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BEFORE THE
SURFACE TRANSPORTATION BOARD

STB Finance Docket No. 35305

ARKANSAS ELECTRIC COOPERATIVE CORPORATION – PETITION FOR DECLARATORY ORDER

OPENING EVIDENCE AND ARGUMENT OF UNION PACIFIC RAILROAD COMPANY

PUBLIC VERSION – CONFIDENTIAL AND HIGHLY CONFIDENTIAL INFORMATION HAS BEEN REDACTED

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Filing contains color.

TABLE OF CONTENTS

ATTACHMENTS

Counsel Exhibit No. 1:	BNSF Railway Company's Responses and Objections to the First Set of Interrogatories and Requests for Production of Documents of Western Coal Traffic League, Concerned Captive Coal Shippers, Entergy Arkansas, Inc., Entergy Gulf States Louisiana, LLC, and Entergy Services, Inc., Interrogatory No. 2
Counsel Exhibit No. 2:	Union Pacific Railroad Company's Objections and Responses to Western Coal Traffic League, Concerned Shippers and Entergy's First Set of Interrogatories and Requests for Production of Documents, Interrogatory No. 2
Counsel Exhibit No. 3:	General Order No. 19 (Orin Subdivision Timetable Amendments)
Counsel Exhibit No. 4:	Joint Line Agreement

VERIFIED STATEMENT OF DAVID CONNELL

Exhibit DC-1:	Dr. Erol Tutumluer's March 15, 2009 article Laboratory Characterization of Fouled Railroad Ballast Behavior
Exhibit DC-2:	UP/BNSF Orin Subdivision Dustfall Collector Network Sample Data, Nov. 2009
Exhibit DC-3:	BNSF/UP Coal Load Groomed Profile Field Testing, Sept–Dec 2005
Exhibit DC-4:	Joint Initiative Mitigation of Track Ballast Fouling, April 19, 2006
Exhibit DC-5:	BNSF/UP Chemical Dust Suppression Agents Field Testing, 9/05-8/06
Exhibit DC-6:	Ecofab Presentation, 2007
Exhibit DC-7:	Coleman Aerospace Report and Email, 2008
Exhibit DC-8:	Shannon & Wilson's Union Pacific Railroad Ballast Study: North Platte Division, dated July 30, 2008
Exhibit DC-9:	UPRR's SPRB Coal Route: Capacity Improvements 2000-2009 Trackage
Exhibit DC-10:	Shannon & Wilson's Union Pacific Railroad Ballast Study: North Platte Division, dated January 2010

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Arkansas Electric Cooperative Corporation ("AECC") alleges that BNSF Railway Company's ("BNSF's") Tariff 6041-B Items 100 and 101, with respect to its coal dust emission standard, represent an unreasonable rule or practice and an illegal refusal to provide service. In its December 1, 2009 Order, the Board instituted a declaratory order proceeding and invited interested parties to participate.

That Order identified three issues to be addressed: (1) whether BNSF's tariff provisions constitute an unreasonable rule or practice; (2) whether BNSF may establish rules designed to prevent coal dust emissions from coal trains operating over its lines; and (3) whether BNSF actions to enforce compliance with those tariff provisions would violate BNSF's common carrier obligation. *Arkansas Elec. Coop. Corp.—Petition for Declaratory Order*, STB Docket No. 35305 (STB Decision served Dec. 1, 2009) at 1. Union Pacific Railroad Company ("Union Pacific") believes that BNSF, or any railroad, can and should establish rules that promote safe, reliable and efficient transportation over its lines. Union Pacific also believes that the BNSF rules in question are reasonable because reducing coal dust emissions would promote safety, reliability and efficiency.

Although Union Pacific submits that the BNSF tariff rules in question do not apply to Union Pacific contract or common carrier customers and that BNSF has indicated no intention of refusing to allow Union Pacific trains to run over the Joint Line if they do not comply with the coal dust rules, Union Pacific reserves the right to challenge any such BNSF attempts to enforce its rules by stopping Union Pacific trains. Finally, Union Pacific is concerned that if the Board restricts BNSF's ability to adopt such rules, its own efforts to develop measures to prevent coal dust emissions on its lines in conjunction with Union Pacific customers will be impeded.

INTRODUCTION

Union Pacific is a co-owner of the Joint Line, transporter of Southern Powder River Basin ("SPRB") coal on the Joint Line for AECC and other customers, and operator of its own rail lines that transport SPRB coal.

Union Pacific and BNSF each own 50% of the Joint Line, a 102-mile stretch of railroad used to serve numerous coal mines and transport coal from Wyoming's SPRB. (Glass VS at 2; Connell VS at 3.) Under the ICC-approved Joint Line Agreement entered into by BNSF's and Union Pacific's predecessors, BNSF is the operating railroad but both railroads operate trains on the Joint Line. (Connell VS at 3-4.) Each railroad pays 50% of capacity projects on the Joint Line. Additionally, each railroad pays its share of maintenance and operating costs in proportion to each railroad's usage. (*Id.*)

Union Pacific transports coal from the SPRB for customers over the Joint Line and its own lines to destinations in 23 states across the western two-thirds of the United States. (Glass VS at 2.) Union Pacific's Joint Line-originating coal network runs from Shawnee Junction in eastern Wyoming to Fremont, Nebraska (spanning approximately

533 route miles), and south on its Kansas Subdivision to Menoken Junction, just west of Topeka, Kansas (amounting to approximately 612 route miles). (Glass VS at 3.) Union Pacific's track miles from Shawnee Junction to Fremont and Gibbon Junction to Menoken Junction total nearly 1,600. (Glass VS at 3; Connell VS at 17-18.)

Our submission will discuss the accumulation of coal dust on railroad right-of-way, describe coal dust's harm to track infrastructure and how it disrupts traffic flow, and survey methods to reduce coal dust emissions from rail cars. We also explain how we reached the conclusion that preventing the accumulation of coal dust is superior to continuous efforts to remove it. Based on the review of an independent engineering expert, BNSF's Items 100 and 101 tariff rules appear to address a legitimate concern as well as rest on significant underlying data and research. On their face, the BNSF rules do not impose unreasonable or disproportionate consequences for failure to comply. Next we explain that AECC's concern that BNSF might refuse service is unwarranted because coal shipped by rail to AECC's plants moves under long-term contracts with Union Pacific, and BNSF tariff rules do not apply to movements on Union Pacific. Finally, we address how a Board finding that the BNSF rules constitute an unreasonable practice would interfere with Union Pacific's ability to develop and implement coal dust prevention measures with its customers.

These opening arguments are supported by the accompanying verified statements of David Connell, Vice President-Engineering of Union Pacific ("Connell VS"), Douglas Glass, Vice President and General Manager-Energy of Union Pacific ("Glass VS") and independent expert witness Gregory Muleski, Ph.D of Midwest Research Institute ("Muleski VS").

Mr. Connell discusses Union Pacific's coal history in the Southern Powder River Basin, the composition of the lines Union Pacific uses to move coal, the 2005 Joint Line derailments, and the railroads' response to those derailments. He then addresses Union Pacific's research of various methods of reducing coal dust loss during transport, and the implications of coal dust removal based on the scope and rate of coal dust accumulation.

Mr. Glass explains Union Pacific's coal transportation system and Union Pacific's customer relationship with AECC. He also explains Union Pacific's concerns regarding coal dust, the importance of adopting reasonable rules that insure customers assume responsibility for their lading, that AECC's concern that its trains would be stopped is misplaced, and the pronounced and detrimental impact a Board decision finding the BNSF tariff rules unreasonable would have on Union Pacific's collaborative efforts with its customers.

Finally, Dr. Muleski summarizes his findings about the coal dust monitoring along the Joint Line and concludes based on his extensive experience that rail cars filled with coal are susceptible to erosion which results in coal dust being emitted into the airflow above the cars, that the fixed TSM location at MP 90.7 and the IDV.2 value appear to be a reasonable method to characterize airborne dust from a passing car, and that several viable and proven methods exist to mitigate fugitive coal dust.

ARGUMENT

I. Coal Dust Rules Promote Safe, Reliable and Efficient Rail Transportation

The accumulation of coal dust creates significant safety concerns regarding the stability of the track, harm to track infrastructure, and the possibility of derailments to the detriment of service to rail customers. Coal dust rules that prevent such accumulation promote safe, reliable and efficient rail transportation.

A. SPRB Coal Cars Emit Excessive Coal Dust that Threatens Track Integrity

AECC suggests that BNSF has not provided facts showing that "coal or coal dust emitted from coal cars during transit can have adverse effects on rail roadbeds, and thus overall rail operations." (AECC Pet. at 3.) AECC even goes as far to question "if there even is" a coal dust problem. (AECC Pet. at 6.) But as explained below, the overwhelming factual information and observation of railroad inspectors, maintenance personnel and scientific researchers demonstrate otherwise. (Connell VS at 9, 12-14; Muleski VS at 2-3.) The fact that coal dust is dispersed by coal trains, accumulates on railroad right-of-way, and has a harmful impact on ballast and track is well-documented by scientific and engineering studies. (Connell VS at 13-17, Ex. DC-1.)

After the two Joint Line derailments in May 2005 and the accompanying unparalleled damage and widespread instability throughout the Joint Line, Union Pacific undertook to learn how these events occurred and so that it could prevent a recurrence, has developed an understanding of how serious a threat coal dust is to rail ballast integrity.[1] (Connell VS at 5, 9-17.) "[T]he root cause of the instability of the ballast was excessive coal dust that had become unstable when mixed with the substantial

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[1] Prior to those derailments, BNSF found coal dust accumulating primarily near switches and bridges during the 2002 to 2003 time period, and increased levels of coal on the Joint Line right-of-way resulted in spontaneous fires. (Connell VS at 6.) Both railroads approved additional maintenance in those areas of concern. (*Id.*). As a result of those efforts, key indicators suggested the track was in a stable and safe condition by late 2004 and during the first quarter of 2005. (*Id.*) These indicators included a joint inspection in October 2004, a decrease in slow orders, good geometry car readings and improved volume. (*Id.*)

precipitation that had occurred on the Joint Line" that spring. (Connell VS at 9.) Extraordinary track restoration over an extended period of time was necessary to fix track stability. (Connell VS at 10-11.) The combination of ballast instability and extraordinary track maintenance resulted in slow orders and disrupted coal transportation service. (Connell VS at 10.)

Falling or blowing coal from the top of open cars as a result of wind erosion is the primary source of coal loss, although coal loss also occurs due to improper car sealing or defective bottom dump cars. (Muleski VS at 2, 4.) Coal dust fouls the ballast and is harmful because the coal dust foulants "reduce the shear strength and thus load-bearing capacity of the ballast." (Connell VS at 13.) As a result, the ballast may not be able to perform its function of distributing the load to the sub-ballast between cross ties, rails or ties may become unstable, and the possibility of derailments increases. (Connell VS at 12-13.) Research by Professor Tutumluer at the University of Illinois demonstrated "a relationship between ballast shear strength, coal dust contamination, and moisture content." (Connell VS at 13-14.)

Those 2005 events led to coal dust investigations and studies by BNSF, Union Pacific, shippers and producers to better understand the impact of coal dust on the ballast and to evaluate ways to reduce coal dust deposition on the rail right-of-way. (Connell VS at 12-16.) For example, Dr. Erol Tutumluer conducted the first detailed examination of the mechanical properties of coal dust. He concluded that the coal dust significantly compromises the shear strength of railroad ballast and that it is an unusually dangerous fouling agent, particularly if it accumulates in dry conditions and is later saturated by heavy precipitation. (Connell VS at 13-14, Ex. DC-1.) Additionally, Union Pacific, in cooperation with shippers and customers, has explored methods to prevent coal dust deposits. (Glass VS at 9-11.) The National Coal Transportation Association ("NCTA") formed three committees to study how repairs or improvements to cars, load profiling, and the application of surface sprays could reduce the loss of coal dust during coal rail transport.

