SECTION 2

Occupational Exposure Limits

Section Contents

Occupational Exposure Limits

What are "occupational exposure limits"?

Occupational exposure limits (OELs) are measurable levels of chemicals, noise, radiation, vibration, temperature, and other workplace hazards, above which workers will suffer harmful health effects. The harmful health effects can be acute or immediate effects, like irritation of the throat or headaches, or the effects can be chronic or long-term effects, like liver failure, cancer or deafness. The employer's responsibility is to keep all workers' workplace exposures below the OELs.

Although the OELs are intended to prevent harmful effects to exposed workers, some workers may experience problems at levels below the OELs because they are particularly sensitive to the hazard or they have an illness aggravated by the exposure. The OELs are not an absolute level where all workers will have no effects if the exposure levels are below the OEL.

There are different types of OELs. Some are legally enforceable limits established by the government, like China's GuoBiao "Maximum Allowable Concentration" (MAC) or the U.S. government's "Permissible Exposure Limits" (PEL). Other limits have been established by professional, non-governmental organizations, such as the Threshold Limit Values (TLV) of the American Conference of Governmental Industrial Hygienists (ACGIH).

Some countries, like Mexico and Indonesia, have adopted the voluntary ACGIH TLVs as their legal limits, which are then enforced by government agencies.

What are Occupational Exposure Limits based on?

The OELs are based on worker exposures of 8 hours a day for a five-day, 40-hour work week. Although some adjustments can be made for longer single days of work, OELs have not been calculated for longer work weeks, such as the 50 to 72 hour work weeks common in China.

The ACGIH TLV daily limit is called a "time weighted average," or "TWA," because the exposure is averaged over the 8 hours of the shift. During the work shift, there might be time when exposures are higher than the TLV, but the 8 hour average must be below the TLV. The TLVs are set at a level where most, but not all, workers will not experience harmful health effects. The TLVs also take into account the technological and economic feasibility of keeping worker exposure levels below the TLV.

In addition to the 8 hour time weighted average (TWA) limit, there are OELs for 15 minute exposures (called a "short term exposure limit" or "STEL") and for the absolute maximum exposure anytime during the shift (called a "ceiling limit").

What are China's Occupational Exposure Limits based on?

China has adopted a slightly different system of OELs called "maximum allowable concentration" or "MAC." The MAC limits are also time weighted average concentrations, averaged over an 8 hour day and 40 hour work week. The MAC limits are designed to be the concentration of a chemical or compound in air to which nearly all workers can be exposed repeatedly without observed harmful health effects.

China's MACs are generally lower than the ACGIH TLVs because the MAC is set at the exposure level when the first signs of harmful health effects, whether temporary or permanent, occur. The MAC values are based solely on the biological and medical information available, and do not take into account technological or economic feasibility.

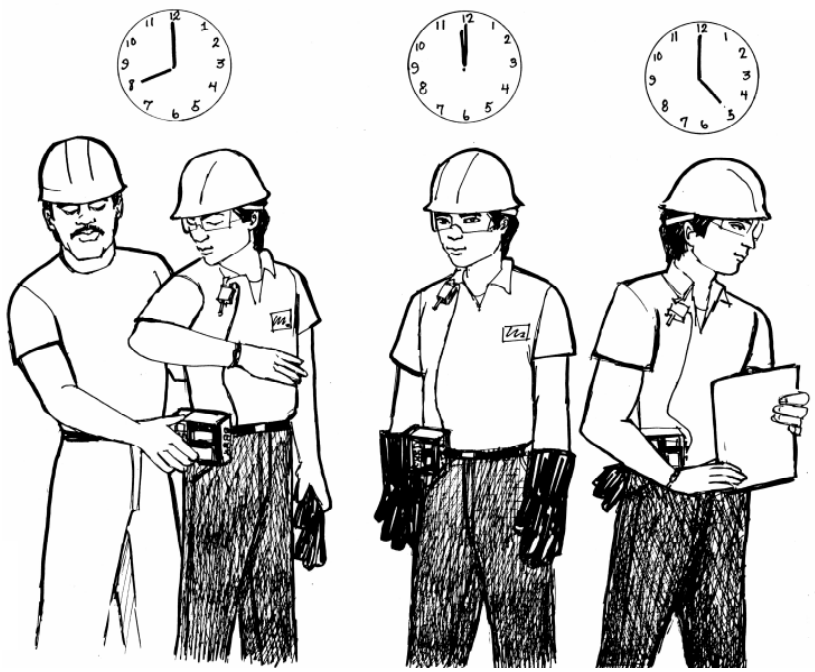
The three companies participating in this training – adidas, Reebok and Nike – have adopted the ACGIH TLVs as the OELs for their plants in China.

