Chemical Substances and Biological Agents

Studies and Research Projects

TECHNICAL GUIDE **T-22**

Guide for the adjustment of permissible exposure values (PEVs) for unusual work schedules

3rd edition revised and updated

Daniel Drolet

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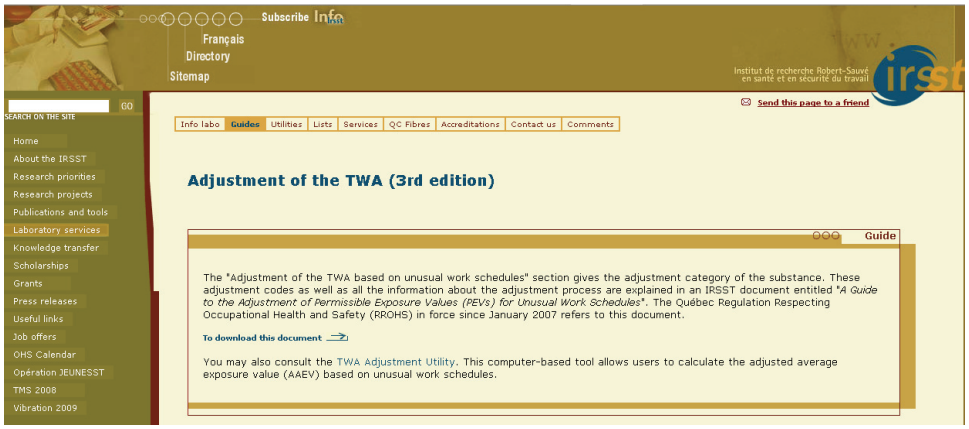

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New information in this version

This third version of the *Guide for the adjustment of permissible exposure values (PEVs) for unusual work schedules* contains some changes from the previous version. This version is necessary to be consistent with the changes to Schedule I of the RROHS published in January 2007. The RROHS contains in the *Definitions and notes* section a provision on the principle of the adjustment of PEVs with a reference to the present guide. The new substances in Schedule I have been evaluated to assign them an adjustment category. As well, substances whose PEVs or notation(s) have been modified have also been reevaluated for the same purpose. Appendix IV of this guide contains the updated adjustment category list for each of the 703 substances in the RROHS.

Furthermore, the computer-based tool available on the IRSST's Web site integrates these modifications and allows users to apply the PEV adjustment principle to any of the substances in the RROHS.

Table of contents

Préamble

The standards for chemical contaminants found in various national regulations and reference values such as the TLVs® (Threshold Limit Values) of the American Conference of Governmental Industrial Hygienists (ACGIH®)[2] have contributed greatly to the prevention of occupational diseases caused by worker exposure to hazardous substances. However, it is important to clearly understand the scope and limitations of the standards and TLVs® in order to discuss their adjustments. Standards such as TLVs® assume an applicability to workers with a regular work schedule of 8 hours per day, five days per week. The ACGIH® emphasizes that the adjustment of TLVs® in the case of extended work schedules requires a *particular judgment* and has recommended, for several years, the use of the *Brief and Scala* correction model. Since 2004, the ACGIH® has also referred to the model jointly developed by the Université de Montréal and the Institut de recherché Robert-Sauvé en Santé et en Sécurité du Travail of Québec described in this guide, while emphasizing that it generates results even closer to the physiologically-based toxicokinetic models (PBPK) than the *Brief & Scala* model.

This guide is the result of scientific expertise, consultations and the bipartite consensus of Technical Committee (3.33.1) on Schedule I of the RROHS. It proposes a structured process that remains complex despite the efforts that have been made to simplify it without increasing worker health risks. However, this complexity reflects the significance and method of application of PEVs that serve as reference conditions.

PEV adjustment is based on the toxicological knowledge available in the scientific and technical literature. However, the limits of our knowledge have to be recognized regarding dose-response relationships applicable to humans, dose-absorption kinetics relating to saturation of defense mechanisms, animal-human extrapolation of toxicological data, the distribution of contaminants and their metabolites at the point of action of target organs, etc.

Introduction

Current knowledge on the adjustment of PEVs to unusual work schedules, meaning schedules other than eight hours per day, five days per week, was recently summarized in several publications particularly relevant to the Québec context[3,4,5,6,7,8]. These publications describe the main methods for calculating PEV adjustment factors in the case of substances that require an adjustment.

> **Guiding principle**
>
> ... ensuring an equivalent degree of protection to workers with a conventional schedule of 8 hours a day, 5 days a week, and to workers with unusual work schedules.

The PEV adjustment process in this guide is based on a *guiding principle* that was agreed on in Technical Committee 3.33.1 for Schedule I of the RROHS[7]. In toxicological terms, for many chemical contaminants, an equilibrium is established between the accumulation of a contaminant in the body during the time at work and the elimination of the contaminant during the time away from work (this period is assumed to be exposure-free) until the maximum body burden or accumulation plateau in the body is reached. The time-weighted average exposure value (TWAEV) applicable to workers exposed to these contaminants during unusual work schedules must therefore be modified to ensure that the maximum body burden does not exceed the maximum body burden reached by a worker with a conventional work schedule. As a corollary, *no adjustment of the standard is necessary for any means of exposure or any toxic action of a contaminant that is unrelated in any way to the body burden*.

With this guiding principle as a basis and using the logic of the Occupational Safety and Health Administration[3] (OSHA) as inspiration, a group of toxicologists met at the IRSST to propose adjustment categories[9] (I, II, III and IV) for each of the substances found in Schedule I of the RROHS as well as a method for calculating adjustment factors supported by toxicokinetic modeling[10,11]. This group of experts also defined the conditions and limitations of application of the adjustment procedure.

Using these recommendations, the members of Technical Committee 3.33.1 for Schedule I of the RROHS of the Commission de la Santé et de la Sécurité du Travail (CSST, Québec workers' compensation board) established a consensus on the conditions of application of PEV adjustment (see Appendix I). The present guide is the tool for facilitating the application of PEV adjustment for unusual work schedules using toxicological considerations as a basis as reviewed by consensus by the members of the Schedule I committee. It provides several definitions and conditions of application, explains the PEV adjustment process and the interpretation of the ***adjusted average exposure value*** (AAEV), and presents some application examples in the appendix II.

Adjustment recommendations

Definitions

Repetitive work cycle: calendar period during which the work schedule (work shift) is exactly repeated on a daily and weekly basis.

> For example, a conventional schedule of 8h/d (Monday to Friday) and 5d/wk is a *repetitive calendar-week work cycle*; a schedule of 10 h/d (Tuesday to Friday) is also a *repetitive calendar-week work cycle.* However, a schedule of 12 h/d for 7 consecutive days, followed by 7 days off, would be a 14-day *repetitive cycle*. If this same schedule consists of alternating weeks of day and night shifts, it would *then be a 28-day repetitive cycle*.

Average exposure duration in hours per week based on a repetitive work cycle: the arithmetic mean in hours (H_w) of the weekly total (7 days) of the work shifts during the repetitive work cycle.

