PRODUCT SPECIFICATION RESOURCE

Contains specifications and test reports for ConduRod manufactured by SAE Inc.

ConduRod is designed and manufactured to be fully compliant with NESC, CSA Standard C22.2, and ESA On. Reg 22/04.

CONDU ROD

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ConduRod Technical Specifications

Physical Properties

Property	Typical Value	Unit	Test Method
Physical State	Black Solid		
Odor	None		
Water Permeability	1.72×10^{-7}	cm/sec	ASTM D5084 (2.6 psi)
Flammability	No ignition		Exposed to a propane torch (~2000 °C) for 60 seconds
Electrical Corrosion Resistance Copper Steel Galvanized Steel	 100 98.09 99.91	%	SAE Inc. Standard 100
Compatibility Copper Steel Galvanized Steel	 Yes Yes Yes		SAE Inc. Standard 100
Environmental Impact	Neutral		Ontario Regulation 558/00 (Leachate Testing)
Freeze-thaw Withstand	30	Years	SAE Inc. Standard 102

Electrical Properties

Property	Typical Value	Unit	Test Method
Resistivity	30.39	Ω·cm	SAE Inc. Standard 105
Conductivity	0.03	S/cm	SAE Inc. Standard 105

Leachate (TCLP) Results

Leachate Data (TCLP Procedure) based on Ontario Regulation 558/00

Constituent	ConduRod TCLP Concentration (mg/L)	USEPA Maximum Contaminant Level (mg/L)
Arsenic	BDL	0.010
Barium	1.490	2.000
Boron	1.067	2.000 *
Chromium	0.026	0.100
Mercury	BDL	0.002
Selenium	0.013	0.050
Silver	BDL	0.100 **
Uranium	BDL	0.030
Fluoride	0.190	2.000 **
Nitrate (as Nitrogen)	BDL	10.000
Nitrite (as Nitrogen)	BDL	1.000
Cyanide	BDL	0.200

BDL means the result is “Below the Detection Level” of the analytical procedure
* No MCL established; value shown is USEPA’s Lifetime Drinking Water Health Advisory
** No MCL established; value shown is USEPA’s Secondary Drinking Water Standard

Published Date: May 2023

ConduRod Freeze-Thaw Testing

1. INTRODUCTION

1.1 The behaviour of the ConduRod material under freeze-thaw conditions is analyzed in this report. Due to the uniqueness of the material, a combination of studies and standards for similar materials were used to develop an appropriate test procedure. The test procedure involved the rapid freezing and thawing of samples with varying water and salt-water exposure. The samples were studied over 90 freeze-thaw cycles, which is equivalent to 30 years of freeze-thaw withstand.

1.2 The mass results of the 90 freeze-thaw cycles for the ConduRod indicate that physically none of the samples were adversely affected by freezing. The dry samples and the wet samples all experienced minor fluctuations in their masses during the 90 freeze-thaw cycles however, these were determined not to be a cause for concern since the samples are all within 6 g of the initial mass conditions. The freshwater submerged samples and the saltwater submerged samples all experienced a relatively steady increase in mass as the samples absorbed water. This increase in mass of the submerged samples does not indicate that the samples were adversely affected by the freeze-thaw testing since the samples followed the same trend with no major deviations.

1.3 The resistance results of the ConduRod agree with the mass results that no degradation of the samples occurred. All of the samples either returned to their initial resistance values or became more conductive over the 90 freeze/thaw cycles. Any spikes in the resistance of the dry and soaked/wet samples was during freeze measurements and the resistance always dropped during the subsequent thaw measurement. An increase in the conductivity of the ConduRod samples after freeze-thaw testing is a very positive outcome and indicates that ConduRod surround material improves as freeze-thaw cycling occurs.

1.4 Both the mass and resistance results strongly indicate that the ConduRod will continue to perform in situ for at least 30 years with no degradation due to freezing and thawing experienced during winter conditions.

2. TEST SETUP

2.1 Background and Development

2.1.1 The freeze-thaw stability testing of any product is a topic of great debate, resulting in varying standards and practices even for commonly tested materials such as concrete. Due to its composition and properties the ConduRod cannot be closely compared with other materials that are tested for freeze-thaw stability or withstand. This study aims to estimate the material's freeze-thaw behaviour.

2.1.2 Most existing test methods for building materials were deemed not entirely appropriate for the testing of the ConduRod material. "Masonry: Research, Application, and Problems" (Grogan and Conway) was used as a starting point for the development of the freeze-thaw testing of the ConduRod material. According to Grogan and Conway, a realistic freeze-thaw test method includes subjecting samples to 90 freeze-thaw cycles, which equates to 30 years of exposure to an extreme environment. It is also suggested in the same literature that three freeze-thaw cycles is to be the equivalent of one year of natural weathering.

2.2 Experimental Design

2.2.1 The largest factors in freeze-thaw behaviour include freeze-thaw rate and exposure to water. To account for the most extreme cases, samples were frozen and thawed as quickly as possible. The exposure to water was also varied. The conditions for each sample are summarized in Table 1.

Table 1: Test Conditions for ConduRod Samples

Sample	Condition
1, 2	Dry
3, 4	Soaked in water, removed prior to freeze cycle
5, 6	Completely submerged in freshwater
7, 8	Completely submerged in saltwater

2.2.2 One freeze-thaw cycle in this study was defined as a freeze period for 16 hours +/- 2 hours, a thaw period for 24 hours +/- 2 hours, then samples 3 and 4 were soaked in water for 5 – 7 hours and a new cycle began with the freeze period. Testing of these samples continued until 90 freeze-thaw cycles had been completed, roughly equating to 30 years of exposure to an extreme environment.

3. RESULTS AND ANALYSIS

3.1 Test Conditions

3.1.1 The ConduRod is expected to face significant exposure to water in-situ. Thus, emphasis is placed on the material's ability to withstand freezing and thawing conditions in water. Samples 1 through 8 were half-disc samples of the ConduRod material, with approximately 2.0'' radius and 1.0'' thickness. The initial measurements of each sample are listed in Table 2.

