AMTRAK

SPECIFICATION

FOR

HIGH PERFORMANCE WIRE AND CABLE

FOR USE ON PASSENGER VEHICLES

DOCUMENT NUMBER: 323

(Replaces Q-78-7)

ORIGINAL ISSUE DATE: 3/23/1990

REVISION: C REV. DATE: 5/15/2003

ABSTRACT:
This document describes the physical and electrical properties for 110°C rated wire and cable, multi conductor cable and high temperature wire used on Amtrak Rolling Stock.

KEY WORDS: Wire, cable, multi conductor cable, high temperature wire

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REVISION HISTORY

Revision	Description of Change	Date	App'd
--	Original release	3/23/90	CJE
A	-Champlain was Haveg; -Added Approved Vendors: Brand-Rex and Rockbestos -Corrected Page Numbers	3/11/92	RFB
B	-Disapproved Champlain; -Combined Rockbestos with Suprenant	11/21/97	RFB
C	-Reformatted; Added 3 drawings; added multi conductor & Hi temp wire	5/15/03	RFB

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D-04-7229-E Multiconductor Cable Characteristics: Cross Linked Polyolefin 600V 110°C
D-12-7228-B High Temperature Wire Characteristics: Abrasion Resistant Teflon 600V, 260°C

1. OVERVIEW

1.1 Scope

This document describes the physical and electrical properties for 110°C rated wire and cable, multi conductor cable and high temperature wire used on Amtrak Rolling Stock.

1.2 Purpose

The purpose is to establish a standard for general purpose car and locomotive wire.

2. GENERAL

All wire and cable procured under this specification must exhibit the properties outlined in the specification and must either be on Amtrak's approved source list, (paragraph 7.0) or must be approved, in writing, by Amtrak Design Engineering Department.

3. WIRE CONSTRUCTION

Conductor:	Soft Annealed Copper
Coating:	Tin
Stranding:	Per AAR 589 (See paragraph 5.0)
Insulation:	Crosslinked Polyolefin

4. PROPERTIES

4.1 Applicable Documents

The wire and cable manufactured under this specification shall be tested and inspected in accordance with the latest issues of the following standards, as applicable or as modified herein:

ASTM B-33	Tinned Soft or Annealed Copper Wire
ASTM D-149	Test for Dielectric Breakdown Voltage and Dielectric Strength of Electrical Insulating Materials at Commercial Power Frequencies
IPCEA S-19-81	Rubber Insulated Wire & Cable
IPCEA S-66-524	Cross-Linked-Thermosetting-Polyethylene Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
UL 44	Standard for Rubber Insulated Wire and Cable

IEEE Std.383-1974 Type Test of Class 1E Electrical Cable, Field Splices & Connectors for Nuclear Power Generating Stations

4.2 Electrical

-Dielectric Strength per ASTM D-145	700V/Mil Minimum
-Insulation Resistance	5000 megohms Minimum
-Insulation Resistance K	17,500 Minimum
-Accelerated Water Absorption:	
Gravimetric 7 days @ 70°C	8mg/in 2 Maximum
Electrical SIC 24 hours @ 75°C	6.0 Maximum
Increase in Capacitance	
1-14 Days (% of Original)	7.5 Maximum
7-14 Days (% of Original)	1.5 Maximum
Stability Factor after 14 days	1.0

4.3 Physical

-Unaged	
Tensile Strength, Min PSI	2000 Minimum
Elongation at Rupture, Min. %	250 Minimum
-Aged	
After air oven 7 days @ 158°C ±2°C	
Tensile Strength (% of original)	90 Minimum
Elongation (% of original)	55 Minimum
-Heat Distortion, 1 hour @ 200°C Clause 4.3.6.1 CSA Std. C22.2 No. 0.3	20 Maximum
-Cold Bend, 120 hours @-55°C	* 6KV-5 Minutes
-Cold Bend, 2 inch Mandrel – 85°F (per Paragraph 4.7.4.15 MIL-C-22759)	* Pass

* Must Not Exhibit Cracking

4.4 Qualification

Tension Set:
Test per-IPCEA-S-66-524, Paragraph 6.4.11.4 (.Except with gauge marks 4" apart).

Requirement: 30% Maximum

Ozone Resistance:
After 24 hours exposure to an ozone concentration of 0.03% by volume at 90°C ±2%, there shall be no insulation cracks.

