DEBU DI LINGKUNGAN INDUSTRI-2
## Threshold Limit Value

<table>
<thead>
<tr>
<th>Bahan</th>
<th>TLV (mppcf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>2.5</td>
</tr>
<tr>
<td>Asbestos</td>
<td>2.5</td>
</tr>
<tr>
<td>Mica</td>
<td>20</td>
</tr>
<tr>
<td>Portland Cement</td>
<td>50</td>
</tr>
<tr>
<td>Talc</td>
<td>20</td>
</tr>
</tbody>
</table>
Penentuan konsentrasi debu

Penentuan konsentrasi debu (C) dalam udara untuk yang bekerja 8 jam/hari, 40 jam/minggu adalah:

\[ C \text{ (mppcf)} = \frac{250}{5 + \% \text{kristal SiO}_2 \text{ dalam udara}} \]
Prevention

- Pneumoconiosis can be prevented by enforcing maximum allowable dust levels in mines and at other work sites, and by using protective masks.
- Regular medical examinations, including chest x-rays for people at risk, can detect pneumoconiosis during its earlier stages, before it becomes disabling.
Metoda Pengontrolan
The only treatment is to avoid smoking and further exposure to dust, and to treat complications.
### General Methods of Control

1. **Substitution of a less harmful material for one which is dangerous to health**
2. **Change or alteration of a process to minimize worker contact**
3. **Isolation or enclosure of a process or work operations such as mining and quarrying**
4. **Local exhaust at the point of generation or dispersion of contaminant**
5. **General or dilution ventilation with clean air to provide a safe atmosphere**
6. **Personal Protective devices, such as special clothing or eye and respiratory protective**
Selection Methods of Control
Substitution

- Replacement of a toxic material with a harmless one
- Substitution of solvent
  - Experiment on a small scale before making the new solvent part of the operation or process
  - Carbon tetrachloride $\rightarrow$ methyl chloroform, dichloromethane, aliphatic petroleum hydrocarbons.
  - Benzene $\rightarrow$ toluene (paint remover)
  - Foundries using parting compounds that contain free silica (minimize silicosis)
Changing the process

- Often offers an ideal chance to improve working condition
  - Changes are made to improve quality or reduce cost of production only occasionally to improve the in-plant environment
Examples

Automobile industry

- The amount of lead dust created by grinding solder
  - Small, rotary, high speed sanding disk → low speed, oscillating-type sanders
- Brush painting or dipping instead of spray painting will minimize the concentration of airborne contaminants from toxic pigments
- Arc welding in place in place of riveting, vapor degreasing with adequate controls to replace hand-washing of parts in open container
Examples

- Airless spraying techniques and electrostatic devices to minimize overspray as replacements for hand-spraying
- Machine application of lead oxide to battery grids which reduced lead exposure to operators in making storage batteries
- Before purchase the new machine, should be considered:
  - Ventilation
  - Vibration
  - Heat control
Isolation or Enclosure

- Some potentially dangerous operations can be isolated from the people nearby, which solves the exposure problem
  - Physical barrier
  - By time (semi automatic equipment)
  - By distance (remote control)
- Enclosure will prevent or minimize the escape of solvent vapor into the workroom atmosphere
- Where highly toxic solvents are used, enclosure should be one of the first measures attempted after considering substitution.
Examples

- Shipbuilding: using dry sand
  - isolation the process
  - Off shift: few employees, should wear an air supplied respirator
- Radium dial painting, gloves booths
- Airless blast or shoot blast machines for cleaning castings, and abrasive blasting cabinets
- In chemical industry: using closed system
- Mechanical industries: complete enclosure from sand blasting or metal spraying operations
Isolation & enclosure

Fig. 12-4.—Air inlets and exhausts are arranged to sweep contaminated air away from worker’s breathing zone in this enclosed sandblast area. Downdraft averages 80 fpm over the entire floor area. Air should exhaust downward, as shown here, or on two sides of the room at floor line. 

Courtesy Connecticut State Department of Health.
Wet methods

Dust hazards can frequently be minimized or greatly reduced by application of water or other suitable liquid at the source of dust.

Simplest methods for dust control. Its effectiveness, however, depends upon proper wetting of the dust.

Kelembaban udara dengan NAB sekitar 75% dapat mengurangi jumlah debu di udara.

examples: rock drilling operation, foundries → sandblasting
Local Exhaust Ventilation

- A local exhaust system traps the air contaminant near its source so that a worker standing at the process is not exposed to harmful concentrations.
- Should be used when the contaminant cannot be controlled by substitution, changing the process, or isolation or enclosure.
Its performance should be checked

- Correct rates of air flow
- Duct velocities
- Negative pressures
- The others
A Local exhaust system consists of four part

- **Hood**: the air borne contaminant is drawn
- **Ducts**: carrying the contaminated air to a central point
- **An air-cleaning devices**: a dust arrestor for purifying the air before it is discharged
- **A fan**: create the required air flow through the system
Local exhaust system

- **Duct**
  - Single duct, hanya melayani satu sumber pengotor
  - Multiple duct, bercabang
Velocity contour

Fig. 14–1.—Velocity contours (expressed as percentages of velocity at the opening) and stream lines for both plain and flanged circular openings.

