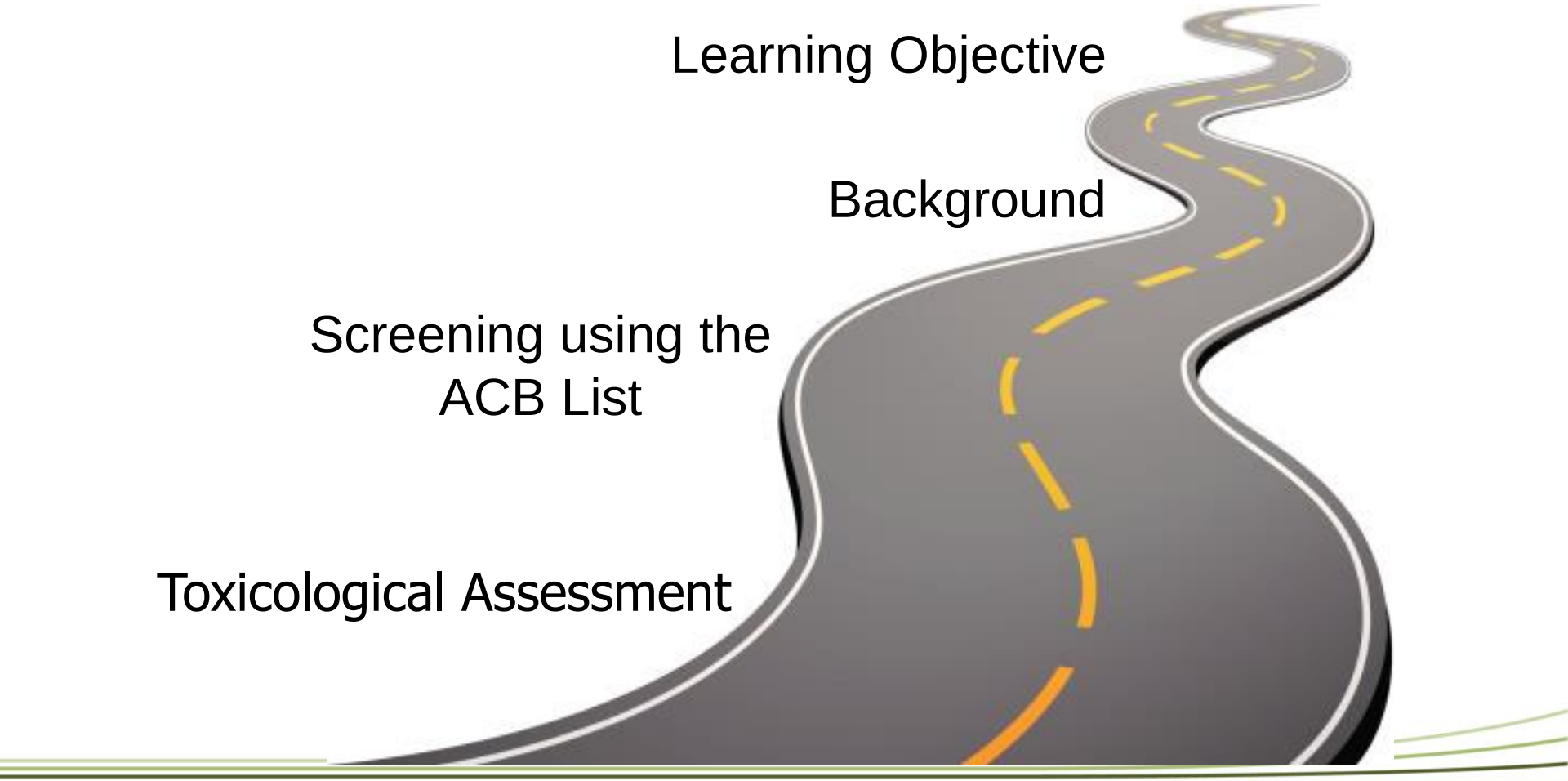
An overview of toxicological assessments of air contaminants without limits

May 24, 2017
Air and Waste Management Association

Tania Onica
Brianne Attard
Standards Development Branch
Ministry of the Environment and Climate Change

Today's Road Map



Ontario

Learning Objective

- To obtain a general understanding of the process to carry-out a toxicological assessment of air contaminants without limits including the use of the Air Contaminant Benchmarks (ACB) list to screen contaminants

Note: This presentation is not intended to be training on how to do a toxicological assessment of contaminants in air.

Background – Assessing Contaminants without Limits

- Under O. Reg. 419/05 (Local Air Quality Regulation) and O. Reg 1/17 (Air Emissions EASR Regulation), **all contaminants released to air** above negligible amounts **must be assessed** for their potential to cause adverse effects
- Contaminants are assessed against benchmarks, if available, or by a toxicological assessment
- Benchmarks to be used: ACB list

