



Services

TUNRA Bulk Solids is an established business of The University of Newcastle Research Associates (TUNRA)

We are world leaders in applied and fundamental bulk solids handling research. TUNRA Bulk Solids has been in business for more than 40 years and has built a strong reputation in industry for our professional contract research services and our world class research in materials handling and flow properties. We have completed more than 3,000 projects for over 1,000 companies across Australia and more than 40 countries internationally.

Consulting and Contracted Research

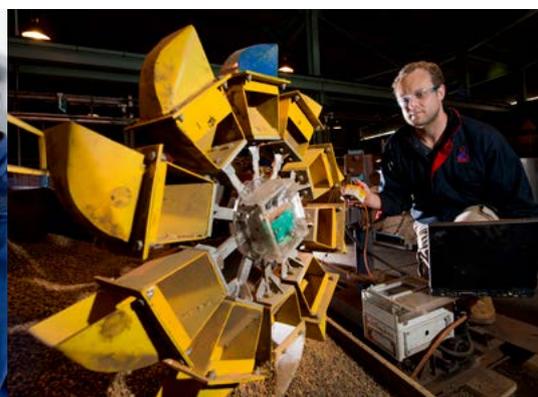
Our team of experts provide consulting and contract research services to a wide range of industries. Our business success is a result of our commitment to building long-term partnerships with business. We work with industry to overcome unique materials handling or flow issues. We add value for industry in our capacity to plan our projects and ensure trouble-free plant operation.

We provide services to industry that include:

- ▶ Expert site assessment and site performance recommendations for efficient materials handling
- ▶ Advanced analytics through numerical and computational modelling
- ▶ Materials handling and flow property solutions including concept designs
- ▶ Large-scale commercial and industrial research and development projects
- ▶ Advanced and individualised testing services
- ▶ Full engineering workshop services to enable prototyping of scale designs

TUNRA Bulk Solids consulting, research and development service encompasses handling and processing of powder-form and bulk materials in most industries ranging from:

- ▶ Mining and mineral processing
- ▶ Power generation
- ▶ Chemical processing
- ▶ Agriculture
- ▶ Manufacturing
- ▶ Food production
- ▶ Pharmaceuticals





We have proven expertise in identifying solutions for industries who have engaged us to undertake the following:

Materials Testing

- ▶ Flow properties testing
- ▶ Dust (environmental) testing
- ▶ Shipping-related testing – Transportable Moisture Limit (TML) and Stowage Factor.
- ▶ Abrasive wear, erosion and attrition
- ▶ Conveyor belt testing against Australian and International Standards
- ▶ Conveyor Belt Indentation Rolling Resistance (IRR) testing in world class facilities
- ▶ Idler roll testing against Australian and International Standards
- ▶ Conveyor component Fire Resistance Anti-Static (FRAS) testing
- ▶ Pneumatic conveying
- ▶ Hydraulic conveying

Materials Handling Consultancy

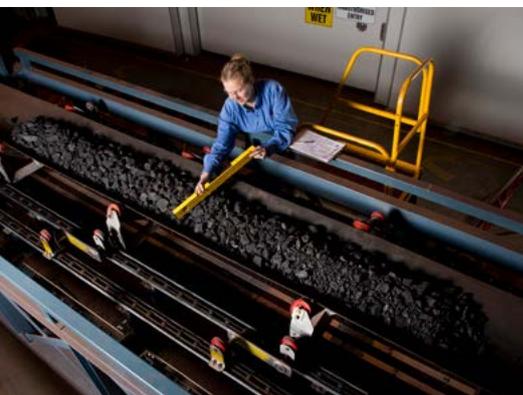
- ▶ Customised in-house short courses and on-site training
- ▶ Bin design, wall loads and flow patterns
- ▶ Stockpile draw-down geometries

