LEAD-X

Advanced Technology
Pure Lead-Tin VRLA Battery

Technical Manual

HBL™

Pure Lead-Tin Technology

Pure Lead-Tin technology offers many advantages which include:

- High overall efficiency
- High energy density
- Excellent high rate performance
- Excellent low temperature performance
- High cycle life

The technology enables continuous manufacture of thin plates using automated assembly lines complete with sophisticated equipment and online quality checks.

A battery is a critical component of any power supply system and has a significant impact on its performance and reliability. Today, there is a distinct preference for high-performance, compact and light weight batteries.

Engineered by HBL, Lead-X redefines performance. Lead-X batteries employ Pure Lead-Tin, thin plate design for high performance. These Valve Regulated Lead Acid (VRLA) batteries are designed using Absorbent Glass Mat (AGM) separators that render the batteries spill-proof. Use of AGM separators in combination with self-resealing, pressure regulating valves and a starved electrolyte design enable recombination of gasses generated during normal operation. This eliminates the need for electrolyte top-up.

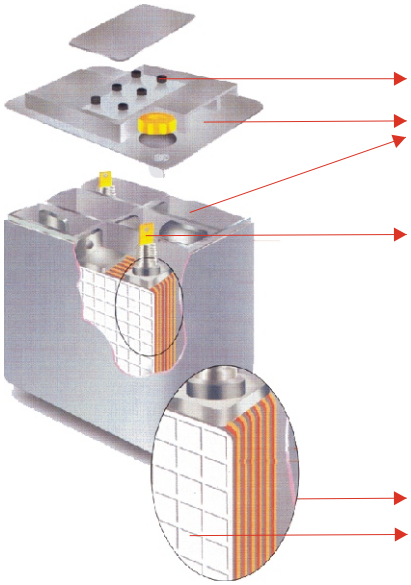
Lead-X batteries are delivered fully charged and can be commissioned immediately without delay.

Superior Features

- Maintenance-free and spill-proof. This enables flexible mounting
- Compact and light weight for easy handling
- Wide operating temperature range (-40ºC to +50ºC)
- High energy density (gravimetric and volumetric)
- Good charge retention leading to long storage life
- Low internal resistance ensures quick recharge
- Excellent high rate capability permits use of smaller capacity batteries
- Superior raw materials for good performance and life
- Excellent deep discharge recovery characteristics
- UL recognized plastic components

'Lead-X' Batteries are tested and verified by Intertek testing services as per IEC/EN 60896-21 & 22- 2004

Construction



Applications

Lead X batteries are the ideal choice for all applications requiring reliable back-up. Typical applications include

- Telecommunications
- Front Terminal batteries for ETSI telecom cabinets
- UPS
- Solar photovoltaic (SPV)
- Duty Cycle

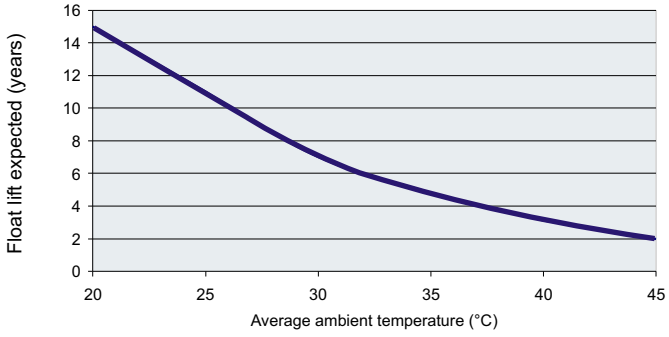
Float Life

In a float arrangement, the battery is kept connected across a charger which continually replenishes the drain in the battery caused due to self-discharge.

The expected life of a battery, also known as its designed life, is influenced by the ambient temperature. Based on the Arrhenius Equation, which relates ambient temperature and the rate of positive-grid corrosion of the battery, it is estimated that the expected life of lead acid batteries is reduced by 50% for every 8 to 10ºC rise in the average ambient temperature.

The expected float life of batteries at various average ambient temperatures, when floated at a float voltage of 2.25 volts per cell, is shown in Graph1.

Graph 1 - Float life Vs Average temperature



When a lead acid battery reaches the end of its life, the failure mode is positive grid corrosion. Grid corrosion reduces the available cross section of the grid which is required to carry current. While this reduced cross section is adequate to deliver low currents while carrying out capacity tests, it is not adequate to sustain high currents.

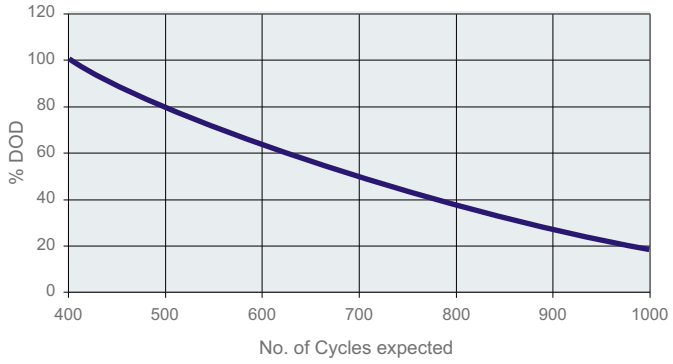
The special Pure Lead-Tin alloy minimizes positive grid corrosion.

Cycle Life

An alternative method of expressing battery life is the number of cycles that can be delivered by a battery at a specified discharge rate to a specified end voltage at an ambient temperature of 25ºC.

The depth of discharge (DOD) is an important variable affecting the battery's cycle life expectancy (as shown in Graph 2 below). It is important to optimize the charging regime of the battery for cycling applications in order to ensure full recharge before discharging the battery. Full recharge can be achieved by using an elevated voltage for charging. It is highly detrimental to subject an undercharged battery to cycling since this will cause premature battery failure.

Graph 2 - Cycle Life Vs Depth of Discharge



Charging

Constant voltage charging is the most preferred charging method for Lead-X batteries.

When charging the battery with a constant voltage charger in float applications, the charger must be set at the following voltages at 25^{0}C.

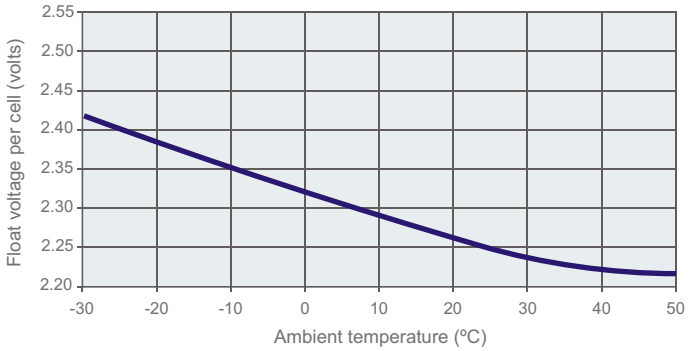
Boost: 2.4V per cell , Float: 2.25V per cell.

For cyclic applications, where the time available for re-charging is limited, rapid charging can be carried out at the boost voltage specified above.

No current limit is required during constant voltage charging. However, the charger should be capable of giving at least 0.1C_{10} A (where C_{10} is the capacity of battery at 10 hr rate of discharge to end 1.80V per cell). The charger should automatically sense the current drawn by the battery and switch over to the float mode when the battery is fully charged.

The charger should provide temperature compensation (as shown in Graph 3) to ensure optimum charging of the battery. The charger should also have an AC voltage ripple of <3% RMS.

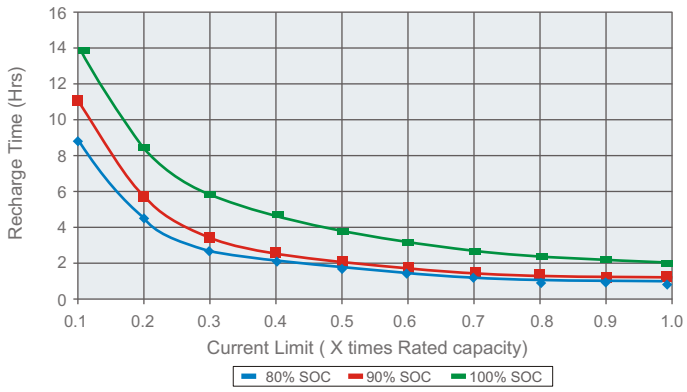
Graph 3 - Temperature Compensation



Fast charging

Lead-X Batteries can accept a high charge current limit compared to other technologies because of having a low internal resistance. The maximum current limit can be as much as 1C, equivalent to rated capacity of battery. A typical charge characteristics with a charge voltage of 2.4 Volts per cell for a fully discharged battery is shown as follows.

Charge Characteristics With Different Current Limits



Battery housing and ventilation

Lead-X batteries can be installed in cabinets or enclosures with a gap of 10 to 15 mm in between batteries and with a free space of minimum 100 mm on top of terminals for the accessibility of installation and maintenance.

The gassing evolved during normal float charging will be negligible. The cabinet must have an air circulation to limit the hydrogen gas accumulation to less than 1% during the boost charging of the battery to comply with the requirements of EN 50272 Part-2.

The charger must have temperature compensation to regulate the charge input at different ambient temperatures and the thermal sensor should sense the battery temperature. When batteries are installed in a closed cabinet, the temperature will rise during charging. Forced air circulation by means of fans (or by any other means) must be provided to dissipate the heat and maintain the temperature within 5^0C above ambient.

Storage

Batteries lose capacity when not in use, a phenomenon termed as self-discharge. The use of pure raw materials decreases the rate of self-discharge and enhances storage life. Loss of capacity during storage is to be compensated for by giving a freshening charge to the battery. In case the batteries are stored for very long periods or at high temperatures without giving a freshening charge, there will be an irreversible sulphation leading to permanent loss in capacity.

