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TANK CAR SAFETY RESEARCH
Volume II: Test Plan for Accelerated
Life Testing of Thermally Shielded Tank Cars

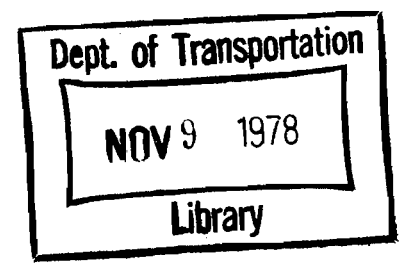
Milton R. Johnson
Owen J. Viergutz

IIT Research Institute
10 West 35th Street
Chicago IL 60616



AUGUST 1978
FINAL REPORT

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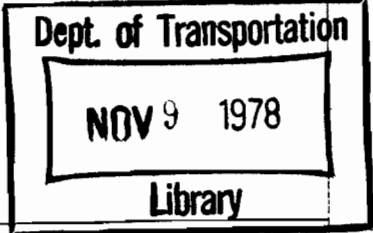
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16. Abstract A test plan for the accelerated life testing of thermally shielded tank cars is described. The test program would be conducted at the DOT Transportation Test Center in Pueblo, Colorado. Eighteen tank cars would be included in the program. Five cars would be equipped with a jacketed thermal shield, and 13 cars would be equipped with a spray-on chemical insulation coating. In addition, most cars would be equipped with head shield end-of-car protection systems. The goal of the tests is to simulate the effects of 10 years of normal service operations. This will involve subjecting the cars to a large number of coupling impacts as well as running the cars for a mileage representative of the 10 year period. This is the second volume of a two-volume report. Volume I, Fatigue Evaluation of Prototype Tank Car Head Shield, has 82 pages.					
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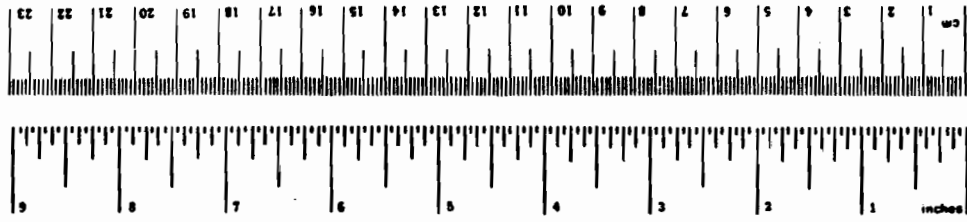


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METRIC CONVERSION FACTORS

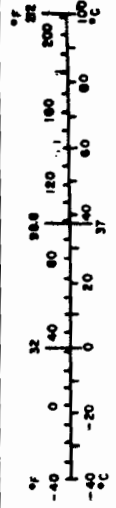
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi ²	square miles	2.6	square kilometers	km ²
ac	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
VOLUME				
cup	teaspoons	5	milliliters	ml
fl oz	tablespoons	15	milliliters	ml
pt	fluid ounces	30	milliliters	ml
qt	cup	0.24	liters	l
gal	quarts	0.47	liters	l
cu ft	gallons	0.95	liters	l
cu yd	gallons	3.8	liters	l
cu ft	cubic feet	0.03	cubic meters	m ³
cu yd	cubic yards	0.76	cubic meters	m ³
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
AREA				
cm ²	square centimeters	0.16	square inches	in ²
m ²	square meters	1.2	square yards	yd ²
km ²	square kilometers	0.4	square miles	mi ²
ha	hectares (10,000 m ²)	2.5	acres	ac
MASS (weight)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	sh
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m ³	cubic meters	36	cubic feet	ft ³
m ³	cubic meters	1.3	cubic yards	yd ³
TEMPERATURE (exact)				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

The work described in this report was conducted by IIT Research Institute (IITRI) under the authorization of Transportation Systems Center (TSC) Contract DOT-TSC-1043. The report is issued in two volumes. Volume I describes the evaluation of the structural integrity of a prototype tank car head shield when exposed to conditions representative of the normal service environment. Volume II describes a test plan for accelerated life testing of thermally shielded tank cars. The tests are to be conducted at the Transportation Test Center.

Staff members from IITRI who contributed to this project include: Dr. M. R. Johnson, Project Manager, Mr. O. J. Viergutz and Mr. G. Ebey. Dr. A. Robert Raab was the cognizant TSC Technical Monitor. His helpful suggestions and guidance throughout the course of the work are gratefully acknowledged.

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EXECUTIVE SUMMARY

The requirements for accelerated life testing of thermally shielded tank cars are presented. The primary objective of the Accelerated Life Test (ALT) is to simulate, in a limited environment, a 10-year service life of a typical tank car for the purpose of evaluating the in-service degradation of various thermal shielding arrangements. As is practical, other evaluations of specified equipment will be conducted parallel with this effort to the extent that the primary mission integrity is retained. The critical parameter of interest is the susceptibility of the thermal shielding to over-the-road vibrations, coupling impacts, and environmental cycling, which would result in separation and/or shakedown of the insulating material.

Subordinate objectives that will be considered include the determination of: the susceptibility of various head shield designs to damage in the over-the-road and coupling impact environment, and the in-service reliability of thermal and acceleration sensing derailment and hot-box detection equipment.

The tank car test fleet will consist of 18 cars from five sources. Five cars will be supplied by the RPI-AAR for thermal jacket evaluations. DuPont Chemical will provide two cars which will be included in the spray-on thermal coating evaluations and miscellaneous tests. Dow Chemical will provide four cars and Shell Oil Co. will provide three cars which will be utilized for thermal coating evaluations. In addition four cars will be leased for inclusion in the thermal coating evaluations.

The tests will be conducted at the DOT Transportation Test Center (TTC) in Pueblo, Colorado. The ALT will consist of running the cars approximately 160,000 miles at an average speed of 40 to 50 mph and subjecting them to simulated coupling impacts.

The initial mileage accumulation tests will be run on the Railroad Test Track at TTC. Subsequently the test will be integrated with the FAST program and the balance of the mileage will be accumulated under this program.

The car-coupling impact phase of the test will include subjecting selected cars to a distributed velocity spectrum from 4 to 10 mph of simulated coupling impacts. These simulations will be run in two segments of about 248 impacts per car; the first segment before the mileage tests, and the second segment after the mileage tests.

Ten of the 112A cars in the consist will be equipped with head shields. Derailment and on-board hot-box detection equipment, as supplied by Naval Surface Weapons Center, will be mounted on the 18 cars. This equipment consists of accelerometer and thermal sensors mounted adjacent to each bearing adapter, an air-dump valve, and the associated cabling.

Most of the test cars will be subjected to a range of test conditions which simulate, as nearly as possible, actual service conditions. This will include conducting the car-coupling impacts and the mileage runs with the cars loaded for one-half of the tests and unloaded for the remainder of the tests. In addition, the coupling impacts would be conducted both before and after the mileage tests as the most practical way of simulating the distribution of these impacts during normal operations. Some cars would be tested at other conditions, e.g., all impacts with the car unloaded, or all mileage run with the car loaded, to determine the effects of these variables on the performance of the thermal and head shields.

One of the parameters considered in developing appropriate test conditions is the characteristics of the track over which the cars will be operated. If the track is in perfect alignment and has no profile irregularities, there will be little excitation of the primary suspension system and as a result, the fluctuating loads tending to develop damage in the various components of the car will be minimal. Measurements taken on a 112A tank car during train operations have revealed that severe vertical oscillations can be developed under certain combinations of speed and track irregularities. Therefore, a plan is presented for modifying a representative length of the test track to ensure that vertical vibrations of similar magnitude to those observed under severe operating conditions are developed during the test.

TEST PLAN FOR ACCELERATED LIFE TESTING OF THERMALLY SHIELDED TANK CARS

1. INTRODUCTION

This report sets forth the test requirements for the accelerated life testing of thermally shielded tank cars. The primary objective of the Accelerated Life Test (ALT) is to simulate, in a limited environment, a 10 year service life of a typical tank car for the purpose of evaluating the in-service degradation of various thermal shielding arrangements. As is practical, other evaluations of specified equipment will be conducted parallel with this effort to the extent that the primary mission integrity is retained. The critical parameter of interest is the susceptibility of the thermal shielding to over-the-road vibrations, coupling impacts, and environmental cycling, which would result in separation and/or shakedown of the insulating material.

Subordinate objectives that will be considered include the determination of the susceptibility of various head shield designs to damage in the over-the-road and coupling impact environment, and the in-service reliability of thermal and acceleration sensing derailment and hot-box detection equipment.

2. SUMMARY OF TEST PROCEDURES

Test cars will be provided by participating organizations and delivered to DOT, Transportation Test Center (TTC) Pueblo, Colorado. Eighteen tank cars of various configurations will be included (see Table 4.1). The Accelerated Life Test will consist of running the cars approximately 160,000 miles at an average speed of 40 to 50 mph and subjecting them to 496 simulated coupling impacts per car.

The initial mileage accumulation tests will be run on the Railroad Test Track (RTT) at TTC. Subsequently the test will be integrated with the FAST program and the balance of the mileage will be accumulated under this program.

The car-coupling impact will include subjecting selected cars to a distributed velocity spectrum from 4 to 10 mph of simulated

coupling impacts. These simulations will be run in two segments of about 248 impacts per car, the first segment before the mileage tests and the second segment after the mileage tests.

The details of the test plan are contained in the sections which follow. The major features of the plan are described by the list of equipment, Table 4.1, page 4, the test sequence, Table 5.1, page 10, and the schedule, Table 11.1, page 50.

3. PARTICIPATING ORGANIZATIONS AND COGNIZANT INDIVIDUALS

IIT Research Institute (IITRI) is responsible for the development of the Accelerated Life Test Plan under authorization of Transportation Systems Center (TSC) Contract No. DOT-TSC-1043. This project is one facet (Phase 11) of a joint Railway Progress Institute (RPI) — Association of American Railroads (AAR) Railroad Tank Car Safety Research and Test Project. The program is to be undertaken by the Federal Railroad Administration (FRA) and conducted at the Transportation Test Center (TTC) in Pueblo, Colorado. Participation by several organizations for evaluation of specific equipment includes DuPont, Dow, Shell Oil, and Naval Surface Weapons Center (NSWC).

The following is a listing of responsible individuals for this program:

- | | |
|--------------------------------------|---------------------------------------|
| ● FRA
Washington, D.C. | Mr. Donald Levine |
| ● TSC
Cambridge, Mass. | Dr. A. Robert Raab |
| ● TSC
Consultant | Mr. John Armstrong |
| ● TTC
Pueblo, Colorado | Mr. James Eckland
Mr. Ben Thompson |
| ● RPI-AAR
Chicago, | Mr. E. Phillips |
| ● AAR
Chicago, Illinois | Dr. G. Martin |
| ● Dow Chemical
Midland, Michigan | Mr. J. R. Hopkins |
| ● DuPont Co.
Wilmington, Delaware | Mr. Howard D. Irwin |
| ● NSWC
Silver Spring, Md. | Mr. Peter Gratton
Mr. H. Snider |

- | | |
|---|------------------------------------|
| ● IITRI
Chicago, Illinois | Dr. M. Johnson |
| ● AVCO
Boston, Mass. | Mr. W. Christenson |
| ● TSI
Washington, D.C. | Mr. W. Beckmeier |
| ● DeSoto, Inc.
Des Plaines, Illinois | Mr. R. Wydeen
Mr. T. E. Kearney |
| ● Shell Oil Co. | Mr. R. Gates |

4. EQUIPMENT

The test fleet will consist of 18 cars from five basic sources. Five cars will be supplied by the RPI-AAR for thermal jacket evaluations. DuPont Chemical will provide two cars which will be included in the spray-on thermal coating evaluations and miscellaneous tests. Dow Chemical will provide four cars and Shell Oil Co. will provide three cars which will be utilized for thermal coating evaluations. In addition four cars will be leased for inclusion in the thermal coating evaluations. Table 4.1 presents the characteristics of each car in the test consist.

4.1 Tank Car Inventory

The five cars to be supplied by RPI-AAR, cars 1 to 5, will be fitted as follows:

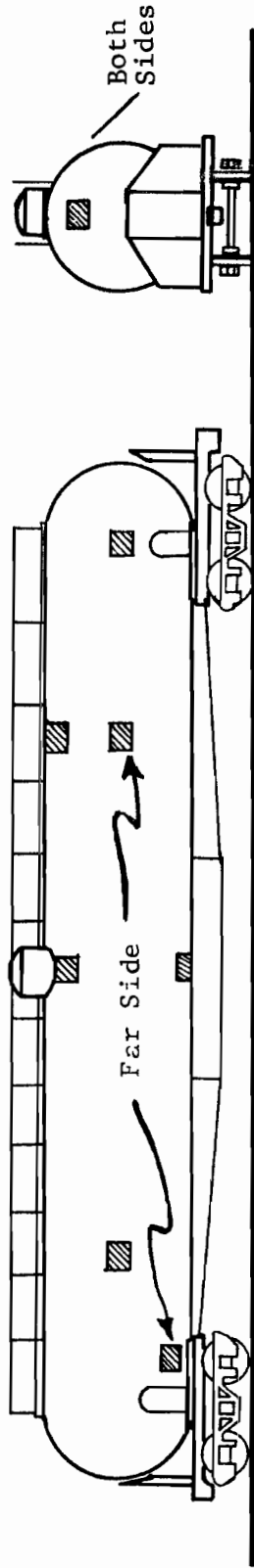
- ACFX, GATX, NATX, and UTLX, will each provide one insulated-jacketed 112A tank car using the 'M-1' insulating material at one inch thickness and 12 lb/ft³ density.
- Each of the 112A cars will have the thermal shield insulation and jacket applied per the respective company's design.
- Each of the 112A cars is to have an 11 gage steel jacket overall and a 1/2 inch thick steel jacket head over the entire tank head. Material of the jacket head to be in accordance with that prescribed in HM-109.
- One new 100 ton, 111A class tank car, approximately 20,000 gallons in capacity, insulated with 4 inch fiberglass will be supplied to provide a comparative reference.

