FREIGHT CAR TRUCK DESIGN OPTIMIZATION PROJECT

PHASE I - MAGNETIC DATA TAPES

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Springfield, VA 22161

Test No.	Tape No.	Accession No.	Variables: Gibs Nominal	Gibs Closed	Side Bearings Tight	Side Bearings Nominal	Side Bearings Open
1-1-3	0010 0011	PB 250 163/AS PB 250 164/AS	X				X
1-1-1	0012 0013 0014	PB 250 165/AS PB 250 166/AS PB 250 167/AS	X			X	
1-1-2	0015 0016 0017	PB 250 168/AS PB 250 169/AS PB 250 170/AS	X		X		
1-1-5	0017 0018	PB 250 170/AS PB 250 171/AS		X	X		
1-1-6	0019 0020	PB 250 172/AS PB 250 173/AS		X		X	
1-1-4	0001 0002	PB 250 160/AS PB 250 161/AS		X			X
1-1-4-C	0003	PB 250 162/AS		X			X
1-1-6-C	0021	PB 250 174/AS		X		X	
1-1-5-C	0021 0022	PB 250 174/AS PB 250 175/AS		X	X		
1-1-2-C	0022	PB 250 175/AS	X		X		
1-1-1-C	0023	PB 250 176/AS	X			X	
1-1-3-C	0023	PB 250 176/AS	X				X
1-3-2	0024 0025	PB 250 177/AS PB 250 178/AS	X				X
1-3-1	0026 0027	PB 250 179/AS PB 250 180/AS		X	X		
1-2-2-C	0028	PB 250 181/AS		X	X		
1-2-1-C	0028 0029	PB 250 181/AS PB 250 182/AS		X		X	
1-2-3-C	0029	PB 250 182/AS		X			X
1-2-4-C	0030	PB 250 183/AS	X				X
1-2-6-C	0030 0031	PB 250 183/AS PB 250 184/AS	X			X	
1-2-5-C	0031	PB 250 184/AS	X		X		
1-2-2	0032 0033	PB 250 185/AS PB 250 186/AS	X		X		

Car Load			Track Type		
MT	1/2	GRL	H.S. Tang.	M.S. Tang.	Curved
		X	X	X	
		X	X	X	
		X	X	X	
		X	X	X	
		X	X	X	
		X	X	X	
		X			X
		X			X
		X			X
		X			X
		X			X
		X			X
	X		X	X	
	X		X	X	
X					X
X					X
X					X
X					X
X					X
X					X
X			X	X	

Test No.	Tape No.	Accession No.	Variables				
			Gibs		Side Bearings		
			Nominal	Closed	Tight	Nominal	Open
1-2-4	0033 0034	PB 250 186/AS PB 250 187/AS		X			X
1-2-3	0035 0036	PB 250 188/AS PB 250 189/AS	X				X
1-2-1	0036 0037	PB 250 189/AS PB 250 190/AS	X			X	
1-2-6	0038 0039	PB 250 191/AS PB 250 192/AS		X		X	
1-2-5	0038 0039 0040	PB 250 191/AS PB 250 192/AS PB 250 193/AS		X	X		

*The equipment combination for these tests consisted of a mechanical refrigerator car (SPFE 459997) with ASF Ride Control 70-ton (63.6-mt) trucks. For further information concerning Series 1 Tests, see Freight Car Truck Design Optimization Introduction And Detailed Test Plans Series 1, 2, and 3 Tests - Phase I, Report No. FRA-OR&D 75-59

Car Load			Track Type		
MT	1/2	GRL	H.S. Tang.	M.S. Tang.	Curved
X			X	X	
X			X	X	
X			X	X	
X			X	X	
X			X	X	

