ATTACHMENT 2: EMAIL AND PAPER ON ORE DUSTING FROM RAIL CARS

Richard Cook

From: Richard Cook
Sent: February 14, 2019 5:28 PM
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Cc: 'Stephen Atkinson <stephen.atkinson@xplornet.com> (stephen.atkinson@xplornet.com)'
Subject: RE: Dust Study Design for Rail Cars
Attachments: Davies 1974 Transportation of Iron Ore - A Practical Exercise in Enviro....pdf

Hi Brad et al.,

Thanks for sending the coal dust generation paper. I've attached the paper referenced in Volume 5 of the 2012 FEIS, which supported the conclusion that ore dust-off from the rail cars at Mary River will be negligible. A couple of important notes in regard to the paper's applicability to the Mary River Project, and the basis of our conclusion that dust-off from the rail cars will be negligible:

1. The amount of blow-off of ore that may occur from the rail cars is a function of product density, particle size and speed (or wind velocity).

2. **Density** - The Davies 1974 study evaluated several different iron ore products; a couple of the products generated meaningful blow-off, but not the Cerro Bolivar ore. The iron content of the Cerro Bolivar ore closely matches that of Mary River ore (mostly 64-69%) https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10111256). As such, the specific gravity (a measure of relative density compared to water) of the Mary River iron ore can be expected to be very similar to the Cerro Bolivar ore. Relative to coal (which has a specific gravity in the range of 1.2 to 1.5), the Mary River iron ore is about 3x as dense, with a specific gravity of 4.36.

3. **Particle Size** - The Davies 1974 study evaluated fine ore products. With the Phase 2 Proposal, only primary crushing (crushing of oversized material) will occur at the mine site, and so the product transported by the railway will be 100 cm minus (i.e., virtually no fines).

4. **Speed** - The Cerro Bolivar ore had negligible blow-off at 100 km/h, and the maximum speed the Mary River trains will operate at is comparatively lower at 60 km/h.

Essentially, the Mary River iron ore is dense relative to even some other iron ore products, there will be minimal fines with the 100 cm minus product transported on the railway, and the railway will be operating at a speed where even the fines of lower specific gravity ores won't have meaningful blow-off.

Best regards,
Richard

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Subject: Dust Study Design for Rail Cars

Hello Everyone

During the TEWG we discussed the possibility of dust generation from uncovered ore cars. What I was trying to convey was that there are far too many unknowns due to a lack of literature on specifically iron ore transport by rail to simply state that the cars will not produce dust. The attached paper contains a study design that was used to assess the rate of dust production from coal cars. This study could be adapted to use on the proposed iron ore cars and based on the results we could say definitively if the ore cars need to be covered or not.

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TRANSPORTATION OF IRON ORE

A PRACTICAL EXERCISE IN ENVIRONMENTAL CONTROL

G. M. DAVIES

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Abstract—At a very early stage in the planning of high speed iron-ore trains, British Rail and the British Steel Corporation concerned themselves with the possible environmental effects from iron ore "blow-off". Two trials were run, the first, using a wind jet at the Royal Aircraft Establishment, Farnborough, indicated that problems could arise from certain ores. The second trial was run on the main line between Llanwern, near Newport, and Swindon, a distance of 50 miles, at full operating speed and this confirmed the earlier findings. Control measures were tried and successfully contained the "blow-off".

Facilities for dust control designed with the experience gained from the trials have been incorporated at the appropriate loading sites.

WITH ore terminal developments at Port Talbot and Immingham, British Rail (B.R.) and the British Steel Corporation (B.S.C.) have been planning fast rail runs using continuously coupled trains designed to achieve minimum loading and discharge times. Calculations have shown that it will be most economical to use trains of twenty wagons, each 100 ton gross weight, operating at 60 m.p.h. with minimum delays. Any extra handling such as would occur by introducing covers on the wagons would appreciably affect the economics of the operation. It is expected to transport large quantities of iron ore (approximately 15 million ton*/annum) and it was realised that under the new operating conditions special precautions might be necessary to prevent the possible spread of dust along the route, which could create a nuisance to the general public and even a material loss of economic significance.

During discussions between B.R. and B.S.C. it was suggested that it might be possible to simulate the flow conditions in a wind tunnel using an ore loaded model. Although it soon became clear that an accurate simulation would not be possible, it was decided that comparative tests would prove useful.

Blowing facilities were made available at the Royal Aircraft Establishment, Farnborough and consisted of a 6 ft dia. jet blower tunnel capable of producing wind speeds up to a maximum of 120 m.p.h.

