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Report R16-01-01

ANSI Design Test Report ANSI 52-5L Glass Bells Catalog # PSN12146

This design test report records the results of laboratory tests performed on the ANSI 52-5L Glass Bells which met or exceeded all performed tests of these standards:

ANSI/NEMA C29.2B-2013, "American National Standard for Insulators Wet Process Porcelain and Toughened Glass— Transmission Suspension Type"

A handwritten signature in blue ink, appearing to read "B. Besouw".

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8.2.1 LOW-FREQUENCY DRY FLASHOVER TEST

Test Procedure

Three insulators shall be tested in accordance with 4.2 of ANSI C29.1. Failure of the average dry flashover value of these three insulators to equal or exceed 95 percent of the rated dry flashover value, 95% of 80kV = 76kV, shall constitute failure to meet the requirements of this standard.

Test Results

All samples tested met the requirements of Section 8.2.1 of ANSI/NEMA C29.2B - 2013. Table 1 shows individual results of the Low Frequency Dry Flashover Test.

	Unit 1		Unit 2		Unit 3	
	Uncorrected kV _{RMS}	Corrected kV _{RMS}	Uncorrected kV _{RMS}	Corrected kV _{RMS}	Uncorrected kV _{RMS}	Corrected kV _{RMS}
1	77	84	79	86	76	83
2	78	85	78	85	80	87
3	78	85	81	88	77	84
4	77	84	81	88	78	85
5	79	86	80	87	80	87
6	80	87	78	85	81	88
7	79	86	79	86	78	85
8	81	88	82	89	77	84
9	78	85	81	88	76	83
10	80	85	80	87	78	85
Average	79	86	80	87	78	85

Table 1



8.2.2 LOW-FREQUENCY WET FLASHOVER TEST

Test Procedure

Three insulators shall be tested in accordance with 4.3 of ANSI C29.1. Failure of the average dry flashover value of these three insulators to equal or exceed 90 percent of the rated wet flashover value, 90% of 50kV = 45kV, shall constitute failure to meet the requirements of this standard.

Test Results

All samples tested met the requirements of Section 8.2.2 of ANSI/NEMA C29.2B - 2013. Table 2 shows individual results of the Low Frequency Wet Flashover Test.

	Unit 1		Unit 2		Unit 3	
	Uncorrected kV _{RMS}	Corrected kV _{RMS}	Uncorrected kV _{RMS}	Corrected kV _{RMS}	Uncorrected kV _{RMS}	Corrected kV _{RMS}
1	51	52	52	54	52	53
2	50	52	51	53	51	53
3	50	52	51	53	51	53
4	50	52	52	54	53	55
5	51	53	51	53	53	55
6	52	54	51	53	51	53
7	50	52	51	53	51	53
8	51	53	51	53	52	53
9	51	52	54	56	53	55
10	53	55	52	53	52	54
Average	51	53	52	53	52	54

Table 2



8.2.3 CRITICAL IMPULSE FLASHOVER TESTS – POSITIVE AND NEGATIVE

Test Procedure

Three insulators shall be subjected to a critical impulse flashover test, positive and three to the critical impulse flashover test, negative, in accordance with 4.7 of ANSI C29.1. Failure of the average critical impulse flashover value of these three insulators to equal or exceed 92 percent of the rated critical impulse flashover value, 92% of 125kV = 115kV Positive / 92% of 130kV = 120kV Negative, shall constitute failure to meet the requirements of this standard.

Test Results

All samples tested met the requirements of Section 8.2.3 of ANSI/NEMA C29.2B - 2013. Tables 3, 4 and 5 show individual results of the Critical Impulse Flashover Test.

