Exposure Assessment:
Establishing Similar Exposure Groups
Important Clarification (1)

• **Homogeneous exposure group (HEG)**
  - A group of employees who experience agent exposures similar enough that monitoring the agent exposures of any worker in the group provides data useful for predicting exposures to the remaining workers.
  - The categorization of workers into these groups often involves categorization by process, job description, and agents, although finer separation can be attained by further dividing on the basis of task analysis.

• **Similar exposure group (SEG)**
  - Groups of workers having the same general exposure profile for the agent(s) being studied because of the similarity and frequency of the tasks they perform, the materials being used, process being run, and controls in place.
  - The problem is **how similar** in exposure profile we can conclude a SEG is formed.
• **Uniform exposure group**
  - A uniformly exposed group is defined as one where the (arithmetic) mean exposure is the same for all individuals.

• **Monomorphic group**
  - A monomorphic group has been defined as a group in which the (arithmetic) mean exposures of the individual workers can be described by a lognormal distribution.
Two General Methodologies Used to Define SEGs

• Observational approach
  – SEGs are determined according to an examination of the activities workers perform and a judgment on the expected similarity of their exposures.
  – Exposure monitoring data are not considered.
  – Also called qualitative approach

• Sampling approach
  – Many workers’ exposures are measured and the statistical analysis of the exposure data is used to assign the individual workers to SEGs.
  – Also called quantitative approach
Integration of Both Approaches

• To form a comprehensive exposure assessment strategy
  – Use the observational approach as the primary, default approach to defining SEGs.
  – Assess exposures for the SEGs formed by observation.
  – Identify critical SEGs for which the consequences of misclassifying an individual worker’s exposure are very severe.
  – Use exposure monitoring and statistical analysis to check and refine critical SEGs using the sampling approach.
Establishing Similar Exposure Groups by Observation (1)

- **Four determinants:**
  - **process**
    - A stand-alone manufacturing or service operation.
  - **job**
    - A position or occupation held by one or more persons in an organization. In the hierarchy of many workplace, a process or department frequently contains one or more jobs. One or more tasks or work activities are often assigned to each job.
  - **task**
    - A work element or series of work elements.
  - **agent (environmental agent)**
    - A chemical, radiological, thermal, physical, or biological entity that may cause deleterious effects in an exposed worker.
Establishing Similar Exposure Groups by Observation (2)

- Suggested hierarchical strategies:
  - Classifying by process and environmental agent;
  - Classifying by process, job, and environmental agent;
  - Classifying by process, job, task, and environmental agent;
  - Classifying by process, task, and environmental agent;
  - Classifying work teams; and
  - Classifying nonrepetitive work
Important Concerns

• Several industrial hygienists independently assessing a workplace may not determine identical SEGs. With training, the differences may be insignificant.

• Basic characterization of the workplace uses not only a review of records but also time on the production floor talking to workers and surveying the work process.
S1. Classifying by Process-Environmental Agent

• To identify major work processes
  – To evaluate whether each administrative department represents a unique process.
    • If so, the administrative department may be considered equivalent to the process element of the SEG.
    • To confirm whether an administrative department may contain two or more major processes --- requiring further review and possible SEG refinement.

• To collect the inventory of environmental agents
  – The inventory should be comprehensive and include all production- and maintenance-related chemical agents, products, byproducts, significant physical agents, and significant biological agents.
  – The inventory should include each chemical mixture in use and its components.
    • Component information is usually available from MSDS.
  – To link every environmental agent identified in the basic characterization to one or more SEGs.
S2. Classifying by Process-Job-Environmental Agent

- To review the site’s official job classification scheme available from the organization’s human resources or personnel staff.
  - Although it is a useful tool, it should not be automatically accepted as SEGs.
  - In many workplaces, employees are assigned to personnel job classes for payroll purposes, and these job classes may not represent SEGs.
  - To observe all work shifts and interview workers on each shift (day, evening and night) as needed.

- To ask if the exposures for some personnel job classification are unique.