FARNBOROUGH TRIALS

Model test rig

For the trials eighth-scale models of a locomotive and three trucks were made. The containers of the model trucks were 55 in. long, 12½ in. wide and 10 in. deep. An aluminium tray 3 in. deep was fitted into each truck for most of the tests, so that

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**Conversion factors:* 1 ton = 1016 kg; 1 cwt = 50·8 kg; 1 lb = 454 g; 1 ft = 30·48 cm; 1 in. = 25·4 mm; 1 $yd^2 = 0·836 m^2$; 1 gal = 4·54 l., 1 m.p.h. = 0·447 m/s.

the amount of ore used for each test could be reduced to a manageable quantity and the loss of weight easily determined. The complete model was mounted on a British Road Services trailer (see Fig. 1) on the centre line of the tunnel with the front end of the train positioned at a distance of 12 ft from the jet tunnel outlet.

TABLE 1. R.A.E. FARNBOROUGH WIND TUNNEL TRIALS (FIRST DAY)
Two-minute runs at 60 m.p.h.: Weather—bright sunshine, cross wind, 3–4 m.p.h.

Ore	Weight of ore lost (lb/wagon)		
	Wagon 1	Wagon 2	Wagon 3
Olengorsky	13·5	9	8
Kovdorsky	50·5	34·25	19
Cerro Bolivar	5	8	1·5
Granada smalls	27	25	2
Tazadit A	7	31*	2
Labrador	0	1·75	0
Itabira	4	3	3

*Suspect weighing reading error.

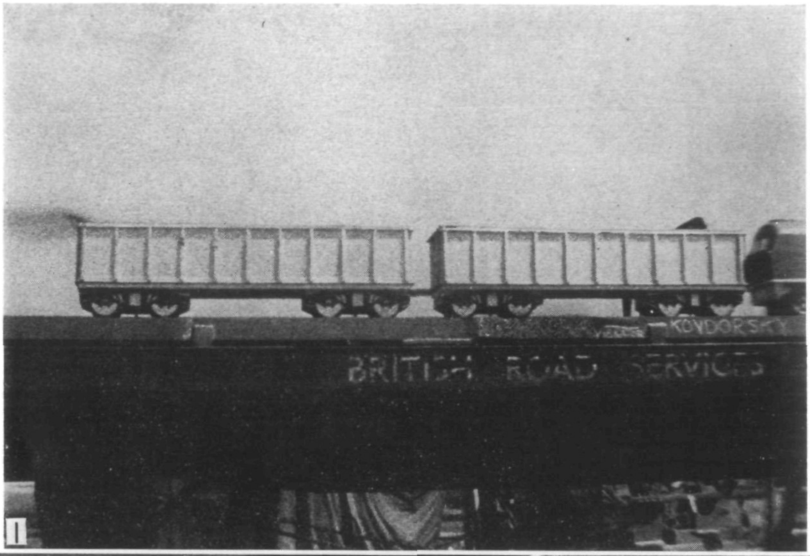
Model trials

The ores and mixes tested and listed in Table 1 are typical of the types of ores which will be used. The procedure for the earlier tests was to load each tray so that it presented a flat surface flush with the upper edge. Although it was appreciated that this was an unrealistic contour, it was felt that it would give useful indications for comparing the performances of different ores subjected to a high velocity air jet stream. Having determined the ores most likely to give trouble, further tests were carried out on them. These included heaping to simulate actual loading, and treatment with a latex spray to contain dust.

The results obtained during the two days of test, are given in Tables 1 and 2. Each trial on the first day was limited to two minutes. On the second day the runs were increased to four minutes.

TABLE 2. R.A.E. FARNBOROUGH WIND TUNNEL TRIALS (SECOND DAY)
Four-minute runs at 60 m.p.h.: Weather—bright sunshine, cross wind 3–4 m.p.h.

Ore	Weight of ore lost (lb/wagon)		Comments
	Wagon 1	Wagon 2	
Kovdorsky	85	not used	Ore poured into truck in 3 heaps topping truck sides by approx. 1 in. Very dusty
Kovdorsky	64	not used	Ore poured into truck in 3 heaps below level of truck sides by approx. 1 in.
Kovdorsky	0	73	Truck 1 filled flat to top of sides and treated with Latex. Truck 2 filled flat to top of sides
Kovdorsky	0	70·5	As in previous experiment but a petrol engine run mounted on platform to vibrate trucks
Kovdorsky	No measurement	48	Truck 1 heaped in 3 piles and treated with Latex. Truck 2 flat and 1¼ in. below top of truck sides



