Boxes with Prepunched Knockouts used (misused) with flexible cord: For Safety Professionals and Others

(NEC® references contained herein are from the 2014 edition unless otherwise noted)

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What are they:

Boxes with these “prepunched knockouts” as they are called are metallic boxes designed to contain electrical splices, and devices such as receptacle outlets, snap switches, etc. They are available in various standard sizes such as what is commonly referred to as a “single gang” or “handy box” which is only wide enough to contain a single electrical device such as one snap switch or one duplex receptacle outlet. There are square or double gang boxes with prepunched knockouts which are basically twice as wide as the single gang box and can contain two snap switches side by side or two duplex receptacles side by side. The boxes may also be referred to as “two gang”, “double wide”, “4 square”, or a “1900 box” (nineteen hundred box).

Handy box

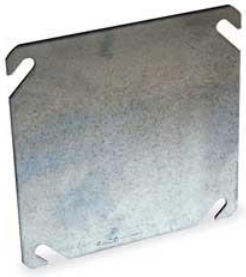
square box or 1900 box

These boxes are also available in different depths to accommodate numerous wires and splices in addition to the devices used inside them (snap switches or duplex receptacles) allowing for additional cubic inches required by NFPA70 which is the National Electrical Code (NEC®) depending on the number of conductors or wires and devices contained in the box. Also these boxes may be installed without any devices and used only as a splicing box to extend or route circuits in multiple directions. In this case it will only have a flat metal blank cover installed on it to enclose the box.

Handy box
duplex receptacle cover

handy box
snap switch cover

1900 box double duplex cover



blank cover

Their purpose:

The boxes are stamped metal or sometimes have welded corners or sides and the prepunched knockouts are stamped in the metal box to allow removal of the knockout (by knocking the slug out with a hammer) in order to run cable assemblies such as type NM/"Romex" or raceways/conduits from any side, into the box, using an appropriate box connector to connect the cable assembly or raceway to the box. The boxes can be purchased with various trade size knockouts such as ½ inch, ¾ inch, 1 inch, etc. to accommodate standard trade size fittings for the larger cable and/or various conduit sizes.

Their fundamental purpose relative to safety is to first enclose energized parts such as the terminals on devices for electrocution protection. Secondly the boxes contain any arcing or sparking of devices and or splices inside for the control of electrical fire hazards. This is one reason for insuring that any unused openings (missing knockouts) are effectively closed using listed knockout plugs. The closure of unused openings also keeps out rodents including their bodily fluids, and also environmental contaminants (dusts etc.) from entering the box and becoming a fire hazard propagating outside the enclosure. To underscore the severity of this all one has to do is examine the compelling numbers of electrical fires published annually by the National Fire Protection Agency (NFPA®).

The closure of these unused openings is required by OSHA's 29CFR 1910.303(b)(7)(i), 910.305(b)(1)(i), 1926.405(b)(1) as well as NEC® articles 110.12(A) and 314.17(A).

The listing requirements:

OSHA 1910.303(a), 1926.403(a) and the NEC® article 110.2 requires all electrical equipment to be approved/listed by an OSHA Nationally Recognized Testing Laboratory (NRTL). With perhaps one exception in my career I have never seen a box with prepunched knockouts that wasn't listed.

Examples of listed knockout plugs used to insert in box missing prepunched knockouts

Not a listed box

I suspect that the reason for this is the fact that the boxes are inexpensive, and readily available in quantity, which discourages the manufacturing of these with counterfeit UL listing labels.

The typical misuse of boxes:

At the onset let me state emphatically that boxes with prepunched knockouts cannot be used on the end of a “flexible cord”. If you don’t know if you are dealing with flexible cord as opposed to a cable assembly, you can observe and record the markings on the cord/cable in question indicating the type of flexible cord and check the markings against table 400.4 in the NEC®. NEC® Article 400 is all about flexible cords and cables and table 400.4 contains virtually every flexible cord known to humankind. In other words if it’s not in table 400.4 it’s not flexible cord and it’s probably a cable assembly which is likely to be found in Chapter 3 of the NEC® (Articles 300-399). The proper installation of cable assemblies is addressed in the respective articles contained in Chapter 3.

Let me repeat that! Boxes with prepunched knockouts are never permitted to be used on the end of a flexible cord! There are other types of boxes and devices for that purpose.


