C.A. & M.J. LOMMERS PTY LTD

Suite 10, 1321 Hay Street • WEST PERTH • W.A. • 6005
Phone: (08) 9481 1008 • Fax: (08) 9481 5034
Email: admin@lommers.com.au
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REF.: Z:\Projects\2007\2007.0106 L104 Dust Control v2.docx
Date: 30 October 2009

TOWN OF PORT HEDLAND
P.O. Box 41
PORT HEDLAND WA 6721

Attention Mr. T. Sargeant

Dear Sir,

PROJECT: PROPOSED "WEST END" DEVELOPMENTS – PORT HEDLAND

RE: COMMENT ON PROPOSED MEASURES TO REDUCE DUST IMPACT

In accordance with your instructions we have assessed the dust ingress minimisation guidelines provided including further suggestion as applicable.

Air quality improvement initiatives such as residential density, hermetically sealed buildings, window and door orientation, and air-conditioning filtration have been suggested by the Port Hedland Dust Taskforce.

The following commentary has been prepared with the intent to provide our assessment considering the effectiveness and practicability of the suggested dust minimisation options presented.

1. CHARACTERISTICS OF AIR-BORNE DUST

Airborne dust consists of many different size particles from a variety of sources, ranging from industrial dust, such as soot and ash produced from burning of fuels, to naturally occurring particles, such as earth and silica type materials or moulds, bacteria and viruses. (1)

These particles can form the following contaminant sub-classes(2);

- Dusts, fumes and smokes, usually consisting of solid particles
- Mists, fogs and smogs, of which most are suspended liquid particles and are smaller than those in dusts fumes and smokes; and
- Bioaerosols, such as viruses, bacteria, spores and pollens.

Of interest to this report, dust particles range in size from 0.1to 25µm(3), respirable particles (those particles which may be accumulated in the body) vary in size from <1 to 10µm. This may be illustrated in Figure 1 outlining a range of particle diameters.

Due to their mode of movement, particles in this range greater than 1µm settle out from air by gravitational forces. Smaller particles are dominated by "Brownian" movement, movement resulting from a series of collisions with air molecules, and therefore are unlikely to settle out from the air.(1)

