



SYSTEM MANUAL

FOR MINING APPLICATIONS

Revised Apr. 4, 2016

DISCLAIMER

***** WARNING *****

The communications system described herein shall be installed, operated, and maintained under the supervision of a MSHA certified mine electrical superintendent and follow all State, Federal and MSHA electrical codes and guidelines as applicable.

Read entire document before proceeding.

The communications system described herein shall be installed, operated, and maintained under the supervision of a MSHA-certified mine electrical superintendent and follow all State, Federal, and MSHA electrical codes and guidelines as applicable.

This equipment will require periodic servicing to maintain correct operability. Such servicing and maintenance is the responsibility of the end user. This includes periodic inspection of power supplies and all connections.

**If you have any questions regarding the use, installation, or service of this equipment,
contact your local dealer or Tunnel Radio directly at:**

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Corvallis, OR 97330

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ELECTRICAL BLASTING CONSIDERATIONS AND RADIO IN MINES

Safety Library Publication #20⁽¹⁾ provides an overview of using blasting caps with radio transmitters. This document was developed by the Institute of Makers of Explosives relative to this issue. In summary, tests have shown that the probability of inadvertent detonation of electric caps is “almost nil,” but concerns persist about the use of radio underground near electric blasting caps.

Publication #20⁽¹⁾ limits radio use to 5 watts maximum RF power no closer than 20 feet from electric caps. In 1979, the U.S. Bureau of Mines⁽²⁾ conducted a study in which three mobile-radio-equipped vehicles and three portable radios were located within a few yards of a mine face that was loaded with live un-terminated electric caps. The radios were set to transmit simultaneously at full power for one minute. No detonation occurred as a result. This controlled test was conducted by scientists and engineers from Motorola, the Pittsburg Research Center (PRC), and the U.S. government. See the note below to obtain a copy of the #20 report.

Notes:

1. Institute of Makers of Explosives, 1120 19th Street NW, Washington DC 20023. www.ime.org
Publication Safety Library Publication #20
2. USBM Report Implementation of UHF Radio Communications in a Room and Pillar Mine, March 1981, Isburg, Allen

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Section I – Company History

Tunnel Radio of America, Inc., was formed in 1988 to meet the demand for better wireless communications in the underground mining environment. The first reliable VHF radio system in the United States was installed by Tunnel Radio at the Greens Creek mine near Juneau, Alaska, in 1988. This installation continues to operate today, having expanded many miles during the intervening years. Tunnel Radio also continues to grow and has installed wireless systems in numerous mines in the U.S. and around the world.

In 1993, we launched our first railroad communication system, and have continued to expand our product line to meet industry needs. Our Tunnel Radio Link technology has been instrumental in allowing Union Pacific and BNSF to double their long-haul freight carrying capacity and reduce fuel costs. Our development team is currently supporting Positive Train Control (PTC), as mandated by the Rail Safety Improvement Act of 2008.

Tunnel Radio has installed wireless radio and data systems for some of the biggest names in transportation and mining, including: Union Pacific, BNSF, Metro-Link, Alaska Railroad, Barrick Gold, Newmont, Rio Tinto, Alpha Natural Resources and many others.

Tunnel Radio is committed to providing the most reliable, high-performance, and cost-effective radio systems available worldwide. Our engineering department is continually working to develop and refine our product line, in order to offer quality equipment perfectly suited to our clients' operational requirements. We believe in strong customer support and utilize in-house training of customer employees to provide basic servicing and system expansions. We also strive to deliver our products and services to you with the utmost in personal honesty and integrity.

Our innovative radio systems, along with tracking, diagnostics, and control systems have revolutionized underground communication. Much of our product line can be monitored and controlled remotely, providing administrative access from anywhere in the world. As a full-line Motorola Two-way radio dealer, we can provide the most advanced wireless equipment available.



Section II – System Summary

Needs

Two-way radios are used in almost every industrial activity, providing instantaneous communication for work crews, safety personnel, and administration. Unfortunately, underground mines and other enclosed environments by their nature block radio signals, preventing effective underground communication.

Some have tried to address this problem by placing hard-wired phone systems at strategic locations. The use of these systems has proven to be very cumbersome, and often does little to help in emergency situations. Other systems have been developed that rely on wireless hotspots, but still lack the necessary full radio coverage of an entire site.

Maintenance of a radio system can also be challenging, especially in mines, where the radio system is required to grow with the mine expansion. Simplicity is key, as complex systems tend to go without proper maintenance.

Another important consideration is ease of system integration, since many industrial systems often require the use of radio channels for telemetry. Identifying such a radio system can be a daunting task.

Solutions

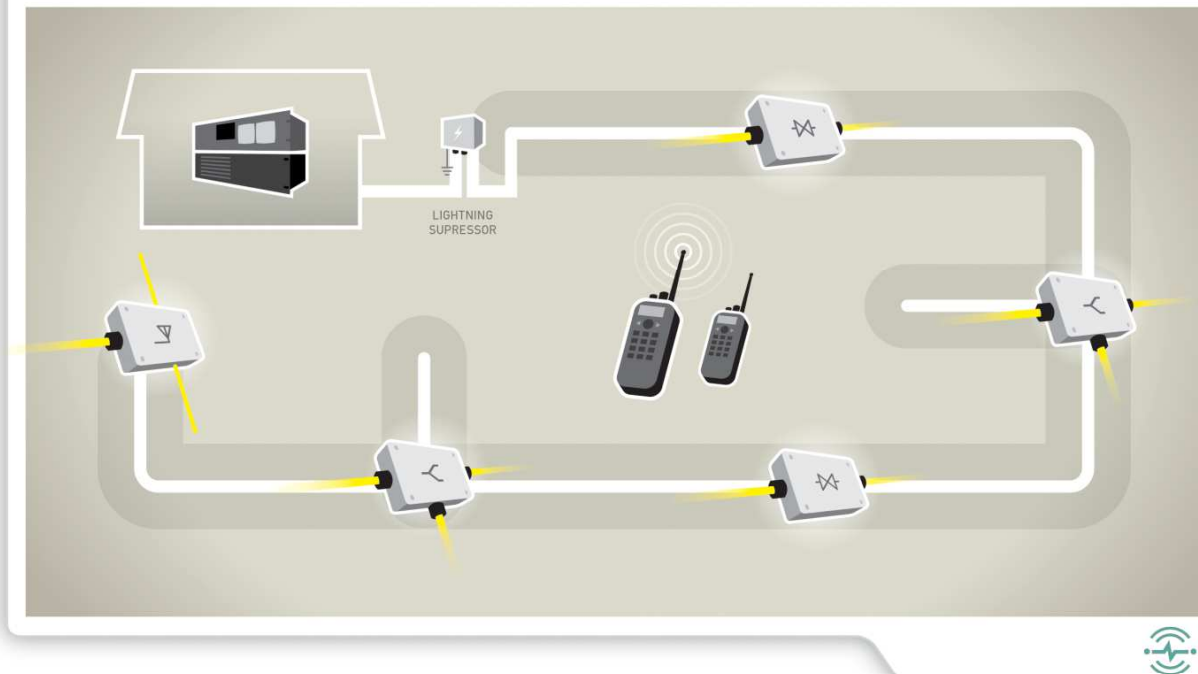
Tunnel Radio has developed the Ultracomm[®] radio system with these needs in mind. Ultracomm[®] is a leaky feeder radio system that can be installed in enclosed environments, providing instantaneous communication. This facilitates seamless radio coverage above-ground and underground using standard industrial two-way radios (such as the Motorola MotoTRBO series).

Leaky feeder is a well-established technology that provides continuous coverage by allowing the radio signals to "leak" from the whole length of the cable, much like a sprinkler hose. As radio signal strength diminishes towards the end of the cable, an amplifier is installed, boosting signal strength to support another run of cable. A number of amplifiers and cable runs can be added before requiring more power from the AC line. This makes the system very extensible, cost-effective, and easy to maintain.

Ultracomm is compatible with a wide range of radio systems and devices. It can be seen as the "backbone" system that supports and enables all other radio systems. Tunnel Radio continues to develop a whole product ecosystem around the Ultracomm backbone, including personnel and asset tracking, system diagnostics, SCADA, gas monitoring, collision avoidance, and more.

Tunnel Radio is committed to providing products with the best performance, quality, and support that meet customers' real-world needs. For more information, visit www.tunnelradio.com.

THE ULTRACOMM™ COMMUNICATIONS BACKBONE



HEAD END UNIT/
REPEATER



MOTOROLA™
HANDHELD RADIO



AMPLIFIER



SPLITTER



ANTENNA

REASONS FOR ULTRACOMM[®]

THE BASIC RADIO

Simple and convenient wireless radio communication in the industrial environment improves both the safety and efficiency of operations.

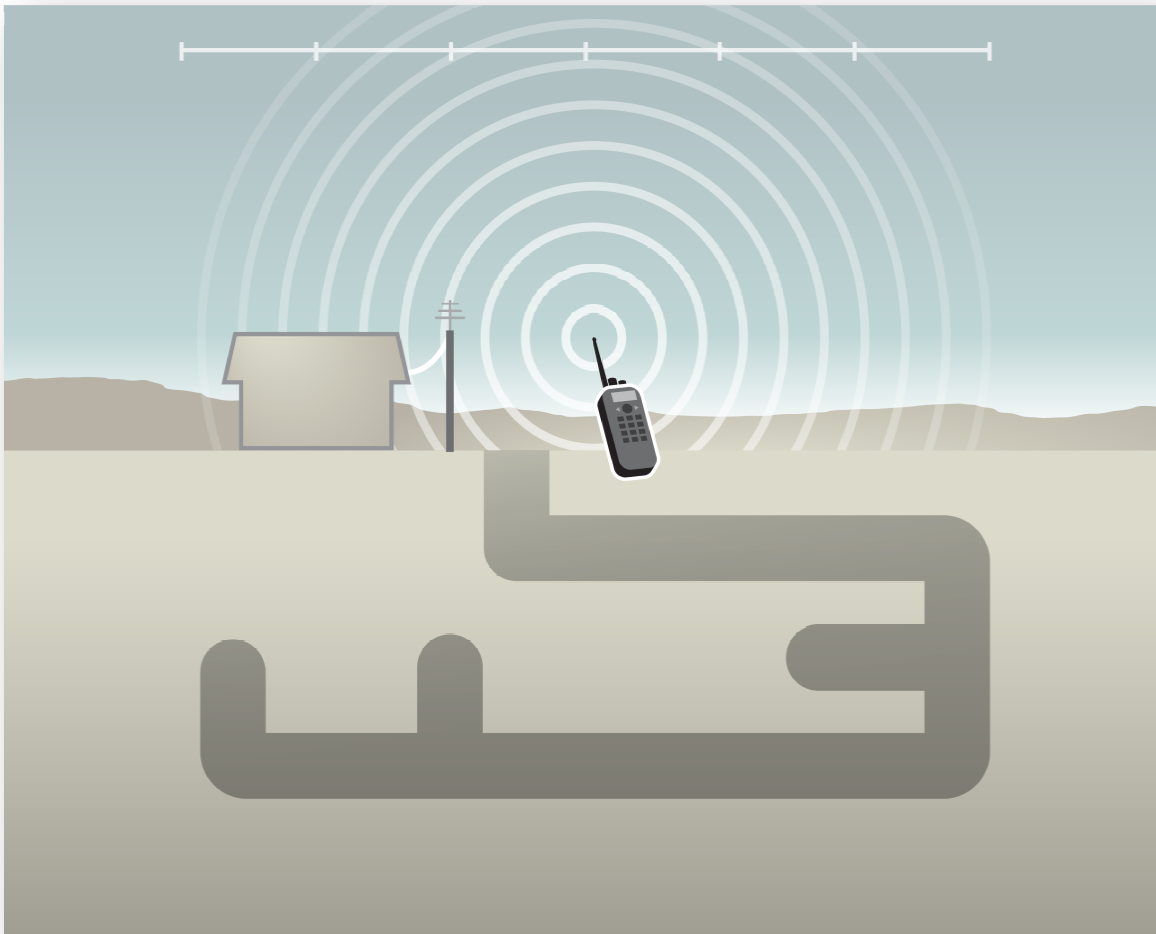
Two-way radios are used at almost every industrial activity, and are available in mobile, stationary base, and hand-held portable configurations.

Computers can also be equipped with data radios to “talk” to each other.



RADIO RANGE

Typical radios can operate over miles or even tens of miles in surface operations.



A radio that may be able to operate over miles on the surface may operate only several hundred feet underground!

Underground range is affected by the height, width, and number of turns in the enclosed area.

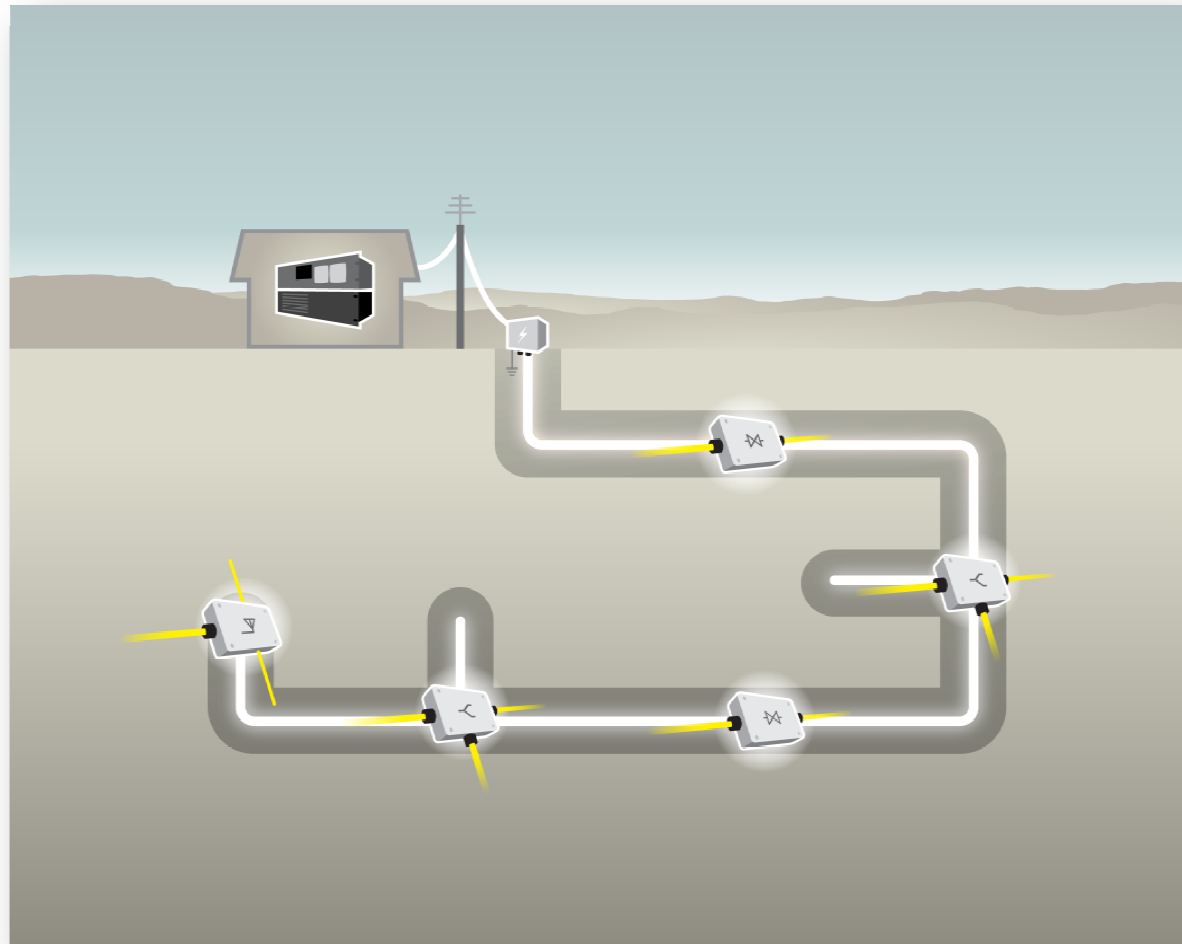
EXTENDING RANGE THROUGHOUT THE MINE

The Ultracomm® system extends radio coverage by emitting and receiving radio signals throughout a Leaky Feeder System (LF).

In radio terms, signals traveling on the LF from the surface down into the mine are called downlink signals.

Radio signals coming from inside the mine toward the surface are called uplink signals.

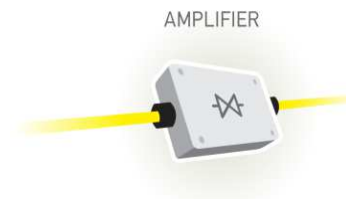
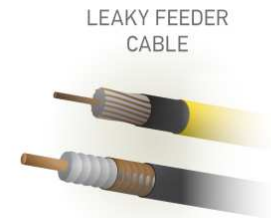
By understanding the system components and knowing some simple terms and rules, you will be able to properly extend and maintain your mine-wide Ultracomm® Leaky Feeder System.



UNDERSTANDING SYSTEM COMPONENTS

The Ultracomm® system is made up of the following components:

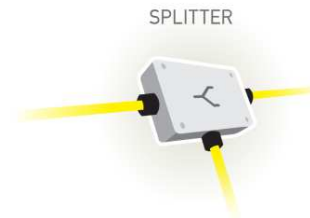
- **Base Interface Unit (a.k.a. Head Unit)** – Communications bridge between surface and underground radio systems.
- **Lightning Suppressor** – Protects underground components from lightning strikes.
- **Leaky Feeder Cable** – Carries radio signals to and from underground areas, providing radio coverage wherever present.
- **Amplifier** – Boosts weak radio signals back up to proper levels.