The characteristics that make coal dust an unusually dangerous fouling agent are multiplied by its ability to permeate ballast and leave no outward sign at numerous locations that it has attained unacceptable levels. That allows it to accumulate without being revealed by ordinary inspection techniques until after the coal dust is wet and the damage has begun. (Connell VS at 14.)

Based on its increased understanding of the danger of accumulating coal dust to track stability and integrity, Union Pacific retained the engineering firm Shannon & Wilson, Inc. to determine coal dust levels on Union Pacific's principal main lines used to transport SPRB coal by taking core samples. (Connell VS at 16.) Shannon & Wilson found that coal dust comprises as much as 20% of the fines volume on Union Pacific's own line nearly 600 miles beyond the Joint Line. (Connell VS at 17.) Substantial volumes were found at many locations that on the surface appeared clean. This is consistent with Dr. Muleski's views that "one could expect coal dust to be lost throughout the trip." (Muleski VS at 3.)

B. Coal Dust Prevention Is Superior to Removal

AECC apparently recognizes the likelihood that the Board will conclude that coal dust impacts track stability and safety because it alternatively argues that normal maintenance can adequately address any coal dust concerns. (AECC Pet. at 3.) But coal dust continues to accumulate on coal routes despite ongoing and extensive efforts by BNSF and Union Pacific to remove it through undercutting and other maintenance activities. Track maintenance and undercutting alone cannot solve coal dust problems, and the best solution is for shippers to keep their coal in their railcars in the first place. (Connell VS at 18-19.)

As a result of the 2005 derailments, significant undercutting, shoulder ballast cleaning, tie repairs, and switch replacement and cleaning to restore the Joint Line that year and continued into 2006. Since that time, Union Pacific has expanded those efforts to areas on its own coal rail corridor, and some of those same areas on the Joint Line required cleaning again due to the rapid new accumulation of coal dust. (Connell VS at 11.)

Despite coal dust mitigation efforts, coal dust continues to accumulate at disturbing rates of deposition on the Joint Line as well as Union Pacific's main line as far as 600 miles beyond the Joint Line, a finding recently confirmed by Shannon & Wilson. (Connell VS at 17; Glass VS at 6.) Simpson Weather studied the rate of coal dust deposition on the Joint Line and methods to contain the dust. It similarly concluded that unless further mitigation measures are employed, coal dust will continue to accumulate on the Joint Line at very high rates. (Connell VS at 14.)

The increasing amount of coal dust deposition over time on its own line has required Union Pacific to undercut more frequently. (Connell VS at 11; Glass VS at 4-5.) Where before, Union Pacific expected the need to undercut main line track every eight to twenty years, it now anticipates that the same track may need to be undercut as often as every six years (and three years on switches). (Connell VS at 17.)

Undercutting hundreds of miles of Union Pacific rail corridor annually is not feasible, sustainable or acceptable, due to the significant disruption of transportation service it poses and the railroad's inability to remove all coal dust. (Connell VS at 18.) Increased undercutting and maintenance, particularly at the rates necessary to keep up with the increased accumulation rate, disrupt traffic flow and may slow down service to customers because maintenance crews are on the track more often, reducing track capacity and delaying trains. (Glass VS at 5; *see also* Connell VS at 17-18.) Based on a 6-year average undercutting cycle of Union Pacific's Joint Line-originating coal network (totaling 1590 track miles), Union Pacific would need to undercut an average of 265 miles per year on this corridor. Given average production rates for undercutting and a working season limited to approximately seven months, Union Pacific would have to deploy at least one undercutting gang nearly continuously and a second much of the time to achieve the necessary average of 1.24 miles every day of the working season. (Connell VS at 17-18.) Due to machinery and gang down-time, and necessary movement from one job site to another, it is unlikely that Union Pacific could sustain this amount of annual undercutting perpetually. (*Id.*)

Adding to the complexity of the problem, coal dust is not always visually apparent. (Connell VS at 14; Glass VS at 6.) Ballast that looks clean based on a visual inspection may have coal below the surface. (Connell VS at 14.) Finally, undercutting and ballast cleaning cannot remove all of the deposited coal dust fines that are in the ballast, and the presence of coal dust even in small amounts increases the likelihood of track-related problems and derailments. (Connell VS at 18; Glass VS at 4, 6.)

The pernicious characteristics of coal dust on the track bed and the increasing evidence of deposition beyond the Joint Line demonstrate that preventing coal dust emissions before they accumulate on the right-of-way is both necessary and appropriate. As Mr. Glass explains, the best solution is for shippers to keep their lading (in this case, coal) and the dust particles from it in the railcars and off of the right-of-way." (Glass VS at 5.)

C. Railroads Can and Should Adopt Common Sense Rules that Promote Safe, Reliable and Efficient Rail Transportation

Railroads are responsible for safely transporting freight over their lines. But railroads must depend on shippers to load freight so that it can be moved safely and remain in the cars tendered for shipment. In connection with that responsibility and in recognition that rail transportation relies on shipper, railroad and receiver cooperation, railroads have authority to adopt rules or practices related to the rail transportation they provide, including rules to promote safe and efficient operations. 49 U.S. C. § 10702(2).[2] As shown above, coal dust emissions affect both track safety and service to customers, and track maintenance efforts do not sufficiently address the problem. Thus, reasonable rules dealing with coal dust emissions from open top coal railcars promote safe, reliable, and efficient rail transportation.

In light of the track instability problems caused by coal dust, it is sensible for a railroad to adopt reasonable rules to increase the probability that customers' coal stays in the open top cars and off the railroad right-of-way. Generally, shippers are responsible for loading their freight into cars so that it remains in the car and does not fall on the

[2] AECC implicitly concedes the existence of such authority to adopt rules because it has not challenged the load profiling requirements under Items 100 and 101.

track, which creates safety risks to other trains, the railroad's track, and the right-of-way. (Glass VS at 5-6.) Similar to customer rules for other products transported by railroads, coal owners should bear responsibility for keeping their lading in the railcar after it is loaded at the mine. (Glass VS at 6.)

On Union Pacific lines, we have similar rules directed towards commodities that present particular risks if they are deposited on the track during transit. And railroad loading rules addressing coal dust emissions from unit coal train open top cars would be similar to Union Pacific's tarpaulin requirement for scrap metal or iron moving in open gondolas and netting requirement for woodchips: in both examples, loading rules require customers to take precautions to keep their lading in the railcar due to safety and track concerns. (Glass VS at 6-7.) Likewise, Union Pacific's rules concerning the transportation of soda ash in covered hoppers with the bottom gates secured help prevent leakage of that caustic substance onto Union Pacific's track. (Glass VS at 6.)

Thus, similar to rules governing other products moved by railroads, railroads should be permitted to adopt reasonable unit coal train open top car rules that address safety problems associated with shippers' coal leaving open top coal railcars and being deposited on railroad right-of-way.

II. *BNSF's Tariff Rules for Inhibiting Coal Dust Are Reasonable*

Railroad rules designed to reduce or prevent coal dust emissions from railcars operating on their lines directly address a known safety concern—accumulation of coal dust on the right-of-way—and assist railroads in performing their obligation to provide safe, reliable and efficient rail transportation. BNSF's Items 100 and 101 are not an unreasonable approach to dealing with track problems associated with the accumulation of coal dust.

A. Because Railroads Cannot Prevent Emissions by Unilateral Action, Shippers Must Change Loading Practices

Coal dust prevention cannot be achieved without securing shippers' coal in the railcars. Dr. Muleski explains that coal-loaded open-top railcars are "susceptible to wind erosion resulting in coal dust becoming incorporated into the airflow above the car," where larger coal dust particles are deposited on or near the track bed, and smaller coal dust particles become suspended in the air. (Muleski VS at 2, 5, 7.) But unilateral mitigation by a railroad cannot solve coal dust problems or prevent the causes of coal dust emissions for the following reasons: (1) shippers own the coal; (2) shippers own virtually all of the railcars used to transport SPRB coal over rail lines; (3) shippers' suppliers load the coal into the railcars; and (4) the coal is loaded before the railcars are released to the railroad for transport. (Glass VS at 9.)

Due to these circumstances, neither BNSF nor Union Pacific can take unilateral actions to keep shippers' coal (and associated coal dust) from leaving the railcars, such as by installing covers on railcars, repairing railcar holes and seams, or changing coal loading practices. Therefore, shippers must change their loading practices and/or implement railcar modifications in order to prevent coal dust emissions. Otherwise, coal dust will continue to accumulate on the Joint Line and on Union Pacific's own lines used to transport SPRB coal.

B. Coal Dust Prevention Methods Exist, More Are Being Developed, and BNSF's Tariff Rules Do Not Require any Particular Approach.

BNSF's coal dust tariff rules are performance-based instead of conduct-based, which provides flexibility and discretion to shippers. The Integrated Dust Value (IDV.2) performance standard does not require shippers to use any particular type of technology or method of reducing coal dust emissions, giving shippers various options.

Effective and viable options for preventing coal dust exist. Various methods exist to reduce coal dust emissions and accumulation of coal dust on railroad right-of-way, and others are being developed. (*Cf.* AECC Pet. at 5.) Examples of preventative methods include:

- uniformly shaping loaded coal cars in a bread-loaf shape, which Simpson Weather concludes makes them less likely to dust during rail transport;[3]
- repairing railcars to close holes and seams throughout which coal may fall, as suggested by NCTA committee studies; and
- spraying surfactant on the surface of the coal, which Simpson Weather concludes makes it "less susceptible to blowing off during transportation."

(*see generally* Connell VS at 15-16; Glass VS at 9; Muleski VS at 3, 8, 9.) In addition, efforts are underway to develop compression (using pressure or vibration or both) or car covers as additional alternatives. (Glass VS at 9-10; *see also* Muleski VS at 3, 8.)[4] A manufacturer plans to introduce a mechanical system that can compact coal in coal cars,

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[3] Coal dust emissions are "accentuated if the coal surface is higher than the car sidewalls," and the surface profile of the coal load also can affect the level of emissions. (Muleski VS at 2, 5-6.)

[4] "Compaction reduces the surface area available for erosion and smoothes the service to reduce shearing from the air." (Muleski VS at 8.)

and Union Pacific hopes to field test the system with one or more of our customers. (Glass VS at 10; *see also* Connell VS at 16.) Additionally, Union Pacific currently is evaluating covers as an alternative method of coal dust prevention and is working with manufacturers and interested parties on design and testing. (Glass VS at 10; *see also* Connell VS at 16.)[5]

Simpson Weather and the NCTA committee studies all conclude that these methods, alone or in combination, can effectively reduce coal dust emissions and the resulting accumulation on the track bed. (Connell VS at 14-16.) BNSF's tariff rules reasonably leave the decision of which preventative method, or combination of measures to use, in the hands of shippers, based on their individual needs and what is best-suited to their unique company circumstances.

C. There Is Ample Evidence to Support the Reasonableness of the IDV.2 Standard

Consistent with the goal of safe and efficient rail transportation, BNSF Items 100 and 101 explain that the purpose of the Integrated Dust Value (IDV.2) emission standard[6] is "to enhance retention of coal in rail cars." (BNSF 6041-B, Items 100-101, Ex. A to AECC Pet.) And the IDV.2 standard adopted by BNSF is not an arbitrary standard, despite AECC's suggestions otherwise. (AECC Pet. at 1, 4, 6.) Instead, ample evidence supports the reasonableness of BNSF's IDV.2 standard.

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5 Dr. Muleski concludes that "[c]overing the coal very effectively prevents wind erosion by isolating the coal surface from the wind." (Muleski VS at 8.)

6 BNSF's tariff rule, Item 100 (which applies to the Joint Line), states that trains shall not emit more than an IDV.2 of 300 units. An IDV.2 unit is "a measure of the volume of coal dust coming off of the coal train over its entire length." (Ex. A to AECC Pet.)