1. CHARACTERISTICS OF AIR-BORNE DUST (cont.)

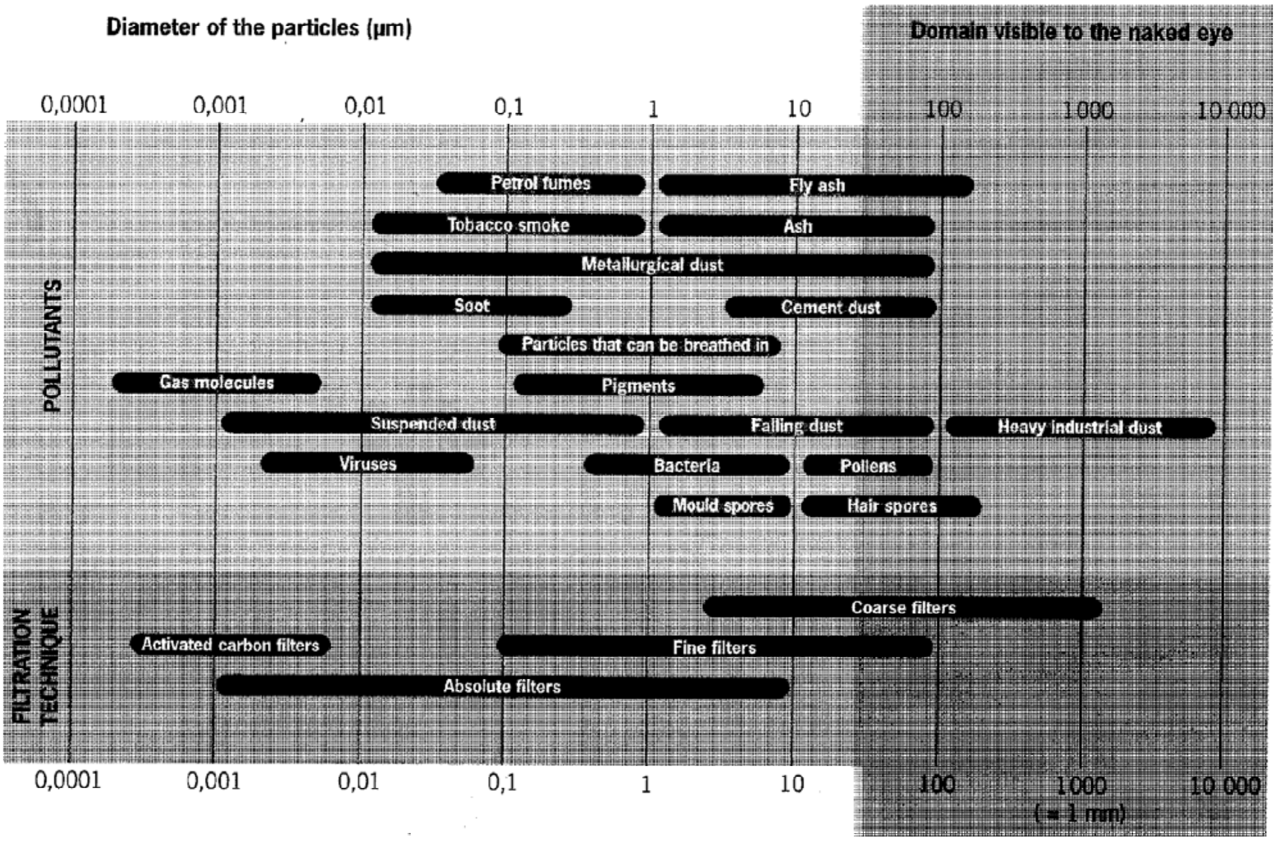


Figure 1 – Diagram of Particle Sizes (Camfil Farr – 2003)

The respiration of dust by the human body is dealt with in two main modes, deposition in the upper respiratory tract (the nose) and the lower respiratory tract (the pulmonary spaces of the lungs). The major proportion of dust is exhaled directly, the remainder is deposited in the lungs[(1)].

The following figure 2 illustrates the propensity for different sized particles to lodge in the respiratory system.

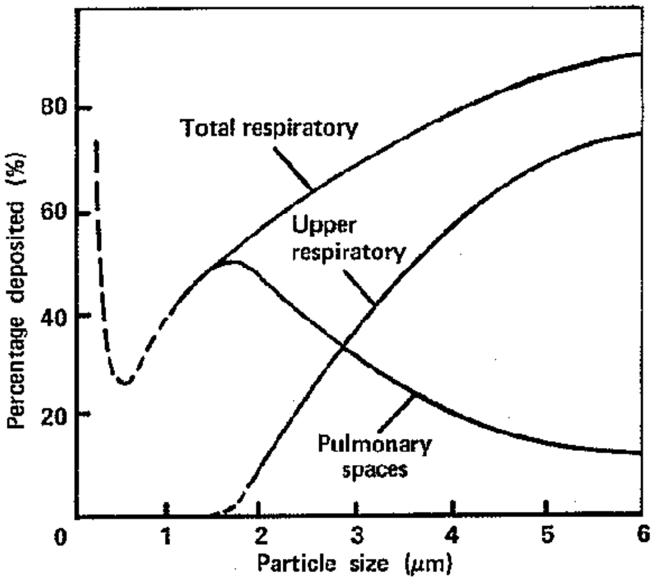


Figure 2 – Dust Deposition in the Respiratory System (AIRAH DA15)

1. CHARACTERISTICS OF AIR-BORNE DUST (cont.)

For this reason, this report has been written with the intent to consider air-borne dust particles in the range of 2 to 10µm, as these sizes represent the most likely and significant risk to persons sensitive to dust exposure.

The dominant characteristics of this type of dust may be summarised as follows;

- Will settle out from the surrounding air over time[1];
- Are considered "respirable" and are likely to be deposited in the pulmonary system[3];
- Represents industrial and naturally occurring dusts, such as coal dust, ash and silica[1].

2. HERMETICALLY SEALED / POSITIVELY PRESSURISED BUILDINGS

High levels of building sealing and/or positive pressurisation must be considered in conjunction with other dust ingress modes such as location of ventilation openings and filtration systems

The effectiveness of the building sealing may be difficult to control for the life of the building due to tenant/owner modifications and maintenance regime. Detailed inspection and maintenance must be performed on a regular basis to ensure sealing components are effective.

Due to the low occurrence of cracks or fissures expected in new or recently constructed buildings this is not considered a significant source of duct ingress.