Lead-X batteries can be stored for a maximum period of two years at 20ºC with open circuit voltage (OCV) monitoring every 4 months. If the OCV falls to 2.1V per cell, the battery should be given a freshening charge at 2.4V per cell for 12hrs. OCV Monitoring interval with respect to temperature of storage is given in Table 1.

Table 1

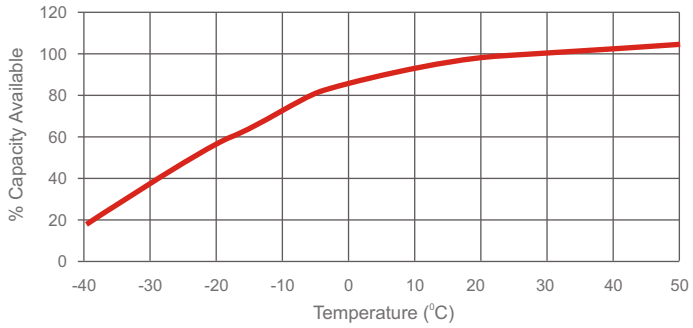
Temperature (ºC)	Monitoring Frequency (months)
< 20	6
20 – 29	4
30 – 35	3
36 – 40	2
41 – 50	1

Discharge Performance

Lead-X batteries are rated at the 10hr rate of discharge to end 1.80 V per cell at 25ºC. Discharge currents and power available at 25ºC from these batteries for different time periods and to different end voltages is given in this manual.

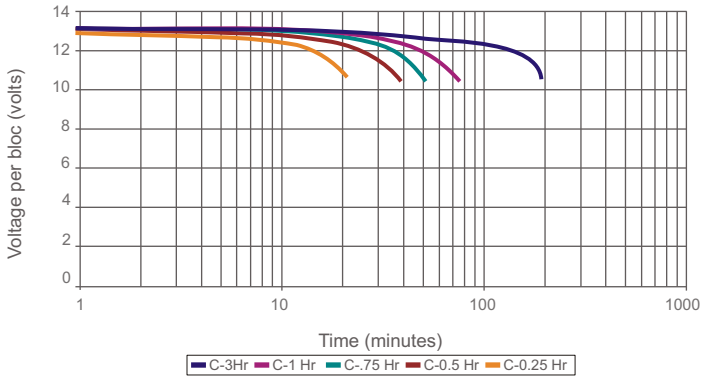
These batteries are capable of performing between -40ºC and +50ºC. The performance of the battery will however be reduced at low temperatures (see Graph 4). At higher temperatures, the performance will be enhanced, but the life of battery is reduced.

Graph 4 - Capacity available at different temperatures (% of rated 10 hr capacity)

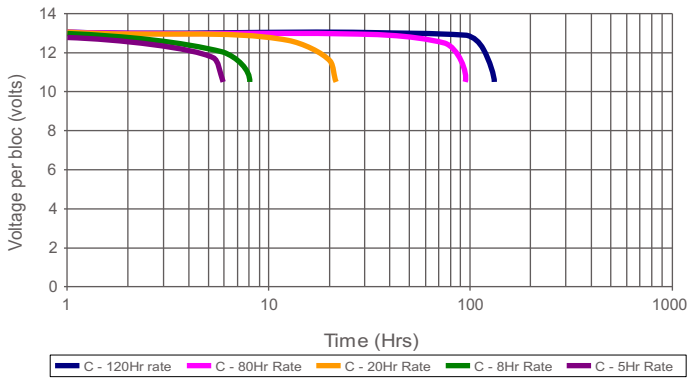


These batteries can be used for applications with back-up duration of as short as 5 minutes (high rate discharge) to as long as 120 hours (low rate discharge). Discharge graphs (Graph 5 and Graph 6) at various rates of discharge for these batteries are given below:

Graph 5 - Voltage Vs Time



Graph 6 - Voltage Vs Time



Range of 12V Monoblocs

Model	Capacity C_{10}, 1.80 (Ah)	Dimensions (mm) L	W	H	Approx.Wt. (kgs)	Terminal
LX-12 13	13	175	85	130	5	M6 (F)
LX-12 16	16	181	76	168	6	M6 (F)
LX-12 20	20	163	142	147	9	M6 (F)
LX-12 26	26	249	97	151	10	M6 (F)
LX-12 30	30	163	142	200	12	M6 (F)
LX-12 38	38	249	97	201	13	M6 (F)
LX-12 50	50	220	121	250	18	M6 (F)
LX-12 70	70	330	168	176	23	M6 (F)
LX-12 80	80	286	268	182	32	M8 (F)
LX-12 100	100	410	175	225	36	M8 (F)
LX-12 150	150	525	220	225	56	M8 (F)

Front Terminal Monoblocs

LX-12 75 FT	75	490	110	225	24	M8 (F)
LX-12 100 FT	100	510	110	240	32	M8 (F)
LX-12 110 FT	110	558	125	228	38	M8 (F)

Range of 6V Monoblocs

Model	Capacity C_{10}, 1.80 (Ah)	Dimensions (mm) L	W	H	Approx.Wt. (kgs)	Terminal
LX-6 120	120	205	197	235	23	M8 (F)
LX-6 140	140	205	197	235	25	M8 (F)

Range of 2V Monoblocs

Model	Capacity C_{10}, 1.80 (Ah)	Dimensions (mm) L	W	H	Approx.Wt. (kgs)	Terminal
LX-2 350	350	205	197	235	26.5	M8 (F)

* Nominal capacity is at 10 hour rate of discharge to 1.80 Vpc at 25° C

Constant Current Performance at 25°C

End Voltage 1.60 VPC — Discharge Current in Amperes

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	58	36.3	27.6	21.0	16.1	12.0	9.6	5.4	3.78	2.90	2.44	2.09	1.80	1.58	1.45	1.41	0.75
LX-12 16	71	44.5	33.8	25.8	19.8	14.7	11.7	6.6	4.63	3.56	2.99	2.56	2.21	1.94	1.78	1.73	0.92
LX-12 20	90	56	42.6	32.5	24.9	18.5	14.8	8.4	5.8	4.49	3.77	3.23	2.78	2.45	2.24	2.18	1.16
LX-12 26	116	73	55	41.9	32.2	23.9	19.1	10.8	7.6	5.8	4.9	4.2	3.59	3.16	2.89	2.81	1.50
LX-12 30	134	84	64	48.5	37.2	27.6	22.1	12.5	8.7	6.7	5.6	4.81	4.15	3.65	3.34	3.25	1.73
LX-12 38	156	107	81	62.0	47.2	35.0	28.0	15.8	11.1	8.5	7.2	6.2	5.27	4.64	4.25	4.13	2.20
LX-12 50	224	140	106	81	62	46.1	36.8	20.8	14.6	11.2	9.4	8.0	6.9	6.1	5.6	5.4	2.89
LX-12 70	314	195	148	113	87	64	52	29.1	20.3	15.6	13.1	11.2	9.7	8.5	7.8	7.6	4.04
LX-12 80	359	224	170	129	99	74	59	33.3	23.3	17.9	15.0	12.9	11.1	9.8	8.9	8.7	4.62
LX-12 100	449	280	212	162	124	92	74	41.6	29.1	22.4	18.8	16.1	13.9	12.2	11.2	10.8	5.8
LX-12 150	673	420	319	243	186	138	111	62	43.7	33.6	28.2	24.1	20.8	18.3	16.8	16.3	8.7
LX-6 120	538	335	255	194	149	110	88	49.9	34.9	26.8	22.5	19.3	16.6	14.6	13.4	13.0	6.9
LX-6 140	628	391	298	226	174	129	103	59	40.8	31.3	26.3	22.5	19.5	17.1	15.6	15.1	8.1
LX-2-350	1570	978	744	566	435	322	257	147	102	78	66	56	48.6	42.7	39.1	37.8	20.3

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX -12 75 FT	336	209	159	121	93	69	55	31.3	21.8	16.8	14.1	12.1	10.4	9.1	8.4	8.1	4.3
LX -12 100 FT	448	279	212	162	124	92	74	41.6	29.1	22.4	18.8	16.1	13.9	12.2	11.2	10.8	5.8
LX -12 110 FT	494	308	234	178	137	101	81	45.7	32.0	24.6	20.6	17.7	15.2	13.4	12.3	11.9	6.3

End Voltage 1.63 VPC — Discharge Current in Amperes

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	58	36.1	27.4	20.9	16.0	11.9	9.5	5.4	3.75	2.88	2.42	2.07	1.79	1.57	1.44	1.40	0.75
LX-12 16	71	44.3	33.6	25.6	19.7	14.6	11.7	6.6	4.61	3.54	2.97	2.55	2.19	1.93	1.77	1.72	0.92
LX-12 20	89	55	42.1	32.1	24.6	18.3	14.6	8.2	5.8	4.43	3.72	3.19	2.75	2.42	2.21	2.15	1.15
LX-12 26	115	72	55	41.7	31.9	23.7	18.9	10.7	7.5	5.7	4.84	4.14	3.57	3.14	2.87	2.79	1.49
LX-12 30	133	83	63	48.0	36.9	27.3	21.9	12.3	8.6	6.6	5.6	4.77	4.11	3.62	3.31	3.22	1.72
LX-12 38	162	106	80	61	46.8	34.7	27.7	15.7	11.0	8.4	7.1	6.1	5.23	4.60	4.21	4.09	2.18
LX-12 50	222	138	105	80	61	45.6	36.5	20.6	14.4	11.1	9.3	8.0	6.9	6.0	5.5	5.4	2.86
LX-12 70	311	194	147	112	86	64	51	28.8	20.2	15.5	13.0	11.1	9.6	8.5	7.7	7.5	4.01
LX-12 80	355	221	168	128	98	73	58	32.9	23.0	17.7	14.9	12.7	11.0	9.7	8.8	8.6	4.58
LX-12 100	445	277	210	160	123	91	73	41.2	28.8	22.2	18.6	15.9	13.7	12.1	11.1	10.7	5.7
LX-12 150	666	415	316	240	185	137	109	62	43.2	33.2	27.9	23.9	20.6	18.1	16.6	16.1	8.6
LX-6 120	533	332	252	192	148	109	88	49.4	34.6	26.6	22.3	19.1	16.5	14.5	13.3	12.9	6.9
LX-6 140	622	388	294	224	172	128	102	58	40.4	31.0	26.0	22.3	19.3	16.9	15.4	15.0	8.0
LX-2 350	1554	970	736	561	430	319	255	144	101	77	65	56	48.1	42.2	38.6	37.6	20.1