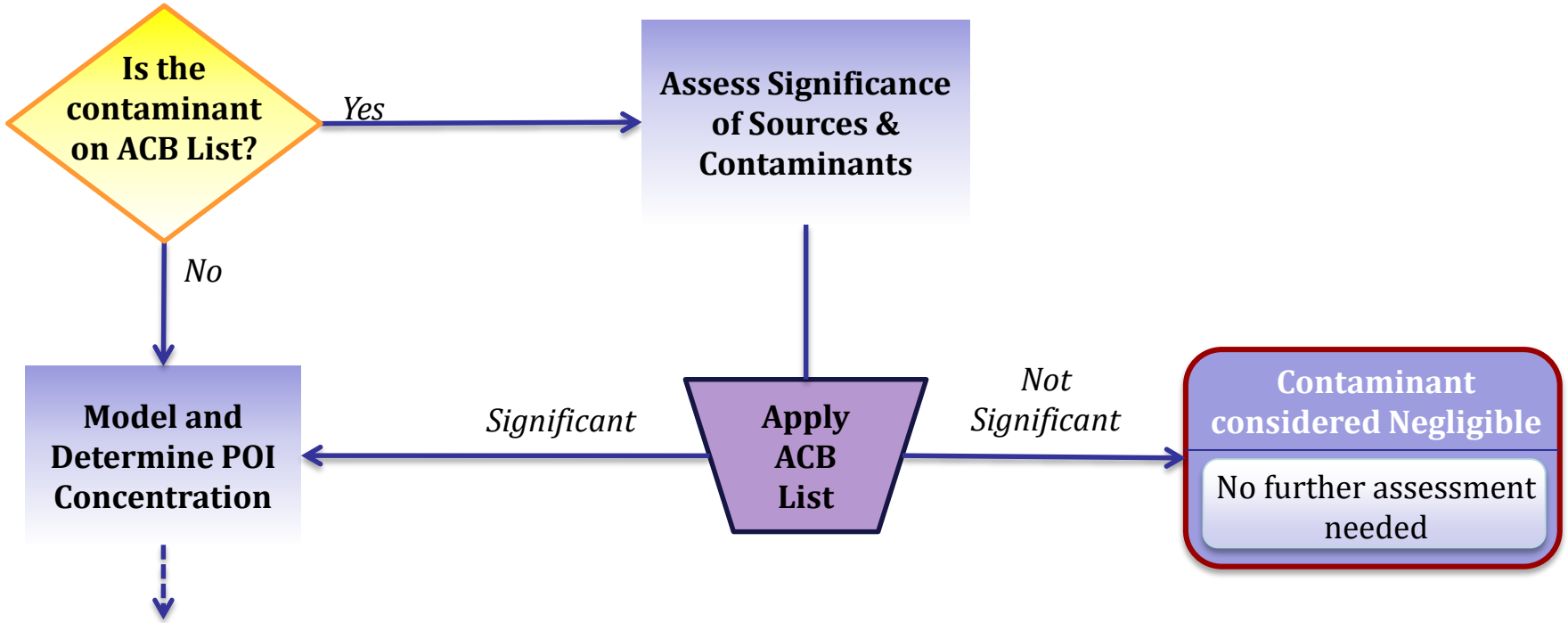
Air Contaminants Benchmarks (ACB) List

- Posted on the ministry website and on the Environmental Registry as an information notice on January 4, 2017
- Consolidates and replaces separate existing lists of benchmarks (standards, guidelines and jurisdictional screening levels)
- Includes benchmarks for over 1600 contaminants
  - Air standards – for 134 contaminants **(B1 values)**
  - Guidelines for ~ 200 contaminants **(B1 values)**
  - Screening levels for ~1300 contaminants **(B2 values)**

Screening Using the ACB List

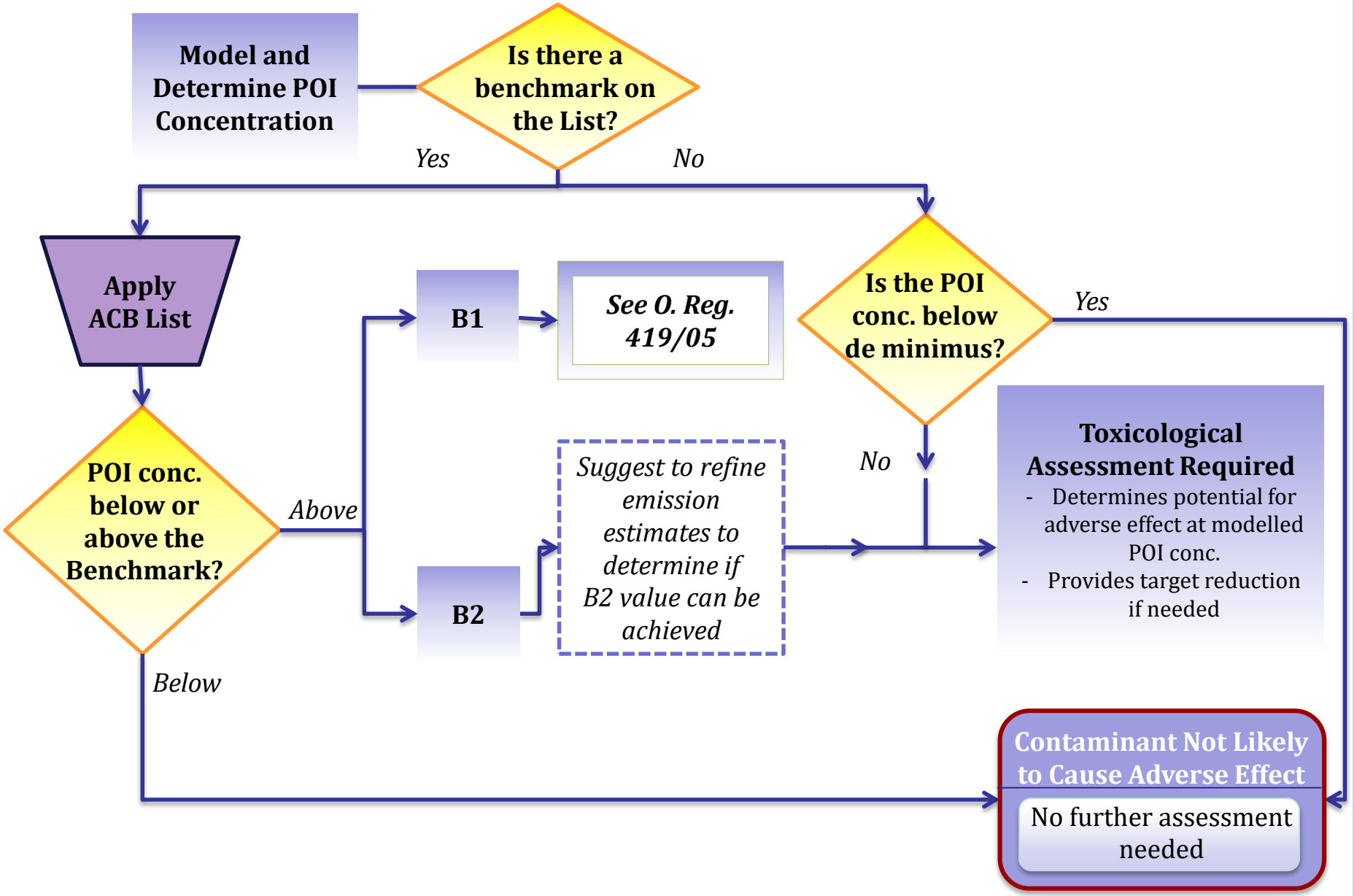
Step 1: Determine Significant Sources/Contaminants