- ▶ Stockpile live capacity estimates
- ▶ Belt conveying design reviews and audits
- ▶ Conveyor motion resistance calculations
- ▶ Feeder performance and load calculations
- ▶ Pneumatic conveyor scale modelling
- ▶ Transfer chute conceptual designs
- ▶ Wear and flow design optimisation
- ▶ Hydraulic conveying
- ▶ Instrumentation
- ▶ Fatigue testing
- ▶ General material handling design audits
- ▶ Discrete element modelling (DEM)
- ▶ Computational fluid dynamics (CFD)
- ▶ Finite Element Analysis (FEA)
- ▶ Site inspections

Technology and Knowledge Transfer

TUNRA Bulk Solids also provide a platform for commercialising research and transferring technology to ensure the expertise we gain through research is widely distributed for industry application.

We offer on-site and in-house training, innovation and development workshops to ensure our industry partners are working with the best research and technology available.



Further information

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Services

Transfer Chute Design

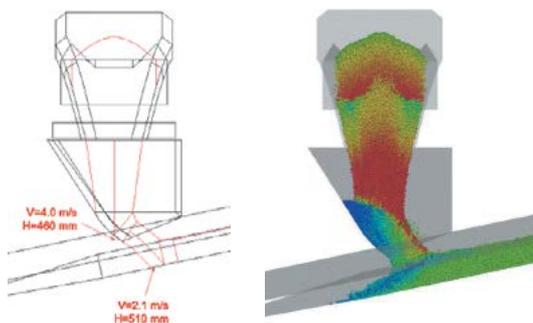
Transfer Chute Audits, Reviews and Conceptual Design

In the field of bulk solid materials handling, transfer chutes are critical components of mines, ports and power plants. The key to design an optimal transfer chute is a deep understanding of granular dynamics and material properties. TUNRA Transfer Chute Technology includes the utilisation of both continuum modelling and DEM simulation.

Continuum Modelling

With regard to transfer chute analysis techniques, the continuum method was developed by Em/ Prof Alan Roberts in 1965 – based on granular dynamics and uses measured material properties

- Equations of motion
- Material properties

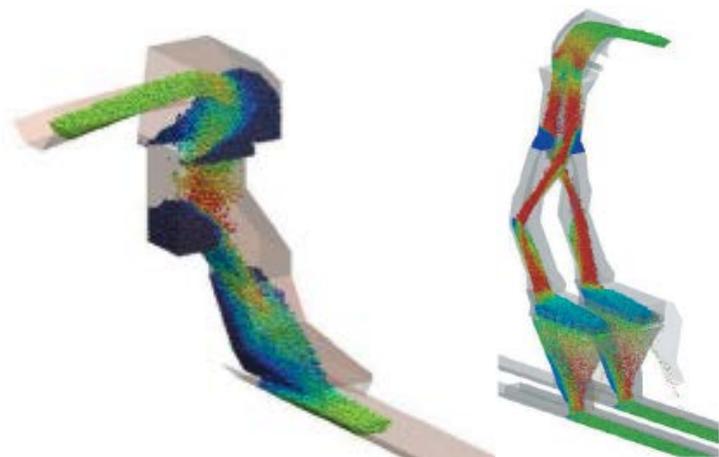


Continuum – granular dynamics based on bulk density and friction – predicts velocities and burden depths

Discrete Element Modelling (DEM)

DEM has proven itself to be an effective tool for analysing and optimizing particulate flow in a wide range of bulk material processing and handling operations. TUNRA Bulk Solids provides consulting services involving the use of DEM, including audits/reviews and conceptual design of transfer chutes.

