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NSB BLUE+ Battery®

Thin Plate Lead Carbon

The NSB BLUE+ Battery® delivers ultra fast recharge and exceptional PSoC cycling performance.

PSoC CYCLING

FASTER RECHARGE

The NSB BLUE+ Battery® is ideal for use in applications such as telecom backup, electric vehicles, energy storage, renewable energy, and hybrid gensets.

- Exceptional PSoC cyclic performance 2050 cycles @50% DoD
- Design life 12+ years at 20°C (68°F)
- EUROBAT design life definition: Very Long Life (12+ years)
- Ultra fast recharge
- Shelf life of up to 24 months
- Lead carbon added to negative electrodes increases power and reduces sulfation
- High potential fuel savings when used with hybrid genset applications
- Operating temperature range -40°C to +65°C (-40°F to 149°F)
- State-of-the-art automated manufacturing ensures consistency and reliability
- Advanced 3 stage terminal design to ensure leak-free operation - brass terminals provide maximum performance
- Container and cover made from flame retardant UL94-V0 material, highly resistant to shock and vibration
- Integral handles and front access terminals ensure ease of installation and maintenance
- Approved as non-hazardous cargo for ground, sea, and air transport - DOT 49CFR173.159(d), (i) and (ii)

	NSB 100FT BLUE+	NSB 170FT BLUE+
Height	11.3 in (288 mm)	11.1 in (283 mm)
Width	4.3 in (108 mm)	4.9 in (125 mm)
Length	15.6 in (395 mm)	22.1 in (561 mm)
Weight	72 lbs (32.6 kg)	116 lbs (52.5 kg)
Terminal	Female M8 x 1.25	Male M6
Terminal Torque	5.0 Nm (44 in-lbs)	9.0 Nm (81 in-lbs)
10 hr Capacity to 1.80VPC @ 25°C (77°F)	100 Ah	170 Ah
8 hr Capacity to 1.75VPC @ 25°C (77°F)	100 Ah	168 Ah
Float Voltage at 20°C (68°F) / 25°C (77°F)	2.28 / 2.27 VPC	2.28 / 2.27 VPC
Impedance (1kHz)	5.6	3.5
Short Circuit Current	2210 A	3500 A
Maximum Charge Current	No Limit	No Limit
Nominal Voltage	12 V	12 V

	NSB 190FT BLUE+	NSB 210FT BLUE+
Height	12.4 in (316 mm)	12.9 in (328 mm))
Width	4.9 in (125 mm)	4.96 in (126 mm)
Length	22.1 in (561 mm)	22.0 in (560 mm)
Weight	132 lbs (60 kg)	139 lbs (63 kg)
Terminal	Male M6	Male M6
Terminal Torque	9.0 Nm (81 in-lbs)	9.0 Nm (80 in-lbs)
10 hr Capacity to 1.80VPC @ 25°C (77°F)	183 Ah	200 Ah
8 hr Capacity to 1.75VPC @ 25°C (77°F)	180 Ah	198 Ah
Float Voltage at 20°C (68°F) / 25°C (77°F)	2.28 / 2.27 VPC	2.28 / 2.27 VPC
Impedance (1kHz)	3.3	3.3
Short Circuit Current	3990 A	3800 A
Maximum Charge Current	No Limit	No Limit
Nominal Voltage	12 V	12 V

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NSB 100FT BLUE+ Battery®

Discharge tables @ 20°C (68°F)

Current / A

Duration		End of Discharge Voltage					
Minutes	Hours	1.85	1.80	1.75	1.70	1.67	1.65
60	1	68.9	70.8	72.5	73.8	74.5	74.9
120	2	40.6	41.2	41.6	42.0	42.2	42.3
180	3	29.0	29.3	29.5	29.7	29.8	29.8
240	4	22.6	22.8	23.0	23.1	23.2	23.2
300	5	18.6	18.7	18.8	18.9	19.0	19.0
480	8	12.1	12.2	12.3	12.4	12.4	12.5
600	10	9.8	9.9	10.0	10.1	10.2	10.2
1200	20	5.0	5.1	5.2	5.3	5.4	5.4

Capacity / Ah

Duration		End of Discharge Voltage					
Minutes	Hours	1.85	1.80	1.75	1.70	1.67	1.65
60	1	68.9	70.8	72.5	73.8	74.5	74.9
120	2	81.2	82.3	83.3	84.0	84.4	84.6
180	3	87.1	87.9	88.6	89.1	89.4	89.5
240	4	90.5	91.3	91.9	92.4	92.6	92.7
300	5	92.8	93.6	94.2	94.7	94.9	95.1
480	8	96.5	97.5	98.4	99.2	99.5	99.7
600	10	97.7	99.0	100.1	101.1	101.6	101.9
1200	20	99.2	102.0	104.6	106.8	108.0	108.7

Power / WPC

Duration		End of Discharge Voltage					
Minutes	Hours	1.85	1.80	1.75	1.70	1.67	1.65
60	1	130.2	133.6	136.6	139.0	140.2	140.9
120	2	76.6	77.7	78.6	79.3	79.7	79.9
180	3	54.8	55.3	55.8	56.1	56.3	56.3
240	4	42.7	43.1	43.4	43.6	43.7	43.7
300	5	35.1	35.3	35.6	35.7	35.8	35.8
480	8	22.8	23.0	23.2	23.3	23.4	23.4
600	10	18.4	18.6	18.8	19.0	19.0	19.1
1200	20	9.3	9.6	9.8	9.9	10.0	10.1

NSB 100FT BLUE+ Battery®

Discharge tables @ 25°C (77°F)

Current / A

Duration		End of Discharge Voltage					
Minutes	Hours	1.85	1.80	1.75	1.70	1.67	1.65
60	1	71.9	73.9	75.6	77.0	77.7	78.2
120	2	41.9	42.5	43.0	43.4	43.6	43.7
180	3	29.8	30.1	30.3	30.5	30.6	30.7
240	4	23.2	23.4	23.5	23.7	23.7	23.7
300	5	19.0	19.1	19.3	19.4	19.4	19.4
480	8	12.3	12.4	12.5	12.6	12.6	12.7
600	10	9.9	10.0	10.2	10.3	10.3	10.3
1200	20	5.0	5.1	5.3	5.4	5.4	5.5

Capacity / Ah

Duration		End of Discharge Voltage					
Minutes	Hours	1.85	1.80	1.75	1.70	1.67	1.65
60	1	71.9	73.9	75.6	77.0	77.7	78.2
120	2	83.8	85.0	86.0	86.8	87.2	87.4
180	3	89.5	90.3	91.0	91.6	91.8	92.0
240	4	92.7	93.5	94.1	94.6	94.8	94.9
300	5	94.8	95.6	96.3	96.8	97.0	97.1
480	8	98.1	99.1	100.0	100.8	101.2	101.4
600	10	99.0	100.4	101.5	102.5	103.0	103.3
1200	20	99.9	102.8	105.3	107.6	108.8	109.5

Power / WPC

Duration		End of Discharge Voltage					
Minutes	Hours	1.85	1.80	1.75	1.70	1.67	1.65
60	1	135.8	139.4	142.5	145.0	146.3	147.0
120	2	79.1	80.2	81.2	82.0	82.3	82.5
180	3	56.3	56.8	57.3	57.7	57.8	57.9
240	4	43.8	44.1	44.4	44.6	44.7	44.8
300	5	35.8	36.1	36.3	36.5	36.6	36.6
480	8	23.2	23.4	23.5	23.7	23.8	23.8
600	10	18.7	18.9	19.1	19.2	19.3	19.4
1200	20	9.4	9.6	9.8	10.0	10.1	10.2

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Discharge tables @ 20°C (68°F)

Current / A

Duration		End of Discharge Voltage					
Minutes	Hours	1.85	1.80	1.75	1.70	1.67	1.65
60	1	101.2	107.3	112.5	116.8	118.8	119.9
120	2	61.2	64.0	66.3	68.1	69.0	69.5
180	3	44.8	46.4	47.8	48.9	49.4	49.6
240	4	35.6	36.7	37.6	38.3	38.7	38.9
300	5	29.7	30.5	31.1	31.6	31.9	32.0
480	8	20.0	20.4	20.7	20.9	21.1	21.1
600	10	16.5	16.8	17.0	17.2	17.2	17.3
1200	20	8.9	9.0	9.0	9.1	9.2	9.2

Capacity / Ah

Duration		End of Discharge Voltage					
Minutes	Hours	1.85	1.80	1.75	1.70	1.67	1.65
60	1	101.2	107.3	112.5	116.8	118.8	119.9
120	2	122.4	127.9	132.6	136.3	138.0	139.0
180	3	134.4	139.3	143.4	146.6	148.1	148.9
240	4	142.6	146.9	150.5	153.3	154.7	155.4
300	5	148.6	152.4	155.6	158.2	159.5	160.2
480	8	160.2	163.1	165.5	167.6	168.6	169.2
600	10	165.1	167.6	169.8	171.6	172.5	173.0
1200	20	177.6	179.3	180.9	182.4	183.2	183.7

