CONDUCTOR PARTICULARS (UNWORN CONTACT CONDITION)	UNITS	OPEN ROUTE MAIN LINES AUTO-TENSIONED SIMPLE CATENARY CONDUCTOR		MAIN LINES IN TUNNEL FIXED TERMINATED SIMPLE CATENARY CONDUCTOR		YARD AND SHOP TRACKS FIXED TERMINATED SINGLE CONTACT WIRE
		CONTACT WIRE	MESSENGER WIRE	CONTACT WIRE	MESSENGER WIRE	
CONDUCTOR TYPE	–	350 KCMIL SOLID GROOVED	500 KCMIL 19 STRAND	350 KCMIL SOLID GROOVED	500 KCMIL 19 STRAND	350 KCMIL SOLID GROOVED
MATERIAL	–	HARD DRAWN COPPER	HARD DRAWN COPPER	HARD DRAWN COPPER	HARD DRAWN COPPER	HARD DRAWN COPPER
DIAMETER	IN	0.620	0.810	0.620	0.810	0.620
CROSS SECTIONAL AREA	SQ IN	0.2758	0.393	0.2758	0.393	0.2758
CONDUCTOR BREAKING STRENGTH	LB	11810	21590	11810	21590	11810
MODULUS OF ELASTICITY	PSI	16000000	17000000	16000000	17000000	16000000
COEFFICIENT OF EXPANSION	/°F	0.0000094	0.0000094	0.0000094	0.0000094	0.0000094
WEIGHT OF CONDUCTOR	LB/FT	1.063	1.543	1.063	1.543	1.063
WEIGHT OF HANGERS (ASSUMED)	LB/FT	0.032		0.032		0.25
WEIGHT OF SYSTEM	LB/FT	2.638		2.638		0.270
RADIAL THICKNESS OF ICE (O)	IN	0.25	0.5	0.25	0.5	1.333
WEIGHT OF ICE (O)	LB/FT	0.270	0.815	0.270	0.815	
WEIGHT OF SYSTEM WITH ICE (O)	LB/FT	3.723		3.723		
RADIAL THICKNESS OF ICE (NO)	IN	0.5	0.5	0.5	0.5	0.5
WEIGHT OF ICE (NO)	LB/FT	0.696	0.815	0.696	0.815	0.696
WEIGHT OF SYSTEM WITH ICE (NO)	LB/FT	4.149		4.149		1.759
EQUIVALENT SPAN FOR TENSION CALCULATIONS	FT	25	150	25	50	80
CONDUCTOR TENSIONS AT:						
60°F, NO WIND	LB	3300	5000	2500	4500	2500
120°F, NO WIND	LB	3300	5000	503	1873	1037
165°F, NO WIND	LB	1481	3669	248	1176	693
−5°F, WITH ICE (O), NO WIND	LB	3718	6166	5183	8477	5065
−5°F, WITH ICE (NO), NO WIND	LB	3729	6465	5188	8508	5122
MAXIMUM MESSENGER SPAN: BALLASTED TRACK	FT		215		50	120
MAXIMUM HANGER SPACING	FT	25		25		
CONDUCTOR SAG AT MAXIMUM SPAN AT:						
60°F, NO WIND	FT	0	3.049	0	0.183	0.765
120°F, NO WIND	FT			0.422	0.440	1.846
165°F, NO WIND	FT	1.162	4.155	0.853	0.701	2.761
32°F, WITH ICE (NO), NO WIND	FT			0.059	0.205	0.853
−5°F, WITH ICE (O), NO WIND	FT	0.468	3.489			
−5°F, WITH ICE (NO), NO WIND	FT	0.697	3.708	−0.004	0.152	0.618
NORMAL SYSTEM HEIGHT	FT	4.0		2.0		
NORMAL CONTACT WIRE HEIGHT	FT	20.5	–	13.8	–	18.5
NORMAL CONTACT WIRE HEIGHT: AERIAL STRUCTURE	FT	18.5	–			
MINIMUM SAFETY FACTOR	–	2.44	2.87	2.28	2.54	2.30
CONDUCTOR PARTICULARS (WORN CONTACT CONDITION)	UNITS	CONDUCTOR		CONDUCTOR		CONDUCTOR
		CONTACT WIRE	MESSENGER WIRE	CONTACT WIRE	MESSENGER WIRE	CONTACT WIRE
PERMISSABLE WEAR	% OF AREA	30		30		30
WEIGHT OF SYSTEM	LB/FT	2.319		2.319		0.744
WEIGHT OF SYSTEM WITH ICE (O)	LB/FT	3.404		3.404		1.015
WEIGHT OF SYSTEM WITH ICE (NO)	LB/FT	3.830		3.830		1.440
CONDUCTOR TENSIONS AT:						
−5°F, WITH ICE (NO), 40 MPH WIND	LB	3723	6277	5186	8488	5092
CONDUCTOR BREAKING STRENGTH	LB	8267	21590	8267	21590	8267
MINIMUM SAFETY FACTOR	–	2.22	2.87	1.59	2.54	1.62

LEGEND:

(O) IS OPERATING CONDITION

(NO) IS NON-OPERATING CONDITION

NOTES:

1. ICE CONDITIONS:
   (O) ¼" ON CONTACT WIRE, ½" ON MESSENGER WIRE
   (NO) ½" ON CONTACT WIRE, ½" ON MESSENGER WIRE
2. MAXIMUM WIND SPEED FOR STRUCTURAL DESIGN = 70 MPH (NO)
3. MAXIMUM WIND SPEED FOR LRV OPERATIONS = 55 MPH (O)
4. WORST CASE DESIGN TENSIONS OCCUR AT −5°F WITH NO ICE
5. DROOP IS THE SAG OF THE CONTACT WIRE FROM NORMAL CONTACT WIRE HEIGHT AT 60°F. FOR SIMPLE CATENARY, CONTACT WIRE SAG VALUE INCLUDES MESSENGER SAG CHANGES.
6. WIND CONDITIONS:
   (O) 55 MPH WITHOUT ICE
   (O) 40 MPH WITH ICE
   (NO) 70 MPH WITHOUT ICE
   (NO) 40 MPH WITH ICE BELOW 32°F

THIS PRINT ACCURATE HALF SCALE

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City of Seattle
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SDOT:

Designed By: D. WINTER
Drawn By: B. PORTER
Checked By: A. GILLESPIE
Approved By: E. ROWE

EXPIRES 06/09/05

LTK Engineering Services
Submitted: D. PORTER Date: 09/22/04

SOUNDTRANSIT
Approved: R. PARSONS Date: 09/22/04

Scale: NTS
Filename: C87_L00_J710.dwg
Contract No.: C 807
Date: 06/10/04

LINK LIGHT RAIL PROJECT
OVERHEAD CONTACT SYSTEM

TECHNICAL SHEETS
CONDUCTOR CHARACTERISTICS AND PARAMETERS

Drawing No.: L00-J710
Vault Plan No. 231-807
Sheet No.: 412
Rev.: 0

34386 VAULT SERIAL NO. | DATE | MARK | NATURE REVISIONS | MADE | CHK'D | REV'D

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NOTES:

1. UNLOADED MESSENGER WIRE TENSIONS SHOWN FOR APPLICATION DURING WIRE ERECTION PRIOR TO THE ERECTION OF CONTACT WIRE.

2. ERECTION TENSIONS SHOWN APPLY FOR A/T CATENARY ONLY WITH BALANCE WEIGHTS LOCKED AT 60° F POSITION.

3. FOR INTERMEDIATE EQUIVALENT SPANS BETWEEN THOSE INDICATED IN THE GRAPH, THE TENSION VALUES CAN BE INTERPOLATED ON A STRAIGHT LINE BASIS.