We also note that BCA Vol 1 Clause J3.6 (also Volume 2 – cl 3.12.3.5) already requires a high level of construction to minimise air leakage from air-conditioned residential buildings.

Further investigation should be performed to quantify the prevalence of dust ingress through cracks and fissures in existing buildings. In our opinion this mode of dust ingress is a low contributor to the overall level of dust ingress.

It is also expected that costs may be excessive for little improvement in dust ingress.

3. WINDOW AND DOOR ORIENTATION

As the mode of dust ingress is similar for all openings in the building envelope, we have considered "Window Orientation" and "Door Orientation" simultaneously.

The location and protection of openings is vital to reduce the ingress of dust into the space.

Surface flow patterns of the external surfaces of buildings are characterised by the influence of the approaching wind.[5]

The following figure 3 illustrates how air flows around rectangular buildings. It can been established from the streamlines, in the illustration, that wind velocities on the leeward side of the building are lower than the windward side due to the re-circulating of wind down-wind from the building.

This reduction in wind velocity may provide air-borne dust opportunity to settle out of the air and not be drawn into the building.

3. WINDOW AND DOOR ORIENTATION (cont.)

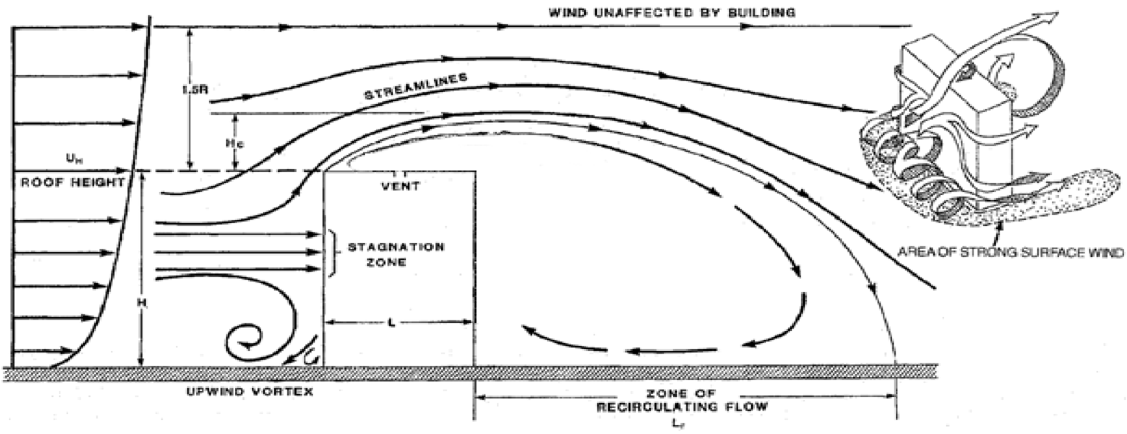
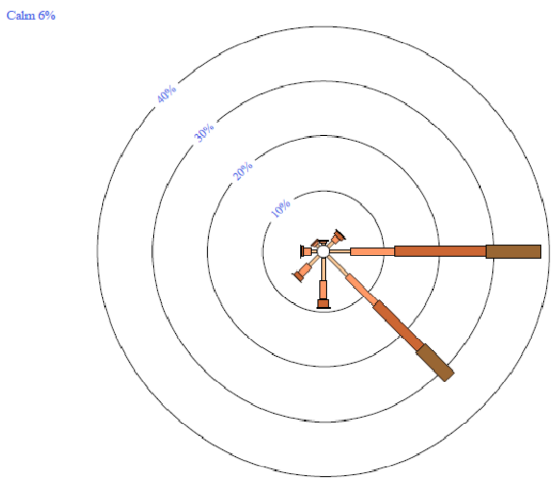


Figure 3 – Flow Patterns around a Rectangular Building (ASHRAE – Fundamentals 2001)

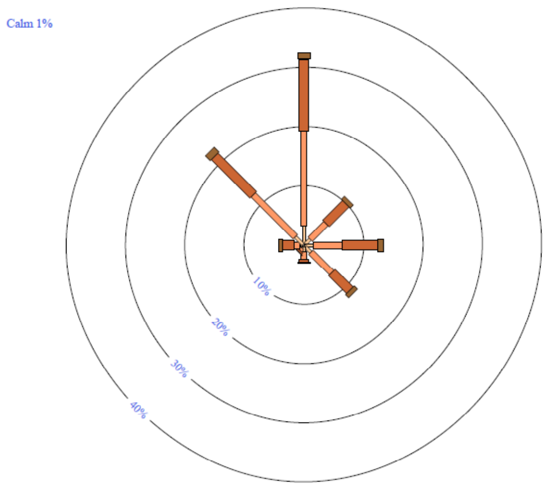
For this reason, openings should be limited to walls on the leeward side of the prevailing winds in Port Hedland.