Power / WPC

Duration		End of Discharge Voltage					
Minutes	Hours	1.85	1.80	1.75	1.70	1.67	1.65
60	1	195.7	205.5	213.9	220.7	224.0	225.8
120	2	118.0	122.5	126.3	129.3	130.7	131.5
180	3	86.2	88.8	91.0	92.8	93.6	94.1
240	4	68.4	70.2	71.7	72.8	73.4	73.7
300	5	56.9	58.2	59.3	60.2	60.6	60.8
480	8	38.2	38.9	39.4	39.8	40.0	40.2
600	10	31.5	31.9	32.3	32.6	32.8	32.9
1200	20	16.9	17.1	17.2	17.4	17.4	17.5

NSB 170FT BLUE+ Battery®

Discharge tables @ 25°C (77°F)

Current / A

Duration		End of Discharge Voltage					
Minutes	Hours	1.85	1.80	1.75	1.70	1.67	1.65
60	1	105.6	111.9	117.4	121.8	123.9	125.1
120	2	63.2	66.1	68.5	70.4	71.3	71.8
180	3	46.1	47.7	49.1	50.2	50.7	51.0
240	4	36.5	37.6	38.5	39.3	39.6	39.8
300	5	30.4	31.1	31.8	32.3	32.6	32.7
480	8	20.3	20.7	21.0	21.3	21.4	21.5
600	10	16.7	17.0	17.2	17.4	17.5	17.5
1200	20	8.9	9.0	9.1	9.2	9.2	9.3

Capacity / Ah

Duration		End of Discharge Voltage					
Minutes	Hours	1.85	1.80	1.75	1.70	1.67	1.65
60	1	105.6	111.9	117.4	121.8	123.9	125.1
120	2	126.5	132.1	136.9	140.8	142.6	143.5
180	3	138.2	143.1	147.3	150.6	152.2	153.1
240	4	146.0	150.4	154.1	157.0	158.4	159.2
300	5	151.8	155.7	159.0	161.6	162.9	163.6
480	8	162.8	165.7	168.2	170.3	171.3	171.9
600	10	167.4	169.9	172.1	173.9	174.9	175.4
1200	20	178.9	180.7	182.3	183.7	184.5	185.0

Power / WPC

Duration		End of Discharge Voltage					
Minutes	Hours	1.85	1.80	1.75	1.70	1.67	1.65
60	1	204.2	214.4	223.2	230.3	233.6	235.5
120	2	121.9	126.5	130.4	133.5	135.0	135.8
180	3	88.5	91.3	93.5	95.4	96.2	96.7
240	4	70.0	71.8	73.4	74.6	75.2	75.5
300	5	58.1	59.5	60.6	61.4	61.9	62.1
480	8	38.9	39.5	40.0	40.5	40.7	40.8
600	10	31.9	32.4	32.8	33.1	33.2	33.3
1200	20	17.1	17.2	17.4	17.5	17.6	17.6

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Discharge tables @ 20°C (68°F)

Current / A

Duration		End of Discharge Voltage					
Minutes	**Hours**	**1.85**	**1.80**	**1.75**	**1.70**	**1.67**	**1.65**
60	1	120.4	125.1	129.4	133.0	134.9	136.0
120	2	70.9	72.4	73.7	74.8	75.4	75.7
180	3	50.9	51.5	52.1	52.6	52.9	53.1
240	4	39.9	40.3	40.6	40.9	41.0	41.1
300	5	32.9	33.2	33.4	33.6	33.7	33.7
480	8	21.8	22.0	22.1	22.2	22.3	22.3
600	10	17.9	18.1	18.2	18.3	18.3	18.4
1200	20	9.7	9.9	10.0	10.2	10.2	10.3

Capacity / Ah

Duration		End of Discharge Voltage					
Minutes	**Hours**	**1.85**	**1.80**	**1.75**	**1.70**	**1.67**	**1.65**
60	1	120.4	125.1	129.4	133.0	134.9	136.0
120	2	141.8	144.7	147.3	149.6	150.8	151.5
180	3	152.6	154.6	156.4	157.9	158.7	159.2
240	4	159.6	161.0	162.3	163.5	164.2	164.6
300	5	164.6	165.8	166.9	167.8	168.4	168.7
480	8	174.7	175.7	176.6	177.5	178.0	178.3
600	10	179.4	180.6	181.7	182.7	183.2	183.6
1200	20	195.0	198.1	200.9	203.2	204.4	205.1

Power / WPC

Duration		End of Discharge Voltage					
Minutes	**Hours**	**1.85**	**1.80**	**1.75**	**1.70**	**1.67**	**1.65**
60	1	235.5	243.3	250.2	256.0	259.0	260.8
120	2	140.5	142.9	145.0	146.9	147.8	148.4
180	3	101.5	102.5	103.5	104.3	104.8	105.0
240	4	79.9	80.4	80.9	81.4	81.7	81.9
300	5	66.1	66.4	66.8	67.1	67.3	67.4
480	8	44.0	44.2	44.4	44.5	44.6	44.7
600	10	36.2	36.4	36.5	36.7	36.8	36.8
1200	20	19.6	19.9	20.1	20.3	20.4	20.5

NSB 190FT BLUE+ Battery®

Discharge tables @ 25°C (77°F)

Current / A

Duration		End of Discharge Voltage					
Minutes	**Hours**	**1.85**	**1.80**	**1.75**	**1.70**	**1.67**	**1.65**
60	1	125.6	130.5	134.9	138.7	140.7	141.8
120	2	73.2	74.8	76.1	77.3	77.9	78.2
180	3	52.3	52.9	53.6	54.1	54.4	54.5
240	4	40.8	41.2	41.6	41.9	42.0	42.1
300	5	33.6	33.9	34.1	34.3	34.4	34.5
480	8	22.2	22.3	22.4	22.5	22.6	22.7
600	10	18.2	18.3	18.4	18.5	18.6	18.6
1200	20	9.8	10.0	10.1	10.2	10.3	10.3

Capacity / Ah

Duration		End of Discharge Voltage					
Minutes	**Hours**	**1.85**	**1.80**	**1.75**	**1.70**	**1.67**	**1.65**
60	1	125.6	130.5	134.9	138.7	140.7	141.8
120	2	146.5	149.5	152.2	154.5	155.7	156.5
180	3	156.8	158.8	160.7	162.3	163.1	163.6
240	4	163.4	164.9	166.2	167.4	168.1	168.5
300	5	168.2	169.3	170.4	171.4	172.0	172.3
480	8	177.6	178.6	179.5	180.4	180.9	181.2
600	10	181.9	183.1	184.2	185.2	185.8	186.1
1200	20	196.4	199.6	202.4	204.7	205.9	206.6

Power / WPC

Duration		End of Discharge Voltage					
Minutes	**Hours**	**1.85**	**1.80**	**1.75**	**1.70**	**1.67**	**1.65**
60	1	245.6	253.7	260.9	267.0	270.2	272.0
120	2	145.1	147.6	149.8	151.7	152.7	153.3
180	3	104.3	105.3	106.3	107.2	107.7	107.9
240	4	81.8	82.4	82.9	83.4	83.7	83.8
300	5	67.5	67.9	68.2	68.5	68.7	68.8
480	8	44.7	44.9	45.1	45.3	45.4	45.4
600	10	36.7	36.9	37.0	37.2	37.3	37.3
1200	20	19.8	20.0	20.3	20.5	20.6	20.6

NSB 210FT BLUE+ Battery®

Discharge tables @ 20°C (68°F)

Current / A

Duration		End of Discharge Voltage					
Minutes	Hours	1.85	1.80	1.75	1.70	1.67	1.65
60	1	132.1	137.3	142.0	145.9	148.0	149.2
120	2	78.3	80.1	81.7	83.1	83.7	84.1
180	3	56.2	57.1	57.9	58.6	58.9	59.1
240	4	44.0	44.6	45.1	45.5	45.7	45.8
300	5	36.2	36.6	37.0	37.3	37.4	37.5
480	8	23.9	24.1	24.3	24.5	24.5	24.6
600	10	19.5	19.7	19.9	20.0	20.1	20.1
1200	20	10.5	10.6	10.7	10.8	10.9	10.9

Capacity / Ah

Duration		End of Discharge Voltage					
Minutes	Hours	1.85	1.80	1.75	1.70	1.67	1.65
60	1	132.1	137.3	142.0	145.9	148.0	149.2
120	2	156.7	160.3	163.5	166.1	167.5	168.2
180	3	168.5	171.3	173.8	175.8	176.8	177.4
240	4	175.8	178.2	180.3	182.0	182.8	183.3
300	5	181.0	183.1	184.9	186.5	187.2	187.7
480	8	191.0	192.8	194.4	195.7	196.4	196.8
600	10	195.4	197.3	198.9	200.2	201.0	201.4
1200	20	210.2	212.7	214.9	216.9	217.9	218.5

Power / WPC

Duration		End of Discharge Voltage					
Minutes	Hours	1.85	1.80	1.75	1.70	1.67	1.65
60	1	259.1	266.2	272.7	278.3	281.2	283.0
120	2	153.5	157.3	160.5	163.1	164.4	165.1
180	3	110.3	112.8	114.9	116.6	117.4	117.9
240	4	86.5	88.4	89.9	91.2	91.7	92.1
300	5	71.4	72.9	74.1	75.0	75.5	75.7
480	8	47.5	48.2	48.8	49.3	49.5	49.6
600	10	39.2	39.6	40.0	40.3	40.4	40.5
1200	20	21.7	21.5	21.4	21.3	21.3	21.3