Test No.	Tape No.	Accession No.	Gibs Nominal	Gibs Closed	Side Bearings Tight	Side Bearings Nominal	Side Bearings Open	D-3
2-1-2	0041 0042	PB 250 194/AS PB 250 195/AS		X	X			
2-1-1	0042 0043 0044	PB 250 195/AS PB 250 196/AS PB 250 197/AS	X				X	
2-2-5	0045 0046	PB 250 198/AS PB 250 199/AS	X				X	
2-2-6	0047 0048	PB 250 200/AS PB 250 201/AS	X				X	X
2-2-3	0048 0049 0051	PB 250 201/AS PB 250 202/AS PB 250 204/AS	X				X	
2-2-4	0049 0050	PB 250 202/AS PB 250 203/AS		X	X			
2-2-3-C	0051 0052	PB 250 204/AS PB 250 205/AS	X				X	
2-3-3-C	0052 0053	PB 250 205/AS PB 250 206/AS	X				X	
2-3-3	0053 0054	PB 250 206/AS PB 250 207/AS	X				X	
2-3-6	0055 0056	PB 250 208/AS PB 250 209/AS		X	X			
2-3-4	0057 0058	PB 250 210/AS PB 250 211/AS	X				X	
2-3-5	0059 0060	PB 250 212/AS PB 250 213/AS	X				X	X
2-4-1	0061 0062	PB 250 214/AS PB 250 215/AS	X				X	
2-4-2	0063 0064	PB 250 216/AS PB 250 217/AS		X	X			
2-4-3	0065 0066	PB 250 218/AS PB 250 219/AS		X	X			
2-4-4	0067 0068	PB 250 220/AS PB 250 221/AS	X				X	

Variables												
Springs			Snubbing		Wheel Profile			Car Load		Track Type		
D-5	D-5 Reduced	D-7	2/3	Nominal	New	1/2 Worn	Worn	MT	GRL	H.S. Tang.	M.S. Tang.	Curved
X				X		X		X		X	X	
X				X		X		X		X	X	
		X		X			X	X		X	X	
				X			X	X		X	X	
X				X			X	X		X	X	
X				X			X	X		X	X	
X				X			X	X				X
X				X			X		X			X
X				X			X		X	X	X	
X				X			X		X	X	X	
		X		X			X		X	X	X	
				X			X		X	X	X	
X			X		X				X	X	X	
X			X		X				X	X	X	
X			X		X			X		X	X	
X			X		X			X		X	X	

Test No.	Tape No.	Accession No.	Variables: Gibs		Side Bearings			Springs				Snubbing		Wheel Profile			Car Load		Track Type		
			Nominal	Closed	Tight	Nominal	Open	D-3	D-5	D-5 Reduced	D-7	2/3	Nominal	New	1/2 Worn	Worn	MT	GRL	H.S. Tang.	M.S. Tang.	Curv
2-4-5	0069 0070	PB 250 222/AS PB 250 223/AS	X				X			X			X	X			X		X	X	
2-4-6	0071 0072	PB 250 224/AS PB 250 225/AS		X	X					X			X	X			X		X	X	
2-4-7	0073 0074	PB 250 226/AS PB 250 227/AS		X	X					X			X	X				X	X	X	
2-4-8	0075 0076	PB 250 228/AS PB 250 229/AS	X				X			X			X	X				X	X	X	

*The equipment combination for these tests consisted of a mechanical refrigerator car (SPFE 459997) with ASF Ride Control 70-ton (63.6-mt) trucks. For further information concerning Series 2 Tests, see Freight Car Truck Design Optimization Introduction And Detailed Test Plans Series 1, 2, and 3 Tests - Phase I, Report No. FRA-OR&D 75-59