Flammability Requirements:
Insulated conductors shall pass the flame tests described in Paragraph 6.19.6 of IPCEA S-19-81 and the VW-1 vertical flame test described in UL Subject 44. The maximum afterburn after each flame application shall be no greater than 3 seconds.

Corrosion Tests:

A. Copper Mirror
(Ref. ASTM 2671) A 0.4 gram sample of insulation shall be placed in the bottom of a 1/2 inch 12 inch test tube. A copper-coated glass mirror shall be suspended 6 inches over the sample by a thin copper wire. The lower two inches of the test tube shall be heated to 175°C for 16 hours.
Requirements: Shall not remove more than 5% of the copper film.

B. Acid Gas Detection
A 1.0 mg sample shall be heated to combustion in a closed quartz tube. The resulting gases shall be drawn through a detector tube (MSA #91636) using a special air sampling pump manufactured by Mine Safety Apparatus Company. The amount of acid gas shall be determined by measuring the length of the color change in the detector tube.
Requirement: 300 ppm/mg maximum average. (350 ppm/mg maximum any single sample).

Oil Resistance:
Hot Oil Swell Tests - Insulated wires shall be pre-measured and immersed in a hot oil bath. After the required exposure time, they shall be removed and measured for the amount of swell.
Requirement:

A.	ASTM No. I-Oil 100 Hours @150°C Max. % Swell	20
B.	ASTM No. 2-Oil 100 hours @150°C Max. % Swell	40
C.	ASTM No. 3-Oil 100 hours @150°C Max. % Swell	50
D.	Diesel Oil 120 hours @60°C Max. % Swell	15

Note: When tested in accordance with AAR589 (ASTM =2 oil at 121°C for 18 hours) the retention of tensile and elongation shall be: Tensile - 70% Minimum, Elongation 90% Minimum.

Smoke Emission: The test shall be performed in an N.B.S. Smoke Chamber using #l2 AWG wire insulated with 45 mils of insulation. The procedures shall be per NFPA Standard 258 in the

flaming (F) and non-flaming (N) modes.

	Dm	T16	T.9DM
(F) Flaming plus Radiant Furnace	447	1.05	7.15
(N) Non-Flaming Radiant Furnace	199	11.6	27.1

Dm = Max. Specified Optical Density
T16 = Time to reach critical Ds (Specified Optical Density)
T.9DM = Time to reach 90% of Dm

Abrasion Resistance:
Rotating Scrape Abrader (Ref. Mil-C-915). A 24 inch specimen shall be draped over an 8 inch rotating drum with two (2) 90° vee edge abrading tools 180° apart. Failure shall be detected by electrical contact between abrading tool and conductor. The cable shall be weighted with a 450 gram mass.
Requirement: 2500 cycles minimum.

Cut-Through Penetration:
Specimen of insulated wire shall be preconditioned at 125°C for 1 hour. While at this temperature, a weighted (1000 gm) 90°C chisel cutting edge shall be applied perpendicular to the longitudinal axis of the specimen. Detection of cut-through shall be monitored with a 12 volt lamp circuit connected in series with the plunger and conductor in the specimen.
Requirement: 10 minutes minimum.

Crush Resistance:
A wire sample shall be placed between two (2) parallel flat plates and compressed until electrical contact is detected across conductor to the plate.
Requirement: 7500 lbs. minimum.

