



## WORKING IN SWITCHGEAR CUBICLES JUST GOT A LOT SAFER: THE CUBICLE INSPECTION & REPAIR SAFETY (CIRS) DEVICE

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### ABSTRACT

The patent-pending Cubicle Inspection & Repair Safety Device (“CIRS Device” or “Device”) provides a safe work environment within switchgear cubicles by eliminating the risk of accidental/incidental contact with energized bus components. The CIRS Device provides mechanics the ability to safely perform inspections, preventative maintenance (“PM”) and corrective maintenance (“CM”) on most components within the cubicle without the need for a bus section outage. The Device has proven to be a safe and reliable solution at Con Edison.

Use of the CIRS Device in PM and CM activities within switchgear cubicles enhances work practices by eliminating the need for bus section outages which would require coordinated de-loading and field switching. This results in:

- Reductions in the potential for high hazard injury
- Reduction in human performance errors
- Increases in system reliability
- Significant O&M cost savings
- Most importantly: Provides employees with the ability to work safely within the switchgear cubicle

### INTRODUCTION – SAFETY FIRST

Daily work in the electric utility industry often includes exposure to high energy, which is high risk, so safety is always the priority. According to OSHA, in 2017 alone, 5,147 workers were killed on the job across all industries and 71 of those were a result of electrocution. As of 2018, 5,250 workers were killed with a total of 86 caused by electrocution [1]. These numbers are extremely high, and behind the numbers are people and families. The goal is, and always will be, to achieve zero incidents. In May 2015, the author experienced a personal loss of a coworker who was killed by accidental contact with an energized bus component. As a result, the Cubicle Inspection and Repair Safety (CIRS) Device was developed as a tribute to the author’s late friend, and to help prevent this type of accident from ever occurring again.

**Table 1**  
**OSHA Statistics – Workers Killed on the Job 2015 - 2017**

OSHA Statistics	2015	2016	2017	2018
Workers Killed on the Job - General	4,836	5,190	5,147	5,250
Workers Killed on the Job - Electrocution	81*	82	71	86

\*One of those 81 workers killed by electrocution was a personal friend of the author (May 2015)

In tandem with the personal loss mentioned above, there was a need to enhance switchgear inspection and preventative maintenance work practices to improve reliability and find issues before they become a problem or result in a catastrophic failure. Specifically, there was a dire need to create a safe work environment for mechanics to perform repairs and complete inspections without the need for bus section outage. This includes but is not limited to inspecting live bus components and exercising the switchgear racking mechanism without need for bus section outage.

With the CIRS Device, a mechanic can now safely perform inspections, PM and CM activities on most components within the cubicle without the need for a bus section outage.

## **POWERVAC SWITCHGEAR AT CON EDISON**

The CIRS Device was first developed for the General Electric PowerVac / Powell Power/Vac application as it is the majority of the switchgear for Con Edison's 13kV substations. There are approximately 1,800 PowerVac circuit breakers across the Con Edison 13kV system which totals to approximately 67% of the fleet. There are an additional 100 PowerVac circuit breakers in the 4kV system and that number is growing every year with two annual scheduled lineup upgrades. Lastly, PowerVac switchgear and circuit breakers are even a part of our steam generation facilities.

Due to the size of this fleet of equipment, there are approximately 200 annual cubicle PM opportunities where the CIRS Device can be used in tandem with a circuit breaker PM. At the same time, with the ability to track and trend switchgear issues, Con Edison performs approximately 100 – 150 CM tasks a year where the Device could be installed to keep the mechanics safe and prevent unnecessary bus section outages.

## **CURRENT SWITCHGEAR WORK PRACTICES**

As part of cubicle inspection, cleaning, and preventative maintenance, a mechanic's job is to perform a thorough visual inspection, clean the cubicle of dirt and debris, remove old grease, and re-lubricate components. Lastly, mechanics are to perform an operational check of the racking mechanism/shutter mechanism and perform a visual inspection of the bus for signs of pitting, arcing, and wear. There is limited access inside the cubicle to perform work, so only one mechanic can enter or perform work at a time.

Without the CIRS Device, the racking mechanism and shutter mechanism cannot safely be inspected or tested while the bus is energized due to safety constraints and clearances.