> For example, a schedule of 8 h/d (Monday to Friday), 5 d/wk, gives an average exposure duration in hours per week based on a repetitive work cycle of 40 h/wk; a schedule of 10 h/d, 4 d/wk (Tuesday to Friday) also represents an average exposure duration in hours per week based on a repetitive work cycle of 40 h/wk. However, a schedule of 12 h/d for 7 consecutive days, followed by 7 days off, corresponds to an average exposure duration in hours per week based on a repetitive work cycle of 42 h/wk.

Multiple exposure: daily exposure to several substances

Nominal schedule: normal work schedule based on the agreement between the employer and worker without including overtime and occasional replacement work. As a general rule, this schedule should represent at least 80% of the hours actually worked.

Conditions of application

- The *short-term exposure values (STEV) and ceiling values (CV) are not subject* to the adjustment principle; only the TWAEVs are subject to the adjustment principle;
- The TWAEV adjustment process applies only to nominal schedules with shifts of no less than 4 hours and no more than 16 hours.
- In no case can the AAEV be greater than the TWAEV.
- In the case of daily exposures to several substances, the equation in part 3 of Schedule I of the RROHS applies by replacing T (TWAEV) by T_a (AAEV).
- The excursion limits for substances that have no STEV apply directly to the AAEV. Similarly, exposures between the STEV and the TWAEV must be taken into consideration as described in the RROHS by replacing the TWAEV by the AAEV.

PEV adjustment procedure

The adjustment procedure is based on the assignment of adjustment categories (Table 1) as proposed by OSHA[3]. Appendix IV gives the adjustment category for each of the substances in the RROHS, namely *no* adjustment (category I), *daily* adjustment (category II), *weekly* adjustment (category III), and *the most conservative* of the daily or weekly adjustments (category IV). The adjustment category for each of the substances in Schedule I of the RROHS is also available on the IRSST's Web site. A computer-based tool (an Excel file) for applying the adjustment procedure is also available on the Internet (see Appendix III).

Table 1 : List of adjustment categories

Ad	Adjustment classification	Type of adjustment
I-a	Substances regulated by a ceiling value	**No** adjustment
I-b	Irritating or malodorous substances	
I-c	Simple asphyxiants, substances presenting a safety risk or a very low health risk, whose half-life is less than 4 hours. Technological limitations	
II	Substances that produce effects following *short-term* exposure	**Daily** adjustment
III	Substances that produce effects following *long-term* exposure	**Weekly** adjustment
IV	Substances that produce effects following a *short-* or *long-term* exposure	Daily or weekly adjustment **the most conservative of the two**

Calculating the AAEV

In the case of **Category I** substances, the TWAEV does not have to be adjusted, regardless of the type of work schedule. For substances belonging to the other categories, the TWAEV is adjusted by applying one of the following equations:

$F_a = 8 / H_d$ **Category II** substances, requiring a *daily* adjustment,

$F_a = 40 / H_{wk}$ **Category III** substances, requiring a *weekly* adjustment,

F_a = adjustment factor

H_d = exposure duration in hours per shift

H_{wk} = average duration of work shifts per week *based on a repetitive work cycle*.

In the case of **Category IV** substances, the F_a must be calculated for each of the two equations for Categories II and III, and the lowest F_a must be applied. It should be noted that the above-mentioned computer-based tool automatically calculates the AAEV from the most conservative F_a.

To obtain F_a rapidly, Appendix IV of this document supplies the adjustment categories for all of the substances in the RROHS, and Table 2 presents the F_a for most of the possible unusual schedules. The only exception to the application of Table 2 involves Category II and IV substances in the case of work schedules in which the work shifts vary in duration from day to day.

To use Table 2, the length of the repetitive work cycle must be determined and the average exposure durations be established based on the adjustment category of the substance considered.

Interpreting the AAEV

TWAEV

The RROHS defines the TWAEV in the following way :

"The time-weighted average concentration for an 8-hour workday and a 40-hour workweek of a chemical substance (in the form of gases, dusts, fumes, vapours or mists) present in the air in a worker's respiratory zone."

To verify compliance with the TWAEV, the occupational health and safety professional will evaluate the concentration of a substance present in the worker's breathing zone by weighting the result or results of the measured concentrations on the basis of a workshift of eight consecutive hours. In this case, *the repetitive work cycle* is one week and the duration of the work shifts is constant from day to day and corresponds to the duration of the hours worked, or eight hours. Regardless of the nature of the pathologies that can be caused by the presence of this substance in the workplace, *verification of compliance with the TWAEV or AAEV is always done a daily basis*.

Table 2 : Adjustment factor for unusual work schedules based on the duration of work shifts (h/d) and the average duration of work weeks (h/wk)

Category I : No adjustment

Category II*

h/day	F_A
8,0	1,00
8,5	0,94
9,0	0,89
9,5	0,84
10,0	0,80
10,5	0,76
11,0	0,73
11,5	0,70
12,0	0,67
12,5	0,64
13,0	0,62
13,5	0,59
14,0	0,57
14,5	0,55
15,0	0,53
15,5	0,52
16,0	0,50

*: the duration of work shifts must be equal from one day to the next

Category III

h/wk	F_A
40	1,00
41	0,98
42	0,95
43	0,93
44	0,91
45	0,89
46	0,87
47	0,85
48	0,83
49	0,82
50	0,80
51	0,78
52	0,77
53	0,75
54	0,74
55	0,73
56	0,71
57	0,70
58	0,69
59	0,68
60	0,67

Category IV

h/wk, *base on the repetitive cycle* \ h/day	F_A	8,0	8,5	9,0	9,5	10,0	10,5	11,0	11,5	12,0	12,5	13,0	13,5	14,0	14,5	15,0	15,5	16,0
40,0		1,00	0,94	0,89	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
40,5		0,99	0,94	0,89	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
41,0		0,98	0,94	0,89	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
41,5		0,96	0,94	0,89	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
42,0		0,95	0,94	0,89	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
42,5		0,94	0,94	0,89	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
43,0		0,93	0,93	0,89	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
43,5		0,92	0,92	0,89	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
44,0		0,91	0,91	0,89	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
44,5		0,90	0,90	0,89	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
45,0		0,89	0,89	0,89	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
45,5		0,88	0,88	0,88	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
46,0		0,87	0,87	0,87	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
46,5		0,86	0,86	0,86	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
47,0		0,85	0,85	0,85	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
47,5		0,84	0,84	0,84	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
48,0		0,83	0,83	0,83	0,83	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
48,5		0,82	0,82	0,82	0,82	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
49,0		0,82	0,82	0,82	0,82	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
49,5		0,81	0,81	0,81	0,81	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50
50,0		0,80	0,80	0,80	0,80	0,80	0,76	0,73	0,70	0,67	0,64	0,62	0,59	0,57	0,55	0,53	0,52	0,50

Blue: The most conservative **daily** adjustment

Red: The most conservative **weekly** adjustment

Calculating the AAEV

In the case of AAEVs, three situations may arise based on the adjustment category, namely :

Daily adjustment

For a substance whose adjustment must be done on a daily basis (**Category II**), if the work shifts are all of the same length, e.g., 12 hours, the AAEV will be 0.67 * TWAEV, and the results of the concentrations will be weighted over 12 hours. The condition requiring work shifts of constant duration would represent the great majority of real situations.