4. EQUIVALENT SPAN IS DETERMINED BY THE FOLLOWING FORMULA:

$$\sqrt{\frac{L_1^3 + L_2^3 + L_3^3 + ---L_N^3}{L_1 + L_2 + L_3 + ---L_N}}$$

WHERE L_1, L_2, L^3---L^N ARE THE LENGTHS OF THE SPANS IN EACH FULL TENSION LENGTH (ANCHOR TO ANCHOR)

L =	EQUIVALENT SPAN [FT]	75' SPAN	100' SPAN	125' SPAN	150' SPAN	175' SPAN	200' SPAN
TEMPERATURE	0	8385	8094	7730	7304	6829	6330
	10	7766	7483	7133	6726	6282	5823
	20	7149	6877	6543	6162	5753	5342
	30	6536	6277	5964	5614	5249	4892
	40	5926	5686	5400	5089	4773	4479
	50	5323	5108	4856	4592	4335	4103
	60	4730	4546	4339	4130	3936	3768
	70	4153	4010	3858	3711	3582	3472
	80	3596	3508	3419	3338	3269	3212
	90	3074	3053	3032	3014	2999	2987
	100	2603	2654	2699	2737	2766	2791
	110	2197	2318	2419	2502	2567	2621
	120	1867	2043	2187	2303	2396	2471

MESSENGER ERECTION TENSIONS FOR AUTO-TENSIONED WIRING

L =	EQUIVALENT SPAN [FT]	75' SPAN	100' SPAN	125' SPAN	150' SPAN	175' SPAN	200' SPAN
TEMPERATURE	0	7791	7431	6986	6472	5918	5363
	10	7175	6825	6398	5914	5405	4912
	20	6561	6226	5822	5376	4920	4497
	30	5951	5635	5263	4863	4471	4120
	40	5349	5059	4725	4381	4059	3782
	50	4755	4499	4215	3937	3689	3485
	60	4176	3965	3744	3538	3364	3224
	70	3619	3467	3318	3187	3081	2997
	80	3095	3016	2945	2884	2837	2800
	90	2620	2623	2625	2626	2627	2628
	100	2212	2293	2357	2409	2447	2478
	110	1878	2023	2138	2224	2292	2347
	120	1619	1807	1953	2068	2158	2231

MESSENGER ERECTION TENSIONS FOR FIXED TERMINATED WIRING

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Submitted: D. PORTER Date: 09/22/04

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Approved: R. PARSONS Date: 09/22/04

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LINK LIGHT RAIL PROJECT
OVERHEAD CONTACT SYSTEM

TECHNICAL SHEETS
MESSENGER WIRE
TEMPERATURE/TENSION CHARTS

Drawing No.: L00-J711
Vault Plan No. 231-807
Sheet No.: 413 Rev.: 0

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BALLASTED TRACK		
MAXIMUM SPAN [FEET]	MINIMUM TRACK RADIUS [FEET]	PERMISSABLE MID SPAN OFFSET [INCHES]
20	23	11.4
30	51	11.3
40	92	11.2
50	144	11.0
60	209	10.8
70	288	10.6
80	380	10.3
90	486	10.0
100	609	9.6
110	748	9.2
120	906	8.8
130	1084	8.4
140	1285	7.9
150	1510	7.4
160	1762	6.8
170	2045	6.2
180	2364	5.6
190	2723	4.9
200	3129	4.2
210	3589	3.4
215	3843	3.0
220	4113	2.6

CONTACT WIRE BLOW OFF	
SPAN [FEET]	BLOW OFF [INCHES]
20	0.1
30	0.2
40	0.3
50	0.5
60	0.7
70	0.9
80	1.2
90	1.5
100	1.8
110	2.2
120	2.6
130	3.1
140	3.6
150	4.1
160	4.7
170	5.3
180	5.9
190	6.6
200	7.3
210	8.0
215	8.4
220	8.8

EMBEDDED TRACK		
MAXIMUM SPAN [FEET]	MINIMUM TRACK RADIUS [FEET]	PERMISSABLE MID SPAN OFFSET [INCHES]
20	22	12.7
30	49	12.6
40	87	12.5
50	137	12.3
60	199	12.1
70	273	11.9
80	361	11.6
90	462	11.3
100	578	11.0
110	709	10.6
120	858	10.2
130	1026	9.7
140	1214	9.2
150	1424	8.7
160	1660	8.1
170	1924	7.5
180	2220	6.9
190	2551	6.2
200	2925	5.5
210	3346	4.8
215	3577	4.4
220	3824	4.0

NOTES:

1. THESE TABLES HAVE BEEN DETERMINED FOR TEMPERATURE OF 60° F WITH A WIND SPEED OF 55 MPH.
2. THE SPANS SHOWN ARE THE ABSOLUTE MAXIMUM FOR 20'-6" CONTACT WIRE HEIGHT. FOR DESIGN CONSIDERATIONS THE MAXIMUM SPAN IS REDUCED BY 5 FEET TO CATER FOR SITE ADJUSTMENTS IF OBSTRUCTIONS ARE ENCOUNTERED.
3. THE PERMISSIBLE STATIC OFFSET IS THE MAXIMUM DISTANCE THAT THE CONTACT WIRE CAN BE FROM THE CENTER LINE OF A STATIC PANTOGRAPH UNDER STILL AIR CONDITIONS.
4. THE PERMISSIBLE STATIC OFFSET INCLUDES A STAGGER EFFECT VALUE OF 0.16 FEET. IF THE ACTUAL MID SPAN OFFSET EXCEEDS THE PERMISSIBLE VALUE, THE STAGGER EFFECT SHOULD BE CALCULATED PRIOR TO CATENARY ADJUSTMENT.
5. MAXIMUM STAGGER = 12".
6. CONTACT WIRE INSTALLATION TOLERANCE = ±1 INCH.
7. FOR CATENARY LAYOUT DESIGN PURPOSES THE SPAN LENGTHS SHOWN IN THESE DESIGN SHOULD BE REDUCED BY 5'-0" TO CATER FOR POSSIBLE SITE ADJUSTMENT.
8. IN THE VICINITY OF GRADE CROSSINGS THE MAXIMUM SPAN SHOULD BE REDUCED BY 10'-0"
9. MAXIUM SPAN FOR 2'-0" SYSTEM HEIGHT IS 125 FEET. MAXIMUM SPAN FOR 3'-0" HEIGHT IS 165 FEET.
10. EXAMPLE SPAN DETERMINATION:

GIVEN – RADIUS OF CURVATURE = 3100 FT ON BALLASTED TRACK
FIND – MAXIMUM CONSTRUCTED SPAN = 190 FT
∴ – MAXIMUM DESIGN SPAN = 185 FT
– PERMISSABLE MIDSPAN OFFSET = 4.9 IN

HALF SCALE

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DAVID O. NIVEN, STATE OF WASHINGTON, 23844, REGISTERED PROFESSIONAL ENGINEER
EXPIRES 08/09/05

LTK Engineering Services
Submitted: D. PORTER Date: 09/22/04

SOUNDTRANSIT
Approved: R. PARSONS Date: 09/22/04

Scale: NTS
Filename: C87_L00_J712.DWG
Contract No.: C 807
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LINK LIGHT RAIL PROJECT
OVERHEAD CONTACT SYSTEM

TECHNICAL SHEETS
BLOW OFF AND MIDSPAN OFFSET CHARTS

Drawing No.: L00-J712
Vault Plan No. 231-807
Sheet No.: 414 Rev.: 0

34386 VAULT SERIAL NO. | DATE | MARK | NATURE REVISIONS | MADE | CHK'D | REV'D

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BALLASTED TRACK		
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100	609	9.6
110	748	9.2
120	906	8.8
130	1084	8.4
140	1285	7.9
150	1510	7.4
160	1762	6.8
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180	2364	5.6
190	2723	4.9
200	3129	4.2
210	3589	3.4
215	3843	3.0
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CONTACT WIRE BLOW OFF	
SPAN [FEET]	BLOW OFF [INCHES]
20	0.1
30	0.2
40	0.3
50	0.5
60	0.7
70	0.9
80	1.2
90	1.5
100	1.8
110	2.2
120	2.6
130	3.1
140	3.6
150	4.1
160	4.7
170	5.3
180	5.9
190	6.6
200	7.3
210	8.0
215	8.4
220	8.8

EMBEDDED TRACK		
MAXIMUM SPAN [FEET]	MINIMUM TRACK RADIUS [FEET]	PERMISSABLE MID SPAN OFFSET [INCHES]
20	22	12.7
30	49	12.6
40	87	12.5
50	137	12.3
60	199	12.1
70	273	11.9
80	361	11.6
90	462	11.3
100	578	11.0
110	709	10.6
120	858	10.2
130	1026	9.7
140	1214	9.2
150	1424	8.7
160	1660	8.1
170	1924	7.5
180	2220	6.9
190	2551	6.2
200	2925	5.5
210	3346	4.8
215	3577	4.4
220	3824	4.0

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DAVID O. WINTERS, STATE OF WASHINGTON, 25944, REGISTERED PROFESSIONAL ENGINEER
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Approved: R. PARSONS Date: 09/22/04

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LINK LIGHT RAIL PROJECT
OVERHEAD CONTACT SYSTEM

TECHNICAL SHEETS
BLOW OFF AND MIDSPAN OFFSET CHARTS

Drawing No.: L00-J712
Vault Plan No. 231-807
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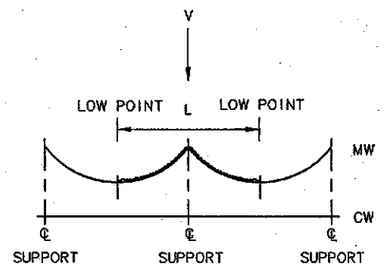
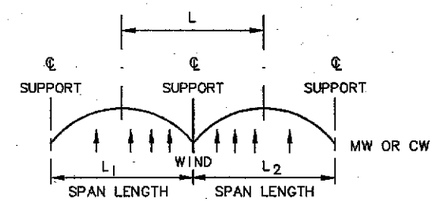


MW = MESSENGER WIRE
CW = CONTACT WIRE

L = SUM OF THE DISTANCE TO THE LOW POINT OF THE CONDUCTOR ON EACH SIDE OF THE SUPPORT.

