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# DESIGN TEST REPORT

## Polymer Bushing Well
## 200Amp Bushing Well

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## CORONA VOLTAGE LEVEL TEST

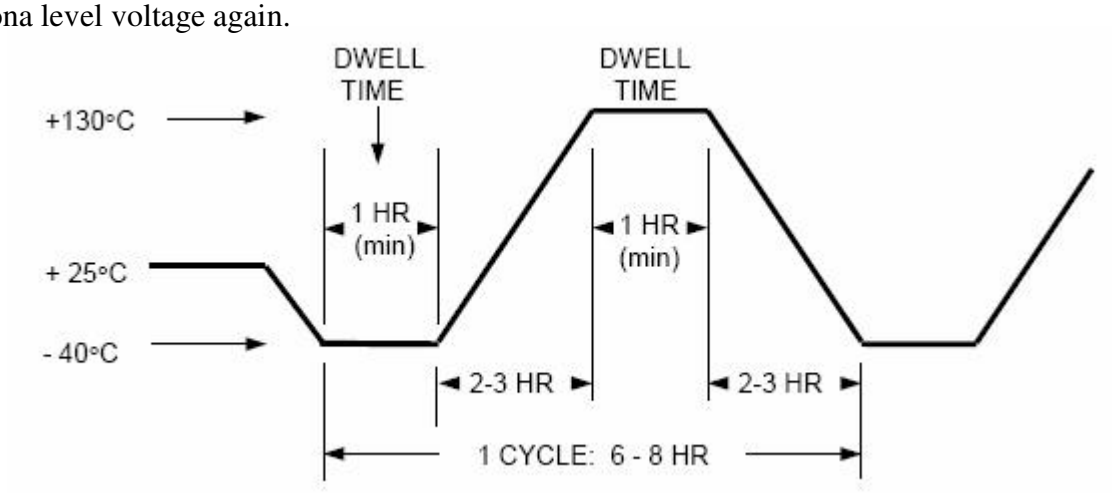
### Object

To verify that the corona voltage level of CHARDON's bushing well meets the 25kV class of IEEE STD 386-1995, and the elevated 28kV class Canadian requirement level of 21.5kV. The corona voltages were verified both on new parts and aged parts.

### Procedure

Bushing wells were mated with Hubbell Power Systems' Bushing Inserts and the test voltage was gradually increased until corona exceeded 3pC. Once corona exceeded 3pC, the test voltage was reduced until the corona disappeared. This was maintained for 60 seconds.

An aging process then treated the tested samples. The aging process complied with the thermal cycle profile as shown with ten cycles. After thermal cycle aging, measure the corona level voltage again.




### Results

| Samples No. | #01 | #02 | #03 | #04 | #05 | #06 | #07 | #08 | #09 | #10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Corona Voltage CIV/CEV** | 38/34 kV | 37/33 kV | 28/25 kV | 35/32 kV | 36/33 kV | 32/29 kV | 36/34 kV | 33/32 kV | 35/32 kV | 35/32 kV |
| **After Aging** | 29/26 kV | 28/24 kV | 31/29 kV | 31/29 kV | 30/28 kV | 33/30 kV | 32/29 kV | 31/29 kV | 33/31 kV | 30/28 kV |

CIV = Corona Inception Voltage
CEV = Corona Extinction Voltage

The samples of CHARDON's Bushing Well met or exceeded the 25kV Class IEEE STD 386-1995 minimum corona voltage level of 19kV rms and the elevated 28kV Class Canadian requirement level of 21.5kV rms, both before and after aging.

## AC WITHSTAND VOLTAGE

### Object

To verify that the CHARDON bushing well can withstand 45kV, 60Hz one minute without any flashover, puncture, and damage as required by IEEE STD 386-1995 for 25kV class and the 28kV Class Canadian requirement.

### Procedure

The sample were installed onto the wall of tank and fill the tank with transformer oil to simulate the field condition. The samples mated with Hubbell Power Systems' Bushing Inserts. The test voltage was raised to 45kV in less than 30 seconds and held there for one minute.

### Results

| Sample No. | #1 | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **45kV 1 minute** | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |

## DC WITHSTAND VOLTAGE

### Object

To verify that the CHARDON bushing well can withstand a DC voltage of 100kV for 15 minutes without any flashover, puncture, and damage as required by IEEE STD 386-1995 for 25kV class and Canadian requirement level for 28kV Class.

