

Table 12. Refinery Gases Health Effects Data Matrix

CASRN	Endpoint Ranges (ppm)										
	Acute LC ₅₀		Repeated-Dose[1]		In vitro Genotoxicity			Developmental Toxicity ¹		Reproductive Toxicity ¹	
	Minimum	Maximum[2]	Minimum	Maximum	Serial Mutagen	Non-bacterial	in vivo Genotox	Minimum	Maximum	Minimum	Maximum
8006-20-0	6,023	9,035	333	500	Negative	Negative	Negative	217	325	100	150
	Carbon monoxide[3]		Carbon monoxide		No genotoxic constituents			Carbon monoxide		Carbon monoxide	
68308-27-0	>100%[4]	>100%	4,274	6,757	Positive	Positive	Positive	115,433	692,600	15,385	24,324
	1,3-Butadiene		C1 – C4 HCs		Contains up to 2% 1,3-butadiene[5]			C5 – C6 HCs		C1 – C4 HCs	
68476-26-6	36,140	-364,100	2,000	20000	Negative	Equivocal	Negative	1,300	13,000	600	6,000
	Carbon Monoxide		Carbon monoxide		Contains up to 45% hydrogen sulfide			Carbon monoxide		Carbon monoxide	
68476-27-7	36,140	364,100	2,000	20,000	Negative	Negative	Negative	1,300	13,000	600	6,000
	Carbon Monoxide		Carbon monoxide		No genotoxic constituents			Carbon monoxide		Carbon monoxide	
68476-28-8	18,070	361,400	1,000	20,000	Negative	Negative	Negative	650	13,000	300	6,000
	Carbon monoxide		Carbon monoxide		No genotoxic constituents			Carbon monoxide		Carbon monoxide	
68476-29-9	>100%	>100%	4,237	6,250	Positive	Positive	Positive	8,475	12,500†	15,254	22,500
	1,3-Butadiene		C1 – C4 HCs		Contains up to 2% 1,3-butadiene			NOAEL†[6]		C1 – C4 HCs[7]	
68477-65-6	1,776	4,440	120	300	Negative	Equivocal	Negative	433	13,000	200	6,000
	Hydrogen sulfide		Hydrogen sulfide		Contains up to 45% hydrogen sulfide			Carbon monoxide		Carbon monoxide	
68477-66-7	9,035	361,400	500	10,000	Positive	Positive	Positive	325	13,000	150	6,000
	Carbon monoxide		Benzene		Contains up to 2% benzene			Carbon monoxide		Carbon monoxide	
68477-67-8	12,047	361,400	500	10,000	Positive	Positive	Positive	433	13,000	200	6,000
	Carbon monoxide		Benzene		Contains up to 2% benzene			Carbon monoxide		Carbon monoxide	
68477-68-9	9,035	361,400	500	20,000	Negative	Negative	Negative	325	13,000	150	6,000
	Carbon monoxide		Carbon monoxide		No genotoxic constituents			Carbon monoxide		Carbon monoxide	
68477-77-0	16,667	25,000	4,167	6,250	Negative	Negative	Negative	8,333	12,500†	15,000	22,500
	no lethality[8]		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68477-80-5	12,047	361,400	500	10,000	Positive	Positive	Positive	433	13,000	200	6,000
	Carbon monoxide		Benzene		Contains up to 2% benzene			Carbon monoxide		Carbon monoxide	
68477-81-6	17,094	28,571	4,274	7,143	Negative	Negative	Negative	69,260	692,600	15,385	25,714
	no lethality		C1 – C4 HCs		No genotoxic constituents			C5 – C6 HCs		C1 – C4 HCs	
68477-82-7	18,070	361,400	500	10,000	Positive	Positive	Positive	650	13,000	300	6,000
	Carbon monoxide		Benzene		Contains up to 2% benzene			Carbon monoxide		Carbon monoxide	
68477-92-9	2,960	88,800	200	6,000	Negative	Positive	Negative	533	16,000†	11,392	18,750
	Hydrogen sulfide		Hydrogen sulfide		Contains up to 0.5% ethanethiol			NOAEL†		C1 – C4 HCs	
68477-95-2	11,100	444,000	750	30,000	Positive	Positive	Positive	173,150	> 100%	9,018	9,677
	Hydrogen sulfide		Hydrogen sulfide		Contains up to 2% 1,3-butadiene			C5 – C6 HCs		C1 – C4 HCs	
68477-97-4	18,070	361,400	1,000	20,000	Negative	Negative	Negative	650	13,000	300	6,000
	Carbon monoxide		Carbon monoxide		No genotoxic constituents			Carbon monoxide		Carbon monoxide	