Additionally, there are components inside the cubicle that fail and need to be repaired or replaced. These include secondary blocks, auxiliary switches, heaters, racking mechanisms/chains/linkages, and other miscellaneous components. Without the CIRS Device, these components cannot be safely worked on without a bus section outage due to the clearance to energized parts and an open underside design.

Other safety barriers for cubicle inspection and repair created to-date are inadequate. They are not always specific to the switchgear and do not work safely or efficiently for the work to be done. These other barriers may enable the mechanic to operate the racking and shutter mechanism, but the barriers do not create a safe work environment. The present options are not stable and are of flimsy construction, which can result in an even more unsafe condition. The present options also block access to components that need to be inspected and occasionally repaired, making a bus section outage necessary to perform the work.

## ENHANCING SWITCHGEAR WORK PRACTICES

There is a great need for improved switchgear work practices, which has been confirmed with several other users and utilities around the United States. The goals for the project are to enhance switchgear work practices that:

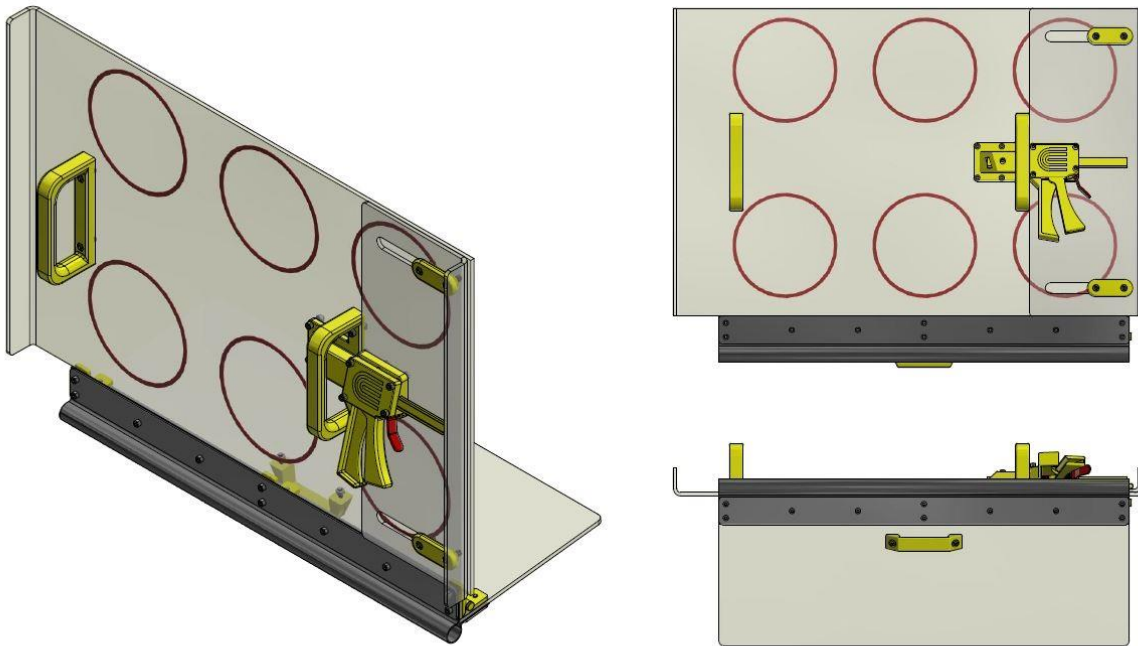
- Reduce potential for high hazard injury
- Reduce human performance errors
  - Including switching and coordination on an emergency basis
- Reduce system reliability risk
- Reduce costs
- Most importantly, provide employees with the ability to work safely without the need for a bus section outage

