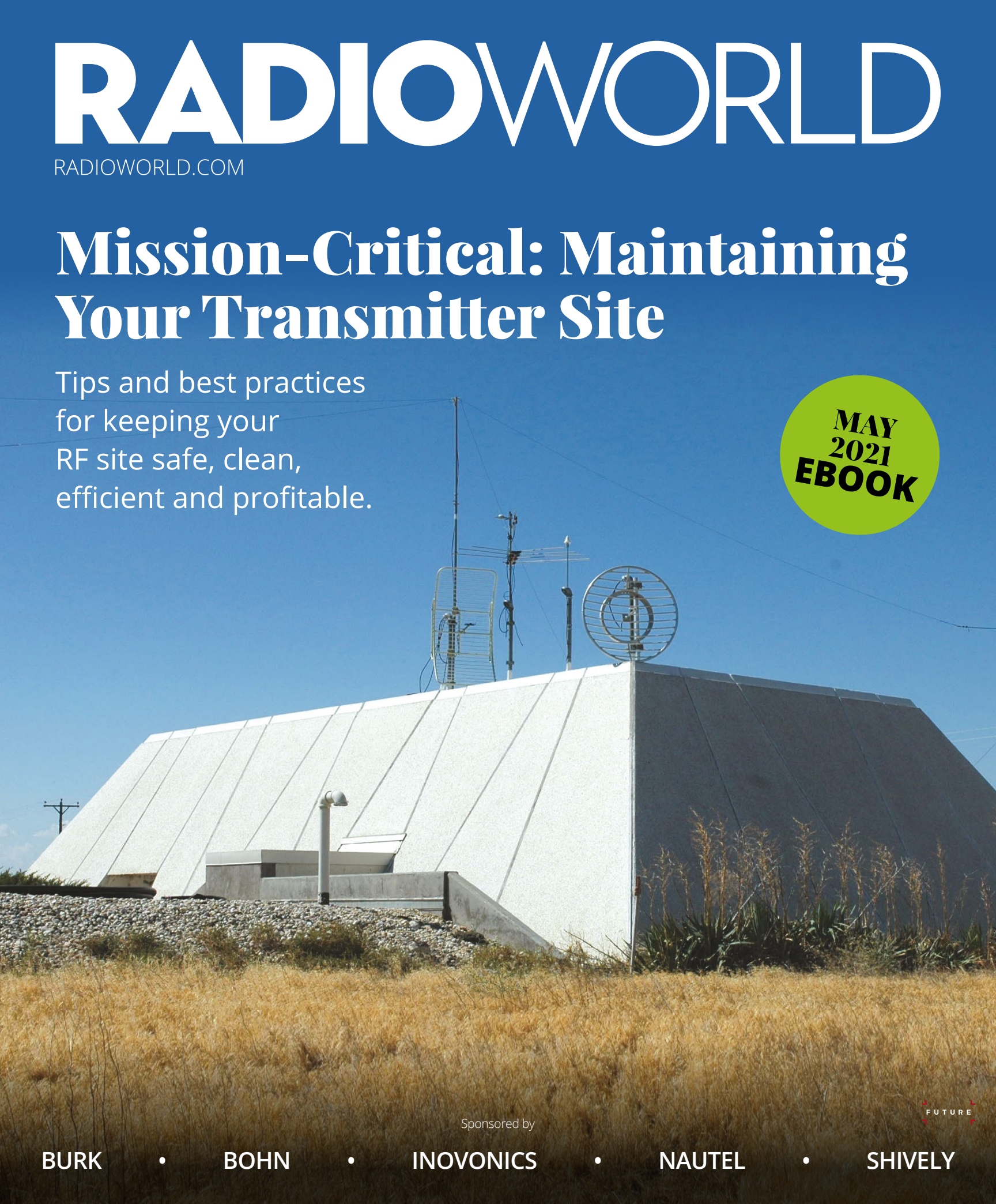
RADIOWORLD
RADIOWORLD.COM

Mission-Critical: Maintaining Your Transmitter Site

Tips and best practices for keeping your RF site safe, clean, efficient and profitable.

MAY 2021 EBOOK



Sponsored by

BURK • BOHN • INOVONICS • NAUTEL • SHIVELY

FUTURE

11 THINGS
YOU DIDN'T KNOW ABOUT GV

- **NEW** future-ready embedded compute engine with 10X more processing power
- **NEW** efficient power supplies for reduced cost of ownership
- Cool operation for long life & reliability
- Field-serviceable RF power modules
- More power FETS for more power headroom
- Full cabinet design for easy service
- Positive pressure airflow for better heat transfer
- Cold start to full power in seconds
- ON-Air fan replacement
- Outstanding reliability based on 2,000+ installs
- HD Spectrum/Efficiency Optimizer for pristine signal quality & high efficiency

