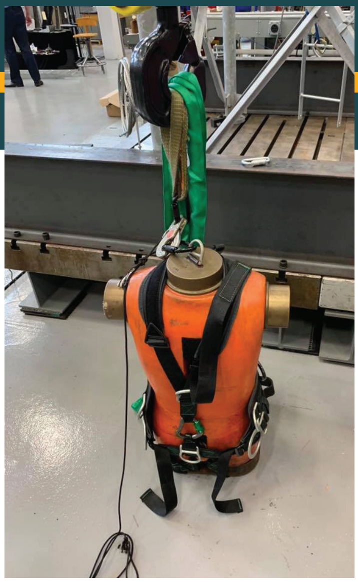
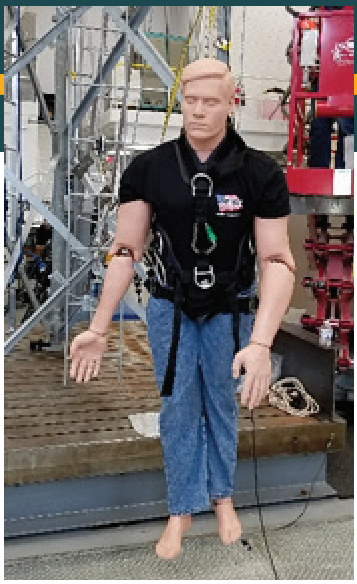
NATE

THE COMMUNICATIONS INFRASTRUCTURE CONTRACTORS ASSOCIATION

SAFETY SLEEVE TESTING

FINAL REPORT





This report was prepared for

NATE

THE COMMUNICATIONS INFRASTRUCTURE CONTRACTORS ASSOCIATION

by the NATE Safety Sleeve Testing Team for future publication to the Association's Members to further enhance safety in the telecommunications tower industry.

ACKNOWLEDGMENT

First and foremost, the testing team would like to acknowledge NATE for agreeing to sponsor the safety sleeve testing event and their dedication to the safety of men and women who make wireless communication possible. Without their leadership, support and vision this safety sleeve testing would not have been possible.

Next, we would like to thank the following organizations and each participant from these organizations for their support:

- **3M**
- **AMERICAN TOWER**
- **CROWN CASTLE**
- **GME SUPPLY**
- **NATE**
- **SABRE INDUSTRIES**
- **SAFETY LMS**
- **SBA COMMUNICATIONS**
- **SKYLOTEC**
- **TRYLON**
- **TUF-TUG**
- **UNIVERSITY OF DAYTON RESEARCH INSTITUTE (UDRI)**
- **VERTICAL BRIDGE**

FOREWORD

This document describes the overall scope and methodology utilized for testing wire rope safety sleeves ("safety sleeves") when used in conjunction with a wire rope safety climb. From a practical sense wire rope safety climbs are considered an appurtenance on an antenna supporting structure until such time they are used with a safety sleeve. When utilizing the wire rope safety climb in conjunction with a safety sleeve and full body harness the entire assembly becomes part of the users fall arrest system and is herein referenced as a safety climb system. As with any personal protective equipment (PPE) it is expected the entire wire rope safety climb system will be inspected before each use in accordance with OSHA and manufacturer standards. The inspections of such systems are outside the scope of this document.

The intent of this testing was to push the design limits/standards of the safety sleeves and test outside of parameters established by ANSI/ASSP Z359. Therefore, most of the tests performed were in direct conflict with the manufacturers design and test requirements and the test results should only be used to validate and reinforce existing safety procedures.

All participants followed the NATE antitrust rules of engagement during all meetings and the NATE antitrust statement was read at each testing event.

PURPOSE

The testing protocols outlined in this document were not conducted under strict ANSI requirements and therefore shouldn't be construed as ANSI testing. The tests performed were not intended to conform to the current ANSI/ASSP Z359 testing protocol, but rather to closer emulate how the safety sleeves are being utilized by tower climbers in the telecommunication tower industry.

The testing event was performed to provide feedback to NATE and its membership, and to provide future guidance for the Safety Equipment Manufacturers Committee (SEMC) for developing new testing parameters and safety climb system performance criteria. The results of the testing event are meant to raise the bar on safety for the telecommunications industry.

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SUMMARY

All testing was conducted at the UDRI facility, performed over three different events for a total six days with over one hundred and ten (110) drops completed. All of the test drops were videoed and reviewed by the team to verify the accuracy of the results recorded in this report. The tests performed clearly indicate that additional testing is required by the SEMC group and that the current ANSI/ASSP Z359 testing procedures may not be adequate for the telecommunications industry. The tests did however provide enough data to help the SEMC group develop new testing protocol and procedures that are more indicative of how wire rope safety climbs are installed and how tower climbers utilize safety sleeves. Results indicated that using an anthropomorphic manikin in a climbing harness instead of the standard two hundred and eighty-two-pound (282#) steel weight can greatly influence the dynamic results and outcome of the drop tests. Testing also verified some of the manufacturer's warnings and will be added in the next revision of ANSI/ASSP A10.48 to reinforce lessons learned.

Testing confirmed that the wire rope safety climb ("safety climb") must be tensioned in accordance with manufacturers specifications in order for the safety sleeve to function as designed. Testing also verified that an un-attached wire rope at the bottom assembly (effectively zero tension with the wire rope moving freely) of the safety climb system negatively impacts the performance of the safety sleeve; especially on 3/8" 1x7 galvanized wire rope ("wire rope"). Testing indicated that 3/8" 7x19 galvanized/stainless wire rope ("wire rope") performed better at lower tensions and this is inherent to the wire rope characteristics and flexibility compared to 3/8" 1x7 galvanized wire rope which is much stiffer.

While testing performed was limited to a small sample size of wire rope in various conditions the results for unattached 3/8" 1x7 wire galvanized rope definitely correlated to a higher probability that some safety sleeves may not function as effectively as when the wire rope is properly tensioned. This test scenario was performed to reaffirm the importance of the manufacturer's specifications to properly tension the wire rope before each use.

Sun camber, commonly referred to as the "Sunflower Effect", on towers can adversely impact the tension of a wire rope safety climb. The Sunflower Effect is caused by the thermal expansion and contraction of the steel due to the temperature differences through the course of the day caused by direct sunlight. For self-supporting towers it will cause the tower to increase or decrease in height at a rate that may be slightly different from that of the wire rope. This is dependent upon a number of factors such as shade, full sun, wind direction, and ambient air temperature. The wire rope tension will vary during the course of the day due to thermal expansion and contraction, but it will expand and contract at rates similar to the self-supporting tower.

On monopoles the Sunflower Effect is more dramatic and noticeable as the sunny side will expand at a much greater rate than the shaded side of the tower, thus the tower will bend away from the sun. As the sun moves throughout the course of the day, the tower will cycle through this sunflower effect from sunrise to sunset. This effect will change the tension in the wire rope, with a corresponding increase in tension on the sunny side and decrease in tension on the shaded side.

In order to account for the environmental changes in wire rope safety climb tensions throughout the day we recommend that manufacturers provide a means to maintain adequate tension. One way to possibly achieve this would be to add some type of spring assembly at the bottom or top of the tower to maintain a minimum tension in the system accounting for the thermal expansion and contraction of the tower.

In order to simulate "real life conditions" we conducted a "Safety Climb Shake Test". This test was developed to address the common practice of climbers leaving an unattended safety sleeve attached to the wire rope at heights. The shake test verified our suspicions/field observations that some sleeves will slide down the wire rope due to vibrations/oscillations from wind or other forces on the wire rope if left unattended/untethered. This is an all too common practice and will be addressed the SEMC group and included the next revision of ANSI/ASSP A10.48.

The safety sleeve testing event also included real life conditions which included wire rope with various levels of corrosion and contaminated bird droppings. Tests included class one (1) corrosion on both 3/8" 1x7 and 7x19 wire rope, 3/8" 7x19 wire rope with class two (2) and class three (3) corrosion and a 3/8" 1x7 wire rope with heavy accumulations of bird droppings.

The "168 Hour Salt Spray Test" (Salt Spray Test) was developed to closely emulate surface corrosion similar to wire ropes exposed to coastal environments. This test was performed on 3/8" 1x7 and 7x19 wire ropes that were subjected to one hundred and sixty-eight (168) hours of Salt Spray Environmental conditioning per ASTM Standard B117 and ISO Standard 9227 using a Q-Fog CCT1100 Cyclic Corrosion Chamber. The overall condition of both safety climbs closely resembled and performed similar to the wire rope bird dropping test completed during the October 2018 Test Event.

The salt spray wire rope safety climbs were installed and tensioned per the manufacturer's specifications. The TUF-TUG recommended tension for their 3/8" 7x19 wire rope safety climb is 220 lb +/-10%. The 3M recommended tension for their 3/8" 1x7 wire rope safety climb is 320 lb minimum tension. Safety sleeve drop tests were recorded for both types of wire rope with the 3/8" 7x19 wire rope performing better with all sleeves tested.

Maintenance tests were performed on a 3/8" 7x19 wire rope with class 2 corrosion (corrosion with minor pitting without scale or material loss). Some safety sleeves tested on the wire rope exhibited travel function issues, especially while traversing down, however, all sleeves performed extremely well in the drop tests. The function test was a sample test conducted by a competent climber, and the results of that test may vary between climbers depending on climbing style and experience level. The testing yielded results that indicate that 3/8" 7x19 wire rope, with class 2 corrosion, performs as expected and may be utilized as PPE as long as it is tensioned and installed per the manufacturer's specifications.

Testing of class 2 corrosion on 3/8″ 1x7 wire rope was not performed because the representatives of this testing team believe that the test data from the salt spray test would most likely yield similar results.

All safety sleeves tested on the 3/8″ 7x19 wire rope with class 3 corrosion (corrosion with pitting, scale and material loss) did exhibit some sleeve travel function issues but performed extremely well in the drop tests. After drop testing concluded the class 3 wire rope was sent to Tri State Wire Rope and successfully pull tested to 5000 lb.

Safety sleeve testing on the 3/8″ 1x7 wire rope covered in bird droppings was a repurposed safety climb that been carefully removed from the field, bagged and re-installed at the test facility. Drop tests were performed with a limited number of sleeves however, when the wire rope was properly tensioned the safety sleeves performed as designed in both the functional and drop tests.

The results of the Salt Spray Test indicate that SEMC should incorporate this test protocol going forward as the test is repeatable and can be standardized. The wire rope test criteria should include a function test fully up and down the wire rope one (1) time to remove the excess powdery salt residue prior to drop testing. Observations indicate that even when the excess powdery residue was removed, the salt and slight red rust patina potentially impacted sleeve performance, especially on the 3/8″ 1x7 wire rope.

Results also indicated that 3/8″ 7x19 wire rope with class 2 corrosion could be potentially used, after a fall event, for tower rescue if inspected and deemed safe by a Competent Climber/Rescuer. Wire rope with class 3 corrosion would not be recommended, as there is no way to quickly verify the wire rope material integrity.

Thin Film Ice Testing (Ice Testing) was completed on March 6, 2019 for both 3/8″ 1x7 and 7x19 wire rope. This test was developed specifically to replicate actual field conditions that tower climbers may encounter while accessing antenna supporting structures, at height, during cold weather. This test was developed to emulate the ice fog effect when water vapor freezes on contact with wire rope creating a thin icy film.

Initial ice testing conducted on January 31, 2019 resulted in an ice build-up exceeding 1/8″. When the safety sleeve was drop tested the ice effectively separated from the wire rope. The thicker ice was created in part due to the high volume of water spray from a tank sprayer, instantaneously freezing water to the wire rope due to an ambient air temperature of 4°F. This test closely followed the [illegible]″ radial ice test currently performed in other industries. Based on testing and practical experience radial ice is easily removed from the wire rope as opposed to thin film ice.

The thin film ice test was performed outside of the UDRI facility on a 30′ test tower, anchored to the pavement, with an ambient air temperature of 11°F. The test was started at twilight so that we could conclude testing prior to the sun shining and warming up the tower steel. The wire rope was sprayed with a fine mist of water from a hand bottle sprayer in order to get an even thin film ice coating on the wire. Ice build-up in excess of 1/8″ was removed and water mist re-applied to achieve a consistent film of ice.

The safety sleeves tracked smoothly during the up and down function test without removing the thin film ice. All safety sleeves drop tested, with the 282 lb steel cylinder test weight in a straight static drop test, functioned as designed on both the

3/8" 1x7 and 7x19 wire rope. The test team opted to use the 282 lb steel test weight instead of the 310 pound test torso to prevent any potential damage to the test torso rubber coating due to the extreme cold.

The thin film ice test is not currently included within the ANSI/ASSP Z359 testing criteria and we recommend that SEMC incorporate this test protocol.