Test No.	Tape No.	Accession No.	Equipment Arr.*	New Wheels
3-1-2	0077 0078 0079	PB 250 230/AS PB 250 231/AS PB 250 232/AS	A	X
3-2-2	0080 0081 0082	PB 250 233/AS PB 250 234/AS PB 250 235/AS	B	X
3-2-2-C	0083	PB 250 236/AS	B	X
3-1-2-C	0084	PB 250 237/AS	A	X
3-1-1-C	0085	PB 250 238/AS	A	X
3-2-1-C	0086	PB 250 239/AS	B	X
3-2-1	0087 0088 0089	PB 250 240/AS PB 250 241/AS PB 250 242/AS	B	X
3-1-1	0090 0091	PB 250 243/AS PB 250 244/AS	A	X
3-3-1	0102 0103	PB 250 252/AS PB 250 253/AS	C	X
3-4-1	0111 0112 0113	PB 250 261/AS PB 250 262/AS PB 250 263/AS	D	X
3-4-1-C	0110	PB 250 260/AS	D	X
3-3-1-C	0098 0104	PB 250 251/AS PB 250 254/AS	C	X

* A=SP FE Mech. Refer.--Barber S-2-C 70-ton (63.6-mt) trucks

B=SP 60-foot (18.3-m) Box Car--Barber S-2-C 100-ton (90.9-mt) trucks

C=SCL Box Car X5B--Barber S-2-C 70-ton low level trucks

D=LN Covered Hopper Car--ASF Ride Control 100-ton trucks

E=SP 89-foot, 4-inch (27.2-m) Flat Car--ASF Ride Control 70-ton trucks

Variables					
Worn	Car Load		Track Type		
Wheels	MT	GRL	H.S. Tang.	M.S. Tang.	Curved
		X	X	X	
	X		X	X	
	X				X
		X			X
	X				X
		X			X
		X	X	X	
	X		X	X	
		X	X	X	
		X	X	X	
		X			X
		X			X

Test No.	Tape No.	Accession No.	Equipment Arr.*	New Wheels
3-3-2-C	0097	PB 250 250/AS	C	X
3-4-2-C	0114	PB 250 264/AS	D	X
3-4-2	0115 0116	PB 250 265/AS PB 250 266/AS	D	X
3-3-2	0092 0093	PB 250 245/AS PB 250 246/AS	C	X
3-5-1	0094 0095	PB 250 247/AS PB 250 248/AS	E	X
3-5-1-C	0096	PB 250 249/AS	E	X
3-5-2-C	0105	PB 250 255/AS	E	X
3-5-2	0106 0107	PB 250 256/AS PB 250 257/AS	E	X
3-5-3	0108 0109	PB 250 258/AS PB 250 259/AS	E	

Variables					
Worn	Car Load		Track Type		
			H S.	M.S.	
Wheels	MT	GRL	Tang.	Tang.	Curved
	X				X
	X				X
	X		X	X	
	X		X	X	
	X		X	X	
	X				X
		X			X
		X	X	X	
X	X		X		

Test No.	Tape No.	Accession No.	Modifications: Ctr. Plt. Friction: Lt.	Med.	Hvy.	Ped. Shims	Intertie	Elast. Adapt. Pads	Hydr. Dmpr.
4-1-1	0124	PB 250 267/AS	X						
4-1-2	0125	PB 250 268/AS	X			X			
4-1-3	0126	PB 250 269/AS		X		X			
4-1-4	0127	PB 250 270/AS		X					
4-1-5	0129	PB 250 272/AS			X				
4-1-6	0128	PB 250 271/AS			X	X			
4-2-1	0132 0133	PB 250 273/AS PB 250 274/AS	X			X	X		
4-2-2	0134 0135	PB 250 275/AS PB 250 276/AS	X				X		
4-2-3	0138 0139	PB 250 279/AS PB 250 280/AS	X				X	X	
4-2-4	0136 0137	PB 250 277/AS PB 250 278/AS	X			X	X	X	
4-3-1	0142 0143	PB 250 283/AS PB 250 284/AS	X			X	X		X
4-3-2	0140 0141	PB 250 281/AS PB 250 282/AS	X				X		X
4-3-3	0146 0147	PB 250 287/AS PB 250 288/AS	X						X
4-3-4	0144 0145	PB 250 285/AS PB 250 286/AS	X			X			X
4-4-1	0150 0152 0153	PB 250 291/AS PB 250 293/AS PB 250 294/AS	X			X			

* The equipment combination for these tests consisted of a mechanical refrigerator car (SPFE 459997) with ASF Ride Control 70-ton (63.6-mt) trucks.