PLUS

FOR A LIMITED TIME: FREE 2nd back-up Exciter*

Contact your Nautel Rep today

877-628-8350 or nautel.com/11things

Worry-Free Transmission | Because Radio Matters

* • Limited time offer
• Offer cannot be combined with other promotions or discounts
• Worldwide

nautel

RADIOWORLD

May 2021 eBook
www.radioworld.com

FOLLOW US
www.twitter.com/radioworld_news
www.facebook.com/RadioWorldMagazine

CONTENT
Managing Director, Content & Editor in Chief Paul J. McLane, paul.mclane@futurenet.com, 845-414-6105
Senior Content Producer — Technology Brett Moss, brett.moss@futurenet.com
Technical Advisors Thomas R. McGinley, Doug Irwin
Technical Editor, RW Engineering Extra W.C. "Cris" Alexander
Contributors: Susan Ashworth, John Bisset, James Careless, Ken Deutsch, Mark Durenberger, Charles Fitch, Travis Gilmour, Donna Halper, Craig Johnston, Alan Jurison, Paul Kaminski, John Kean, Peter King, Larry Langford, Mark Lapidus, Jim Peck, Mark Persons, Stephen M. Poole, James O'Neal, Rich Rarey, Jeremy Ruck, John Schneider, Randy Stine, Tom Vernon, Jennifer Waits, Chris Wygal
Production Manager Nicole Schilling
Managing Design Director Nicole Cobban
Art Editor Rob Crossland

ADVERTISING SALES
Senior Business Director & Publisher, Radio World
John Casey, john.casey@futurenet.com, 845-678-3839
Publisher, Radio World International
Raffaella Calabrese, raffaella.calabrese@futurenet.com, +39-320-891-1938

SUBSCRIBER CUSTOMER SERVICE
To subscribe, change your address, or check on your current account status, go to www.radioworld.com and click on Subscribe, email futureplc@computerfulfillment.com, call 888-266-5828, or write P.O. Box 1051, Lowell, MA 01853.
Licensing/Reprints/Permissions
Radio World is available for licensing. Contact the Licensing team to discu ss partnership opportunities.
Head of Print Licensing Rachel Shaw licensing@futurenet.com

MANAGEMENT
Senior Vice President, B2B Rick Stamberger
Chief Revenue Officer Mike Peralta
Vice President, Sales & Publishing, B2B Aaron Kern
Vice President, B2B Tech Group Carmel King
Vice President, Sales, B2B Tech Group Adam Goldstein
Head of Production US & UK Mark Constance
Head of Design Rodney Dive

FUTURE US, INC.
11 West 42nd Street, 15th Floor, New York, NY 10036

Connectiv The Business Information Association, a division of SIIA

All contents ©2021 Future US, Inc. or published under licence. All rights reserved. No part of this magazine may be used, stored, transmitted or reproduced in any way without the prior written permission of the publisher. Future Publishing Limited (company number 02008885) is registered in England and Wales. Registered office: Quay House, The Ambury, Bath BA1 1UA. All information contained in this publication is for information only and is, as far as we are aware, correct at the time of going to press. Future cannot accept any responsibility for errors or inaccuracies in such information. You are advised to contact manufacturers and retailers directly with regard to the price of products/services referred to in this publication. Apps and websites mentioned in this publication are not under our control. We are not responsible for their contents or any other changes or updates to them. This magazine is fully independent and not affiliated in any way with the companies mentioned herein.

If you submit material to us, you warrant that you own the material and/or have the necessary rights/permissions to supply the material and you automatically grant Future and its licensees a licence to publish your submission in whole or in part in any/all issues and/or editions of publications, in any format published worldwide and on associated websites, social media channels and associated products. Any material you submit is sent at your own risk and, although every care is taken, neither Future nor its employees, agents, subcontractors or licensees shall be liable for loss or damage. We assume all unsolicited material is for publication unless otherwise stated, and reserve the right to edit, amend, adapt all submissions.

FUTURE
Connectors. Creators. Experience Makers.

Future plc is a public company quoted on the London Stock Exchange (symbol: FUTR)
www.futureplc.com

Chief executive **Zillah Byng-Thorne**
Non-executive chairman **Richard Huntingford**
Chief financial officer **Rachel Addison**

Tel +44 (0)1225 442 244

ipso Regulated

Mission-critical: maintaining your transmitter site

Paul McLane
Editor in Chief

Whether your transmitter site is collocated with your studios, sitting in a country field or high atop a mountain, it's a critical component of your broadcasting airchain. The RF site is more than a transmitter and a tower, it's an entire ecosystem.

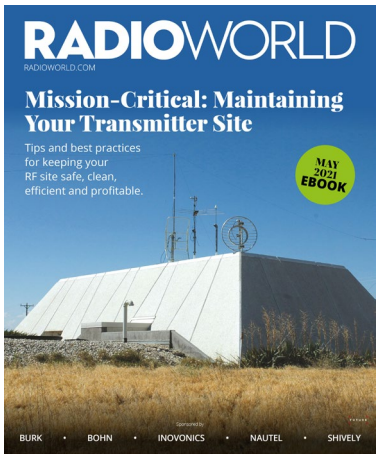
This Radio World ebook relates best practices and tips for maintaining that site for clean, safe, efficient and profitable operation.

What items should be on the engineer's checklist for each site visit and for quarterly or annual review? What provisions for redundancy or backup should be taken into account?

How can managers help in the creation and execution of a maintenance program? What should a non-engineer know if they need to check on a site?

We asked Jeff Welton, John Bisset, Paul Tinkle, Buc Fitch, Josh Bohn, Peter Burk and Sean Edwards to give us the benefit of their experience.

As always I welcome your comments on this ebook or any other Radio World content at *radioworld@futurenet.com*. That email address comes right to me.



