Dune Express – The World's 2nd Longest Conveyor System

Andrew Jennings P.E.[1], **Bradley Lawson MIE Aust CPEng**[1]

[1] *Conveyor Dynamics Inc. 3633 Alderwood Ave, Bellingham, Washington State, USA*
cdi@cvdyn.com

Abstract

At 67.8km Atlas Energy Solutions, Dune Express Overland Conveyor system is the second longest chain of conveyors ever built and the longest built in 50 years. The conveyor system transports 1905 tph of frac sand across the Permian Basin and into New Mexico where it supplies remote distribution facilities. Dune Express negotiates countless existing infrastructure obstacles including highways, railway corridors, service roads, flood plains, powerline and pipeline easements and oil wells on its way from the existing Kermit sand plant in West Texas to New Mexico. This is the story of how this conveyor was engineered and constructed.

1. Introduction

Frac sand is a highly spherical silica that is mixed into fracking fluid. A typical 3050 m lateral well requires around 12,500 tons of sand. Before the construction of Dune Express, sand was transported from mine to well head on public roads and highways in trucks carrying 24 tons each. Thus, the typical well requires 520 truckloads of sand, with each truck driving up to 320 kilometres round trip. These 520 trucks must arrive at the wellhead within a 4-day time window. Every day around 6,000 truckloads of sand are delivered to wells in the west Texas and New Mexico Permian Basin placing great strain and safety hazard upon public roads and increasing the cost of well development.

In 2017, Atlas Energy Solutions (Atlas) determined that if they could construct a ~68 kilometre overland conveyor system from their existing Kermit Sand plant, through the middle of the Permian Basin, and if they could find a way to offload the sand at any point along the conveyor, then they could drastically reduce their haulage costs and increase public safety. Rather than engage a traditional EPC company, Atlas elected to use their in-house procurement and construction management team to build the system, but selected Conveyor Dynamics, Inc. (CDI) to supply the mechanical design details, and M3 Engineering to supply the structural, civil, and electrical engineering details.

The project required Atlas to acquire a 22.9 m wide easement from five major landowners including the New Mexico Bureau of Land Management. Dune Express (Figure **1**) crosses 1 highway, 5 public roads, 14 lease roads, includes 18 cattle/wildlife crosses, and 96 pipeline crossings. Building permits were needed in both Texas and New Mexico, and 12 MW of electricity is supplied by grid operators spread across these two states.

The Dune Express Project includes 5 transfer stations, 9 conveyors, a maintenance road, and 2 silo storage and truck loading facilities at the State Line and End of Line. The total cost of this mega-infrastructural project including studies, engineering, land acquisition, procurement, and construction was approximately $400 million dollars - about USD $6 million/kilometre.