The "Transition 10° Angle to Vertical Climb Test (Zero/negative)" (Transition Test) was trialed during the October test event but could not be fully vetted/tested due to limited number of safety sleeves. This was rectified during the February test event as we fully tested the safety sleeves performance on both the 3/8" 1x7 and 7x19 wire rope. The original test plan was modified by positioning the torso 45° to the wire and pressing against the wire rope as opposed to lying centered on the wire. Based on video evidence, while reviewing in slow motion, it became apparent that when the torso was lying on the wire rope, the safety sleeve could get trapped underneath the torso harness and D-Ring attachment. While in this configuration the torso would essentially trap and push the safety sleeve down the wire rope without allowing the safety sleeve to properly engage.

Therefore the test procedure was changed to drop the torso at a 45° angle while pressing/leaning on the wire rope with the safety sleeve and carabineer racked. This prevented the safety sleeve and carabineer from being trapped under the torso harness and D-ring but allowed the safety sleeve to be 90° out of alignment. The sleeve and carabineer distance was minimal (less than 1") from the wire rope as opposed to the standard ANSI/ASSE Z359 drop test of 4".

> *Note: This test was similar to the ANSI/ASSP Z359.16 Angle test, but did not utilize a traditional ladder but rather a step peg climbing facility that is indicative of a wire rope safety climb system that is used at the transition zone of a self-supporting tower (see fig. AC-TZ1).*

In this configuration when the torso was dropped the results where more consistent. The video showed the torso riding on the side of the wire rope for a very short distance before deflecting off to the side. At that point the sleeve and carabineer would get in alignment and the safety sleeve would lock up.

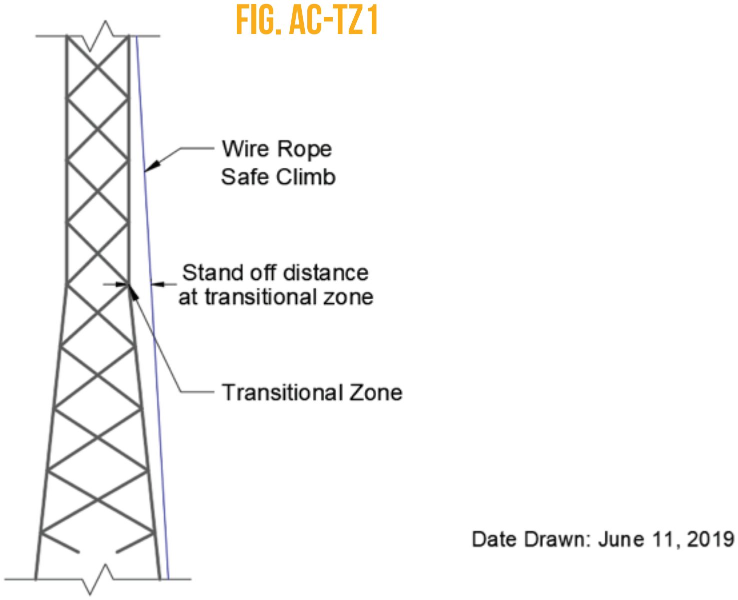
Testing in this altered methodology yielded consistent results however this scenario needs further testing and evaluation as the torso and safety sleeve placement/ alignment was critical and potentially problematic during our limited testing in the original configuration.

The "Ascending/Descending Climber Test" was performed on a vertical climb to provide dynamic motion during the drop test. The torso was raised and/or lowered at the same rate of 0.35 ft. /sec, which was the lift speed of the overhead crane, and the drop was performed while the sleeve was ascending or descending the wire rope. The torso total travel distance, up or down the wire rope, was approximately 19" for each test. This test was performed on both 3/8 "1x7 and 7x19 wire rope under tension.

Measurements were not taken as this was a Pass/Fail only test with overall sleeve travel less than 12" total as verified by video. In this test, all of the sleeves functioned and deployed with both 3/8" 1x7 and 7x19 galvanized wire rope. We recommend that

LAYBACK LATTICE TOWER TRANSITIONAL SECTION

FIG. AC-TZ1



SEMC adopt this as a test protocol with a set travel speed and maximum travel distance for this test.

"Ascending-Rocking Climber in Motion Test" was performed to mimic the dynamic motion of a tower climber while ascending. This test was developed during the October Testing Event and was further refined during the January testing event. Only four sleeves, connected to a 3/8" 7x19 wire rope, were tested. All sleeves functioned properly during the test. This was also a Pass/Fail test with no measurement taken during the drops however video results indicated that each drop was less than 12". This test incorporated a gently rocking motion of the test weight torso while it was being raised and then released.

This test has the potential to verify the true performance of the sleeves being utilized in the telecommunications industry but needs further refinement by the SEMC to set speed parameters for the ascending/descending rate with an acceptable rocking motion rate that can be duplicated by other research and test facilities (slight variations are not important as each climber ascends, descends and moves differently while climbing). This test is not currently required per ANSI/ASSP Z359 nor any European or Canadian standards. We recommend that SEMC further develop and refine this test to ensure that we replicate "real use" conditions.

Using an anthropomorphic manikin for the tests added a more realistic dynamic to the drop tests. It is recommended that the SEMC incorporate a 310 pound anthropomorphic manikin for dynamic drop testing instead of the standard 282 pound steel cylinder.

The "Transition 10° Angle to Vertical Climb Test (Zero/negative)" did have one sleeve damaged as a result of the drop test done during the October Testing. This sleeve was bent during a drop test when the carabiner racked sideways and caused physical damage to the sleeve. After reviewing the drop videos, it was noted that this style sleeve and carabiner combination does not use a captive pin in the carabiner, thus the carabiner was able to rack sideways, and the carabiner gate caused damage to the sleeve.

Testing completed included limited compatibility testing of some of the most popular and commercially available sleeves. Testing was performed on 3/8" 7x19 and 1x7 wire rope of mixed material and manufacturers. Although more testing and data is necessary, preliminary results indicate that sleeves tested generally performed better on 3/8" 7x19 wire rope, regardless of tensions, and then they did on 3/8" 1x7 wire rope that wasn't properly tensioned. However, the main takeaway is that regardless of wire rope type (3/8" 7x19 or 1x7) is that all wire rope should be properly tensioned prior to use with a safety sleeve.

Testing included the reuse of safety sleeves that had been previously tested deployed/impacted to determine the feasibility of reuse during emergency situations such as a climber rescue and retrieval. The results of the tests showed that the fully impacted sleeves (with and without energy absorbers) and wire rope safety climb systems can potentially be reutilized for climber rescue and retrieval if deemed safe by the Competent Rescuer. Ultimately additional testing, with a larger sample size of sleeves and wire rope, is needed to fully authenticate the results of this limited test event. Ultimately, in order to replicate real life conditions, it is recommended that utilizing deployed/impacted sleeves and wire rope for climber rescue and retrieval be included in the SEMC testing protocol.

During testing a drop was performed on an older model safety sleeve, taken out of use/service, which was specifically designed to be used only on 3/8" 7x19 wire rope. It was tested on 3/8" 7x19 wire rope and performed well however, when tested on a properly tensioned 3/8" 1x7 wire rope it failed to function. SEMC advises that it is critical for the competent person on site to determine safety sleeve compatibility based on manufacturers literature/instructions and wire rope size, construction and tension.

During testing all damage incurred to the wire rope and safety sleeves was thoroughly documented/photographed. While testing it became apparent that the damage inflicted to the wire rope, by the safety sleeves, was noticeable and could be significant enough to justify replacement of the wire rope after a fall event pending a thorough inspection. Significant not in terms of structural damage or loss of integrity but that the use of a safety sleeve, where the drop occurred, may prove difficult for a climber ascending/descending past the point the wire rope may be kinked/damaged. Pictures of the damaged safety climb included in this document should be utilized for informational/educational purposes only.

We want to emphasize that all wire rope safety climbs and components (bottom and top assemblies, hardware, etc.) utilized during testing operated and functioned per the manufacturers design.

Upon completion of testing, pull tests, of the impacted wire rope safety climbs, were performed to determine if there was loss of strength due to damage inflicted by the safety sleeves. See Appendix B for pull test results completed by Tri State Wire Rope. All pull tests conducted on the 3/8" 7x19 galvanized and 3/8" 1x7 wire rope passed.

CONCLUSIONS

The Nate Safety Sleeve Testing consisted of one hundred ten (110) different drop tests, over ninety-three (93) safety sleeves and fifteen (15) wire rope safety climbs for an estimated retail cost of approximately forty-seven thousand dollars ($47,000). This estimate excludes the time and travel expenses of all the volunteers who worked tirelessly to help the telecommunications industry to become safer and smarter while removing some myths on how the safety climb systems and safety sleeves function and operate. The test results confirmed that the existing ANSI/ASSP Z359 standard testing protocol is not robust enough, in terms of simulating real life conditions on antenna supporting structures, and that additional testing criteria should be considered going forward.

It is important to note that while conducting tests in accordance with ANSI/ASSP Z359 standards all safety sleeves performed within the expected parameters. This includes the simulated drop tests with both the lighter 165 pound (Rescue Randy/manikin) and heavier 310 pound (torso) weights. However, without question, when we went outside to the normal testing criteria the test manikin and the torso added another layer of complexity to the dynamic drop tests that a steel round cylinder weight simply cannot duplicate or impose upon the wire rope safety climb system during testing. Based on actual tests performed we were surprised that there was very little difference between the lighter and heavier test weights. Ultimately it is our opinion a three hundred ten pounds (310 pound) anthropomorphic manikin, in lieu of a two hundred and eighty-two-pound (282 pound) steel round cylinder, should be utilized for testing purposes for the ANSI/ASSP Z359 qualification testing as it adds a more complex and realistic dynamic to the drop.

Test results also indicates that all wire rope safety climbs perform better when properly tensioned however when tension was in a slack condition (i.e. not properly tensioned) the 3/8″ 7x19 wire rope performed substantially better than 3/8″ 1x7 wire rope. The 3/8″ 1x7 wire rope systems needs to be tensioned in accordance with the manufacturer's recommendation to adequately and positively deploy the safety sleeve as designed. Inadequate tension on a 3/8″ wire rope safety climb has the potential to result in the manufacturer's safety sleeve not deploying properly during a fall. In our opinion additional vetting/tests may be necessary to confirm this observation since the overall drop testing was relatively small and could have influenced the results.

Based on preliminary test results wire rope tension is important and we recommend that the SEMC group establish guidelines for the minimum required tension, if possible, required for all wire rope safety climbs based on safety sleeve performance. Assuming consensus is established we recommend adding this information to the next revision of ANSI/ASSP A10.48. This information would help enhance the competent climber's ability to properly assess and inspect the wire rope safety climb prior to using as PPE.

During testing we learned that some common practices within the tower community should be stopped immediately. Such as leaving unsecured safety sleeves on the wire rope at heights (safety sleeve can slide down the wire rope if left unattended/ unsecured) and utilizing without proper tension and or securing the bottom assembly of the wire rope safety climb. We also learned that confirming that the safety sleeve is compatible with the wire rope is critical as there are multiple units designed for use on other diameter wire ropes (i.e. 8mm, 5/16", 3/8" 7x19, etc). Per ANSI/TIA-222-H all wire rope safety climbs for antenna supporting structures shall be 3/8" diameter.

Based on the results of the Corrosion Test (class 1 and 2) we believe that more testing is warranted and necessary on 3/8" 1x7 galvanized wire rope. We believe this will help replicate site conditions in areas prone to salt spray or excessive bird droppings.

Testing indicated that the safety sleeve performance and function can be negatively impacted when the manikin/torso falls in such a way that the safety sleeve gets trapped under the safety harness and against the wire rope safety climb. However, while this failure occurred during the Transition Angle Vertical Climb test with the torso laying on the wire rope we learned that by simply changing the angle of the torso, so as not to have the torso harness trap the safety sleeve or lay on the wire rope, greatly improved its performance. This test should be further developed because how a person falls shouldn't make a difference to the functionality of the safety sleeve.

For a comprehensive and exhaustive list of all tests performed on the safety sleeves and wire rope safety climbs please see the section labeled Testing and Results below.

Finally, we want to extend a special thank you to the staff at UDRI for helping to facilitate this event along with the manufacturers who helped by supplying components, their time and support throughout this event. Lastly, we want to thank NATE: The Communications Infrastructure Contractors Association because without their support and guidance the NATE Safety Sleeve Testing event would have never occurred. Because of NATE's leadership and foresight we were able to hold such a ground breaking testing event to improve telecommunications tower technician safety throughout the telecommunications industry.

TESTING AND RESULTS

TESTS PERFORMED – OCTOBER TESTING EVENT

TEST SET UP

Test Facility: University of Dayton Research Institute, 300 College Park, Dayton, Ohio 45469 - 0101 under the direction of Mr. Jordan Speers, UDRI Facility Manager

Date of tests: October 2, 3, 4 2018

Temperature: Ambient temperature at floor level was 73°

Test Tower Set-Up: The tower section used was a New 3 leg self-supporting 20' tower section supplied by Sabre Industries and built per drawings supplied by Sabre Industries with 20' ladder sections installed on two faces and an angle climb ladder installed at 10°. Note: the 15° angle climb was attempted but the radical angle was thought to be un-realistic to actual field conditions and was lowered to 10° to facilitate better bolting method of the ladder section to the test tower section.