Table 2: Initial Measurements of ConduRod Samples

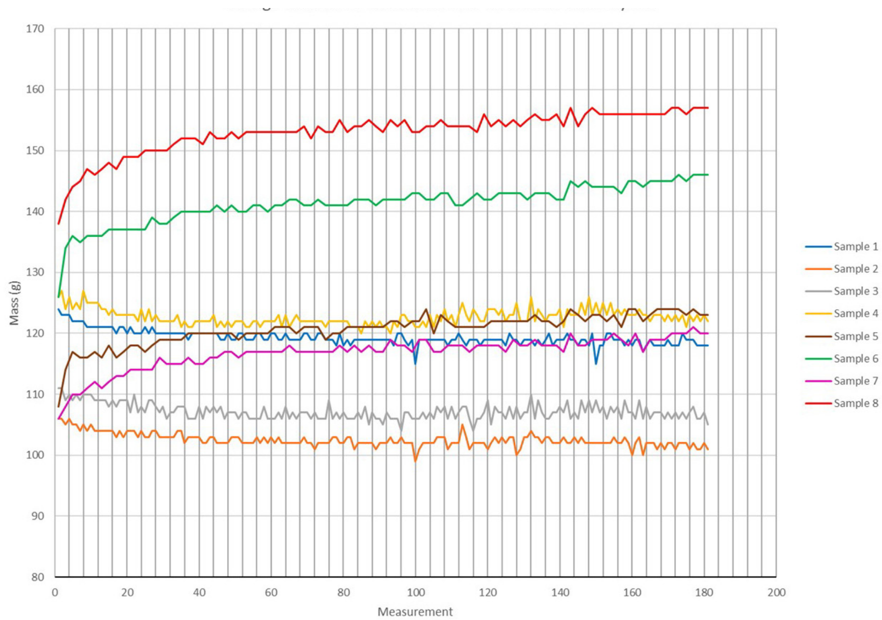
Sample	Date	Temperature (°C)	Resistance (Ω)	Mass (g)	System Mass* (g)
1	Oct 16, 2017	15.4	6.0	124	-
2	Oct 16, 2017	15.4	5.7	106	-
3	Oct 16, 2017	15.2	6.0	111	-
4	Oct 16, 2017	15.1	6.1	126	-
5	Oct 16, 2017	15.1	6.0	108	1058
6	Oct 16, 2017	14.4	5.5	126	1058
7	Oct 16, 2017	14.3	5.7	106	1069
8	Oct 16, 2017	14.3	5.4	138	1069

*System mass is defined as the combined mass of the samples, water, and container.

3.1.2 The test procedure was followed immediately after initial measurements were taken. The measurements were taken during each freeze or thaw period and the results were analyzed at the 90-cycle mark.

3.2 Changes in Mass Over 90 Freeze-Thaw Cycles

Figure 1: Changes in Mass of ConduRod Over 90 Freeze-Thaw Cycles



3.2.1 The physical condition of the sample serves as the best indicator of freeze-thaw stability. Ideally, no changes to the appearance of the material should be observed. Cracking and other physical damage should not be observed. The mass of the samples may be used as another indicator of freeze-thaw stability; large deviations from the original mass of the sample signal material instability. Finally, the samples should not experience extreme deviations in resistance readings. Note that the vertical lines in Figure 1 above indicate data obtained during a freeze period, and the spaces between the vertical lines indicate thaw periods.

3.2.2 For the dry samples (1 and 2), the mass did fluctuate on occasion, however these fluctuations were small and were likely due to the inherent scale error, it is accurate to +/- 1 g. The data for these samples indicates that both samples lost a small amount of mass over the 90 cycles, however this loss in mass was only 6 g or 4.8% for sample 1 and 5 g or 4.7% for sample 2 and does not indicate that the samples were adversely affected by freezing.

3.2.3 For the wet samples (3 and 4), the mass generally increased when measured after a freeze cycle, since these samples were soaked in water prior to freezing, this indicates that some water is absorbed. The samples expelled the water and returned to approximately their initial mass or lower during thaw periods. There were periods when both samples experienced no change in mass between freeze and thaw cycles which indicated that no water was absorbed or expelled by the samples at this time.

3.2.4 The two samples submerged in freshwater (5 and 6), demonstrate a relatively steady increase in mass as the samples absorbed water for the first 15 cycles. During the remaining 75 cycles the samples still demonstrated an increase in mass as the samples absorbed water however the rate of water absorption had significantly decreased, the samples appeared to be approaching constant mass. These samples can only be measured during thaw cycles since they are frozen in their containers during freeze cycles. The increase in the mass of the submerged samples does not indicate that the samples were adversely affected by the freeze-thaw testing since there were no significant deviations from the trend. Both of the samples had absorbed a similar amount of water after the 90 cycles. Sample 5 had increased in mass by 15 g or 13.9% and sample 6 had increased in mass by 20 g or 15.9%.

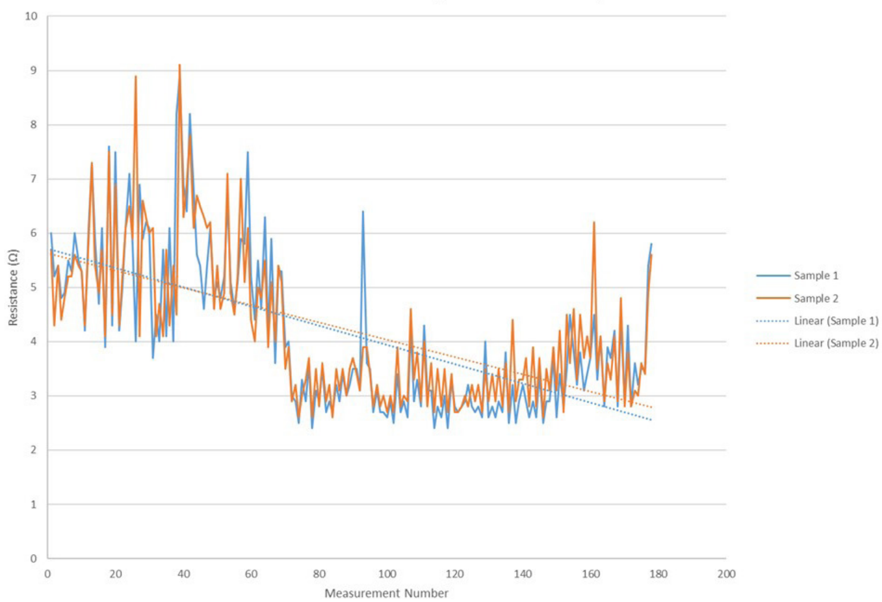
3.2.5 The two samples submerged in saltwater (7 and 8), also demonstrate a relatively steady increase in mass as the samples absorbed water for the first 15 cycles. During the remaining 75 cycles the samples still demonstrated an increase in mass as the samples absorbed water however the rate of water absorption had significantly decreased, the samples appeared to be approaching constant mass. These samples were also only measured during thaw cycles since they were frozen in their containers during freeze cycles. The increase in mass of the samples does not indicate that the samples were adversely affect by the freeze-thaw testing since there were no significant deviations from the trend. Both of the samples had absorbed a similar amount of water after the 90 cycles. Sample 7 had increased in mass by 14 g or 13.2% and sample 8 had increased in mass by 19 g or 13.8%.

3.2.6 None of the samples in this study experienced any change in the appearance of the material after 90 freeze-thaw cycles. No cracking or other physical damage to the samples was observed.

3.2.7 One month after testing of the ConduRod samples was completed the samples were analyzed. The dry samples, 1 and 2, had not changed from the final reading after 90 cycles and had lost 6 g (4.8%) and 5 g (4.7%) respectively from their initial mass. The wet samples, 3 and 4, had also only experienced a small change in mass from their initial values. Sample 3 was still the same value as the final reading after 90 cycles and had lost 6 g (5.4%) from its initial mass. Sample 4 had lost 2 g of water mass since the final reading after 90 cycles and had lost a total of 6 g (4.8%) from its initial value. All of the submerged samples, freshwater and saltwater, had lost all of the water mass they absorbed during the testing and were slightly lower than their initial mass. Sample 5 was 6 g (5.6%) lower than its initial mass, sample 6 was 6 g (4.8%) lower than its initial mass. Sample 7 was 6 g (5.7%) lower than its initial mass, sample 8 was 7 g (5.1%) lower than its initial mass.