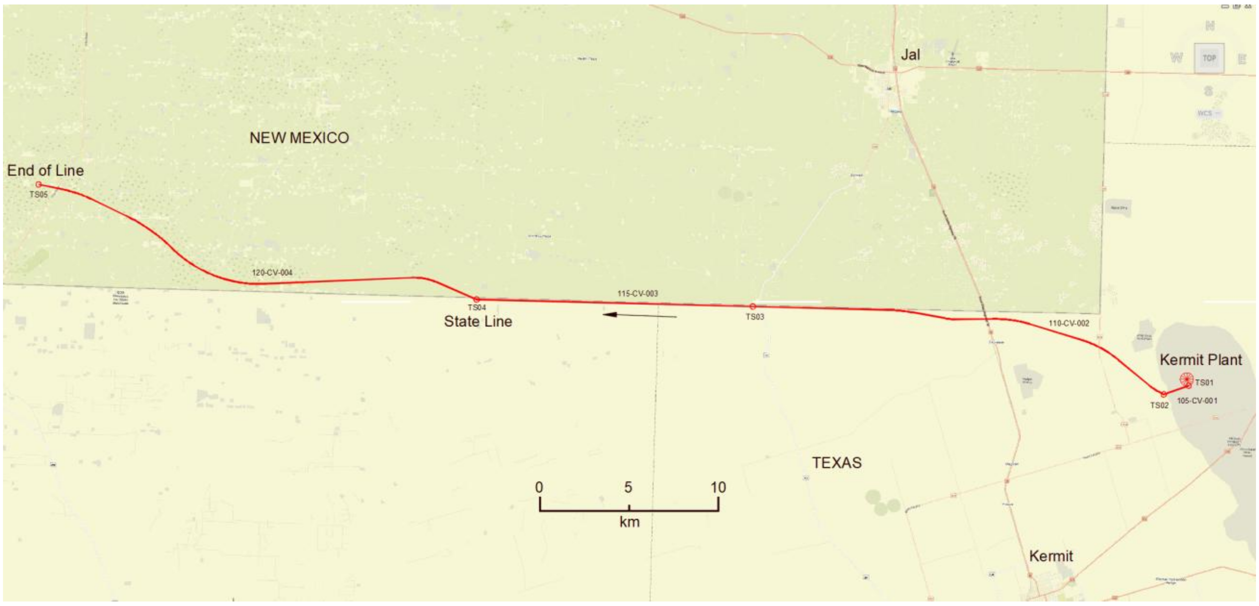

Figure 1: Dune Express OLC system - Site Plan

2. System Description

The Dune Express Overland Conveyor system transports 1,905 t/hr of two main products: 100 mesh sand, and 40/70 sand from Atlas's Kermit Plant to product storage and truck loading silos located at the Texas-New Mexico 'State Line', and to silos in New Mexico 'End of Line'. These products are transported separately and are stored in different silos. Batches of both products are sometimes present in the system at the same time, so the control system tracks what product is present at every location in the system to ensure each batch is discharged in the correct silo. A flow sheet for the system appears in *Figure **2***.

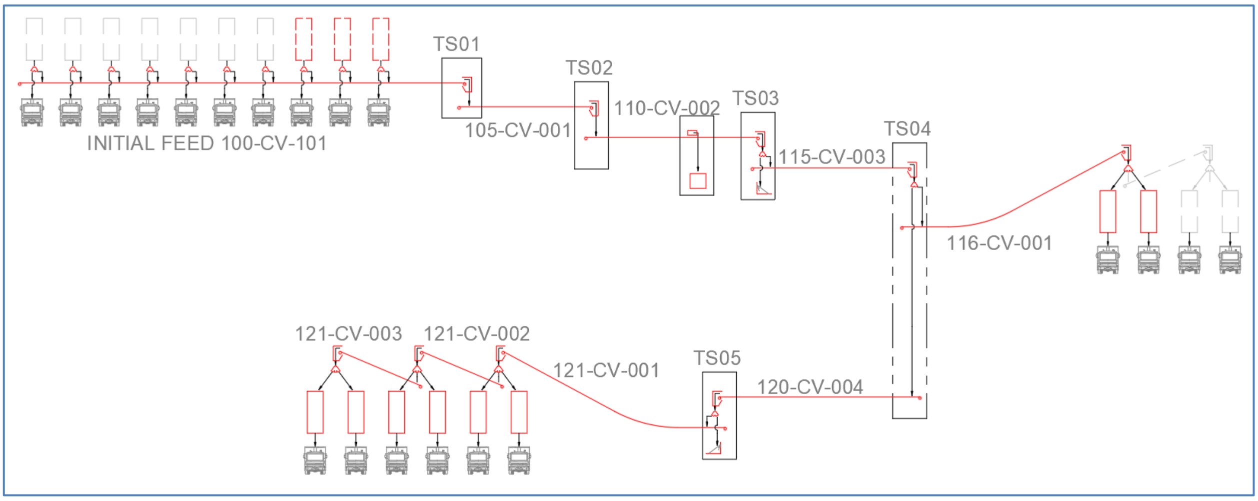

Figure 2: Dune Express - Flow Diagram

The system is fed from the existing truck loading silos at the Kermit Plant.

100-CV-101 Initial Feed Conveyor was threaded between the existing Kermit plant silo columns and mass flow gates were added in the silos to feed this new conveyor stream. 100-CV-101 crosses the plant access road and feeds the first overland conveyor segment, 105-CV-001, at Transfer Station TS01.

105-CV-001 is a 1.4 km conveyor which transports sand across the dunes, crosses the plant access road, and feeds overland conveyor 110-CV-002 at Transfer Station TS02.