V = VERTICAL LOAD



$$L = \frac{L_1 + L_2}{2}$$

MW = MESSENGER WIRE
CW = CONTACT WIRE

VERTICAL LOADS (LB)

SUPPORTED LENGTH L (FEET)	BARE WIRES	ICED WIRES	
		OPERATING	NON-OPERATING
30	102.3	138.4	151.1
40	136.4	184.5	201.5
50	170.6	230.6	251.9
60	204.7	276.7	302.3
70	238.8	322.8	352.7
80	272.9	369.0	403.0
90	307.0	415.1	453.4
100	341.1	461.2	503.8
110	375.2	507.3	554.2
120	409.3	553.4	604.6
130	443.4	599.6	654.9
140	477.5	645.7	705.3
150	511.7	691.8	755.7
160	545.8	737.9	806.1
170	579.9	784.0	856.5
180	614.0	830.2	906.8
190	648.1	876.3	957.2
200	682.2	922.4	1007.6
210	716.3	968.5	1058.0
220	750.4	1014.6	1108.4

WIND LOADS (LB)

SUPPORTED LENGTH L (FEET)	OPERATING BARE WIRES 55 MPH WIND		NON-OPERATING BARE WIRES 70 MPH WIND		OPERATING ICE: M/W – 1/2", C/W – 1/4" 40 MPH WIND		NON-OPERATING ICE: 1/2" BOTH WIRES 40 MPH WIND	
	CONTACT	MESSENGER	CONTACT	MESSENGER	CONTACT	MESSENGER	CONTACT	MESSENGER
30	12.0	19.3	19.5	31.3	11.5	20.5	16.6	20.5
40	16.0	25.8	26.0	41.7	15.3	27.3	22.1	27.3
50	20.0	32.2	32.5	52.2	19.1	34.1	27.7	34.1
60	24.0	38.6	38.9	62.6	23.0	40.9	33.2	40.9
70	28.1	45.1	45.4	73.0	26.8	47.7	38.7	47.7
80	32.1	51.5	51.9	83.5	30.6	54.6	44.3	54.6
90	36.1	58.0	58.4	93.9	34.4	61.4	49.8	61.4
100	40.1	64.4	64.9	104.3	38.3	68.2	55.3	68.2
110	44.1	70.8	71.4	114.8	42.1	75.0	60.9	75.0
120	48.1	77.3	77.9	125.2	45.9	81.8	66.4	81.8
130	52.1	83.7	84.4	135.6	49.7	88.7	71.9	88.7
140	56.1	90.2	90.9	146.1	53.6	95.5	77.5	95.5
150	60.1	96.6	97.4	156.5	57.4	102.3	83.0	102.3
160	64.1	103.0	103.9	166.9	61.2	109.1	88.5	109.1
170	68.1	109.5	110.4	177.4	65.0	115.9	94.1	115.9
180	72.1	115.9	116.8	187.8	68.9	122.8	99.6	122.8
190	76.1	122.4	123.3	198.2	72.7	129.6	105.1	129.6
200	80.2	128.8	129.8	208.6	76.5	136.4	110.7	136.4
210	84.2	135.2	136.3	219.1	80.4	143.2	116.2	143.2
220	88.2	141.7	142.8	229.5	84.2	150.0	121.7	150.0

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City of Seattle
Work Order No.
Permit No. Y6375
SDOT:
Approved:
Inspector's Book:
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Revised As Built:

Designed By: D. WINTER
Drawn By: B. PORTER
Checked By: A. GILLESPIE
Approved By: E. ROWE

09/21/04 — REGISTERED PROFESSIONAL ENGINEER — EXPIRES 06/09/05

LTK Engineering Services
Submitted: D. PORTER Date: 09/22/04

SOUNDTRANSIT
Approved: R. PARSONS Date: 09/22/04

Scale: NTS
Filename: C87_L00_J714.dwg
Contract No.: C 807
Date: 06/10/04

LINK LIGHT RAIL PROJECT
OVERHEAD CONTACT SYSTEM

TECHNICAL SHEETS
VERTICAL LOADS AND WIND LOADS
SIMPLE CATENARY SYSTEM

Drawing No.: L00–J714
Vault Plan No. 231–807
Sheet No.: 415 Rev.: 0

XREF'S
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LTK-2234SEA
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LTSCALE
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34386 VAULT SERIAL NO. | DATE | MARK | NATURE REVISIONS | MADE | CHK'D | REV'D

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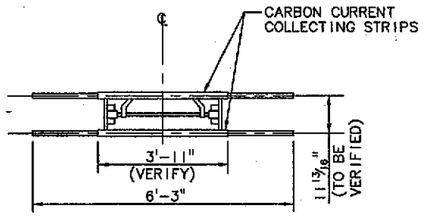
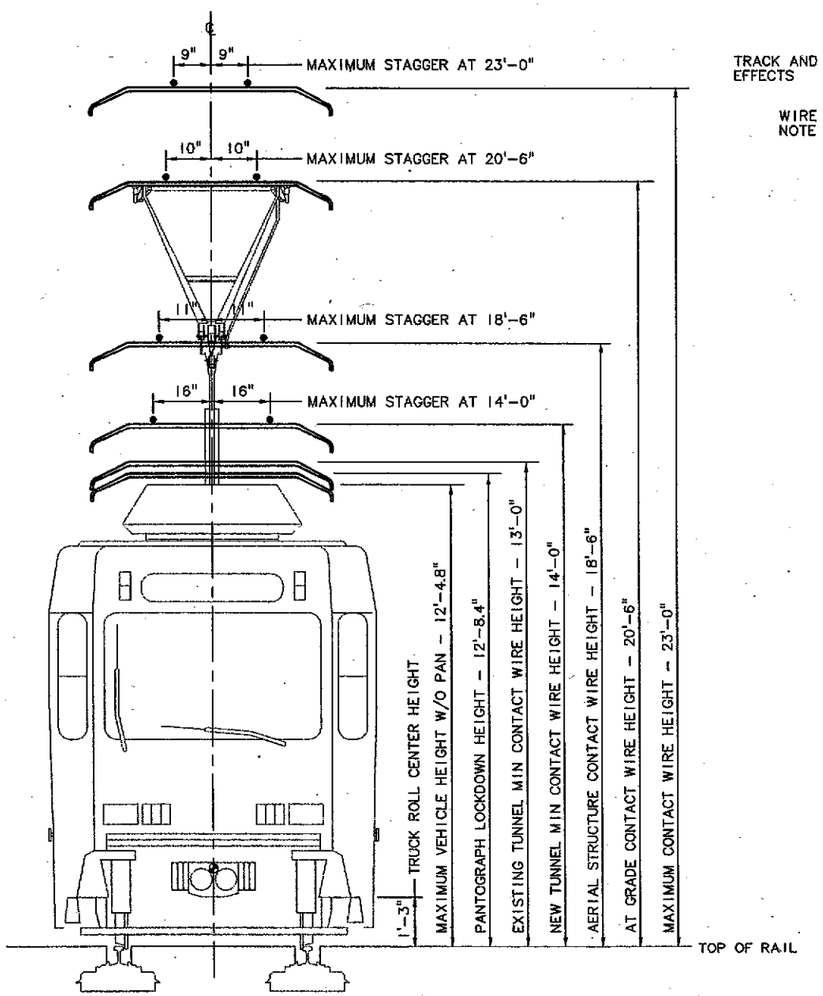
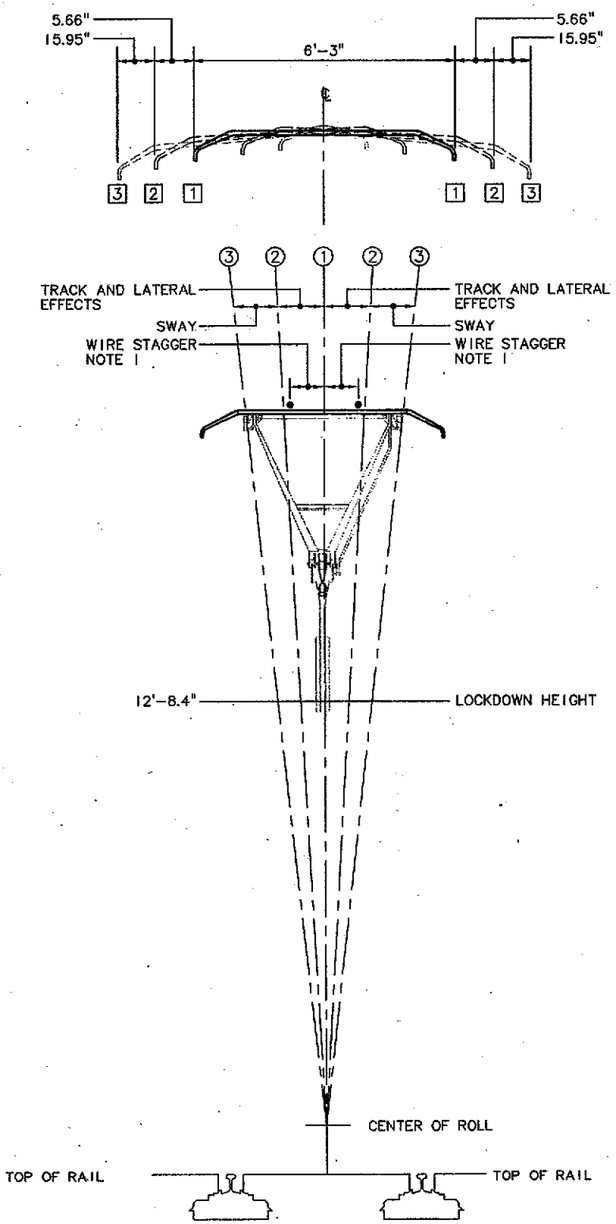


