SBS™

The Power of Thin Plate Technology

Specifiers Manual

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Introduction

Hawker Energy SBS™ Thin Plate Technology (TPT®) batteries offer exceptional performance and are designed for applications that demand a high integrity standby power source. To guarantee optimum performance it is essential to select the correct battery.

This manual will enable you to specify the most appropriate SBS™ batteries for your particular application. It includes detailed specifications for each size of SBS™ in the range together with performance data and technical information on battery sizing, charging, maintenance and storage. It also includes information on the battery stand options that are available.

Using this manual, it should be possible to specify the appropriate battery type and size without any further assistance. However, occasionally additional technical information and advice may be required and this is readily available by contacting the sales department at Newport or, where appropriate, your local distributor.

HAWKER

Specifications And Dimensions

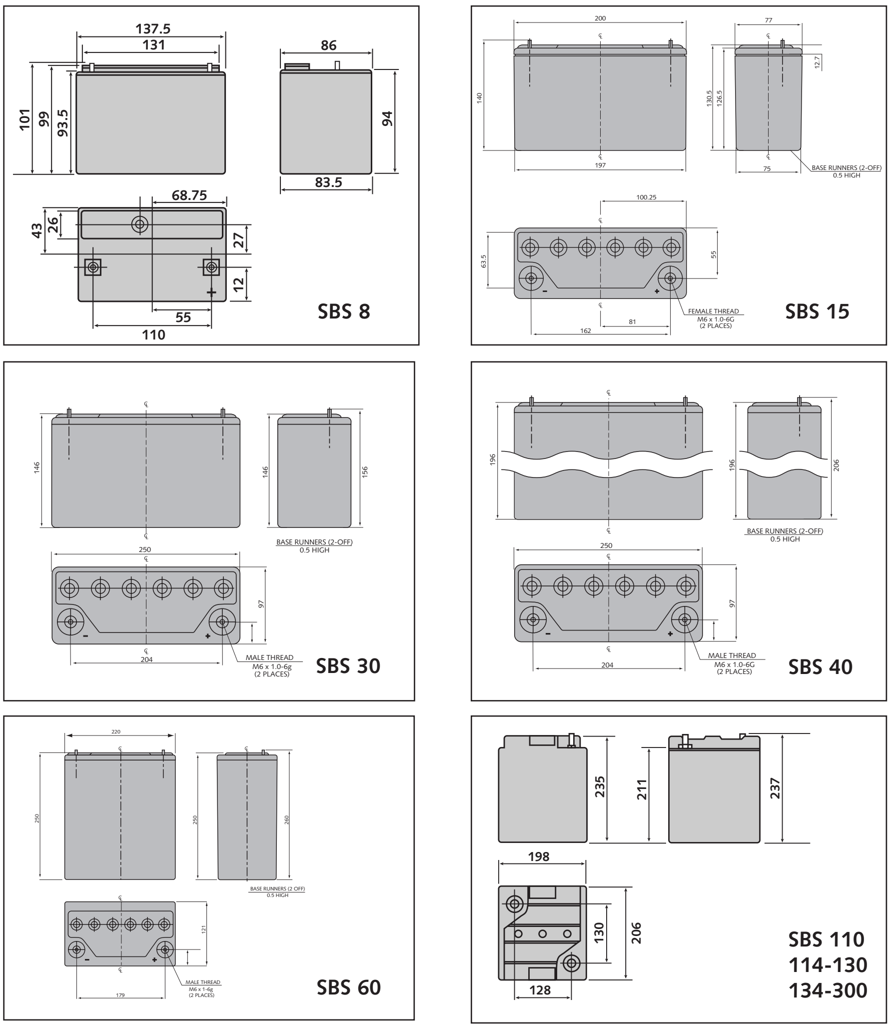
The SBS™ range offers a choice of compact 2 to 12 volt monoblocs with capacities from 7.4 to 360 Ah at the 10 hour rate. Container dimensions conform to standard telecom racking and cabinet sizes to make the most effective use of available space.

Figure 1

PRODUCT	NOMINAL VOLTAGE	CAPACITY (10HR TO 1.8VPC) @ 20°C	DIMENSIONS				WEIGHT	TERMINAL THREAD
			A	B	C	D		
SBS 8	12	7.4Ah	137.5	86	99	101	2.8	M4
SBS 15	12	14Ah	200	77	130.5	140	5.1	M6
SBS 30	12	25.8Ah	250	97	146	156	8.9	M6
SBS 40	12	36.6Ah	250	97	196	206	12.8	M6
SBS 60	12	50.8Ah	220	121	250	260	18.1	M6
SBS 110	6	115Ah	198	206	235	237	20.6	M8
SBS 114	4	115Ah	198	206	235	237	15.1	M8
SBS 130	6	132Ah	198	206	235	237	22.3	M8
SBS 134	4	132Ah	198	206	235	237	16	M8
SBS 300	2	310Ah	198	206	235	237	20.8	M8
SBS 390	2	360Ah	198	206	235	237	22.5	M8

Notes: Weight is in Kg. Dimensions are in mm. A = Length; B = Width; C = Container Height; D = Height over terminals

Figure 2



NB: The SBS 390 is manufactured with 4 terminals

HAWKER

Gas Recombination Mechanism

SBS™ TPT® batteries use gas recombination technology to offer a high-performance, low-maintenance capability. Oxygen evolved during the final stages of the recharging operation is chemically recombined, eliminating water loss. As a result, a sealed construction can be employed which eliminates the need for topping-up and together with the absorbed electrolyte system permits the battery to operate in any position (except inverted).

The chemical reaction taking place in a lead-acid storage battery is as shown in the formula below:

PbO_2	+	$2H_2SO_4$	+	Pb	Discharge ⇄ Charge	$2PbSO_4$	+	$2H_2O$
(Lead dioxide) Positive Active Lead		**(Sulphuric acid)** Electrolyte		**(Spongy lead)** Negative Active Material		**(Lead sulphate)** Pos/Neg Active Material		**(Water)** Electrolyte

The reaction at the positive electrode is

$$PbO_2 + 3H^+ + HSO_4^- + 2e \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} 2H_2O + PbSO_4$$

and at the negative electrode,

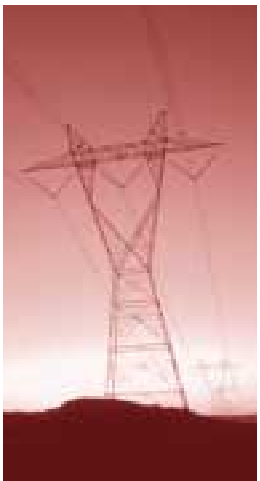
$$Pb + HSO_4^- \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} H + PbSO_4 + 2e$$

In an SBS™ TPT® VRLA battery, the cells are filled with only enough electrolyte to coat the surfaces of the plates and the individual glass strands in the separator, thus creating the 'starved-electrolyte' condition.

During discharge lead dioxide in the positive plates and spongy lead in the negative plates react with sulphuric acid in the electrolyte and gradually transform into lead sulphate, during which the sulphuric acid concentration decreases.

When the cell is recharged, finely divided particles of $PbSO_4$ are electrochemically converted to spongy lead at the negative electrode and PbO_2 at the positive electrode by the charging source, driving current through the battery. As the cell approaches complete recharge the overcharge reactions begin. The result of these reactions is the production of hydrogen and oxygen gas and subsequent loss of water.

The pressure release (Bunsen) valve maintains an internal pressure of between 4 and 6 p.s.i. This retains gases within the cell causing the water to be electrochemically cycled taking up the excess overcharge current beyond what is used for conversion of active material. Conversion is therefore possible of virtually all of the active material without loss of water, especially at the recommended recharge rates. Charging at higher rates is not so efficient thus resulting in a shortened battery life because of faster grid corrosion and increased water loss.



Battery Sizing

Each of the examples on the following page gives a step-by-step guide to sizing batteries to ensure that they meet the required duty load. They should be read in conjunction with the performance tables on pages 10 - 14. For split duty regimes and for other more complex, sizing it is advisable to contact the sales department.

BATTERY SIZING

Some commonly used power relationships:

DC Power = (DC Voltage) x (DC Current)

AC Power = (AC Voltage) x (AC Current) x (PF)

The two examples listed below have been deliberately simplified in order to illustrate the processes involved in determining the correct battery sizing for system's back-up requirements. The sizings here are based on a battery temperature of 20°C. The effect of excursions different from this temperature is shown in the 2 tables on page 18.

In general, UPS systems are rated in KVA, (Kilo Volt Amperes). This is a multiplication of the output voltage in Kilo Volts and output current in amperes. The KVA rating is always an AC rating. The KVA rating may be converted to KW by simply multiplying the KVA by the Power Factor (PF).

KW Rating of UPS = (KVA of UPS) x (PF of UPS)

KW Rating of UPS Battery = <u>KVA x PF</u>
Inverter Efficiency

EXAMPLE 1

This first example covers a basic sizing procedure with no power factor or efficiency involvement. This procedure details only the fundamental steps required.

In an example such as this the following information is needed as a minimum requirement:
(i) system kilowatts
(ii) required autonomy (run time)
(iii) minimum DC voltage
(iv) maximum DC voltage

If the load is given in KVA, then the PF and inverter efficiency values must also be known.
Therefore, for a UPS requiring the following autonomy,
Battery KW Rating: 10
Battery nominal voltage: 120
Battery end voltage: 1.67 Vpc
Battery run time: 10 minutes

Step 1:

Number of cells needed per string = 120 (nom.volt) /2 (nominal cell voltage)

= 60 cells

Step 2:

Watts per cell required to support load = 10,000 (watts) /60 (cells)

= 166.67 watts per cell

Once the required watts per cell are determined, the appropriate battery rating chart should be consulted to determine the most suitable battery type for the system back-up requirements.

Step 3:

Consult the discharge tables referencing end point voltage to 1.67 Vpc. From the table read down the column for the required battery run time i.e 10 mins.

Step 4:

Having determined the correct battery type it is then necessary to calculate the quantity of batteries required per string. Number of batteries per string = No. of cells x the nominal voltage of selected battery type.

Step 5:

By reference to the tables it can be seen that 166.67 Wpc can easily be supported by the SBS 40 product which is in fact capable of 205 Wpc for 10 mins.

EXAMPLE 2

This example is slightly more complex in that it takes into account both the power factor and the system efficiency.

UPS KVA rating: 10.0
Inverter power factor: 0.80
Inverter efficiency: 85%
Battery nominal voltage: 120
Battery end-voltage: 1.67 Vpc
Battery run time:15 minutes

Step 1:

Total power required from battery = <u>KVA x PF</u>
Inverter Efficiency

=<u>10.000</u><u>(KVA)</u>**<u>x0.80</u>**<u>(PF)</u>
0.85 (Inv.eff)

= **9.412 KW**

Step 2:

Watts per cell required to support load

= **Total power required from battery**
no. of cells

= <u>9412</u> <u>(watts)</u>
60 (cells)

= 156.9 watts per cell

Once the required watts per cell are determined, the appropriate battery rating chart should be consulted to determine the most suitable battery type for the system back-up requirements.

Step 3:

Consult the discharge tables referencing end point voltage to 1.67 Vpc. From the table read down the column for the required battery run time i.e 15 mins.

Step 4:

By reference to the tables it can be seen that 159.6 Wpc can easily be supported by the SBS 60 product which is in fact capable of 206 Wpc for 15 mins.

With both of these examples by reference to the discharge tables it is possible to use a parallel string system with smaller SBS™ types in the configuration.

These are basic examples for split duty regime and for other more complex sizings, contact our sales department.

Service Life And Float Life

The long service life of the SBS™ TPT® battery is a product of the Pure Lead grain structure.