Scientific researchers agree that coal dust has a harmful impact on track ballast. And coal dust continues to accumulate on coal routes, despite railroads' ongoing efforts to remove coal dust by undercutting and other maintenance activities. (Connell VS at 16-17; *see generally* Muleski VS at 3-6.) In light of these facts, BNSF's coal dust emission standard is not an unreasonable approach to addressing coal dust problems. (*See generally* Muleski VS at 6-9.)

AECC opines that the provisions of Items 100 and 101 are without justification, but it fails to acknowledge the underlying coal dust problems or to fairly evaluate the process BNSF undertook in the development of the IDV.2 standard. First, BNSF studied the coal dust situation, collected dusting event data on the Joint Line, and analyzed the accumulated data before developing a performance standard, all reasonable steps.

Second, BNSF's testing process and development of an Integrated Dust Value approach are not unreasonable. "The general description of how the IDV.2 value is calculated appears to be a reasonable method to characterize airborne dust from a single train passage." (Muleski VS at 9.) For example, the location of the Track Side Monitor equipment at milepost 90.7 on the Joint Line was based on the balancing of various factors, including access to utility services, ease of maintenance, interference with railroad operations, security, and ambient conditions, and is reasonable for the testing performed. (Muleski VS at 6-7.) Similarly, it is reasonable to conclude that an "event with a higher IDV value corresponds to more mass being deposited on the right-of-way," assuming wind conditions are similar, "[b]ecause (a) airborne dust at the sampling location is due to erosion of the coal surface and (b) large (saltating) particles are necessary for erosion." (Muleski VS at 8, 9.)

D. It Is Premature for the Board to Find BNSF Rules Unreasonable Because There Are No Negative Consequences to Weigh Against the Benefits

It would be premature for the Board to decide that the BNSF rules are unreasonable and invalidate them at this time. The rules do not establish any negative consequences for shippers whose trains do not comply, so shippers cannot be injured by the rules as they exist. Items 100 and 101 do not contain any enforcement provisions, and BNSF has not announced any plans to enforce the coal dust emission standards in those tariff rules. (BNSF's Obj. & Resp. to WCTL's et al.'s 1st Set of Interr. & Req. for Prod. of Docs., Interr. No. 2 [Counsel's Ex. 1].)

In particular, ABCC's concern that BNSF will refuse to move trains that do not comply with the standards is misplaced and unwarranted in Union Pacific's view. For reasons stated below in Part III, these rules do not apply to AECC. Moreover, stopping Union Pacific trains because their emissions exceeded the IDV.2 would be ineffective. A Union Pacific train must already be released from the mine and moved as much as 75 miles and at least 28 over the Joint Line before it can pass the monitor at mile post 90.7, the device that measures the emission. (*See generally* Glass VS at 8 and n.1; *see generally* Connell VS at 3, illustration.) By the time the data on the train is captured and analyzed, the train will have likely covered the remaining 27 miles to the end of the Joint Line. *Id.* So if this is a Union Pacific train, it will have passed Shawnee Junction at MP 117.1 and be on Union Pacific line by the time BNSF would have reason to stop the train. *Id.*

If and when the BNSF adopts definite enforcement mechanisms, the Board can then assess whether the benefits of the rules outweigh the drawbacks based on facts and not speculation. Until then, hypothetical penalties cannot be fairly weighed against the probable benefits of the BNSF rules.

Allowing the BNSF rules to remain in effect at this time will deliver benefits. The accumulation of coal dust unquestionably causes serious problems. Methods to control coal dust exist; others are being developed. The existence of the BNSF rules and the necessity to continue monitoring and measuring will add to the data and information available on the absolute and relative efficacy of those methods.

III. AECC's Concern that BNSF Would Stop Movement of Trains Is Misplaced and Unwarranted

AECC, without any factual basis, asserts that "BNSF threatens to refuse to allow trains handling the shipper's cars to operate over . . . [the Joint Line] or otherwise penalize the shippers," presumably concerned that its own coal shipments will be impacted. (AECC Pet. at 1, 6.) But any fears weighing on AECC's shoulders are misplaced and the result of misconceptions about the nature and scope of the provisions in BNSF's Item 100 in Tariff 6041-B.[7]

A. BNSF Tariff Rules Do Not Apply to AECC Coal that Moves Under Union Pacific Contracts

AECC is <u>not</u> a customer of BNSF, a point immediately acknowledged by BNSF. (BNSF Reply to AECC Pet. at 3, 7.) Therefore BNSF's tariff rules do not apply to AECC shipments. Instead, AECC is Union Pacific's customer: AECC owns an interest in three coal-fired power plants, all of which are subject to long-term contracts with Union Pacific under 49 U.S.C. § 10709. (Glass VS at 3-4.)

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7 Item 101 applies to the BNSF Black Hills subdivision. Union Pacific has no ownership interest in or trackage rights over those tracks and Union Pacific trains do not operate over that line. Accordingly, only Item 100 which applies to the Joint Line could conceivably be relevant to Union Pacific's trains carrying AECC coal.

BNSF's tariff rules do not bind Union Pacific customers any more than Union Pacific tariff rules can bind another railroad's customers. While railroads providing transportation are to establish reasonable rules and practices on matters related to the transportation that the railroad provides, those rules are for transportation that the railroad establishing the rules provides. 49 U.S.C. § 10702(2). Moreover, transportation under § 10709 contracts is not subject to the Interstate Commerce Commission Termination Act ("ICCTA"), including § 10702. *See* 49 U.S.C. § 10709(c)(1).

B. BNSF Has Not Stated It Will Stop Union Pacific Trains From Operating

Union Pacific has received no information that BNSF intends to enforce the provisions of traveling on the Joint Line by refusing to allow Union Pacific trains to move. (Glass VS at 7; UP's Obj. & Resp. to WCTL's et al.'s 1st Set of Interr. & Req. for Prod. of Docs., Interr. No. 2 [Counsel's Ex. 2].) Nor do the tariff rules contain any enforcement provisions. BNSF's discovery responses likewise state that it is not formally considering any penalties or consequences for failing to comply with Items 100 and 101 and that no decisions have been made regarding such penalties or consequences. (BNSF's Obj. & Resp. to WCTL's et al.'s 1st Set of Interr. & Req. for Prod. of Docs., Interr. No. 2. [Counsel's Ex. 1].)

While BNSF operating rules for the Joint Line can govern Union Pacific, its coal-dust related operating rules are not at issue in this proceeding.[8] Nevertheless, BNSF's coal dust operating rule, General Order No. 19 (Orin Subdivision Timetable Amendments) poses no threat to AECC or other Union Pacific customers because it

[8] AECC specifically cited two BNSF tariff rules. Its petition was silent on BNSF operating rules.

contains no provision authorizing BNSF to stop or refuse to allow a non-complying train to move over the Joint Line. (General Order No. 19 [Counsel's Ex. 3].) Nor has BNSF notified Union Pacific that it would do so. (Glass VS at 8.)[9] Moreover, for the reasons explained in II.D., it would be counterproductive for BNSF to stop Union Pacific trains just as they were leaving the Joint Line.[10]

Thus, BNSF's rules addressing coal dust, whether found in BNSF Tariff 6041 or in BNSF's operating rules, should not impact Union Pacific's movement of coal for AECC or other Union Pacific customers.

C. If BNSF Were to Stop Union Pacific Trains in the Future, Union Pacific Would Seek Immediate Relief

BNSF's authority to issue and apply operating rules to the detriment of Union Pacific and its customers is limited. The Joint Line Agreement requires that BNSF control the Joint Line, and that its direction shall be without discrimination. (Joint Line Agreement, Section 2.1. [Counsel's Ex. 4].) BNSF operating rules must be reasonable, just and fair, and trains of both owners given equal dispatch. (*Id.*, Section 2.7.) Accordingly, BNSF cannot interfere with Union Pacific trains operating over the Joint Line because they are emitting too much coal dust unless it does so for its own trains as well.

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9 *See also* UP's Obj. & Resp. to WCTL's et al.'s 1st Set of Interr. & Req. for Prod. of Docs., Interr. No. 2 [Counsel's Ex. 2]. Similarly, based on BNSF answers in discovery, BNSF has formed no intention to do so. (BNSF's Obj. & Resp. to WCTL's et al.'s 1st Set of Interr. & Req. for Prod. of Docs., Interr. No. 2. [Counsel's Ex. 1].)

10 All of the Joint Line mines are located on the northern half of the Joint Line, but the monitoring station that would measure the emissions on loaded Union Pacific trains is located near the southern end where all Union Pacific trainloads exit the Joint Line.

Should BNSF modify its operating rules in the future to provide that it can stop trains or otherwise begin to interfere with their operations solely because they are emitting too much coal dust, and then apply the rule in a manner that interferes with Union Pacific's contractual or common carrier obligations to its customers, Union Pacific will seek immediate relief, challenging the rules and their application. (Glass VS at 8.) But this is hypothetical and speculative, and should not be addressed now in the absence of actual facts that allow a judgment of whether the BNSF actions are reasonable.

IV. A Board Finding the BNSF Rules Unreasonable Would Interfere with Union Pacific's Ability to Develop Coal Dust Emission Prevention Measures in Conjunction with its Customers

By ruling now that BNSF's tariff rules are unreasonable or by narrowly defining what constitutes a reasonable rule, the Board's decision would chill Union Pacific's ongoing efforts to collaborate with its customers on the reduction of coal dust deposits. (Glass VS at 9-13.) As a result, the Board's decision would interfere with Union Pacific's ability to provide safe, reliable and efficient rail transportation to our customers by inhibiting cooperation from customers and by limiting our responses to coal dust to those that are within the sole control of a railroad.

Union Pacific has a demonstrated history of collaboration with our customers in developing and implementing technology and methods that improve service and operations. (Glass VS at 11-12.) Successes include the deployment of distributed power, adoption of higher capacity cars, shifting to longer trains, and improved mechanical inspections and repairs that dramatically reduced equipment-caused derailments. (Glass VS at 11-12.) None of these could be achieved by Union Pacific or the customer acting alone. . Each effort has delivered benefits in safety or reliability or both. All required communication and sharing of information over time to accomplish.

The example of the reduction in equipment-caused derailments illustrates this process well. In response to a number of broken wheel and axle derailments involving heavy-haul cars, Union Pacific conducted a comprehensive mechanical evaluation. Based on this research, we adopted a number of improvements on our own coal cars that were in heavy-haul coal service. To further reduce equipment-caused derailments, in April 2005 we reached out to customers asking that they voluntarily follow the same inspection and repair standards that we were using for our cars. In late 2006, we incorporated those standards as recommendations in our Wyoming rules circular. At the beginning of 2008 we adopted these standards as requirements in the rules circular. The number of derailments caused by equipment failure declined from 17 during 2002 to only six in 2008. (Glass VS at 12.) We shared information about why the changes were necessary and the resulting reduction in derailments. We also provided time to become familiar with and to understand the new standards. (*See generally* Glass VS at 12.)

Union Pacific is following the same process on coal dust. Unlike the program for the prevention of mechanically-related derailments, however, where we had access to all of the information we needed on the causes of derailments, we require the active assistance of our customers to collect and refine data and to develop alternative technologies to control coal dust. We have two projects underway that will share data and information on coal dust prevention with our customers. One will share the coal dust emissions data collected at the Track Station Monitors located on the Joint Line and on Union Pacific's South Morrill subdivision. The other will share visual images of actual load profiles of customers' loaded cars on the Joint Line. Both sets of data will be available to Union Pacific customers and their mines via a secured website. The information will allow the shippers, mines and Union Pacific to observe the amount of dust emitted from the trains as well as the consistency of loading profiles. (Glass VS at 10-11.) The ability to collect this data will enhance our ability to measure the effectiveness of prevention methods for individual trains and trends over time. In order to test other methods for limiting coal dust emissions, such as compression, we will require active cooperation of some mines and customers to test the technique because the cars, the coal and the loading facilities belong to them, not Union Pacific.