NSB 210FT BLUE+ Battery®

Discharge tables @ 25°C (77°F)

Current / A

Duration		End of Discharge Voltage					
Minutes	**Hours**	**1.85**	**1.80**	**1.75**	**1.70**	**1.67**	**1.65**
60	1	137.8	143.2	148.1	152.2	154.3	155.6
120	2	80.9	82.8	84.4	85.8	86.5	86.9
180	3	57.7	58.7	59.5	60.2	60.6	60.8
240	4	45.0	45.6	46.1	46.6	46.8	46.9
300	5	37.0	37.4	37.8	38.1	38.2	38.3
480	8	24.3	24.5	24.7	24.9	24.9	25.0
600	10	19.8	20.0	20.2	20.3	20.4	20.4
1200	20	10.6	10.7	10.8	10.9	11.0	11.0

Capacity / Ah

Duration		End of Discharge Voltage					
Minutes	**Hours**	**1.85**	**1.80**	**1.75**	**1.70**	**1.67**	**1.65**
60	1	137.8	143.2	148.1	152.2	154.3	155.6
120	2	161.8	165.6	168.9	171.6	173.0	173.8
180	3	173.2	176.1	178.6	180.7	181.7	182.3
240	4	180.1	182.5	184.6	186.3	187.2	187.7
300	5	184.9	187.1	188.9	190.5	191.2	191.7
480	8	194.1	195.9	197.5	198.9	199.6	200.0
600	10	198.2	200.0	201.6	203.0	203.7	204.2
1200	20	211.7	214.2	216.5	218.5	219.5	220.2

Power / WPC

Duration		End of Discharge Voltage					
Minutes	**Hours**	**1.85**	**1.80**	**1.75**	**1.70**	**1.67**	**1.65**
60	1	270.2	277.7	284.4	290.2	293.3	295.1
120	2	158.6	162.5	165.8	168.5	169.8	170.6
180	3	113.3	115.9	118.1	119.9	120.7	121.1
240	4	88.6	90.5	92.1	93.4	94.0	94.3
300	5	73.0	74.5	75.7	76.6	77.1	77.3
480	8	48.3	49.0	49.6	50.1	50.3	50.5
600	10	39.7	40.1	40.5	40.8	41.0	41.1
1200	20	21.8	21.6	21.5	21.5	21.5	21.5

NorthStar®
an EnerSys company

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NSB BLUE+ Battery®

Thin Plate Lead Carbon

NSB Blue+ Battery®
Application Manual

PSoC CYCLING

FASTER RECHARGE

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Thin Plate Lead Carbon Technology

1 Introduction

1.1 Blue+ Lead Carbon Technology

The Blue+ battery has been designed for applications where there are frequent power interruptions. Several features of the Blue+ battery have been enhanced to meet the demands: cyclic endurance for moderate to shallow cycles, charge acceptance and the ability to remain at partial state of charge. The battery uses more lead per capacity than normal AGM batteries and it uses specially selected carbon additives to enhance charge acceptance and endurance in partial state of charge. It also uses a higher compression in order to keep the active mass in place for harsh servicing conditions.

1.2 Definitions

The definition for each of the following terms or abbreviations describes the context employed throughout this document.

Monobloc: Set of cells in one housing connected, physical unit in our case the 12 V battery with 6 cells.

Battery: Functional unit for storage of electrical power in either one monobloc or several connected in series.

DOD: Depth of Discharge, fraction of total capacity used in discharge, 0-100 %

SOC: State of charge fraction of total capacity that is charged in most cases 100%-SOC = DOD

EODV: End of Discharge Voltage
VPC: Volts per cell

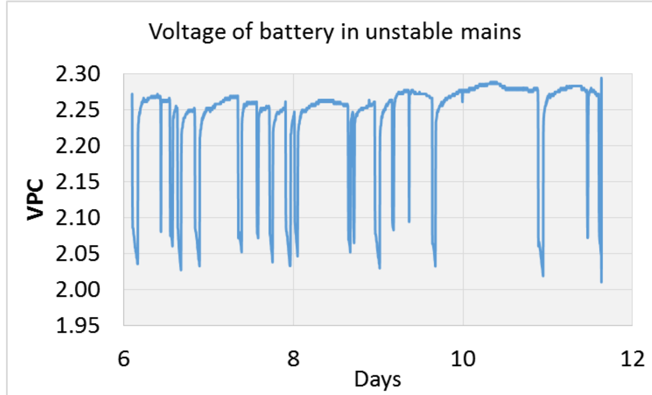
Electrolyte: In lead acid batteries a solution of sulfuric acid in water

String: Set of cells or monoblocs connected in series.

Note some terms may be used interchangeably given the circumstance.

1.3 Unstable mains service

Where the main electrical supply is of poor quality the batteries are used to provide service when the mains is off. Common to the poor grid operation are frequent interruptions. Often the time between the interruptions is so short that the battery cannot be fully recharged. So the battery may be fully recharged only rarely. This type of service is sometimes referred to as u-PSOC: uncontrolled-partial state of charge. Below an example of a battery in such an unstable mains environment.



As may be seen from the above chart. The monoboc operates at low voltage (VPC stated here) frequently in the first days of this graph. Rarely staying long enough at the float voltage level to reach full charge.

It has been shown that this type of service is stressful for normally designed AGM batteries. The Lead Carbon technology used in the Blue+ however enables greatly improved endurance in this type of service. Batteries which are not designed for this purpose only lasted 1/3 to 1/4 of the time of Blue+ when tested in laboratory cycles using the above field profile.

2 Charge

It is presumed that the batteries will be recharged following an outage (power interruption). Below you will find an outline of how this shall be performed, with descriptions of the terminology used and as well the basics of the use of the batteries. In real application it is presumed that the batteries will be used in a DC power system where the system functionality will control charge and discharge.

2.1 Charge & Discharge Rate

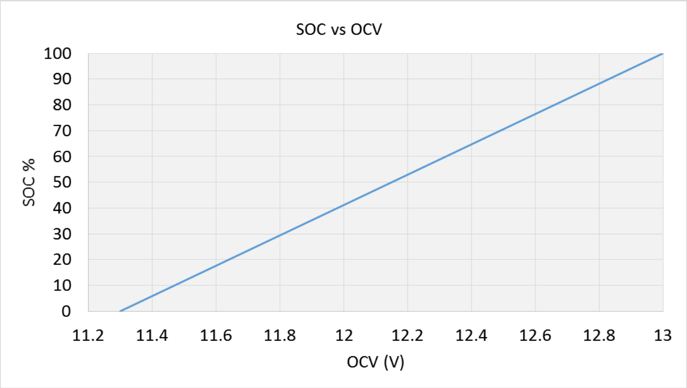
In this document, the charge and discharge rates (amps) are expressed as multiples of I10, where I10 is the current for a 10-hour discharge to 100% depth-of-discharge (DOD). These values serve to normalize data across a range of monobloc sizes. Consider the following example:

10-h discharge capacity NSB 100FT = 100 Ah (EODV =1.80 VPC @ 25°C).

1 x I10 = 1 x (10-h discharge current)
1 x I10 (NSB 100FT) = 1 x 10A = 10 A
2 x I10 (NSB 100FT) = 2 x 10A = 20 A

2.2 Determining State of Charge (SOC)

The SOC of a monobloc can be estimated by measuring the open-circuit-voltage (OCV) of the monobloc. If the monobloc has been recently recharged, a rest period of at least 12 hours after completion of recharge is required before taking measurements. If measured earlier the voltage is slightly higher and will indicate a too high SOC. The relationship between OCV and SOC for the Blue+ batteries is displayed in the following graph:

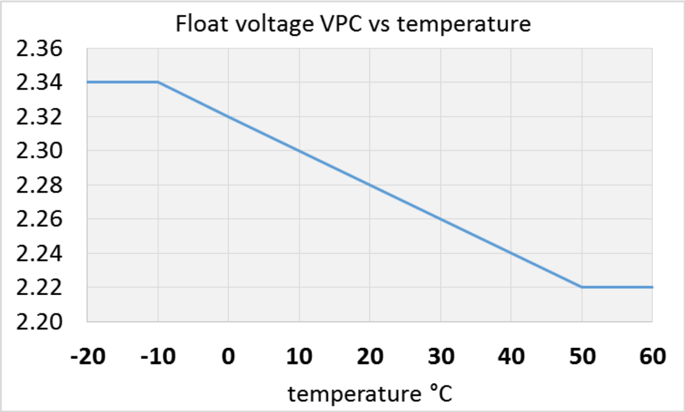


2.3 Float charge and thermal compensation

Thermal Compensation is the control of charging voltage depending on temperature. This serves to decrease the amount of overcharge that the batteries absorb at higher temperatures. Higher temperatures lead to quicker aging of the batteries. Temperature compensation cannot off-set all the detrimental effects that higher temperatures have.

The optimum level for float charging the Blue+ is 2.27 VPC ±0.02VPC at +25°C (+77°F). If the monobloc temperature increases above this level, a thermal compensation of -2 mV/cell/°C is recommended for safe operation and achieving optimal life. Conversely, if the temperature decreases below 25°C, the voltage should be increased by 2 mV/cell/°C. Most modern charge rectifiers have integrated temperature monitoring and voltage regulation which should be used in any environment where temperature is not precisely controlled.