## THE CUBICLE INSPECTION & REPAIR SAFETY (CIRS) DEVICE

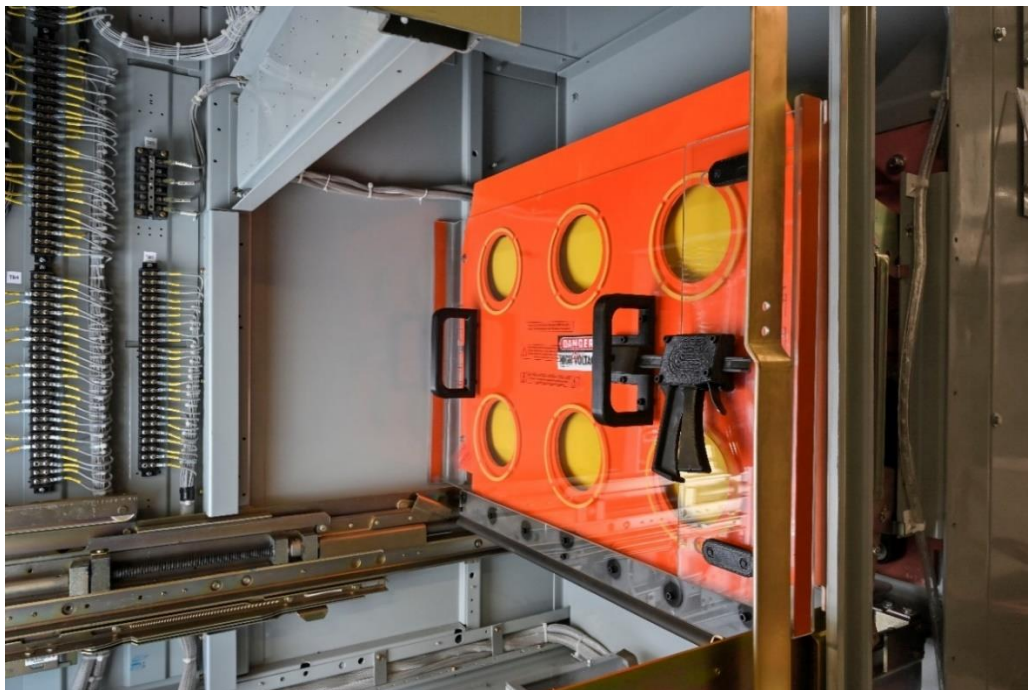
### Design

The Device is made up of three planes of ¼-inch polycarbonate sheets with an adjustable clamping mechanism to secure the Device in place – refer to Figure 1; a fixed plane, sliding plane, and lower/underside plane. The large main polycarbonate fixed plane serves as the barrier in front of the shutter assembly that protects the user from the energized bus. It is composed of the placement handles and reference circles to assist the mechanic with placement and alignment in the cubicle over the existing shutter assembly. The right sliding plane is used to lock the Device into place inside the cubicle and the lower/underside plane serves as additional protection for the user to work safely on components that do not have any Micarta board or insulation from the feeder tubes or bottles. The majority of the components (handles, clamping mechanism, sliders, etc.) are 3D printed nylon made in the company's fabrication shop. All the remaining hardware is made of nylon and rubber.

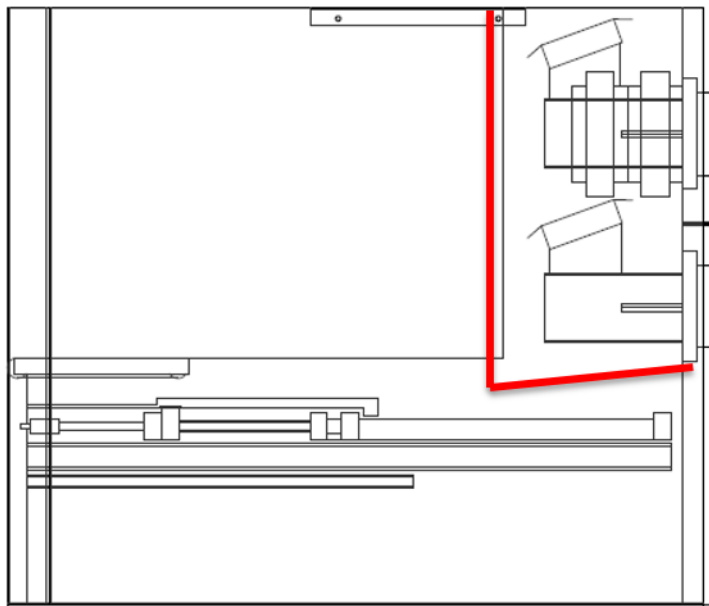
The CIRS Device went through eight working prototypes to get to the final design shown in Figure 1, Figure 2 and Figure 4. A diverse team of operators, mechanics, subject matter experts, and safety specialists were involved in trials and testing. The driving guideline throughout the prototyping phases was Safety by Design. All potential hazards were identified early on and the components inside the switchgear cubicle were taken into consideration to make the installation and removal ergonomic and user friendly. For example, the CIRS Device, when installed, sits on the rails that guide the circuit breaker into the cubicle. This step takes the strain off the users back and arms and makes the overall installation easier to make fitment and locking it in place stress-free.



