**IoT BASED ENVIRONMENT MONITORING IN INDUSTRIES FOR EMPLOYEES’ SAFETY**

**Survey Report**

**Dust**

The acceptable level of dust density (particulate matter concentration) for humans depends on various factors such as the size and composition of the particles, exposure duration, and individual susceptibility. Dust density is typically measured in micrograms per cubic meter (µg/m³). In general, high levels of particulate matter in the air can have adverse health effects, especially for vulnerable populations such as children, the elderly, and individuals with respiratory or cardiovascular conditions. Here are some guidelines for particulate matter concentrations:

1. **World Health Organization (WHO) Guidelines:** The WHO sets air quality guidelines for particulate matter. According to the WHO, the recommended annual average concentration of PM2.5 (particles with a diameter of 2.5 micrometers or smaller) is 10 µg/m³. The 24-hour average should not exceed 25 µg/m³. For PM10 (particles with a diameter of 10 micrometers or smaller), the recommended annual average is 20 µg/m³, and the 24-hour average should not exceed 50 µg/m³.
2. **Environmental Protection Agency (EPA) Standards:** The EPA in various countries sets air quality standards for particulate matter based on health considerations. These standards vary by region but are generally in line with WHO guidelines.
3. **Occupational Exposure Limits:** Occupational safety organizations may establish exposure limits for particulate matter in workplace environments. These limits are typically higher than outdoor air quality standards but still aim to protect workers from adverse health effects.
4. **Local Regulations:** Some regions may have specific regulations or guidelines for particulate matter concentrations based on local air quality conditions and health considerations.

Considering these guidelines, a dust density of 1500 µg/m³ would likely be considered high and potentially harmful to human health, especially if sustained over a long period. It's important to take measures to reduce exposure to high levels of particulate matter, such as using air filtration systems, avoiding outdoor activities during periods of high pollution, and following local air quality advisories. Dust density of 1500 µg/m³ is not considered safe for humans for prolonged exposure. Here's why:

* **Recommended Limits:** Occupational safety organizations like OSHA (Occupational Safety and Health Administration) set exposure limits for dust. While OSHA's Permissible Exposure Limit (PEL) for total dust is 15 mg/m³ (milligrams per cubic meter) as a time-weighted average (TWA) for an 8-hour workday, this translates to 15,000 µg/m³.
* **1500 µg/m³ Exceeds Safe Levels for Many Dust Types:** While 1500 µg/m³ is lower than the OSHA PEL for total dust, it's important to consider:
  + **Dust composition:** Different types of dust have varying health risks. Some dusts, like silica, are hazardous at much lower levels than 1500 µg/m³.
  + **Particle size:** Smaller particles (less than 10 micrometers) are more harmful as they penetrate deeper into the lungs.

**Potential Health Effects of 1500 µg/m³ Dust Density:**

* **Respiratory irritation:** Dust exposure at this level can irritate the respiratory tract, causing coughing, sneezing, and shortness of breath.
* **Aggravated asthma and allergies:** Dust can trigger asthma attacks and worsen allergies for those who are susceptible.
* **Long-term health risks:** Chronic exposure to even moderate dust levels can increase the risk of lung diseases like chronic obstructive pulmonary disease (COPD) over time.
* **Eye irritation:** Dust can irritate the eyes, causing redness, watering, and itching.

**What to Do if Exposed to 1500 µg/m³ Dust Density:**

* **Minimize exposure:** If possible, leave the dusty environment or wear appropriate personal protective equipment (PPE) like a respirator rated for the specific dust type.
* **Improve ventilation:** If working in the environment, ensure proper ventilation to remove dust particles from the air.
* **Monitor dust levels:** Regularly monitor dust levels to ensure they stay within safe limits.
* **Seek medical attention:** If you experience any respiratory problems or eye irritation after exposure to dust, consult a doctor.

**In conclusion:** While 1500 µg/m³ might be below the OSHA PEL for total dust, it's still considered a moderate dust level that can be harmful for prolonged exposure. It's crucial to consider the specific type of dust and particle size for a more accurate assessment of the health risks. When in doubt, prioritize minimizing exposure and using appropriate protective measures.