5. CABLE CONSTRUCTION

Area (CM)	Size AWG/MCM	Each Wire In Strand	Type Strand	Dia. Inches	Thickness (Mils) 600V	Thickness (Mils) 2000V	Max. Dia. (In) 600V	Max. Dia. (In) 2000V
1900	18	19/30	Conc	.052	30	45	.120	.150
2413	16	19/29	Conc.	.062	30	45	.130	.160
3831	14	19/27	Conc.	.074	30	45	.145	.175
6088	12	19/25	Conc.	.094	30	45	.165	.195
10910	10	27/24	Bunch	.128	30	45	.200	.230
14950	8	37/24	Conc.	.147	45	55	.250	.270
24640	6	61/24	Conc.	.207	45	55	.310	.330
36760	5	91/24	Rope	.248	45	55	.345	.365
42420	4	105/24	Rope	.268	45	55	.367	.385
50550	3	125/24	Rope	.292	45	55	.394	.410
60600	2	150/24	Rope	.330	45	55	.430	.450
90900	1	225/24	Rope	.395	55	65	.515	.535
111100	1/0	275/24	Rope	.445	55	65	.565	.585
131300	2/0	325/24	Rope	.490	55	65	.615	.635
181800	3/0	450/24	Rope	.565	55	65	.695	.715
222200	4/0	550/24	Rope	.620	55	*105	.750	.850
262600	262	650/24	Rope	.665	65	75	.810	.835
313100	313	775/24	Rope	.740	65	75	.880	.900
373700	373	925/24	Rope	.795	65	75	.960	.980
444400	444	1100/24	Rope	.870	65	75	1.025	1.045
535300	535	1325/24	Rope	.970	80	90	1.160	1.185
646400	646	1600/24	Rope	1.070	80	90	1.250	1.270
777700	777	1925/24	Rope	1.140	80	90	1.325	1.345
929200	929	2300/24	Rope	1.230	80	90	1.435	1.455
1111000	1111	2750/24	Rope	1.370	95	120	1.595	1.645

* double wall thickness: 50 mil inner wall; 55 mil outer wall

6. IDENTIFICATION

The surface of the-cable shall be printed with the following information at intervals not greater than two feet:

- Manufacturer
- Insulation Type
- Conductor Size
- Voltage Rating.

7. APPROVED VENDORS AND PRODUCTS

1.	Rockbestos- Suprenant:	Exane per Specification DAA1068A
2.	Brand-Rex-	Polyrad XT

APPENDIX

The following drawings define properties of the wire and cable covered in this document.

D-12-7205-G Wire: Single Conductor
D-04-7229-E Multiconductor Cable Characteristics: Cross Linked Polyolefin 600V 110°C
D-12-7228-B High Temperature Wire Characteristics: Abrasion Resistant Teflon 600V, 260°C

REVISION				
LTR	ZONE	DESCRIPTION	DATE	APPRO
G		REDRAWN WITHOUT CHANGE	1/28/03	4/26/03

ITEM NO.	CONDUCTOR SIZE #AWG	CIRCULAR MILLS	STRANDING	NOMINAL INSULATION THICKNESS (MILS)	CABLE DIAMETER MINIMUM (INCHES)	CABLE DIAMETER MAXIMUM (INCHES)	AREA (SQ. INCHES)	WEIGHT PER 1000' (LBS)	DC RESISTANCE PER 1000' (OHMS) 2c	CURRENT RATING (AMPERES) 2a 1 COND 40° C AMB	3 COND 55° C AMB	4-6 COND	7-24 COND	25-42 COND	> 43 COND	ITT #	AMMS #
1	18	1900	19/30	30	.102	.110	.010	11	6.22	30	20	16	14	12	10	FXE 1930U030	25 613 0154X
2	16	2413	19/29	30	.111	.122	.012	13	4.82	35	24	19	17	14	12	FXE 1929U030	25 613 02008
3	14	3831	19/27	30	.124	.140	.015	18	3.05	41	28	22	19	17	14	FXE 1927U030	25 613 01902
4	12	6088	19/25	30	.142	.162	.021	26	1.92	52	33	26	23	20	16	FXE 1925U030	25 613 0170X
5	10	10910	27/24	30	.175	.195	.030	44	1.10	73	46	36	32	27	23	FXE 2724U030	25 613 01507
6	8	14950	37/24	45	.225	.246	.048	65	.702	85	54	43	38	32	27	FXE 3724U045	25 613 04206
7	6	24640	61/24	45	.276	.296	.069	102	.474	120	72	58	50	43	36	FXE 6124U045	25 613 04003
8	4	42420	105/24	45	.344	.367	.106	165	.281	168	99	79	69	60	50	FXE 10524U045	25 613 03203
9	2	60600	150/24	45	.402	.427	.143	233	.199	214	124	99	87	74	62	FXE 15024U045	25 613 02307
10	1/0	111100	275/24	55	.535	.565	.251	408	.108	304	182	146	128	109	91	FXE 27524U055	25 613 01304
12	2/0	131300	325/24	55	.585	.615	.297	481	.092	338	198	159	139	119	99	FXE 32524U055	25 045 10556
13	3/0	181800	450/24	55	.645	.685	.369	653	.065	414	237	190	166	142	119	FXE 45024U055	
14	4/0	222200	550/24	55	.705	.745	.436	765	.054	472	263	210	184	158	131	FXE 55024U055	DO NOT PURCHASE
2b 15	444 MCM	444400	1100/24	75	.990	1.045	.858	1529	.0269	734	417	334	292	250	209	FXE 110024U075	
2b 16	535 MCM	535300	1325/24	90	1.125	1.185	1.103	1904	.0223	828	458	366	320	275	230	FXE 132524U090	
2b 17	1111 MCM	1111000	2750/24	120	1.560	1.645	2.124	3742	.0108	1254	-	-	-	-	-	FXE 275024U120	
4 2b 18	4/0	222200	550/24	50 INNER 55 OUTER 105 TOTAL	.805	.850	.560		.054	472	263	-	-	-	-	FLXE 55024U105	25 613 03414