Unit 1										
Impulse	Positive					Negative				
	Charge (kV)	FO/FW	Impulse (kV)	FO Time (μS)	Corrected Impulse (kV)	Charge (kV)	FO/FW	Impulse (kV)	FO Time (μS)	Corrected Impulse (kV)
1	34	FW	120		125	32	FW	115		119
2	35	FO	124	3.3	130	33	FO	119	4.08	124
3	34	FO	126	3.7	131	32	FO	117	4.08	122
4	32	FW	115		120	30	FW	108		113
5	34	FO	121	3.7	127	31	FW	112		116
6	32	FW	115		120	33	FO	119	5.08	124
7	33	FW	119		124	31	FW	113		117
8	34	FO	122	4.5	128	32	FO	116	5.48	120
9	32	FO	116	4.9	121	31	FW	112		116
10	31	FW	111		116	32	FO	116	4.48	120
11	33	FO	120	4.9	125	31	FW	111		115
12	32	FW	115		120	32	FW	116		120
13	33	FO	120	4.3	125	33	FO	121	4.08	126
14	32	FW	115		120	32	FO	116	3.88	120
15	33	FW	119		124		FW	113		117
16	34	FO	122	3.9	128	33	FO	118	4.88	123
17	33	FO	119	3.9	124	32	FO	115	4.08	119
18	32	FW	115		120	31	FW	112		116
19	33	FO	120	4.1	125	32	FW	117		122
20	32	FW	115		120	33	FO	119	4.28	124
Average			118		123			115		120

Table 3



Unit 2										
Impulse	Positive					Negative				
	Charge (kV)	FO/FW	Impulse (kV)	FO Time (μS)	Corrected Impulse (kV)	Charge (kV)	FO/FW	Impulse (kV)	FO Time (μS)	Corrected Impulse (kV)
1	34	FO	122	4	128	32	FW	117		14
2	33	FW	119		124	33	FO	119	6.6	124
3	34	FW	121		127	32	FW	116		120
4	35	FO	126	3.6	131	33	FO	121	4.8	126
5	34	FO	122	3.6	128	32	FW	117		122
6	32	FW	115		120	33	FW	121		126
7	33	FW	119		124	34	FO	122	4.2	127
8	34	FO	121	3.6	127	33	FO	119	4.2	124
9	33	FW	119		124	32	FW	115		119
10	34	FO	122	3.6	128	33	FW	119		124
11	33	FO	119	3.6	124	34	FO	123	4	128
12	32	FW	115		120	33	FO	119	4	124
13	33	FO	120	4.8	125	32	FO	117	6.6	122
14	32	FO	116	4.8	121	31	FW	115		119
15	31	FW	113		118	32	FW	115		119
16	32	FW	112		117	33	FO	118	4.2	123
17	33	FO	121	4.8	127	32	FW	116		120
18	32	FW	117		122	33	FO	118	4.6	123
19	33	FW	121		127	32	FO	115	6.2	119
20	34	FO	122	4.8	128	31	FW	113		117
Average			119		124			118		123

Table 4



Unit 3										
Impulse	Positive					Negative				
	Charge (kV)	FO/FW	Impulse (kV)	FO Time (μS)	Corrected Impulse (kV)	Charge (kV)	FO/FW	Impulse (kV)	FO Time (μS)	Corrected Impulse (kV)
1	34	FW	120		125	32	FW	115		119
2	35	FO	124	3.3	130	33	FO	119	4.08	124
3	34	FO	126	3.7	131	32	FO	117	4.08	122
4	32	FW	115		120	30	FW	108		113
5	34	FO	121	3.7	127	31	FW	112		116
6	32	FW	115		120	33	FO	119	5.08	124
7	33	FW	119		124	31	FW	113		117
8	34	FO	122	4.5	128	32	FO	116	5.48	120
9	32	FO	116	4.9	121	31	FW	112		116
10	31	FW	111		116	32	FO	116	4.48	120
11	33	FO	120	4.9	125	31	FW	111		115
12	32	FW	115		120	32	FW	116		120
13	33	FO	120	4.3	125	33	FO	121	4.08	126
14	32	FW	115		120	32	FO	116	3.88	120
15	33	FW	119		124		FW	113		117
16	34	FO	122	3.9	128	33	FO	118	4.88	123
17	33	FO	119	3.9	124	32	FO	115	4.08	119
18	32	FW	115		120	31	FW	112		116
19	33	FO	120	4.1	125	32	FW	117		122
20	32	FW	115		120	33	FO	119	4.28	124
Average			118		123			115		120

Table 5



8.2.4 RADIO-INFLUENCE VOLTAGE TEST

Test Procedure

Three insulators shall be tested in accordance with 4.9 of ANSI C29.1. All insulators shall have less than 50 μ V RIV at 10kV supplied voltage.