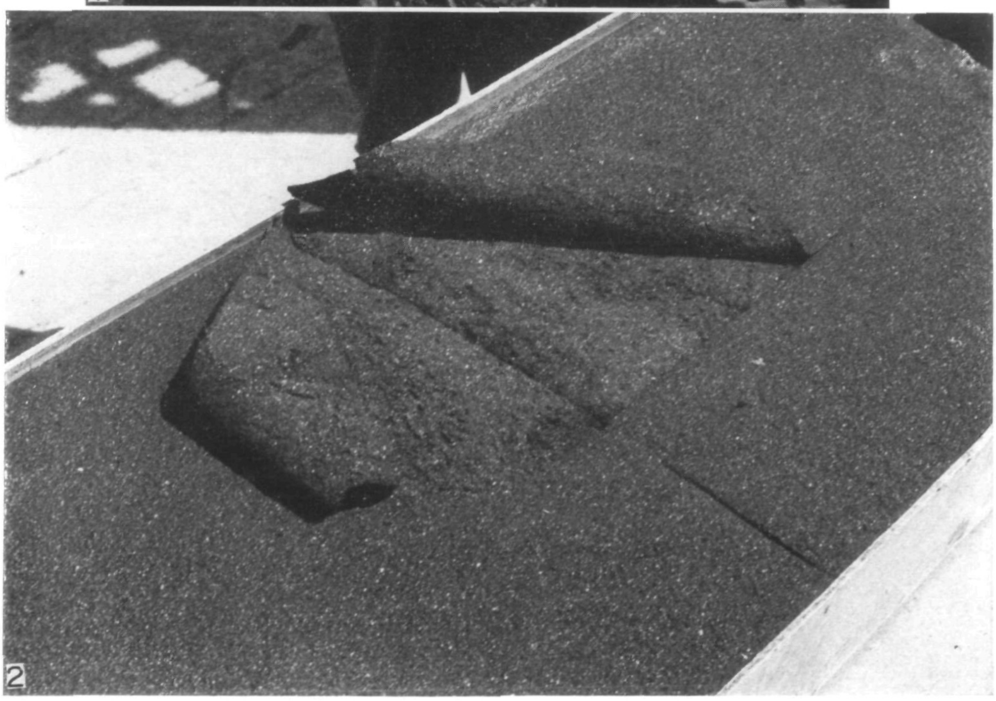


FIG. 1. Ore blow-off from model during Farnborough trials.

FIG. 2. Latex treatment of surface.

(facing page 42)

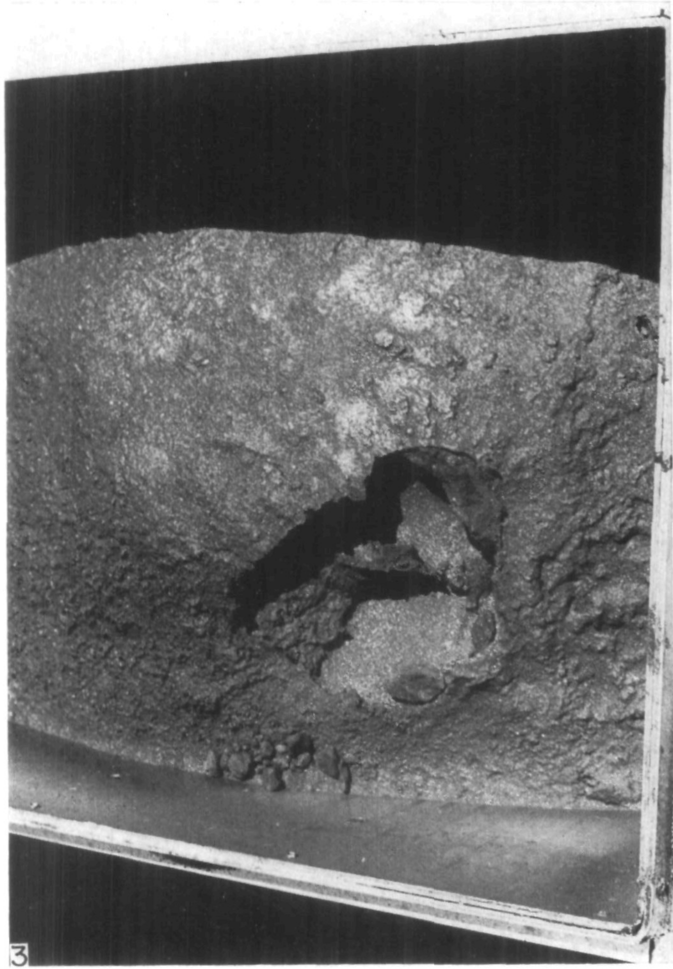

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FIG. 3. Effects of latex skin rupturing.

