Mouth Alcohol Determination
Using the New Dräger Evidential Portable Alcohol System (EPAS)
Objectives:

- To determine how quickly mouth alcohol dissipates from the oral cavity
- To determine how well the Dräger EPAS unit detects mouth alcohol
- To determine how necessary the required 15 minute observation period is with the new EPAS instrument
Background

- Title 17 requirements
- Traditional instrumentation
- EPAS specifics
The breath sample shall be collected only after the subject has been under continuous observation for at least fifteen minutes prior to collection of the breath sample, during which time the subject must not have ingested alcoholic beverages or other fluids, regurgitated, vomited, eaten, or smoked.

(California Code of Regulations: Title 17., Division 1., Chapter 2., Subchapter 1., Group 8., Article 5., Section 1219.3)
Title 17 requirements con’t

- For each person tested, breath alcohol analysis shall include analysis of 2 separate breath samples which result in determinations of blood alcohol concentrations which do not differ from each other by more than 0.02 grams per 100 milliliters.

(California Code of Regulations: Title 17., Division 1., Chapter 2., Subchapter 1., Group 8., Article 5., Section 1221.4.a1)
Traditional Instrumentation

- IR based
- non-portable
  - have to back extrapolate
- susceptible to interferents
Dräger EPAS
Dräger EPAS con’t

- Instrument and all its amenities are on the NHTSA Conforming Products list
- Meets all Title 17 requirements
- Fuel Cell based
How does EPAS meet Title 17 requirements?

- Ensures a deep lung (alveolar) breath by having a required:
  - volume of breath given (1.2L)
  - flow rate of breath given (6L/min)
  - time that subject must blow (4-12s)
- Sample is taken after there is a decrease in blowing pressure
For an evidential test, the unit requires two breath samples which do not differ by more than 0.02%.

The unit performs air blank tests before each breath sample until the results are 0.00%.
Accuracy Checks

- The software requires accuracy checks every 10 days or every 150 subjects tested.
- Performed with Scotty Ethanol Breath Standard (0.100% ethanol in nitrogen).
- The accuracy test result must be between 0.09 and 0.110%.
Fuel Cell Background
Basic Hydrogen Fuel Cell

- Catalyst
- Electrolyte
- Cathode
- Anode
- External Circuit

**Chemical Reactions:**
- $\text{H}_2$ (hydrogen)
- O (oxygen)
- $\text{H}_2\text{O}$ (water)
- e (H$_2$ electron)
- p (H$_2$ proton)
EPAS Fuel Cell

A View from the Outside

The Inside Layers

- Catalytic electrode (Platinum black) - 2
- Conductive layer (Gold) - 2
- Porous membrane
- Ethanol is oxidized to CO$_2$

$$\text{C}_2\text{H}_5\text{OH} + 3\text{H}_2\text{O} \rightarrow 2\text{CO}_2 + 12\text{H}^+ + 12\text{e}^-$$

$$3\text{O}_2 + 12\text{H}^+ + 12\text{e}^- \rightarrow 6\text{H}_2\text{O}$$

Overall reaction:
$$\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow \text{CO}_2 + 3\text{H}_2\text{O}$$
Alcohol from breath changes potential across the electrodes

- Change in current is directly related to the concentration of alcohol in the breath sample
Methods

- 25 subjects
- 5 types of alcoholic solutions
- 0.00% v. 0.08%
- spitting v. swallowing
- BrAC v. BAC
Alcoholic Solutions

- Beer – Michelob Lager (5%)
- Wine – Charles Shaw 2003 California Merlot (12.5%)
- Hard Liquor – Grey Goose Vodka (40%)
- Cough Syrup – Kirkland Cherry Flavor Night-Time Cough Syrup (10%)
- Mouthwash – Listerine Cool Mint Mouthwash (21.6%)
Experimental Design

Part 1 – spit out solution at 0.00% BAC
Part 2 – swallow solution at 0.00% BAC
Part 3 – give calculated amount of alcohol for subject to reach 0.08% and draw blood
Part 4 – spit out solution at 0.08%
Part 5 – swallow solution at 0.08%
Experimental Design con’t

