APEC-WW Australia 2010 Report: codes/specifications

John C.K. Cheung[a] and John D. Holmes[b]

[a]*JCKC Pty Ltd, 402 Clayton Road, Clayton South, VIC 3169, Australia*
[b]*JDH Consulting, P.O. Box 269, Mentone, VIC 3194, Australia*
and Chair, BD006-02-Wind actions, for Standards Australia/Standards New Zealand

ABSTRACT: The purpose of this country report is to present a brief summary to APEC-WW on codes/specifications relevant activities carried out in Australia in the last twelve months. The country report for Australia on wind-related disaster risk reduction and climate change is given separately at the IG-WRDRR joint workshop and the Asian Ministerial Conference 4AMCDRR. The new developments on the Australian wind code/standards AS/NZS1170.2 have been detailed in the previous 2009 Report and have progressed to the public review and ballot stages. The present report includes the more recent wind hazard data and provides data/specifications, in Australian perspective, for the proposed standardization of terrains/profiles, Environmental and Dispersion issues raised during the last APEC-WW meetings.

KEYWORDS: Australian, wind hazard data, environmental and dispersion specifications.

1 AS/NZS1170.2 AND AWES ACTIVITIES

All proposed changes to AS/NZS1170.2 were reported at the previous APEC-WW meetings in Shanghai and Taiwan in 2007 and 2009 respectively. The revised document went through a public review in October-December 2009, and a ballot by a higher committee of Standards Australia in June-July 2010. Currently some issues resulting from the latter are being resolved – the new Standard is now expected to be published in late 2010 or early 2011.

Another major activity held during the year was the 14th Australasian Wind Engineering Society (AWES) Workshop (AWES14), organised by Geoscience Australia, Canberra, in August 2010. The AWES14 proceedings included over 50 papers covering topics such as windborne debris [1], [2], wind loads/response [3], [4], risk analysis [5] and vulnerability [6], etc. Preceding AWES14 was an adjunct meteorological workshop, *Southern Hemisphere Extreme Winds* (SHEW); this event is described in more detail in Section 1.2.

1.1 Standardization of wind profiles

With regard to the standardization of terrains and wind speed profiles, comparisons of the power law exponents and the gradient heights were presented [7] with respect to the various terrain roughness used in different wind codes and regions, such as AS/NZS1170, BS6399, ASCE7, China, Taiwan, Hong Kong, Korea and Vietnam. The comparisons for both extra-tropical gales and tropical cyclone wind characteristics are given in Figure 1. It can be seen that the different terrain exposure described in different countries may be related to a common quantifier, the terrain roughness length z_0. The corresponding power law exponents and gradient heights for the various wind profiles for different terrain roughness are suggested for both the extra-tropical and tropical cyclone wind characteristics, as given in Table 1.