On the cover: The transmitter building serving Cumulus Media station KBOI(AM) in Boise, Idaho, has been likened to an inverted hog trough. Built in 1968 for the station's move from 950 to 670, it still looks futuristic. Promotional statements at the time claimed the concrete structure's sloping walls wouldn't interfere with the 50,000-watt signal from KBOI's six towers. What's more, there was a Cold War-era boast that if the site were ever attacked, radiation would slide off the building's walls. Photo courtesy Scott Fybush.

THIS ISSUE

NEWS

Best practices at your transmitter site

A compilation of tips from Radio World's popular Workbench column

Writer
John Bisset
CPBE
is in his 31st year of gathering and editing user tips in Workbench.

Working more efficiently is a "must" in this day of multiple studios and transmitter sites — especially when you are the sole engineer.

Even though every site is different, you can use this basic checklist as a starting point, and customize it for each of your sites.

Take a drive

We'll start with the drive up to the transmitter site — which begins in the studio!

Yes, the studio. Do you have a set of clear driving instructions to get to all of the transmitter sites from the studio location? Are the legal addresses also listed, to be given to a 911 operator if needed? Is there a site telephone number? Should an emergency occur, it's important to have clear concise instructions, with a map, for each location. Inform your management — owner, GM, OM, SM and PD — of this information and where it is kept.

One engineer printed and laminated small cards with the site addresses and telephone numbers printed on them, and gave one to each department head. You can't be too safe!

Now you're ready to drive to the site. Especially for AM directionals, which may be affected by new construction, keep an eye out for anything being constructed near your site — especially towers - which could affect your pattern.

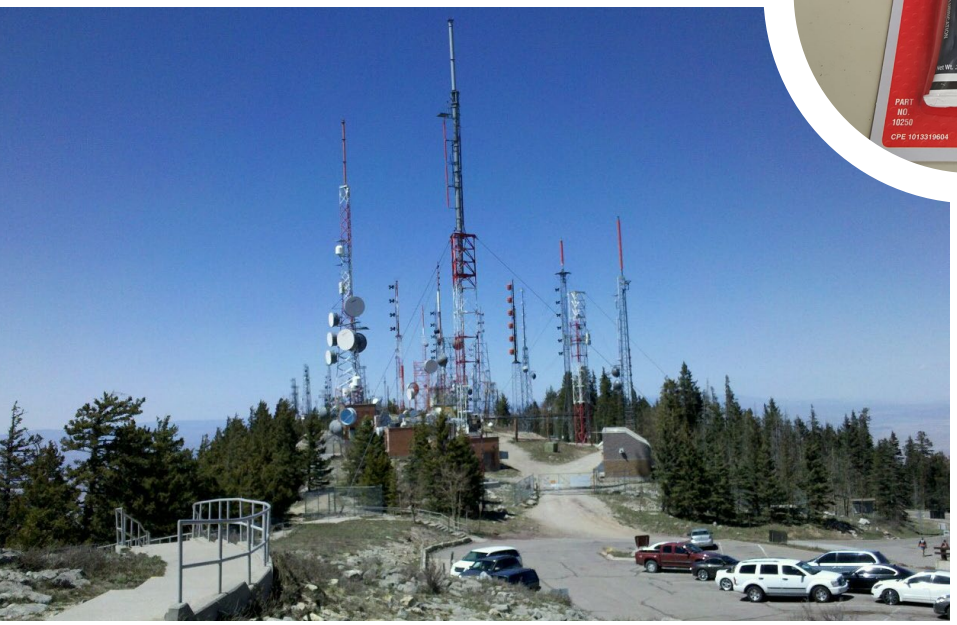
As you arrive, inspect your driveway chain, gate, fencing and locks. Situations like that depicted in Fig. 2 are no fun to discover when you are off the air!

Be sure to lubricate locks at least twice a year, or quarterly in harsher environments, and replace any rusted locks. After lubricating the locks, work the mechanism to ensure that the lubricant coats the internal parts.

You can find a variety of cleaning/lubricating compounds at the big box stores. Powdered graphite, shown in Fig. 3, is one choice.

If you need to replace locks, consider paying the premium to get multiple locks keyed identically. One key opens all the locks (and reduces the size of your key ring). Personally, I like Master Combination Locks. Should there be a security breach, you can easily change all the combinations, instead of replacing a half-dozen keyed locks.

Always reset your combination locks to 0-0-0-0 after opening. This discourages someone from "reading"



Below left
Fig. 1: A mountaintop site in New Mexico, a mile above Albuquerque.

Below right
Fig. 2: The start of a bad day at the transmitter site.

Middle
Fig. 3: Powdered graphite keeps locks functioning properly.

Left
Fig. 4: This IP camera monitors both a door and an exhaust flapper on a generator.

Above
Fig. 5: An example of the efficiency of pleated air filters.

the combination should they come upon the open lock while you are visiting the site. And if on your next visit you find anything other than 0-0-0-0, you know someone has tried to enter the site, prompting a more thorough site inspection. Many engineers add another level of security by re-locking the lock after entering.

If appropriate, install an outdoor "wildlife" camera near the gate entrance. These cameras are motion-activated, and some models have the ability to capture images at night.

Closer to the building, consider a "live" IP camera to surveil the site. Fig. 4 shows an IP camera used by Cumulus Media at one of its Charleston sites. It serves a dual purpose. Market Engineer Justin "J.T." Tucker mounted the camera so as to capture not only the building entrance but also the exhaust flapper on the generator — a quick means of verifying generator engine operation.

