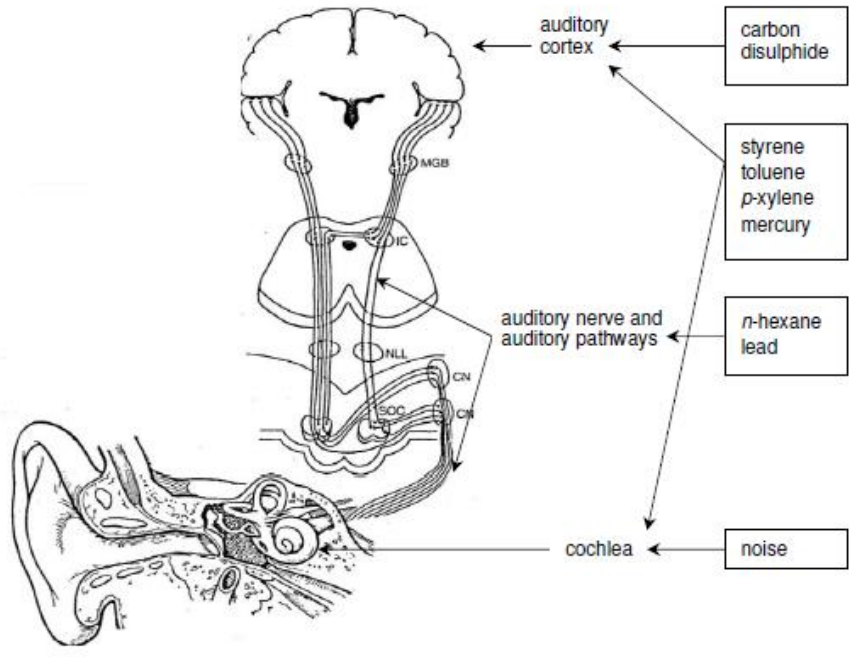
Concurrent Exposure to Ototoxic Chemicals and Noise

Many common industrial chemicals are ototoxic (poisonous to the ears) and as damaging to employees' hearing as the industrial noise to which they are often exposed. But exposure to noise and ototoxic chemicals at the same time can devastate hearing. That's because the combined effects of chemicals and noise are often synergistic rather than merely additive. Certain medications and drugs—both physician-prescribed and over-the-counter—are ototoxic as well, but this article will focus on chemicals often found in an industrial environment.

Researchers studying the effects of noise on industrial workers found a higher incidence of hearing loss in workers exposed to low levels of noise than workers in an area where the noise levels were higher. However, the workers exposed to the lower noise levels were also exposed to industrial solvents concurrently with the noise, and that made all the difference in the findings. The noise and chemical exposure together increased the risk for hearing loss.

Exposure to some chemicals by themselves can cause hearing loss. The worst culprits are organic solvents: benzene, toluene, xylene, styrene, and similar compounds. Phosphate-based chemicals used in farming, gardening, and industrialized agriculture, and some non-benzene carbon compounds, like carbon disulfide and carbon monoxide, also have a profound impact on hearing, as do the vapors and dusts of certain metals, like lead, mercury, manganese, and arsenic

Diagram of How Ototoxic Chemicals Effect Hearing



Activities where noise and ototoxic chemicals often combine include: painting, printing, boat building, construction, furniture making, manufacture of metal, fiberglass, leather and petroleum products, aircraft maintenance, assay labs, radiator repair, fueling vehicles and aircraft, firefighting, and pesticide spraying.

Exposure standards for chemicals and noise have not yet been altered to take account of increased risk to hearing. Material Safety Data Sheets in many cases do not contain warnings about potential hearing loss.

For workers currently participating in an audiometric testing program due to excessive noise, suitably trained reviewers of the audiometric data should be alert to the relationship between the exposure to noise and ototoxic chemicals.

If workers exposed to ototoxic chemicals complain of hearing difficulties, but have normal audiometric test results, they should be referred for more comprehensive audiological tests to evaluate the more central parts of the auditory system.

Control measures such as substitution, isolation and local ventilation should be implemented to eliminate or reduce chemical exposures. Personal protective equipment should be used to prevent skin and respiratory absorption when other controls are insufficient.