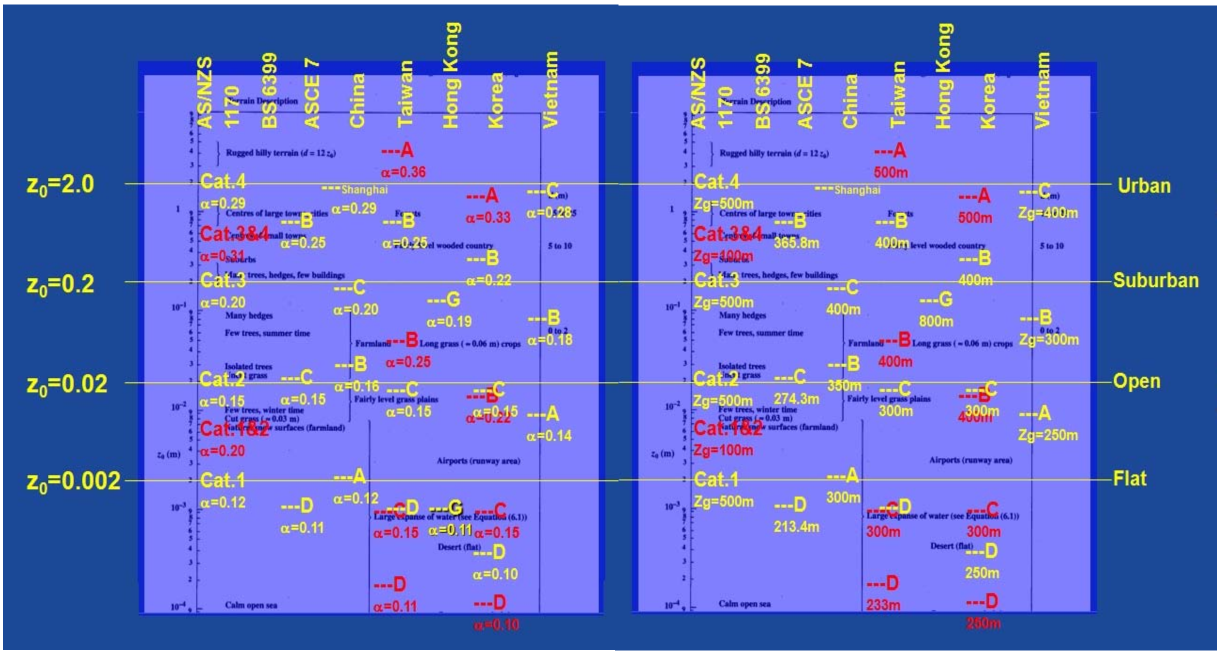

Figure 1 Comparison of mean wind speed profile power law exponents and gradient heights for different terrain roughness used in various wind codes for extra-tropical gales (values shown in red are for tropical cyclone wind characteristics).

Table 1 Proposed power law exponents and gradient heights as a function of terrain roughness for extra-tropical and tropical cyclone (typhoon) wind characteristics

Terrain	Terrain roughness length z_0 (m)	Extra-tropical gale wind characteristics	Tropical Cyclone (Typhoon, Hurricane)
Urban	2.0	Power law exponent = 0.29	Power law exponent = 0.34
		Gradient height = 500m	Gradient height = 250m
Suburban	0.2	Power law exponent = 0.20	Power law exponent = 0.25
		Gradient height = 400m	Gradient height = 200m
Open	0.02	Power law exponent = 0.15	Power law exponent = 0.20
		Gradient height = 350m	Gradient height = 150m
Flat	0.002	Power law exponent = 0.12	Power law exponent = 0.15
		Gradient height = 300m	Gradient height = 100m

1.2 Southern Hemisphere Extreme Winds Workshop

Nearly fifty people attended the first ever Southern Hemisphere Extreme Winds Workshop on August 4th 2010 at Geoscience Australia, Canberra. This was a new concept that brought together meteorologists and wind engineers from several countries in the Southern Hemisphere. To quote the Workshop flier: "Southern Hemisphere land masses (i.e. Southern Africa, South America, Australia, New Zealand) are essentially affected by the same synoptic weather systems producing strong winds – these well may differ in some respects from the Northern Hemisphere due to the much greater proportion of open ocean in the Southern Hemisphere. The prevalence of severe local wind events due to thunderstorms, and their effects on structures such as transmission line towers in Argentina, Brazil, South Africa and Australia has also been noted, and has been the subject of previous workshops associated with the transmission line industry".

Thanks to the financial support of Geoscience Australia and the Australasian Wind Engineering Society, an impressive array of invited speakers participated. These were:

Valeria Duranona – University of the Republic, Uruguay,
Jeff Kepert - CAWCR, Bureau of Meteorology, Australia,
Acir Loredo-Souza, UFRGS, Porto Alegre, Brazil,
Bruno Natalini, National University of the Northeast, Argentina,
Andries Kruger, South African Weather Service,
Richard Turner, NIWA, New Zealand.

Most unfortunately Professor Jorge Riera (UFRGS, Brazil) had his flight leg from Santiago, Chile, cancelled, and didn't make it to the Workshop. However, Michael Chay from CPP very kindly stepped in at short notice, and delivered most of Professor Riera's Powerpoint presentation on a windfield model for an intense downburst. Valeria Duranona, Bruno Natalini and Acir Loredo-Souza all gave interesting, and well-illustrated, presentations on extreme wind events in their respective countries. Acir's slides on Brazil's one-and-only tropical cyclone in 2004 sparked considerable interest, since the South Atlantic does not normally suffer from such events, in contrast to the Indian and South Pacific Oceans. Andries Kruger's paper described an extreme value analysis of extreme winds in the mixed climates of certain regions of South Africa.

Jeff Kepert's interesting presentation on modeling the dynamic response of the Dines anemometer, preceded a series of paper presenting preliminary results from the project funded by the Department of Climate Change and Energy Efficiency, Australia, on the response of that instrument, (used extensively by the Bureau of Meteorology up to the early 1990s), to extreme wind gusts. Finally a presentation by John McBride on the official 'world's highest wind gust' of 113 m/s recorded at Barrow Island, Western Australia, in 1996 provoked considerable interest.