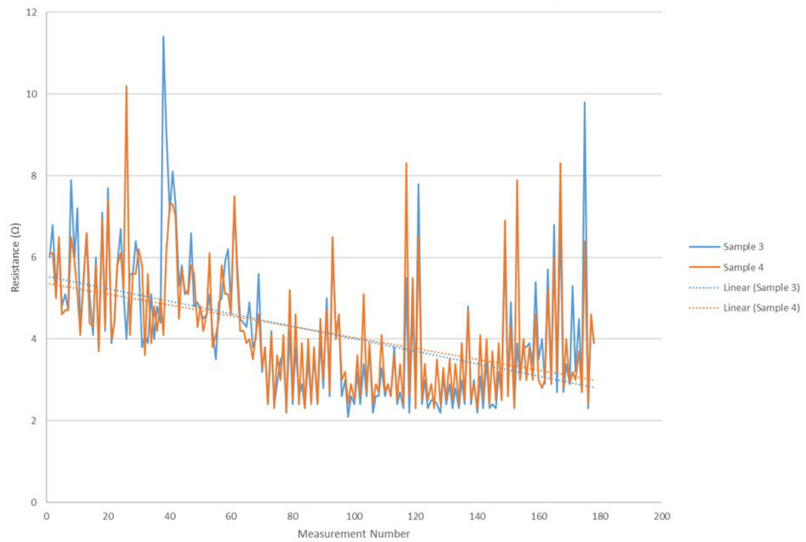
3.3 Resistance Measurements Over 90 Freeze-Thaw Cycles

Figure 2: Resistance Trends of the Dry ConduRod Samples



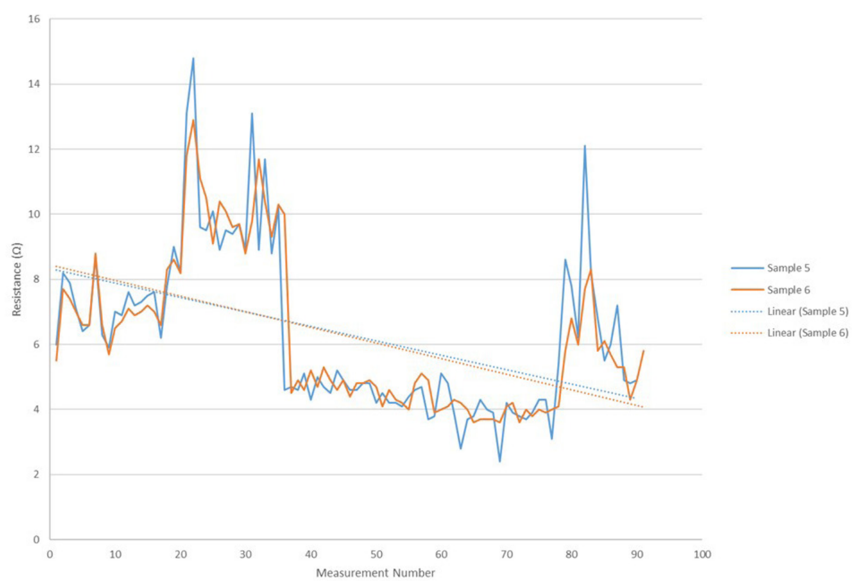
3.3.1 Both dry ConduRod samples demonstrated very similar resistance trends. There were fluctuations between the resistances of the samples when measured during a freeze cycle or a thaw cycle. In general, both dry ConduRod samples were more resistive when frozen and less resistive when thawed. After 90 cycles the resistance of both dry ConduRod samples was slightly lower than their initial values, sample 1 had decreased in resistance by 0.2 ohms (3.3%), and sample 2 had decreased in resistance by 0.1 ohms (1.8%). One month after testing of the samples was complete the resistance was checked. The samples had decreased in resistance significantly, sample 1 was 3.4 ohms (56.7%) lower than the initial resistance and sample 2 was 2.9 ohms (50.9%) lower than the initial resistance. This is a very positive result, indicating that the performance of the samples is not negatively affected, and actually improves when subjected to the freeze-thaw conditions. The less resistive the samples are, the easier the flow of electrons through the material to ground.

Figure 3: Resistance Trends of the Wet ConduRod Samples



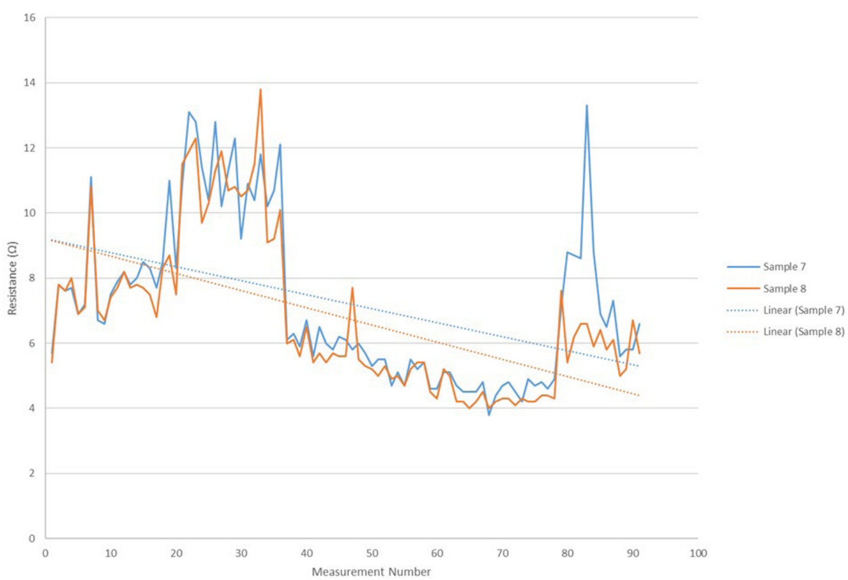
3.3.2 Both wet ConduRod samples demonstrated very similar resistance trends. There were fluctuations between the resistances of the samples when measured during a freeze cycle or a thaw cycle. In general, both wet ConduRod samples were more resistive when frozen and less resistive when thawed. After 90 cycles the resistance of both wet ConduRod samples had decreased by approximately 2.1 ohms (35%). One month after testing of the samples was complete the resistance was checked. The samples further decreased in resistance from their initial values, sample 3 was 3.8 ohms (63.3%) lower than the initial resistance and sample 4 was 4.0 ohms (65.6%) lower than the initial resistance. This is a very positive result, indicating that the performance of the samples improved when subjected to the freeze-thaw conditions. The more conductive the samples are, the easier the electrons flow through the material to ground.

