Schedule IX – Chimney Design Guide and Combustion of Fuels

PART A - CHIMNEY HEIGHT REQUIREMENTS

IXA-1 CHIMNEY HEIGHT REQUIREMENTS – FOR DISCHARGE FROM THE EXTERNAL COMBUSTION OF NATURAL OR LIQUEFIED PETROLEUM GAS [1]

METHODOLOGY

1.1 In terrain where the land does not rise to more than half, and buildings do not rise to more than 0.4 times, the indicative height of the chimney within a ground distance of five times the indicative height, and where there are no other significant sources or air-borne contaminants, the height of any chimney discharging the products of combustion from fuel burning equipment will be determined generally in accordance with the following guidelines:

(a) For any discharge from the combustion of natural gas or liquefied gas where the release of nitrogen oxides is less than 0.5 kg/h or the rate of heat release is less than 2 MW: The minimum chimney height should be the higher of either 8 m above finished ground level or 3 m above the highest substantial part of any building located within 40 m of the chimney, or any part of the building to which the chimney may be attached.

(b) For any discharge from the combustion of natural gas or liquefied gas where the release of nitrogen oxides is equal to or exceeds 0.5 kg/h but is less than 20 kg/h and the rate of heat release is less than 50 MW: The height of the chimney should be calculated in accordance with Table i (with the minimum height being whichever is the greater height of those corresponding to the heat input (MW) and the nitrogen oxides discharge (kg/h)), or be 3.3 m above the highest substantial part of any building located within 40 m of the chimney, or any part of the building to which the chimney may be attached, whichever is the higher.

Table i. Natural gas or liquefied gas used as a fuel

Heat input (MW)	Nitrogen oxides (kg/h)	Chimney height above ground (m)
2	0.5	8.3
2.5	0.6	8.5
3.0	0.8	8.7
4.0	1.1	9.1
5.0	1.7	9.4
6.0	1.7	9.7
7.0	2.0	10.0
8.0	2.4	10.3
9.0	2.7	10.6
10.0	3.0	10.8
11.0	3.4	11.0
12.0	3.7	11.3
13.0	4.1	11.5
14.0	4.5	11.7
15.0	4.8	11.9
16.0	5.2	12.1
17.0	5.6	12.3
18.0	5.9	12.5

[1] These criteria only apply to permitted and controlled activities. This includes large scale fuel burning appliances with combined heat outputs of less than 50MW for natural gas and liquefied petroleum gas. Discretionary activities require a site specific evaluation which takes into account the impact of the chimney height on ground level concentrations of contaminants as a part of the resource consent application.

Heat input (MW)	Nitrogen oxides (kg/h)	Chimney height above ground (m)
19.0	6.3	12.7
20.0	6.7	12.8
25.0	8.6	13.7
30.0	10.6	14.5
35.0	12.7	15.2
40.0	16.9	16.4
45.0	16.9	16.4
50.0	19	17.0

1.2 In the following circumstances, the height of the chimney should generally be determined so that the discharge will not give rise to sulphur dioxide and nitrogen oxides levels in excess of an indicator level based on 40% of the 'New Zealand Ambient Air Quality Guidelines' (Ministry for the Environment, 2002), using the 99.9% modelled percentile:

(a) In terrain where the land rises to more than half, or buildings rise to more than 0.4 times, the indicative height of the chimney, within a ground distance of five times the indicative height.

IXA-2 CHIMNEY HEIGHT REQUIREMENTS – FOR DISCHARGE FROM THE EXTERNAL COMBUSTION OF KEROSENE, DIESEL, COAL, HEAVY FUEL OIL, LIGHT FUEL OIL, UNTREATED WOOD OR PELLET FUEL[2].

1.3 In relation to any large scale fuel burning appliance burning diesel, kerosene, coal, heavy fuel oil, light fuel oil, untreated wood, or pellet fuel, discharges into air from external combustion after the notification date of Plan Change 2[3], must be via an emission stack where:

(a) the discharge point is at least 12.5 metres above ground level, or

(b) the discharge point is 2.5 metres higher than the apex of any building, tree, slope or other structure within a horizontal radius of 2.5 times the stack height (whichever discharge point a) or b) is the higher), and

(c) the exhaust gases are directed vertically into air and are not impeded by any obstruction that would lower the velocity of the exhaust gases.