2 WIND HAZARD DATA

Based on the Australian Bureau of Meteorology data, there were 8 tropical cyclones occurred during 2009-2010 season. The most severe one was Cyclone Laurence, which was formed near the south coast of Papua New Guinea and then moved west along the north of the Top End on 10 December 2009. The system hovered and strengthened into a Category 5 cyclone crossing the Kimberley coast on 16 December. The cyclone meandered overland, then veered south-west, and re-intensified before making landfall on the Western Australia on 21 December. The maximum wind gust was estimated to reach 295 km/hr (81.94 m/s) and rainfall in the region has exceeded 250mm, causing flooding rain as far as South Australia. The storm has brought severe damage to numerous homes and power infrastructure. Although no human fatality was caused by the storm, hundreds of livestock were feared to have been killed in the affected region. The overall wind hazard data for tropical cyclones during the last year can be summarised in Table 2 as follows:

Table 2 Wind hazard data for tropical cyclones in Australia during 2009-2010 season

Duration		Tropical Cyclone	Category	intensity (km/hr)	V10min (m/s)	mbar	fatalities	damage (2010 US$)
8-Dec-2009	23-Dec-2009	Laurence	5	205	57	925		9.0
14-Jan-2009	22-Jan-2009	Neville	1	65	18	994		
19-Jan-2009	22-Jan-2009	Magda	3	130	36	975		
20-Jan-2009	30-Jan-2009	Olga	2	100	28	983	2	126.2
14-Mar-2010	21-Mar-2010	Ului	4	195	54	925	1	72.0
23-Mar-2010	1-Apr-2010	Paul	2	100	28	982		
2-Apr-2010	7-Apr-2010	Robyn	2	110	31	980		
22-Apr-2010	25-Apr-2010	Sean	2	100	28	987		
					Total		3	207.2 million

The corresponding cyclone tracks are given in Figure 2 below:

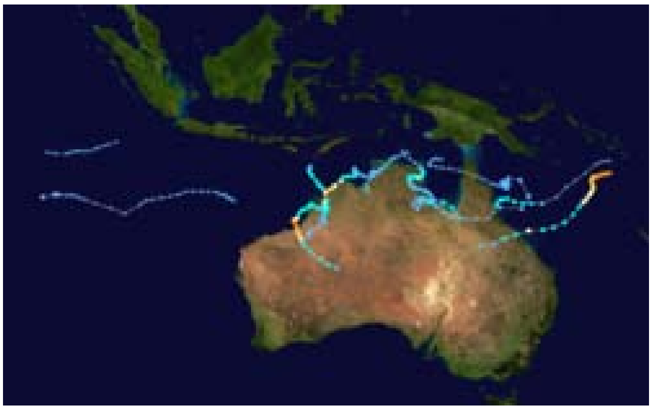

Figure 2 2009-2010 Season Summary Map

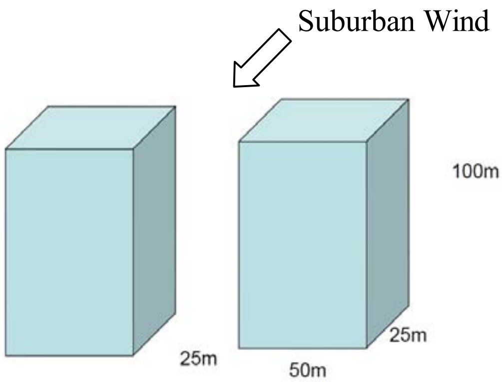

Figure 3 Building configuration for Environmental wind speed study

3 ENVIRONMENTAL WIND SPEED STUDIES

Environmental wind speed studies on a prescribed building configuration, as shown in Figure 3, were proposed in previous APEC meetings. This building configuration incorporates two identical rectangular tall buildings, 50m by 25m by 100m high, separated with a gap width of 25m with the onset flow from a suburban terrain normal to the broad face of the buildings. Wind tunnel studies on the effect of building gap between two identical rectangular buildings on pedestrian wind were conducted four decades ago [8]. Nevertheless, similarities of wind tunnel flow and the natural wind on wind profile and turbulence characteristics were not seriously considered at that time. To provide data for comparison among measurements made in different APEC countries, mean and peak local wind speeds at designated locations were recently measured in the 450kW wind tunnel at Monash University in Melbourne, Australia.