The SBS™ long float life is the result of Hawker's extensive research into:

- advanced grid metallurgy
- high purity materials
- advanced electro - chemical design

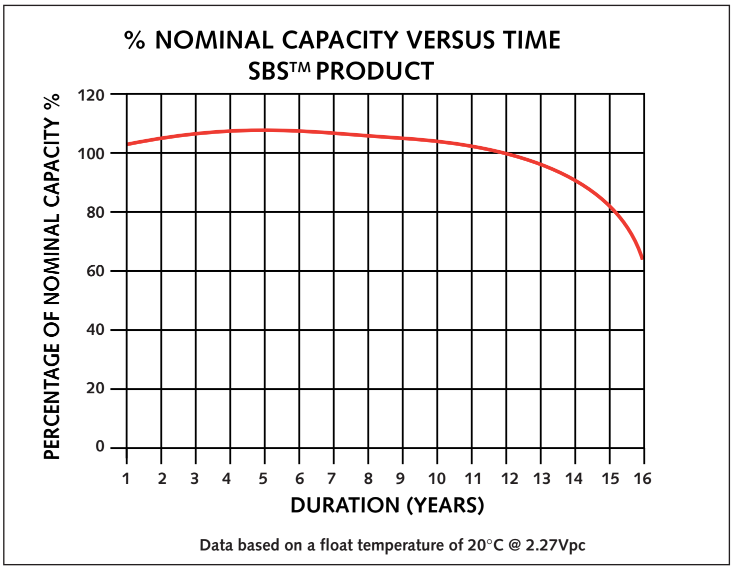


Figure 4

Service Life And Float Life

The table below shows the life expectancy, in years, for an SBS™ product when operated at a constant 20°C temperature except for annual excursions throughout its life, for a number of months to a specific temperature.

Figure 5

Months/ year	20°C	25°C	30°C	35°C	40°C	45°C	50°C	55°C
1	15.0	14.6	14.2	13.8	13.4	13.0	12.6	12.3
2	15.0	14.2	13.4	12.6	11.9	11.3	10.6	10.0
3	15.0	13.8	12.6	11.6	10.6	9.7	8.9	8.2
4	15.0	13.4	11.9	10.6	9.5	8.4	7.5	6.7
5	15.0	13.0	11.3	9.7	8.4	7.3	6.3	5.5
6	15.0	12.6	10.6	8.9	7.5	6.3	5.3	4.5
7	15.0	12.3	10.0	8.2	6.7	5.5	4 5	3.7
8	15.0	11.9	9.5	7.5	6.0	4.7	3.8	3.0
9	15.0	11.6	8.9	6.9	5.3	4. 1	3.2	2.5
10	15.0	11.3	8.4	6.3	4.7	3.6	2.7	2.0
11	15.0	l0.9	8.0	5.8	4.2	3.1	2.2	1.6
12	15.0	10.6	7.5	5.3	3.8	2.7	1.9	1.3

Notes:
1) Applies to 12V, 6V, 4V and 2V SBS™ monoblocs

Energy Density

GRAVAMETRIC / VOLAMETRIC ENERGY DENSITIES

DISCHARGE RATE / 20 CELSIUS / TO 1.70 VPC						
	5 MIN	30 MIN	1 HOUR	C 3	C 10	C 20
Amp Hour/ Kilo (Ah/Kg)	1.2	2.0	2.3	2.7	3.1	3.4
Amp Hour/ Litre (Ah/l)	3.2	5.2	6.0	7.0	7.9	8.8
Amp Hour/ Kilo (WH/Kg)	14.5	21.5	27	33.0	38.0	41
Amp Hour/ Litre (W/l)	37.3	57	70	85.4	98.4	111
Watts/Kg (W/Kg)	162	46.4	27	10.5	3.7	2.1
Watts/Litre (W/l)	418	120	71	28	9.5	5.3

PERFORMANCE TABLES

Performance Tables
Constant Power and Constant Current

Discharge Performance

End voltage = 1.85 Vpc

CONSTANT POWER DISCHARGE (watts per cell)

	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	80.9	63.3	45.7	35.8	29.4	25.0	21.7	19.2	17.2	15.5	12.1	6.33	4.27	3.22	2.59	2.17	1.86	1.64	1.46	1.32	0.69
SBS 15	170	112	75.2	58.0	47.6	40.7	35.6	31.7	28.7	26.2	20.9	11.8	8.32	6.47	5.31	4.51	3.92	3.48	3.12	2.84	1.51
SBS 30	322	208	139	107	87.5	74.6	65.2	58.1	52.4	47.9	38.1	21.5	15.1	11.8	9.62	8.17	7.10	6.29	5.64	5.12	2.70
SBS 40	363	262	184	145	121	104	91.2	81.6	73.9	67.6	54.1	30.6	21.6	16.7	13.7	11.6	10.1	8.92	8.00	7.26	3.81
SBS 60	449	326	233	185	155	134	118	106	96.3	88.4	71.2	41.0	29.2	22.8	18.7	16.0	13.9	12.3	11.1	10.1	5.34
SBS 110	670	532	402	329	281	247	221	200	184	170	139	83.8	61.1	48.5	40.4	34.7	30.5	27.3	24.7	22.6	12.5
SBS 130	924	693	509	411	348	304	271	245	224	207	169	101	72.9	57.5	47.6	40.7	35.7	31.7	28.6	26.1	14.0
SBS 300	-	1169	1053	901	793	701	630	565	516	456	381	206	148	119	101	87.3	77.9	70.4	64.9	59.9	33.2
SBS 390	1759	1574	1267	1064	923	822	735	671	617	569	468	277	201	158	130	113	98.2	87.4	78.8	71.5	38.4

Discharge Performance

End voltage = 1.85 Vpc

CONSTANT CURRENT DISCHARGE (amps)

	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	53.7	33.6	21.7	16.3	13.2	11.1	9.61	8.49	7.62	6.92	5.45	3.01	2.11	1.63	1.34	1.14	1.00	0.89	0.80	0.73	0.40
SBS 15	91.6	59.3	39.3	30.0	24.5	20.8	18.1	16.1	14.5	13.2	10.5	5.83	4.09	3.17	2.59	2.20	1.91	1.69	1.52	1.38	0.73
SBS 30	174	110	72.4	55.1	45.0	38.2	33.3	29.6	26.6	24.3	19.3	10.8	7.56	5.85	4.79	4.07	3.53	3.13	2.81	2.55	1.35
SBS 40	196	139	96.5	75.3	62.2	53.3	46.7	41.7	37.6	34.4	27.4	15.4	10.8	8.33	6.81	5.77	5.01	4.43	3.97	3.60	1.90
SBS 60	243	173	122	95.9	79.8	68.7	60.5	54.2	49.1	45.0	36.1	20.6	14.6	11.4	9.34	7.94	6.91	6.12	5.50	5.00	2.65
SBS 110	344	290	223	183	156	137	122	110	101	92.9	75.7	44.4	31.9	25.1	20.7	17.7	15.5	13.8	12.4	11.4	6.19
SBS 130	505	370	268	215	181	157	140	126	115	106	86.3	50.8	36.6	28.8	23.8	20.3	17.8	15.8	14.3	13.0	6.94
SBS 300	-	826	622	500	413	357	310	282	255	239	187	109	78.1	62.0	52.0	45.3	40.3	36.1	32.8	30.6	17.2
SBS 390	979	866	683	567	488	429	385	349	319	295	241	142	102	79.7	65.8	55.9	48.7	43.5	39.0	35.7	19.0

Discharge Performance

End voltage = 1.80 Vpc

CONSTANT POWER DISCHARGE (watts per cell)

	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	88.2	66.3	46.9	36.4	29.8	25.3	21.9	19.3	17.3	15.7	12.2	6.39	4.33	3.27	2.63	2.20	1.89	1.67	1.49	1.34	0.70
SBS 15	186	117	77.1	58.9	48.2	41.1	35.9	32.0	28.9	26.4	21.0	11.9	8.39	6.53	5.36	4.55	3.96	3.51	3.16	2.87	1.51
SBS 30	352	219	143	109	89.2	75.9	66.3	58.9	53.2	48.5	38.6	21.7	15.3	11.9	9.74	8.27	7.19	6.36	5.71	5.19	2.72
SBS 40	405	277	191	149	123	106	92.8	82.9	75.0	68.6	54.9	31.1	21.9	17.0	13.9	11.8	10.2	9.05	8.12	7.36	3.84
SBS 60	514	352	244	191	159	137	121	108	98.2	90.0	72.4	41.7	29.7	23.2	19.0	16.2	14.1	12.5	11.3	10.2	5.39
SBS 110	758	582	432	350	297	259	231	209	192	177	145	86.3	62.7	49.6	41.3	35.4	31.1	27.8	25.1	23.0	12.6
SBS 130	1029	745	537	430	362	315	280	252	231	213	173	103	74.1	58.4	48.4	41.4	36.2	32.2	29.0	26.4	14.1
SBS 300	-	1480	1240	1037	870	752	664	594	541	497	401	235	165	129	109	92.7	81.9	73.3	66.7	61.2	33.2
SBS 390	1993	1699	1335	1108	956	850	754	690	635	584	477	284	204	160	132	114	99.3	88.3	79.5	72.2	38.6

Discharge Performance

End voltage = 1.80 Vpc

CONSTANT CURRENT DISCHARGE (amps)

	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	58.7	35.5	22.5	16.8	13.5	11.3	9.81	8.66	7.76	7.04	5.54	3.05	2.13	1.66	1.36	1.16	1.01	0.90	0.81	0.74	0.41
SBS 15	102	62.8	40.6	30.8	25.0	21.2	18.4	16.3	14.7	13.4	10.6	5.91	4.15	3.22	2.63	2.23	1.94	1.72	1.54	1.40	0.74
SBS 30	193	117	75.5	57.0	46.2	39.1	34.0	30.2	27.2	24.7	19.6	10.9	7.66	5.93	4.86	4.12	3.58	3.17	2.85	2.58	1.36
SBS 40	223	149	101	78.0	64.1	54.6	47.8	42.6	38.4	35.0	27.9	15.6	10.9	8.46	6.91	5.86	5.08	4.49	4.03	3.66	1.92
SBS 60	284	190	129	100	82.9	71.0	62.3	55.7	50.4	46.1	36.9	21.0	14.9	11.6	9.49	8.06	7.02	6.22	5.59	5.08	2.68
SBS 110	405	321	239	193	163	142	126	114	104	95.7	77.6	45.3	32.5	25.5	21.0	18.0	15.7	14.0	12.6	11.5	6.26
SBS 130	576	405	286	227	190	164	145	131	119	110	88.8	51.9	37.3	29.3	24.2	20.7	18.1	16.1	14.5	13.2	7.03
SBS 300	-	870	664	548	471	400	346	313	282	253	201	116	83.7	66.2	54.3	47.8	41.6	37.4	34.3	31.0	17.3
SBS 390	1132	952	733	602	511	447	401	363	331	304	247	145	103	80.8	66.5	56.6	49.3	43.9	39.4	36.0	19.2

Discharge Performance

End voltage = 1.75 Vpc

CONSTANT POWER DISCHARGE (watts per cell)

	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	95.9	69.1	47.8	36.9	30.1	25.4	22.0	19.4	17.4	15.7	12.2	6.46	4.38	3.32	2.67	2.24	1.93	1.70	1.52	1.37	0.72
SBS 15	201	122	78.8	59.8	48.8	41.5	36.2	32.2	29.1	26.5	21.1	12.0	8.46	6.58	5.41	4.60	4.00	3.55	3.19	2.89	1.52
SBS 30	381	229	147	112	90.8	77.1	67.2	59.7	53.8	49.1	39.0	22.0	15.5	12.0	9.85	8.36	7.27	6.44	5.78	5.24	2.74
SBS 40	446	292	197	152	126	107	94.2	84.0	76.0	69.5	55.5	31.4	22.2	17.2	14.1	11.9	10.4	9.17	8.22	7.45	3.86
SBS 60	578	377	255	198	163	140	123	110	100	91.6	73.6	42.2	30.1	23.5	19.3	16.4	14.3	12.7	11.4	10.4	5.44
SBS 110	848	631	460	369	311	271	241	218	199	183	149	88.6	64.2	50.7	42.1	36.1	31.7	28.3	25.5	23.3	12.7
SBS 130	1134	795	562	447	374	324	288	259	236	218	177	104	75.3	59.3	49.1	41.9	36.7	32.6	29.4	26.8	14.3
SBS 300	-	1575	1247	1042	877	758	671	602	547	503	409	238	168	131	110	93.9	82.8	74.0	67.2	61.6	33.3
SBS 390	2198	1813	1399	1152	989	876	776	709	651	598	487	289	207	162	134	113	101	89.5	80.6	73.1	39.0

