.7	5.3	3.4
	Codina and Ambrosini filtered	3.0	2.4	2.2
	Codina and Ambrosini Numerical	7.2	3.7	2.2
	ProSAir Simulation	3.1	2.8	2.5
First Phase Impulse (kPa.msec)	Codina and Ambrosini Unfiltered	8.7	14.3	7.1
	Codina and Ambrosini filtered	7.8	13.9	6.7
	Codina and Ambrosini Numerical	8.9	15.5	8.1
	ProSAir Simulation	9.6	16.9	8.7

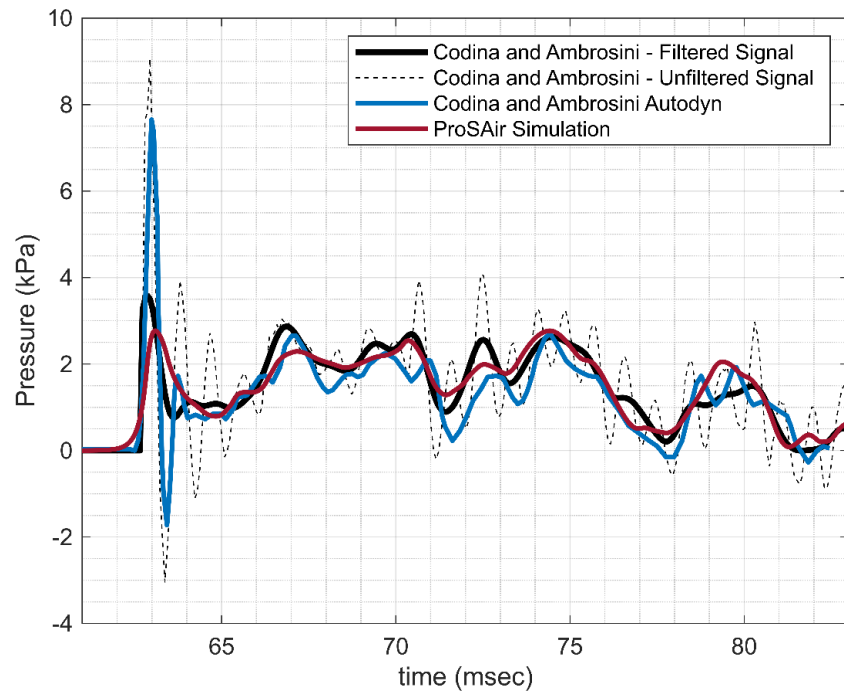


Figure Apx B-7 – Test 2 Gauge 1 Comparative Results - Overpressure

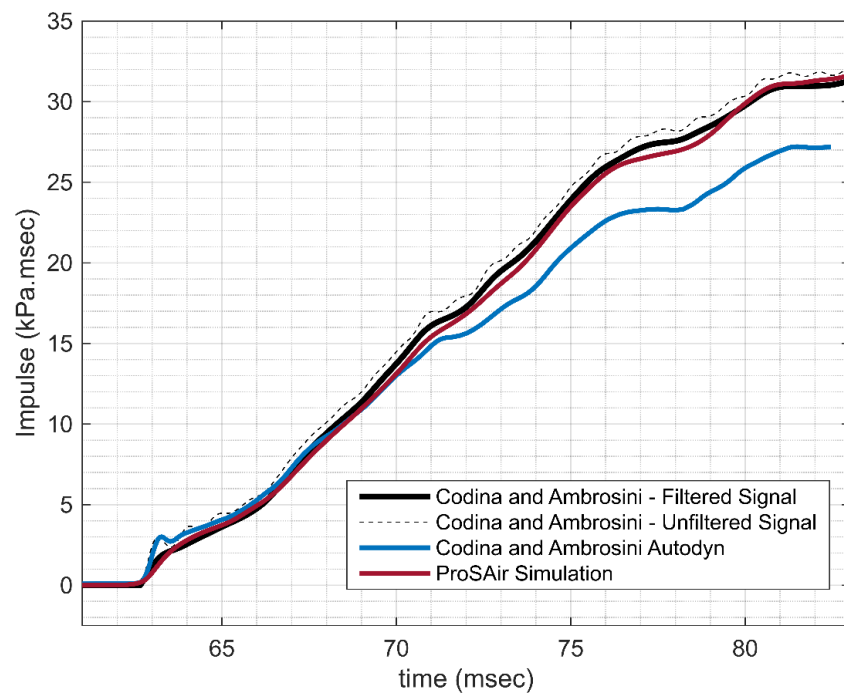


Figure Apx B-8 – Test 2 Gauge 1 Comparative Results – Impulse