In general, OELs are based on the results of scientific experiments on animals and people, and actual industrial experience, to determine the level at which most workers will become sick or injured by the exposure. Research is always continuing, so OELs are revised, almost always to a lower limit, to protect workers' health as more information becomes available.

The ACGIH TLVs are reviewed every year and some TLVs are changed every year, almost always to a lower limit.

Chemical exposure limits

What do the OELs measure?



The OELs establish how much of a chemical can be in the air that workers breathe. The chemical may be in the form of a gas, or a vapor (liquid droplets in air), or a solid in air (such as dust or welding fume).

Gases and vapors in the air are usually measured in a unit called "parts per million" or "ppm." Solids in the air are usually measured in a unit called "milligrams per cubic meter of air" or "mg/m3." But a simple calculation can be made to convert a ppm measurement to a mg/m3 measurement, or vice versa.

The OEL values are very, very small amounts of chemicals in the air. For example, one part per million, or 1 ppm, is the equivalent of 1 RMB in 1,000,000 RMB, or one second in all the seconds in 12 days. One milligram per cubic meter, or 1 mg/m3, is the equivalent of a grain of sand in a cardboard box that is 1 meter by 1 meter by 1 meter in size.

The OEL values are very small because even small amounts of chemical substances – depending on the nature of the chemical – can cause health problems for exposed workers.

The chart on the next page gives information about seven industrial chemicals which have exposure limits.

Occupational Exposure Limits: China MACs and ACGIH TLVs*

Selected Chemicals

Chemical (CAS number)	Special Hazard	Odor Threshold (Mean)	ACGIH TLV 8-hour TWA**	China GB MACs	Skin absorption hazard
Acetone (67-64-1)	Fire hazard	62 ppm	500 ppm 1185 mg/m3	169 ppm 400 mg/m3	No
Benzene (71-43-2)	Causes cancer	61 ppm	0.5 ppm 1.6 mg/m3	12.5 ppm 40 mg/m3	Yes
Ethyl Acetate (141-78-6)	Irritation	18 ppm	400 ppm 1438 mg/m3	83 ppm 300 mg/m3	No
n-Hexane (110-54-3)	Peripheral neuropathy	22 ppm	50 ppm 176 mg/m3	Not established	Yes
Methyl Ethyl Ketone (MEK) (79-93-3)	Fire hazard	16 ppm	200 ppm 589 mg/m3	Not established	No
Toluene (108-88-3)	Reproductive hazard	11 ppm	50 ppm 188 mg/m3	26.6 ppm 100 mg/m3	Yes
Toluene diisocyanate (TDI) (584-84-9)	Respiratory sensitizer	2 ppm	0.005 ppm 0.035 mg/m3	0.028 ppm 0.200 mg/m3	No

*** China MACs =** "Maximum Allowable Concentration" (MAC), legal limits for an 8 hour work day, according to GB TJ36-79 "Factory Industrial Hygiene Design Standards" (1979).
* **ACGIH TLVs** = Threshold Limit Values (TLVs) of the ACGIH (American Conference of Governmental Industrial Hygienists), recommended 2001 limits for employee exposure averaged over 8 hours.
** **TWA** = Time Weighted Average, the recommended limit for an 8 hour exposure averaged over the actual time of the work day.
CAS number = individual chemical identification number.
Odor threshold = the airborne concentration when the chemical can be detected.

