SO_2 is for discussion at HEAC on 9/4/2018. CalOSHA has not prepared a draft health summary for SO_2 at this time.

SO_2: Summary of controlled human exposure studies with asthmatic adults. Table organized by increasing SO2 concentration and reports the percentage of subjects experiencing the increase in sRAW or decrease in FEV_1 at that concentration/time. Note that ventilation varies between studies.
https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=338596

Causal determination for different health effects from exposure to SO2 from EPA's Integrated Assessment of SO2 for the National Ambient Air Quality Standards Program. The table provides findings from 2008 Integrated Assessment and the updated assessment (December, 2017). The latest assessment provides of review of the epidemiologic and animal data for the different health effects.
https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=338596

OEHHA Prop 65 Maximum Allowable Dose Level for SO2 (March, 2012) https://oehha.ca.gov/proposition-65/crnr/revision-proposed-specific-regulatory-level-and-augmentation-record-proposed
Maximum Allowable Dose Levels (MADLs) are for chemicals causing reproductive toxicity that are below the safe harbor levels are exempt from the requirements of Proposition 65. The text cites the study in mice that was used to establish the NOAEL and a safe dose in a mouse. This dose is then scaled to humans based on body weight.

Percentage of asthmatic adults in controlled human exposure studies experiencing SO_2-induced decrements in lung function and respiratory symptoms. EPA, 2015.

					Cumulative Percentage of Responders (Number of Subjects)[1]			
					sRaw			
					≥100% ↑	≥200% ↑	≥300% ↑	
					FEV_1			
SO_2 Conc (ppm)	Exposure Duration (min)	No. Subj	Ventil-ation (L/min)	Lung Func	≥15% ↓	≥20% ↓	≥30% ↓	Study
0.2	5	23	~48	sRaw	9% (2)[2]	0	0	Linn et al. (1983b)
	10	40	~40	sRaw	5% (2)	0	0	Linn et al. (1987)[3]
	10	40	~40	FEV_1	13% (5)	5% (2)	3% (1)	Linn et al. (1987)
0.25	5	19	~50–60	sRaw	32% (6)	16% (3)	0	Bethel et al. (1985)
	5	9	~80–90	sRaw	22% (2)	0	0	Bethel et al. (1985)
	10	28	~40	sRaw	4% (1)	0	0	Roger et al. (1985)
0.3	10	20	~50	sRaw	10% (2)	5% (1)	5% (1)	Linn et al. (1988)[4]
	10	21	~50	sRaw	33% (7)	10% (2)	0	Linn et al. (1990)[4]
	10	20	~50	FEV_1	15% (3)	0	0	Linn et al. (1988)
	10	21	~50	FEV_1	24% (5)	14% (3)	10% (2)	Linn et al. (1990)
0.4	5	23	~48	sRaw	13% (3)	4% (1)	0	Linn et al. (1983b)
	10	40	~40	sRaw	25% (10)	8% (3)	3% (1)	Linn et al. (1987)
	10	40	~40	FEV_1	30% (12)	25% (10)	13% (5)	Linn et al. (1987)
0.5	5	10	~50–60	sRaw	60% (6)	40% (4)	20% (2)	Bethel et al. (1983)
	10	28	~40	sRaw	18% (5)	4% (1)	4% (1)	Roger et al. (1985)
	10	45	~30	sRaw	36% (16)	16% (7)	13% (6)	Magnussen et al. (1990)[6]
0.6	5	23	~48	sRaw	39% (9)	26% (6)	17% (4)	Linn et al. (1983b)
	10	40	~40	sRaw	35% (14)	28% (11)	18% (7)	Linn et al. (1987)
	10	20	~50	sRaw	60% (12)	35% (7)	10% (2)	Linn et al. (1988)
	10	21	~50	sRaw	62% (13)	29% (6)	14% (3)	Linn et al. (1990)
	10	40	~40	FEV_1	53% (21)	48% (19)	23% (9)	Linn et al. (1987)
	10	20	~50	FEV_1	55% (11)	55% (11)	5% (1)	Linn et al. (1988)
	10	21	~50	FEV_1	43% (9)	38% (8)	14% (3)	Linn et al. (1990)
1.0	10	28	~40	sRaw	50% (14)	25% (7)	14% (4)	Roger et al. (1985)[5]
	10	10	~40	sRaw	60% (6)	20% (2)	0	Kehrl et al. (1987)

Conc = concentration; FEV1 = forced expiratory volume in 1 second; func = function ppm = parts per million; sRaw = specific airway resistance; SO2 = sulfur dioxide; subj = subject. Data presented from all references from which individual data were available. Percentage of individuals who experienced greater than or equal to a 100, 200, or 300% increase in specific airway resistance (sRaw), or a 15, 20, or 30% decrease in FEV1. Numbers in parenthesis represent the number of subjects experiencing the indicated effect.