Explanatory Note

1.4 To ensure that the plume released from the stack is not affected by building downwash effects, therefore creating high ground level concentrations, the stack must be at least 2.5 metres higher than the tallest building or obstacle within the vicinity of the stack (meaning within a circle drawn around the stack with a radius 2.5 times the height of the stack). For example, in a building that has a stack 10 metres high relative to ground level, there would be a 25 metre radius drawn around the stack for potential downwash effects. The discharge point would have to be 2.5 metres higher than any obstacle within this circle in order to achieve good dispersion of emissions from the stack.

[2] These criteria only apply to permitted and controlled activities. This includes large scale fuel burning appliances with combined heat outputs of less than 100 kW for coal, heavy fuel oil, light fuel oil and untreated wood, less than 5MW for diesel, less than 2 MW for kerosene, and less than 600 kW for wood pellet fuel being burned in modified pellet boilers, and less than 1.2 MW for wood pellet fuel being burned in custom designed boilers. Discretionary activities require a site specific evaluation which takes into account the impact of the chimney height on ground level concentrations of contaminants as a part of the resource consent application.

[3] 10 December 2008

IXA-3 EXPLANATION

1.5 The combustion of any fuel will generate airborne contaminants. The most accepted method of managing discharges of these contaminants is by remaining within desired maximum ground level concentrations. The 'New Zealand Ambient Air Quality' Guidelines (Ministry for the Environment, 2002) set out the desired maximum ground level concentrations for pollutants, and the Resource Management (National Environmental Standards for Air Quality) Regulations 2004 set out ambient air quality standards that maximum ground level concentrations must remain within. To give effect to these standards and guidelines, it is necessary to have a chimney of sufficient height to disperse contaminants effectively by diluting the combustion gases to a level where the adverse effects are no more than minor.

1.6 In flat terrain and in the absence of high buildings, simple formulae (e.g. Table i) can be used to calculate the height of the chimney required for various fuels. If these guidelines cannot be met the Council will have the ability to apply more general guidelines when determining adequate heights for chimneys, or if considered necessary require modelling to be carried out.

Part B – Emissions from Combustion

IXB-1 INTRODUCTION

1.7 The rules in this Plan regulate the discharge of contaminants into air from combustion processes. For ease of implementation, the rules regulate heat release rates rather than emission rates of contaminants. However, it is important to consider what contaminants are emitted from combustion processes. This Schedule provides guidance on the nature of emissions that can be expected from the combustion processes regulated by the rules in this Plan.

1.8 Emission rates can vary enormously, depending on fuel specification/composition, fuel quality, process of combustion, load, equipment age and technical sophistication maintenance and operating practice, use of control systems and filters, and ambient conditions (temperature and humidity of feed air). It is very difficult to assign a particular emission to a particular activity, and the only way to determine this properly is by measurement. Table iii in this Schedule shows a Worst case, a Typical case, and a Best case.

IXB-2 FUEL USE

1.9 A first step in estimating emissions is to estimate the fuel used in the various processes (shown in Table iii). Assuming continuous operation of a process for one year, the fuel used can be calculated as follows:

$$\text{Annual fuel consumption (kg/y)} = \frac{\text{Process size (J/s)}}{\text{Fuel calorific value (J/kg)}} \times 3.1536 \times 10^7 \text{ s/y}$$

where:

- Fuel calorific value is the energy released per unit fuel:

Natural Gas	36 MJ/m^3
LPG	46 MJ/kg
Oil	41 MJ/kg
Coal	25 MJ/kg
Wood	10 MJ/kg

- 3.1536 x 10^7 s/y is the factor needed to scale the process to one year.

