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Dust controls at the coarse ore storage facility, Oyu Tolgoi, Mongolia

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Abstract

The coarse ore storage (COS) facility is repeatedly identified by Oyu Tolgoi as a major source of dust that presented a significant risk to worker health and the environment. Dust monitoring and observations conducted since 2013 demonstrated high concentrations of airborne particulate that were likely to be exceeding air quality standards. Dust generation at the COS occurred from the discharge to the covered stockpile and resulted in fine particulate depositing on the ground surface surrounding the COS. A foam dust suppression system was added to the COS feed in November 2014, with observed and measured reduction in dust emissions. An analysis of dust-monitoring data indicates some reduction in airborne particulate as a result of the foam dust suppressant addition. However, the measured reduction is not as significant as is suggested from visual observation of the COS. Additionally, dust curtains installed in 2019 continue to manage dust at the COS facility. Moreover, we implement some operational mitigations at the facility, including area cleaning, watering, and keeping the COS stockpile to at least 70% capacity to minimise drop-down distances, thereby decreasing dust generation. The dust-monitoring dataset demonstrates the substantial positive impact the installation of dust curtains, and other mitigations, have achieved.

Keywords: *particulate matters, mitigation, and foam dust suppressant*

1 Introduction

The Oyu Tolgoi (OT) deposit is the largest copper-gold deposit in Mongolia and is among the world's largest developing copper-gold projects. The deposit is located 600 km south of the Mongolian capital of Ulaanbaatar and 100 km north of the Chinese–Mongolian border (Oyu Tolgoi LLC 2016; Figure 1). The mineral resources were discovered in 2001 and contain of a series of copper, gold, silver and minor amounts of molybdenum deposits. OT currently operates open pit mining at the Southern Oyu deposit. This is planned to be supplemented in the future by production from block cave underground mining operations in the higher-grade Hugo North deposit. First production from the underground phase is expected in 2023. Current annual production is 175,000–200,000 tonnes. The process design to convert the ore into concentrate is based on conventional milling and flotation technology. The process includes primary crushing with stockpiling of resultant coarse ore. Crushed ore from the primary crusher is transferred via a 2.7 km overland conveyor to the coarse ore storage (COS) facility near the concentrator. This material is then fed via conveyor into a grinding circuit where a series of large diameter mills reduce the ore to small particle sizes. This material is then either sent to the concentrator for flotation or recycled back to the grinding circuit. The flotation system separates valuable ore from waste minerals in large flotation cells in which the copper-containing materials are skimmed off. Waste sludge (tailings) is filtered to approximately 60% solids in two thickeners to recycle water back into the process circuit. Non-recycled sludge is pumped to the tailings storage facility for final disposal. The final copper concentrate is thickened and filtered before storage in sealed bags (Eco Trade LLC 2016).

Figure 1 Location of the Oyu Tolgoi mine site

Stockpile is a main source of fugitive dust induced by wind if it is unclosed (Cong et al. 2012; Zamorano 2006). In this sense, stockpile in the COS facility is one of the dust sources at the OT mine site, since it is semi-enclosed, with the north side fully open and the other sides half open (Figure 2). After the ore is mined, it is crushed first at the primary crusher and becomes a coarse ore, which varies from 0.025 mm to 175 mm. This coarse ore is then transferred via overland conveyor from the primary crusher to the COS facility (Strength et al. 2020). During the unloading process, the fugitive dust is released. With the commissioning of the concentrator, the issue of dust generated from the COS has been raised, and we have been studying the causes of this dust, measures to reduce it, and have taken the necessary measures in the past. There have been several practices that reduce dust in the ambient air that are relevant to the stockpiles at OT. The most common method is spraying water to stockpile (Andrew et al. 2012). A polymeric chemical dust suppressant was experimented with and identified as an effective dust suppressant for stockpiles and reducing the fugitive emissions (Wang et al. 2022). In order to reduce dust generated from the COS, several mitigation actions were taken, and a foam dust suppressant system was the first substantial change, installed at the primary crusher in 2013.