See "Procedure for Preparing an Emission Summary and Dispersion Modelling (ESDM) Report" (PIBS#3614e04) for further details



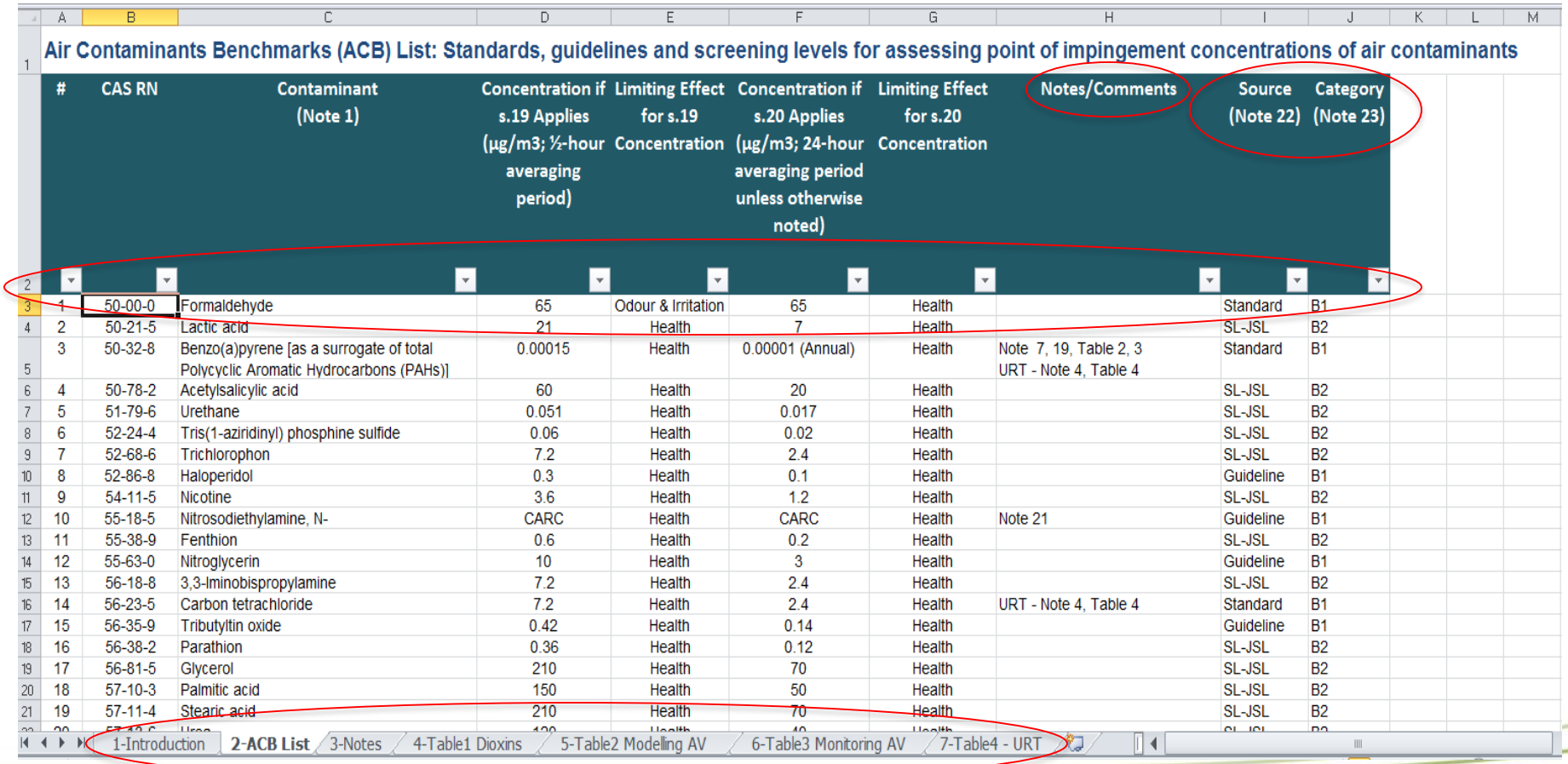
Ontario

Step 2: Compare ACB List to modelled POI concentration



ACB List

https://www.ontario.ca/page/air-contaminants-benchmarks-list-standards-guidelines-and-screening-levels-assessing-point



Air Contaminants Benchmarks (ACB) List: Standards, guidelines and screening levels for assessing point of impingement concentrations of air contaminants