However, if the work shifts are not all of the same length, the simple approach resulting from the consensus of the Schedule I committee (use of the average duration of work shifts) cannot be applied due to toxicological reasoning because it could lead to situations in which the guiding principle would no longer be respected. It then becomes necessary to adjust the TWAEV for *each work shift duration* and to weight the results according to the duration of the corresponding work shift.

Weekly adjustment

Category III substances, which require a weekly adjustment, consist of all the substances whose effects appear following a long-term exposure. Adjustment on the basis of the *average exposure duration in hours per week based on a repetitive work cycle* is logical toxicologically. Therefore, a work schedule of 12 h/d for 7 consecutive days followed by 7 days off gives an average of 42 h/wk and an adjustment factor of 40/42 or 0.95.

The adjustment factor is used only to calculate the AAEV. Weighting of the concentration measurement(s) to verify compliance with the standard must be calculated over the duration of the work shift. In the example, weighting will be over 12 hours. If work shifts are of unequal length from one shift to the next, the weighting must be done over the duration of each of the work shifts..

Daily or weekly adjustment *(the most conservative of the two)*

For **Category IV** substances, the most conservative of the daily or weekly adjustments must be calculated. The same calculation criteria for the AAEV and the weighting of the results apply to this category.

Using the AAEV

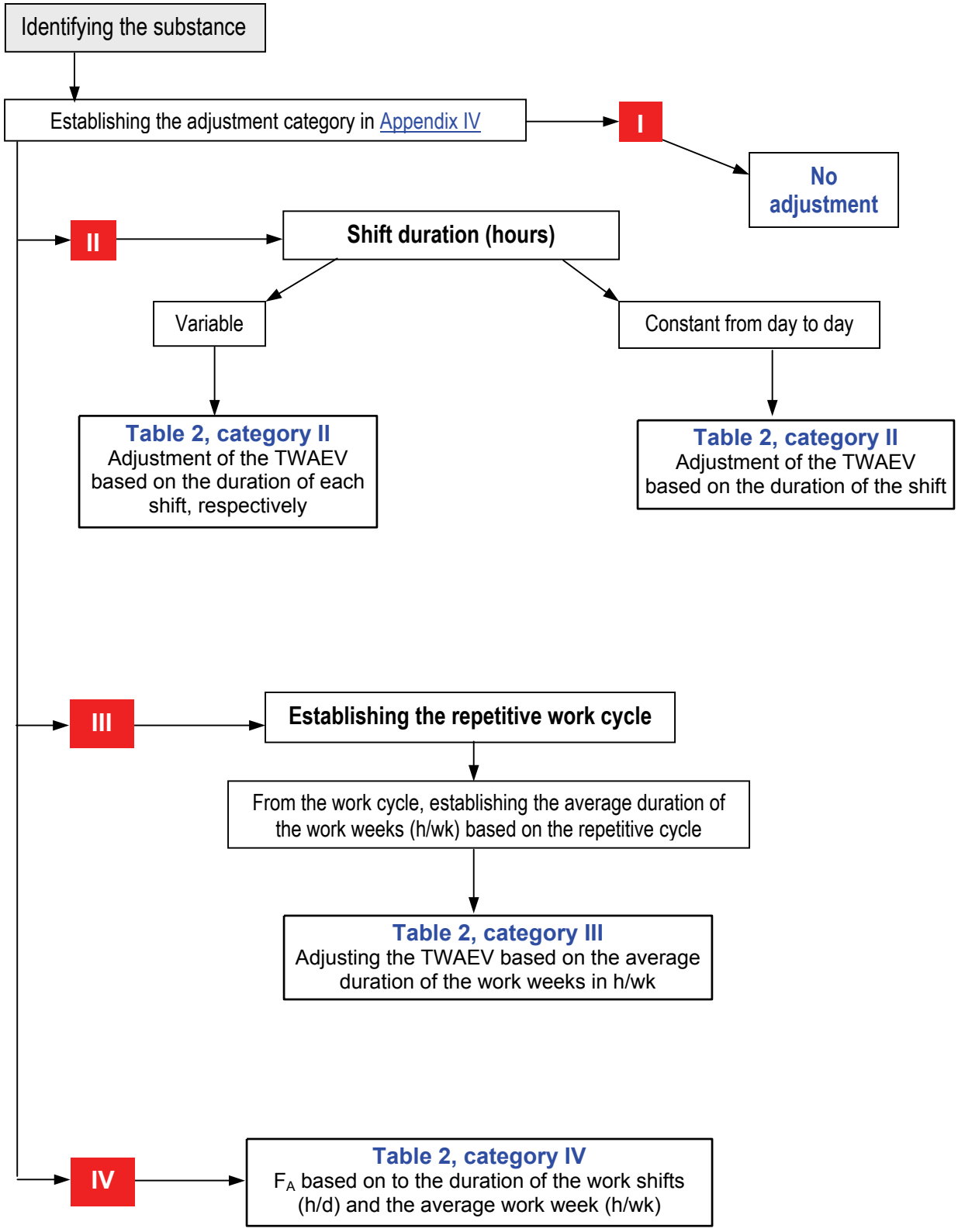
In the case of a daily exposure to a given substance for a worker working at several work locations and who has an unusual work schedule, calculation of the *average daily exposure* is done over the entire work shift and is then compared to the AAEV, as described in Part 2 of Schedule I of the RROHS [1].

In the case of a situation in which there is daily exposure to several substances and an unusual work schedule, the *mixed exposure index* (Rm) is calculated by using the AAEV instead of the TWAEV in the denominator, as described in Part 3 of Schedule I of the RROHS. The MIXIE computer-based tool developed jointly by the Université de Montréal and the IRSST can be an invaluable aid in identifying substances in the RROHS with similar effects on the same organs of the human body [12,13].

Conclusion

The process of adjusting TWAEVs into AAEVs is summarized in Figure 1. An AAEV cannot be greater than the TWAEV. STEVs and CVs are never adjusted. All the other definitions and provisions of the RROHS apply to the AAEV by replacing the TWAEV with the AAEV in the text.

Figure 1 : TWAEV adjustment process



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Appendix I : Consensus of the Schedule I Committee

Conditions of application

- The adjustment must not allow exposure above the time-weighted average exposure value (TWAEV).
- Short-term exposure values (STEV) are not subject to adjustment.

Assigning adjustment categories

- Add to Category **I**, without adjustment, “Substances whose half-life is less than 4 hours”.
- Include acetone, aniline, chlorine, hexane (other isomers) and hydrogen sulfide in Category **I**, without adjustment.

Appendix II: Examples of PEV adjustment

The PEV adjustment process is presented in the form of scenarios taken from real workplace situations. Appendix IV indicates the adjustment categories for all the substances in Schedule I of the RROHS..