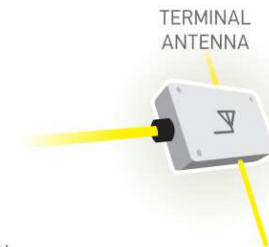
- **Splice Box** – Joins two pieces of leaky feeder cable together.



- **Splitter** – Forms a new branch of leaky feeder cable.



- **Terminal Antenna** – Terminates leaky feeder while extending radio coverage.



- **Termination Unit** – Properly caps a leaky feeder end point.

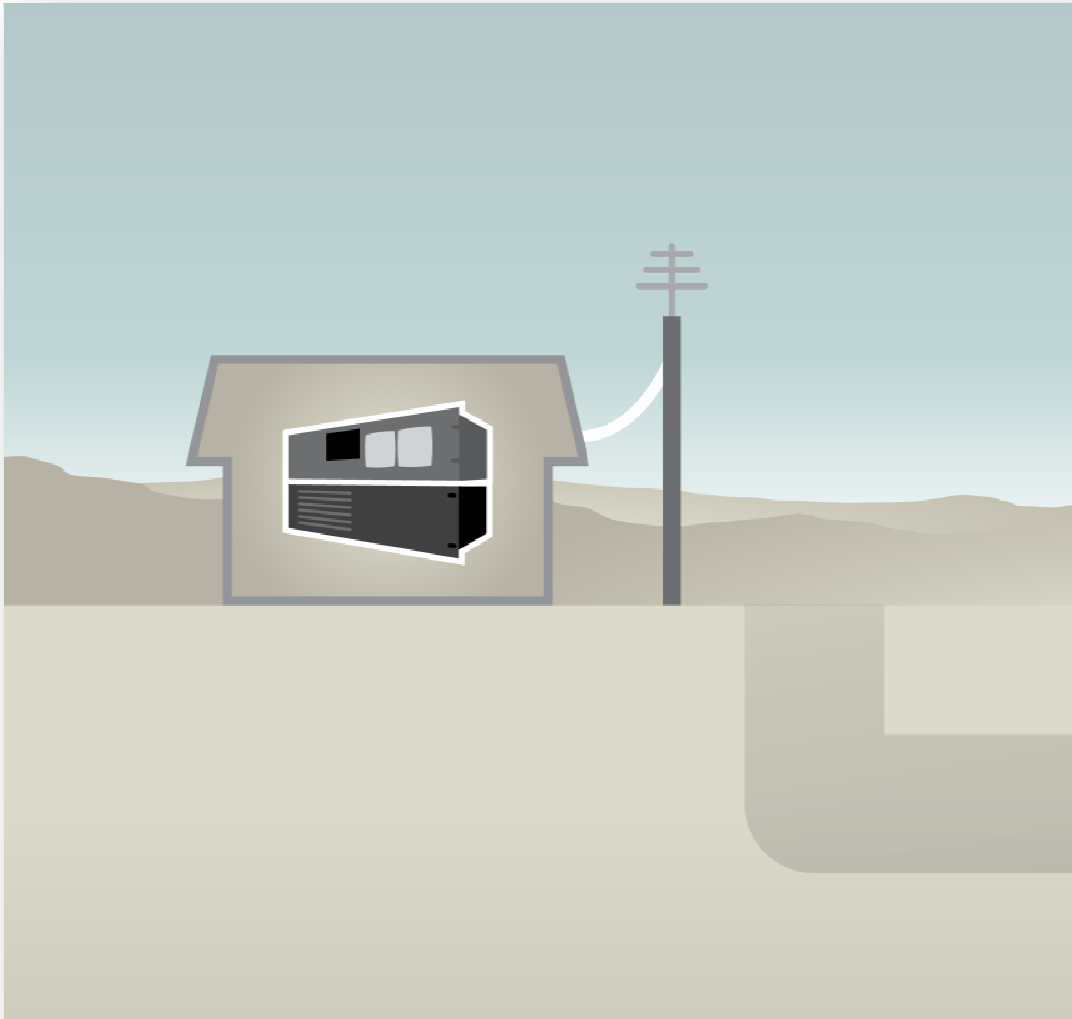


- **DC Power Supply & Insert** – Provide additional DC power to extend the leaky feeder system.



SYSTEM COMPONENTS

BASE INTERFACE UNIT (a.k.a. Head Unit)



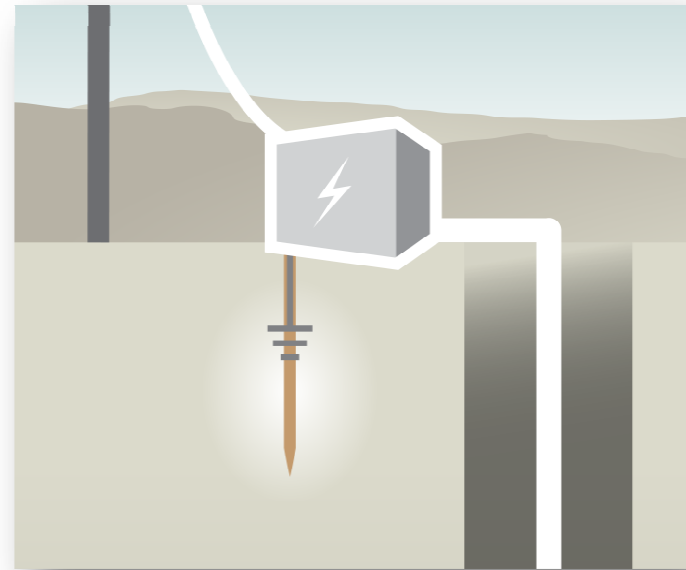
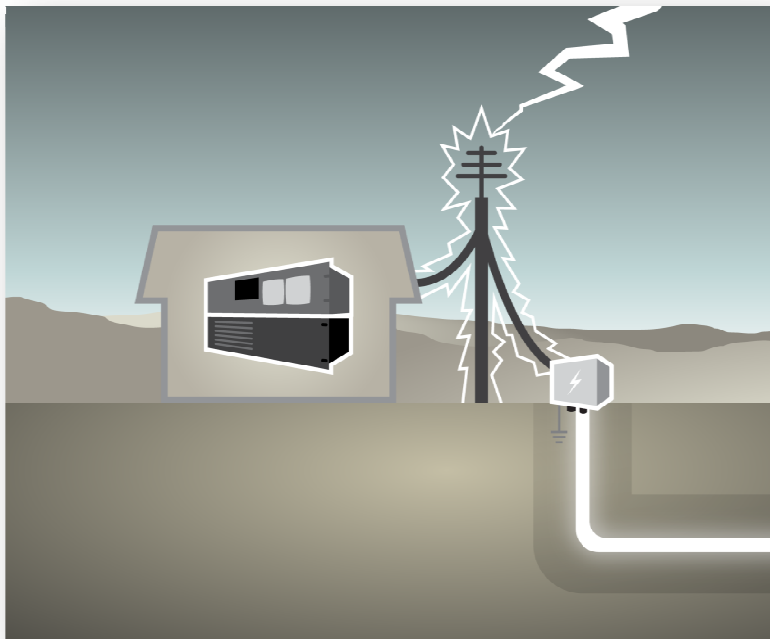
This unit acts as a communications bridge between the surface and underground radio systems, typically located at the mine entrance.

The Head Unit typically supports 4 radio channel pairs (some models support up to 8), and also includes support for TMS diagnostics to monitor system status 24/7.

In addition to directing radio signals, the Head Unit also provides DC power to the first section of LF communications system.

LIGHTNING SUPPRESSOR

The Lightning Suppressor is used to protect the underground communication system from harmful electrical storms, spikes and/or surges. It is positioned between the above-ground head-end unit and the underground components, at the point where the leaky feeder cable enters the mine.



MSHA requires lightning suppression at every installation, with minimally one suppressor unit per mine entrance cable.

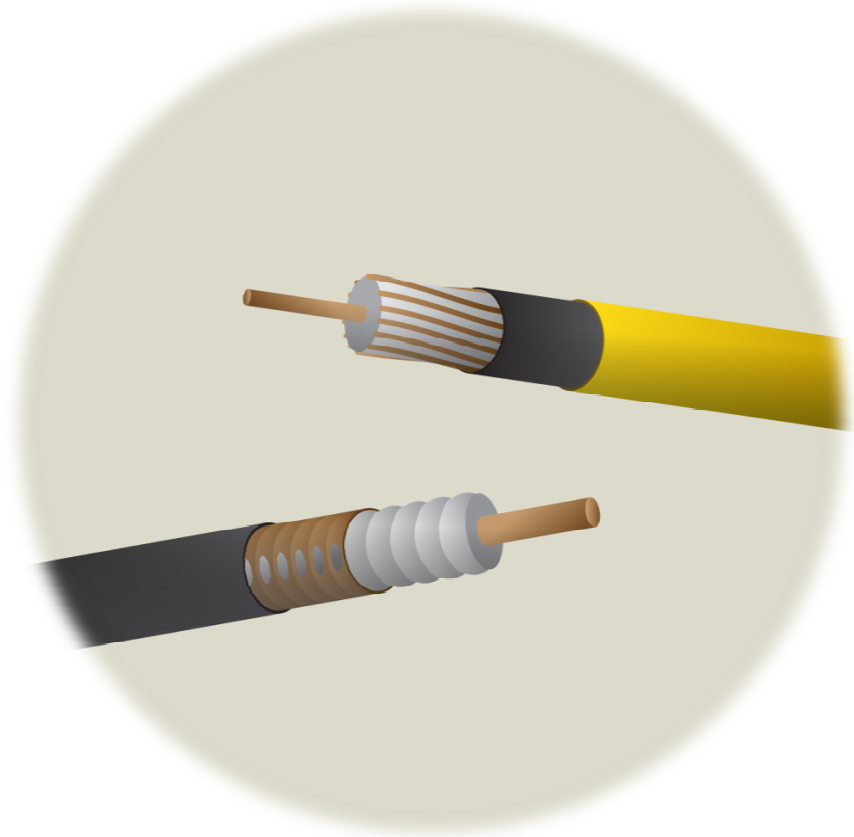
Correct operation of the suppressor will depend on a quality ground path. Proper grounding and maintenance of this ground is an END USER responsibility. Operation of this device is dependent upon such.

LEAKY FEEDER

Leaky feeder cable runs along the length of the tunnel to emit and absorb radio waves, and must be installed wherever communication is desired.

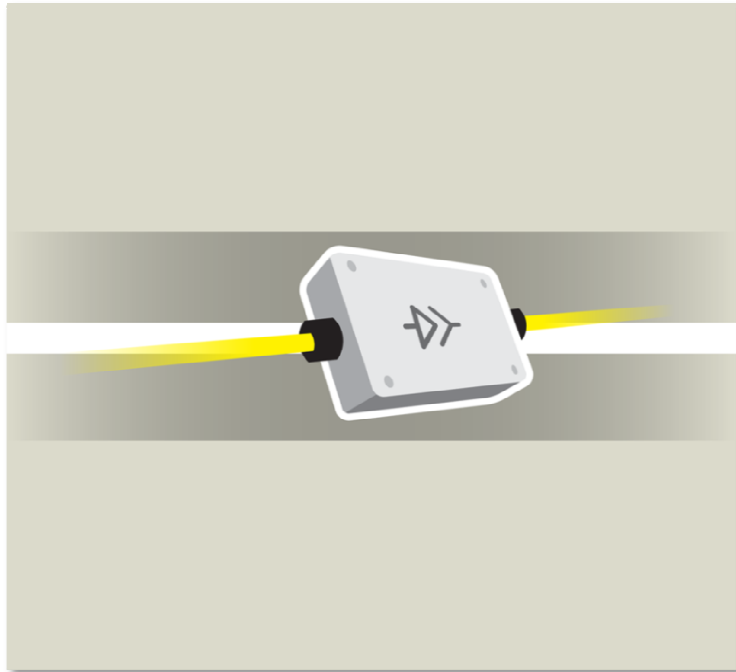
The cable is called “Leaky” because it contains openings in its outer shielding to allow signals to leak in and out of the cable for its entire length.

In addition to radio waves, the leaky feeder cable also can carry DC voltage used to power attached amplifiers and diagnostic equipment.



YELLOW CABLE (VHF) AND BLACK CABLE (UHF)

SPLICE BOXES



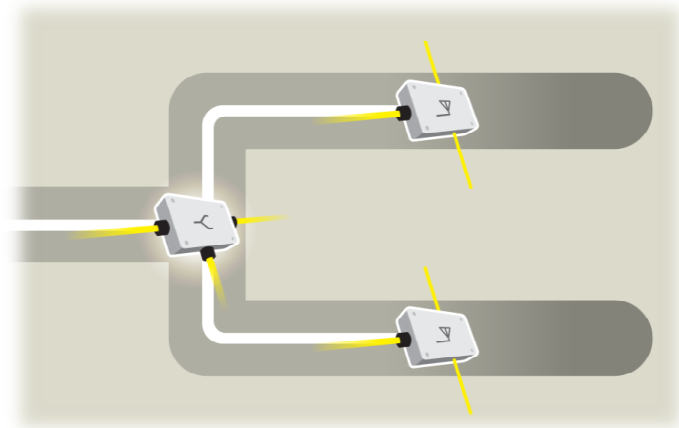
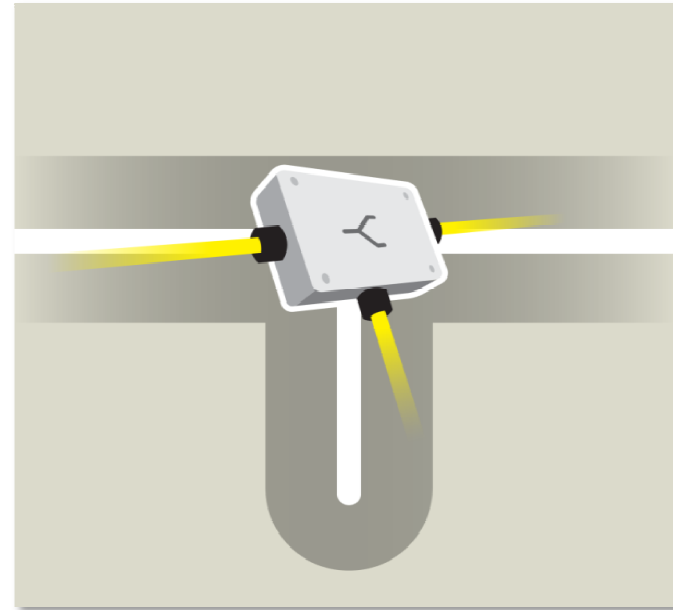
If the leaky feeder is ever damaged and a segment needs replacing, cut away the bad segment and use splice boxes to join a new segment.

NOTE: Due to the physics of a splice, a splice is never as good as the original undamaged cable. As such, no more than four splice boxes may be used per cable run. If additional splices become necessary, the entire cable should be replaced, as excess splice boxes will unacceptably degrade system performance.

SPLITTERS

As mine tunnels split and branch, so too should leaky feeder coverage. Splitters are used to fork a cable run into 2 or 3 separate branches.

NOTE: Splitters divide the radio signal strength evenly between the branches. This means that the length of the affected cable run is reduced. Please use the table below to calculate the length reduction for your splitter and cable type.