Figure 4: Resistance Trends of the Submerged Freshwater ConduRod Samples



3.3.3 Both ConduRod samples submerged in freshwater demonstrated fairly similar resistance trends. The values shown in Figure 4 above are the resistance readings taken during the thaw cycles, the samples were frozen in their containers during the freeze cycles and the resistances could not be measured. There were fluctuations in the resistances of the samples however all of the measured values are within +/- 9 ohms of the initial resistance value. After 90 cycles the resistance of ConduRod sample 5 submerged in freshwater had decreased by 1.1 ohms (18%) and the resistance of sample 6 submerged in freshwater returned to approximately the original value, it increased by only 0.3 ohms (5.4%), which can be attributed to the method used to measure the resistance. One month after testing of the samples was complete the resistance was checked. The samples further decreased in resistance from their initial values, sample 5 was 4.2 ohms (70.0%) lower than the initial resistance and sample 6 was 3.8 ohms (69.1%) lower than the initial resistance. This is a very positive result, indicating that the performance of the samples improved when subjected to the freeze-thaw conditions. The more conductive the samples are, the easier the electrons flow through the material to ground.

Figure 5: Resistance Trends of the Submerged Saltwater ConduRod Samples



3.3.4 Both ConduRod samples submerged in saltwater demonstrated fairly similar resistance trends. The values shown in Figure 5 above are the resistance readings taken during the thaw cycles, the samples were frozen in their containers during the freeze cycles and the resistances could not be measured. There were fluctuations in the resistances of the samples however all of the measured values are within +/- 8 ohms of the initial resistance value. After 90 cycles the resistance of both ConduRod samples submerged in saltwater had returned to roughly the initial resistance value, the small increases in the resistance can be attributed to the method for measuring the resistance. One month after testing of the samples was complete the resistance was checked. The samples had decreased in resistance significantly, sample 7 was 3.9 ohms (68.4%) lower than the initial resistance and sample 8 was 3.6 ohms (66.7%) lower than the initial resistance. This is a positive result, indicating that the performance of the samples improved when subjected to the freeze-thaw conditions. The more conductive the samples are, the easier the electrons flow through the material to ground.

4. CONCLUSIONS

4.1 The results of the 90 freeze-thaw cycles when analyzing the changes in mass of the samples indicate that none of the samples were adversely affected by freezing. The dry samples and the wet samples all experienced minor fluctuations in their masses during the 90 freeze-thaw cycles however, these were determined not to be a cause for concern since the samples are all within 6 g of the initial mass conditions. The freshwater submerged samples and the saltwater submerged samples all experienced a relatively steady increase in mass as the samples absorbed water. This increase in mass of the submerged samples does not indicate that the samples were adversely affected by the freeze-thaw testing since the samples followed the same trend with no major deviations. Also none of the samples experienced any physical deterioration in the form of cracking, or other physical damage.

4.2 The resistance results agree with the mass results that no degradation of the samples occurred. All of the samples became more conductive or returned to their initial resistance values over the 90 freeze/thaw cycles which is a very positive result. One month after the completion of the testing all of the samples were significantly more conductive than their initial resistance values. This indicates that the performance of the ConduRod will improve when subjected to freeze-thaw conditions.

4.3 The results of this study strongly indicate that the ConduRod will perform in situ for at least 30 years with no significant degradation due to freezing and thawing experienced during winter conditions.

Published Date: October 2022

Resistance of Encased Copper in ConduRod to Electrolytic Corrosion

1. INTRODUCTION

1.1 SAE Inc. has developed the ConduRod; a conductively molded, increased surface area ground rod that dramatically enhances grounding performance while reducing installation costs and hazards associated with traditional methods. The ConduRod grounding electrode virtually eliminates electrode corrosion and ensures protection devices function as designed for their lifetime.

1.2 In order to determine the effectiveness of the ConduRod, the following experiment measuring the electrolytic corrosion resistance of copper when encased in ConduRod surround was conducted.

2. TEST SETUP

2.1 Two rectangular copper strips (approximately. 3" x ¾") were weighed using an electronic balance and connected to insulated wire. One of the strips was left bare and the other was encased in a cylinder of ConduRod. The cylinder was allowed to cure for 3 weeks prior to the start of the experiment. Each sample was placed in a 5 US gallon pail and surrounded with topsoil. A length of steel rebar was placed in each container approximately six inches from the copper. One litre of water and 20 g of sodium sulfate was added to each of the containers. The pair of samples was connected in series in a DC circuit and energized by a 60 V power supply to ensure equal current load across each sample. The power source was set to supply 3 mA for the duration of the experiment. Water was added to the samples on a regular bases to ensure the soil was moist. The resistance data was recorded throughout the experiment.

3. RESULTS AND ANALYSIS

3.1 The resistance data was recorded throughout the experiment and can be seen below in Table 1.

Table 1: Resistance Data for the ConduRod Experiment

Date	Voltage (V)	Current (A)	Circuit Resistance (Ω)
Nov 11, 2016	3.56	0.003	1186.67
Nov 14, 2016	5.08	0.003	1693.33
Nov 15, 2016	4.63	0.003	1543.33
Nov 17, 2016	5.29	0.003	1763.33
Nov 18, 2016	4.85	0.003	1616.67
Nov 21, 2016	6.16	0.003	2053.33
Nov 22, 2016	6.27	0.003	2090.00
Nov 23, 2016	5.21	0.003	1736.67
Nov 24, 2016	4.96	0.003	1653.33
Nov 25, 2016	4.86	0.003	1620.00
Nov 28, 2016	4.78	0.003	1593.33
Nov 29, 2016	5.08	0.003	1693.33
Dec 1, 2016	5.94	0.003	1980.00
Dec 2, 2016	8.35	0.003	2783.33
Dec 5, 2016	8.63	0.003	2876.67
Dec 7, 2016	5.80	0.003	1933.33
Dec 8, 2016	10.84	0.003	3613.33
Dec 9, 2016	60.00	0.001	60000.00
Dec 12, 2016	6.93	0.003	2310.00

3.2 After thirty-two days the experiment was completed and both samples were removed from the soil for analysis. As seen in Figures 1 and 2 all of the copper directly in contact with the soil was consumed. The copper sample encased in the ConduRod was removed from the cylinder for examination. Images of the copper encased in ConduRod before and after the experiment can be seen in Figures 1, 3 and 4. The copper encased in the ConduRod appeared unaffected from the electrolysis. This result was verified by weighing each piece of copper using an electronic balance. The copper sample directly in contact with soil lost 92.37% of its mass during the 32-day test running at 3 mA, whereas the ConduRod encased copper sample experienced no loss in mass.

Table 2: Summary of Loss of Copper Mass

Sample	Initial Mass (g)	Final Mass (g)	Mass Difference (g)	Percentage Loss (%)
Copper #1 (Bare)	3.93	0.30	- 3.63	- 92.37
Copper #3 (ConduRod)	4.00	4.00	0	0

Figure 1: Copper Samples, Before Experiment

Figure 2: Copper #1, After Experiment

Figure 3: Copper #3 Encased in a Cylinder of ConduRod Material Before (left) and After (right) Experiment

Figure 4: Copper #3, After Experiment

4. CONCLUSIONS

4.1 As seen in Table 2 above, the bare copper sample experienced complete consumption of copper directly in contact with the soil. Copper #1 experienced a 92.37% loss in mass. Copper #3 encased in the ConduRod cylinder was unaffected by the electrolysis process and lost no copper mass. These results are similar to previous experimentation with other SAE materials and demonstrate that the ConduRod effectively prevents the corrosion of buried copper.