NOTES

1 - MAXIMUM ALLOWED VOLTAGE DROP WITHIN CAR, 1.5%

2 - CONDTIONS

- a: 55°C AMBIENT (130° F) EXCEPT AS NOTED
- b: 2000V. 110°C
- c: CONDUCTOR TEMPERATURE 75°C (167°F)

3 - CHARACTERISTICS: CROSS-LINKED POLYOLEFIN 600V - 110°C

4: DOUBLE WALL INSULATION.

SOURCE

ITEM 1 - 17 PER SUPRENANT SPEC DAA 1068A, TABLE - I
ITEM 18 PER SUPRENANT SPEC DAA 1068A, TABLE - III

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MICROFILM RATIO 24 X

DRAWING NUMBER D - 12 - 7205 REV G

LIST OF MATERIAL: QTY | PART NUMBER | DESCRIPTION | MATERIAL | INFO/SPEC | ITEM

REFERENCE DRAWINGS: SPEC Q-78-7

DO NOT SCALE DRAWING

AMTRAK MECHANICAL DEPARTMENT

TOLERANCES

TITLE: WIRE SINGLE CONDUCTOR

D - 12 - 7205 G

This drawing defines single conductor wire.

REVISION				
LTR	ZONE	DESCRIPTION	DATE	APPR'D
E		REDRAWN WITHOUT CHANGE	11/28/03	4/26/03

ITEM NO.	CABLE DESIGNATION: COND #AWG	CABLE DESIGNATION: SHIELDING	CONDUCTOR CIRCULAR MILLS	STRANDING	6 COND INSUL THICKNESS (MILS)	CONDUCTOR DIAMETER INCLUDING INSULATION: MINIMUM (INCHES)	CONDUCTOR DIAMETER INCLUDING INSULATION: MAXIMUM (INCHES)	SHIELDING: % COVER	SHIELDING: STRANDING	SHIELDING: DRAIN (TINNED COPPER)	JACKET NOMINAL THICKNESS (MILS)	CABLE DIAMETER: MINIMUM (INCHES)	CABLE DIAMETER: MAXIMUM (INCHES)	AREA (SQ. INCHES)	WEIGHT PER 1000' (LBS)	DC RESISTANCE PER 1000' OHMS 1		AMMS #
1	2/C #14	YES	3831	19/27	30	.124	.140	100	1 MIL ALUM/ MYLAR TAPE	19/29 (#16)	45	.370	.400	.126		3.2	2	
2	5-2/C #14	YES / PAIR	3831	19/27	30 7	.124	.140	100	1 MIL ALUM/ MYLAR TAPE & 1 MIL MYLAR TAPE	19/29 (#16)	60	.740	.790	.490		3.2	8	25 613 01523
3	2/C #16	NO	2413	19/29	30	.111	.122	—	—	—	45	.315	.345	.093		4.9	3	
4	2/C #16	YES	2413	19/29	30	.111	.122	85	1 MIL ALUM/ MYLAR TAPE	19/30 (#18)	30	.300	.330	.085		4.9	4	25 613 01531
5	3/C #16	YES	2413	19/29	30	.111	.122	85	#36 TINNED COPPER	19/30 (#18)	45	.360	.390	.119		4.9		25 613 01515
6	4/C #16	YES	2413	19/29	30	.111	.122	85	#36 TINNED COPPER	19/30 (#18)	45	.365	.395	.123		4.9		
7	8/C #16	NO	2413	26/30	30	.120	.124	—	—	—	45	.480	.520	.212		4.9	10	25 045 00008