We have assessed wind rose data for the area, provided by the Bureau of Meterology, and as such it can be concluded that operable openings on Northern or Eastern facades should be avoided to reduce direct ingress of airborne dust particles.

The prevailing winds in the Northern Dry Season (May to September) indicate the vast majority of the time the wind comes from East-South-Easterly in the morning swinging around to North-Nor-Westerly in the afternoon.(5)



Wind Rose - Dry Season – 9am



Wind Rose - Dry Season – 3pm

Figure 4a & 4b – Wind Rose Illustrations for Port Hedland (Bureau of Meteorology)

Protective screens or louvers may be implemented to reduce the direct impact of winds onto the windows and produce slow moving re-circulating air zones such as those depicted in Figure 3. In the same manner, eaves provided at roof level are expected to function in a similar way.

By reducing the localised wind velocity, it expected more dust will settle out from the air, lessening ingress into the dwelling.

3. WINDOW AND DOOR ORIENTATION (cont.)

Windows on the west facades should be protected on the left hand side of the opening, windows on the south facade should be protected on the right hand side of the opening.

These screens should be the full height of the windows and designed such that wind may be directed away from the window whilst still maintaining vision out of the window.

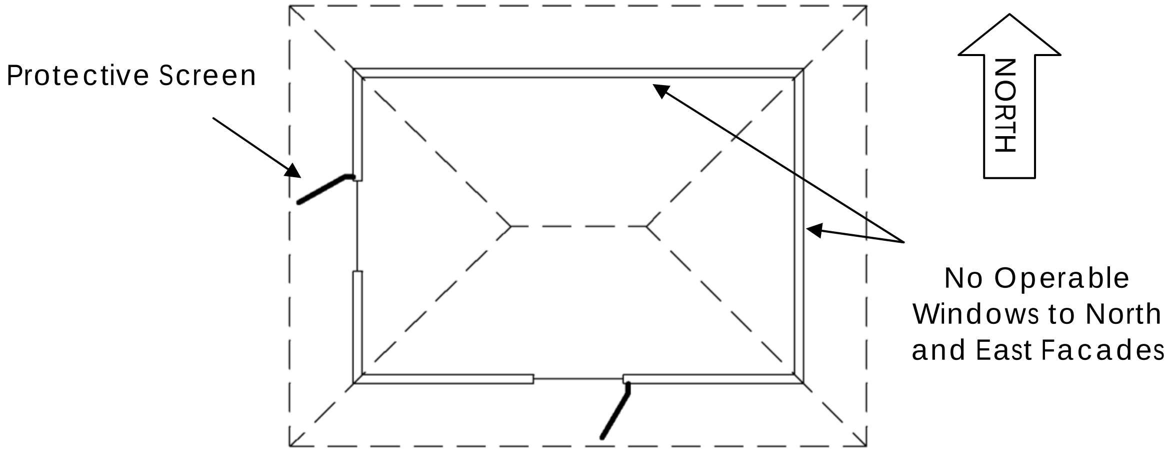


Figure 5 – Window and Deflection Screen Locations

High density developments and high roofs of buildings can be effective to create a building boundary layer that may reduce the direct air-flow into the building. (4)

By grouping dwellings together atmospheric boundary layers are formed, reducing the local wind velocity in proportion to the height and density of building.

Orienting buildings such that wind-tunnelling effects of prevailing winds amplifying wind velocity should be avoided.

Protective screens and porticos in front of the main building entrance may be of assistance to reduce the direct impact of wind onto the opening.

4. FILTERED AIR-CONDITIONING

Air-filtration systems associated with air-conditioning equipment actively remove dust from the air drawn through. There is an ongoing requirement for maintenance, cleaning and replacement of the media to ensure adequate performance.

Whilst the only “active” dust reduction strategy mentioned, it is also considered the highest on-going cost for maintenance and replacement. Filtration media must be checked and cleaned on a monthly basis and replaced annually.