Safe Climbs Installed and Tested: The tower was outfitted with multiple manufacturers 3/8" diameter galvanized wire rope safety climbs for the test. These new safety climbs where supplied and installed as per manufacturers specifications with the manufacturer verifying the install and wire rope tension as follows:

1. TUF-TUG 3/8" 7x19 wire rope safety climb installed on the #2 tower leg
2. TUF-TUG 3/8" 7x19 wire rope safety climb installed on the 10 degree angle ladder
3. TUF-TUG 3/8" 7x19 wire rope safety climb Installed on the #2 tower face ladder
4. 3M Lad Saf 3/8" 1x7 wire rope safety climb installed on the #1 tower leg
5. Trylon 3/8" 7x19 wire rope safety climb installed on the #1 tower face ladder.

Used safety climbs field removed from service and re-installed as per manufacturer's specifications for Environmental Tests:

1. Used DBI SALA 3/8" 1x7 wire rope safety climb on the #2 Tower Face (Bird Dropping Test)
2. Used TUF-TUG 3/8" 7x19 wire rope safety climb on the #2 Tower Leg (Class 3 corrosion test)

Tension in the safety climbs were verified with a Dillion Tension Gauge set for 3/8" cable.

Note: The test event was NOT designed to test the entire safety climb, but rather the performance of the safety sleeve. However the safety climb system test results were compared and recorded during this event.

Test Weight A & B:

A. 165 pound anthropomorphic manikin (Rescue Randy) plus 10 pound Buckingham Harness weight - low weight test of 175 pound. Rescue Randy - used a Buckingham Linesman Y Harness with Sternal D-Ring and stretch when raised was 8" for first lift and testing stretch of harness from center of chest to bottom of D-Ring at the carabineer. An 8' sling safety strap was utilized to protect the test weight from hitting the laboratory steel deck floor.

B. 310 lb Torso with a Buckingham Lineman's Harness - ANSI/ASSP Z359 test weight Buckingham Lineman Y Harness with Sternal ring stretch was approximately 9 1/2" measured from center of chest to bottom of D-Ring where it hits the carabineer during lift at rest. An 8' sling safety strap was utilized to protect the test weight from hitting the laboratory steel deck floor.

Note: Buckingham Lineman's Harnesses where used since they did not have impact indicators and had both dorsal and sternal steel heavy duty D-Rings for all tests completed on Oct 2&3. Other harnesses where used on Oct 4 for additional tests, but had to be replaced and adjusted often during the testing due to deployment and stretch.

SAFETY SLEEVES TESTED:

1. Skylotec Claw Vertical Fall Arrest Sleeve **(Skylotec Claw)**
2. 3M DBI Lad-Saf X3 Detachable Cable Sleeve **(DBI Lad-Saf X3)**
3. Miller VGCS Vi-Go Auto Pass-Through Cable Safety Sleeve **(VGCS Vi-Go)**
4. TUF-TUG 3/8" Cable Safety Sleeve TTWG-500 **(TUF-TUG)**
5. Trylon Cougar Safety Climb System **(Cougar)**
6. Yoke N623 Cable Safety Sleeve with Carabineer **(Yoke N263)** - (same as GME Supply branded RG-5000 and Elk River 19401)

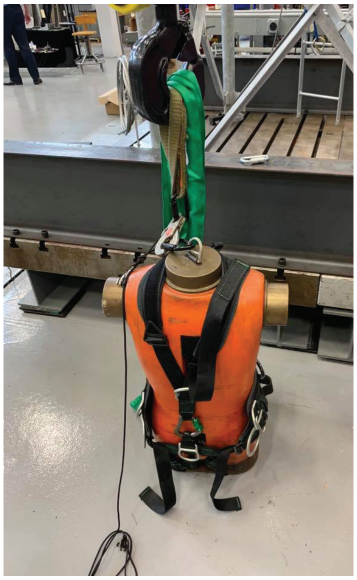
The above safety sleeves were supplied by the manufacturers in a new unused condition except the Miller VGCS Vi-Go Auto Pass-Through Cable Safety Sleeve was purchased new off the shelf from a distributor by NATE members.

All Drop tests were done using the same quick release mechanism supplied by UDRI and released from the Dorsal D-Ring. Testing objectives were to measure sleeve movement down the wire rope from starting point to end of drop at rest and measurements were recorded in Inches. The maximum sleeve travel during the test was limited to the sling safety strap travel distance and is noted in the tests as "Caught by Safety". Control Test Measurements were taken prior to starting Dynamic Test with sleeve connected to the Test Weight Harness to measure stretch and proper alignment.

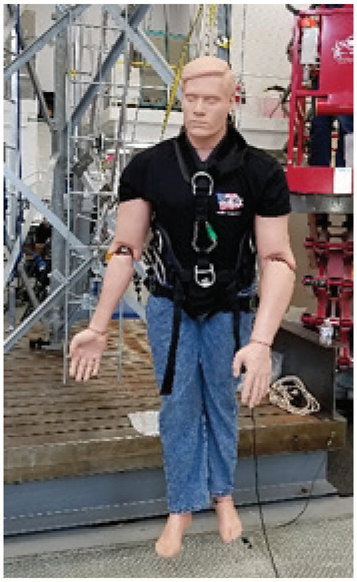
53 official drop tests with an additional 5-6 drops of the torso and 1 additional with Randy - close to 60 drop tests. The Buckingham Harness was used for all drops on

Tuesday and Wednesday 310 torso - a DBI Sala was used on Wednesday and performed 9 drops before it came apart, and a Skylotec harness was used for 4 drops before strap deployments necessitated replacement. *NOTE: The testing did not directly test harness performance, but both the DBI and Skylotec Climber Harnesses performed as per manufacturer's statements.*

University of Dayton Research Institute - Smart Lab



Test Weight B



Test Weight A

20' Tower Section

SECTION 1

DYNAMIC TESTING:

This testing will also allow the SEMC Group to develop further testing criteria to be used in future more extensive safety sleeve and safety climb system testing. See Appendix-A

SYSTEM FUNCTION TEST WITH SAFETY SLEEVE

CLIMB TEST - Automatic up and down Basic function test - Pass/Fail

• *No weight - Climb function performed by Cody Jones, from LMS*

Grading System Scale 1 to 10
1 not working - 5 some hang ups - 10 works smoothly up and down

SLEEVE	GRADE
1. Skylotec Claw	8
2. DBI Lad-Saf X3	10
3. VGCS Vi-Go	10
4. TUF-TUG	10
5. Cougar	10
6. YOKE 263	10

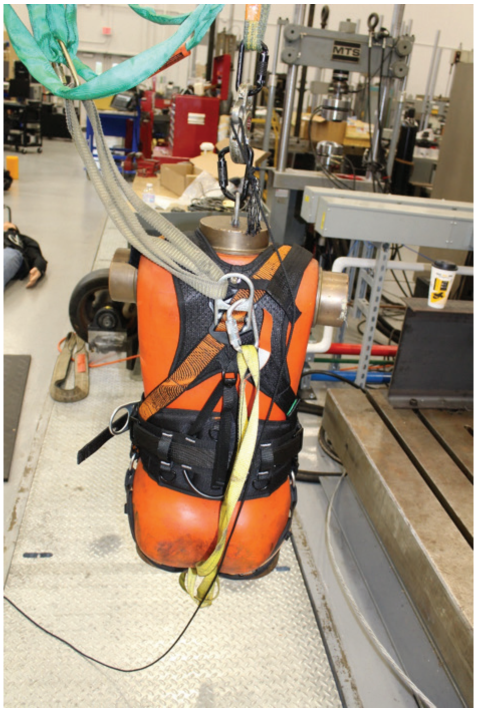
The results showed that the sleeves tested all passed the basic function test on the three new safety climbs tested with both 3/8" 1x7 wire rope and 3/8" 7x19 galvanized wire rope.

Note: Skylotec identified a manufacturer inconsistency during this initial testing that has since been corrected in later production units.

DYNAMIC DROP TEST - measured in inches

A. 175 pound Soft Mass (165 pound anthropomorphic Rescue Randy manikin plus 10 pound Buckingham Harness weight - low weight test) was dropped from the dorsal D-Ring and was positioned so that the manikin was at its highest before sleeve travel and positioned approximately 9-12" from the wire rope depending upon sleeve and carabineer design limitations. The harness stretch at rest was approximately 8-9" for each sleeve manufacturer and was within tolerance as the harness had to be adjusted each time it was lowered to the ground and was measured from the center of the chest to the top of the dorsal D-Ring.

B. 310 pound Torso was dropped from the dorsal D-Ring and was positioned so that the torso was at its highest before sleeve travel and positioned approximately 9-12" from the wire rope depending upon sleeve and carabineer design limitations. The harness



Test Weight B with
Sling Safety Strap

Climber Ready for
Function Testing

stretch was also measured and was consistently 8 1/2"-9" for each sleeve tested and was measured from the center of the chest to the top of the dorsal D-Ring.

DYNAMIC TESTS PERFORMED:

- TUF-TUG Safety Climb System Full Tension - 3/8" galvanized 7x19 wire rope installation on ladder with wire tensioned to manufacturer's specification (200 pound) with test weight A and measurements in inches from start of fall to stop of sleeve travel and held for 1 minute.

	A Manikin Wire Rope Tension with Sleeve on System - Tension Tight (i.e. 200 lb)
Skylotec Claw	1 1/16"
DBI Lad-Saf X3	2 3/4"
VGCS Vi-Go	1"
TUF-TUG	9/16"
Cougar	1/32"
YOKE 263	1/8"

The test results indicated that for the 3/8" galvanized 7x19 wire rope tension to manufacturer's specifications all of the tested sleeves performed as per manufacturer's statements and within acceptable industry limits. The VGCS Vi-Go sleeve did have

Sample Dynamic Test Drop
with Weight ASling Safety Strap

a partial deployment of the internal energy absorber. The Skylotec Claw attached external energy absorber shock pack also partially deployed.

The TUF-TUG System assembly had no damage and the 3/8" 7x19 wire rope did have some rough spots from the sleeves, but the damage to the wire was minimal and would not require replacement.

- **TUF-TUG Safety Climb System Slack Tension -** 3/8" 7x19 wire rope installation on ladder with wire tensioned to slack (1%) with test weight A and measurements in inches from start of fall to stop of sleeve travel and held for 1 minute

	A Manikin - Wire Rope Tension with Sleeve on System - Zero Tension 1% Slack
Skylotec Claw	8 1/4"
DBI Lad-Saf X3	5 1/4"
VGCS Vi-Go	3/4"
TUF-TUG	7/8"
Cougar	1/2"
YOKE 263	1/2"

Dynamic Drop Test - Weight A - 1% Slack Test

The sleeves tested all had some deterioration of performance with a slack wire situation. The results indicate that more testing of this scenario is required, but preliminary tests indicate that a lack of tension may have an impact on sleeve performance. The DBI Lad-Saf X3 did do some damage to the wire rope, but the VGCS Vi-Go did enough damage to the wire rope that it may impact future sleeve functionality in that area of the wire rope. The Skylotec Claw external energy absorber shock pack did partially deploy and the VGCS Vi-Go sleeve partially deployed the internal energy absorber.

- **Shake Test** - Wire rope shaken for 10 seconds to see if an un-attended sleeve would travel down the wire rope due to the wire rope safety climb system vibration or oscillation. There were three separate tests completed. Test #1 completed on the Trylon safety climb system with 3/8" 7x19 wire rope tensioned to manufacturers specification (220 pounds). Test #2 completed on a 3M 3/8" 1x7 system tensioned to 420 pounds as per manufacturer. Test #3 was also completed on the same 3M 1x7 system but tension lowered to 340 pounds as verified by the Dillon Tension Gauge.

	Wire Shake Test - Trylon 7x19 System at Tension as per Manufacturer (220 lb)	Wire Shake Test - 3 M System at Tension as per Manufacturer (420 lb)	Wire Shake Test - 3 M System at Tension Lowered (340 lb)
Skylotec Claw	33"	6 1/4"	4 3/8"
DBI Lad-Saf X3	7/8"	5/8"	1 /16"
VGCS Vi-Go	62 1/2"	23 1/8"	11"
TUF-TUG	5/8"	1 3/4"	1/8"
Cougar	28 1/16"	8"	3 5/8"
YOKE 263	12 1/2"	5 3/4"	3 3/4"

The results from this test prove that tower climbers who leave the safety sleeve un-supported may come back to find their sleeve has dropped to the bottom of the tower. This test shows that sleeves need to be secured at all times when left attached to the safety climb system. Some sleeves travel more than others, but from the limited testing completed during this event, the results reflect that it is not a best

Shake Test Example - Safety Sleeve Un-Supported on the 7x19 Wire Rope

practice to leave the sleeve unsecure on the safety climb system when working at heights.