TABLE 4.1 ALT TANK CAR CHARACTERISTICS

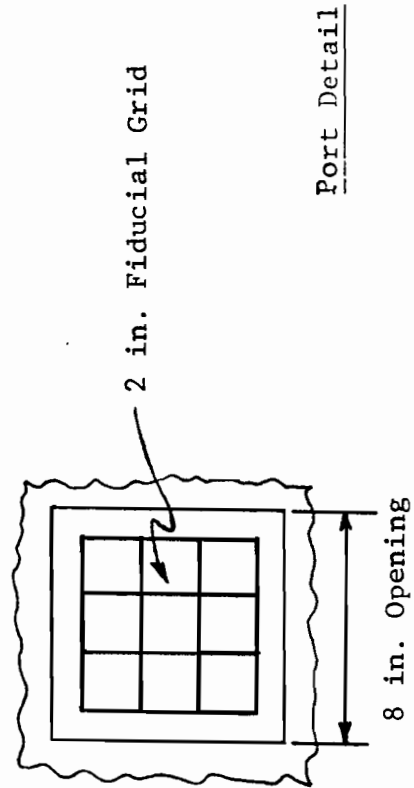
Test Car	Source	Type	Number	Light Wt (lb)	Load Limit (lb)	Capacity (gals)	Thermal Shield (thickness of coating, inch)	Head Shield Design	Safety Valve Relief Pressure (psi)
1	RPI-AAR	112A	ACFX 80162	104,400	158,600	33,756	'M-1'* Jacket to ACFX Design	Steel 1/2-inch thick over head	340
2	RPI-AAR	112A	GATX 27953	111,100	151,900	33,505	'M-1'* Jacket to GATX Design	Steel 1/2-inch thick over head	400
3	RPI-AAR	112A	NATX 35018	106,000	157,000	33,987	'M-1'* Jacket to NATX Design	Steel 1/2-inch thick over head	340
4	RPI-AAR	112A	UTLX 30430	117,800	145,200	33,849	'M-1'* Jacket to UTLX Design	Steel 1/2-inch thick over head	400
5	RPI-AAR	111A	NATX 76733	79,100	183,900	23,677	4 inch Fiberglass Jacket	-	100
6	DuPont	112A	DUPX 20457	91,200	171,800	33,622	TSI-Coating (.150)	DuPont Design	340
7	DuPont	111A	DUPX 29245	71,400	191,600	29,408	TSI-Coating (.150)	-	100
8	Dow (Wanda Pet.)	112A	LEYX 556	88,300	174,700	33,638	AVCO Coating(.170)	UTLX	340
9	Dow (Wanda Pet.)	112A	LEYX 542	89,100	173,900	33,617	AVCO Coating(.170)	UTLX	340
10	Dow	112A	DOWX 3316	90,400	224,600	31,379	TSI Coating (.150)	UTLX	340
11	Dow	112A	DOWX 3346	90,300	224,700	31,413	DeSoto Coating(.180)	UTLX	340
12	FRA Lease	112A	ACFX 17749	91,500	171,500	33,353	AVCO Coating (.170)	ACFX	340
13	FRA Lease	112A	GATX 92557	84,400	178,600	33,642	DeSoto Coating (.180)	GATX	340
14	FRA Lease	112A	NATX 34436	91,400	174,700	33,916	AVCO Coating (.170)	NATX	340
15	FRA Lease	112A	UTLX 99207	104,800	163,100	33,641	TSI Coating (.150)	UTLX	340
16	Shell	112A	SOEX 3020	90,700	172,300	33,350	TSI Coating (.200)	-	340
17	Shell	112A	SCMX 3688	99,800	167,500	33,586	TSI Coating (.250)	Shell	400
18	Shell	112A	SOEX 3227	89,100	176,900	33,966	TSI Coating (.150)	-	340

*'M-1' material jacket to be 1 in. thick and have an average density of 12 lb/ft³.

- The steel jacket on all five cars will have inspection ports, in number and of design as shown in Figure 4.1. Insulation behind inspection ports will be marked as shown to facilitate determination of settling characteristics.
- Each of the 112A (114A) cars will have the thermal shield insulation and jacket applied per the respective company's design. The methods of applying the systems will all be different to the degree practical in order to provide a broader test range. These will be:
 - ACFX Design - Metal angles (1 inch x 1 inch x 3/16 inch) welded on 2 ft contours to 3 inch x 8 inch steel bands around shell in 12 locations. Insulation then banded in place with banding material. Insulation secured to jacket head using pin weld studs.
 - GATX Design - Apply preassembled 4 ft x 30 ft panels of insulation with chicken wire reinforcement on jacket side only to tank shell. Stitch weld 1 inch x 1 inch x 1/8 inch angles on 4 ft centers around tank (rolled leg down). Apply insulation around tank and hold with two steel bands per 4 ft section. Apply chicken wire reinforced insulation over tank heads and tie down with straps running over head from circumferential angle near head seam.
 - NATX Design - Prefabricate 2 inch x 1/8 inch x 30 ft long bars with 7/8 inch spacers attached. Stitch weld bars to tank on 4 ft centers. Insulation will be banded in place with two steel tapes. Heads per ACF Design.
 - UTLX Design - Stitch weld 1 inch x 1/4 inch bars over shell running longitudinally at 12:00, 3:00, 6:00, and 9:00 o'clock position with 1 inch x 1/4 inch rolled bars running circumferentially on 6 ft centers. Band insulation in place with plastic banding material. Heads per ACF Design.
- Each of the 112A (114A) cars will have an 11 gage steel jacket and a 1/2 inch thick steel jacket head over each tank head. Material of the 1/2 inch portion of the jacket head to be as prescribed in HM-109. Paint exterior of jacket black and give inside surface a protective coating per tank car specifications.
- Insulation will be weighed to provide "density map" over entire surface of each of the four 112A (114A) cars. Each panel will be weighed to within 1/4 lb and a developed drawing prepared identifying the panel location. A table of corresponding panel weights and locations will be furnished.



Inspection Port Locations



Port Detail

FIGURE 4.1 PLACEMENT OF JACKET INSPECTION PORTS

- One new 100 ton, 111A class tank car, approximately 20,000 gallons in capacity, insulated with 4 ft fiberglass to be provided by one of the four companies.
- The steel jacket on all five cars to have nine inspection ports, 8 inch x 8 inch (Figure 4.1). Cover to be bolted and gasketed with inside surface flush with inside of jacket. Insulation behind inspection ports to be given light spray coat of white paint to facilitate determination of settling characteristics.
- Each company to provide sketch of insulation jacket application details to the project.

The DuPont cars 6 and 7 will be supplied as follows:

- One 100-ton 111A100W1 car, Number DUPX 29245, will be equipped with one elastomeric cushioned center plate, additionally other optional equipment may be provided.
- One 100-ton 112A340W car Number DUPX 20457 with formed head shields of DuPont design.

The Dow cars 8 to 11 will be equipped as follows:

- Two 112A340W cars Number DOWX 3316 and DOWX 3336 conforming to General American Transportation Corp. general arrangement drawing 1058-745 dated November 17, 1966. These cars are nominal 125 ton capacity cars.
- Two 100-ton 112A cars operated by Wanda Petroleum Company. These cars will conform to Union Tank Car Company data sheet dated October 1, 1966 for LEYX-556 and General American data sheet dated May 26, 1966 for LEYX-542.

The lease cars 12 to 15 will consist of four 112A cars to be obtained through the RPI/AAR Tank Car Project. The cars will conform to all pertinent design specifications. The coatings which are to be applied to these cars will be removed following the tests.

Shell Oil Co. will provide cars 16 to 18 as follows:

- Three 100-ton 112A cars of approximately 33,000 gallon capacity. One of these cars will be equipped with a head shield of Shell design.

4.1.1 Coatings for DuPont, Dow, Shell Oil and Lease Cars

- The DuPont cars - Both cars to be coated with the TSI spray-on material.
- The Dow Cars - One car to be coated with the TSI spray-on material as per current specification. Two cars to be coated with the AVCO spray-on material and one car to be coated with DeSoto spray-on coating.
- The FRA-Lease cars - One car to be coated with the TSI spray-on material. Two cars to be coated with the AVCO spray-on material. One car to be coated with DeSoto spray-on coating.
- The Shell Oil Cars - All three cars to be coated with the TSI spray coating.
- See Table 4.1 for coating thicknesses.

4.1.2 Head Shielding

Ten of the 112A cars in the consist will be equipped with head shields. The following head shield designs will be utilized:

- Car 13, head shield of GATX design
- Car 14, head shield of NATX design
- Cars 8-11 and 15, head shield of UTLX design
- Car 12, head shield of ACFX design
- Car 6, head shield of DuPont design
- Car 17, head shield of Shell Oil design

4.2 Derailment Detection Equipment

Derailment and on-board hot-box detection equipment as supplied by NSWC will be mounted on the 18 cars. This equipment consists of accelerometer and thermal sensors mounted adjacent to each bearing adapter, an air-dump valve and the associated cabling. The devices will be run for a period of time in the nonactivated state to assess the reliability of the device. After this initial period the devices will be actuated and in-service reliability determined.

5. TEST PHILOSOPHY

Most of the test cars will be subjected to a range of test conditions which simulate, as nearly as possible, actual service conditions. This will include conducting the car-coupling impacts and the mileage runs with the cars loaded for one-half of the tests and unloaded for the remainder of the tests. In addition, the coupling impacts would be conducted both before and after the mileage tests as the most practical way of simulating the distribution of these impacts during normal operations. Some cars would be tested at other conditions, e.g. all impacts with the car unloaded, or all mileage run with the car loaded, to determine the effects of these variables on the performance of the thermal and head shields. These variations are shown in Table 5.1 which presents the overall sequence to be followed during the test program.

As indicated in Table 5.1 the test plan calls for running the cars approximately 160,000 miles during the mileage runs. These runs would be scheduled in 4 segments of about 40,000 miles each. The cars would be thoroughly inspected between each of these segments. The first mileage segment is scheduled to be run on the RTT. The program is then scheduled to be integrated with the FAST program and the remaining mileage segments accumulated under this program. The details of the specific test conditions are described in the following paragraphs.

5.1 Thermal Shield Evaluations

The four RPI/AAR 112A cars equipped with jacketed thermal shield designs will be run at conditions which duplicate as much as possible the normal service environment. They will be impacted under full and empty conditions and they will be both full and empty when the test mileage is being accumulated. These cars utilize similar designs for the application of the thermal shield so there is no substantial difference that is anticipated in the test results. Two of the cars, 1 and 4, will receive coupling impacts before the test mileage begins. This will make it possible

TABLE 5.1 PROPOSED TEST SEQUENCE

Test Car No.	Car Identification No.	Type	Head Shield	Thermal Shield	Coupling Impacts (Premileage Tests)	Mileage Segments (~40,000 miles each)				Coupling Impacts (Postmileage Tests)
						1	2	3	4	
1	ACFX 80162	112A	JKT.	JKT.	E-F	F	F	E	E	E
2	GATX 27953	112A	JKT.	JKT.	-	F	F	E	E	E
3	NATX 35018	112A	JKT.	JKT.	-	E	E	F	F	F
4	UTLX 30430	112A	JKT.	JKT.	E-F	E	E	F	F	F
5	NATX 76733	111A	-	JKT.	E-F	F	F	E	E	E
6	DUPX 20457	112A	DuPont	TSI	F	F	F	F	F	F
7	DUPX 29245	111A	-	TSI	E-F	F	F	E	E	E
8	LEYX 556	112A	UTLX	AVCO	E	F	F	F	F	F
9	LEYX 542	112A	UTLX	AVCO	F	F	F	F	F	F
10	DOWX 3316	112A	UTLX	TSI	E-F	F	F	E	E	E
11	DOWX 3346	112A	UTLX	DeSoto	E	F	F	F	F	F
12	ACFX 17749	112A	ACFX	AVCO	E-F	F	F	E	E	E
13	GATX 92557	112A	GATX	DeSoto	E-F	F	F	E	E	E
14	NATX 34436	112A	NATX	AVCO	-	E	E	F	F	F
15	UTLX 99207	112A	UTLX	TSI	E-F	E	E	F	F	F
16	SOEX 3020	112A	-	TSI	E	F	F	F	F	F
17	SCMX 3688	112A	SHELL	TSI	E-F	E	E	F	F	F
18	SOEX 3227	112A	-	TSI	-	E	E	E	E	F

To be Scheduled after Mileage Runs

E - Empty (unloaded) Car
 F - Full (loaded) Car

to examine the effect of coupling impacts on the performance of jacketed thermal shield designs. The damage, if any, which is due to coupling impacts can then be isolated from that which occurs under normal running conditions.

The fifth RPI/AAR car, the 111A car, will be equipped with a standard 4 in. thick jacketed fiberglass insulation. This type of insulation system has been used for many years and there is a wealth of background information available to demonstrate its reliable performance in the normal service environment. This will be a comparative car by which to reference the test conditions. That is, it is anticipated that relatively little, if any, damage will occur to this jacketed thermal shield system over the life of the tests. If damage does occur, it will be an indication that the test environment is more severe than desired.

The remaining cars, 6-18, will be used to determine the performance of three different thermal coating systems and to compare their performance with that of the jacketed insulation systems on cars 1-4. It will be possible to examine a greater range of parameters with the coated cars to separate out the effects of coupling impacts and full and empty car conditions. Three different coatings will be applied to these cars. A TSI coating will be applied to cars 6, 7, 10 and 15-18. An AVCO coating will be applied to cars 8, 9, 12 and 14. A DeSoto coating will be applied to cars 11 and 13.

Six coated cars (cars 7, 10, 15 and 17, TSI coating, car 12, AVCO coating, and car 13, DeSoto coating) will be run as close as practical to the same conditions used for two jacketed cars, cars 1 and 4, so that direct comparisons can be made of the performance of the coatings with the jacketed thermal systems.

A second group of coated cars (car 14, AVCO coating, and car 18, TSI coating) will not be impacted at the beginning of the test. This will permit a direct comparison of the effect of initial impacts on the performance of the coating and the head shields which are attached to these cars. It will make possible a direct comparison

with the jacketed insulation systems, namely, cars 2 and 3, which also will not be impacted at the beginning of the test series.

