

# PURE LEAD TIN BATTERIES

VRLA Monobloc batteries for Standby applications



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Technical Manual

## The Company

HBL is dedicated to providing engineered power solutions around a number of technologies. It is one of a few battery and energy businesses in the world to offer the full range of battery technologies.

The many specialized battery technologies offered by HBL, reflecting its strengths, include:

- ◆ Nickel Cadmium (Pocket Plate, Fibre Plate, Sintered Plate)
- ◆ Silver Zinc (Primary & Secondary)
- ◆ Lithium (Thionyl Chloride & Iron di Sulphide)
- ◆ Valve Regulated Lead Acid (Flat plate AGM & Tubular Gel)

The company has one of the highest levels of engineers to direct its work forces.

This unique combination of technologies and talent pool gives us an opportunity to provide customers purpose made solutions for their application needs.

## Pure Lead-Tin (PLT) Technology

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.

Pure Lead-Tin technology offers many advantages which include:

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

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

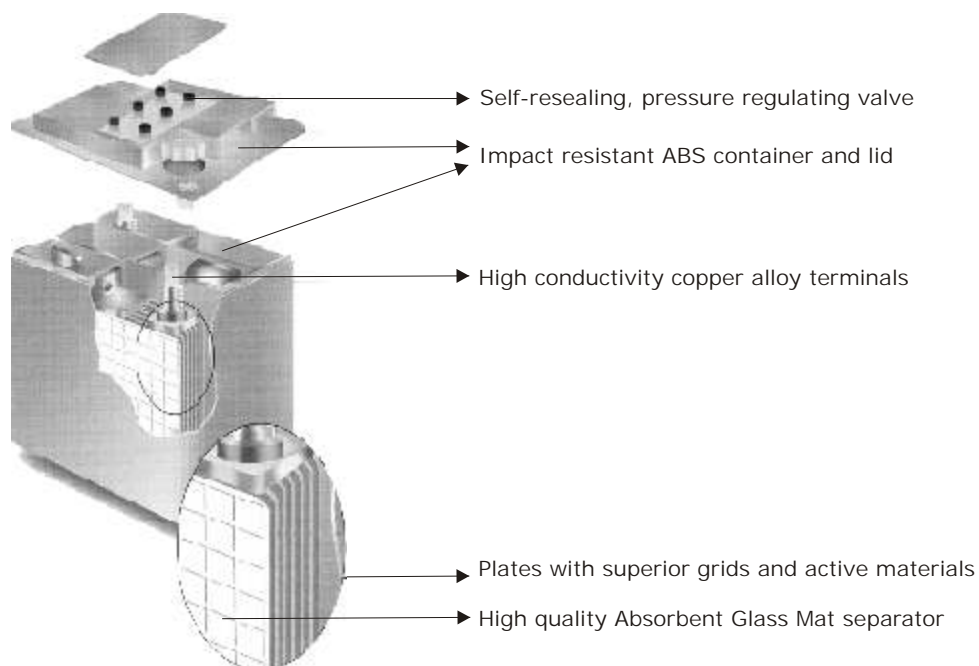
Engineered by HBL, PLT redefines performance. These batteries employ Pure Lead-Tin, thin plate technology for high performance. These Valve Regulated Lead Acid (VRLA) batteries are designed using Absorbent Glass Mat (AGM) separators that render the batteries spill-proof. Use of AGM separators in combination 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.

PLT 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 (-40°C to +50°C)
- ◆ 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

## Construction



## Applications

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

- ◆ Telecommunications
- ◆ Railway Signalling
- ◆ Solar Photovoltaic
- ◆ Duty Cycle
- ◆ Emergency Lighting

PLT batteries conform to IEC 60896-2:1995, TEC No.: G/BAT-01/02 March 2000

## Life

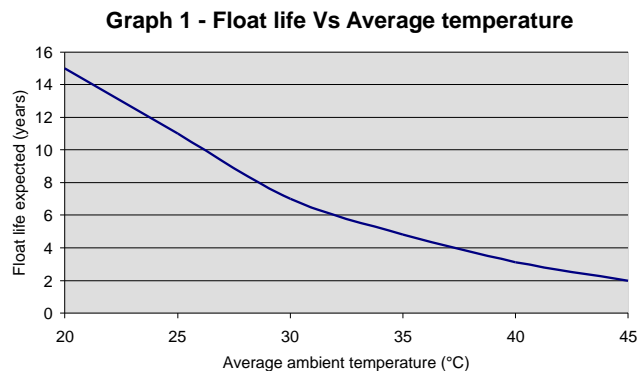
The expected life of a battery, also known as its designed life, is influenced by the ambient temperature. Based on the Arrhenius Equation, which relates ambient temperature and the rate of positive-grid corrosion of the battery, it is estimated that the expected life of lead acid batteries is reduced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

## Float Life

A Float Application is defined based on the time interval between two successive discharges. The minimum time interval between two successive discharges must be more than 14 days and average interval may be 30 days.

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 charger also supplies power to the load (like Electronic Switches, Control Circuits etc.,). The life of the battery, in this instance, is defined in calendar years at a standard temperature of 25°C.