- Material properties
- Contact model
- Calibration



DEM – parameters are selected based on calibration testing – excellent visualisation tool as well as allowing numerical analysis



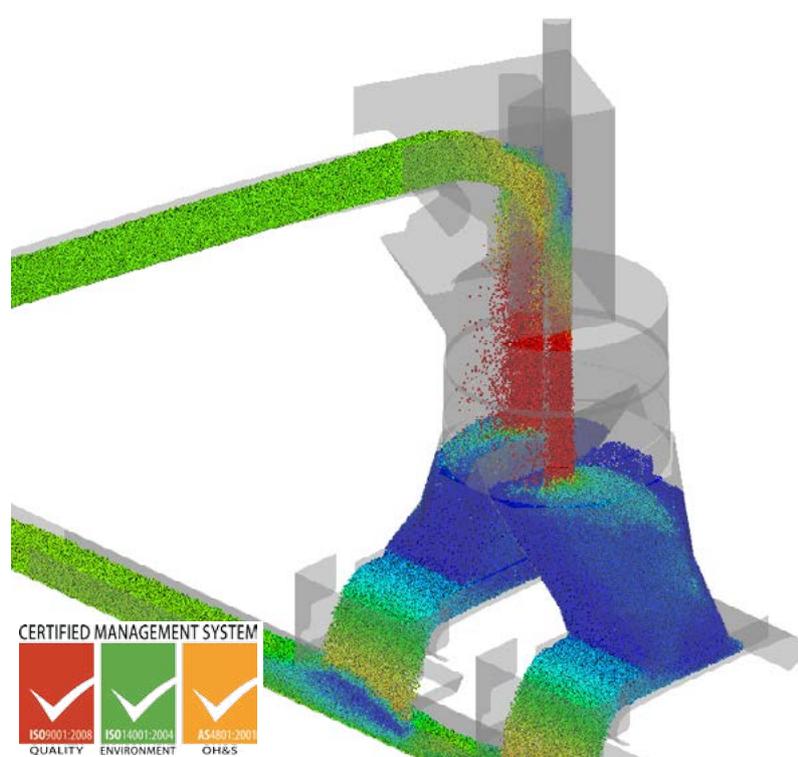
What Transfer Chute Design Services are available?

With the track record of successful completion of transfer chute projects in various industries, TUNRA Transfer Chute Technology ensures:

- ▶ Increase of plant throughput by efficient transfer of bulk solids without spillage and blockages;
- ▶ Cost reduction of chute and belt wear;
- ▶ Minimisation of plant stoppages caused by belt mis-tracking;
- ▶ Environmental control by reducing dust emission and noise;
- ▶ Favourable chute cut-off angles (slope) to guarantee flow at specified rate under all conditions, minimising flow retardation and preventing blockage;
- ▶ Selection of the most favourable wall lining material based on flow property testing results - lowest friction, highest abrasive wear resistance;
- ▶ Minimisation of normal component of bulk solid material stream velocity at loading point - reducing impact wear on the belt.

Our wide-range experience includes:

- ▶ Hood & spoon type and "rock box" type - transfer chutes;
- ▶ Large/small vertical drop transfer chutes;
- ▶ Stacker and reclaimer chutes;
- ▶ Ship loaders;
- ▶ Train loaders and discharge;
- ▶ And much more.



Why TUNRA Bulk Solids?

Experience and Expertise

We have provided expert solutions to industry for over 40 years and are the leading organisation for materials handling research and consulting in Australia and internationally

Research and Development

We have a proven track record in research and development through the close association with The University of Newcastle

Quality Service

We have highly qualified, well-trained and specialist staff that are committed to delivering excellence

First Class Facilities

Our laboratory is a state of the art facility located within the Newcastle Institute of Energy and Resources (NIER)