A third group of cars (car 8, AVCO coating, car 16, TSI coating, and car 11, DeSoto coating) will be run at what may be a more severe combination of conditions, namely, all impacts conducted with an empty car (which results in the highest accelerations associated with impact conditions) and the over-the-road mileage accumulated under fully loaded conditions.

A fourth group of cars (car 9, AVCO coating, and car 6 TSI coating) will be impacted full and run full during all of the mileage runs. This will make possible a comparison of this set of environmental conditions with the other groups of cars.

An additional comparison can be made of the effects, if any, of car design. Car 7 is of 111A design and will have a TSI coating. Its performance can be compared with cars 10, 15 and 17 which are of 112A design and also have a TSI coating.

The thermal shield evaluations are summarized in Figure 5.1 where the cars are grouped in different combinations (empty, empty and full, or full) for both the pre-mileage coupling impact tests and the mileage tests.

5.2 Head Shield Evaluations

The effects of various combinations of the environment on head shields will also be examined by the tests. Cars 1 to 4 will be equipped with the RPI/AAR 1/2-inch-thick full head shield which is integral with the jacket. The effects of initial coupling impacts will be examined by comparing the results of cars 1 and 4 (subjected to initial impacts) and cars 2 and 3 (not impacted initially).

Five cars, 8-11 and 15 will be equipped with a head shield of UTLX design. Two of these cars, 10 and 15, will receive pre-mileage impacts in both the loaded and empty condition and be run on the mileage tests both loaded and empty. Two of these cars with UTLX

head shields, 8 and 11, will be empty during all the pre-mileage impacts and loaded during all the mileage runs, a set of conditions which may be more severe than used on the first two cars. One car with a UTLX head shield (9) will be full during both the pre-mileage impacts and the mileage runs permitting a comparison of this set of conditions with the other test conditions.

Premileage Impact Conditions	Mileage Accumulation Conditions		
	Empty	Empty - Full	Full
None		TSI(18) JKT AVCO(14)	
Empty			DeSoto(11) AVCO(8) TSI(16)
Empty-Full		TSI(7) AVCO(12) TSI(10) DeSoto(13) TSI(15) TSI(17) JKT(1,4,5)	
Full			TSI(6) AVCO(9)

FIGURE 5.1 DISTRIBUTION OF CAR COATINGS BY TEST CONDITIONS

One car each will be equipped with head shields of NATX (car 14), ACFX (car 12), GATX (car 13), Shell (car 17), and DuPont (car 6) design. Four of these designs, ACFX, GATX, Shell, and DuPont, will be installed on cars run at the standard set of test conditions, namely, empty and full for both the pre-mileage coupling impacts and the mileage runs. The car equipped with the NATX head shield will not receive pre-mileage coupling impacts and will be run both empty and full during the mileage runs.

The head shield evaluations are summarized in Figure 5.2 where the cars are grouped in different combinations (empty, empty and full, or full) for both the premileage coupling impact tests and the mileage tests.

Premileage Impact Conditions	Mileage Accumulation Conditions		
	Empty	Empty - Full	Full
None		NATX(14)	
Empty			UTLX(11) UTLX(8)
Empty-Full		UTLX(10) UTLX(15) ACFX(12) SHELL(17) GATX(13)	
Full			DuPont (6) UTLX(9)

FIGURE 5.2 DISTRIBUTION OF HEAD SHIELDS BY TEST CONDITIONS

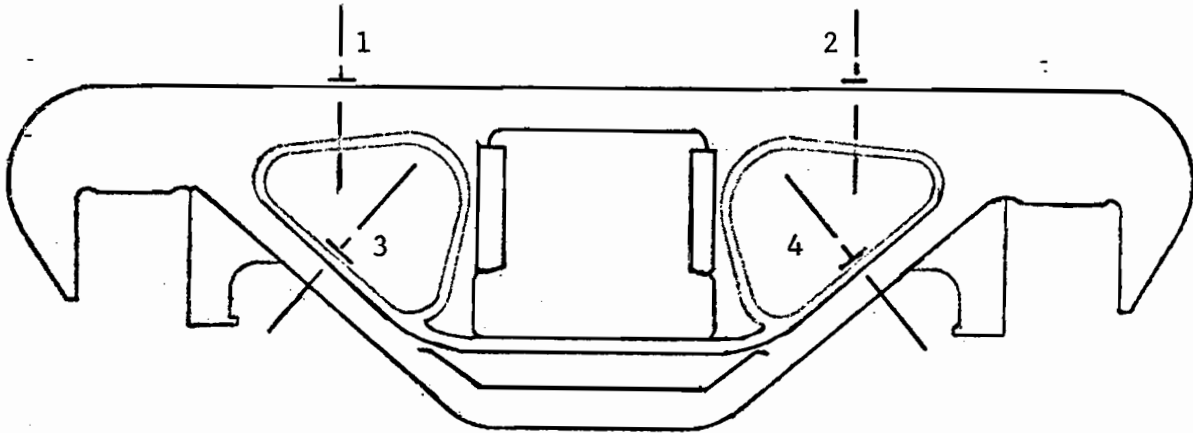
6. TEST TRACK CHARACTERIZATION

One of the parameters which must be considered in developing appropriate test conditions is the characteristics of the track over which the cars will be operated. If the track is in perfect alignment and has no profile irregularities there will be little excitation of the primary suspension system, and as a result the fluctuating loads tending to develop damage in the various components of the car will be minimal. Measurements taken on a 112A tank car during train operations have revealed that severe vertical oscillations can be developed under certain combinations of speed and track irregularities. Therefore, it is recommended that a representative length of the test track be modified to ensure that vertical vibrations of similar magnitude to those observed under severe operating conditions are developed during the test. The proposed plan for introducing the appropriate modified track conditions at the test site is described in the following paragraphs.

6.1 Truck Side Frame Instrumentation and Calibration

It is proposed that both trucks on a 112A tank car, specifically car 6, DUPX 20457, be instrumented to record vertical side frame force. The instrumentation would consist of strain gages applied to each of the side frames on the car. Four strain gages would be used on each side frame, one on each of the two tension members, and one on each of the two compression members, as illustrated in Figure 6.1. These gages would be wired into a four active arm bridge. This has proven to be a successful method of monitoring vertical truck load. Following installation of the strain gages the trucks should be calibrated to a vertical load of 400,000 lb applied to the center plate of the truck bolster. In addition to the instrumented side frames, two vertical accelerometers should be mounted on the stub sills at both ends of the car.

Strain Gages placed at middle
of Window Openings on centerline
of Casting



NOTE: Gages on each side frame are wired
into a four active arm bridge -

Strain gages Micromeasurements
LWK-06-W250B-350 or equivalent.

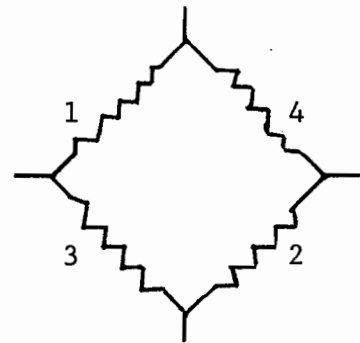


FIGURE 6.1 PLACEMENT OF SIDE FRAME STRAIN GAGES

6.2 Track Characterization Measurements

The instrumented car would be run over the track so as to characterize the vertical load environment. Provisions should be made for continuously recording the output data from the transducers during these test runs. An FM analog tape recorder would be set up in an instrumentation car which would be run with the instrumented tank car. The instrumentation car would contain the tape recorder and appropriate signal conditioning equipment. In addition to recording data from the six transducer bridges on the tank car, one channel should record velocity, one channel used for a time code reference and a voice channel should be used for providing positional references and other pertinent information as the test runs are made.

During the mileage runs on the RTT the characteristics of the test loop should be measured once a week, initially. A longer interval may be acceptable after the tests have been in progress and a data base has been established. Records should be obtained for at least three traverses of the test loop.

As noted in the schedule (Table 11.1) the consist will move to the FAST loop for the final mileage accumulation segments. The ALT program will then be integrated with the FAST program. The philosophy of the FAST program is to start the tests with a track that is in excellent condition over the entire loop. The total tonnage developed over this track would be quite high, on the order of 1,000,000 tons per day. Specified limits would be set on the condition of the track and it would be maintained to this level. It is recommended that load characterization measurements be made approximately every 2 weeks during this phase of the test program.

Following each track characterization test run, the data should be analyzed to determine the truck loads induced by the track characteristics. The side frame data should be filtered with a low-pass filter at a frequency of 20 Hz and digitized at 100 samples per second.

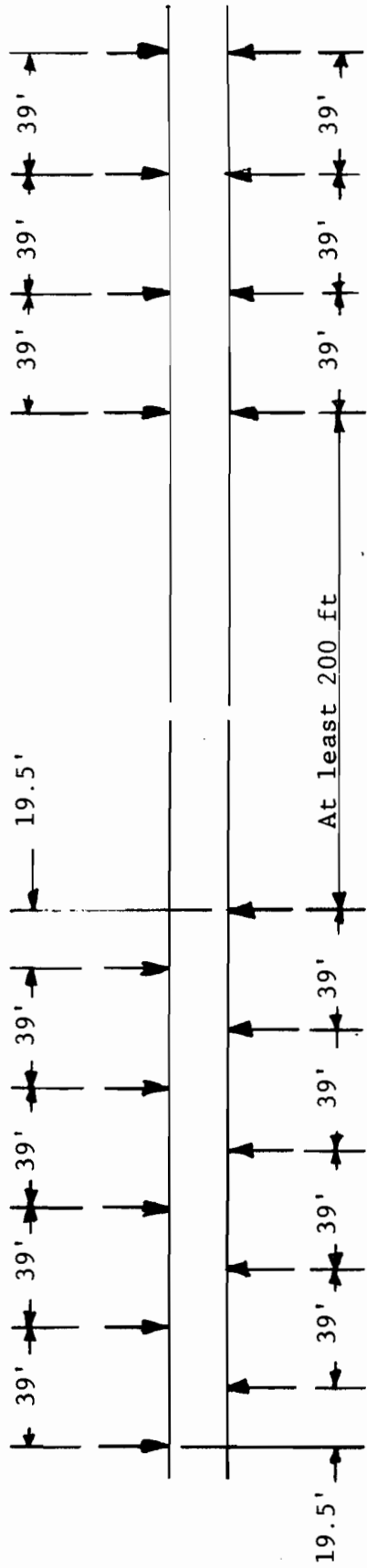
The data from the side frames would be processed to provide eight load spectra (defined as a counts of peak loads between crossings of the mean level). The load spectra would include vertical load for each of the four side frame channels, the bounce load for each truck (defined as the instantaneous sum of the truck side frame loads), and the rock load for each truck (defined as the difference between the instantaneous side frame loads).

Frequency analyses should be performed on all four side frame load channels and both accelerometer channels. The suggested ranges for playback of this data are approximately 0.5 to 50 Hz. The frequency data should be averaged over the entire track loop.

A time-history plot which provides an output versus time for all six channels of load and accelerometer data should be obtained for the 5 highest loading events during the traverse of the loop. The data should be plotted for approximately ± 0.5 seconds about the point in time when the maximum load was obtained. This will permit a review of the phenomena which produces the high load event, e.g., whether the car is undergoing a bounce or pitch motion, etc., and also to determine if electrical noise is present.

6.3 Track Profile Modification

A major question is how much vertical roughness should be built into the track to produce a meaningful vertical vibrational environment. To examine this it is proposed that approximately 500 feet of the track be modified with shims as indicated in Figure 6.2 to represent the effects of rail joints on staggered jointed rail. Also, several discontinuities at opposite locations on the track would be introduced to represent the effects of grade crossings, bridges, etc. At the center of each shim position, as indicated in Figure 6.2, there would be three consecutive ties where the nominal shim thickness would be used between the tie plate and the tie. Also as shown in the figure, additional shims would be used to ramp up to and down from the maximum shim height. The number of these shims placed at the tie plate positions before



Staggered Shim Array, 5 each side

Opposite Shim Array, 4 each side

Arrows show mid-positions of shims placed as illustrated below. Nominal shim height, h .

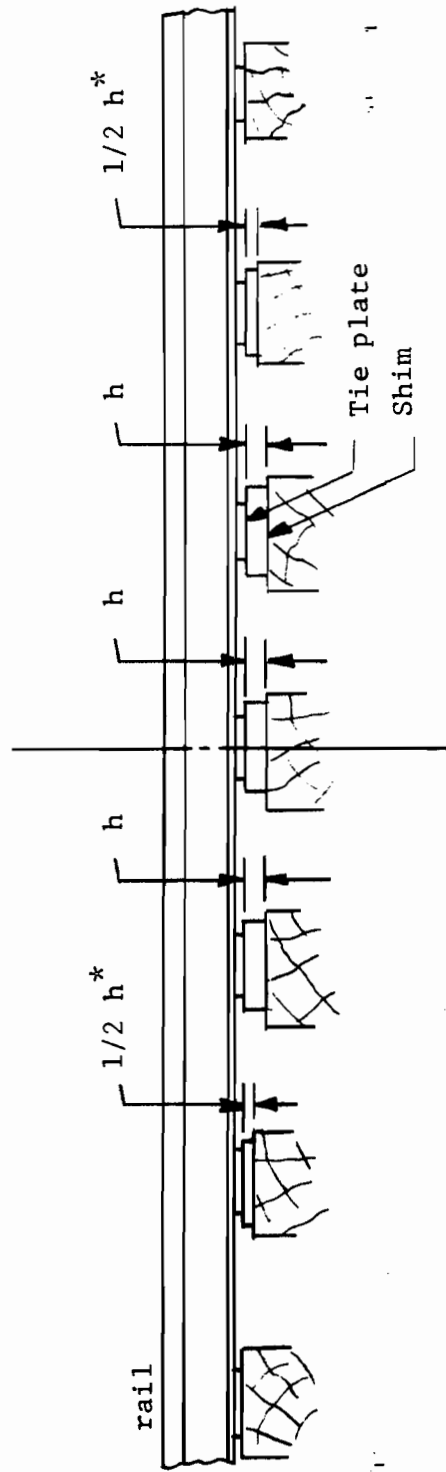


FIGURE 6.2 DETAIL OF SHIMMED TRACK SECTION

* Pattern of ramp up and ramp down varied with shim height

and after the nominal height shims would depend on the maximum height of these shims.