For each part involving breath testing:

- 1 oz. randomly assigned solution
- swirl/swish in mouth 5 times
- spit out or swallow accordingly
- immediately give breath test
- continuous testing for 15 minutes
- no talking, drinking, or breathing with mouth open
Alcohol Calculation

- Used Fred’s Widmark Formula-LAPD Version:

\[ \text{oz}^{100} = (BA)(W)(r) \]

Men = 0.27 and Women = 0.22

derived from Widmark Formula:

\[ C_0 = \frac{A}{W^r} \]
Results
Mouth Alcohol Decay

- Exponential decay (as found by Gullberg, 1992)
- \( r^2 \) ranged from 0.9821 to 0.6053
- Average \( r^2 \): 0.8454

- Also true for difference between BrACs
- \( r^2 \): 0.9245 – 0.5775, average = 0.7930
Ave. BrAC when swallowing beer at 0.00%

\[ y = 0.2801e^{-0.366x} \]

\[ R^2 = 0.944 \]
Average BrAC when swallowing vodka at 0.00%

\[ y = 0.4469e^{-0.1907x} \]

\[ R^2 = 0.7714 \]
Average Baselines After Drinking

<table>
<thead>
<tr>
<th>Type of Experiment</th>
<th>Baseline BrAC (%)</th>
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<tbody>
<tr>
<td>beer</td>
<td>0.06</td>
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<tr>
<td>wine</td>
<td>0.05</td>
</tr>
<tr>
<td>cough syrup</td>
<td>0.04</td>
</tr>
<tr>
<td>mouthwash</td>
<td>0.03</td>
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<tr>
<td>vodka</td>
<td>0.02</td>
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</tbody>
</table>

- spitting
- swallowing
Comparison of Initial BrACs

BrAC (%)

Type of experiment

- 0.00 spit
- 0.00 swallow
- 0.08 spit
- 0.08 swallow

- beer
- wine
- cough syrup
- mouthwash
- vodka
Comparison of Time Back to Baseline

Type of experiment

Time (min)

beer
wine
cough syrup
mouthwash
vodka
Average BrAC Away From Baseline if Didn't Return

<table>
<thead>
<tr>
<th>Type of Experiment</th>
<th>BrAC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beer</td>
<td></td>
</tr>
<tr>
<td>Wine</td>
<td></td>
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<td>Cough Syrup</td>
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<td>Mouthwash</td>
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<tr>
<td>Vodka</td>
<td></td>
</tr>
</tbody>
</table>

BrAC (%): 0.00 spit 0.00 swallow 0.08 spit 0.08 swallow
Time to Two Sequential Tests within 0.02%

- **Type of experiment**
  - 0.00 spit
  - 0.00 swallow
  - 0.08 spit
  - 0.08 swallow

- **Time (min)**
  - beer
  - wine
  - cough syrup
  - mouthwash
  - vodka

Legend:
- beer
- wine
- cough syrup
- mouthwash
- vodka

Bar chart showing the time for each type of experiment and each concentration level.
0.00% v. 0.08%

- Initial BrACs are higher with no alcohol in their systems – 0.006-0.129% higher
- More subjects did not return to baseline with alcohol in their systems
- Having alcohol in their systems made the mouth alcohol decay less exponential
Spitting v. Swallowing

- Swallowing produced consistently higher initial BrACs (0.024 to 0.149% higher)
- It consistently took longer for the subject to return to baseline after swallowing than after spitting (0.5 to 5 minutes longer)
- More subjects didn’t return to baseline after swallowing than after spitting
- Swallowing gave a less exponential decay rate
Problems

- Accuracy checks wouldn’t stay within the acceptable limits over time
- Baseline built up with breath tests that had a high concentration
- Build up was maintained over time
- Could give skewed readings to tests
NH-0303 Accuracy Checks

BrAC value (%)

Date/Time
Conclusions

- Amount of mouth alcohol depends on concentration of solution
- BrAC almost always underestimates BAC
- It takes longer to return to baseline if there is alcohol in the body
- Swallowing produces a higher mouth alcohol concentration and a longer return to baseline
- Still need 15 minute observation period
Acknowledgements

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