Discharge Performance

End voltage = 1.75 Vpc

CONSTANT CURRENT DISCHARGE (amps)

	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	63.5	37.3	23.3	17.3	13.8	11.6	10.0	8.83	7.91	7.17	5.62	3.09	2.16	1.68	1.38	1.17	1.02	0.91	0.82	0.75	0.41
SBS 15	112	66.1	41.9	31.5	25.5	21.5	18.7	16.6	14.9	13.6	10.7	5.99	4.21	3.26	2.67	2.27	1.97	1.75	1.57	1.42	0.75
SBS 30	213	124	78.3	58.6	47.4	40.0	34.7	30.7	27.6	25.1	19.9	11.1	7.76	6.01	4.92	4.17	3.63	3.21	2.88	2.61	1.37
SBS 40	251	160	105	80.4	65.7	55.9	48.8	43.3	39.1	35.6	28.3	15.8	11.1	8.58	7.01	5.94	5.15	4.60	4.08	3.70	1.93
SBS 60	327	206	136	105	85.8	73.1	64.0	57.0	51.6	47.1	37.6	21.3	15.1	11.7	9.63	8.18	7.12	6.31	5.66	5.14	2.70
SBS 110	471	352	254	203	170	147	131	117	107	98.2	79.3	46.1	33.0	25.8	21.3	18.2	15.9	14.2	12.8	11.7	6.32
SBS 130	652	440	303	238	198	171	151	135	123	113	91.1	52.9	37.9	29.8	24.6	21.0	18.3	16.3	14.7	13.4	7.12
SBS 300	-	986	731	581	492	421	381	333	300	275	216	123	87.0	67.8	56.7	49.2	42.4	37.7	34.5	31.5	17.3
SBS 390	1305	1041	780	630	534	465	414	373	340	314	254	148	105	81.9	67.4	57.2	50.1	44.3	39.7	36.2	19.3

Discharge Performance

End voltage = 1.70 Vpc

CONSTANT POWER DISCHARGE (watts per cell)

	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	104	71.6	48.5	37.1	30.2	25.5	22.1	19.5	17.4	15.8	12.3	6.53	4.45	3.38	2.72	2.29	1.97	1.73	1.55	1.40	0.73
SBS 15	215	126	80.3	60.6	49.3	41.8	36.5	32.5	29.3	26.7	21.3	12.0	8.52	6.64	5.45	4.63	4.03	3.57	3.21	2.92	1.53
SBS 30	408	238	151	114	92.2	78.1	68.0	60.4	54.4	49.6	39.4	22.2	15.6	12.1	9.95	8.45	7.34	6.50	5.83	5.29	2.76
SBS 40	485	305	202	155	128	109	95.4	85.1	76.9	70.3	56.1	31.8	22.4	17.4	14.3	12.1	10.5	9.26	8.30	7.52	3.88
SBS 60	638	399	264	203	167	143	126	112	102	93.0	74.6	42.8	30.4	23.7	19.5	16.6	14.5	12.8	11.5	10.5	5.47
SBS 110	938	677	485	386	324	281	250	225	205	189	154	90.6	65.4	51.6	42.8	36.7	32.1	28.7	25.9	23.6	12.8
SBS 130	1239	842	586	462	386	333	295	265	242	222	180	106	76.3	60.0	49.7	42.4	37.1	33.0	29.8	27.1	14.4
SBS 300	-	1645	1314	1081	914	793	698	618	562	516	412	245	173	134	114	94.8	83.5	74.3	67.6	61.8	33.3
SBS 390	2447	1930	1455	1189	1014	899	793	724	663	609	496	294	209	164	136	117	102	90.3	81.3	74.0	39.2

Discharge Performance

End voltage = 1.70 Vpc

CONSTANT CURRENT DISCHARGE (amps)

	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	68.1	39.0	24.0	17.7	14.1	11.8	10.2	8.99	8.04	7.29	5.71	3.13	2.19	1.70	1.40	1.19	1.04	0.92	0.83	0.76	0.42
SBS 15	122	69.1	43.0	32.1	25.9	21.8	18.9	16.8	15.1	13.7	10.8	6.05	4.26	3.30	2.71	2.30	2.00	1.77	1.59	1.44	0.76
SBS 30	231	130	80.8	60.1	48.3	40.7	35.3	31.2	28.0	25.5	20.1	11.2	7.85	6.08	4.97	4.22	3.67	3.24	2.91	2.64	1.38
SBS 40	278	169	109	82.5	67.1	56.9	49.6	44.0	39.7	36.1	28.6	16.0	11.2	8.69	7.10	6.01	5.22	4.61	4.13	3.74	1.94
SBS 60	369	222	143	108	88.3	75.0	65.5	58.2	52.6	48.0	38.2	21.6	15.3	11.9	9.75	8.28	7.21	6.38	5.73	5.20	2.72
SBS 110	540	382	268	211	176	152	134	120	109	100	80.8	46.7	33.4	26.2	21.6	18.5	16.1	14.4	12.9	11.8	6.38
SBS 130	731	474	320	248	205	176	155	139	126	116	93.0	53.8	38.5	30.2	24.9	21.3	18.6	16.5	14.9	13.5	7.20
SBS 300	-	1062	772	614	518	448	397	353	316	289	221	127	88.6	68.8	58.0	49.6	42.8	38.0	34.8	31.6	17.3
SBS 390	1504	1133	823	658	554	481	426	384	347	321	259	149	107	83.1	68.2	58.2	50.6	45.0	40.3	36.7	19.4

Discharge Performance

End voltage = 1.67 Vpc

CONSTANT POWER DISCHARGE (watts per cell)																					
	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	109	72.9	48.8	37.2	30.2	25.5	22.1	19.5	17.4	15.8	12.3	6.57	4.49	3.41	2.76	2.32	2.00	1.76	1.57	1.42	0.74
SBS 15	222	128	81.1	61.0	49.6	42.0	36.7	32.6	29.4	26.8	21.3	12.1	8.56	6.66	5.47	4.65	4.05	3.59	3.22	2.93	1.53
SBS 30	422	242	153	115	92.9	78.6	68.4	60.7	54.7	49.9	39.6	22.3	15.7	12.2	10.0	8.49	7.38	6.53	5.86	5.32	2.77
SBS 40	506	312	205	157	129	110	96.0	85.6	77.4	70.7	56.4	32.0	22.6	17.5	14.3	12.1	10.5	9.31	8.34	7.55	3.88
SBS 60	669	410	269	206	169	145	127	113	102	93.7	75.1	43.0	30.6	23.9	19.6	16.7	14.5	12.9	11.6	10.5	5.49
SBS 110	990	702	498	395	331	287	254	229	209	192	156	91.7	66.1	52.1	43.2	37.0	32.4	28.9	26.1	23.8	12.9
SBS 130	1301	869	599	471	392	338	299	269	244	225	182	107	76.8	60.4	50.0	42.7	37.3	33.2	29.9	27.2	14.5
SBS 300	-	1679	1325	1093	930	798	705	623	566	521	417	248	174	135	114	95.6	84.1	74.8	68.0	62.3	33.3
SBS 390	2575	1987	1481	1207	1027	910	801	733	670	612	501	294	211	166	136	117	102	90.8	81.9	74.3	39.2

Discharge Performance

End voltage = 1.67 Vpc

CONSTANT CURRENT DISCHARGE (amps)																					
	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	70.6	39.9	24.4	18.0	14.3	12.0	10.3	9.08	8.13	7.36	5.77	3.16	2.21	1.72	1.41	1.20	1.05	0.93	0.84	0.76	0.42
SBS 15	127	70.7	43.6	32.4	26.1	22.0	19.1	16.9	15.2	13.8	10.9	6.09	4.29	3.33	2.73	2.31	2.01	1.78	1.60	1.45	0.76
SBS 30	242	134	82.1	60.8	48.8	41.1	35.6	31.4	28.2	25.7	20.2	11.3	7.89	6.12	5.01	4.24	3.69	3.26	2.93	2.66	1.39
SBS 40	294	174	111	83.6	67.8	57.4	50.0	44.4	39.9	36.4	28.8	16.1	11.3	8.75	7.15	6.05	5.25	4.64	4.16	3.77	1.94
SBS 60	393	230	146	110	89.6	76.0	66.2	58.9	53.1	48.4	38.5	21.8	15.4	12.0	9.82	8.34	7.25	6.42	5.77	5.23	2.73
SBS 110	582	399	276	216	180	154	136	122	111	101	81.6	47.1	33.6	26.4	21.8	18.6	16.2	14.4	13.0	11.9	6.41
SBS 130	780	493	329	254	209	179	158	141	128	117	94.1	54.3	38.8	30.4	25.1	21.4	18.7	16.6	15.0	13.6	7.24
SBS 300	-	1080	788	621	522	447	397	355	318	289	222	128	89.2	69.4	58.4	49.6	42.8	38.2	34.8	31.7	17.3
SBS 390	1636	1186	849	675	565	487	432	387	354	323	262	151	107	83.9	68.9	58.6	50.9	45.2	40.5	36.9	19.4

Discharge Performance

End voltage = 1.65 Vpc

CONSTANT POWER DISCHARGE (watts per cell)																					
	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	112	73.7	48.9	37.2	30.2	25.4	22.0	19.4	17.4	15.8	12.3	6.59	4.52	3.44	2.78	2.34	2.02	1.78	1.59	1.44	0.75
SBS 15	226	129	81.5	61.3	49.8	42.2	36.7	32.7	29.5	26.9	21.4	12.1	8.58	6.68	5.49	4.66	4.06	3.60	3.23	2.93	1.53
SBS 30	431	245	154	115	93.3	78.9	68.7	60.9	54.9	50.0	39.7	22.3	15.8	12.3	10.0	8.52	7.41	6.55	5.88	5.33	2.77
SBS 40	519	316	207	158	129	110	96.4	85.9	77.6	70.9	56.6	32.1	22.6	17.6	14.4	12.2	10.6	9.34	8.36	7.57	3.88
SBS 60	688	417	272	208	170	145	127	114	103	94.2	75.5	43.2	30.7	24.0	19.7	16.8	14.6	12.9	11.6	10.5	5.50
SBS 110	1023	718	507	401	335	290	257	231	211	194	157	92.3	66.5	52.4	43.4	37.2	32.5	29.0	26.2	23.9	12.9
SBS 130	1340	886	607	476	395	341	301	271	246	226	183	107	77.1	60.7	50.2	42.9	37.5	33.3	30.0	27.3	14.6
SBS 300	-	1745	1344	1111	946	810	709	629	567	523	419	252	176	137	115	95.9	84.2	74.8	68.0	62.3	33.3
SBS 390	2713	2043	1509	1221	1036	917	808	735	672	617	502	296	212	166	138	118	103	91.2	82.1	74.6	39.3