Published Date: October 2022

Resistance of Encased Steel and Galvanized Steel in ConduRod to Electrolytic Corrosion

1. INTRODUCTION

1.1 SAE Inc. has developed the ConduRod; a conductively molded, increased surface area ground rod that dramatically enhances grounding performance while reducing installation costs and hazards associated with traditional methods. The ConduRod grounding electrode virtually eliminates electrode corrosion and ensures protection devices function as designed for their lifetime.

1.2 In order to determine the effectiveness of the ConduRod, the following experiment measuring the electrolytic corrosion resistance of steel and galvanized steel when encased in ConduRod surround was conducted.

2. TEST SETUP

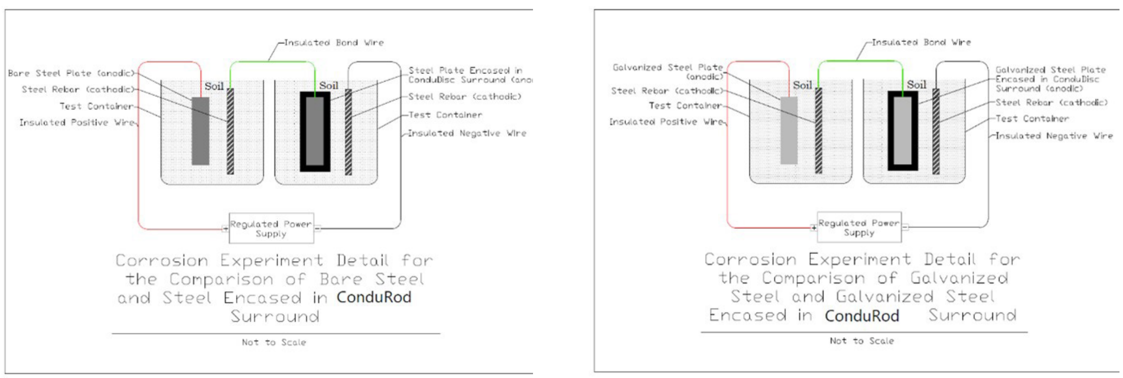
2.1 Four rectangular pieces of steel (approximately. 2" x ¾") were cut using an angle grinder and weighed using an electronic balance. A ¼" hole was drilled into each sample. Two coats of Rustoleum Cold Galvanizing Compound were applied to two of the samples, numbered 7 and 8. These samples were Hot Dip Galvanized at Supreme Galvanizing in Burlington so Rustoleum Cold Gavlanzing Compound was only applied to the edges of the samples that had been cut with the angle grinder. Samples 1 and 2 were left ungalvanized. Lengths of Dual Insulated Wire (HMWPE and Kynar) were attached to each sample by soldering the wire to the steel samples. Rectifier leads were soldered to the end of the samples with no surround material, numbered 1 and 7. Samples 1 and 7 were left bare in the soil, while samples 2 and 8 were encased in ConduRod surround. The samples were allowed to cure for 4 weeks prior to the start of the experiment. Each of the samples were placed in pails and surrounded with a mixture of top soil and sand. A length of steel rebar was placed in each container approximately six inches from the anode. One liter of water and twenty grams of sodium sulfate was added to each container. Each pair of samples was connected in a series circuit to an individual channel of a 30 V rectifier, to ensure an equal current load.

Figure 1: Bare Steel #1 (left) and Galvanized Steel #7 (right), Before Experiment

2.2 As seen in Figure 1 sample 1 had begun to corrode prior to the start of the experiment simply due to exposure to the air.

2.3 The power source was set to provide 3 mA throughout the duration of the test. A schematic of the layouts can be seen below in Figure 2. Two hundred and fifty milliliters of water was added to each pail twice a week to ensure that the soil remained moist. Voltage and current readings were taken throughout the experiment. All samples were removed from the soil after thirty days, cleaned, and weighed using an electronic balance.

Figure 2: Schematics of the Circuit Configuration for Each Sample



3. RESULTS AND ANALYSIS

3.1 The resistance data was recorded throughout the experiment and can be seen below in Tables 1 and 2.

Table 1: Resistance Data for the Galvanized Steel Samples

Date	Voltage (V)	Current (A)	Circuit Resistance (Ω)
Oct 16, 2018	42.79	0.001	42790.00
Oct 17, 2018	6.428	0.003	2142.67
Oct 18, 2018	7.714	0.003	2571.33

Date	Voltage (V)	Current (A)	Circuit Resistance (Ω)
Oct 19, 2018	8.248	0.003	2749.33
Oct 22, 2018	8.602	0.003	2867.33
Oct 24, 2018	8.701	0.003	2900.33
Oct 25, 2018	8.823	0.003	2941.00
Oct 26, 2018	8.879	0.003	2959.67
Oct 29, 2018	9.000	0.003	3000.00
Oct 30, 2018	8.795	0.003	2931.67
Oct 31, 2018	8.825	0.003	2941.67
Nov 1, 2018	8.865	0.003	2955.00
Nov 2, 2018	8.989	0.003	2996.33
Nov 5, 2018	8.992	0.003	2997.33
Nov 6, 2018	8.561	0.003	2853.67
Nov 7, 2018	8.617	0.003	2872.33
Nov 8, 2018	8.752	0.003	2917.33
Nov 9, 2018	8.877	0.003	2959.00
Nov 12, 2018	7.909	0.003	2636.33
Nov 13, 2018	8.654	0.003	2884.67
Nov 14, 2018	8.911	0.003	2970.33
Nov 15, 2018	9.093	0.003	3031.00

Table 2: Resistance Data for the Bare Steel Samples

Date	Voltage (V)	Current (A)	Circuit Resistance (Ω)
Oct 16, 2018	12.69	0.003	4230.00
Oct 17, 2018	10.99	0.003	3663.33
Oct 18, 2018	10.76	0.003	3586.67
Oct 19, 2018	10.51	0.003	3503.33
Oct 22, 2018	9.10	0.003	3003.33
Oct 24, 2018	8.57	0.003	2856.67
Oct 25, 2018	8.57	0.003	2856.67
Oct 26, 2018	8.75	0.003	2916.67
Oct 29, 2018	8.59	0.003	2863.33

Date	Voltage (V)	Current (A)	Circuit Resistance (Ω)
Oct 30, 2018	8.68	0.003	2893.33
Oct 31, 2018	8.62	0.003	2873.33
Nov 1, 2018	8.58	0.003	2860.00
Nov 2, 2018	8.41	0.003	2803.33
Nov 5, 2018	7.98	0.003	2660.00
Nov 6, 2018	7.73	0.003	2576.67
Nov 7, 2018	7.65	0.003	2550.00
Nov 8, 2018	7.56	0.003	2520.00
Nov 9, 2018	7.61	0.003	2536.67
Nov 12, 2018	5.47	0.003	2156.67
Nov 13, 2018	7.23	0.003	2410.00
Nov 14, 2018	7.33	0.003	2443.33
Nov 15, 2018	7.42	0.003	2473.33

3.2 After thirty days the experiment was completed and the samples were removed from the soil for analysis. The samples were cleaned and weighed using an electronic balance. As shown in Table 3 and Figure 3 both the bare steel sample in soil, sample #1, and the galvanized steel sample in soil, sample #7, had experienced significant corrosion and consumption of steel. The galvanized steel sample in soil, sample #7, had actually corroded almost twice as much as the bare steel sample #1. This is likely due to the rapid consumption of the zinc layer as it sacrificed itself to protect the steel underneath. In comparison as shown in Table 3 and Figure 4 the bare steel and galvanized steel samples encased in ConduRod surround, samples #2 and #8 respectively, experienced minimal changes in mass and there was no visible corrosion on the samples.