C.C. Side Bear. (psi)			Opti-mized Comb.	Car Load		Track Type		
32	64	96		MT	GRL	H.S. Tang.	M.S. Tang.	Curved
				X		X		
				X		X		
				X		X		
				X		X		
				X		X		
				X		X		
				X		X	X	
				X		X	X	
				X		X	X	
				X		X	X	
				X		X	X	
				X		X	X	
				X		X	X	
				X		X	X	
X				X		X	X	

Test No.	Tape No.	Accession No.	Modifications: Ctr. Plt. Friction Lt.	Med.	Hvy.	Ped. Shims	Inertie	Elast. Adapt. Pads	Hydr. Dmpr.
4-4-2	0150 0151 0152 0153	PB 250 291/AS PB 250 292/AS PB 250 293/AS PB 250 294/AS	X						
4-4-3	0151 0152 0154	PB 250 292/AS PB 250 293/AS PB 250 295/AS	X						
4-4-1-C	0148	PB 250 289/AS	X						
4-4-2-C	0148 0149	PB 250 289/AS PB 250 290/AS	X						
4-4-3-C	0149	PB 250 290/AS	X						
4-4-4-C	0155 0156	PB 250 296/AS PB 250 297/AS	X						
4-4-5-C	0156	PB 250 297/AS	X						
4-4-6-C	0157	PB 250 298/AS	X						
4-4-6	0159 0163	PB 250 300/AS PB 250 304/AS	X						
4-4-5	0158 0160 0162	PB 250 299/AS PB 250 301/AS PB 250 303/AS	X						
4-4-4	0158 0160 0161	PB 250 299/AS PB 250 301/AS PB 250 302/AS	X						
4-5-1	0164 0165	PB 250 305/AS PB 250 306/AS							
4-5-1-C	0166	PB 250 307/AS							
4-5-2-C	0167	PB 250 308/AS							
4-5-2	0168 0169	PB 250 309/AS PB 250 310/AS							

C.C. Side Bear. (psi)			Optimized Comb.	Car Load		Track Type		
32	64	96		MT	GRL	H.S. Tang.	M.S. Tang.	Curved
	X			X		X	X	
		X		X		X	X	
X				X				X
	X			X				X
		X		X				X
X					X			X
	X				X			X
		X			X			X
		X			X	X	X	
	X				X	X	X	
X					X	X	X	
			X		X	X	X	
			X		X			X
			X	X				X
			X	X		X	X	

Test No.	Tape No.	Accession No.	Equip. Arr.*	Variables					
				Cyl. Whls.	1/40 Tpr. Whls.	Selec.** Whls.	Spring Nest	Snubbers Fric.	Hydr.
5-1-1	0174 0175 0178	PB 250 315/AS PB 250 316/AS PB 250 319/AS	A	X					
5-1-1-C	0177	PB 250 318/AS	A	X					
5-1-2-C	0182	PB 250 323/AS	A		X				
5-1-2	0179 0180 0181	PB 250 320/AS PB 250 321/AS PB 250 322/AS	A		X				
5-2-1	0183 0184	PB 250 324/AS PB 250 325/AS	A		X				
5-2-1-C	0185	PB 250 326/AS	A		X				
5-2-3	0099 0100	PB 250 352/AS PB 250 353/AS	A	X					
5-2-2-C	0101	PB 250 354/AS	A	X					
5-2-4	0117 0118	PB 250 355/AS PB 250 356/AS	A			X			
5-2-4-C	0119	PB 250 357/AS	A			X			
5-2-5-C	0120	PB 250 358/AS	A			X			
5-2-5	0121 0122	PB 250 359/AS PB 250 360/AS	A			X			
5-1-3-C	0131	PB 254 326/AS	A			X			
5-1-3	0123 0130	PB 254 324/AS PB 254 325/AS	A			X			
5-1-4	0171 0172	PB 250 312/AS PB 250 313/AS	A			X			
5-1-4-C	0170	PB 250 311/AS	A			X			
5-4-3	0173 0176	PB 250 314/AS PB 250 317/AS	B			X			
5-4-3-C	0186	PB 250 327/AS	B			X			
5-4-4-C	0187	PB 250 328/AS	B			X			
5-4-4	0188 0189	PB 250 329/AS PB 250 330/AS	B			X			