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX -12 75 FT	333	207	158	120	92	68	55	30.9	21.6	16.6	13.9	11.9	10.3	9.1	8.3	8.1	4.3
LX -12 100 FT	444	277	210	160	123	91	73	41.24	28.82	22.15	18.59	15.92	13.73	12.08	11.06	10.74	5.72
LX -12 110 FT	489	304	231	176	135	100	80	45.36	31.70	24.36	20.45	17.52	15.10	13.29	12.16	11.82	6.29

Constant Current Performance at 25°C

End Voltage 1.67 VPC — Discharge Current in Amperes

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	57	35.8	27.2	20.7	15.9	11.8	9.4	5.3	3.73	2.86	2.41	2.06	1.78	1.56	1.43	1.39	0.74
LX-12 16	71	44.0	33.4	25.5	19.6	14.5	11.6	6.6	4.58	3.52	2.96	2.53	2.18	1.92	1.76	1.71	0.91
LX-12 20	88	55	41.5	31.6	24.3	18.0	14.4	8.1	5.7	4.37	3.67	3.14	2.71	2.39	2.18	2.12	1.13
LX-12 26	114	72	54	41.4	31.7	23.5	18.8	10.6	7.5	5.7	4.80	4.11	3.55	3.12	2.85	2.77	1.48
LX-12 30	132	82	62	47.6	36.6	27.1	21.7	12.2	8.6	6.6	5.5	4.73	4.08	3.59	3.28	3.19	1.70
LX-12 38	167	105	79	61	46.4	34.4	27.5	15.5	10.9	8.3	7.0	6.0	5.18	4.55	4.17	4.05	2.16
LX-12 50	220	137	104	79	61	45.1	36.1	20.4	14.3	11.0	9.2	7.9	6.8	6.0	5.5	5.3	2.83
LX-12 70	308	192	146	111	85	63	51	28.6	20.0	15.4	12.9	11.0	9.5	8.4	7.7	7.4	3.97
LX-12 80	352	219	166	127	97	72	58	32.6	22.8	17.5	14.7	12.6	10.9	9.6	8.8	8.5	4.53
LX-12 100	440	274	208	159	122	90	72	40.8	28.6	21.9	18.4	15.8	13.6	12.0	11.0	10.6	5.7
LX-12 150	660	411	312	238	183	136	108	61	42.8	32.9	27.6	23.7	20.4	17.9	16.4	16.0	8.5
LX-6 120	528	329	250	190	146	108	87	49	34.2	26.3	22.1	18.9	16.3	14.4	13.1	12.8	6.8
LX-6 140	616	384	291	222	171	127	101	58	39.9	30.7	25.8	22.1	19	16.8	15.3	14.9	7.9
LX-2 350	1539	960	728	556	427	317	252	144	100	77	65	55	47.6	41.9	38.3	37.3	19.8

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX -12 75 FT	330	205	156	119	91	68	54	30.6	21.4	16.4	13.8	11.8	10.2	9.0	8.2	8.0	4.3
LX -12 100 FT	441	274	208	159	122	90	72	40.82	28.57	21.93	18.42	15.77	13.61	11.96	10.95	10.64	5.67
LX -12 110 FT	485	301	229	175	134	99	79	44.90	31.43	24.12	20.26	17.35	14.97	13.16	12.05	11.70	6.24

End Voltage 1.70 VPC — Discharge Current in Amperes

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	56	34.8	26.5	20.2	15.5	11.5	9.2	5.2	3.63	2.79	2.34	2.00	1.73	1.52	1.39	1.35	0.72
LX-12 16	69	43.1	32.7	24.9	19.1	14.2	11.3	6.4	4.48	3.44	2.89	2.48	2.13	1.88	1.72	1.67	0.89
LX-12 20	86	54	40.8	31.1	23.9	17.7	14.2	8.0	5.6	4.30	3.61	3.09	2.66	2.34	2.14	2.08	1.11
LX-12 26	112	70	53	40.5	31.1	23.1	18.4	10.4	7.3	5.6	4.70	4.02	3.46	3.05	2.80	2.71	1.45
LX-12 30	130	81	61	46.8	35.9	26.6	21.3	12.0	8.4	6.5	5.4	4.65	4.01	3.53	3.23	3.13	1.67
LX-12 38	164	103	78	60	45.5	33.7	27.0	15.2	10.7	8.2	6.9	5.9	5.07	4.47	4.09	3.97	2.12
LX-12 50	216	135	102	78	60	44.3	35.4	20.0	14.0	10.8	9.0	7.7	6.7	5.9	5.4	5.2	2.78
LX-12 70	302	188	143	109	84	62	49.6	28.0	19.6	15.1	12.6	10.8	9.3	8.2	7.5	7.3	3.89
LX-12 80	345	215	164	125	96	71	57	32.0	22.4	17.2	14.5	12.4	10.7	9.4	8.6	8.4	4.45
LX-12 100	432	269	204	156	120	89	71	40.0	28.0	21.5	18.1	15.5	13.3	11.7	10.7	10.4	5.6
LX-12 150	647	404	307	234	179	133	106	60	42.0	32.3	27.1	23.2	20.0	17.6	16.1	15.7	8.3
LX-6 120	518	323	245	187	143	106	85	48	33.6	25.8	21.7	18.6	16.0	14.1	12.9	12.5	6.7
LX-6 140	604	377	286	218	168	125	99	56	39.2	30.2	25.3	21.6	18.6	16.5	15.0	14.6	7.8
LX-2 350	1511	942	715	546	419	311	247	139	98	75	63	54	46.6	41.2	37.6	36.5	19.6

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX -12 75 FT	323	202	153	117	90	66	53	30.0	21.0	16.1	13.6	11.6	10.0	8.8	8.1	7.8	4.2
LX -12 100 FT	431	269	204	156	119	89	71	40.00	28.01	21.51	18.08	15.48	13.33	11.74	10.74	10.43	5.56
LX -12 110 FT	474	296	225	171	131	98	78	44.00	30.81	23.66	19.89	17.03	14.67	12.91	11.82	11.47	6.11

Constant Current Performance at 25°C

End Voltage 1.75 VPC **Discharge Current in Amperes**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	55	34.4	26.1	19.9	15.3	11.3	9.1	5.1	3.58	2.75	2.31	1.98	1.70	1.50	1.37	1.33	0.69
LX-12 16	68	42.4	32.2	24.5	18.8	14.0	11.2	6.3	4.41	3.39	2.84	2.44	2.10	1.85	1.69	1.64	0.85
LX-12 20	85	53	40.1	30.6	23.5	17.4	13.9	7.9	5.5	4.22	3.55	3.04	2.62	2.30	2.11	2.04	1.06
LX-12 26	110	69	52	39.6	30.4	22.6	18.0	10.2	7.1	5.5	4.60	3.93	3.39	2.98	2.74	2.64	1.37
LX-12 30	127	79	60	45.9	35.2	26.1	20.9	11.8	8.2	6.3	5.3	4.56	3.93	3.46	3.16	3.06	1.59
LX-12 38	161	101	76	59	44.6	33.1	26.4	14.9	10.5	8.0	6.8	5.8	4.97	4.38	4.01	3.87	2.01
LX-12 50	212	132	100	76	59	43.5	34.8	19.6	13.7	10.6	8.9	7.6	6.5	5.8	5.3	5.1	2.65
LX-12 70	297	185	140	107	82	61	48.7	27.5	19.2	14.8	12.4	10.6	9.2	8.1	7.4	7.1	3.71
LX-12 80	338	211	160	122	94	69	56	31.4	21.9	16.9	14.2	12.1	10.4	9.2	8.4	8.1	4.23
LX-12 100	423	264	200	153	117	87	69	39.2	27.4	21.1	17.7	15.2	13.1	11.5	10.5	10.2	5.3
LX-12 150	635	396	300	229	176	130	104	59	41.2	31.6	26.6	22.7	19.6	17.3	15.8	15.3	7.9
LX-6 120	508	316	240	183	141	104	83	47.1	32.9	25.3	21.2	18.2	15.7	13.8	12.6	12.2	6.4
LX-6 140	592	370	280	214	164	121	98	55	38.4	29.5	24.8	21.2	18.3	16.1	14.7	14.3	7.4
LX-2 350	1480	924	700	535	409	304	244	136	96	74	62	53	45.8	40.1	36.8	35.8	18.5