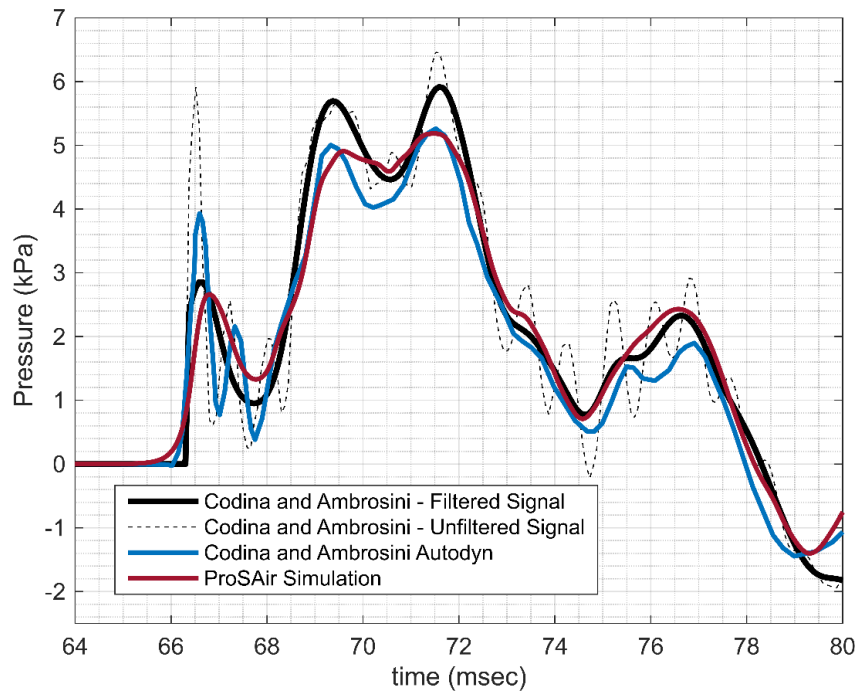


Figure Apx B-9 – Test 2 Gauge 2 Comparative Results - Overpressure

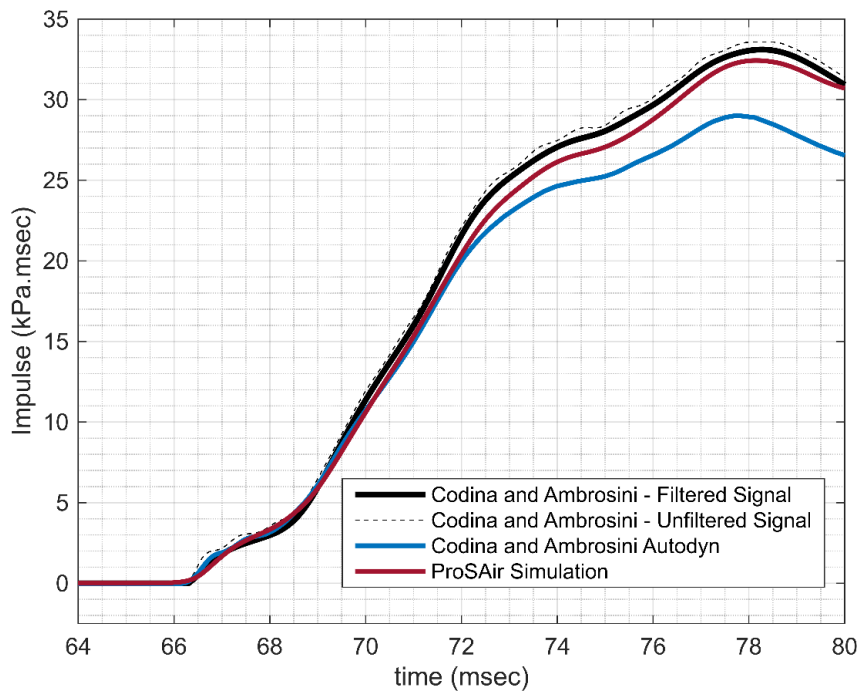


Figure Apx B-10 – Test 2 Gauge 2 Comparative Results - Impulse

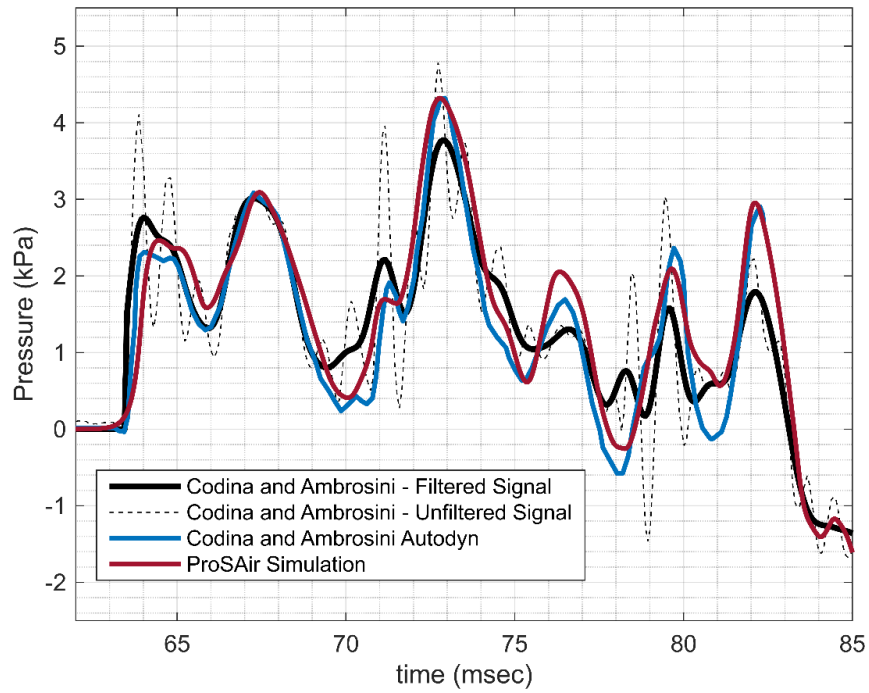


Figure Apx B-11 – Test 2 Gauge 4 Comparative Results - Overpressure

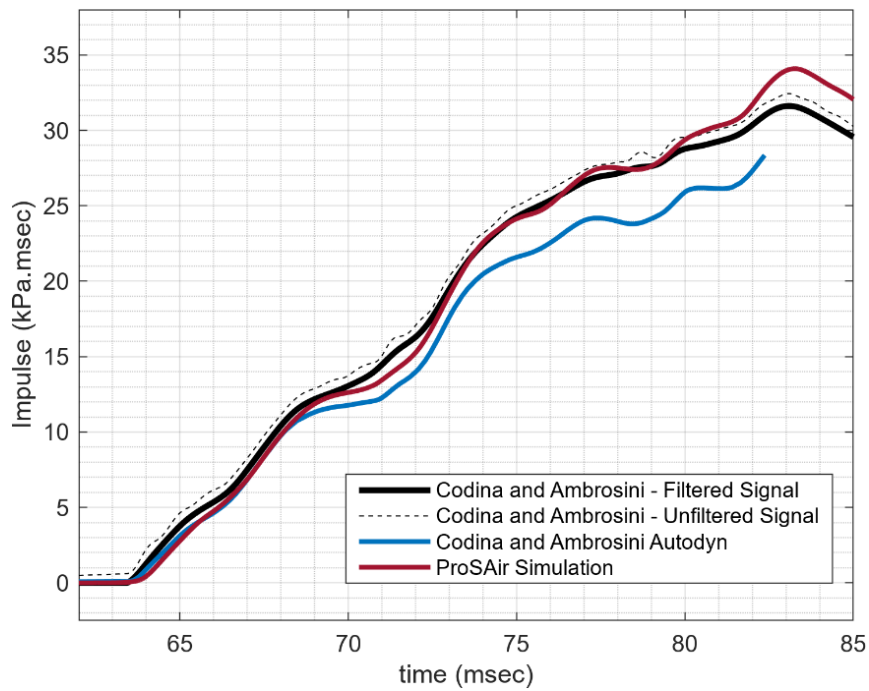


Figure Apx B-12 – Test 2 Gauge 4 Comparative Results - Impulse

Table Apx B-2 – Test 2 Result Comparison

		Gauge Number		
		1	2	4