68477-98-5	9,035	361,400	500	20,000	Negative	Negative	Negative	325	13,000	150	6,000
	Carbon monoxide		Carbon monoxide		No genotoxic constituents			Carbon monoxide		Carbon monoxide	
68478-00-2	4,440	88,800	300	6,000	Negative	Equivocal	Negative	650	13,000	300	6,000
	Hydrogen sulfide		Hydrogen sulfide		Contains up to 45% hydrogen sulfide			Carbon monoxide		Carbon monoxide	
68478-01-3	12,047	361,400	667	20,000	Negative	Negative	Negative	433	13,000	200	6,000
	Carbon monoxide		Carbon monoxide		No genotoxic constituents			Carbon monoxide		Carbon monoxide	
68478-02-4	36,140	361,400	2,000	20,000	Negative	Equivocal	Negative	1,300	13,000	600	6,000
	Carbon Monoxide		Carbon monoxide		Contains up to 45% hydrogen sulfide			Carbon monoxide		Carbon monoxide	
68478-03-5	8,880	88,800	600	6,000	Negative	Equivocal	Negative	1,300	13,000	600	6,000
	Hydrogen sulfide		Hydrogen sulfide		Contains up to 45% hydrogen sulfide			Carbon monoxide		Carbon monoxide	
68478-04-6	14,800	88,800	1,000	6,000	Negative	Equivocal	Negative	2,167	13,000	1,000	6,000
	Hydrogen sulfide		Hydrogen sulfide		Contains up to 45% hydrogen sulfide			Carbon monoxide		Carbon monoxide	
68478-05-7	8,880	88,800	500	10,000	Positive	Positive	Positive	650	13,000	300	6,000
	Hydrogen sulfide		Benzene		Contains up to 2% benzene			Carbon monoxide		Carbon monoxide	
68478-25-1	16,949	25,000	4,237	6,250	Negative	Negative	Negative	8,475	12,500†	15,254	22,500
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68478-27-3	685,000	>100%	500	10,000	Positive	Positive	Positive	1,000	20,000	15,000	300,000
	Benzene		Benzene		Contains up to 2% benzene			Benzene		Benzene	
68478-28-4	685,000	>100%	500	10,000	Positive	Positive	Positive	1,000	20,000	15,000	300,000
	Benzene		Benzene		Contains up to 2% benzene			Benzene		Benzene	
68478-29-5	10,630	106,300	4,310	8,333	Negative	Negative	Negative	34,630	346,300	15,517	30,000
	no lethality		C1 – C4 HCs		No genotoxic constituents			C5 – C6 HCs		C1 – C4 HCs	
68478-30-8	7,087	33,433	4,464	10,000	Negative	Negative	Negative	23,087	115,433	16,071	36,000
	no lethality		C1 – C4 HCs		No genotoxic constituents			C5 – C6 HCs		C1 – C4 HCs	
68513-11-1	16,949	25,000	4,237	6,250	Negative	Negative	Negative	8,475	12,500†	15,254	22,500
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68513-13-3	16,949	25,000	4,237	6.25	Negative	Negative	Negative	8,475	12,500†	15,254	22,500
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68513-14-4	16,949	25,000	4,237	6,250	Negative	Negative	Negative	8,475	12,500†	15,254	22,500
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68513-16-6	88,800	444,000	2,551	2,809	Negative	Equivocal	Negative	5,102	5,618†	9,184	10,112
	Hydrogen sulfide		C1 – C4 HCs		Contains up to 45% hydrogen sulfide			NOAEL†		C1 – C4 HCs	
68513-18-8	20,408	40,000	5,102	10,000	Negative	Negative	Negative	10,204	20,000†	18,367	36,000
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68513-19-9	20,408	40,000	5,102	10,000	Negative	Negative	Negative	10,204	20,000†	18,367	36,000
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68513-68-8	>100%	>100%	1,000	20,000	Positive	Positive	Positive	2,000	40,000	9,474	11,250
	Benzene		Benzene		Contains up to 2% benzene			Benzene		C1 – C4 HCs	
68527-13-9	987	1,269	67	86	Negative	Equivocal	Negative	650	6,500	300	3,000
	Hydrogen sulfide		Hydrogen sulfide		Contains up to 45% hydrogen sulfide			Carbon monoxide		Carbon monoxide	
68527-14-0	12,500	16,667	3,125	4,167	Negative	Negative	Negative	6,250	8,333†	11,250	15,000
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68527-15-1	9,035	361,400	500	20,000	Negative	Negative	Negative	325	13,000	150	6,000

