

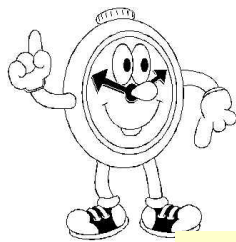


# Adjustments for Unusual Hours

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# Adjustments for Unusual Hours





## Adjustments for Unusual Hours

- Most common type of adjustment of exposure limits
- Most documented in literature and legislation
- Good introduction to the approach of adjusting for unusual conditions



## Usual Work Schedules


TLVs<sup>®</sup> assume:

8 hour days


5 days per week


A total of 40 hours






## Usual Work Schedules








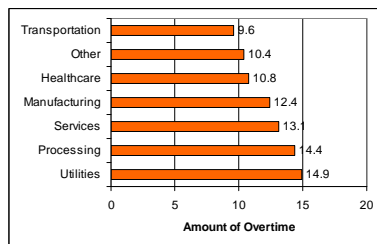
## Unusual Work Schedules

- Overtime
  - Extra hours
  - Extra days
- Compressed work week
  - Four 10-hour days
  - Three 12-hour days
- Flex time





## Percent Overtime for Different Industries (Kerin, 2004)



## The Formula

This formula calculates an adjustment factor for unusual work hours but is rather difficult to use

$$F_p = \frac{(1 - e^{-kT_s}) \left[ 1 - \exp(-kt_n) + \exp\left(-k \sum_{i=n-1}^n t_i\right) - \dots + \dots - \exp\left[\left(-k \sum_{i=1}^n t_i\right)\right] \right]}{(1 - e^{-kt_n}) \left[ 1 - \exp(-kt_s) + \exp\left(-k \sum_{j=s-1}^s t_j\right) - \dots + \dots - \exp\left(-k \sum_{j=1}^s t_j\right) \right]_s}$$

6 ..



## “Simpler Version”

...This simplified version is only slightly less daunting

The general Equation for regular repetitive schedules simplifies to

$$F_p = \frac{[1 - e^{-kt_{1n}}] [1 - e^{-k(t_{1n} + t_{2n})n}] [1 - e^{-kT_n}] [1 - e^{-k(t_{1s} + t_{2s})}]}{[1 - e^{-kt_{1s}}] [1 - e^{-k(t_{1s} + t_{2s})m}] [1 - e^{-kT_n}] [1 - e^{-k(t_{1n} + t_{2n})}]}$$


in which, using hours as the time unit,

- $t_{1n}$  = length of normal daily work shift (8 hours),
- $t_{2n}$  = length of normal daily nonexposure periods (16 hours),
- $t_{1n} + t_{2n}$  = length of normal day (24 hours),
- $T_n$  = length of normal week (168 hours),
- $n$  = number of workdays per normal week (5),
- $t_{1s}$  = length of special “daily” work shift, hours,
- $t_{2s}$  = length of special nonexposure periods between shifts, hours,
- $t_{1s} + t_{2s}$  = length of basic work cycle, analogous to the “day,” hours,
- $T_s$  = length of periodic work cycle, analogous to the “day,” hours,
- $m$  = number of work “days” per work “week” in the special schedule.

## Three Models



- Brief and Scala
- OSHA
- Pharmacokinetic






## Brief and Scala

- Corrects for both increased exposure time and decreased recovery time
- Simple to use
- Very conservative



## Brief and Scala

- First such model
- Corrects for both increased exposure time and decreased recovery time
- Simple to use
- Very conservative



## Brief and Scala

- Doesn't consider health effect
- Doesn't consider half life of product
- Doesn't consider mechanism



## Daily Adjustment Formula

Adjusted TLV<sup>®</sup> =

$$= \text{TLV} \times \frac{(8)}{h} \times \frac{(24 - h)}{16}$$

Where h = # of hours worked per day



## Weekly Adjustment Formula

Adjusted TLV<sup>®</sup> =

$$= \text{TLV} \times \left( \frac{40}{h} \right) \times \left( \frac{168 - h}{128} \right)$$

Where h = # of hours worked per week



## Brief and Scala

- Calculate reduction from both daily and weekly formula
- Apply the formula that recommends the greater reduction



## Brief and Scala Example

- Solvent has a TLV<sup>®</sup> of 100 ppm
- Worker works four 10-hour days.
- What adjustment (if any) would you recommend?