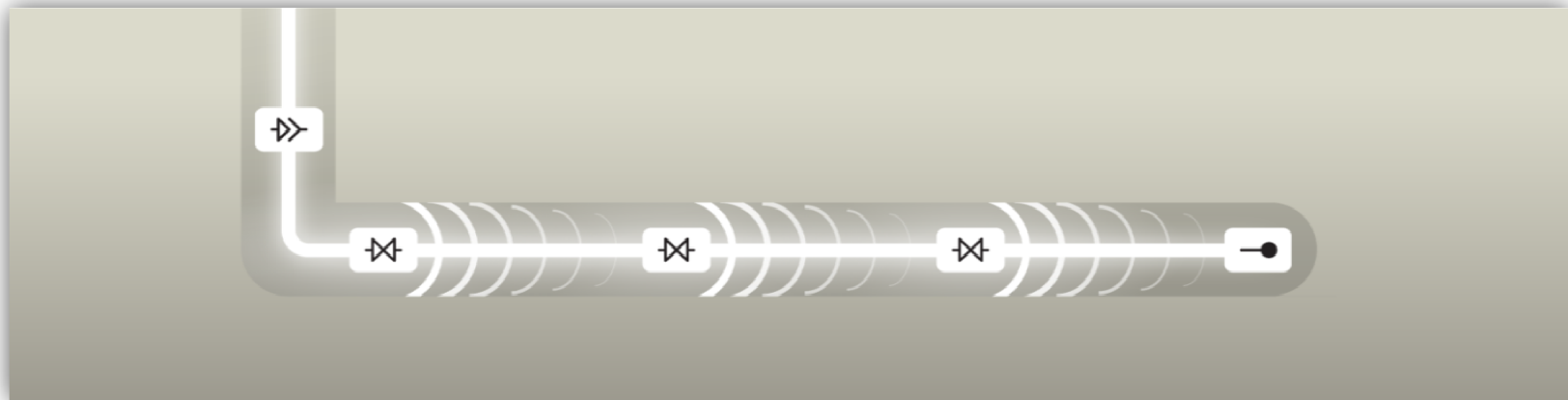
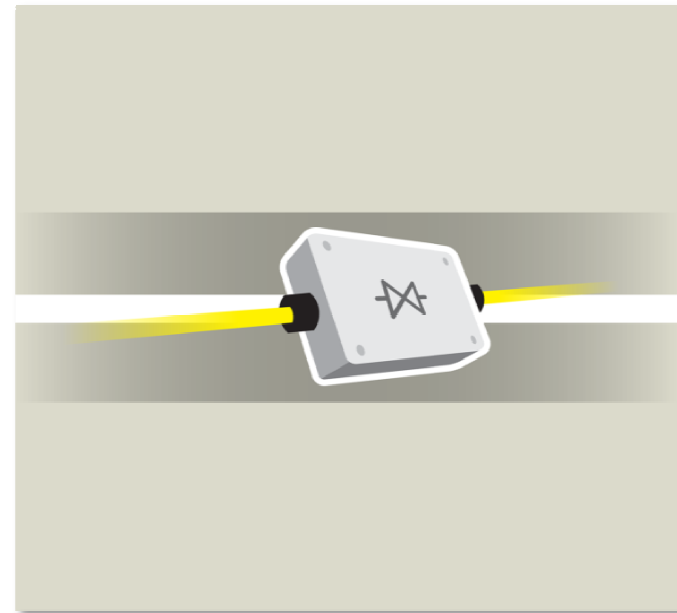


	VHF	UHF	900 MHz
2-way splitter	218 ft	200 ft	140 ft
3-way splitter	344 ft	316 ft	215 ft

AMPLIFIERS

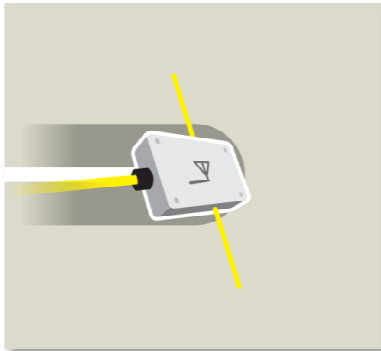
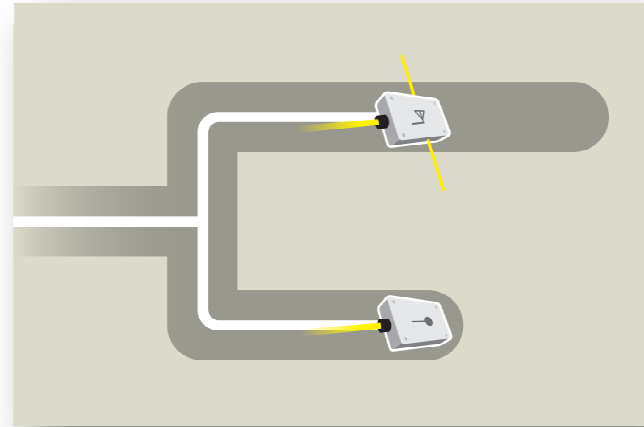
As the leaky feeder gets longer and is spliced and split, the radio signals become weaker. To counter this, amplifiers are installed to boost the radio signals to normal operating levels.

Without amplifiers, the maximum leaky feeder length would only be in the range of 1000-1500 ft. By using amplifiers, the leaky feeder length can be extended for miles.

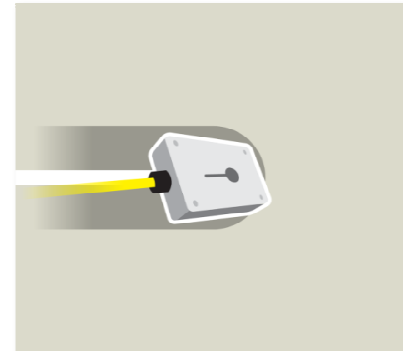


TERMINATION UNITS & TERMINAL ANTENNAS

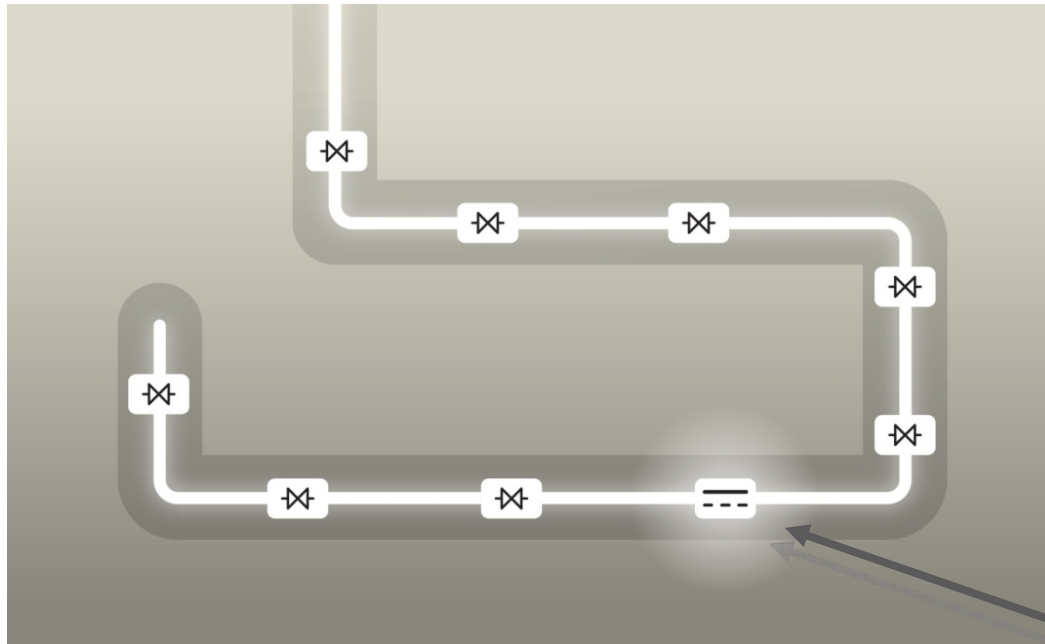
Termination units are used to properly cap the leaky feeder end points, in order to protect the mine from a possible spark hazard. Termination units also keep the cable clean and free from moisture ingress.



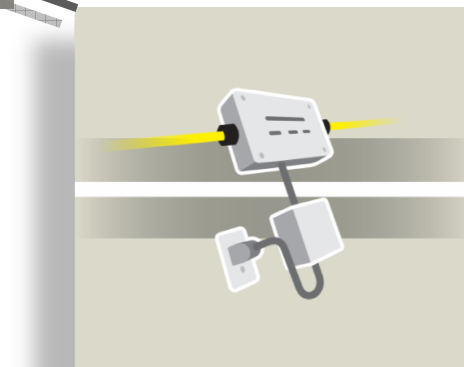
Terminal antennas perform the same safety functions as Termination units, but also provide radio coverage into working sections and stopes.



DC POWER SUPPLY & INSERT



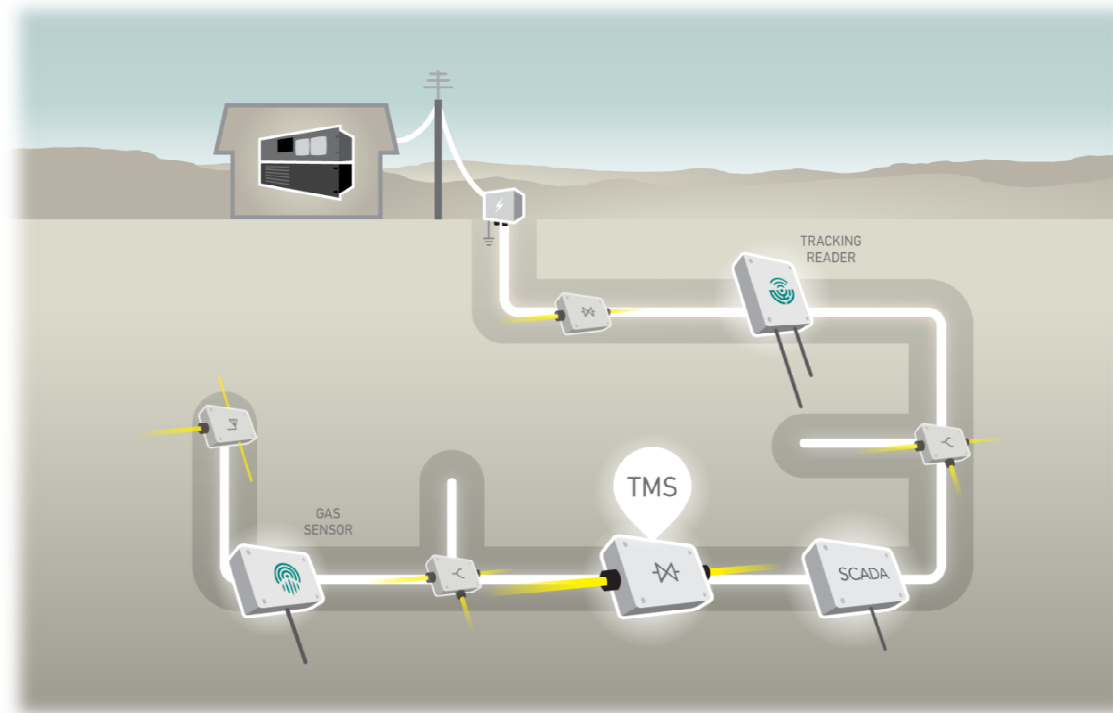
DC power supplies and inserts are added to the leaky feeder approximately every 6-15 amplifiers to ensure that the amplifiers have enough power to perform their function. (See amplifier manuals for details.)



INTEGRATED SYSTEMS

TUNNEL RADIO ECOSYSTEM

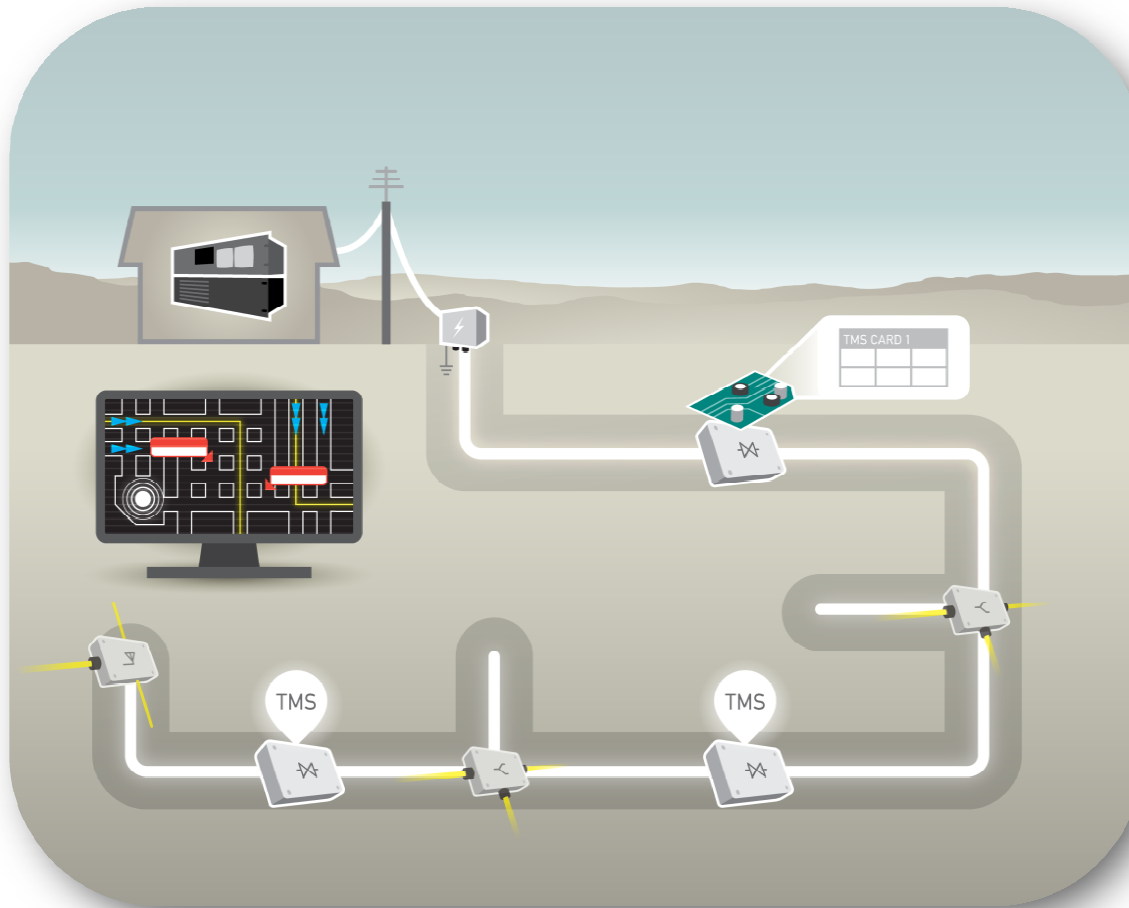
Ultracomm is compatible with a wide range of radio systems and devices. It can be seen as the "backbone" system that supports and enables all other radio systems. Tunnel Radio continues to develop a whole product ecosystem around the Ultracomm backbone, including personnel and asset tracking, system diagnostics, SCADA, gas monitoring, collision avoidance, and more.



These systems use dedicated radio frequencies to request and send data between devices. Most can be viewed and controlled remotely from a dispatch office many miles away, enabled by our web-based interface software. Some of these systems are described in the following pages.

ULTRACOMM DIAGNOSTICS

Tunnel Monitoring System (TMS)



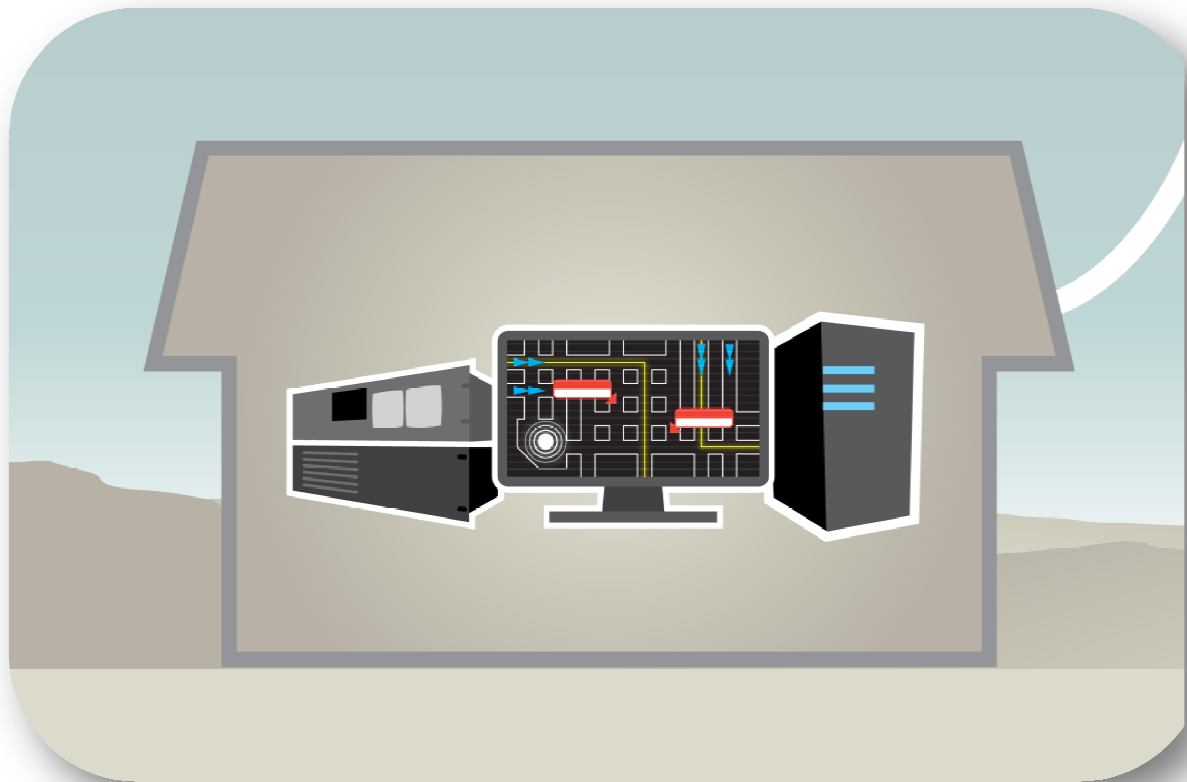
As communication systems continue to expand, their complexity increases as well. Intricate mine systems with Leaky Feeder networks can contain hundreds of amplifiers and other devices. These networks can be complicated to manage, thus the ability to efficiently troubleshoot dense systems is critical. In response to these needs, Tunnel Radio has developed the Tunnel Monitoring System (TMS).

MineAx SERVER AND SOFTWARE

The MineAx® tracking system requires a server to process data and provide a web-based user interface. Tag reader data flows from the readers to the head unit and up to the MineAx server, where the MineAx software stores the information for 30 days. The MineAx user interface can be accessed from any computer on the local network or around the world by using a web browser.

