Dust control is a major concern for industry. Mining, primary metals, steel production, power generation, and most other industries have issues with fugitive and/or wind-blown dusts. Dusts emitted from industrial sources can have detrimental effects on nearby residential areas, farmland, and natural habitats; not to mention the employees who work at the industries themselves.

By implementing dust management plans and adhering to dust control strategies, most of these dust issues can be effectively mitigated. RWDI AIR Inc. (RWDI) provides the consulting expertise needed by industry to build cost-effective, practical solutions for fugitive and wind-blown dust.

Dust sources can include, but are not limited to: on-site traffic, drilling and blasting, loading and unloading of raw materials or finished products, crushing, screening and stockpiles.
CASE STUDY – CVRD INCO LIMITED, SUDBURY, ONTARIO, CANADA

RWDI conducted on-site portable wind tunnel testing of different surfaces and stockpile materials ranging from nickel concentrate and mixed reverts to crushed slag at the CVRD-Inco facility in Sudbury. Several surfaces were tested with and without the application of a chemical binding agent to accurately replicate and test the effectiveness of fugitive dust management practices at the facility. The results from the wind tunnel tests were compared to published data to ensure that the results were in line with observations for similar materials.

Dust emissions are affected by a number of meteorological factors. Five years of hourly wind speed, precipitation, and snow cover data were used to predict hourly emissions for each material and stockpile tested. These data were then incorporated into a comprehensive air quality model of the facility. Fugitive and wind-blown dust emissions were assumed to be negligible whenever:
- wind speeds fell below the material-specific threshold;
- significant amounts of precipitation occurred; or,
- snow cover was >10cm in depth.

Dust emissions from on-site paved and unpaved roads can also be a major contributor to elevated particulate levels. RWDI quantified the silt loading and chemical composition of surface material from internal roads at the Inco facility using US EPA approved methods. Emissions from these sources were also included in the air quality dispersion modelling. Since that time, RWDI has completed dozens of air quality model sensitivity runs to further quantify how fugitive and wind-blown dust affect offsite impacts.

RWDI has conducted similar projects at numerous primary metal smelters and pulp and paper mills across Ontario.
EMERGING ISSUES

BOUNDARY LAYER WIND TUNNELS FOR DUST CONTROL SOLUTION DEVELOPMENT

There are numerous techniques for reducing fugitive and wind-blown dust emissions at industrial facilities. Most approaches tend to be site specific and require an on-site assessment by a dust expert to determine the most cost-effective combination of solutions.

 Typical solutions include, but are not limited to:
• Reduced vehicle speeds on haul routes and internal roads.
• Road watering and/or application of stabilizing agents.
• Stock and material waste pile reshaping and orientation.
• Covered conveyors and water/foam spray systems.
• Cessation of activities during high wind events.
• Wind fences, berms, and retaining walls.

At RWDI we have combined our expertise in the field of dust entrainment/transport with our years of experience performing boundary layer wind tunnel studies to provide a unique capability for dust control solution testing. Boundary layer wind tunnels have proven to be an effective tool for replacing complex wind flows around structures and stockpiles at industrial facilities and testing a wide range of solutions options, such as wind screens, berms, surface stabilization, etc.

1:200 Scale Model Testing of Mitigation Options

CASE STUDY – COAL STORAGE PILES

RWDI was recently engaged in reviewing and assessing potential mitigation options for controlling fugitive and wind-blown dust emissions at a coal storage facility in Eastern North America. The facility already follows detailed operating procedures and undertakes an impressive array of dust control measures. However, due to the physical constraints of the site and unique local meteorological conditions, wind-blown dust from the coal piles is still an issue of concern. Based on an on-site assessment, a wind fence was identified as a leading option for achieving additional reductions in fugitive dust emissions.

A 1:200 scale model of the coal piles was constructed and instrumented with 49 wind speed sensors that measure wind speed and direction at −2m above grade (six ports per sensor). Wind tunnel testing was performed for a range of wind directions and a number of different wind fence configurations.

Proposed Solution: 30% Porous Fence with Retaining Wall.

Surface wind speeds and directions measured at each sensor were presented as wind vectors (directional arrows where the length is proportional to the wind speed). Wind vectors for current conditions and different wind fence configurations are plotted together using different colours to allow for a simultaneous comparison between the different options.

Modelled surface wind speeds were then equated to relative reductions in dust emissions to quantify the effectiveness of the proposed wind fence solutions.

RWDI has performed similar wind tunnel testing for wood chip piles and stockpiles at mine sites. Solutions tested have included various combinations of porous wind fences, vegetated berms, and enclosures.

Wind Tunnel Results
WIND-BLOWN DUST – A PRIMER

Wind erosion occurs when lift and drag forces exerted by the wind, also referred to as frictional or shear stresses, exceed the retention forces acting on particles at the surface. Primary retention factors include particle mass, moisture content/capillary tension, and particle bonding/aggregation due to natural or artificially enhanced chemical bonds that form between particles.

The shear stress acting on a surface is expressed as the surface friction velocity or $U^*$, and is determined from the slope of the logarithmic velocity profile or relationship of wind speed with height above the surface.

Once the minimum wind speed required to initiate particle motion (particle entrainment threshold) has been reached, the rate of erosion ($Q$) is roughly proportional to the wind power or wind speed ($U$) cubed ($Q \propto U^3$). In an industrial setting, emissions from material stockpiles are also highly dependent on the frequency and nature of disturbances (e.g., vehicle traffic, material handling).

**Traditional Aerodynamic Entrainment**
- **Factors Promoting Entrainment**
  - $L_f$: Lift Force
  - $D_f$: Drag Force
  - $M$: Moment Force

- **Factors Inhibiting Entrainment**
  - $W_g$: Gravity Force
  - $l_p$: Interparticle Cohesion
  - $P$: Centre Point
  - $a, b, c$: Movement Arms

Air, Noise, Water & Waste Services

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