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



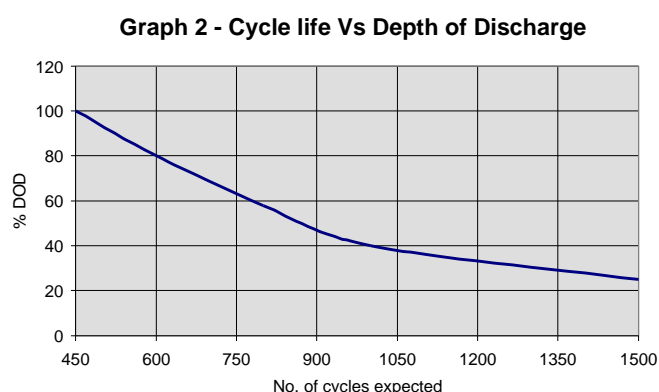
When a lead acid battery reaches the end of its life, the failure mode is positive grid corrosion. Grid corrosion reduces the available cross section of the grid which is required to carry current. While this reduced cross section is adequate to deliver low currents while carrying out capacity tests,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

The special Pure Lead-Tin alloy minimizes positive grid corrosion. The cross-sections of the grids have also been designed so as to minimize the effect of 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 25°C.

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.



## Charging

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

For float applications, the charger must be set at the following voltages.

- Boost: 2.33 V per cell
- Float: 2.28 V per cell.

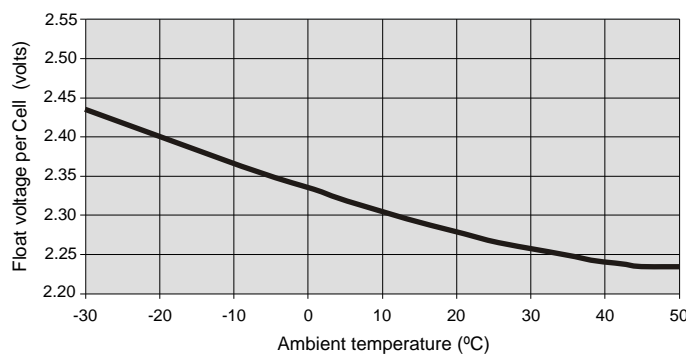
For cyclic applications, where the time available for re-charging is limited, rapid charging can be carried out at the boost voltage specified below.

- Boost: 2.40 V per cell

No current limit is required during constant voltage charging. However, the charger should be capable of giving at least  $0.1C_{20}$  A (where  $C_{20}$  is the capacity of battery at 20 hr rate of discharge to end 1.75V 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. This switch-over from Boost to Float should occur when the charge current drops to a numerical value equal to 3% of the rated capacity of the battery. The charger automatically switches to Boost mode from Float mode when the battery draws a charge current of minimum 5% of the numerical value of the rated capacity of the battery. The charger should preferably 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**



## 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.

PLT batteries can be stored for a maximum period of one year at 25°C with open circuit voltage (OCV) monitoring every 4 months. If the OCV falls to 2.1 V per cell, the battery should be given a freshening charge at 2.37V for 12hrs. In cases where the ambient temperature is more than 25°C, OCV monitoring should be done at more frequent intervals as shown in Table I below:

Table 1

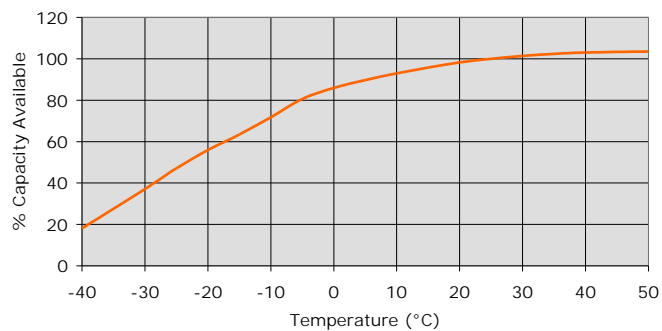
Temperature (°C)	Monitoring Frequency (months)
< 20	6
20 – 29	4
30 – 35	3
36 – 40	2
41 – 50	1

## Capacity and Discharge Performance

PLT batteries are rated at the 20hr rate of discharge to end 1.75 V per cell at 25°C. Discharge currents available at 25°C from these batteries for different time periods and to different end voltages is given in this manual.

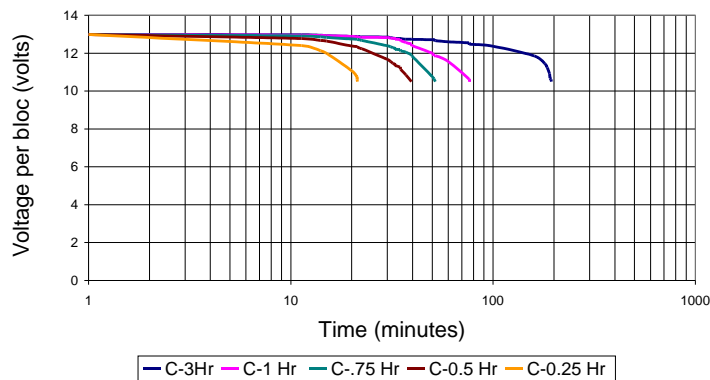
These batteries are capable of performing between -40°C and +50°C. The performance of the battery will however be reduced at low temperatures (see Graph 4). At higher temperatures, the performance will be enhanced, but the life of battery is reduced.