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX -12 75 FT	318	198	150	115	88	65	52	29.4	20.6	15.8	13.3	11.4	9.8	8.6	7.9	7.6	4.0
LX -12 100 FT	424	264	200	153	117	87	69	39.22	27.47	21.10	17.73	15.17	13.07	11.49	10.53	10.19	5.29
LX -12 110 FT	466	290	220	168	129	96	76	43.14	30.22	23.21	19.50	16.69	14.38	12.64	11.58	11.21	5.82

End Voltage 1.80 VPC **Discharge Current in Amperes**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	52	32.7	24.8	18.9	14.5	11.1	8.9	5.0	3.52	2.70	2.27	1.95	1.68	1.48	1.35	1.30	0.68
LX-12 16	64	39.9	30.3	23.1	17.7	13.6	10.9	6.1	4.30	3.30	2.77	2.37	2.04	1.80	1.65	1.60	0.83
LX-12 20	80	50	38.0	28.9	22.2	17.1	13.6	7.7	5.4	4.14	3.47	2.98	2.56	2.26	2.07	2.00	1.04
LX-12 26	104	66	49.4	37.6	28.9	22.2	17.7	10.0	7.0	5.4	4.51	3.87	3.33	2.93	2.68	2.60	1.35
LX-12 30	120	75	57	43.4	33.3	25.6	20.4	11.5	8.1	6.2	5.2	4.46	3.84	3.38	3.10	3.00	1.56
LX-12 38	152	94	72	54.9	42.2	32.4	25.9	14.6	10.3	7.8	6.6	5.6	4.87	4.28	3.92	3.80	1.97
LX-12 50	200	125	95	72	56	42.6	34.1	19.2	13.5	10.3	8.7	7.4	6.4	5.6	5.2	5.0	2.60
LX-12 70	281	175	133	101	78	60	47.7	26.9	18.9	14.5	12.2	10.4	9.0	7.9	7.2	7.0	3.64
LX-12 80	321	200	152	116	89	68	55	30.8	21.5	16.5	13.9	11.9	10.2	9.0	8.3	8.0	4.16
LX-12 100	401	250	190	145	111	85	68	38.5	26.9	20.7	17.4	14.9	12.8	11.3	10.3	10.0	5.2
LX-12 150	601	375	285	217	167	128	102	58	40.4	31.0	26.0	22.3	19.2	16.9	15.5	15.0	7.8
LX-6 120	481	300	228	174	133	102	82	46.2	32.3	24.8	20.8	17.9	15.4	13.5	12.4	12.0	6.2
LX-6 140	561	350	266	203	155	119	96	54	37.7	28.9	24.3	20.8	17.9	15.8	14.4	14.0	7.3
LX-2 350	1403	875	664	507	389	299	239	134	94.0	72.0	61.0	52.0	44.8	39.4	36.0	35.0	18.3

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX -12 75 FT	300	188	142	109	83	64	51	28.8	20.2	15.5	13.0	11.2	9.6	8.5	7.7	7.5	3.9
LX -12 100 FT	400	250	190	145	111	85	68	38.46	26.95	20.66	17.36	14.88	12.80	11.27	10.31	10.00	5.18
LX -12 110 FT	440	275	209	159	122	94	75	42.31	29.65	22.73	19.10	16.37	14.08	12.40	11.34	11.00	5.70

Constant Current Performance at 25°C

End Voltage 1.85 VPC — Discharge Current in Amperes

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	48.1	30.0	22.8	17.4	13.3	9.9	7.9	4.46	3.12	2.40	2.02	1.73	1.49	1.31	1.20	1.16	0.62
LX-12 16	59	36.8	27.9	21.3	16.3	12.1	9.7	5.5	3.83	2.94	2.47	2.11	1.82	1.60	1.47	1.43	0.76
LX-12 20	74	46.0	34.9	26.6	20.4	15.1	12.1	6.8	4.78	3.68	3.09	2.64	2.28	2.01	1.84	1.78	0.95
LX-12 26	96	60	45.4	34.6	26.6	19.8	15.8	8.9	6.2	4.79	4.02	3.44	2.96	2.61	2.39	2.32	1.24
LX-12 30	110	69	52	39.8	30.5	22.6	18.1	10.2	7.2	5.5	4.62	3.95	3.41	3.00	2.74	2.66	1.42
LX-12 38	140	87	66	50.3	38.6	28.7	22.9	12.9	9.0	7.0	5.9	5.00	4.31	3.79	3.47	3.37	1.80
LX-12 50	184	115	87	66	51	37.8	30.2	17.1	11.9	9.2	7.7	6.6	5.7	5.00	4.58	4.45	2.37
LX-12 70	258	161	122	93	71	53	42.3	23.9	16.7	12.8	10.8	9.2	8.0	7.0	6.4	6.2	3.32
LX-12 80	294	183	139	106	81	60	48.3	27.3	19.1	14.7	12.3	10.5	9.1	8.0	7.3	7.1	3.79
LX-12 100	368	229	174	133	102	76	60	34.1	23.9	18.3	15.4	13.2	11.4	10.0	9.2	8.9	4.74
LX-12 150	552	344	261	199	153	113	91	51	35.8	27.5	23.1	19.8	17.1	15.0	13.7	13.3	7.1
LX-6 120	442	275	209	159	122	91	73	41	28.7	22.0	18.5	15.8	13.6	12.0	11.0	10.7	5.7
LX-6 140	516	321	244	186	143	106	84	47.8	33.5	25.7	21.6	18.4	16	14	12.9	12.5	6.7
LX-2 350	1289	803	610	466	358	265	211	119	84	64	54	46	39.9	35	32.2	31.1	16.7

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX -12 75 FT	276	172	131	100	76	57	45	25.6	17.9	13.8	11.6	9.9	8.5	7.5	6.9	6.7	3.6
LX -12 100 FT	368	229	174	133	102	76	60	34.13	23.87	18.35	15.41	13.19	11.38	10.01	9.17	8.90	4.74
LX -12 110 FT	404	252	192	146	112	83	67	37.54	26.25	20.18	16.95	14.51	12.51	11.01	10.08	9.79	5.21

End Voltage 1.90 VPC — Discharge Current in Amperes

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	42.7	26.6	20.2	15.4	11.8	8.8	7.0	3.96	2.77	2.13	1.79	1.53	1.32	1.16	1.06	1.03	0.55
LX-12 16	53	32.9	25.0	19.0	14.6	10.8	8.7	4.90	3.42	2.63	2.21	1.89	1.63	1.44	1.31	1.28	0.68
LX-12 20	66	41.1	31.2	23.8	18.3	13.6	10.8	6.1	4.28	3.29	2.76	2.37	2.04	1.79	1.64	1.60	0.85
LX-12 26	85	53	40.6	30.9	23.7	17.6	14.0	7.9	5.5	4.26	3.59	3.07	2.64	2.33	2.13	2.07	1.10
LX-12 30	99	62	47.0	35.9	27.5	20.4	16.3	9.2	6.4	4.95	4.16	3.56	3.07	2.70	2.47	2.40	1.28
LX-12 38	125	78	60	45.2	34.7	25.7	20.5	11.6	8.1	6.3	5.24	4.49	3.87	3.40	3.11	3.03	1.61
LX-12 50	165	103	78	60	45.8	34.0	27.2	15.3	10.7	8.2	6.9	5.9	5.1	4.50	4.12	4.00	2.13
LX-12 70	231	144	110	83	64	47.5	38.0	21.5	15.0	11.5	9.7	8.3	7.1	6.3	5.8	5.6	2.98
LX-12 80	264	165	125	95	73	54	43.4	24.5	17.1	13.2	11.1	9.5	8.2	7.2	6.6	6.4	3.40
LX-12 100	330	206	156	119	91	68	54	30.6	21.4	16.4	13.8	11.8	10.2	9.0	8.2	8.0	4.25
LX-12 150	495	309	234	179	137	102	81	45.9	32.1	24.7	20.7	17.8	15.3	13.5	12.3	12.0	6.4
LX-6 120	396	247	187	143	110	81	65	36.7	25.7	19.7	16.6	14.2	12.2	10.8	9.9	9.6	5.1
LX-6 140	462	288	218	167	128	95	76	42.8	30.0	23.1	19.4	16.6	14.3	12.6	11.5	11.1	6.0
LX-2 350	1156	721	546	417	319	237	190	107	75	58	48	41	35.8	31.4	28.8	27.8	14.9

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX -12 75 FT	248	154	117	89	69	51	41	22.9	16.1	12.3	10.4	8.9	7.6	6.7	6.2	6.0	3.2
LX -12 100 FT	330	206	156	119	91	68	54	30.58	21.41	16.45	13.81	11.83	10.19	8.98	8.22	7.97	4.26
LX -12 110 FT	363	226	172	131	101	75	60	33.64	23.55	18.09	15.19	13.02	11.21	9.87	9.04	8.77	4.68