Discharge Performance

End voltage = 1.65 Vpc

CONSTANT CURRENT DISCHARGE (amps)																					
	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	72.2	40.5	24.7	18.1	14.4	12.1	10.4	9.15	8.18	7.41	5.80	3.18	2.23	1.73	1.42	1.21	1.05	0.94	0.84	0.77	0.42
SBS 15	130	71.6	43.9	32.6	26.2	22.1	19.1	16.9	15.2	13.8	10.9	6.11	4.30	3.34	2.74	2.32	2.02	1.79	1.61	1.46	0.76
SBS 30	248	136	82.8	61.2	49.1	41.3	35.7	31.6	28.4	25.8	20.3	11.3	7.92	6.14	5.03	4.26	3.70	3.28	2.94	2.67	1.39
SBS 40	304	177	112	84.2	68.2	57.7	50.2	44.5	40.1	36.5	28.9	16.2	11.4	8.79	7.18	6.08	5.27	4.66	4.17	3.78	1.94
SBS 60	408	235	148	111	90.4	76.6	66.7	59.3	53.4	48.7	38.7	21.9	15.4	12.0	9.86	8.37	7.28	6.45	5.79	5.25	2.74
SBS 110	610	410	281	219	181	156	137	123	111	102	82.1	47.3	33.8	26.5	21.9	18.7	16.3	14.5	13.1	11.9	6.42
SBS 130	813	506	335	257	212	181	159	142	129	118	94.7	54.6	39.0	30.5	25.2	21.5	18.8	16.7	15.0	13.7	7.26
SBS 300	-	1105	800	633	532	449	398	354	318	290	226	130	89.7	69.7	58.9	49.8	43.1	38.2	35.0	31.8	17.3
SBS 390	1731	1223	863	684	571	492	434	390	354	325	264	152	109	84.3	69.4	58.8	51.3	45.5	40.8	37.1	19.4

Discharge Performance

End voltage = 1.63 Vpc

CONSTANT POWER DISCHARGE (watts per cell)																					
	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	115	74.5	49.0	37.2	30.1	25.4	22.0	19.4	17.4	15.8	12.3	6.62	4.55	3.47	2.81	2.36	2.04	1.80	1.61	1.45	0.76
SBS 15	230	130	81.9	61.5	49.9	42.3	36.8	32.7	29.5	26.9	21.4	12.1	8.60	6.70	5.50	4.68	4.07	3.61	3.24	2.94	1.54
SBS 30	439	247	155	116	93.6	79.2	68.9	61.1	55.1	50.2	39.8	22.4	15.8	12.3	10.1	8.55	7.43	6.57	5.90	5.35	2.78
SBS 40	532	320	208	159	130	111	96.7	86.2	77.9	71.1	56.8	32.2	22.7	17.6	14.4	12.2	10.6	9.36	8.38	7.59	3.88
SBS 60	705	423	274	209	172	146	128	114	103	94.6	75.8	43.3	30.8	24.0	19.8	16.8	14.6	13.0	11.6	10.6	5.50
SBS 110	1055	733	514	406	339	293	260	233	213	195	158	92.9	66.9	52.7	43.6	37.3	32.7	29.1	26.2	23.9	12.9
SBS 130	1379	902	615	481	399	344	303	272	247	227	184	108	77.4	60.9	50.4	43.0	37.6	33.4	30.1	27.4	14.6
SBS 300	-	1753	1352	1116	951	817	714	634	572	527	424	254	177	137	115	96.0	84.4	74.9	68.2	62.3	33.3
SBS 390	2776	2065	1568	1227	1040	922	810	740	675	620	505	298	213	168	138	119	104	91.5	82.5	74.8	39.3

Discharge Performance

End voltage = 1.63 Vpc

CONSTANT CURRENT DISCHARGE (amps)																					
	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	73.7	41.0	24.9	18.3	14.6	12.2	10.5	9.21	8.23	7.46	5.84	3.20	2.24	1.74	1.43	1.21	1.06	0.94	0.85	0.77	0.42
SBS 15	133	72.4	44.2	32.7	26.3	22.1	19.2	17.0	15.3	13.9	11.0	6.13	4.32	3.35	2.75	2.33	2.03	1.80	1.61	1.46	0.76
SBS 30	255	138	83.5	61.6	49.4	41.5	35.9	31.7	28.5	25.9	20.4	11.3	7.95	6.16	5.04	4.28	3.72	3.29	2.95	2.68	1.39
SBS 40	314	180	113	84.7	68.6	58.0	50.4	44.7	40.3	36.6	29.0	16.2	11.4	8.82	7.21	6.10	5.29	4.67	4.18	3.79	1.94
SBS 60	422	239	150	113	91.1	77.1	67.1	59.6	53.7	49.0	38.9	21.9	15.5	12.1	9.89	8.40	7.31	6.47	5.81	5.27	2.75
SBS 110	637	421	285	222	183.	157	138	124	112	103	82.5	47.5	33.9	26.6	21.9	18.7	16.4	14.6	13.1	12.0	6.44
SBS 130	846	518	340	260	214	183	160	143	130	119	95.2	54.8	39.1	30.7	25.3	21.6	18.8	16.7	15.1	13.7	7.29
SBS 300	-	1123	800	640	539	450	395	354	318	290	227	130	90.2	69.1	59.0	49.8	43.4	38.3	35.0	31.8	17.3
SBS 390	1827	1260	879	692	576	497	439	394	356	327	265	153	109	84.7	69.7	59.1	51.4	45.6	41.0	37.3	19.4

Discharge Performance

End voltage = 1.60 Vpc

CONSTANT POWER DISCHARGE (watts per cell)																					
	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	120	75.4	49.1	37.0	30.0	25.3	21.9	19.3	17.3	15.7	12.3	6.66	4.59	3.51	2.85	2.40	2.07	1.83	1.63	1.48	0.77
SBS 15	234	132	82.4	61.8	50.1	42.4	37.0	32.8	29.6	27.0	21.5	12.2	8.62	6.72	5.52	4.69	4.08	3.62	3.25	2.95	1.54
SBS 30	449	250	156	116	94.0	79.5	69.1	61.3	55.3	50.3	40.0	22.5	15.9	12.3	10.1	8.58	7.46	6.60	5.92	5.37	2.78
SBS 40	548	325	210	160	130	111	97.1	86.5	78.2	71.4	57.0	32.3	22.8	17.7	14.5	12.3	10.6	9.39	8.40	7.60	3.87
SBS 60	726	431	278	211	173	147	129	115	104	95.2	76.2	43.5	30.9	24.1	19.8	16.9	14.7	13.0	11.7	10.6	5.51
SBS 110	1099	753	525	413	344	297	263	236	215	198	160	93.7	67.4	53.0	43.9	37.5	32.8	29.2	26.4	24.0	12.9
SBS 130	1433	924	625	487	403	347	306	275	249	229	185	108	77.8	61.2	50.6	43.2	37.8	33.6	30.2	27.5	14.6
SBS 300	-	1790	1370	1129	953	821	717	647	580	527	426	255	177	138	115	96.4	84.6	75.1	68.4	62.4	33.3
SBS 390	2994	2148	1550	1245	1053	930	817	746	679	622	507	299	215	169	139	119	104	92.2	82.9	75.3	39.4

Discharge Performance

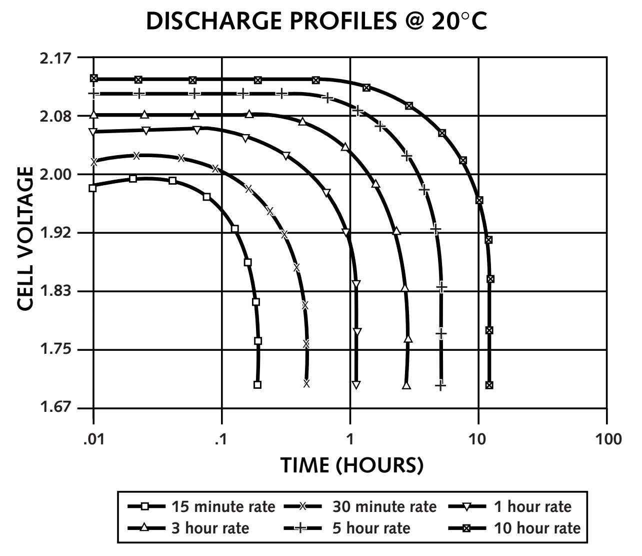
End voltage = 1.60 Vpc

CONSTANT CURRENT DISCHARGE (amps)																					
	Minutes										Hours										
	2	5	10	15	20	25	30	35	40	45	1	2	3	4	5	6	7	8	9	10	20
SBS 8	75.7	41.8	25.3	18.5	14.7	12.3	10.6	9.30	8.31	7.53	5.89	3.23	2.26	1.75	1.44	1.22	1.07	0.95	0.86	0.78	0.43
SBS 15	137	73.5	44.6	33.0	26.5	22.2	19.3	17.1	15.3	13.9	11.0	6.16	4.34	3.37	2.76	2.35	2.04	1.80	1.62	1.47	0.77
SBS 30	263	140	84.3	62.0	49.7	41.7	36.0	31.8	28.6	26.0	20.5	11.4	7.99	6.19	5.07	4.30	3.74	3.30	2.96	2.69	1.40
SBS 40	328	184	114	85.4	69.0	58.3	50.6	44.9	40.4	36.8	29.2	16.3	11.5	8.87	7.25	6.13	5.32	4.69	4.20	3.80	1.94
SBS 60	441	246	153	114	92.1	77.8	67.7	60.0	54.1	49.3	39.1	22.1	15.6	12.1	9.94	8.44	7.34	6.50	5.83	5.29	2.75
SBS 110	677	435	292	225	186	159	139	125	113	103	83.0	47.7	34.1	26.7	22.1	18.8	16.5	14.6	13.2	12.0	6.46
SBS 130	894	536	347	265	217	185	162	145	131	120	95.9	55.1	39.4	30.8	25.4	21.7	19.0	16.8	15.2	13.8	7.32
SBS 300	-	1148	806	650	547	453	397	351	320	290	230	131	90.5	70.5	59.4	50.1	43.4	38.3	35.1	31.9	17.3
SBS 390	1983	1315	899	703	584	503	443	396	360	329	267	154	110	85.7	70.5	59.6	52.0	46.1	41.3	37.5	19.4

Discharge Performance

Hawker Energy's thin plate technology produces a high energy density - offering up to 30% more power to volume than gas recombination batteries using conventional lead-calcium grids. SBS™ batteries can successfully sustain high current discharges over short periods and are particularly resilient to abuse.

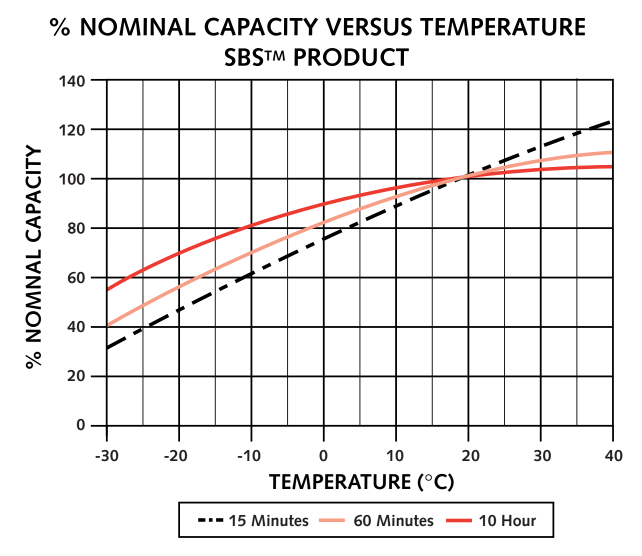
Figure 6



DISCHARGE PERFORMANCE CURVES

Figure 6 shows typical discharge profiles for the SBS™ range at various discharge rates. With the SBS™ product the capacity increases as temperature increases. Likewise the capacity decreases as temperature decreases. Capacity also increases as the discharge rate decreases.

Figure 7



Discharge Performance

MINIMUM DISCHARGE VOLTAGE

The voltage point at which 100% of the useable capacity of the battery has been removed is a function of the discharge rate. For optimum cell life, it is recommended that the battery is disconnected from the load at the end-voltage point.

The shaded area in the figure below represents the recommended disconnect voltage for various rates of discharge. The upper portion of the shaded area represents the point at which 100% of the available capacity is removed. The lower portion represents the minimum voltage that the cell should be discharged to, at given rates of discharge. The cell should be disconnected from the load when voltage is within the shaded area for optimum cell life.