Scenario 1: Hydrogen cyanide

Scenario 1 raises the question about exposure to ***hydrogen cyanide*** or HCN (hydrocyanic acid) by workers with different schedules of 8h/d, 5 d/wk.

The adjustment category for this substance as found in Appendix IV of this document is **I-a**. Figure 1 informs us that for all Category **I** substances, there is no adjustment regardless of the work schedule.

Scenario 2: Acetonitrile

A laboratory technician uses ***acetonitrile*** regularly as a solvent. He works 12 h/d, 4 d/wk, with alternating weeks from Monday to Thursday and from Tuesday to Friday. What is the AAEV that applies in his case?

The adjustment category for this substance as found in Appendix IV of this document indicates category **II** for acetonitrile, or a daily adjustment. Figure 1 indicates that for all category II substances, one first has to specify whether the work shifts in his nominal schedule are always the same length from day to day. In this case, the duration of the work shifts is constant at 12 hours, so we consult Table 2. Under the "Category II" heading, at 12.0 h/day, the adjustment factor is 0.67. The AAEV is therefore **45 mg/m³** (67 mg/m³ * 0.67).

The sampling strategy[14] must anticipate a 12-hour weighting of the representative results for the entire shift.

Scenario 3 : Lead

In a plant recovering ***lead*** from automobile batteries and other sources, workers have schedules with 12-hour shifts for two consecutive weeks of 3 days and 4 days. What would be the AAEV for lead that would apply to these workers?

The adjustment category for this substance as found in Appendix IV of this document indicates category **III** for "Lead and its inorganic compounds, dusts and fumes (expressed as Pb)", or a weekly adjustment. Figure 1 indicates that for all category **III** substances, the **repetitive work cycle** must first be specified, or two weeks (14 days), and *the average exposure duration in hours per week based on a repetitive work cycle*, or 42 hours (36+48)/2. This allows us to consult Table 2; under the "Category III" heading, at 42.0 h/week, the adjustment factor is 0.95. Therefore the AAEV becomes **0.14 mg/m³** (0.15 mg/m³ * 0.95).

The sampling strategy must anticipate a 12-hour weighting of the representative results[14] for the entire shift.

Scenario 4 : Styrene

A fiberglass pleasure boat manufacturing plant has a work schedule consisting of three working days followed by three days off. All the work shifts are 12 h/d. For workers using ***styrene*** to manufacture the polymeric coating, what would the AAEV be?

The adjustment category for this substance as found in Appendix IV of this document indicates category **IV** for styrene, or that the most conservative daily or weekly value must be used. Figure 1 indicates that for all category **IV** substances, categories II and III must be calculated and the most conservative result of the two must be applied.

Therefore, for category II, since all the work shifts are of the same length, or 12 hours, Table 2, under the "Category II" heading at 12 h/day, gives the adjustment factor as 0.67. The AAEV would therefore be **142 mg/m³** (213 mg/m³ * 0.67).

For category III, the **repetitive work cycle** must first be specified, which is 42 days, as summarized in the following table:

Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	W	W	W	A	A	A	W
2	W	W	A	A	A	W	W
3	W	A	A	A	W	W	W
4	A	A	A	W	W	W	A
5	A	A	W	W	W	A	A
6	A	W	W	W	A	A	A

W: work A: Absence

This cycle includes three weeks of 3 shifts (36 hours) and three weeks of 4 shifts (48 hours). The *average exposure duration in hours per week based on a repetitive work cycle* is 42 hours ((36*3)+(48*3))/6. We then consult Table 2; under the "Category III" heading, at 42.0 h/week, the adjustment factor is 0.95. Therefore the AAEV would be **203 mg/m³** (213 mg/m³ * 0.95).

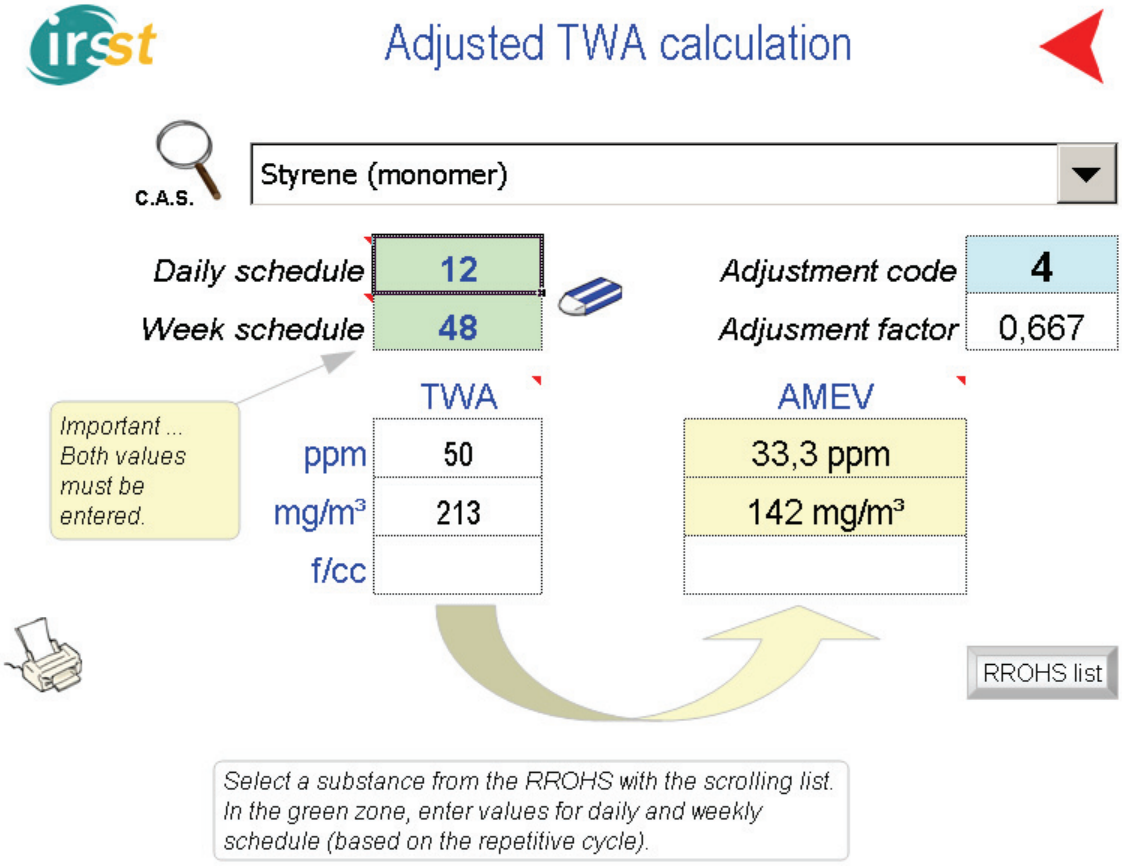
The AAEV of **142 mg/m³**, being the most conservative, is therefore applicable to these workers' exposure. Table 2 under the "Category IV" heading arrives at the same conclusion. In fact, the intersection point of the 42-hour row and the 12-hour column gives an adjustment factor (F_a) of 0.67.