### Procedure

The sample were installed onto the wall of tank and fill the tank with transformer oil to simulate the field condition. The samples were mated with Hubbell Power Systems' Bushing Inserts and a DC Voltage of 100kV was applied for 15 minutes.

### Results

| Sample No. | #1 | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **100kV 15minute** | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |

The samples of CHARDON Bushing Well successfully passed 78kV DC voltage for 15 minutes and met the 25kV class IEEE STD 386-1995 and Canadian requirement level for 28kV Class.

## IMPULSE WITHSTAND VOLTAGE

### Object

To verify that the CHARDON bushing well can withstand an impulse voltage of 125kV without puncturing or flashover as required by IEEE STD 386-1995 for 25kV class.

### Procedure

Samples of bushing wells were mounted to an oil-filled tank and mated with Hubbell Power Systems' Bushing Inserts. Each sample was subjected to three positive and negative full wave impulses, which have wave sharp and crest values of 125kV.

### Results

| Sample No. | #1 | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **+125kV 3 times** | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |
| **-125kV 3 times** | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |

The samples of CHARDON Bushing Well successfully passed 125kV 1.2/50∝V impulse voltage and met the 25kV class IEEE STD 386-1995.

## SHORT TIME CURRENT TEST

### Object

To verify that the CHARDON bushing well is capable of withstanding the short time current as required by IEEE STD 386-1995 for 200A connectors. The magnitude and duration are 10kA-0.17sec and 3.5kA 3sec.

### Procedure

The sample was mated with Hubbell Power Systems' Bushing Insert and Elbow connectors as in a normal service application. The assembled connectors were then subjected to short time current with magnitudes and duration of 3.5kA rms for 3 seconds and 10kA rms for 0.17sec. The rms values of the first major loop of the current wave exceeded 1.3 (X/R=6) times the stated current values.

After short time current test, the CHARDON bushing wells were checked for corona voltage levels, 40kV AC withstand voltage, 78kV DC withstand voltage and 125kV impulse voltage test.

### Results

| **Sample No.** | **#1** | **#2** | **#3** | **#4** |
|---|---|---|---|---|
| **3.5kA – 3sec** | Pass | Pass | Pass | Pass |
| **10kA – 0.17sec** | Pass | Pass | Pass | Pass |
| **Corona Voltage Level 21.5kV 3pC** | Pass | Pass | Pass | Pass |
| **AC Withstand 45kV 1minute** | Pass | Pass | Pass | Pass |
| **Impulse Withstand ± 125kV 3 times** | Pass | Pass | Pass | Pass |

The samples of CHARDON Bushing Well successfully passed 3.5kA-3sec and 10kA-0.17sec short time current tests, and met the 200A class of IEEE STD 386-1995.

## ACCELERATED THERMAL TEST

### Object

To verify that the CHARDON bushing well can carry rated current under usual service conditions with loadbreak bushing inserts and loadbreak elbows.

### Procedure

Four assemblies, each consisting of a loadbreak elbow, a loadbreak bushing insert and a CHARDON bushing well, were connected in series. Thermocouples were placed at the following current transfer points:

Point (a): probe to compression lug
Point (b): probe to female contact
Point (c): between bushing inert and bushing well

The ambient temperature is between 15 and 35°C. A current of 319 Amps was applied to the test circuit and maintained a steady-state temperature rise of 100°C to 105°C.

The test consists of 50 cycles with current-on 4 hours and current-off 2 hours. At the end of current-on cycle the assemblies were de-energized and put into water of 5°C ± 5°C within 3 minutes for the remainder of the current-off cycle.

At the end of 10th, 25th and 40th cycles (±2 cycles), after the samples have returned to room temperature, a short time ac rms current of 3500 ± 300 Amps was applied to each assembly for a minimum of 3 seconds.

For each assembly, a dc resistance measurement between the elbow cable equalizer and bushing well stud at the end of 10th, 20th, 30th, 40th and 50th (±2 cycles) after the assemblies were stabilized at room temperature.