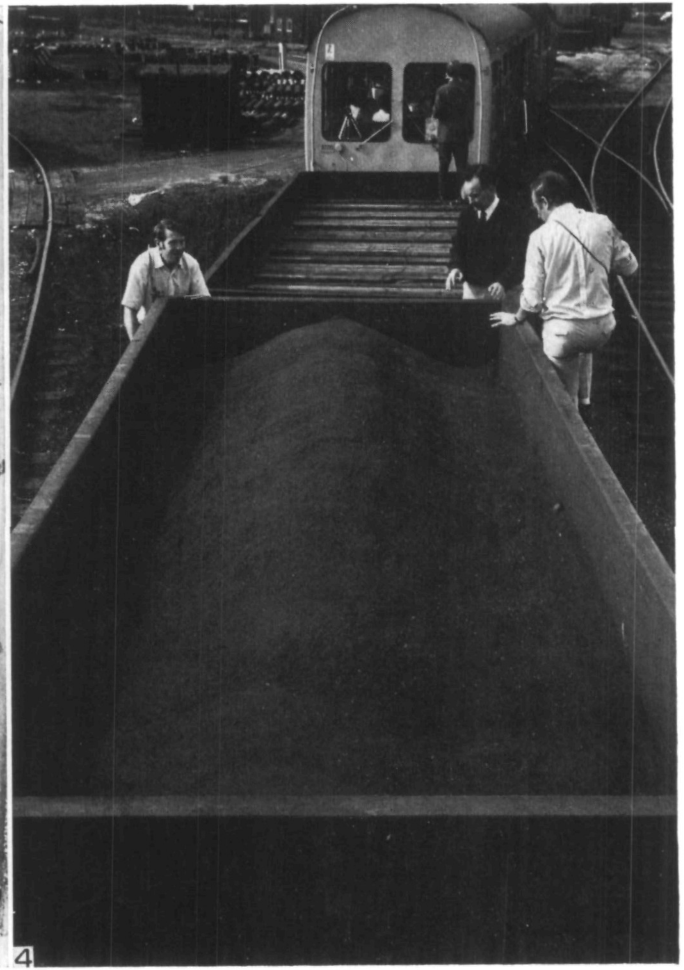
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FIG. 4. Single ridge profile.

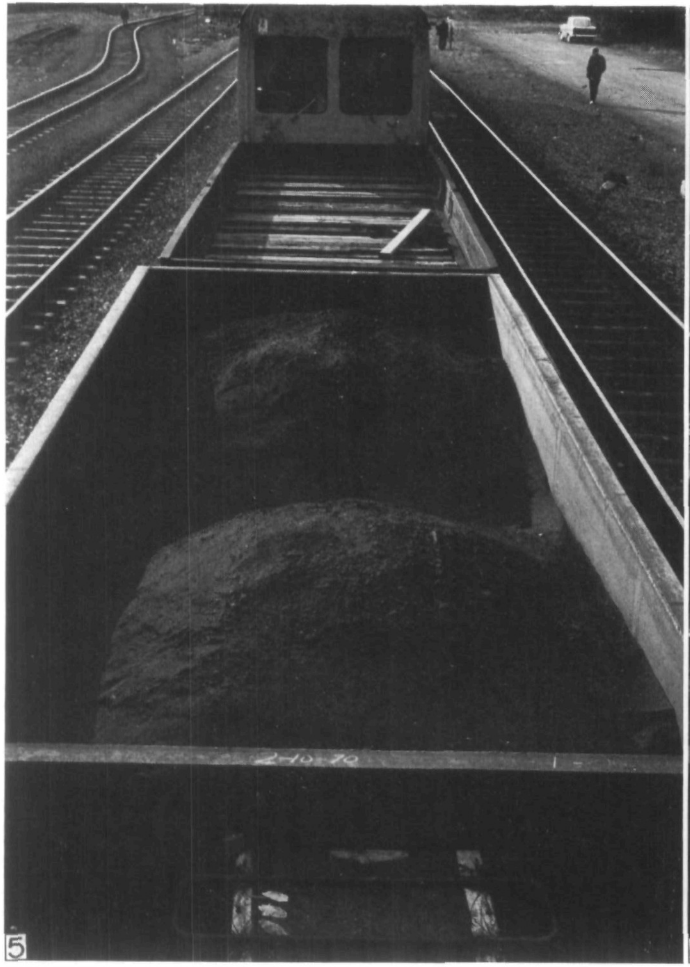

FIG. 5. Double hump profile.

