

C-15-1



PROPOSED
TORSIONAL AND LATERAL CRITICAL SPEED ANALYSIS

ENGINE NUMBERS 74010/12
DELAVAL-ENTERPRISE ENGINE MODEL DSR-48
3500 KW/4889 BHP AT 450 RPM

FOR
STONE & WEBSTER ENGINEERING CORP.
LONG ISLAND LIGHTING COMPANY

TRANSAMERICA DELAVAL ENGINE & COMPRESSOR DIVISION
550 - 85th AVENUE
OAKLAND, CALIFORNIA 94621

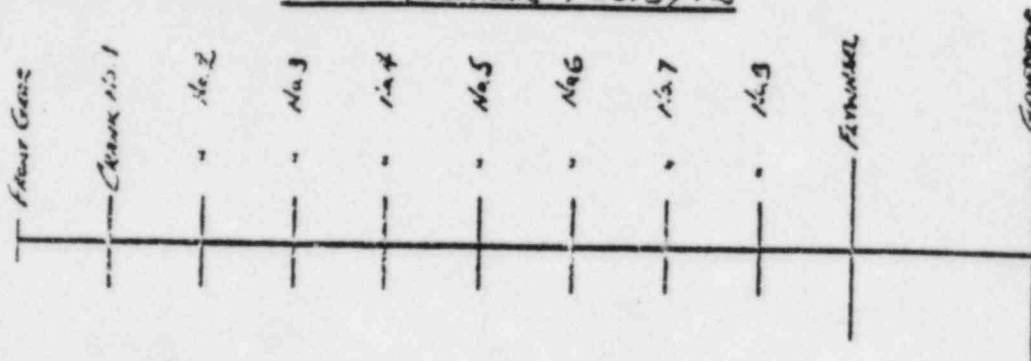
By: ROLAND YANG

AUGUST 22, 1983

AC1577

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PDR ADOCK 05000322
Q PDR

LONG ISLAND LIGHTING COMPANY
DE LAVAL ENTERPRISE DSR 4-B
3500 KW (4887 BHP) @ 450 RPM
225.6 BMEP
ENGINE NUMBER 74010/12



MASS ELASTIC DATA.

CRANKSHAFT GEAR	26.52
WATER PUMP DRIVE	63.10
CON & PUL	119.70
SHAFT	9.63
	<u>218.95 LB. FT.</u>

I = 6.805 LB. FT. SEC.

CRANK NO. 1

CRANK	1541.85
SHAFT	41.81
	<u>1583.66 LB. FT.</u>

I = 49.222

CRANK NO. 2-7

JOURNAL	43.13
PIN	202.17
2 WBS. NO CRW	679.81
ROD WT.	309.99
TOTAT. WT.	306.75
	<u>1541.85 LB. FT.</u>

I = 47.922

CRANK NO. 8

CRANK	1541.85
SHAFT	71.63
	<u>1613.48 LB. FT.</u>

I = 50.149

CRANKSHAFT FLANGE	255.08
FLYWHEEL 73064	34764.
GENERATOR SHAFT FLANGE	374.00
	<u>35393.08 LB. FT.</u>

I = 1100.052

GENERATOR ROTOR	65275 LB. FT.
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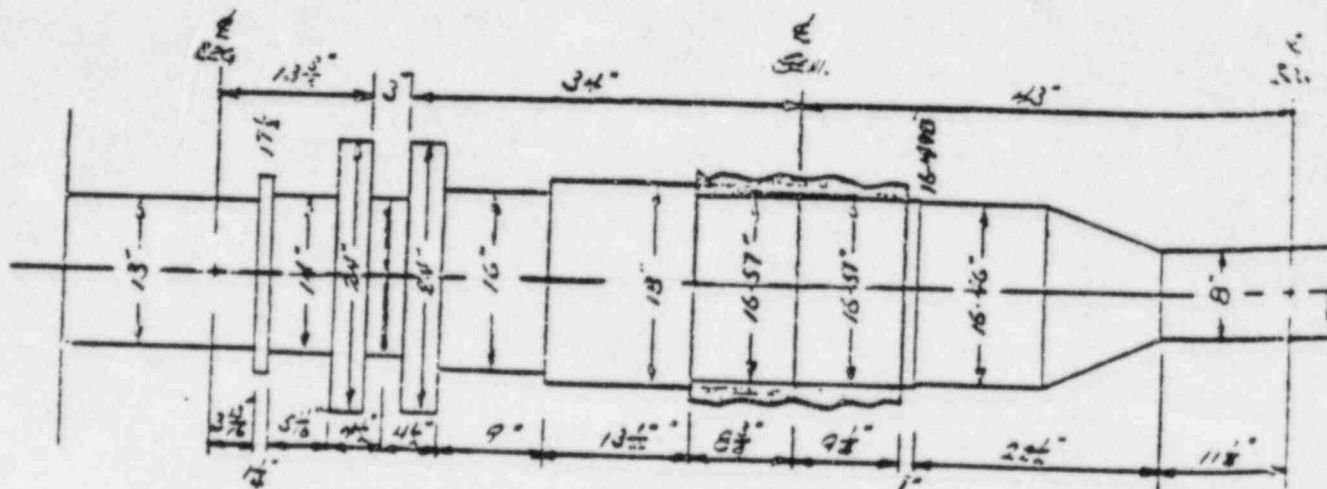
I = 2650.432