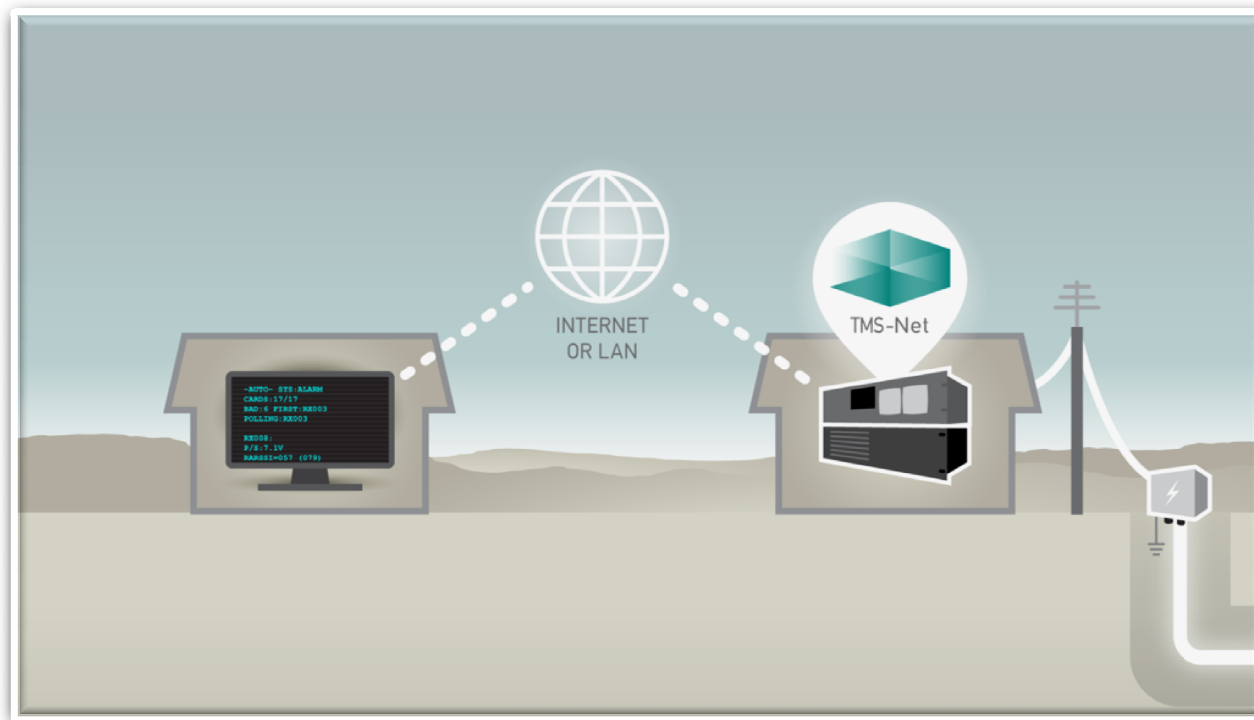
The MineAx software can simultaneously retrieve data from multiple head units and Ethernet readers. The tracking information is displayed in a tabular view or overlaid on a site map. Other features include detailed tracking history, search, and a variety of reports.

MineAx also displays the current TMS state and history graphs for all recorded measurements, as well as supporting other optional subsystems, such as industrial controls and gas monitoring.



TMS-Net

TMS-Net provides the ability to remotely access your TMS system anytime and anywhere. It contains an embedded network server, providing a basic level of web-based administrative functions to be used in conjunction with a TMS system. A system administrator may monitor the current operating state, control the TMS system via the command console, or update firmware from hundreds of miles away.



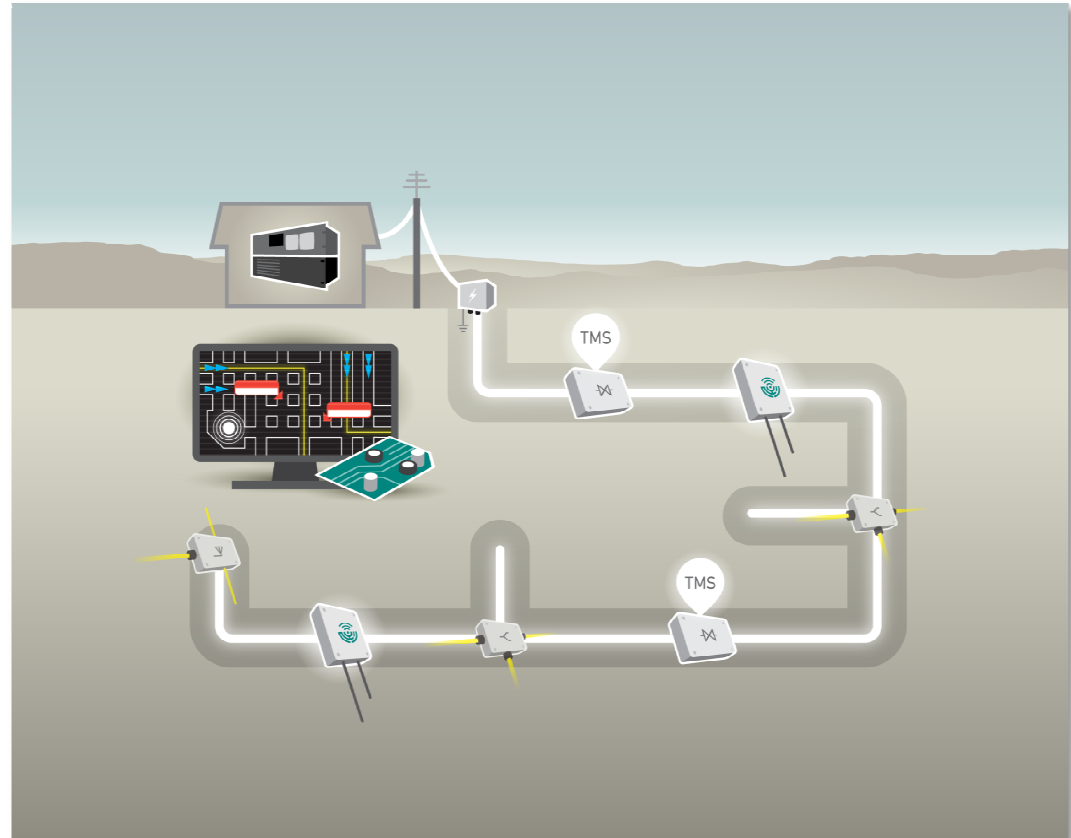
WIRELESS TRACKING

MineAx® RFID Personnel and Asset Tracking System

The MineAx® RFID tracking system provides you with the critical ability to locate people and equipment onsite, both on the surface and underground.

Our intrinsically safe MineAx system offers tremendous flexibility in system design and installation, supporting configurations that include wireless readers via leaky feeder, wireless MultiHop readers, Ethernet-connected readers, and a hardwired surface reader.

MineAx tag readers can be located anywhere within the leaky feeder radio system coverage area, or installed independently of a leaky feeder system, thus providing customizable coverage for each unique installation.

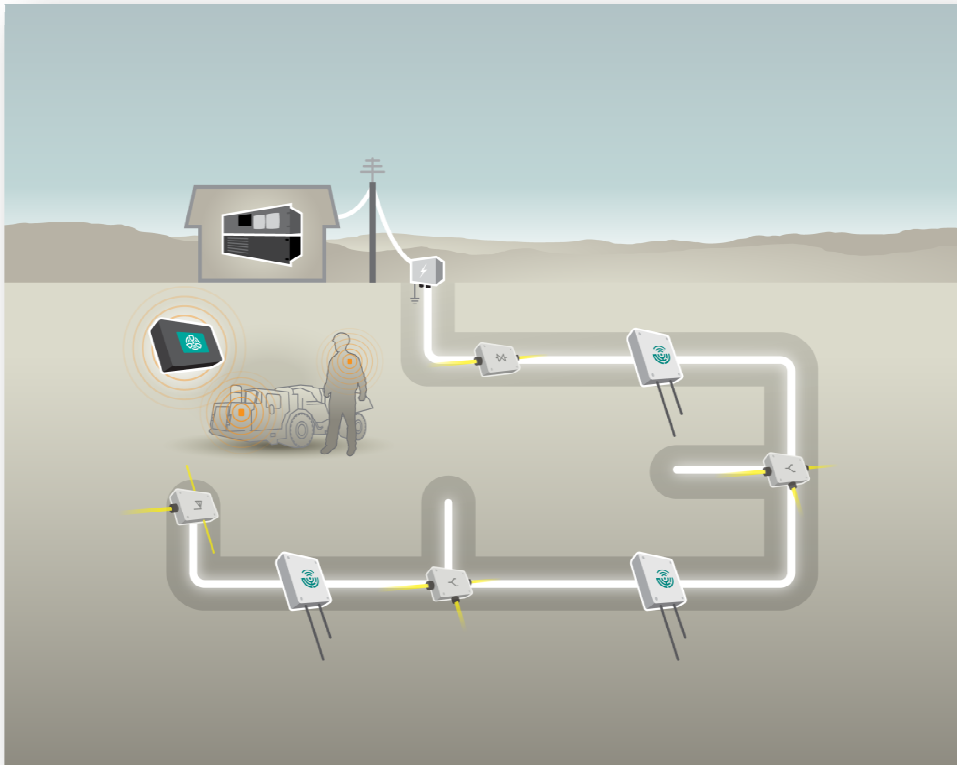


Our MultiHop units can be placed beyond the leaky feeder coverage, as they use a node-based system to relay the data to the nearest leaky feeder. This can be an ideal option for working areas where leaky feeder is not present.

Powerful, web-accessible software allows tracking and diagnostics data to be overlaid on site maps or as a tabular display. Detailed history reports and many other features are included.

MineAx RFID TAGS

MineAx® RFID tags are designed to be carried by personnel or attached to vehicles.

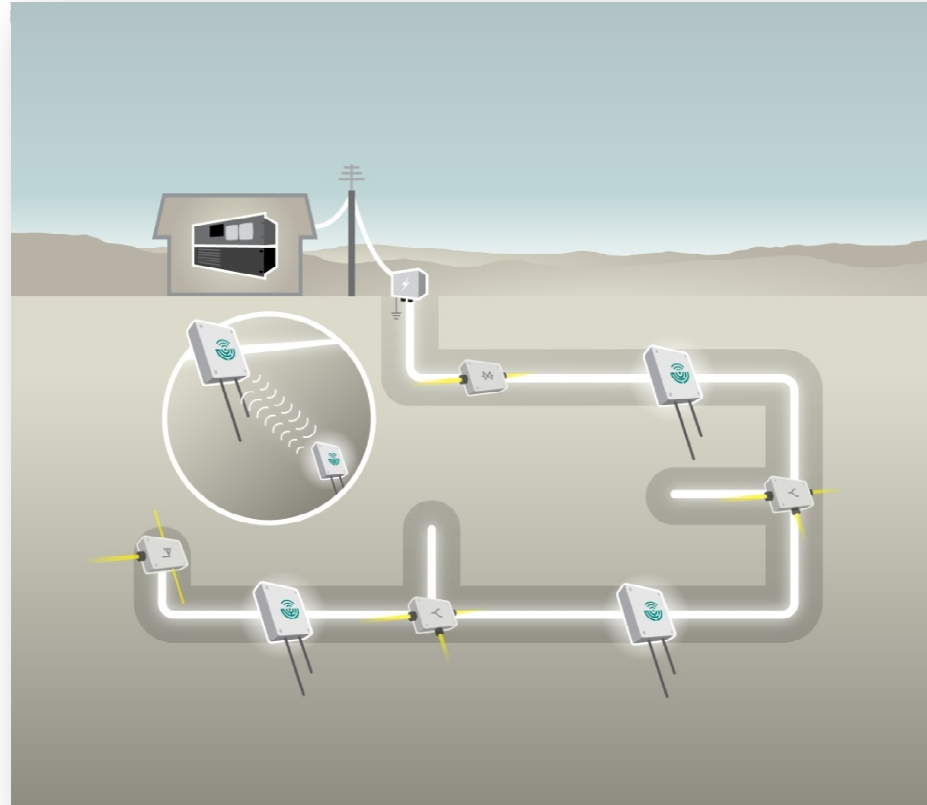


- The unique RFID serial number is transmitted every few seconds, allowing nearby readers to identify personnel and assets within that read zone.
- The tag battery is replaceable and should last at least 2 years under normal daily use.
- When the battery is nearing end of life, the tag will transmit a low battery warning, allowing about 30 days for the battery or tag to be replaced.

MineAx RFID READER (VHF, UHF or 900MHz)

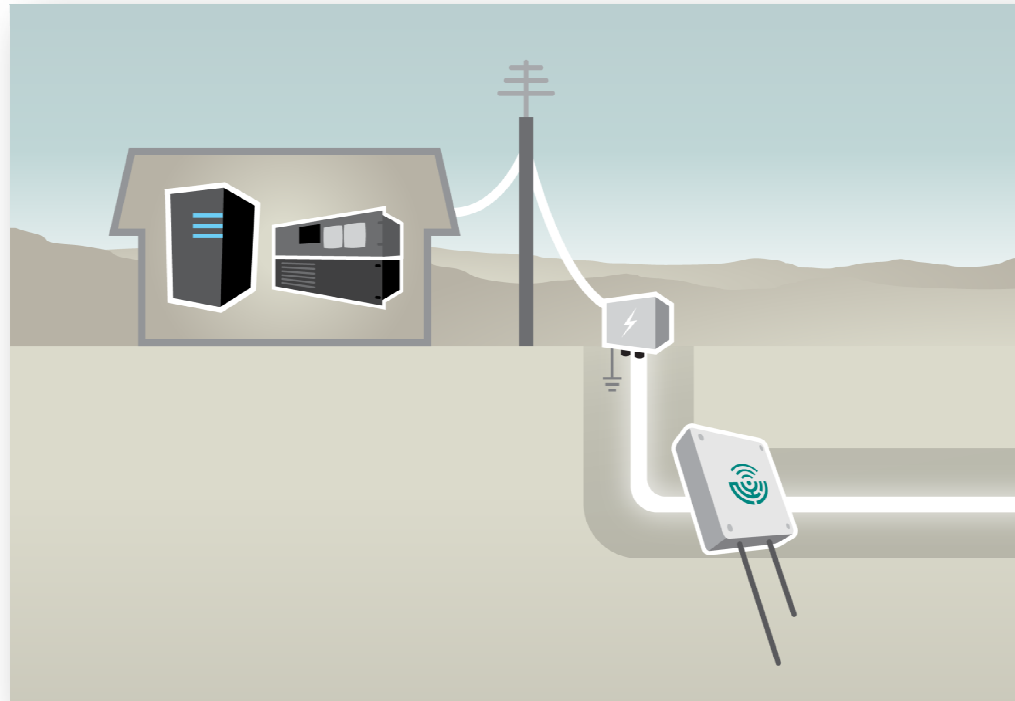
Wireless MineAx® tag readers receive the radio transmissions from RFID tags in the area.

- Read range extends up to 400 feet, depending on conditions.
- When the tag data arrives, the reader stores the tag with a precise time-stamp in memory and relays the data to the MineAx server when polled.
- For standard wireless readers, the data is relayed to the server via the leaky feeder system.
- MineAx MultiHop readers utilize a node-to-node structure to pass the data back to the leaky feeder system.



MineAx HEAD UNIT (VHF, UHF or 900 MHz)

The MineAx® tracking system has a master unit known as the “head unit,” which controls the polling of all the MineAx readers on the leaky feeder system. The MineAx head unit is connected to the head unit of the leaky feeder system, alongside the radio repeaters. In some Ultracomm systems, the two head units may be sold as one combination unit.

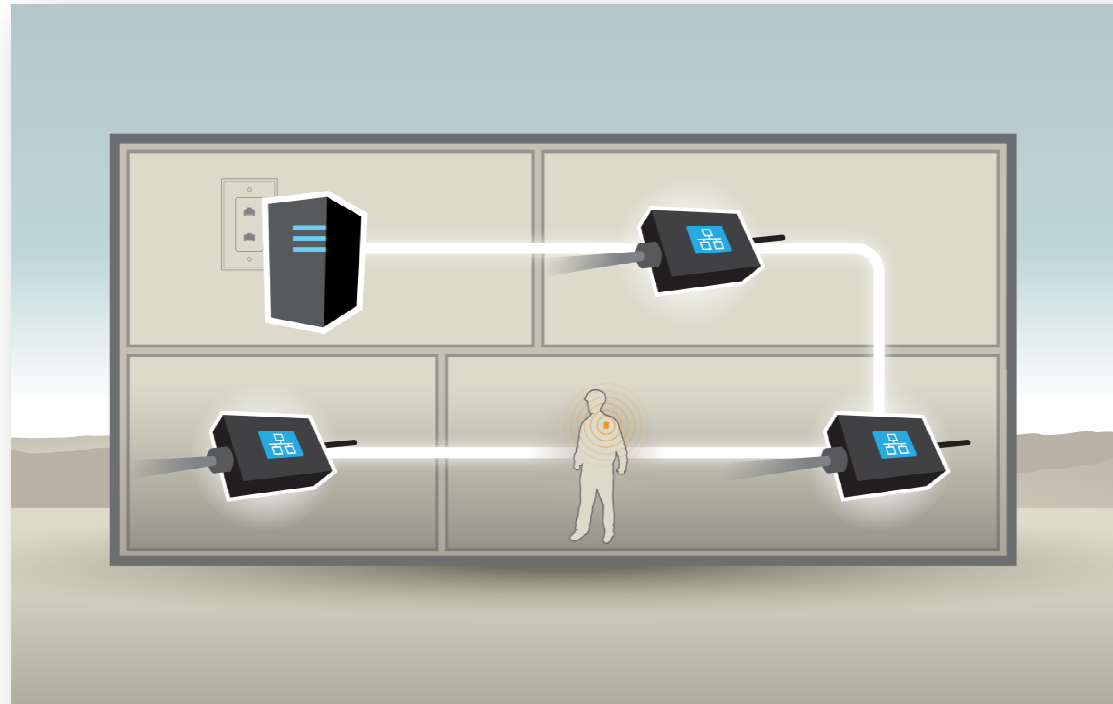


The head unit operates on the MineAx-dedicated radio channel, sending data requests to the wireless readers. When the tag data arrives, it is forwarded to the MineAx server for processing.