Table ii. Typical fuel use for combustion processes

Process	Size	Fuel use per Year	Rate per MW
Natural gas	5 MW 50 MW	4,400,000 m^3 44,000,000 m^3	880,000 m^3
LPG	5 MW 50 MW	3,400 tonnes 34,000 tonnes	680 tonnes
Oil	40 kW 10 MW	31 tonnes 7,700 tonnes	770 tonnes
Coal	40 kW 10 MW	50 tonnes 12,600 tonnes	1,300 tonnes
Wood	40 kW 10 MW	130 tonnes 31,500 tonnes	3,200 tonnes

IXB-2 KEY CONTAMINANTS

1.10 The key contaminants from combustion processes are as follows:

PM_{10} The fraction of particulate matter in the air of size less than 10 micrometres.
24 hour standard: 50 $\mu g/m^3$.
Annual guideline : 20 $\mu g/m^3$.

CO Carbon monoxide.
8 hour standard: 10 mg/m^3.
1 hour guideline: 30 mg/m^3.

NO_x Oxides of nitrogen, mainly NO, NO_2 and small amounts of NO_3.
Standards and Guidelines for NO_2 only:
24 hour standard: 100 $\mu g/m^3$.
1 hour guideline: 200 $\mu g/m^3$.

SO_x Oxides of sulphur, mostly SO_2.
Standards and Guidelines for SO_2 only:
24 hour guideline: 120 $\mu g/m^3$.
1 hour standard: 350 $\mu g/m^3$.
1 hour standard 570 $\mu g/m^3$ (no exceedences)

O_3 Ozone
1 hour standard: 150 $\mu g/m^3$.
8 hour guideline: 100 $\mu g/m^3$.

VOC Volatile organic compounds, usually light hydrocarbons, sometimes with small amounts of hazardous contaminants. Guideline levels for these are currently under review.

IXB-3 CALCULATION DETAILS & EMISSION RATES

1.11 Taking the fuel consumption data (from Table ii) and standard emissions factors from the literature (USEPA (AP-42), WHO, IPCC or the Air Pollution Engineering Manual – see "Bibliography") for each of the key contaminants, the annual emissions can then be calculated according to:

Annual emissions = Annual fuel consumption x Standard emission factor

1.12 The resultant emissions are reported in Table iii for three cases - worst, typical and best - based on the following assumptions:

- Sulphur content of coal = 1.0% by weight (range 0.4 to 2.0).
- Ash content of coal = 4.0% by weight (range 3.0 to 5.0).
- Density of LPG = 0.5 kg/l.
- Density of fuel oil = 0.845 kg/l.

1.13 The ranges given are subjective estimates. At the extremes, it may be possible to find either very poorly operated equipment, or conversely highly efficient equipment that may lie outside these limits.

Table iii. Typical Emission Rates for Combustion Processes

PROCESS	SIZE	EMISSION RATE BY CONTAMINANT				
		PM_{10} (kg/y)	CO (kg/y)	NO_x (kg/y)	SO_x (kg/y)	VOC (kg/y)
Gas/LPG	5MW worst	870	4,300	10,000	42	790
	5MW typical	370	2,400	5,700	33	440
	5MW best	210	1,400	2,500	24	180
	50MW worst	6,700	81,000	390,000	420	29,000
	50MW typical	2,100	28,000	200,000	330	4,000
	50MW best	700	25,000	37,000	240	1,300
Oil	40kW worst	22	22	260	120	12
	40kW typical	9	20	86	120	6
	40kW best	2	19	22	9	1
	10MW worst	5,400	5,500	65,000	31,000	3,100
	10MW typical	2,200	4,900	21,000	31,000	1,400
	10MW best	540	4,700	5,400	2,300	310
Coal	40kW worst	350	280	930	2,000	53
	40kW typical	250	120	410	880	3
	40kW best	25	15	170	400	3
	10MW worst	88,000	110,000	270,000	490,000	13,000
	10MW typical	63,000	32,000	110,000	220,000	760
	10MW best	6,300	3,200	81,000	81,000	630
Wood	40kW worst	440	1,400	180	13	110
	40kW typical	160	250	42	5	19
	40kW best	10	38	42	1	11
	10MW worst	110,000	760,000	57,000	3,200	27,000
	10MW typical	41,000	410,000	36,000	1,200	4,700
	10MW best	2,500	63,000	950	160	2,800

IXB-4 BIBLIOGRAPHY

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