The wind tunnel tests were conducted on a 1/400 scale model in the 2m by 2m square working section with a tunnel wind speed of approximately 23m/s. The wind tunnel floor roughness elements used were 45mm by 45mm by 68mm high, spaced at 300mm between centers and staggered at 150mm centre spacing, with a total fetch length of approximately 8m long. The resulting mean wind velocity profile has a power law exponent of 0.2 and the turbulence intensity profile matches closely with that of AS1170 for the suburban approach flow up to 250mm, with a turbulence intensity of 0.19 at a full scale height of 50m. The turbulence intensity of the modeled wind profile tends to be lower than required at higher heights. However, as the wind profile was sufficiently modeled up to the building height, this is considered to be adequate for this preliminary study of ground level pedestrian wind measurements. The scale of turbulence was modeled with a full scale longitudinal length scale of 1034m, as shown in the spectra given in Figure 4. The experimental set-up is shown in Figure 5.

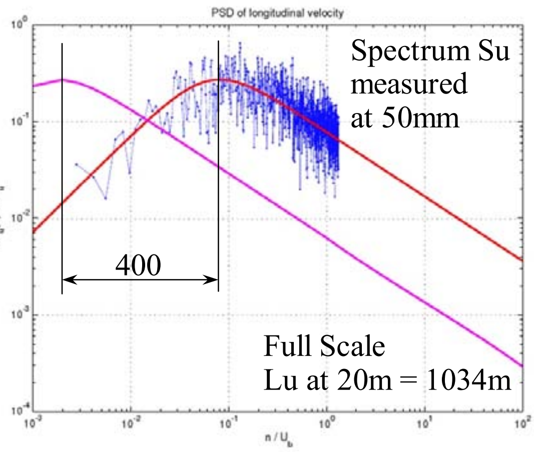

Figure 4 Spectrum of 1/400 scale wind model

Figure 5 Experimental set-up at Monash wind tunnel

Mean and peak wind velocities were measured at full scale height of 1.5m and 10m, at locations as specified in previous APEC meetings, by using a four-hole Cobra probe. The sampling time was 20.48 seconds for 12,800 samples at a rate of 625Hz. For a full scale gradient mean wind speed of approximately 50 m/s, this sampling time is equivalent to approximately one hour full scale. This is also shown from the free-stream wind velocity having a peak factor of about 3.7 at gradient height in the approach flow. Otherwise, some filtering should be included in the wind velocity measurement set-up so that the peak gusts measured are equivalent to 2-3 second period full scale gusts. To achieve a better data collection, the cobra probe was adjusted to face in the direction of the local wind flow such that the v and w components were an order of magnitude smaller than that of the u components. The total mean and maximum wind velocities are given as a ratio of the upstream mean wind speed at a reference height of 100m, as shown in Figures 6 and 7. The data given in black are velocity ratios measured at 10m above ground and the data in red are velocity ratios measured at 1.5m above ground.

Many different criteria proposed by the various investigators exist in the assessment of pedestrian comfort in street level wind environment. A detailed review [9] has shown that these criteria are mostly similar, except that they were expressed at different levels of probability of exceeding such wind speeds, such as once per week, per month or per year. Melbourne's criteria [10] has expressed these wind speed levels in terms of a probability of once per year, i.e. these criteria are expressed in terms of annual wind speeds having a return period or recurrence level of one year.

As such, his criteria simply state that in main public access-ways wind conditions are generally acceptable if the annual maximum gust wind speed does not exceed 16 m/s.