#	CAS RN	Contaminant (Note 1)	Concentration if s.19 Applies (µg/m3; ½-hour averaging period)	Limiting Effect for s.19 Concentration	Concentration if s.20 Applies (µg/m3; 24-hour averaging period unless otherwise noted)	Limiting Effect for s.20 Concentration	Notes/Comments	Source (Note 22)	Category (Note 23)
1	50-00-0	Formaldehyde	65	Odour & Irritation	65	Health		Standard	B1
2	50-21-5	Lactic acid	21	Health	7	Health		SL-JSL	B2
3	50-32-8	Benzo(a)pyrene [as a surrogate of total Polycyclic Aromatic Hydrocarbons (PAHs)]	0.00015	Health	0.00001 (Annual)	Health	Note 7, 19, Table 2, 3 URT - Note 4, Table 4	Standard	B1
4	50-78-2	Acetylsalicylic acid	60	Health	20	Health		SL-JSL	B2
5	51-79-6	Urethane	0.051	Health	0.017	Health		SL-JSL	B2
6	52-24-4	Tris(1-aziridinyl) phosphine sulfide	0.06	Health	0.02	Health		SL-JSL	B2
7	52-68-6	Trichlorophon	7.2	Health	2.4	Health		SL-JSL	B2
8	52-86-8	Haloperidol	0.3	Health	0.1	Health		Guideline	B1
9	54-11-5	Nicotine	3.6	Health	1.2	Health		SL-JSL	B2
10	55-18-5	Nitrosodiethylamine, N-	CARC	Health	CARC	Health	Note 21	Guideline	B1
11	55-38-9	Fenthion	0.6	Health	0.2	Health		SL-JSL	B2
12	55-63-0	Nitroglycerin	10	Health	3	Health		Guideline	B1
13	56-18-8	3,3-Iminobispropylamine	7.2	Health	2.4	Health		SL-JSL	B2
14	56-23-5	Carbon tetrachloride	7.2	Health	2.4	Health	URT - Note 4, Table 4	Standard	B1
15	56-35-9	Tributyltin oxide	0.42	Health	0.14	Health		Guideline	B1
16	56-38-2	Parathion	0.36	Health	0.12	Health		SL-JSL	B2
17	56-81-5	Glycerol	210	Health	70	Health		SL-JSL	B2
18	57-10-3	Palmitic acid	150	Health	50	Health		SL-JSL	B2
19	57-11-4	Stearic acid	210	Health	70	Health		SL-JSL	B2

1-Introduction | 2-ACB List | 3-Notes | 4-Table1 Dioxins | 5-Table2 Modelling AV | 6-Table3 Monitoring AV | 7-Table4 - URT

Ontario

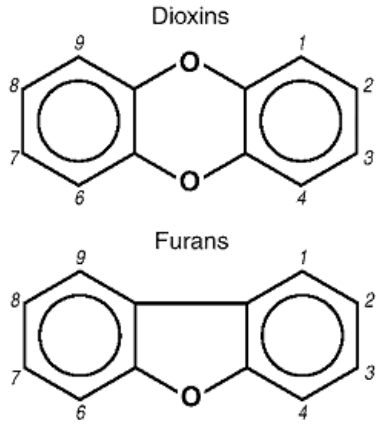
Standard Interpretation

- Some air standards have additional Chemical Abstract Service Registry Numbers (CAS RNs) associated with them.
- Often listed in Ministry documents (i.e., Decision Document) but not explicitly listed on the ACB list
  - Dioxins/Furans
  - Metal and Metal Compounds
  - Mercaptans
  - Mineral Spirits
  - Polyaromatic Hydrocarbons (PAHs)
  - Trimethylbenzenes
  - Xylenes

Ontario

Dioxins, Furans and Dioxin-Like PCBs

- Table 1 in ACB list
- Requires the calculation of the total toxicity equivalent (TEQ) concentration contributed by all dioxin-like compounds in the mixture.



- Because there are 209 other possible PCBs, (i.e., the non-dioxin-like PCBs) these should continue to be evaluated against the existing guideline for PCBs.

Ontario

Metals and Metal Compounds

- Several B1 values are listed as “Metal and metal compounds” – for any metal containing contaminant, the benchmark would apply to the % weight of the metal in that contaminant
- The % weight is determined using the structure and the molecular weight of the contaminant
- For those contaminants which are regulated under the same B1 value, the % wt is calculated for each contaminant and compared to the standard and the combined (site-wide) concentrations need to be determined and compared to the standard

Metals and Metal Compounds (cont'd)

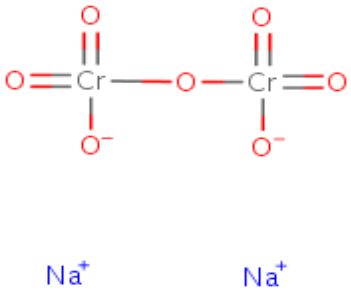
Example: Sodium dichromate- Standard for hexavalent chromium applies to the % weight of Cr(VI)

1) Determine the molecular wt% of the metal

%wt = wt Cr / wt $Cr_2O_7Na_2$ x 100%

= 52(2) / 262 x 100%

= 40% Cr(VI)



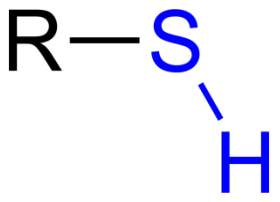
2) Determine the resulting POI conc. of Cr(VI)

POI conc. = 0.4 Cr(VI) x POI concentration of $Cr_2O_7Na_2$

= 0.4 Cr(VI) x 10 µg/m^3 $Cr_2O_7Na_2$

= 4 µg/m^3 Cr(VI)

Mercaptans



- Mercaptan means any organic compound that contains a thiol group.
- Mercaptans are expressed as methyl mercaptan
- Benchmarks mercaptans are captured under:
  - Mercaptans (CAS N/A; B1 – standard)
  - Total Reduced Sulphur (TRS) compounds (CAS N/A; B1-standard) – if mercaptans are released in a mixture of reduced sulphur compounds such as dimethyl disulphide, dimethyl sulphide, and hydrogen sulphide.

Mineral Spirits

- In industry the term “Mineral Spirits” can include a large group of contaminants.
- The MOECC mineral spirit standard is only applicable to those that meet our definition below

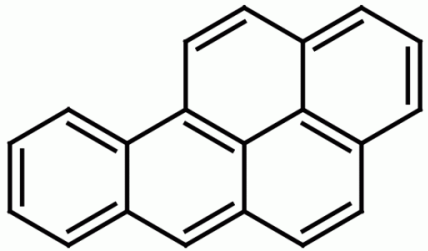
a petroleum distillate mixture of C7 to C12 alkanes (paraffins) and cycloalkanes (naphthenes) where the mixture is in the range from 5 to 20 per cent aromatics by weight, is less than 0.1 per cent benzene by weight, has a boiling point in the range from 130 to 220 degrees Celsius and has a flash point in the range from 21 to 60 degrees Celsius.