The instrumented car should be run over the shimmed track at speeds varying from 20 to 60 mph in 5 mph increments to determine the force level input into the car as a function of speed. The tank should be loaded during these tests to the permissible rail load of 263,000 lbs. A water load with approximately 40 percent outage is acceptable.

The data should be compared with road test data, such as that obtained under Contract No. TSC-1043, to match the characteristics of the severe vertical load environment which was obtained on that program. This data is characterized by the load spectrum for truck bounce load data shown in Figure 6.3. The load spectrum presents the peak loads between mean level crossings as a function of the average number of exceedings per mile. A comparison of the measured spectrum within \pm 20 percent of the spectrum shown in Figure 6.3 will be deemed an acceptable one. If the comparison with the load data is acceptable the modified track area should be extended so that an acceptable number of high-magnitude fluctuating loads are developed on each traverse of the RTT.

Track modification tests should begin with 1/4-inch shims. If the 1/4-inch shims do not provide sufficient roughness to excite the desired level of vertical vibrations then the test section should be reshimmmed to give greater track irregularity and the tests repeated. The tests would be repeated in this way until a suitable shimming pattern is developed for use on the accelerated tests.

6.4 Schedule for Track Modification Tests

The tests for the characterization of modified track should be conducted before the accelerated test program begins so that meaningful environment can be established. It is estimated that once the instrumentation has been set up that the tests and data reduction would take approximately two weeks to perform. This includes a period for the analysis of the data.

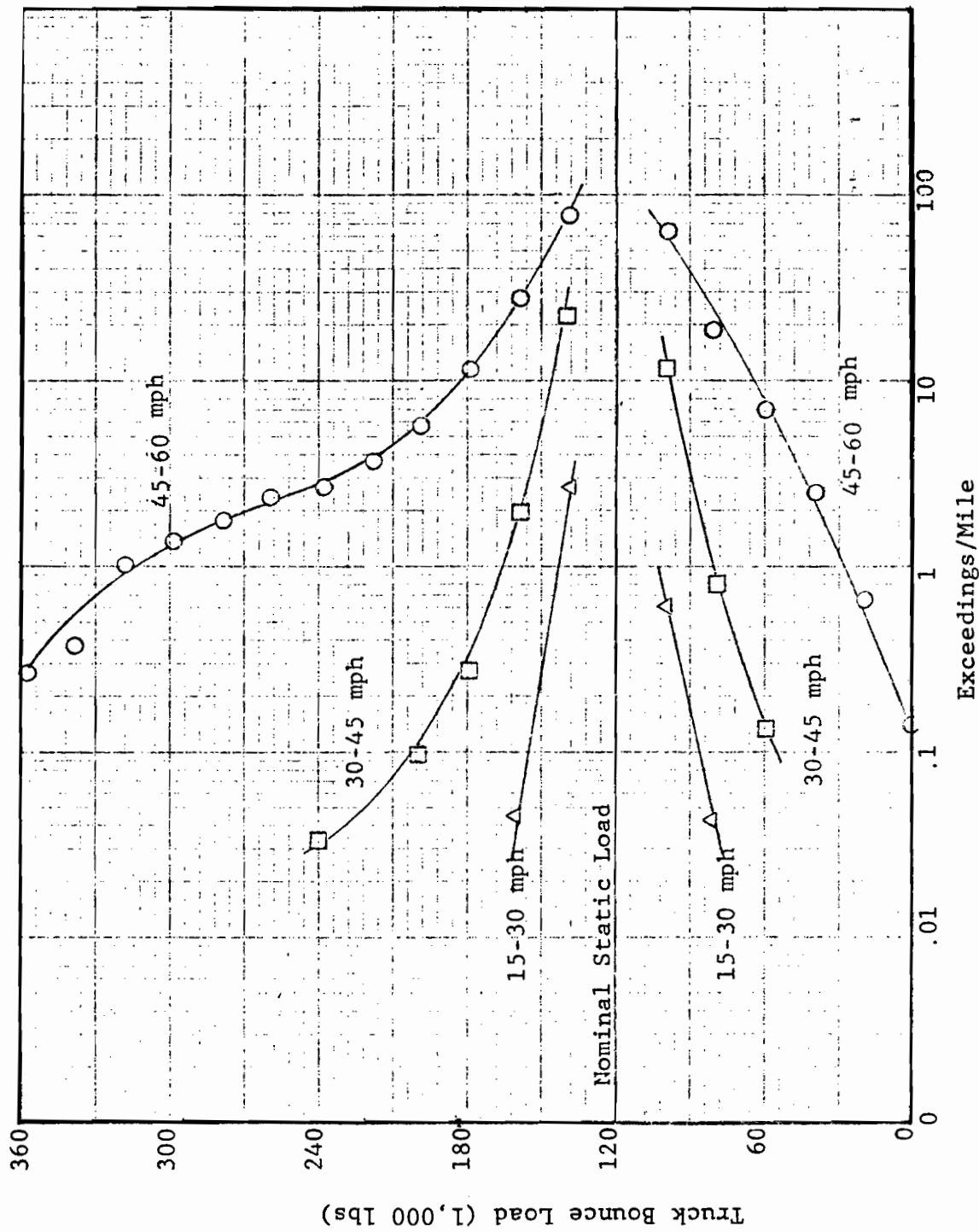


FIGURE 6.3 LOAD SPECTRUM OF TRUCK BOUNCE LOAD (SUM OF SIDE FRAME VERTICAL LOADS) FOR LOADED TANK CAR MOVEMENT, RAX 203.

7. SLOSH TESTS

Prior to the start of the mileage tests a series of tests should be conducted to evaluate any possible problems that may be associated with longitudinal sloshing of the lading (water). Sixteen of the eighteen tank cars will be DOT 112A340W or 112A400W type of 33,000 gallon (nominal) capacity. These cars are to be loaded with water to the maximum rail load of 263,000 lb which will result in outages ranging from 36 to 48%. These outages could induce considerable sloshing due to normal train action experienced in slack-in, slack-out conditions and braking. Such sloshing, especially where a number of partially loaded tank cars are handled in series, could cause difficulty in train handling.

7.1 Instrumentation

Measurements would be limited to recording the coupler force at the front of the tank car consist. A dynamometer car would be located between the locomotive and the tank car consist, and would serve as the instrumentation car and test control center. The lead tank car should be equipped with a dynamometer coupler. The instrumentation system should include:

- a. A direct writing oscillograph to provide monitoring of coupler force during the tests. The oscillograph should be able to record the output of the dynamometer coupler through a galvanometer having a flat response of 600 Hz damped to within 64% of critical. (A galvanometer such as C.E.C. Type 7-320, Honeywell Type M-1000 or equivalent meets this requirement).
- b. A calibration system so that the absolute magnitude of the measured forces can be immediately assessed.
- c. Parallel recording of the force data on magnetic tape.

7.2 Test Procedure

The test procedure is recommended as follows:

- a. A test consist of 5-112A340W/112A400W tank cars should be run initially. Ten minutes of continuous running should be made at speeds of 10, 20, 30, 40, and 50, mph. Some train braking should be included at each speed. The force measurement should be monitored to detect any indication of rapid and sudden increases in force magnitude. These could be associated with in-phase sloshing caused by a resonant condition at some particular speed or triggered by a brake application. In addition to the communication link between the dynamometer car and locomotive there should be a means of radio communication between the locomotive and several ground observers. These observers should be dispersed around the test track to visually monitor the performance of the train and to provide instant warning to the locomotive engineer in the event of adverse action. Close communication should be maintained with the locomotive engineer to directly correlate the effect of sloshing and force input to the locomotive on train handling.
- b. To provide a basis of comparison relative to in-train force, a test consist of 5 loaded 100 ton hopper cars should be run. The test procedure should be similar to (a) above except that the time at each speed can be reduced to 5 minutes.
- c. If the results of (a) do not indicate an unsafe condition a test consist of 12-112A340W/112A400W cars should be run. This is the maximum number of loaded tank cars that are planned to be run at any one time.

- d. In the event that the test (a) exhibits an indication of unsafe operation the test should be repeated with the five hopper cars interspersed between the tank cars.
- e. In the event that test (a) does not exhibit unsafe operation, but test (c) does, test (c) should be repeated with the 5 hopper cars interspersed between the 12 tank cars.

8. CAR INITIAL INSPECTION AND PREPARATION

The cars are to be delivered to TTC no later than 1 June 1976. The suppliers of the cars will be responsible for transit of the cars to the site and pick-up after test completion. The ALT tests will require approximately 12 months to complete. For those cars left in the program for the completion of the FAST program an additional 6 months will be required. The cars will be inspected after testing and returned to an in-service condition by FRA as necessary.

8.1 Initial Inspection

Each of the cars will undergo an initial inspection in accordance with Part 215 - Railroad Freight Car Safety Standards.* Also included in this inspection procedure will be a complete inspection of test related equipment, such as insulation jackets, inspection ports, and head shield installations. In particular a photographic record will be made for insulation positioning, headshield mounting brackets, and any other wear susceptible components to be evaluated.

Before beginning the mileage tests the degree of wheel wear will be carefully measured by obtaining tread profiles on the wheels of each of the 18 cars in the test consist. Periodic inspections will be made to determine the accumulation of wheel wear during the tests.

On those cars which will be impacted before being run to accumulate mileage an inspection of the truck bolster centerplate rim will be performed prior to and following the impact tests. Previous investigations have revealed that this is a particularly sensitive area for the development of damage under car impact conditions.

8.2 Requirements for the Application of Thermal Coatings

Thirteen cars of the test fleet will have thermal coatings applied. The cars will be coated with the following materials:

- AVCO spray coating
- TSI spray coating
- DeSot^e spray coating

* See Appendix A

8.2.1 Coating Procedures

The AVCO spray coating will be applied at TTC by their personnel. This material will be applied to four cars as indicated in Table 4.1. It will require approximately one week for preparation and application. The required supporting services and equipment to be provided by TTC are indicated in Table 8.1. The cars will be coated to a material thickness of 170 mils.

The TSI spray coating will be applied at TTC by their personnel. This material will be applied to seven cars as indicated in Table 4.1. Two weeks notice is required to ensure availability and transportation of material and equipment requirements are the same as for the AVCO coating (Table 8.1). It is estimated that the cars will require three days to prepare and coat, with a minimum of seven days for curing afterward prior to test initiation. The coatings will be applied by TSI personnel with support from TTC as required. Coating thicknesses will range from 150 to 250 mils (see Table 4.1).

The DeSoto spray coating will be applied at TTC by their personnel. This material will be applied to two cars as indicated in Table 4.1. The coating application will take approximately two days. The support equipment requirements are as listed in Table 8.1. The coating thickness will be 180 mils.

TABLE 8.1
REQUIRED SUPPORT SERVICES FOR THERMAL COATING APPLICATIONS

-
- Sandblasting equipment for white metal cleaning of paint and rust from tank structure.
 - Compressed air source (100 cfm at 100 psi) for spray equipment.
 - Portable scaffolding for accessing top of tank.
 - Primer coat to be put on same day as sandblasting is completed.
-

8.2.2 Establishment of Coating Application Costs

Arrangements will be made for Wesson and Associates to perform a time and motion study of the coating process to establish a base-line cost estimate for industry wide application. The following data will be obtained:

- a) Manhours required for preparation of the tank cars for thermal coating application; manhours for coating primer application, base thermal coating application, and top-coat application, as applicable.
- b) A summary of individual coating system component material costs.
- c) A summary of individual coating system application equipment requirements.
- d) A description of on-site preparations, such as mixing of various coating system ingredients that cannot be shipped as premixed systems, and the manhours associated with such coating preparations.
- e) Individual coating system "spray application" techniques, with departures from conventional spray techniques specifically noted.
- f) All special spray area work control regulations and the effect of *OSHA safety regulations on the coating applications.
- g) Definition of any special "hazard control" requirements that may be required for a particular type of coating system during the preparation and/or application of this coating (such as possible flammable solvent mixing and overspray).

After these data are collected and analyzed, a summary of the total installed costs for each type of coating system, the differential cost over the conventional painting of a tank car, the applicable OSHA requirements for control of the coating application, shelf-life of the on-site mixed coating materials, application equipment and clean up requirements, and any "special hazard control" requirements will be reported.

*Occupational Safety and Health Administration

8.3 Requirements for the Installation of Derailment Detectors

Derailment and hot box detection equipment will be mounted on all 18 test cars. The installation requires drilling, spot-facing, and tapping, of four 3/8 inch diameter hoses on the side frames as shown in Figure 8.1. A cable from each sensor will be routed to a central junction point and the air dump valve. Initial installation will consist of mounting this equipment in a non-operational state, i.e., without triggering thermal batteries. The initial machine work and measurement will require about one day to complete per car.

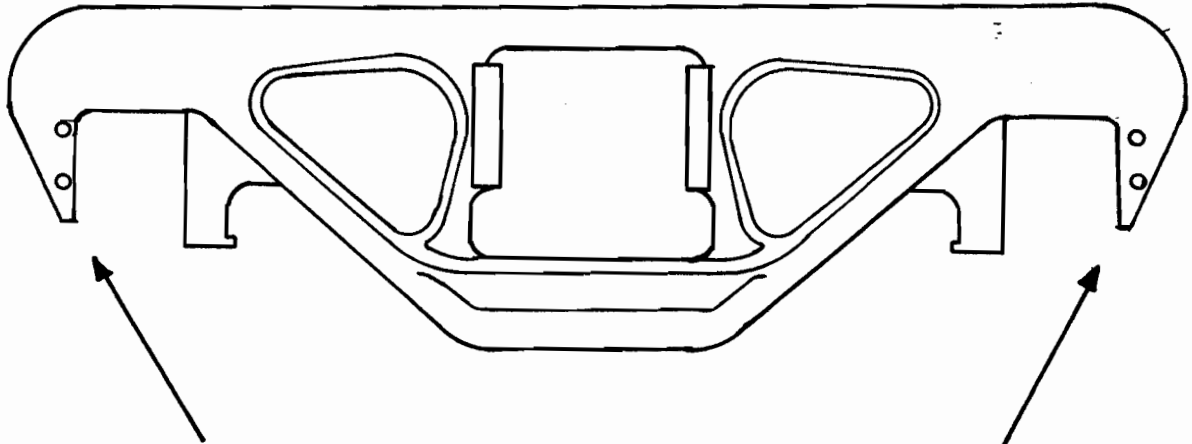
The cars will be run for a period of time to determine optimum acceleration and thermal trigger levels. At or before the first schedule inspection, the devices will be made operational, by installation of the batteries, however, the air dump valve will be deactivated until running data indicates an acceptable immunity to false actuation. Full operational state will be initiated at or before the second schedule inspection. Supervisory personnel will be provided by NSWC for installation with the remainder of the work crews consisting of TTC staff personnel.