Table 3: Percentage of Mass Consumed from Each Sample

Sample	Initial Mass (g)	Final Mass (g)	Mass Difference (g)	Percentage Loss (%)
Bare Steel #1 (Soil)	20.67	19.07	- 1.60	- 7.74
Bare Steel #2 (ConduRod)	22.98	22.54	- 0.44	- 1.91
Galvanized Steel #7 (Soil)	24.99	21.02	- 3.97	- 15.89
Galvanized Steel #8 (ConduRod)	22.76	22.74	- 0.02	- 0.09

Figure 3: Uncoated Samples, Bare Steel #1 (left) and Galvanized Steel #7 (right), After Experiment

Figure 4: Sample Encased in ConduRod Surround, Bare Steel #2 (left) and Galvanized Steel #8 (right), After Experiment

4. CONCLUSIONS

4.1 This experiment compared the consumption rates of bare and galvanized steel in damp soil at low current to the consumption rates of bare and galvanized steel encased in ConduRod surround in damp soil at low current. The bare and galvanized steel samples that were in direct contact with the damp soil both experienced a fairly significant loss in mass at the completion of the test. The bare steel in direct contact with the damp soil had a consumption of 7.74% of the sample and the galvanized steel in direct contact with the damp soil had a consumption of 15.89%. In comparison the bare and galvanized steel samples encased in ConduRod surround both experienced minimal loss of mass at the completion of the test. The bare steel sample encased in ConduRod surround had a consumption of 1.91% and the galvanized steel sample encased in ConduRod surround had a consumption of 0.09%. Therefore, this experiment demonstrates that the ConduRod effectively reduces the rate of corrosion of both bare and galvanized steel in buried grounding applications.

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CONDU ROD

ConduRod Permeability Testing

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter by ASTM D5084 | Constant Volume

Sample Name	ConduRod
Type	Tube
Permeant Fluid	De-aired distilled water
Orientation	Vertical
Sample Preparation	Placed into permeameter at as received density and moisture content
Assumed Specific Gravity	1.18

Parameter	Initial	Final	Unit
Height	7.13	7.095	inches
Diameter	3.96	3.96	inches
Area	12.34	12.34	$inches^2$
Volume	87.95	87.65	$inches^3$
Mass	1639	1672	grams
Bulk Density	70.8	72.55	pcf
Moisture Content	3.8	6	%
Dry Density	68.25	68.55	pcf
Degree of Saturation	58	97	%

B Coefficient Determination

Cell Pressure, psi	89.99	Increased Cell Pressure, psi	94.96	Cell Pressure Increment, psi	4.97
Sample Pressure, psi	87.38	Corresponding Sample Pressure, psi	92.16	Sample Pressure Increment, psi	4.78
				B Coefficient	0.96

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Flow Data

Date	Trial #	Pressure, psi		Manometer Readings			Elapsed Time, sec	Gradient	Permeability K, cm/sec	Temp, °C	R_t	Permeability K, @ 20°C, cm/sec
		Cell	Sample	Z_1	Z_2	Z_1-Z_2						
May 8 2017	1	90	87.4	23.75	23.5	0.25	43	16.6	1.70E-07	19.5	1.013	1.70E-07
May 8 2017	2	90	87.4	23.75	23.5	0.25	45	16.6	1.83E-07	19.5	1.013	1.84E-07
May 8 2017	3	90	87.4	23.75	23.5	0.25	49	16.6	1.59E-07	19.5	1.013	1.60E-07
May 8 2017	4	90	87.4	23.75	23.5	0.25	51	16.6	1.58E-07	19.5	1.013	1.63E-07

PERMEABILITY AT 20° C: 1.72 x 10^{-7} cm/sec (@ 2.6 psi effective stress)

These results are the summary of results generated from testing conducted by GeoTesting Express located in Acton, MA. Testing was performed from May 5, 2017 to May 9, 2017.

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ConduRod Leachate Data

The ConduRod is environmentally neutral. It is provided as a solid that does not leach, dissolve or migrate into the soil or water. A table of toxicity characteristic leaching procedure (TCLP) results for ConduRod surround material is included below. The ConduRod surround material was tested to EPA Standard SW846-6020A. TCLP is a soil sample extraction method for chemical analysis employed as an analytical method to simulate leaching through a landfill. Because the testing methodology is used to determine if a waste is characteristically hazardous, similar conditions are not expected in a typical groundwater environment, and the results overestimate the amount of leaching that would occur.

The TCLP results are compared to the Maximum Contaminant Level (MCL) established by the U.S. Environmental Protection Agency (USEPA) for each constituent in the table below. The MCL is the highest level of a contaminant that is allowed in drinking water. For those constituents detected in the leachate, none exceeded USEPA regulatory standards for drinking water. Additionally, because of TCLP conditions, these constituents would not be expected to present a risk for migration in a typical groundwater environment.

Constituent	ConduRod TCLP Concentration (mg/L)	USEPA Maximum Contaminant Level (mg/L)
Arsenic	BDL	0.010
Barium	1.490	2.000
Boron	1.067	2.000*
Chromium	0.026	0.100
Mercury	BDL	0.002
Selenium	0.013	0.050
Silver	BDL	0.100**
Uranium	BDL	0.030
Fluoride	0.190	2.000**
Nitrate (as Nitrogen)	BDL	10.000

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Constituent	ConduRod TCLP Concentration (mg/L)	USEPA Maximum Contaminant Level (mg/L)
Nitrite (as Nitrogen)	BDL	1.000
Cyanide	BDL	0.200

BDL means the result is “Below the Detection Level” of the analytical procedure
* No MCL established; value shown is USEPA’s Lifetime Drinking Water Health Advisory
** No MCL established; value shown is USEPA’s Secondary Drinking Water Standard