Industry Standards

We are accredited to ISO 9001, AS4801 and ISO14001

Independent

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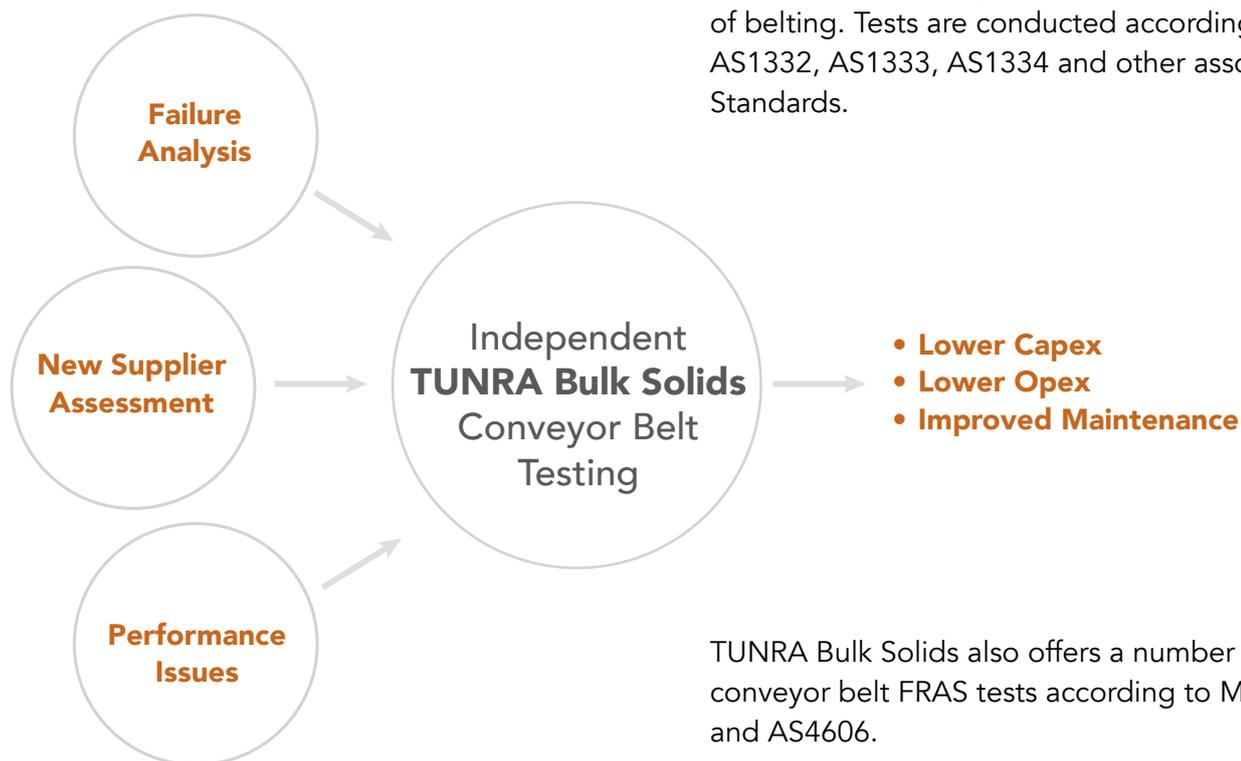
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Services

Conveyor Belt Testing



TUNRA Bulk Solids offers a wide range of conveyor belt testing services covering all types of belting. Tests are conducted according to AS1332, AS1333, AS1334 and other associated Standards.

TUNRA Bulk Solids also offers a number of conveyor belt FRAS tests according to MDG3608 and AS4606.

TUNRA Bulk Solids will carry out custom Conveyor Belt tests to suit the individual needs of our clients and according to requested International Standards





What Conveyor Belt Testing Services are available?

Textile Reinforced Belting

- ▶ Thickness of belting and rubber covers across the width
- ▶ Full thickness tensile strength and elongation
- ▶ Troughability
- ▶ Cover and ply adhesion
- ▶ Resistance to tear propagation
- ▶ Electrical resistance
- ▶ Ignitability and flame propagation characteristics
- ▶ Ignitability and maximum surface temperature of belting subjected to friction
- ▶ Belt tracking

Steel Cord Belting

- ▶ Belt tracking
- ▶ Cord diameter
- ▶ Cover thickness of belting across the belting width
- ▶ Cover thickness and vertical cord location of cords in belting
- ▶ Cord pitch
- ▶ Cord breaking force
- ▶ Static pull-out strength before and after reheating
- ▶ Laminate adhesion
- ▶ Dynamic cord pull-out fatigue resistance
- ▶ Cord elastomeric compound penetration