The graph below shows values for an individual cell. The tolerance is ±0.02 V per cell.



2.4 Recharging

If the charging system is properly sized, a fast charging regime will serve to minimize the time needed to recharge Blue+ batteries.

There are two factors governing the recharge time: energy balance and charge acceptance. Batteries have charge acceptance – When applying the charging voltage to the batteries a current will flow into the battery. The more current the battery can accept the higher the charge acceptance. The charging current is dependent on factors like the SOC, the temperature and the charging voltage and actual design of the battery. To some extent the charge acceptance is also dependent on the nature of the preceding discharge. If the battery is freshly discharged the battery has a higher charge acceptance than when it has been stored a long time.

The energy in the battery must be restored when recharging a battery. This is done by restoring the charge into the battery with at least as much charge as has been taken out. The ratio between charge input and the preceding discharge is called charge return.

In the case that a battery has very high charge acceptance, it is the energy balance/charge balance that determines the charging time. When making rough estimates of size of charger and charging times this is the first consideration to look at. Charging times will always be longer than what is stated from the charge/energy balance.

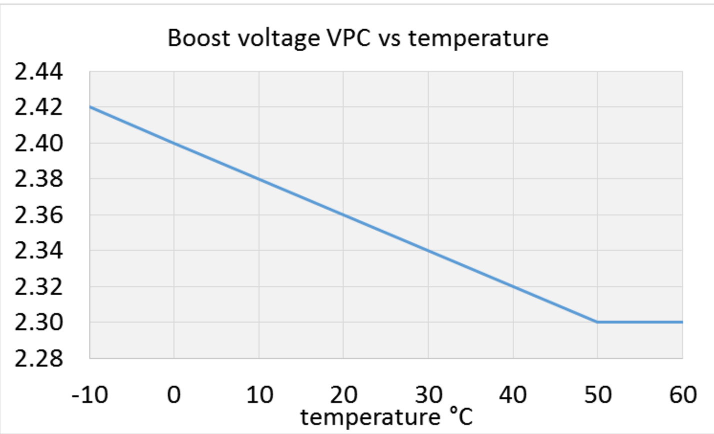
Batteries will need a charge return of a little more than a 100% in order to compensate for the coulometric-charge inefficiencies. Depending of the temperature and DOD this may vary from 0.5-6%, i.e. charge return of 100.5-106%. The higher the DOD and the higher the temperature is the higher this overcharge need to be to fully charge the battery.

2.4.1 Boost voltage

A charging voltage higher than the float voltage is recommended in situations where there are frequent power interruptions. This increases the charge acceptance and is especially helpful to shorten the time to full charge return and will speed up the achievement of a proper over charge. This is the boost voltage.

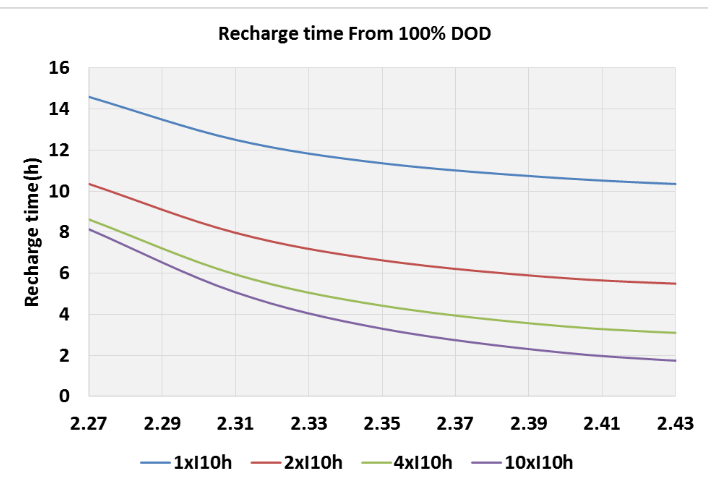
NorthStar recommends 2.35 VPC as boost voltage. This voltage is normally acceptable in 48 V power system used in telecomm application.

NorthStar recommends that the boost charge voltage shall be temperature controlled (temperature compensated) according to the graph below.



NorthStar also strongly recommend that the boost charge voltage shall be limited to 5 h of duration. This is counted from the time the battery voltage reaches the boost voltage and the charging current starts to decrease.

The following chart shows the time required to fully recharge a NSB Blue+ battery from a complete 100% DOD discharge, as a function of applied average voltage and available current.



2.4.2 Equalizing charge

Equalizing charge has the purpose of equalizing all the batteries or cells in a string by applying a higher voltage for a limited time. The individual objects in a string. Batteries, can become unbalanced i.e. the cells have slightly deviating voltages due to various reasons: cell differences, exposed to different temperatures for instance. The equalizing charge shall commence first when the batteries have been charged by normal means. The voltage should be the same as for the boost and same temperature controls shall be applied. Batteries shall be charged for 12-24 hours.

It shall be limited to the boost voltage level and shall not be longer than 16 hours.

3 Heat and Temperatures

Batteries will evolve heat especially during cycling, the charging and discharging. As a rule of thumb 15% of the turned over energy shall be assumed to be heat in a charge discharge cycle. This number will apply when the total cycle for a full turn-over is at least 24 h. So the climate system has to provide this cooling. A high operating temperature will be more stressful to the battery and active cooling is recommended.

The batteries need to be spaced and arranged so that the cooling of the monoblocs will be as uniform as possible. When batteries are placed on different shelves it is important that the air flow to the different shelves shall be arranged so that the batteries on different shelves have as uniform temperatures as possible.

3.1 Battery high temperature cut-off

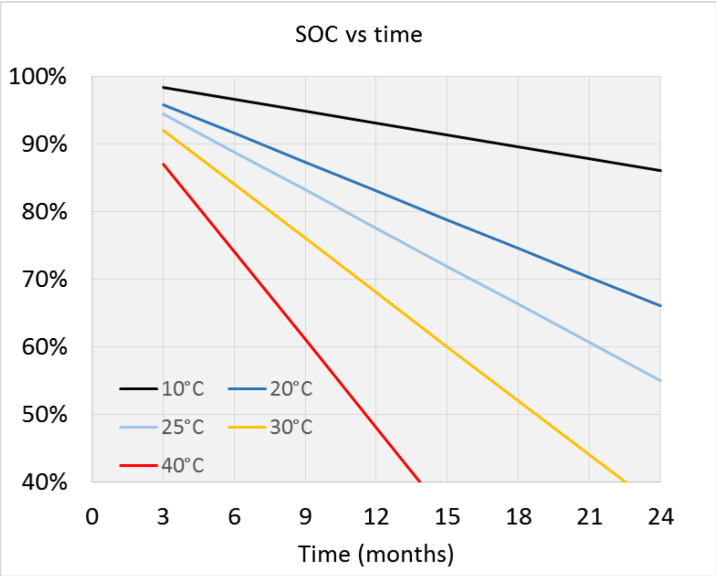
It is highly recommended to have a system which disconnects the battery at a pre-set high temperature. The pre-set temperature shall be in the interval 60-75 °C. This is in order to avoid thermal damage to the battery and as well in order to avoid thermal runaway.

4 Discharge

4.1 Storage and Self Discharge

During storage, lead-acid batteries will gradually self-discharge. It is recommended that monobloc SOC be maintained above 12.20 V at all times, while the battery is in storage, in order to avoid irreversible capacity loss. The rate of self-discharge increases with increasing temperature.

For example: a monobloc at 25°C will drop from 90% to 60% in 15 months, whereas the same monobloc at 40 °C will take just 6 months. As a result, maintenance charging needs to be performed more frequently at higher temperatures



The 50% SOC limit corresponds to 12.2 V for a monobloc recharge before this limit is passed.

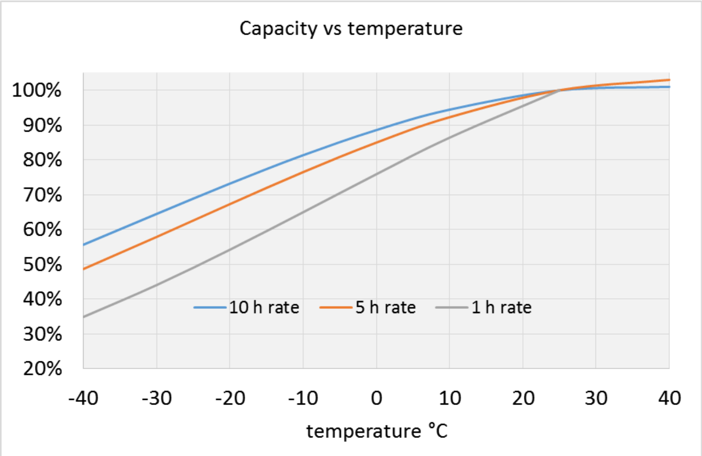
4.2 End of Discharge Voltage (EODV)

In the event of a deep discharge, a recommended minimum end-of-discharge voltage (EODV) should be used to avoid over discharge. The EODV should be adjusted based on the discharge rate, the following table provides a guide for EODVs at various discharge rates.