8.4 Installation of Head Shields

All 112A lease cars are to be fitted with an approved form of head shield. These installations will be made by the lessor. Inspection of the head shield will be performed prior to installation of the coating.

8.5 Loading of Cars

Water will be used to bring designated cars to their maximum allowable rail weight. Since most of the cars are designed for LPG service, a low density product, there will be up to approximately 40% outage in the loaded cars. All loaded cars are also to be pressurized to 100 psi except for the two 111A cars which should remain unpressurized.



Two (Each End) Drilled and Tapped
Holes 3/8" with Spot Face

NOTE: Drilling fixture will be provided
by NSWC.

FIGURE 8.1 SIDE FRAME MODIFICATION FOR INSTALLATION
OF DERAILMENT DETECTION EQUIPMENT

9. TEST SUPPORT

9.1 Summary of TTC Requirements

Table 9.1 summarizes the major requirements for TTC support of the ALT program. The items listed in the table are cross-referenced to the task numbers shown in the schedule, Table 11.1.

9.2 Support of Participating Organizations

Several TTC supporting requirements are introduced by the special requirements of organizations participating in the program. These include:

- DuPont - accelerometers are to be placed at each end of the DuPont car (7) equipped with an elastomeric center plate. Also, data are to be recorded by these transducers during the mileage tests. After the first 10,000 miles, and at approximately 20,000 mile intervals thereafter, the elastomeric center plate should be disassembled and inspected for signs of deterioration. During these inspections the thickness of the pad should be measured at four positions.
- Shell Oil - Strain gages are to be mounted on the head shield attachments of the Shell car (17). Data are to be obtained from these gages during impact tests in the speed range of 4 to 10 mph. The conditions for these tests are:
 - The instrumented car will be empty and will be impacted by a car with a gross weight of 220,000 lb.
 - Both ends of the instrumented car will be impacted.
 - Two sets of tests will be conducted on the "A" end so that the effectiveness of special absorption devices can be evaluated.
 - Strain readings will be recorded from each impact.
 - The initial impact velocity on each set of tests will be approximately 4 mph. Subsequent impact speeds will be increased in approximately 1 mph increments until a peak coupler force of 1,250,000 lb is obtained (this may be assumed to occur at an impact speed of approximately 8 mph).

TABLE 9.1

MAJOR TTC SUPPORT REQUIREMENTS

Task No. (See Table 11.1)

-
- 2.0 ● Mechanical technician support for transducer installation
 - Calibration of truck load to 400,000 lb through center plate (two trucks)
 - 2.1 ● Car suitable for mounting and running of instrumentation, including 115V 60C power supply (5 kw)
 - Operation of test consist, tank car and instrumentation car, at speeds up to at least 55 mph
 - 2.2 ● Track crew for modification of 500 feet of track
 - 2.3 ● Track crew for modification of additional portion of test loop track
 - 3.0 ● Track storage for 18 tank cars
 - 3.2 ● Train crew and inspectors for certification of 18 cars
 - Photographic technician for documentation of 18 cars
 - Mechanical technician support for miscellaneous inspections
 - 3.3 ● Receipt of spray-on thermal coating material
 - Mechanical, spray and miscellaneous equipment for coating application
 - Mechanical technician support for coating applications
 - Support Wesson and Associates in establishing coating application costs
 - 3.4 ● Receipt of derailment detection equipment
 - Mechanical, electrical and miscellaneous equipment for installation of derailment detectors
 - 3.5 ● Train crew and instrumentation support for conducting slosh tests
 - 3.6 ● Support special tests required by NSWC, DuPont, and Shell Oil
 - 4.0 ● Trackage and train crew for running of 248 impact simulations on each of 14 cars
 - Loaded cars for impact backstop
 - 4.1 ● Trackage and train crew for accumulation of 160,000
 - (4.4) train miles in four segments
 - 4.6 ● Spray equipment and salt bath for wetting cars
 - Air compressor for pressurizing car up to 100 psi
 - Water transfer equipment for filling cars to maximum rail load (263,000 lb)
-

- NSWC - Special runs of the instrumented car (6) and Dynamometer car will be performed. This will include both track characterization and impact tests so that NSWC can record data relative to the vibrational environment on the truck side frames where the derailment sensors are located.

9.3 Spare Parts and Repairs

Another major TTC requirement will be the maintenance of an adequate stock of spare parts to replace car components which might wear past the condemning limit during the tests. For example, the coated tank cars which will be used in this test will be removed from service and therefore it is anticipated that they will reflect a variety of wheel wear conditions. It is quite likely that there will be wheel wear beyond the condemning limit during the course of the run. This will be revealed during the periodic inspections of the equipment. Spare wheel/axle sets should be available at TTC to replace those sets which are worn beyond acceptable limits to minimize downtime of the equipment.

It is also possible that the tank cars could receive minor damage during the course of the tests. Thus, in addition, to the requirement for spare parts there must be provisions made to perform minor car repairs should this be necessary.

10. TEST PROTOCOL

The following discussion details each of the major task items that are necessary for conduct of the ALT program.

10.1 Initiating Test Program

It is necessary to prepare a detailed Test Request to be submitted to TTC through TSC/FRA. The Test Request delineates the test objectives and basic methodology for achieving those objectives. (This document, which describes the detailed test plan, can serve as the Test Request.) After review and acceptance of the test concept a Support Requirements Summary is prepared detailing all anticipated test program requirements. Through coordinated effort between TSC/FRA and TTC the final test plan is developed and the Test Support Specifications are submitted which describe the detailed test program.

10.2 Test Documentation

Each test car will be undergoing a different series of dynamic and environmental simulations for evaluation of a variety of equipment. In order to maintain test integrity and traceability it will be necessary to prepare a test car log which will be specific to each single tank car. Each days testing and/or inspection maintenance operations will be noted and a continuous updated record obtained for every car.

10.3 Car-Coupling Impacts

The longitudinal inertial loads developed during normal yard coupling operations are thought to significantly impact thermal shield bonding as well as the structural elements of the car. Therefore it is important to include some representation of this effect in the ALT program. Current research* indicates that a typical tank car receives approximately 60 coupling impacts per year while in service. Each of these impacts represents movement

* RPI-AAR Railroad Tank Car Safety Research and Test Project, Report No. RA-05-3-35, Phase 05 Report on Head Shield Fatigue Tests, Nov. 1975.

of the car into standing cars. The additional "impacts" on the subject car as other cars are coupled into the string of cars are not counted in this tally. The coupling impacts are distributed over a velocity spectrum as indicated in the first column of Table 10.1.

In order to reasonably replicate this impact environment over an average of 10 years service life, the 600 impacts as indicated would have to be run for each car tested. This total may be reduced by truncating the lower velocity regime which does not significantly load the tank structure. If it is assumed that no impact below 4 mph is significant, then the total number of impacts per car to be run is reduced by 20 percent.

TABLE 10.1
SPECIFICATIONS FOR SIMULATED
YARD COUPLING IMPACT TESTS

Velocity Range	Number of Simulated Impacts per Year of in Service Life	Total Impacts per Car for 10 Year Simulated Life
0 to 2 mph	1	10
2 to 3 mph	3	30
3 to 4 mph	8	80
4 to 5 mph	13	130
5 to 6 mph	14	140
6 to 7 mph	11	110
7 to 8 mph	6	60
8 to 9 mph	3	30
9 to 10 mph	1	10
		600 total impacts

If the impacts are run on a production basis and with a minimum of data acquisition it may be assumed that each impact will require approximately three minutes to complete. The impacts would be staged by cutting loose the appropriate car from the consist while the train is proceeding at a given velocity as determined by the locomotive speedometer.

The tests must be conducted in a way to insure that the cars are subjected to a proper range of test conditions. Each car must be impacted at speeds in accordance with the desired velocity distribution, and the sequencing of cars must be varied so that no two cars would be impacted together for an excessive percentage of the total number of impacts. Reversals in the orientation of the cars must also be accomplished at timely intervals.

10.3.1 Car-Coupling Impact Test Schedule

The proposed test sequence states that one-half of the impacts be conducted before the mileage accumulation runs, and one-half of the impacts be conducted after these runs. During the first half of the pre-mileage impacts 12 of the 14 cars would be empty (the other two would be loaded). Eleven cars would be loaded and three cars empty during the second half of the pre-mileage impacts. Each car in the impact test consist is to be subjected to 248 impacts during the pre-mileage tests.

Table 10.2 summarizes the overall schedule for the pre-mileage impact tests. The first line describes the test consist. Note that the first one-half of the tests would be conducted with empty cars (except for two cars which would remain loaded all the time) and the last one-half of the impacts would be conducted with 11 fully loaded and three empty cars.

The second line in Table 10.2 calls out four different sequences in the way the cars are to be placed in the test consist. These are chosen so that no two cars are impacted together in the respective

TABLE 10.2
PREMILEAGE IMPACT TEST SERIES

Test Consist	2 Loaded Cars - 12 Empty Cars			11 Loaded Cars - 3 Empty Cars		
	1	2	3	4	Reverse	Forward
Car Sequence*						
Car Sequence Orientation	Forward	Forward	Forward	Forward	Reverse	Reverse
Total Impacts Per Car	31	31	31	31	31	31

- * Car Sequence 1: 1-4-5-6-7-8-9-10-11-12-13-15-16-17
 2: 4-6-8-10-12-15-17-1-5-7-9-11-13-16
 3: 5-9-13-1-7-11-16-4-8-12-17-6-10-15
 4: 9-17-8-16-7-15-6-13-5-12-4-11-1-10

Note: Total of 248 impacts per car

Note: Car numbers in sequence listing refer to Table 4.1.

sequences. The first car and the last car are also different in each case.*

The orientation of the cars should also be varied during the tests. Initially all cars should be positioned with the B end toward the locomotive. Line 3 of Table 10.2 calls for four reversals of the test consist one-half way through the tests with each of the car sequences. The entire string of cars should be turned end to end so that the trailing car becomes the lead car in the consist.

The fourth line in the table indicates the total number of impacts per car under each set of conditions. Since there are 14 cars scheduled for the test consist a grand total of 3,472 impacts would be required for the pre mileage impact tests.

10.3.2 Order of Impact Velocities

The schedule of velocities to be followed in impacting the cars is shown in Table 10.3. This is a proposed test log and control chart for the locomotive engineer. One of these tables would be completed for each car sequence and for each orientation of the cars in the consist. It calls out the target speeds for each of the 31 impact velocities. All the cars in the consist should be individually impacted at the target speeds indicated with each impact block number. The indicated variation of target speeds will achieve the desired ratio between lower and higher speed impacts. The table serves as a test log for the locomotive engineer to indicate the date and time that each set of impacts is conducted.

10.3.3 Recording of Impact Velocities

The impact velocities of each of the cars is to be measured and recorded. The use of a portable radar set capable of 0.1 mph

* Figure 10.1, shows all possible combinations of cars in the test consist. The car combinations included in the four sequences are indicated. Car combinations not included in these four sequences would be covered by other car sequences used in the post mileage impact tests.

1															
4	1														
5	2	1													
6		2	1												
7	3		2	1											
8		3		2	1										
9			3		2	1									
10	4			3		2	1								
11	4	4			3		2	1							
12		4	4			3		2	1						
13	3		4	4			3		2	1					
15				4	4			3		2	1				
16		3			4	4			3		2	1			
17	2			3		4	4			3		2	1		
	1	4	5	6	7	8	9	10	11	12	13	15	16	17	

Car Number

Sequence Nos.	Car Order
1:	1-4-5-6-7-8-9-10-11-12-13-15-16-17
2:	4-6-8-10-12-15-17-1-5-7-9-11-13-16
3:	5-9-13-1-7-11-16-4-8-12-17-6-10-15
4:	9-17-8-16-7-15-6-13-5-12-4-11-1-10

FIGURE 10.1 CAR PAIRS INCLUDED IN SEQUENCES 1 THRU 4
PROPOSED FOR IMPACT TESTS

TABLE 10.3

TEST LOG - LOCOMOTIVE ENGINEER

Car Sequence (No. ___): _____

Car Sequence Orientation: _____

Locomotive Engineer: _____

Car Adjacent to Locomotive: _____

Date	Time	Impact Block No. **	Target Speed (mph)	Date	Time	Impact Block No. **	Target Speed (mph)
		1	4.5			17	6.5
		2	6.5			18	5.5
		3	5.5			19	7.5
		4	4.5			20	4.5
		5	6.5			21	6.5
		6	5.5			22	5.5
		7	7.5			23	8.5
		8	4.5			24	4.5
		9	6.5			25	6.5
		10	5.5			26	5.5
		11	8.5			27	7.5
		12	4.5			28	4.5
		13	6.5			29	5.5
		14	5.5			30	7.5
		15	9.5			31	5.5
		16	4.5				

* Denotes Loaded Car

** Each Block Consists of Impacting all Cars in Sequence at Target Speed

resolution of velocities from 2 to 12 mph is recommended. Table 10.4 presents the log of impact velocities which would be maintained by the individual monitoring impact velocities. The test log shown in Table 10.4 includes the measured velocities for all 14 cars in the consist as they are impacted, one at a time, at the target velocity. A separate log would be maintained for each of the impact block numbers listed in Table 10.3.

10.3.4 Car Impact Summary

A control chart, Table 10.5 would be maintained to keep an impact history on each car. The measured velocities recorded in Table 10.4, will be transferred to Table 10.5. Table 10.5 would cover all of the 31 impact block numbers conducted for the first car sequence and for the forward orientation. Additional tables would be used for other sequences and reverse car orientations. The impact velocities then would be summed as shown in the bottom of the second page of the table and compared with the target total of impact velocities.

