Addendum 2: Correlations of VPM-B(2), RGBM, and GF
Gradients and Tensions

Compartment Gradients and Tensions are Tracked
Stop-by-Stop for 3 Alternative Ascents from a
120 min dive to 200 ft on Trimix 18/45

• This addendum tracks and compares gradients for ascents from 1 dive only: 120min at 200ft on 18/45. Alternative ascent tables for this dive are shown on page 49. VPM-B was at conservatism level (2), GAP RGBM and GF were at nominal conservatisms.

• Page 4 of the original slides notes that "TATs are closely related to comparative surfacing gradients." TATs were therefore used as convenient 1-point summaries of correlations of VPM-B to GAP RGBM and GF schedules.

• A more detailed comparison of compartment gradients and tensions requires analysis of many more data points for each ascent. Essentially, the TAT data summarized by the two red-colored points on the two plots on page 22 have been expanded into 12 plots each, with 16 points per plot, shown on pages 55 and 57.

• Correlation plots for times at each stop and stair-step profiles are shown in the lower right-hand charts on pages 18 and 19 for VPM-B(2) vs. RGBM, and on page 20, and 21 for VPM-B(2) vs. GF.

Organization

• Original Slides VPM-B vs GAP RGBM and GF Slides (pages 1-38)
  VPM-Bv3.2_vs_GAP_RGBM_and_GF_200ft_3mix1845_Dives.pdf

• Addendum 1 HSE RGBM vs. GAP RGBM (pages 39-46)
  HSE_vs_GAP_RGBM_200ft_3mix1845_Dives.pdf

• Addendum 2 (pages 47-57)
  TandG_VPMB_vs_GAP_RGBM_and_GF_200ft_3mix1845.pdf

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Notations and Conventions

Gradients and Tensions were calculated as functions of time from ascent schedules generated by V-Planner and GAP decompression models.

Profiles

- The ascent schedules calculated by V-Planner and GAP software, shown on page 49, were used to calculate compartment tensions and gradients in a custom Mathematica program.
- If you really want details, then review all of the modeling assumptions (such as compartment half-times, partial pressure of H2O, etc.) in the open source code of the obsolete Mathematica VPM program at my website: http://www.decompression.org/maiken/VM/multigas_vpm.htm

Plots

- Both compartment tensions (T) and gradients (G) are considered, even though the information is redundant. Although tensions are conventional, gradients are more closely related to physical and physiological processes.
- Compartments are labeled according to Buhlmann's ZHL-16 Nitrogen half-times. Conventionally, Helium half-times are scaled by the ratio of the two gas's diffusivities. This is physically inconsistent with the idea that compartments represent time-scales for perfusion. Just another deco model inconsistency!

Discussion of Correlation Plots

- VPM-B(2) and RGBM Ts and Gs, shown on pages 54 and 55, are much more nearly correlated than VPM-B(2) and GF Ts and Gs, shown on pages 56 and 57.
- VPM-B(2) and RGBM Gs and Ts are 1:1 correlated for compartments ranging from the slowest (635 min), to the controlling compartment (a point near plot's upper right-hand corner).
- RGBM fast compartment Gs and Ts are lower than VPM-B(2) for the deepest stops, nonetheless, RGBM Gs and Ts are greater than either VPM-B(2) and GF from 30ft up to the surface.
- Slide 5 discusses the general (ie: applies to all 200ft dives) operational factors that lead to larger surfacing gradients for RGBM compared to VPM-B(2) and GF.
- GF surfacing Gs and Ts are much less than VPM-B(2) and RGBM, but GF TATs are 138 mins longer than VPM-B(2) and RGBM (which are virtually identical at ~356 min TAT).
Ascent Schedules

For reference, the depths, run times, and gas oxygen and nitrogen fractions are tabulated for the three alternative ascent models. Stair-step plots of the ascents are shown in the lower right-hand plots of slides 18 and 20.