- **3M Safety Climb System Full Tension A -** 3/8" 1x7 wire rope installation on tower leg with wire tensioned to manufacturer's recommended tension (420 pounds as measured with a Dillon Tension Gauge) with test weight A and measurements in inches from start of fall to stop of sleeve travel and held for 1 minute.

	A Torso 3M System Tensioned to Manufacture Spec 1x7 New Galvanized Wire
Skylotec Claw	3/16"
DBI Lad-Saf X3	3 1/16"
VGCS Vi-Go	2"
TUF-TUG	7/8"
Cougar	1/16"
YOKE 263	3/8"

Test Weight A Dynamic Drop Test - 3M Safety Climb System 1x7 Wire Rope

The test results showed that all of the sleeves tested performed as design and were within the 4" drop criteria initially established in Appendix A - "Discussion Points". The 1x7 wire did have some damage from all sleeves, but was most noticeable from the VGCS Vi-Go sleeve which left a permanent indent to the 1x7 wire rope. The Skylotec Claw shock pack started to deploy and the VGCS Vi-Go sleeve energy absorber partially deployed with the A test weight.

The 3M safety climb system was also re-checked and there was no head damage or deformation from any of the drops. The wire rope remained fully tensioned and functional during the entire test.

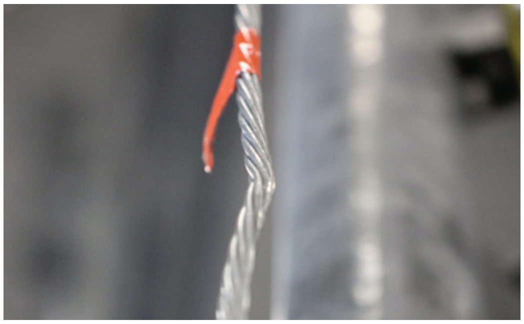
- **3M Safety Climb System Full Tension B** - 3/8" 1x7 wire rope installation on tower leg with wire tensioned to manufacturer's recommended tension (420 pounds as measured with a Dillon Tension Gauge) with test weight B and measurements in inches from start of fall to stop of sleeve travel and held for 1 minute

	B Torso 3M System Tensioned to Manufacture Spec 1x7 New Galvanized Wire
Skylotec Claw	2 3/8"
DBI Lad-Saf X3	3 1/8"
VGCS Vi-Go	6 5/8"
TUF-TUG	2 1/8"
Cougar	1/8"
YOKE 263	5 1/2"

The B test weight definitely changed the dynamics of the test drop as the added weight did have a direct correlation to the sleeve function and damage to the 1x7 wire rope. The sleeves all did function, but two sleeves, the YOKE 263 and the VGCS Vi-Go did not stop within the original test criteria established in Appendix A -"Discussion Points". The DBI Lad-Saf X3 sleeve did permanent damage to the 1x7 wire rope with 1/2" kink in the rope. The VGCS Vi-Go sleeve also did permanent damage to the 1x7 wire rope where the sleeve traveled down the wire. Both of these areas would impact future sleeve function and would necessitate replacement of the wire rope.

The DBI Lad-Saf X3 internal energy absorber did fully deploy as did the VGCS Vi-Go sleeve internal energy absorber. The Skylotec Claw external energy absorber shock pack did deploy but not fully. The TUF-TUG, YOKE 263, and Cougar sleeves had no damage or deformation from the drop test.

The 3M safety climb system was also re-checked and there was no head damage or head deformation from any of the drops and the wire rope remained tensioned and functional during the entire test. The base assembly also appeared to be fully functional. This was after six drops with test weight A and six drops with test weight B. The top assembly was checked with a micrometer and the measurement variance was within the error limits of the micrometer (variance of less than +/-.003").



3/8" 1x7 Galvanized 3M System Wire Rope Damage from Test Weight B Drop

- **Repeat of the B weight Drop test** on the 3M 3/8" 1x7 galvanized system with the impacted sleeves - this test was conducted to see if a impacted sleeve could be still utilized by the climber for self-rescue. The test was limited to only the three sleeves that had impacted and deployed internal or external energy absorber systems.

	Repeat on 3M system with deployed sleeves
Skylotec Claw	6"
DBI Lad-Saf X3	6"
VGCS Vi-Go	18"
TUF-TUG	N/A
Cougar	N/A
YOKE 263	N/A

The test results show that the impacted sleeve can be used for self-rescue, but the sleeve travel distance if a second fall occurs could be greater. The second impact of the Skylotec Claw showed no apparent damage to the sleeve, but the external energy absorber shock pack did fully deploy, and was not recommended for further testing. The second impact of the DBI Lad-Saf X3 did do significantly more damage to the 1x7 galvanized wire rope, but the sleeve functioned even though the internal energy absorber system was previously fully deployed. The second impact with the VGCS Vi-Go sleeve caused internal damage to the sleeve and considerable damage to the wire rope and was difficult to remove from the wire rope. This scenario requires further testing and analysis.

Dynamic Drop with 3M Lad Saf X3 Safety Sleeve and Test Weight B on
3M 1x7 Wire Rope Safety Climb System - Side Load on Carabineer After Drop

- **Trylon Safety Climb System Test** – the Trylon Safety Climb 3/8" 7x19 wire rope system was tested as a system, and not for compatibility as the previous tests. This was due to the limitation of manufacturer's sleeves available for further testing. If we would have had more manufacturer's sleeves available we would have more data available for the SEMC.

	A Torso Trylon System 7x19 Wire Rope to Manufacturer Tension	B Torso Trylon System First Drop	B Torso Trylon System 2nd Drop - Slack Wire Rope
Skylotec Claw	N/A	N/A	N/A
DBI Lad-Saf X3	N/A	N/A	N/A
VGCS Vi-Go	N/A	N/A	N/A
TUF-TUG	N/A	N/A	N/A
Cougar	0"	1/8"	1/8"
YOKE 263	N/A	N/A	N/A

3M Safety Climb System with 1x7 Wire Rope Damage After 15 Drop Tests

The main purpose of the test was to see how impact effects the deformation of the top assembly of the Trylon safety climb system so that climbers assessing the Trylon systems in the field can make a field judgement if the Trylon assembly requires replacement from the impact of a fall or other damage. The results indicate that a minor impact does not cause any permanent deformation. When Test Weight A was dropped, the assembly deflected 3/8" (from 90°) and when the weight was removed it went back to normal with no permanent deformation. When test weight B was dropped on the system using the Trylon Cougar sleeve, the top assembly had a visible permanent deflection of 6 1/2" from 90° as designed by the manufacturer. The wire rope was also very slack with zero tension. The Trylon system was then subjected to a second drop of Test weight B without re-tensioning to simulate a self-rescue and subsequent fall. The Trylon system did not fail but did permanently deform to 83 1/2° - 11 1/4" from 90°. A third drop of Test weight B (1/8" sleeve travel same as previous two drops) was then performed on the system. The head deflected downward with a permanent deflection of 108° but did not fail. No other drops were performed on the system after the third 310 pound drop.

The test concludes that a Trylon system deformed from a fall can be utilized if deemed safe for a self-rescue or for other tower climbers to assist in rescue. Again the system needs to be visually inspected and deemed safe for the emergency situation.

For routine maintenance, any permanent deflection of the top assembly qualifies for replacement prior to use. Lack of wire rope tension in the system could also be an indicator of head deformation from a previous fall or misuse. An inspection of the head would be required before re-tensioning.

Trylon Safety Climb System - installed on the left side of the tower face after the 3rd Drop Test

Trylon Safety Climb System after 3rd Test Weight B Drop Test

- **Lateral Angle Climb Test 10°** – this test was conducted using a TUF-TUG 3/8" 7x19 wire rope safety climb attached to a ladder positioned at a ten degree angle on the tower section. Test weight B was used for this test.

	B Torso - Angle Allowable Lateral Climb (Right +10°) - Drop Test
Skylotec Claw	5 1/2"
DBI Lad-Saf X3	8 1/2"
VGCS Vi-Go	N/A
TUF-TUG	10 1/4"
Cougar	3/4"
YOKE 263	3/8"

This test was to simulate the angle climb on some self-supporting structures. The test concludes that this test procedure is valid and should be included in the SEMC testing protocol. The VGCS Vi-Go sleeve was not tested as we had no undamaged sleeves to test. The testing did provide some valuable feedback that the safety climb system does work in this situation and the sleeves do function in the forward angle climb but performance is affected. This is not a normal drop test in the ANSI/ASSP Z359 testing requirements but is tested in European Standards at fifteen° instead of the 10° tested during this event.

Test Weight B was used for this test, and it is recommended that the SEMC conduct more testing with an anthropomorphic manikin to further define and refine this testing procedure. The dynamics of utilizing the anthropomorphic manikin may change some of the results experienced during this testing event.

10° Lateral Climb Test -
Ladder and Safety Climb System Set Up

- **Transition 10° Angle to Vertical Climb Test** - This test was formulated to test the scenario when a climber climbs a layback tower and approaches the transition zone to the straight section of the tower indicative of many self-supporting structures in the telecommunications industry as well as the electric utility industry. The test procedure utilized a TUF-TUG 3/8" 7x19 galvanized system with the bottom wire rope attached onto the test table floor away from the tower with 150 pounds of

10° Lateral Climb Sample Test Drop in Motion

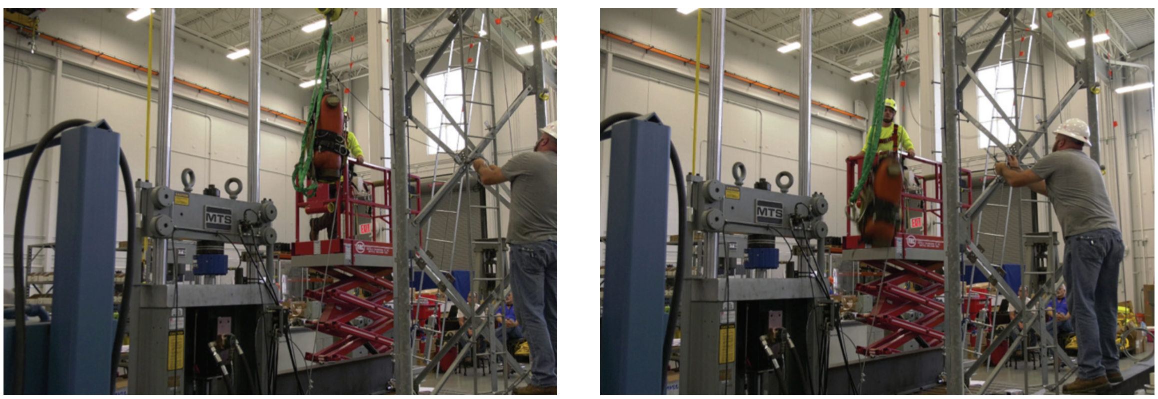
tension and test weight B laying on the wire rope creating a ten degree angle below the B weight torso and 5° above the B weight torso. This would be indicative of the transition zone a climber would encounter as he travels from the layback section to the straight section of the tower. (See Figure ZT1). The sleeve was attached to the test weight harness and the sleeve was pointed to the side of the wire rope since the weight was physically on the wire rope.

	B Torso - Distance to Climber (Zero/negative) Maximum Distance Out of Plane through Transition
Skylotec Claw	31 1/16"
DBI Lad-Saf X3	6 13/16"
VGCS Vi-Go	N/A
TUF-TUG	7 3/8"
Cougar	1/16"
YOKE 263	*43 3/8"

* = Caught by Safety

The testing concluded that definitely more testing is required, but did prove that this test procedure needs to be included in the SEMC protocol. The tests showed that the sleeve performance in this scenario is affected for some manufacturers since the sleeve and the carabineer are not in line. One sleeve, the YOKE 263, was physically damaged by the carabineer racking causing side load and bending the sleeve where the carabineer attaches to the sleeve. The test weight with the YOKE 263 was caught by the safety strap. The Torso traveled down the wire rope prior to the Skylotec Claw shock absorber fully deploying. The Skylotec Claw shock pack deployed and the DBI Lad-Saf X3 internal arrestor also fully deployed. It should be noted that carabineer side/gate loading was evident during more than one dynamic drop during the test event. The side loading of the carabineer and how it impacts the performance of the sleeve also needs further testing.

It should be noted that the YOKE 263, TUF-TUG, and Cougar were used without a captive eye pin in the carabineer. The Skylotec Claw and the VGCS Vi-Go had attached swivel carabineer, and the DBI Lad-Saf X3 had a carabineer with a captive eye pin.