PAN HEAD PLAN



PANTOGRAPH RANGE OF MOTION–VERTICAL



PANTOGRAPH RANGE OF MOTION–HORIZONTAL

NOTES:

1. CONTACT WIRE DISPLACEMENT IS DUE TO WIRE STAGGER AT THE POLE OR IS DUE TO WIRE OFFSET PLUS WIRE BLOW-OFF AT MIDSPAN.
2. ALL WIRING IS AUTO-TENSIONED EXCEPT FOR FIXED TERMINATED WIRING IN THE YARD AND TUNNELS.

RANGE OF MOTION

WIDTH OF PANTOGRAPH = 6'-3" [1] TO [1]

TRACK ALLOWANCES:

ALIGNMENT	= 0.50"
CROSS LEVEL @0.50	= 2.44"
TOTAL TRACK TOLERANCE EFFECTS	= 2.94"
VEHICLE LATERAL MOTION	= 2.72"
TOTAL TRACK & LATERAL EFFECTS (EACH SIDE OF CENTERLINE)	= 5.66 INCHES [1] TO [2]

FULL SWAY OF VEHICLE = 3° EACH SIDE OF ℄

FULL SWAY AT 23'-0"	= 14.45"
SWAY OF PANTOGRAPH	= 1.50"
TOTAL SWAY	= 15.95 INCHES [2] TO [3]

PANTOGRAPH SECURITY AT POLE

HALF PANTOGRAPH WIDTH	= 37.5"
VEHICLE + PANTOGRAPH SWAY	= 15.95"
TRACK ALLOWANCES:	
ALIGNMENT	= 0.50"
CROSS LEVEL	= 2.44"
STAGGER CHANGE–ALONG TRACK MOVEMENT	= 2"
ERECTION TOLERANCE	= 1"
PANTOGRAPH SECURITY ALLOWANCE	= 6"
* MAX STAGGER AT 23'-0"	= 9.61"

PANTOGRAPH SECURITY AT MIDSPAN

PANTOGRAPH SECURITY AT 23'-0":	
HALF PANTOGRAPH WIDTH	= 37.5"
TRACK ALLOWANCES:	
ALIGNMENT	= 0.50"
CROSS LEVEL	= 2.44"
⊗ VEHICLE + PANTOGRAPH SWAY INTO WIND	= 8.48"
BLOW OFF OF CONTACT WIRE (200 FT)	= 8"
POLE DEFLECTION DUE TO WIND	= 2"
STAGGER CHANGE–ALONG TRACK MOVEMENT	= 2"
STAGGER EFFECT ALLOWANCE	= 2"
ERECTION TOLERANCE	= 1"
PANTOGRAPH SECURITY ALLOWANCE	= 6"
* MIDSPAN OFFSET	= 0.83"
TOTAL ALLOWANCES	= 33.25"

PANTOGRAPH PARAMETERS

DESCRIPTION	IN	FT
OVERALL WIDTH OVER HORNS	75.00	6.25
CARBON WIDTH	47.00	3.92
PANTOGRAPH SWAY AT ALL HEIGHTS (SIDE TO SIDE)	3.00	0.25
PANTOGRAPH UPLIFT ALLOWANCE	3.00	0.25
PANTOGRAPH SECURITY ALLOWANCE	6.00	0.50
MAXIMUM PANTOGRAPH OPERATING HEIGHT	–	23.00
MINIMUM PANTOGRAPH OPERATING HEIGHT	–	13.5

OVERHEAD CONTACT SYSTEM PARAMETERS

DESCRIPTION	IN	FT
MAXIMUM CATENARY SPAN	–	200
OPERATING WIND SPEED WITHOUT ICE	55 MPH	
OPERATING WIND SPEED WITH 1/2" RADIAL ICE	40 MPH	
MAXIMUM POLE DEFLECTION AT CONTACT WIRE HEIGHT DUE TO WIND	2.00	0.17
STATIC POLE DEFLECTION AT ANY HEIGHT	2.3% OF HEIGHT	
STAGGER CHANGE DUE TO ALONG TRACK MOVEMENT	2.00	0.17

TRACK PARAMETERS

DESCRIPTION	IN	FT
GAGE	56.50	4.72
GAGE TOLERANCE (INCLUDED IN LATERAL MOTION)	–	–
TRACK TYPE – PRIMARY TRACK	DIRECT FIXATION	
HORIZONTAL ALIGNMENT TOLERANCE	0.50	0.04
CROSS LEVEL TOLERANCE	0.50	0.04
SUPERELEVATION – MAXIMUM	6.00	0.50

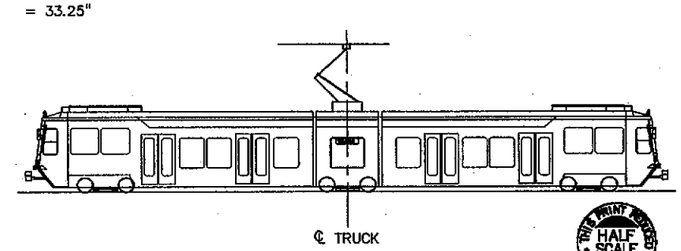
VEHICLE PARAMETERS

DESCRIPTION	IN	FT
TRUCK ROLL CENTER HEIGHT	15.00	1.25
LATERAL MOTION AT TRUCK ROLL CENTER	2.72	0.23
MAXIMUM VEHICLE ROLL ANGLE BY DEGREES	3 DEGREES (BROKEN SPRING)	
MAXIMUM DISTANCE OF PANTOGRAPH SHOE TO CENTERLINE TRUCK	46.00	3.83
MAXIMUM HEIGHT OF VEHICLE EQUIPMENT (EXCEPT PANTOGRAPH)	–	12.40
PANTOGRAPH LOCKDOWN HEIGHT	–	12.70

LEGEND:

⊗ AREA RECOMMENDED: 50% OF FULL SWAY INTO WIND

* BY DIFFERENCE



VEHICLE CRITERIA

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City of Seattle
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Inspector's Book:
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SDOT:

Designed By: L. EDWARDS
Drawn By: B. PORTER
Checked By: A. GILLESPIE
Approved By: E. ROWE