TOTAL WK. 133335 LB. FT.

AC-1571

EQUIVALENT LENGTH 2nd

FRONT GEAR TO CYLINDER NO. 1	.001661"	$K = 58.121 \times 10^6$	ST. 2
BETWEEN CYLINDERS	.0011394"	$K = 84.727 \times 10^6$	ST. 2
CYLINDER NO. 8 TO FLYWHEEL	.0012547"	$K = 76.941 \times 10^6$	ST. 2
FLYWHEEL TO GENERATOR			



$$L_e = \frac{3 - 0.515 \times 16.25}{22} + \frac{0.55 \times 16 + 7 + 0.3 \times 16}{15} + \frac{0.73 \times 16 + 12.85 + 0.21 \times 16.52}{18} + \frac{0.21 \times 16.52}{16.52}$$

$$= 1.0000122 + 0.001530 + 0.001163 + 0.000593 = 0.003408"$$

$$K = 276.773 \times 10^6$$

SHAFTING DIAMETERS

FRONT GEAR TO CYLINDER NO. 1	3 in.
BETWEEN CYLINDERS	12 in.
CYLINDER NO. 8 TO FLYWHEEL	12 in.
FLYWHEEL TO GENERATOR	16 in.

FLYWHEEL WEIGHT = 6935 LB.

GENERATOR ROTOR WEIGHT = 17150 LB.

PERMANENT NATURAL FREQUENCIES

FIRST MODE	2323	VRM
SECOND MODE	5576	VRM
THIRD MODE	7000	VRM

GENERATOR SHAFT LATERAL NATURAL FREQUENCY.

3191 VRM.

$$N = \frac{3500}{11260 \times 60}$$

AC4575

MODE 1
 OMEGA SQUARED IN (RADIAN/SECOND)² = .05918702
 NATURAL FREQUENCY IN V.P.M. = 2323.19

NO.	INERTIA	THETA	IQM2T	SIGMA M	SHAFT K	DTHETA
1	6.8	1.00000	.403	.403	58.1	.00693
2	49.2	.99307	2.893	3.296	84.7	.03890
3	47.9	.95417	2.706	6.002	84.7	.07084
4	47.9	.88333	2.505	8.508	84.7	.10041
5	47.9	.78291	2.221	10.728	84.7	.12652
6	47.9	.65529	1.861	12.590	84.7	.14859
7	47.9	.50770	1.440	14.030	84.7	.16559
8	47.9	.34211	.970	15.000	84.7	.17704
9	50.1	.16507	.440	15.400	76.9	.20132
10	1100.1	-.03625	-2.360	13.130	276.8	.04744
11	2550.4	-.08369	-13.123	.001		

MODE 1
 OMEGA SQUARED .0532
 NATURAL FREQUENCY 2323.1900
 SIGMA 1*THETA**2 2325.7810
 SIGMA 1*THETA**2 2707.4396

T INT 9561.73
 T EXT 3419.27
 STRESSED DIAMETER OF EXTERNAL SHAFT 16.00
 EQUILIBRIUM AMPLITUDE .000652131052
 F IN 7487.33
 F INT 8.15
 F EXT 2.91
 F S 17744623.
 F D 0.
 F CR 0.
 F CS 0.
 F D 0.