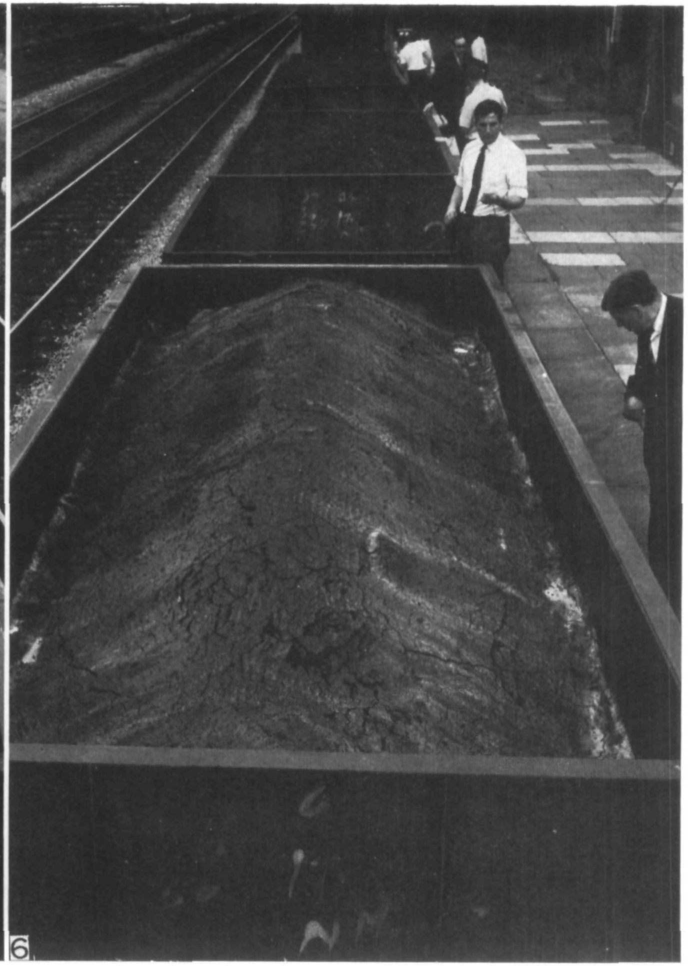

FIG. 6. Treated surface after a journey.

Apart from one result there was good agreement between the visual observations of dustiness and the measured losses in weight. During the trials on the first day with "flat tray" loadings, Labrador Blend ore showed the lowest weight loss. It was apparent that the dusty ores behaved in quite different ways. With Olengorski the dust given off diminished after the first minute, whilst Kovdorsky showed no apparent lessening after a period of two minutes. With some of the less dusty ores such as Cerro Bolivar, it was observed that larger particles of approximately $\frac{1}{4}$ in. dia., bounced across the top of the ore, and over the tail ends of the wagon to form mounds between them. It is very doubtful whether this would happen in practice as these particles would hardly clear the considerably higher " freeboard " of the full scale wagons.

Loading profile also had a considerable effect on ore loss as was shown by the results of the trials on the second day when it was decided to simulate the loading of ore in heaps as will occur in practice rather than on the flat. For this, Kovdorsky was tipped into the wagons in three similar conical heaps. Trials were made, firstly with the heaps protruding above the sides of the wagon, and secondly with the heaps below this level. As may be seen from the results in Tables 1 and 2 the differences were not conclusive.

Table 3 contains sieve analyses of the ores used in the survey and if these are examined together with the data from Table 1 it will be seen that there is some sort of relationship between sieve sizes and blow-off characteristics. For example, Kovdorsky suffered the highest blow-off weight and also had the largest amount of material in the smallest sieve range—28 %. Labrador had the lowest loss from blow-off and also the lowest quantity in the smallest size range—0·5 %. However, this relationship is far from linear and sieve analyses could not be used on their own to predict blow-off characteristics of ores.

During the tests no attempt was made to measure the effect of moisture on the dustiness of the ore. Throughout the trials the weather conditions were unusually hot and dry so that ore samples which appeared to be damp were soon dried in the shallow trays when exposed to the sun and the jet stream. This might well represent the actual situation in dry weather, but the influence of rain on the settling of dust was not established.

The effect of vibraton which would occur in practice also was not determined. It is not known whether it would have a stabilising effect on the ore by acting as a packing mechanism, or conversely agitating it to such an extent that removal by air flow would be facilitated. Having shown that certain ores, notably Kovdorsky and Olengorsky might create an unacceptable nuisance, it was decided to test the effect of a proprietary latex spray previously used successfully for controlling dust emission induced by wind around iron ore stock piles. The experiments were carried out using two wagons (Fig. 1) the one downstream was left untreated. After a five minute drying period the air jet stream was turned on. From visual observation, it was obvious that the sprayed wagon gave off virtually no dust, whilst the second wagon gave off large quantities. This was confirmed by subsequent weighings, and the results were not altered on a repeat run when some attempt was made to simulate the vibration of the full scale wagon with a small petrol engine mounted on the trailer. After these experiments the latex covering was examined by cutting and rolling back (Fig. 2).