Fig. 1


Fig. 2

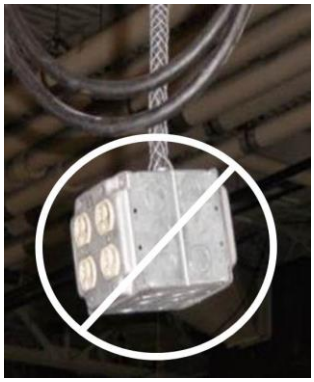


Fig. 3

These are all typical misuses of these boxes with prepunched knockouts used on the end of a flexible cord. Figures 1 & 2 show these boxes used at the end of a flexible cord in a cordset (the technical term for an extension cord). As I already stated this is not permitted and this is a violation of standards. Figure 3 shows a pendant hung outlet frequently referred to as simply “pendant” for short. The fact that all three are boxes with prepunched knockouts used at the end of a flexible cord makes all three applications violations of the electrical standards.

The excuses:

During my multi decade OSHA career, I have heard repeatedly, “we installed these boxes decades ago and they were permitted and met the codes at the time they were installed”.

Now I don’t know who allegedly permitted them to be installed, nor do I care as the “authority having jurisdiction” (AHJ). Qualified electrical workers understand perfectly the concept of AHJ. One only needs to consult the definition of AHJ in Article 100 of the NEC® as well as Article 90.4 enforcement. Article 100 definition of AHJ defines and states that the AHJ’s include “Federal, State Local or other departments” such as “Labor Department”. That’s Federal or State OSHA compliance officers and State Consultation personnel. Article 90.4 states that “the AHJ (remember we said OSHA) has the responsibility for making interpretations of the rules”, (and) “for deciding the approval of equipment and materials”. Qualified electrical workers don’t get to tell the AHJ what’s acceptable. Try that with the local electrical inspector.
The codes (NEC®) never permitted boxes with prepunched knockouts to be used on the end of a flexible cord!

The codes that apply to their installation and the usual installation errors:

NFPA 70 which is the NEC® is an “installation specification” standard as opposed to an electrical safety related work practice standard such as NFPA 70E. The NEC® specifies installation specifications for electrical hardware and equipment in order to insure the “practical safeguarding of persons and property from hazards arising from the use of electricity” [Article 90.1(A)].

Article 314 covers boxes and Article 314.23 covers the support of boxes. Article 314.23 lists 8 ways to properly support boxes ranging from surface mounting (on the surface of a wall for example) to structural mounting (as on a column, joist or beam) to mounting in finished surfaces such as recessed in a finished wall. All of these methods require the rigid securing of the box to its mounting surface. The only reference that addresses flexible cords is 314.23(H)(1) Pendant Boxes on Flexible Cord, which states that “a box shall be supported from a multiconductor cord or cable in an approved manner that protects the conductors against strain, such as a strain-relief connector threaded into a box with a hub”. Key word used here is ”hub”. A hub is not a prepunched knockout but rather a threaded inlet to the box, typical of a weatherproof box which contains threaded hubs/inlets.

Prepunched knockouts

Weatherproof box showing its threaded “hubs”

Threaded plugs are also commonly available to close unused box hubs.

While these weatherproof boxes with treaded “hubs” would be acceptable for use on the end of a flexible cord with an appropriate strain relief/box connector for the flexible cord they must still meet additional requirements including grounding because they are metallic/metal/conductive. My personal preference for flexible cord application is non-metallic (plastic/PVC) boxes or a cord connector.

The cap on these compression type fittings screws/tightens down to compress the rubber grommet against the flexible cord to secure the cord in place

Flexible cord with a compression type strain relief

cord connectors

Some history on the standard:

Some ask, why does the code say “such as” rather than “shall”? This reference to boxes mounted as pendants (on the end of flexible cords) first appeared in the 1987 NEC®. In 1987 it was codified Article 370-13(h) Pendant boxes, and the language is the same as it is today, “boxes shall be supported from a multiconductor cord or cable in an approved manner that protects the conductors against strain, such as a strain-relief connector threaded into a box with a hub”.

The “old timers” who wrote this reference crafted the code language with great consideration and were truly visionary. Had they written the language to read “shall be a hub” that would have precluded newer technological advances in the manufacturing of boxes specifically for this purpose and not allowed for the advancement of boxes to have newer features (which are NRTL listed for use on the end of a flexible cord). If such a seemingly subtle code language change (from “such as” to “shall be a hub”) were used it would have prevented the newer boxes which were since developed and currently manufactured, from being used today. Thankfully these early code writers understood the ramifications of the code language

and crafted the code language accordingly. Regrettably this foresight is often omitted in today's code proposals and language.