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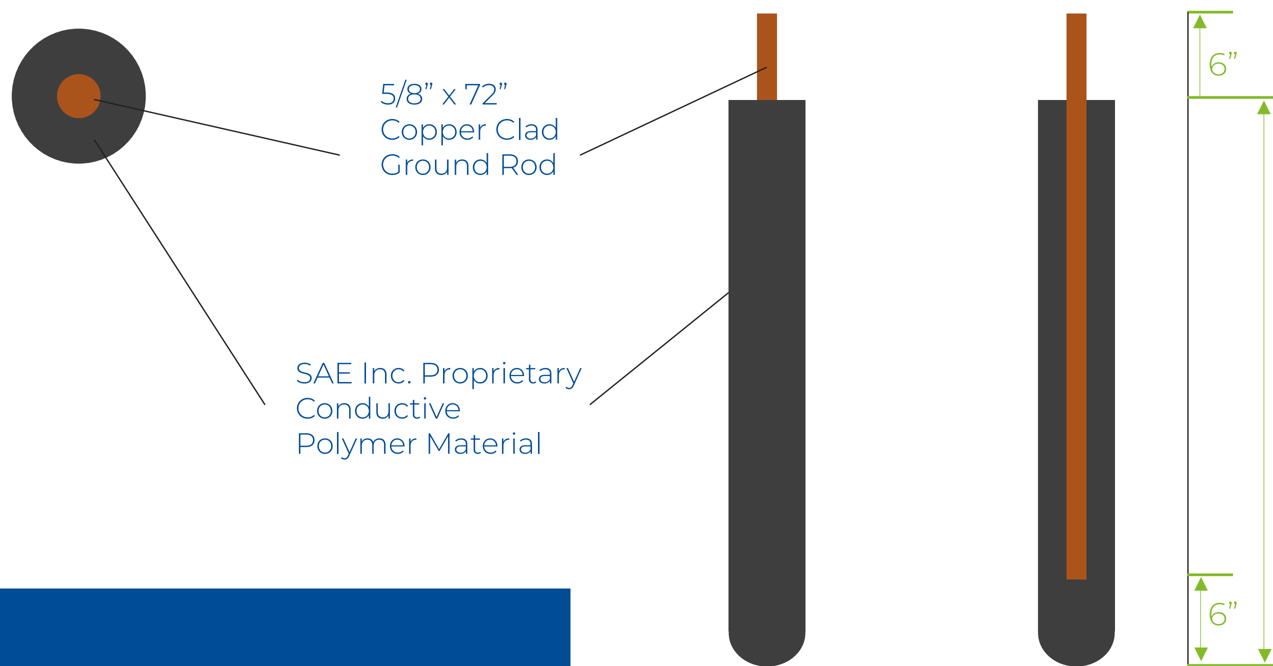
ConduRod Product Specifications | 6’

Top View   Side View   Cross Section



5x Ground rod equivalent!

4” Diameter ConduRod uses a ground rod with:

- 99.9% pure electrolytic copper coating
- Minimum copper coating of 10 mils on rods listed to UL-467

Not to Scale

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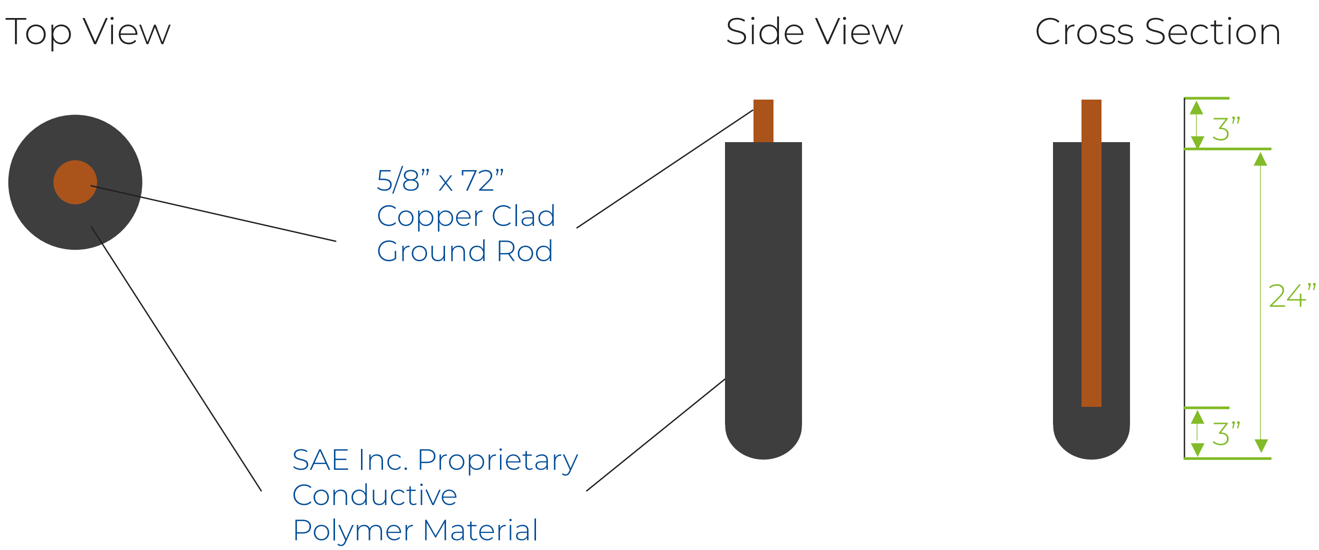
CONDU ROD

ConduRod Product Specifications | 2’



4” Diameter ConduRod
uses a ground rod with:

- 99.9% pure electrolytic copper coating
- Minimum copper coating of 10 mils on rods listed to UL-467

5x Ground rod equivalent!

Not to Scale

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SAFETY DATA SHEET

SECTION 1 | PRODUCT AND COMPANY IDENTIFICATION

PRODUCT

Product Identifier	ConduRod
Synonyms	ConduRod
Product Description	Utility Pole and General Use Grounding Rod
Recommended Use	Electrical Grounding Systems

COMPANY IDENTIFICATION

Supplier

SAE Inc
691 Bayview Drive
Barrie, Ontario, Canada L4N 9A5
+1 705 733 3307
www.saeinc.com

SECTION 2 | HAZARDS IDENTIFICATION

2.1 CLASSIFICATION OF THE MIXTURE

Not classified for physical or health hazards under GHS.

LABELLING

Symbols
None

Signal Word
None

Hazard Statements
Not applicable

Precautionary Statements
Observe good industrial hygiene practices
This product is considered inert and is not hazardous

Trade Secret
A trade secret is being claimed for specific chemical identity and exact percentages

SECTION 3 | COMPOSITION / INFORMATION ON INGREDIENTS

This product is classified as a “manufactured article” and does not constitute a hazardous material in solid form under the definition of the OSHA Hazard Communication Standard (29 CFR 1910.1200) and Section 12 of the Canadian Hazardous Products Act.

3.1 MIXTURE

Chemical Name	CAS No.	Wt. %
Calcined Petroleum Coke	64743-05-1	40-80
Proprietary Styrene Butadiene Polymer	00000-00-0	1-20
Portland Cement	65997-15-1	1-5
Deionized Water	7732-18-5	1-20
Non-Hazardous Components are Proprietary		

SECTION 4 | FIRST AID MEASURES

4.1 EYE
Rinse or flush exposed eye gently using water. Remove contact lenses, if present, while rinsing. If irritation persists or you are concerned seek medical attention.

4.2 SKIN
Not applicable.

4.3 INHALATION
Not applicable.

4.4 INGESTION
Rinse mouth thoroughly. Do NOT induce vomiting. Do not give anything by mouth to an unconscious person. Seek medical attention if irritation persists or concerned.

4.5 MOST IMPORTANT SYMPTOMS AND EFFECTS, BOTH ACUTE AND DELAYED
Not applicable.

4.6 INDICATION OF ANY IMMEDIATE MEDICAL ATTENTION AND SPECIAL TREATMENT NEEDED
If seeking medical attention provide SDS document to physician. Physician should treat symptomatically.