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

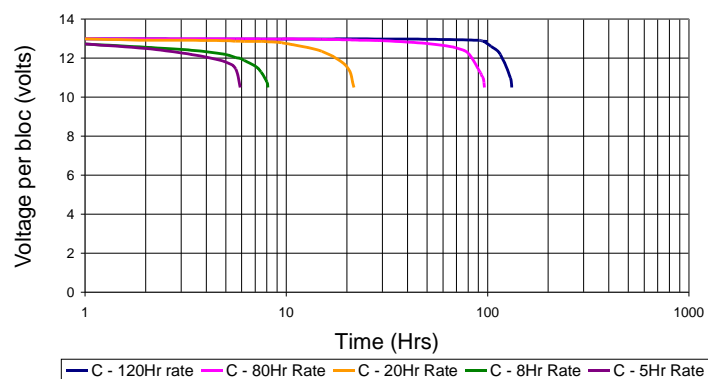


These batteries can be used for applications with back-up duration of as short as 5 minutes (high rate discharge) to as long as 120 hours (low rate discharge). Discharge graphs (Graph 5 and Graph 6) at various rates of discharge for these batteries are given below:

Graph 5 - Voltage Vs Time



Graph 6 - Voltage Vs Time



## Range of 12V Monoblocs

Model	Capacity (Ah)	Dimensions (mm)			Approx.Wt. (Kgs)
		L	W	H	
PLT 14-12	12	175	85	130	5
PLT 17-12	17	181	76	168	6
PLT 20-12	20	163	142	147	9
PLT 25-12	25	249	97	151	10
PLT 26-12	26	175	166	125	11
PLT 32-12	32	163	142	200	12
PLT 38-12	38	197	165	170	13
PLT 40-12	40	249	97	201	13
PLT 52-12	52	220	121	250	17
PLT 70-12	70	330	168	176	23
PLT 83-12	83	286	268	182	32
PLT 110-12	110	410	175	250	40
PLT 125-12	125	525	220	225	48
PLT 160-12	160	525	220	225	56

## Range of 6V Monoblocs

Model	Capacity (Ah)	Dimensions (mm)			Approx.Wt. (Kgs)
		L	W	H	
PLT 120-6	120	205	197	234	23
PLT 140-6	140	205	197	234	25

Nominal capacity is at 20 hour rate of discharge to 1.75 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	
PLT 14-12	59	37.0	28.1	21.4	16.4	12.2	9.7	5.5	3.85	2.96	2.48	2.13	1.83	1.61	1.48	1.43	0.74	
PLT 17-12	72	44.9	34.1	26.0	20.0	14.8	11.8	6.7	4.68	3.59	3.01	2.58	2.23	1.96	1.79	1.74	0.90	
PLT 20-12	85	53	40.1	30.6	23.5	17.4	13.9	7.9	5.5	4.23	3.55	3.04	2.62	2.31	2.11	2.04	1.06	
PLT 25-12	106	66	50	38.2	29.4	21.8	17.4	9.8	6.9	5.3	4.43	3.80	3.27	2.88	2.64	2.55	1.33	
PLT 26-12	110	69	52	39.8	30.5	22.6	18.1	10.2	7.2	5.5	4.61	3.95	3.40	3.00	2.74	2.65	1.38	
PLT 32-12	136	85	64	49.0	37.6	27.9	22.3	12.6	8.8	6.8	5.7	4.86	4.19	3.69	3.38	3.27	1.70	
PLT 38-12	161	100	76	58	44.6	33.1	26.5	14.9	10.5	8.0	6.7	5.8	4.97	4.38	4.01	3.88	2.01	
PLT 40-12	170	106	80	61	47.0	34.8	27.8	15.7	11.0	8.5	7.1	6.1	5.2	4.61	4.22	4.08	2.12	
PLT 52-12	220	137	104	80	61	45.3	36.2	20.4	14.3	11.0	9.2	7.9	6.8	6.0	5.5	5.3	2.76	
PLT 70-12	297	185	141	107	82	61	48.7	27.5	19.3	14.8	12.4	10.6	9.2	8.1	7.4	7.1	3.71	
PLT 83-12	352	219	167	127	97	72	58	32.6	22.8	17.5	14.7	12.6	10.9	9.6	8.8	8.5	4.40	
PLT 110-12	466	291	221	168	129	96	77	43.2	30.3	23.3	19.5	16.7	14.4	12.7	11.6	11.2	5.8	
PLT 125-12	530	330	251	191	147	109	87	49.1	34.4	26.4	22.2	19.0	16.4	14.4	13.2	12.8	6.6	
PLT 160-12	678	423	321	245	188	139	111	63	44.0	33.8	28.4	24.3	20.9	18.4	16.9	16.3	8.5	
PLT 120-6	505	315	239	182	140	104	83	46.7	32.8	25.2	21.1	18.1	15.6	13.7	12.6	12.2	6.3	
PLT 140-6	594	370	281	214	164	122	97	55	38.5	29.6	24.8	21.3	18.3	16.1	14.8	14.3	7.4	