Working hours are much longer in China than the work shifts the OELs are designed to cover. China's MAC are also based on 8 hour days and 40 hour work weeks. While it is acceptable to adjust a single day's OEL for longer hours, it is not acceptable to adjust the OEL for an entire work week longer than 40 hours because of the adverse effect on the human body of so many additional hours of exposure during the week.

Occupational Exposure Limits: ACGIH TLVs Adjusted for Longer Shifts On A Single Day

Selected Chemicals

Chemical	8 Hour TWA*	10 Hour TWA	11 Hour TWA	12 Hour TWA
Acetone	500 ppm	400 ppm	364 ppm	33 0 ppm
Benzene	0.50 ppm	0.40 ppm	0.36 ppm	0.33 ppm
n-Hexane	50 ppm	40 ppm	36 ppm	33 ppm
Ethyl acetate	400 ppm	320 ppm	291 ppm	267 ppm
Methyl Ethyl Ketone (MEK)	200 ppm	160 ppm	145 ppm	133 ppm
Toluene diisocyanate (TDI)	0.005 ppm	0.004 ppm	0.0036 ppm	0.0033 ppm
Toluene	50 ppm	40 ppm	36 ppm	33 ppm

*** TWA** = Time Weighted Average, the recommended limit for an 8 hour exposure averaged over the actual time of the work day.

The daily OEL for 50-72 hour work weeks would have to be much lower than the 8 hour OEL, but there are no official numbers for any OEL for an extended work week. It is the employer's responsibility to reduce employee exposures to as low as possible, and certainly below the level where workers experience health problems.

Does smelling a chemical odor mean the exposure is harmful?

Simply being able to smell an odor does not automatically mean the exposure is higher than the OEL and a health hazard. Many chemicals, especially solvents like acetone, methyl ethyl ketone or ethyl acetate, have "odor thresholds" (the level where people can smell the chemical) that are much lower than their OEL.

Look at the chart on page 64 and compare the odor thresholds and OELs of acetone and ethyl acetate. This means that workers can smell these chemicals at a low level, but the OEL is much higher.

According to the research for each OEL, most workers should not experience adverse health effects at levels below the OEL, even though the chemical odor can be detected. However, some workers may experience irritation of the throat and eyes, headaches, etc., at levels above the odor threshold but below the OEL.

The ACGIH TLVs have been set at levels higher than where some workers develop health effects because these effects are considered "temporary" and go away "without any lasting effects."

There are also chemicals where harmful effects start at concentrations below the odor threshold, such as benzene or toluene diiscoyanate (see the chart on page 64). Also there are some other harmful chemicals, such as carbon monoxide, that have no odor at all and cannot be detected by smell in the workplace.

So not being able to smell these chemicals does not mean that the exposure levels are below the OEL or that workers will not have health problems.

How much exposure is "safe"?

The OEL values are important because, in general, if workers' exposures are above the OEL, it is likely that they will suffer immediate or long-term health problems. Because some workers will have health problems below the OEL as well, the goal is to reduce worker exposures to chemicals to the lowest possible level. The employers' legal responsibility is to maintain workplace exposures below the appropriate OEL.

The OEL values also indicate the relative toxicity or health hazard for specific chemicals. In general, chemicals that have a lower OEL – like benzene, toluene or toluene diisocyanate – are more dangerous than chemicals that have higher OEL value, such as acetone or ethyl acetate. Again workers who have specific health problems or who are very sensitive to chemicals can experience health problems even with chemicals that have higher OELs.

The OEL values also help prioritize control measures among chemicals in the workplace. Chemicals with a low OEL should be given higher priority to be eliminated from the workplace, or to be controlled by ventilation to reduce the exposure.