Selection of suitable filtration type and media may also be subject to a trial as the rate at which the dust builds up in the media is directly proportional to the hours of use of the air-conditioning system.

4. FILTERED AIR-CONDITIONING (cont.)

The following filtration systems have been considered;

- Panel filters – made up from a random series of fibre mats, of varying thickness, fibre sizes and densities.[6] Media in these filters achieves filtration (adhesion of the dust particles to the filter fibres) of the air generally due to three modes, inertia, interception and diffusion[1], and can be illustrated in the following figure.

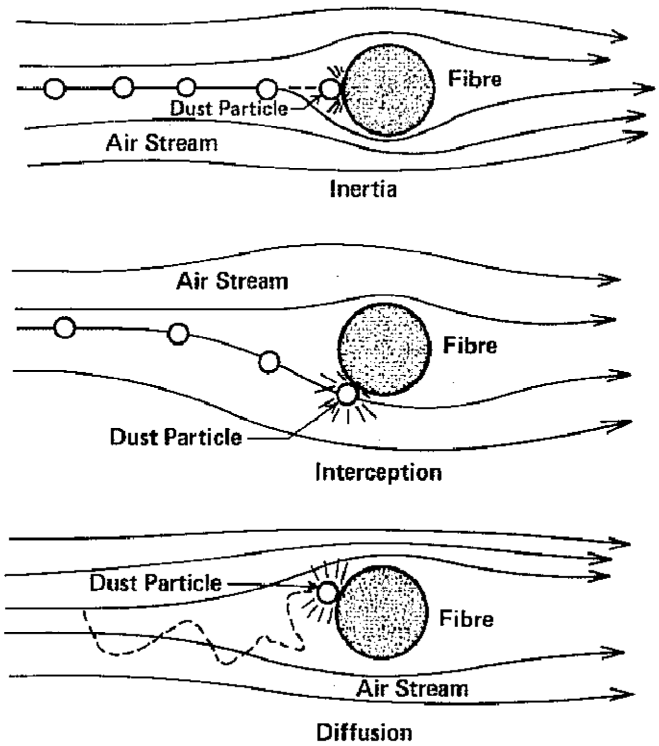


Figure 6 – Particle Deposition on Filter Fibres (AIRAH DA15)

These filter fibres usually consist of one of the following types;

  - Disposable Media – includes a cardboard frame and is designed to be replaced when showing signs of clogging. It is not washable and has a shorter life-span to washable media, however cost less and are more reliable where maintenance practices may fall short. Due to their cost and convenience, these are considered to be the most effective filtration system.
  - Washable Media – usually consists of filter media supported by a metal frame and is designed to be washed when dirty. Washable filters progressively lose efficiency when washed and as such can become ineffective without the occupants knowledge.

- Active Electrostatic – consisting of an array of alternately charged plates, electrostatic filters attract dust particles to the plates, removing them from the air-stream. Electrostatic filters can be "self-cleaning" however require a continuous power-source and specialist routine maintenance. This option is considered expensive in comparison to other filtration methods.

4. FILTERED AIR-CONDITIONING (cont.)

- Cyclonic Filtration – is a process in which the air is accelerated in a circular chamber to remove the airborne particles via centrifugal force. Whilst effective and relatively maintenance free, these units are significantly noisier than other options due to the high fan power requirements. This option is considered expensive in comparison to other filtration methods.

Consideration should be given to a system of "cheap" coarse disposable filtration upstream from effective fine washable media filtration.(6) This system can serve multiple purposes by using inefficient filtration to protect fine filtration media from the effect of high dust environments.

The location of fresh air intakes should be selected to ensure openings are oriented downwards, on the leeward side of the dwelling and sized to ensure low velocities are experienced and minimum dust pickup from the surrounding, as illustrated in Figure 3 of this report.(4)

5. RECOMMENDATION AND DISCUSSION

Filtration of incoming air into buildings is the only "active" mode of dust removal from air streams incoming into the dwelling. For this reason it is our opinion that it is the most reliable and effective "dust minimisation strategy" if designed intelligently.