Take a walk

Before entering the transmitter building, take a few minutes to walk around the outside.

In northern New Hampshire, as soon as the snow is gone, contract engineer Stephanie Donnell takes a walk around her sites to check for vandalism — broken floodlights, holes in the building wall, graffiti or any other problem that doesn't look right.

Notify the sheriff or the police of any discoveries. A police report may be needed should the damage require an insurance claim. Be sure to snap pictures of damage/vandalism with your camera phone.

The invention of the camera-phone is perhaps one of the most useful for the broadcast engineer — use it liberally.

Stephanie also goes out to the guy wire anchor points and makes an inspection. Check for loose ground jumper connections, and visually inspect the condition of the anchors, ground rods and connections. She tries to do this in the short period after the snow melts and before the ticks arrive!

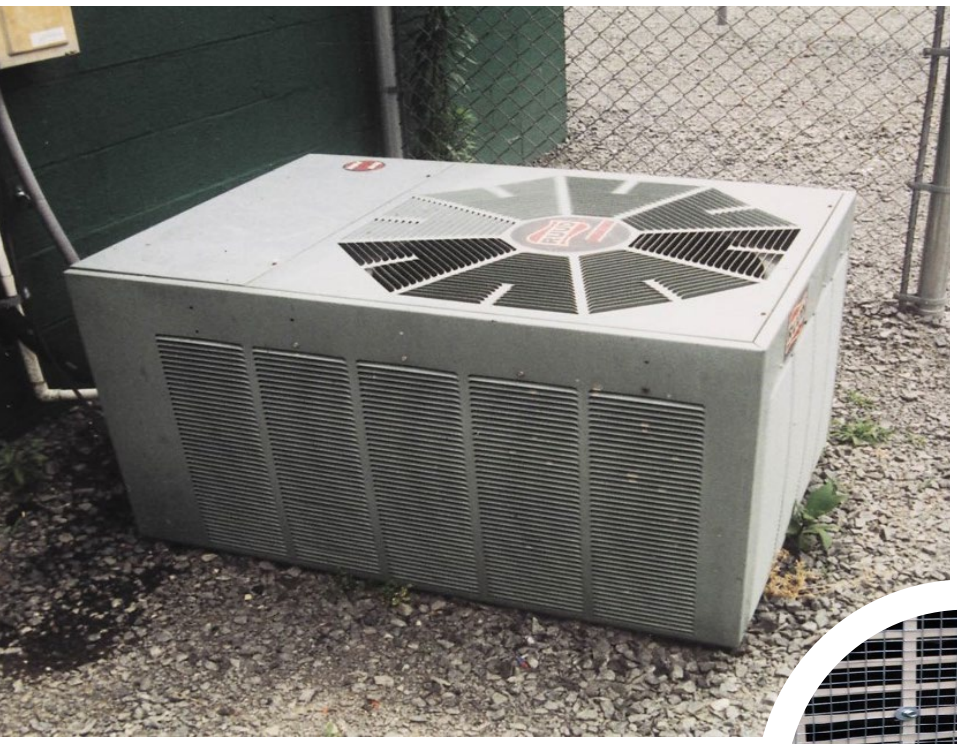
If you have an old lawnmower, you can fight the tick issue by mowing a path through the brush to the anchor points and to each tower. Be sure to check any other station grounds around the building.

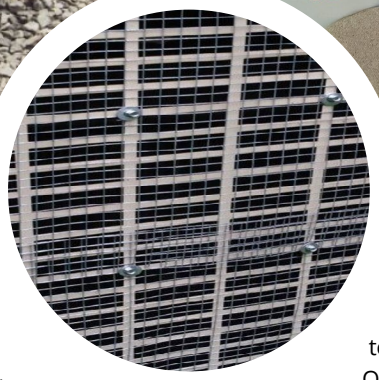
Other, less glamorous, things that can be done this time of the year include clearing drainage culverts and checking for dead trees/limbs that could damage phone or electrical lines.

The spring is also a good time to replace air conditioning filters, so that things inside your building stay COOL. If you're not using pleated air filters, like those shown in Fig. 5, pay the extra money and watch how clean they keep your site!

If your building circulates outside air, check the air intakes. Keep them clear of weeds, debris and nesting insects like wasps. In a closed air system, inspect the air conditioning. This includes the belts on the air handlers.

Problems with weeds growing around the building can





Above
Fig. 6: Crushed stone placed over landscape fabric to prevent weeds also repels snakes and mice.

Middle
Fig. 7: Screening with 1/2-inch mesh blocks rodents from entering your generator.

Above Right
Fig. 8: An investment of less than $10 to provide a snack for your service folks will reap dividends.

be addressed by spreading a weed barrier or heavy black plastic along the perimeter of the building, and then covering the plastic with crushed stone, as shown in Fig. 6. This also deters snakes and rodents, which prefer the camouflage of grass and weeds looking for an entry point to your building.

If your site has a generator, open the enclosure and check for leaking fluids. Of particular importance are the coolant and oil levels.

Are the battery terminals free of corrosion? Look around inside the enclosure, checking for anything unusual — this includes loose hardware or belts, as well as rodent or insect infestation. Half-inch wire mesh on the air intake, as seen in Fig. 7, will discourage rodents.