Constant Power Performance at 25°C

End Voltage 1.60 VPC — Discharge Power in Watts / Cell

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	106	68	52	40.1	31.0	23.1	18.7	10.6	7.5	5.8	4.85	4.16	3.59	3.16	2.90	2.82	1.48
LX-12 16	131	84	64	49.4	38.2	28.5	23.0	13.1	9.2	7.1	6.0	5.1	4.42	3.90	3.57	3.47	1.82
LX-12 20	163	104	80	62	47.6	35.5	28.7	16.4	11.5	8.8	7.4	6.4	5.5	4.86	4.46	4.33	2.27
LX-12 26	212	135	104	80	61	46.1	37.1	21.2	14.9	11.4	9.7	8.3	7.2	6.3	5.7	5.6	2.93
LX-12 30	245	156	120	92	71	53	43.0	24.5	17.2	13.3	11.2	9.6	8.3	7.3	6.7	6.5	3.40
LX-12 38	310	198	152	117	90	68	54	31.0	21.8	16.7	14.2	12.1	10.5	9.2	8.4	8.2	4.30
LX-12 50	409	261	200	154	119	89	72	40.9	28.7	22.1	18.6	16.0	13.8	12.2	11.1	10.8	5.7
LX-12 70	572	365	280	215	167	124	100	57	40.1	30.9	26.1	22.3	19.3	17.0	15.6	15.1	7.9
LX-12 80	652	416	319	246	190	142	114	65	45.8	35.3	29.7	25.5	22.0	19.4	17.8	17.3	9.0
LX-12 100	816	521	399	307	238	177	143	82	57	44.1	37.2	31.9	27.5	24.3	22.2	21.6	11.3
LX-12 150	1224	781	599	461	357	266	215	122	86	66	56	47.8	41.3	36.4	33.4	32.4	17.0
LX-6 120	979	625	479	369	285	213	172	98	69	53	44.6	38.2	33.0	29.1	26.7	25.9	13.6
LX-6 140	1143	730	559	430	334	248	201	114	80	62	52.1	44.7	38.6	34	31.2	30.3	15.9
LX-2 350	2857	1825	1397	1076	834	620	502	286	201	154	130	112	96.5	84.9	78.0	75.7	39.6

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 75 FT	612	391	299	230	179	133	107.3	61.5	42.8	33.1	27.9	23.9	20.6	18.2	16.7	16.2	8.5
LX-12 100 FT	816	521	399	307	238	177	143.0	82.0	57.0	44.1	37.2	31.9	27.5	24.3	22.2	21.6	11.3
LX-12 110 FT	898	573	439	338	262	195	157.3	90.2	62.7	48.5	40.9	35.1	30.3	26.7	24.4	23.8	12.4

End Voltage 1.63 VPC — Discharge Power in Watts / Cell

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	105	67	52	39.7	30.7	22.9	18.5	10.5	7.4	5.7	4.80	4.12	3.56	3.13	2.87	2.79	1.46
LX-12 16	130	83	64	48.9	37.8	28.2	22.8	13.0	9.1	7.0	5.9	5.07	4.38	3.86	3.54	3.44	1.80
LX-12 20	162	103	79	61	47.2	35.2	28.4	16.2	11.4	8.8	7.4	6.3	5.5	4.81	4.41	4.29	2.25
LX-12 26	210	134	103	79	61	45.6	36.8	21.0	14.7	11.3	9.6	8.2	7.1	6.2	5.7	5.5	2.91
LX-12 30	243	155	119	91	71	53	42.6	24.3	17.0	13.1	11.1	9.5	8.2	7.2	6.6	6.4	3.37
LX-12 38	307	196	151	116	89	67	54	30.8	21.6	16.6	14.0	12.0	10.4	9.1	8.4	8.1	4.26
LX-12 50	405	258	198	152	118	88	71	40.5	28.4	21.9	18.4	15.8	13.7	12.0	11.0	10.7	5.6
LX-12 70	567	362	277	213	165	123	99	57	39.8	30.6	25.8	22.1	19.1	16.8	15.4	15.0	7.9
LX-12 80	646	412	316	243	188	140	113	65	45.3	34.9	29.4	25.2	21.8	19.2	17.6	17.1	9.0
LX-12 100	808	516	396	304	236	176	142	81	57	43.7	36.8	31.6	27.3	24.0	22.0	21.4	11.2
LX-12 150	1213	774	594	457	353	264	213	121	85	66	55	47.4	40.9	36.1	33.1	32.1	16.8
LX-6 120	970	619	475	365	283	211	170	97	68	52	44.2	37.9	32.7	28.8	26.4	25.7	13.5
LX-6 140	1132	723	554	426	330	246	199	113	79	61	51.6	44.3	38.2	33.7	30.9	30.0	15.8
LX-2 350	2831	1807	1385	1065	826	615	497	283	198	152	129	111	95.5	84.2	77.2	74.9	39.4

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 75 FT	606	387	297	228	177	132	106.5	60.8	42.8	32.8	27.6	23.7	20.5	18.0	16.5	16.1	8.4
LX-12 100 FT	808	516	396	304	236	176	142.0	81.0	57.0	43.7	36.8	31.6	27.3	24.0	22.0	21.4	11.2
LX-12 110 FT	889	568	436	334	260	194	156.2	89.1	62.7	48.1	40.5	34.8	30.0	26.4	24.2	23.5	12.3

Constant Power Performance at 25°C

End Voltage 1.67 VPC — Discharge Power in Watts / Cell

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	104	67	51	39.3	30.4	22.7	18.3	10.4	7.3	5.6	4.75	4.08	3.52	3.10	2.85	2.76	1.45
LX-12 16	129	82	63	48.4	37.5	28.0	22.6	12.9	9.0	7.0	5.9	5.02	4.34	3.82	3.51	3.41	1.78
LX-12 20	160	102	78	60	46.7	34.9	28.1	16.0	11.3	8.7	7.3	6.3	5.4	4.77	4.37	4.25	2.23
LX-12 26	208	132	102	78	60	45.1	36.5	20.8	14.6	11.2	9.5	8.1	7.0	6.1	5.6	5.5	2.88
LX-12 30	241	154	118	91	70	52	42.2	24.1	16.9	13.0	11.0	9.4	8.1	7.2	6.6	6.4	3.34
LX-12 38	305	194	149	115	88	66	53	30.5	21.4	16.4	13.9	11.9	10.3	9.0	8.3	8.1	4.22
LX-12 50	401	256	196	151	117	87	70	40.1	28.1	21.7	18.3	15.7	13.5	11.9	10.9	10.6	5.6
LX-12 70	561	358	275	211	164	122	99	56	39.4	30.3	25.6	21.9	18.9	16.7	15.3	14.9	7.8
LX-12 80	640	408	313	241	187	139	112	64	44.9	34.6	29.1	25.0	21.6	19.0	17.4	16.9	8.9
LX-12 100	800	511	392	301	233	174	140	80	56	43.3	36.5	31.3	27.0	23.8	21.8	21.2	11.1
LX-12 150	1201	767	588	452	350	261	211	120	84	65	55	46.9	40.5	35.7	32.7	31.8	16.7
LX-6 120	961	613	470	362	280	209	169	96	67	52	43.8	37.5	32.4	28.6	26.2	25.4	13.3
LX-6 140	1121	715	549	422	326	244	197	112	78	61	51.1	43.9	37.8	33.4	30.6	29.6	15.5
LX-2 350	2803	1789	1372	1055	816	610	492	281	196	152	128	110	94.4	83.4	76.4	74.1	38.9

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 75 FT	600	383	294	226	175	131	105.0	60.0	42.0	32.5	27.4	23.5	20.3	17.9	16.4	15.9	8.3
LX-12 100 FT	800	511	392	301	233	174	140.0	80.0	56.0	43.3	36.5	31.3	27.0	23.8	21.8	21.2	11.1
LX-12 110 FT	880	562	431	331	256	191	154.0	88.0	61.6	47.6	40.2	34.4	29.7	26.2	24.0	23.3	12.2

End Voltage 1.70 VPC — Discharge Power in Watts / Cell

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	102	65	50.1	38.6	29.8	22.3	18.0	10.2	7.2	5.5	4.66	4.00	3.45	3.04	2.79	2.71	1.42
LX-12 16	126	80	62	47.5	36.8	27.4	22.1	12.6	8.9	6.8	5.7	4.93	4.25	3.75	3.44	3.34	1.75
LX-12 20	157	100	77	59	45.8	34.2	27.6	15.7	11.0	8.5	7.2	6.1	5.3	4.68	4.29	4.16	2.18
LX-12 26	204	130	100	77	59	44.3	35.8	20.4	14.2	11.0	9.3	8.0	6.9	6.0	5.5	5.4	2.83
LX-12 30	236	151	115	89	69	51	41.4	23.6	16.6	12.8	10.7	9.2	8.0	7.0	6.4	6.2	3.27
LX-12 38	299	191	146	113	87	65	52	29.9	21.0	16.1	13.6	11.7	10.1	8.8	8.1	7.9	4.15
LX-12 50	393	251	192	148	115	85	69	39.3	27.6	21.3	17.9	15.4	13.3	11.7	10.7	10.4	5.5
LX-12 70	550	351	269	207	160	120	97	55	38.6	29.8	25.1	21.5	18.6	16.4	15.0	14.6	7.6
LX-12 80	628	401	307	236	183	136	110	63	44.0	33.9	28.6	24.5	21.2	18.7	17.1	16.6	8.7
LX-12 100	785	501	384	296	229	171	138	79	55	42.4	35.8	30.7	26.5	23.3	21.4	20.8	10.9
LX-12 150	1178	752	577	444	343	256	207	118	83	64	54	46.0	39.7	35.0	32.1	31.2	16.3
LX-6 120	942	601	461	355	275	205	165	94	66	51	42.9	36.8	31.8	28.0	25.7	24.9	13.1
LX-6 140	1099	702	538	414	320	239	194	110	77	60	50.1	42.9	37.1	32.7	30	29.1	15.2
LX-2 350	2749	1755	1346	1035	800	597	484	275	193	149	125	107	92.6	81.8	74.9	72.8	38.1

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 75 FT	589	376	288	222	172	128	103.5	59.3	41.3	31.8	26.9	23.0	19.9	17.5	16.1	15.6	8.2
LX-12 100 FT	785	501	384	296	229	171	138.0	79.0	55.0	42.4	35.8	30.7	26.5	23.3	21.4	20.8	10.9
LX-12 110 FT	864	551	422	326	252	188	151.8	86.9	60.5	46.6	39.4	33.8	29.2	25.6	23.5	22.9	12.0