Spring Comp.			Car Load		Track Type			
D-3	D-5	D-7	MT	GRL	H.S. Tang.	M.S. Tang.	Curved	Mod. w/ Low Joints
	X		X		X	X		X
	X		X				X	
	X		X				X	
	X		X		X	X		X
	X			X	X	X		X
	X			X			X	
	X			X	X	X		X
	X			X			X	
X				X	X	X		X
X				X			X	
		X		X			X	
		X		X	X	X		X
		X	X				X	
		X	X		X	X		X
X			X		X	X		X
X			X				X	
		X		X	X	X		X
		X		X			X	
X				X			X	
X				X	X	X		X

Test No.	Tape No.	Accession No.	Equip. Arr.*	Cyl. Whls.	1/40 Tpr. Whls.	Variables Selec.** Whls.	Spring Nest Snubbers Fric.	 Hydr.	Spring Comp. D-3	 D-5	 D-7	Car Load MT	 GRL	Track Type H.S. Tang.	 M.S. Tang.	 Curved	 Mod. w/ Low Joints
5-4-5	0191 0192	PB 250 332/AS PB 250 333/AS	B			X				X			X	X	X		X
5-4-5-C	0190	PB 250 331/AS	B			X				X			X			X	
5-4-2	0193 0194	PB 250 334/AS PB 250 335/AS	B			X	X			X			X	X	X		X
5-4-1	0195 0196	PB 250 336/AS PB 250 337/AS	B			X		X		X			X	X	X		X
5-3-5	0197 0198	PB 250 338/AS PB 250 339/AS	B			X		X		X		X		X	X		X
5-3-4	0199 0200	PB 250 340/AS PB 250 341/AS	B			X	X			X		X		X	X		X
5-3-1	0201 0202	PB 250 342/AS PB 250 343/AS	B			X				X		X		X	X		X
5-3-1-C	0203	PB 250 344/AS	B			X				X		X				X	
5-3-3-C	0209 0210	PB 250 349/AS PB 250 350/AS	B			X			X			X				X	
5-3-3	0208 0211	PB 250 348/AS PB 250 351/AS	B			X			X			X		X	X		X
5-3-2	0205 0206	PB 250 346/AS PB 250 347/AS	B			X					X	X		X	X		X
5-3-2-C	0204	PB 250 345/AS	B			X					X	X				X	

*A = SPFE 70-ton (63.6-mt) mechanical refrigerator car 459997 with ASF Ride Control 70-ton capacity trucks

B = SP 60-foot (18.3-m), 100-ton (90.9-mt) box car with Barber S-2-C Low-Profile 100-ton capacity trucks

** Selected wheels will be chosen from either the 1/40 taper or cylindrical wheels following test 5-2-2-C

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16. Abstract

This report describes an analytical approach to estimation of fuel consumption in rail transportation, and provides sample computer calculations suggesting the sensitivity of fuel usage to various parameters. The model used is based upon careful deliniation of the relevant physical mechanisms of energy dissipation under steady-state conditions rolling and aerodynamic resistance (using the Davis equations), braking, idling, and locomotive power generation and conversion losses. Both simple and more complex formulations are applied as appropriate. Several classes of service are considered: branch line freight, intercity freight, conventional and high-speed passenger, and commuter. Numerous graphs illustrate typical results for specific fuel consumption as a function of speed, grade, power/weight, load factor, weight per seat, etc.