After inspecting the inside of the generator, run a test under load, noting and recording all the engine readings. A load test is necessary because the generator may run fine until the load of the transmitter is connected through the transfer switch. Better to discover a problem now than when you need the generator in an emergency.

Take a sip

If you are not familiar with the transmitter site generator, budget for a service visit by a qualified generator tech and service company. If you're new to the site, ask for a recommendation from other engineers in the market. Shadow the tech and take lots of notes and pictures with the cell camera. You're not there to take over the tech's job, just become more familiar with the equipment.

Bring a couple of soft drinks or coffee and a snack for you and the tech to share, something simple such as that in Fig. 8. You'll find that this gesture goes a long way in establishing rapport with any technician doing work at your site.

One important thing to find out, about your generator, is the rate of fuel consumption under load. Determine your fuel tank capacity and calculate how often the tank must be filled during an actual emergency. Taking the time to determine this information under "non-emergency" conditions is less stressful. It's also a good idea to pplan how fuel will be delivered, having the fuel service contact information posted at the site.

Inside the building

Ensure the door lock operates properly and the door closes completely — this will not only reduce the chance of vermin or insects entering your building, but combined with the better filtering, the equipment will be kept cleaner.

First, if you don't have an emergency flashlight with fresh batteries right inside the door, make that a priority. Showing up at a site at night, with no power, can be a dangerous proposition. Having a flashlight right inside the door is good insurance.

Many hardware stores sell inexpensive bright LED flashlights. Fig. 9 shows a model found at Ace Hardware. Pictured in Fig. 10 is a light that looks like a light switch, and includes a variable brightness control. This particular LED light also has a magnet on the back, making it convenient to "stick" on steel walls, conduit or door frames.

PROFESSIONAL REMOTE MONITORING

FROM ANY LOCATION. ON ANY DEVICE.

AM | FM | HD | DAB | DAB+

TAP INTO YOUR BROADCASTS THROUGH AN EASY TO USE REMOTE WEB INTERFACE
WITH INOVONICS' EXPANSIVE OFFERING OF REMOTE MONITORING EQUIPMENT.

531N FM Modulation Analyzer

Direct and off-air reception. Keep a sharp eye on total RF signal performance.

525N AM Modulation Analyzer

Third generation AM Modulation Monitor designed for accurate AM readings even in the presence of Hybrid Digital (IBOC) transmissions.

INOMINI 635 FM/RDS SiteStreamer™

SOFIA 568 HD Radio® SiteStreamer+™

SiteStreamers

Compact Size with huge features.
Powerful web graphics & Internet streaming.
Dante AoIP available on all SOFIAS.

www.inovonicsbroadcast.com | sales@inovonicsbroadcast.com | 831-458-0522

WHY **INOVONICS?**

- Quality Solutions. Competitive Prices.
- Quick to install. Easy to Program.
- Three-year Factory Warranty.
- Quality after sales service.

TRY OUR LIVE PRODUCT DEMOS!

INOVONICS BROADCAST

Above Left
Fig. 9: One of a variety of inexpensive but bright LED lamps found at Ace Hardware.

Above Right
Fig. 10: This LED light is dimmable and has a magnet on the back for easy attachment to steel racks, cabinets or door frames.

Below
Fig. 11: A telltale sign of rodent issues: mouse droppings on the floor.

Once inside the building, with everything operating normally, take a set of readings of your critical on-air equipment. If you don't like paper logs, snap pictures of the test meters with your camera phone. The point is to obtain a set of readings when everything is operating normally as a reference later when a problem arises. The comparison of readings can help you diagnose what's wrong.

This "composite" set of readings are not just for the transmitter but include the STL gear, audio processor, remote control and any other equipment. On subsequent visits, before adjusting anything, check these critical readings first. They become your "baseline" for normal operation.

Years ago at one of the NAB transmitter workshops I presented, one of the manufacturer panelists wisely observed he had never seen lightning or a power surge "readjust" the phasor or the transmitter tuning. Why is it we are quick to adjust these controls before observing the whole picture? Look — don't touch — first!

Make sure the readings include power supply voltages. Power supply component failures can cause a multitude of problems. If you know what's "normal," a problem can be diagnosed more easily and quickly.

Stop — look — listen

Use your ears, eyes and the sense of smell and touch as you enter the building.

When you entered, did you notice a rodent scurrying for cover out of the corner of your eye? Though you may not see the rodent, are mouse droppings visible on the floor, as pictured in Fig. 11?

To guard against infestation, scatter a few mothballs on the floor of equipment racks, or invest in Bonide's Mouse Magic packets, available online (http://www.bonide.com) or in garden centers.

Do not eat or drink in the building, but if you must, remove all trash and food wrappers.