Mineral Spirits (cont'd)

- Examples (in Mineral Spirits Decision Document):
  - Naphtha (CAS RN: 8030-30-6)
  - Ligroine (CAS RN: 8032-32-4)
  - Stoddard solvent (CAS RN: 8052-41-3)
  - Heavy hydrotreated petroleum naphtha (CAS RN: 64742-48-9)
  - Medium aliphatic solvent petroleum naphtha (CAS RN: 64742-88-7)
  - Light aliphatic solvent petroleum naphtha (CAS RN: 64742-89-8)
- Note that individual and combined (site-wide) emissions for all minerals spirits must meet the standard

Polyaromatic Hydrocarbons (PAHs)

- Benzo(a)pyrene is used as a surrogate to total PAHs
- Captures all PAHs except those that have their own standards or guideline values (i.e., naphthalene [91-20-3])



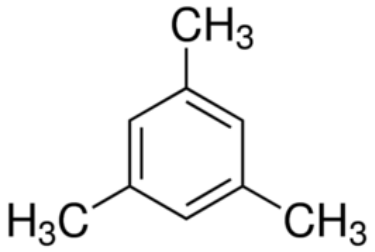
- The maximum modelled POI concentration of B[a]P is compared to the air standard for B[a]P as a surrogate for all PAHs.
- Note: combined (site-wide) emissions are not considered

PAHs (cont'd)

- 53-70-3 Dibenzo[a,h]anthracene
- 56-55-3 Benz[a]anthracene
- 57-97-6 7,12-Dimethylbenzo[a]anthracene
- 83-32-9 Acenaphthene
- 85-01-8 Phenanthrene
- 86-73-7 Fluorene
- 91-57-6 2-Methylnaphthalene
- 120-12-7 Anthracene
- 129-00-0 Pyrene
- 189-55-9 Dibenzo[a,i]pyrene
- 189-64-0 Dibenzo[a,h]pyrene
- 191-24-2 Benzo[g,h,i]perylene
- 191-26-4 Anthanthrene
- 191-30-0 Dibenzo[a,l]pyrene
- 192-65-4 Dibenzo[a,e]pyrene
- 192-97-2 Benzo[e]pyrene
- 193-39-5 Indeno[1,2,3-cd]pyrene
- 194-59-2 7H-Dibenzo[c,g]carbazole
- 194-69-4 Benzo[c]chrysene
- 195-19-7 Benzo[c]phenanthrene
- 196-78-1 Benzo[g]chrysene
- 205-82-3 Benzo[j]fluoranthene
- 205-99-2 Benzo[b]fluoranthene
- 206-44-0 Fluoranthene
- 207-08-9 Benzo[k]fluoranthene
- 208-96-8 Acenaphthylene
- 218-01-9 Chrysene
- 224-42-0 Dibenz[a,j]acridine
- 225-11-6 Benzo[a]acridine
- 226-36-8 Dibenz[a,h]acridine
- 260-94-6 Acridine
- 607-57-8 2-Nitrofluorene
- 781-43-1 9,10-Dimethylanthracene
- 1705-85-7 6-Methylchrysene
- 1706-01-0 3-Methylfluoranthene
- 2381-16-0 9-Methylbenzo[a]anthracene
- 2381-31-9 8-Methylbenzo[a]anthracene
- 2381-39-7 6-Methylbenzo[a]pyrene
- 2422-79-9 12-Methylbenzo[a]anthracene
- 2541-69-7 7-Methylbenzo[a]anthracene
- 3697-24-3 5-Methylchrysene
- 3697-27-6 5,6-Dimethylchrysene
- 4514-19-6 12-Methylbenzo[a]pyrene
- 5385-75-1 Dibenzo[a,e]fluoranthene
- 5522-43-0 1-Nitropyrene
- 7496-02-8 6-Nitrochrysene
- 14207-78-4 5,11-Dimethylchrysene
- 16757-80-5 11-Methylbenzo[a]pyrene
- 16757-81-6 3-Methylbenzo[a]pyrene
- 16757-82-7 2-Methylbenzo[a]pyrene
- 16757-83-8 4-Methylbenzo[a]pyrene
- 16757-85-0 1,2-Dimethylbenzo[a]pyrene
- 16757-89-4 4,5-Dimethylbenzo[a]pyrene
- 16757-90-7 1,6-Dimethylbenzo[a]pyrene
- 16757-91-8 3,6-Dimethylbenzo[a]pyrene
- 22349-59-3 1,4-Dimethylphenanthrene
- 23189-63-1 4,10-Dimethylphenanthrene
- 27208-37-3 Cyclopenta[c,d]pyrene
- 31647-36-6 5-Methylbenzo[a]pyrene
- 33543-31-6 2-Methylfluoranthene
- 40568-90-9 1-Methylbenzo[a]pyrene
- 42397-64-8 1,6-Dinitropyrene
- 42397-65-9 1,8-Dinitropyrene
- 52171-92-3 5,7-Dimethylchrysene
- 54986-62-8 5-Ethylchrysene
- 57835-92-4 4-Nitropyrene
- 63018-94-0 2,9,10-Trimethylanthracene
- 66552-77-0 2,3,9,10-Tetramethylanthracene
- 77969-74-5 11-Methylbenzo[b]fluorene