One such box is a rubberized box which is virtually indestructible and manufactured by Daniel Woodhead Company. It does not have a threaded hub but has a strain relief clamp that's an integral part of the box and is Underwriters Laboratory (UL) listed as acceptable for use on the end of a flexible cord. Being rubber it is nonconductive and obviously, as such does not require grounding of the box.

Rubber boxes manufactured by Daniel Woodhead company, UL listed to be used on the end of a flexible cord

Prior to the 1987 NEC® all previous editions only permitted boxes to be mounted and specifically stated "in all cases boxes shall be securely and rigidly mounted in place". In other words no boxes of any type were permitted to be used on the end of flexible cord, as pendants, etc. Only cord connectors were permitted for pendant use (use on the end of a flexible cord) by the NEC® prior to 1987.

Boxes aside for the moment, and anecdotally regarding flexible cord, it's interesting to note that the first edition of the NEC® of 1897 stated the "The use of no flexible cord will be permitted, unless specifically approved by this board." (The National Board of Fire Underwriters who were the original publishers of the NEC). The use of flexible cord expanded ever so slightly from 1899, having a couple of small paragraphs in sections 32 & 30 respectively in the 1915 and 1920 editions, with some additional requirements added in 1923 through 1935 editions where in 1937 became Chapter 4 Article 400 Flexible Cord, where it remains to this day nearly three quarters of a century later. *Now back to our regularly scheduled program…*

There is one additional type of box which is a nonmetallic (plastic/PVC) box which is used with nonmetallic raceway/conduit (PVC) but can also be used with cable assemblies, as well as flexible cord with the proper strain relief/box connector. The box has mounting tabs to allow it to be mounted/secured to a building surface if used with conduit or cable assemblies, however the mounts do not need to be used and it can be used at the end of a flexible cord.
This box (or boxes of any type such as with 'hubs) cannot be "fixed" mounted while used with flexible cord since this would be a violation of the standards of attaching flexible cord to building surfaces 1910.305(g)(1)(iv)(D), 1926.405(g)(1)(iii)(D), NEC® 400.8(4). Such an installation would also be using flexible cord "as a substitute for the fixed wiring of a structure" which is prohibited by 1910.305(g)(1)(iv)(A), 1926.405(g)(1)(iii)(A), and NEC® 400.8(1).

Since this box is PVC the strain relief/compression fitting is a PVC type which must be cemented (with PVC cement) to the box hub. In this case it's a non threaded hub because it's a PVC box, and PVC/nonmetallic raceways/conduits are typically cemented directly into to the box hub without the need for any fittings/box connectors.

Acceptable PVC box in pendant use
Box manufactured by IPEX/Scepter
contains no prepunched knockouts only hubs

strain relief connector/compression fitting showing flexible cord entry

Strain relief connector/compression fitting showing collar which would be cemented directly into the PVC box hub

So why do boxes with prepunched knockouts continue to be improperly used on the end of flexible cords? The answer is simple. Because they are inexpensive! That however is not an acceptable excuse or reason to violate the code requirements.

Now back to the standards:

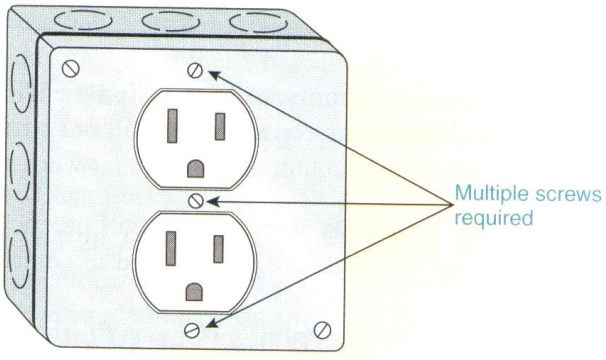
In virtually all installations where boxes with prepunched knockouts are used on the end of flexible cords there are nearly always several additional code violations of improper installation.

One common example is the strain relief/box connector used. Typically a box connector which is for type NM (nonmetallic sheathed cable) aka “Romex” is used. While this is a UL listed connector, it is only listed for use on nonmetallic sheathed cable assemblies such as Romex wire. It is not listed or approved for flexible cord. This is a violation of OSHA standards 1910.303(b)(2), 1926.403(b)(2), and NEC® Article 110.3(B) Installation and Use, which states that “listed or labeled equipment shall be installed and used in accordance with any instructions included in the listing or labeling.”