10.4 Test Mileage Accumulation

The test car consist for the mileage tests will be composed of all 18 cars (Table 4.1). The schedule for loading these cars will be in accordance with Table 5.1. The test operations will be conducted on the conventional rail test tracks at TTC. A general schematic of the track layout is shown in Figure 10.2.

The first one or two mileage segments (approximately 40,000 miles each) will be run on the Railroad Test Track (RTT) portion of the facility (Figure 10.2b). This section is 13.5 miles in length and includes a short portion of the FAST track. The train will be in operation approximately 16 hours per day with an average speed of 40 to 50 mph. Every 2 or 3 days the train should be turned to equalize wheel wear. Every 3 or 4 days two cars of the consist should be rotated to the rear from the front of the train. Daily mileage accumulation will be approximately 720 miles. The train is to be run over this track 6 days a week for about 8 weeks to generate the 40,000 miles. At the completion of each 40,000 mile

TABLE 10.5

IMPACT HISTORY - CAR NUMBER _____

Car Sequence (No. _____): _____

Car Sequence Orientation: _____

Car Condition: _____

Impact Block No.	Date	Impact Velocity Range (MPH)					
		4-5	5-6	6-7	7-8	8-9	9-10
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
Subtotal (1-16)							

TABLE 10.5 (CONT'D)

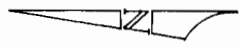
IMPACT HISTORY - CAR NUMBER _____

Car Sequence (No. _____): _____

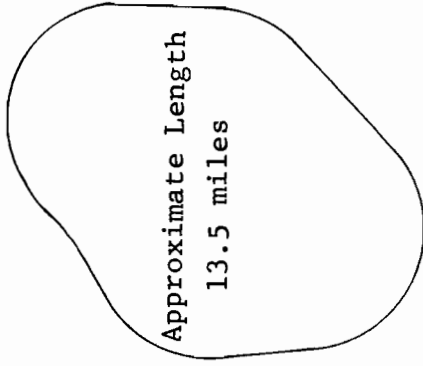
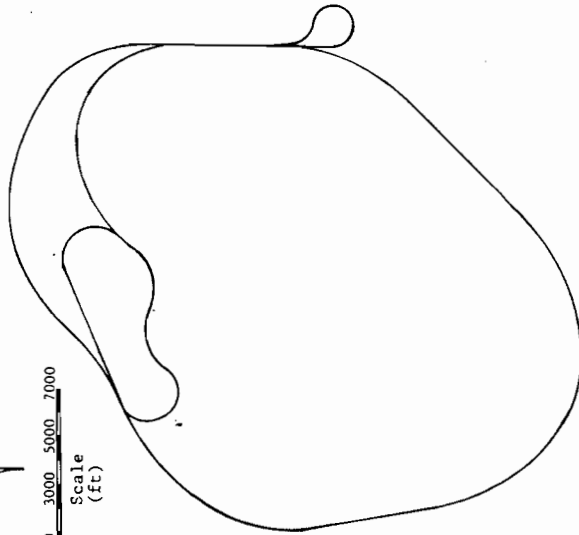
Car Sequence Orientation: _____

Car Condition: _____

Impact Block No.	Date	Impact Velocity Range (MPH)					
		4-5	5-6	6-7	7-8	8-9	9-10
17							
18							
19							
10							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
Subtotal (17-31)							
Subtotal (1 -16)							
Total							
Target Total		8	9	7	4	2	1



1000 3000 5000 7000
Scale
(ft)



Approximate Length
13.5 miles

Figure 10.2b
Railroad Test Track (RTT)



Approximate Length
4.8 miles

Figure 10.2c FAST Track

FIGURE 10.2a CONVENTIONAL RAIL TEST TRACKS,
TRANSPORTATION TEST CENTER
PUEBLO, COLORADO

segment the cars will be brought in for in-shop inspections. During the running of the mileage on the RTT the track characteristics should be monitored regularly by taking and processing data on the instrumented car as specified in Section 6.2.

The last two or three mileage segments are tentatively scheduled to be run on the FAST facility (Figure 10.2c) which is approximately 4.8 miles in length. The cars will then be subject to the limitations of the FAST program. This may mean that all 18 cars will not be allowed in the consist at any one time. Also, the cars will be pulled out individually for in-shop service and inspection rather than as a group.

The four mileage segments will allow for a total mileage accumulation of about 160,000 miles over a variety of speed and running conditions.

10.5 Car Inspections

10.5.1 Coordination with FAST Inspection Requirements

The car inspection requirements for the ALT program will follow basically the requirements for the FAST program since ALT operations are scheduled to be integrated with the FAST program at some point during the mileage tests.

FAST requirements will call for two classes of inspection:

Group 1, which are primarily related to the safety of train operations. This inspection will determine conformance of the consist to AAR operating rules and FRA safety standards.* Inspections involve:

- Truck wheel-wear, etc.
- Journal roller bearing grease loss, wear, etc.
- Bearing adapter and pedestal roof-wear
- Sideframe columns, bolster gib, friction casting wear, etc.
- Truck and body center plate wear, etc.
- Coupler head and knuckle wear
- Coupler shank length, butt thickness, pin and pin hole wear
- Center sill permanent set

*The pertinent sections of this document are included in Appendix A.

Group 2, which are measurements of specific characteristics to fulfill one of the experimental objectives.

The Group 2 measurements on the tank car would include items which are of direct concern to tank car performance such as:

- Conditions of coatings, indicating cracks or other deficiencies*
- Condition of car body structural components, including head shields and attaching structure with respect to fatigue crack initiation
- Removal of inspection ports on jacketed cars noting any change in insulation position
- Obtaining wheel profiles to indicate wheel wear
- Special inspections required by participating organizations.

10.5.2 Levels of Inspection

- Initial Inspection

The requirements for the initial inspection as the cars are received has been described in Section 8.1.

- Walkaround Inspection

The first level inspection the car receives will be a 'walk-around' inspection twice a day. These inspections will be performed during both the coupling impact tests and the mileage tests. The walk-around inspection will take place at normal crew change intervals. If any equipment has incurred a safety related failure, then that car will be brought into the shop for immediate corrective action. If a nonsafety-critical defect is present it will be so noted in the test log. All subsequent inspections will then verify and track the propagation (if any) of the defect.

- Premileage Inspections

Those cars which have been included in the premileage coupling impact tests will be thoroughly inspected prior to the mileage tests. Both Group 1 and Group 2 inspections, as outlined above, will be performed. Wheel profiles on each of the test cars should also be established.

*The Ballistic Research Laboratories (BRL) has the responsibility to develop procedures for detailed inspections of the coatings.

- 20,000 Mile Inspection (RTT Mileage Run)

The cars would receive a thorough inspection in accordance with Groups 1 and 2 above after the first 20,000 miles of operation under the mileage tests.

- 40,000 Mile Inspection

Every 40,000 miles each car will be brought into the shop to receive maintenance and inspection services as specified in Groups 1 and 2. Test participants may also perform any specific inspections of their own at this time.

- FAST Inspections

When the program is integrated into the FAST program inspections will be conducted according to the established procedures for this program. Every 21 days, which will represent about 15,000 miles, cars will be brought into the shop where the Group 1 and 2 measurements will be made. Wheel profile measurements to establish wear will need to be obtained only at every second 15,000 mile inspection.

- Final Inspections

At the conclusion of all the test procedures the cars will again undergo an in-shop inspection as delineated under the 40,000 mile inspection. At this time the particular item undergoing test will receive its detailed inspection. Procedures to be used will be arrived at through the cooperative efforts of all test participants. As a minimum it would include a complete teardown inspection of mechanical items such as derailment detectors and an integrity check for thermal coatings. Each participant may perform any other additional inspections.

These inspections will form the basis for evaluating in-service suitability of the cars and indicate those maintenance items necessary to restore the car to service.

10.6 Car Maintenance Requirements

Any deficiencies in the cars which are noted at the initial inspection will be corrected before any tests are initiated. If at any time it becomes necessary to modify, correct, or replace a test component it will be so noted in the car test log. :

All necessary maintenance operations will be conducted during the in-shop inspections. Also, any of the items of test equipment may be reviewed and revised at this time if so indicated. The specific maintenance and revision procedures will be documented in the car test log.

If roller bearing lubrication is required at 12 month intervals under normal service conditions this lubrication will be performed at the 15,000 mile inspection.

10.7 Other Environmental Simulations

The dynamic environment under which the tank cars will operate is only one set of deleterious factors impacting overall survivability, although it is the most critical. Another set of environmental factors are those associated with chemical aging and/or weathering. In order to replicate, in part, this effect the cars will undergo a periodic wetting down. These wettings will occur at one week intervals with a 10 percent salt spray or other suitable chemical contaminant. A fixture for spraying the cars should be set up at a suitable location.

The thermal stressing of the cars will be uncontrolled. However, normal climatic conditions at TTC will provide an average temperature variation of approximately 20°F (-6°C) to 92°F (31°C) over the test duration.

11. TEST SCHEDULE

The overall test program schedule is presented in Table 11.1.
ALT test program milestone dates are:

- Submission of test request to TTC by TSC - 21 March 1976.
- Completion of TTC Test Plan - 3 May 1976.
- TSC/FRA approval of TTC Test Plan - 8 June 1976.
- Completion of track characterization and modification - 30 July 1976.
- Final receipt of test cars at TTC - 1 June 1976.
- Completion of thermal coating and equipment installation - 9 July 1976.
- Completion of initial coupling impact simulations - 10 August 1976.
- Completion of slosh tests - 18 August 1976.
- Beginning of mileage accumulation tests on high speed train loop - 22 August 1976.
- Completion of first 40,000 mile test segment - 17 December 1976.
- Completion of second 40,000 mile test segment - 22 April 1977.
- Completion of third 40,000 mile test segment - 19 August 1977.
- Completion of final 40,000 mile test segment - 16 December 1977.
- Completion of final coupling impact simulations - 13 January 1978.
- Preparation of test reports - 28 February 1978.

APPENDIX A
PERTINENT SECTIONS OF RAILROAD FREIGHT CAR SAFETY STANDARDS

Subpart A-General

§ 215.1 Scope of part.

This part prescribes minimum Federal safety requirements for railroad freight cars.

§ 215.5 Definitions.

As used in this part-

(a) "Break" means a fracture or separation resulting in a loss of structural integrity so that the component involved can no longer perform the function for which it was designed.

(b) "Cracked" means broken or fractured without complete separation into parts. Castings with shrinkage cracks or hot tears that do not significantly diminish the strength of the member are not considered to be "cracked."

§ 215.15 Designation of qualified persons.

(a) Each railroad that operates railroad freight cars to which this part applies shall designate persons qualified to inspect railroad freight cars for defects prescribed by this part. Each person designated must have demonstrated to the railroad his knowledge and ability to inspect railroad freight cars for compliance with the applicable requirements of this part.

(b) With respect to designations under paragraph (a) of this section, each railroad shall maintain written records of-

- (1) Each designation in effect; and
 - (2) The basis for each designation.
-

Subpart B-Inspection

§ 215.21 Scope.

This subpart prescribes requirements for inspection of railroad freight cars.

§ 215.27 Periodic inspection: Suspension and draft systems.

Each inspection under § 215.25 must include an examination by a person designated under § 215.15, to determine that all components of a railroad freight car's-

(a) Suspension system, including wheels, axles, bearings, adapters and truck components; and

(b) Draft system, including couplers, cushioning units, center sill, body bolsters and center plates-comply with the requirements of this part.

Subpart C-Wheels

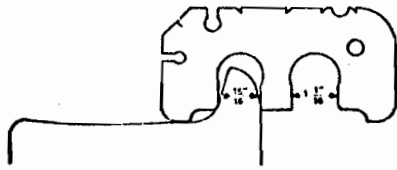
§ 215.41 Scope.

This subpart prescribes minimum safety requirements for wheels on railroad freight cars.

§ 215.43 Defective wheels.

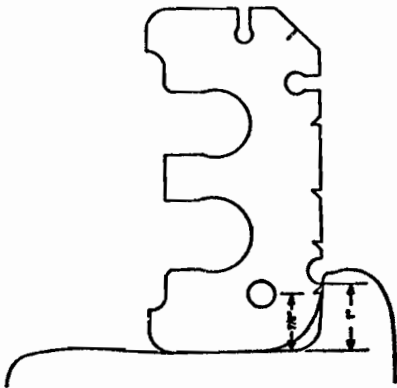
A wheel is defective if it has any of the following conditions:

(a) The flange is worn to a thickness of fifteen-sixteenths inch or less measured at a point three-eighths inch above the tread. (See Figure 1.)



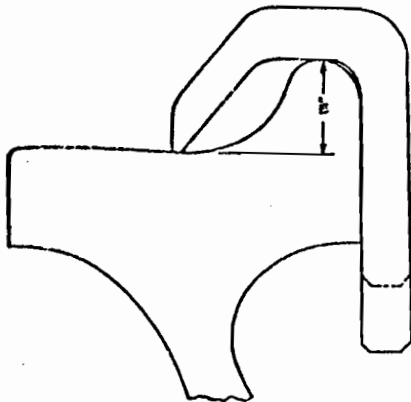
METHOD OF MEASURING WHEEL FLANGE THICKNESS
USING GAGE NO. 1
FIGURE 1

(b) The flange has a flat vertical surface extending one inch or more from the tread. (See Figure 2).



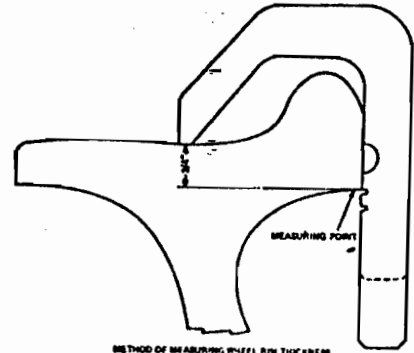
METHOD OF MEASURING FLAT VERTICAL SURFACE
ON WHEEL FLANGE USING GAGE NO. 1
FIGURE 2

(c) The flange is 1 1/2 inches or more from the tread to the top of the flange. (See Figure 3).