17. Key Words
Fuel Consumption
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16. Abstract

Fuel consumption measurements have been carried out in cooperation with several railroads for a variety of types of revenue freight service. Intermodal operations have been emphasized, but this report also includes studies relating to branchline and general freight movements. The wide range of operating parameters examined include train speed, weight, length, type, power-to-weight ratio, and terrain. In particular, this report describes the test conditions, operating parameters and fuel usage indices for 80 separate line-haul movements on six different railroads, covering 53,000 train miles. Trailer-On-Flatcar (TOFC) service predominates, but several manifest freights, two unit coal trains, and two COFC trains are included. Branchline service is also reported and analysed for six 174-mile round trips. In spite of considerable variation in relevant parameters and inherent imprecision in the data, the results are found to exhibit a basic consistency both internally and with past estimates.

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16. Abstract

Measurements of the noise generated by an SD40-2 diesel electric locomotive are described. The noise was measured in three types of moving tests: the first with the locomotive passing a 6-microphone array while under maximum power acceleration, the second with the locomotive simulating the pulling of a train, and the third with the locomotive coasting by unpowered. Stationary noise measurements were made at 16-microphone positions around the locomotive while it was attached to a load cell. The moving tests show that at the lower throttle settings, wheel/rail noise may be an important contributor to the overall locomotive noise signature even at modest speeds (20 mph and above at throttle 1 and 30 mph and above at throttle 4). At throttle 8, wheel/rail noise does not become a significant source until speeds in excess of 50 mph are reached. At throttle 8 and at speeds below 50 mph, noise spectra measured opposite the moving locomotive are comparable to noise spectra measured opposite the stationary locomotive. Diagnostic tests to determine how much the various sources contributed to the overall noise were performed at seven positions on one side of the locomotive. The engine exhaust and intake, the engine/generator, the radiator cooling fans, the dynamic brake fans, the traction motor blowers, the dust bin blower compressor, and structure-borne noise have all been identified. At high throttle settings the exhaust and radiator cooling fans dominate. At low throttle settings the engine/generator, the exhaust and the cooling fans all contribute to the overall noise.

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16. Abstract

The aerodynamic forces on trailers and containers on flatcars have been measured in wind tunnel tests. The forces were measured on the central car of a five-car train consisting of a locomotive, three flatcars with various loadings and a boxcar. Tests were made over a range of yaw angles and with different loadings. Standard trailers, containers and flatcars were tested as well as a variety of modifications designed to improve the aerodynamic performance. In addition to the railroad-car tests, a series of blocks simulating containers and trailer bodies were tested to determine the effect of gap spacing, corner radius, and surface roughness. The flatcars loaded with containers were found to have about forty percent less drag than when loaded with trailers. Various modifications that reduced the frontal area of the trailers or filled in the empty space between the trailer body and the car were all found to be effective in reducing the drag. Gap spacing size had little effect until it became of the order of the body width, and then the drag increased with increased spacing. Side and lift forces are chiefly caused by yaw angle and side area. The forces act near the centroid of the side area, but when the gap spacing becomes large they move farther forward. The research reported is intended to increase the knowledge base in understanding the aerodynamic drag component of trail resistance.

17. Key Words
Freight Car Aerodynamics
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ERRATA

"Rail Dynamics Laboratory Requirements and Hardware Configurations"

Page 90 first sentence under Fig. 6, Vibration Test Unit should read as follows:

"The vertical excitation modules (each under independent servo control) are designed around a 60,000 lb (27,216 kg) hydraulic actuator, equipped with a 200 gpm (.0126 m^3/s) high performance servo-valve."

Page 90 first sentence of second major paragraph from bottom starting "The hydraulic flow demands ..." should be changed to read as follows:

"The hydraulic flow demands of the various excitation modules and hydrostatic bearing elements at peak excitation levels can be as high as 1000 gpm (.0631 m^3/s) @ 3,000 psi (20,684,271 N/m^2). This has been provided for via three 360 gpm (.0227 m^3/s) variable volume pumping systems each capable of delivering the rated flow at 3,000 psi (20,684,271 N/m^2)."