A Board decision rejecting or curtailing aspects of BNSF's coal dust tariff rules will discourage customer participation in coal dust discussions and demonstrations with Union Pacific and halt our progress toward reaching informal agreements with customers concerning the reduction of their coal dust emissions. (Glass VS at 13.)

CONCLUSION

Accumulating coal dust on railroad ballast and other areas of the right-of-way is a significant and ongoing concern impacting the safe and efficient transportation of SPRB on the Joint Line and Union Pacific's coal routes on its own rail line. In furtherance of railroads' obligation to provide safe and efficient coal transport over their rail lines, the Board should permit railroads to adopt reasonable rules to prevent coal dust emissions from open top coal cars and the subsequent accumulation of coal dust on rail lines. A Board decision that concludes BNSF's Item 100 and 101 are unreasonable or that narrowly and prematurely defines the scope of reasonable enforcement provisions will both discourage communications between railroads and coal customers and chill Union Pacific's efforts to work with its customers on developing coal dust solutions.

Dated: March 16, 2010

Respectfully submitted,

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COUNSEL'S EXHIBIT 1

BEFORE THE
SURFACE TRANSPORTATION BOARD

STB Finance Docket No. 35305

PETITION OF ARKANSAS ELECTRIC COOPERATIVE FOR A DECLARATORY ORDER

BNSF RAILWAY COMPANY'S RESPONSES AND OBJECTIONS TO THE FIRST SET OF INTERROGATORIES AND REQUESTS FOR PRODUCTION OF DOCUMENTS OF WESTERN COAL TRAFFIC LEAGUE, CONCERNED CAPTIVE COAL SHIPPERS, ENTERGY ARKANSAS, INC., ENTERGY GULF STATES LOUISIANA, LLC, AND ENTERGY SERVICES, INC.

BNSF Railway Company ("BNSF"), pursuant to 49 C.F.R. §§ 1114.26 and 1114.30, hereby responds and objects to the First Set of Interrogatories and Requests for Production of Documents served by Western Coal Traffic League, Concerned Captive Coal Shippers, Entergy Arkansas, Inc., Entergy Gulf States Louisiana, LLC, and Entergy Services, Inc. (collectively "WCTL") on December 18, 2009 ("WCTL's First Set of Discovery Requests").

GENERAL OBJECTIONS AND

OBJECTIONS TO DEFINITIONS AND INSTRUCTIONS

The following general objections and objections to definitions and instructions are made with respect to WCTL's First Set of Discovery Requests.

1. BNSF objects to WCTL's First Set of Discovery Requests to the extent they seek documents that contain confidential and proprietary information relating to

relating to coal dust emissions: Cordilleran Environmental Consultants, General Electric Railcar Services Corporation (along with Operations Management International, Inc.), Six-Sigma Qualtec, Smarter Solutions, Inc., and Zeta-Tech Associates, Inc.

Interrogatory Number 2:

Please identify any penalties or consequences that BNSF has considered, discussed, or otherwise reviewed, relating to any trains operating on the Joint Line or Black Hills Sub-Division, including UP trains that are operated on the Joint Line, that fail to comply with Items 100 and 101 of BNSF's Price List 6041-B.

BNSF Response: BNSF objects to Interrogatory Number 2 to the extent it seeks information relating to compliance with Items 100 and 101 of BNSF's Price List 6041-B that is protected from disclosure by the attorney-client privilege, the work product doctrine, or any other privilege. Subject to and without waiving its specific and general objections, BNSF states that no formal non-privileged consideration has been given to specific penalties or consequences relating to trains that fail to comply with Items 100 and 101 of BNSF's Price List 6041-B, no decisions have been made regarding such penalties or consequences, and no actions have been taken to enforce compliance with Items 100 and 101 of BNSF's Price List 6041-B.

Interrogatory Number 3:

Identify any Federal or State agencies, departments or governmental authority that raised concerns relating to the release of coal dust from railcars and/or the accumulation of coal dust on the Joint Line. For each such agency please identify:

a. The agency, department or governmental authority involved;

b. The nature of the concerns raised;

c. Any regulatory steps that may have been contemplated to minimize the release and/or accumulation of coal dust, including any proceedings or investigations that may have been instituted; and

d. Any conclusions, recommendations, findings, reports, or other action ordered by the agency, department or governmental authority involved.

__Request for Production Number 34:__

Produce all documents identified in your answer to Interrogatory No. 5, supra.

BNSF Response: BNSF states that it did not identify any documents in its response to Interrogatory Number 5.

__Request for Production Number 35:__

Produce all documents identified in your answer to Interrogatory No. 6, supra.

BNSF Response: BNSF states that it did not identify any documents in its response to Interrogatory Number 6.

__Request for Production Number 36:__

Produce all documents identified in your answer to Interrogatory No. 7, supra.

BNSF Response: As stated in response to Interrogatory No. 7, BNSF will produce the names of persons whose files were searched in response to these discovery requests.

Respectfully submitted,

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ATTORNEYS FOR
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January 8, 2010

COUNSEL'S EXHIBIT 2

BEFORE THE
SURFACE TRANSPORTATION BOARD

STB Finance Docket No. 35305

ARKANSAS ELECTRIC COOPERATIVE CORPORATION – PETITION FOR DECLARATORY ORDER

UNION PACIFIC RAILROAD COMPANY'S OBJECTIONS AND RESPONSES TO WESTERN COAL TRAFFIC LEAGUE, CONCERNED SHIPPERS AND ENTERGY'S FIRST SET OF INTERROGATORIES AND REQUESTS FOR PRODUCTION OF DOCUMENTS

Union Pacific Railroad Company ("UP") responds to Western Coal Traffic League's, Concerned Captive Coal Shippers', Entergy Arkansas, Inc.'s, Entergy Gulf States Louisiana, L.L.C.'s, and Entergy Services, Inc.'s (collectively, all five entities, "Propounding Parties") First Set of Interrogatories and Requests for Production of Documents ("Discovery Requests") as follows:

GENERAL OBJECTIONS

UP objects to each and every one of the Propounding Parties' Discovery Requests as noted below. In addition to its General Objections, UP's specific objections are stated at the beginning of the response to each request.

1. UP objects to the Discovery Requests because the Board, in its Decision, served on December 1, 2009, provided that discovery would only be permitted "among BNSF, AECC, and any other shippers potentially affected by the tariff, including shipper organizations that represent those shippers." *Arkansas Elec. Coop Corp.—Petition for Declaratory Order*, STB Docket No. 35305 (STB served Dec. 1, 2009) at 3. The Board did not permit discovery from

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discuss this matter with the Propounding Parties if this is of concern with respect to any particular answer.

INTERROGATORIES

INTERROGATORY NO. 1: **Identify all consultants, consulting firms, and/or engineering companies that have been retained by UP and/or UP and BNSF jointly, to perform or prepare any studies, analyses, investigations, reports, and any and all field work or field monitoring activities (whether on UP property, BNSF property, jointly owned property, mine property, etc.), relating to the release and/or accumulation of coal dust and its potential or actual impacts on rail operations, track maintenance, rail economics or environmental concerns.**

ANSWER: UP objects to Interrogatory No. 1 to the extent that it seeks information used in connection with other litigation, including but not limited to the identification of experts retained in other litigation, disputes and/or proceedings. UP further objects to this interrogatory because it is unreasonably cumulative and unnecessarily duplicative to the extent the information sought from UP was initially and also requested from BNSF.

Subject to and without waiving these objections and UP's General Objections, UP identifies the following entities as consultants or engineers that UP has retained, individually, outside of litigation: Simpson Weather Associates, Charlottesville, VA; Conestoga-Rovers & Associates, Farmers Branch, TX; Shannon & Wilson, Inc., Seattle, WA.

INTERROGATORY NO. 2: **Please identify any penalties or consequences that UP has discussed, been advised of, or otherwise reviewed, relating to any UP trains operating on the Joint Line that fail to comply with Item 100 of BNSF's Price List 6041-B, including but not limited to any potential threat that BNSF may refuse to allow trains operated by UP to move over the Joint Line because of non-compliance with Item 100, as referenced at page 3 of UP's Petition.**

ANSWER: UP objects to Interrogatory No. 2 as it misstates and mischaracterizes UP's Petition because UP's Petition is the best evidence of its content and terms. UP further objects to this interrogatory because it seeks legal conclusions, and necessarily requires the disclosure of counsel's mental impressions and/or information that is protected by the attorney/client privilege. UP also objects to this interrogatory as vague because the terms "penalties" and "consequences" are undefined and thus, answering this interrogatory would require UP to do so based on conjecture. UP further objects to this interrogatory as vague to the extent it seeks information about communications between UP and its customers about BNSF's intentions because the Propounding Parties are able identify any such communication—if any exists—they had with either UP or BNSF. UP also objects to this interrogatory to the extent it seeks information based on hearsay and/or speculation in that such information is neither relevant nor reasonably calculated to lead to the discovery of admissible evidence. UP also objects to this interrogatory as overly broad and unduly burdensome to the extent it requests UP to search for information based on pure speculation.

Subject to and without waiving these objections and UP's General Objections, UP states that BNSF has not indicated to UP what plans, if any, it has to enforce BNSF's Item 100 of BNSF's Price List 6041-B and that UP has received no information that BNSF intends to apply any penalties to UP trains operating over the Joint Line. UP refers Propounding Parties to UP's July 17, 2009 customer communication, wherein UP advised its customers that "BNSF has not indicated to UP that it plans to take steps to prevent UP from operating trains that do not comply" with BNSF's Item 100 or BNSF's operating rule, General Order No. 19. UP also refers Propounding Parties to BNSF's Response to Interrogatory No. 2 from BNSF's Responses and Objections to the First Set of Interrogatories and Requests for Production of Western Coal Traffic League, Concerned Captive Coal Shippers, Entergy Arkansas, Inc., Entergy Gulf States Louisiana, LLC, and Entergy Services, Inc.

<u>INTERROGATORY NO. 3:</u> Please identify, by name, title and address, the person(s) who prepared each answer to these Interrogatories and who reviewed and selected the

Dated: January 12, 2010

Respectfully submitted,

SHOOK, HARDY & BACON L.L.P.

By: ______________________

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COUNSEL'S EXHIBIT 3

REDACTED

COUNSEL'S EXHIBIT 4

REDACTED

BEFORE THE
SURFACE TRANSPORTATION BOARD

STB Finance Docket No. 35305

ARKANSAS ELECTRIC COOPERATIVE CORPORATION—PETITION FOR DECLARATORY ORDER

VERIFIED STATEMENT OF DAVID CONNELL

TABLE OF CONTENTS

DC- 4	**Joint Initiative Mitigation of Track Ballast Fouling, April 19, 2006**
DC- 5	**BNSF/UP Chemical Dust Suppression Agents Field Testing, 9/05-8/06**
DC- 6	**Ecofab Presentation, 2007**
DC- 7	**Coleman Aerospace Report and Email, 2008**
DC- 8	**Shannon & Wilson's Union Pacific Railroad Ballast Study: North Platte Division, dated July 30, 2008**
DC- 9	**UPRR's SPRB Coal Route: Capacity Improvements 2000-2009 Trackage**
DC- 10	**Shannon & Wilson's Union Pacific Railroad Ballast Study: North Platte Division, dated January 2010**

Appendix:

DC- App. 1	**Workpapers supporting calculation of rate of production for undercutting**

VERIFIED STATEMENT OF
DAVID CONNELL

My name is David Connell. I am the Vice President–Engineering of Union Pacific Railroad Company ("Union Pacific"). I was promoted to this position in 2008. I am responsible for the day-to-day operation of the Engineering Department, which includes overseeing track, bridge and signal maintenance and new construction.