Trimethylbenzenes

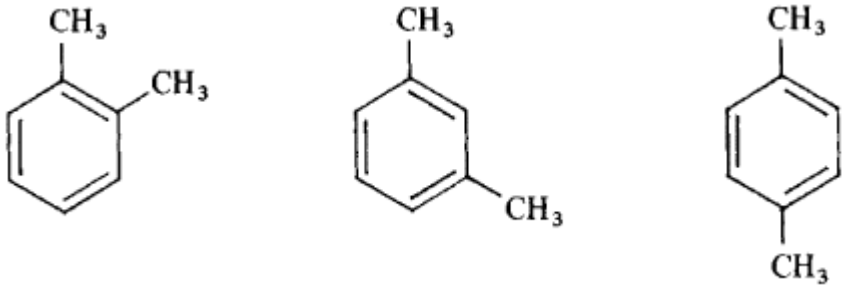
- Trimethylbenzene Decision Document:
  - 1,2,4-Trimethylbenzene (CAS RN: 95-63-6)
  - 1,3,5-Trimethylbenzene (CAS RN: 108-67-8)
  - 1,2,3-Trimethylbenzene (CAS RN: 526-73-8)



- Also includes:
  - Mixed trimethylbenzene isomers (CAS RN: 25551-13-7)
- Note that individual and combined (site-wide) emissions for all trimethylbenzenes must meet the standard

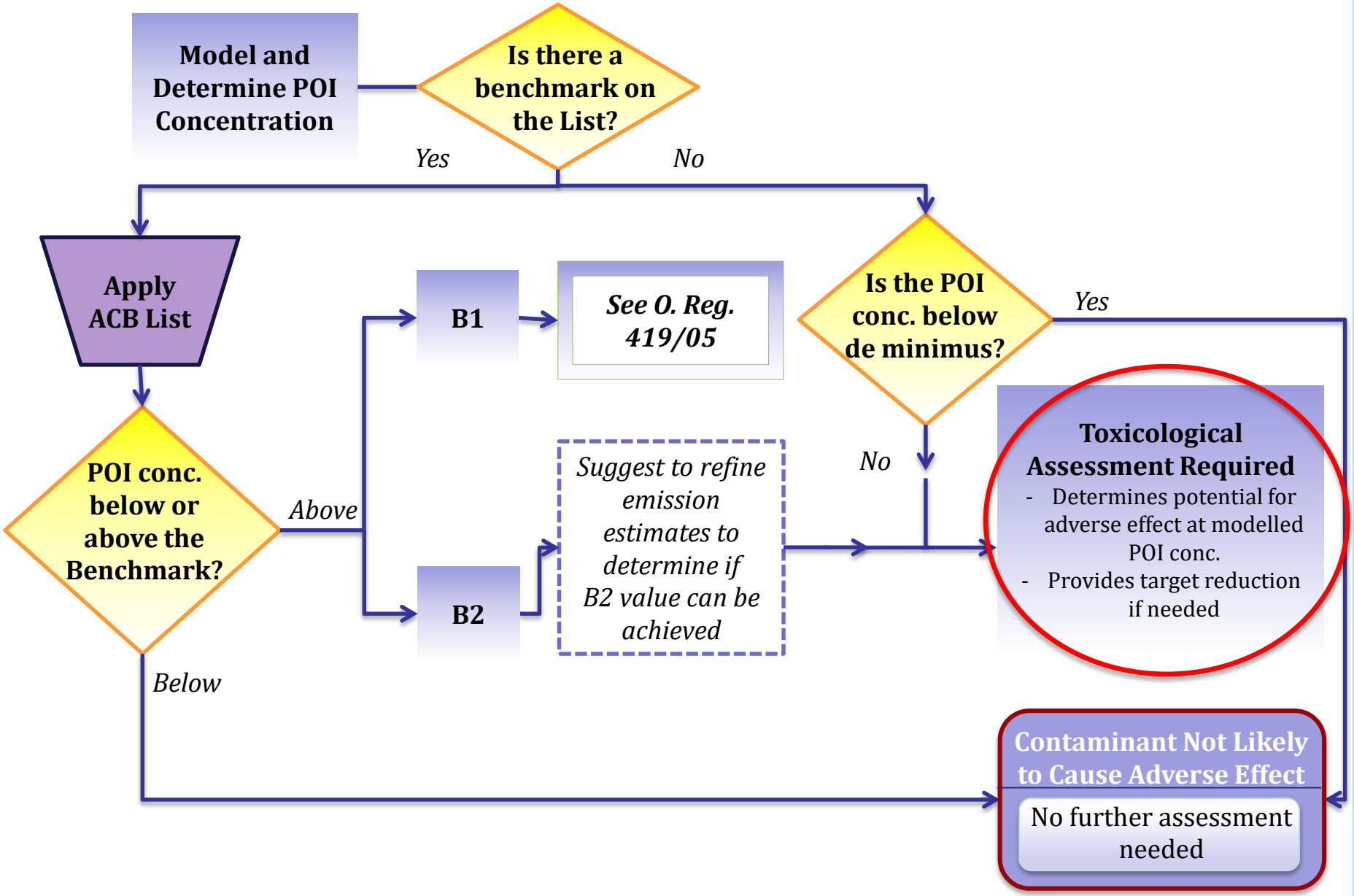
Xylenes

- Xylenes (CAS RN: 1330-20-7) Decision Document includes all isomers:
  - m-xylene (CAS RN: 108-38-3)
  - o-xylene (CAS RN: 95-47-6)
  - p-xylene (CAS RN: 106-42-3**)**
- Note that individual and combined (site-wide) emissions for all xylenes must meet the standard



Ontario

Step 2: Compare ACB List to modeled POI concentration



Tox. Assessments - Background

- A toxicological assessment is required if a B2 value is exceeded or if no benchmark value is available
- These assessments are carried out by a consultant for the company in the case of O. Reg 1/17 and generally by the ministry in the case of an O. Reg 419/05
- Assessments are intended to be carried-out by scientists with appropriate knowledge and experience to interpret complex toxicological information

Who can Carry-Out a Toxicological Assessment?