**Amine:**

The acceptability of a certain concentration of amine gas (such as ammonia) for humans depends on several factors, including exposure duration, individual susceptibility, and the specific circumstances of exposure. Amine gas concentrations are typically measured in parts per million (ppm). Ammonia is one example of an amine gas, and it is commonly encountered in various industrial, agricultural, and household settings. Here are some considerations regarding ammonia exposure:

1. **Occupational Exposure Limits (OELs):** Regulatory agencies such as the Occupational Safety and Health Administration (OSHA) in the United States and similar organizations in other countries set permissible exposure limits (PELs) or threshold limit values (TLVs) for ammonia in workplace environments. These limits are intended to protect workers from adverse health effects during a typical 8-hour workday. OSHA's permissible exposure limit for ammonia is 25 ppm as an 8-hour time-weighted average (TWA), with a short-term exposure limit (STEL) of 35 ppm over a 15-minute period.
2. **Health Effects:** Exposure to high concentrations of ammonia can cause irritation of the eyes, nose, throat, and respiratory system. Prolonged or repeated exposure to elevated levels of ammonia may lead to more serious health effects, including lung damage and respiratory issues.
3. **Thresholds for Odor Detection:** Ammonia has a strong and pungent odor at relatively low concentrations, typically well below levels that would cause immediate health effects. Most people can detect the odor of ammonia at concentrations of around 5 to 50 ppm, depending on individual sensitivity and environmental conditions.
4. **Environmental Considerations:** In addition to human health effects, exposure to high concentrations of ammonia can also have environmental impacts, including damage to aquatic ecosystems and soil fertility.

**Noise**

1. **Occupational Noise Exposure Limits:** Regulatory agencies such as the Occupational Safety and Health Administration (OSHA) in the United States set permissible exposure limits (PELs) for noise in the workplace. The OSHA standard for occupational noise exposure is 85 dB averaged over an 8-hour workday. Exposures at or above this level require hearing protection for workers.
2. **Community Noise Guidelines:** The World Health Organization (WHO) recommends outdoor noise levels of less than 55 dB during the day and 45 dB at night to prevent adverse health effects in residential areas. These guidelines are intended to protect against annoyance, sleep disturbance, and other health issues related to environmental noise.
3. **Health Effects:** Exposure to high levels of noise can cause temporary hearing loss, tinnitus (ringing in the ears), and stress. Prolonged exposure to loud noise can lead to permanent hearing damage and other health problems such as cardiovascular disease, hypertension, and sleep disturbances.
4. **Individual Sensitivity:** Individuals may vary in their sensitivity to noise and their ability to tolerate loud sounds. Factors such as age, pre-existing hearing loss, and overall health can affect an individual's susceptibility to noise-related health effects.
5. **Context and Duration:** The context in which noise occurs and the duration of exposure are important factors to consider. For example, short-term exposure to loud noise, such as attending a concert or using power tools, may be tolerable for most people as long as it is not frequent or prolonged.

In general, prolonged exposure to noise levels above 85 dB can increase the risk of hearing damage and other health problems over time. It's important to take measures to reduce exposure to high levels of noise, such as using hearing protection devices, limiting exposure to loud sounds, and implementing noise control measures in occupational and community settings.

**Temperature**

A temperature of 35 degrees Celsius (95 degrees Fahrenheit) can be considered acceptable for humans in an industrial working environment, but it may still pose challenges, particularly if additional factors such as humidity, physical exertion, and duration of exposure are high. Here are some considerations:

1. **Heat Stress:** At 35°C, individuals may still experience heat stress, especially if they engage in strenuous physical activity or work in environments with limited ventilation. Heat stress can lead to discomfort, fatigue, dehydration, and an increased risk of heat-related illnesses.
2. **Humidity:** High humidity levels can exacerbate the effects of heat by making it harder for the body to dissipate heat through sweating. The combination of temperature and humidity, known as the heat index or apparent temperature, provides a more accurate measure of perceived heat stress.
3. **Workload:** The nature of the work being performed and the level of physical activity can significantly impact how individuals respond to high temperatures. In industrial environments, where workers may be exposed to hot machinery or work in confined spaces, heat exposure can be particularly challenging.
4. **Occupational Health and Safety Standards:** Occupational health and safety regulations in India, as well as international standards, typically define limits for indoor temperature and humidity to ensure the well-being of workers. Employers are responsible for implementing measures to mitigate heat-related risks, such as providing adequate ventilation, hydration, rest breaks, and protective equipment.
5. **Personal Factors:** Individual factors such as age, fitness level, acclimatization, and pre-existing health conditions can influence an individual's tolerance to heat. Some people may be more susceptible to heat-related illnesses than others and may require additional precautions.

In summary, while a temperature of 35°C may be considered acceptable for humans in an industrial working environment, it's essential to monitor and manage heat exposure effectively to prevent heat-related illnesses and ensure the health and safety of workers. Employers should implement measures to reduce heat stress, provide training on heat-related risks, and encourage workers to take appropriate precautions to protect themselves from excessive heat.

**Humidity**

The ideal humidity range for a comfortable and healthy working environment generally falls between **40% and 60%**. Here's a breakdown of why this range is preferred:

**Benefits of 40-60% Humidity:**

* **Thermal Comfort:** This range allows for optimal sweat evaporation, which helps regulate body temperature and prevents overheating, especially in warmer environments.
* **Reduced Health Risks:** Moderate humidity minimizes the risk of respiratory problems that can be aggravated by excessively dry or humid air. Dry air can irritate airways and make allergies worse, while very high humidity can promote mold growth.
* **Improved Productivity:** Studies suggest that a comfortable humidity level can contribute to better focus, concentration, and overall worker productivity [1].

**Potential Issues Outside the Ideal Range:**

* **Below 40% Humidity:** Low humidity can cause dry skin, irritated eyes, and respiratory problems. It can also increase static electricity and make dust particles more noticeable.
* **Above 60% Humidity:** High humidity can feel muggy and uncomfortable, especially in warm environments. It can hinder sweat evaporation and contribute to heat stress. Additionally, high humidity can promote mold growth, which can trigger allergies and other health problems.

**Important Considerations:**

* **Temperature:** Humidity perception is subjective and depends on temperature. 40% humidity might feel comfortable at 23°C (73°F) but unpleasant at 30°C (86°F).
* **Activity Level:** People engaged in strenuous physical activity might require slightly lower humidity levels for optimal comfort.
* **Individual Preferences:** Some people might have a natural preference for slightly higher or lower humidity levels within the acceptable range.

**Maintaining Comfort:**

* **Monitor humidity levels:** Utilize hygrometers to track humidity in your workspace.
* **Air conditioning/humidifiers:** Depending on your climate, these appliances can help regulate humidity levels.
* **Proper ventilation:** Good air circulation is crucial for maintaining comfort and preventing stuffiness, regardless of humidity.
* **Employee feedback:** Encourage employees to provide feedback on their comfort levels so adjustments can be made if necessary.

**Conclusion:**

A humidity range of 40% to 60% is generally considered ideal for most workplaces. By monitoring conditions, maintaining good ventilation, and considering individual preferences, you can create a work environment that promotes both comfort and well-being for your employees.

**Table 1: Threshold values of the sensor parameters for monitoring**

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| --- | --- | --- | --- |
| **Parameters** | **Threshold value** | **Notification** | **Side Effects** |
| Temperature | T=35 | Buzzer | Dehydration, fatigue, Heat related Illness |
| Humidity | High>60; low<40 | Buzzer | Low humidity cause skin irritation, respiratory problems, high humidity cause uncomfortable to skin cause an allergic and other health problems |
| Amine gas | A>200 | Buzzer | High concentrations of ammonia can cause irritation of the eyes, nose, throat, and respiratory system |
| Dust particles | D>1000 | Buzzer | Respiratory irritation,  Aggravated asthma and allergies, Long-term health risks, Eye irritation |
| Noise | N>70 | Buzzer | hearing loss, tinnitus (ringing in the ears), and stress |