I began my career with Union Pacific in 1983 and I have held a variety of positions with the company, including Director of Track Maintenance, General Director of Engineering Technology, Chief Engineer–Central Region, and Assistant Vice President–Engineering-Construction. I have a BS degree in Civil Engineering from North Carolina State University. I am a member of the American Railway Engineering and Maintenance-of-Way Association ("AREMA"), and have served on various AREMA committees, including Committee 5, Track. I also co-chair the American Association of Railroads (AAR) Heavy Axle Load, Engineering Research Committee. I recently served as chair of the Transportation Research Board's Committee on Railway Track System Design. I am also on the Advisory Board of the Mid-America Transportation Center, which steers research sponsored by the DOT over six affiliated university systems in the mid-west.

I. Introduction

Based on our experience in attempting to mitigate coal dust on Union Pacific's coal lines, and on the independent studies by the University of Illinois and the engineering firm of Shannon & Wilson, Inc. relating to coal dust in railway ballast, we have concluded that track maintenance alone is not a solution to the coal dust problems.

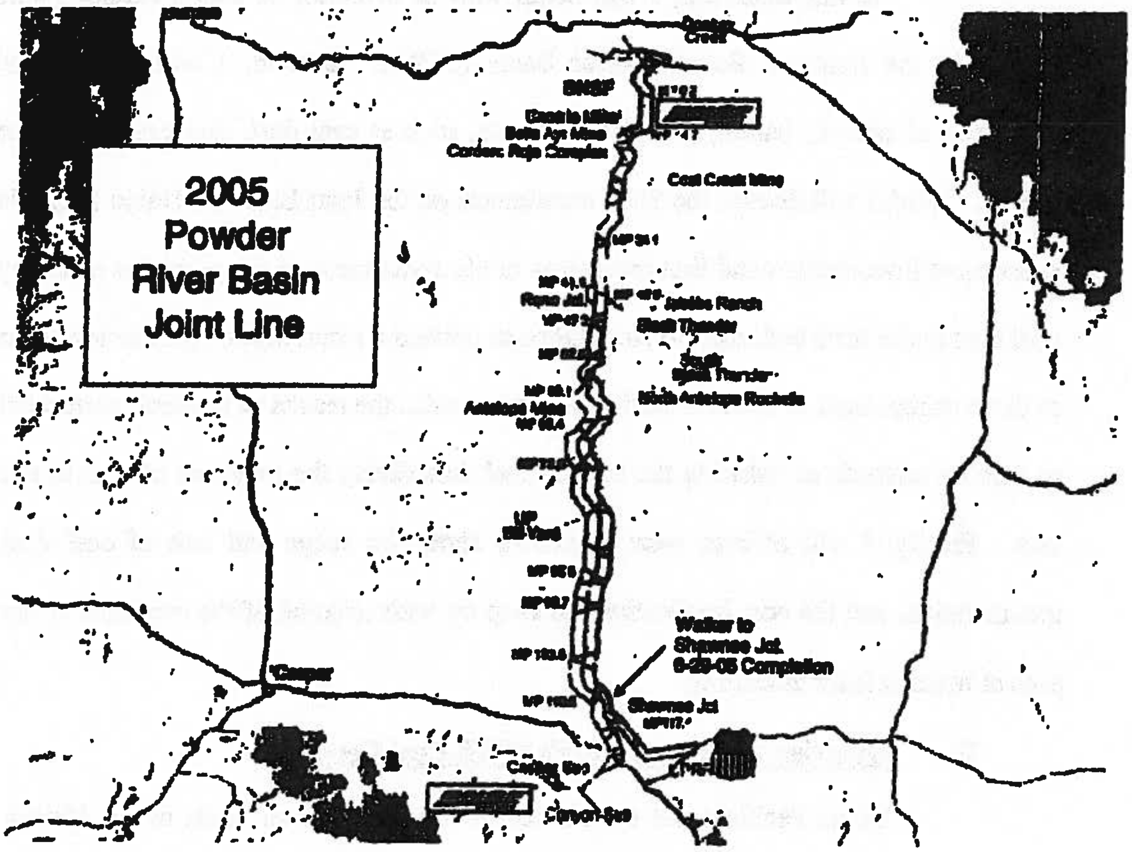
Coal dust is an unusually pernicious fouling agent that can quickly become a serious threat to track stability when it becomes wet. Undercutting does not remove all of the coal dust fines that are in the ballast and cannot be sustained at the rate that the coal dust is accumulating on the Union Pacific mainlines in Wyoming, Nebraska and Kansas. Further, undercutting, especially at the rates necessary to try to keep up with the accumulation rate, disrupts service to customers. After substantial investigation and study of the problem, our conclusion is that the best solution is to keep coal dust inside the rail cars (and out of the ballast) in the first place.

In this statement, I will begin with an overview of Union Pacific's coal history in the Southern Powder River Basin (SPRB). Second, I will address the properties of railroad ballast and fouling agents, such as coal dust, that can destabilize ballast. Third, I will discuss the 2005 derailments on the Joint Line and Union Pacific's subsequent investigation and first awareness of the seriousness of the problems posed by coal dust in the track bed, and the steps taken to prevent a recurrence of problems similar to those encountered in 2005. Fourth, I will summarize the results of research performed to date on methods of reducing the loss of coal dust during the transport of coal in rail cars. Finally, I will address what is known about the scope and rate of coal dust accumulation, and the cost implications to keep up with removal of the coal dust at the pace at which it is accumulating.

II. Overview of Union Pacific's SPRB Coal Corridor

Union Pacific's rail system covers the western two-thirds of the United States. Currently, there are more than 32,000 miles of track in the Union Pacific rail system. More than 40% of Union Pacific's revenue ton-miles involve the transportation of coal, with the vast majority concentrated in our SPRB coal corridor, which extends from eastern Wyoming, across Nebraska and stretching into northeast Kansas.

Coal production first began in the mid-70s in the SPRB and has grown to approximately 344 million tons per year in 2009. The southern and largest portion of the SPRB is served by both Union Pacific and BNSF Railway using the 102-mile-long multiple track Joint Line that runs from Shawnee Junction, Wyoming, on the south to Caballo Junction, Wyoming, on the north. The illustration below shows the configuration of the Joint Line in 2005.



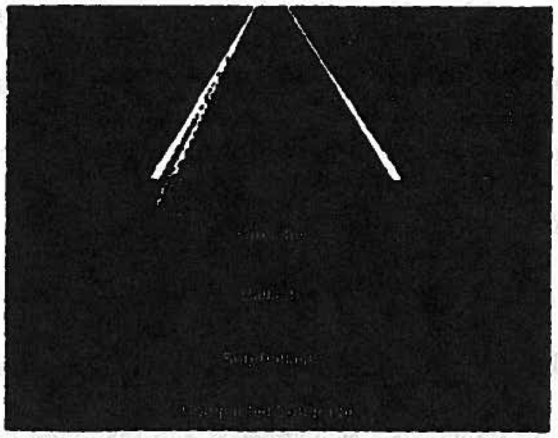
Union Pacific and BNSF each own 50% of this line under an ICC-approved Joint Line Operating Agreement. Under the Joint Line Agreement, BNSF operates, maintains and dispatches the Joint Line. Union Pacific has the right to operate trains over the line. BNSF, as the designated operator, inspects the Joint Line frequently and Union Pacific, as co-owner, participates in joint inspection trips to evaluate track conditions and discuss BNSF maintenance plans.

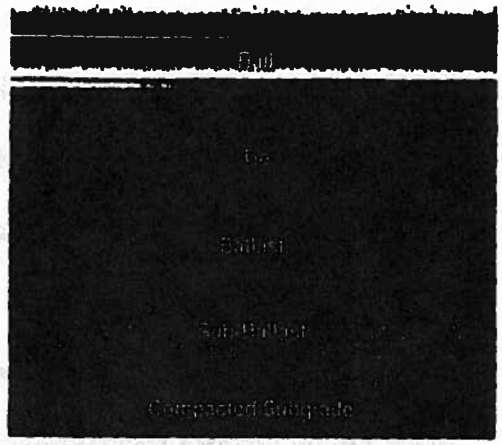
Between Union Pacific and BNSF, the railroads operate between 60 and 70 trainloads (or 120 to 140 loaded and empty trains total) daily over the line. Currently Union Pacific averages approximately 33 trainloads. Maintenance and operating costs are allocated to each railroad in proportion to each railroad's usage of the Joint Line. In 2009, Union Pacific paid roughly of these costs. (Glass VS at p. 2).

Union Pacific provides the locomotive power, crews and track infrastructure to transport unit coal trains to and from the coal mines to our customers. Customers negotiate directly with the mines to purchase the coal and most maintain their own sets of coal cars for transporting the coal. Union Pacific then pulls the unit trains to the mines where they are loaded by mine operators. Once loaded at mines, Union Pacific is notified that the trains are available for transport to our customers' plants or to distant interchange points or river terminals where trains are turned over to other railroads or barges to move the remainder of the way.

III. Composition of Heavy-Haul Lines

Because of its weight, coal is transported over heavy-hail rail lines. The illustrations below depict the typical constitution of our heavy-haul rail lines along the SPRB corridor. These rail lines are constructed with continuously welded steel rails that are supported on pre-stressed concrete ties spaced at two-foot centers. The pre-stressed concrete ties are typically supported on a minimum of 12 inches of granite ballast placed over a minimum of 12 inches of sub-ballast on the subgrade.





A critical component of the railroad track structure is the ballast. Railroad ballast is uniform-graded coarse aggregate placed between and immediately underneath the crossties. Ballast provides load distribution between ties and the subgrade and facilitates drainage to quickly move away any moisture that may fall on the track. Ballast supplies both structural support and drainage for the heavy loads applied by trains.

IV. The 2005 Derailments and the Repair of the Joint Line

On May 14, 2005, a BNSF loaded coal train derailed at milepost 76.9 on the Joint Line. Less than 24 hours later and 14 miles away, a Union Pacific loaded coal train derailed. The occurrence of back-to-back derailments, accompanied by the sudden appearance of widespread instability throughout the Joint Line, were shocking – especially for track on which the Federal Railroad Administration (FRA) geometry car inspection had found few defects less than two weeks before the derailments. The suddenness, scope and severity of the damage were unprecedented in the experience of the engineering personnel of both BNSF and Union Pacific. As we tried to understand the root cause of the May 2005 Joint Line failure, Union Pacific began to learn how coal dust poses a unique and especially severe threat to rail ballast integrity. I will briefly review a chronology of the events that led to the derailments in 2005 and the measures that have been taken since then to attempt to ensure that such impairments to service do not occur in the future.

A. Appearance of Coal Dust in 2002-2003 and Efforts to Remove

BNSF inspectors began to notice accumulations of coal dust on the Joint Line in 2002-2003. The coal dust was observed primarily in the areas of switches and bridges and it was noted that these areas were starting to require increased maintenance. The levels of coal dust around the Joint Line also were resulting in spontaneous fires along the right-of-way that were of concern both to BNSF and to local fire departments whose crews would be dispatched to the fire scenes.

As a result of the 2003 annual joint inspection by BNSF and Union Pacific, it was determined that additional resources were needed to clean up the coal dust in the areas of the bridges and the switches. Both railroads approved additional funding for this work and BNSF forces worked to remove the coal dust and repair the areas where the track was unstable.