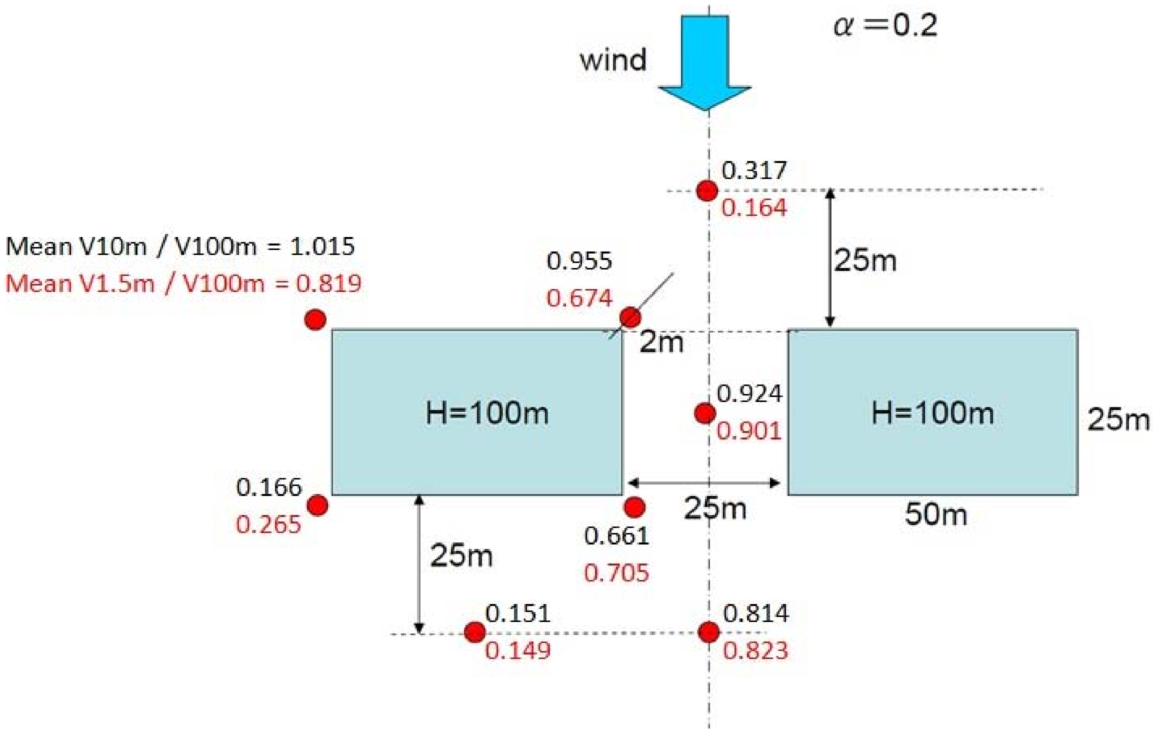

Figure 6 Local mean wind speed ratios measured at 10m and 1.5m above ground level

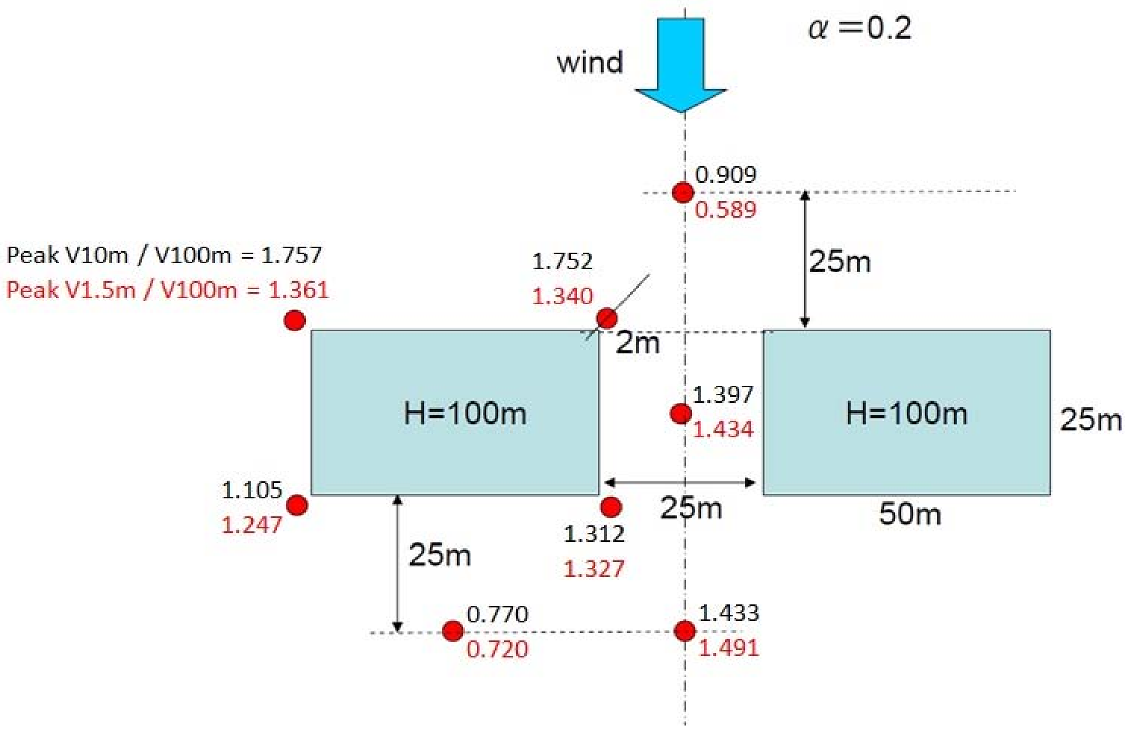

Figure 7 Local peak wind speed ratios measured at 10m and 1.5m above ground level