**Drawing of the Cubicle Inspection & Repair Safety Device  
Figure 1**



**Photo of the Cubicle Inspection & Repair Safety Device Installed (Training Cubicle)  
Figure 2**



**Drawing Showing Cubicle Inspection & Repair Safety Device Installed  
Figure 3**



**Photo of the Cubicle Inspection & Repair Safety Device Installed (Training Cubicle)  
Figure 4**

## **CIRS Device in Use**

The CIRS Device itself has already provided significant costs savings for the Company. It was used more than fifteen times for corrective maintenance in 2019 and has helped alleviate some operating expenses. These cost avoidances include switching support (both inside the substation and in the field), repairs, control center support, engineering, etc. More importantly, the Device is being used on a regular basis for preventative maintenance/inspections, which provides long-term equipment savings, reliability, and employee safety. One cannot put a price on saving a life.

The CIRS Device is the solution to improving safety and system reliability. This new innovation has been shared at industry conferences where great interest has been obtained; many peer utilities and other companies want to implement these improved work practices into their programs. Con Edison will continue to work with peer utilities and other companies to push the program to the next level. These partnerships with utility peers and users will help the company to find new ways to better the program and continue to improve safe switchgear work practices.

## **Field Application - Granite Hill Substation Cubicle Secondary Block Repair**

As discussed, the CIRS Device is a solution that took over two years and eight prototypes to perfect. As a result of cross-company involvement, the Device was made available for corrective maintenance conditions. Success has been measured through the achievement of the goals originally set to accomplish: ensuring safety, reliability and savings associated with not having to take a bus section outage for repairs and finding and correcting issues before they led to failures. An example of this success is the first use case for a corrective maintenance event which serves as a great case study and the first real use application.

On January 11, 2019, one of the Granite Hill Substation (13kV) bus sections was taken out of service for a failed transformer replacement. While attempting to restore the bus section, it was found that the circuit breaker would not charge and as a result could not be safely closed. Upon removal of the circuit breaker from the cubicle, it was visually noticed that the secondary contact block was damaged (burned contacts and wires) and needed to be repaired.

Normally, prior to the development of the CIRS Device, the practice would be to take the bus section out of service to be able to safely make repairs. However, this was an uncommon scenario. Due to the bus section being out of service for the failed transformer replacement, four feeders were already out of service on the south bus. If the north bus section was to be removed from service to perform repairs, an additional three feeders would have to be removed from service for a total of seven feeders out of service. The north bus section and associated three feeder outages would have required a significant amount of field work to avoid customer outages.

Working as a team, the mechanics, operator, supervisors, planner, and one of the inventors (the author) worked together to make sure everyone understood the instructions for inspection and use. The CIRS Device was installed and used to complete the repair safely and efficiently without the need for a bus section outage. Each of the goals set out in the early stages of the project were achieved:

- High hazard injury avoidance
- Human performance error avoidance through the elimination of the need for switching and coordination on an emergency basis
- System reliability risk avoidance
- Significant cost avoidance
- Provide employees with the ability to work safely without the need for a bus section outage

The company employees involved came together as a group and with the support of EH&S, union representation, and engineering, were able to use the newly developed CIRS Device to work on the cubicle while keeping the bus section in service. Using the new Device, the crew safely and effectively repaired the damaged cubicle and restored the bus section. Figure 5 is a photo taken during the job while the mechanics were using the CIRS Device to perform the repair. The mechanics and operator who performed this work were very happy with the Device and felt extremely comfortable with their safety using this Device in the energized cubicle.