The sampling strategy must anticipate a 12-hour weighting of the representative results[14] for the entire shift.

Appendix III: Computer-based tool for TWAEV adjustment

The following figure shows the EXCEL bilingual computer-based tool available on the IRSST's Web site. It works with Microsoft EXCEL version 97 (or a later version) and can be downloaded from the following address: http://www.irsst.qc.ca/en/_outil_100011.html.

The data for scenario 4 of Appendix II have been used as an example.



Appendix IV: Adjustment category for RROHS substances

Acetaldehyde	I-a
Acetic acid	I-b
Acetic anhydride	I-b
Acetone	I-c
Acetone cyanohydrin	I-a
Acetonitrile	II
Acetophenone	I-b
Acetylene	I-c
Acetylsalicylic acid (Aspirin)	II
Acrolein	I-b
Acrylamide	III
Acrylic acid	I-b
Acrylonitrile	III
Adipic acid	III
Adiponitrile	IV
Aldrin	IV
Allyl alcohol	I-b
Allyl glycidyl ether (AGE)	I-b
Allyl propyl disulfide	I-b
Aluminum [7429-90-5], (as Al), Alkyls (NOC)	I-b
Aluminum (as Al), Metal	I-c
Aluminum [7429-90-5], (as Al), Pyrotechnical powders	I-c
Aluminum [7429-90-5], (as Al), Soluble salts	I-b
Aluminum [7429-90-5], (as Al), Welding fumes	I-c
Aluminum oxide (as Al), Pt	I-c
4-Aminodiphenyl	III
2-Aminoethanol	III
2-Aminopyridine	II
Amitrole	III
Ammonia	I-b
Ammonium chloride fume	I-b
Ammonium perfluorooctanoate	III
Ammonium sulfamate	I-b
Aniline	I-c
o-Anisidine	II
p-Anisidine	II
Antimony [7440-36-0], metal and compounds (as Sb)	III
Antimony trioxide (as Sb)	III
Antimony trioxide, production (as Sb)	III
ANTU (alpha-Naphthylthiourea)	II
Argon	I-c
Arsenic, elemental [7440-38-2], and inorganic compounds (except Arsine) (as As)	III
Arsenic trioxide, production	III
Arsine	IV
Asbestos, Actinolite	III
Asbestos, Amosite	III
Asbestos, Anthophyllite	III
Asbestos, Chrysotile	III
Asbestos, Crocidolite	III
Asbestos, Tremolite	III
Asphalt (petroleum) fumes	III
Atrazine	II
Azinphos-methyl	IV
Barium, soluble compounds (as Ba)	II
Barium sulfate, Pt	III
Barium sulfate, Pr	III
Benomyl	I-c
Benz(a)anthracene	III
Benzene	III
Benzidine (production)	III
Benzo(a)pyrene	III
Benzo(b)fluoranthene	III
p-Benzoquinone	I-b
Benzoyl peroxide	I-b
Benzyl chloride	IV
Beryllium [7440-41-7], metal and compounds (as Be)	III
Biphenyl	I-b
Bismuth telluride (as Bi2Te3), Se-doped	III
Bismuth telluride (as Bi2Te3), Undoped	I-c
Boron oxide	I-b
Boron tribromide	I-a
Boron trifluoride	I-a
Bromacil	III
Bromine	I-b
Bromine pentafluoride	I-b
Bromoform	IV
Bromotrifluoromethane	I-c
1,3-Butadiene	III
Butane	I-c
2-Butoxyethanol	III
n-Butyl acetate	I-b
sec-Butyl acetate	I-b
tert-Butyl acetate	I-b
n-Butyl acrylate	I-b
n-Butyl alcohol	I-a
sec-Butyl alcohol	II
tert-Butyl alcohol	II
tert-Butyl chromate (as CrO3)	I-a
n-Butyl glycidyl ether (BGE)	III
n-Butyl lactate	I-b
Butyl mercaptan	I-b
n-Butylamine	I-a
o-sec-Butylphenol	I-b
p-tert-Butyltoluene	III
Cadmium elemental and compouds (as Cd)	III
Calcium carbonate, Pt	I-c
Calcium chromate (as Cr)	III
Calcium cyanamide	I-b
Calcium hydroxide	I-b
Calcium oxide	I-b
Calcium silicate (synthetic), Pt	I-c
Calcium sulfate, Pt	I-c
Calcium sulfate, Pr	I-c
Camphor (synthetic)	I-b
Caprolactam, Dust	I-b
Caprolactam, Vapour	I-b
Captafol	III
Captan	III
Carbaryl	IV
Carbofuran	IV
Carbon black	III
Carbon dioxide	I-c
Carbon disulfide	IV
Carbon monoxide	IV
Carbon tetrabromide	IV
Carbon tetrachloride	IV
Carbonyl fluoride	IV
Catechol	IV
Cellulose (paper fibres), Pt	I-c
Cesium hydroxide	I-b
Chlordane	IV
Chlorinated camphene	IV
Chlorinated diphenyl oxide	III