STATE OF WASHINGTON DAVID O. WINTERS 12814 REGISTERED PROFESSIONAL ENGINEER
EXPIRES 08/09/06

LTK Engineering Services
Submitted: D. PORTER Date: 09/22/04

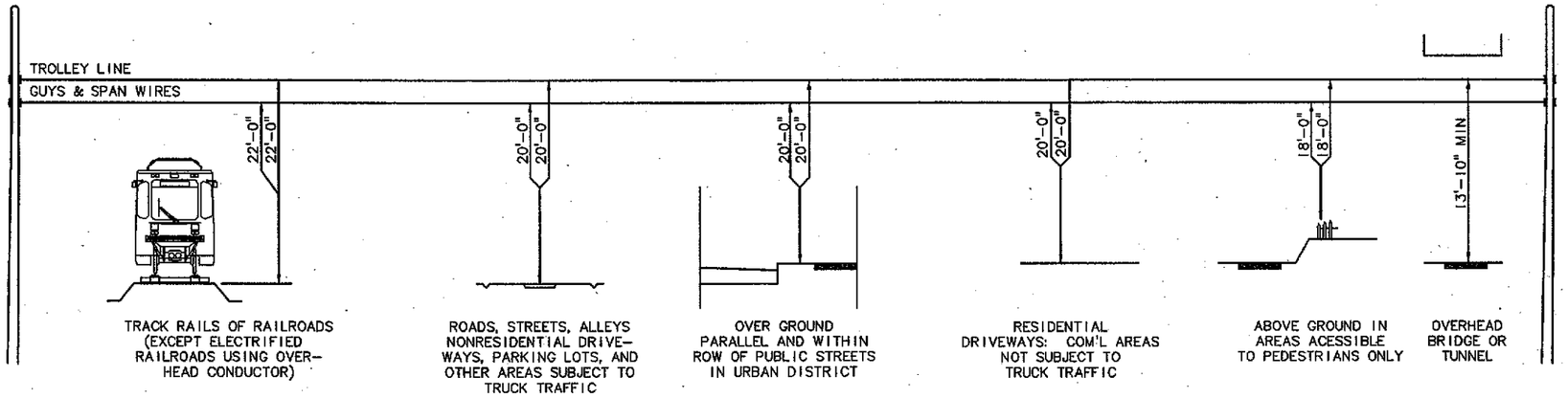
SOUNDTRANSIT
Approved: R. PARSONS Date: 09/22/04

Scale: NTS
Filename: C87_L00_J717.dwg
Contract No.: C 807
Date: 06/10/04

LINK LIGHT RAIL PROJECT
OVERHEAD CONTACT SYSTEM

TECHNICAL SHEETS
6'-3" WIDE PANTOGRAPH
SECURITY AND OPERATIONS INFORMATION

Drawing No.: L00-J717
Vault Plan No. 231-807
Sheet No.: 416
Rev.: 0



NOTES:

1. BASIC CLEARANCES (CATENARY WIRES). THE CLEARANCES APPLY UNDER THE FOLLOWING CONDITIONS:

   A. CONDUCTOR TEMPERATURE OF 60°F, NO WIND, WITH FINAL UNLOADED SAG IN THE WIRE.

   B. SPAN LENGTHS NOT GREATER THAN THE FOLLOWING:

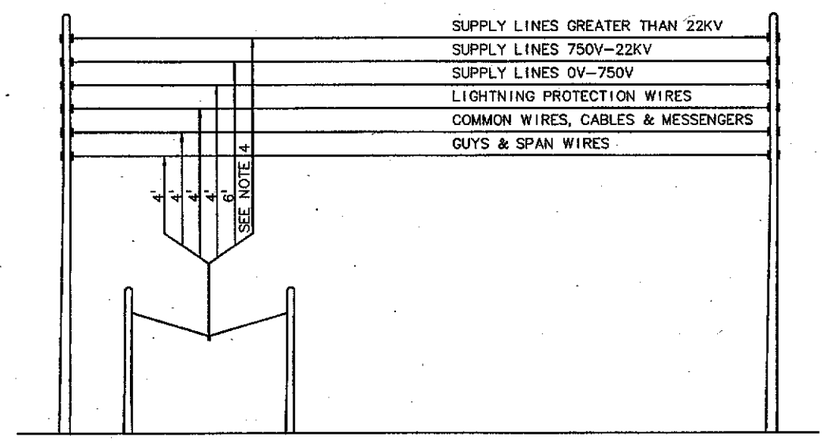
   SINGLE CONTACT LINE – 100 FT
   SIMPLE CATENARY – 200 FT

2. ALL CLEARANCES ARE MINIMUM.
3. MAXIMUM CONTACT WIRE SLOPE AS A FUNCTION OF VEHICLE SPEED TO BE DETERMINED.
4. FOR VOLTAGES EXCEEDING 22KV (UP TO 470KV) THE CLEARANCE SHALL BE INCREASED BY 0.4 INCHES FOR EACH 1KV, OR FRACTION THEREOF, IN EXCESS OF 22KV.
5. BASIC CLEARANCES (SUPPLY CONDUCTORS) THE CLEARANCES APPLY UNDER THE FOLLOWING CONDITIONS:

   A. CONDUCTOR SAG AT 120°F OR

   B. MAXIMUM CONDUCTOR TEMPERATURE IS GREATER THAN 120°F OR

   C. 32°F WITH RADIAL ICE OF 0.25 INCHES.



TROLLEY CONTACT CONDUCTOR

No.	Date	Dsn.	Chk.	App.	Revisions
0	09/22/04				ISSUED FOR CONSTRUCTION

City of Seattle

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	Received:
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SDOT:	

Designed By: D. WINTER
Drawn By: J. SMITH
Checked By: A. GILLESPIE
Approved By: E. ROWE

DAVID O. WINTER, STATE OF WASHINGTON, 23844, REGISTERED PROFESSIONAL ENGINEER, EXPIRES 06/09/06

LTK Engineering Services
Submitted: D. PORTER Date: 09/22/04

SOUNDTRANSIT
Approved: R. PARSONS Date: 09/22/04

Scale: NTS
Filename: C87_L00_J718.DWG
Contract No.: C 807
Date: 06/10/04

LINK LIGHT RAIL PROJECT
OVERHEAD CONTACT SYSTEM

TECHNICAL SHEETS
CLEARANCE FROM OVERHEAD CONDUCTORS
SHEET 1 OF 2

Drawing No.: L00–J718
Vault Plan No.: 231–807
Sheet No.: 417 Rev.: 0

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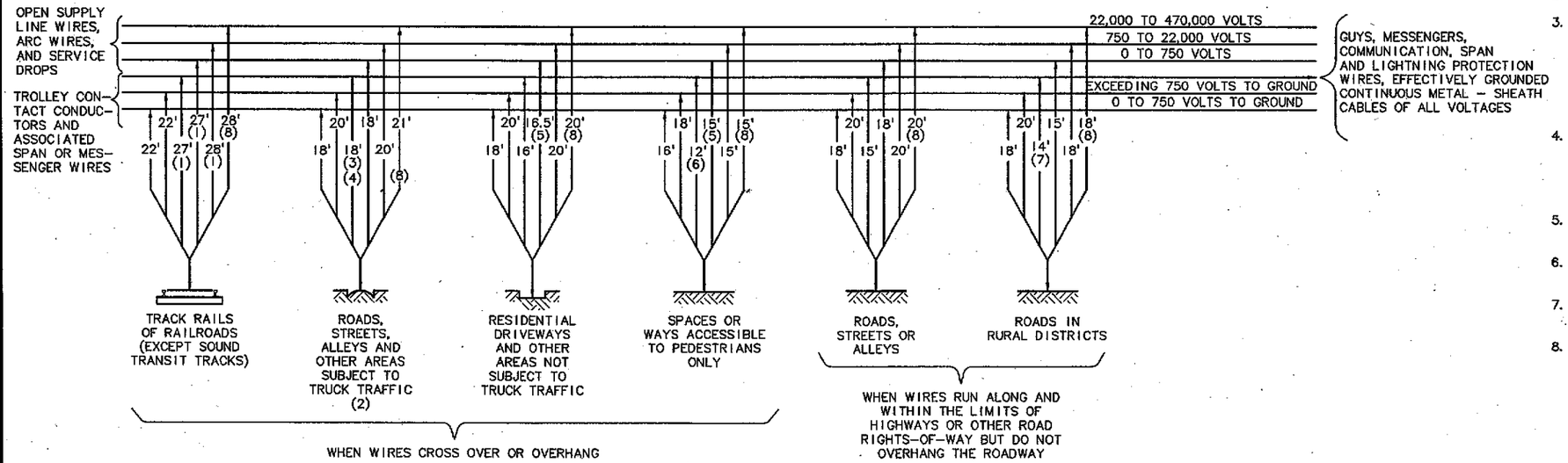
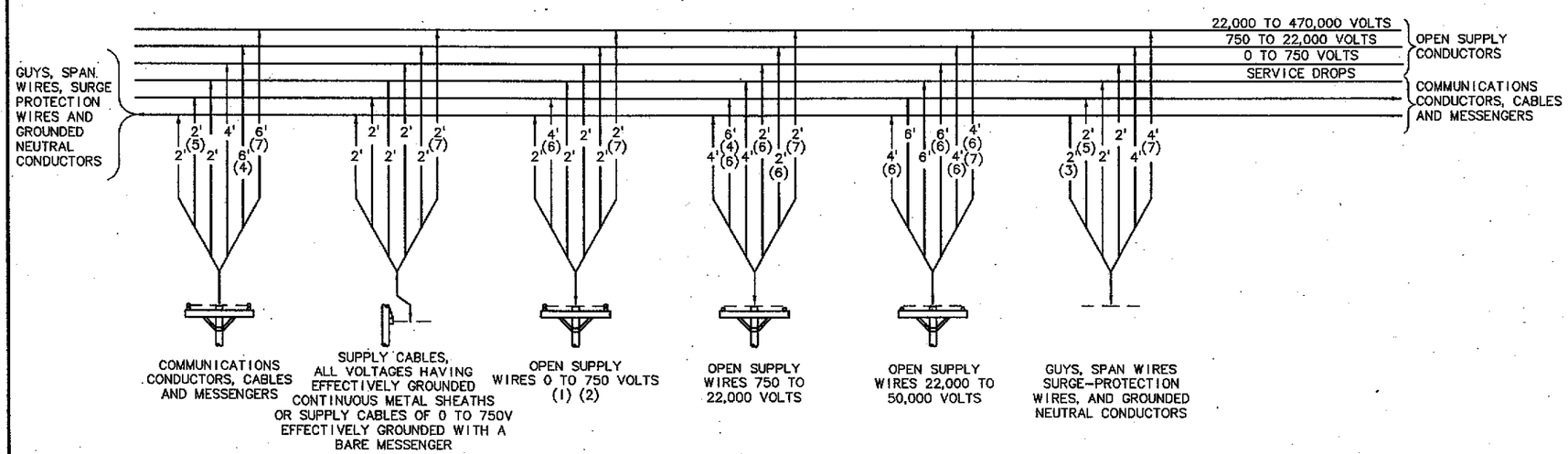