SECTION 5 | FIRE FIGHTING MEASURES

5.1 FLASHING POINT
Carbonic matter: May burn if exposed to temperatures above 1290 °F (700 °C).

5.2 EXTINGUISHING MEDIA
Use extinguishing media appropriate to the surrounding fire conditions. Water Fog, Dry Chemical, Foam, or Carbon Dioxide.

5.3 SPECIAL HAZARDS
Products of combustion may contain carbon monoxide, carbon dioxide and sulfur dioxide. Firefighters should wear self-contained breathing apparatus and full protective clothing as normal.

5.4 EXPLOSION DATA
Not applicable.

SECTION 6 | ACCIDENTAL RELEASE MEASURES

6.1 PERSONAL PRECAUTIONS, PROTECTIVE EQUIPMENT AND EMERGENCY PROCEDURES
Not applicable.

6.2 ENVIRONMENTAL PRECAUTIONS
Not applicable.

6.3 METHODS AND MATERIALS FOR CONTAINMENT AND CLEANING UP
Use normal housekeeping procedures. Material can be picked up by sweeping, shoveling, or vacuuming.

6.4 REFERENCE TO OTHER SECTIONS
See Section 8 for information on selection of personal protective equipment.

SECTION 7 | HANDLING AND STORAGE

7.1 PRECAUTIONS FOR SAFE HANDLING
The ConduRod may be damaged by rough handling.

7.2 CONDITIONS FOR SAFE STORAGE
Store in a dry, well-ventilated area, out of the elements. Protect from physical damage or significant water exposure.

SECTION 8 | EXPOSURE CONTROLS / PERSONAL PROTECTION

8.1 CONTROL PARAMETERS
No applicable occupational exposure limits.

8.2 EXPOSURE CONTROLS

8.2.1 Engineering Controls
Handle in accordance with good industrial hygiene and safety practices.

8.2.2 Personal Protection
Workers must comply with the Personal Protective Equipment requirements of the workplace in which this product is handled.

8.2.3 Eye / Face Protection
Not required under normal conditions of use. When installing the ConduRod wear approved safety glasses.

8.2.4 Skin Protection
Not required under normal conditions of use.

8.2.5 Respiratory Protection
Not required under normal conditions of use.

8.2.6 Other Protection
Perform routine housekeeping. Do not eat, drink, or smoke where this material is handled, stored, and processed. Wash hands thoroughly before eating, drinking, and smoking.

SECTION 9 | PHYSICAL / CHEMICAL PROPERTIES

9.1 INFORMATION ON BASIC PHYSICAL AND CHEMICAL PROPERTIES

Appearance	Solid; black
Odor	Odorless
Odor Threshold	Not applicable
pH	Not applicable
Melting Point / Freezing Point	Not applicable
Initial Boiling Point and Boiling Range	Not applicable
Flash Point	Not applicable
Flammability	Not flammable or combustible
Auto-ignition temperature	>1290 °F, >700 °C
Upper / Lower Flammability or Explosive Limits	Not applicable
Explosive Properties	Not applicable
Oxidizing Properties	Not applicable
Sensitivity to Mechanical Impact	Not applicable
Sensitivity to Static Discharge	Not applicable
Vapor Pressure	Not applicable
Vapor Density	Not applicable
Density	111 lbs/ft^3, 1778 kg/m^3
Solubility	Not applicable
Partition Coefficient (n-octanol / water)	Not applicable
Decomposition Temperature	>2400 °F, >1316 °C
Viscosity	Not applicable

SECTION 10 | STABILITY AND REACTIVITY

10.1 REACTIVITY
Non-reactive under normal conditions.

10.2 CHEMICAL STABILITY
Stable under normal conditions.

10.3 POSSIBILITY OF HAZARDOUS REACTIONS
None known.

10.4 CONDITIONS TO AVOID
Avoid contact with incompatible materials.

10.5 INCOMPATIBLE MATERIALS
Oxidants - Incompatible with strong oxidizing agents.

10.6 HAZARDOUS DECOMPOSITION PRODUCTS
In normal combustion, carbon oxides and sulfur oxides will be released.

SECTION 11 | TOXICOLOGICAL INFORMATION

11.1 LIKELY ROUTES OF EXPOSURE
The ConduRod is inert and insoluble, and is not expected to present an ingestion hazard, or other toxicity hazard.

11.2 ACUTE TOXICITY DATA
Not classified.

11.3 CHRONIC TOXICITY
Not applicable

11.3.1 Respiratory and/or Skin Sensitization
Not known to be a respiratory or skin sensitizer.

11.3.2 Germ Cell Mutagenicity
Not available.

11.3.3 Reproductive Effects
Not available.

11.3.4 Developmental Effects
Not available.

11.3.5 Carcinogenicity
Not available.

11.3.6 Interactions with Other Chemicals
Not available.

SECTION 12 | ECOLOGICAL INFORMATION

12.1 TOXICITY
The ConduRod is inert and insoluble. It does not present any environmental hazards and is not a hazard to aquatic organisms.

12.2 PERSISTENCE AND DEGRADABILITY
Non-biodegradable. The ConduRod is stable, unreactive in water under ambient conditions, and is insoluble.

12.3 BIOACCUMULATION POTENTIAL
Low bioaccumulation potential as negligible water solubility restricts route of exposure to the aquatic environment.

12.4 MOBILITY IN SOIL
Mobility is insignificant due to negligible water solubility and vapor pressure. May incorporate within soil for extended periods of time.

12.5 OTHER ADVERSE EFFECTS
Not available.

SECTION 13 | DISPOSAL CONSIDERATIONS

13.1 WASTE DISPOSAL
Reuse or recycle packaging whenever possible to minimize the generation of waste. All Federal, Provincial / State, and Local regulations regarding health and pollution must be followed for disposal.

SECTION 14 | TRANSPORT INFORMATION

This product is not classified as a Hazardous Material under U.S. DOT or Canadian TDG regulations. This material is not classified as dangerous under ADR, RID, ADNR, IMDG and IATA regulations.

SECTION 15 | REGULATORY INFORMATION

SAFETY, HEALTH AND ENVIRONMENTAL REGULATIONS / LEGISLATION SPECIFIC FOR THE SUBSTANCE OR MIXTURE

15.1 USA
15.1.1 TSCA Status
Substances are listed on the TSCA inventory or are exempt.

15.2 CANADA
This product has been classified in accordance with the hazard criteria of the *Controlled Products Regulations* and the SDS contains all the information required by the *Controlled Products Regulations*.

15.2.1 NSNR Status
Substances are listed on the DSL or are exempt

15.2.2 RCRA
If discarded in its purchased form, this product would not be a hazardous waste by listing or characteristic. However, under RCRA, it is the responsibility of the product user to determine at the time of disposal, whether a material containing the product or derived from the product should be classified as hazardous waste.

SECTION 16 | OTHER INFORMATION

16.1 REVISION DATE
September 23, 2022

16.2 ADDITIONAL INFORMATION
This safety data sheet is believed to provide a useful summary of the hazards of ConduRod as it is commonly used but cannot anticipate and provide all the information that might be needed in every situation. It relates specifically to the product designated and may not be valid for the product when used within any other materials or products or in a particular process.

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