110-CV-002 is a 24.1 km long horizontally curved conveyor that threads a path though the oil fields until it meets the border of New Mexico. It then turns west, following the border until transferring the sand to 115-CV-003 in Transfer Station TS03 just after crossing Frying Pan Road. This conveyor includes 7 cattle crossings, 3 lease road culvert crossings, two public roads overhead crossings, and crosses over State Highway TX-18.

115-CV-003 is a 15.6 km straight conveyor that continues along the border until it reaches Transfer Tower TS04. At TS04, sand flows either to the State Line Truck Loading Facility onto the Silo Feed Conveyor 116-CV-001 or it flows to Overland conveyor 120-CV-004. The route crosses 4 lease roads in culverts and incorporates one overhead cattle crossing.

116-CV-001 discharges into a chute with a three-position gate supplying sand to two new storage silos with an option to add an additional pair of silos in future expansions.

120-CV-004 is a 26.2 km horizontally curved conveyor that includes 10 wildlife crossings, 7 lease road culvert crossings, and 2 public road overhead crossings before discharging sand on Silo Feed Conveyor 121-CV-001 at Transfer station TS05 near the End of Line storage and truck loading facility.

Silo Feed Conveyor 121-CV-001 feeds a three-position chute. This chute feeds two silos and 121-CV-002 then feeds two more silos and 121-CV-003. 121-CV-003 feeds the final two silos at the End of Line Truck Loading Facility with the option to add an additional 4 silos in future expansions.

The conveyors in this system, while among the longest in the world (120-CV-004 is the second longest), are not unprecedented in length. Similar length conveyors have been constructed in the past namely Impumelelo, 26.8 km (Thompson & Jennings, 2016) [1], Curragh North, 20.3 km (Steven, 2008) [2] and Zisco, 15.6 km (du Toit & Fletcher, 1997) [3].

3. Design Considerations

At the onset of the project, Atlas insisted that the engineering include:

- Full scale 1:1 testing on of the conveyor ground module to validate CFD simulations and prove no product would be lost or contaminated by moisture during the strong storms that are common in west Texas.
- Personnel must be able to change idler rolls without stopping the conveyor or even pausing conveyor feed in a safe and efficient manner.
- The system must be able to off-load material at any point along the route. The system shall interface around the standard conveyor ground modules, i.e. a tripper on rails is not acceptable. It shall not spill product. The conveyor must remain operational and not require shutdown when the system is introduced and removed.
- The control system shall track the location of all products along the full length of the conveyor system, and the control system shall record how much and where batches are offloaded along the route.
- Negotiate major highways, rail corridors, lease roads and existing pipeline crossings as well as provide cattle and wildlife crossings along the route.

- The frac sand process involves separating the sand in a hydrocyclone and then drying it. Depending on the time the sand spends in the silo, it may arrive at the overland with a temperature up to 77°C. The overland belt shall tolerate this temperature and minimise the effect of rubber aging, and it shall be a Low Rolling Resistance rubber compound.
- The conveyor crosses numerous pipelines, and some pipelines may not be identified before construction starts or built during construction of the Overland Conveyor system. An inexpensive standardised bridge assembly for spanning conveyor ground modules over pipeline crossings shall be designed.

Conveyor Belt

Atlas standardised all overland belts to minimise spares. A Heat Resistant-Low Rolling Resistance (HR-LRR) was selected to mitigate the rubber aging effects whilst still providing a good low rolling resistance performance. A 914 mm wide, ST-3150 belt, with 7.9 mm x 4.8 mm covers was supplied to Atlas. The belts were shipped on 615 m long racetrack rolls and delivered to 7 main belt flaking yards strategically located along the route determined by the maximum belt pulling force required. The belt was flaked out and pre-spliced into 1320 mm tall flake stacks approximately 330 m long with up to 20.7 km of belt each stack (Figure **3**).

A custom belt pulling plate was designed and tested to withstand the 12 ton maximum pull force generated by the winder which was spooled with 4.5 km of 1” diameter steel rope.