- If a useful job classification scheme is not available, the industrial hygienist will need to rely more heavily on the information gathered on the workplace, workforce, and environmental agents.
Task characterization is important only when the additional detail will contribute significantly to understanding and managing the exposure(s).

- Assessing peak exposure is inherently task-related.

- Both frequency, for example, days per year and number of peak excursions occurring per day on significant tasks should be recorded.

- A specific task must be identified as an element of the SEG when assessing exposure relative to a ceiling or short-term exposure limit.
It is possible to ignore identification of jobs for the determination of SEGs. This strategy is effective under two conditions:

- Processes are strongly linked to manufacture of a product or application of a service; and

- Tasks are strongly linked to identification and control of workplace exposure to environmental agents,
S5. Classifying Work Team

- Work team may be assigned to production work in a department or process line, or to maintenance work in an area or facility.

- A work team may correspond to the process and job elements of the exposure group.

- Criteria used for classifying work teams:
  - If workers are more or less permanently assigned to work positions, these positions are the SEG’s job element.
  - If worker rotate among positions but work the entire day at a given position, the work team is the SEG’s job element and the position is the SEG’s task element.
  - If workers rotate among the positions and there is within-day rotation, the team is the SEG’s job element and identification of tasks is important only when assessing exposure relative to a ceiling or STEL; such assessments are inherently task-related.
S6. Classifying Nonrepetitive Work

- It is difficult to establish SEGs in these workplaces. Meaningful exposure groups might exist one day and change the next.

- To designate the product or project as the process or task.
Nonroutine operation

• Definition:
  – A process, job, or task characterized by some of the following: short lead time, short duration, transient work force, nonrepetitive, variable work sites, and variable work practices.

• Nonroutine operations include research and develop, environmental remediation, and hazardous waste cleanup. Maintenance and repair duties are more often routine than nonroutine.

• For nonroutine operations, examination of work at the process-job-task level is often the easiest way to establish SEGs. One proven observational approach is to use a work hierarchy, as is customary in a project management environment. (project exposure assessment approach)
  – Consider a non routine operation a “project” that can be divided into several steps, or what is commonly called a work breakdown structure.
  – Each work element is further reduced to a set of smaller work tasks and these are further divided into detailed subtasks.
Advantages and Disadvantages of the Project Exposure Assessment Approach

• Advantages
  – It relates well to a project management environment because it uses the language and structure to which project managers and engineers are accustomed.

• Disadvantages
  – Examination of work for the exposure assessment propose requires buy-in form the project manager, because the industrial hygienist alone cannot adequately describe the work elements and tasks.
Example --- Resin-coated Sheet Metal Manufacturing Plant

- Information on the workplace, work force, and environmental agents is used to identify SEGs.

- The strategy begins with identification of the site’s major processes.

- Five departments:
  - Casting;
  - Rolling;
  - Coil coating;
  - Shipping and receiving; and
  - Maintenance
## A List of SEGs for the Simplified Hypothetical Example