WIRE CLEARANCES ABOVE GROUND OR RAILS

NOTES:

1. THESE CLEARANCES MAY BE REDUCED TO 25 FT WHERE PARALLELED BY TROLLEY-CONTACT CONDUCTOR ON THE SAME STREET OR HIGHWAY.
2. THESE CLEARANCES DO NOT ALLOW FOR FUTURE ROAD RESURFACING.
3. IF A COMMUNICATION SERVICE DROP OR A GUY WHICH IS EFFECTIVELY GROUNDED CROSSES RESIDENTIAL STREETS AND ROADS, THE CLEARANCE MAY BE REDUCED TO 16 FT AT THE SIDE OF THE TRAVELED WAY PROVIDED THE CLEARANCE AT THE CENTER OF THE TRAVELED WAY IS AT LEAST 18 FT. THIS REDUCTION IN CLEARANCE DOES NOT APPLY TO ARTERIAL STREETS AND HIGHWAYS WHICH ARE PRIMARILY FOR THROUGH TRAFFIC, USUALLY ON A CONTINUOUS ROUTE.
4. FOR COMMUNICATIONS CABLES SUPPORTED ON A MESSENGER, AND WITH SPAN LENGTHS NOT EXCEEDING 150 FT, THE CLEARANCE MAY BE REDUCED TO 17'-0" ABOVE OR ALONG LOCAL STREETS OR ROADS. THIS REDUCTION DOES NOT APPLY TO ARTERIAL STREETS OR HIGHWAYS WHICH ARE PRIMARILY FOR THROUGH TRAFFIC, USUALLY ON A CONTINUOUS ROUTE.
5. THIS CLEARANCE MAY BE REDUCED TO 12 FT FOR SUPPLY CONDUCTORS LIMITED TO 300V TO GROUND.
6. THIS CLEARANCE MAY BE REDUCED TO 10.5 FT FOR INSULATED SERVICE DROPS LIMITED TO 300V TO GROUND.
7. THIS CLEARANCE MAY BE REDUCED TO 13.5 FT FOR COMMUNICATION CONDUCTORS.
8. FOR VOLTAGES EXCEEDING 22,000 VOLTS, THE CLEARANCE SHALL BE INCREASED BY 0.4 INCH FOR EACH 1,000 VOLTS, OR FRACTION THEREOF IN EXCESS OF 22,000 VOLTS. FOR VOLTAGES IN EXCESS OF 470,000 VOLTS, REFER TO NATIONAL ELECTRICAL SAFETY CODE.



WIRE CROSSING CLEARANCES

NOTES:

1. FOR CLEARANCE PRUPOSES, INSULATED, NON-SHIELDED CABLES CARRYING 750 TO 2,900 VOLTS SUPPORTED ON AND CABLED TOGETHER WITH AN EFFECTIVELY GROUNDED BARE MESSENGER SHALL BE TREATED AS OPEN SUPPLY CONDUCTOR CARRYING 0 TO 750 VOLTS.
2. FOR CLEARANCE PURPOSES, CABLES OF ANY VOLTAGE OVER 750 VOLTS, COVERED WITH A CONTINUOUS AUXILIARY SEMICONDUCTING SHIELD IN COMBINATION WITH SUITABLE METALLIC DRAINAGE AND SUPPORTED ON AND CABLED TOGETHER WITH AN EFFECTIVELY GROUNDED BARE MESSENGER SHALL BE TREATED AS OPEN SUPPLY CONDUCTOR CARRYING 0 TO 750 VOLTS.
3. THIS CLEARANCE MAY BE REDUCED WHERE BOTH GUYS ARE ELECTRICALLY INTERCONNECTED.
4. THIS CLEARANCE MAY BE REDUCED TO 4 FT WHERE SUPPLY CONDUCTORS OF 750V TO 8.7KV CROSS A COMMUNICATION LINE MORE THAN 6FT HORIZONTALLY FROM A COMMUNICATION STRUCTURE.
5. THE CLEARANCE OF COMMUNICATION CONDUCTORS AND THEIR GUY, SPAN, AND MESSENGER WIRES FROM EACH OTHER IN LOCATIONS WHERE NO OTHER CLASSES OF CONDUCTORS ARE INVOLVED MAY BE REDUCED BY MUTUAL CONSENT OF THE PARTIES CONCERNED, SUBJECT TO THE APPROVAL OF THE REGULATORY BODY HAVING JURISDICTION, EXCEPT FOR FIRE ALARM CONDUCTORS AND CONDUCTORS USED IN THE OPERATION OF RAILROADS, OR WHERE ONE SET OF CONDUCTORS IS FOR PUBLIC USE AND THE OTHER IN THE OPERATION OF SUPPLY SYSTEMS.
6. IN GENERAL, THIS TYPE OF CROSSING IS NOT RECOMMENDED.
7. FOR VOLTAGES EXCEEDING 22,000V, THE CLEARANCE SHALL BE INCREASED BY 0.4 INCH FOR EACH 1,000 VOLTS OR FRACTION THEREOF, IN EXCESS OF 22,000 VOLTS. IF BOTH UPPER AND LOWER WIRES EXCEED 22,000 VOLTS CALCULATE INCREASES SEPARATELY FOR UPPER AND LOWER WIRES AND ADD BOTH TO CLEARANCE. FOR VOLTAGE ABOVE 470,000 VOLTS, SEE NESC.

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Designed By: D. WINTER
Drawn By: J. SMITH
Checked By: A. GILLESPIE
Approved By: E. ROWE

DAVID O. WINTER, STATE OF WASHINGTON, 23344, REGISTERED PROFESSIONAL ENGINEER, EXPIRES 06/09/05

LTK Engineering Services
Submitted: D. PORTER Date: 09/22/04

SOUNDTRANSIT
Approved: R. PARSONS Date: 09/22/04

Scale: NTS
Filename: C87_L00_J719.DWG
Contract No.: C 807
Date: 06/10/04

LINK LIGHT RAIL PROJECT
OVERHEAD CONTACT SYSTEM

TECHNICAL SHEETS
CLEARANCE FROM OVERHEAD CONDUCTORS
SHEET 2 OF 2

Drawing No.: L00-J719
Vault Plan No. 231-807
Sheet No.: 418
Rev.: 0

34386 VAULT SERIAL NO.

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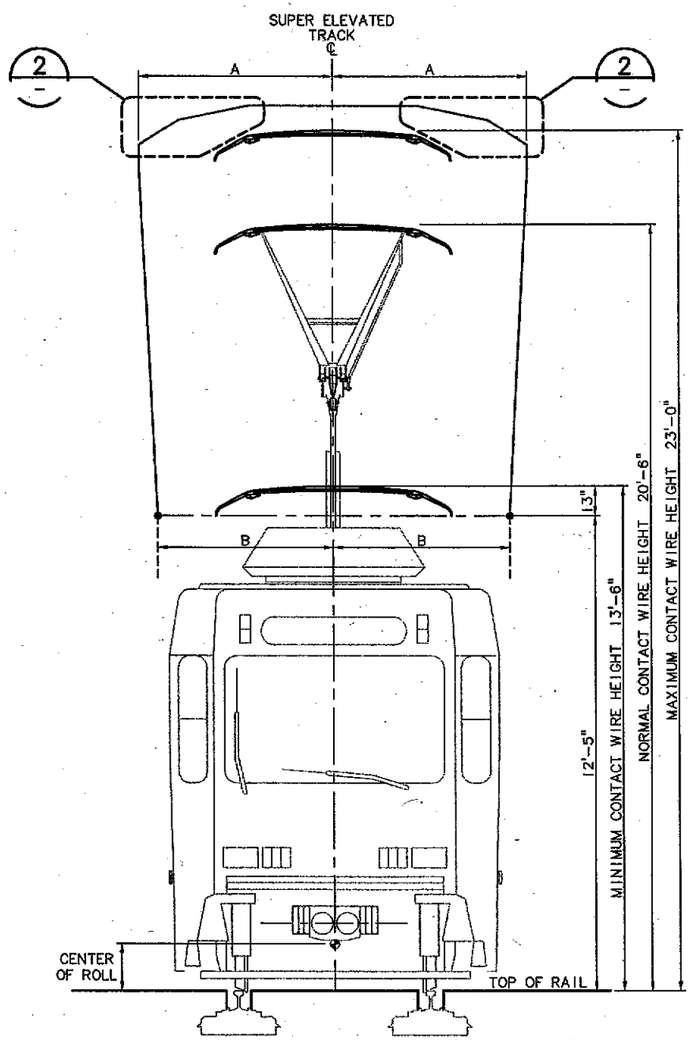
NOTES:

1. THE PANTOGRAPH CLEARANCE ENVELOPE DIMENSIONS AS SHOWN SHALL APPLY WHEN OCS, TRACK AND POLES, MASONRY WALLS AND STRUCTURES ARE BUILT. THEY ARE TO BE MEASURED RELATIVE TO THE SUPERELEVATED TRACK.
2. FOR VALUES OF CONTACT WIRE HEIGHT BETWEEN THOSE LISTED IN TABLE 1, USE LINEAR INTERPOLATION TO DETERMINE A VALUE FOR DIMENSION A.
3. MINIMUM CLEARANCES FOR USE PRIOR TO CONSTRUCTION ARE TO BE CALCULATED USING ALLOWANCES SHOWN ON DRAWING L00-J721.



PANTOGRAPH CLEARANCE ENVELOPE (1 / L00-J720)

SCALE: NTS SEE NOTE 1

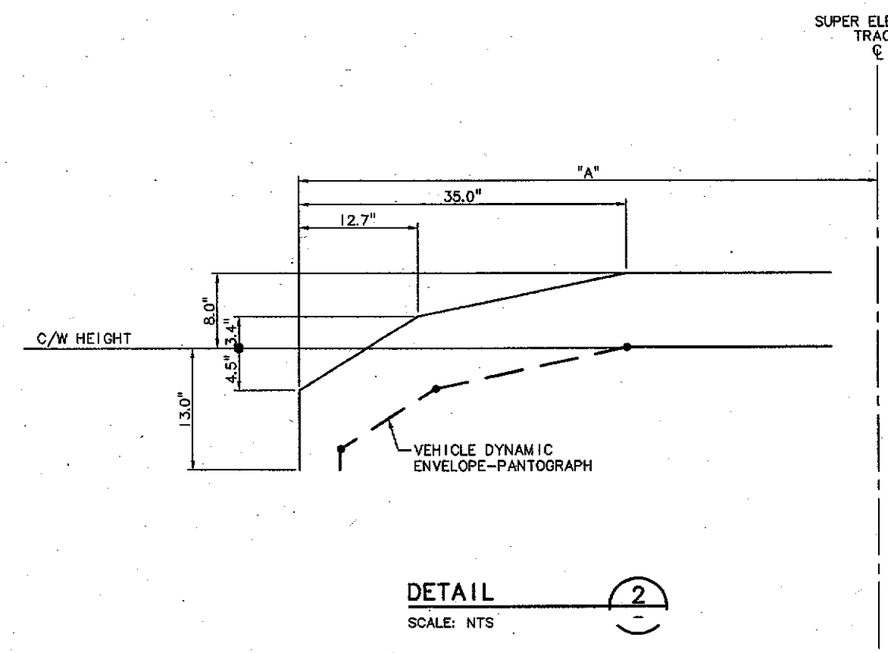
TRACK PARAMETERS		
DESCRIPTION	IN	FT
GAUGE	56.50	4.71
GAUGE TOLERANCE (INCLUDED IN LATERAL MOTION)	–	–
TRACK TYPE	DIRECT FIXATION	
HORIZONTAL ALIGNMENT TOLERANCE	0.50	0.04
TRACK TYPE	BALLASTED	
HORIZONTAL ALIGNMENT TOLERANCE	2.50	0.21
CROSS LEVEL TOLERANCE	1.00	0.08
SUPERELEVATION – MAXIMUM	6.00	0.50

PANTOGRAPH PARAMETERS		
DESCRIPTION	IN	FT
OVERALL WIDTH OVER HORNS	75.00	6.25
WIDTH OVER CARBON COLLECTORS	47.00	3.92
LATERAL ELECTRICAL CLEARANCE TO DYNAMIC PANTOGRAPH	4.00	0.33
PANTOGRAPH SWAY AT ALL HEIGHTS (SIDE TO SIDE)	2.99	0.25
PANTOGRAPH UPLIFT ALLOWANCE (MECHANICAL PLUS ELECTRICAL)	7.00	0.58
MAXIMUM OPERATING HEIGHT	–	23.00
NORMAL CONTACT WIRE HEIGHT AT SUPPORTS – STREET	–	20.50
NORMAL CONTACT WIRE HEIGHT AT SUPPORTS – AERIAL STRUCTURE	–	18.50
MAXIMUM STATIC PANTOGRAPH PRESSURE	25 LB	
PANTOGRAPH LOCKDOWN HEIGHT	–	12.70
MAXIMUM PANTOGRAPH CARBON WEAR	1.00	0.08
MAXIMUM PANTOGRAPH REACH		

VEHICLE PARAMETERS		
DESCRIPTION	IN	FT
TRUCK ROLL CENTER HEIGHT	15.00	1.25
LATERAL POSITION AT TRUCK ROLL CENTER	2.72	0.23
MAXIMUM VEHICLE ROLL ANGLE BY DEGREES EACH SIDE OF CENTERLINE	3 DEGREES	

OVERHEAD CONTACT SYSTEM PARAMETERS		
DESCRIPTION	IN	FT
ELECTRICAL CLEARANCE TO GROUNDED STRUCTURES	4.00	0.33

TABLE 1: DIMENSIONS TABLE		
	DIMENSION A	
CONTACT WIRE HEIGHT	DIRECT FIXATION	BALLASTED
23'-0"	61.9"	63.9"
20'-6"	59.0"	61.0"
18'-6"	58.2"	60.2"
	DIMENSION B	
ALL HEIGHTS	56.0"	58.0"



DETAIL (2)

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VAULT SERIAL NO. 34386

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SDOT:

Designed By: R. BENNELL
Drawn By: B. PORTER
Checked By: A. GILLESPIE
Approved By: E. ROWE

STATE OF WASHINGTON DAVID O. WINTER 2544 REGISTERED PROFESSIONAL ENGINEER
EXPIRES 06/09/05

LTK Engineering Services
Submitted: D. PORTER Date: 09/22/04

SOUNDTRANSIT
Approved: R. PARSONS Date: 09/22/04

Scale: NTS
Filename: C87_L00_J720.dwg
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LINK LIGHT RAIL PROJECT
OVERHEAD CONTACT SYSTEM

TECHNICAL SHEETS
6'-3" PANTOGRAPH CLEARANCE ENVELOPE

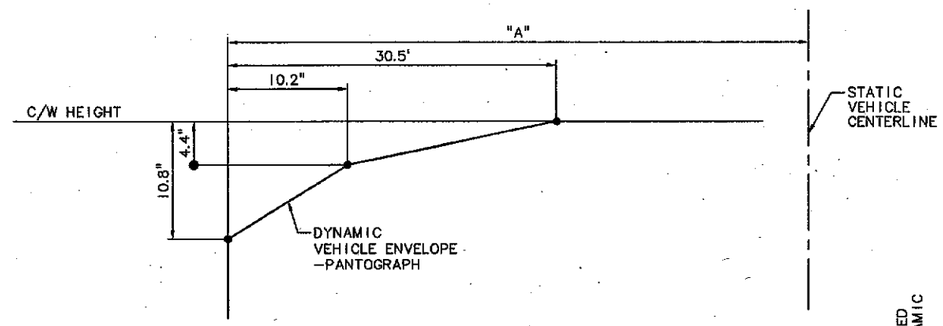
Drawing No.: L00-J720
Vault Plan No. 231-807
Sheet No.: 419 Rev.: 0