The experiment was repeated with the ore poured into the trays in three approximately conical piles, instead of flat as in the previous test. In the early stages of the blow there was no noticeable loss from the treated wagon; but then it appeared that the latex cover fractured and pulled away and a considerable amount of dust escaped (Fig. 3). This suggested that the spray treatment required greater care with the heaped ore, so the spraying was repeated. Subsequently the wind speed was increased to 120 m.p.h. as a final test. The ore treated with the latex spray remained intact.

The trials indicated that certain ores could be expected to give trouble from dust pollution when carried in open wagons. It was therefore recommended that a full scale main-line trial should be carried out with the dustiest ores in order that the effect of treatment and loading properties could be investigated.

MAIN LINE TRIALS

Composition of train

It was agreed that for most of the trial the train should comprise one diesel loco, one engineer's observation car, an empty platefit (B.R. term for a sideless wagon), two or three loaded modified platefits, a further empty platefit and a brake van. However this formation was altered on the first day. The platefits were 30 ft 6½ in. long with the floor 4 ft 4 in. from the rail. The modifications consisted in fitting a rectangular steel box to carry the ore, 18 ft long × 6 ft 9 in. wide × 2 ft 8 in. high. It was fixed centrally on the platefit floor, the top of the box thus being about 7 ft above rail level. It was considered that the airflow over the top of the box would be sufficiently near the airflow over the top of a train of proposed wagons to give valid results, provided an empty platefit preceeded and followed the loaded test wagons.

Materials

It was decided that the Kovdorsky ore, which had produced the worst pollution at the Farnborough trials, should be used on the initial runs; however, other ores such as Olengorsky and Cerro Bolivar were available from the Llanwern Works ore stocks.

Variables monitored

(i) Weights and loss of weights of ore
(ii) Moisture content of ore
(iii) Meteorological conditions of humidity, sunshine, rain and wind characteristics
(iv) Train speed and air speed above trains if possible
(v) Loading profile of ore
(vi) Control techniques, if found necessary.

Both B.R. and B.S.C. photographic units were available to cover these events.

Procedures

The test runs carried out during the 5-day period in September 1970, were timed at 30 m.p.h. from Llanwern near Newport to Pilning and then 60 m.p.h. maximum to Swindon, with a stop at Chipping Sodbury. No operational difficulties were experienced.

No travelling or shunting shocks occurred, and over the majority of the runs, 60 m.p.h. was maintained steadily. For all tests the profile of the ore in the wagon box was arranged to be representative of that expected in practice from a discharge hopper having a long slot, except for one wagon on one day which was filled with a double hump profile representative of discharge from a two-door hopper. The profiles can be seen in Figs. 4 and 5.

The necessary loading, unloading, treatment and weighing of the wagons was carried out before the tests and between trips on the weighbridge at Llanwern. Intermediate weighing was carried out on the Locomotive Works weighbridge at Swindon. Facilities in both cases were kindly provided by the Works Managements.

DISCUSSION

The weather conditions on all five days helped in no small way in making the trials a success. The low relative humidities on the Monday, Tuesday and Thursday produced drying conditions whilst on Wednesday slight drizzle occurred and Friday was showery.

The runs are described on a daily basis:

On the first day the train comprised the locomotive, saloon, empty platefit, modified platefit loaded with Kovdorsky, empty platefit, another modified platefit loaded with Kovdorsky, empty platefit and brake van. The humidity decreased during the day from 89 per cent at 10.00 hr to 58 per cent at 16.15 hr, it was sunny most of the day and the S.E. wind speed was 12–14 m.p.h. One wagon was allowed to run without reloading all week to act as a control. The overall losses of ore from two loaded wagons, Llanwern to Llanwern were 7 cwt (5 cwt on the outward and 2 cwt on the return journey) and 7 cwt (about 4 cwt on the outwards and just over 3 cwt on the return), respectively. The wind was generally against the train on the outward journey, and with it on the return.

The process of "blow-off" appeared to be one of surface-drying by wind action, followed by saltation. A cloud of dust then appeared to come from most of the top surface. It was noticeable that the more sheltered parts of the loaded wagons (corners and to a less extent the sides) were covered, after a run, with a layer of fine dry ore, but the rest of the surface was as before, with a slight caking appearance (Fig. 4). A number of fine cracks appeared due to the load settling under vibration, but they did not get progressively worse.

