The Missing Link

- Search google images for “missing link” -- [96752-missing_link_animals_civilized_man_discovered.jpg]
4, 5 AND 6 ARE REMOTE INDICATORS OF HAZARD AT STRUCTURE.

1, 2 AND 3 ARE MORE DIRECT INDICATORS.
VADOSE ZONE

MONITORING

VADOSE PROBES

WATER WELL

GROUND WATER

VADOSE (UNSATURATED) ZONE
PUSH RIG

HAND AUGER
<table>
<thead>
<tr>
<th>Rule 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>In evaluating explosion hazard in building space, there is <em>no</em> inherently unsafe methane soil gas concentration.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rule 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>For hazard to exist, there must be sufficient volume/flow of the combustible fraction of the available soil gas to result in gas concentrations $&gt;\text{L.e.l.}$ inside the structure.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rule 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only pressurized methane soil gas can achieve explosive concentrations in building space abutting the gassy soil.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rule 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undiluted or &quot;whole&quot; soil gas is likely to exhibit inherent or “genesis” pressure.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rule 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repressurization conditions can result in hazard with diluted soil gases at concentrations greater than or equal to the LEL.</td>
</tr>
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</table>

Sepich 2007
<table>
<thead>
<tr>
<th>Site</th>
<th>General Location</th>
<th>Date of Construction</th>
<th>Minimum Subsurface Methane Concentration (ppmv)</th>
<th>Source of Methane</th>
<th>Gas Mitigation Improvements Installed?</th>
<th>Number of Homes or Buildings</th>
<th>Maximum Interior Methane Concentration (ppmv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>1997</td>
<td>370,000</td>
<td>biogenic (oilfield)</td>
<td>No</td>
<td>Yes</td>
<td>140</td>
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<tr>
<td>2</td>
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<td>1970</td>
<td>960,000</td>
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<td>1999</td>
<td>205,000</td>
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<td>155</td>
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<tr>
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</tr>
<tr>
<td>4</td>
<td></td>
<td>1999</td>
<td>135,000</td>
<td>biogenic (dairy)</td>
<td>No</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>1999</td>
<td>450,000</td>
<td>biogenic (dairy)</td>
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<td>3</td>
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<tr>
<td>6</td>
<td></td>
<td>1999</td>
<td>17,000</td>
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<td>3</td>
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<td>7</td>
<td></td>
<td>2000</td>
<td>270,000</td>
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<td>No</td>
<td>105</td>
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<td>8</td>
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<td>25,000</td>
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<tr>
<td>9</td>
<td></td>
<td>1930 - 1985</td>
<td>1,000,000</td>
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<td>No</td>
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<td>10</td>
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<td>1950 - 1960</td>
<td>500,000</td>
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<td>11</td>
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<td>1995</td>
<td>350,000</td>
<td>biogenic (dairy)</td>
<td>No</td>
<td>23</td>
<td></td>
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</tbody>
</table>
SOIL GAS ATTENUATION
MODELED VS. EMPIRICAL

Up to 50,000 ppm methane in soil always safe
*Approx Max based on sandy soil @ 5°C at bottom of slab
*Approx Min based on sandy-clay soil @ 20°C at 25' below slab
**Methane Transport (MTRANS) Model, Applied Geokinetics, Irvine, CA, 2002

CH₄+CO₂ etc. 50³ - 750³ ±
Determine repressurization potential
Treat as whole gas

750³ ± to one million
WHOLE GAS

0.1
0.01
10
100
1000
10000
100000
Building Concentration (ppmv)

Soil Gas Concentration (ppmv)

J&E RANGE
 MODELED DATA (J&E)
Approximate MAX
Approximate MIN

J095 - LA
JES/JAH
11/20/2008

EMPIRICAL DATA (MTRANS)
Without mitigation
With mitigation

Brownfield Subslab / 4007 McCullough Ave #469 / San Antonio, TX, 78212 / jasepich@gmail.com
WHOLE GASES = UNDILUTED

*Thermogenic:* C1-C5+, H2S, CO2, other trace

*Microbial:* CH4, CO2, other trace

GENESIS PRESSURE = THE GAS PRESSURE AT THE POINT OF INTRODUCTION TO THE SOIL MATRIX

INHERENT PRESSURE = OVER AND ABOVE, AND NOT ASSOCIATED WITH BAROMETRIC LAG, ADETECTION, OR CONVECTION (THE RESIDUAL OF THE GENESIS PRESSURE AT ANY POINT ALONG THE MIGRATION PATHWAY)
Q = KIA

Q (m³/sec or ft³/sec) -- soil vapor flow;
• K (m/sec or ft/sec) – permeability coefficient
• I (dimensionless) -- hydraulic gradient
• A (m² or ft²) -- cross sectional area of flow

Ranges of K (after CA DTSC “Biogenic Methane”)