<table>
<thead>
<tr>
<th>Worker</th>
<th>Process</th>
<th>Job</th>
<th>Task</th>
<th>Environmental Agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coil coating</td>
<td>Coil feed operator</td>
<td>General</td>
<td>Noise</td>
</tr>
<tr>
<td>2</td>
<td>Coil coating</td>
<td>Coil feed operator</td>
<td>General</td>
<td>2-butoxyethanol</td>
</tr>
<tr>
<td>3</td>
<td>Coil coating</td>
<td>Coil feed operator</td>
<td>Cleanup</td>
<td>MIBK</td>
</tr>
<tr>
<td>4</td>
<td>Coil coating</td>
<td>Coil feed operator</td>
<td>Cleanup</td>
<td>Cyclohexanone</td>
</tr>
<tr>
<td>5</td>
<td>Coil coating</td>
<td>Discharge operator</td>
<td>General</td>
<td>Noise</td>
</tr>
<tr>
<td>6</td>
<td>Coil coating</td>
<td>Discharge operator</td>
<td>General</td>
<td>2-butoxyethanol</td>
</tr>
<tr>
<td>7</td>
<td>Coil coating</td>
<td>Discharge operator</td>
<td>QC</td>
<td>MIBK</td>
</tr>
<tr>
<td>8</td>
<td>Coil coating</td>
<td>Discharge operator</td>
<td>Cleanup</td>
<td>MIBK</td>
</tr>
<tr>
<td>9</td>
<td>Coil coating</td>
<td>Discharge operator</td>
<td>Cleanup</td>
<td>Cyclohexanone</td>
</tr>
<tr>
<td>10</td>
<td>Coil coating</td>
<td>Helper</td>
<td>General</td>
<td>Noise</td>
</tr>
<tr>
<td>11</td>
<td>Coil coating</td>
<td>Helper</td>
<td>Lubricate</td>
<td>Paxking Grease 609</td>
</tr>
<tr>
<td>12</td>
<td>Coil coating</td>
<td>Helper</td>
<td>Cleanup</td>
<td>MIBK</td>
</tr>
<tr>
<td>13</td>
<td>Coil coating</td>
<td>Helper</td>
<td>Cleanup</td>
<td>Cyclohexanone</td>
</tr>
<tr>
<td>14</td>
<td>Casting</td>
<td>Helper</td>
<td>Fluxing</td>
<td>Hexachloroethane</td>
</tr>
<tr>
<td>15</td>
<td>Casting</td>
<td>Helper</td>
<td>Fluxing</td>
<td>Hydrogen chloride</td>
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<td>16</td>
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<td>Helper</td>
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<td>Hexachlorobenzene</td>
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<td>Helper</td>
<td>Fluxing</td>
<td>Octochlorostyrene</td>
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<tr>
<td>18</td>
<td>Casting</td>
<td>Helper</td>
<td>Fluxing</td>
<td>Heat</td>
</tr>
</tbody>
</table>
Establishing Similar Exposure Group by Sampling (1)

- To use measured exposure values to classifying workers into SEGs.

- To collect enough measurements and use a statistical technique such as analysis of variance (ANOVA) to classify workers into groups.

- A useful quantitative criterion for determining a SEG is to group employees in a way that long-term average exposures of 95% of workers in a group differ by a maximum factor of two.
They used the random-effects ANOVA model to estimate the within- and between-worker exposure variability.

They calculated the ratio of the 97.5th and 2.5th percentiles of the log-normally distributed exposures of a group of workers to evaluate whether the workers’ exposures are uniform.

This ratio is designated as the following:

\[ B \hat{R}_{0.95} = \exp(3.92 \cdot B \sigma_L) \quad B \sigma_L^2 \leq 0.0313 \text{ (or } B R_{0.95} \leq 2) \]

where \( B \sigma_L \) is the between-worker exposure variability. It can be estimated by \( B S_L \).
Worker Arithmetic Mean Exposures

(GSD = 1.2)
Advantages of using the sampling approach to forming SEGs:
  – objectivity
  – more accurate than classification by observation

Required data for conducting the sampling approach:
  – A large number of random measurements is needed.
  – Multiple measurements must be made on individual workers.

With monitoring data collected for each worker there is less need to form groups since each individual’s exposure has been quantitatively characterized.
  – Do you agree it?
Combining the Observational and Sampling Approaches

- The observational approach is stronger when variability arises principally from the process; it is weaker when variability arises principally from individual work practices.
  - Day-to-day variability in exposure for workers in an SEG has two sources: process or environmental conditions, and work practices.

- The observational approach is a practical methodology for identifying SEGs that allows the industrial hygienists to proceed with economical exposure assessment and management.

- In the observational approach, error in the expected similarity of exposure can lead to misclassification of individual exposures.

- To reduce the misclassification, industrial hygienists should make an effort to generate exposure monitoring data to check the homogeneity of the grouping and refine worker exposure classifications as appropriate.