Figure 3: Pre-spliced belt flake stacks up to 20.7 km in length with custom belt pulling plate and 4.5 km cable winder capacity

Pre-form splice kits were used to ensure accurate splice geometry and minimise splice construction time. We calculate a 12.9 year splice fatigue life with a L10 of 9.9 years for all splices on the conveyor. The constructor provided test splice samples which were destructively tested on CDI’s Universal Tensile Machine to verify that the splice contractor was achieving the correct static cord pullout strength.

Conti MultiProtect systems are also installed on all Overland Conveyors using the magnetic flux leakage principle on cables as well as rip inserts to provide rip protection and continuous monitoring of steel cord and splice integrity. In addition, the head and tail positions, the MultiProtect arrays were installed at minimum 3.8 km intervals to monitor both carry and return belt strands for belt rips to mitigate the extent of belt damage due to external causes.

Conveyor Drive Control

After evaluating VFD's, fluid couplings, and Dodge CST drive technologies, Voith fill controlled fluid couplings were selected to manage the 10 minute starting ramp time for the long overland conveyors. Voith fixed fill extended delay chamber fluid couplings were selected to manage torque on the shorter conveyors. VFDs were seriously considered, but Atlas has found VFD's challenging to maintain in the past and felt the mechanical nature of fluid couplings is better suited for their operational environment.

No mid station boosters were necessary in the Dune Express system as all long Overland Conveyors used only head and tail drives. The tail drive torque is controlled such that the belt tension at the tail is maintained a constant. This is the first installation featuring the new displacement-based belt tension measurement device that does not require load cells (Figure 4). In this device, a weighted pulley deflects the belt, and the deflection angle is measured by a rotary encoder. The rotary encoder measured angle is used to compute belt tension through an algorithm. Fundamentally, rotary encoders are more reliable and easier to maintain than load cells and only require zeroing rather than calibration. Another advantage is that the belt tension can be visually interpreted with the design placing the rotating arm horizontal when the belt is at the target belt tension setpoint.

Figure 4: Rotary Encoder based Belt Tension Measurement for Tail Drive Control

When the conveyor is in the running state, the Voith fill-controlled fluid coupling controller fills the head drive Master coupling to minimise hydrodynamic slip and maximize efficiency. The head drive Slaves fill levels are moderated by the fill-controlled fluid coupling to match the Master drive torque output level.

A creep mode was also incorporated in the control system to facilitate maintenance inspection with an empty belt. Fluid coupling external coolers are activated at low speed while operating continuously at low speed (high coupling slip) to avoid thermally overloading the fluid couplings whilst operating continuously.

Idler Rolls

A wide idler spacing of 4.88m x 9.75m was chosen to minimise the idler count while maintaining belt sag below 1% during normal steady state running conditions. The carry and return trough angles are 45° x 20° to assist in belt tracking and horizontal curves. Minimising power consumption was an important goal for Atlas, so roller drag of pre-production rolls was measured using the CDI 'Dragon' testing shown in Figure **5** to ensure the roller manufacturer delivered a low rolling resistance product.

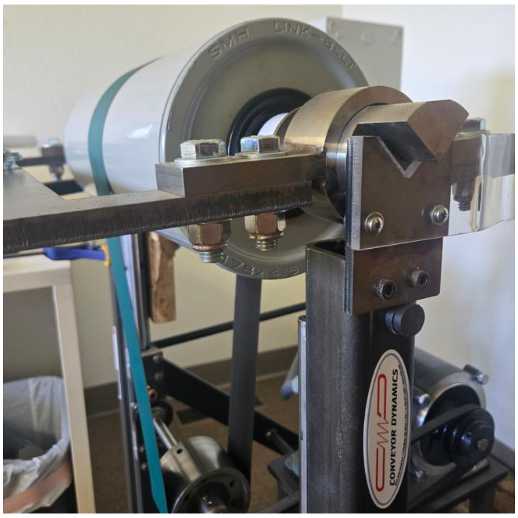

Figure 5: CDI Dragon Idler Drag Measurement for low rolling resistance verification pre-production

Each idler roll (> 66,000 installed) is also a Smart Idler equipped with Vayeron technology that measures bearing temperature, vibration, and speed. These sensors transmit their measurements via gateways to the cloud where the smart idler application analyses the data and informs Atlas if a roll is beginning to fail and required replacement.