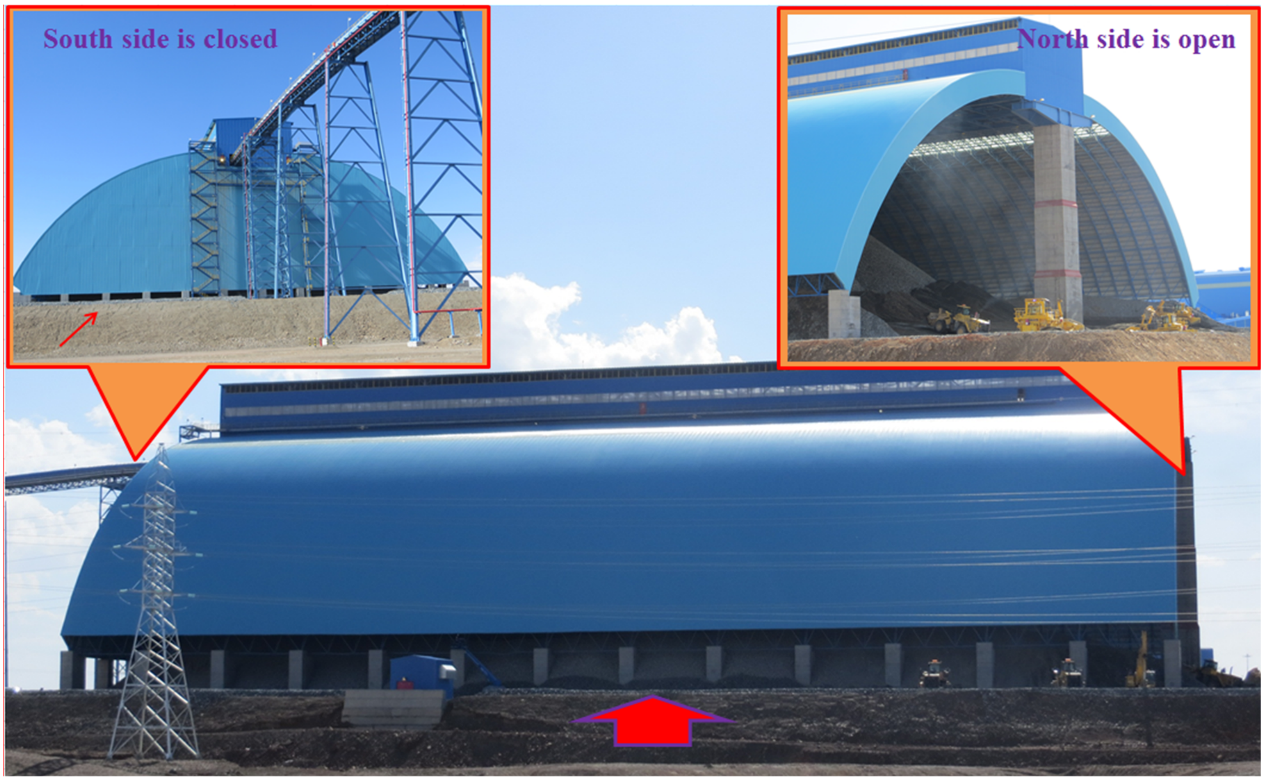


Figure 2 Coarse ore storage facility

In addition to the foam dust suppressant system, the dust curtain installation was started in July and continued until September in 2018; however, installation ceased to develop a more robust attachment that could function in the wind conditions prevalent at OT. New dust containment was installed in Q1/2019. The purpose of this paper is to summarise the dust reduction mitigation actions that the company has been taking since 2013 and their results.

2 Methodology

2.1 Dust monitoring

Dust-monitoring activity around the COS began in March 2013 using TSI 8533 DustTrak DRX aerosol monitor (DustTrak) monthly and continued until April 2020. A small number of measurements were not made due to delays in the shipment of instruments sent abroad for calibration and necessary maintenance and, in some cases, malfunctioning. DustTrak measures particulate matter less than 2.5 microns (PM2.5) and 10 microns (PM10). There are two dust-monitoring points at the COS, called DMP-COS01 and DMP-COS02. DMP-COS01 is located north of the COS building and DMP-COS02 is located south of the COS building and both in the concentrator's COS operation area. These two were in consideration of prevailing wind direction, coming from a north and northwest direction (Oyu Tolgoi LLC 2020), and the movements of the heavy mobile equipment as well. The results of the measurements from DMP-COS01 and DMP-COS02 compared with the results of the control point, located 15 km north of the OT mining site, and are not influenced by the OT project activities. Measurements were taken by placing DustTrak for 24-hour data on the same day.