What are the employer's responsibilities?

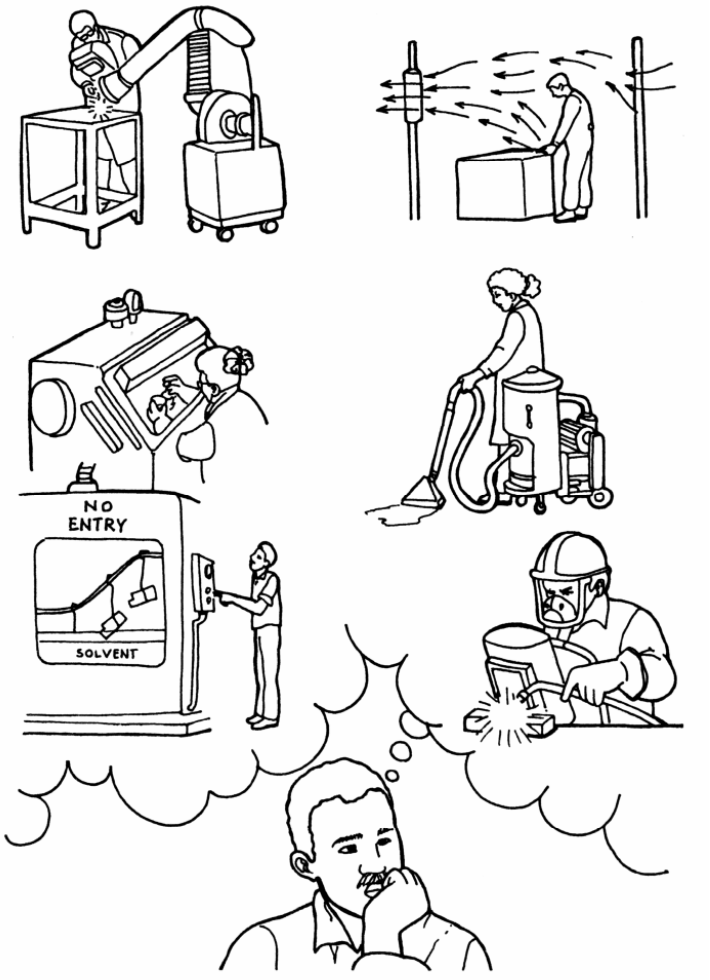
The employer has the responsibility to identify the health hazards that are present in the workplace; to monitor and evaluate these health hazards; to compare the monitoring results to the appropriate OEL, and to reduce or control hazardous exposures to the lowest possible level.

Are there problems with OELs?

It is important to understand that OELs do not represent an absolute dividing line between safe exposures (below the OEL) and unsafe exposures (above the OEL).

The fact that ACGIH TLVs are continuously being lowered, due to new information on adverse health effects, shows that exposures considered "safe" before are now considered a health risk for exposed workers. Sensitive workers, such as those with illnesses, or sensitive populations, such as pregnant women, may have health problems at levels well below the OELs.

There are no "absolutely safe" levels for some very toxic chemicals that cause cancer, or birth defects and other reproductive problems. It is not known what level of exposure triggers long-term diseases that do not appear until years after the exposure occurred.



There are no OELs for mixtures of different chemicals, or for the combined effects of two or more chemicals that produce even greater health problems together. Routes of entry other than breathing the chemicals – such as absorption through the skin or swallowing chemicals when smoking, eating or drinking – do not have OELs. These routes of entry into the body can be very important, which is why the ACGIH identifies some chemicals which easily pass through the skin as "skin absorption" hazards.

Only about 700 of the 60,000 chemicals now in industrial use around the world have OELs. There are many, many chemicals in use which have never been tested at all.

Despite the lack of information and absolute certainty about chemical effects, it is important to use the existing OELs as one tool for evaluating chemical exposures in the workplace and to prioritize actions to reduce or eliminate the hazards.