### Results

Part A: Temperature Rise

| Sample No. | Point (a) | Point (b) | Point (c) |
|---|---|---|---|
| **01** | 83.1°C | 83.6°C | 80.9°C |
| **02** | 78.2°C | 74.3°C | 75.5°C |
| **03** | 76.0°C | 75.5°C | 76.3°C |
| **04** | 81.5°C | 80.7°C | 83.4°C |

The temperature at each transfer point did not exceed the temperature of the controlconductor and met the requirements as stated in Section 7.10.1 of IEEE 386-1995.

Part A: Resistance Rise

| | #1 | #2 | #3 | #4 |
|---|---|---|---|---|
| Beginning | 174μΩ | 168μΩ | 172μΩ | 180μΩ |
| 12th cycle | 192μΩ | 172μΩ | 179μΩ | 189μΩ |
| 20th cycle | 194μΩ | 173μΩ | 176μΩ | 189μΩ |
| 29th cycle | 199μΩ | 176μΩ | 179μΩ | 195μΩ |
| 40th cycle | 207μΩ | 175μΩ | 178μΩ | 207μΩ |
| 50th cycle | 208μΩ | 176μΩ | 179μΩ | 206μΩ |
| Average | 200μΩ | 174μΩ | 178μΩ | 197μΩ |

Note:Average does not include the temperature at beginning.

The dc resistance was stable and did not vary by more than ±5% from the average and met the requirements as stated in Section 7.10.1 of IEEE 386-1995.

## ACCELERATED SEAL LIFE TEST

### Object

To verify that the CHARDON bushing well can maintain a long-term seal at all interfaces and prevent the entrance of moisture under usual service conditions with loadbreak bushing inserts and loadbreak elbows.

### Procedure

Four assemblies each consisting of a loadbreak elbow, a loadbreak bushing insert and a bushing well were connected in series on a #1 AWG conductors. A Delron mandrel was used to simulate the test cable during the oven-aging portion of the test.

The four assemblies were placed in an oven of 121°C and remained there for three weeks. After the time had lapsed, the four samples were removed from the oven and each operated once by using the pulling eye.

The four assemblies were reassembled and subjected to 50 cycles of the following sequence of operations:

The assemblies were heated in air using sufficient current to raise the temperature of the conductor of control cable to 90°C ± 5°C. The test consists of 50 cycles with current-on 1 hour and current-off 1 hour. At the end of current-on cycle the assemblies were de-energized and put into conductive water of 25°C ± 10°C within 3 minutes for the remainder of the current-off cycle.

After the 50 cycles, each assembly was subjected to three positive and three negative full wave impulses with 125 crest values. Each assembly was subjected to a test point voltage test as described in Section 7.17.2 of IEEE 386-1995.

### Results

| **Sample No.** | **#1** | **#2** | **#3** | **#4** |
|---|---|---|---|---|
| **+125 kV 3 times** | Pass | Pass | Pass | Pass |
| **-125 kV 3 times** | Pass | Pass | Pass | Pass |
| **Test Point Voltage** | 12.0kV | 12.5kV | 13.0kV | 12.5kV |

The CHARDON bushing wells can withstand 50 accelerated sealing life test cycles without impairing the ability to meet the requirements of section 7.12 of IEEE STD 386-1995.

## THERMOCYCLE WITHSTAND TEST

### Object

To verify that the CHARDON bushing well can withstand ten thermocycles having a temperature range of -40°C to 140°C without impairing the ability of the bushing wells to meet other requirements of the IEEE STD 386-1995.

### Procedure

Five CHARDON bushing well were mated with Hubbell Power Systems' Bushing Inserts and subjected to ten thermocycles, each consists -40°C for 1 hours and 140°C for 1 hours. The procedure has been described in the paragraph of CORONA VOLTAGE TEST.

After thermocycled procedure was completed, the bushing wells were subjected to a corona voltage level test and a 45kV AC withstand voltage for one minute.

### Results

| | Corona Test | | 45kV AC Withstand | |
|---|---|---|---|---|
| | Before aging | After Aging | Before aging | After Aging |
| #1 | 24kV/ 1.3pC | 26kV/0.8pC | Pass | Pass |
| #2 | 25kV/ 1.7pC | 26kV/1.0pC | Pass | Pass |
| #3 | 23kV/1.2pC | 26kV/1.0pC | Pass | Pass |
| #4 | 24kV/1.4pC | 26kV/1.4pC | Pass | Pass |
| #5 | 22kV/2.4pC | 26kV/0.8pC | Pass | Pass |

The CHARDON bushing wells can withstand 50 accelerated sealing life test cycles without impairing the ability to meet the requirements of section 7.12 of IEEE STD 386-1995.