Test Results

All samples tested met the requirements of Section 8.2.4 of ANSI/NEMA C29.2B - 2013. Tables 6 show individual results of the Radio Influence Voltage Test.

Unit	RIV @ 10kV _{RMS} (μ V)	50 μ V RIV (kV _{RMS})
1	2.00	24.7
2	1.10	22.8
3	4.70	17.7

Table 6



8.2.5 THERMAL-MECHANICAL LOAD CYCLE TEST

Test Procedure

Ten assembled insulators shall be subjected to the thermal-mechanical load cycle test. The insulators, which may be connected in series or parallel provided each is equally loaded, shall be subjected to four 24 hour cycles of ambient air cooling and heating with a simultaneously applied minimum tensile load maintained at 60 percent of the rated combined mechanical and electrical strength of the insulators as described in Figure 8. Each 24 hour cycle shall start with a cooling period during which a low temperature of -22°F (-30°C) shall be maintained for at least a four hour period. A heating period will follow the cooling period.

During the heating period a high temperature of 104°F (40°C) shall be maintained for at least a four hour period. During the four hour extreme temperature periods, the ambient air temperature shall be maintained at the specified extreme temperature within 9°F (5°C). The rate of temperature change is not specified. The tensile load shall be applied at room temperature before starting the first thermal cycle. The tensile load shall be completely removed and reapplied after the first, second and third 24 hour thermal cycle. After the fourth thermal cycle, upon cooling to room temperature, the tensile load shall be removed. The ten insulators shall then be subjected to a Combined Mechanical and Electrical test in accordance with 5.2 of ANSI C29.1. The criteria for determining conformance with the standard are as given in 8.3.4 with the exception that no re-test procedure is applicable in this case.

Test Results

All samples tested met the requirements of Section 8.2.5 of ANSI/NEMA C29.2B - 2013. Tables 7 show individual results of the Thermal-Mechanical Load Cycle Test.

Unit	Ultimate Load (lbs)	Failure mode
1	36,873	Cap
2	35,772	Cap
3	36,478	Cap
4	37,005	Cap
5	35,066	Cap
6	35,904	Cap
7	35,551	Cap
8	37,712	Cap
9	37,093	Cap
10	34,625	Cap
Average \bar{X}	36,208	
St. Dev. S	984.3	

Table 7

$$\bar{X} \geq \text{Rating} + 3 \times S$$

$$36,208\text{lbs} \geq 25,000\text{lbs} + 3 \times 984.3\text{lbs}$$

$$36,208\text{lbs} \geq 27,952\text{lbs}$$



8.2.6 THERMAL SHOCK TEST

Test Procedure

Five insulators shall be tested for ten complete cycles in accordance with 5.5 of ANSI C29.1. The temperature of the hot water bath shall be approximately 205°F (96°C), and the temperature of the cold water bath shall be approximately 39°F (4°C). Failure of any insulator shall constitute failure to meet the requirements of this standard.

Test Results

All samples tested met the requirements of Section 8.2.6 of ANSI/NEMA C29.2B - 2013. Table 8 shows individual results of the Thermal Shock Test.

Unit	Uncorrected kV _{RMS}	Corrected kV _{RMS}
1	79	89
2	76	85
3	77	86
4	77	86
5	77	86

Table 8



8.2.7 RESIDUAL STRENGTH TEST

Test Procedure

Twenty-five insulators shall have the shells broken off. No portion of the shell shall remain outside the maximum diameter of the cap. Each unit shall then be subjected to a mechanical-strength test in accordance with 5.1 of ANSI C29.1. The criteria for determining conformance to this standard are:

$$\bar{X}_R \geq (1.2 \times \text{proof load}) + 1.645 \times S_R$$

Where:

\bar{X}_R = average residual strength of 25 units

S_R = standard deviation of residual strength of the 25 units tested

Proof load = tension proof load (12,500lbs)