Transition 10° Angle to Vertical Climb Test - Set Up and Release of Test Weight B

YOKE 263 Damaged Sleeve after Transition 10° Angle to Vertical Climb Test

SECTION 2

MAINTENANCE TESTING:

Test set up was the same as for Section 2 Dynamic Tests with the same tower section and ladder attachments. This testing was done October 4, without the manufacturers present to observe.

ENVIRONMENTAL CONDITIONING

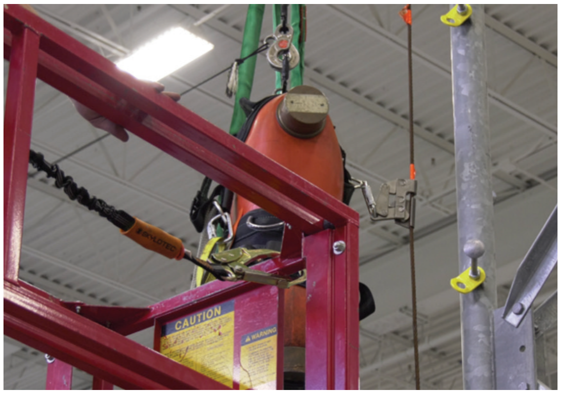
- No testing was done as the UDRI facility is not set up for freezing temperature testing and does not have an adequate water collection system to allow the water/ rain tests.
- The participants believe that the 1/4" of ice is not indicative of a real climber situation since the 3/8" wire rope can be cleared of ice by shaking.
- The participants feel that the thin film ice would be more indicative of a real world scenario when a tower climber is already on the tower and experiences an ice fog or freezing rain. This would be a good test, but UDRI could only do this during certain times of the year outside in the parking lot of the facility when the ambient temperature is below 32°.
- Standard ANSI/ASSP Z359 Environmental tests where not performed due to limited test time and availability of enough manufacturers sleeves for testing
- The standard ANSI/ASSP Z359 tests are already part of the existing manufacturers testing protocol so it would have been a duplication of already known industry data
- The dirt and grime test was emitted since the bird dropping wire closely imitates that same condition and is being captured in that test event
  - Paint on the wire rope was not tested either as we did not have a good field removed example to test

MAINTENANCE/TAG OUT EVENTS

The wire rope tested was field removed from service (tag out). The Class 3 Corrosion wire rope was a TUF-TUG system utilizing 3/8" 7x19 galvanized wire rope. The Bird Dropping wire rope also came from the coast, but was removed from a tower that was a sea gull roosting site. This wire rope was on an older DBI SALA 3/8" 1x7 galvanized system.

This testing was also limited due to the limited manufacturer's sleeves available, but the feedback gained will help the industry.

- Corrosion Test (Class 3) – wire tested was a field removed Tuf-Tug system with 3/8" 7x19 wire rope that was field removed from South Texas near the Gulf Coast and provided by SBA. The wire was tested with the original TUF-TUG top assembly and was tensioned to 200 pound with a new TUF-TUG base assembly. Both a function test and drop test were performed.



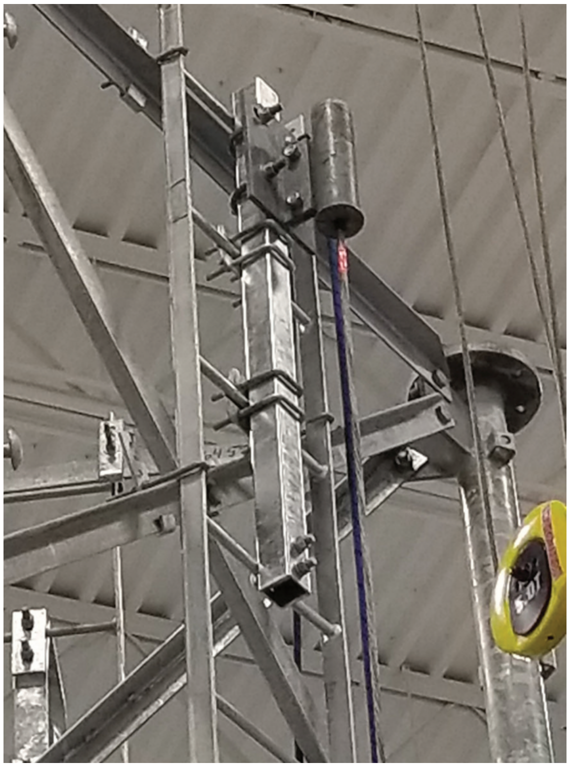
3/8" 7x19 Class 3 Corrosion Wire Rope Test

	Corrosion (Class 3) - Function Test 7x19 System 200 lb Tension	Corrosion (Class 3) - Drop Test 7x19 System 200 lb Tension
Skylotec Claw	4	1/16"
DBI Lad-Saf X3	N/A	N/A
VGCS Vi-Go	N/A	N/A
TUF-TUG	7	3/8"
Cougar	2	0
YOKE 263	N/A	N/A

Only three manufacturer's sleeves were tested for this condition. Functionality of some of the sleeves was dramatically impacted. The Cougar had some difficulty traveling up, but was more noticeable in the downward travel where it was hard to climb down smooth. The Skylotec Claw traveled up with only a little hang-up issues, but did have some hang-ups traveling down. The TUF-TUG sleeve did have some resistance going up and going down, but did function.

The drop tests concluded that 3/8" 7x19 wire rope in this condition does not create a problem for the sleeve lock up during a fall event.

• **Bird Dropping Wire Test** – A field removed old style DBI SALA safety climb system was installed on the tower section on a ladder. The 3/8" 1x7 galvanized wire was exposed to years of bird droppings, but no visible signs of corrosion were present. The top assembly was checked for previous deployment or damage prior to installing. The system was tensioned to 760 pound (manufacturer's specification 750 pound +/-10%) as verified by a Dillion Tension Gauge. Both a function test and drop test were performed.



Used DBI SALA 1x7 Wire Rope Safety Climb –
Bird Dropping Wire Rope Test

Used CABLOC PROTECTA 3/8" Safety Sleeve for 7x19 Wire Rope Only

	Bird Dropping - Function Test DBI System 750 lb Tension 1x7 Wire	Bird Dropping - Drop Test Tension 750 lb DBI System 1x7 Wire
Skylotec Claw	N/A	N/A
DBI Lad-Saf X3	N/A	N/A
VGCS Vi-Go	N/A	N/A
TUF-TUG	7	1"
Cougar	7	1/16"
YOKE 263	N/A	N/A
USED CABLOC Protecta 3/8" 7x19 Only	10* too easy	Caught by Safety

Only two manufacturer's sleeves were originally tested for this condition, the Cougar and the TUF-TUG. Both sleeves passed the functionality test with limited hang ups traveling up and down. Both sleeves also performed well during the drop test. The sleeve travel during a fall is actually reduced from the friction caused by the grit in the bird droppings.

An additional sleeve was tested. This sleeve was a used sleeve that had previously been in service. The CABLOC Protecta sleeve was clearly identified and marked for use on 7x19 wire rope. The functionality of the sleeve was extremely easy and when the drop test on the 3/8" 1x7 wire rope was performed, the test weight safety deployed as the sleeve totally failed to stop the fall and was caught by the safety strap. This sleeve should never be used on a 1x7 system.

> *Note: This same CABLOC Protecta 3/8" 7x19 sleeve was then used on the 10° Forward Angle 7x19 wire rope system test ladder and did deploy with a 1 15/16" travel.*

The DBI SALA top assembly was monitored after each drop. After a total of 4 drops there was no apparent movement of the strand vise tail from the original position.

SECTION 3

ADDITIONAL TESTS PERFORMED

Test set up was the same as section 2 dynamic tests with the same tower section and ladder attachments. This testing was done October 4.

ADDITIONAL TESTS:

The below tests were conducted without the manufacturers present. The below tests were conducted to further the safety of the industry and gain knowledge for the SEMC.

- **Wire Rope Bottom Free Test** with a 3/8" 1x7 Safety Climb - for this test the existing DBI SALA Bird Dropping base assembly was disconnected and the bottom of the wire rope was allowed to swing freely. This work practice was observed previously in the field during new construction of self-supporting and monopole towers.

	B Torso - 1x7 Wire Rope Tension with Sleeve on System - Bottom Free Hanging
Skylotec Claw	N/A
DBI Lad-Saf X3 **	*
VGCS Vi-Go	N/A
TUF-TUG	4"
Cougar	*
YOKE 263	N/A

*Caught by safety
**previously impacted

Three sleeve manufacturers' sleeves were tested and two failed to deploy before the test weight safety stopped the fall of over 44". This limited test is enough to prove that safety climbs with 3/8" 1x7 wire rope should never be utilized unless the base assembly is secure and there is tension in the wire rope. This situation would not be recommended for emergency rescue.

- **Wire Rope Bottom Free Test with a 3/8" 7x19 TUF-TUG Safety Climb** - wire rope base assembly was disconnected and the bottom of the wire rope was allowed to swing freely. This work practice was observed previously in the field during new construction of self-supporting and monopole towers.

	B Torso - 7x 19 Wire Rope Tension with Sleeve on System - Bottom Free Hanging * - Drop test
Skylotec Claw	N/A
DBI Lad-Saf X3**	*21 1/2"
VGCS Vi-Go**	*19 1/8"
TUF-TUG	1 5/8"
Cougar	3/4"
YOKE 263	N/A

*Caught by safety
**previously impacted

Four sleeves were utilized for this test, with the VGCS Vi-Go and the DBI Lad-Saf X3 failing to fully stop the weight before the test weight safety strap deployed, however both of these sleeves had previously impacted internal arrestors from earlier tests. The Cougar and the TUF-TUG sleeves did deploy as designed, but the reaction to the test weight torso was extremely violent and the test weight banged and bounced repeatedly on the tower section steel. This limited test is enough to prove that safety climb systems with 3/8" 7x19 wire rope should never be utilized unless the base assembly is secured and tensioned. In emergency situations the safety climb system could be used for tower rescue if the bottom was secured such as the case in an impacted system utilizing 3/8" 7x19 wire rope.

Note: The safety strap was shortened from 44" for this test to limit potential damage to the test facility

- **Simulated Climber Test** – This test was formulated to emulate a tower climbing ascending and descending the tower. The test weight B Torso was raised by the overhead crane and was gently rocked back and forth to create a slight shoulder rotation of the test weight torso. As the torso was rotating and ascending with the safety sleeve attached the quick release was deployed. This test was performed on a TUF-TUG Safety Climb 3/8" 7x19 system tensioned to 200 pound as per manufacturer's specifications. (See Fig. SC1)

The test was repeated with the test weight descending and slight shoulder rotation with similar results for both sleeves tested.

The test was also duplicated with a used DBI SALA 3/8" 1x7 wire rope safety climb tensioned to 750 lb. This was by far the most creative testing, but closely emulates the motion and how the safety sleeve interacts with the wire rope and the climber.

	Simulated Climber Rotating Torso - TUF-TUG System 7x19 Wire 200 lb Tension Ascending & Descending	Simulated Climber Rotating Torso - DBI 1x7 Wire 750 lb Tension
Skylotec Claw	N/A	N/A
DBI Lad-Saf X3	N/A	N/A
VGCS Vi-Go	*NR	N/A
TUF-TUG	4"	*44 3/16
Cougar	4"	*48"
YOKE 263	N/A	N/A

*Caught by safety

The tests indicate that this test procedure is valid for our industry, but needs more refinement and automation of the rotating torso weight to get a consistent slight rocking motion during the raising of the torso before the quick release is activated. It was also evident that you cannot get this same effect with a steel cylinder weight. It must be a torso or manikin to get the full effect and results in the test.

The 7x19 wire rope performed significantly different in this test than from the straight drop or fall back test. The racking of the sleeve and carabineer connections cause the sleeve to lock up slower and thus resulting in more travel of the safety sleeve. The TUF-TUG and Cougar sleeves tested did perform well, but drastically more travel than the straight drop test.

The results of both tests indicate that we need to do more testing and study of this motion effect with the safety sleeve manufacturers and the SEMC.

Note: NR The VGCS Vi-Go sleeve was a previously impacted sleeve used for the Ascending and Descending 7x19 wire test and the drop measurements were not recorded, but the weight was caught by the safety strap in the Ascending test, but did deploy within 24 inches for the Descending test.*

Sample of Safety Sleeves Utilized During October Testing Event

TESTS PERFORMED

FEBRUARY TESTING EVENT

TEST SET UP

Test Facility: University of Dayton Research Institute, 300 College Park, Dayton, Ohio 45469 - 0101 under the direction of Mr. Jordan Speers, UDRI Facility Manager

Date of tests: February 20-21, 2019

Temperature: Ambient temperature at floor level was 73°

Test Tower Set-Up: The tower section used was a new narrow 3 leg self-supporting 20' tower section supplied by Valmont. The tower was bolted to the steel test deck inside of the UDRI facility.