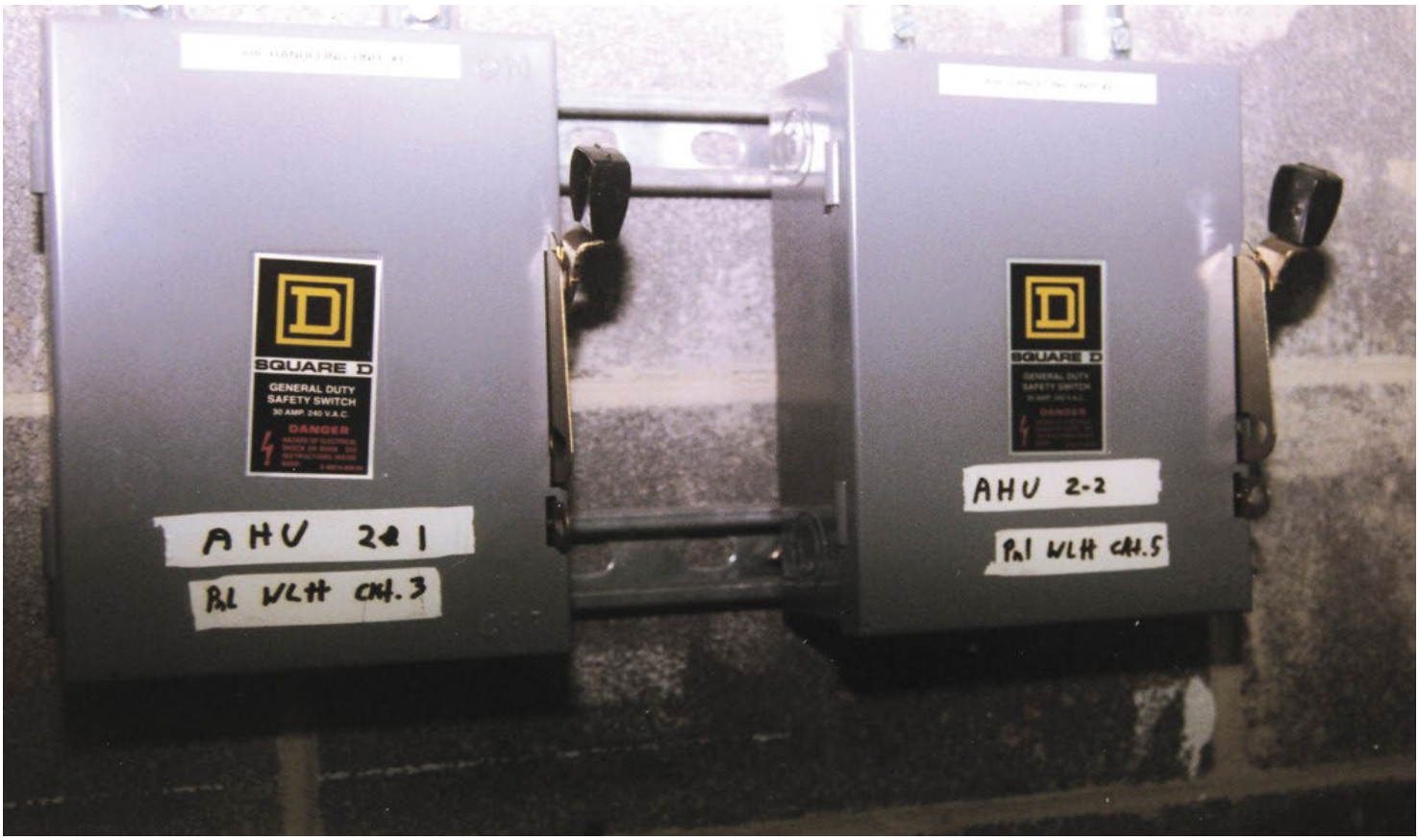
Is there a smell of burning or over-heated insulation in the air? If you have rigid transmission line, are the elbows and junctions warm or hot to the touch? (Warm is OK, hot signifies a problem to be investigated.)

Does a high-power transmitter blower motor have a squealing bearing? If that blower stops working, you're off the air. Address the problem now.

During her career in New England, Stephanie Donnell has maintained many transmitter sites, and she recommends paying special attention to the electrical panels. For the most part, these are out of sight, out of mind; and there can be a problem brewing behind that cover.

Feel the outside of the panel cover and the breakers themselves for any unusually warm breakers. Just like the rigid transmission line, warm is usually OK, hot is not. A quick visual scan may identify a breaker that tripped on seldom-used equipment. Better to find that problem now.

A tripped breaker may not always be evident, so inspect them all. While you're at the electrical panels, label the big



fused circuit disconnects as seen in Fig. 12. Knowing what equipment is associated with which disconnect can be a lifesaver in an emergency.

Breakers that feed Ground Fault Interrupter outlets are another source of potential problems. A GFI can trip, but a plug may cover the "test/reset" buttons so that you can't see that the GFI has tripped. The lesson is not to plug any critical gear into GFI outlets.

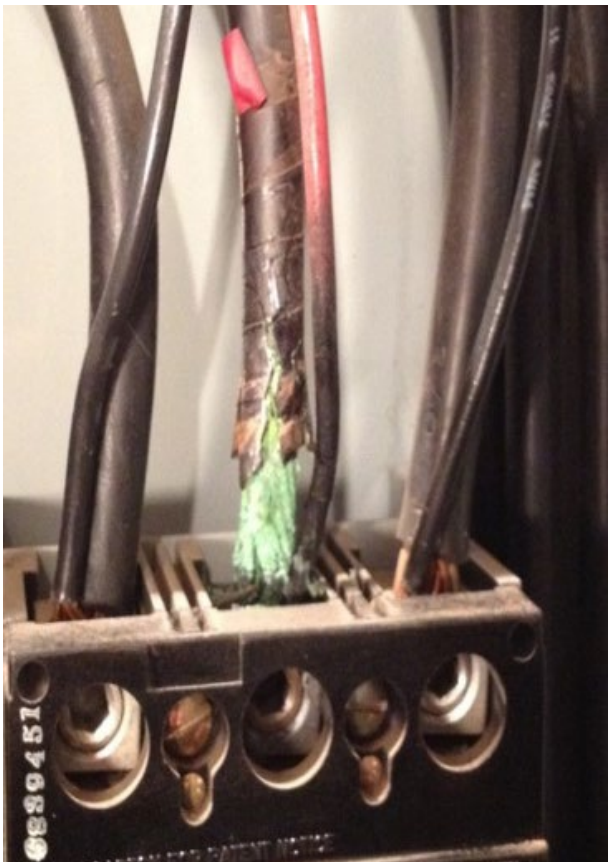
During an inspection, Stephanie noticed that one of the HVAC units at a remote site was off. Since it was early spring in northern New Hampshire, the second HVAC unit was easily keeping the equipment room cool.