<table>
<thead>
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<th>VPM-B(2)</th>
<th>RGBM(N)</th>
<th>GF(N)</th>
</tr>
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<tbody>
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<td>min</td>
<td>fO_2 / fN_2</td>
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<td>2</td>
<td>0.18 / 0.37</td>
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<td>120</td>
<td>0.18 / 0.37</td>
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<td>121</td>
<td>0.18 / 0.37</td>
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<tr>
<td>134</td>
<td>122</td>
<td>0.18 / 0.37</td>
</tr>
<tr>
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<td>141</td>
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<tr>
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<td>474</td>
<td>0.18 / 0.37</td>
</tr>
<tr>
<td>0</td>
<td>611</td>
<td>0.18 / 0.37</td>
</tr>
</tbody>
</table>
Notes on Reading Tension Plots

Saturation Tension at Surface
\[ T_0 = (1 - (p_{H_2O} + p_{CO_2})) \times 0.79 \]

Ascent to 1st stop
Switch to O₂ at 20 ft rapidly reduces tensions in fast compartments (to 0 for the fastest)
Sea level pressure

Ascent to surface
Switch to Nitrox 50% at 70 ft rapidly reduces tensions in fast compartments

Fastest Compartments
In-gas 78% N₂ + 1% Ar at surface after desaturation by O₂ at 20 and 10 ft stops
Saturation Tension at Surface

Slow compartments out-gas after surfacing

Fastest Compartment

120 min TAT 90 min

120 min

Slowest Compartment

635 min

Fastest Compartment

4 min
Notes on Reading Gradient Plots

Compartment Gradients vs. Time

- Fastest compartments control deepest stops
- Slowest compartments drive bubble growth after surfacing
- Negative surface saturation gradient
- Ascent to surface
- Switch to O₂ at 20 ft rapidly reduces gradients in fast compartments
- Switch to Nitrox 50% at 70 ft rapidly reduces gradients in fast compartments
- Ascent to 1st stop

Graphical annotations:
- +G supports bubble growth
- -G drives bubble dissolution

Key times:
- 120 min
- TAT
- 90 min
- 635 min
- 4 min

Legend:
- Slowest Compartment
- Fastest Compartment
Plots of Tensions and Gradients vs. Run Time

**VPM-B (2)**

**Total Compartment Tensions vs. Time**

**Compartment Gradients vs. Time**

**RGBM**

**Total Compartment Tensions vs. Time**

**Compartment Gradients vs. Time**

**Gradient Factor**

**Total Compartment Tensions vs. Time**

**Compartment Gradients vs. Time**

*Note horizontal scale change*

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Construction of Tension and Gradient Correlation Plots

Example: Comparative Tensions at end of 120 ft stop

3 example points corresponding to total tensions ($T_{\text{Total}} = T_{N_2} + T_{He}$) in compartments representing 635 min, 38.3 min, and 4 min $N_2$ Bhulmann ZHL-16 compartments.

1-to-1 correlation line. Points above the line have larger RGBM Tensions. Points below the line have larger VPM tensions.

Plot RGBM tensions as Y components for end of 120 ft Stop

Plot VPM tensions, just like the RGBM illustration, as X components for end of 120 ft Stop

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Stop-by-Stop Correlation Plots of RGBM vs. VPM-B(2) Tensions

RGBM vs. VPM-B Compartment Tensions at End of Each Decompression Stop on Ascent from 120 min Dive to 200 feet

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Stop-by-Stop Correlation Plots of RGBM vs. VPM-B(2) Gradients

RGBM vs. VPM–B Compartment Gradients at End of Each Decompression Stop on Ascent from 120 min Dive to 200 feet

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Stop-by-Stop Correlation Plots of GF vs. VPM-B(2) Tensions

GF vs. VPM–B Compartment Tensions at End of Each Decompression Stop
on Ascent from 120 min Dive to 200. feet

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Stop-by-Stop Correlation Plots of GF vs. VPM-B(2) Gradients

GF vs. VPM–B Compartment Gradients at End of Each Decompression Stop on Ascent from 120 min Dive to 200 feet

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