### 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	
PLT 14-12	59	36.7	27.8	21.2	16.3	12.1	9.7	5.4	3.82	2.93	2.46	2.11	1.82	1.60	1.46	1.42	0.74	
PLT 17-12	71	44.5	33.8	25.8	19.8	14.7	11.7	6.6	4.63	3.56	2.99	2.56	2.20	1.94	1.78	1.72	0.89	
PLT 20-12	84	52	39.8	30.3	23.3	17.2	13.8	7.8	5.5	4.19	3.51	3.01	2.59	2.28	2.09	2.02	1.05	
PLT 25-12	105	65	49.7	37.9	29.1	21.6	17.2	9.7	6.8	5.2	4.39	3.76	3.24	2.85	2.61	2.53	1.31	
PLT 26-12	109	68	52	39.4	30.2	22.4	17.9	10.1	7.1	5.4	4.57	3.91	3.37	2.97	2.72	2.63	1.37	
PLT 32-12	134	84	64	48.5	37.2	27.6	22.1	12.4	8.7	6.7	5.6	4.82	4.15	3.65	3.34	3.24	1.68	
PLT 38-12	160	99	76	58	44.2	32.8	26.2	14.8	10.4	8.0	6.7	5.7	4.93	4.34	3.97	3.84	2.00	
PLT 40-12	168	105	80	61	46.5	34.5	27.6	15.6	10.9	8.4	7.0	6.0	5.2	4.57	4.18	4.05	2.10	
PLT 52-12	218	136	103	79	60	44.8	35.9	20.2	14.2	10.9	9.1	7.8	6.7	5.9	5.4	5.3	2.73	
PLT 70-12	294	183	139	106	81	60	48.3	27.2	19.1	14.7	12.3	10.5	9.1	8.0	7.3	7.1	3.68	
PLT 83-12	349	217	165	126	97	72	57	32.3	22.6	17.4	14.6	12.5	10.8	9.5	8.7	8.4	4.36	
PLT 110-12	462	288	219	167	128	95	76	42.8	30.0	23.0	19.3	16.6	14.3	12.6	11.5	11.1	5.8	
PLT 125-12	525	327	249	189	145	108	86	48.6	34.1	26.2	22.0	18.8	16.2	14.3	13.1	12.6	6.6	
PLT 160-12	672	419	318	242	186	138	110	62	43.6	33.5	28.1	24.1	20.7	18.3	16.7	16.2	8.4	
PLT 120-6	500	312	237	180	138	103	82	46.3	32.4	24.9	20.9	17.9	15.4	13.6	12.4	12.0	6.2	
PLT 140-6	588	367	278	212	163	121	97	54	38.2	29.3	24.6	21.1	18.2	16.0	14.6	14.2	7.4	

### 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	
PLT 14-12	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	1.40	0.73	
PLT 17-12	71	44.1	33.5	25.5	19.6	14.5	11.6	6.6	4.59	3.53	2.96	2.53	2.18	1.92	1.76	1.70	0.88	
PLT 20-12	83	52	39.4	30.0	23.0	17.1	13.7	7.7	5.4	4.15	3.48	2.98	2.57	2.26	2.07	2.00	1.04	
PLT 25-12	104	65	49.2	37.5	28.8	21.4	17.1	9.6	6.8	5.2	4.35	3.73	3.21	2.83	2.59	2.50	1.30	
PLT 26-12	108	67	51	39.0	30.0	22.2	17.8	10.0	7.0	5.4	4.52	3.88	3.34	2.94	2.69	2.60	1.35	
PLT 32-12	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	3.21	1.66	
PLT 38-12	158	99	75	57	43.8	32.5	26.0	14.6	10.3	7.9	6.6	5.7	4.88	4.30	3.93	3.81	1.98	
PLT 40-12	166	104	79	60	46.1	34.2	27.3	15.4	10.8	8.3	7.0	6.0	5.1	4.52	4.14	4.01	2.08	
PLT 52-12	216	135	102	78	60	44.4	35.5	20.0	14.0	10.8	9.0	7.8	6.7	5.9	5.4	5.2	2.70	
PLT 70-12	291	182	138	105	81	60	47.8	27.0	18.9	14.5	12.2	10.4	9.0	7.9	7.2	7.0	3.64	
PLT 83-12	345	215	163	125	96	71	57	32.0	22.4	17.2	14.4	12.4	10.7	9.4	8.6	8.3	4.32	
PLT 110-12	458	285	217	165	127	94	75	42.4	29.7	22.8	19.1	16.4	14.1	12.4	11.4	11.0	5.7	
PLT 125-12	520	324	246	188	144	107	85	48.2	33.8	25.9	21.7	18.6	16.1	14.1	12.9	12.5	6.5	
PLT 160-12	666	415	315	240	184	137	109	62	43.2	33.2	27.8	23.9	20.6	18.1	16.6	16.0	8.3	
PLT 120-6	495	309	234	179	137	102	81	45.9	32.1	24.7	20.7	17.7	15.3	13.5	12.3	11.9	6.2	
PLT 140-6	582	363	276	210	161	120	96	54	37.8	29.0	24.4	20.9	18.0	15.8	14.5	14.0	7.3	