How are chemical exposures measured?

Workplace exposure measurements are usually done by trained professionals using specific types of monitoring devices. It is important that the monitoring is done correctly or the results will not be accurate or representative of the exposures of the workers.

There are two types of monitoring that are done:

1. immediate measurements of the worker's exposure at the moment the test is being done, using "direct reading" instruments;

2. full shift measurements of the worker's exposure over the entire length of the work day (8 hours, 10 hours, 12 hours, or whatever the shift length is), using battery-powered air sampling pumps and other equipment.

The procedure is the same for other hazards – such as noise, temperature, and radiation – as for chemicals. The kinds of equipment used are in the table below:

Hazard	Immediate, "direct-reading" equipment	"Full-shift" monitoring equipment
Chemicals	Detector tubes; gas meters, vapor meters	Air pumps, tubes and filters of many different types
Noise	Sound Level Meters	Personal dosimeters
Heat stress	"WBGT" meters	
Ventilation	Smoke tubes, flow rate meters of different types	

In order to compare the measured exposures to the OELs, the monitoring must be done with individual workers, be full shift and be representative of the "normal" work day of the job classification being monitored. Different chemicals require different sampling methods and different analytical methods, so it is important that the correct equipment be used, the required procedures be followed, and the samples be analyzed with the correct method.

How often should monitoring be done?

The employer has the responsibility to determine what the actual level of hazardous exposure is to the workers. The employer must have monitoring results in order to know whether worker exposures are above or below the OEL. The employer cannot meet its obligation to keep worker exposures below the OEL if the employer has no information about what the actual exposures are.

The employer should have a schedule of workplace monitoring that will, over time, provide the information needed to know what level of exposure occurs with each job classification where there are hazardous exposures in the plant. The chemicals or other hazards that are most harmful should be monitored first.

Re-testing of the exposures at a job classification should be done:

- if new chemicals or work processes are introduced;
- if there are new machines in use or new production quotas that change the level of worker exposure;
- if there are new workers in the job who are doing the work differently than the previously monitored worker.

Other exposure limits

Are there OELs for noise exposures?

There are OELs for noise exposures in workplaces in China. The noise OELs are also based on an 8 hour work day and 40 hour work week. There are no noise OELs for longer shifts and work weeks, but, as with long shift chemical exposures, the employer's obligation is to reduce noise exposures to as low as possible.

The units of measurement for noise are called "decibels" (dB) and there are three scales – A, B and C – with different measurement criteria. The noise OEL uses the A scale of decibels or "dBA".

It is important to understand that decibels do not add up like regular numbers. Because the measurement scale is "logarithmic" the intensity of the noise doubles every three decibels. That is 85 dBA is twice as loud as 82 dBA, and 88 dbA is twice as loud as 85 dBA.

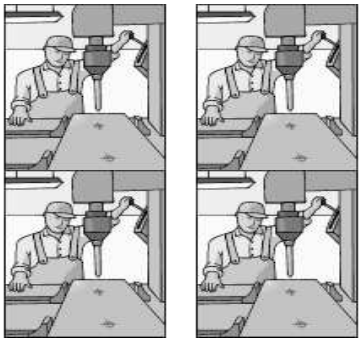
This means that even a small increase in the decibel number means a large increase in the intensity of the noise, which can result in serious and permanent damage to the ear and the workers' hearing.

Monitoring of noise exposures can be done with a direct reading instrument called a “sound level meter” or with a full shift monitor called a “personal dosimeter.”