	Carbon monoxide		Carbon monoxide		No genotoxic constituents			Carbon monoxide		Carbon monoxide	
68602-82-4	18,070	361,400	1,000	10,000	Positive	Positive	Positive	650	13,000	300	6,000
	Carbon monoxide		Benzene		Contains up to 2% benzene			Carbon monoxide		Carbon monoxide	
68602-84-6	22,222	28,571	5,556	7,143	Negative	Negative	Negative	11,111	14,288†	20,000	25,714
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68607-11-4	22,727	47,619	5,682	11,905	Negative	Negative	Negative	11,364	14,288†	20,455	25,714
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68783-05-1	1,480	2,220	100	150	Negative	Equivocal	Negative	58	78†	58	78†
	Hydrogen sulfide		Hydrogen sulfide		Contains up to 45% hydrogen sulfide			NOAEL†		NOAEL†	
68783-06-2	16,949	25,000	4,237	6,250	Negative	Negative	Negative	8,475	12,500†	15,254	22,500
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68783-07-3	11,100	444,000	750	30,000	Positive	Positive	Positive	1,300	13,000	600	6,000
	hydrogen sulfide		Hydrogen sulfide		Contains up to 2% 1,3-butadiene			Carbon monoxide		Carbon monoxide	
68783-62-0	1,100	444,000	75	30,000	Positive	Positive	Positive	1,300	13,000	600	6,000
	Hydrogen sulfide		Hydrogen sulfide		Contains up to 2% 1,3-butadiene			Carbon monoxide		Carbon monoxide	
68814-47-1	1,269	2,220	86	150	Positive	Positive	Positive	34,630	346,300	18,367	36,000
	Hydrogen sulfide		Hydrogen sulfide		Contains up to 2% 1,3-butadiene			C5 – C6 HCs		C1 – C4 HCs	
68814-67-5	16,949	25,000	4,237	6,250	Negative	Negative	Negative	8,475	12,500†	15,254	22,500
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68814-90-4	16,949	25,000	4,237	6,250	Negative	Negative	Negative	8,475	12,500†	15,254	22,500
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68911-58-0	8,880	88,800	600	6,000	Negative	Equivocal	Negative	1,300	13,000	600	6,000
	Hydrogen sulfide		Hydrogen sulfide		Contains up to 45% hydrogen sulfide			Carbon monoxide		Carbon monoxide	
68911-59-1	36,140	361,400	2,000	20,000	Negative	Negative	Negative	1,300	13,000	600	6,000
	Carbon monoxide		Carbon monoxide		No genotoxic constituents			Carbon monoxide		Carbon monoxide	
68919-01-7	987	1,776	67	120	Negative	Equivocal	Negative	178	320†	16,364	22,500
	Hydrogen sulfide		Hydrogen sulfide		Contains up to 45% hydrogen sulfide			NOAEL†		C1 – C4 HCs	
68919-02-8	2,960	44,400	200	3,000	Positive	Positive	Positive	34,630	346,300	20,455	36,000
	Hydrogen sulfide		Hydrogen sulfide		Contains up to 2% 1,3-butadiene			C5 – C6 HCs		C1 – C4 HCs	
68919-03-9	18,519	25,000	4,630	6,250	Negative	Negative	Negative	9,259	12,500†	16,667	22,500
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68919-04-0	2,960	44,400	200	3,000	Negative	Equivocal	Negative	34,630	346,300	20,455	36,000
	Hydrogen sulfide		Hydrogen sulfide		Contains up to 45% hydrogen sulfide			C5 – C6 HCs		C1 – C4 HCs	
68919-07-3	16,949	25,000	4,237	6,250	Negative	Negative	Negative	8,475	12,500†	15,254	22,500
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68919-08-4	222,000	888,000	4,630	10,000	Negative	Equivocal	Negative	23,087	69,260	16,667	36,000
	Hydrogen sulfide		C1 – C4 HCs		Contains up to 45% hydrogen sulfide			C5 – C6 HCs		C1 – C4 HCs	
68919-12-0	18,519	25,000	4,630	6.25	Negative	Negative	Negative	9,259	12,500†	16,667	22,500
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68952-79-4	16,949	25,000	4,237	6,250	Negative	Negative	Negative	8,475	12,500†	15,254	22,500
	no lethality		C1 – C4 HCs		No genotoxic constituents			NOAEL†		C1 – C4 HCs	
68952-80-7	>100%	>100%	4,310	8,333	Positive	Positive	Positive	34,630	364,300	15,517	30,000
	1,3-Butadiene		C1 – C4 HCs		Contains up to 2% 1,3-butadiene			C5 – C6 HCs		C1 – C4 HCs	