Discharge time (h)	EODV (VPC)
20	1.85
10	1.80
5	1.75
1	1.70

4.3 Low Temperature Performance

At low temperatures the capacity decreases. The capacity can be estimated using the graph below.



5 Useful Life

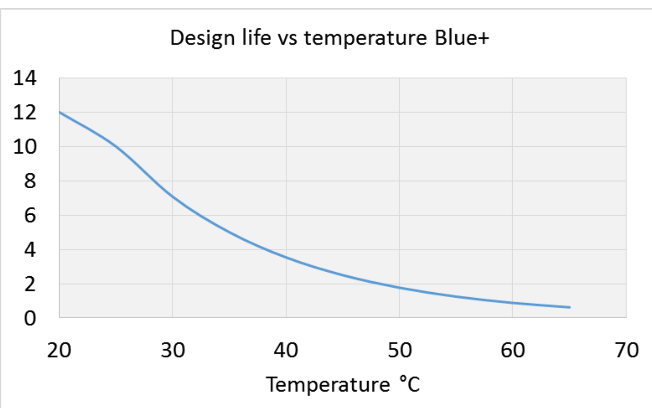
5.1 Shelf Life

NSB Blue+ batteries may be stored for up to 2 years, provided that the SOC is maintained above 50%. Failure to provide the required maintenance charging (see Section 4.1 Storage and Self Discharge) may lead to irreversible capacity loss.

5.2 Float Life vs. Temperature

Due to constant float charging, the lead grids within the positive plates undergo slow corrosion, which is a normal aging mechanism. The rate of this process increases with increasing temperature and, as a result, the temperature of monoblocs has a large effect on their float life.

For example, if the temperature rises from the recommended operating temperature of +25°C, to +45°C, the expected life of the monobloc will decrease from 10 to 2 years (see chart below). This is the overall average operating temperature during the life of the monobloc.



Under float operation, a monobloc is considered to have reached its end of life (EOL) when it can no longer deliver 80% of its original rated capacity. For example, a 100 Ah monobloc has reached EOL when its discharge capacity has dropped below 80 Ah.

6 Hybrid Operation Cyclic Operation

Hybrid operation refers to the use of Blue+ batteries in parallel to a generator set in a defined scheme, where the generator is run intermittently charging the batteries. When generator is not running the batteries provides the power. By this scheme there are savings in fuel consumption and the generator run time is decreased.

Blue+ batteries are well suited to this type of service. The following operational strategies can be applied

6.1 PSOC

It is recommended that the battery is cycled between a low SOC in the region 50-65% and is charged to SOC 95%. The charge return shall be in the range 100.5-101%. Every second week the battery shall be equalized using a 16 h equalization charge at 2.41 VPC.

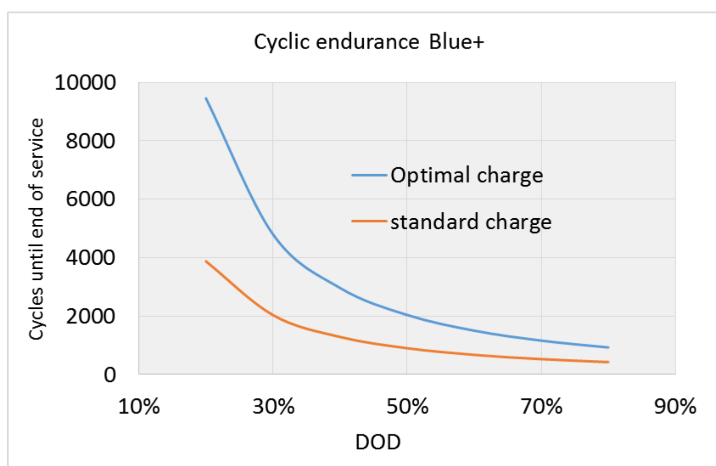
6.2 High Window PSoC (Q-charge)

It is recommended that the battery is cycled between a low SOC in the region 50-30% and is charged to 100%SOC using a charge return somewhat dependent on the DOD. Following table condenses the recommended charging times and recommended charge returns to use:

DOD window		30%	40%	50%
Charge return	min	101.00%	101.20%	101.40%
	max	101.20%	101.40%	101.60%
Charge time (h)	$2xI_{10h}$	2.25	3.00	3.75
	$3xI_{10h}$	1.50	2.00	2.50

6.3 Cycle Life vs. Depth of Discharge

Blue+ batteries are designed to be able to operate in highly cyclic applications as well as PSOC applications. During optimal PSOC charging regime, NSB Blue+ batteries can be expected to achieve cycle life according to the chart below.



7.1 Battery Safety and Environmental Information

For full information please read the Material Safety Data Sheet (SDS). The SDS document may be downloaded from the NorthStar website www.northstarbattery.com

When dealing with Valve Regulated Lead Acid Batteries (VRLA) some additional safety information is required.

	Please read and observe the installation and operation instructions.
	When working on batteries wear appropriate Personal Protective Equipment (PPE). Refer to battery SDS for complete list.
	Do not expose the battery to an open flame or other ignition source. During operation an explosive mixture of hydrogen gas may accumulate.
	Battery terminals are always energized and, if short-circuited, cause electrical arcing. Always use insulated tools.
	Batteries are heavy objects. Use proper handling equipment safety gear during installation.
	Inappropriate lead acid battery disposal can result in environmental contamination. Please dispose of batteries according to regulations.
	Battery may be returned, shipping pre-paid, to the manufacturer or any distributor for recycling.
	Batteries contain concentrated sulfuric acid in water. Any fluid found outside the batteries should be regarded as acid.
	Clean all acid splash in eyes or on skin with plenty of clean water. Then seek medical help. Acid on clothing is to be washed with water
	Risk of explosion or fire. Avoid any short circuit. Metallic parts under voltage on the battery - do not place tools or items on top of the battery.

8 Receiving the Shipment

In addition to safety requirements (see section 7) special care should be taken when handling monoblocs. The following are some DOs and DON'Ts.

DO

Always use both handles on the monoblocs when lifting or carrying them.

Always have a straight back and lift using your legs when lifting or carrying monoblocs.

Always have appropriate safety gear (see section 7) available when handling monoblocs.

Always perform an Open Circuit Voltage (OCV) check on a monobloc PRIOR to installation, see section 10.2 Checking the Voltage Spread, and section 10.7 Charging.

Always perform a visual inspection of the monobloc prior to handling. If any damage or electrolyte leakage is detected during this inspection, do not install the monoblocs. Stop flow of material, contain/absorb small spills with dry sand, earth or vermiculite. Do not use combustible materials. If possible, carefully neutralize spilled electrolyte with soda ash, sodium bicarbonate, lime, etc. Wear acid- resistant clothing, boots, gloves and face shield. Do not allow discharge of un-neutralized acid to sewer.

Acid must be managed in accordance with approved local, state, and federal requirements. Consult state environmental agency and/or federal EPA.

Always use the packing from new monoblocs for transporting old monoblocs for proper disposal. If unavailable, place batteries on a pallet and strap them down securely for shipping.

Always dispose of monoblocs in accordance with local and national requirements.

Always follow the instructions provided with the monoblocs when installing them.

Always use insulated tools when handling monoblocs. Failure to do so can lead to electric shock, burns and/or damage to batteries and equipment

DON'T

Don't drag a monobloc along the floor. Doing so could cause damage to the monobloc case leading to a possible leakage of electrolyte.

Don't install a monobloc that has been dropped into any application. A dropped monobloc could have damage to either its internal or external casing leading to a possible leakage of electrolyte and damage to equipment.

Don't make the final connection to an application until all batteries in the string have had their interconnections finished and properly torqued. Battery terminals are always energized and, if short-circuited, can cause electrical arcing as well as damage to the batteries and equipment.

Don't dispose of batteries in unapproved sites. The batteries contain electrolyte and compounds of lead that are harmful to nature and can contaminate the environment if not disposed of properly.

Don't drill, or in any other way attempt to breach the monoblocs case. Doing so could lead to a possible leakage of electrolyte.

Don't force a monobloc into equipment. Forcing the monobloc into equipment can lead to a breach in the monoblocs internal or external casing causing a possible leakage or electrolyte or electrical short circuit.

Don't move the monoblocs using the terminals. The terminals are not designed to support the weight of the monobloc and damage to internal components could result.

9 Storage

9.1 Storage conditions

Below is a list of equipment that is recommended to be on hand in the area where monoblocs are stored.

1. DC volt meter
2. Battery chargers (with controlled voltage output setting +/- 0.05V)
3. Mechanical lifting device (such as a fork lift etc.)
4. Appropriate Personal Protective Equipment (PPE), as listed in the Battery Safety and environmental information section of this document.

It is strongly recommended to store the monoblocs in a cool dry environment. For more information see section 4.1 Storage and Self Discharge

The monoblocs should be stored in the original containers. The packaging serves to protect the monoblocs from harsh environmental conditions and accidental damage. If they must be removed, palletize them, and utilize as much of the original packaging as possible.

9.2 Storage time

For more information see section 4.1 Storage and Self Discharge

Shown above: different ways to correctly store monoblocs

10 Commissioning

Always use the installation instructions provided with the monoblocs and follow all outlines for safety and handling mentioned earlier in this document.