Package clearly states that these fittings/box connectors are listed only for use with Non-Met (nonmetallic) sheathed cable (romex type cable).

Romex type box connector improperly used on flexible cord and UL listing instructions and use of connector indicated on packaging

The next problem typically encountered is the mounting of the receptacles in the box. NEC® Article 406.5(C) states that “receptacles mounted to and supported by a cover shall be held rigidly against cover by **more than one screw** or shall be a device assembly or box cover listed and identified for securing by a single screw.” I have not seen one of these specially listed assemblies or covers however I suspect that this again is progressive code language that allows for the possibility of new development of products that are listed (by an NRTL) for the purpose. At this point in time we require multiple screws to mount the receptacle outlet.



Violation of Article 405.5(C)
(only one screw holding each duplex receptacle)

Last but not least and perhaps the most critical relative to safety issues is the proper grounding (equipment grounding) of the boxes. The purpose of equipment grounding is to "*prevent electrocution*".

NEC® Article 250.148(C) Metal Boxes, states that "a connection shall be made between the one or more equipment grounding conductors and a metal box by means of a grounding screw that shall be used for no other purpose, equipment listed for grounding, or a listed grounding device."

Almost universally when flexible cord is run to a metal box it is installed with its green equipment grounding conductor connected directly to the receptacle only. This violates the above grounding reference.

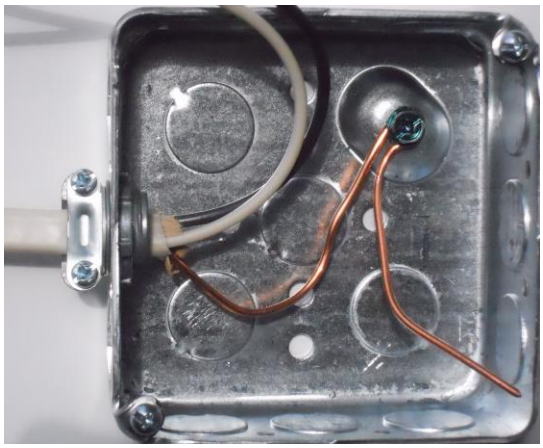
There are only two recognized and listed devices that can be used to correctly ground the metal box. One is the "grounding screw" that is referenced which is a listed screw with specific machine threads (3/8 10-32). These are designed to screw into a matching threaded hole in the rear of the box. All other types of screws are prohibited (no pan heads, sheet metal, etc.).

The other method is a "grounding clip" which bonds or electrically connects the ground wire to the box at the edge of the box. It's interesting to note that some manufacturers' instructions state that these grounding clips are only for solid wire (typical of romex) which would preclude its use on flexible cord which always contains stranded wire. That narrows the options for box grounding to the grounding screw only, unless the box is fixed mounted and supplied with a cable assembly such as romex wire, in which case a grounding clip is an acceptable alternative for grounding the box. I rarely if ever see grounding clips used even for fixed/permanent wiring applications since they are problematic to install and the cover does not seat against the box very well in a completed installation. Recent information on these suggests that they are also not UL listed.

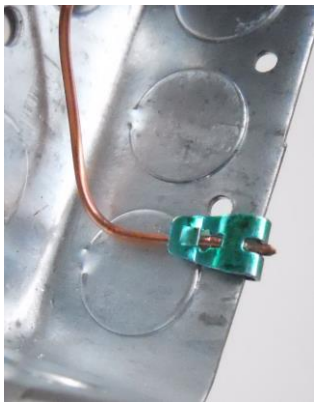
Grounding screw

Grounding clips

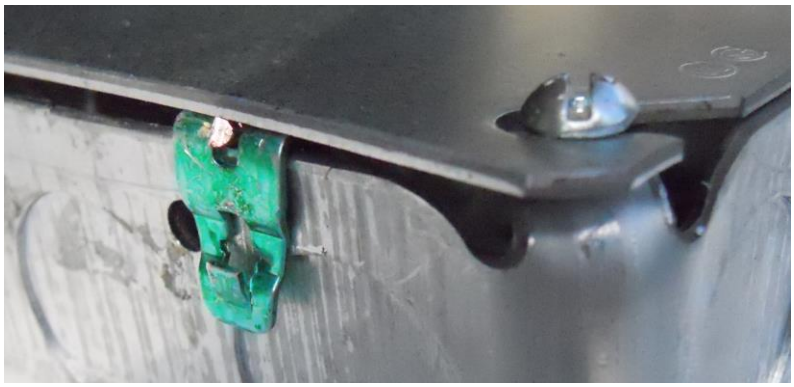
Screw visible through rear of box



Grounding conductor attached to screw
excess pig tail left to attach to receptacle etc.