**Photo of the Cubicle Inspection & Repair Safety Device Installed at Granite Hill Substation  
Figure 5**

### **CIRS Device DNV-GL Testing**

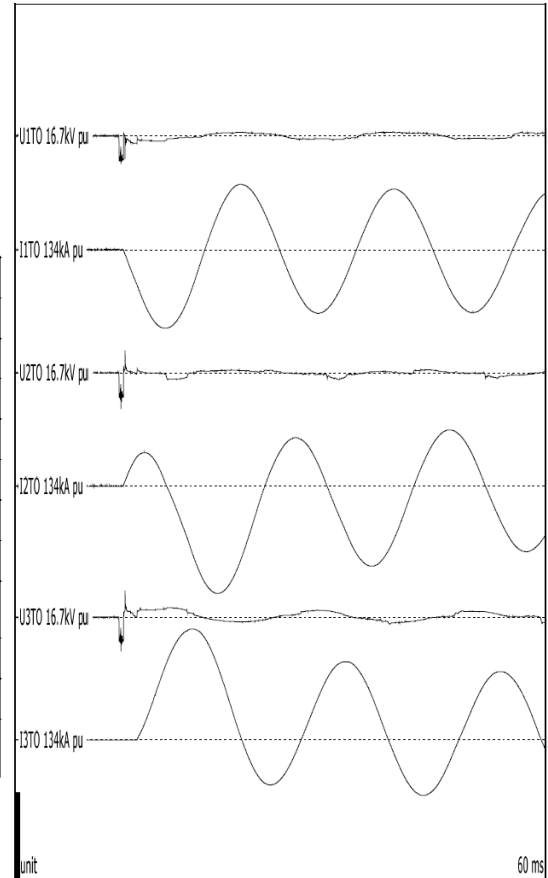
As past practices are improved and advanced, it is understood that there is the need for testing and trials to prove concepts. Though the Device went through several prototyping and testing phases, the final proof of concept would eventually have to be put to test in a simulated worst case scenario. To do so, the CIRS Device was brought to DNV-GL Laboratories in Chalfont, Pennsylvania to perform testing on the material properties and see how the Device would hold up in a 63 kA arc flash event.

The testing performed was a full simulation of the CIRS Device installed in a General Electric PowerVac switchgear cubicle. A 63kA arc flash was applied to the bus (3 phases were tied together with bonding wire) while a Fire Resistant rated mannequin wearing Con Edison's standard 12.4 cal/cm<sup>2</sup> HRC 2 FR coveralls, hard hat, and gloves was in the cubicle. The mannequin was used to simulate a mechanic performing corrective maintenance such as a MOC/TOC switch (auxiliary switch) or secondary block repair/replacement. The test exposed the cubicle, the Device, and the mannequin to >63 kA flash for a duration of approximately 6 cycles (94 ms) [2].

**Table 2**  
**DNV-GL Test 181219-0003 – Magnitude of Arc Flash Test of the Cubicle Inspection & Repair Safety Device**

**Test number: 181219-9003**

Phase		A	B	C
Applied voltage, phase-to-ground	kV <sub>RMS</sub>	4,44	4,44	4,44
Applied voltage, phase-to-phase	kV <sub>RMS</sub>	7,69		
Making current	kA <sub>peak</sub>	-120	-164	169
Current, a.c. component, beginning	kA <sub>RMS</sub>	73,6	79,9	75,3
Current, a.c. component, middle	kA <sub>RMS</sub>	61,5	67,7	64,8
Current, a.c. component, end	kA <sub>RMS</sub>	63,2	67,2	68,2
Current, a.c. component, average	kA <sub>RMS</sub>	66,3	71,4	69,2
Current, a.c. component, three-phase average	kA <sub>RMS</sub>	68,9		
Duration	s	0,094	0,094	0,092
Arc energy	MJ	6,92		
Equivalent RMS value and duration		63,0 kA during 0,103 s		



Upon completion of the test, the data showed that the generated arc flash blast was approximately seven mega-joules. As anticipated, the safety Device pushed the mannequin out of the cubicle due to the force of the flash/blast. As shown in Figure 6, the mannequin had no burns or damage – the hard hat was blown off and had a small amount of copper and metallic splatter. The cubicle shutters and Micarta board were destroyed in the event. The force of the blast associated with the arc flash blew the Micarta board up and over the CIRS Device while the CIRS Device held in place for several milliseconds before projecting out of the cubicle. Figure 6 is a screen capture from the video of the test where you can see the Micarta board outside of the cubicle on the right side with the CIRS Device just starting to be pushed out of its clamped in position. The three main polycarbonate components of the CIRS Device were separated as a result of the blast (fixed plane, sliding plane and lower/underside plane). The polycarbonate components had signs of carbon deposits from the flames and some splatter from molten metal, but were not structurally damaged



(no cracks) and the CIRS Device polycarbonate components did not shatter. The nylon components (handles, hardware, etc.) were separated from the polycarbonate, but saw little damage.