## Daily Adjustment Formula

Adjusted TLV<sup>®</sup> =

$$= \text{TLV}^{\text{®}} \times \frac{(8)}{10} \times \frac{(24 - 10)}{16}$$

$$= 70 \text{ ppm}$$



## Weekly Adjustment Formula

$$\begin{aligned}\text{Adjusted TLV}^{\circledR} &= \\ &= \text{TLV} \times \left( \frac{40}{40} \right) \times \left( \frac{168 - 40}{128} \right) \\ &= 100 \text{ ppm (no adjustment)}\end{aligned}$$



## Brief and Scala Example

- Daily formula gives 70 ppm
- Weekly formula gives 100 ppm
- Take lower of the two
- Adjusted TLV<sup>®</sup> = 70 ppm
- Gives same protection as 100 ppm for five 8-hour days



## Brief and Scala

- Easy to use
- Only need to know hours worked
- Very conservative
- Gives more restrictive recommendations than other models



## OSHA Model

- Named after US Occupational Safety and Health Administration
- “middle of the road” approach



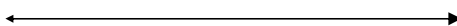
## OSHA Model

- Distributes “standard” exposure over an extended time period
- Considers health basis and short-term vs. long-term effects
- Still simple to use



## Best Job in the World

Drink 8 bottles of beer over 8 hours

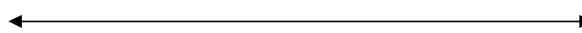


60 minutes per bottle



## Second Best Job in the World

Drink 8 bottles of beer over 10 hours



75 minutes per bottle



## Standards are Based on Different Health Effects

Organ toxicity 49%


Irritation 40%

Narcosis 5%



Odor, visibility, taste 3%

Note: Not all deal with body  
burdens, e.g., sugar






Health Code	Health Effect
1	Cancer
2	Chronic toxicity – suspected carcinogen or mutagen
3	Chronic toxicity – long term organ toxicity other than nervous
4	Acute toxicity -short term high hazard effects
5	Reproductive hazards –fertility impairment or teratogenesis
6	CNS disturbances -cholinesterase inhibition
7	CNS disturbances -nervous system effects other than narcosis
8	CNS disturbances -narcosis
9	Respiratory effects -respiratory sensitization, asthma
10	Respiratory effects -cumulative lung damage
11	Respiratory effects -acute lung damage / edema
12	Haematologic disturbances - anemias
13	Haematologic disturbances – methaemoglobinaemia
14	Marked irritation – eye, nose, throat, skin
15	Moderate irritation – eye, nose, throat, skin
16	Mild irritation – eye, nose, throat, skin
17	Asphyxiants
18	Explosive, flammable, safety, no adverse effects encountered when good housekeeping practices are followed.
19	Low risk health effects -nuisance particulates, vapors gases
20	Low risk health effects -odors antabuse
21	Dermal effects -dermal sensitization acne

## OSHA Model Categories

Category	Classification	Criteria
1A	Ceiling	None
1B	Irritants	None
1C	Technical limitations	None
2	Acute effects	Hours/day
3	Chronic effects	Hours/week
4	Acute & chronic	Hours/day & hours/week



## OSHA Model

- Considers Health Effect
- Different approach for acute and chronic agents
- Introduces the “no adjustment”



## Category 1

- No adjustments to normal TLV<sup>®</sup> required
- Standards are not related to body burden



## Category 2

Adjusted TLV<sup>®</sup> =

TLV x (8 / # of hours per day)

e.g., 10-hour days

$$\begin{aligned} \text{TLV}_{\text{adj}} &= \text{TLV} \times (8 / 10) \\ &= 0.8 \times \text{TLV} \end{aligned}$$



## Category 3


Adjusted TLV<sup>®</sup> =

TLV x (40 / # of hours per week)

e.g., 44-hour weeks



$$\begin{aligned} \text{TLV}_{\text{adj}} &= \text{TLV} \times (40 / 44) \\ &= 0.91 \times \text{TLV} \end{aligned}$$






## Category 4


- Calculate both daily and weekly formulae and use formula that gives most restrictive adjustment



## How Do I Know Which Model to Use?

- *Documentation*
- Desktop Guide







Chemical Name	Health Codes	Description of Health Effects	UWHA Code	Primary Data TLV® is Based on
Acetaldehyde	15, 5, 2	irritation, <i>reproductive effects</i> , <i>suspected carcinogen</i>	1A	combination


UWHA code = unusual work hour adjustment code

Tells you which OSHA category a chemical falls into based on the health effect of that chemical.