For example, for a city having an annual gust design wind speed of 26 m/s,
Peak $V_{10m,open\ terrain} = 26$ m/s
Turbulence intensity $Iu_{10m,\ open\ terrain} = 0.183$
Therefore, mean $V_{10m,\ open\ terrain} = 26 / (1+3.7\times0.183) = 15.5$ m/s
Then, mean $V_{100m,\ suburban\ terrain} = 15.5 \times (350/10)^{0.15} \times (100/400)^{0.2} = 20.0$ m/s

Hence, for the criteria of acceptable conditions for comfort for walking in public access-ways, the local annual maximum gust should not exceed 16 m/s or the local peak wind speed ratio should not exceed 16/20 or 0.8 of the mean wind speed at 100m in the suburban approach flow.
As shown in Figure 7, it can be seen that all regions except the areas upstream or directly behind the tall building have exhibited local peak wind speed ratios above 0.8 exceeding the criteria for walking. It can be concluded that a 100m tall rectangular building, without upstream shielding, would likely create unacceptable pedestrian level wind environment. Corrective actions, such as adding canopies, planters or other solutions [11] would be required to ameliorate the excessive wind conditions to acceptable level.

4 INDOOR AND OUTDOOR AIR QUALITY SPECIFICATIONS

To provide indoor and outdoor air quality criteria as speculated in previous APEC meetings, the following specifications are extracted, as given in Tables 3 and 4, from the information given by the Department of the Environment, Water, Heritage and the Arts, Australian Government, http://www.environment.gov.au.

Table 3 National Air Quality Standards

Indicator	Averaging period	Maximum (ambient) Concentration by vol.	Goal within 10 years (maximum allowable exceedence)
Carbon monoxide	8 hour	9.0 ppm	1 day a year
Nitrogen dioxide	1 hour	0.12 ppm	1 day a year
	1 year	0.03 ppm	none
Ozone	1 hour	0.10 ppm	1 day a year
	4 hour	0.08 ppm	1 day a year
Sulphur dioxide	1 hour	0.20 ppm	1 day a year
	24 hour	0.08 ppm	1 day a year
	1 year	0.02 ppm	none
Lead	1 year	0.5 $\mu g/m^3$	none
Particles as $*PM_{10}$	24 hour	50 $\mu g/m^3$	5 days a year
Particles as $*PM_{2.5}$	24 hour	25 $\mu g/m^3$	To be reviewed
	1 year	8 $\mu g/m^3$	

Sampling must be carried out for a period of 24 hours at least every sixth day.
$*PM_{10}$ = Coarse particulate matter 10 micrometers (μm) in diameter
$*PM_{2.5}$ = Fine particulate matter 2.5 micrometers (μm) in diameter

Table 4 Indoor Air Quality Health Guidelines

Indicator	Averaging period	Exposure Limit
Ammonia	15 minutes	24 mg per m^3 of air
	8 hour	17 mg per m^3 of air
Carbon monoxide	15 minutes	200 ppm
	30 minutes	100 ppm
	1 hour	60 ppm
	8 hour	34 mg per m^3 of air (30 ppm)
Nitrogen dioxide	15 minutes	9.4 mg per m^3 of air (5 ppm)
	8 hour	5.6 mg per m^3 of air (3 ppm)
Nitric oxide	8 hour	31 mg per m^3 of air (25 ppm)
Nitrous oxide	8 hour	45 mg per m^3 of air (25 ppm)
Lead, lead arsenate	8 hour	0.15 mg/m^3
Lead chromate	8 hour	0.05 mg/m^3
Formaldehyde	15 minutes	2.5 mg per m^3 of air (2 ppm)
	8 hour	1.2 mg per m^3 of air (1 ppm)

5 ACKOWLEDGEMENT

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6 REFERENCES

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