B. Improved Performance on Joint Line in 2004-early 2005

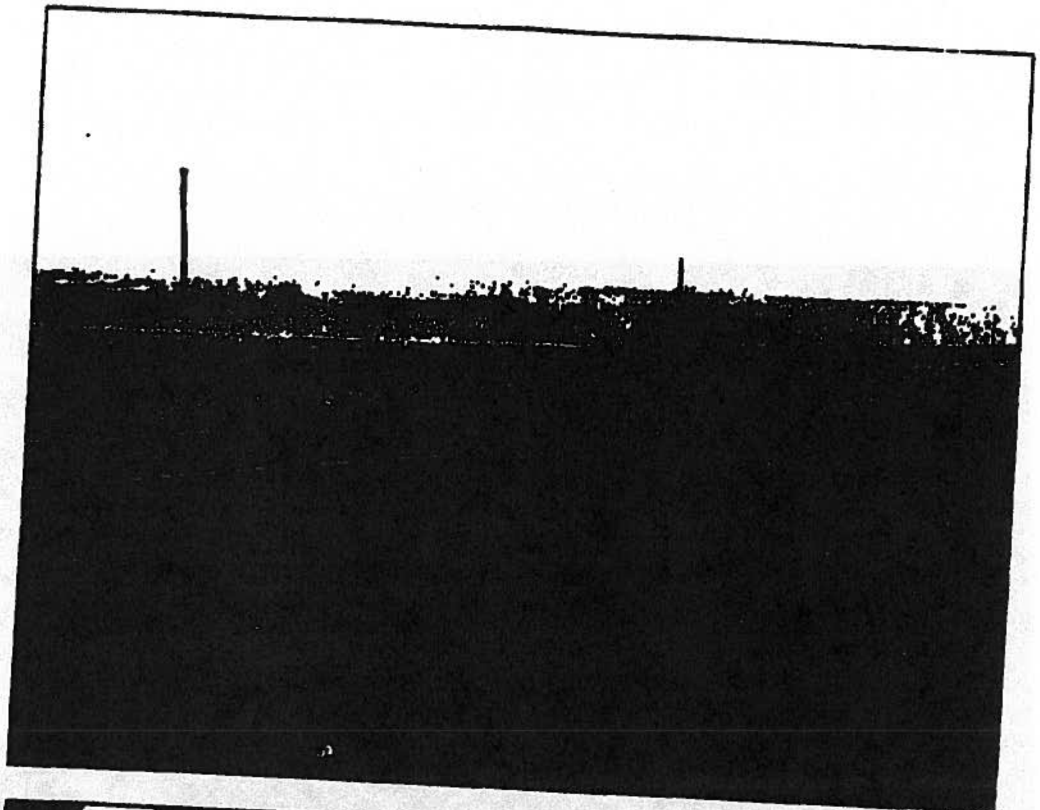
Throughout 2004, overall loadings increased, and slow orders decreased as the extra work authorized in 2003 was being completed. The reduction in the number of slow orders, and the increase in the relative speed allowed where slow orders were in place, was an indication of the safe and stable condition of the track at that time. In October 2004, the two railroads conducted a joint inspection of the Joint Line and noted significant improvements with respect to the presence of coal dust. Union Pacific engineering personnel were impressed with how good the track appeared.

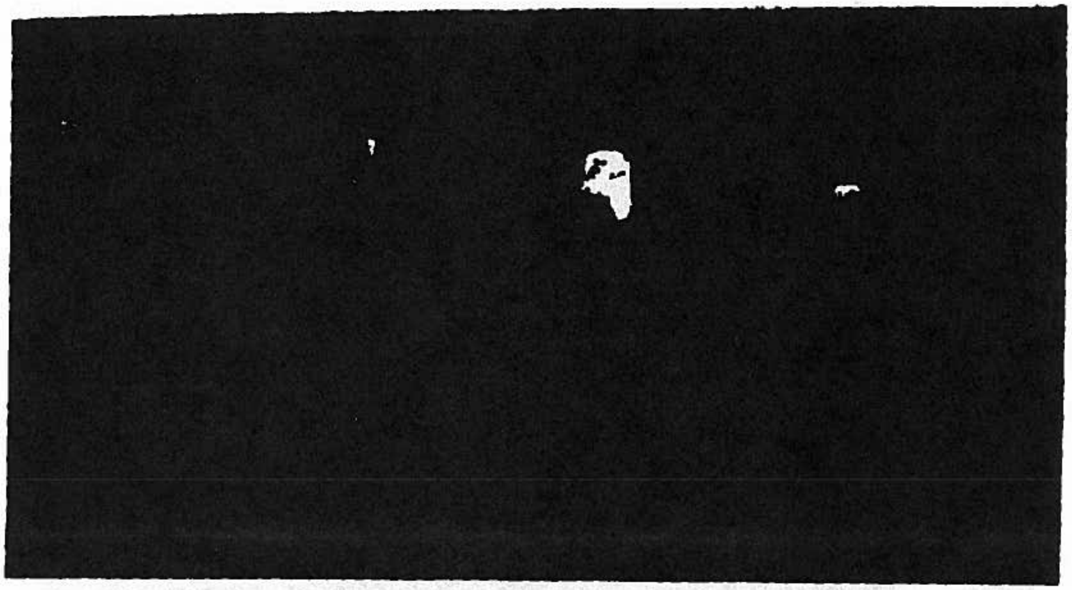
In the first quarter of 2005, Union Pacific moved record volumes of coal out of the SPRB. The FRA conducted a geometry car inspection in early May 2005 on the Joint Line. The geometry car readings confirmed a very low incidence of track defects, thus indicating the track was in good and serviceable condition.

C. Impact of Heavy Precipitation and Coal Dust on Joint Line in Spring 2005

In late April-early May 2005, there was a major blizzard that shut down the SPRB mines and the Joint Line. This was followed by other significant snow and rain events, including a blizzard followed by rain on May 11. This precipitation was particularly significant because this area had been suffering through a prolonged (almost 10 year) and historically severe period of drought which masked the impacts of the coal dust.

As noted above, on May 14 and 15, 2005, there were two major derailments on the Joint Line. At the time of these two derailments, inspectors noted widespread track instability and issued numerous slow orders. Representative photos of the Joint Line taken shortly after the derailments are shown below.

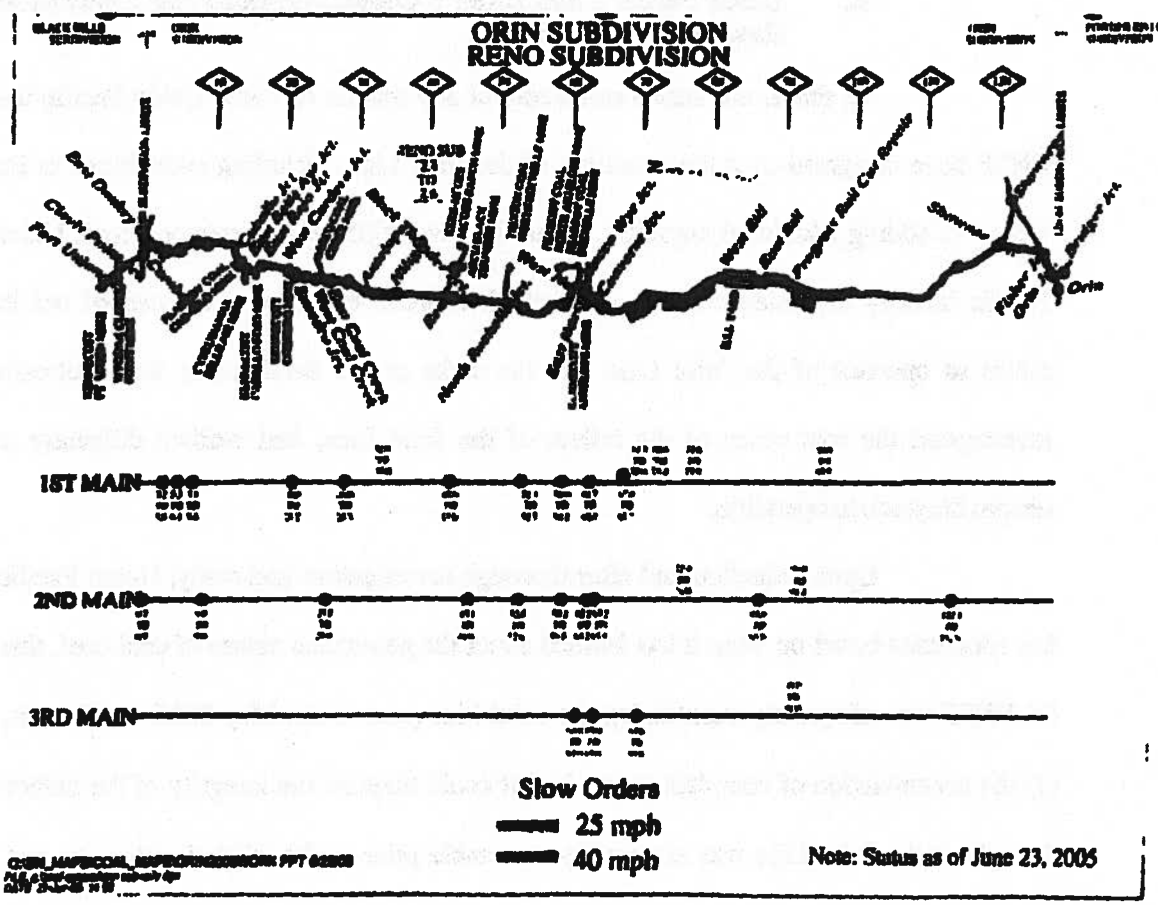




As the first photo shows, the rails were literally "wavy," as the supporting ballast and infrastructure had been compromised. As shown by the second photo, inspectors found many sections with broken concrete ties and widespread muddy conditions on the track. The third photo shows how the coal dust had permeated many sections of the ballast and drainage of the ballast was severely impeded. When trains ran over the track and the ballast could not support the weight, concrete ties were damaged, which increased the stress on adjoining ties. Based on careful review of the track structure, it was determined that the root cause of the instability of the ballast was excessive coal dust that had become unstable when mixed with the substantial precipitation that had occurred on the Joint Line.

D. Restoration Efforts and Resulting Delays

BNSF and Union Pacific determined that extraordinary measures would be needed to restore the track stability. Numerous slow orders were put in place throughout the Joint Line, both to ensure safe passage due to the track conditions, and to accommodate the extraordinary restoration that was needed. The volume of coal loadings fell and trains were slowed while the track was restored. The following map shows the location, number and degree of slow orders as of the end of June 2005, some five weeks after the derailments.



During the course of several months, BNSF used undercutters to undercut and clean the ballast structure. As of May 2005, the 102-mile Joint Line was comprised of approximately 250 track miles. Approximately 93 miles of out-of-face undercutting and 162 miles of shoulder ballast and cleaning were initiated in 2005 and continued into 2006. These efforts have continued on other parts of the coal corridor since 2006. In addition, it has become necessary for BNSF to return to some portions of the Joint Line that were undercut and cleaned in 2005 – 2006 and clean them again due to the rapid accumulation of coal dust.

E. Union Pacific's and BNSF's Communications and Conclusions Regarding the Joint Line

At times, not unlike co-owners of any section of track, Union Pacific and BNSF have disagreed over the operation of the Joint Line, including such things as the timing of adding additional capacity. After the May 2005 derailments occurred, Union Pacific initially expressed concern over whether BNSF had adequately carried out its duties as operator of the Joint Line. In the wake of the derailments, both railroads investigated the root cause of the failure of the Joint Line, and worked diligently to restore the track to operation.

Upon reflection and after thorough investigation and study, Union Pacific has concluded based on what it has learned about the pernicious nature of coal dust, that (1) BNSF was adequately maintaining the Joint Line prior to the May 2005 derailments, (2) the accumulation of coal dust at levels that could threaten the integrity of the ballast throughout the Joint Line was not readily detectable prior to the 2005 derailments, and (3) the potential for sudden and widespread deterioration of the track following heavy precipitation was neither known nor knowable prior to the 2005 derailments.

V. Studying Coal Dust in Railroad Track Structure

The events of 2005 have led to investigations and studies to try to understand the harmful nature of coal dust and its impact on the ballast system. Both BNSF and Union Pacific have studied coal dust and have concluded it is a particularly pernicious foulant.