Chlorine	I-c
Chlorine dioxide	II
Chlorine trifluoride	I-a
Chloroacetaldehyde	I-a
Chloroacetone	I-a
alpha-Chloroacetophenone	I-b
Chloroacetyl chloride	I-b
Chlorobenzene	IV
o-Chlorobenzylidene malononitrile	I-a
Chlorobromomethane	III
Chlorodifluoromethane	I-c
Chlorodiphenyl (42% chlorine)	III
Chlorodiphenyl (54% chlorine)	III
Chloroform	IV
Chloromethyl methyl ether	III
bis (Chloromethyl) ether	III
1-Chloro-1-nitropropane	II
Chloropentafluoroethane	I-c
Chloropicrin	II
ß-Chloroprene	IV
3-Chloropropene	III
2-chloropropionic acid	III
o-Chlorostyrene	IV
o-Chlorotoluene	I-b
Chlorpyrifos	IV
Chromite ore processing (chromate) (as Cr)	III
Chromium (metal)	III
Chromium (III) compounds (as Cr)	III
Chromium IV, water insoluble inorganic compounds (as Cr)	III
Chromium IV, water soluble inorganic compounds (as Cr)	III
Chromyl chloride	III
Chrysene	III
Clopidol	I-c
Coal dust (less than 5% crystalline silica), Pr	III
Coal dust (more than 5% crystalline silica), Pr	III
Coal tar pitch volatiles, as benzene solubles	III
Cobalt, elemental and inorganic compounds (as Co)	III
Cobalt hydrocarbonyl (as Co)	II
Cobalt tetracarbonyl (as Co)	II
Copper [7440-50-8], Fume (as Cu)	II
Copper [7440-50-8], Dust and mists (as Cu)	I-b
Corundum, Pt	I-c
Cotton dust, cotton waste processing operation of waste recycling and garnetting	III
Cotton dust, in yarn manufacturing and cotton washing operations	III
Cotton dust, in textile mill waste house operations or in yarn manufacturing to dust from "lower-grade washed cotton"	III
Cotton dust, in textile slashing and weaving operations	III
Cresol (all isomers)	I-b
Crotonaldehyde	I-b
Crufomate	IV
Cumene	II
Cyanamide	I-b
Cyanides (as Cn)	I-a
Cyanogen	I-b
Cyanogen chloride	I-a
Cyclohexane	I-b
Cyclohexanol	IV
Cyclohexanone	III
Cyclohexene	I-b
Cyclohexylamine	I-b
Cyclonite	III
Cyclopentadiene	I-b
Cyclopentane	IV
Cyhexatin	I-c
2,4-D	III
DDT (Dichlorodiphenyltrichloroethane)	IV
Decaborane	IV
Demeton®	IV
Di-sec-octyl phthalate	III
2,6-Di-tert-butyl-p-cresol	I-c
Diacetone alcohol	I-b
1,6-Diaminohexane	I-b
Diazinon®	IV
Diazomethane	IV
Diborane	IV
1,2-Dibromoethane	III
Dibutyl phenyl phosphate	IV
Dibutyl phosphate	I-b
Dibutyl phthalate	I-b
2-N-Dibutylaminoethanol	III
1,3-Dichloro -5,5-dimethyl hydantoin	I-b
Dichloroacetylene	I-a
o-Dichlorobenzene	I-a
p-Dichlorobenzene	III
3,3'-Dichlorobenzidine	III
1,4-Dichloro-2-butene	III
Dichlorodifluoromethane	I-c
1,1-Dichloroethane	IV
1,2-Dichloroethane	III
Dichloroethyl ether	II
1,1-Dichloroethylene	III
1,2-Dichloroethylene	IV
Dichlorofluoromethane	IV
1,1-Dichloro-1-nitroethane	II
1,2-Dichloropropane	IV
Dichloropropene (cis and trans)	IV
2,2-Dichloropropionic acid	I-b
1,2 Dichloro-1,1,2,2-tetrafluoroethane	I-c
Dichlorvos	IV
Dicrotophos	IV
Dicyclopentadiene	III
Dicyclopentadienyl iron	I-c
Dieldrin	IV
Diethanolamine	I-b
Diethyl ether	I-b
Diethyl ketone	II
Diethyl phthalate	III
Diethylamine	I-b
2-Diethylaminoethanol	I-b
Diethylene triamine	III
Difluorodibromomethane	IV
Diglycidyl ether (DGE)	III
Diisobutyl ketone	I-b
Diisopropyl ether	I-b
Diisopropylamine	I-b
Dimethyl carbamoyl chloride	III
Dimethyl sulfate	III
N,N-Dimethylacetamide	IV
Dimethylamine	I-b
N,N-Dimethylaniline	IV
N,N-Dimethylformamide	III
1,1-Dimethylhydrazine	III
Dimethylphthalate	I-b
Dinitolmide	III
Dinitro-ortho-cresol	III
Dinitrobenzene (all isomers)	IV
Dinitrotoluene	IV
Dioxane	III
Dioxathion	III
Diphenylamine	IV
Dipropylene glycol monomethyl ether	II
Diquat, Pt	III
Diquat, Pr	III
Disulfiram	II

Disulfoton	IV
Diuron	I-c
Divinyl benzene	I-b
Emery, Pt	I-c
Endosulfan	IV
Endrin	II
Enflurane	II
Epichlorohydrin	IV
EPN	IV
Ethane	I-c
Ethion	IV
2-Ethoxyethanol (EGEE)	IV
2-Ethoxyethyl acetate (EGEEA)	IV
Ethyl acetate	I-b
Ethyl acrylate	III
Ethyl alcohol	I-b
Ethyl amyl ketone	I-b
Ethyl benzene	III
Ethyl bromide	IV
Ethyl butyl ketone	II
Ethyl chloride	IV
Ethyl formate	I-b
Ethyl mercaptan	I-b
Ethyl silicate	III
Ethylamine	I-b
Ethylene	I-c
Ethylene chlorohydrin	I-a
Ethylene glycol (vapour and mist)	I-a
Ethylene glycol dinitrate	I-a
Ethylene imine	IV
Ethylene oxide	III
Ethylenediamine	III
Ethylidene norbornene	I-a
N-Ethylmorpholine	II
Fenamiphos	IV
Fensulfothion	IV
Fenthion	IV
Ferbam	I-b
Ferrovanadium (dust)	I-b
Fibres, Artificial Vitreous Mineral Fibres, Fibrous glass, continuous filament, Pt	I-c
Fibres, Artificial Vitreous Mineral Fibres, Fibrous glass, microfibres	III
Fibres, Artificial Vitreous Mineral Fibres, Insulation wool fibres, Glass wool	I-b
Fibres, Artificial Vitreous Mineral Fibres, Insulation wool fibres, Rock wool	I-b
Fibres, Artificial Vitreous Mineral Fibres, Insulation wool fibres, Slag wool	
Fibres, Artificial Vitreous Mineral Fibres, Refractory fibres (ceramic or others)	III
Fibres, Natural Mineral Fibres, Attapulgite	III
Fibres, Natural Mineral Fibres, Erionite	I-a
Fibres-Natural Mineral Fibres, Wollastonite, Pt	I-b
Fibres-Natural Mineral Fibres, Wollastonite, Pr	I-b
Fibres, Organic Synthetic Fibres, Carbon and graphite fibres, Pt	III
Fibres, Organic Synthetic Fibres, Carbon and graphite fibres, Pr	III
Fibres, Organic Synthetic Fibres, Para-aramide fibres (Kevlar®, Twaron®)	III
Fibres, Organic Synthetic Fibres, Polyolefin fibres, Pt	I-c
Fluorides (as F)	III
Fluorine	I-b
Fonofos	IV
Formaldehyde	I-a
Formamide	III
Formic acid	I-b
Furfural	I-b
Furfuryl alcohol	I-b
Gasoline	II
Germanium tetrahydride	II
Glutaraldehyde	I-a
Glycerin (mist)	I-c
Glycidol	I-b
Grain dust (oat, wheat, barley), Pt	IV
Graphite (all forms except fibers), Pr	III
Gypsum, Pt	I-c
Gypsum, Pr	I-c
Hafnium	III
Halothane	IV
Helium	I-c
Heptachlor	IV
Heptachlore epoxide	III
n-Heptane	II
Hexachlorobenzene	III
Hexachlorobutadiene	III
Hexachlorocyclopentadiene	IV
Hexachloroethane	III
Hexachloronaphthalene	III
Hexafluoroacetone	IV
Hexamethyl phosphoramide	III
Hexamethylene diisocyanate	III
n-Hexane	IV
Hexane (other isomers)	I-c
sec-Hexyl acetate	I-b
Hexylene glycol	I-a
Hydrazine	III
Hydrogen	I-c
Hydrogen bromide	I-a
Hydrogen chloride	I-a
Hydrogen cyanide	I-a
Hydrogen fluoride (as F)	I-a
Hydrogen peroxide	I-b
Hydrogen selenide (as Se)	IV
Hydrogen sulfide	I-c
Hydrogenated terphenyls	III
Hydroquinone	IV
2-Hydroxypropyl acrylate	I-b
Indene	I-b
Indium [7440-74-6] and compounds (as In)	IV
Iodine	I-a
Iodoform	II
Iron pentacarbonyl (as Fe)	II
Iron salts, soluble (as Fe)	I-b
Iron trioxide, dust and fume (as Fe)	III
Isoamyl alcohol	II
Isobutyl acetate	I-b
Isobutyl alcohol	I-b
Isocyanate oligomers	III
Isooctyl alcohol	II
Isophorone	I-a
Isophorone diisocyanate	III
Isopropoxyethanol	III
Isopropyl acetate	I-b
Isopropyl alcohol	II
Isopropyl glycidyl ether (IGE)	III
Isopropylamine	I-b
N-Isopropylaniline	II
Kaolin, Pr	III
Ketene	II
L.P.G. (Liquified petroleum gas)	I-c
Lead and inorganic compounds	III
Lead arsenate (as Pb3(AsO4)2)	IV
Lead chromate (as Cr)	III
Lead tetraethyl (as Pb)	III
Lead tetramethyl (as Pb)	III
Limestone, Pt	I-c
Lindane	IV
Lithium hydride	I-b
Magnesite, Pt	I-c
Magnesium oxide fume (as Mg)	II