During the second day the humidity decreased from 71 per cent at 09.00 hr in the morning to 54 per cent at 16.15 hr in the afternoon, it was dry all day with sunny periods; the wind was westerly with speed varying from 7–18 m.p.h. The train comprised the loco, the engineers' saloon coach, an empty platefit, the control platefit with untreated Kovdorsky, a platefit containing Kovdorsky sprayed first with water at 1 gal/5 yd^2 and then with a latex solution at 1 gal/10 yd^2, a platefit containing Kovdorsky sprayed with a bituminous emulsion material at 1 gal/2 yd^2, a further empty platefit and finally the brake van. As will be seen from Table 4 the two treated ores suffered little alteration in weight, whilst the untreated ore in the control platefit once again experienced a loss of 7 cwt (just over 2 cwt on the outward journey with the following wind and nearly 5 cwt. on the return with a head wind). It is interesting to note that unlike the previous day's trip the greater loss of weight occurred on the return trip; this might possibly have been due to the change of wind direction.

The surface on both the treated wagons developed cracks due to vibration, the latex being rather the worse of the two (Fig. 6). There was however no loss of weight, presumably because the moisture in the ore preserved a slight caking of the crack sides, and the stagnant air inside the crack caused little or no drying-out and consequent blow-off.

TABLE 3. SIEVE PARTICLE SIZE ANALYSIS

	Cumulative oversize analysis (As delivered)												
	+125 mm	+63 mm	+31·5 mm	+16 mm	+8 mm	+4 mm	+2 mm	+1 mm	+500 µm	+250 µm	+125 µm	+63 µm	+31·5 µm
Olengosky	0	0	0	0	0	0	0	0·1	2·1	26	64·2	85·6	100
Kovdorsky	0	0	0	0	0	0	0	0	4	16	44	72	100
Cerro Bolivar	0	0	0	0	0	5	22·5	41·2	58·7	75	87·4	96	100
Granada smalls	0	0	0	0	5	23	38	52	63	72·5	81·5	90·5	100
Tazadit A	0	0	0	0	4	28	43	52	59	65	75	89	100
Labrador	0	1	12·5	23·5	34	44	54	62	71	79	87	95·5	100
Itabira	0	0	0	0	1	15	26	35	39	54	70	85	100

TABLE 4. MAIN LINE TRIALS

Day	Journey	Weight loss (cwt) Wagon 1 (Control)	Wagon 2	Wagon 3	Weather
		Kov'sky untreated	Kov'sky untreated		Dry
	Llanwern–Swindon	5	3¾		Sunny
1	Swindon–Llanwern	2	3¼		SE 1–2
	Llanwern–Llanwern	7	7		
		Kov'sky untreated	Kov'sky sprayed	Kov'sky sprayed	Dry
	Llanwern–Swindon	2¼	¼		Sun/cloud
2	Swindon–Llanwern	4¾	+½		W 3–4
	Llanwern–Llanwern	7	+¼	+¼	
		Kov'sky untreated	Ol'sky untreated	Kov'sky untreated	Cloudy, drizzle a.m.
	Llanwern–Swindon	1	3¼	2¼	Sunny p.m.
3	Swindon–Llanwern	5	4¾	4	SW 6
	Llanwern–Llanwern	6	8	6¼	
		Kov'sky untreated	Ol'sky untreated	Kov'sky watered	Dry
	Llanwern–Swindon	2	+¾	+1¼	Cloudy/Sunshine
4	Swindon–Llanwern	6½	6¼	¼	WNW 4
	Llanwern–Llanwern	8½	5½	+1	
		Kov'sky untreated	Cerro Boliver untreated	Kov'sky untreated since yesterday	Dry a.m. Drizzle p.m.
	Llanwern–Swindon	1	½	0	Cloudy
5	Swindon–Llanwern	3½	+ ¾	+ ¾	WNW 5–6
	Llanwern–Llanwern	4½	+ ¼	+ ¾	

Reading to ¼ cwt (28 lb) on total weight of 26–28 tons.

The third day was cloudy with little sunshine and occasional drizzle, the humidity ranged from 94 per cent at 11.15 hr down to 61 per cent at 15.45 hr while the south westerly wind speed varied from 12 to 23 m.p.h. Two platefits (one the control) containing untreated Kovdorsky and a third containing untreated Olengorsky were studied. The control platefit lost 6 cwt on the round trip from Llanwern to Llanwern, 1 cwt on the outward and 5 cwt on the return journey and other wagons containing untreated Kovdorsky also lost an overall weight of about 6 cwt—just over 2 cwt on the outward and 4 cwt on the return journey. The wagon containing Olengorsky lost an overall weight of 8 cwt, just over 3 cwt on the outward and nearly 5 cwt on the return journey.