10.1 Unpacking the Batteries

When received, a visual check should be made on the monoblocs. If the monoblocs show transportation damage, physical damage to the case, leaking electrolyte etc. they should not be installed, and a claim should be initiated immediately.

Make sure all the accessories are present in the delivery. Please observe the cardboard sleeves around the monoblocs has no bottom! The cardboard should be removed prior to lifting the monoblocs. Please keep all packing material for future use if possible.

If the monoblocs cannot be put into place directly and need to be put on the floor/ground, put some of the cardboard material under them in order to protect the monobloc from hard surfaces. An alternative material is to use the top of the crate that the monoblocs were shipped in.

10.2 Checking the Voltage Spread

Before connecting the monoblocs in series, the voltage variation must be checked and the voltages shall recorded. If the voltage varies more than 0.15 V between the highest and the lowest monobloc voltage, the monoblocs should be charged individually before being connected in series.

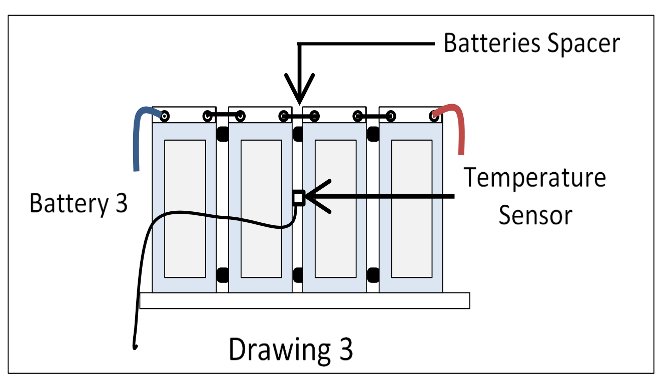
Alternatively the monoblocs may be matched in each string so that all the monoblocs have a voltage spread of less than 0.15V.

10.3 Putting the Batteries in Place

Make sure the monoblocs are all evenly spaced, aligned and rest on a flat surface. Resting the monoblocs on an acid resistant, electrically isolating surface is recommended to avoid possible ionic connection to ground and potential damage to equipment.

Monoblocs can be installed in any orientation, but inverted is not recommended.

Temperature sensors shall be installed in a proper way see figure for placement. The sensor shall be placed approximately at 2/3 of the height.

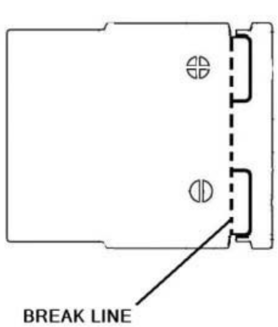


10.4 Connecting the Batteries

The monoblocs shall be connected in series using the cable and connectors designed for the particular layout of your application. Refer to the particular layout of the system. Please observe the risk for arcing and high currents when connecting the monobloc string to the system. Preferably the last connection should be made at distance from the monobloc string.

If the system comprises a monobloc circuit breaker or any other means of disconnection, this shall be in an off condition when connecting the monobloc to the system. Before connecting cables, clean contact surface and apply a light coating of anti- oxidizing grease to contact surfaces. A torque wrench must be used for tightening the bolts on the battery. Recommended torque will vary depending on the size of the battery. Refer to the product label applied directly to the battery for recommended torque values.

The covers shall be put back after all connections have been completed. Please observe that when heavy cables are used, these need to be supported in order not to stress the monoblocs terminals. The isolation covers should be put back after all connections have been completed. See the figures below:



10.5 Application of Grease after Tightening Electrical Connections

Electrical grade conductive grease is applied directly to the battery terminals as a corrosion preventative measure during manufacturing. In typical indoor installations no additional grease is required to protect the terminals and other electrical connections after installation. The bus bars and other hardware provided with the batteries are plated to protect from corrosion.

10.6 Cleaning

Batteries shall only be cleaned using a dry soft cloth or alternatively cloth moistened with water – Any other substances should not be used or sprayed on the batteries. The plastic used for the batteries is sensitive to many solvents and other substances. Especially pesticides, insect repellants should be avoided entirely as these are known to have caused the plastic to experience severe cracking.

10.7 Charging

Please note! Never charge the batteries in their packaging! Batteries need to be unpacked and positioned with space between them before any charging is started.

10.8 First charge commissioning charge

Depending on the state of charge of the batteries it may take some time before they reach full state of charge. Below recommended charge based on the OCV values of the monoblocs.

OCV	Recharge Time
>12.80 V	3 day charge 2.27 VPC
12.6 - 12.8 V	3 day charge 2.27 VPC
12.3 - 12.6 V	1 day charge 2.41 VPC
12.1 - 12.3 V	1 day charge 2.41 VPC

10.9 Setting charging voltages in the system

Charging systems for batteries need you to set the float voltage, temperature compensation values and boost voltage settings. For convenience the settings for some of the most common configurations and temperatures have been added. The table below shows float voltage using temp compensation -2mV/cell/°C

T °C / °F	V (float) 24 V	48 V
20 / 68 13.68 ± 0.12V	27.36 ± 0.24V	54.72 ± 0.48V
25 / 77 13.62 ± 0.12V	27.24 ± 0.24V	54.48 ± 0.48V
30 / 86 13.56 ± 0.12V	27.12 ± 0.24V	54.24 ± 0.48V
35 / 95 13.50 ± 0.12V	27.00 ± 0.24V	54.00 ± 0.48V

For the boost voltage setting please consult section 2.4.1.

10.10 Over temperature safety feature setting

When the system has a high temperature disconnect it shall be set to disconnect the battery at a temperature preferably at 65°C but not higher than 75°C.

10.11 Battery block position labeling

Some customers may require marking/labeling of each battery block's position within a battery string, i.e. block number 1through 4 for a -48VDC battery string. Mark each battery in accordance with customer requirement (some customers may require the battery block connected to the 0V lead to be block #1 and the block connected to the -48VDC lead to be #4 or vice versa).

If marking is made with stickers or marker, put the mark on the existing battery label to avoid possible reaction between the glue of the sticker and the plastic jar or the marker's solvent and the plastic jar.

11 Maintenance

In absence of automatic monitoring systems the following maintenance is recommended:

Every 6 months check voltage of the power plant and individual voltages of the monoblocs. If the battery is judged to be fully charged no unit shall deviate more than 0.15 V from other units.

Check the batteries for integrity and cleanliness. If necessary, clean the dirty units.

12 Technical Specifications

For detailed technical specification, please refer to the product datasheet at www.northstarbattery.com

13 Contacts

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NorthStar®
an EnerSys company

Industrial Lead Acid Battery Safety Data Sheet

1. *IDENTIFICATION*

REVISION DATE: 01-1-2022

Product Name: Lead Acid Battery, Non-Spillable Wet **Synonyms:** Industrial Battery, Traction Battery, Stationary Battery, Deep Cycle Battery	**Product Use:** Electric Storage Battery **Manufacturer/Supplier:** NorthStar Battery, Co., LLC **Address:** 4000 E. Continental Way, Springfield, MO 65803
General Information Number: 417.575.8200	**CAS Number:** Not Applicable CHEMTREC: 800-424-9300

2. *GHS HAZARDS IDENTIFICATION*

Health	Environmental	Physical
Acute Toxicity (Oral/Dermal/Inhalation) - Category 4 Skin Corrosion/Irritation - Category 1A Eye Damage - Category 1 Reproductive - Category 1A Carcinogenicity (lead) - Category 1B Carcinogenicity (arsenic) - Category 1A Carcinogenicity (acid mist) - Category 1A Specific Target Organ Toxicity (repeated exposure) - Category 2	Aquatic Chronic - 1 Aquatic Acute - 1	Explosive Chemical, Division 1.3

GHS Label:

Health	Environmental	Physical
		

Hazard Statements **DANGER!** Causes severe skin burns and eye damage. Causes serious eye damage. May damage fertility or the unborn child if ingested or inhaled. May cause cancer if ingested or inhaled. Causes damage to central nervous system, blood and kidneys through prolonged or repeated exposure. May form explosive air/gas mixture during charging. Extremely flammable gas (hydrogen). Explosive, fire, blast or projection hazard.	***Precautionary Statements*** Wash thoroughly after handling. Do not eat, drink or smoke when using this product. Wear protective gloves/protective clothing, eye protection/face protection. Avoid breathing dust/fume/gas/mist/vapors/spray. Use only outdoors or in a well-ventilated area. Causes skin irritation, serious eye damage. Contact with internal components may cause irritation or severe burns. Avoid contact with internal acid. Irritating to eyes, respiratory system, and skin.

3. *COMPOSITION / INFORMATION ON INGREDIENTS

INGREDIENTS (Chemical/Common Names):	CAS No.:	% by Wt:
Lead and Lead Compounds (inorganic)	7439-92-1	**50**
Electrolyte (H2SO4/H2O)	7664-93-9	**17**
Lead Oxide	1309-60-0	**20**
Tin	7440-31-5	**0.2**

4. FIRST AID MEASURES

INHALATION:
Sulfuric Acid: Remove to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Consult a physician.
Lead: Remove from exposure, gargle, wash nose and lips; consult physician.