The substances in the following tables appear in health and safety legislation in Australia but originate from a list given in:

Morata T.C. (2007) Promoting hearing health and the combined risk of noise-induced hearing loss and ototoxicity, Audiological Medicine, Vol.5, Issue 1, pp33-40.

Solvents

Name	Skin absorption
Butanol	Yes
Carbon disulphide	Yes
Ethanol	No
Ethyl benzene	No
n-heptane	No
n-hexane	No
Perchloroethylene	No
Solvent mixtures and fuels Stoddard solvent (white spirits)	Yes
Styrene	No
Toluene	Yes
Trichloroethylene	Yes
Xylenes	No

Metals

Name	Skin absorption
Arsenic	No
Lead	No
Manganese	No
Mercury	Yes
Organic tin	Yes

Similar lists (i.e., similar chemicals and metals are recognized in OSHA legislation and technical documents.

CHEMICAL AGENT	MAJOR USES
Toluene	Production of benzoic acid, benzaldehyde, explosives, dyes, and many other organic compounds; solvent for paints, lacquers, gums, resins; extracting agent; petrol and naphtha constituent; additive; fabric and paper coating, artificial leather and detergent manufacture. Toluene is often found together with other solvents.
Ethylbenzene	Almost exclusively used for the production of styrene. Only a small proportion is used as a solvent.
n-Propylbenzene	Textile dying, solvent for cellulose acetate.
Styrene	Manufacture of plastics, rubber articles, glass fibres; synthetic rubber; insulators; used as a chemical intermediate, particularly in the resin and plastics production, component in agricultural products and stabilising agent.
Methylstyrene	Manufacture of modified polyester and alkyd resins. Low-molecular polymers are viscose liquids that are used as softener in polymers, paints and waxes.
Trichloroethylene	Solvent for a variety of organic materials. Trichloroethylene is a cleaning and degreasing agent and a means of extraction.

Source: Combined exposure to noise and ototoxic substances, European Risk Observatory Literature Review, European agency for Safety and Health at Work (2009).

Table continues on next page.

This document also identifies other agents such as pharmaceuticals and tobacco smoke as categories of ototoxic exposures but are not listed in this resource because these agents have limited occupational exposure.

CHEMICAL AGENT	MAJOR USES
p-Xylene	Manufacture of resins, paints, varnishes, general solvent for adhesives; in aviation kerosene; protective coatings; synthesis of organic chemicals; solvent (e.g. for paints, coatings, adhesives and rubber); used in production of quartz crystal oscillators, perfumes, insect repellents, epoxy resins, pharmaceuticals, and in the leather industry. Used as a solvent in phenoxyalkanoic herbicides.
n-Hexane	Used as a cleaning agent in textile, furniture, and leather industries; laboratory reagent; component of many products associated with the petroleum and petrol industries; solvent, especially for vegetable oils; low-temperature thermometers; calibration; polymerisation reaction medium; paint diluent; alcohol denaturant. Used as reaction medium in manufacture of polyolefins, elastomers, pharmaceuticals and as a component of numerous formulated products.
n-Heptane	Used as a solvent in laboratories and for quick-drying glossy paints and glues.
Carbon disulfide	Manufacture of rayon, soil disinfectants, electronic vacuum tubes and carbon tetrachloride. Used as solvent for lipids, sulfur, rubber, phosphorus, oils, resins and waxes.
Carbon monoxide	Component of exhaust fumes emerging from incomplete combustion processes, e.g. in motor vehicles or poorly ventilated stoves and furnaces, acetylene welding or in enclosed areas (mines, tunnels).
Halogenated hydrocarbons	Intermediate product for the synthesis of organic compounds. Moreover they are used as solvents, anaesthetics, fire-extinguishing agents, refrigerants and propellants.
Nitriles	Used for the preparative synthesis of carboxylic acids. Of commercial importance are acetonitrile as a solvent, benzonitrile as an initial compound for melamine resins and acrylonitrile as a monomer for polyacrylonitrile.
Cyanides	Used as an intermediate product in the organic synthesis of carboxylic acids, pharmaceuticals, dyes and pesticides. Relatively large quantities are also required for the surface treatment of metals, galvanising and the cyanide leaching process.
Lead	Manufacture of lead-acid batteries; ship breaking; manufacture of paint; also in petrol and plastic manufacture, may emerge during car radiator repair; welding; plumbing; smelting, refining and mining.
Mercury	Used in the chloralkali industry. Mercury compounds may be used in batteries (mercuric oxide), pigments, catalysts, explosives (mercury fulminate), laboratory-based research, and in some pharmaceutical applications.
Manganese	Manufacture of steel alloys, dry-cell batteries, electrical coils, ceramics, matches, glass, dyes, in fertilizers, welding rods, as oxidizing agents, and as animal food additives.
Tin, organic compounds	Tri-n-alkyltins are phytotoxic and can be powerful bactericides and fungicides.
Arsenic	Production of pesticides, smelters, semiconductors, antifouling paints, electroplating industry and pigments.