Constant Power Performance at 25°C

End Voltage 1.75 VPC **Discharge Power in Watts / Cell**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	100	64	49.1	37.8	29.3	21.8	17.6	10.0	7.0	5.43	4.57	3.92	3.39	2.98	2.74	2.66	1.39
LX-12 16	124	79	61	46.6	36.0	26.9	21.7	12.4	8.7	6.7	5.6	4.83	4.17	3.68	3.37	3.27	1.72
LX-12 20	154	98	75	58	44.9	33.5	27.1	15.4	10.8	8.3	7.0	6.0	5.2	4.58	4.20	4.08	2.14
LX-12 26	200	128	98	75	58	43.5	35.0	20.0	14.0	10.8	9.0	7.8	6.8	5.9	5.4	5.3	2.77
LX-12 30	231	148	113	87	67	50.3	40.6	23.1	16.2	12.5	10.5	9.0	7.8	6.9	6.3	6.1	3.21
LX-12 38	293	187	144	110	85	64	51.4	29.3	20.5	15.8	13.4	11.4	9.9	8.7	8.0	7.7	4.07
LX-12 50	385	246	189	145	112	84	68	38.6	27.1	20.8	17.6	15.1	13.0	11.5	10.5	10.2	5.3
LX-12 70	540	344	264	203	157	117	95	54	37.9	29.2	24.6	21.1	18.2	16.0	14.7	14.3	7.5
LX-12 80	615	393	301	232	179	134	108	62	43.2	33.3	28.0	24.0	20.8	18.3	16.8	16.3	8.5
LX-12 100	770	491	377	290	224	167	135	77	54	41.6	35.1	30.1	26.0	22.9	21.0	20.4	10.7
LX-12 150	1155	737	565	435	337	251	203	116	81	62	53	45.1	39.0	34.3	31.5	30.6	16.0
LX-6 120	924	590	452	348	269	201	162	92	65	49.9	42.1	36.1	31.2	27.5	25.2	24.5	12.8
LX-6 140	1078	688	528	407	314	235	189	108	75	59	49.1	42.1	36.3	32	29.4	28.5	14.9
LX-2 350	2694	1719	1320	1017	785	587	474	270	188	147	123	105	90.8	80	73.6	71.3	37.3

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 75 FT	578	368	283	218	168	125	101.3	57.8	40.5	31.2	26.3	22.6	19.5	17.2	15.8	15.3	8.0
LX-12 100 FT	770	491	377	290	224	167	135.0	77.0	54.0	41.6	35.1	30.1	26.0	22.9	21.0	20.4	10.7
LX-12 110 FT	847	540	415	319	246	184	148.5	84.7	59.4	45.8	38.6	33.1	28.6	25.2	23.1	22.4	11.8

End Voltage 1.80 VPC **Discharge Power in Watts / Cell**

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	95	61	46.7	35.9	27.8	20.7	16.7	9.5	6.7	5.2	4.34	3.72	3.22	2.84	2.60	2.52	1.32
LX-12 16	117	75	57	44.2	34.2	25.5	20.6	11.8	8.2	6.3	5.4	4.59	3.96	3.49	3.20	3.11	1.63
LX-12 20	146	93	72	55	42.7	31.9	25.7	14.7	10.3	7.9	6.7	5.7	4.94	4.36	3.99	3.88	2.03
LX-12 26	189	121	93	72	55	41.3	33.3	19.0	13.3	10.3	8.6	7.4	6.4	5.6	5.2	5.0	2.63
LX-12 30	220	140	108	83	64	47.8	38.6	22.0	15.4	11.9	10.0	8.6	7.4	6.5	6.0	5.8	3.05
LX-12 38	278	178	137	105	81	61	48.8	27.8	19.5	15.0	12.6	10.9	9.3	8.3	7.6	7.4	3.86
LX-12 50	366	234	179	138	107	80	64	36.6	25.7	19.8	16.7	14.3	12.4	10.9	10.0	9.7	5.08
LX-12 70	513	327	251	193	149	111	90	51	36.0	27.7	23.4	20.0	17.3	15.2	14.0	13.6	7.1
LX-12 80	585	373	286	220	170	127	103	58	41.0	31.6	26.6	22.8	19.7	17.4	15.9	15.5	8.1
LX-12 100	731	467	358	275	213	159	128	73	51	39.5	33.3	28.6	24.7	21.7	19.9	19.4	10.1
LX-12 150	1097	700	537	413	320	239	193	110	77	59	50.0	42.9	37.0	32.6	29.9	29.1	15.2
LX-6 120	878	560	430	331	256	191	154	88	62	47.4	40.0	34.3	29.6	26.1	23.9	23.2	12.2
LX-6 140	1024	654	501	386	299	222	180	103	72	56	46.6	40.0	34.6	30.5	27.9	27.1	14.2
LX-2 350	2561	1634	1253	965	746	556	450	257	180	139	117	100	86.5	76.2	69.7	67.7	35.5

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 75 FT	548	350	269	206	160	119	96.0	54.8	38.3	29.6	25.0	21.5	18.5	16.3	14.9	14.6	7.6
LX-12 100 FT	731	467	358	275	213	159	128.0	73.0	51.0	39.5	33.3	28.6	24.7	21.7	19.9	19.4	10.1
LX-12 110 FT	804	514	394	303	234	175	140.8	80.3	56.1	43.5	36.6	31.5	27.2	23.9	21.9	21.3	11.1

Constant Power Performance at 25°C

End Voltage 1.85 VPC — Discharge Power in Watts / Cell

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	87	56	42.7	32.9	25.5	19.0	15.3	8.7	6.1	4.72	3.98	3.41	2.95	2.60	2.38	2.31	1.21
LX-12 16	108	69	53	40.5	31.4	23.4	18.9	10.8	7.5	5.8	4.90	4.20	3.63	3.20	2.93	2.85	1.49
LX-12 20	134	86	66	50.5	39.1	29.2	23.5	13.4	9.4	7.3	6.1	5.2	4.53	3.99	3.66	3.55	1.86
LX-12 26	174	111	85	66	51	37.8	30.5	17.4	12.2	9.4	7.9	6.8	5.8	5.2	4.7	4.6	2.41
LX-12 30	201	128	98	76	59	43.8	35.3	20.1	14.1	10.9	9.2	7.9	6.8	6.0	5.5	5.3	2.79
LX-12 38	255	162	124	96	74	55	44.7	25.5	17.9	13.8	11.6	10.0	8.6	7.6	7.0	6.8	3.53
LX-12 50	335	214	164	126	98	73	59	33.6	23.5	18.1	15.3	13.1	11.3	10.0	9.1	8.9	4.65
LX-12 70	470	300	230	177	137	102	82	47.0	32.9	25.4	21.4	18.3	15.8	14.0	12.8	12.4	6.5
LX-12 80	535	342	262	202	156	116	94	54	37.6	28.9	24.4	20.9	18.1	15.9	14.6	14.2	7.4
LX-12 100	670	427	328	252	195	146	118	67	47.0	36.2	30.5	26.2	22.6	19.9	18.3	17.7	9.3
LX-12 150	1005	641	492	379	293	218	176	101	71	54	45.8	39.3	33.9	29.9	27.4	26.6	13.9
LX-6 115	771	492	377	290	225	168	135	77	54	41.7	35.1	30.1	26.0	22.9	21.0	20.4	10.7
LX-6 136	911	582	446	343	266	198	160	91	64	49.3	41.5	35.6	30.7	27.1	24.8	24.1	12.6
LX-2 350	2344	1498	1148	883	685	510	412	234	165	127	107	92	79.0	69.7	63.8	62.0	32.4

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 75 FT	503	320	246	189	146	110	88.5	50.3	35.3	27.2	22.9	19.7	17.0	14.9	13.7	13.3	7.0
LX-12 100 FT	670	427	328	252	195	146	118.0	67.0	47.0	36.2	30.5	26.2	22.6	19.9	18.3	17.7	9.3
LX-12 110 FT	737	470	361	277	215	161	129.8	73.7	51.7	39.8	33.6	28.8	24.9	21.9	20.1	19.5	10.2

End Voltage 1.90 VPC — Discharge Power in Watts / Cell

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 13	78	50.0	38.3	29.5	22.8	17.0	13.7	7.8	5.49	4.23	3.57	3.06	2.64	2.33	2.13	2.07	1.09
LX-12 16	96	62	47.2	36.3	28.1	21.0	16.9	9.6	6.8	5.2	4.39	3.77	3.25	2.87	2.63	2.55	1.34
LX-12 20	120	77	59	45.3	35.1	26.2	21.1	12.0	8.4	6.5	5.5	4.70	4.06	3.58	3.28	3.18	1.67
LX-12 26	156	100	76	58	45	33.9	27.4	15.6	10.9	8.4	7.1	6.1	5.3	4.6	4.2	4.1	2.16
LX-12 30	180	115	88	68	53	39.2	31.7	18.1	12.7	9.8	8.2	7.0	6.1	5.4	4.92	4.78	2.50
LX-12 38	228	146	112	86	67	49.7	40.1	22.9	16.0	12.3	10.4	8.9	7.7	6.8	6.3	6.1	3.17
LX-12 50	301	192	147	113	88	65	53	30.1	21.1	16.3	13.7	11.7	10.1	8.9	8.2	8.0	4.17
LX-12 70	421	269	206	159	123	92	74	42.1	29.5	22.8	19.2	16.4	14.2	12.5	11.5	11.1	5.8
LX-12 80	480	306	235	181	140	104	84	48.0	33.7	25.9	21.9	18.7	16.2	14.3	13.1	12.7	6.7
LX-12 100	600	383	294	226	175	131	105	60	42.1	32.4	27.3	23.4	20.2	17.8	16.4	15.9	8.3
LX-12 150	901	575	441	339	263	196	158	90	63	48.7	41.0	35.2	30.4	26.8	24.6	23.9	12.5
LX-6 120	721	460	353	271	210	157	126	72	50.6	38.9	32.8	28.1	24.3	21.4	19.6	19.1	10.0
LX-6 140	841	536	412	317	245	183	147	84	59	45.5	38.3	32.8	28.4	25	23	22.2	11.6
LX-2 350	2103	1341	1029	793	613	458	368	211	147	114	96	82	71.0	62.5	57.4	55.6	29.1