Ground clip with ground wire attached inside box



Exterior view of box with cover in place-notice that the clip is visible You can see the cover does not fit/seat tightly against the box

I'm frequently asked if the compression fitting to the box (either at the top of the pendant drop or at the bottom) is adequate for strain relief on the flexible cord since it secures the cord by compression over a small area of the cord.

If there is indication that this concentrated strain, supporting the weight on the flexible cord is causing damage (outer jacket tearing, etc.) or the pendant drop is a very long drop combined with the weight of a heavy gage flexible cord, along with the weight of the box or cord connector at the bottom with equipment plugged into it, then there may be a need for additional strain relief. Typically this is accomplished by the use of cable support grips usually referred to as Kellems® grips, named after the inventor, and currently a registered trade mark by Hubbell® Incorporated.

Standard compression fitting

Example of a twist lock plug which can be locked into a twist lock receptacle permanently mounted on the ceiling. This common application allows for pendants to be relocated easily throughout a facility.

Box connector fitting with Kellems® grip. This can be directly threaded into a box "hub".

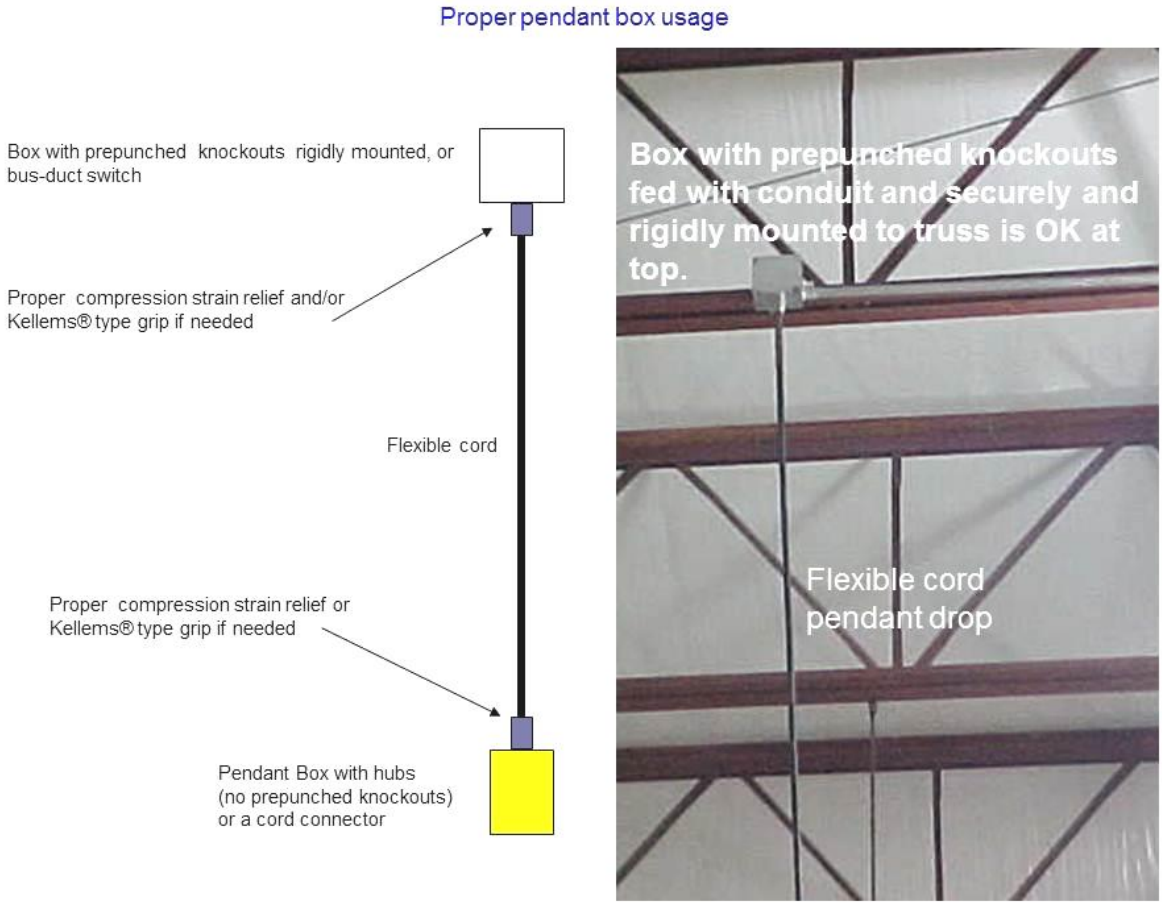
Various types of Kellems® grips

Requirements for using these special grips to provide additional strain relief is not precisely prescribed in the NEC®. Since individual installations vary widely with myriad factors contributing to the overall weight needed to be supported, including: overall length of the drop, physical size/gage of the wire, type of flexible cord affecting the thickness of its outer jacket, the weight of the box and receptacle at the bottom of the drop including equipment and cord weight plugged into it, etc. The best advice is to use good judgment and be on the lookout for excessive strain on the flexible cord at the compression fitting/connector as evidenced by stretching and or tearing of the outer jacket etc. and install the additional support in order to support the total weight over a greater length and area of the cord if needed.

Why is this box stuff on the end of a flexible cord so important:

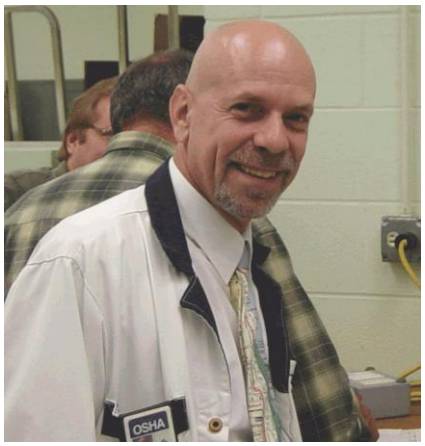
If a box containing a receptacle outlet were mounted on say a wall or column, one would just plug in the electrical equipment into the outlet without touching the box at all. However in the case where the box is mounted on the end of a flexible cord (either pendant or cordset use) a person would have to physically grab and hold the box in order to plug into it or to remove a plug from the receptacle mounted in the box.