Discharging the cell below these voltage levels or leaving the cell connected to a load in a discharged state will impair the ability of the cell to accept a charge.

Should the cell be discharged to values below those shown in the lower portion it is considered to be in an 'over-discharged' condition. In this condition the sulphuric acid electrolyte can be depleted of the sulphate ion and become essentially water, which can create several problems. This lack of sulphate ions will increase the cell's impedance thus increasing charge time. This will then require changes to the charging procedure (longer charge time or increased charging voltage) before normal charging can be resumed.

Another potential problem is lead sulphate's solubility in water. In a severe deep discharge condition, the lead sulphate present at the plate's surfaces can go into solution in the electrolyte. Upon recharge, the water and sulphate ion in the lead sulphate convert to sulphuric acid. This can leave a precipitate of lead metal in the separator which can result in dendritic shorts between plates leading to eventual cell failure.

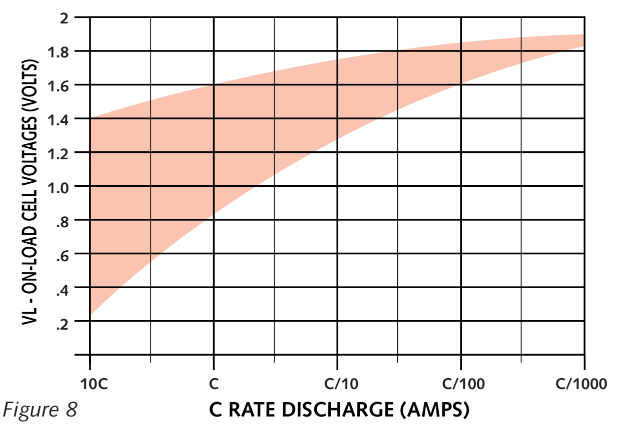


Figure 8

Discharging the SBS™ cell below these voltage levels or leaving the cell connected to a load in a discharged state will impair the ability of the cell to accept a charge.

As noted previously, disconnecting the battery from the load as indicated in Figure 8 will totally eliminate the over-discharge problems and allow the cell to provide its full cycle life and charge capabilities.

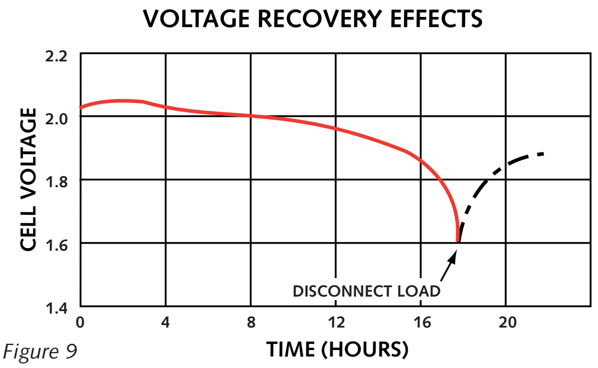


Figure 9

LOW VOLTAGE RECONNECT

It is important to note that when the load is removed from the cell, the cell voltage will increase up to approximately 2 Volts per cell dependent on the precedent discharge. Because of this phenomenon, some hysteresis must be designed into the battery-disconnect circuitry so that the load is not continuously reapplied to the battery as the battery voltage recovers.

The reconnect voltage must be above the open circuit voltage of the battery yet below the lowest temperature compensated float voltage i.e. 2.2 Volts per cell; this then ensures that the mains voltage has been restored and that the batteries are capable of being recharged prior to them being reconnected to the circuit.

ENGINE STARTING PERFORMANCE

The following table shows the discharge current available from each of our monoblocs according to the specific test methods.

	SAE -18°C 30 secs to 1.2Vpc	DIN -18°C 30 secs to 1.5Vpc	BS -18°C 60 secs to 1.4Vpc	GA -18°C 60 secs to 1.2Vpc
SBS15	156	119	114	120
SBS30	274	21 0	200	211
SBS40	410	313	300	315
SBS60	629	481	460	483
SBS110	1301	995	951	1000

All figures in amperes *Figure 10*

INTERNAL RESISTANCE

Figures quoted for the internal resistance of a battery can only be approximations. They reflect the voltage response for a given current usually for the fully charged battery. The SBS™ product, being suitable for high rate discharges, is characterised by a low internal resistance, otherwise the voltage drop caused by the current would limit the discharge too early.

The table on page 18 shows the internal resistance for the SBS™ product range measured using the method outlined in BS6290.

Discharge Performance

SHORT-CIRCUIT CURRENT

The short-circuit current represents a dynamic parameter that decreases quickly with proceeding discharge. The values specified in figure 11 refer to the charged product.

As with the internal impedance the short-circuit figures are measured using the method outlined in BS6290 whereby the current value is extrapolated from other discharges.

Note 1.

Resistance is measured in accordance with BS6290 Part 1, involving voltages and currents obtained at two different discharge rates, ie C_3 Amps & $3C_3$ Amps.

Note 2.

Short circuit current is measured in accordance with BS6290 Part 1. This involves the extrapolation of voltage back to 0V using figures obtained from two discharge tests, ie C_3 Amps & $3C_3$ Amps.

Figure 11

SHORT CIRCUIT AND INTERNAL RESISTANCE - BS6290 METHOD		
PRODUCT	INTERNAL RESISTANCE (mΩ)	SHORT CIRCUIT CURRENT (Amps)
SBS 8	27.1	455
SBS 15	13.5	891
SBS 30	7.9	1556
SBS 40	5.6	2184
SBS 60	4.4	2618
SBS 110	1.7	3804
SBS 130	1.4	4111
SBS 300	0.5	8700
SBS 390	0.18	11101

BATTERY CAPACITY VERSUS TEMPERATURE

The table on the left shows the effect of battery temperature on the electrical discharge performance at different discharge rates. Performance is given as a percentage of the performance at 20°C.

Rate	Temperature								
	0°C	5°C	10°C	15°C	20°C	25°C	30°C	35°C	40°C	REPV
2 m	64%	72%	81%	90%	100%	111%	122%	134%	147%	1.60Vpc
5 m	66%	76%	85%	92%	100%	108%	116%	125%	133%	1.63Vpc
10 m	73%	80%	86%	93%	100%	107%	113%	119%	125%	1.65Vpc
15 m	74%	81%	87%	94%	100%	106%	111%	116%	121%	1.65Vpc
20 m	76%	82%	88%	94%	100%	105%	110%	114%	118%	1.67Vpc
25 m	77%	83%	89%	95%	100%	105%	109%	113%	117%	1.67Vpc
30 m	78%	84%	90%	95%	100%	105%	109%	112%	116%	1.70Vpc
45 m	80%	85%	91%	95%	100%	104%	107%	110%	113%	1.70Vpc
60 m	81%	86%	91%	95%	100%	103%	107%	109%	111%	1.75Vpc
2 hrs	83%	88%	93%	97%	100%	103%	105%	107%	108%	1.80Vpc
3 hrs	85%	89%	93%	97%	100%	102%	105%	106%	107%	1.80Vpc
4 hrs	86%	90%	94%	97%	100%	102%	104%	105%	106%	1.80Vpc
10 hrs	88%	91%	95%	98%	100%	102%	103%	104%	105%	1.80Vpc

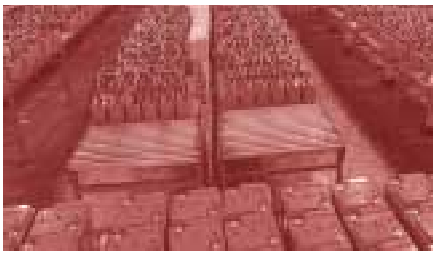
Figure 12

Rate	Temperature									
	-5°C	-10°C	-15°C	-20°C	-25°C	-30°C	-35°C	-40°C	-45°C	REPV
2 m	56%	49%	43%	36%	29%	25%	21%	17%	14%	1.60Vpc
5 m	57%	51%	45%	39%	34%	29%	24%	20%	16%	1.63Vpc
10 m	62%	55%	49%	43%	37%	32%	27%	22%	18%	1.65Vpc
15 m	64%	58%	52%	46%	40%	34%	29%	24%	19%	1.65Vpc
20 m	66%	60%	54%	47%	42%	36%	30%	25%	20%	1.67Vpc
25 m	68%	62%	55%	49%	43%	37%	31%	26%	21%	1.67Vpc
30 m	69%	63%	56%	50%	44%	38%	32%	27%	22%	1.70Vpc
45 m	71%	65%	59%	52%	46%	40%	34%	28%	23%	1.70Vpc
60 m	73%	67%	60%	54%	49%	42%	36%	30%	25%	1.75Vpc
2 hrs	76%	70%	64%	58%	52%	45%	39%	33%	28%	1.80Vpc
3 hrs	78%	72%	66%	60%	54%	48%	41%	35%	29%	1.80Vpc
4 hrs	79%	74%	68%	62%	56%	49%	43%	37%	31%	1.80Vpc
10 hrs	82%	77%	72%	67%	61%	55%	49%	43%	37%	1.80Vpc

Figure 13

- *Figures apply to all SBS™ products*
- *REPV = Recommended End Point Voltage (the on-load voltage at which it is recommended to disconnect the battery from any load)*

CHARGING



The SBS™ TPT® design offers a faster recharge capability without the need for an increase in the charge voltage. There are two methods of charging - constant voltage and constant current. Constant voltage charging is recommended as the most efficient and safest method. Although constant current charging is efficient it is also more complex, requiring a greater degree of control to avoid potentially damaging overcharge.

CHARGING TECHNIQUES

There are basically 2 different methods of charging the SBS™ valve regulated battery. These are constant voltage and constant current.

CONSTANT VOLTAGE CHARGING (RECOMMENDED CHARGING METHOD)

Constant voltage charging is the most efficient and safest method of charging a sealed lead acid cell. There are basically 2 methods of constant potential charging, float and fast.

1. FLOAT CHARGING

This type of charging is to be used in standby applications.

Voltage Setting

When the SBS™ valve regulated cell is to be float charged in a standby application, the constant voltage charger should be maintained at 2.27 Volts per cell whilst at an ambient temperature of 20°C for maximum float life. (see curve fig 4). Temperature excursions away from this will cause a reduction in life for high temperatures or a reduction in capacity due to undercharge at lower temperatures. The general rule is that for every 10°C rise in temperature there is a 50% reduction in the float life of the product. A curve showing the recommended float voltages for a given temperature is shown in figure 14. Using these values it is possible to maintain the battery condition whilst retaining its longevity of operation. To compensate for variations in ambient temperature the following formula should be applied:

Float = 2.3773 - (T x 0.00598) + (T^2 x 0.00004)

Note: At temperatures in excess of 40°C the compensated voltage approaches the open circuit voltage of the battery. The voltage should therefore be capped at this level so a reduction in life at temperatures greater than 40°C, even with temperature compensation, is to be expected. It is important to remember that the battery has a large thermal mass. Placement of the temperature indicating device is very important as instantaneous changes in the ambient temperature are not immediately reflected within the internal mass of the battery. It is therefore recommended that temperature probes/indicators should either be placed against the outer case of the battery with the outer face of the probe being insulated, or commercially available ring tag temperature probes can be used, fitted over the battery terminal during installation. Typical recharged profiles are shown in Figure 15.

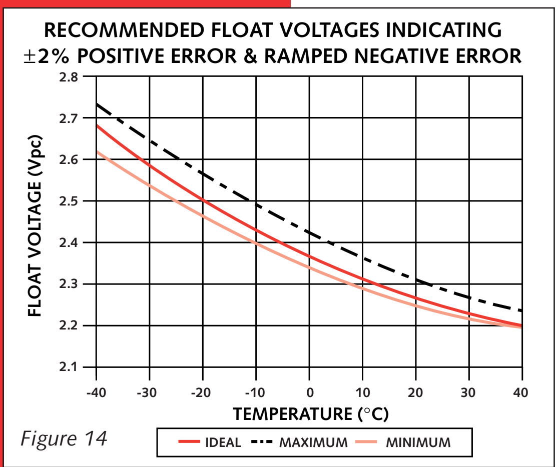


Figure 14

Current Setting

There is no upper limit setting to the current requirements during constant potential charging as the battery itself will regulate the current only accepting as much as is required to reach its fully charged condition. It should however be noted that the higher the charge current available from the charging source, the quicker the battery will recharge. In its fully charged float condition at 20°C, the SBS™ product range will draw between 5 and 50 milli-amps from the charger depending on the battery type.