- In the context of discharges to air, a person may be asked to determine,
  - i. Whether the concentration of a contaminant with no limit may cause an adverse effect at a point of impingement?
  - ii. Whether the concentration of a contaminant that is above a Benchmark 2 limit may cause an adverse effect at a point of impingement?
- In order to make such a determination the person must have an education background and practical experience sufficient to provide the person with to an in-depth understanding of toxicology and risk assessment. This should include:
  - i. A recognized degree in toxicology or related field (e.g. biology, biochemistry);
  - ii. Professional experience in the practice of toxicology; and
  - iii. Experience in assessing the probability, or likelihood, that particular chemicals, processes or situations present a risk to human health and/or the environment.
- At the current time there is no formal professional designation that meets these requirements, however, people that are qualified to do this work are generally referred to as Toxicologists or Risk Assessors.

Recommended Toxicological Assessment

- **General areas of evaluation:**
  - General Chemical Information
  - Toxicological Information
  - Air Quality Criteria from Other Jurisdictions
- **Recommendation:**
  - Acceptable Thresholds
  - Site specific information
  - Unacceptable concentrations

General Chemical Information

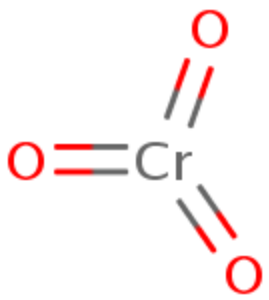
- **Chemical Abstract Service Registry Number (CAS RN)**
  - Unique numeric identifier for a chemical
  - Most effective means of searching for and identifying a contaminant
  - Format: xxx(….)-xx-x
  - CAS RN validation
    - By hand
    - Web-based validation tools (e.g. TOXNET)

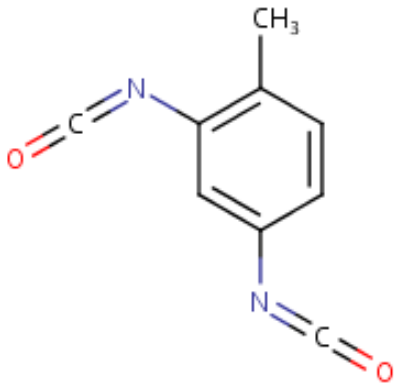
General Chemical Information (cont'd)

- **Chemical Abstract Service Registry Number (CAS RN)**
  - What if it's proprietary?
    - Contact the supplier / manufacturer
      - Frequently successful in obtaining the CAS RN
    - Assess based on systematic name, structure
      - Rare
      - Takes longer to complete
      - Results in a more conservative assessment

General Chemical Information (cont'd)

- **Chemical Structure**
  - Useful for:
    - Application of benchmarks (e.g. metal compound)
    - Hazard identification (certain functional groups, common constituents or chemical class)



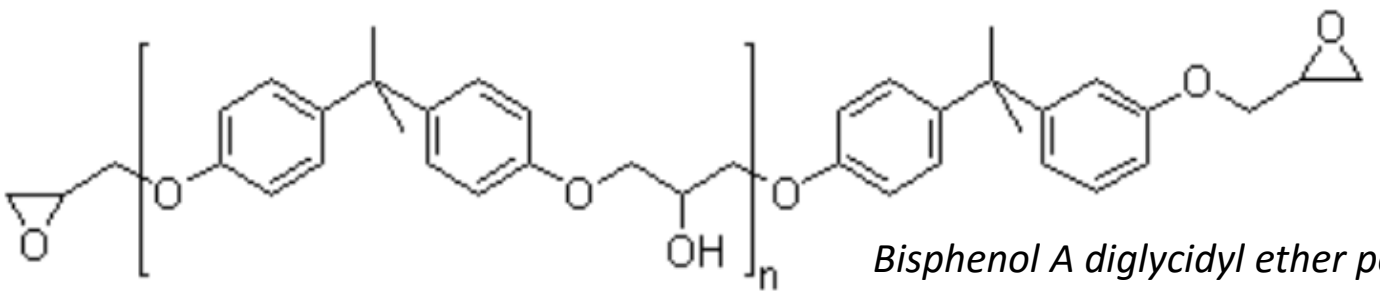


General Chemical Information (cont'd)

- **Physical-Chemical Properties**
  - Physical state
    - Solid? Liquid? Gas?
  - Particle size
    - Suspended Particulate Matter (< 44 µm)
    - Inhalable particulates are hazardous
  - Metals
    - Use molecular formula to determine % weight, POI concentration of metal component

General Chemical Information (cont'd)

- Polymers
  - Polymeric molecular weight
  - % residual monomers / oligomers
  - physical form
  - presence of reactive functional groups
  - Swellability



Bisphenol A diglycidyl ether polymer
CAS RN: 25036-25-3

Ontario

Toxicological Information

- **Hazard Identification**
  - Recommended toxicity data networks / databases
    - e.g. TOXNET, eChemPortal, Pharos
  - Web search
  - MSDS sheets (in data-poor situations)
  - Summarize:
    - Acute toxicity, irritation/sensitization, chronic toxicity, developmental/reprotoxicity, genetic toxicity, carcinogenicity

3A. TOXICOLOGICAL INFORMATION FOR REQUESTED SUBSTANCE *(If no information available for a particular subsection, specify **N/A** in box)*

Acute/Subacute:

The oral LD_{50} values for MOS were 2260 mg/kg bw for male Fischer 344 rats and 2650 mg/kg bw for female Fischer 344 rats. The substance caused reversible narcotic type effects on the nervous system, significant oxidative destruction of red blood cells, and splenic changes indicative of erythrolysis (at all dose levels [295, 980, 1960, and 2950 mg/kg bw]); generalized hepatocyte cytoplasmic vacuolation and lymphoid depletion/necrosis was observed in some animals that died. No information regarding acute inhalation and acute dermal toxicity is available	Reference: OECD SIDS