First Overpressure Peak (kPa)	Codina and Ambrosini Unfiltered	9.1	6.5	4.8
	Codina and Ambrosini filtered	3.6	2.9	2.8
	Codina and Ambrosini Numerical	7.7	3.9	2.3
	ProSAir Simulation	2.8	2.7	2.5
First Phase Impulse (kPa.msec)	Codina and Ambrosini Unfiltered	31.8*	33.6	29.5*
	Codina and Ambrosini filtered	30.1*	33.1	28.8*
	Codina and Ambrosini Numerical	27.1*	28.7	25.9*
	ProSAir Simulation	31.3*	32.4	29.4*

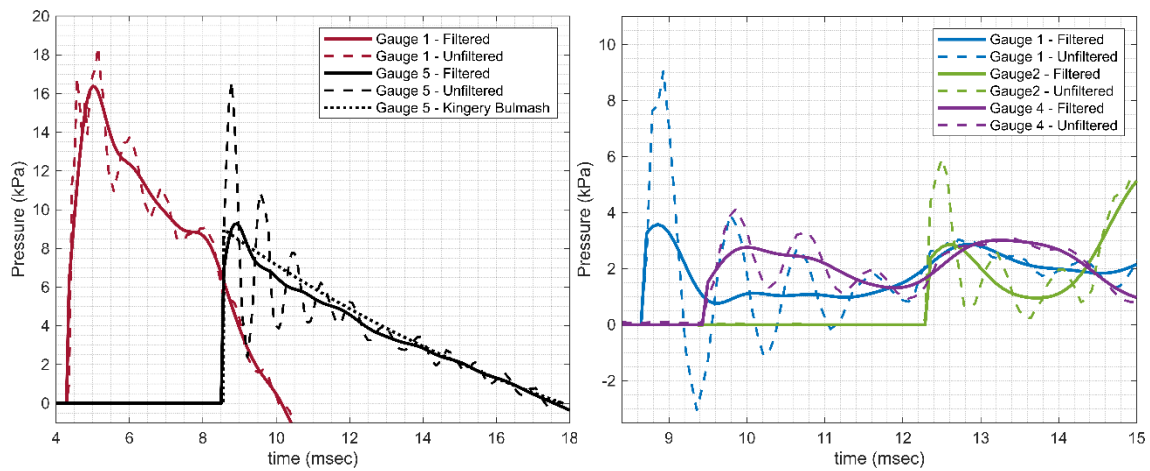


Figure Apx B-13 (a,b) – Codina and Ambrosini (2018) Test 2 original and filtered data using a 200Hz passband frequency; a. (left) – Exterior gauges 1 and 5, b. (right) – Interior gauges 1 (middle of the room), 2 (centre of back wall) and 4 (centre of side wall)



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Discussion and re-evaluation of recent research on pressure ingress into a room from an opening

Eytan, Alex; Burrows, Stephanie J.; Pickering, Erik G.; Forth, Shaun A.

2026-12-31

Sage

<https://doi.org/10.1177/20414196251413706>

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