ORDER	ARM	TN	VEC	TSTINT	TSTEXT	PHI	TMAXI	TMAXE
.5	4646	155.86	.701	889.8	318.2	.738	7053.	2522.
1.0	2323	94.58	.146	112.7	40.3	.159	1513.	541.
1.5	1548	129.52	1.394	1471.3	526.1	1.454	13904.	4972.
2.0	1161	41.05	.376	125.7	45.0	.670	6400.	2292.
2.5	929	71.71	1.394	814.6	291.3	1.050	10036.	3589.
3.0	774	16.16	.146	19.3	6.9	.044	423.	151.
3.5	663	42.79	.701	244.3	87.4	.376	3596.	1286.
4.0	580	27.66	5.265	1191.1	425.9	2.066	19750.	7063.
4.5	516	23.75	.701	135.7	48.5	.216	2063.	738.
5.0	464	17.37	.146	20.7	7.4	.061	587.	210.
5.5	422	12.84	1.394	145.8	52.2	.433	4138.	1480.
6.0	387	5.68	.376	17.4	6.2	.052	494.	176.
6.5	357	4.49	1.394	51.0	18.2	.151	1447.	517.
7.0	331	3.69	.146	4.4	1.6	.013	125.	45.
7.5	309	2.05	.701	17.4	6.2	.052	494.	176.
8.0	290	2.02	5.285	108.4	38.8	.322	3076.	1100.
8.5	273	2.26	.701	12.9	4.5	.038	366.	131.
9.0	258	1.97	.146	2.3	.8	.007	67.	24.
9.5	244	1.53	1.394	17.2	5.2	.051	492.	176.
10.0	232	1.27	.376	3.9	1.4	.012	110.	39.
10.5	221	1.14	1.394	13.0	4.6	.038	368.	122.
11.0	211	1.00	.146	1.0	.4	.001	12.	12.

MODE 2
 OMEGA SQUARED IN (RADIAN/SECOND)**2 = .34090021
 NATURAL FREQUENCY IN V.P.M. = 5575.52

NO.	INERTIA	THETA	IQM2T	SIGMA M	SHAFT K	DTHETA
1	6.8	1.30000	2.320	2.320	58.1	.03391
2	43.2	.96009	16.110	16.430	84.7	.21732
3	47.9	.74257	12.131	30.561	84.7	.36070
4	47.9	.35187	6.208	36.799	84.7	.43433
5	47.9	-.05246	-.857	35.342	84.7	.42421
6	47.9	-.47657	-7.787	29.155	84.7	.33200
7	47.9	-.80898	-13.215	14.939	34.7	.17632
8	47.9	-.98530	-16.096	-1.137	84.7	-.01366
9	50.1	-.97164	-16.011	-1.768	76.9	-.23093
10	1100.1	-.74070	-277.770	-295.533	276.8	-1.06790
11	2650.4	.32710	293.542	.004		

MODE 2
 OMEGA SQUARED .3409
 NATURAL FREQUENCY 5575.5200
 SIGMA 1+THETA**2 2578.9555
 SIGMA 1+THETA**2 13306.1514
 T INT 32715.43
 T EXT 76363.02
 STRESSED DIAMETER OF EXTERNAL SHAFT 16.00
 EQUILIBRIUM AMPLITUDE .000030103703
 F IN 7487.33
 F INT .68
 F EXT 2.32
 F SF 110479321.
 F O 0.
 F CR 0.
 F CS 0.
 F D 0.