MineAx RFID READER (ETHERNET)

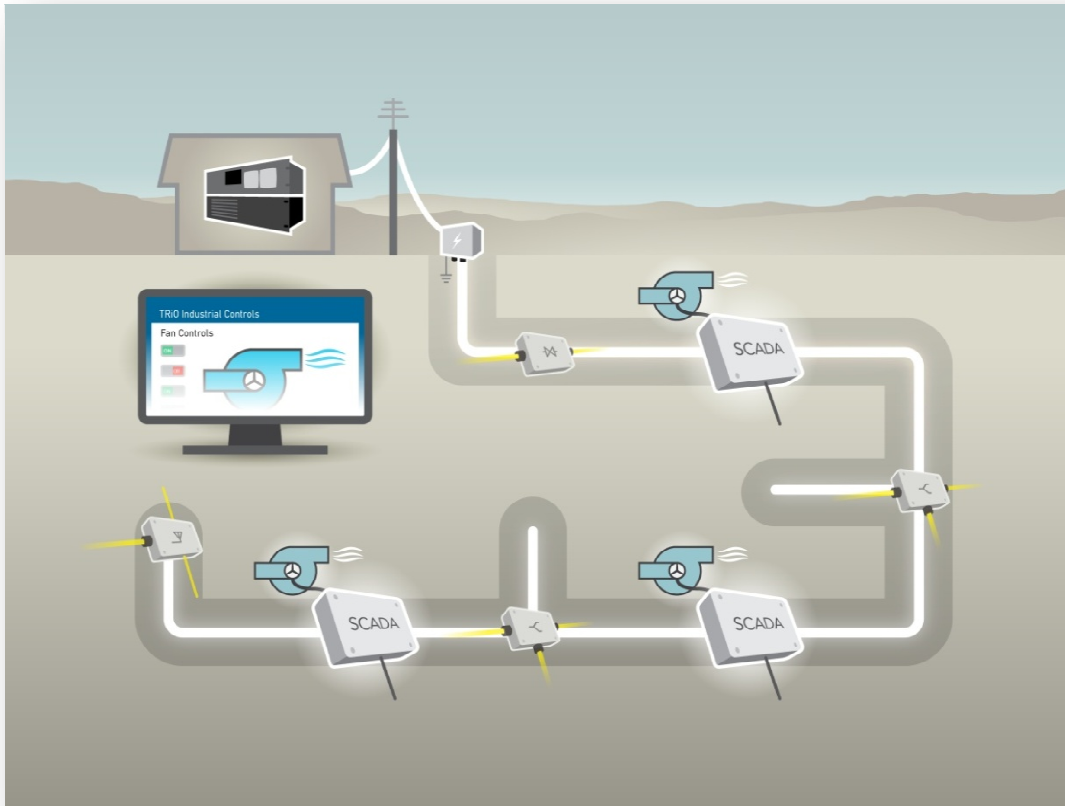
MineAx® Ethernet tag readers receive the radio transmissions from RFID tags in the area.

- Read range extends up to 400 feet, depending on conditions.
- When the tag data arrives, the reader immediately sends the tag data to the MineAx server via a TCP/IP network.
- The tag data is then time stamped and processed at the MineAx server.



TRiO INDUSTRIAL CONTROLS

TRiO is a simple SCADA system, utilizing the MineAx software for the user interface, leaky feeder or Ethernet for communication, and robust electrical hardware to perform the work.



TRiO is useful for remotely controlling fans, pumps, stench release, and many other applications.

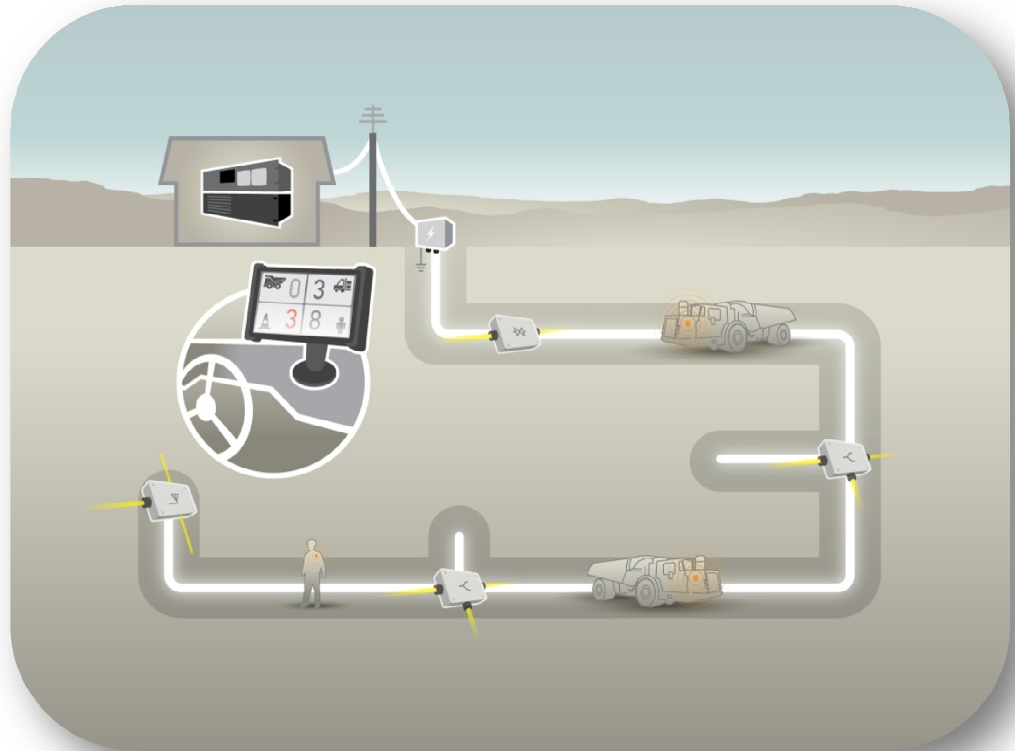
TRiAD COLLISION AVOIDANCE

TRiAD is a simple collision avoidance alert system that uses the same RFID technology as our MineAx tracking system.

The TRiAD unit is dash-mounted inside vehicles to provide visual and audible alerts to the driver when another person or vehicle is within range.

While the system operates independently from MineAx, the same RFID tags are used.

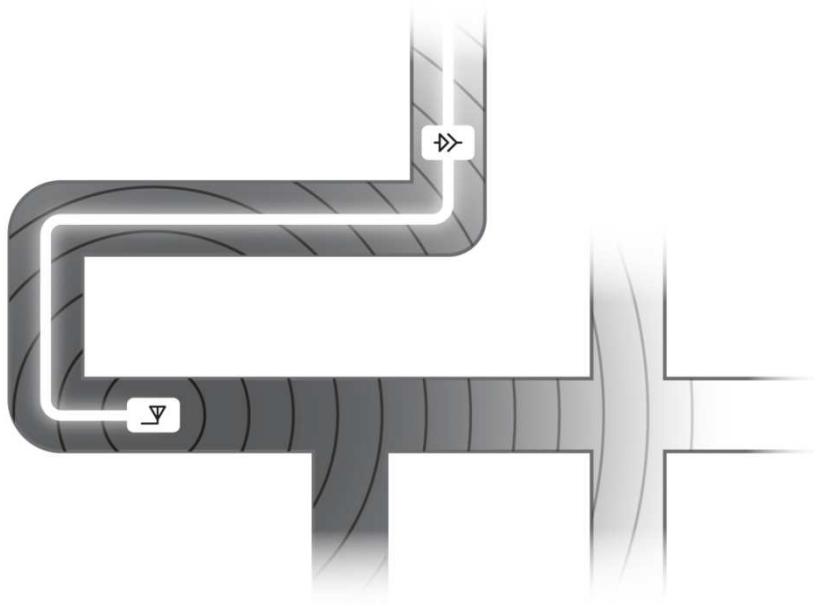
TRiAD features a large touch screen, quick and easy installation, and simple operation.



PLANNING A SYSTEM EXTENSION

THE NEED FOR GROWTH

As a mine expands, it will be necessary to provide radio coverage by extending the LF system into the newly formed areas.



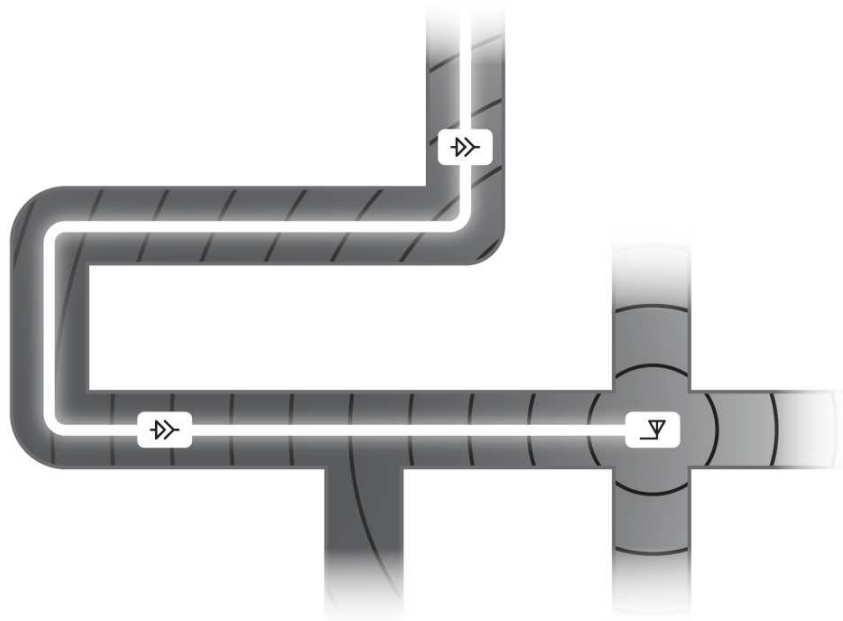
Careful planning is the
first step in every
successful system extension.

USE EXTRA CAPACITY FIRST

The extra capacity of a branch will tell you how much further the leaky feeder can be extended before installing an additional amplifier. Examine the mine map and identify the nearest upstream amplifier to support the area into which you want to expand.

Refer to amplifier manual to determine the proper length of cable between amplifiers. Remember, splitters will reduce the length of cable between amps. Refer to the splitter component overview on page 19 for details.

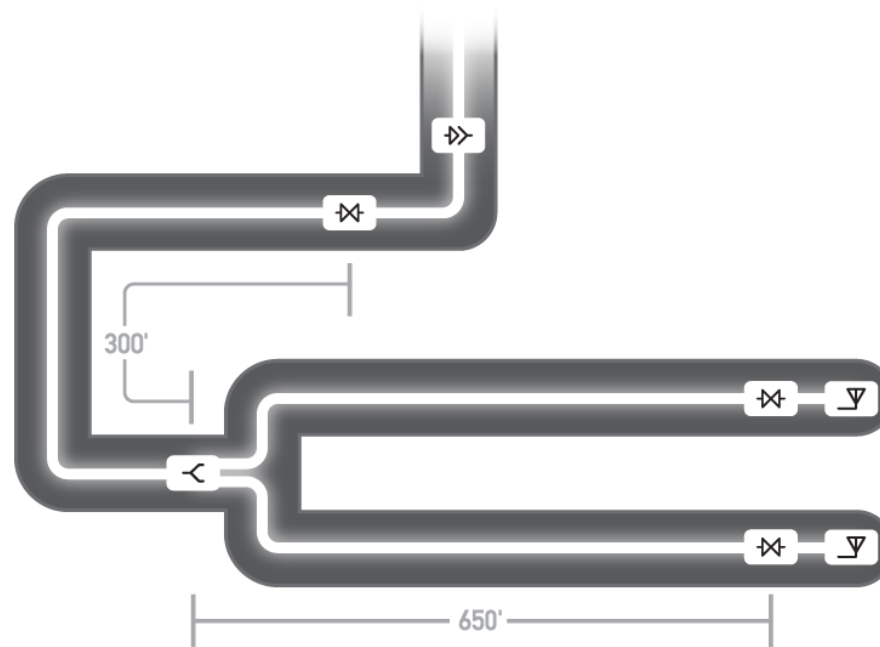
If necessary, use a splice box to add to existing leaky feeder.



HOW TO ADD AN AMPLIFIER

Attach an amplifier to the end of the leaky feeder, taking care to use the extra capacity first. (See page 40.) On a scale drawing of the area to be covered, draw in the paths that you expect the leaky feeder to follow. Draw in splitters, if necessary.

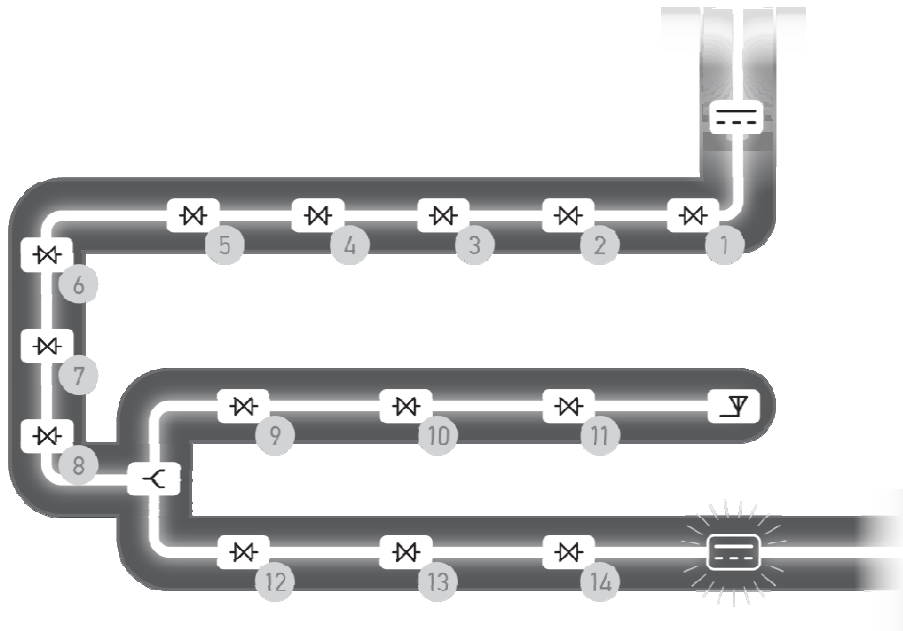
Refer to amplifier manual to determine the proper length of cable between amplifiers. Remember, splitters will reduce the length of cable between amps. Refer to the splitter component overview on page 19 for details.



A VHF installation might look something like this example.

HOW TO ADD A DC POWER SUPPLY & INSERT

As the mine expands, it may be necessary to provide additional DC power to the system, so that the amplifiers can perform their function.



Examine the mine map and identify the nearest DC power supply. In smaller installations, the head unit may be the only power supply.

Count the number of downstream amplifiers. If the number of amplifiers is more than the limit described in the amplifier manual, a DC power supply should be added.

The new insert should be located no closer than 10' to an amplifier.

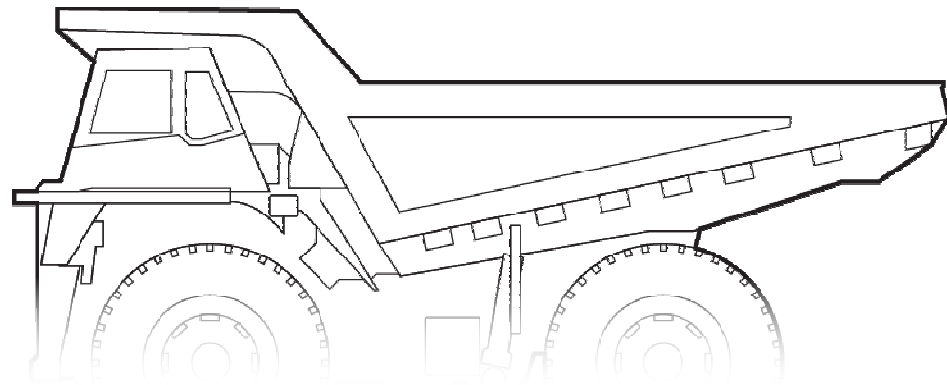
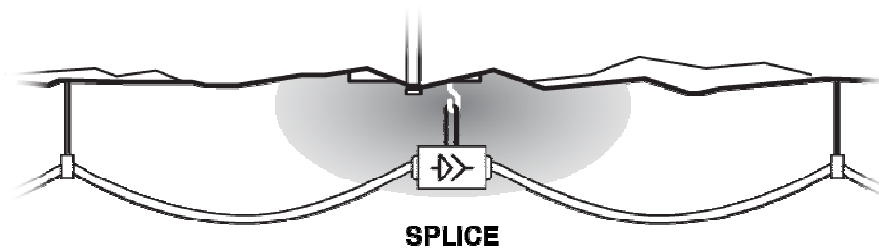
Certain VHF installations might resemble this example.