## Constant Current Performance at 25°C

### 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
PLT 14-12	57	35.6	27.0	20.6	15.8	11.7	9.4	5.3	3.71	2.85	2.39	2.05	1.76	1.55	1.42	1.38	0.71
PLT 17-12	69	43.2	32.8	25.0	19.2	14.2	11.4	6.4	4.50	3.46	2.90	2.49	2.14	1.89	1.73	1.67	0.87
PLT 20-12	82	51	38.6	29.4	22.6	16.8	13.4	7.6	5.3	4.07	3.41	2.92	2.52	2.22	2.03	1.97	1.02
PLT 25-12	102	64	48.3	36.8	28.3	20.9	16.7	9.4	6.6	5.1	4.26	3.66	3.15	2.77	2.54	2.46	1.28
PLT 26-12	106	66	50	38.3	29.4	21.8	17.4	9.8	6.9	5.3	4.44	3.80	3.28	2.88	2.64	2.55	1.33
PLT 32-12	131	81	62	47.1	36.2	26.8	21.4	12.1	8.5	6.5	5.5	4.68	4.03	3.55	3.25	3.14	1.63
PLT 38-12	155	97	73	56	42.9	31.8	25.5	14.4	10.1	7.7	6.5	5.6	4.79	4.21	3.86	3.73	1.94
PLT 40-12	163	102	77	59	45.2	33.5	26.8	15.1	10.6	8.1	6.8	5.8	5.0	4.44	4.06	3.93	2.04
PLT 52-12	212	132	100	77	59	43.6	34.8	19.7	13.8	10.6	8.9	7.6	6.6	5.8	5.3	5.1	2.65
PLT 70-12	286	178	135	103	79	59	46.9	26.5	18.5	14.2	11.9	10.2	8.8	7.8	7.1	6.9	3.57
PLT 83-12	339	211	160	122	94	70	56	31.4	22.0	16.9	14.2	12.1	10.5	9.2	8.4	8.2	4.23
PLT 110-12	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	5.6
PLT 125-12	510	318	241	184	141	105	84	47.2	33.1	25.4	21.3	18.3	15.7	13.9	12.7	12.3	6.4
PLT 160-12	653	407	309	236	181	134	107	60	42.4	32.5	27.3	23.4	20.2	17.7	16.2	15.7	8.2
PLT 120-6	486	303	230	175	134	100	80	45.0	31.5	24.2	20.3	17.4	15.0	13.2	12.1	11.7	6.1
PLT 140-6	571	356	270	206	158	117	94	53	37.1	28.5	23.9	20.5	17.6	15.5	14.2	13.8	7.1

### 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
PLT 14-12	56	34.9	26.5	20.2	15.5	11.5	9.2	5.2	3.64	2.79	2.34	2.01	1.73	1.52	1.39	1.35	0.70
PLT 17-12	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
PLT 20-12	80	49.9	37.9	28.9	22.2	16.4	13.1	7.4	5.2	3.99	3.34	2.87	2.47	2.17	1.99	1.93	1.00
PLT 25-12	100	62	47.3	36.1	27.7	20.5	16.4	9.3	6.5	4.99	4.18	3.58	3.09	2.72	2.49	2.41	1.25
PLT 26-12	104	65	49.2	37.5	28.8	21.4	17.1	9.6	6.8	5.2	4.35	3.73	3.21	2.83	2.59	2.50	1.30
PLT 32-12	128	80	61	46.2	35.5	26.3	21.0	11.9	8.3	6.4	5.4	4.59	3.95	3.48	3.18	3.08	1.60
PLT 38-12	152	95	72	55	42.1	31.2	25.0	14.1	9.9	7.6	6.4	5.4	4.69	4.13	3.78	3.66	1.90
PLT 40-12	160	100	76	58	44.3	32.9	26.3	14.8	10.4	8.0	6.7	5.7	4.94	4.35	3.98	3.85	2.00
PLT 52-12	208	130	98	75	58	42.7	34.1	19.3	13.5	10.4	8.7	7.5	6.4	5.7	5.2	5.0	2.60
PLT 70-12	280	175	133	101	78	57	46.0	25.9	18.2	14.0	11.7	10.0	8.6	7.6	7.0	6.7	3.50
PLT 83-12	332	207	157	120	92	68	55	30.8	21.6	16.6	13.9	11.9	10.3	9.0	8.3	8.0	4.15
PLT 110-12	440	274	208	159	122	90	72	40.8	28.6	21.9	18.4	15.8	13.6	12.0	10.9	10.6	5.5
PLT 125-12	500	312	237	180	139	103	82	46.3	32.5	24.9	20.9	17.9	15.4	13.6	12.4	12.0	6.3
PLT 160-12	640	399	303	231	177	131	105	59	41.5	31.9	26.8	22.9	19.8	17.4	15.9	15.4	8.0
PLT 120-6	476	297	225	172	132	98	78	44.1	30.9	23.7	19.9	17.1	14.7	12.9	11.8	11.5	6.0
PLT 140-6	560	349	265	202	155	115	92	52	36.4	27.9	23.4	20.1	17.3	15.2	13.9	13.5	7.0

### 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
PLT 14-12	53	33.2	25.2	19.2	14.7	10.9	8.7	4.93	3.45	2.65	2.22	1.91	1.64	1.45	1.32	1.28	0.67
PLT 17-12	65	40.3	30.6	23.3	17.9	13.3	10.6	6.0	4.19	3.22	2.70	2.32	1.99	1.76	1.61	1.56	0.81
PLT 20-12	76	47.4	36.0	27.4	21.1	15.6	12.5	7.0	4.93	3.79	3.18	2.72	2.35	2.07	1.89	1.83	0.95
PLT 25-12	95	59	45.0	34.3	26.3	19.5	15.6	8.8	6.2	4.74	3.97	3.40	2.93	2.58	2.36	2.29	1.19
PLT 26-12	99	62	46.8	35.6	27.4	20.3	16.2	9.2	6.4	4.93	4.13	3.54	3.05	2.69	2.46	2.38	1.24
PLT 32-12	122	76	58	43.9	33.7	25.0	20.0	11.3	7.9	6.1	5.1	4.36	3.75	3.31	3.03	2.93	1.52
PLT 38-12	144	90	68	52	40.0	29.6	23.7	13.4	9.4	7.2	6.0	5.2	4.46	3.93	3.59	3.48	1.81
PLT 40-12	152	95	72	55	42.1	31.2	25.0	14.1	9.9	7.6	6.4	5.4	4.69	4.13	3.78	3.66	1.90
PLT 52-12	198	123	94	71	55	40.6	32.4	18.3	12.8	9.9	8.3	7.1	6.1	5.4	4.92	4.76	2.47
PLT 70-12	266	166	126	96	74	55	43.7	24.6	17.3	13.3	11.1	9.5	8.2	7.2	6.6	6.4	3.33
PLT 83-12	315	197	149	114	87	65	52	29.2	20.5	15.7	13.2	11.3	9.7	8.6	7.8	7.6	3.94
PLT 110-12	418	261	198	151	116	86	69	38.7	27.1	20.8	17.5	15.0	12.9	11.4	10.4	10.1	5.2
PLT 125-12	475	296	225	171	132	98	78	44.0	30.8	23.7	19.9	17.0	14.7	12.9	11.8	11.4	5.9
PLT 160-12	608	379	288	219	168	125	100	56	39.5	30.3	25.4	21.8	18.8	16.5	15.1	14.6	7.6
PLT 120-6	452	282	214	163	125	93	74	41.9	29.4	22.5	18.9	16.2	14.0	12.3	11.3	10.9	5.7
PLT 140-6	532	332	252	192	147	109	87	49.3	34.5	26.5	22.2	19.1	16.4	14.5	13.2	12.8	6.7

