DISCUSSION

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The authors are to be complimented for their contribution to the literature which has served to broaden the knowledge of the possible use of plasma torches for railway adhesion increase. Heat has been considered a prime way to degrade or destroy a lubricant film and the plasma torch is an available source of intense heat.

It would appear from Figs. 7 and 8 in the paper by Gifford and Yoshino that some increase of adhesion occurred during the first rotation of the test "rail" under the plasma torch, when it was applied at the 1 mph speed and at a distance of 0.75 in. from the rail in the rolling adhesion test. Also, from Table 2 and the above figures the adhesion continued to rise with additional passes. Thus, adhesion increase could be equated to the time at which elevated temperature is applied to railhead contamination. At higher speed the time would be shorter, and although the temperature of the plasma may be raised, the product of the time at elevated temperature of the contamination immediately adjacent to the rail may be difficult to maintain.

There is evidence, perhaps best summarized by Bowden and Tabor,[3] that the lubricity of certain mineral oils increases with the oxidation that occurs at elevated temperature. Thus it is possible that if the time at elevated temperature of an oily contaminant film were not great enough to fully destroy the film, the adhesion might actually be reduced, in certain areas, by application of a plasma torch. This may account for some of the lower adhesion areas found in the report, by D. J. Dobbs[4] of the British Railways Boards, to the U.S. Federal Railroad Administration.

In that report, four plasma torches were attached to the rear of a vehicle that was towed over various sections of track at speeds up to 30 mph. Adhesion was measured, both before and after application of the plasma torches at numerous places, by the leading axle of a stationary locomotive that immediately followed the plasma torch vehicle. While wheel diameters and unit loads may be different from American locomotives, the rail contamination and plasma applications are what might be expected in daily operational use. Taking the data from the Dobbs report and plotting the 50 percent slip-risk points of 17 test series, as shown in Fig. 10, results in a curve through the center of gravity of the points that is a net loss in adhesion at all speeds above 8 mph. This would indicate that to effectively raise the adhesion the product of the time at elevated temperature of the contamination must be increased. This was further indicated by the increase of adhesion that was obtained by a second pass of the plasma torch over the same section of the rail (see Figs. 11 and 12). It is possible that a fleet of locomotives equipped with plasma torches might raise the adhesion level by repeated application over a given section of track, assuming that recontamination does not take place between successive trains.

Dobbs reported that low adhesion values were found on short sections of track. Only a few of the data points in his report at 50 percent risk of slip were 0.25 or lower coefficient of adhesion. These are the most important, especially at low speed, and they were raised an average of 8 percent on the first pass of the plasma jets and 12 percent on the second pass. There was, however, a considerable spread in the adhesion of these points, and the average increase was not large when a 10 percent average change in adhesion was measured in a one hour time lapse on a given test site with no treatment of any kind, with maximum and minimum values which ranged from 0.10 to 0.24 and 0.14 to 0.28 (see Fig. 13)

In order to determine if lower adhesion values were raised most readily, the data on Fig. 14 were assembled from other than the 50 percent slip-risk portion of the curves. Here again there was no clear evidence that these plasma torches would consistently increase wheel to rail adhesion.

It seems appropriate that the data from Dobbs' report of locomotive tests be cited here as a complement and enlargement on the laboratory work of Gifford and Yoshino. I assume from