Courtesy American Conference of Governmental Industrial Hygienists.
Principles of hood design

- Enclose the operation as much as possible to reduce the rate of air flow needed to control the contaminant (Picture A)
- Always locate a hood so the contaminant is moved away from the breathing zone of the operator (Picture B)
- Locate and shape the hood so the initial velocity of the contaminant will throw it into the hood opening operator (Picture C)
Principles of hood design...2

- Solvent vapors in health-hazard concentration are *not* appreciably heavier than air. Capture them at their source rather than collect them at the floor level (Picture D)
- Locate the hood as *close* as possible to source of contaminant (Picture E)
- Design the hood so it will *not interfere* with the worker
The more completely the hood encloses the source, the less air is required for control in this straight-line automatic buffing operation.
The hood should be located so the contaminant is removed away from the breathing zone of the worker.
No protection from toxic fume

Fig. 3-7. - Metal volatilized by the heat of welding later condenses to form a fume. On this bench-welding installation, fumes are removed at their point of origin by a properly located local exhaust installation (against wall).

Courtesy American Foundrymen's Society.
THE HOOD SHOULD BE SO LOCATED AND SHAPED THAT THE ORIGINAL VELOCITY OF THE CONTAMINANT WILL THROW IT INTO THE HOOD OPENING
Exhaust from the floor usually gives fire protection only
The required volume varies with the square of the distance from the source.
Perhitungan:

Kecepatan aliran udara dapat dihitung dengan rumus:

\[ v = \frac{Q}{A} = \frac{Q}{4 \pi X^2} \]

dimana \( X \) = jarak terhadap suatu titik dari mulut hood

- \( Q \) = air flow into duct (cfm)
- \( X \) = distance outward along hood axis (ft)
- \( A \) = area of hood opening (sq ft)
- \( B \) = a constant which depends on the shape of the opening

Rumus pendekatan untuk \( X < 1,5 \) diameter Hood

\[ v = \frac{bQ}{(X^2 + bA)} \]

dimana \( b = 0,1 \) untuk mulut hoods berbentuk lingkaran atau bujursangkar
Contoh:

- V suatu aliran udara pada duct yang berdiameter 6” adalah 4000 fpm beberapa pada jarak 2” dan 4”?
  - Untuk jarak 2”, v adalah 47,5%×4000 fpm=1900 fpm
  - Untuk jarak 4”, v adalah 19,3%×4000 fpm=771 fpm
  - Jika X>diameter duct, rumus pendekatannya adalah:
    \[ v = \frac{Q}{10 X^2} \]
Canopy Hood

Perkiraan jumlah udara yang diperlukan adalah dapat dihitung dengan rumus pendekatan:

\[ Q = 1.4 \times 2 (L+W) H \times V \]

\( Q \) = rate of air flow (cfm)
\( L \) = tank length (ft)
\( W \) = tank width (ft)
\( H \) = height of canopy above tank (ft)
\( V \) = desired control velocity (fpm)
Canopy Hood

A

Floppy doors close automatically

Window lets worker see what's going on inside

B

Canopy or hood
Air cleaner (Pembersih Udara)

- Kolektor sentrifugal: tunggal dan paralel
- Kolektor sentrifugal basah
- Electrostatic precipitator
Fan

Penghisap berbentuk kipas yang digerakkan oleh motor listrik, ada 2 macam:

- Sentrifugal, aliran udara bergerak mengelilingi sumbu kipas, baik untuk LEV, terdiri dari 2 macam:
  - Backward curved blades, efisiensi tinggi, bising
  - Forward curved blades, untuk beban yang rendah, silent.

- Axial, aliran udara bergerak searah sumbu putaran kipas, baik untuk mengurangi kelembapan pada ventilasi umum (yang tidak mengandung partikel)
More local exhaust

An example of local exhaust ventilation over a storage vessel containing isocyanates.
Hoods and ducts

Fig. 3-6. Dust from foundry sand is generated during casting shake-out. The mechanical action of the shake-out machine disperses the dust. Path taken by the dust particles as they are drawn into the hood shows the efficiency of the local exhaust system in trapping these particles.