Irritation/Sensitization:

MOS was slightly irritating to rabbit skin (erythema and edema were observed) and was slightly irritating to moderately irritating to rabbit eyes producing corneal opacity, circumcorneal injection of the iris, conjunctival redness, chemosis, and discharge, which completely subsided by day 7. No information is available on the respiratory tract irritation. No experimental data are available for skin sensitization in animals.	Reference: OECD SIDS

Repeated Dose/Chronic:

The repeated dose toxicity of the MOS has been investigated in one study. In a combined repeated-dose/reproductive/developmental toxicity screening test (OECD TG 422) 10 Wistar rats/sex/dose were administered MOS via gavage at 0, 10, 50 and 250 mg/kg bw/day for at least 28 days. No mortality, treatment-related clinical signs or effects on food consumption, body weights and body weight gain were seen. In the Functional Observational Battery, a decreased number of rearings and decreased mean grip strength of hindpaws was observed in males at 250 mg/kg bw/day. Decreased mean body temperature was observed in both sexes at 250 mg/kg bw/day and in males at 50 mg/kg bw/day. Hematology measurements were not possible for animals at 250 mg/kg bw/day; at 50 mg/kg bw/day, changes in hematology were noted. Changes in clinical chemistry were observed in animals dosed at 250 mg/kg bw/day. Discolored kidneys (250 mg/kg bw) and enlarged spleen (50 and 250 mg/kg bw/day) were observed at necropsy. Heart (250 mg/kg bw/day), liver (50 (males only) and 250 mg/kg bw/day) and spleen (50 and 250 mg/kg bw) weights were increased. At 50 and/or 250 mg/kg bw/day, microscopic changes in the liver, spleen, kidneys and bone marrow were observed. Based on hematology, blood chemistry and histopathological findings, the **NOAEL for repeated dose oral toxicity was 10 mg/kg bw/day**. A similar toxicity profile was observed for MEKO.	Reference: OECD SIDS

Reproductive/Developmental:

In a combined repeated-dose/reproductive/developmental toxicity screening test in rats, MOS was administered via gavage to 10 animals/sex/dose at 0, 10, 50 and 250 mg/kg bw/day. Dosing occurred in all groups for at least 28 days. Groups of ten female Wistar rats were dosed for 14 days prior to pairing, through the pairing and gestation periods until the F1 generation reached day 4 post partum. No death was observed in either sex. No adverse effects on reproductive parameters were observed up to the highest dose tested. No test substance-related effects were observed in any of the developmental parameters evaluated. Based on no adverse effects on reproductive parameters **NOAEL for reproductive/developmental toxicity was 250 mg/kg bw/day (the highest dose tested).**	Reference: OECD SIDS
MEKO (CAS RN 96-29-7)- Hydrolysis product **Endpoints** | **Lowest effect levels[1]/Results** Subchronic toxicity | **Lowest inhalation LOAEC** = 36 mg/m^3, based on degeneration of the olfactory epithelium in the nasal cavity (incidence and severity increased with increasing exposure concentration) in male CD-1 mice exposed by inhalation (whole body) to 0, 3, 10, 30 or 100 ppm (0, 11, 36, 107 or 356 mg/m^3), 6 h/day, 5 days/week, for 13 weeks (10 males per concentration per time point) (Newton et al. 2002).	Reference: Health Canada. Screening Assessment for CAS RN 96-29-7
Repeated inhalation and oral dose toxicity studies have shown MEKO to have effects on the red blood cells (effects on blood parameters indicative of	Reference:

Toxicological Information (cont'd)

- **Hazard Identification (cont.)**
  - Structural Surrogates (if needed)
    - Used when toxicological information is limited or absent
    - Compare against chemicals with established toxicological profiles
    - Include an appropriate level of conservatism

Toxicological Information (cont'd)

- **Hazard Identification (cont.)**
  - **Mixtures**
    - e.g. welding fumes
    - Ideally, toxicological data exists for mixture
    - Alternatively, suggest use of most toxic constituent, or most common constituent, as a surrogate

Air Quality Criteria from Other Jurisdictions

- Sources:
  - Environmental Jurisdictions
    - trusted jurisdictions with transparent protocols for setting limits based on human health effects
  - Occupational Exposure Limits (OELs) are not used!
- Limits:
  - Limits appropriate for chronic exposure
    - Other averaging times can be converted
  - Used to support toxicological assessment and should not serve as the sole basis for the recommendation

Averaging Time Conversion Factors

Table A: Averaging Time Conversion Factors

Convert from \ Convert to	10 min	½ hour	1 hour	8 hour	24 hour	Annual
10 min	1	1/1.36*		-	-	-
½ hour	1.36*	1	1/1.2	0.5	1/3	1/15
1 hour	1.65	1.2	1	0.6	0.4	1/12.5
8 hour		1/0.5	1/0.6	1		
24 hour		3	2.5		1	0.2
Annual		15	12.5		5	1

Approximations of Section 17 of O. Reg. 419/05

Recommendation

- Is the POI Concentration Acceptable?
- Ministry Targets
  - Cancer: 1 in 1 million risk level
  - Non-Cancer: protective target air concentration intended for continuous chronic exposure, below which no adverse effects are expected
- Other considerations
  - Mobile sources
  - Land use
  - Site-wide emissions

Recommendation

When the assessment indicates the POI concentration is too high:

- A lower, acceptable POI concentration must be recommended
- Considerations:
  - Physical-chemical properties
  - Toxicological data:
    - Derived directly from the data using best practices
    - Apply conservative assumptions accounting for all sensitive individuals
  - Range of jurisdictional values and rationale (if available)

Contact Info

Human Toxicology and Air Standards Section

Standards Development Branch

Tania Onica

Tania.Onica@ontario.ca

416-327-7712

Brianne Attard

Brianne.Attard@ontario.ca

416-314-3184

Ontario