Safety Climb Systems Installed and Tested: The tower was outfitted with multiple manufacturers 3/8" diameter wire rope safety climbs for the test. These new systems where supplied and installed as per manufacturers specifications with the manufacturer verifying the install and wire rope tension as follows:

1. TUF-TUG 3/8" 7x19 wire rope safety climb installed on tower face #1
2. TUF-TUG 3/8" 7x19 wire rope safety climb installed on Tower Leg (Face #1 & Face #2)
3. 3M Lad Saf 3/8" 1x7 wire rope safety climb installed on the Tower Leg (Face #2 & Face #3)

The three wire rope safety climbs where installed to allow the maximum number of test, and for the location of the videographer. The overhead shop crane was used for all test weight lifts, and the steel test deck allowed for the tower section to be unbolted and rotated for each test set up.

Tension in the wire rope safety climbs were verified with a Straightpoint Tension Meter - Model COLT5TU - serial number 30299 - calibration date: 8/30/2018. The tension gauge was set for 3/8" cable.

> *Note: The test event was NOT designed to test the entire safety climb system, but rather the performance of the safety sleeve on 1x7 and 7x19 3/8" galvanized wire rope.*

Straightpoint Tension Meter - Model COLT5TU - Serial Number 30299

Test Tower Set Up for Part II Tests

TEST WEIGHT:

310 lb Torso with a Buckingham Lineman's Harness - ANSI/ASSP Z359 test weight Buckingham Lineman Y Harness with Sternal ring. An 8' sling safety strap was utilized to protect the test weight from hitting the laboratory steel deck floor. The Sweeney Quick Release device with a pin safety and pull rope deployment was used to facilitate all drops. The Sweeney Quick Release worked flawlessly for all drops.

Note: Buckingham Lineman's Harnesses where used since they did not have impact indicators and had both dorsal and sternal steel heavy duty D-Rings for the initial drops. The harness was checked and retightened when necessary after each drop. A Skylotec Wind Harness was used for the drops on February 21 and performed very well with minimal stretch and no damage from multiple drops

SAFETY SLEEVES TESTED:

1. Skylotec Claw Vertical Fall Arrest Sleeve **(Skylotec Claw)**
2. 3M DBI Lad-Saf X2 Detachable Cable Sleeve **(DBI Lad-Saf X2)**
3. 3M DBI Lad-Saf X3 Detachable Cable Sleeve **(DBI Lad-Saf X3)**
4. Miller VGCS Vi-Go Auto Pass-Through Cable Safety Sleeve **(Vcgs-Sc)**
5. TUF-TUG 3/8" Cable Safety Sleeve TTWG-500 **(TUF-TUG)**
6. Trylon Cougar Safety Climb System **(Cougar)**

The safety sleeves (page 40) were supplied by the manufacturers in a new unused condition except the Miller VGCS Vi-Go Auto Pass-Through Cable Safety Sleeve was purchased new off the shelf from a distributor by NATE members.

All Drop tests were done using the Sweeney quick release mechanism supplied by UDRI and released from the D-ring mounted on the neck (top) of the Torso. Testing objectives were to measure sleeve movement down the wire rope from starting point to end of drop at rest and measurements were recorded in Inches. The maximum sleeve travel during the test was limited to the sling safety strap travel distance and is noted in the tests as "Caught by Safety".

The Buckingham Harness was used for all drops on Wednesday February 20, 2019 and a Skylotec harness was used for the drops on Thursday February 21, 2019. The Skylotec Harness, once adjusted, stayed tight and there was no apparent damage to the harness as a result of the drops. The shock indicator strip did deploy on the first drop, but did not affect the overall performance of the harness during the rest of the drops.

CORROSION TEST

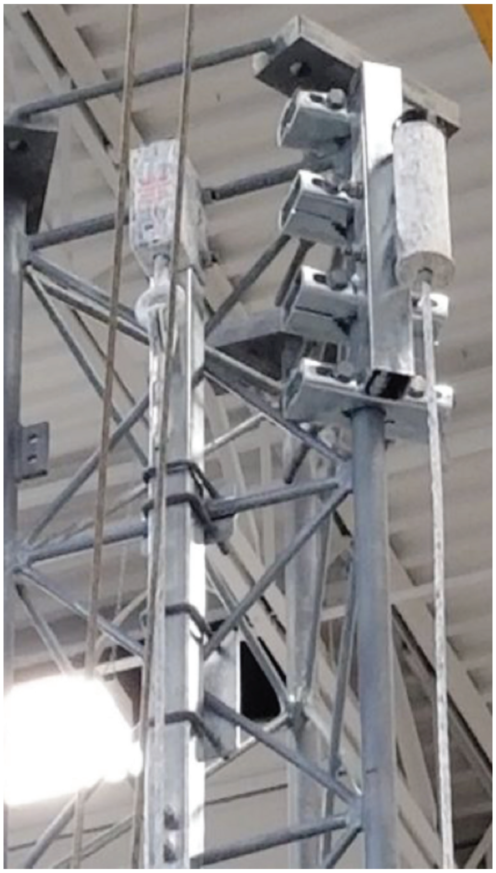
Salt Spray Test - Corrosion Class 1&2

This test was performed on 30' of 1x7 galvanized 3/8" wire rope and a DBI Sala top assembly, and 30' of 7x19 galvanized 3/8" wire rope with a TUF-TUG top assembly.

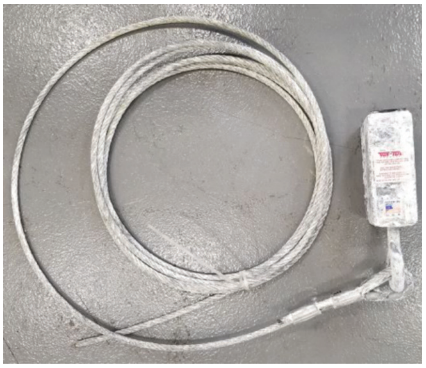
The components were tested in accordance with ASTM Standard B117 and ISO Standard 9227 using a Q-Fog CCT1100 Cyclic Corrosion Chamber for a period of 168 hours.

Date of tests: February 20, 2019

Test Tower Set-Up: The 1x7 galvanized DBI Sala system was installed on the tower leg and the 7x19 galvanized TUF-TUG system was installed on the tower face. Tension was set at 240 pounds for the 7x19 system and 325-330 pound for the 1x7 system. Tension was checked after each drop and the tension was re-adjusted if required within +/-2%. The test drops were measured and recorded in inches.



168 Hour Salt Spray Test - Tower Set Up



1x7 DBI Sala and 7x19 Tuf-Tug Wire Rope - 168 Hour Salt Spray

168 HOUR SALT SPRAY – CORROSION CLASS 1/2 SLEEVE FUNCTION TEST:

Function test performed by Justin Ligoncain, SBA Health and Safety Technician, while climbing the 20' on the test tower.

Grading system scale 1 to 10 - 1 not working - 5 some hang ups - 10 works smoothly up and down

Although this test was very subjective, it was a very good basis for how the sleeve travels on a corroded wire rope. The other finding by the team was that the wire rope had a powdery residue and similar characteristics to the Bird Dropping wire test performed in October. Both the 1x7 and the 7x19 wire rope had a good salt powdery residue remaining and installation on the tower and both had a slight red rust patina on the wire, once the white salt powder was removed.

The 168 Hour Salt Spray Function test was only performed on the 7x19 wire rope safety climb. The initial function test was the Skylotec sleeve, which had functionality issues with the amount of salt build up that was coming off of the wire rope. The first sleeve removed the excess powdered salt built up on the wire rope which caused issues with sleeve function. The Skylotec sleeve function test was re-done after the TUF-TUG sleeve and performed much better.

Salt Spray 168 Hour Test - Function Test

Sleeve	Function rating Scale
Skylotec Claw	8-UP, 6-DOWN
3M DBI Lad-Saf X3	9-UP, 9-DOWN
3M DBI LAD-Saf X2	9-UP, 5-DOWN
Trylon Cougar	4-UP, 1-DOWN
TUF-TUG TTWG-500	9-UP, 9-DOWN
M/H - Vgcs-Sc	9-UP, 9-DOWN

Function Test Performed by Justin Ligoncain, SBA Health and Safety Technician

168 HOUR SALT SPRAY – CORROSION CLASS 1/2 SLEEVE STATIC DROP TEST:

The 168 Hour Salt Spray drop tests were done utilizing the 310 pound torso with the safety strap. Both the 1x7 and the 7x19 wire rope safety climbs where used for this drop test. Tension was checked and adjusted after each drop to the initial criteria +/-2%. The salt spray test wire rope looked and felt very similar to the extreme Bird Dropping wire rope tested in NATE Safety Sleeve Test Event 1, October 2018. The sleeve performance was also very similar.

NOTE: 1x7 redo with the Trylon and Miller - new sleeves were used for the redo tests. The first Miller test was caught by the safety strap and the Energy Absorber did deploy, the second sleeve did deploy and stopped at 6 1/2" of travel.

Both Trylon sleeves were caught by the safety strap on the 1x7 wire rope.

Salt Spray 168 Hour - Dynamic Test

Sleeve	Drop #1 7x19 Galvanized	Drop #2 1x7 Galvanized	1X7 Galvanized Redo
Skylotec Claw	1 3/16	5/8	X
3M DBI Lad-Saf X3	4 1/4	2 7/8	X
3M DBI LAD-Saf X2	1 1/2	4 1/2	X
Trylon Cougar	1/4	* 80 3/8	* 80
TUF-TUG TTWG-500	1 13/16	2 5/8	X
M/H - Vgcs-Sc	5 3/8	* 72 7/8	6 1/2

*Caught by safety

CORROSION CLASS 2 TESTS

CORROSION CLASS 2 FUNCTION TEST:

Date of tests: February 20, 2019

Test Tower Set-Up: The class 2 corrosion 7x19 wire rope was installed on a TUF-TUG system and was installed on the tower face. Tension was set at 220 lb for the 7x19 system. Tension was checked after each drop and the tension was re-adjusted if required within +/-2%. The test drops were measured and recorded in inches. The 30 feet of 7x19 wire rope was a section from a field removed safe climb system, and a new eye and top assembly installed at the TUF-TUG factory.

CORROSION CLASS 1/2 SLEEVE FUNCTION TEST:

Function test performed by Justin Ligoncain, SBA Health and Safety Technician, while climbing the 20' on the test tower.

Grading system scale 1 to 10 - 1 not working - 5 some hang ups - 10 works smoothly up and down

Although this test was very subjective, it was a very good basis for how the sleeve travels on a corroded class 2 wire rope.

Corrosion Class 2 7x19 Wire Rope Safety Climb

Corrosion Class 2 Function Test

TEST	Function rating Scale
Skylotec Claw	8-up, 8-down
3M DBI Lad-Saf X3	9-up, 9-down
3M DBI X2	9-up, 6-down
Trylon Cougar	**1-up, 0-down
TUF-TUG TTWG-500	6-up, 9-down
M/H - Vgcs-Sc	9-up, 9-down

** Trylon Cougar did not function at all on way down, had to hold open to descend

CORROSION CLASS 2 DYNAMIC DROP TEST:

The Corrosion Class 2 drop tests were done utilizing the 310 lb torso with the safety strap. Only the 7x19 wire rope safety climb was used for this drop test since all of the participants agreed that the 1x7 wire rope Corrosion Test completed the October Test was sufficient testing. The wire rope had the classic red rust patina and surface corrosion, but did not have any significant material loss or flakey rust surface scale. Tension was checked and adjusted after each drop to the initial criteria +/-2%.

All of the drop tests were measured and all of the sleeves deployed as designed.

Corrosion Class 2 Dynamic Test

TEST	7x19 Galvanized
Skylotec Claw	5 1/8
3M DBI Lad-Saf X3	1 3/8
3M DBI X2	3 1/2
Trylon Cougar	1/4
TUF-TUG TTWG-500	1 3/8
M/H - Vgcs-Sc	3 1/2

TRANSITION 10° ANGLE TO VERTICAL CLIMB DYNAMIC TEST (ZERO/NEGATIVE)

SET UP

Date of tests: February 20-21, 2019

Test Tower Set-Up: The 20' test tower set up on the UDRI steel test deck was utilized for this test as depicted in fig Z-1. The initial set up was with a 3M top assembly on the tower leg with a 1x7 wire rope installed at a 10 degree angle to the tower. The base assembly was installed 30" from the base of the tower. The base assembly was created utilizing a 1/2" turnbuckle to make it easier to increase or decrease tension in the wire rope as necessary. The tension in the wire rope was set at 180 lb to correspond to the manufacturer (Skylotec) with the lowest tension allowed for recommended operation. The same set up was used for the 7x19 wire rope on a TUF-TUG top assembly, with the same 180 lb except the TUF-TUG safety climb was mounted on the tower face.