OT has been doing an environmental monitoring rationalisation program, installing continuous monitoring stations. As per this program, a continuous air quality monitoring for particulate matter near the COS building is carried out at the AQMNS-COS station. Installation and commissioning of this station was completed in July 2020. Use of this station to assess ambient air quality replaces the previous monthly hand-held DustTrak monitoring undertaken at stations. Figure 3 shows the location of the monitoring points and stations.

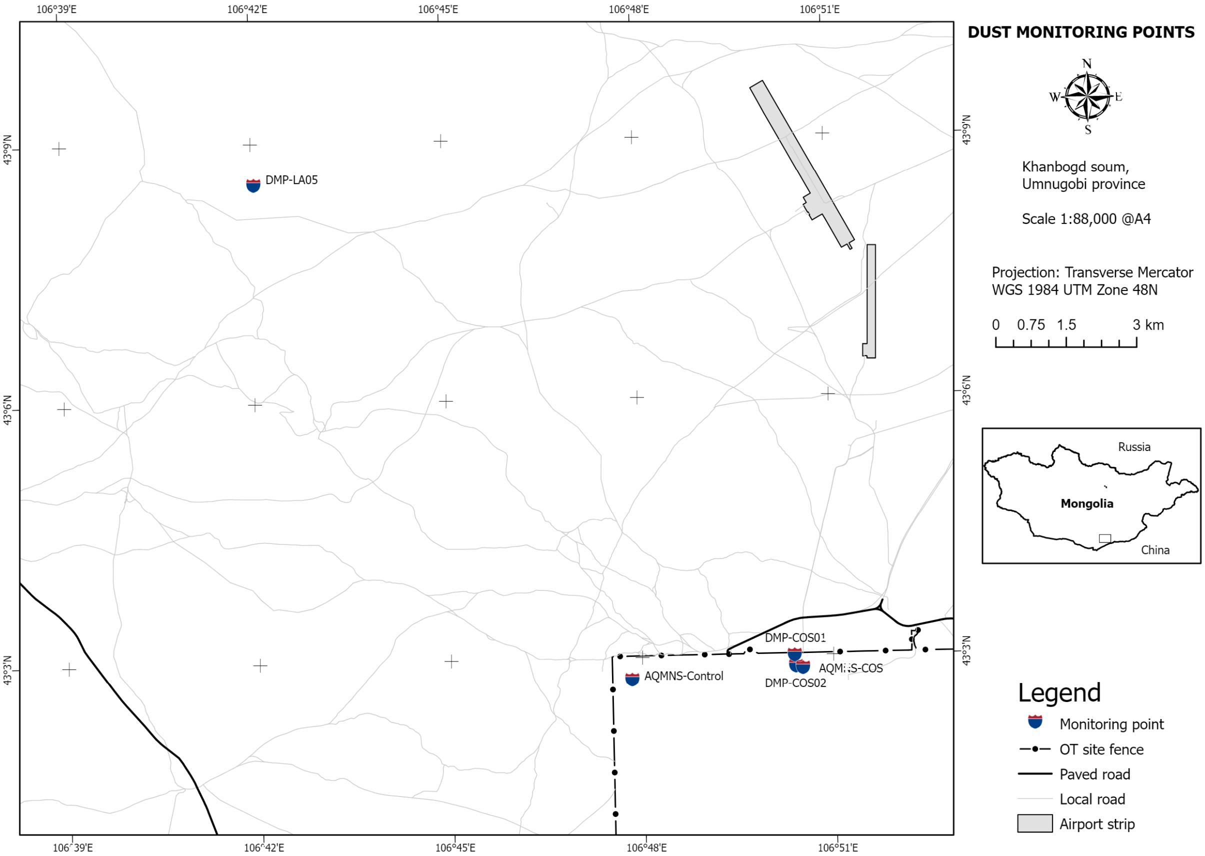


Figure 3 Location of the monitoring points and the stations

2.2 Mitigation actions

Based on the initial dust-monitoring result, the dust generation at the facility was excessive. The concentrator operation team started project initiation of a foam dust suppressant system, adding to the primary crusher feed in September 2013; installation was completed in November 2014 but commissioned in March 2015. The first foam dust suppressant was Chemlock, and it was used for more than three years. In 2017, OT conducted a trial on a total of four reagents, including Chemlock, Dustfoam, Dusttreat, and F13S foam dust suppressants, to select the most effective one. A new reagent, F13S, was selected as it performed better than the other three reagents. F13S has been used since June 2018. As particulate levels do not meet the standard requirements, additional curtain closure was installed in the winter of 2018–2019 and commissioned in February 2019. These curtains are made of high-density polyethylene, contain an anti-UV agent, are fire retardant, and widely used in various industrial fields to prevent dust emissions. It was expected that the curtains will reduce wind velocities by up to 90% and correspondingly reduce dust generation (Figure 4 and Table 1).

Figure 4 Installed dust curtains at the coarse ore storage facility, from west, front, and east sides

2.3 Data and data analysis