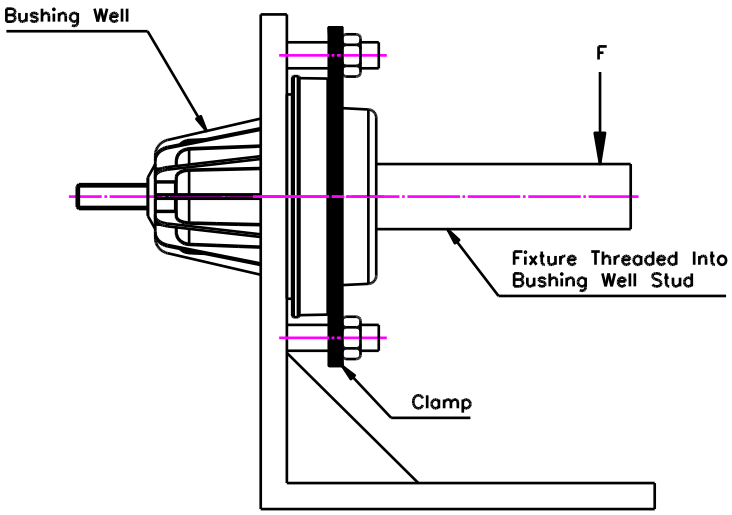
## CANTILEVER WITHSTAND TEST

### Object

To verify that the CHARDON bushing well can withstand a cantilever force of 200 ft-lbs.

### Procedure

The bushing well was mounted on a simulated tank wall and a fixture was threaded on the stud of bushing well. A force was then applied at the end of the fixture and then the stud withstood a torque. The torque values were measured when the bushing well fractured.




### Results

All CHARDON bushing wells can withstand a cantilever force more than 200 ft-lbs.

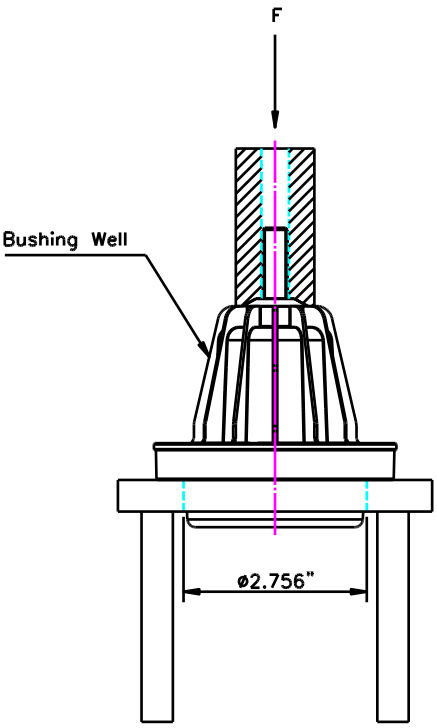
## FLANGE WITHSTAND TEST

### Object

To verify that the flange of the CHARDON bushing well can withstand a force of 2,100 ft-lbs.

### Procedure

A ring at the flange supported four bushing wells and an axial force was applied at the bottom portion of plastic around the stud.




Flange Withstand Test Set Up

### Results

All CHARDON bushing wells can withstand an axial force of more than 2,100 ft-lbs.

## SEALING WITHSTAND

### Object

To verify that the CHARDON bushing well and gasket can withstand ten thermocycles having a temperature range of -40°C to 140°C without impairing the sealing ability of the product.

### Procedure

Ten CHARDON bushing wells with gaskets were subjected to ten thermocycles, each consists -40°C for 1 hours and 140°C for 1 hours. The procedure has been described in the paragraph of CORONA VOLTAGE TEST.

After thermocycle procedure, the bushing wells were mounted onto a closed tank as normal installation. The tank was filled with transformer oil and pressurized to 15 PSI.

The pressure inside the tank was keeping at 15 PSI for 3 weeks and monitor if any leakage of oil happened daily.

### Results

After the process of ten thermocycles between -40°C and 140°C, The sealing ability of DEN MAR bushing wells will not be influenced.