Schedule IX. Combustion of Fuels

PART A - DETERMINING CHIMNEY HEIGHT

IXA-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 coal or oil where the release of sulphur dioxide or nitrogen oxides is individually less than 2 kg/h:** 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, liquefied gas or untreated wood, 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.

(c) **For any discharge from the combustion of coal or oil where the release of sulphur dioxide is equal to or exceeds 2 kg/h but is less than 50 kg/h and the rate of heat release is less than 10 MW:** The height of the chimney should be calculated in accordance with Table i, or be 3.5 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. Coal and Oil Used as Fuel

SO_2 (kg/h)	Chimney height above ground (m)
2.0	8.5
2.5	9.5
3.0	10.4
4.0	12.0
5.0	13.4
6.0	14.7
7.0	15.9
8.0	17.0
9.0	18.0
10.0	19.0
11.0	19.4
12.0	19.7
13.0	20.0
14.0	20.3
15.0	20.6
16.0	20.9
17.0	21.1
18.0	21.4
19.0	21.6
20.0	21.8
25.0	22.8
30.0	23.7
35.0	24.4
40.0	25.1
45.0	25.7
50.0	26.2

(d) **For any discharge from the combustion of natural gas, liquefied gas or untreated wood, 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 ii (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 ii. Natural gas, liquefied gas or wood 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
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, 1994), using the 99.9% modelled percentile:

(a) For any discharge from a chimney where the rate of heat release from the combustion of coal or oil exceeds 10 MW or the release of sulphur dioxide exceeds 50 kg/h.

(b) For any discharge from a chimney where the rate of heat release from the combustion of natural gas, liquefied gas, or wood exceeds 50 MW.

(c) 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, and

(d) Where there are other sources of sulphur dioxide or nitrogen oxides within close proximity such that cumulative effects may occur.

IXA-2 EXPLANATION

1.3 The combustion of any fuel will generate airborne contaminants. In fuel burning equipment, sulphur dioxide and the oxides of nitrogen are of most concern in terms of the potential for adverse environmental effects. The most accepted method of managing discharges of these contaminants is by aiming to remain within desired maximum ground level concentrations. The "New Zealand Ambient Air Quality Guidelines" (Ministry for the Environment, 1994) set out the desired maximum ground level concentrations for these pollutants. To give effect to these 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.

1.4 In flat terrain and in the absence of high buildings, simple formulae can be used to calculate the height of the chimney required for various fuels; these guidelines are set out in Tables i and ii. If these guidelines cannot be met, or if the sources are large, the Council will have the ability to apply more general guidelines when determining adequate heights for chimneys. If considered necessary, modelling should be carried out.

1.5 The tables have been developed from information published in the United Kingdom, the Australian States of Victoria and New South Wales, and by the United States Environmental Protection Agency. The criteria applied are generally accepted technical standards for chimney height calculations in New Zealand.

PART B – EMISSIONS FROM COMBUSTION

XIB-1 INTRODUCTION

1.6 Rules in this Plan regulate the discharge of contaminants into air from combustion processes. For ease of implementation, they 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.

1.7 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 iv in this Schedule shows a **Worst** case, a **Typical** case, and a **Best** case.

XIB-2 FUEL USE

1.8 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
- 3.1536×10^7 s/y is the factor needed to scale the process to one year.

Table iii. 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

1.9 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. Guideline levels are currently under review.

CO Carbon monoxide.
8 hour guideline: 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.
Guidelines for NO_2 only: 24 hour guideline: 100 $\mu g/m^3$.
1 hour guideline: 300 $\mu g/m^3$.

SO_x Oxides of sulphur, mostly SO_2.
Guidelines for SO_2 only: Annual guideline: 50 $\mu g/m^3$.
24 hour guideline: 125 $\mu g/m^3$.
1 hour guideline: 350 $\mu g/m^3$.

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

1.10 Taking the fuel consumption data (from Table iii) 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

1.11 The resultant emissions are reported in Table iv 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.

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

Table iv. 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

Buonicore, AJ; Davis, WT (*eds*) 1992: *Air Pollution Engineering Manual.* Air & Waste Management Association. Van Nostrand Reinhold.

Economopoulos, AP (ed) 1993: *Assessment of Sources of Air, Water and Land Pollution. A Guide to Rapid Source Inventory Techniques and their Use in Formulating Environmental Control Strategies.* World Health Organisation, Geneva.

Intergovernmental Panel on Climate Change 1995: *IPCC Guidelines for National Greenhouse Gas Inventories. Vol 3 - Greenhouse Gas Reference Manual.* United Kingdom.

United States Environmental Protection Agency 1992: *Compilation of Air Pollution Emission Factors (AP-42)*. United States Government. Code of Federal Regulations 40.