<table>
<thead>
<tr>
<th>No.</th>
<th>Material</th>
<th>m/sec</th>
<th>ft/sec</th>
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<tr>
<td>1</td>
<td>coarse gravel</td>
<td>1.10E+00</td>
<td>3.61E+00</td>
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<tr>
<td>2</td>
<td>sandy gravel</td>
<td>1.60E-01</td>
<td>5.25E-01</td>
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<td>fine gravel</td>
<td>7.10E-02</td>
<td>2.33E-01</td>
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<td>silty gravel</td>
<td>4.60E-03</td>
<td>1.51E-02</td>
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<tr>
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<td>coarse sand</td>
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<td>3.61E-03</td>
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<td>medium sand</td>
<td>2.90E-04</td>
<td>9.51E-04</td>
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<td>fine sand</td>
<td>9.60E-05</td>
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<td>1.50E-04</td>
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<td>6.68E-08</td>
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<td>silt</td>
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<td>sand</td>
<td>8.91E-06</td>
<td>2.92E-05</td>
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</tbody>
</table>
INTERIOR GAS CONCENTRATION

- $Q$ = flowrate;
- $V_B$ = Building Volume;
- $\text{aer}$ = Air Exchange Rate;
- $C$ = vapor concentration;
- $Q_1 C_1 + Q_2 C_2 = Q_3 C_3$; and
- $Q_3 = V_B \times \text{aer}$.

If $C_1 = 0$, then:

- $C_3 = C_2 Q_2 / (V_B \times \text{aer})$

AER’s may vary from several per hour to several per day, depending upon structure and ventilation. Example: aer 4/hour = 1/15 minutes in calculation.

Sepich 2012

Soil gas flow volumes from channelized pathways often exceed the Darcy flux contribution from the predominant soil matrix.
METHANE INSIDE STRUCTURE

>20% LEL  
NO

OPEN ALL DOORS 
AND WINDOWS. 
EVACUATE, AND 
call 911

SOIL GAS DETERMINATION

SOIL GAS

GAS CONCENTRATION ≥ LEL

Q / V₆ x AER ≥ LEL

GAS PRESSURE ≥ 2" H₂O

WHOLE GAS

RE-PRESSURIZATION CONDITIONS

NO

YES

NO

YES

MITIGATE

NO ACTION

J. Sepich / April 2012
<table>
<thead>
<tr>
<th>Category</th>
<th>Method</th>
<th>Type</th>
<th>VOC’s</th>
<th>CH4</th>
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<td>institutional controls</td>
<td>covenants</td>
<td>deed re: monitoring / access</td>
<td>x</td>
<td>x</td>
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<td>owners associations re: o&amp;m</td>
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<td>x</td>
<td>x</td>
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<td>use restrictions</td>
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<td>food crops</td>
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<td>ignition sources</td>
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<td></td>
<td>signage, i.e. prop. 65</td>
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<td>signage, warnings re: slab-cuts</td>
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<td>subgrade, subslab, indoor</td>
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<td></td>
<td>based upon monitoring</td>
<td></td>
<td>x</td>
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<td>based upon use</td>
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<td></td>
<td>clean-up / removal</td>
<td>excavation</td>
<td>x</td>
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<td>clean-up / treatment</td>
<td>vapor extraction</td>
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<td>in-situ treatment/oxidation</td>
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<td>pump and treat</td>
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<td>oxygenation of anaerobes (temp.)</td>
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<td>barriers and venting</td>
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<td>mat slabs</td>
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<td>barrier membranes</td>
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<td>passive crack repair</td>
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<td>pathway plugging</td>
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<td>passive venting</td>
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<td>active venting – air permit</td>
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<td>positive pressure hvac</td>
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<td>Indoor air treatment</td>
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<tr>
<td>intrinsically safe</td>
<td>open structure</td>
<td>ambient ventilation</td>
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<tr>
<td></td>
<td>ventilated crawl-space</td>
<td>passive or active ventilation</td>
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<td>x</td>
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<tr>
<td></td>
<td>ventilated podium, basement</td>
<td>passive or active ventilation</td>
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<td>x</td>
</tr>
</tbody>
</table>
AMBIENT VENTILATION

CAR PORT

OPEN STRUCTURE

SOIL VAPOR

INTRINSICALLY SAFE
SPRAY-SHEET SANDWICH

WALL
SLAB
SAND
SHEET
SPRAY CORE
SHEET
SAND
SUBGRADE

Sepich 2012
VENT TRENCH

Sepich 2012

MEMBRANE SANDWICH

ROCK

PERFORATED HORIZONTAL PIPE

GEOTEXTILE

SLAB

PERFORATIONS

OPTIONAL SOCK

4”
FLAT PIPE

PLAN

SECTION

12" WIDE

1 1/2"

SAND

SAND

Sepich 2012
ELEVATOR PISTON
(Acts as gas conduit/collection well)