INGESTION:
Sulfuric Acid: Give large quantities of water; Do NOT induce vomiting or aspiration into the lungs may occur and can cause permanent injury or death. Consult a physician.
Lead: Consult a physician immediately.

SKIN:
Sulfuric Acid: Flush with large amounts of water for at least 15 minutes; remove contaminated clothing completely, including shoes. If symptoms persist, seek medical attention. Wash contaminated clothing before reuse. Discard contaminated shoes.
Lead: Wash immediately with soap and water.

EYES:
Sulfuric Acid and Lead: Flush immediately with large amounts of water for at least 15 minutes while lifting lids; Seek immediate medical attention if eyes have been exposed directly to acid.

5. FIRE FIGHTING MEASURES

Flash Point: Not Applicable
Flammable Limits: LEL = 4.1% (Hydrogen Gas in air); UEL = 74.2%
Extinguishing media: CO2; foam; dry chemical. Do not use carbon dioxide directly on cells. Avoid breathing vapors. Use appropriate media for surrounding fire.

Fire Fighting Procedures:
Use positive pressure, self-contained breathing apparatus. Beware of acid splatter during water application and wear acid-resistant clothing, gloves, face and eye protection. If batteries are on charge, shut off power to the charging equipment, but note that strings of series connected batteries may still pose risk of electric shock even when charging equipment is shut down.

Hazardous Combustion Products:
Highly flammable hydrogen gas is generated during charging and operation of batteries. If ignited by burning cigarette, naked flame or spark, may cause battery explosion with dispersion of casing fragments and corrosive liquid electrolyte. Carefully follow manufacturer's instructions for installation and service. Keep away all sources of gas ignition and do not allow metallic articles to contact, simultaneously, the negative and positive terminals of a battery. Follow manufacturer's instructions for installation and service.

6. ACCIDENTAL RELEASED MEASURES

Stop flow of material, contain/absorb small spills with dry sand, earth or vermiculite. Do not use combustible materials. If possible, carefully neutralize spilled electrolyte with soda ash, sodium bicarbonate, lime, etc. Wear acid-resistant clothing, boots, gloves, and face shield. Do not allow discharge of un-neutralized acid to sewer. Acid must be managed in accordance with approved local, state, and federal requirements. Consult state environmental agency and/or federal EPA.

7. HANDLING AND STORAGE

Handling:
Unless involved in recycling operations, do not breach the casing or empty the contents of the battery. Handle carefully and avoid tipping, which may allow electrolyte leakage. There may be increasing risk of electric shock from strings of connected batteries. Keep containers tightly closed when not in use. If battery case is broken, avoid contact with internal components. Keep vent caps on and cover terminals to prevent short circuits. Place cardboard between layers of stacked automotive batteries to avoid damage and short circuits. Keep away from combustible materials, organic chemicals, reducing substances, metals, strong oxidizers and water. Use banding or stretch wrap to secure items for shipping.

Storage:
Store batteries under roof in cool, dry, well-ventilated areas separated from incompatible materials and from activities that may create flames, spark, or heat. Store on smooth, impervious surfaces provided with measures for liquid containment in the event of electrolyte spills. Keep away from metallic objects that could bridge the terminals on a battery and create a dangerous short-circuit.

Charging:
There is a possible risk of electric shock from charging equipment and from strings of series connected batteries, whether or not being charged. Shut-off power to chargers whenever not in use and before detachment of any circuit connections. Batteries being charged will generate and release flammable hydrogen gas. Charging space should be ventilated. Keep battery vent caps in position. Prohibit smoking and avoid creation of flames and sparks nearby. Wear face and eye protection when near batteries being charged.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure Limits (mg/m^3) **Note: N.E. = Not Established**

INGREDIENTS (Chemical/Common Names):	OSHA PEL	ACGIH	US NIOSH	Quebec PEV	Ontario OEL	EU OEL
Lead and Lead Compounds (inorganic)	0.05	0.05	0.05	0.05	0.05	0.15 (b)
Electrolyte (H_2SO_4/H_2O)	1	0.2	1	1	0.2	0.05 (c)
Tin	2	2	2			

(a) As dusts/mists **(b)** As inhalable aerosol **(c)** Thoracic fraction **(d)** Potential occupational carcinogen

(e) Based on OEL's of Austria, Belgium, Denmark, France, Netherlands, Switzerland, & U.K.

(f) Based on OEL of Belgium **(g)** Based on OEL of Netherlands

Engineering Controls (Ventilation):
Store and handle in well-ventilated area. If mechanical ventilation is used, components must be acid-resistant. Handle batteries cautiously, do not tip to avoid spills. Make certain vent caps are on securely. If battery case is damaged, avoid bodily contact with internal components. Wear protective clothing, eye and face protection, when filling, charging or handling batteries. Do not allow metallic materials to contact, simultaneously, both the positive and negative terminals of the batteries. Charge batteries in areas with adequate ventilation. General dilution ventilation is acceptable.

Respiratory Protection (NIOSH/MSHA approved):
None required under normal conditions. When concentrations of sulfuric acid mist are known to exceed PEL, use NIOSH or MSHA-approved respiratory protection.

Skin Protection:
If battery case is damaged, use rubber or plastic acid-resistant gloves with elbow-length gauntlet, acid-resistant apron, clothing and boots.

Eye Protection:
If battery case is damaged, use chemical goggles or face shield.

Other Protection:
In areas where water and sulfuric acid solutions are handled in concentrations greater than 1%, emergency eyewash stations and showers should be provided, with unlimited water supply. Chemically impervious apron and face shield recommended when adding water or electrolyte to batteries. Wash Hands after handling.

9. PHYSICAL AND CHEMICAL PROPERTIES

Properties Listed Below are for Electrolyte:			
Boiling Point:	**203 - 240° F**		
Specific Gravity (H20 = 1)			
Silver Product	**1.320 +/- 0.01**		
Blue Product	**1.280 +/- 0.01**		
Red Product	**1.320 +/- 0.01**		
Blue +	**1.320 +/- 0.01**		
Boiling Point:	**203 – 204°F**		
Melting Point:	**N/A**	Vapor Pressure (mm Hg):	**10**
Solubility in Water:	**100%**	Vapor Density (AIR = 1):	**Greater than 1**
Evaporation Rate: (Butyl Acetate = 1)	**Less than 1**	% Volatile by Weight:	**N/A**
pH:	**~1 to 2**	Flash Point:	**Below room temperature (as hydrogen gas)**
LEL (Lower Explosive Limit)	**4% (Hydrogen)**	UEL (Upper Explosive Limit)	**74% (Hydrogen)**
Appearance and Odor:	**Manufactured article; no apparent odor. Electrolyte is a clear liquid with a sharp, penetrating, pungent odor.**		

10. STABILITY AND REACTIVITY

Stability: Stable _X_ Unstable ____
This product is stable under normal conditions at ambient temperature.

Conditions to Avoid: Prolonged overcharge at high current; sources of ignition.

Incompatibilities: (materials to avoid)
Electrolyte: Contact with combustibles and organic materials may cause fire and explosion. Also reacts violently with strong reducing agents, metals, sulfur trioxide gas, strong oxidizers, and water. Contact with metals may produce toxic sulfur dioxide fumes and may release flammable hydrogen gas.

Lead compounds: Avoid contact with strong acids, bases, halides, halogenates, potassium nitrate, permanganate, peroxides, nascent hydrogen, and reducing agents.

Hazardous Decomposition Products:
Electrolyte: Sulfur trioxide, carbon monoxide, sulfuric acid mist, sulfur dioxide, hydrogen sulfide.

Lead compounds: Temperatures above the melting point are likely to produce toxic metal fume, vapor, or dust. Contact with strong acid or base or presence of nascent hydrogen may generate highly toxic arsine gas.

Hazardous Polymerization:
Will not occur.

11. TOXICOLOGICAL INFORMATION

Routes of Entry:
Sulfuric Acid: Harmful by all routes of entry.
Lead Compounds: Hazardous exposure can occur only when product is heated, oxidized or otherwise processed or damaged to create dust, vapor or fume. The presence of nascent hydrogen may generate highly toxic arsine gas.

Inhalation:
Sulfuric Acid: Breathing of sulfuric acid vapors or mists may cause severe respiratory irritation.
Lead Compounds: Inhalation of lead dust or fumes may cause irritation of upper respiratory tract and lungs.

Ingestion:
Sulfuric Acid: May cause severe irritation of mouth, throat, esophagus and stomach.
Lead Compounds: Acute ingestion may cause abdominal pain, nausea, vomiting, diarrhea and severe cramping. This may lead rapidly to systemic toxicity and must be treated by a physician.

Skin Contact:
Sulfuric Acid: Severe irritation, burns and ulceration.
Lead Compounds: Not absorbed through the skin.

Eye Contact:
Sulfuric Acid: Severe irritation, burns, cornea damage, and blindness.
Lead Compounds: May cause eye irritation.

Effects of Overexposure - Acute:
Sulfuric Acid: Severe skin irritation, damage to cornea, upper respiratory irritation.
Lead Compounds: Symptoms of toxicity include headache, fatigue, abdominal pain, loss of appetite, muscular aches and weakness, sleep disturbances and irritability.