Malathion	IV
Maleic anhydride	IV
Manganese [7439-96-5] (as Mn), Dust and compounds	III
Manganese (as Mn), Fume	IV
Manganese cyclopentadienyl tricarbonyl (as Mn)	IV
Manganese methyl cyclopentadienyl tricarbonyl (as Mn)	IV
Manganese tetroxide	III
Mercury [7439-97-6], Alkyl compounds (as Hg)	IV
Mercury [7439-97-6], aryl compounds (as Hg)	III
Mercury [7439-97-6], inorganic compounds (as Hg)	III
Mercury [7439-97-6], mecury vapor (as Hg)	III
Mesityl oxide	I-b
Methacrylic acid	I-b
Methane	I-c
Methomyl	IV
Methoxychlor	IV
2-Methoxyethanol (EGME)	IV
2-Methoxyethyl acetate (EGMEA)	IV
4-Methoxyphenol	I-b
Methyl acetate	II
Methyl acetylene	I-c
Methyl acetylene-propadiene mixture (MAPP)	I-c
Methyl acrylate	III
Methyl alcohol	IV
Methyl amyl alcohol	I-b
Methyl n-amyl ketone	I-b
Methyl bromide	IV
Methyl tert-butyl ether	IV
Methyl n-butyl ketone	III
Methyl chloride	IV
Methyl chloroform	II
Methyl 2-cyanoacrylate	III
Methyl demeton	IV
Methyl ethyl ketone (MEK)	I-b
Methyl ethyl ketone peroxide	I-a
Methyl formate	I-b
Methyl hydrazine	I-a
Methyl iodide	IV
Methyl isoamyl ketone	I-b
Methyl isobutyl ketone	I-b
Methyl isocyanate	III
Methyl isopropyl ketone	I-b
Methyl mercaptan	I-b
Methyl methacrylate (monomer)	I-b
Methyl parathion	IV
Methyl propyl ketone	II
Methyl silicate	II
alpha-Methyl styrene	II
Methylacrylonitrile	IV
Methylal	I-b
Methylamine	I-b
N-Methylaniline	IV
Methylcyclohexane	I-b
Methylcyclohexanol	III
o-Methylcyclohexanone	I-b
Methylene chloride	IV
4,4'-Methylene bis (2-chloroaniline) (MOCA)	IV
Methylene bis (4-cyclohexylisocyanate)	III
4,4'-Methylene dianiline	III
Methylene bis (4-phenyl isocyanate) (MDI)	III
Metribuzin	II
Mica, Pr	III
Mineral oil (mist)	III
Molybdenum [7439-98-7] (as Mo), Insoluble compounds	I-c
Molybdenum [7439-98-7] (as Mo), Soluble compounds	I-c
Monocrotophos	IV
Morpholine	I-b
Naled	IV
Naphthalene	I-b
ß-Naphthylamine	III
Neon	I-c
Nickel, Metal	III
Nickel [7440-02-0], Insoluble compounds (as Ni)	III
Nickel [7440-02-0], Soluble compounds (as Ni)	III
Nickel carbonyl (as Ni)	II
Nickel sulfide roasting, fume and dust (as Ni)	III
Nicotine	II
Nitrapyrin	I-c
Nitric acid	II
p-Nitroaniline	IV
Nitrobenzene	IV
p-Nitrochlorobenzene	IV
4-Nitrodiphenyl	III
Nitroethane	I-b
Nitrogen	I-c
Nitrogen dioxide	IV
Nitrogen monoxide	II
Nitrogen trifluoride	II
Nitroglycerin (NG)	I-a
Nitromethane	IV
1-Nitropropane	III
2-Nitropropane	III
N-Nitrosodimethylamine	III
Nitrotoluene (all isomers)	II
Nitrous oxide	III
Nonane	II
Octachloronaphthalene	III
Octane	II
Osmium tetroxide (as Os)	I-b
Oxalic acid	I-b
Oxygen difluoride	I-a
Ozone	I-a
Paraffin wax, fume	I-b
Paraquat, respirable particulates, Pr	III
Parathion	IV
Particulates Not Otherwise Classified (PNOC), Pt	I-c
Pentaborane	II
Pentachloronaphthalene	III
Pentachloronitrobenzene	III
Pentachlorophenol	III
Pentaerythritol	I-c
n-Pentane	II
n-Amyl acetate	I-b
sec-Amyl acetate	I-b
tert-Amyl acetate	I-b
Isoamyl acetate	I-b
2-Methyl-1-butyl acetate	I-b
3-Pentyl actetate	I-b
Perchloroethylene	IV
Perchloromethyl mercaptan	II
Perchloryl fluoride	IV
Perfluoroisobutylene	I-a
Perlite, Pt	I-c
Perlite, Pr	I-c
Phenol	IV
Phenothiazine	III
Phenyl ether, vapour	I-b
Phenyl glycidyl ether (PGE)	III
Phenyl mercaptan	I-b
meta-Phenylenediamine	III
ortho-Phenylenediamine	III
p-Phenylenediamine	III
Phenylhydrazine	III
n-Phenyl-ß-naphthylamine	III