In this section, I will explain the purpose of railroad ballast and the effects of coal dust as a fouling agent on ballast, particularly when saturated. I will also discuss the problems associated with coal dust even when accumulation is not readily apparent. Finally, I will address the results of recent studies that have looked at ways of reducing the deposition of coal dust on the track bed.

A. Coal Dust and Ballast

Let me start by explaining why coal dust is so harmful to the ballast. Shear strength is an important component of ballast performance. Shear strength is the characteristic of compacted ballast that allows the ballast to distribute the load to the sub-ballast between crossties. Heavy-haul railroads typically use 1" to 2" granite with multiple fracture faces for ballast. Friction exists when one stone contacts another. The friction is the key to shear strength. If friction is lost, the shear strength is lost and components like rails or ties may become unstable.

When foreign matter fouls the ballast, shear strength is compromised and the ballast can lose the ability to perform its function. Foulants can include worn pieces of ballast, soil, sand, or coal dust, among other materials. These foulants fill the voids between the ballast particles and lubricate the friction interfaces between the stones, thus reducing stone-to-stone friction and lowering shear strength of the ballast. If the voids become too filled with foulants, ballast particles can lose contact and vertical water drainage is impeded, which will further reduce the shear strength and thus load-bearing capacity of the ballast.

Researchers have examined the properties of fouled railroad ballast. Historically, the most common ballast foulant has been degraded ballast itself that is worn down by the forces being placed on the ballast section by the loads from passing trains.[1] However, based on a more recent study by the University of Illinois, coal dust has become a more significant foulant.

B. Problems Caused by Coal Dust in Ballast

Professor Erol Tutumluer at the University of Illinois has investigated the effect of coal dust on ballast structure. Dr. Tutumluer's laboratory findings are the first detailed examination of the mechanical properties of coal dust. (Dr. Tutumluer's March 15, 2009 article, entitled Laboratory Characterization of Fouled Railroad Ballast Behavior, is attached as Ex. DC- 1).

Dr. Tutumluer's research indicates a relationship between ballast shear strength, coal dust contamination, and moisture content. Dr. Tutumluer has determined and reported that the shear strength of railroad ballast is significantly compromised by coal dust. Specifically, Dr. Tutumluer reports: "Coal dust was by far the worst fouling agent for its impact on track substructure and roadbed and caused the most drastic shear strength decreases especially at high fouling levels." (Ex. DC- 1 at 8). In sufficient quantities, coal dust can result in decreased stability, and ultimately loss of track gauge and proper geometry. According to Dr. Tutumluer, even more drastic strength reductions can be realized when dry coal dust, which has never been saturated or soaked in the field

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1 Selig, E.T. and J.M. Waters, *Track Geotechnology and Substructure Management*, Thomas Telford Publications, 1994.

and therefore having a high suction potential, is subjected to inundation and 100% saturation. (Id.) This is true because exposure of coal dust to moisture significantly reduces the friction component of the shear strength and can cause significant reduction in load bearing capacity. In other words, if coal dust accumulates while it is dry and is then exposed to precipitation, its danger as a fouling agent increases both quickly and significantly.

So we know that coal dust is harmful. What we don't know is exactly where it can be found in the track bed. Based on our experience in inspecting the Joint Line in 2004, we understand that even ballast that looks clean can have unacceptable levels of coal dust below the surface. Thus, if we assume that we have good track conditions based on surface appearance, coal dust can still be a hidden problem, which can quickly become unstable and muddy when it rains or snows.

In light of the destructive effects of coal dust, BNSF and Union Pacific commissioned Simpson Weather to study the rate of deposition of coal dust on the Joint Line track structure and to study means to contain the dust. They have done extensive studies of coal dust for Norfolk Southern. They also have been studying coal dust on the Joint Line for more than five years.

Simpson Weather's research has indicated that unless further mitigation measures are employed, coal dust will continue to accumulate on the Joint Line at very high rates. (UP/BNSF Orin Subdivision Dustfall Collector Network Sample Data, Nov. 2009, Ex. DC- 2 at 8993).

C. Reducing Coal Dust Deposition

Simpson Weather's research also indicates that there are several means available to reduce coal dust and prevent it from fouling track structure. One of these measures involves changing the profile in which the coal is loaded into each rail car from uneven loads with sharp edges above the car sills to more bread-loaf shaped, uniform loads. Simpson Weather found that the bread-loaf shaped loads were not as susceptible to "dusting" during transport. (BNSF/UP Coal Load Groomed Profile Field Testing, Sept–Dec 2005, Ex. DC- 3 at 68). Most of the mines have changed their loading chutes to contour the loads. But even with this change, loads are somewhat inconsistent in their forms.

Following the 2005 derailments, the National Coal Transportation Association (NCTA) formed three committees to study different means of mitigating the loss of coal dust during rail transport. One committee focused on coal cars themselves, while another focused on the profile of the loaded coal in the car, and the third committee focused on the use of surface sprays to reduce the loss of dust from the moving car. While the NCTA's coal car committee did not suggest that holes in cars were a major source of coal dust in the track bed, it remains the case that customers can repair rail cars to close holes and seams in order to better seal them to ensure that coal and coal dust do not fall from the bottom of the cars onto the track.

The NCTA committee that focused on the load profile reached a conclusion similar to that reached by Simpson Weather about the benefits of grooming the coal profile in a bread-loaf shaped form within the car to reduce dust loss during transport. (Joint Initiative Mitigation of Track Ballast Fouling, April 19, 2006, Ex. DC- 4 at 9686).

Further, both Simpson Weather and the NCTA committee focusing on the use of surface sprays determined that surfactants can be sprayed onto the surface of the coal to bond it together and make it less susceptible to blowing off during transportation. (BNSF/UP Chemical Dust Suppression Agents Field Testing, 9/05-8/06, Ex. DC- 5 at 48, Ex. DC- 4 at 9682). Finally, there are ongoing studies of the possibility of either covering the rail car or compressing the coal in the rail car (i.e., shaking the coal fines away from the surface) to further aid efforts to keep it in the car and off of the track structure. (Ecofab Presentation, 2007, Ex. DC- 6 at 8565-68; Coleman Aerospace Report and Email, 2008, Ex. DC- 7 at 9957-58, 58127-139).

VI. The Scope and Impact of Coal Dust

The problem with coal dust extends not only to the Joint Line but also to lines beyond the Joint Line owned and maintained by Union Pacific. Union Pacific has retained Shannon & Wilson, Inc., an expert engineering firm, to determine coal dust levels on Union Pacific's main coal lines. Shannon & Wilson obtained samples of ballast along almost 660 miles of rail line. They have determined that coal dust is present throughout this expanse of track. (See Shannon & Wilson's Union Pacific Railroad Ballast Study: North Platte Division, dated July 30, 2008, Ex. DC- 8 at 3). This is true even though some of this track is hundreds of miles from the Joint Line where the rail cars are loaded.

It is disturbing to learn how much coal dust has permeated the ballast even though much of the track inspected was double or triple-track installed or completely rebuilt (i.e., the line was shifted to widen track centers, and new rail and concrete ties were installed and new ballast laid) relatively recently. After Union Pacific completed the triple track North Platte to Gibbon project in late 1999, it continued the Project Yellow III capacity expansion to double-track from Shawnee Jct. to O'Fallons, install a fourth main between O'Fallons and North Platte, and install double track on the

Marysville subdivision east of Gibbon. This project was only completed in 2009. (See UPRR's SPRB Coal Route: Capacity Improvements 2000-2009 Trackage, Ex. DC- 9). Yet coal dust has found its way into and comprises as much as 20% of the fines volume of Main Track 2 nearly 600 miles beyond the Joint Line.

Shannon & Wilson obtained samples from the shoulders of Union Pacific's main line track in 2008 and from the shoulder and center of the tracks in 2009 to determine what percentage of foulant was coal dust as opposed to other foulants. The 2009 follow up to the 2008 Shannon & Wilson study determined that coal dust continues to be deposited onto the Union Pacific line. (See Shannon & Wilson's Union Pacific Railroad Ballast Study: North Platte Division, dated January 2010, Ex. DC- 10 at 4-5). The coal dust that has been deposited across the expanse of Union Pacific's coal corridor is necessitating that Union Pacific undercut more often and more miles.

The industry standard for ballast undercutting/cleaning is every 8 to 20 years on heavy tonnage railroads. Historically, Union Pacific would anticipate a need to undercut a main line track once every 10 to 15 years. With the impact of coal dust on its tracks, Union Pacific is anticipating it must now undercut on a much shorter cycle, potentially once every six years. Further, in areas of heavy coal dust concentration like bridges or switches, it anticipates the need to undercut as often as once every three years.

In addition to the potential coal dust causes for track-related problems, coal dust removal efforts also interfere with Union Pacific's service to its coal customers. The presence of maintenance workers on the rail lines reduces track capacity that is available for moving coal customers' cars, resulting in service delays. For example, based on a six-year average undercutting cycle of Union Pacific's Joint Line-originating coal network (totaling 1590 track miles), Union Pacific would need to undercut an average of 265 miles per year on this corridor. Undercutters average .75 or 1.5 miles per day, depending on whether the track is returned to service each night. Therefore, it would take between 177 and 363 working days to undercut 265 miles of track. (DC App.1). The working season in this zone is about 214 days. In order to accomplish this extensive amount of undercutting, Union Pacific would have to undercut an average rate of 1.24 miles every day of the working season. Due to machinery and gang down time, and necessary movement from one job site to another, it is unlikely that Union Pacific could sustain this amount of annual undercutting perpetually. If coal dust volumes continue to grow, it will become a severe and intolerable strain.

VII. Conclusion

In sum, even a modest amount of coal dust in the track bed can become serious if it becomes wet. It is also important to note that when you undercut the track it does not remove all of the coal dust, and over time coal dust will continue to build up in spite of undercutting. Further, undercutting does have an impact on Union Pacific's coal customers because it disrupts traffic flow and may slow down service to our customers.

Another problem that we are dealing with is an inability to determine exactly where the coal dust can be found. The fact that the ballast looks clean and in good condition is not an indication that there is no coal dust that needs to be remediated. Oftentimes, our inspectors only determine there is a need to remove coal dust when an area becomes soft because of moisture and rails become misaligned, in other words, after the damage is done.

Based on our ongoing experiences in repairing ballast damaged by coal dust, we have concluded the best long term solution is to find ways to keep the coal dust from blowing from the cars and onto the track structure. We are working closely with a variety of engineers and our customers to find ways to accomplish containment of the coal dust. We already have persuaded customers and the mines to shape the profile of the loads in the coal cars in a manner that softens the sharp edges that have blown away in the past and this has appreciably reduced the loss of coal dust during transport. BNSF is currently running trials in the Joint Line to test the effectiveness of surfactants that can be sprayed on the car loads. We also are finding some promise in the compression of coal in the cars to create a better load profile and to lessen dusting during transport.

We are committed to continuing to work with our customers to come up with solutions that keep the coal dust in the cars and out of the ballast.

VERIFICATION

I, David Connell, Vice President - Engineering of Union Pacific Railroad Company, declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge.

Executed on 12 day of March, 2010.

GENERAL NOTARY-State of Nebraska
DEBORAH L. McMILLIN
My Comm. Exp. Sept. 8, 2012

David Connell

Notary Public. State of Nebrask

Exhibit DC-1

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LABORATORY CHARACTERIZATION OF FOULED RAILROAD BALLAST BEHAVIOR

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ABSTRACT

Fouling refers to the condition of railroad ballast when voids in this unbound aggregate layer are filled with relatively finer materials or fouling agents commonly from the ballast aggregate breakdown, outside contamination such as coal dust from coal trains, or from subgrade soil intrusion. Effects of the different fouling agents on ballast aggregate shear strength were recently studied at the University of Illinois. Through the use of a large direct shear (shear box) device, the strength properties of both clean and fouled ballast samples were determined when three types of fine materials, i.e., coal dust, plastic clayey soil and mineral filler, were added to clean ballast samples at various percentages by weight of ballast under both dry and wet (mostly optimum moisture content) conditions. Realistic sample preparation procedures were conducted to closely simulate field fouling scenarios. Test results showed that when the coal dust fouling percentage increased, the ballast shear strength steadily decreased. Wet fouling was found to exacerbate this trend. Results of ballast samples fouled with clay and mineral filler also showed decreasing trends in strength properties; however, coal dust was by far the worst fouling agent for its impact on track substructure and roadbed. Approximately 15% coal dust fouling by weight of ballast was statistically significant to cause considerable strength reductions. In the case of ballast fully fouled with wet coal dust at 35% optimum moisture content, the friction angles obtained were as low as the friction angle of coal dust itself.