Report FRA-RT-70-27 • Percent Gain or Loss of Adhesion Vs. Speed

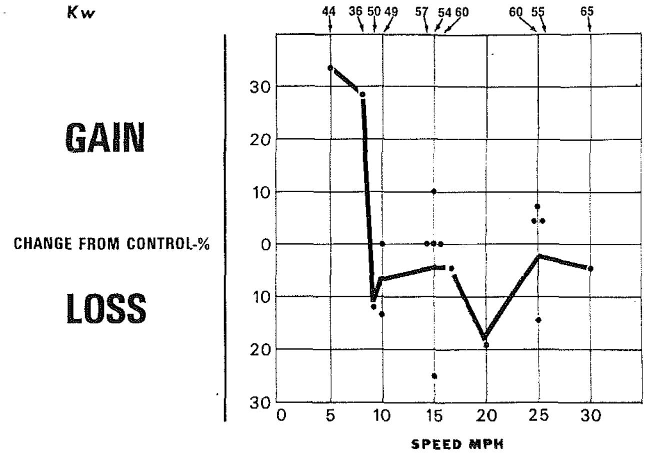

Fig. 10

Report FRA-RT-70-27 • First Plasma Torch Application

	CONTROL ADHESION	AFTER PLASMA	SPEED	COMMENTS	% GAIN (LOSS)
Useful Gain	.15	.20	5	Oily Rails - Misty	33
	.21	.27	8	Oily Rails - Misty	28
Small Gain	.31	.34	15	Oily Rails - Misty	10
	.17	.18	25	Fine Rain	6
	.28	.29	25	Oily Rails - Rain	3
	.36	.37	25	Salt Spray - Dry	3
No Value	.29	.29	10	Coal Dust - Dry	0
	.28	.28	15	Light Rain	0
	.34	.34	15	Coal Dust - Dry	0
	.39	.39	15	Salt Spray - Dry	0
Detriment	.28	.27	18	Dry	(4)
	.23	.22	30	Oily Rails - Dry	(4)
	.25	.22	9	Coal Dust - Dry	(12)
	.31	.27	10	Coal Dust - Dry	(13)
	.21	.18	25	Oily Rail - Misty	(14)
	.36	.29	20	Oily Rail - Dry - 2 passes	(19)
	.38	.28	15	Oily Rail - Dry	(26)

Fig. 11

Report FRA-RT-70-27 • Second Plasma Torch Application

2ND CONTROL ADHESION	AFTER 2ND PLASMA	% GAIN (LOSS)	SPEED	COMMENTS	ORIG. % GAIN (LOSS)
.29	.34	17	10	Coal dust - dry	(13)
.31	.40	29	15	Oily rails - misty	10
.32	.35	9	10	Coal dust - dry	0
.28	.31	11	9	Coal dust - dry	(12)
.39	.39	0	15	Oily rails - dry	(26)
.27	.31	15	18	Dry	(3)
.16	.23	44	25	Oily rail - fine rain	6
.30	.32	7	25	Oily rail - rain	3
.25	.23	(8)	25	Oily rail - misty	(14)
.37	.40	8	25	Salt spray - dry	3
.24	.24	0	30	Oily rail - dry	(4)
.33	.36	9	15	Coal dust - dry	0
.37	.38	3	15	Salt spray - dry	0
.39	.41	5	20	Oily rail - dry	(19)
.36	.36	0	15	Dry	0
Second Avg.		10%		First Avg.	(5%)
μ .25 & Below		12%		μ .25 & Below Avg.	8%

Fig. 12

[2] Transportation Technology Center, General Electric Company, East Lake Road, Erie, Pa.

[3] Bowden, F. P., and Tabor, D., *Friction and Lubrication of Solids*, Oxford Press, London, 1950, pp. 254–257.

[4] Dobbs, D. J., "Evaluation of the Plasma Torch," British Railways Board report to U. S. Federal Railroad Administration, Report No. FRA-RT-70-27, 1970.

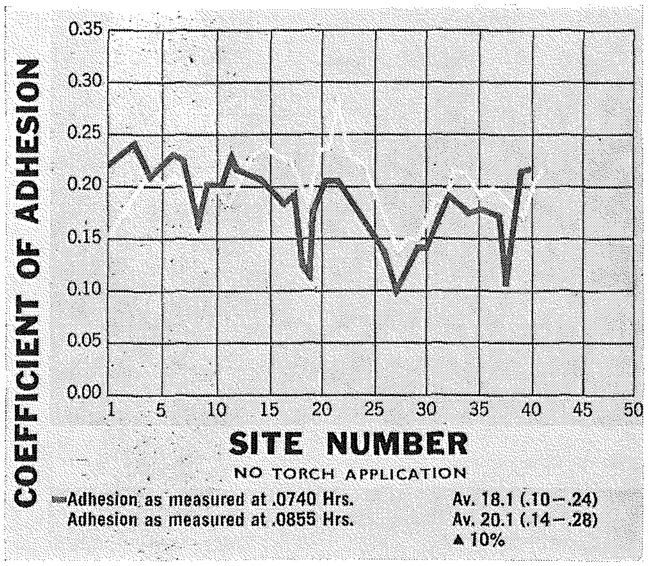

Fig. 13

Report FRA-RT-70-27 • Lower Adhesion Values from Curves

	CONTROL ADHESION	AFTER PLASMA	SPEED	COMMENTS	% GAIN LOSS
Adhesion Gain	13	17	5	Oily Rails – Misty	31
	17	24	8	Oily Rails – Misty	41
	20	21	10	Coal Dust – Dry	5
	12	13	25	Oily Rails – Fine Rain	8
	20	22	25	Oily Rails – Rain	10
	18	21	15	Light Rain	17
Adhesion Loss	27	24	10	Coal Dust – Dry	11
	27	25	15	Oily Rails – Misty	7
	21	20	9	Coal Dust – Dry	5
	35	25	15	Oily Rails – Dry	29
	17	15	25	Oily Rails – Misty	12
	20	15	30	Oily Rails – Sunny	25
	30	22	15	Coal Dust – Dry	27
	34	20	15	Salt Spray – Dry	41
	29	12	20	Oily Rails – Dry	57

Fig. 14

their report that the increased effectiveness of the nitrogen-hydrogen plasma torch was not considered attractive enough to warrant continued experimentation in the light of installation, hazard and maintenance problems involved in the use on a locomotive.