INSTALLING LEAKY FEEDER

MAKE YOUR MARKS

In accordance with your planning, survey the routing area and mark the splice, splitter, amplifier, and power insert locations.

Consider vehicle clearances when selecting component placement to minimize the possibility of damage due to snagging or collision.

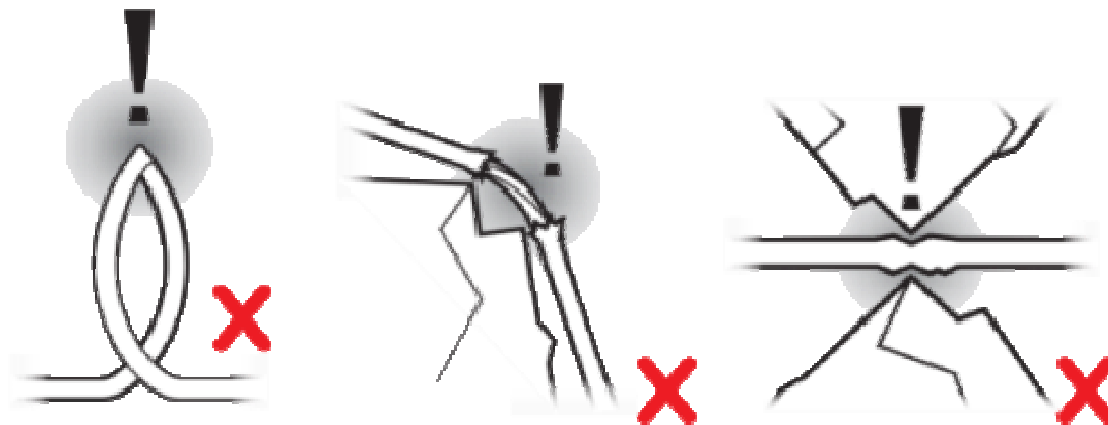


LEAKY FEEDER CABLE IMPORTANT CONSIDERATIONS

The primary function of the leaky feeder cable is to act as an antenna which transmits and receives signals throughout the mine. The secondary functions are to carry DC voltage to networked amplifiers and transfer RF from amp to amp.

Inspect each spool for shipping damage. Spools should be stored inside a covered area and kept dry to prevent water ingress.

DOs and DON'Ts for leaky feeder:



The leaky feeder cable must not be kinked, chafed or pinched.

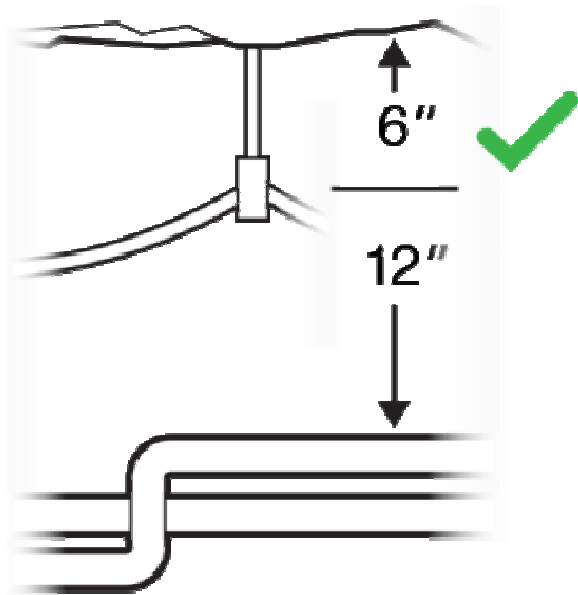
Place as little tension on the cable as possible.



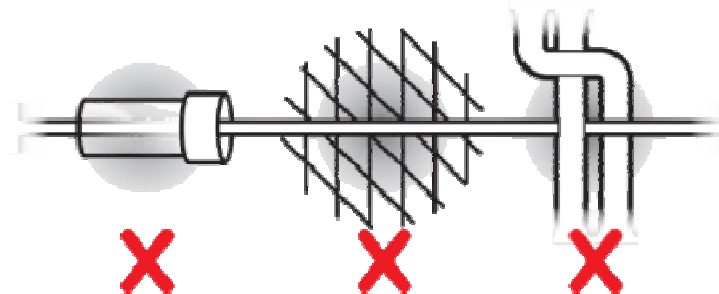
Pulling or stretching cable long distances will damage the cable internally.



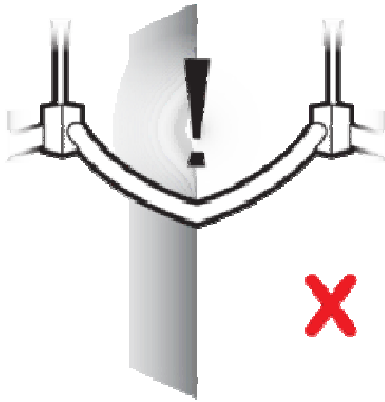
Try to keep cable around 6" away from the roof and wall.



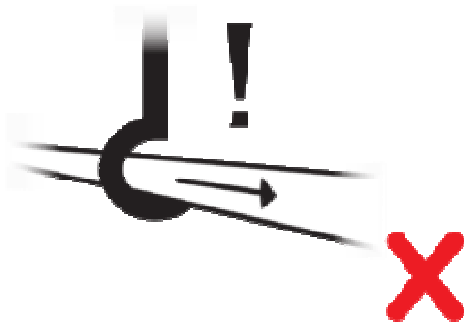
To the greatest extent possible, keep away from metallic conductors, conduit, pipes, metal mesh, etc.



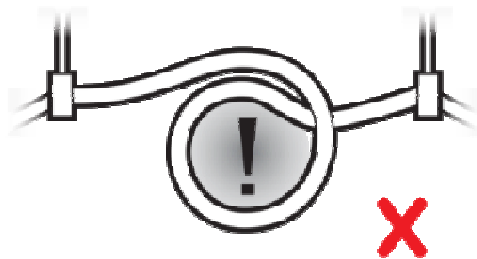
Use standoffs as necessary to maintain a 12" gap between the cable and such objects.



Pulling or stretching cable around corners will damage the cable internally.



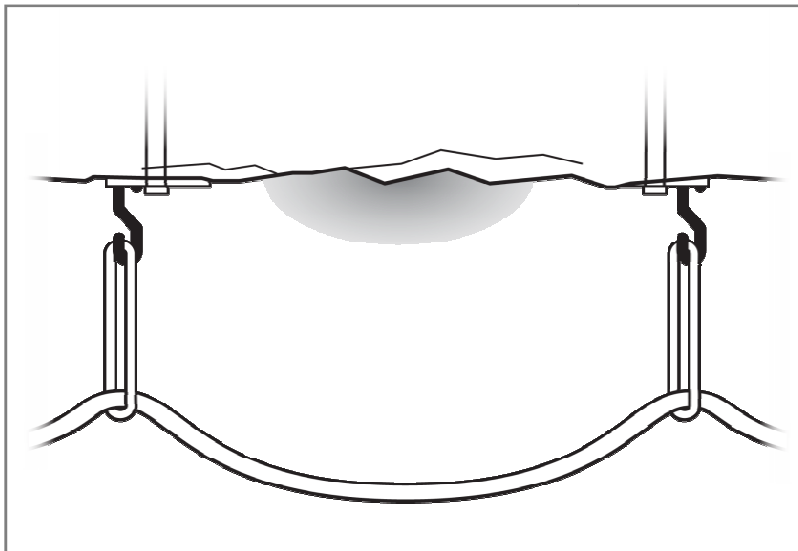
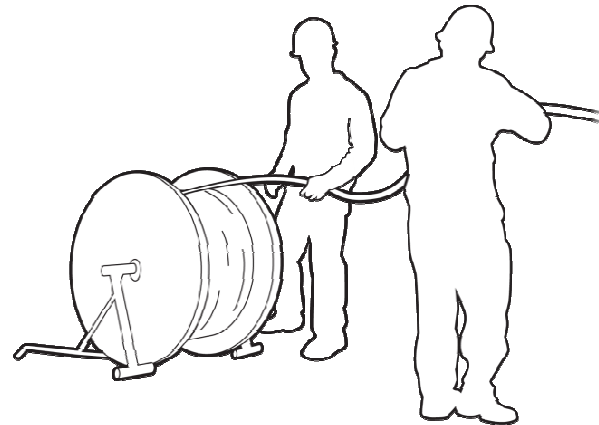
The cable cannot be pulled through hooks or hangers due to its delicate internal design.



Do not install the cable looped onto itself.

▪ LEAKY FEEDER CABLE - DRIFT INSTALLATION METHODS

Using a spool winder or reel buck, carefully unreel no more than 20' of leaky feeder cable at a time along the routing area.



Attach the cable to roof bolts as you go, using cable ties or tie wrap. Tie to the outside of metal hooks with cable ties.

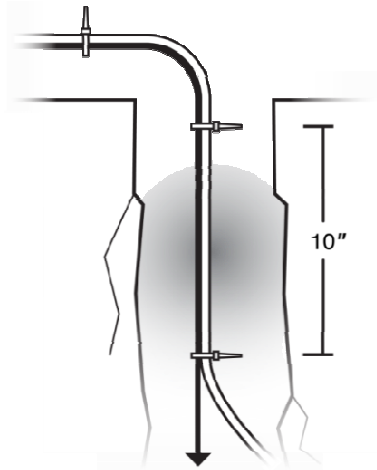
The recommended distance between hangers is eight (8) feet.

Allow the cable to sag at least 6 inches from the roof.

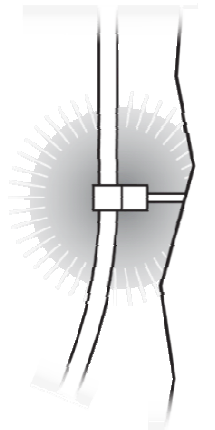
At every splice, splitter, amplifier, and power insert location be sure to leave 3' of slack. Do not install the cable in a loop on itself.

LEAKY FEEDER - SHAFT INSTALLATION METHODS

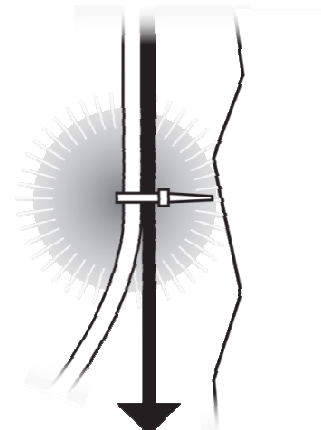
Shaft installations require special attention to cable location and attachment. If not properly installed, debris and moving parts can damage cable and/or amplifiers. Contact factory for assistance if in doubt.



If you are clamping to an existing messenger cable, clamp the leaky feeder to the messenger every 10'. Mount a spool winder or reel buck on the elevator and pay out the cable as the cage is slowly lowered.



If installing directly onto shaft wall, use cable clamps (Tunnel Radio part# TR-CL15x3). Place clamps every 6' to 10' in the wall and simply snap in cable as the cage is lowered.



If the LF cable must be dropped down through the shaft, tie-wrap the LF to a messenger cable every 10' and slowly lower the joined cables together. When fully extended, attach messenger cable to shaft wall, as necessary, for support.

No matter what installation method you use, leave 12' of slack at each end of shaft for future repairs.

As always, observe the important considerations when handling leaky feeder.

LEAKY FEEDER INSPECTION

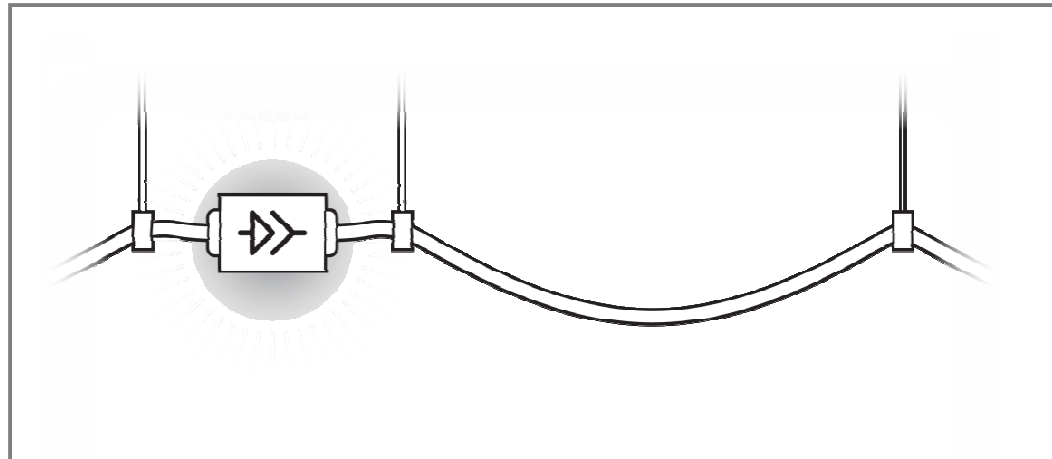


Replace any areas of pinched or kinked cable.

If internal damage is found, cut out the damaged segment and use a splice box to reconnect. Leave 3' of slack for future repairs.

Inspection of the leaky feeder cable should be done on a regular basis.

- If cuts in the outer jacket are found, inspect for damage to the internal metallic shield.
- If no internal damage is found, use seal tape on areas with jacket damage to prevent moisture ingress.



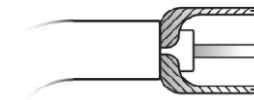
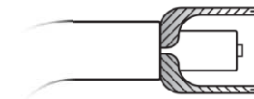
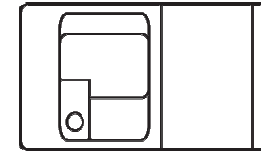
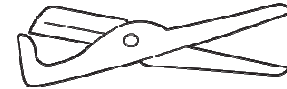
PREPARE LEAKY FEEDER FOR CONNECTIONS

Before you install splice boxes, splitters, amplifiers, and power inserts into the system, you will need to prepare the leaky feeder connections for attachment.

In order to work with clean conductors, use cable shears to cut off the end of the cable. Verify that there is no moisture in the end of cable. If moisture is discovered, then the cable may be unusable.

For VHF cable

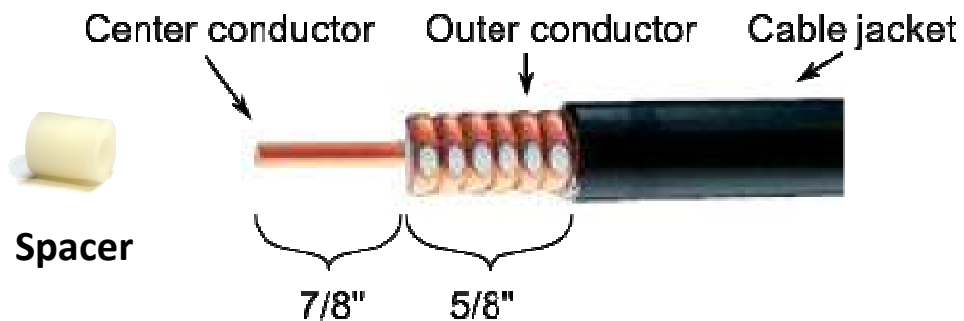
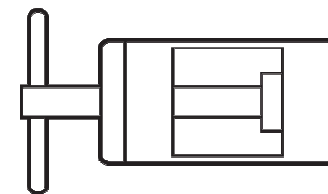
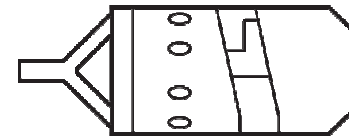
1. Use cable strippers to remove about $\frac{3}{4}$ " (19mm) of outer jacket without nicking or damaging ANY of the outer wires. Any wire broken off here will dramatically reduce the quality of your system.
2. Separate the outer small copper wires into two equal groups and use pliers to twist each group together. Include all of the wires. If any wires break off, use the cable shears to cut off the entire end of the cable and start again.
3. Cut back inner insulation $\frac{1}{2}$ " (13mm) to bare center conductor. To eliminate the possibility of stress damage later, be sure not to cut into this wire when removing the insulation.



PREPARE LEAKY FEEDER FOR CONNECTIONS (cont'd)

For UHF cable

1. Using the Tunnel Radio cable preparation tool (TR-RFS-TOOL-DRILL), strip 1½ " of the cable jacket from the cable.
2. Cut the exposed outer conductor to reveal 7/8" of the center conductor.
3. Carefully scrape the center conductor to remove the plastic coating, if present.
4. Using the cable coring tool (TR-RFS-TOOL), core out enough of the insulator between the inner and outer conductors to allow for insertion of the supplied plastic spacer.
5. Install the supplied plastic spacer.