Key Words: Railroad track, ballast, aggregate, fouling, coal dust, plastic clay, mineral filler, stability, shear strength, laboratory testing.

INTRODUCTION

Railroad ballast is uniformly-graded coarse aggregate placed between and immediately underneath the crossties. The purpose of ballast is to provide drainage and structural support for the loading applied by trains. As ballast ages, it is progressively fouled with materials finer than aggregate particles filling the void spaces. Methods specifically used to assess track ballast condition only deal with checking visually for evidence of fouling, pumping and water accumulation (ponding) at ditches and shoulders. Additionally, ballast sampling and testing for fouling through laboratory sieve analyses generally provide some insight into the compositions of the larger aggregate particles and the amount of fines. Nonetheless, for a better evaluation of the serviceability and proper functioning of the existing ballast layer, ballast strength needs to be characterized for different percentages of fine materials, such as plastic soil fines, mineral filler, and more recently coal dust coming from coal trains, which can fill the voids and cause ballast fouling.

Since rail transport, particularly a unit train, provides the most efficient means of transporting bulk commodities such as coal, the role of rail lines in coal transport has always been predominant. In 2005, two derailments occurred in the Burlington Northern Santa Fe/Union Pacific (BNSF/UP) joint coal line in Powder River Basin (PRB) in Wyoming, the largest source of incremental low-sulfur coal supplies in the U.S., which threatened to interrupt the supply of coal to power plants. Both of the derailments were suspected to be attributed by coal dust fouling, where coal dust spilled over the ballasts and accumulated moisture, allegedly resulting in the loss of strength of the track. In both places where derailments happened, ballast was heavily fouled by coal dust.

This paper presents findings from a comprehensive laboratory-testing program recently initiated at the University of Illinois with the objective to study effects of different fouling agents, i.e., mineral filler, plastic clayey soil and coal dust, on railroad ballast strength. Using large direct shear (shear box) tests, strength and deformation characteristics of granite type ballast material were investigated for clean ballast and ballast fouled by different agents at various stages under both dry and wet conditions. The shear strength properties such as cohesion intercept and friction angle are linked to field ballast fouling levels to better assess the impact of fouling on track instability and ultimately loss of track support leading to derailments.

BALLAST FOULING AND ITS MECHANISM

Fouling materials in ballast have been traditionally considered not favorable for railroad ballast performance. Early research studies reported that around 70% of the fouling materials were from ballast breakdown (*1,2,3*). Railroad company internal studies also noted that almost all fouling fines in the railroad track were commonly from aggregate breakdown (*4*). According to Selig and Waters (*5*), ballast breakdown on the average accounts for up to 76% of the ballast fouling followed by 13% infiltration from subballast, 7% infiltration from ballast surface, 3% subgrade intrusion, and 1% due to tie wear.

Selig and Waters (*5*) proposed two indices to describe ballast fouling: (i) fouling index is the sum of the percent by weight of ballast sample passing the 4.75 mm (No. 4) sieve plus the percent passing the 0.075 mm (No. 200 sieve) and (ii) percentage of fouling is the ratio of the dry weight of material passing 9.5 mm (3/8 in.) sieve to the dry weight of total sample. They also proposed that the particles retained on 0.075 mm (No. 200 sieve) are treated as "coarse fouling materials" and particles passing 0.075 mm (No. 200 sieve) are "fine fouling materials" (*5*).

Raymond (*6*) suggested that if fouled ballast had to be used, the liquid limit of the fines should be less than 25 to maintain the function of drainage. Raymond also (*7*) found that the aggregate breakdown was significantly influenced by the type and especially hardness of the mineral aggregate. Harder aggregates had fewer breakdowns than softer aggregates did. Later on, Raymond (*10*) noted that the wear of tie was more significant at the worst fouled track locations, possibly due to the abrasive effects of the slurry formed by fouling fines and water.

Chiang (*8*) conducted a series of ballast box repeated loading tests on fouled ballast. Test results indicated that ballast settlement typically increased as the amount of fouling material in ballast increased. Similarly, Han and Selig (*9*) also conducted ballast box tests to evaluate the impact of fouling on ballast settlement. They concluded that the degree of ballast fouling indeed had a major impact on the ballast settlement. With an increase in the percentage fouling, both the initial and final ballast settlements increased significantly. Investigations on the strength of fouled ballast and studies on the fouling mechanism, however, have been somewhat limited to date.

In terms of the stability and load carrying ability of the fouled ballast layer, three volumetric phases can be identified for the different conditions of fine materials filling the void space (see Figure 1). Phase I shows a clean or very slightly fouled ballast sample with almost all aggregates establishing contact with each other at the aggregate surface to sufficiently carry the load (see Figure 1a). As shown in Figure 1b, phase II will have the voids in between contacting aggregates filled with enough amount of fine particles that could significantly reduce the strength, however, still maintaining aggregate to aggregate contact. Whereas, in a phase III fouled ballast condition, due to the excessive amount of fine particles, aggregate to aggregate contacts are mostly eliminated and the aggregate particle movements are then only constrained by the fine particles filling the matrix or voids between the particles (see Figure 1c).

As ballast in Phase III is no doubt unacceptable and needs immediate remedial action, ballast in Phase I and II is particularly worth studying from the aspect of how different fouling agents at different phases would affect ballast strength and therefore impact track stability. It is also of great importance to know the dividing line between phase I and II since it is also the suggested starting point of maintenance activities such as ballast cleaning. Hypothetically, if ballast aggregate particles are assumed to be spheres, it is possible to define the maximum size of the fouling materials through 3-dimensonal packing order computations for large and small spheres. Accordingly, Equation 1 defines the radius "*r*" of a single fouling particle approximated as a sphere to fit in between three large contacting spherical particles, each having a radius "*R*," without separating them.

$$r=\left(\sqrt{\frac{32}{27}}-1\right)R \qquad (1)$$

Considering that the maximum size of ballast aggregates is often limited to $2R$=76 mm (=3 in.), the largest diameter of a single fouling particle can then be 6.7 mm (0.26 in.), which is smaller than 9.5 mm (3/8 in.) suggested by Selig and Waters (*5*).

CLEAN AND FOULED BALLAST STRENGTH BEHAVIOR

Materials Tested

The ballast material tested was a granite aggregate obtained from Gillette, WY and commonly used in the PRB joint line railroad track structures as the ballast layer. Figure 2 shows the grain size distribution of the granite sample with a specific gravity of 2.62 tested in compliance with ASTM C 117 test procedure. The granite aggregate size distribution conforms to the typical AREMA No. 24 ballast gradation having a maximum size (D_{max}) of 63.5 mm (2.5 in.), a minimum size (D_{min}) of 25.4 mm (1 in.), and an average particle size corresponding to 50 percent passing by weight (D_{50}) of approximately 45 mm (1.77 in.).

From the average size of the clean ballast (45 mm), an average particle fouling size of 4 mm was chosen in this study based on Equation 1. Accordingly, the three types of fouling materials studied with this granite type ballast aggregate were: (i) coal dust, (ii) refractory clay representing a cohesive fine-grained subgrade soil, and (iii) mineral filler obtained from the crushing operations of the same granite aggregate. Figure 2 shows the typical gradations and Table 1 lists the engineering properties of these fouling materials with the moisture-density information obtained from the standard Proctor ASTM D 698 test procedure. Note that the coal dust sample tested in this study was also collected from the PRB Orin line milepost 62.4 and was sampled on March 10, 2007.

Testing Apparatus

Direct shear strength tests were performed on the reconstituted clean and fouled granite aggregate samples. Figure 3 shows the large shear box equipment used for testing at the University of Illinois. The test device is a square box with side dimensions of 12 in. (305 mm) and a specimen height of 203 mm (8 in.). It has a total 102 mm (4-in.) travel of the bottom 152 mm (6-in.) high component which is large enough for ballast testing purposes to record peak shear stresses. The vertical (normal direction) and horizontal load cells are capable of applying and recording up to 50-kN load magnitudes. The device controls and the data collection are managed through an automated data acquisition system controlled by the operator through a built-in display and the test data are saved on to a personal computer.

Sample Preparation

Clean ballast samples were prepared in the lower shear box to the condition similar to the field according to the following steps:

1. Place aggregates in the lower box by lifts (usually two 76 mm lifts).
2. For each lift, use vibratory compactor on top of a flat Plexiglas compaction platform and compact until no noticeable movement of particles is observed (see Figure 4).
3. Record the weight of aggregate used.
4. Place upper ring (76 mm high) on top of lower box. Align ring with sides and back edge of box (opposite of block) and fill with single lift of ballast and compact (see Figure 4).

Coal dust fouled granite ballast samples were prepared similar to the clean sample procedure by spreading coal dust on the ballast surface and spraying water, if needed. The individual steps are as follows:

1. Obtain clean aggregates of the same weight as previously recorded.
2. Compact ballast sample into the lower box in two lifts.
3. Obtain prescribed weight of coal dust and water (see Figure 5).
4. Spread coal dust over compacted ballast evenly in two lifts (half of material each lift). Shakedown material using vibratory compactor after each lift. If test is conducted with wet fouling material (for example, at the optimum moisture content or OMC), pour proportional amount of water over ballast after shakedown of each lift (see Figure 5). Note that this preparation procedure realistically simulated the actual coal dust accumulation in the ballast layer due to vibration caused by train loading.
5. Step 4 in the clean sample preparation procedure.

Granite samples fouled with clay were prepared following a different procedure to simulate this time subgrade intrusion. The individual steps are as follows:

1. Obtain clean aggregates of the same weight as previously recorded.
2. Obtain described weight of clay and water.
3. Place the clay in the bottom of the lower box. If test is conducted with wet clay, thoroughly mix clay with water before placing them in the lower box.
4. Place aggregates over the clay and compact in two lifts.
5. Step 4 in the clean sample preparation procedure.

For preparing granite samples fouled with mineral filler, the clean ballast and the mineral filler with designated weights were pre-mixed before placement in the lower box. The goal was to simulate the actual ballast breakdown conditions in the field. Aggregate breakdown could take place with chipped pieces and mineral filler uniformly filling the voids in ballast layer.

Before testing, the box and ring assembly were placed into the shearing apparatus. Lower box was clamped in place and load bearing plate was placed on ballast but inside upper ring. Air-bladder was placed on bearing-plate, air supply opened and normal pressure set using an in-line pressure regulator (see Figure 6). The load cell recording applied shear force was adjusted directly against the upper ring. The Labview data logger software was initiated to record normal and shear forces during testing. The loading speed was set to an input shear rate of 12.2 mm/min. (0.48 in./min.), which is approximately 4% strain per minute and the tests were run until the shear force output peaked or 15% strain has occurred.

Sample Volumetrics

After sample preparation, volumetric properties of the shear box sample were calculated based on the granite aggregate properties. It is worth noting that, for all tests, the same amount of material was used to prepare approximately the same number of aggregate contacts and the similar aggregate skeleton. That is to say, the voids available for fouling material to fill in were kept the same in all cases. This void space was found for the clean granite sample to be 43% of the total volume, which corresponds to a void ratio of 0.75 or 75% of the aggregate volume.