Filtration systems should be designed as "two stage" arrangements utilising coarse disposable pre-filtration (suggest G3 or G4 rated – commonly referred to as "coarse filters"), cleaned regularly, and a fine filter (suggest F4 rated – commonly referred to as "fine filters") to efficiently remove particulate matter from the air. This configuration is expected to effectively remove greater than 90% of particles in the 2 to 10µm range.(6)

We have estimated the cost of this filtration arrangement to be relatively in-expensive in the order of $400 for supply and installation, with annual filtration media costs expected to be approximately $150, plus maintenance personnel cost as required.

The pre-filtration media should be cleaned monthly, by vacuuming or "banging" out as much dust as possible, with the fine filtration replaced annually (or sooner depending on actual dust level present).

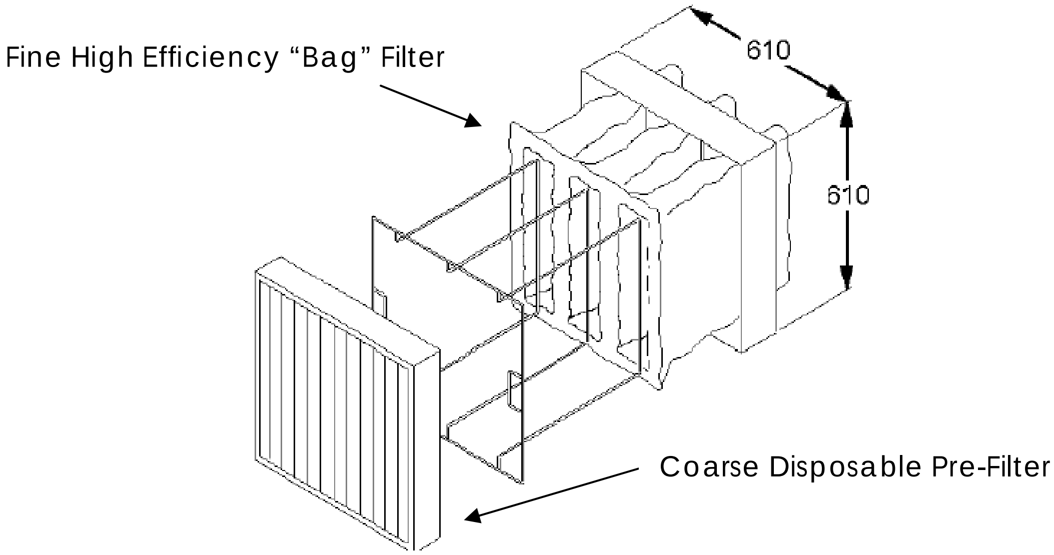


Figure 7 – Two-Stage Filtration Arrangement

5. RECOMMENDATION AND DISCUSSION (cont.)

To further reduce dust ingress into dwellings, via openings, careful design of window and door locations should be carried out to restrict their locations to Western and Southern building facades only.

Deflection screens to the northern and eastern edges of windows should also be considered to reduce the direct path of dust laden wind into the opening.

6. REFERENCES

The following references have been used in this report;

1. Wickham F. 1992, *AIRAH Application Manual DA15 - Air Filters*
   AIRAH/IRHASE, Melbourne
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Inc 2001, *ASHRAE Handbook – Fundamentals (SI)*
   ASHRAE, Atlanta, *Chapter12 – Air Contaminants*.
3. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Inc 2001, *ASHRAE Handbook – Fundamentals (SI)*
   ASHRAE, Atlanta, *Chapter 9 – Indoor Environment Health*.
4. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Inc 2001, *ASHRAE Handbook – Fundamentals (SI)*
   ASHRAE, Atlanta, *Chapter 16 – Airflow Around Buildings*.
5. Commonwealth of Australia 2004, National Climate Centre of the Bureau of Meteorology, Melbourne
   http://www.bom.gov.au accessed 16 September 2009.
6. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Inc 2004, *ASHRAE Handbook – HVAC Systems and Equipment (SI)*
   ASHRAE, Atlanta, *Chapter 24 – Air Cleaners for Particulate Contaminants*.

We trust the information provided meets your approval.
Please do not hesitate to contact our office if you have any queries.

Yours faithfully,
C.A. & M.J. LOMMERS PTY LTD

M.D. Lommers
Mechanical & Fire Safety Engineer

B.Eng (Mech), M.I.E.Aust, M.A.I.R.A.H,
Grad. Cert. Performance Based Building & Fire Codes
Grad. Dip. Building Fire Safety & Risk Engineering