Model	Minutes						Hours										
	5	10	15	20	30	45	1	2	3	4	5	6	7	8	9	10	20
LX-12 75 FT	450	287	221	170	131	98	78.8	45.0	31.6	24.3	20.5	17.6	15.2	13.4	12.3	11.9	6.2
LX-12 100 FT	600	383	294	226	175	131	105.0	60.0	42.1	32.4	27.3	23.4	20.2	17.8	16.4	15.9	8.3
LX-12 110 FT	660	421	323	249	193	144	115.5	66.0	46.3	35.6	30.0	25.7	22.2	19.6	18.0	17.5	9.1

Battery Sizing and Selection

Sizing and selection of a battery is application specific. Certain correction factors also have to be applied before arriving at the final battery capacity.

Correction factors

1) K factor (designated C_K) See Table 2
   It is the ratio of 'Rated Capacity' to 'Amperes' that can be supplied for the required 't' time.

2) Temperature correction factor (designated C_{TC}) See Table 3
   It is the ratio of the 'Rated Capacity' to the Capacity obtainable at t°C.

3) Aging factor (designated C_{AF})
   Normally taken to be 1.25 (1/0.8) considering 80% as the end of life criterion.

4) Design margin (designated C_{DM})
   A nominal 10% cushion is taken as standard over-sizing to take care of design errors in the load specifications. This may also be specified by the user.

5) Over load factor (designated C_{OL})
   Reserve capacity that may be installed to take care of future additional loads. Normally 10% is considered. This again depends on customer's requirement.

A) Battery Sizing for UPS Applications

UPS loads have constant power requirements. The procedure for sizing batteries for constant power loads is given below:

Example

01. Power rating	: 2 KVA
02. Power factor	: 0.8 (not required if power rating is given in KW)
03. Maximum voltage	: 130 V
04. Minimum voltage	: 90 V
05. Inverter efficiency	: 85%
06. End cell voltage	: 1.75 V (10.5 V per 12 V monobloc)
07. Minimum operating temperature	: 25°C
08. Back-up time	: 30 minutes
09. Ageing factor	: 1.25
10. Design margin	: 10%
11. Overload factor	: 10%
12. Charging voltage	: 108 V

Calculations

Step 1 Calculate power output of UPS (W_{UPS})
(not required if power output is already given in KW)

W_{UPS} = KVA x Power factor = 2 x 0.8 = 1.6 KW

Step 2 Calculate power required from battery

W_{bty} = [UPS output wattage (in KW) x 1000] / Inverter efficiency
= (1.6 x 1000) / 0.85 = 1882.4 W

Step 3 Calculate number of blocs required

Minimum number required = Minimum voltage / End of discharge voltage
= 90 / 10.5 = 8.57 blocs

Maximum number required = Maximum voltage / Float charging voltage
= 130 / 13.5 = 9.63 blocs

Number of blocs selected = 9 of 12V each

Step 4 Calculate power required per bloc

W_{bloc} = Total watts / number of blocs
= 1882.4 / 9 = 209.2 W

Step 5 Apply Temperature correction factor

Temperature correction factor for 25ºC (C_T) = 1.0
Wattage required = 209.2 x 1.0 = 209.2 W

Step 6 Apply Ageing factor C_{AF}

Wattage required = 209.2 x 1.25 = 261.5 W

Step 7 Apply Design factor C_{DF}

Wattage required = 261.5 x 1.1 = 287.65 W

Step 8 Apply Overload factor C_{OL}

Wattage required = 287.65 x 1.1 = 316.42 W per 12V bloc or 52.7 W per cell

Step 9 Select monobloc type

From the monobloc range, pick the model which gives the required watts for the duration and end voltage specified.

Monobloc Type selected LX- 12 26

B) Battery Sizing for Telecommunications Applications

Telecommunication loads have constant current requirements. The Procedure for sizing batteries for constant current loads is given below:

Example

1) Load current	:	10 A
2) Back-up duration	:	5 hrs
3) System voltage	:	48 V
4) End cell voltage	:	1.75 V
5) Minimum operating temperature	:	25°C

Calculations

Step 1 Calculate number of Blocs

Number of blocs required = System voltage / Nominal voltage per bloc
= 48 / (12 or 6) = 4 Nos of 12V or 8 Nos of 6V

Step 2 Select K-factor from Table 2

K factor for 5 hrs (300 minutes) discharge to end 1.75Vpc (C_K) = 5.64

Step 3 Calculate discharged ampere hours

Capacity required = Load current x K-factor
= 10 x 5.64 = 56.4 Ah

Step 4 Apply Temperature correction factor (C_{TC})

Temperature correction factor for 25ºC (C_{TC}) = 1.0
Capacity required = 56.4 x 1.0 = 56.4 Ah

Step 5 Apply Ageing factor (C_{AF})

= 56.4 x 1.25 = 70.5 Ah

Step 6 Apply Design factor (C_{DF})

Capacity required = 70.5 x 1.1 = 77.5 Ah

Step 7 Apply Overload factor (C_{OF})

Capacity required = 77.5 x 1.1 = 85.3 Ah

Monobloc type selected LX-12 100

C) Battery Sizing for Solar Photovoltaic Applications

Solar Photovoltaic loads have constant current requirements for typically long back-up durations to provide for number of sunless days.

Example

1)	System voltage:	12 volts
2)	Load:	10 watts
3)	Minimum operating temperature:	25°C
4)	Number of sunless days (autonomy):	4 days
5)	Operation:	Continuous (24 hrs per day)

Calculations

Step 1 Calculate the current

Current = Load in watts / Nominal system voltage
= 10W / 12V = 0.83 amperes

Step 2 Refer the k-factor

Refer Table 2 to determine the k-factor for 96 hrs (4 days x 24 hrs = 96 hrs) and 1.75 end cell voltage
The k-factor is 90.8

Step 3 Calculate the capacity required

Capacity required = Current x k-factor
= 0.83 x 90.8 = 75.36 Ah

Step 4 Apply Temperature correction factor

Temperature correction factor for 25ºC (C_{TC}) = 1.0
Capacity required = 75.36 x 1.0 = 75.36 Ah

Step 5 Apply Ageing factor C_{AF}

Capacity required = 75.36 x 1.25 = 94.20 Ah

Step 6 Apply Design factor C_{DF}

Capacity required = 94.20 x 1.1 = 103.63 Ah

Step 7 Apply Overload factor C_{OF}

Capacity required = 103.63 x 1.1 = 114 Ah at 20 hr rate of discharge

Monobloc type selected LX-6 120 (2 Nos.)

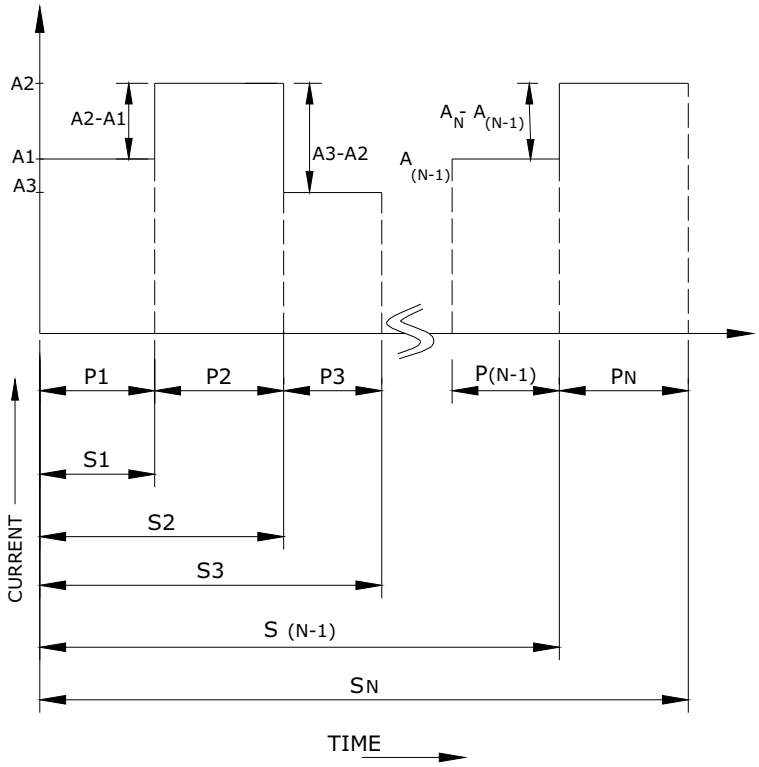
D) Battery Sizing for Duty Cycle Applications

Individual DC loads supplied by the battery during the duty cycle may be classified as under:

1) Continuous loads
2) Non continuous loads (> 1 minute)
3) Non continuous momentary loads (< 1 minute)

The IEEE Std 485-1997 gives the recommended practice for sizing batteries for stationary applications according to a specified duty cycle.
The Generalized duty cycle can be drawn as follows:

Figure 1



The maximum capacity (max Fs) calculated determines the uncorrected cell size that can be expressed by the following general equation.