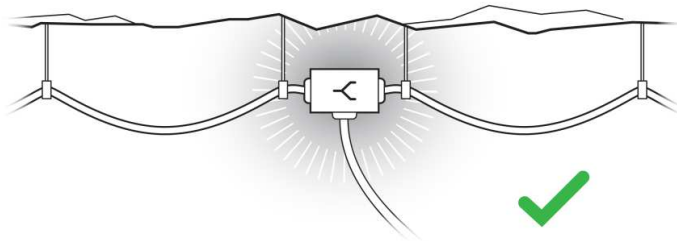
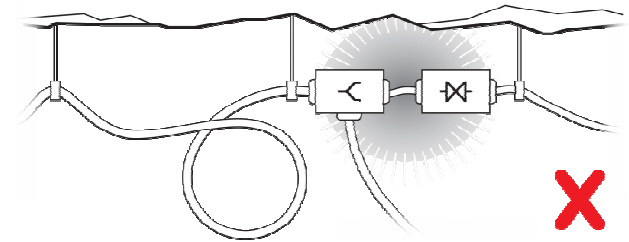
INSTALLING SYSTEM COMPONENTS

COMPONENT INSTALLATION: IMPORTANT CONSIDERATIONS

Warning!

Ensure that power is not being supplied to this branch of the leaky feeder system while component installation is in progress! Turn off power at base unit, power insert, or splitter, as applicable to your installation.

- Leaky feeder components such as amplifiers, power inserts, splitters, and splices must be located no closer than 10' from each other.
- Keep away from metallic conductors, conduit, pipes, metal mesh, etc., where possible.
- Keep components at least 6" from the roof and wall.



- Use the 3'-6' of slack leaky feeder to create drip loops that extend below the component.
- Take up additional slack using a figure-S pattern, being sure not to pinch or kink the cable.
- Separate cable runs by at least 6' immediately after entering or exiting components. Do not loop the cable on itself.

INSTALL SPLICE BOXES

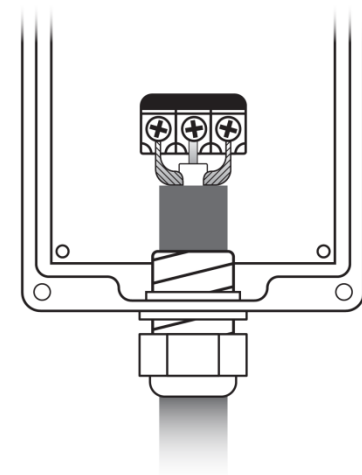
Warning!

Ensure that power is not being supplied to this branch of the leaky feeder system while component installation is in progress! Turn off power at base unit, power insert, or splitter, as applicable to your installation. Use a voltmeter to verify that power is not supplied.

No more than four splice boxes may be used per cable between amplifiers. If additional splices become necessary, the entire cable should be replaced as excess splice boxes will unacceptably degrade system performance.

For VHF Systems:

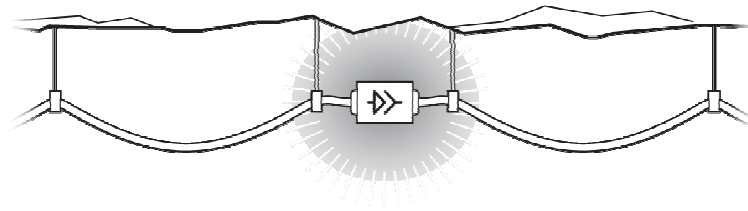
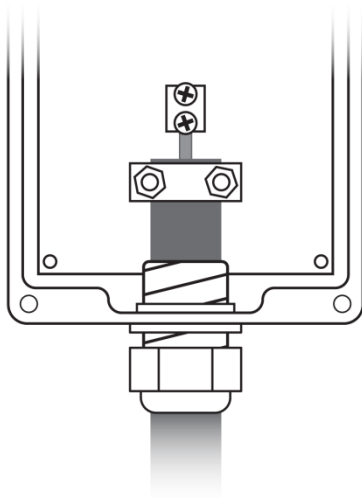
1. Remove the top cover and loosen a strain relief grip nut.
2. With all the wires facing forward, push the leaky feeder cable into the box through the strain relief.
3. Connect the center conductor to the center terminal and each twisted set to a corresponding outer terminal.
4. Tighten the center terminal and then the outers.
5. Tighten the upstream and downstream strain relief grip nuts by hand and replace the cover.



INSTALL SPLICE BOXES (cont'd)

For UHF systems:

1. Remove the top cover and loosen a strain relief grip nut.
2. Push the leaky feeder cable into the box through the strain relief.
3. Push the cable through the center of the clamp and into the hole in the block. The center conductor must be inserted far enough for both block screws to contact it. Take care not to allow the outer conductor to touch the block.
4. Fasten the center conductor to the block terminal using the screws provided. Be sure to tighten them well.
5. Tighten the nuts on the clamp to firmly contact the cable's outer conductor without pinching the cable jacket.
6. Tighten the upstream and downstream strain relief grip nuts by hand and replace the cover.

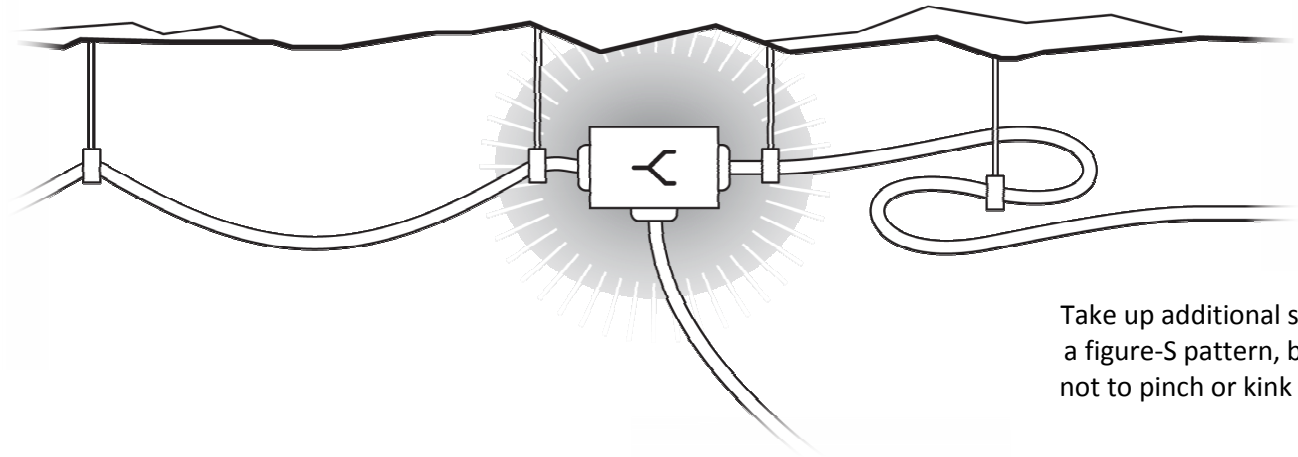


Use the 3'-6' of slack leaky feeder to create drip loops that extend below the component.

INSTALL SPLITTERS

Warning! Ensure that power is not being supplied to this branch of the leaky feeder system while component installation is in progress!

Remove the top cover and examine the splitter orientation. The arrow on the component PC board and/or the label on the outside of the box will indicate where to connect the cable that goes toward the base radio (outside the mine). This is the upstream direction. Make cable connections in the same manner as a splice box.



Take up additional slack using a figure-S pattern, being sure not to pinch or kink the cable.

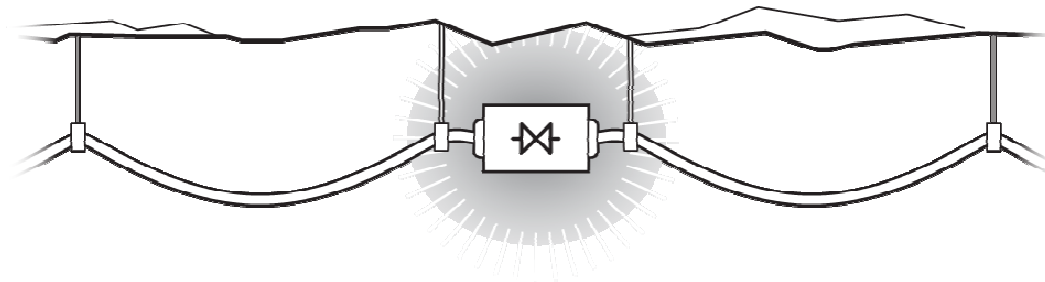
Use the 3'-6' of slack leaky feeder to create drip loops that extend below the component. Ensure that downstream cables are separated immediately for at least 6' upon exiting the splitter.

INSTALL AMPLIFIERS

Warning! Ensure that power is not being supplied to this branch of the leaky feeder system while component installation is in progress!

Note! Do not install amplifiers within 10' of power inserts, splitters or other major system components.

Remove the top cover and examine the amplifier orientation. The arrow on the component PC board and/or the label on the outside of the box will indicate where to connect the cable that goes toward the base radio. This is the upstream direction. Make cable connections in the same manner as a splice box.

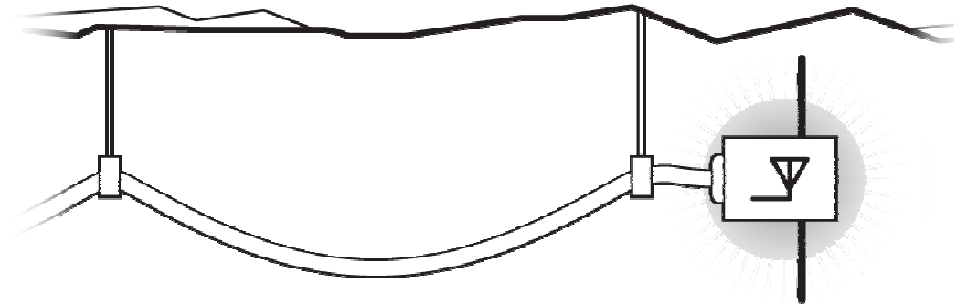


Use the 3'-6' of slack leaky feeder to create drip loops that extend below the component. Take up additional slack using a figure-S pattern, being sure not to pinch or kink.

INSTALL TERMINATION UNITS & TERMINAL ANTENNAS

Warning! Ensure that power is not being supplied to this branch of the leaky feeder system while component installation is in progress!

Make cable connection in the same manner as a splice box installation. (See page 58.)



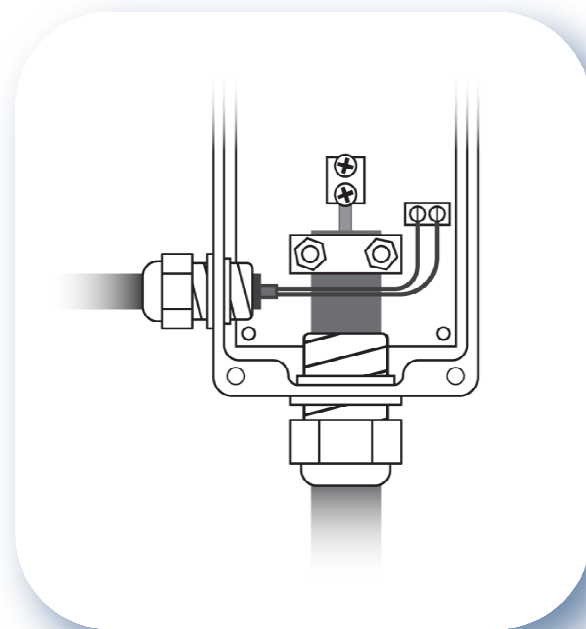
Use the 3'-6' of slack leaky feeder to create a drip loop that extends below the component. Take up additional slack using a figure-S pattern, being sure not to pinch or kink the cable.

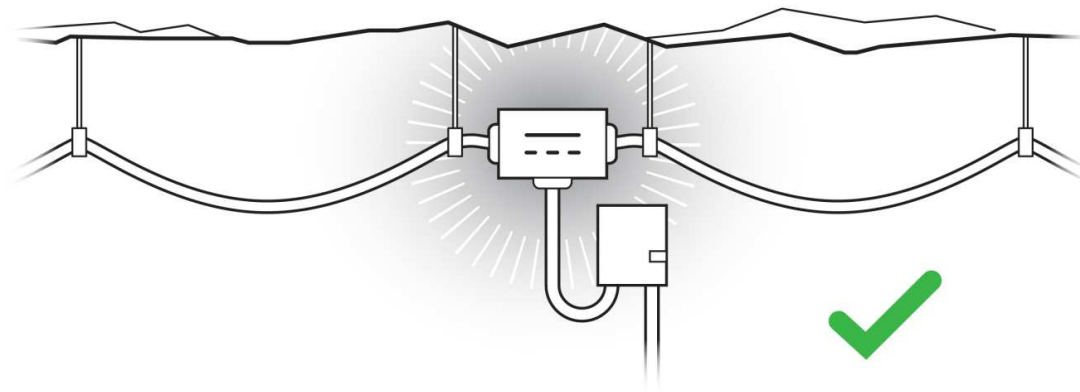
INSTALL DC POWER INSERT

Warning! Ensure that power is not being supplied to this branch of the leaky feeder system while component installation is in progress!

Note! The maximum distance from power supply to cable insert is 400' when using 18 AWG wire.

- Remove the top cover and examine the insert orientation. The arrow on the component PC board and/or the label on the outside of the box will indicate where to connect the cable that goes toward the base radio. This is the upstream direction.
- Make LF cable connections in the same manner as a splice box.
- Remove 2" of outer sheath from the DC cable to expose the internal wires.
- Loosen the DC cable entry strain relief grip nut. Push the DC cable into the box.
- Strip off 3/8" and crimp a ferrule onto each wire.
- Connect the red (+) wire to the positive terminal. Connect the black (-) wire to the negative terminal. Tighten terminals with hand tools only.
- Tighten the DC strain relief nut by hand and replace the cover.





Use the 3'-6' of slack leaky feeder to create drip loops that extend below the component.

Take up additional slack using a figure-S pattern, being sure not to pinch or kink the cable.

Create a drip loop with the DC cable and route the cable to the power supply in accordance with the expansion plan.

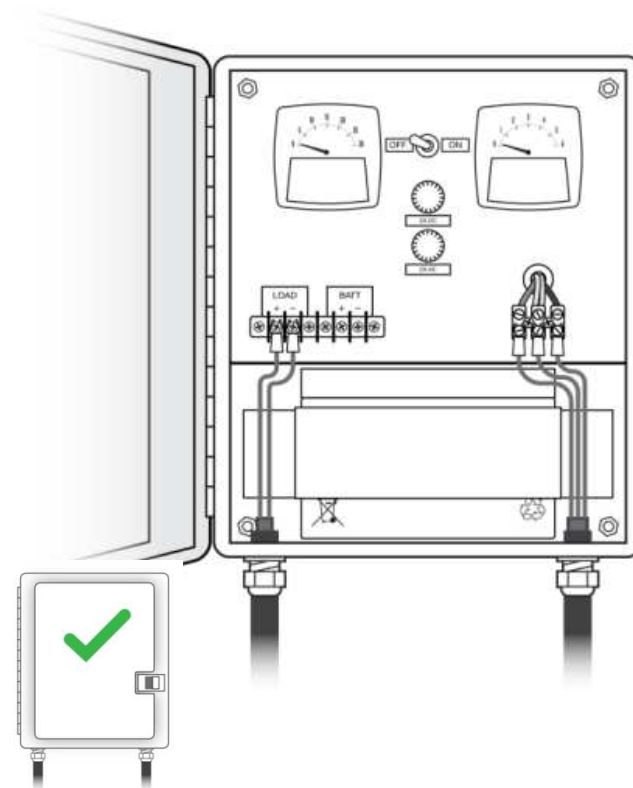
INSTALL DC POWER SUPPLY

Warning! This installation shall be made under the supervision of the certified mine electrical superintendant and follow all State, Federal and MSHA electrical codes and guidelines. Read entire section before proceeding.

Warning! Ensure that applicable AC mains power is disconnected while component installation is in progress!

Note! The maximum distance from AC mains to power supply is 100' with AWG 16/3 wire.

- Mount the power supply to a secure location in accordance with the expansion plan. Open the power supply front panel.
- Remove 2" of the black outer sheath from the DC cable to expose the internal wires.
- Loosen the DC cable entry strain relief grip nut. Push the DC cable into the box.
- Strip off 3/8" and crimp a ring or slip terminal to each wire.
- Connect the red (+) wire to the "LOAD+" lug. Connect the black (-) wire to the "LOAD-" lug. Tighten lugs with hand tools only.
- Tighten the DC strain relief nut by hand and close the cover.
- Secure DC cable, as necessary, to ensure a drip loop.
- Connect the AC plug to 112VAC to complete the installation.

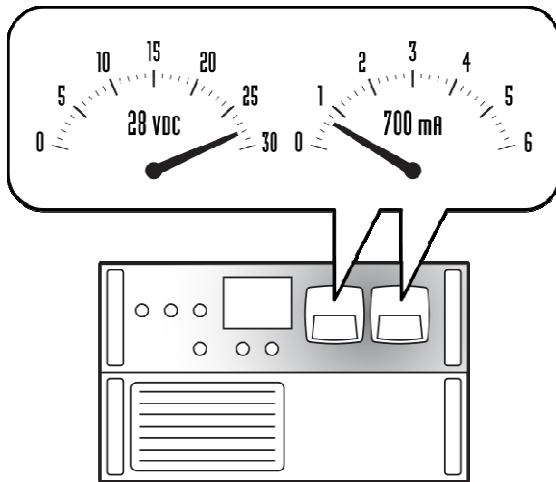


PREVENTIVE INSPECTION

WEEKLY OPERATIONS INSPECTION

Simple procedures, when performed on a regular basis, are the first line in assuring service quality. Regular verification of communications clarity is the best way to assure consistent and reliable coverage throughout the system.