MITIGATION
MONITORING
Table 7 - OUTDOOR HAZARDOUS AREA CLASSIFICATION

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>METHANE VENTILATION LEVEL</th>
<th>MEASURED SOIL GAS CONCENTRATION (ppm)</th>
<th>MEASURED SOIL GAS CONCENTRATION (ppm)</th>
<th>HAZARDOUS AREA CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar finished grade</td>
<td>High</td>
<td>≤ 25 L/L for 15 min</td>
<td>≤ 0.25 L/L for 15 min</td>
<td>Class 1, Division 1</td>
</tr>
<tr>
<td>Solar finished grade with</td>
<td>Medium</td>
<td>≤ 25 L/L for 15 min</td>
<td>≤ 0.25 L/L for 15 min</td>
<td>Class 1, Division 2</td>
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<tr>
<td>Higher than 0.1% but</td>
<td>Low</td>
<td>≤ 25 L/L for 15 min</td>
<td>≤ 0.25 L/L for 15 min</td>
<td>Class 1, Division 3</td>
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<tr>
<td>lower than 0.1%</td>
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<tr>
<td>Solar finished grade with</td>
<td>High</td>
<td>≤ 25 L/L for 15 min</td>
<td>≤ 0.25 L/L for 15 min</td>
<td>Class 1, Division 1</td>
</tr>
<tr>
<td>solar finish</td>
<td>Medium</td>
<td>≤ 25 L/L for 15 min</td>
<td>≤ 0.25 L/L for 15 min</td>
<td>Class 1, Division 2</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>≤ 25 L/L for 15 min</td>
<td>≤ 0.25 L/L for 15 min</td>
<td>Class 1, Division 3</td>
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</table>

Table 8 - VENT RISER HAZARDOUS AREA CLASSIFICATION

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>POWER VENTILATED</th>
<th>HEMISPHERICAL DISTANCE FROM THE MAXIMUM VENT, JADE OR A FITTING</th>
<th>HAZARDOUS AREA CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum</td>
<td>No</td>
<td>≤ 25 L/L for 15 min</td>
<td>Class 1, Division 1</td>
</tr>
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<td></td>
<td>Yes</td>
<td>≤ 25 L/L for 15 min</td>
<td>Class 1, Division 2</td>
</tr>
<tr>
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<td>≤ 25 L/L for 15 min</td>
<td>Class 1, Division 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 25 L/L for 15 min</td>
<td>Class 1, Division 4</td>
</tr>
</tbody>
</table>

Section:

Plan View:
- Sand backfill
- Trench Dam Length (See Notes #3 and #4)
- Trench length 4 min
- Connal depth 6”
- Pipe or conduit
- Slab
- Trench Dam (See Notes #3 and #4)

Table 9 - BUILDING HAZARDOUS AREA CLASSIFICATION

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>METHANE VENTILATION LEVEL</th>
<th>MEASURED SOIL GAS CONCENTRATION (ppm)</th>
<th>MEASURED SOIL GAS CONCENTRATION (ppm)</th>
<th>HAZARDOUS AREA CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building</td>
<td>High</td>
<td>≤ 25 L/L for 15 min</td>
<td>≤ 0.25 L/L for 15 min</td>
<td>Class 1, Division 1</td>
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<tr>
<td></td>
<td>Medium</td>
<td>≤ 25 L/L for 15 min</td>
<td>≤ 0.25 L/L for 15 min</td>
<td>Class 1, Division 2</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>≤ 25 L/L for 15 min</td>
<td>≤ 0.25 L/L for 15 min</td>
<td>Class 1, Division 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class 1, Division 4</td>
</tr>
</tbody>
</table>

Note:
1. Piping and conduit shall be protected from corrosion and structural settlement as follows:
   a. Tape shall be applied on conduit and piping encased in cement slurry or concrete.
   b. Tape shall be PS-37-90, Black Plastic PVC or PE Pressure - Sensitive Corrosion Preventive Tape.

Classified Electrical Detail:
- Service Conduit
- Main Service Pull Box
- Subpanel
- Hazardous Classified Area
- Class I Div. 1, Group D
- Class I Div. 2, Group D
- Unclassified

Classified Trench Dams
- SPS-90 (must be at least 1/4” thick)
- Class I Div. 1, Group D
- Class I Div. 2, Group D
- Unclassified

Trench Dam Installation:
- Install listed conduit or cable seal fitting in conduit located between utility pullbox and main service pull box
- Service Conduit
- To DWP Vault
- Bldg Wall
- Utility Pullbox
- FINISHED GRADE
- WYE SEAL

Wye Seal
- Fiber filter
- Sealing compound
- Horizontal Conduit Seal
- Electrical conduit
- Fiber filter
- Fiber filter

Sepich 2012
| no liability | mitigate well water | vadose pathways | no incidents |
ASTM E50 Methane

- federal and state “onsite” regulations
- local building and fire departments “offsite”
- less information = media field day
- hunker down regulations
- need incident catalog
- need hazard assessment algorithm
- need uniform national guidelines