Idler Roll Replacement

To minimise downtime, the conveyor ground modules were designed around a new idler change system invented to allow Atlas to change rolls whilst the conveyor is running. The system consists of a unique transom frame, a belt lifter, and a frame removal tool (Figure **6**). The special idler frame features two location holes that the frame removal tool grips during extraction and replacement. The idler frames are not bolted to the structure. Instead, they hang from hooks on the ground module H-frame leg assembly.

Figure 6: Special Idler Frame Transom design used in conjunction with the Ninja Idler change system

Dune Express is the first system to deploy the CDI Idler Change tool system. The system comprises of two main tools, the Idler Change Arm (ICA) and the Belt Lifter (BL).

The ICA can be readily disassembled into three main sub-assemblies (vertical carriage, horizontal rail and tool arm) for ease of handing and transportation on the conveyor maintenance vehicle. To minimise system cost, maximise flexibility of use and reliability, robotic arms were not used as has been attempted previously. Instead, a manual tool system was developed with hydraulic, 24 VDC electric and pneumatic assistance.

To extract a roll, the maintenance personnel fasten the vertical carriage to the ground module H frame leg. This precisely locates the tool arm in 3D space relative to the idler frame regardless of module banking and orientation. The horizontal rail is then secured to the vertical carriage, and the tool arm with its pneumatic grippers is connected to the horizontal rail.

The hydraulic powered belt lifter is attached to the end of the tool arm and deposited on a corresponding set of hooks on the conveyor module H frame. To ensure the lifter is positioned at the correct elevation before it is swung between the belts, an interlocking mechanism only allows the tool arm to rotate into the plane of the conveyor if it is in the correct elevation window. The tool arm releases the lifter on the hooks and is swung back to the operator outside of the plane of the conveyor. Hydraulic cylinders on the lifter then lift the moving belt off the idlers set that is to be removed (Figure **7**).

At all times, the tool operator is positioned outside of the plane of the conveyor with the tool located between the operator and conveyor to ensure the work can be completed safely and minimize exposure to hazards.

After the belt is lifted off the idler set, the tool arm is moved to the pivot point on the opposite side of the horizontal rail beam. It then swings into the plane of the conveyor and pneumatic grippers are used to extract the idler transom frame while the belt is supported by the lifter. Once the complete idler frame and roller assembly is rotated out of the plane of the operating conveyor then the idler rolls are replaced as required, and the process is repeated in reverse (Figure **8**) to reinstall.

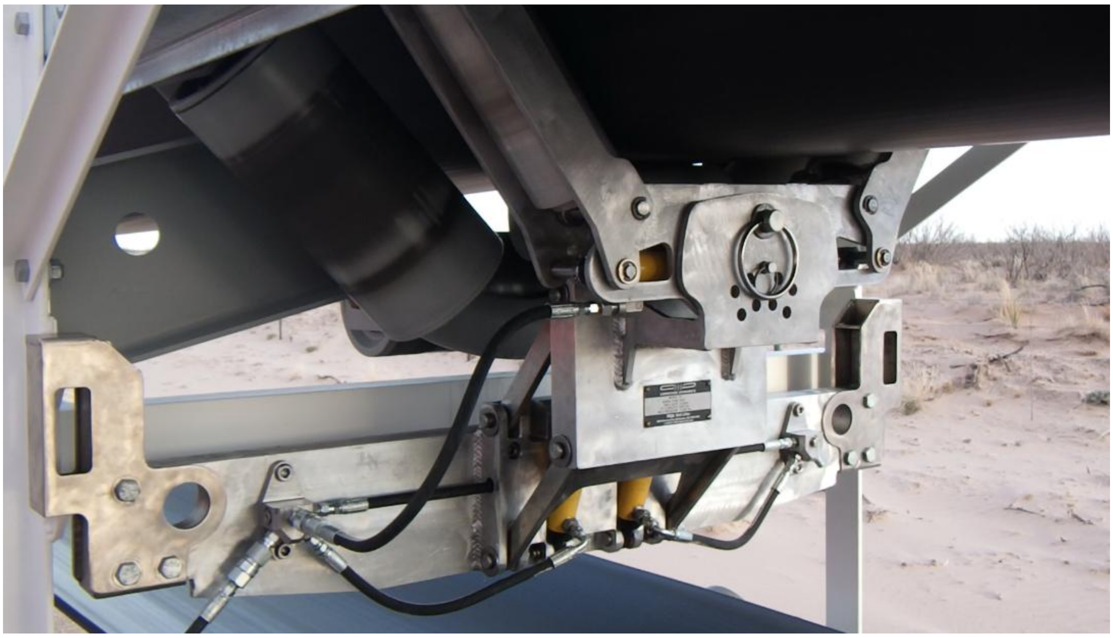

Figure 7: Hydraulic Belt Lifter tool in position with the operating and loaded belt lifted off the idler set