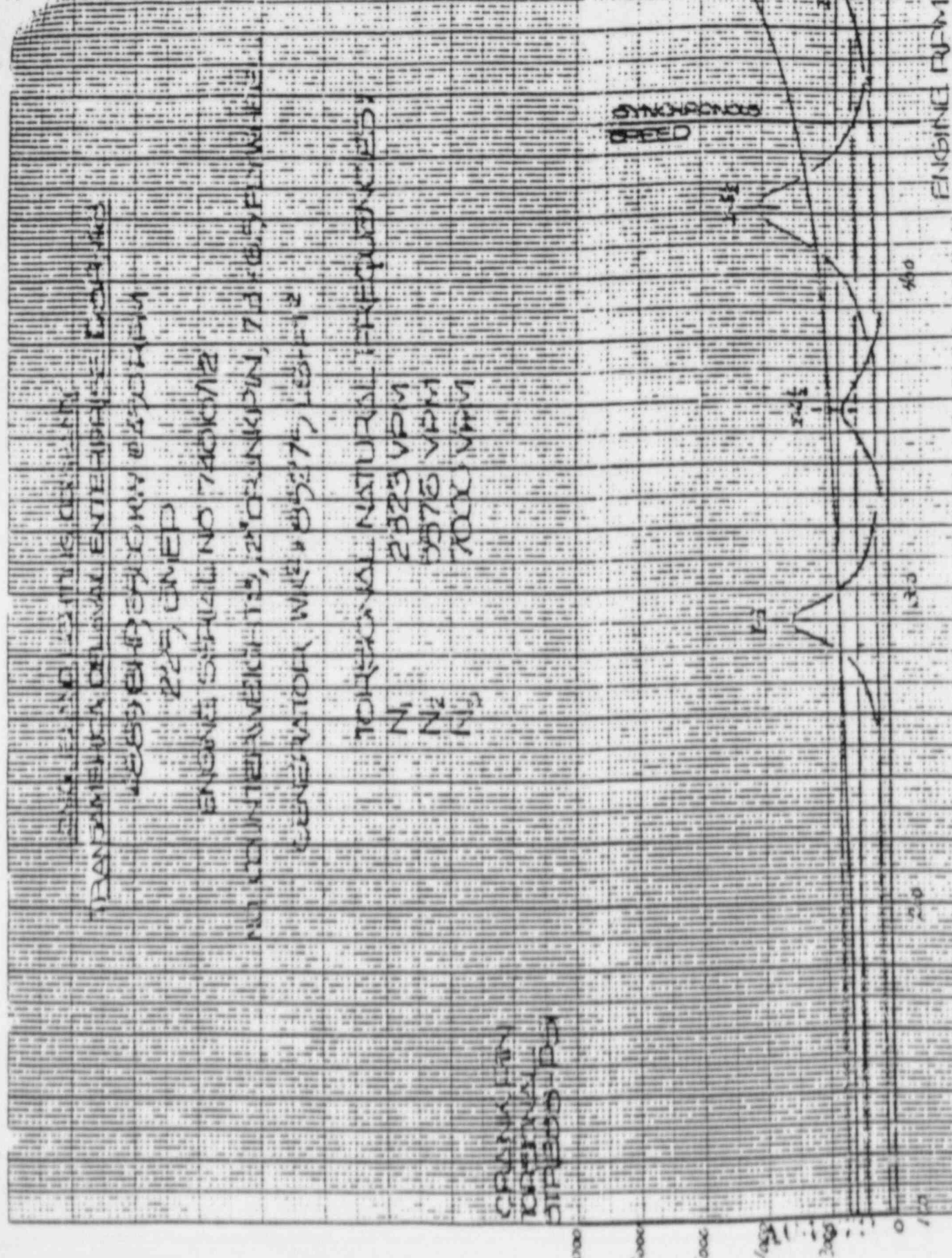
ORDER	RPM	TN	VEC	TSTINT	TSTEXT	PHI	TMAXI	TMAXE
.5	11151	155.86	1.508	150.7	544.6	.255	5792.	19624.
1.0	5575	34.58	.253	16.3	53.4	.044	997.	3379.
1.5	3717	129.52	3.789	335.6	1137.0	.635	14418.	48851.
2.0	2787	41.03	.702	19.7	66.8	.201	4567.	15474.
2.5	2230	71.71	3.789	165.8	629.5	.458	10407.	35260.
3.0	1858	16.16	.253	2.8	9.5	.012	279.	945.
3.5	1593	42.73	1.508	44.1	149.5	.130	2953.	10006.
4.0	1393	27.66	1.211	22.9	77.6	.076	1725.	5849.
4.5	1239	23.76	1.508	24.5	83.0	.075	1694.	5739.
5.0	1115	17.37	.253	3.0	10.2	.009	209.	709.
5.5	1013	12.84	3.789	33.3	112.7	.105	2386.	8085.
6.0	929	11.42	.702	5.5	18.6	.015	352.	1192.
6.5	857	9.08	3.789	23.5	79.7	.066	1500.	5084.
7.0	796	7.61	.253	1.3	4.5	.004	82.	278.
7.5	743	6.17	1.508	6.4	21.6	.018	405.	1373.
8.0	696	5.00	1.211	4.1	14.0	.012	269.	911.
8.5	655	4.74	1.508	4.9	16.6	.013	300.	1018.
9.0	619	4.08	.253	.7	2.4	.002	44.	149.
9.5	586	2.58	3.789	6.7	22.6	.022	510.	1728.
10.0	557	1.87	.702	.9	3.0	.003	79.	266.
10.5	531	1.63	3.789	4.4	14.8	.017	392.1	1293.
11.0	506	1.42	.253	.2	.8	.001	23.	77.

