Substitution of Chemicals – Considerations for Selection Fact Sheets



WHY IS SUBSTITUTION IMPORTANT?

Substitution of currently-used materials with less hazardous materials is one of the most effective ways of eliminating or reducing exposure to materials that are toxic or pose other hazards. A hazard is the source of danger or injury. A hazard includes any chemical or material that has the ability or a property that can cause an adverse health effect or harm to a person under certain conditions. Risk, on the other hand, is the probability or chance that exposure to a chemical hazard will actually cause harm to a person or cause an adverse effect.

Other occupational hygiene methods for controlling employee exposure to chemicals include elimination, isolation, enclosure, local exhaust ventilation, process or equipment modification, good housekeeping, administrative controls and personal protective equipment. All these methods reduce or eliminate the risk of injury or harm by interrupting the path of exposure between the hazardous material and the worker. Substitution removes the hazard at the source.

Why should the substitute product be chosen very carefully?

Extreme care must be taken to ensure that one hazard is not being exchanged for another, especially one that could even be a more serious hazard. Before deciding to replace a chemical, one must know what risks the chemical poses to the employees, the environment, the equipment and facilities. If the risks are serious, then alternatives should be considered. A thorough understanding of the potential risks associated to the alternative solution is necessary.

The selection of a substitute can be a very complex process. In large organizations the selection process may involve a committee with representatives from engineering, purchasing, industrial hygiene, safety, maintenance, research and development, environmental control, waste management, shipping, and the supervisors and workers who directly work with the product. In smaller organizations, one person may carry out many of these functions.

What are some major considerations to look at when considering the suitability of potential substitutes?

1. **Effectiveness.** Will the product meet the technical requirements (e.g., solubility, drying time) for the job or process?
2. **Compatibility.** The substitute must not interfere or react with the process, the other products, or the equipment.
3. **Existing Control Measures**. Existing control methods may not adequately control

the substitute (e.g., a less toxic substitute may evaporate more rapidly, and the existing ventilation system may not adequately capture the vapours).
4. **Waste Disposal.** Will the current waste disposal system meet technical and regulatory requirements when dealing with any new waste created by using the substitute?
5. **Hazard Assessment.** A hazard assessment should be done to decide whether to substitute a chemical or product with a different one.

What are some points to consider when doing a hazard assessment?

Use safety data sheets (SDSs) and other sources of chemical information to compare the hazards of various products. For easier comparison, set up a table with the following categories for each potential substitute. The important properties to compare are:

1. **Vapour Pressure.** Vapour pressure is an indicator of how easily a chemical evaporates into the air. Exposure by inhalation is the primary route of exposure for many products; therefore, the vapour concentration in the air largely influences the potential degree of exposure. If a solvent is not very volatile (does not evaporate easily), the potential for exposure by inhalation may be very low.
2. **Short Term Health Effects.** Comparing animal toxicity values of various chemicals can suggest their relative short-term toxicities (i.e., effects that happen quickly). Examples of acute toxicity data include LD50s and LC50s (the lethal doses or concentrations that kill 50% of test animals exposed to the chemical). It is important to remember that toxicity may vary widely between animal species. Furthermore, biological effects or adverse health effects caused by short-term exposures to high concentrations of a chemical may not be the same as those resulting from low level, long-term exposures. For example, two closely related aromatic hydrocarbons, benzene and toluene, have similar acute toxic properties but only benzene causes cancer following long-term or chronic exposure.
3. **Long-Term Health Effects.** Long term health effects such as chronic lung disease may be more significant than short term health effects.
4. **Skin Toxicity.** Both the potential for direct irritation and allergic sensitization must be examined. One also must consider that, besides breathing in chemicals, some solvents (and even some solvent vapours) can also be absorbed through intact skin. This route of exposure can contribute significantly to the overall uptake of chemicals in the body.
5. **Sensitization of the Respiratory System:** If repeated exposure to the chemical by inhalation can cause hypersensitive reactions, like an asthma attack, then special exposure control methods and workplace practices should be set up and maintained.
6. **Cancer-Causing Potential and Reproductive Effects**. If there is sufficient evidence that a compound could cause cancer or reproductive effects in humans, special handling precautions need to be considered.
7. **Physical Hazards.** Fire and explosion are sometimes the greatest hazards from a product. Properties that must be examined include vapour pressure, autoignition temperature, flash point, flammability limits, and reactivity.

Although substitution is the most direct method of reducing hazards, it is not always practical. A very careful evaluation must be done before any substitution plan to ensure that the new, alternative chemical does not pose a greater hazard than the currently used product. For example, a less environmentally harmful substance may actually pose a more significant risk for the health of the workers.

What is an example of the steps to take when investigating a new product?

The Health and Safety Executive (HSE) in the United Kingdom recommends a seven step process when considering substitution*. These steps include:

1. **Identifying hazards and assessing risks.** This step involves deciding whether the current substance or process is a hazard. Is there a significant risk involved in storing, using or disposing of a substance? A hazard is defined as “the potential a substance or process has to harm someone or damage the environment.” Risk is “how likely this is to happen.”
2. **Identifying alternatives.** Investigate a wide range of options. Compare all of the hazard assessment information as previously mentioned in this document. Compare the different states of a chemical (e.g., will a granular form create less dust than a powder form?) Also consider whether the job is necessary or not (e.g., can the part be replaced rather than cleaned). If you are a supplier, you may need to select options according to your customers’ needs as well as those of your own employees.
3. **Think about what could happen if you use the alternatives.** It is important that you have gathered all available information before this step so that you can make a realistic comparison of both the good and bad points. Remember that you must also consider the way employees use it and how likely it is that they may be exposed. Choosing an alternative chemical may require changes in:
    - the way the work is done,
    - the kind of equipment or parts (e.g., O-rings, gaskets or hose materials) needed to be compatible with the substitute chemical,
    - the ventilation system that may be required,
    - the disposal methods, and
    - regulatory requirements that may apply

1. **Comparing alternatives.** In this step, compare the alternatives with each other, and with the substance or process currently being used. HSE recognizes that it is hard to compare the risks of one chemical that is very flammable with one that is very toxic. They recommend thinking of the effects in simple terms such as “Is the substitute going to explode, or poison people? Will it only affect people who work with it, or could it affect other people in the area?” Remember to consider how and where the alternative will be used.
2. **Decide whether to substitute.** This step is the most difficult. Remember that a change in one step of a process can affect many others. Consult with the workers who will be handling the material directly for their input. It is a good practice to introduce the substitute on a trial or small quantity basis at first.
3. **Introducing the substitute.** Plan the change in material or process carefully. Remember to train and educate the workers involved.

Assessing the change. Check to see if the substitution has produced the intended results. You may find monitoring the health of the workers, monitoring the level of contaminants in the air, or fulfilling legal requirements useful parameters to measure.

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