Figure 8: Idler Transom frame and roller assembly being reinserted

Operational performance has shown that a roller change crew of three persons can replace a roller in less than 10 minutes including setup and demobilization time.

In total, six sets of idler change tool systems were supplied to Atlas for use on the Dune Express project.

Mobile Off-load Plow Station

A mobile offload plow station (Figure **9**) was designed that can be installed at any ground module location of the Dune Express while the conveyor is running.

Figure 9: Mobile off-load plow station installed on a horizontal curve along 120-CV-004

To deploy the system initially, steel rail beams are slid under the operating conveyor (yellow parts in Figure **10**). The cyan portions of plough station transition shown in Figure **10** slide on the rails with elements that run between the belts initially cantilevered. Supports from the opposite side secure the previously cantilevered transition sections (magenta parts in Figure **10**). Idlers (green part in Figure **10**) then rotate up to lift the running belt off the idler transoms and transitions the belt so that sand can be ploughed off (orange part in Figure **10**). Chutes wrap around the overland and discharge onto a separate low profile belt feeder that is inserted under the return belt strand (Figure **11**). This mobile conveyor carries the material to a mobile truck loading system which incorporates a 200 t buffer bin and batch loading.

Figure 10: Mobile Plow Station installation enveloping standard ground modules with a low-profile belt feeder (inset showing 3D model of the plow station mechanism)

The mobile offload system ties into the conveyor PLC and identifies the plough location so that load tracking logic in the PLC is aware that sand is being removed. The PLC logic tracks sand product types so that they are loaded in the correct silos and so that the correct products are ploughed off at mobile offload stations as required.

The mobile offload facility including the mobile offload plough station can be relocated within approximately a 1-week period to a new location along the overland conveyor corridor to meet customer supply demands.

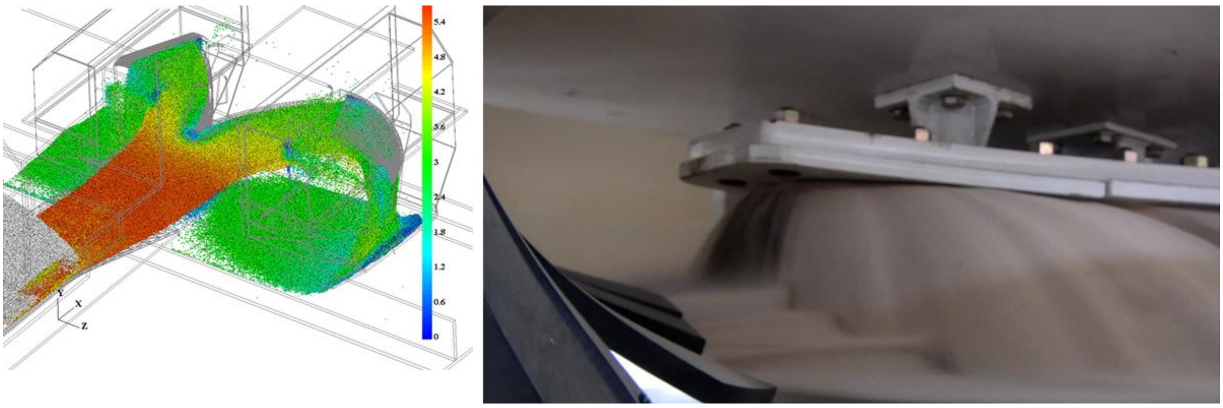

Figure 11: Mobile Offload DEM showing the parabolic plough and twin discharge hoods.