When the test weight torso was positioned centered resting on the wire rope, the wire rope had a 5-7 degree upper angle and 10-12 degree lower angle. This was the same set up that was tested during the October 4, 2018 UDRI Test. Tension was set and rechecked after each drop using the Straightpoint Tension Meter.

With the Torso test weight laying on the wire rope, the quick release was activated and the torso test weight was dropped, the measurement of the sleeve travel was recorded. The first three sleeves dropped did not engage and were caught by the safety strap. The test scenario was modified to have the torso turned 45° offset to the wire rope and resting against the wire rope. (See fig 1 TA-VC and Fig. 1B TA-VC). Those first three test drops were not recorded as the test scenario was modified to replicate a more realistic approach. (see note below)

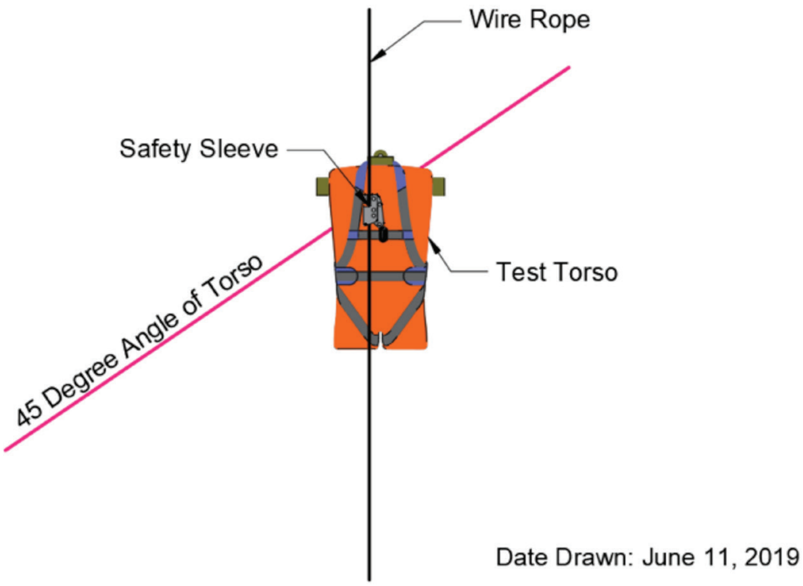
> *Note: When the test torso was positioned on the wire rope at such an angle, it rode straight down the wire rope due in part to the torso design and center of gravity. When the torso was not balanced on the wire rope, the torso would fall off to one side. This was evident in the October test videos. When the torso would fall off to one side the sleeve was less likely to be trapped under the D-ring and harness assembly.*

This still maintained that sleeve and carbineer were racked up against the test torso with the torso contacting the wire rope prior to engaging the quick release, but did not allow the test torso to be balanced and ride straight down the wire.

The dynamic test drop results for the Transition Angle Vertical Climb Test are listed below and where completed for both the 1x7 wire rope and 7x19 wire rope tests. The

TOP VIEW TRANSITION ANGLE CLIMB TEST

FIG. 1 TA-VC

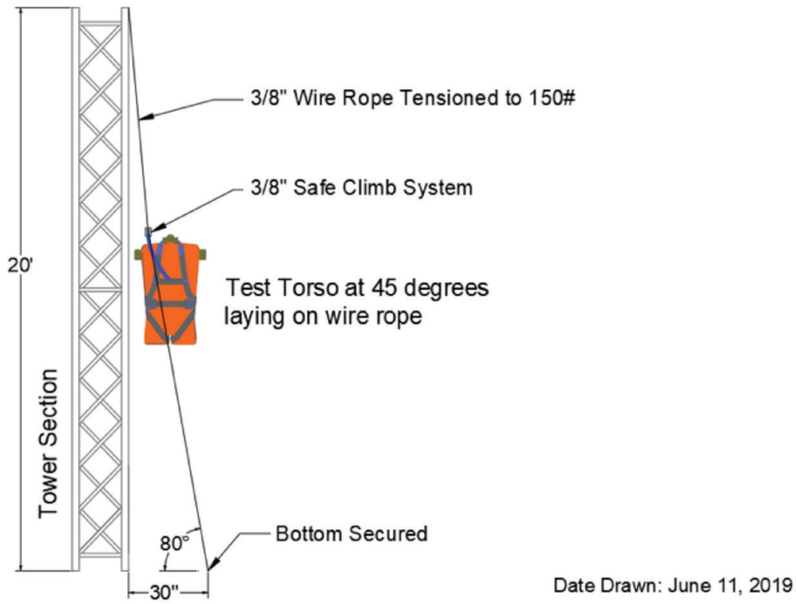


Miller Vcgs-Sc sleeve was not dropped a second time on the new 45 degree angle 1x7 Wire rope set up due to lack of available sleeves. The Skylotec Claw sleeve was not dropped on the new 45 degree angle 1x7 wire rope set up and was an oversight by the test team.

A special note: The Miller Honeywell Vgcs-Sc sleeve was caught by the safety strap during the initial set up on the 7x19 galvanized wire rope. But on the new set up on the 1x7 galvanized wire rope, the sleeve failed to deploy and the safety strap broke and the torso fell 9' hitting the steel test deck floor. The sleeve was inspected after the drop and was found to have not deployed. The torso safety strap set up was re-evaluated and a new stronger safety strap set up was utilized for the remainder of all testing at UDRI. The used M/H was then reattached to the torso and another drop test was performed with this sleeve, this sleeve again did not deploy and the energy arrestor only partially deployed after the torso bounced from being caught by the safety strap.

TRANSITION ANGLE TO VERTICAL CLIMB TEST SET UP

FIG. 1B TA-VC



Transition 10° Angle to Vertical Test Base Assembly Set Up

Transition 10° Angle to Vertical
Test Base Assembly Set Up

Tension Check Between Test Drops

Transition 10° Angle to Vertical Test - Ready for Drop

Transition 10° w/ 45° Offset Angle to Vertical Climb Test (Zero/Negative)

TEST	Drop #1 1x7 Galvanized	Drop #2 7x19 Galvanized	7x19 redo
Skylotec Claw	X+	5 1/2	x
3M DBI Lad-Saf X3	4 3/8	2 1/2	x
3M DBI X2	2 3/4	1 7/8	x
Trylon Cougar	1 5/8	3/8	x
TUF-TUG TTWG-500	2 1/2	1 3/4	x
M/H - Vgcs-Sc	X+	* 72	* 72

Note (X+): The first drop was with the Skylotec Sleeve and in oversight it was not redone with the new set up. The M/H-Vgcs-Sc was not redone due to limited sleeves available for further testing.

*Caught by Safety

ASCENDING/DESCENDING CLIMBER IN MOTION DYNAMIC TEST

Date of tests: February 21, 2019

Test Tower Set-Up: The Ascending/Descending Climber in Motion Test was conceived from the October Test Event to try to emulate how the climber and sleeve work while in a dynamic state as opposed to a straight static test drop as seen in the current ASSP/ANSI Z359 standard tests. The Ascending Test was completed with a 7x19 wire rope with a TUF-TUG head system. The tension was set at 180 pound for the 7x19 system. The Descending Test was completed with a 1x7 wire rope3M top assembly and the tension was set at 320 pound. Tension was checked and re-established after each drop +/- 2% with the same Straightpoint Tension Meter used through-out the testing event. The testing was limited to ascending on the 7x19 wire rope and descending on the 1x7 wire rope due to sleeve availability.

Sleeve travel distance during this test was estimated from the video recording for each drop and a maximum drop of 12" was established as a pass/fail rate. The torso travel distance was approximately 19" for each Ascending and Descending drop test. The travel speed was controlled by the maximum speed of the UDR1 overhead shop crane during lifting and lowering the torso. The ascent and descent speed of the overhead crane hook was consistent for both up and down travel and was measured to be 0.35ft/sec.

The torso was approximately 4" from the wire rope during the ascending or descending travel and once the torso traveled approximately 19" (the length of 1 tower section x brace), the Sweeney quick release was deployed. (See Fig SC1)

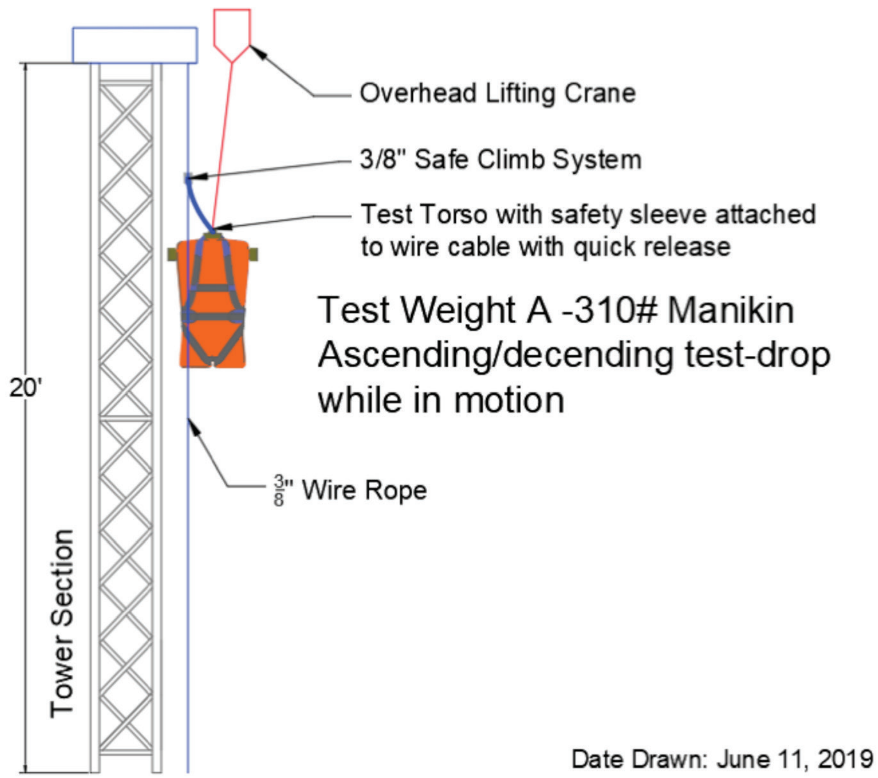
> *Note: The test team felt that this rate (21'/min) was indicative of a slow climber but was still valid. More testing should be done to validate an average tower climber ascending and descending climb rates as the team feels that these rates may be different and faster than the testing concluded with this test event.*

Ascending/Descending Climber in Motion Test

0.35 ft./sec TEST	Ascending 7x19 Galvanized	Descending 1x7 Galvanized
Skylotec Claw	pass	pass
3M DBI Lad-Saf X3	pass	pass
3M DBI X2	pass	pass
Trylon Cougar	pass	pass
TUF-TUG TTWG-500	pass	pass
M/H - Vgcs-Sc	pass	pass

SIMULATED CLIMBER TEST SET UP

FIG. SC1



ASCENDING CLIMBER ROCKING MOTION DYNAMIC TEST

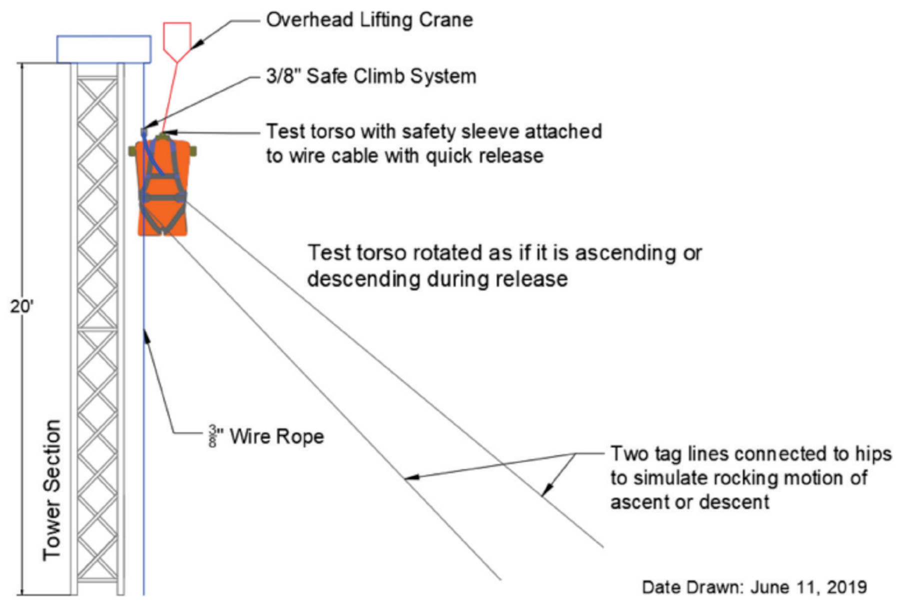
Date of tests: February 21, 2019

Test Tower Set-Up: The Ascending Climber Rocking Motion Test was also conceived from the October Test Event to try to emulate the climber movement from step peg to step peg and how this affects the performance of the safety sleeve. This test was completed with a 7x19 galvanized. Wire rope with a TUF-TUG head system. The tension was set at 180 pound for the 7x19 system. Tension was not rechecked with a meter but was maintained at tight condition. The testing was limited to ascending on the 7x19 wire rope due to sleeve availability.

