Exposure Assessment Concepts

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Section A

Introduction
Origin of Hygiene

- Hygeia was the Greek goddess of health
- Rene Dubos wrote: “For the worshippers of Hygeia, health is … a positive attribute to which men are entitled if they govern their lives wisely”
- Prevention is key
Exposure—Definition

- Contact between the outer boundary of the human body (skin, nose, lungs, GI tract) and a contaminant
- Requires the simultaneous presence of a contaminant and the contact between the person and that medium
- Quantified by concentration of contaminant and time and frequency of contact
Route of Exposure

- Inhalation
- Ingestion
- Dermal
- Direct injection
- Inhalation is most common in workplace—but not in general environment
- Moving towards concept of total exposure
Exposure Assessment

- Magnitude
  - Concentration in media (ppm, f/cc)
- Duration
  - Minutes, hours, days, working life, lifetime
- Frequency
  - Daily, weekly, seasonally
Types of Air Sampling: Time

- **FULL PERIOD SINGLE SAMPLE**
- **FULL PERIOD CONSECUTIVE SAMPLES**
- **PARTIAL PERIOD CONSECUTIVE SAMPLES**
- **(RANDOM) GRAB SAMPLES**

Source: U.S. Government
Section B

Exposure Assessment
Exposure Assessment

1. Assessment of hazard
   – Identification of potential hazards
   – Qualitative assessment of exposure
   – Exposure potential, magnitude, toxicity, etc.
   – Exposure modeling

2. Identification of concerns (hypothesis)
Exposure Assessment

3. Quantification of exposure
4. Determine acceptability
   – Comparison with measure of safe or acceptable
   – Professional judgment and other factors
5. Decision on appropriate action
6. Periodically re-evaluate
1. Assessment of Hazard

- Process description with emphasis on:
  - Raw materials
  - Contaminant chemicals
  - Intermediates
  - By-products
  - Decomposition products
  - Additives

Continued
1. Assessment of Hazard

- Sources of chemical use information
  - Material Safety Data Sheets (MSDS)
  - Inventories
  - Purchasing records
  - Standard operation procedures (SOPs)
  - Inspections of workplace
  - Interviews with workers

Continued
1. Assessment of Hazard

- Methods of chemical use
  - Focus on opportunities for contaminant release to the workplace environment
  - Physical-chemical factors governing release
  - Physical-chemical factors influencing magnitude

Source: U.S. Government
1. Assessment of Hazard

- Methods of chemical use
  - Focus on opportunities for exposure
  - Routes of exposure
  - Influence of work practices

Source: U.S. Government
1. Assessment of Hazard

- Preliminary inspection and observations
  - Worker and management interviews
  - Evaluate work practices
  - Note personal protective equipment
  - Note ventilation/other controls
1. Assessment of Hazard

- Additional preliminary observations
  - Housekeeping
  - Maintenance
  - Emergency procedures
  - Perceptions/experience
1. Assessment of Hazard

- Review of documents
  - Internal reports and records
  - Industry reports
  - Government reports and publications
  - Texts, other publications

- Note: This can be time-consuming
1. Assessment of Hazard

- Review of documents
  - Previous inspections
  - Medical complaints
  - OSHA 200 log

- Note: This can be time-consuming
1. Assessment of Hazard

- **Exposure modeling**
  - Use a mathematical construct to quantitatively estimate exposures
  - Models will typically include
    - Source term
    - Transport in time and space
    - Receptor factors (time activity information)
2. Identification of Concerns

- Given limited resources, focus on limited number of possible exposures
- Develop exposure assessment goals
  - Can be hypotheses about exposures to be tested by quantitative assessment
- Create a written exposure assessment program
3. Quantitative Assessment

- To confirm or refute exposure hypotheses and to serve as a basis for decision making
- Quantitative assessment of exposure via air sampling (i.e., measurement of air concentrations of a contaminant) is a tool for estimating risk or hazard
- Used in conjunction with observations, calculations, discussions, medical data, etc.
3. Quantitative Assessment

- Ideally would like to know or estimate
  - Exposure magnitude or intensity
  - Exposure duration
  - Exposure frequency
  - Numbers exposed
  - Population characteristics

- Statistical description
  - Make inferences in absence of data
Exposure Profile

Time weighted average (TWA)

Peak
Sources of Variability

- Methodological variability
  - Random error from sampling and analysis process
  - ± 5–30 percent

- Environmental variability
  - Non-random error from:
    - Manufacturing process
    - Environment

\{ \text{Spatial/temporal} \}
Sources of Variability

- Environmental variability
  - Inter- and intra-person
  - ± order(s) of magnitude
4. Determine Acceptability

- Role of air sampling
  - Used as a tool for estimating risk or hazard
  - Other observations, calculations, discussions with workers, medical data, etc.
- Comparison with measure of safe or acceptable
- Professional judgment and other factors
Introduction to TLV Book