Solid Woven Belting

Cover Rubber Specific Tests

- ▶ Tension testing of vulcanised or thermoplastic rubber
- ▶ Durometer hardness
- ▶ Abrasion resistance
- ▶ Accelerated aging of elastomers

Splice Inspections and Testing

Indentation Rolling Resistance Testing



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Idler Roll Testing

TUNRA Bulk Solids provides a wide range of idler roll testing services to the mining industry. Commonly testing to SANS 1313, ISO 5048, DIN22112 and MDG3608, TUNRA Bulk Solids also offers a series of additional tests that build upon the Standard tests while providing results more relevant to the idler roll's operating environment.

Additionally, the engineering team at TUNRA Bulk Solids is ready to discuss particular customer requirements and plan a novel test programme that will meet their unique criteria.

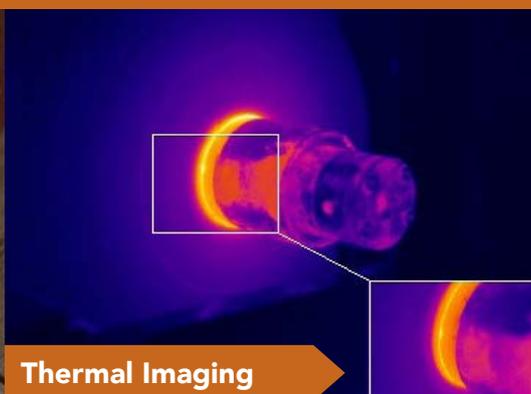
Conveyor idler rolls are integral components of belt conveying systems as they provide load support and control of the belt troughing profile. Between 10 - 20% of the overall rolling losses of a belt conveyor can be caused by the idler rolls of a belt conveyor system. Therefore, care must be taken to choose the best idler roll design for the respective purpose.

The comprehensive test facility of TUNRA Bulk Solids at the University of Newcastle, Australia enables testing of conveyor idler rolls in reference to relevant International Standards and/or Guidelines, including the CEMA 7th Ed., DIN22112-3, ISO 5048 and SABS 1313-1.

TUNRA Bulk Solids conducts tests to meet other International Standards on request



Dust Ingress



Thermal Imaging



Water Ingress



Rim Drag



Operating Noise



What Idler Roll Testing Services are available?

Rotational Resistance

- ▶ Rim Drag
- ▶ Break-away Force
- ▶ Maximum Start-up Drag
- ▶ Temperature Performance

Idler Manufacture Characteristics

- ▶ Total Indicated Run-out
- ▶ Maximum Indicated Slope
- ▶ Dynamic Unbalance and Balance Grade Determination
- ▶ Axial Float
- ▶ Resistance to Pressing Out
- ▶ Dimensional Specifications

Idler Roll Noise

- ▶ Self-noise
- ▶ Operating Noise

Seal Design Effectiveness

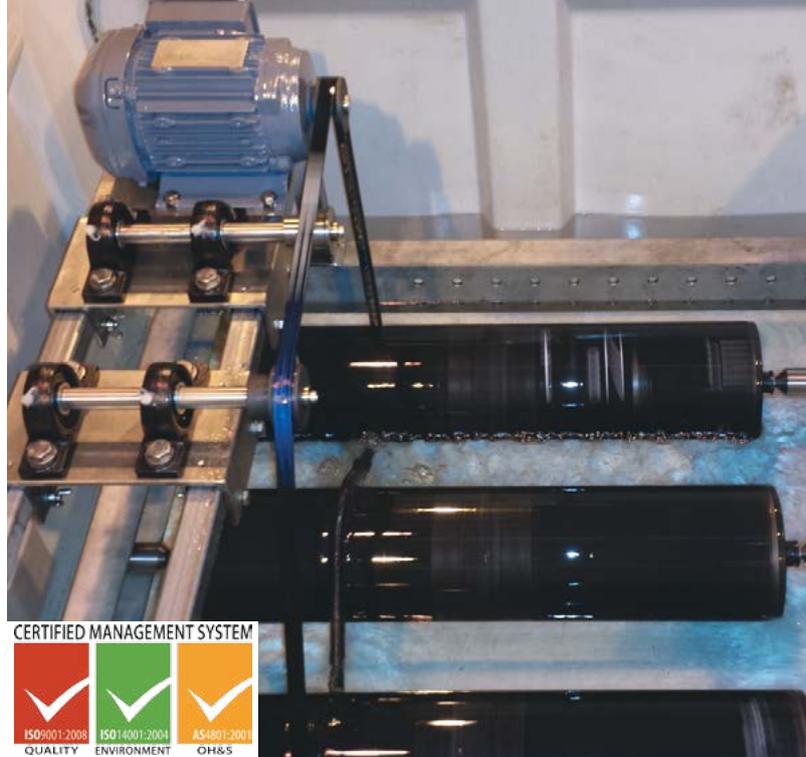
- ▶ SANS Standard Dust Ingress
- ▶ Inclined Dust Ingress
- ▶ SANS Standard Water Ingress
- ▶ Inclined Rain Event Water Ingress