The data were conducted through nine years of dust monitoring close to the COS facility and control point and stations. As previously mentioned in Section 2.1, the dataset was collected using two different types of equipment. Those are continuous monthly data samples of an average of 24 hours of measurement, in order to compare with the standard's permissible levels. OT complies with Mongolian national standards and applicable international standards, with the more stringent standards representing the project standards. The OT project standard for both PM2.5 and PM10 is 0.05 mg/m^3 (Oyu Tolgoi LLC 2022). R version 4.0.3 (R Core Team 2020) was used to calculate two-way ANOVA (Girden 1992), along with Tukey post hoc test and using MS Excel graphics.

Table 1 Summary of mitigations and datasets

Controls	Period	Dust-monitoring data
Before engineering mitigation action (No MA)	Until February 2015	Monthly data by DustTrak (N = 20)
Foam dust suppressant (Chemlock)	March 2015–May 2018	Monthly data by DustTrak (N = 28)
Foam dust suppressant (F13S)	June 2018–January 2019	Monthly data by DustTrak (N = 15)
Foam dust suppressant and Curtain closure (F13S+CC)	Since February 2019	Monthly data by DustTrak until April 2020 (N = 15) and continues monitoring data since July 2020 (N = 535)

3 Result

Initial dust-monitoring results, before installation of the foam suppression system, indicated high dust airborne concentrations surrounding the COS during ore feeding. Similarly, the dust emission from the facility was also highly recognisable (Figure 5).

Figure 5 Dust is generated from the COS, before dust foam suppressant system operation in 2013

As a result of two-way ANOVA on the dust-monitoring results by DustTrak, we found a statistically significant difference in dust average concentration by both monitoring points (PM2.5: f = 11.6, p < 0.000001; PM10: f = 13.2, p < 0.000003) and mitigation types (PM2.5: f = 3.6, p < 0.009; PM10: f(2) = 3.8, p < 0.013). A Tukey post hoc test revealed that DMP-COS02 resulted in a higher dust concentration on average

(0.28 mg/m^3) than the control point ($p < 0.000001$), and a higher dust concentration on average (0.15 mg/m^3) than the DMP-COS01 point ($p < 0.016$), whereas there is no significant difference between DMP-COS01 and the control point ($p > 0.06$). As shown in Figure 6, particulate concentration around the COS facility dropped dramatically and met the project standard limits.