METHOD OF MEASURING WHEEL TREAD WEAR
USING GAGE NO. 2
FIGURE 3

(d) The rim thickness is three-quarters inch or less. (See Figure 4).



METHOD OF MEASURING WHEEL RIM THICKNESS
USING GAGE NO. 2
FIGURE 4

- (e) A cracked or broken rim, flange, plate, or hub.
- (f) A chip in the flange that is more than 1 1/2 inches in length and one-half inch in width.
- (g) Contiguous (adjoining) pieces of metal shelled out of the circumference of the tread.
- (h) A slid-flat spot more than 2 1/2 inches in length or two adjoining flat spots each more than two inches in length.
- (i) A hole through the wheel plate not intended by design.
- (j) A circumferential groove in the tread more than one-eighth inch in depth.

- (k) A scrape, dent, or gouge in the wheel plate surface more than one-eighth inch deep that causes an abrupt change in the finish of the plate surface.
- (l) A loose wheel, as evidenced by movement on the wheel seat, or oil seepage on the back hub or plate from inside the wheel fit.
- (m) Any welding on the wheel.
- (n) A wheel which has been overheated as evidenced by a reddish-brown discoloration from heat on front and back face of rim and plate extending into the plate one-half of the distance from the tread surface to the axle with decreasing intensity.
- (o) Painted so as to conceal defects.

§ 215.45 Defective wheel sets.

A wheel set is defective if the wheels are out of gage so that the distance between the inside faces of the wheel rims is less than 52 15/16 inches or more than 53 3/8 inches.

Subpart D-Axles

§ 215.51 Scope.

This subpart prescribes minimum safety requirements for axles on railroad freight cars.

§ 215.53 Defective axles.

An axle is defective if it has any of the following conditions:
 (a) A break or crack.
 (b) A scrape, dent, or gouge between the wheel seats more than one-eighth inch deep.
 (c) Welding on the axle.

(d) A bend in the axle which produces a runout of more than three-eighths inch at the center of the axle.
 (e) In the case of journals on plain bearing axles, wear beyond the limits set forth in Figure 5.

PLAIN BEARING AXLES

Journal size standard inches	Journal collar, inch	Journal length, inches	Journal diameter, inches
	(A)	(B)	(C)
4½ by 8.....	¾	8½	3¾
5 by 9.....	¾	9½	4½
5½ by 10.....	¾	10½	5
6 by 11.....	¾	11½	5½
6½ by 12.....	¾	12½	6
7 by 12.....	¾	12½	6½



FIGURE 5

(f) Painted so as to conceal defects described by this section.

Subpart E-Journal Bearings

§ 215.81 Scope.

This subpart prescribes minimum safety requirements for journal bearings on railroad freight cars.

§ 215.93 Defective roller bearings.

(a) A roller bearing which has been subjected to any of the following conditions may not be used until it is inspected, and repaired if necessary:

- (1) Derailment.
- (2) Submerged in water.

(b) A roller bearing is defective if it has any of the following conditions:

- (1) Overheating in excess of 250°F.
- (2) A loose or missing cap screw.
- (3) A broken, missing (unless by design), or improperly applied cap screw lock.
- (4) A missing (unless by design) truck side frame key, pedestal bolt or stop block.
- (5) A loose or nonfunctioning seal.

§ 215.95 Defective roller bearing adapters.

A roller bearing adapter is defective if it has any of the following conditions:

- (a) A break or crack.
- (b) Wear to the extent that the adapter is marking the seal assembly.
- (c) Wear on the crown of the adapter to the extent that the frame bears on the relief portion of the adapter, as shown in Figure 8.

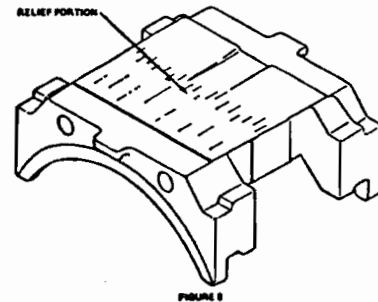
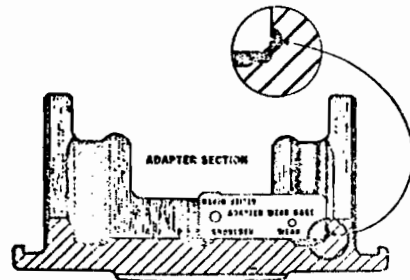


FIGURE 8

(d) Wear on the thrust shoulder of narrow adapters more than .025 inch on either side, as measured by Gage No. 8 (See Figure No. 9).



METHOD OF MEASURING ROLLER BEARING ADAPTER THRUST SHOULDER WEAR USING GAGE No. 8.

FIGURE NO. 9

(e) Warp or other distortion.

Subpart F-Other Truck Components

§ 215.99 Roller bearings.

(a) A roller bearing designed to be periodically lubricated is defective if-

(1) It has not been lubricated as prescribed by the following chart and by paragraphs (b) and (c) of this section; or

(2) The car was not reconditioned or originally constructed within the number of months prescribed in the chart for lubricating roller bearings:

Description of bearing	Size of bearing	Amount of lubricant required	Lubricate bearings within the following numbers of months before car is oper.
Oil lubricated-----	All-----	Fill to maximum level-----	12
Grease lubricated; end caps do not rotate-----	All-----	16 ounces-----	18
Grease lubricated; end caps rotate-----	12 inches----- 11 inches or less	12 ounces----- 8	48 48

(b) In the case of an oil lubricated roller bearing, the filling plug must be properly replaced after the bearing is lubricated.

(c) In the case of a grease lubricated roller bearing, perform the lubrication by-

(1) Immediately before the application of grease-

(i) Cleaning the grease fitting to prevent road dirt and foreign material from being forced into the bearings; and

(ii) Testing the grease fitting to ensure it has not been damaged; and

(2) Insert the amount of grease prescribed in paragraph (a)(2), using a properly calibrated dispensing device which is equipped with a strainer and is checked monthly to accurately measure ounces of grease. Grease inserted must meet or exceed the minimum requirements for Grade B grease, Association of American Railroad specification M-917-64.

(d) In the case of grease lubricated roller bearings, only pressure type grease fittings may be used in lubricating the bearings.

§ 215.121 Scope.

This subpart prescribes minimum safety requirements for truck side frames, bolsters, side bearings, spring assemblies, and spring planks on railroad freight cars.

§ 215.123 Defective car trucks.

A car truck is defective if it has any of the following conditions:

(a) A side frame or bolster which is-

(1) Broken, patched, cracked, or reinforced with plate, including a break or crack in a bolster gib;

(2) Painted so as to conceal defects described in this section;

(3) Welded and not stress relieved; or

(4) Worn or corroded through more than 25 percent of the cross section; except that surfaces in friction snubber pockets, gibs, column guides and cast integral brake beam supports which have been worn or corroded through not more than 40 percent of the cross section may be restored to the original cross section by welding without the necessity for heat treatment, but all friction surface welds must be smooth and free of slag.

(b) Any part of the truck is less than 2 1/2 inches above the top of rail under maximum spring deflection.

(c) With respect to the side bearings-

(1) One is broken or missing;

(2) The bearings at one end of the car on both sides are in contact with the body bolster, except by design;

(3) The bearings at one end of the car have a total clearance from the body bolster of more than three-fourths inch; or

(4) At diagonally opposite sides of the car, the bearings have a total clearance from the body bolsters of more than three-fourths inch.

(d) A spring assembly-

(1) With a broken or missing snubber or outer spring;

(2) Which does not maintain travel or load; or

(3) Which is weakened so as to be compressed solid.

(e) In the case of a car truck whose design includes spring planks, a spring plank is missing, broken, worn, or corroded through more than 25 percent of its cross section.

Subpart G-Car Bodies

§ 215.151 Scope.

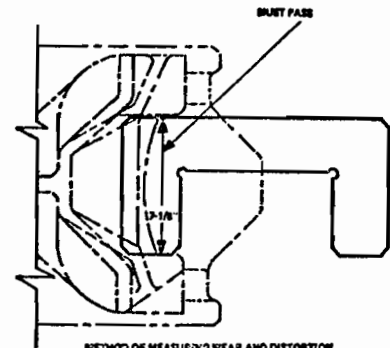
This subpart prescribes minimum safety requirements for certain conditions on railroad freight car bodies.

§ 215.153 Defective car bodies: Loaded or empty.

A car body is defective if it has any of the following conditions:

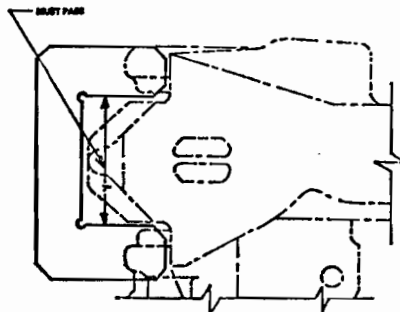
- (a) Clearance above top of rail less than 2 1/2 inches.
- (b) A male portion of a standard cylindrical type center plate extending less than one inch into the female portion of the center plate.
- (c) A center plate not secured.
- (d) A center plate cracked through more than 30 percent of the cross section.
- (e) Center sill broken, cracked, or permanently bent more than 2 1/2 inches in any 6-foot length.
- (f) A broken or missing coupler carrier.

(b) The distance between the interlocking surfaces of the aligning wing pocket is less than 7 1/8 inches or more than 7 3/4 inches. (See Figures 17 and 18).



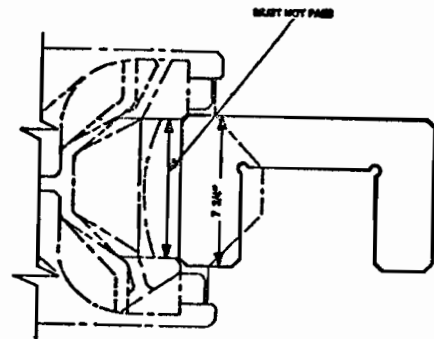
METHOD OF MEASURING WEAR AND DISTORTION OF TYPE F COUPLER ALIGNING WING POCKET USING GAGE NO. 77

FIGURE 17



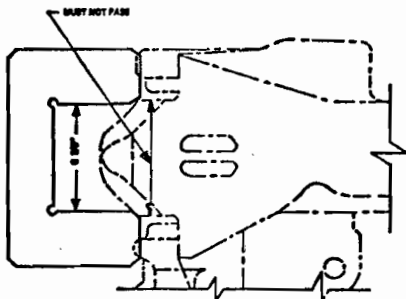
METHOD OF MEASURING WEAR AND DISTORTION OF TYPE F COUPLER GUARD ARM USING GAGE NO. 76

FIGURE 16



METHOD OF MEASURING WEAR AND DISTORTION OF TYPE F COUPLER ALIGNING WING POCKET USING GAGE NO. 78

FIGURE 18



METHOD OF MEASURING WEAR AND DISTORTION OF TYPE F COUPLER GUARD ARM USING GAGE NO. 76

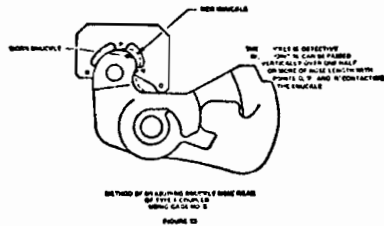
FIGURE 16

(c) A coupler is defective if it has any of the following conditions:

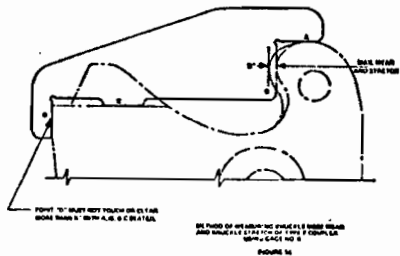
- (1) The locklift is inoperative.
- (2) The coupler assembly does not have anticreep protection.
- (3) The coupler lock is missing, inoperative, bent, cracked, or broken.

§ 215.175 Defective knuckles.

(a) A Type E knuckle is defective if it is worn in excess of the limits indicated by Gage No. 5. (See Figure 13).



(b) A Type F knuckle is defective if it is worn or stretched in excess of the limits indicated by Gage No. 6. (See Figure 14).

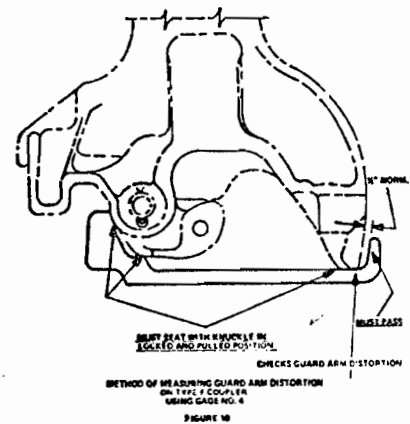


§ 215.179 Defective interlocking features on couplers.

In the case of cars equipped with AAR Type F couplers in accordance with § 179.14 of this title, a coupler is defective if it has any of the following conditions:

(a) The distance between the interlocking surfaces of the guard arm is less than 6 3/8 inches or more than 7 inches. (See Figures 15 and 16).

(c) The guard arm is distorted beyond limits indicated by Gage No. 4. (See Figure 19).



(d) The guard arm or aligning wing pocket is cracked, broken, or missing.

(c) Any knuckle is defective if it has any of the following conditions:

- (1) It is cracked or broken.
- (2) The knuckle pin or knuckle thrower is missing or inoperative.
- (3) In the case of a hopper car, a gondola car, or a car with a spring supported coupler carrier, the knuckle pin retainer or cotter key is missing.

§ 215.177 Defective uncoupling devices.

An uncoupling device is defective if it does not meet the following requirements:

- (a) The device must have sufficient vertical and lateral movement to prevent fouling on curves and unintentional uncoupling.
- (b) In the case of a bottom operated coupler, the lever must have at least one-fourth inch clearance between the operating rod eye and the locklift level when the coupler is centered and the knuckle is fully closed and locked.

Subpart I-Draft Systems

§ 215.191 Scope.

This subpart prescribes minimum safety requirements for draft systems for railroad freight cars.

§ 215.193 Defective draft arrangement.

A draft arrangement is defective if it has any of the following conditions:

- (a) A break in the yoke.
- (b) A yoke strap worn more than 25 percent of its cross sectional area.