Test Results

All samples tested met the requirements of Section 8.2.7 of ANSI/NEMA C29.2B - 2013. Table 9 shows individual results of the Residual Strength Test.

$$33,959\text{lbs} \geq (1.2 \times 12,500\text{lbs}) + 1.645 \times 3,175\text{lbs}$$

$$33,959\text{lbs} \geq 20,223\text{lbs}$$



Unit	Ultimate Tensile Load (lbs)	Failure mode
1	32,756	Broke hardware (y end)
2	24,213	Broke hardware (socket)
3	34,148	Pin pulled out
4	33,554	Broke bell socket
5	35,228	Broke bell socket
6	35,338	Broke bell socket
7	34,323	Broke bell socket
8	35,286	Broke bell socket
9	37,310	Ball end steel yielded
10	37,648	Broke bell socket
11	35,092	Broke bell socket
12	38,267	Broke bell socket
13	28,416	Pin pulled out
14	36,957	Broke bell socket
15	34,800	Pin pulled out
16	33,921	Pin pulled out
17	26,817	Pin pulled out
18	35,497	Broke bell socket
19	34,067	Broke bell socket
20	34,336	Pin pulled out
21	34,352	Ball end steel yielded
22	33,369	Pin pulled out
23	34,365	Pin pulled out
24	34,709	Ball end steel yielded
25	34,213	Pin pulled out
Average \bar{X}_R	33,959	
Standard Deviation S_R	3,175	

Table 9



8.2.8 IMPACT TEST

Test Procedure

Three insulators shall be tested in accordance with 5.1.2.2 of ANSI C29.1. All insulators shall receive an impact of 60inch-lbs.

Test Results

All samples tested met the requirements of Section 8.2.8 of ANSI/NEMA C29.2B - 2013. Table 10 shows individual results of the Impact Test.

Unit	2000lbs Applied	Impact Passed	Uncorrected kV_{RMS}	Corrected kV_{RMS}
1	✓	✓	75	82
2	✓	✓	78	85
3	✓	✓	76	82

Table 10



8.2.9 COTTER KEY TEST

Test Procedure

For three test samples of ball-and-socket insulators, the disengagement force of the cotter key shall be between 25 and 150 pounds (111 and 667 Newton) force for three locking-to-unlocking operations. The cotter key shall be placed in the locking position and a tension load applied to the eye of the cotter key along its axis by means of an appropriate device. The loading shall be gradually increased until the cotter key moves to the unlocking position.

Test Results

All samples tested met the requirements of Section 8.2.9 of ANSI/NEMA C29.2B - 2013. Table 11 shows individual results of the Cotter Key Test.

Unit	Operation 1 (lbf)	Operation 2 (lbf)	Operation 3 (lbf)
1	89.7	87.7	45.3
2	58.8	49.7	55.0
3	58.6	57.0	66.0

Table 11



8.3.5 PUNCTURE TEST

Test Procedure

Five assembled insulators shall be selected at random and tested in accordance with 4.11 of ANSI C29.1. The criterion for determining conformance to this standard is: No puncture shall occur below the specified puncture voltage (110kV). To provide information the test voltage may be raised until puncture occurs, and the puncture voltage recorded. The re-test procedure in section 4.4 is applicable to this test.

Test Results

All samples tested met the requirements of Section 8.3.5 of ANSI/NEMA C29.2B - 2013. Table 12 shows individual results of the Puncture Test.

Unit	Voltage kV _{RMS}
1	179.9
2	180.1
3	166.9
4	180.4
5	181.7

Table 12



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8.3.6 VERIFICATION OF COUPLING LOCK SYSTEM

Test Procedure

Six ball-and-socket insulators shall be coupled in 3 strings of two units with the cotter key in the locking position. Each string shall then be subjected to an attempt to disengage the ball from the socket, applying relative movements by hand representative of those encountered in use. The disengagement of any ball shall constitute failure of the lot to meet the requirements of this standard.

Test Results

All samples tested met the requirements of Section 8.3.6 of ANSI/NEMA C29.2B - 2013.