Fig. 3-9. Centrifugal force created by grinding wheel causes the generated dusts to travel in a well-defined path. To prevent dispersion of dust, exhaust hood is placed directly in the dust stream, close to its source.

Courtesy: American Foundrymen’s Society.
General ventilation

- **Ventilasi umum (General ventilation),** untuk sumber kontaminan yang tersebar dan tidak terlalu berbahaya
- **Ventilasi umum = ventilasi dilusi**
  - ada suplai dan ada udara dikeluarkan
- Penting diperhatikan lokasi udara masuk dan keluar terhadap posisi pekerja dan arah dispersi debu
General ventilation
Perlindungan perorangan (personal protection)

- Perlindungan perorangan (personal protection), berupa perlindungan pernafasan dengan masker, desain sebaik mungkin jika perlu diberi supply oksigen.
- APD: alat pelindung diri
- Untuk debu: yang relevan adalah respirator, proteksi sistem pernafasan
- Kenyamanan penting agar pekerja mau pakai
- Jumlah debu tinggi, respirator harus digunakan, dan dipakai sesaat saja
- Kesulitan respirator adalah dalam memenuhi standar yang berlaku
Fig. 13-1.—Suggested outline for selecting respiratory protective devices. Numbers in parentheses (in the shaded boxes) refer to Bureau of Mines Schedules and their revisions, which cover the items.

From Bureau of Mines Circular 7792.
Fig. 13-5.—Gas mask.
Fig. 13-6.—Mask with chin-type canister.

13—RESPIRATORY PROTECTIVE EQUIPMENT

Fig. 13-8.—Air line respirator. Photograph at left shows the full-face mask. Diagram (right) shows parts and connections.

Fig. 13-9.—Constant-flow air line respirator.

Fig. 13-10.—Demand-type breathing apparatus.

Fig. 13-3.—Mechanical filter respirator.
Fig. 13-4.—Self-generating oxygen breathing apparatus.
<table>
<thead>
<tr>
<th>Atmospheric Contaminants to be Protected Against</th>
<th>Colors Assigned*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid</td>
<td>White</td>
</tr>
<tr>
<td>Hydrocyanic acid gas</td>
<td>White with ½-inch green stripe completely around the canister near the bottom</td>
</tr>
<tr>
<td>Chlorine gas</td>
<td>White with ½-inch yellow stripe completely around the canister near the bottom</td>
</tr>
<tr>
<td>Organic vapors</td>
<td>Black</td>
</tr>
<tr>
<td>Ammonia gas</td>
<td>Green</td>
</tr>
<tr>
<td>Acid gases and ammonia gas</td>
<td>Green with ½-inch white stripe completely around the canister near the bottom</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>Blue</td>
</tr>
<tr>
<td>Acid gases and organic vapors</td>
<td>Yellow</td>
</tr>
<tr>
<td>Hydrocyanic acid gas and chloropicrin vapor</td>
<td>Yellow with ½-inch blue stripe completely around the canister near the bottom</td>
</tr>
<tr>
<td>Acid gases, organic vapors, and ammonia gases</td>
<td>Brown</td>
</tr>
<tr>
<td>Radioactive materials, excepting tritium and noble gases</td>
<td>Purple (Magenta)</td>
</tr>
<tr>
<td>Particulates (dusts, fumes, mists, fogs, or smokes) in combination with any of the above gases or vapors</td>
<td>Canister color for contaminant, as designated above, with ½-inch gray stripe completely around the canister near the top</td>
</tr>
<tr>
<td>All of the above atmospheric contaminants</td>
<td>Red with ½-inch gray stripe completely around the canister near the top</td>
</tr>
</tbody>
</table>

* Gray shall not be assigned as the main color for a canister designed to remove acids or vapors.

NOTE: Orange shall be used as a complete body, or stripe color to represent gases not included in this table. The user will need to refer to the canister label to determine the degree of protection the canister will afford.
Radiation mask
AIR PURIFYING

- Digunakan bila O2 cukup (16%) pada 1 atm
- Masih baik/useful-life
- Ada 3 macam:
  - saringan mekanis: dari serat, untuk debu, asap, fumes, bentuk: half mask, full mask
  (bukan untuk gas)
  - kimia (reaksi): berisi zat kimia yang dapat menetralisir zat kimia tertentu; konsentrasi kontaminan rendah (0,05-0,1 vol%)
  (BUKAN untuk: emergency, toxic gas → kombinasi mekanis dan kimia)
- gas: special gas, ada warna standar: CO=biru, HCN=putih hijau; organik=hitam; tidak ≥2 vol% toxic gas
Housekeeping

- Is always important
- Dust on the floor can readily be dispersed to the inplant atmosphere by traffic, vibration, and random air currents.
Housekeeping
Don't let this happen to you.
Ada Pertanyaan?