The weather on the fourth day was dry with sunny periods, the wind was from the west north west, speed varying between 12–20 m.p.h. and the humidity ranged from 75 per cent at 09.50 hr in the morning to 58 per cent at 16.10 hr. The control platefit suffered an overall loss of 8½ cwt (2 cwt on the outward journey and 6½ cwt on the return journey). The untreated Olengorsky ore lost 5½ cwt on the overall trip, apparently all of this on the return journey. Once again with both the untreated Kovdorsky and Olengorsky ores the major losses appeared to take place on the return journey when the train was running into the prevailing wind.

The wagon containing Kovdorsky, sprayed with untreated water at about 1 gal/1·5 yd^2 before the start of the trip, suffered no significant loss of weight.

During the final (fifth) day of the trials, the weather deteriorated from dry in the morning to showery in the afternoon. Humidity varied from 68 per cent at 09.15 hr down to 43 per cent at 12.00 hr up to 55 per cent at 17.00 hr and the westerly wind speed was from 12 to 21 m.p.h. The control platefit containing untreated Kovdorsky lost 4½ cwt (1 cwt on the outward trip and 3½ cwt on the return). For this final journey the profile of the ore in this platefit was altered from the ridge formation used previously to two heaps (Fig. 5). Another platefit carried untreated Cerro Bolivar, one of the ores which gave off very little pollution at the Farnborough trials. This behaviour was confirmed in these trials where the change in weight for the round trip was insignificant. Finally the wagon of Kovdorsky ore which had been sprayed with water on the previous morning was re-run with its surface undisturbed. Once again the change of weight was not significant.

CONCLUSIONS

(a) There could be substantial losses of some ores such as Kovdorsky and Olengorsky in certain weather conditions whilst other ores such as Cerro Bolivar should not present a problem.

The loss of 6 to 7 cwt of Kovdorsky ore per 100 miles round trip could present a potentially serious problem for two reasons:

(i) *Economics*. The wagons which will be used in the trains operated on the rapid turn-round principle will have approximately 2½ times the surface area of the ones used in the main-line trials. It is reasonable to assume that the rate of ore loss could be proportional to surface area and this could mean a loss of approximately 15 cwt per wagon. A train of 20 wagons would therefore lose something in the region of 15 tons per 100 mile journey if climatic conditions resembled those experienced during the trials. It is anticipated that 9 such trains will be run per day in the South

Wales area, and on these assumptions a daily loss of approximately 135 tons per 100 miles would be expected. At approximately £4 per ton for Kovdorsky and Olengorsky the losses would be somewhere in the region of £200 to £300 per day per 50 miles (approximate distance of the Port Talbot–Llanwern Works journey). It is worth noting that in the South Wales area there were 186 dry days in 1968 and 177 in 1969, of which 120 days in 1968 and 84 days in 1969 had easterly winds.

(ii) *Nuisance.* It was felt that the losses from Kovdorsky and Olengorsky ores could be sufficient to cause complaint both on an immediate and a longer-term basis.

On an immediate basis the ore clouds rising from the wagons would be strongly criticised as offensive to the general public. On a longer term basis the clogging of the track ballast, grit deposit on signal and permanent-way equipment, possible effects on track circuits, and damage to paintwork would be unacceptably high and the lineside residents would complain of nuisance.

(b) It was visually apparent that there was a critical wind speed (train speed and effect of natural wind) which had a pronounced effect on blow-off, this was subsequently assessed to be in the region of 40 m.p.h.

(c) Effects due to passing trains or entering or leaving tunnels, were not significant. The greatest blow-off in general occurred in open country or on embankments, with marked reduction in cuttings.

(d) All three forms of spray treatment experimented with in the trials, latex solution, a bituminous emulsion and water proved successful.

(e) Ore moisture contents as measured by a nucleonic gauge did not appear to be significantly related to losses.

(f) Both rainfall and high humidity seemed to reduce blow-off.

RECOMMENDATIONS

(a) The various ores which it is intended to transport from the main ore-ports should be tested to assess their potential as dust-producers. This could be done with a laboratory rig test.

(b) The ores which prove to be problems as indicated by (a) should be treated to contain the dust " blow-off ".

(c) Water should first be used as a form of treatment but its effectiveness should initially be continuously reviewed in various climatic conditions to ensure that it remains effective. In the event of water treatment proving inadequate the use of a latex solution or bituminous suspension or other forms of treatment should be further investigated.

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