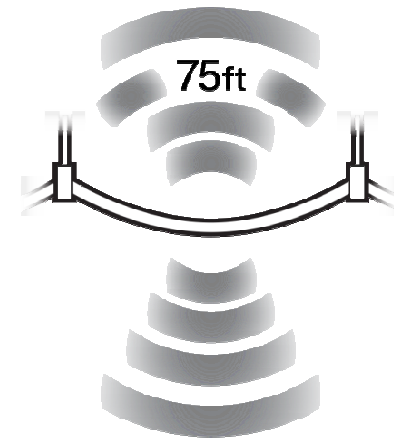
Every week -



- Dust head-end cabinet and keep free of clutter that may interfere with ventilation.
- Verify that head indicates proper supply voltage (*See manual*).
- Verify that head ammeter indicates less than 1A.

- Verify a minimum 75' clear voice communication range from VHF leaky feeder cable throughout mine. (UHF systems can expect over 200' communication range.)

A record of the examination should be kept on file for future

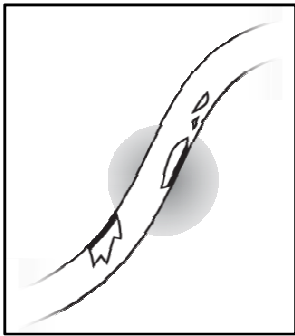


WEEKLY DAMAGE INSPECTION

Over 75% of all failures are due to cable, connection, and water intrusion damage. Establishing a regular routine of system inspection is vital.

Every week:

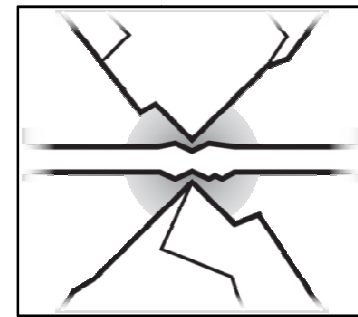
Carefully examine the system for indications of physical damage such as:



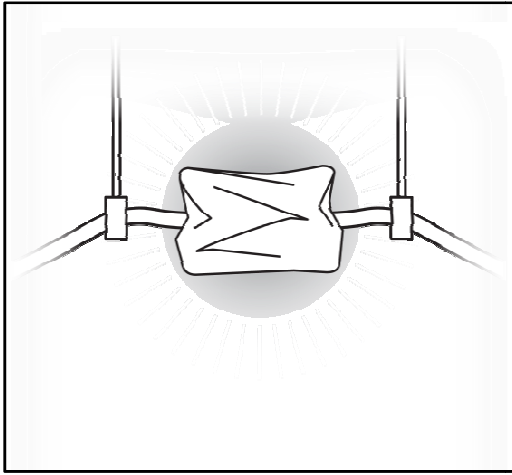
Cut or abraded cable sheathing



Visible signs of corrosion which may suggest pinhole breaks in sheathing



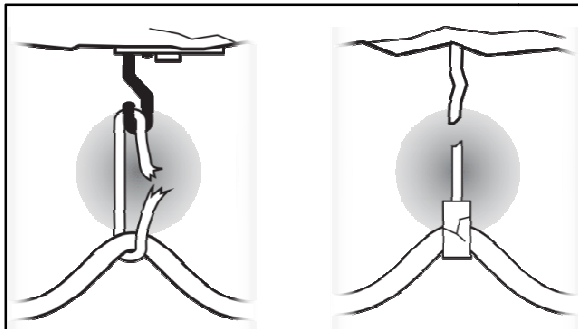
Pinched cables



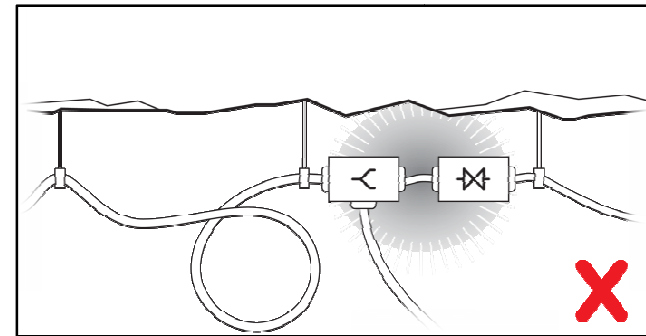
Damaged or compromised enclosures



If cable sheathing is damaged but no internal damage is found, use seal tape on areas with damage to prevent moisture ingress.



Damaged nylon clamps or cable ties



Improperly routed cables which may suggest an unauthorized repair

PERIODIC INTERNAL INSPECTION OF COMPONENTS

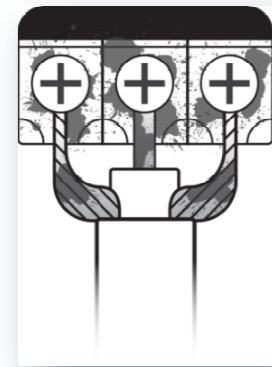
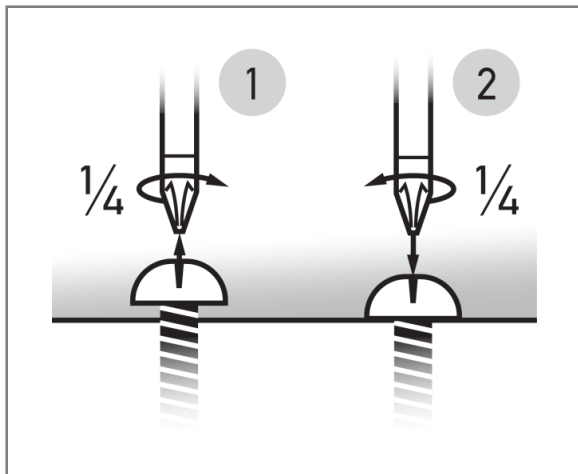
WARNING! These instructions do not apply to power supplies!
For instructions on how to inspect power supplies, see page 73.

Warning! Ensure that power is not being supplied to this branch of the LF system while retightening connections!

Every month:

For each system component, remove the top cover and check for:

- Condensation or standing water
- Corrosion at or near the cable connections
- Corrosion anywhere else, including circuit boards, interconnects, and mounting screws



Additionally, ensure good electrical contact with the terminals by loosening each connection by $\frac{1}{4}$ turn and retightening using hand tools.

PERIODIC INTERNAL INSPECTION OF POWER SUPPLY

Warning! Ensure that power is not being supplied to this branch of the leaky feeder system while retightening connections!

Every month:

Check for:

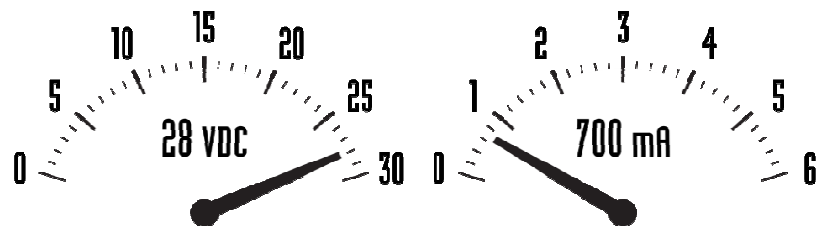
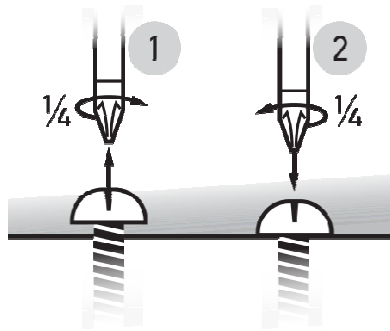
- Condensation or standing water
- Corrosion at or near the cable connections
- Corrosion anywhere else including circuit boards, interconnects, and mounting screws



Every three months:

Ensure good electrical contact and operation:

- Turn off power and see that the volt and current gauges read zero.
- Ensure good electrical contact with the LOAD terminals by loosening each lug by $\frac{1}{4}$ turn and retightening using hand tools.
- Turn power back on and see that voltmeter indicates the proper voltage and ammeter indicates no more than 1A.



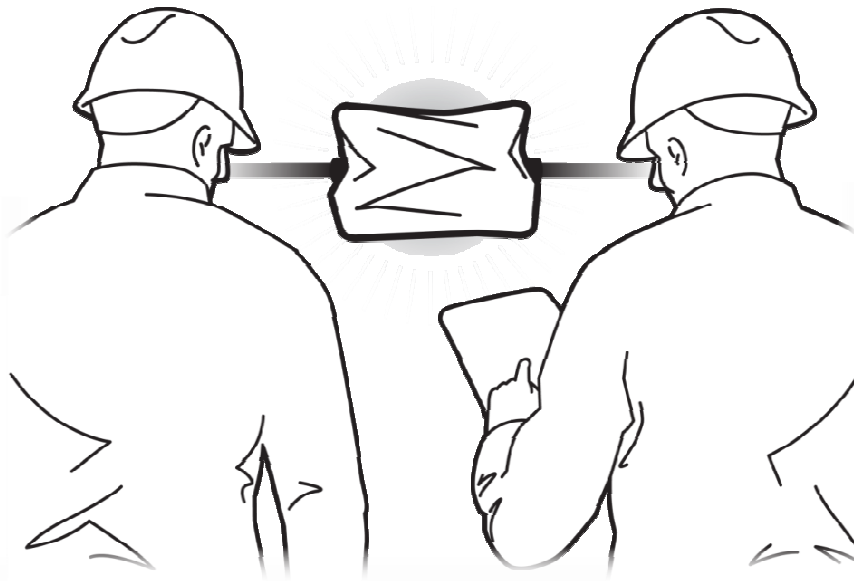
BASIC TROUBLESHOOTING

CONSIDERATIONS

Warning! Always disconnect power when removing and/or replacing system components or tightening connections.

A good understanding of system operation and specific mine system layout are all that is required to properly repair the most common problems. Always keep a system map handy when troubleshooting.

Most faults in a mine radio system center around damaged cable, water intrusion or low DC power. Any of these faults can result in degraded or disabled operation.



Due to simplicity of design, the system can be quickly serviced if a disciplined step-by-step troubleshooting procedure is used.

When troubleshooting, always start at the head unit and work your way downstream to the end of the suspect branch.

It is often best to work in teams of two.

RECOMMENDED TOOLS

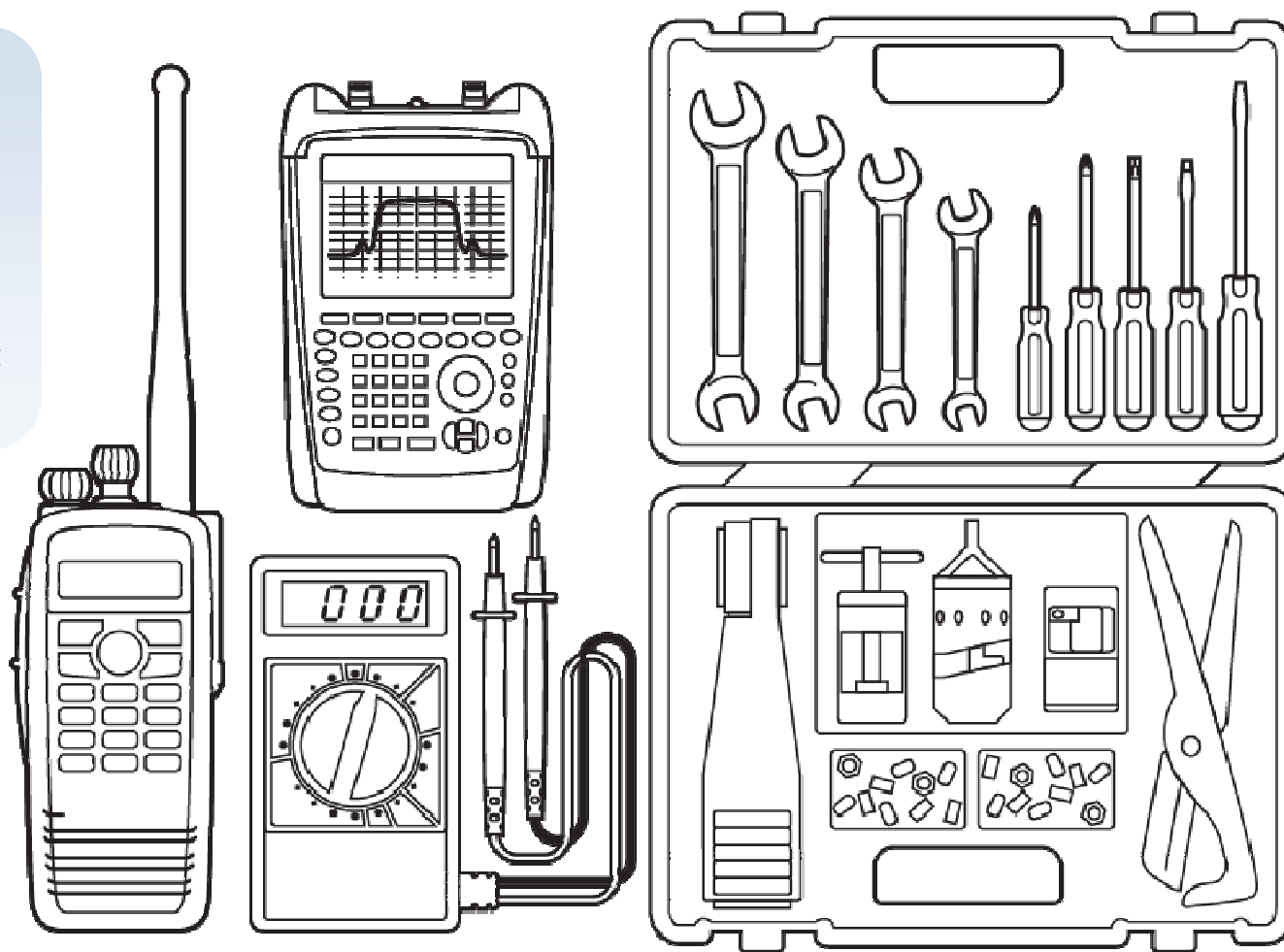
The following is a recommended list of equipment needed to properly service and troubleshoot the system.

Two-way radio

Digital Multimeter

Spectrum Analyzer

Standard tool set, including
cable splice tools



CHECK FOR SHORTS

Proceed to the head unit. Verify operation of repeaters by use of portable radios.

Check status of LEDs on the head unit to verify DC power is “on” and that the voltmeter shows proper voltage is being supplied.

Use the branch power switches to check the amperes supplied to each individual branch. If a single branch is consuming more than 1 ampere of current, then there is probably an electrical short on that branch.

If the branch is consuming less than 1 ampere of current and there are no additional power inserts downstream, then the possibility of a short on this branch has been eliminated.

Otherwise, proceed to the next downstream power insert.

Check status of LEDs on the insert to verify DC power is “on” and that the voltmeter shows proper voltage is being supplied.



Check the amperes supplied. If this segment is consuming more than 1 ampere of current, then there is probably an electrical short on that segment.

Repeat this test for every power insert. If all segments are drawing less than 1 ampere of current then the possibility of a short has been eliminated.

IF A SHORT IS SUSPECTED

Starting at the head or power insert, proceed in the downstream direction and inspect the leaky feeder as you go.

When you reach the nearest downstream amplifier or splitter, open its case and use the switch to turn off downstream power.

Use a voltmeter to probe the DC voltage across the upstream leaky feeder center conductor and shield. If the DC voltage is greater than 8, turn on downstream power, close the case, and proceed to next component. If the DC voltage is less than 8, remove the component from the system.

Measure the voltage across the upstream leaky feeder center conductor and shield again. If the DC voltage is less than 8, then the short is in the upstream leaky feeder segment itself and requires inspection.

If the DC voltage is greater than 8 then the removed component is faulty and should be replaced.

CHECK FOR OPENS

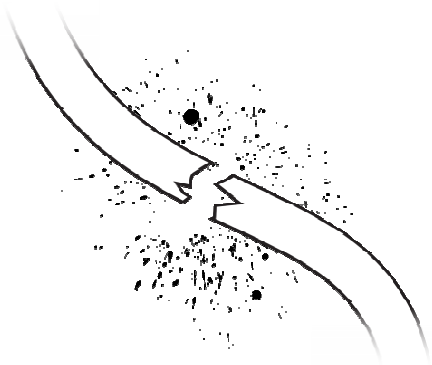
Proceed to the head unit. Verify operation of repeaters by use of portable radios.

Proceed to the first downstream amplifier or splitter. Verify that the "DC OUT" indicator is lit.

If the indicator is not lit, then a probable electrical open has been discovered.

Repeat this process for every component up to the last amplifier in the suspect branch.

Beyond the last amplifier, simply perform a routine component and damage inspection.



IF AN OPEN IS DISCOVERED

Open the component case and use a voltmeter to probe the DC voltage across the upstream leaky feeder center conductor and shield.

If the DC voltage is near zero, then the open is likely within the upstream leaky feeder itself or where connection is made to the nearest upstream component.

If the DC voltage is greater than 8, then the open is possibly within this component.

Disconnect the downstream leaky feeder.

Turn on downstream power and observe the "DC OUT" indicator.

If the "DC OUT" indicator is lit, move to the next component downstream.

If the "DC OUT" indicator is not lit, then the component or possibly internal fuses should be replaced.

TECHNICAL SUPPORT

CONTACT US

We are dedicated to helping you maintain the quality of your communications systems.

For more information about the Ultracomm System, please do not hesitate to contact your local dealer or Tunnel Radio directly at techshop@tunnelradio.com.

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