Using the lists with Caution

While using the list as is would be tempting, there are two factors that may make a chemical ototoxic in principle but not in practice. These two conditions are:

1. The chemical is ototoxic at levels that are significantly above the OEL; and
2. The OEL already takes into account and is based on the ototoxic effect.

Chemical is Ototoxic at levels above the OEL

Some chemicals may have been identified, particularly in animal studies, to show an ototoxic effect but at levels well above the normal occupational range. Thus, its significance in an occupational setting is unclear.

> The ACGIH Notice of Intended Change for noise provides the following information on styrene. “Occupational studies measured mean levels of styrene between 3.5 and 50 ppm and indicated that exposures as low as 3.5 – 22 ppm were associated with statistically significant hearing loss compared to nonexposed controls. Therefore, there is a risk of hearing loss associated with occupational exposures to styrene at levels less than the current TLV-TWA of 20 ppm.

This reference provides clear information that styrene is ototoxic at occupational exposure levels. This area of study is relatively new and information may be limited. For example, although manganese is often listed as ototoxic, information on the effects of manganese at occupational levels is limited.

Chemicals that have an OEL Built In to the OEL

One example would be n-butyl alcohol. The documentation for this chemical mentions this effect specifically and uses the ototoxic effect in the derivation of the current TLV for this chemical. Thus, no additional adjustment would be necessary.

Common Approaches- What are Others Doing?

Several sources take the perspective that the area of ototoxic effects are not well understood and that estimates of the levels at which they may demonstrate this effects may not be well defined. To allow for this, several sources recommend that as a precautionary measure, workers exposed to potentially ototoxic agents have the acceptable noise exposure lowered from 85 to 80 dBA.

France

The French INRS recommends lowering the acceptable noise exposure to workers exposed to ototoxic chemicals from 85 to 80 dBA along with special labelling for ototoxic agents.

Australia

The Australian Model Code of Practice for Managing Noise and Preventing Hearing Loss at Work (Safe Work Australia, 2011) states that the daily noise exposure of workers exposed to ototoxic agents should be reduced to a maximum A-weighted level of 80 dBA. Additionally, it also states that regular audiometric testing is recommended for workers who are exposed to ototoxic substances with airborne exposure more than 50% of the Australian national exposure standards regardless of noise exposure level.

Some potentially ototoxic chemicals may be absorbed through the skin (See Tables). If skin exposures cannot be controlled and are ongoing, annual audiograms are also recommended. https://www.acoustics.asn.au/conference_proceedings/AASNZ2016/papers/p10.pdf

US Army

The U.S. Army, for example, requires any employee exposed to known or suspected ototoxins to be enrolled in its hearing conservation program, whether or not they are exposed to noise.

Sweden

Sweden added a NOISE notation to their OEL list which indicates that exposure to these chemicals approaching existing OELs and simultaneous exposure to noise levels approaching 80 dBA can cause hearing loss.

ACGIH

In its 2017 Notice of Intended Change, ACGIH recommends including workers who are exposed to 20% of the TLV (OEL) be included in the audiometric testing program. ACGIH takes the position that since the exposure threshold where ototoxic effects are not known, the only reliable way to know if the substance is affecting the hearing of exposed workers is to take audiograms. Specifically, “yearly audiograms are highly recommended for workers whose exposures are at 20% or more of the TLV for the ototoxic substance”. They recognize that the 20% is relatively arbitrary but that it will ensure that data from sub-TLV exposures. In addition, if workers are already exposed to noise and enrolled in audiometric testing, the reviewers of the audiometric data should be advised of the exposure to ototoxic chemicals so that they may be alert for synergistic effects between noise and chemical exposure.