## 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	
PLT 14-12	48.7	30.4	23.1	17.6	13.5	10.0	8.0	4.51	3.16	2.43	2.04	1.75	1.50	1.32	1.21	1.17	0.61	
PLT 17-12	59	36.9	28.0	21.3	16.4	12.1	9.7	5.5	3.84	2.95	2.47	2.12	1.83	1.61	1.47	1.42	0.74	
PLT 20-12	70	43.4	33.0	25.1	19.3	14.3	11.4	6.4	4.52	3.47	2.91	2.49	2.15	1.89	1.73	1.68	0.87	
PLT 25-12	87	54	41.2	31.4	24.1	17.9	14.3	8.1	5.6	4.34	3.64	3.12	2.69	2.36	2.16	2.10	1.09	
PLT 26-12	90	56	42.8	32.6	25.1	18.6	14.9	8.4	5.9	4.51	3.78	3.24	2.79	2.46	2.25	2.18	1.13	
PLT 32-12	111	69	53	40.2	30.8	22.9	18.3	10.3	7.2	5.6	4.66	3.99	3.44	3.03	2.77	2.68	1.39	
PLT 38-12	132	82	63	47.7	36.6	27.2	21.7	12.2	8.6	6.6	5.5	4.74	4.08	3.59	3.29	3.18	1.65	
PLT 40-12	139	87	66	50	38.6	28.6	22.9	12.9	9.0	6.9	5.8	4.99	4.30	3.78	3.46	3.35	1.74	
PLT 52-12	181	113	86	65	50	37.2	29.7	16.8	11.7	9.02	7.6	6.5	5.6	4.92	4.50	4.36	2.26	
PLT 70-12	244	152	115	88	67	50	40.0	22.6	15.8	12.1	10.2	8.7	7.5	6.6	6.1	5.9	3.05	
PLT 83-12	289	180	137	104	80	59	47.4	26.8	18.7	14.4	12.1	10.4	8.9	7.9	7.2	7.0	3.61	
PLT 110-12	383	239	181	138	106	79	63	35.5	24.8	19.1	16.0	13.7	11.8	10.4	9.5	9.2	4.79	
PLT 125-12	435	271	206	157	120	89	71	40.3	28.2	21.7	18.2	15.6	13.4	11.8	10.8	10.5	5.4	
PLT 160-12	557	347	264	201	154	114	91	52	36.1	27.8	23.3	20.0	17.2	15.1	13.9	13.4	7.0	
PLT 120-6	414	258	196	149	115	85	68	38.4	26.9	20.6	17.3	14.8	12.8	11.3	10.3	10.0	5.2	
PLT 140-6	487	304	231	176	135	100	80	45.1	31.6	24.3	20.4	17.5	15.0	13.2	12.1	11.7	6.1	

### 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	
PLT 14-12	43.7	27.2	20.7	15.8	12.1	9.0	7.2	4.05	2.84	2.18	1.83	1.57	1.35	1.19	1.09	1.05	0.55	
PLT 17-12	53	33.1	25.1	19.1	14.7	10.9	8.7	4.91	3.44	2.64	2.22	1.90	1.64	1.44	1.32	1.28	0.66	
PLT 20-12	62	38.9	29.5	22.5	17.3	12.8	10.2	5.8	4.05	3.11	2.61	2.24	1.93	1.70	1.55	1.50	0.78	
PLT 25-12	78	48.6	36.9	28.1	21.6	16.0	12.8	7.2	5.1	3.89	3.26	2.80	2.41	2.12	1.94	1.88	0.98	
PLT 26-12	81	51	38.4	29.3	22.5	16.7	13.3	7.5	5.3	4.04	3.39	2.91	2.50	2.21	2.02	1.95	1.01	
PLT 32-12	100	62	47.3	36.0	27.7	20.5	16.4	9.2	6.5	4.98	4.17	3.58	3.08	2.71	2.48	2.40	1.25	
PLT 38-12	119	74	56	42.8	32.8	24.3	19.5	11.0	7.7	5.9	4.96	4.25	3.66	3.22	2.95	2.86	1.48	
PLT 40-12	125	78	59	45.0	34.6	25.6	20.5	11.6	8.1	6.2	5.2	4.47	3.85	3.39	3.10	3.01	1.56	
PLT 52-12	162	101	77	59	44.9	33.3	26.6	15.0	10.5	8.1	6.8	5.8	5.0	4.41	4.04	3.91	2.03	
PLT 70-12	218	136	103	79	60	44.8	35.9	20.2	14.2	10.9	9.1	7.8	6.7	5.9	5.4	5.3	2.73	
PLT 83-12	259	161	123	93	72	53	42.5	24.0	16.8	12.9	10.8	9.3	8.0	7.0	6.4	6.2	3.24	
PLT 110-12	343	214	162	124	95	70	56	31.8	22.3	17.1	14.3	12.3	10.6	9.3	8.5	8.3	4.29	
PLT 125-12	390	243	185	141	108	80	64	36.1	25.3	19.4	16.3	14.0	12.0	10.6	9.7	9.4	4.88	
PLT 160-12	499	311	236	180	138	102	82	46.2	32.4	24.9	20.9	17.9	15.4	13.6	12.4	12.0	6.2	
PLT 120-6	371	231	176	134	103	76	61	34.4	24.1	18.5	15.5	13.3	11.5	10.1	9.2	8.9	4.64	
PLT 140-6	437	272	207	158	121	90	72	40.5	28.4	21.8	18.3	15.7	13.5	11.9	10.9	10.5	5.5	