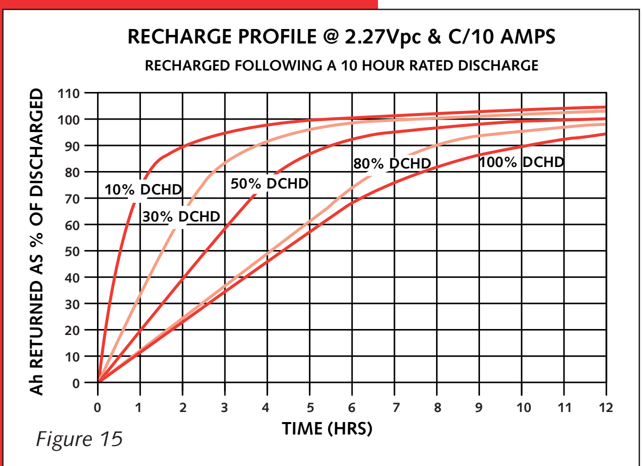


Figure 15

2. FAST CHARGING

2.1 CONSTANT VOLTAGE, FAST CHARGING

In order to facilitate more rapid charging of the SBS™ product it is possible to use the ‘fast’ charge technique, ideally suited to more cyclic applications.

Voltage Setting

For applications requiring a faster recharge, a potential of 2.4 Volts per cell at 20°C can be applied across the battery terminals. This will facilitate a more rapid recharge although due to this higher potential it is recommended that this level is maintained only until the current being drawn by the battery has remained level for a period of 2 hours. Should this recharge potential be applied for extended periods the battery may become warm thus accelerating grid corrosion and reducing the service life of the product.

To compensate for variations in ambient temperature the following formula should be applied:

Fast Charge = 2.5023 - (T x 0.00598) + (T^2 x 0.00004)

CHARGING

Current Setting

As with float charging, the greater the current available from the charging source the faster the recharge will be with no limit being placed on that charging current. However at these elevated voltages the final stabilised current being drawn from the charger as the battery reaches its full state of charge will be higher than the values attained at 2.27 Volts per cell.

2.2 CONSTANT CURRENT CHARGING

Constant current charging although efficient, needs a slightly more complex charging algorithm requiring a greater degree of control to prevent serious overcharge. Constant current charging is accomplished by applying a non-varying current source with a high voltage. The rate at which the current is applied to the battery governs the voltage requirement of the charger source. High current rates require a charging source with a higher voltage.

It is important with constant current charging to know how many ampere-hours (amps x hours) were taken out during discharge so that with a set constant current rate the duration of the recharge can be calculated to return between 100% and 105% of the removed capacity.

In order to calculate the maximum rate that can be used during a constant current recharge simply use 5% of the C_{10} capacity of the battery e.g. for an SBS 40 therefore 5% of 40Ah equals 2 amps. This rate would then be used for the duration required to replace approximately 103% of the battery's removed capacity during discharge.

The effects on the battery of a.c. voltage and current ripple superimposed on the charger supplied d.c. voltage and current are important. Consideration in the design of chargers and power systems must be given to the level of both the a.c. voltage and resulting a.c. current.

1. VOLTAGE RIPPLE

Normally seen as a cyclic variation of the dc charging voltage, usually at twice the mains supply frequency - i e. 100 Hz for 50 Hz supplies - or twice the switching frequency with switch mode power supplies. Under steady state conditions we recommend that the voltage measured across the charger's output (with the load, but not the battery, connected) does not vary by more than ±1% over the range 5% to 100% of the charger's rated output current. When the effects of load and input supply variation are added together the ripple voltage present on the basic d.c. charging voltage, battery disconnected, should not be allowed to vary by more than ±2% of the nominal d.c. value.

An example would be a system floating at a nominal d.c. voltage of 54.5V. With the worst case variation, in mains supply and the worst case load variation, the charger's output voltage - without the battery connected - must not be less than 53.4V or greater than 55.6V.

With symmetrical voltage ripple - which most chargers produce - the average charging current that flows into the battery, for a given apparent d.c. voltage, increases because the positive voltage excursion increases the battery's float current to a greater extent than the reduction which occurs during the negative part of the ripple cycle. This apparent anomaly results from the battery's internal dynamics which allow the current to increase faster with a rising voltage than a falling voltage. The net result is that the battery receives a higher than expected charging current which under float conditions results in overcharging.

2. A.C. CURRENT RIPPLE

The a.c current into a battery connected to a UPS or telecommunications system should under charging or float conditions be as shown in Figure 16. The 'a.c.' ripple sits on top of a d.c. current and the total current into the battery always - unless the charger fails - has a positive value, even if it is very small, i.e. 50 mA. The worst case a.c. ripple current must not be allowed to exceed 10% RMS of the battery's nominal C_1 capacity whilst meeting the requirement that the current never becomes negative - discharge - in value, i.e:

Figure 16

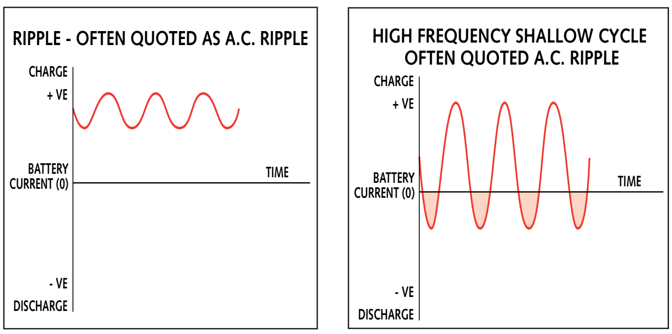
Battery Type	Nominal C_1 Capacity	Maximum RMS Ripple Current
SBS15	10.2 Ah	1.0 A
SBS30	19.5 Ah	1.9 A
SBS40	27.6 Ah	2.7 A
SBS60	37.4 Ah	3.7A

In some UPS inverter systems the output of the charger can be discontinuous in operation resulting in the type of current wave form shown in Figure 17. The repeated small discharges of the battery will result in one or more failure modes. If the net charge into the battery is less than that required to maintain a full charge the battery will slowly become discharged. It should be noted that the ampere hours needed to recharge the battery are dependant on its design, being anything from 102% to 107% of the discharge ampere hours. Batteries discharged in this manner are normally very difficult to recover - impossible at normal float voltages - because the lead sulphate crystals created within the plate's structure are hard and difficult to redissolve. As a result the battery's internal resistance rises thereby lowering the charging current that can flow into the battery for a given charging voltage. This in turn results in undercharging.

If sufficient charge ampere hours are available to the battery the most likely failure mode then becomes loss of electrical contact to the grid - normally the positive plates-due to the overworking of the active material. As the positive active material is discharged it physically grows and then shrinks as it is recharged. This results in elongation of the positive plates allowing the pellets of active material to become detached from the grid. As active material loses electrical contact a creeping loss in battery capacity occurs which cannot be recovered.

All a.c. ripple currents cause internal heating of the battery due to the I_{rms}^{2*} $R_{internal}$ losses. The heat generated causes an increase in the battery's self-discharge rate resulting in increased float currents and can in marginal - high ambient temperature - situations help to cause thermal runaway.

Figure 17



CYCLE LIFE

SBS™ TPT® products can be specifically designed and engineered to perform cyclic duties for different applications.

The cyclability of the SBS™ product range depends upon the following factors:

- Discharge rate / Depth of discharge / Discharge end point voltage.
- Recharge voltage.
- Recharge time.
- Recharge current available.
- Interval current available.
- Charge factor obtained prior to next discharge.
- Operating temperature.
- Charge quality.

Because there are so many variables associated with the determination of the product cycle life, Hawker Energy request that customers contact the technical sales department with specific details of the cyclic application in order to obtain a figure for product cyclic capability.

The recharge time and voltage will influence cell balance, particularly in the early stages of cycle life.

Cycling at float voltage (e.g. 2.27Vpc) generally requires longer recharge intervals because the charging time is limited by the low charging over potential. The charge factor (ratio of charge in / charge out) under float recharge conditions normally reaches >95% in 12 hours. Additional time on float is crucial to keep the cells in a fully charged state and to also electrochemically "balance" the cells. A factor between 102% and 107% (depending on the cycle % depth of discharge) is required to maintain cyclability.

TECHNICAL FEATURES

- Designed to cycle at a wide range of recharge voltages, **2.25 to 2.45** Vpc,
  - Cycle at float voltage
  - Cycle at traditional cyclic / traction voltages
- Specialised formulation plates available for applications where there is a risk of product being deeply discharged or left in a deeply discharge state.
- Excellent cyclic capability at high and low discharge rates.

Please contact Hawker Energy Products Limited with details of your cyclic application and we will advise on the number of cycles for each SBS™ product.

MAINTENANCE AND INSPECTION

HAWKER

The gas recombination technology used in SBS™ TPT® batteries eliminates many of the traditional maintenance activities associated with conventional vented batteries such as topping-up and gravity checks. However, it is still necessary to carry out routine inspections to ensure correct and safe operation.

The optimum maintenance and inspection procedure will vary considerably according to the application, number and critical nature of installations, along with other commercial considerations.

The following is a list of broad generic suggestions for the periodic maintenance and inspection of your batteries.

It is advised that, in addition to the instructions detailed below, the Battery Record Sheet as shown on page 30 is utilised.

Figure 19

MONTHLY INSPECTION			
WHAT TO INSPECT	**METHOD**	**REQUIREMENT**	**ACTION**
Total battery voltage on float charge.	Measure total battery voltage.	Recommended float Volts per cell x number of cells series.	Adjust float voltage as specified in Section 2.
SIX-MONTHLY INSPECTION			
WHAT TO INSPECT	**METHOD**	**REQUIREMENT**	**ACTION**
1 Total battery voltage on float charge.	Measure total battery voltage.	Recommended float Volts per cell x number of cells series.	Adjust float voltage as specified in Section 2.
2 Individual monobloc voltages on float charge.	Measure individual monobloc voltages.	Within ±5.0% of the mean.	Contact Hawker Energy Products Ltd.
3 Appearance.	Check for damage or other impairment.		If a concern is found, check the cause and replace the monobloc as necessary.
4 Cleanliness.	Check for contamination. by dust, etc.		If contaminated ISOLATE monobloc and clean with damp soft cloth.
5 General condition.	Check for corrosion of the cubicle, battery stand, connecting cables and terminals.		Perform cleaning, corrosion prevention treatment, painting, etc.

Maintenance and Inspection

ANNUAL INSPECTION

As with monthly and six monthly checks the type of annual inspection is based on the critical nature of installations and several other commercial considerations i.e feasibility of reduced autonomy, manpower availability etc. One method of checking the state of health of the battery is to perform a partial discharge using the actual system as the load.

By reference to the noted values on the record sheet calculate the average monobloc terminal voltage for each individual string. From this value calculate a voltage equating to 5% less than the average. Monoblocs with a terminal voltage below the calculated value should be replaced at the earliest possible convenience to ensure the maximum system autonomy.

Example

For a system with a back-up autonomy time of 4 hours.

Switch off the mains power supply and allow the battery to supply the required back-up power to the load.

After approximately 30 minutes* measure and note the terminal voltage of the individual monoblocs and the corresponding string from which the measurement was taken. An example of a battery record sheet is shown on page 31.

After all of the monoblocs have had their terminal voltages measured, the mains power should be returned to the system.

*The actual discharge duration is unimportant as the test is one of comparison and does not have a specific pass/fail criteria. It should however be noted that the longer the duration of the discharge is allowed to continue before measurements are taken, the earlier it might be possible to detect monoblocs prematurely failing.