Ground Module Wind Testing

Validating the ground model CFD modules in a wind tunnel large enough to test a 9.75 m long ground module at full scale proved impossible on the timeline specified by Atlas and limitations imposed by test facilities. Alternatively, a movie special effects company agreed to test the ground module using jet engine ‘storm wind generator’ (the same jet engine was used to create the storm effect in the

Forrest Gump trawler scene). The wind expands in a diffusion cone from the jet engine and at 18.3 m from the engine the wind speed is a constant 72 km/hr at medium thrust.

A complete 9.75m long conveyor ground module with a wooden trough shape belt replica was constructed. Trays of 100 mesh product sand were placed on the "belt" and weighed pre - post testing to determine the rate of sand loss. A pitot tube in front of module, and three pitot tubes at different elevations were installed inside the module, as well as strands of yarn and cameras to visualise the air flow (Figure **12**).

Over a three-day period, 12 different wind tests were performed. Wind speeds between 72 and 120 km/hr were tested. Wind was directed perpendicular to the module and at incidence angles of 45 and 60 degrees to the module. On the last day of testing, the local fire department sprayed water into the wind stream to test water ingress during heavy rainstorms. Wind was directed at the centre of the module leg, and halfway between the legs.

The CFD flow predicted wind speeds were reasonably accurate, but by test 7 it was clear that sand losses were unacceptably high ~ 2.4% to 5%. The depth of the stringer was increased by using duct tape and strips of sheet metal. The deeper stringer section reduced sand losses to 0.1%, which was deemed acceptable.

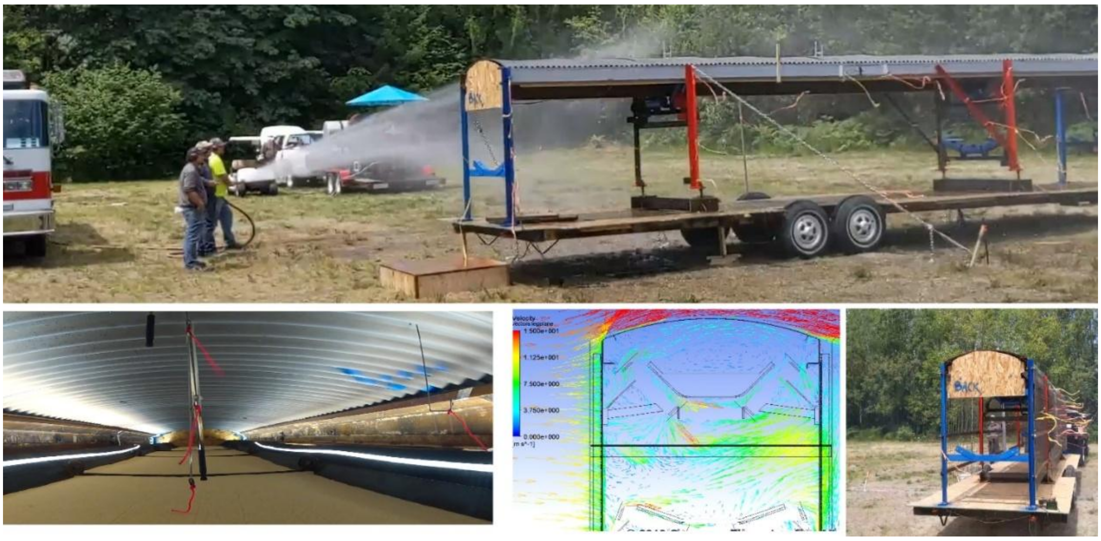

Figure 12: Windstorm testing at full scale to validate product sand loss and water ingress protection

4. Summary

The Dune Express conveyor uses the latest conveyor technology to extend the practical range of conveyor belt systems. Every effort was made to ensure the system of such length will be practical to maintain. It includes several new devices and inventions and utilises all the latest conveying technologies to protect the system and provide comprehensive condition monitoring to minimise system downtime.

5. References

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[2] Steven, R.B. (2008, Vol. 28 No. 3). Belting the World's Longest Single Flight Conventional Overland Belt Conveyor. *Bulk Solids Handling.*

[3] Thompson, M., & Jennings, A. (2016). Impumelelo Coal Mine is home to the world's longest belt conveyor. *Mining Engineering, 14-35.*