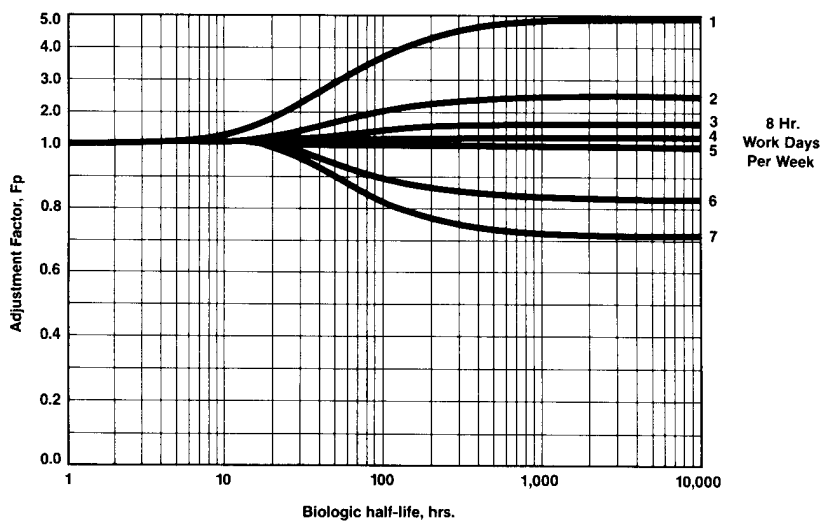



## Pharmacokinetic Model

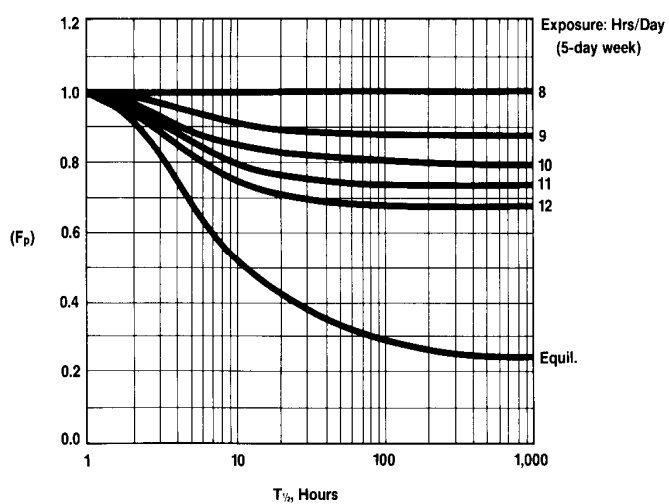
- Calculates adjustment to give same peak body burden
- Considers half life of product
- Hickey and Reist made graphs
- Graphs make it easy
- Graphs appeared in AIHA Journal and in Patty's
- Technically the most "accurate" of the 3 models