MODE 3
 OMEGA SQUARED IN (RADIAN/SECOND)**2 = .53738427
 NATURAL FREQUENCY IN V.P.M. = 7000.25
 NO. INERTIA THETA IOMST SIGMA M SHAFT K DTHETA

1	6.8	1.00000	3.657	3.657	58.1	.06292
2	49.2	.93738	24.787	28.444	84.7	.33571
3	47.9	.50137	15.487	43.931	84.7	.51850
4	47.9	.09288	2.134	46.065	84.7	.54369
5	47.9	-.45081	-11.867	34.198	84.7	.40362
6	47.9	-.06443	-22.261	11.936	84.7	.14088
7	47.9	-1.00531	-25.889	-13.953	84.7	-.16468
8	47.9	-.84063	-21.648	-35.601	84.7	-.42019
9	50.1	-.42044	-11.331	-46.932	76.9	-.60997
10	1120.1	.18953	112.041	65.109	276.8	.23524
11	2630.4	-.04571	-65.129	.000		

MODE 3
 OMEGA SQUARED .5374
 NATURAL FREQUENCY 7000.2500
 SIGMA I+THETA**2 2375.2154
 SIGMA I+THETA**2 2997.4770
 T INT 28973.37
 T EXT 16925.47
 STRESSED DIAMETER OF EXTERNAL SHAFT 16.00
 EQUILIBRIUM AMPLITUDE .000064773254
 F IN 7487.33
 F INT 2.46
 F EXT 1.44
 F B 150397380.
 F O 0.
 F C3 0.
 F C5 0.
 F D 0.

ORDER	RM	TN	VEC	TSTINT	TSTEXT	PHI	TMAXI	TMAXE
.5	14000	155.86	.955	365.7	214.0	.111	3223.	1887.
1.0	7000	94.58	.957	199.0	116.4	.102	2969.	1738.
1.5	4666	129.52	3.103	986.9	577.6	.358	10371.	6070.
2.0	3500	41.05	2.525	254.6	149.0	.498	14432.	8446.
2.5	2600	71.71	3.103	546.4	319.8	.253	7486.	4381.
3.0	2333	16.16	.857	34.0	19.9	.029	831.	486.
3.5	2000	42.79	.955	100.4	58.8	.057	1644.	962.
4.0	1750	27.66	1.370	133.9	78.3	.085	2468.	1445.
4.5	1555	23.76	.955	55.8	32.6	.033	943.	552.
5.0	1400	17.37	.857	36.5	21.4	.022	622.	365.
5.5	1272	12.84	3.103	97.8	57.3	.059	1717.	1005.
6.0	1166	11.42	2.525	70.8	41.4	.038	1111.	651.
6.5	1076	9.08	3.103	69.2	40.5	.037	1079.	632.
7.0	1000	7.61	.857	16.0	9.4	.008	245.	143.
7.5	933	6.17	.955	14.5	8.5	.008	226.	132.
8.0	875	5.00	1.370	24.2	14.2	.013	384.	225.
8.5	823	4.74	.955	11.1	6.5	.006	167.	98.
9.0	777	4.08	.857	8.6	5.0	.005	131.	77.
9.5	736	2.58	3.103	19.7	11.5	.013	367.	215.
10.0	700	1.87	2.525	11.6	6.8	.009	248.	145.
10.5	666	1.69	3.103	12.9	7.5	.009	275.	161.
11.0	636	1.42	.857	3.0	1.7	.002	67.	39.
11.5	608	1.15	.955	2.7	1.6	.002	66.	38.
12.0	583	.96	1.370	4.7	2.7	.004	120.	



ENGINE NO. 12345678
 TRANSMISSION DELIVERY ENTIRE DELIVERY
 WEISSBACH #357689012345
 225 UNIP
 ENGINE SERIAL NO 7400012
 NO. CONTAINER WEIGHT, 2100 LBS, 710 LBS
 GENERATOR WIRE # 85275, LEFT

TORQUE NATURAL FREQUENCIES
 N₁ 2323 RPM
 N₂ 3575 RPM
 N₃ 7000 RPM

CRANKING
 CRANKING
 CRANKING

CRANKING
 CRANKING

ENGINE RPM