Fire Resistance Anti-static (FRAS)

- ▶ Ignitability and Maximum Surface Temperature of Idler Subject to Friction (Seized Idler)
- ▶ Electrical Resistivity
- ▶ Ignitability and Flame Propagation Characteristics (Finger Burn Test)

Miscellaneous Tests

- ▶ Thermal Imaging
- ▶ Failure Analysis and Inspections
- ▶ Shell Wear
- ▶ Complete Idler Wear



CERTIFIED MANAGEMENT SYSTEM



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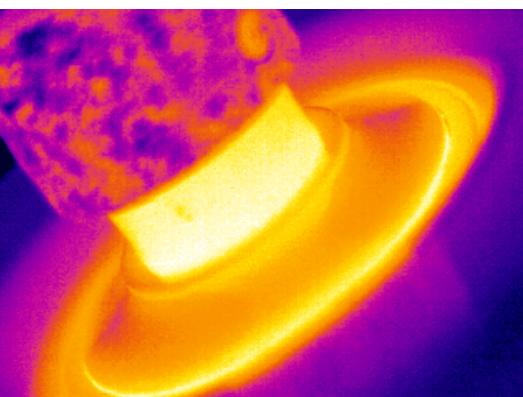
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Flow Properties Testing

The design of bulk solids handling plants requires knowledge of the flow properties of the material under a range of operating conditions. These operating conditions include varying consolidation pressures for instantaneous and extended time storage as well as environmental factors such as temperature, moisture and humidity.

The comprehensive laboratory facilities at TUNRA Bulk Solids permit the characterisation of bulk material properties using well-established test procedures to determine the bulk strength and friction angles as a function of bed depth and major consolidation stress for the bulk material. This testing is principally performed using a TUNRA direct shear testing machine.

The type and range of tests required depend on the moisture content of bulk material and the type of storage facility to be designed.



TUNRA Bulk Solids conducts custom tests to suit the individual needs of our clients





What Flow Properties Testing Services are available?

- ▶ Dust Extinction Testing
- ▶ Transportable Moisture Limits
- ▶ Wall Friction
- ▶ Adhesion
- ▶ Bulk Density and Compressibility
- ▶ Solids or Particle Density
- ▶ Wind Tunnel Testing
- ▶ Chute Wall Angles
- ▶ Hopper Wall Angles
- ▶ Bin Opening Dimensions
- ▶ Ratholing Characteristics
- ▶ Effects of Vibration Time Storage
- ▶ Effects of Undisturbed Time Storage
- ▶ Angle of Repose
- ▶ Conveyor Roll-Back Angle
- ▶ Belt Surcharge Angle
- ▶ Dewatering Characteristics
- ▶ Fluidisation and Deaeration
- ▶ Internal Friction Angle
- ▶ DEM Calibration Tests
- ▶ Particle Shape Characterisation
- ▶ Direct Shear Testing
(low and high consolidation)
- ▶ Worst Case Moisture Content Determination
- ▶ Stockpile Veneer Treatment Efficiency Testing
- ▶ Wall Liner Abrasion Wear Testing
- ▶ Wall Liner Impact Wear Testing
- ▶ Slurry Wear Testing
- ▶ Stockpile Drainage Testing