It is this required human interaction and contact with the box that greatly increases the hazard exposure to a person!



These are the facts.

Remember, boxes with prepunched knockouts are never permitted to be used at the end of a flexible cord! Use the correct box or a cord connector for that purpose!



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"Grizzy", as he likes to be called has been recognized by OSHA's National Office in Washington D.C. as both a National Electrical Code (NEC®) historian as well as "the best electrical safety trainer in the country!" Certainly at the very least Grizzy has been OSHA's electrical safety "go-to guy" and has been instrumental in shaping and interpreting OSHA policy and regulations for several decades.

Grizzy has trained OSHA compliance officers, appeared as OSHA's electrical expert, and guided literally hundreds and hundreds of electrical fatality investigations. Grizzy continues to train OSHA compliance officers and personnel coast to coast, as well as still providing investigative assistance to the Agency on fatality investigations and significant cases. His electrical expertise has not only shaped OSHA policy but also the OSHA Electrical Standard's. Grizzy is currently a **member of the ASTM F-18 Committee** which writes the **"Electrical Protective Equipment for Workers"** standards.

Licensed by the Department of Education, and prior to his OSHA career, Grizzy had been both an **educator and administrator** for various public and private schools and held the position of Electronic Department Chairman and Director of Education at a New York City proprietary school.

In addition to being a **professional speaker** and **nationally recognized seminar leader** with **over 40,000 hours of platform experience**, Grizzy has lectured at numerous colleges and universities all across the US and has numerous published works in video and print which have assisted safety professionals and helped workers for decades.

Recognized nationally as **preeminent in regulatory electrical safety training**, Grizzy conducts training all across the country providing insight into navigating the complex regulatory requirements.

Grizzys passion for electricity and decades of collecting rare electrical artifacts which he is now exhibiting and demonstrating in spectacular high voltage keynote presentations at major conventions affords attendees of his events a unique opportunity to actually see a "slice of history". In fact his events have been characterized by attendees: "It's like watching the History Channel, only live!"