**Photo during Arc Flash DNV-GL Test of the Cubicle Inspection & Repair Safety Device  
Figure 6**

The goal of this test was to prove that the CIRS Device would not worsen the conditions that a mechanic would be exposed to by exposing the mechanic to projected shattered or molten materials from the barrier itself. This test was a success because although the mannequin was pushed out of the cell by the CIRS Device, it acted as shield to reduce the impact to the simulated mechanic.

Even with the CIRS Device in place, the arc flash conditions shown in the test would result in injury and possible death to personnel who might be in the vicinity of such conditions. The CIRS Device's purpose is to create isolation from the energized bus to prevent a mechanic from making accidental contact while performing inspections or repairs that could result in an arc flash event.



**Aftermath of Arc Flash DNV-GL Test of the Cubicle Inspection & Repair Safety Device  
Figure 7**

The testing showed that the CIRS Device was a success. It can be concluded that the CIRS Device will not just protect a mechanic working within a cubicle to additional hazards but will mitigate some of the initial effects of an arc flash. Again, this Device is *not* for arc flash protection or mitigation – it is strictly an isolation barrier to prevent a mechanic from making accidental contact while performing inspections or repairs that could result in an arc flash event.

## **CONCLUSION**

The main intent and purpose for the Cubicle Inspection & Repair Safety Device is for employee safety. The CIRS Device creates a new plane and isolates the mechanic from the energized bus and components. It serves as protection while performing inspections, cleaning, preventative maintenance and repairs. The CIRS Device provides better employee safety, work practices, efficiency, system reliability, and cost savings by eliminating the need for bus section outages as a result of complete inspections and repairs.

This is just the beginning for the Cubicle Inspection & Repair Safety Device. While this Device is specific to the General Electric PowerVac and Powell Power/Vac applications, with simple modifications, this design can easily be applied to all 480V, 5kV, 15kV, 27kV and 38kV rated switchgear applications by using the same design and modifying the shape and size of the polycarbonate sheet. The author and the CIRS Device team is currently in the process of rolling out the next iteration of the Device for the Hyundai HVF application and is starting the internal process to develop the Device for the General Electric MagneBlast application. With the proper team and partnership, the Cubicle Inspection Repair and Safety Device has the ability to become part of every switchgear user's work practices for inspections, preventative maintenance, and corrective maintenance activities.

## **ACKNOWLEDGEMENTS**

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Jozef Szabo – Consolidated Edison Company of New York, Inc.

## **REFERENCES**

- [1] United States Department of Labor: Occupational Safety and Health Administration. "Commonly Used Statistics." <https://www.osha.gov/oshstats/commonstats.html>. 2019.
- [2] DNV-GL. "Final 18227-B, Arc Fault Test, Con Ed NY (Report)." Chalfont, Pennsylvania. December 19, 2018.

## BIOGRAPHY

Eric M. Fell is a Specialist in EH&S Safety at Consolidated Edison Company of New York (Con Edison) working on the development, analysis and implementation of safety technology and innovation improvements to reduce injuries and achieve a zero-harm environment. He recently moved to this role to focus his efforts on the expansion and continued execution of the Cubicle Inspection & Repair Safety (CIRS) Device. Prior to being a specialist, Eric was a Substation Operations Supervisor providing oversight and execution of operations, maintenance & construction activities within 9 transmission and distribution substations (13kV – 345kV) throughout Westchester & Dutchess Counties. Beyond his normal duties, Eric is considered a subject matter expert (SME) in Low and Medium Voltage circuit breaker maintenance and troubleshooting at Con Edison. He brings a wealth of knowledge from his experience as a Substation Supervisor at New York State Electric and Gas (NYSEG) and as Field Engineer for General Electric Industrial Solutions; concentrating on startup, commissioning, and troubleshooting of low and medium voltage (480V – 15kV) power delivery system projects. Eric holds a Master's Degree in Renewable Energy & Sustainable Systems with a concentration in Sustainability Management & Policy from Penn State University and a Bachelor of Science from Roger Williams University. He has also earned a Field Engineering Degree from General Electric and an Infrared Thermography Level I & Level II certification from the Infrasppection Institute.



## APPENDIX

DNV-GL Testing Video

<http://coned.lexcorpinc.com/v/76473/Test-1-Os7-S2-camera-edited>

CIRS E-LEARNING Video

<http://coned.lexcorpinc.com/v/76372/CIRS-External-DOJT-Video-9-5>