It is only possible to check the actual capacity of the system battery by performing a full discharge test on the battery to a known end-point voltage. Unfortunately although this gives excellent battery maintenance cover, it means that for a short period the battery will provide substantially reduced autonomy. Hence this method should only be implemented during times of complete system redundancy.

Hawker Energy can provide a tailor-made maintenance procedure based on your own site's specific needs and capabilities.

HAWKER

GAS EMISSION

The gas recombination process of the SBS™ TPT® battery eliminates the gasing associated with conventional flooded cells. However, a minute quantity of gas is still evolved but this is so small that it normally dissipates rapidly into the atmosphere.

SBS™ STABILISED FLOAT CURRENTS

SBS	Float Current (mA)	SBS	Float Current (mA)
8	3	60	25
15	7	110	30
30	12	130	33
40	18		

During the first week on float slightly higher float currents are expected.

The minute quantities of gases which are released during recommended rates of charge will normally dissipate rapidly into the atmosphere. The SBS™ product operates on 100% recombination of the oxygen gas produced at recommended rates. During normal operation some hydrogen gas is evolved and vented out. The hydrogen outgassing is essential with each discharge charge cycle to ensure internal chemical balance. The TPT® grid construction minimises the amount of hydrogen gas produced.

However one consideration is the potential failure of the charger. If the charger malfunctions, causing higher-than-recommended charge rates, substantial volumes of hydrogen and oxygen will be vented from the battery. This mixture is potentially explosive and should not be allowed to accumulate.

The SBS™ product therefore should not be operated in a gas tight container. It should never be totally encased in a potting compound since this prevents the proper operation of the bunsen valve and free release of gas.

SBS™ HYDROGEN EVOLUTION RATES

5% of float current goes towards hydrogen evolution

1Ah evolves 0.4488 litres of hydrogen.

Example (SBS15 per week)

- Ah charging on float = 0.007A x 168h = 1.18Ah
- 5% towards hydrogen evolution = 5/100 x 1.18Ah = 0.059Ah
- 0.059Ah evolves 0.0265 litres of hydrogen

Therefore an SBS15 evolves 0.0265 litres of hydrogen per week on stabilised float charge.

STORAGE

SBS™ TPT® batteries have an excellent shelf life and depending on temperature and subject to a freshening charge they can be stored for up to 2 years without any damage.

STORAGE

Most batteries lose their stored energy when allowed to stand on open circuit due to the fact that the active materials are in a thermo-dynamically unstable state. The rate of self-discharge is dependent on the chemistry of the system and the temperature at which it is stored.

If the capacity loss due to self-discharge is not compensated by recharging in a timely fashion, the battery capacity may become irrecoverable due to irreversible sulphation. This is the reaction whereby the active materials (PbO_2, lead dioxide, at the positive plates and sponge lead at the negative plates) are gradually converted into an electro-inactive form of lead sulphate, $PbSO_4$.

The SBS™ product is capable of long storage without damage for up to 2 years at a temperature of 20°C.

As the ambient temperature during storage increases, the rate of self-discharge increases which reduces the shelf life of the product before a refresher charge (see fast charging) is required.

The opposite is true for temperatures below 20°C whereby a reduced storage temperature will allow an extended shelf life. Figure 20 shows the self-discharge curves at various temperatures.

It is important to recognise that the self-discharge rate of the SBS™ product is non-linear; thus the rate of self-discharge changes as the state of charge of the cell changes.

Figure 21 shows the curve of open circuit voltage versus percentage of the 3 hour rated capacity. It is recommended that in order to retain the autonomy of a back-up system, batteries should not be installed with an open circuit voltage indicating a remaining percentage capacity of less than 80%.

Batteries should not be allowed to self-discharge below 2.09 Volts per cell because the recharge characteristics change appreciably at these lower levels.

In transit it is possible that batteries will be subject to extreme temperatures over elongated periods which will increase the rate of self-discharge. It is therefore advised that following transportation, especially by sea, batteries should be checked to see whether some form of boost charge is required.

STORAGE

Figure 20

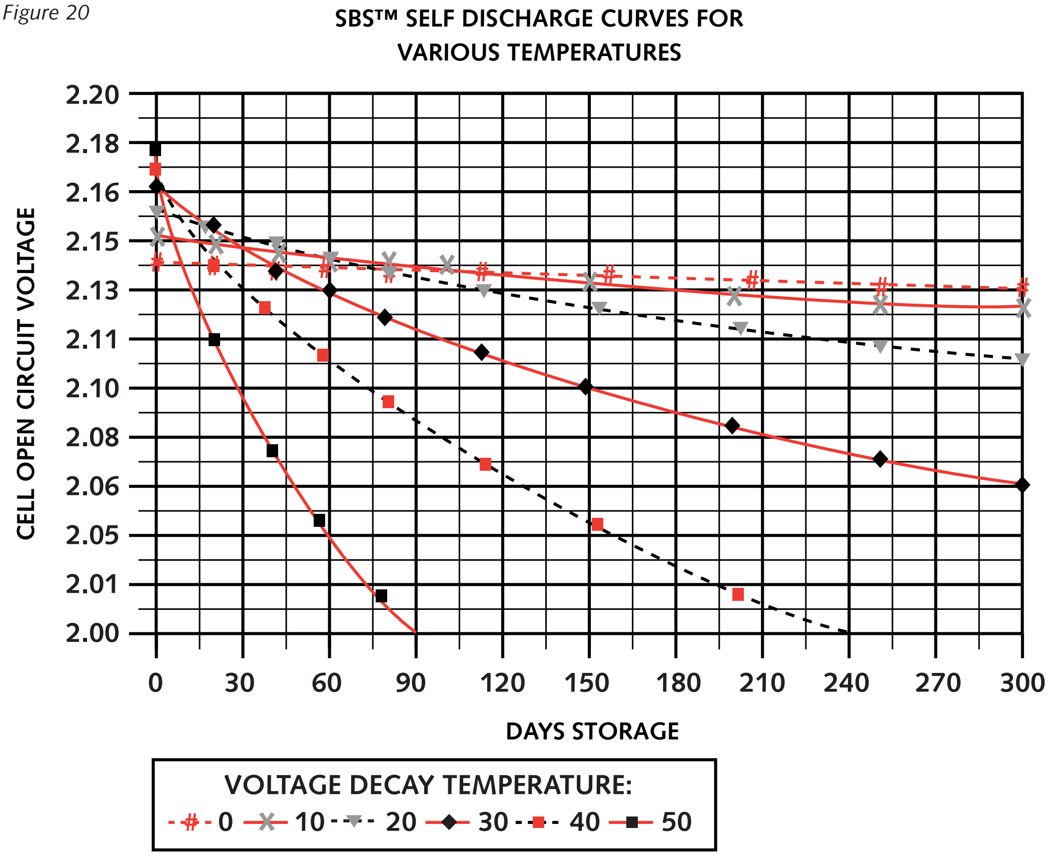
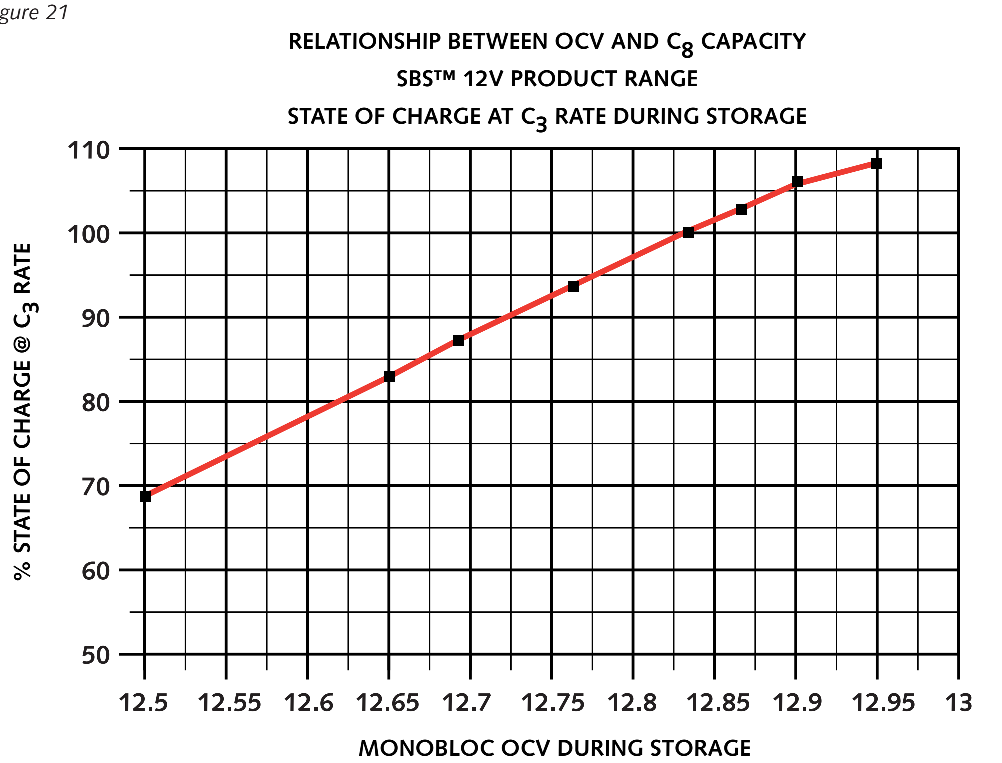
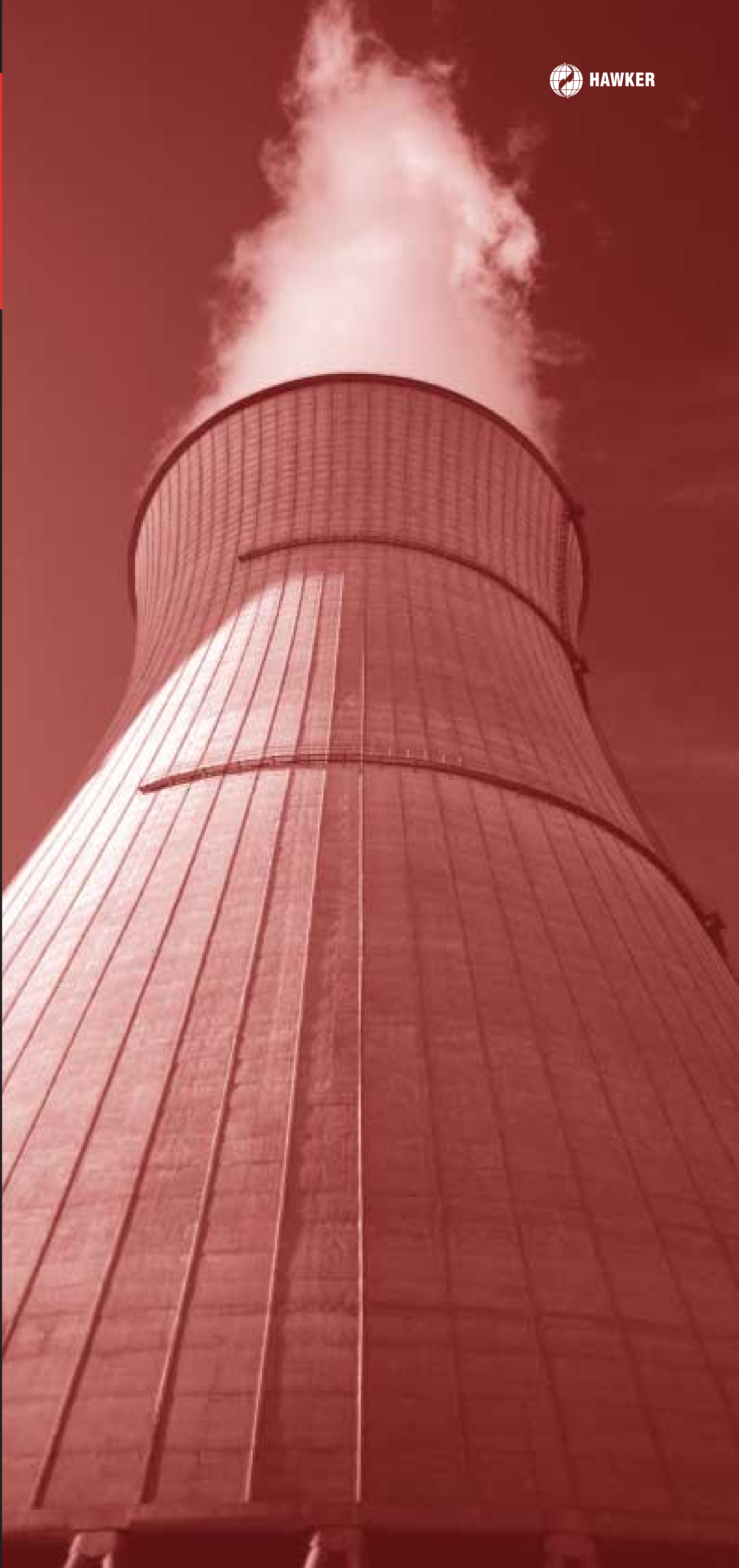


Figure 21



Battery Specification Guide

A definitive battery specification is essential to maintain the integrity of the whole standby application. A sample of such a battery specification is provided on the following page.