Effects of Overexposure - Chronic:
Sulfuric Acid: Possible erosion of tooth enamel, inflammation of nose, throat & bronchial tubes.
Lead Compounds: Anemia; neuropathy, particularly of the motor nerves, with wrist drop; kidney damage; reproductive changes in males and females. Repeated exposure to lead and lead compounds in the workplace may result in nervous system toxicity. Some toxicologists report abnormal conduction velocities in persons with blood lead levels of 50 µg/100 ml or higher. Heavy lead exposure may result in central nervous system damage, encephalopathy and damage to the blood-forming (hematopoietic) tissues.

Carcinogenicity:
Sulfuric Acid: The International Agency for Research on Cancer (IARC) has classified "strong inorganic acid mist containing sulfuric acid" as a Category I carcinogen, a substance that is carcinogenic to humans. This classification does not apply to liquid forms of sulfuric acid or sulfuric acid solutions contained within a battery. Inorganic acid mist (sulfuric acid mist) is not generated under normal use of this product. Misuse of the product, such as overcharging, may result in the generation of sulfuric acid mist.
Lead Compounds: Lead is listed as a 2B carcinogen, likely in animals at extreme doses. Proof of carcinogenicity in humans is lacking at present.

Medical Conditions Generally Aggravated by Exposure:
Overexposure to sulfuric acid mist may cause lung damage and aggravate pulmonary conditions. Contact of sulfuric acid with skin may aggravate diseases such as eczema and contact dermatitis. Lead and its compounds can aggravate some forms of kidney, liver and neurologic diseases.

Acute Toxicity:

Inhalation LD50:
Electrolyte: LC50 rat: 375 mg/m3; LC50: guinea pig: 510 mg/m3
Elemental Lead: Acute Toxicity Point Estimate = 4500 ppmV (based on lead bullion)

Oral LD50:
Electrolyte: rat: 2140 mg/kg
Elemental lead: Acute Toxicity Estimate (ATE) = 500 mg/kg body weight (based on lead bullion)

Additional Health Data:
All heavy metals, including the hazardous ingredients in this product, are taken into the body primarily by inhalation and ingestion. Most inhalation problems can be avoided by adequate precautions such as ventilation and respiratory protection covered in Section 8. Follow good personal hygiene to avoid inhalation and ingestion: wash hands, face, neck and arms thoroughly before eating, smoking or leaving the work site. Keep contaminated clothing out of non-contaminated areas, or wear cover clothing when in such areas. Restrict the use and presence of food, tobacco and cosmetics to non-contaminated areas. Work clothes and work equipment used in contaminated areas must remain in designated areas and never taken home or laundered with personal non-contaminated clothing. This product is intended for industrial use only and should be isolated from children and their environment.

The 19th Amendment to EC Directive 67/548/EEC classified lead compounds, but not lead in metal form, as possibly toxic to reproduction. Risk phrase 61: May cause harm to the unborn child, applies to lead compounds, especially soluble forms.

12. ECOLOGICAL INFORMATION

Environmental Fate: lead is very persistent in soil and sediments. No data on environmental degradation. Mobility of metallic lead between ecological compartments is slow. Bioaccumulation of lead occurs in aquatic and terrestrial animals and plants but little bioaccumulation occurs through the food chain. Most studies include lead compounds and not elemental lead.

Environmental Toxicity: Aquatic Toxicity:

Sulfuric acid:	24-hr LC50, freshwater fish (Brachydanio rerio): 82 mg/L
	96 hr- LOEC, freshwater fish (Cyprinus carpio): 22 mg/L
Lead:	48 hr LC50 (modeled for aquatic invertebrates): <1 mg/L, based on lead bullion

Additional Information

- No known effects on stratospheric ozone depletion.
- Volatile organic compounds: 0% (by Volume)
- Water Endangering Class (WGK): NA

13. DISPOSAL CONSIDERATION (UNITED STATES)

Spent batteries: Send to secondary lead smelter for recycling. Spent lead-acid batteries are not regulated as hazardous waste when the requirements of 40 CFR Section 266.80 are met. Spilled sulfuric acid is a characteristic hazardous waste; EPA hazardous waste number D002 (corrosivity) and D008 (lead).

Electrolyte: Place neutralized slurry into sealed acid resistant containers and dispose of as hazardous waste, as applicable. Large water diluted spills, after neutralization and testing, should be managed in accordance with approved local, state, and federal requirements. Consult state environmental agency and/or federal EPA.

Following local, State/Provincial, and Federal/National regulations applicable to end-of-life characteristics will be the responsibility of the end-user.

14. TRANSPORT INFORMATION

U.S.DOT – (Land Transport): Excepted from the hazardous materials regulations (HMR) because the batteries meet the requirements of 49 CFR 173.159(f) and 49 CFR 173.159a of the U.S. Department of Transportation's HMR. Battery and outer package must be marked "NONSPILLABLE" or "NONSPILLABLE BATTERY". Battery terminals must be protected against short circuits.
IATA Dangerous Goods Regulations DGR (Air Transport): Excepted from the dangerous goods regulations because the batteries meet the requirement of Packing Instruction 872 and Special Provisions A67 of the International Air Transportation Association (IATA) Dangerous goods Regulations and International Civil Aviation Organization (ICAO) Technical Instruction. Battery Terminals must be protected against short circuits. The words "NOT RESTRICTED", "SPECIAL PROVISION A67" must be provided when the air waybill is issued.
IMDG (Sea Transport):

Excepted from the dangerous goods regulations for transport by sea because the batteries meet the requirements of Special Provision 238 of the International Maritime Dangerous Goods (IMDG CODE 2016, Amendment 38-16). Battery terminals must be protected against short circuits.

15. REGULATORY INFORMATION

UNITED STATES: EPA SARA Title III:

Section 302 EPCRA Extremely Hazardous Substances (EHS):
Sulfuric acid is a listed "Extremely Hazardous Substance" under EPCRA, with a Threshold Planning Quantity (TPQ) of 1,000 lbs. EPCRA Section 302 notification is required if 500 lbs or more of sulfuric acid is present at one site (40 CFR 370.10). For more information consult 40 CFR Part 355.

Section 304 CERCLA Hazardous Substances:
Reportable Quantity (RQ) for spilled 100% sulfuric acid under CERCLA (Superfund) and EPCRA (Emergency Planning and Community Right to Know Act) is 1,000 lbs. State and local reportable quantities for spilled sulfuric acid may vary.

Section 311/312 Hazard Categorization:
EPCRA Section 312 Tier Two reporting is required for non-automotive batteries if sulfuric acid is present in quantities of 500 lbs or more and/or if lead is present in quantities of 10,000 lbs or more. For more information consult 40 CFR 370.10 and 40 CFR 370.40

Section 313 EPCRA Toxic Substances:
40 CFR section 372.38 (b) states: If a toxic chemical is present in an article at a covered facility, a person is not required to consider the quantity of the toxic chemical present in such article when determining whether an applicable threshold has been met under § 372.25, § 372.27, or § 372.28 or determining the amount of release to be reported under § 372.30. This exemption applies whether the person received the article from another person or the person produced the article. However, this exemption applies only to the quantity of the toxic chemical present in the article.

Supplier Notification:
This product contains toxic chemicals that may be reportable under EPCRA Section 313 Toxic Chemical Release Inventory (Form R) requirements. For a manufacturing facility under SIC codes 20 through 39, the following information is provided to enable you to complete the required reports:

Toxic Chemical	CAS Number	Approximate % by Weight
Lead	7439-92-1	50
Sulfuric Acid/Water Solution	7664-93-9	17
Lead Oxide	1360-60-0	20
Tin	7440-31-5	0.2

See 40 CFR Part 370 for more details.

TSCA:

TSCA Section 8b – Inventory Status: All chemicals comprising this product are either exempt or listed on the TSCA Inventory.

TSCA Section 12b (40 CFR Part 707.60(b)) No notice of export will be required for articles, except PCB articles, unless the Agency so requires in the context of individual section 5, 6, or 7 actions.

TSCA Section 13 (40 CFR Part 707.20): No import certification required (EPA 305-B-99-001, June 1999, Introduction to the Chemical Import Requirements of the Toxic Substances Control Act, Section IV.A)

RCRA: Spent Lead Acid Batteries are subject to streamlined handling requirements when managed in compliance with 40 CFR section 266.80 or 40 CFR part 273. Waste sulfuric acid is a characteristic hazardous waste; EPA hazardous waste number D002 (corrosivity) and D008 (lead).

STATE REGULATIONS (US):
***Proposition 65 Warning**

Battery posts, terminals and related accessories contain lead and lead compounds, chemicals known to the state of California to cause cancer and reproductive harm. Wash hands after handling.

*Battery companies not party to the 1999 consent judgment with Mateel Environmental Justice Foundation should include a Proposition 65 Warning that complies with the current version of Proposition 65.

INTERNATIONAL REGULATIONS:

Distribution into Quebec to follow Canadian Controlled Product Regulations (CPR) 24(1) and 24(2).

Distribution into the EU to follow applicable Directives to the Use, Import/Export of the product as-sold.

16.*REGULATORY INFORMATION*

NFPA Hazard Rating for Sulfuric Acid:

Flammability (Red)	0
Health (Blue)	3
Reactivity (Yellow)	2

Sulfuric acid is water-reactive if concentrated.