TABLE A

CONDUCTOR	COLOR
FIRST	BLACK
SECOND	WHITE
THIRD	RED
FOURTH	GREEN

TABLE B

PAIR	COLOR	WIRE LABEL
1	BLK WHT	PA1 PA2
2	BLK WHT	PA3 PA4
3	BLK WHT	PA5 PA6
4	BLK WHT	PA7 PA8
5	BLK WHT	RA1 RA2

NOTES

1. CONDUCTOR TEMPERATURE 20° C (68° F)
2. REPLACES BELDEN # 8720
3. REPLACES BELDEN # 8471
4. REPLACES BELDEN # 8719
5. SHIELDS OF INDIVIDUAL PAIRS TO BE ELECTRICALLY INSULATED
6. CONDUCTOR COLORS (SOLID) PER TABLE A
7. WIRE DESIGNATIONS PER TABLE B PRINTED EVERY 2" ALONG WIRE
8. REPLACES 5 BELDEN # 8720
9. JACKET TO BE IDENTIFIED WITH MANUFACTURER, PRODUCT NAME / SPEC #, PART NUMBER, WIRE GAUGE, VOLTAGE & TEMPERATURE
10. NO HALOGEN JACKET

SOURCE:

- SUPRENANT
- BRAND REX
- ROCKBESTOS

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MICROFILM RATIO 24 X

LIST OF MATERIAL

QTY	PART NUMBER	DESCRIPTION	MATERIAL	SPEC/SPEC	ITEM

REFERENCE DRAWINGS

AMTRAK
AMTRAK MECHANICAL DEPARTMENT

MULTICONDUCTOR CABLE CHARACTERISTIC CROSS LINKED POLYOLEFIN 600V 110° C

TOLERANCES

DO NOT SCALE DRAWING

NONE

D - 04 - 7229 E

DRAWING NUMBER D - 04 - 7229 E

This drawing defines the requirements for multiconductor cable employing cross-linked insulation

ITEM NO.	CONDUCTOR SIZE # AWG	CIRCULAR MILLS	STRANDING	NOMINAL INSULATION THICKNESS (MILS)	CABLE DIAMETER MINIMUM (INCHES)	CABLE DIAMETER MAXIMUM (INCHES)	AREA (SQ. INCHES)	WEIGHT PER 1000' (LBS)	DC RESIST (OHMS) PER 1000' @ 20° C	CURRENT RATING (AMPERES) 1 COND 40° C AMB 1	3 COND 55° C AMB 2	4-6 COND 3	7-24 COND 3	25-42 COND 3	> 43 COND 3	ITT #	AMMS #
1	16	2413	19/29	35	.121	.127	.012	17	4.69	38	25	20	18	15	12.5	JET 1929NIC	
2	14	3838	19/27	37	.138	.144	.015	23	2.94	60	40	32	28	24	20	JET 1927NIC	
3	12	6070	19/25	37	.156	.164	.020	32	1.93	80	55	44	39	33	27.5	JET 1925NIC	25 613 01718
4	10	9410	37/26	38	.178	.186	.026	46	1.21	110	75	60	56	45	37.5	JET 3726NIC	
5	8	16851	133/29	40	.244	.254	.049	82	.690	145	95	76	66	57	47.5	JET 13329NIC	
6	6	26880	133/27	40	.291	.303	.069	120	.432	210	120	96	84	72	60	JET 13327NIC	

NATIONAL ELECTRICAL CODE

1 TABLE 310 - 19 250°C COLUMN

2 TABLE 310 - 18 250°C COLUMN

3 THESE VALUES BASED ON NOTE 8 OF "NOTES TO TABLES 310-16 THRU 310-19".

4 CONDITIONS:
a. 55°C AMBIENT (130°F) EXCEPT AS NOTED.

SOURCE

MIL - SPEC W 22759 / 6B
(SUPRENANT SPEC CAA 1002)

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MICROFILM RATIO 24 X

LIST OF MATERIAL

AMTRAK
MECHANICAL DEPARTMENT

HIGH TEMPERATURE WIRE CHARACTERISTICS ABRASION RESISTANT TEFLON 600V, 260°C

TOLERANCES

DO NOT SCALE DRAWING

D - 12 - 7228

This drawing defines high temperature wire used for baseboard and duct/ overhead heater applications