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Ship Loading Chute Design Minimising Dust Emission

Conceptual Design

The principle of dust reduction lies in the patented research previously conducted by TUNRA Bulk Solids in which impact angles are maintained low and the dust stream is encapsulated and constrained within the flowing material stream.

Analysis typically conducted in the development of conceptual designs of ship loading chutes is a combination of the continuum method in parallel with Discrete Element Modelling (DEM).

General deliverables include:

- ▶ Development of conceptual design to within client specified structural criteria
- ▶ Determination of terminal velocity
- ▶ Continuum flow analysis through the conceptual design
 - Material stream cross sectional area and velocity profile
 - Trajectory of the material stream discharging into the vessel
- ▶ 3D Discrete Element Modelling (DEM) flow visualisation through the conceptual design
 - Stream flow profile
 - Discharge trajectory
 - AVI video files
- ▶ Report outlining major dimensions, including any relevant design issues and details
- ▶ 3D CAD model

TUNRA Bulk Solids will develop custom Chute Design solutions to suit the individual needs of our clients





Scale Modelling

Complementary to conceptual design development and analysis, TUNRA Bulk Solids also offers pilot-scale modelling for the purposes of design optimisation, validation and differentiation between alternative designs. Our testing facility can cater for physical sizes approaching 1:10 scale.

Patented Technology and Dust Research

TUNRA Bulk Solids holds a patent "Dust Reduction in Delivery of Particulate Commodities" filed with the Australian, US and Canadian Patent offices in 2006.

Following on from research and consulting projects in which dust emission levels were reduced by up to 80% (compared to original designs), further developments have seen TBS foray into modelling dust with Computational Fluid Dynamics (CFD) coupled with existing techniques.

This has laid the platform for the publication of a number of papers, book chapter "Methods for the Characterisation and Control of Dust in Materials Handling Applications with a Specific Focus on Passive Dust Control in Transfer Chutes" and recently a PhD thesis also completed.



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Wear Testing

Wear is one of the main factors in the replacement of bulk materials handling equipment. Any materials handling equipment which involves the motion of bulk solids relative to surfaces will experience wear problems. Wear in bulk handling equipment may result from impact or abrasion or, as is often the case, a combination of both.

Several areas where abrasive wear is experienced include storage bins and silos, particularly in hoppers operating under mass flow conditions, feeders, transfer chutes, belt conveyors, vibratory conveyors and screw conveyors.

TUNRA Bulk Solids has both an abrasive wear tester and an impact wear tester that are one of a kind test machines that operate on a large scale, offering realistic wear results when compared to the practical applications. The abrasive wear tester can test four liners simultaneously while the impact wear tester can test two liners simultaneously. Both testers subject the wear liners to continual flow and the mass of the liner is monitored over time to determine wear.



Optional Geometry Optimisation

- **Realistic and Controlled Wear Assessment**
- **Lower Capex**
- **Lower Opex**
- **Improved Maintenance**

TUNRA Bulk Solids conducts tests to meet other International Standards on request





Abrasion Test

This test uses an annulus of bulk material which is rotated such that the wall liners (up to 4) are subjected to abrasive wear. Tests are typically run over a period of 40 hours with the wall liners monitored every 8 hours. This test is most useful for chutes, hoppers, skirts and all sliding applications.



Impact Test

This test uses a vertical wheel to rotate the bulk material and drop it through a standpipe onto an inclined wall liner (up to 2). The angle of impact can be varied between 15° and 75°, depending on the application. Tests are typically run over a period of 8 hours with the wall liners being monitored every hour. This test is most useful for chutes, impact zones and conveyor belts.



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