- The values listed in this book are:
  - Guidelines to assist in the control of workplace hazards
  - Not fine lines between safe and dangerous
- TLVs should be used by trained IHs
- Need to refer to individual documentation
5. Decision on Appropriate Action

- Prioritize
- Develop workplace control plan
  - Short term
    - PPE
    - Administrative
    - Work practices
  - Long term
    - Engineering controls
6. Periodically Re-Evaluate

- Whenever significant process or workforce change occurs
- Develop schedule for routine periodic re-evaluation
  - Basic workplace characterization
  - Exposure assessment program
  - Workplace control plan
Record Keeping

- Set up occupational exposures database
  - Can be complicated
  - Keep indefinitely
- Hazard communication
- Workplace control changes
Section C

Standard Methods
Use of Standard Methods

- Developed by NIOSH, OSHA, EPA, and others
- Standardize sampling and analytical procedures
- Limits of detection known
- Sampling and analytical error determined
<table>
<thead>
<tr>
<th>CHEMICAL NAME</th>
<th>METHOD #</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FORMULA</strong></td>
<td>Molecular Weight</td>
</tr>
<tr>
<td>Chemical Abstracts Service #</td>
<td>RTECS #</td>
</tr>
</tbody>
</table>

Method numbers are the same as those in the 3rd edition. Evaluation (Full, Partial, Unrated, N/A) is assigned as described in Method Classification of these "blue pages." Issue date reflects current version (e.g., August 15, 1994) and previous 3rd edition versions, if any.

OSHA: These exposure limit values are those in effect at the time of printing of the method.

NIOSH: Boiling/melting points, equilibrium vapor pressure, and density help determine the sample aerosol/vapor composition.

ACGIH: Synonyms ("yellow pages" in this Manual).

**SYNONYMS:** Common synonyms for the substance. These are all listed alphabetically in the Index of Names and Synonyms ("yellow pages" in this Manual).

**PROPERTIES:**

**SAMPLES:** Brief description of sampling EQUIPMENT.

**FLOW RATE:** Acceptable sampling range, L/min.

**VOL-MIN:** Minimum sample volume (L) corresponds to Limit of Quantitation (LOQ) at OSHA PEL.

**MAX:** Maximum sample volume (L) to avoid analyte breakthrough or overloading.

**BLANKS:** Each set should have at least 2 field blanks, up to 10% of samples, plus 6 or more media blanks in the case of coated sorbents, impinger solutions, or other special samplers.

**ACCUACY**

Data are for experiments in which known atmospheres of the substance were generated and analyzed according to the method. Target accuracy is less than 25% difference from actual concentration over the range of the method.

**TECHNIQUE:** The measurement technique used.

**ANALYTE:** The chemical species actually measured.

**CALIBRATION:** Summary of type of standards used.

**RANGE:** Range of calibration standards to be used from LOQ to upper limit of measurement. Note: More concentrated samples may be diluted in most cases to fall within this calibration range.

**ESTIMATED LOD:** Limit of detection (background + 3).

**PRECISION (%)** Experimental precision of spiked samplers.

**APPLICABILITY:** The conditions under which the method is useful, including the working range in mg/m³ (from the LOQ to the maximum sampler loading) for a stated air volume are given here.

**INTERFERENCES:** Compounds or conditions which are known to interfere in either sampling or measurement are listed.

**OTHER METHODS:** Methods from the 2nd edition ("P&CAM" and "S" methods) and current methods which are related to this one, as well as similar OSHA and literature methods are keyed to REFERENCES.

Source: U.S. Government
# NIOSH Methods

<table>
<thead>
<tr>
<th>Method #</th>
<th>Substances</th>
</tr>
</thead>
<tbody>
<tr>
<td>0001-0799</td>
<td>General air samples</td>
</tr>
<tr>
<td>0800-0999</td>
<td>Bioaerosols</td>
</tr>
<tr>
<td>1000-1999</td>
<td>Organic vapors on charcoal</td>
</tr>
<tr>
<td>2000-3499</td>
<td>Organic vapors on other solid sorbents</td>
</tr>
<tr>
<td>3500-3999</td>
<td>Organic vapors on other samplers (e.g., liquids, direct-reading)</td>
</tr>
<tr>
<td>4000-4999</td>
<td>Organic vapors on diffusive samplers</td>
</tr>
<tr>
<td>5000-5999</td>
<td>Organic aerosols</td>
</tr>
<tr>
<td>6000-6999</td>
<td>Inorganic gases</td>
</tr>
<tr>
<td>7000-7999</td>
<td>Inorganic aerosols</td>
</tr>
<tr>
<td>8000-8999</td>
<td>Biological samples</td>
</tr>
</tbody>
</table>

Source: U.S. Government