Causal determinations for relationships between sulfur dioxide exposure and health effects from the 2008 and current draft Integrated Science Assessment for Sulfur Oxides.

Health Effect Category[a] and Exposure Duration	Causal Determination[b]	
	2008 ISA	Current Draft ISA
Respiratory effects– Short-term exposure Section 5.2.1, Table 5-27	Causal relationship	Causal relationship
Respiratory effects– Long-term exposure Section 5.2.2, Table 5-31	Inadequate to infer the presence or absence of a causal relationship	Suggestive but not sufficient to infer a causal relationship
Cardiovascular effects– Short-term exposure Section 5.3.1, Table 5-41	Inadequate to infer the presence or absence of a causal relationship	Suggestive but not sufficient to infer a causal relationship
Cardiovascular effects– Long-term exposure Section 5.3.2, Table 5-43	Not included	Inadequate to infer the presence or absence of a causal relationship
Reproductive and developmental effects[c] Section 5.4, Table 5-46	Inadequate to infer the presence or absence of a causal relationship	Suggestive but not sufficient to infer a causal relationship
Total mortality– Short-term exposure Section 5.5.1, Table 5-51	Suggestive but not sufficient to infer a causal relationship	Suggestive but not sufficient to infer a causal relationship
Total mortality– Long-term exposure Section 5.5.2, Table 5-55	Inadequate to infer the presence or absence of a causal relationship	Suggestive but not sufficient to infer a causal relationship
Cancer– Long-term exposure Section 5.6, Table 5-56	Inadequate to infer the presence or absence of a causal relationship	Suggestive but not sufficient to infer a causal relationship

ISA = integrated Science Assessment.

[a]An array of outcomes is evaluated as part of a broad health effect category: physiological measures (e.g., airway responsiveness), clinical outcomes (e.g., hospital admissions), and cause-specific mortality. Total mortality includes all nonaccidental causes of mortality and is informed by findings for the spectrum of morbidity effects (e.g., respiratory, cardiovascular) that can lead to mortality. The sections and tables referenced include a detailed discussion of the evidence that supports the causal determinations and the SO_2 concentrations with which health effects have been associated.

[b]Since the 2008 ISA for Sulfur Oxides, the phrasing of causal determinations has changed slightly, and the weight of evidence that describes each level in the hierarchy of the causal framework has been more explicitly characterized.

[c]Reproductive and developmental effects studies consider a wide range of exposure durations.

Maximum Allowable Dose Level for SO_2, Prop 65

“As noted in the Initial Statement of Reasons for the proposed regulation, another inhalation study by Singh (1989)[4] demonstrated reduced birth weight after prenatal exposure to sulfur dioxide. This effect was statistically significant for mice exposed to sulfur dioxide at 65 ppm for 24 hours/day. At 32 ppm, a reduction in birth weight was not statistically significant. Thus, the study by Singh (1989) provided a NOEL of 32 ppm for mice exposed for 24 hours/day and, for purposes of Proposition 65, is now the most sensitive study deemed to be of sufficient quality (Section 25803(a)(4)).

MADL CALCULATION

The following calculations were performed in accordance with Section 25803 to derive the MADL for sulfur dioxide using data and exposure parameters from Singh (1989):

Conversion of air concentration in ppm to milligrams per cubic meter (mg/m3) using a conversion factor of 2.64 mg/m3 per ppm[5]
(32 ppm ´ 2.64 [mg/m3 per ppm]) = 84.48 mg/m3

Calculation of the NOEL dose for a 30 gram mouse (0.030 kilograms [kg]) with an inhalation rate of 0.063 m3/day[6], [7]
(84.48 mg/m3 ´ 0.063 m3/day) ¸
(0.030 kg) = 177.41 mg/kg/day

Calculation of the NOEL dose for a 58 kg woman
177.41 mg/kg/ day ´ 58 kg = 10289.78 mg/day,
or 10,000 mg/day after rounding

The MADL is derived by dividing the NOEL by one thousand (Section 25801(b)(1)). Thus, the adjusted NOEL was divided by 1,000 to obtain the MADL:

MADL = 10,000 mg/day ¸ 1000 = **10,000 micrograms/day”**