Sample Specification

SPECIFICATION FOR RECHARGEABLE VALVE REGULATED BATTERY SUITABLE FOR STATIONARY APPLICATIONS

1. SCOPE.

1.1 This specification defines the requirements for standby rechargeable batteries of the gas recombination valve regulated (VRLA), absorbed glass matt (AGM) type and defines the parameters necessary for a lead acid battery to be designated fit for purpose in a long float life application.

This means that after installation and commissioning, the battery shall perform 100% of the required duty on the first discharge and have an expected float life of at least 15 years to 80% capacity when operated at 20°C in a temperature controlled environment in accordance with the manufacturer's operating instructions.

1.2 The valve regulated battery shall be designed, manufactured and tested in accordance with recognised international standards including:

BS6290 Part 4 Certification. · UL Approval: UL-94B-V0 · ISO 9001
ICAO/IATA Special Provision A67
US DoT Regulation 49 CFR Section 173.159

1.3 The cells/monoblocs shall meet all the approvals and documentation listed above and shall be supplied charged and ready for putting into immediate service after a conditioning charge after which the battery shall perform 100% of the required duty on the first discharge.

1.4 The cells/monoblocs shall be a low maintenance design which requires no addition of distilled water during their service life.

1.5 The cells/monoblocs shall have the following characteristics:

- 15 years float life at 20°C
- 2 years minimum shelf life at 20°C
- Resilient to abuse
- Very high energy density (watts per kilograms)
- When discharged at 20°C to 1.67 Volts per Cell, 12V batteries should give at least 90 watts/Kg and 210 watts per cubic metre, and 6V and 2V batteries should give at least 60 watts per Kg and 140 watts per cubic metre.
- Extremely high current delivery capability
- Ultra low gassing rate
- Low grid corrosion
- Excellent resistance to shock and vibration

1.6 The battery shall be operated in an air conditioned environment to maintain the ambient temperature at 20°C (+/- 2°C)

2. DESIGN AND CONSTRUCTION

2.1 Cells/monoblocs shall be designed and constructed in full compliance with the requirements of BS 6290 Part 4 and manufactured utilising Absorbed Glass Mat (AGM) technology.

2.2 Cell/monobloc containers and lids shall be constructed using flame retardent ABS with a UL94 rating of V0 and an L O I of at least 28%, and shall have leak-proof joints.

The cell/monobloc containers and the lid-to-container joint shall be capable of withstanding an internal pressure of at least four times the normal working pressure. Cells/monoblocs shall be equipped with a low pressure self-resealing one-way safety pressure relief valve which will prevent ambient air entering the cell/monobloc.

2.3 The cell plate shall be a rolled and punched grid type. Re-cycled lead shall not be used in the manufacturing process. No antimony shall be used in any of the components. The grid thickness of the positive plate shall not exceed 1.25mm.

2.4 Intra-cell connections must not be achieved by hand burning.

2.5 All acid shall be fully absorbed within the separator material and no water or acid replenishment shall be required during the service life of the product.

2.6 The design of the cell/monobloc shall be sufficiently robust to withstand external short circuits in full compliance to BS 6290 Part 4.

2.7 Cell/monobloc terminals shall consist of lead-tin coated brass inserts machine cast into the internal lead.

2.8 The links between the cells/monoblocs shall be made from insulated flexible connectors.

3. ELECTRICAL PERFORMANCE

3.1 The nominal cell voltage will be 2 Volts per cell.

3.2 The battery shall be float charged at an equivalent of 2.275 Volts per cell at 20°C to achieve the 15 years float life. To enhance battery life, temperature compensated float charging is recommended if there are changes in the ambient temperature as per manufacturer's instructions.

3.3 After 2 weeks float charging, the float current shall not exceed 0.6 mA/Ah.

3.4 The minimum cell voltage at the end of discharge shall be no less than 1.60 Volts per cell.

3.4 No charge current limit shall be necessary in normal float operation at 20°C.

4. ENVIRONMENT

4.1 The cells/monoblocs will be have a minimum of 2 years shelf life when stored at 20°C.

4.2 The cells/monoblocs will be unaffected by humidity.

4.3 The cells/monblocs will have a recombining efficiency greater than 98% during normal float charge operation.

4.4 After 2 weeks float the hydrogen gas emission rate shall be no more than 0.0025 litres/cell/Ah/week.

5. Operational Requirements

5.1 The cells/monoblocs shall be capable of operation in any orientation (except 'terminals down/inverted') without any loss of performance or life.

5.2 The end of life of the cells/monoblocs shall be defined when the battery system is capable of giving no more than 100% capacity after 15 years at 20°C.

5.3 The cells/monoblocs shall be non-spillable and shall be safe in use, during transport, handling and commissioning.

BATTERY STANDS

A variety of robust stands are available. They can be configured to meet your precise requirements offering compact, secure accommodation while permitting easy access for installation and routine servicing.

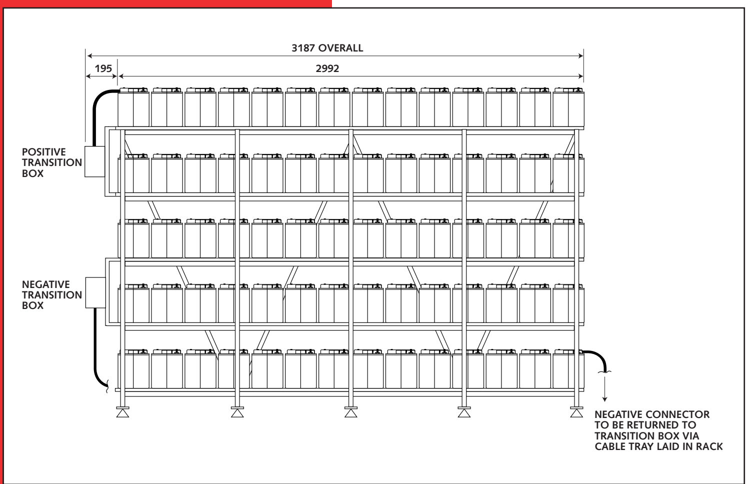
Hawker Energy Products provide battery stands in a variety of configurations ranging from Two Tier-One Row to Six Tier-Three Row.

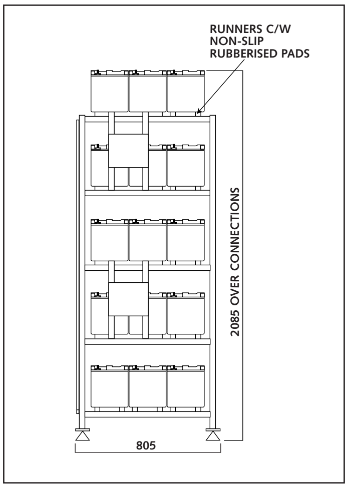
They consist of vertical frames (up to seven - as required) and longitudinal pairs of runners capped by rubber insulators. All fixings are capped with insulating covers. Diagonal tie bars are provided between all frames on one side only, to ensure rigidity.

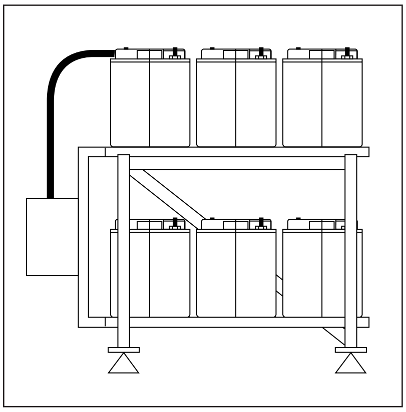
SPECIFICATION

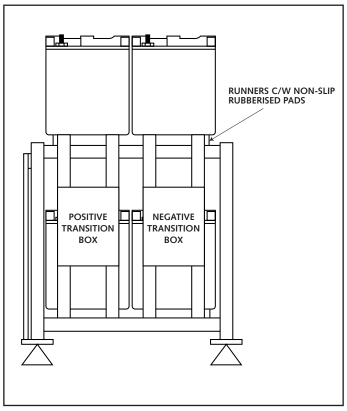
1) Frames	*Mild steel, welded box section approx 1", pre-drilled.*
2) Runners	*Material as above, pre-drilled for fixings and completely removable polypropylene end plugs.*
3) Tie Bars	*Flat strip mild steel, pre-drilled for fixings.*
4) Insulators	*Inverted 'U' section EPDM type rubber capping to fit runners.*
5) Frame Feet Diameters	*Polypropylene, height adjustable by up to 20 mm.* *50 mm - 265 Kg load/foot.* *75 mm - 650 Kg load/foot.*
6) Fixings	*Zinc plated steel, M6 and M8.*
7) Finish	*Black dry powder epoxy.*

Frames of four or more tiers are provided with wall-fixing plates. Stands are shipped in kit form in two packages (frames and runner/tie bars), complete with all fixings, insulators, assembly instructions and diagrams. All battery (monoboc) types are mounted with their length across the runners. Inter-monobloc spacing is 15mm standard but can be increased or decreased if necessary.









BATTERY RECORD SHEET EXAMPLE

Site: Installation date: Inspection date:

Monobloc type: Float voltage:
No series: Temperature:
No parallel:

Battery Number: Bank Number:

Mb No	V/Mb	Mb No	V/Mb	Mb No	V/Mb	Mb No	V/Mb	Mb No	V/Mb	Mb No	V/Mb	Mb No	V/Mb	Mb No	V/Mb
1		29		57		85		113		141		169		197	
2		30		58		86		114		142		170		198	
3		31		59		87		115		143		171		199	
4		32		60		88		116		144		172		200	
5		33		61		89		117		145		173		201	
6		34		62		90		118		146		174		202	
7		35		63		91		119		147		175		203	
8		36		64		92		120		148		176		204	
9		37		65		93		121		149		177		205	
10		38		66		94		122		150		178		206	
11		39		67		95		123		151		179		207	
12		40		68		96		124		152		180		208	
13		41		69		97		125		153		181		209	
14		42		70		98		126		154		182		210	
15		43		71		99		127		155		183		211	
16		44		72		100		128		156		184		212	
17		45		73		101		129		157		185		213	
18		46		74		102		130		158		186		214	
19		47		75		103		131		159		187		215	
20		48		76		104		132		160		188		216	
21		49		77		105		133		161		189		217	
22		50		78		106		134		162		190		218	
23		51		79		107		135		163		191		219	
24		52		80		108		136		164		192		220	
25		53		81		109		137		165		193		221	
26		54		82		110		138		166		194		222	
27		55		83		111		139		167		195		223	
28		56		84		112		140		168		196		224	

Mechanical condition:

Other observations:

Signature:

Organisation:

Key:

Mb = Monobloc

No = Number

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