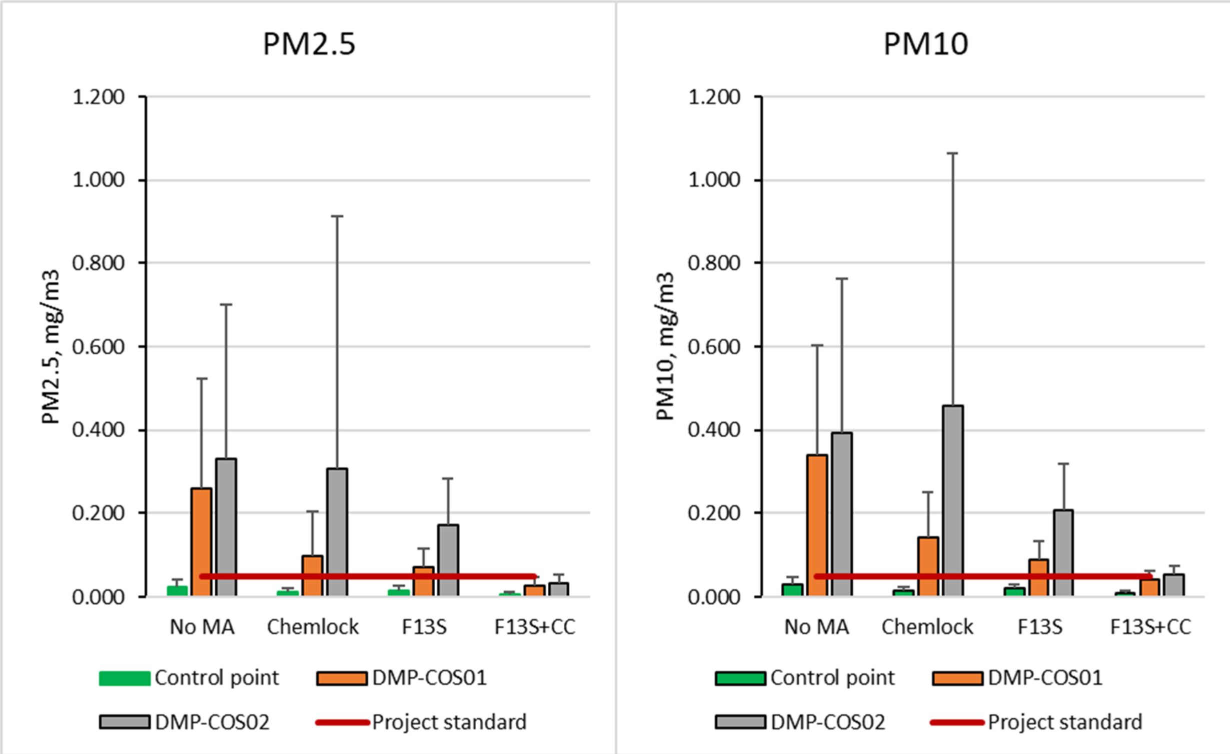


Figure 6 Comparison of average dust concentrations during dust reduction measures; (a) PM2.5 result; (b) PM10 result

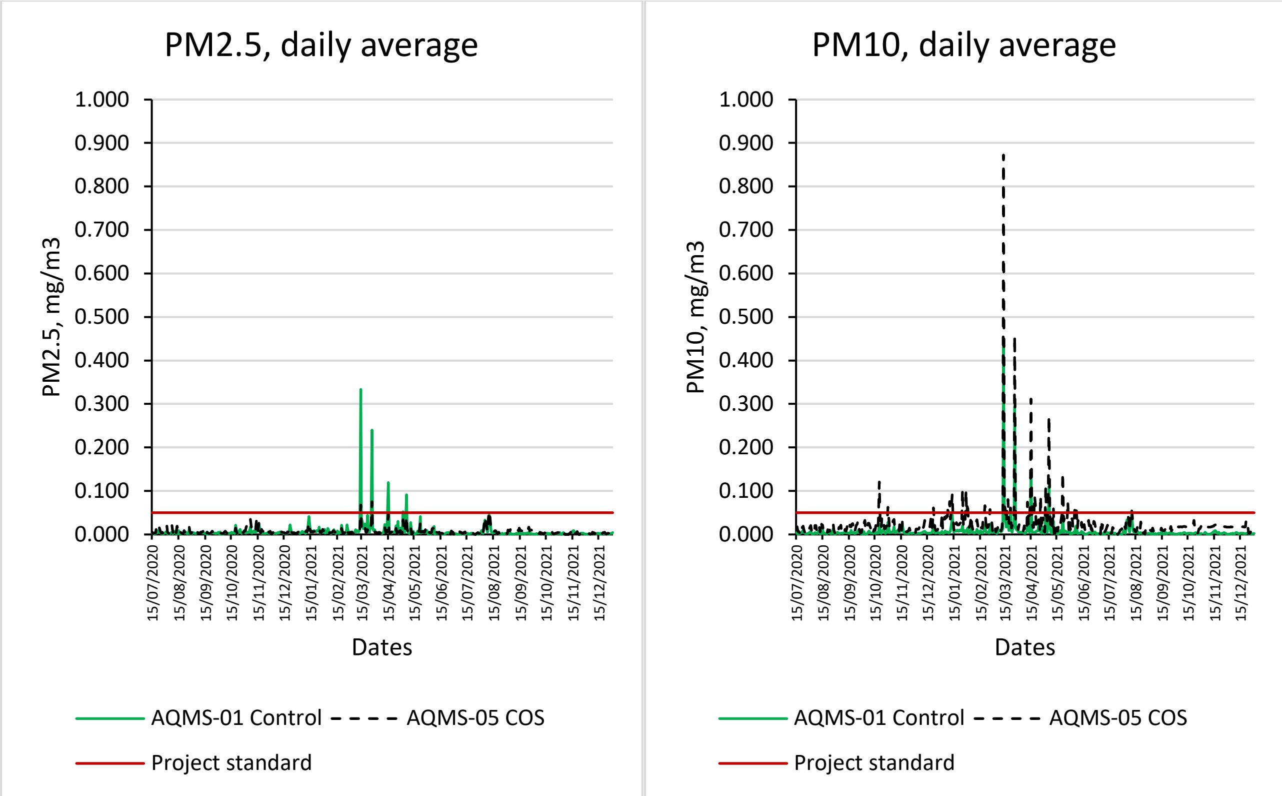
Remarkably, particulate level dropped after each mitigation. After curtain closure installation ($p<0.027$), a statistically significant reduction was indicated, especially at the DMP-COS02 point. Actual average reduction of PM2.5 and PM10 were 0.164 mg/m^3 and 0.205 mg/m^3, respectively. With the PM2.5 result, there is no difference between the two foam dust suppressants ($p = 0.057$). On the contrary, the average PM10 concentration during F13S application was 0.105 mg/m^3 lower than the Chemlock application ($p = 0.029$; Table 2).