Stephanie found the circuit breaker for one of the HVACs to be tripped. After resetting it and checking the HVAC unit, she determined the breaker itself was bad, as the unit still would not run. She de-energized the entire panel, safely, and though the transmitter was off for about 20 minutes, she replaced the breaker. After re-energizing the panel, the transmitter came back up, as did the HVAC unit. There were no further issues.

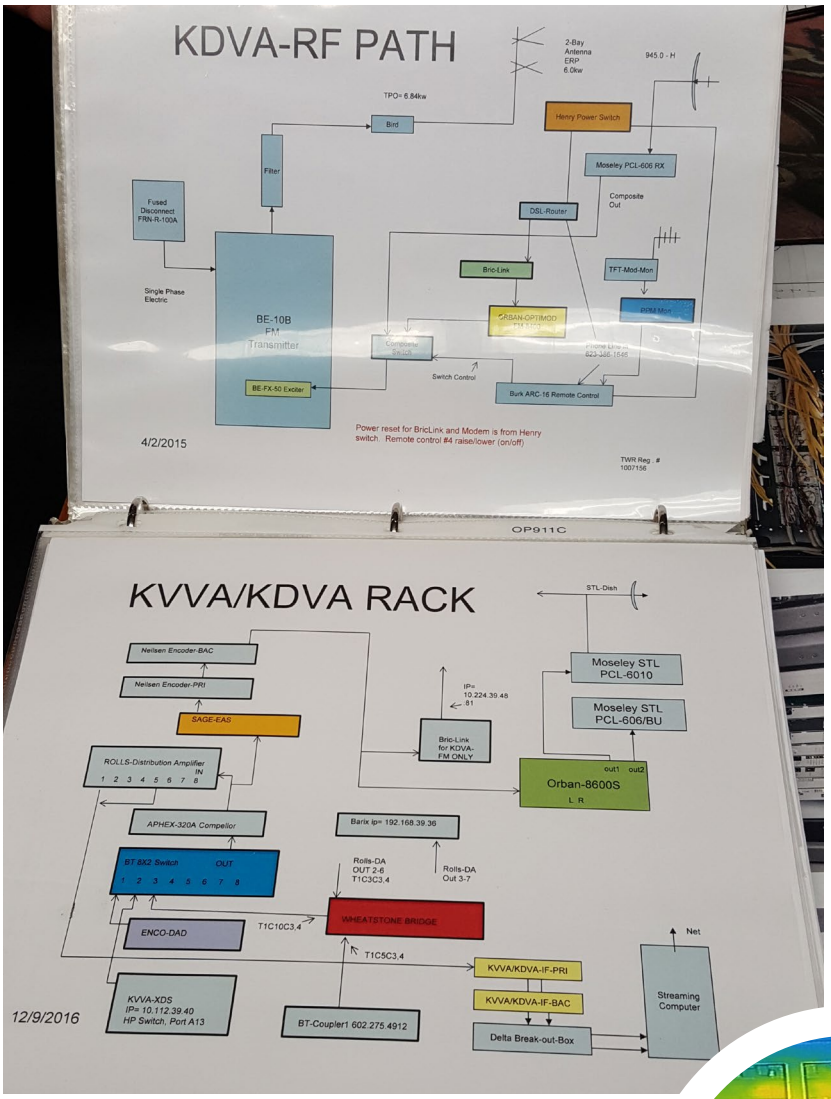
Speaking of disconnects, do you have a supply of spare fuses? Not just one, but several? Add them to your shopping list at the big box store.

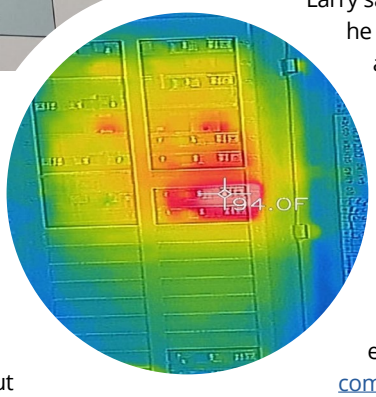
Before COVID-19, the subject of electrical boxes brought a lively discussion at several SBE programs that Telos provided. At least once a year, it is good insurance to bring in an electrician to tighten all wiring connections in your

Above
Fig. 12: Duct or gaffer's tape works just fine for identifying AC disconnects.



Right
Fig. 13: Screws do come loose. Loose wires can generate heat and eventually burn or fail. troubleshooting.





Right
Fig. 14: Use the FLIR IR camera smartphone adaptor to detect overheated breakers.