(c) A missing (except by design) or broken follower plate, draft lugs or fasteners, draft gear, draft key, or draft key retainer.

(d) A draft key worn more than 25 percent of its cross sectional area.

§ 215.195 (Revoked)

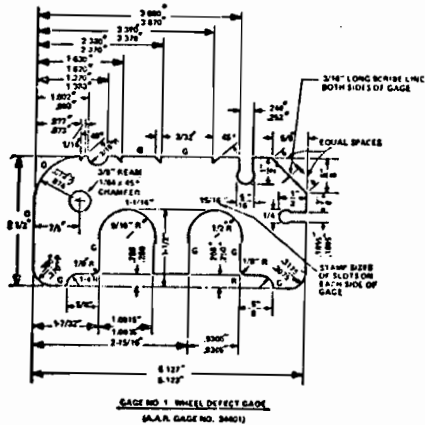
§ 215.197 Defective cushioning devices.

A cushioning device is defective if it is broken, inoperative, or missing a part.

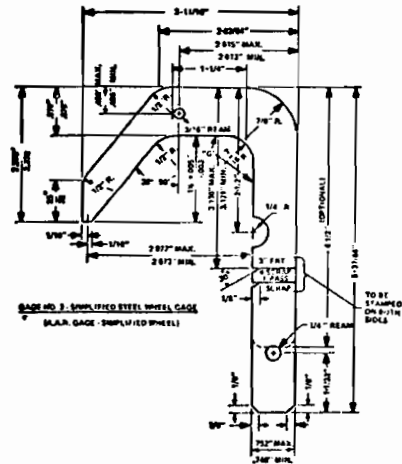
Appendix A-Defect Detection Gages

General. Each gage must be-

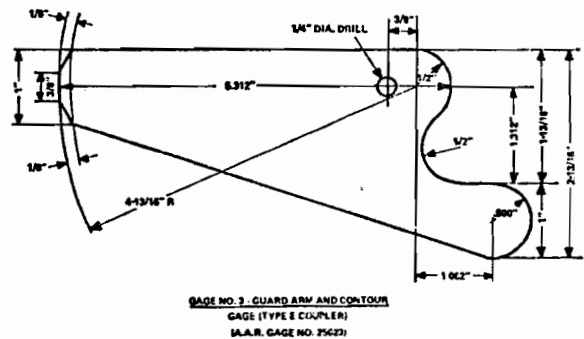
- (a) Fabricated as specified in this appendix;
- (b) Ground on all gaging surfaces;
- (c) Stamped with the appropriate markings.



Material: 3/32" Steel Plate-Hardened; Rust Proof Finish



Material: 3/32" Steel Plate-Hardened; Rust Proof Finish



Material: 1/8" Steel Plate-Hardened; Rust Proof Finish

CODE OF DEFECTS

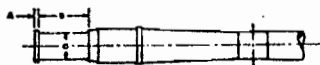
FRA Freight Car Equipment Standards

- 215.009 Failure to meet conditions for movement of defective cars for repairs
- 215.011 Stenciling (improper or illegible)
 - A. Car number;
 - B. Restrictive operation;
 - C. Built or recondition, or lubrication information
- 215.015 - Designation of Qualified Persons
 - A. Improper railroad procedure
 - B. Improper maintenance of records by railroads
- 215.023 Improper Safety Inspection
- 215.025 Periodic Inspection
 - A. Not performed in the required time;
 - B. Not performed in accordance with approved procedure.
- 215.043 Defective Wheels
 - A. Flange 15/16" or less at 3/8" above tread (Gage No. 1);
 - B. Flange has flat vertical surface extending one inch or more from tread (Gage No. 1);
 - C. Flange is 1 1/2" or more from tread to top of flange (Gage No. 2);
 - D. Rim thickness 3/4" or less (Gage No. 2);
 - E. Cracked or broken rim, flange, plate or hub;
 - F. Chip in flange 1 1/2 inches in length and 1/2 inch in depth;
 - G. Contiguous (adjoining) pieces of metal shelled out of circumference of tread;
 - H. Slid flat spot more than 2 1/2 in length or two adjoining flat spots each more than 2" in length;
 - I. A hole in wheel not intended in design;
 - J. A circumferential groove in tread more than 1/8" in depth;
 - K. Scrape, dent, gouge in wheel plate surface more than 1/8" in depth that caused an abrupt change in finish;
 - L. A loose wheel as evidenced by wheel seat movement or oil seepage;
 - M. Welding on wheel;
 - N. Overheating;
 - O. Painted as to conceal defects.

215.045 Defective Wheel Sets
 A. Distance between gage so that distance between inside faces of wheel rim is less than 52 15/16" or more than 53 3/8".

215.053 Defective Axles
 A. Break or crack;
 B. Scrape, dent, or gouge between wheel seats more than 1/8" in depth;
 C. Welding on axle;
 D. Bend in axle which produces run out of more than 3/8" at center of axle;
 E. Journals on plain bearing axles worn beyond limits set forth in chart figure (5).

Journal size standard inches	Journal collar, inch	Journal length, inches	Journal diameter, inches
	(A)	(B)	(G)
4 1/4 by 8	3/16	8 11/16	3 3/4
5 by 9	3/16	9 11/16	4 1/2
5 1/2 by 10	3/16	10 11/16	5
6 by 11	3/16	11 11/16	5 1/2
6 1/2 by 12	3/16	12 11/16	6
7 by 12	3/16	12 11/16	6 1/2



F. Painted to conceal defects.

215.055 Defective plain bearing journal
 A. Break in collar;
 B. Surface of journal has (1) ridge, (2) depression, (3) circumferential score, (4) corrugation, (5) scratch, (6) continuous streak, (7) pitting, (8) rust, (9) etching;
 C. Evidence of overheated.

215.083 Plain bearing box is defective
 A. Does not contain free oil;
 B. Box lid missing, broken, or otherwise not preventing contaminants from entering box;
 C. Contains foreign matter detrimental to lubricant;

215.085 Defective lubricating system with pad missing or any of the following conditions:
 A. Exposed core or metal contacting journal;
 B. Pad not in contact with journal;
 C. Scorched or burned area;
 D. Glazing over half pad surface;
 E. Deteriorated or decayed fibers;
 F. Tear along top, front, back or side more than 1/2 length of pad.

215.087 Plain bearing or wedge missing

215.089 Plain bearing defective if not located in design position or any of the following conditions:
 A. Break or crack;
 B. Evidence of overheating (1) melted babbit; (2) smoke from hot oil; (3) journal surface damaged;
 C. Wear at either end reduces overall length more than 1/4";
 D. Combine wear at both ends reduces length more than 3/8";
 E. Lug worn more than 1/8";
 G. Combine wear on both sides of lug extension more than 1/4";
 F. Loose lining or section of lining broken out;
 H. Lining worn through to brass more than 3/8" above the lower edge of the brass sidewall.

215.091 Plain bearing wedge is defective if not properly located or has any of the following conditions:
 A. Bend, break, or crack;
 B. Wear measured at contact surfaces which reduces its overall length more than 3/16";
 C. Bottom surface unevenness more than 1/64";
 D. Wear on top

4 1/4 by 8 - 3 1/4"	6 by 11 - 5"
5 by 9 -	6 1/2 by 12 - 5 1/2"
5 1/2 by 10 - 4 1/2"	

215.093 A. Roller bearing is defective if it has been subjected to any of the following conditions until it has been inspected and repaired:
 1. Derailment;
 2. Submerged in water.

- B. Roller bearing is defective if it has been subjected to any of the following conditions:
 1. Overheating in excess of 250°F;
 2. Loose or missing cap screw;
 3. A broken, missing (unless by design) or improperly applied cap screw lock;
 4. A missing (unless by design) truck side frame key, pedestal bolt or stop block;
 5. Loose or nonfunctioning seal.

- 215.095 A roller bearing adapter is defective if it has any of the following conditions:
 - A. Break or crack;
 - B. Wear to extent adapter in marking seal assembly;
 - C. Wear on crown of adapter to extent that frame bears on relief portion;
 - D. Wear on thrust shoulder of narrow adapters more than .025"; (Gage No. 8);
 - E. Warp or distortion.

- 215.097 A. Plain bearing boxes defective if not lubricated within preceeding 24 months or stabilized within 30 months;
- B. Improperly replaced.

- 215.099 A. Roller bearing defective if not lubricated per time schedule outlined in rule:

Description of bearing	Size of bearing	Amount of lubricant required	Lubricate bearings within the following numbers of months before car is oper.
Oil lubricated	All	Fill to maximum level	12
Grease lubricated; end caps do not rotate	All	16 ounces	18
Grease lubricated; end caps rotate	12 in.	12 ounces	36
	11 in. or less	8 ounces	36

- D. Spring assembly defective
 1. Broken or missing snubber or outer coil spring;
 2. Does not maintain travel or load;
 3. Weakened to compress solid.
- E. Spring plank on trucks design for use of spring planks, missing, broken or corroded more than 25 percent of cross section.

- 215.153 A car body defective if any of the following conditions exist:
 - A. Failure to have minimum 2 1/2 clearance above rail;
 - B. A male portion of center plate fails to extend less than 1" into female portion;
 - C. Center plate not secured;

- D. Center plate cracked more than 30 percent;
- E. Center sill broken, cracked, or permanently bent more than 2 1/2" in any 6" length;
- F. Broken or missing coupler carrier;
- G. Side sill, crossbearer or body bolster broken;
- H. Center pin missing except by design.

- 215.173 A. Type "E" coupler is defective if it meets any of the following conditions:
 1. Shank is bent out of alignment with head more than 9/16";
 2. Shank is worn more than 7/16";
 3. Distance between guard arm and knuckle hose more than 5 5/16";
 4. There is crack or break in sidewall exceeding the limits shown on attached figure 11 or any crack or break in unshaded area.

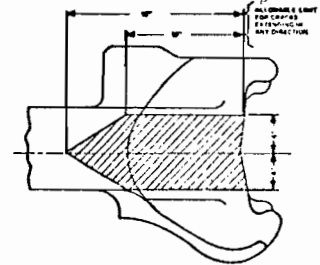


FIGURE 11

- B. Missing filling plug on oil lubricated roller bearing;
- C. Failure to follow proper lubricating procedures on grease lubricated bearing;
- D. Bearing not lubricated with pressure type fitting.

- 215.123 A car truck is defective if it has any of the following conditions:
 - A. Side frame or bolster
 1. Broken, patched, cracked, or reinforced with plate, including a break or crack in bolster gibs;
 2. Painted to conceal defects;
 3. Welded and not stress relieved;
 4. Worn or corroded thru more than 25 percent of cross section, except surfaces in friction snubber pockets, gibs column guides and cast integral brake beam supports which have not worn more than 40 percent which can be restored to original cross section by welding without the necessity for heat treatment, but all friction surfaces welds must be smooth.
 - B. Defective if less than 2 1/2 clearance to top of rail at maximum spring deflection.
 - C. Side bearing defective if:
 1. One is missing or broken;
 2. Bearings at one end of car on both sides in contact with body bolster except by design;
 3. Side bearings at one end of car have total clearance of more than 3/4";
 4. At diagonally opposite sides of car total clearance more than 3/4".

- B. Type "F" coupler is defective if any of the following conditions apply:
 1. Shank bent more than 7/16";
 2. Distance between front face and knuckle nose more than 3 13/16".
- C. Any coupler defective if:
 1. Locklift is inoperative;
 2. Coupler assembly does not have anti-creeper protection;
 3. Coupler lock missing, inoperative, bent, cracked, or broken.

- 215.175 A knuckle is defective if:
 - A. Type "E" knuckle is worn in excess of limit indicated by Gage No. 5;
 - B. Type "F" knuckle is worn in excess of limit indicated by Gage No. 6;
 - C. Any knuckle is defective if it has any of the following conditions:

1. Cracked or broken;
2. Knuckle pin or knuckle thrower missing or inoperative;
3. In case of hopper, gondola or car with spring supported coupler carrier, the knuckle pin retainer or cotter key missing.

- 215.177 An uncoupling device is defective if it does not meet the following requirements:
- A. Device must have sufficient vertical and lateral movement to prevent fouling on a curve and unintentional uncoupling;
 - B. Bottom operated coupler operating lever must have 1/4" clearance between operating rod eye and locklift level when coupler is centered and knuckle is fully closed and locked.
- 215.179 The cars equipped "F" type coupler in accordance with Section 179.14 interlocking feature is defective if any of the following conditions exist:
- A. Distance between the interlocking surfaces of the guard arm is less than 6 3/8" or more than 7". Use Gage No. 7A and B;
 - B. The distance between interlocking surfaces of aligning wing pocket is less than 7 1/8" or more than 7 3/4";
 - C. Guard arm is distorted beyond limits by Gage No. 4;
 - D. The guard arm or aligning wing pocket is cracked, broken, or missing.
- 215.193 A draft arrangement is defective if it has any of the following conditions:
- A. Break in yoke;
 - B. Yoke strap worn more than 25 percent its cross section;
 - C. A missing (except by design) or broken follower plate draft lugs or fasteners, draft gear, draft key or draft key retainer;
 - D. A draft key worn more than 25 percent of its cross section area.
- 215.197 Cushion device is defective if it is broken, inoperative, or missing a part;
- 215.223 Cars equipped with prohibited components listed in Section 1 Appendix "B" may not be operated after:
- A. Dec. 31, 1973 for transporting of Commodities subject to Hazardous Material Regulations in Parts 170-189 of this Title;
-
- B. Dec. 31, 1974 if car has received its initial periodic inspection;
 - C. Dec. 31, 1976.
- 215.225 Cars in excess of 50 years of age, and cars equipped with Duryea Underframes built prior to April 1, 1950, or cars equipped with components listed in Section 11 Appendix "B" are defined as restricted cars and may not be operated after Dec. 31, 1974, without FRA approval.
- A. These cars may not be used in transporting hazardous materials.

APPENDIX B
REPORT OF INVENTIONS

The work conducted under this program involved preparation of detailed plans for an accelerated service test of hazardous material tank cars.

After a diligent review of the work performed under this contract no new innovation, discovery, improvement, or invention was made.

- 110 Copies