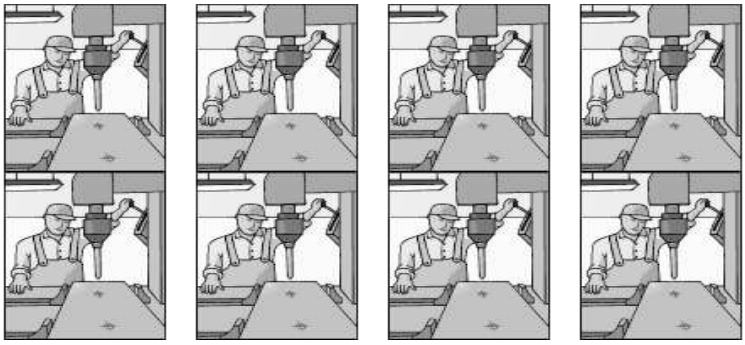
90 dB=

93 dB=

96 dB=



99 dB=



Noise regulations in China are:

Occupational Exposure Limits: Maximum Permissible Noise Levels*

Location in the Workplace	Maximum Permissible Limits - in decibels (dBA)
Workshops (8 hour shift)	90/85 **
Observation room, Break room	75
Computer room	70
Office, laboratory, design room	70
Control Center, telephone switchboard, fire monitoring station	60
Conference room	60
Medical clinic, classroom, daycare center	50

* = Limits as per GB J87-85 Design Standards of Industrial Noise in Factories (1985)
** = The limit for existing factories is 90 dBA while the limit for new factories is 85 dBA.

The process of evaluating noise exposures is the same as with chemical exposures. The monitoring results are compared to the noise OEL and the employer must take action to reduce the noise levels if the exposures are above the OEL.

Are there OELs for temperature?

There are OELs, both government regulations and voluntary professional guidelines, in many countries for both hot and cold temperatures. The ACGIH has TLVs for both heat and cold stress on the job, based on the health problems caused by hot and cold temperatures (see the section on safety hazards).

The heat stress/temperature regulations in China are:

Occupational Exposure Limits: Workplace Temperature Limits*

Outdoor Temperature in degrees Centigrade	Maximum Workplace Temperature Increase in degrees Centigrade	Maximum Indoor Temperature in degrees Centigrade
22	10	32
23	9	32
24	8	32
25	7	32
26	6	32
27	5	32
28	4	32
29-32	3	32-35
>33	2	35

*= Limits according to GB 4200-84 “Factory Temperature Levels” (1984)

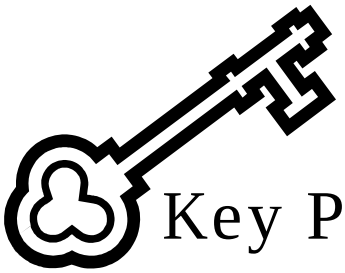
Article 21 of the July 1994 Labor Law (effective January 1, 1995) requires the employer to install air cooling equipment for all facilities with indoor temperatures higher than 35 degrees Centigrade.

Are there OELS for other hazards?

There are OELs, both government regulations and voluntary professional guidelines, in many countries for workplace exposures to ionizing radiation (such as X-rays), non-ionizing radiation (such as ultraviolet, radio frequency and microwaves), lasers, vibrations and ergonomics. Like with chemicals and noise OELs, these exposure limits are based on the health problems caused by these hazards. Radiation hazards in the workplace are discussed in the section on safety hazards.

China has regulations for the following types of radiation:

- GB 8702-88: Regulations for electromagnetic radiation protection;
- GB 9175-88: Hygienic standard for environmental electromagnetic waves;
- GB 10436-89: Hygienic standard for microwave radiation in the work environment;
- GB 10437-89: Hygienic standard for ultra high frequency radiation in the work environment;
- GB 16203-1996: Health Standard for electric field in the work environment.



Key Points

1. It is possible and necessary to measure workers' exposures to hazards in the workplace such as chemicals, noise and heat.

2. There are legal limits and recommended guidelines for specific hazardous exposures at work, and the employer is responsible for keeping workers' exposures below the OEL.

3. Being able to smell a chemical does not automatically mean workers' exposures are above the OEL and that they are hazardous to the workers' health.

Notes