Table 2 Summary of Tukey post hoc test results

Heading	PM2.5 difference	*P* value	PM10 difference	*P* value
'Chemlock' – 'No MA'	−0.048	0.744	−0.036	0.942
'F13S' – 'No MA'	−0.104	0.258	−0.141	0.243
'F13S+CC' – 'No MA'	−0.164	0.017*	−0.205	0.027*
'F13S' – 'Chemlock'	−0.056	0.646	−0.105	0.349
'F13S+CC' – 'Chemlock'	−0.116	0.057	−0.169	0.029*
'F13S+CC' – 'F13S'	−0.060	0.689	−0.065	0.810

*Statistically significant difference.

According to the air quality monitoring station results, the average daily concentrations of PM2.5 and PM10 meet the requirements of the project standard for most of the year. A few occasional exceedances occurred in the windy seasons of spring and autumn (Figure 7).



(a) (b)

Figure 7 (a) PM2.5 result; (b) PM10 result

The project has observed a noticeable decrease in particulate matter at the COS since installation of the curtains.

4 Discussion

In this paper, we mainly concentrated on dust reductions after engineering controls. However, we should state that other mitigations, which have additional minor positive impacts to reach the goal, reducing dust generation to meet the standard limits. Visually, these measures are clearly reducing dust levels to a certain extent, but there is no measured monitoring evidence to prove their impact. The first mitigation action was regular dust cleaning or earth maintenance around the COS facility; the second was regular road and area watering. The third measure taken was to reduce the traffic volume around the facility by authorising only necessary vehicles and heavy mining equipment. These measures are aimed at reducing wind- and traffic-induced dust from the surface around the facility. The last measure, which may have contributed most significantly to reducing dust from the facility, was to keep the stockpile as high as possible and the facility to at least 70% full capacity to minimise drop-down distances to prevent dust generation. Additionally, seasonal behavior, such as humidity, wind speed, and temperature at the southern Gobi Desert, might have been neglected in these results. According to the results of this study, dust reduction can be seen as the result of a series of measures and their combination.

5 Conclusion

Operational and engineering improvements such as using dust suppressant foam and installing dust curtains at OT since 2013 has resulted in a reduction of fugitive dust concentration around the COS facility. Since those initiatives in 2019, particulate matter concentrations have been complying with the project standard, which meets the MNS 4585:2016 Mongolian National Standard and EU Directive 2008/50 EC on Ambient Air Quality standard. Moreover, some additional works, such as regular cleaning of COS surrounding areas and keeping the COS stockpile to at least 70% capacity to minimise drop-down distances to prevent dust generation, has helped.

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