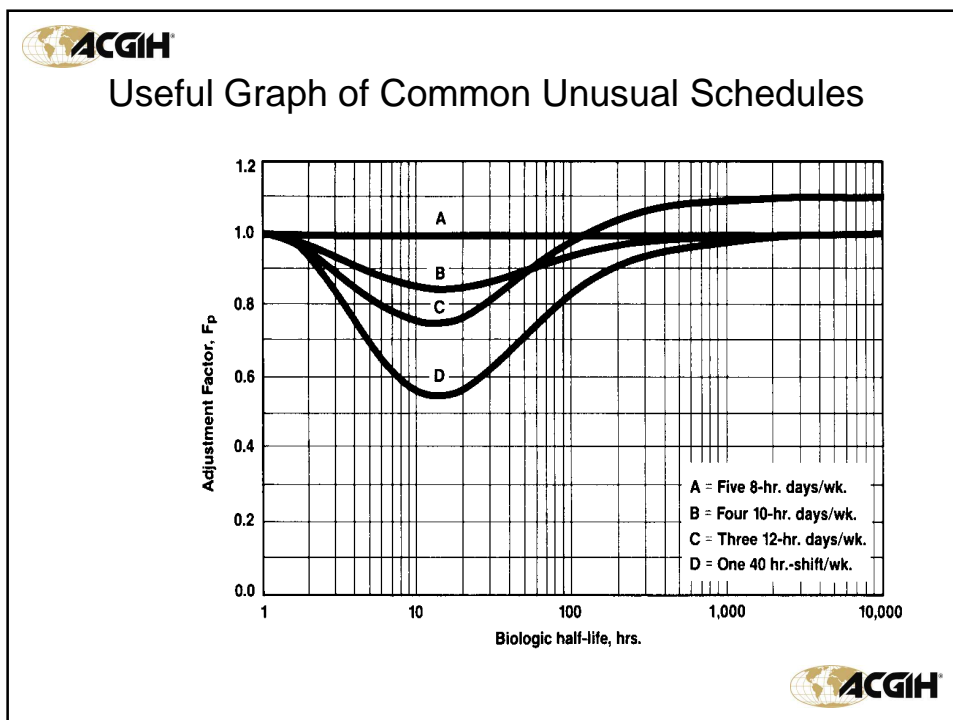
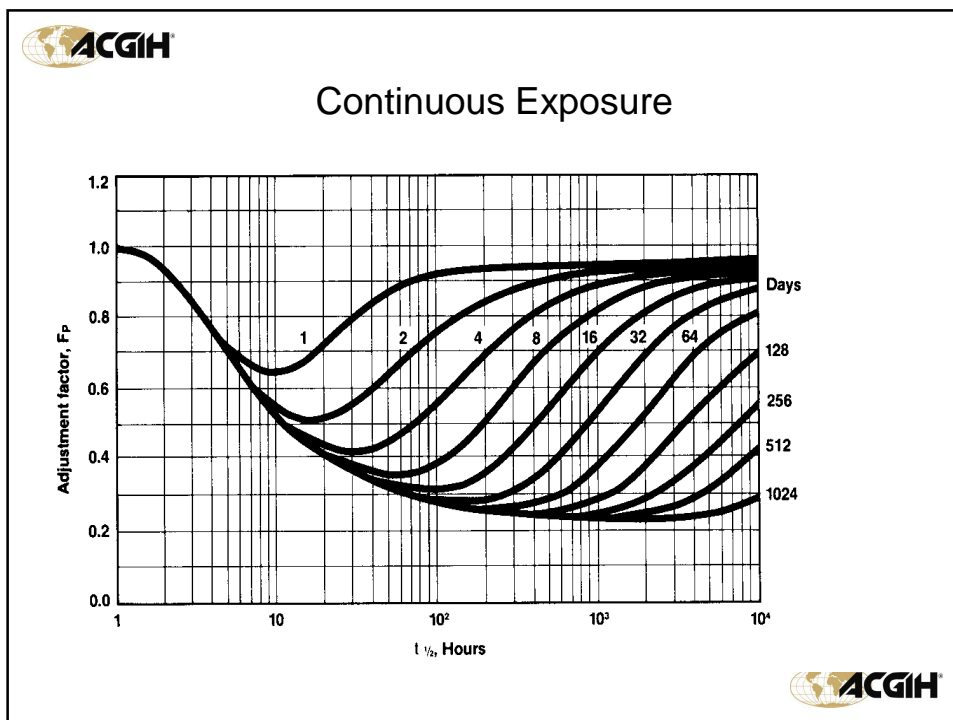


### Adjusting for Number of 8-hour Days Worked in a Week



### Number of Hours/Day worked for 5 days





## Calculate Your Own Unusual Work Hours

Spreadsheet from McMaster University

Enter "Extended Shift" information in the green cells	
length of new (special) shift, hours	11
length of new (special) rest period, hours	13
length of special "day" hours	24
number of "days" in special "work week"	6
number of days in full cycle	7
Enter the biologic half life (T1/2), hours	24.00