$$F = \max_{S=1}^{S=N} Fs$$

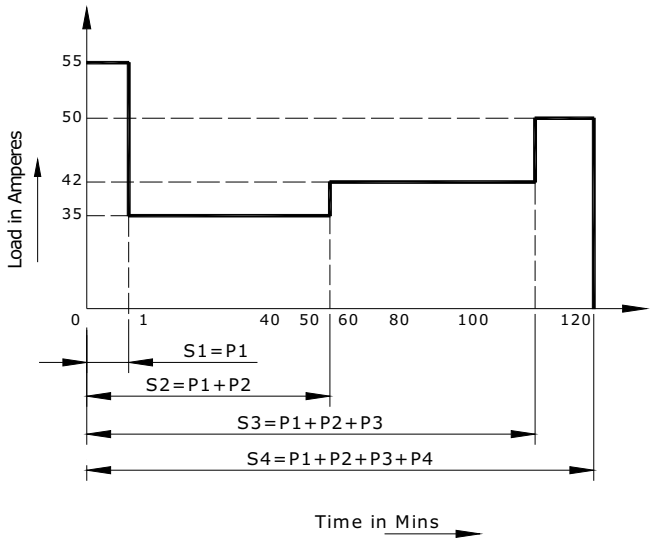
Where

S	is the section of the duty cycle being analyzed. [Section S contains the first S periods of the duty cycle (e.g. section S5 contains periods S1 through S5). See Figure 1 for a Graphical representation of "section".
N	is the number of periods in the duty cycles;
P	is the period being analyzed;
Ap	are the amperes required for period P;
T	is the time in minutes from the beginning of period P through the end of section S;
M	is the time of each period in minutes

If the current for period P+1 is greater than the current for period P, then section S=P+1 will require a larger cell than section S=P. Consequently, the calculations for section S = P can be omitted.

Example

Selection of a battery for a regime having the following load profile for a voltage of 12V, operating temperature of 25°C and considering a Design Margin of 10%



Load Name	Load in amps	Time in Mins
Load A1	55	0.185
Load A2	35	59
Load A3	42	55
Load A4	50	5

Note:

1. Any start period of less than 1 minute duration is considered for 1 minute.
2. In any section N, if the current for the 'N+1' period is higher than the current of the period 'N' then the section 'N' may be skipped as the next section 'N+1' will be of higher size.
3. Number of monoblocs = Total system Voltage / Nominal voltage of a monobloc

Calculations

Step 1 Fill the Load 'A' and period 'M' values in columns 2 & 4
Step 2 Fill the changes in the load as the difference between the present load and previous load with sign (positive or negative) in column 3
Step 3 Fill the duration 'T' for each period from the beginning (T=0) to the end of each section in column 5
Step 4 Enter the k-factor value, for each duration 'T' in column 6. Refer Table 2 for k-factors
Step 5 The capacity for each period 'P' is calculated by multiplying column 3 and column 6 and entered in column 7 with sign (positive or negative)
Step 6 The sum of capacities for all periods in every section is taken as the size of the section.
Step 7 The maximum value of all the sections noted as above plus the value in random load section, if any is taken as the uncorrected size.
Step 8 Apply Temperature Correction Factor (C_{TC})
Step 9 Apply Ageing Factor (C_{AF})
Step 10 Apply Design Margin (C_{DM})

Worksheet

(1) Period (Nos)	(2) Load (amps)	(3) Change in Load (amps)	(4) Duration of period (mins)	(5) Time to end of section (mins)	(6) Cap at T min rate K factor	(7) Reqd sec size 3*6(Ah)
Section 1 – First period only if A2 > A1, go to section 2						
1	A1=55	A1-0=55	M1=1	T=M1=1	0.149	8.19
					Sec 1	Total
Section –2 First two periods only – if A3 > A2 go to section –3						
1	A1=	A1-0=	M1=	T=M1+M2=		
2	A2=	A2-A1=	M2=	T=M2=		
					Sec 2	Total
Section-3 First 3 periods only If A4 > A3 go to section 4						
1	A1=	A1-0=	M1=	T=M1+M3		
2	A2=	A2-A1=	M2=	T=M2+M3		
3	A3=	A3-A2=	M3=	T=M3=		
					Sec 3	Total
Section-4 First 4 periods only, if A3 >A4, go to section 5						
1	A1=55	A1-0=55	M1=1	T=M1+M2+M3+M4= 120 mins	2.55	140.25
2	A2=35	A2-A1= -20	M2=59	T=M2+M3+M4=119 mins	2.55	-51
3	A3=42	A3-A2= 7	M3=55	T=M3+M4=60 mins	1.439	10.07
4.	A4=50	A4-A3=8	M4=5	T=M4=5 mins	0.236	1.888
					Sec 4 Total	101.20
Applying temperature correction factor Capacity required = 101.20 x 1.0 = 101.20 Ah						
Applying Ageing factor Capacity required = 101.20 x 1.25 = 126.5 Ah						
Applying Design Margin Capacity required = 126.5 x 1.1 = 139.15 Ah						
Monobloc Type Selected LX - 12 150						

K - Factor (C_k)

Table 2

Time	End Cell Voltage							
	1.50	1.60	1.67	1.70	1.75	1.80	1.85	1.90
1 minute	0.136	0.140	0.143	0.146	0.149	0.157	0.171	0.191
2 minutes	0.145	0.149	0.152	0.155	0.158	0.166	0.181	0.202
5 minutes	0.220	0.223	0.227	0.232	0.236	0.250	0.272	0.303
10 minutes	0.353	0.358	0.365	0.372	0.379	0.400	0.436	0.486
15 minutes	0.464	0.471	0.480	0.489	0.499	0.527	0.574	0.640
20 minutes	0.609	0.618	0.630	0.642	0.655	0.691	0.753	0.840
30 minutes	0.794	0.805	0.821	0.837	0.853	0.901	0.981	1.094
45 minutes	1.071	1.086	1.107	1.128	1.151	1.173	1.323	1.475
1 hour	1.339	1.358	1.384	1.411	1.439	1.468	1.654	1.845
2 hours	2.37	2.40	2.45	2.50	2.55	2.60	2.93	3.27
3 hours	3.39	3.44	3.50	3.57	3.64	3.71	4.19	4.67
4 hours	4.41	4.47	4.56	4.65	4.74	4.84	5.45	6.08
5 hours	5.25	5.33	5.43	5.53	5.64	5.76	6.49	7.24
6 hours	6.13	6.22	6.34	6.46	6.59	6.72	7.58	8.45
7 hours	7.11	7.22	7.35	7.50	7.65	7.81	8.79	9.81
8 hours	8.09	8.20	8.36	8.52	8.70	8.87	9.99	11.14
9 hours	8.83	8.96	9.13	9.31	9.50	9.70	10.91	12.17
10 hours	9.10	9.22	9.40	9.59	9.81	10.00	11.24	12.54
20 hours	17.07	17.31	17.64	18.00	18.89	19.3	21.1	23.5
24 hours					22.2			
48 hours					43.1			
72 hours					62.4			
96 hours					83.1			
120 hours					98.6			

Temperature correction Factor (C_{TC})

Table3

Temp.	Discharge Duration in minutes															
(°C)	5	10	15	20	30	45	60	120	180	240	300	360	420	480	540	600
- 30	3.644	3.403	3.283	3.205	3.107	3.021	2.967	2.854	2.802	2.769	2.749	2.738	2.726	2.710	2.704	2.698
- 25	2.869	2.680	2.585	2.524	2.446	2.379	2.337	2.248	2.207	2.180	2.165	2.156	2.147	2.135	2.130	2.125
- 20	2.416	2.257	2.177	2.126	2.060	2.004	1.968	1.893	1.858	1.836	1.823	1.816	1.808	1.797	1.793	1.789
- 15	2.186	2.042	1.898	1.923	1.864	1.813	1.780	1.712	1.681	1.661	1.649	1.643	1.636	1.626	1.622	1.619
- 10	1.882	1.757	1.695	1.655	1.604	1.560	1.532	1.474	1.447	1.430	1.420	1.414	1.408	1.400	1.396	1.393
- 5	1.676	1.565	1.522	1.474	1.429	1.389	1.365	1.312	1.289	1.273	1.264	1.259	1.254	1.246	1.244	1.241
0	1.572	1.468	1.404	1.383	1.340	1.304	1.280	1.232	1.209	1.195	1.186	1.181	1.176	1.170	1.167	1.164
5	1.418	1.340	1.302	1.277	1.245	1.217	1.199	1.164	1.143	1.136	1.130	1.127	1.123	1.119	1.117	1.115
10	1.287	1.233	1.206	1.188	1.166	1.145	1.134	1.107	1.096	1.089	1.085	1.083	1.080	1.078	1.076	1.075
15	1.176	1.143	1.125	1.114	1.100	1.087	1.079	1.064	1.056	1.052	1.049	1.048	1.047	1.045	1.044	1.044
20	1.082	1.066	1.057	1.052	1.045	1.040	1.035	1.028	1.025	1.022	1.021	1.021	1.020	1.019	1.019	1.018
25	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
30	0.929	0.943	0.951	0.956	0.962	0.968	0.972	0.978	0.981	0.983	0.984	0.985	0.985	0.986	0.986	0.986
35	0.867	0.895	0.910	0.919	0.931	0.943	0.949	0.962	0.969	0.972	0.974	0.974	0.975	0.977	0.977	0.977
40	0.813	0.851	0.874	0.888	0.906	0.922	0.932	0.951	0.961	0.965	0.967	0.968	0.969	0.971	0.971	0.971

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