68955-33-9	>100%	>100%	4,237	6,250	Positive	Positive	Positive	8,475	12,500†	15,254	22,500
	1,3-Butadiene		C1 – C4 HCs		Contains up to 2% 1,3-butadiene			NOAEL†		C1 – C4 HCs	
68989-88-8	4,440	88,800	300	6,000	Positive	Positive	Positive	650	13,000	300	6,000
	Hydrogen sulfide		Hydrogen sulfide		Contains up to 2% benzene			Carbon monoxide		Carbon monoxide	

[1] [Repeated-dose, developmental, and reproductive toxicity numerical ranges represent LOAEL values unless otherwise noted with the symbol †](#)

[2] [Minimum and Maximum Toxicity Values represent the concentration ranges of the constituent with the highest degree of toxicity per SIDS endpoint in the specific refinery gas; see Appendix 5 \(separate EXCEL file\) for calculations](#)

[3] [Refinery gas constituent characterizing the toxicity for the respective mammalian endpoint for this CASRN; endpoint ranges are based on dilution calculations; note that the constituent characterizing toxicity may vary by endpoint for the same CASRN; see Appendix 5 \(separate EXCEL file\)](#)

[4] [Calculated dilution concentration was greater than 1,000,000 ppm; it would require more than 100% of the gas to cause the respective endpoint effect; note, asphyxiation would occur first at concentrations that reduce oxygen concentrations to approximately < 18% \(<180,000 ppm\)](#)

[5] [When benzene, 1,3-butadiene, or ethanethiol are the positive genotoxic constituents, it is unlikely that refinery gas streams containing at most 0.5 – 2 % of these components would express genotoxicity if the gases were tested directly; mutagenic concentrations of these gases would be above the lower explosive limit.](#)

[6] [‘†’ symbol indicates that the numerical ranges represent NOAEL values; endpoint ranges for these refinery gases are based on the highest concentration tested for the constituent with the lowest NOAEL; no developmental and/or reproductive toxicity was observed for any constituents of these gases \(see Section 7.6 for further explanation\)](#)

[7] [When C1 – C4 HCs was the constituent characterizing reproductive toxicity, it was assumed that 100% of the C1 – C4 HC fraction was isobutane. This is a worst case approach as other alkane gases did not produce reproductive effects when tested in studies of similar design.](#)

[8] [Acute toxicity numerical ranges represent measured LC50 values from experiments where mortality was observed unless the most toxic constituent is listed as “no lethality”; “no lethality” indicates that no mortality was observed at the highest concentration of any of the individual refinery gas constituents tested; consequently this is not a true LC50 value range, but rather the range for the highest concentrations tested in a standard LC50 assay; the refinery gas constituent/constituent fraction with the lowest ‘no lethality’ value was selected to characterize the acute toxicity for these CASRN \(see Section 7.6 for further explanation\)](#)