## 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  $t^\circ\text{C}$ .
- 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 Telecommunications Applications

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

### Example

- |                                  |   |        |
|----------------------------------|---|--------|
| 1. Load current                  | : | 15 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

$$\begin{aligned}\text{Number of blocs required} &= \text{System voltage} / \text{Nominal voltage per bloc} \\ &= 48 / (12 \text{ or } 6) = 4 \text{ Nos of } 12\text{V or } 8 \text{ Nos of } 6 \text{ V}\end{aligned}$$

Step 2 Select K-factor from Table 2

$$\text{K factor for 5 hrs (300 minutes) discharge to end 1.75Vpc (C}_K\text{)} = 5.98$$

Step 3 Calculate discharged ampere hours

$$\begin{aligned}\text{Capacity required} &= \text{Load current} \times \text{K-factor} \\ &= 15 \times 5.98 = 89.7 \text{ Ah}\end{aligned}$$

Step 4 Apply temperature correction factor (C<sub>TC</sub>)

$$\begin{aligned}\text{Temperature correction factor for } 25^\circ\text{C (C}_{TC}\text{)} &= 1.0 \\ \text{Capacity required} &= 89.7 \times 1.0 = 89.7 \text{ Ah}\end{aligned}$$

Step 5 Apply ageing factor (C<sub>AF</sub>)

$$= 89.7 \times 1.25 = 112.2 \text{ Ah at 20 hr rate of discharge}$$

Step 6 Select monobloc type

From the monobloc range, pick the nearest higher capacity available

Monobloc Type selected : PLT 125-12 (4 Nos.) or PLT 120-6 (8 Nos)

Note: Correction factors for design margin & overload factor have not been applied since they have not been specified in this example.

## B) 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

$$\begin{aligned}\text{Current} &= \text{Load in watts} / \text{Nominal system voltage} \\ &= 10\text{W} / 12\text{V} = 0.83 \text{ amperes}\end{aligned}$$

#### 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

$$\begin{aligned}\text{Capacity required} &= \text{Current} \times \text{k-factor} \\ &= 0.83 \times 90.8 = 75.36 \text{ Ah}\end{aligned}$$

#### Step 4 Apply Temperature correction factor

$$\begin{aligned}\text{Temperature correction factor for } 25^{\circ}\text{C} (C_{TC}) &= 1.0 \\ \text{Capacity required} &= 75.36 \times 1.0 = 75.36 \text{ Ah}\end{aligned}$$

#### Step 5 Apply Ageing factor $C_{AF}$

$$\text{Capacity required} = 75.36 \times 1.25 = 94.20 \text{ Ah}$$

#### Step 6 Apply Design factor $C_{DF}$

$$\text{Capacity required} = 94.20 \times 1.1 = 103.63 \text{ Ah}$$

#### Step 7 Apply Overload factor $C_{OF}$

$$\text{Capacity required} = 103.63 \times 1.1 = 114 \text{ Ah at 20 hr rate of discharge}$$

Monobloc type selected PLT 125-12 or PLT 120-6 (2 Nos.)