**RESULT- for specific half-life**

**Fp = 0.75 at T1/2 24.00**

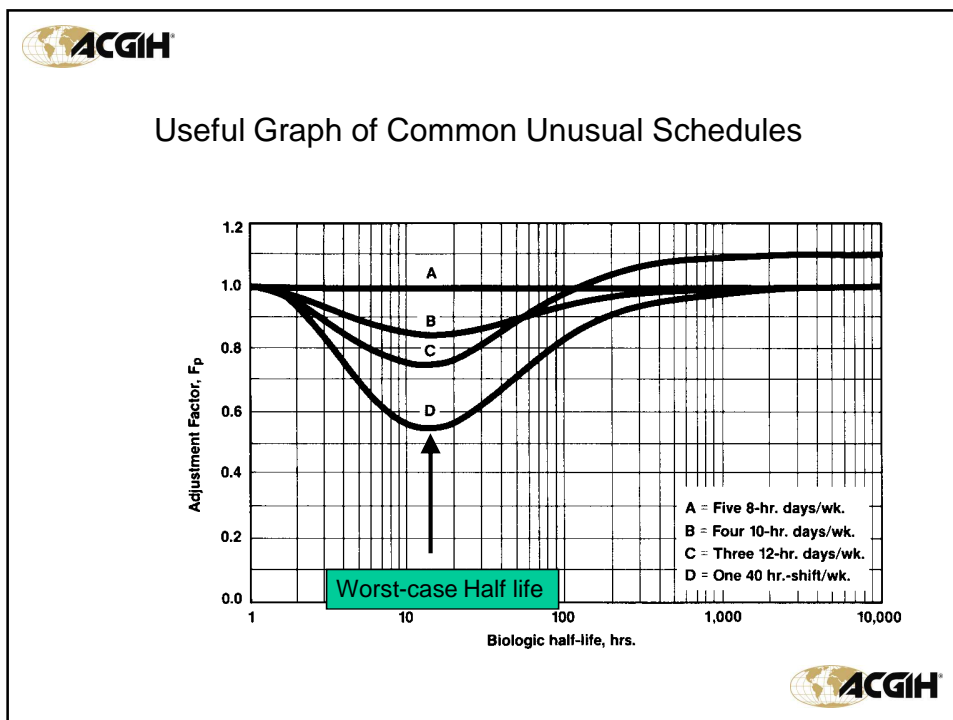
<http://www.mcmaster.ca/oehl> and look under "downloads"



## What if You Don't Know the Half Life?

- Look in the general literature
- Use a model that doesn't use the half life
- Assume a worst-case half life





### IRSST Web-Based System

Adjusted TWA calculation interface for Styrene (monomer).

**Inputs:**

- Substance: Styrene (monomer)
- Daily schedule: 12
- Week schedule: 48
- Adjustment code: 4
- Adjustment factor: 0.667

**Outputs:**

- TWA:** 50 ppm, 213 mg/m<sup>3</sup>, 1.0 f/cc
- AMEV:** 33.3 ppm, 142 mg/m<sup>3</sup>

*Important... Both values must be entered.*



Category II\*    Category III

h/day	F <sub>A</sub>	h/wk	F <sub>A</sub>
8,0	1,00	40	1,00
8,5	0,94	41	0,98
9,0	0,89	42	0,95
9,5	0,84	43	0,93
10,0	0,80	44	0,91
10,5	0,76	45	0,89
11,0	0,73	46	0,87
11,5	0,70	47	0,85
12,0	0,67	48	0,83
12,5	0,64	49	0,82
13,0	0,62	50	0,80
13,5	0,59	51	0,78
14,0	0,57	52	0,77
14,5	0,55	53	0,75
15,0	0,53	54	0,74
15,5	0,52	55	0,73
16,0	0,50	56	0,71

IRSST System has some handy tables either as references or as learning aid

The Tables to the left show the adjustment for Category 2 and Category 3 depending on the number of hours per day and week respectively



		h/day																
		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
h/wk, base on the repetitive cycle	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	

Category 4


Find the intersect of hours per day and hours per week

		h/day																
		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
h/wk. base on the repetitive cycle	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	

11 hours per day and 44 hours per week = 0.73 adjustment

## Which Model to Use

- Brief & Scala is simple but too conservative
- Pharmacokinetic model is good if graph/data available
- OSHA model is perhaps “best” as it still simple and somewhat conservative



## Physical Agents

OSHA Model works well for many types of physical agents.

- Noise
- UV
- Vibration



## Unique Approaches

- Radiofrequency standard based on a rolling 6 minutes
- Lasers based on millisecond intraocular exposure



## You Can Do This

- Not overly complicated
- Use readily available information
- Consistent with existing IH methods



## Starting to See Extended Hour Adjustments in Legislation

### 5.50 Extended work periods

(1) If the work period is more than 8 hours in a 24-hour day, the 8-hour TWA limit must be reduced by multiplying the TWA limit by the following factors:

Factor	Length of work period (in hours)
0.7	more than 8, but not more than 10
0.5	more than 10, but not more than 12
0.25	more than 12, but not more than 16
0.1	more than 16

[Amended by B.C. Reg. 315/2003, effective October 29, 2003.]





Questions??