TABLE 1: HORIZONTAL OFFSET DUE TO TRACK SUPERELEVATION (OS)						
C/W HEIGHT ABOVE RAIL	SUPERELEVATION (INCHES)					
	1	2	3	4	5	6
23'-8"	5.0	10.1	15.1	20.1	25.1	30.2
21'-2"	4.5	9.0	13.5	18.0	22.5	27.0
19'-2"	4.1	8.1	12.2	16.3	20.4	24.4
14'-2"	3.0	6.0	9.0	12.0	15.0	18.1

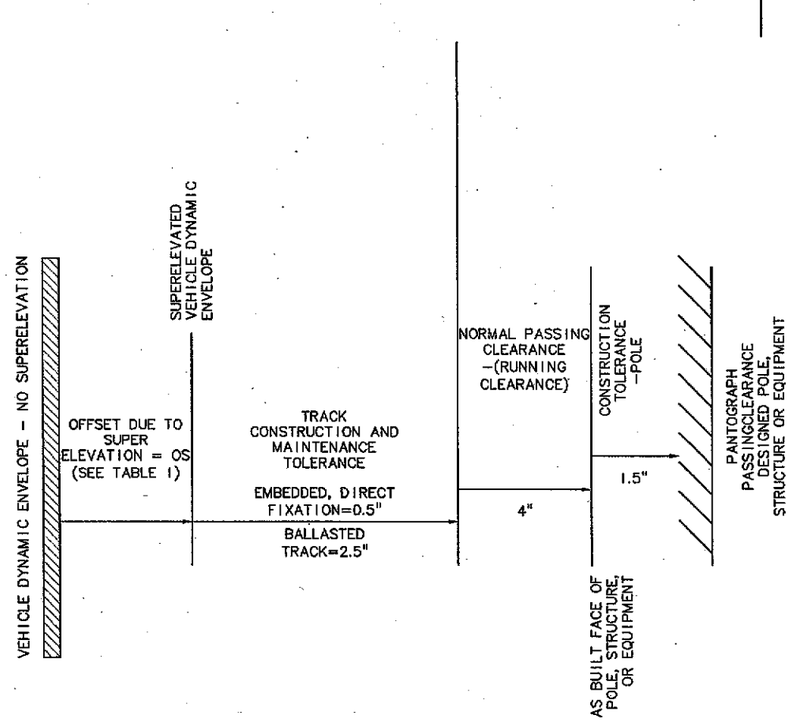
TABLE 2: VEHICLE DIMENSIONS	
C/W HT	DIMENSION A
23'-0"	57.4"
20'-6"	54.5"
18'-6"	53.7"
13'-6"	51.5"

NOTES:

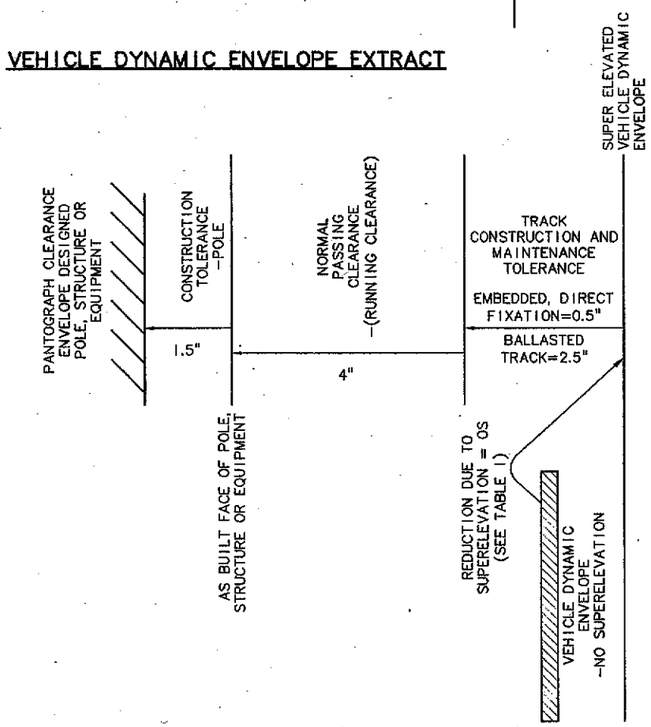
1. THIS DRAWING PROVIDES RELATIONSHIPS AND DIMENSIONS FOR DETERMINATION OF MINIMUM CLEARANCES BETWEEN A PANTOGRAPH AND ADJACENT FIXED INFRASTRUCTURE. THESE CLEARANCES MAY BE FURTHER REDUCED ONLY FOR THOSE CASES LISTED IN NOTE 2.
2. FOR THE PURPOSE OF DETERMINATION OF CLEARANCES TO A PANTOGRAPH, AN OCS FITTING SHALL BE CONSIDERED LIVE WHERE IT IS SEPARATED FROM GROUNDED POLES OR LIVE WIRING OF ADJACENT TRACKS, BY AT LEAST ONE LEVEL OF SYSTEM RATED INSULATION.
   - FOR IN-RUNNING LIVE STEADY ARMS, SEE DRAWING L00-J722
   - FOR OTHER LIVE OCS EQUIPMENT, SEE DRAWING L00-J723
   - ALL OTHER STRUCTURES, POLES OR EQUIPMENT REQUIRE PANTOGRAPH CLEARANCES DETERMINED FROM THE DRAWING
3. FOR OBJECTS DIAGONALLY SEPARATED, BOTH HORIZONTAL AND VERTICAL CLEARANCES ARE TO BE APPLIED. RUNNING CLEARANCES COMPONENTS MAY BE MEASURE RADIALLY.
4. MINIMUM CLEARANCES BETWEEN LIVE WIRES OR FITTINGS AND OTHER FIXED INFRASTRUCTURE SHALL BE DETERMINED FROM NATIONAL ELECTRIC SAFETY CODE (N.E.S.C.) AND DRAWINGS L00-J718 AND L00-J719.



VEHICLE DYNAMIC ENVELOPE EXTRACT



HORIZONTAL CLEARANCE TO A PANTOGRAPH FROM OBJECTS ON THE INSIDE OF CURVE
NTS



HORIZONTAL CLEARANCE TO A PANTOGRAPH FROM OBJECTS ON THE OUTSIDE OF CURVE
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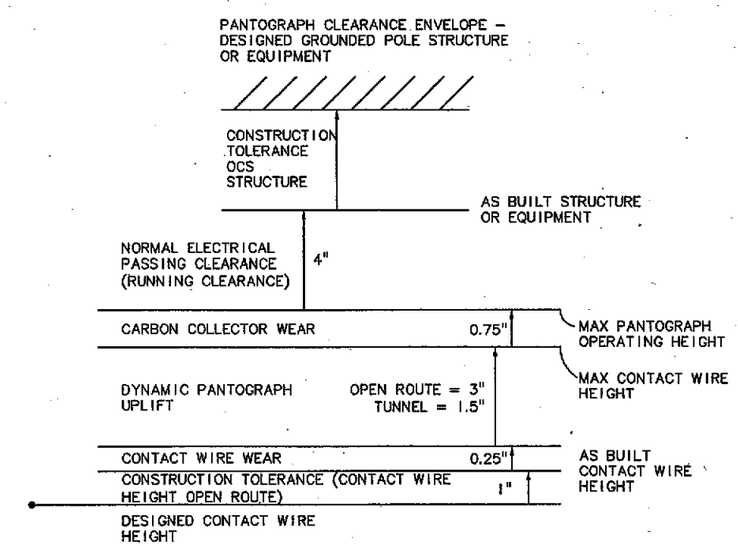

VERTICAL CLEARANCE TO A PANTOGRAPH

THIS PRINT REPRODUCED HALF SCALE

No.	Date	Dsn.	Chk.	App.	Revisions
0	09/22/04				ISSUED FOR CONSTRUCTION

City of Seattle
Work Order No.
Permit No. Y6375
Approved:
Inspector's Book:
Received:
Revised As Built:
SDOT:

Designed By: L. EDWARDS
Drawn By: J. MCCARL
Checked By: A. GILLESPIE
Approved By: E. ROWE

DAVID C. WINTER, STATE OF WASHINGTON, 22044, REGISTERED PROFESSIONAL ENGINEER, 09/09/04
EXPIRES 06/09/05

LTK Engineering Services
Submitted: D. PORTER Date: 09/22/04

SOUNDTRANSIT
Approved: R. PARSONS Date: 09/22/04

Scale: NTS
Filename: C87_L00_J721.dwg
Contract No.: C 807
Date: 08/10/04

LINK LIGHT RAIL PROJECT
OVERHEAD CONTACT SYSTEM
TECHNICAL SHEETS
PANTOGRAPH CLEARANCE DETAILS

Drawing No.: L00-J721
Vault Plan No. 231-807
Sheet No.: 420
Rev.: 0

VAULT SERIAL NO. 34386

C:\work\C87_L00_J721.dwg
08/20/04 13:28 : porterb OEW2088