### C) Battery Sizing for Duty Cycle Applications

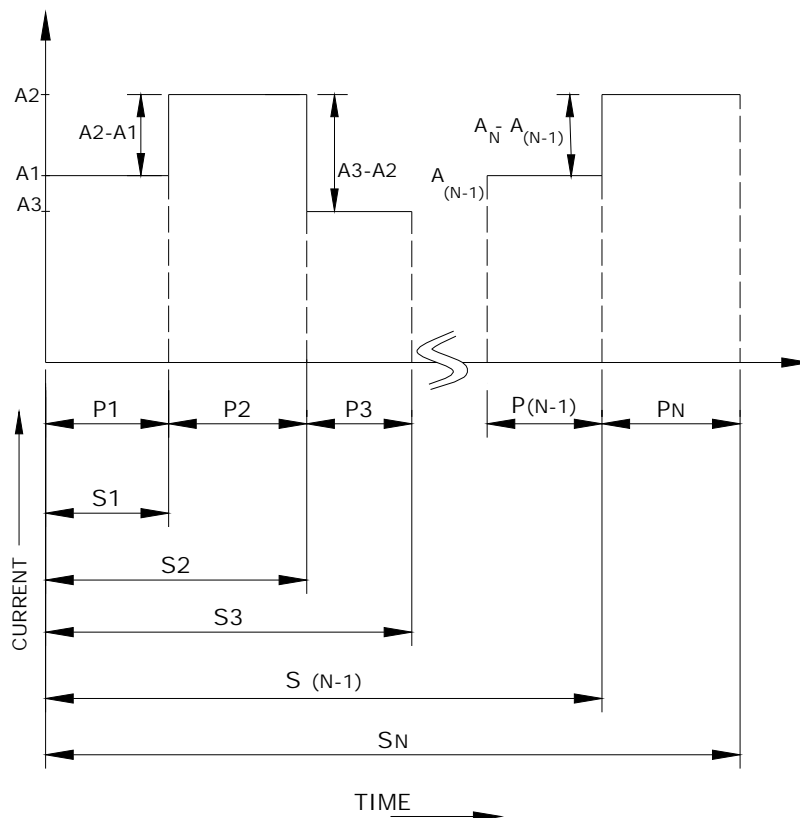
Individual DC loads supplied by the battery during the duty cycle may be classified as under:

- 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  $F_s$ ) calculated determines the uncorrected cell size that can be expressed by the following general equation.

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

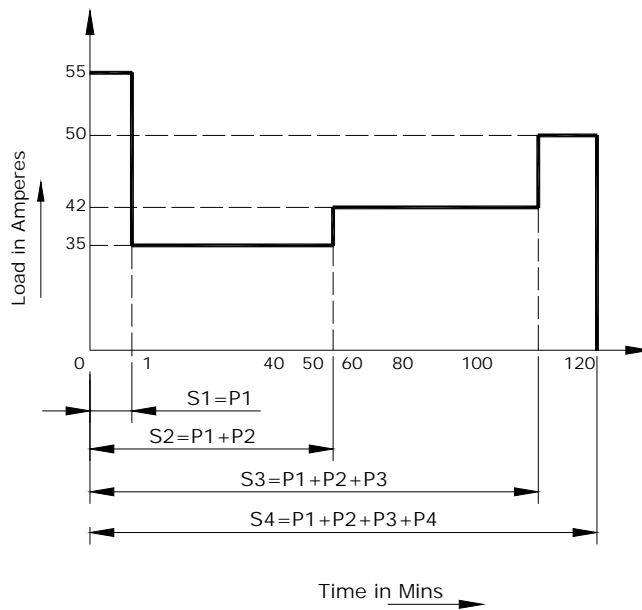
Where

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;
$A_p$	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

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=0.02	0.157	8.64
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	2.70	148.5
2	A2=35	A2-A1= -20	M2=59	T=M2+M3+M4=119 mins	2.70	-54
3	A3=42	A3-A2= 7	M3=55	T=M3+M4=60 mins	1.523	10.66
4.	A4=50	A4-A3=8	M4=5	T=M4=5 mins	0.250	2.0
Sec 4 Total						107.2
Applying temperature correction factor						
Capacity required = 107.2 x 1.0 = 107.2 Ah						
Applying Ageing factor						
Capacity required = 107.2 x 1.25 = 134.0						
Applying Design Margin						
Capacity required = 134.0 x 1.1 = 147.4 Ah at 20 hr rate of discharge						
Monobloc Type Selected PLT 160-12						

## 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	0.145	0.149	0.152	0.155	0.157	0.172	0.181	0.202
2 minutes	0.153	0.158	0.161	0.164	0.167	0.182	0.192	0.214
5 minutes	0.233	0.236	0.240	0.245	0.250	0.263	0.287	0.320
10 minutes	0.374	0.378	0.386	0.393	0.401	0.422	0.461	0.514
15 minutes	0.492	0.498	0.508	0.518	0.528	0.556	0.607	0.677
20 minutes	0.646	0.653	0.666	0.679	0.692	0.729	0.796	0.888
30 minutes	0.841	0.851	0.868	0.884	0.902	0.950	1.037	1.157
45 minutes	1.135	1.149	1.170	1.193	1.218	1.281	1.399	1.561
1 hour	1.420	1.437	1.464	1.492	1.523	1.602	1.750	1.952
2 hours	2.52	2.55	2.60	2.65	2.70	2.84	3.10	3.46
3 hours	3.59	3.63	3.70	3.77	3.85	4.05	4.43	4.94
4 hours	4.68	4.73	4.82	4.92	5.01	5.28	5.76	6.43
5 hours	5.56	5.64	5.75	5.86	5.98	6.29	6.87	7.67
6 hours	6.50	6.58	6.70	6.84	6.96	7.34	8.02	8.94
7 hours	7.54	7.64	7.78	7.94	8.10	8.52	9.31	10.38
8 hours	8.57	8.68	8.84	9.02	9.20	9.68	10.57	11.79
9 hours	9.36	9.48	9.66	9.85	10.05	10.58	11.55	12.88
10 hours	9.64	9.79	9.98	10.18	10.38	10.93	11.93	13.31
20 hours	18.10	18.87	19.23	19.61	20.00	21.1	23.0	25.6
24 hours					24.2			
48 hours					47.1			
72 hours					68.1			
96 hours					90.8			
120 hours					107.6			

## Temperature correction Factor ( $C_{TC}$ )

Table 3

Temp. (°C)	Discharge Duration in minutes															
	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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