Phenylphosphine	I-a
Phorate	IV
Phosdrin	IV
Phosgene	II
Phosphine	II
Phosphoric acid	I-b
Phosphorus (yellow)	I-b
Phosphorus oxychloride	I-b
Phosphorus pentachloride	I-b
Phosphorus pentasulfide	I-b
Phosphorus trichloride	I-b
Phthalic anhydride	III
m-Phthalodinitrile	I-c
Picloram	I-c
Picric acid	III
Pindone	III
Piperazine dihydrochloride	III
Plaster of Paris, Pt	I-c
Plaster of Paris, Pr	I-c
Platinum, Metal	III
Platinum [7440-06-4], Soluble salts (as Pt)	III
Polytetrafluoroethylene decomposition products	II
Portland cement, Pt	I-b
Portland cement, Pr	I-b
Potassium hydroxide	I-a
Propane	I-c
Propane sultone	III
Propargyl alcohol	I-b
ß-Propiolactone	III
Propionic acid	I-b
Propoxur (baygon)	IV
n-Propyl acetate	I-b
n-Propyl alcohol	I-b
n-Propyl nitrate	II
Propylene	I-c
Propylene glycol dinitrate	IV
Propylene glycol monomethyl ether	IV
Propylene imine	III
Propylene oxide	III
Pyrethrum	III
Pyridine	III
Resorcinol	II
Rhodium [7440-16-6], Metal and insoluble compounds (as Rh)	III
Rhodium [7440-16-6], Soluble compounds (as Rh)	III
Ronnel	IV
Rosin core solder pyrolysis products (as Formaldehyde)	III
Rotenone	IV
Rouge, Pt	I-c
Rubber solvent (Naphtha)	II
Selenium and compounds (as Se)	IV
Selenium hexafluoride (as Se)	IV
Sesone	III
Silica, Amorphous, Diatomaceous earth (uncalcined), Pt	I-c
Silica - Amorphous, fumes, Pr	III
Silica, Amorphous, fused, Pr	III
Silica, Amorphous, gel, Pr	I-c
Silica, Amorphous, precipitated, Pt	I-c
Silica, Crystalline, Cristobalite, Pr	III
Silica, Crystalline, Quartz, Pr	III
Silica, Crystalline, Tridymite, Pr	III
Silica, Crystalline, Tripoli, Pr	III
Silicon, Pt	I-c
Silicon carbide (non fibrous), Pt	I-c
Silicon tetrahydride	II
Silver, Metal	III
Silver [7440-22-4], Soluble compounds (as Ag)	III
Soapstone, Pt	III
Soapstone, Pr	III
Sodium azide	I-a
Sodium bisulfite	I-b
Sodium fluoroacetate	II
Sodium hydroxide	I-a
Sodium metabisulfite	I-b
Borates, tetra, sodium salt , Anhydrous	I-b
Borates, tetra, sodium salt , Decahydrate	I-b
Borates, tetra, sodium salt , Pentahydrate	I-b
Starch, Pt	III
Stibine (as Sb)	IV
Stoddard solvent	IV
Strontium chromate (as Cr)	III
Strychnine	II
Styrene (monomer)	IV
Subtilisins (Proteolytic enzymes as 100 % pure crystalline enzyme)	I-c
Succinaldehyde	I-b
Sucrose	I-c
Sulfometuron methyl	III
Sulfotep	IV
Sulfur dioxide	I-b
Sulfur hexafluoride	I-c
Sulfur monochloride	I-a
Sulfur pentafluoride	I-a
Sulfur tetrafluoride	I-a
Sulfuric acid	I-b
Sulfuryl fluoride	III
Sulprofos	IV
2,4,5-T	I-c
Talc, fibrous	III
Talc, non fibrous, Pr	III
Tantalum [7440-25-7], metal and oxide dusts (as Ta)	I-c
Tellurium and compounds (as Te)	IV
Tellurium hexafluoride (as Te)	II
Temephos	IV
TEPP	IV
Terephthalic acid	I-c
Terphenyls	I-a
1,1,2,2-Tetrabromoethane	IV
1,1,1,2-Tetrachloro-2,2-difluoroethane	IV
1,1,2,2-Tetrachloro-1, 2-difluoroethane	IV
1,1,2,2-Tetrachloroethane	IV
Tetrachloronaphthalene	III
Tetrahydrofuran	I-b
Tetramethyl succinonitrile	II
Tetranitromethane	IV
Tetrasodium pyrophosphate	I-b
Tetryl	III
Thallium, elemental [7440-28-0], and soluble compounds (as Tl)	III
4,4'-Thiobis (6-tert-butyl-m-cresol)	I-c
Thioglycolic acid	I-b
Thionyl chloride	I-a
Thiram®	III
Tin, Metal	III
Tin [7440-31-5], Organic compounds (as Sn)	III
Tin [7440-31-5], Oxide and inorganic compounds, except SnH4 (as Sn)	III
Titanium dioxide, Pt	I-c
o-Tolidine	III
Toluene	IV
Toluene diisocyanate (TDI) (isomers mixture)	III
o-Toluidine	IV
m-Toluidine	II
p-Toluidine	IV
Tributyl phosphate	I-b
Trichloroacetic acid	I-b
1,2,4-Trichlorobenzene	I-b
1,1,2-Trichloroethane	IV

Trichloroethylene	II
Trichlorofluoromethane	I-a
Trichloronaphthalene	III
1,2,3-Trichloropropane	III
1,1,2-Trichloro-1,2,2-trifluoroethane	II
Tri-o-cresyl phosphate	III
Triethanolamine	III
Triethylamine	IV
Triglycidyl isocyanurate (TGIC) (alpha-)	III
Triglycidyl isocyanurate (TGIC) (beta)	III
Triglycidyl isocyanurate (TGIC) (mixed isomers)	III
Trimellitic anhydride	III
Trimethyl benzene	III
Trimethyl phosphite	I-b
Trimethylamine	I-b
2,4,6-Trinitrotoluene (TNT)	III
Triphenyl amine	I-c
Triphenyl phosphate	IV
Tungsten [7440-33-7] (as W) , Insoluble compounds	I-c
Tungsten [7440-33-7] (as W) , Soluble compounds	II
Turpentine	I-b
Uranium [7440-61-1] (natural) , Insoluble compounds (as U)	III
Uranium (natural) [7440-61-1], Soluble compounds (as U)	III
n-Valeraldehyde	I-b
Vanadium pentoxide, fume and respirable dust (as V2O5)	I-b
Vegetable oil mists (except castor, cashew and other similar irritant oils)	I-c
Vinyl acetate	I-b
Vinyl bromide	III
Vinyl chloride (monomer)	III
Vinyl cyclohexene dioxide	III
Vinyl toluene	I-b
VM&P Naphtha	I-b
Warfarin	IV
Welding fumes (not otherwise classified)	II
Wood dust (western red cedar), Pt	III
Wood dust hard and soft, except red cedar, Pt	III
Xylene (o-,m-,p- isomers)	II
m-Xylene-alpha, alpha'-diamine	I-a
Xylidine (mixed isomers)	III
Yttrium [7440-65-5], metal and compounds (as Y)	III
Zinc chloride, fume	II
Zinc chromates [13530-65-9;11103-86-9; 37300-23-5] (as Cr)	III
Zinc stearate	I-c
Zinc, oxide, Dust, Pt	I-c
Zinc, oxide, Fume	II
Zirconium [7440-67-7] and compounds (as Zr)	I-c