Sleeve travel distance during this test was estimated from the video recording for each drop and a maximum drop of 12" was established as a pass/fail rate. The torso travel distance was approximately 19" for each Ascending drop test. The travel speed was controlled by the maximum speed of the UDRI overhead shop crane during lifting and

SIMULATED CLIMBER IN MOTION TEST SET UP

FIG. SC2



lowering the torso. The ascent and descent speed of the overhead crane hook was consistent for both up and down travel and was measured to be 0.35ft/sec.

The torso was approximately 4" from the wire rope during the ascending travel and 30' tag lines were tied to each side ring of the torso harness. A team member was on each tag line and gently pulled on the tag line to gently rock the torso back and forth. The torso was then raised with the overhead crane and once the torso traveled approximately 19" (the length of 1 tower section x brace) and maintaining a gentle rocking motion, the Sweeney quick release was deployed. (See Fig SC2)

> *Note: This test does need more refinement, but it is a very realistic test for how the safety sleeves perform in actual field conditions.*

Ascending-Rocking Climber in Motion Test
Ascending Rate Speed: _ 0.35 _ ft./sec
Twisting Motion Back and Forth While Ascending

TEST	Drop #1 7x19 Galvanized
Skylotec Claw	Pass
3M DBI Lad-Saf X3	X
3M DBI X2	Pass
Trylon Cougar	X
TUF-TUG TTWG-500	Pass
M/H - Vgcs-Sc	Pass

ADDITIONAL TEST:

UNSUPPORTED BOTTOM WIRE ROPE STATIC TEST

Date of tests: February 21, 2019

Test Tower Set-Up: The Unsupported Bottom Wire Rope Test was conceived from the October Test Event and the team wanted to test more sleeves to see the effect with a 1x7 wire rope with a 3M head system. The base assembly was removed and the 1x7 wire rope was left unsupported at the bottom for these test drops.

Unsupported Bottom Wire Rope

TEST	Drop #1 1x7 Galvanized
Skylotec Claw	X
3M DBI Lad-Saf X3	X
3M DBI X2	X
Trylon Cougar	X
TUF-TUG TTWG-500	Passed
M/H - Vgcs-Sc	* caught by safety strap

This test was done on a Tuf-Tug sleeve and the last Miller Vgcs-Sc Sleeve. The Miller Vgcs-Sc was not available during the October test of this condition. The sleeve failed to deploy and actually flattened out the wire rope and came off of the wire. The torso was caught by the safety strap. The sleeve had visible damage and was bent, but energy arrestor did fully deploy.

The Thin Film Ice Tests where originally scheduled to be done in the February Test Event, but due to warm weather and rain, the test had to be postponed until the weather cooperated. This test event had to be held outdoors since the test facility was too warm inside to emulate the thin film icing condition of a tower. We were able to assemble enough team members and the safety sleeve manufacturers who participated, submitted more sleeves for the tests. The weather at the UDRI facility that day was perfect for the testing and testing started at sunrise to try to get the immediate effect of the icing condition when the wire rope was sprayed with water.

THIN FILM ICE DYNAMIC TEST

SET UP

Test Facility: University of Dayton Research Institute, 300 College Park, Dayton, Ohio 45469 - 0101 under the direction of Mr. Jordan Speers, UDRI Facility Manager

Date of tests: March 6, 2019

Temperature: Ambient temperature at Ground level was 11° F with slight wind and dry.

Time: 7:00 a.m. start at morning twilight and all testing was completed prior to 9:00 a.m. before the sun angle got above 30°.

Test Tower Set-Up: The tower section used was a new 3 leg self-support 30' tower section supplied by Sabre Industries and built per drawings supplied by Sabre Industries with 20' ladder section installed on the North face. The tower was set up and anchored to the concrete pad in the parking area at the UDRI facility. The top of the test tower had a rope and sheave block rigging and a 1000 lb Capstan winch was utilized to raise and lower the test weight on the tower. (Note: Since this test was outdoors, we could not utilize the overhead crane for lifting)

Safety Climb Systems Installed and Tested: The tower was outfitted with a 3/8" 7x19 wire rope TUF-TUG Safety Climb system, and a 3M 3/8" 1x7 wire rope systems for the test. These new systems where supplied and installed as per manufacturers specifications to the 20' ladder section. Tension was set by the base assembly spring compression measurement, but was not field verified with a Tension Meter. The tower and safety climb systems where installed the day before and stayed outdoors overnight in 10 degree F dry weather.

Test Weight: ANSI/ASSP Z359 test weight - 282 pound steel cylinder utilizing the Sweeney Quick Release device. Note: The steel cylinder weight was used instead of the 310 pound Torso due to the cold weather and fear of damage to the rubber outside coating on the test torso since it was rented.

Test Criteria: This test was similar to ANSI/ASSP Z359.16 drop test requirements with the exception that the ice build-up was limited to less than 1/8" ice build to emulate a thin film of ice on the wire rope.

SAFETY SLEEVES TESTED:

1. Skylotec Claw Vertical Fall Arrest Sleeve **(Skylotec Claw)**

2. 3M DBI Lad-Saf X3 Detachable Cable Sleeve **(DBI Lad-Saf X3)**

3. 3M DBI Lad-Saf X2 Detachable Cable Sleeve **(DBI Lad-Saf X2)**

4. TUF-TUG 3/8" Cable Safety Sleeve TTWG-500 **(TUF-TUG)**

5. Trylon Cougar Safety Climb System **(Cougar)**

6. Miller VGCS Vi-Go Auto Pass-Through Cable Safety Sleeve **(Vcgs-Sc)**

The above safety sleeves were supplied by the manufacturers in a new unused condition except the Miller Vcgs-Sc Vi-Go Auto Pass-Through Cable Safety Sleeve was purchased new off the shelf from a distributor by NATE members.

All Drop tests were done using the same quick release mechanism supplied by UDRI and released from a carbineer connected to the eyebolt on top of the steel test weight.

The wire rope was sprayed with a fine mist of water and care was taken not to get more than a thin film, less than 1/8" radial ice build-up on the wire rope. A limited Sleeve Function Tested was performed for each sleeve functioned properly with no noticeable change due to the thin film of ice on the wire rope. This was strictly an up and down test over a small distance. Ice build-up and frozen drips where removed before each drop and the wire rope was inspected and re-sprayed with water on areas as required before the next drop. The ambient air temperature starting at first light prior to the sun hitting the tower proved beneficial to getting the water spray to freeze almost instantly to the wire rope. This water spray procedure was done for both the 1x7 and 7x9 wire rope safety climbs tested.

Testing objectives were to measure sleeve movement down the wire rope from starting point to end of drop at rest and measurements were recorded in Inches. The 12 drop tests were completed during the two hour test session, with all sleeves and results recorded below. All sleeves passed the test.

Thin Film Ice Test-Function Test

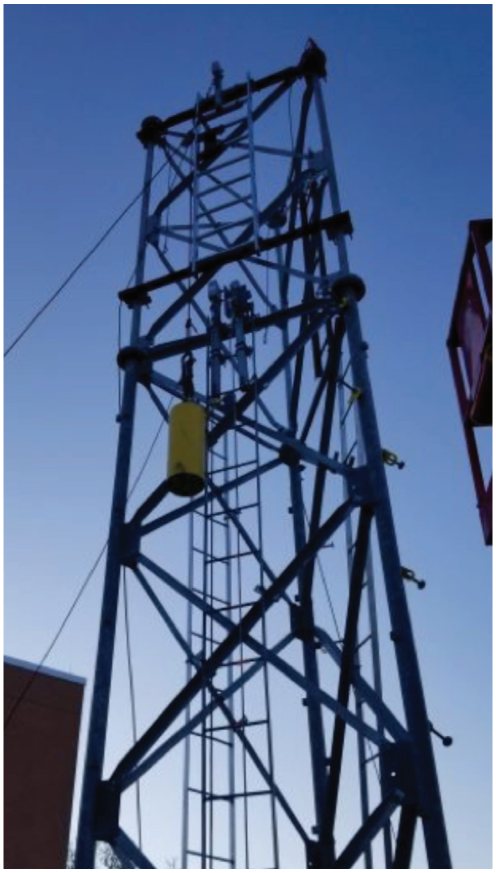
SLEEVE	Function Rating
Skylotec Claw	9
3M DBI Lad-Saf X3	9
3M DBI Lad-Saf X2	9
Trylon Cougar	9
TUF-TUG TTWG-500	9
M/H - Vgcs-Sc	9

Thin Film Ice Test-Drop Test

SLEEVE	Drop #1 - 7x19 Wire Rope	Drop #2 - 1x7 Wire Rope
Skylotec Claw	2 3/4	5 3/8
3M DBI Lad-Saf X3	4 5/8	3/4
3M DBI Lad-Saf X2	2 7/8	3 7/8
Trylon Cougar	3/8	1
TUF-TUG TTWG-500	3	5 3/4
M/H - Vgcs-Sc	7 3/8	7

282 Pound Steel Test Cylinder with the Sweeney Quick Release Mechanism

Tower and Capstan Set Up



Tower Ready for Drop

Thin Film Ice on the Wire Rope

ADDITIONAL TESTS NOT COMPLETED

The following were some tests that were proposed and could not be completed either due to UDRI facility limitations, time constraints or lack of supply of safety sleeves.

- Climber utilizing the safety sleeve as a tie off point with safety lanyard - needs a drop test
- Water Test - 30L per hour rate test
- Worn or Broken Wire Strands Test - 1x7 and 7x19 3/8" wire rope was not tested and field removed systems need to be collected
- Painted Wire Test - 1x7 and 7x19 3/8" wire rope was not tested and field removed systems need to be collected as this would have aged dry paint with dirt and grit in the wire rope strands
- Entrapment/Panic Testing (ANSI Z359.16) - testing to understand everyday situations that can create an entrapment of the safety sleeve during climbing and how to best train/warn against these situations

NATE TESTING EVENT ATTENDANCE ROSTER

Company	Attendee Name	Participant / Observer
3M	Chris Coyle	Observer
3M	Rick Miller	Observer
American Tower	Falicia Hill	Participant
American Tower	Michael Deese	Participant
American Tower	Nathan Haselden	Participant
American Tower	Sarah Rucker	Participant
Crown Castle	Allen Turcotte	Participant
Crown Castle	Kenneth Hill	Participant
Crown Castle	Richard Cullum	Participant
GME	John Lamond	Observer
NATE	John Paul Jones	Participant
Sabre Industries	Stephanie Brewer	Observer
Safety LMS	Cody Jones	Set-up/Climber
SBA	David Sams	Participant
SBA	Jeremy Buckles	SEMC rep
SBA	Justin Ligoncain	Set-up/ Climber
SBA	Nick Wilkerson	Participant
Skylotec	Douglas Mercier	Observer
Trylon	Devin Finnigan	Observer
TUF-TUG	Joey Deuer	Observer
TUF-TUG	Sheri O'Dell-Deuer	Observer
TUF-TUG	Dawn Smith	Observer
UDRI	Jordan Speers	set-up
Vertical Bridge	Michael De Boer	Participant

REFERENCES:

ANSI/ASSP A10.48-2016 Criteria for Safety Practices with the Construction, Demolition, Modification and Maintenance of Communication Structures.

ANSI/ASSP Z359.1-2016 - The Fall Protection Code

ANSI/TIA-222 Rev H Structural Standard for Antenna Supporting Structures, Antennas and Small Wind Turbine Support Structures

ANSI ASC A14.3-2008: American National Standards for Ladders - Fixed - Safety Requirements

NATE Planning Advisory Notice (PAN) -Wire Rope Safety Climb - Mar/Apr-2018 (1)

CAN/CSA Z259.2.5 "Fall Arresters and Vertical Lifelines"

ANSI/ASSP Z359.1-2016 "Fall Protection Code"

ANSI/ASSP Z359.16-2016 "Safety Requirements for Climbing Ladder Fall Arrest systems"

ANSI/ASSP Z359.11-2014 "Safety Requirements for Full Body harness"

ANSI/ASSP Z359.7-2019 "Qualification and Verification Testing of Fall Protection Products"

3M DBI-Sala Lad-Saf Vertical Safety System Installation, Maintenance and Inspection Instructions - 5908353/5908555/5908556

TUFF-TUG - Safe Climb System Installation Instructions

Miller by Honeywell User Instruction Manual I183 Rev D / 34-9720076 6 May 2013

YOKE NIAGARA N-623 Instruction User Guide / Cable Rope Grab With Eye - RG-5000 and Elk River 19401 -3/8'' Cable Grab

Final Translated Claw MAT-BA-US-0186 ChSd 20180329 - Skylotec User Instructions Claw Vertical Fall Arrester