Above
Fig. 15: A notebook with block diagrams of your signal flow speeds troubleshooting.

disconnect panels.

As seen in Fig. 13, loose wires generate heat and eventually will burn and cause failure. The yearly electrical "maintenance" will more than pay for itself, should you have a burnout.

Fig. 14 demonstrates a thermal image from a FLIR Pro Infra-red camera. These smartphone add-ons are not inexpensive but well worth the cost for what they can diagnose. For contract engineers, they provide another source of revenue. You can take thermal pictures of a station's electrical boxes to diagnose problems before they turn into catastrophes.

Do you know what LEDs or pilot lights indicate normal operation? Snap a picture of the normal operation of these lamps, using your camera phone, print it out and post it in your maintenance log. You do have a maintenance log, right? Although no longer required by the FCC, such a logbook can be invaluable as a repository for descriptions of maintenance and repair tasks at the transmitter site.

Larry Wilkins is the director of engineering service at the Alabama Broadcasters Association. Larry says that while the FCC doesn't use the words "maintenance logs" in the rules, it does state in section 73.1350 that each licensee is responsible for maintaining and operating its broadcast station in a manner that complies with the technical rules set forth elsewhere and in accordance with the terms of the station authorization, i.e. the FCC license.

Monitoring procedures and schedules must enable the licensee to determine compliance with §73.1560 regarding operating power and AM station mode of operation, §73.1570 regarding modulation levels, and, where applicable, §73.1213 regarding antenna tower lighting, and §73.69 regarding the parameters of an AM directional antenna system.

When an FCC or Alternative Broadcast Inspection Program inspector comes by, they will want to know how you comply with that section of the rules. The log itself doesn't have to be anything fancy; a 25-cent notebook works fine.

Each time you visit the transmitter site, make a note of all the items you observed and checked, along with any repairs or adjustments you made.

Not only will this satisfy the inspector, but it will provide a record of maintenance issues over the years. Given the reliability of most broadcast gear, I found that when a failure occurred and I logged the repair, I didn't have to remember how I previously solved a problem. I just read the "fix" in the maintenance log. Again, being efficient.

As for posting the FCC licenses at the transmitter site, Larry says that in the ABA's engineering courses, he doesn't push keeping a copy of the license at the transmitter anymore, since they are normally posted on the station's online public inspection file. If it is not posted (as with a lot of AM stations), you should keep a copy at the transmitter site or load it on to your phone so it will be available.

Larry works through the ABA to offer a variety of free radio and television engineering courses. Visit https://al-ba.com/wp2/aba-engineering-academy to find out more.

As systems become more complex, signal paths proliferate and backups are installed, do you have a flowchart for your signal paths? A notebook outlining signal paths for each site can be invaluable, as displayed in Fig. 15. Dwight Morgan, shares that with Workbench readers. Not only is this kind of information useful for you, it can help your "fill-in" when you are on vacation.

You ARE taking a vacation now and then, right?

Send your tips to be shared with fellow readers. Email johnpbisset@gmail.com.

200+

FREE Technical Tools

to have in your toolbox

Online resources to help you operate worry-free in these challenging times

Transmission Talk Tuesdays

Learn from your peers in these popular round-table discussions.

Register for upcoming sessions:

June 8	How Technology has changed our Lives
June 15	SNMP: How to and Why
June 22	STLs: Moving Signals from Here to There
June 29	Tips & Thoughts for Contract Engineering

See the full archive here ›

How to Videos

Over 25 videos that answer your most common technical questions.

See all our how-to videos here ›

Tips 'n' Tricks

From security to critters! Technical tips from our award-winning educator, Jeff Welton.

See the full archive here ›

eBooks

Over 30 comprehensive eBooks covering a wide range of radio broadcasting topics.

9 Mistakes to Avoid when Buying a Transmitter ›

More eBooks ›

Webinars

40+ in-depth webinars covering a wide range of topics that qualify for SBE Recertification Credits.

See the full archive here ›

White Papers

In-depth technical papers from Nautel engineers.

Lightning Protection for Radio Transmitter Stations ›

Transmitter Site Preparation Recommendations ›

More white papers ›

Worry-Free Transmission | Because Radio Matters

nautel

The manager's engineering notebook

"Everything a manager should know to help the engineer"

Writer
Paul Freeman Tinkle
President, Thunderbolt Broadcasting, Martin, Tenn.

In 1970, 15-year-old high school sophomore Paul Tinkle joined WCMT(AM/FM) as a "cleanup" boy.

Today he is the president and part-owner of Thunderbolt Broadcasting, which includes one AM and four FMs as well as seven translators (Tinkle calls them "local FMs") that serve northwest Tennessee and parts of Kentucky. He is also a former member of the NAB Radio Board.

He recalls that years ago, when an engineer took ill for several months, Tinkle suddenly realized how little he knew about his own facilities. So he started to bone up.

Today he advocates for owners and managers to participate in the creation of maintenance programs and technical documentation, and encourages them to become familiar with their facilities and with basic engineering concepts.

His engineer visits Thunderbolt's RF sites monthly, checking everything from the ASRN sign to the tower lights and replacing transmitter filters. Each RF site has a metal bookcase filled with equipment manuals; and Tinkle's cellphone has the names of dozens of engineers and suppliers he could call if necessary, to help if he had an urgent problem.

Paul Tinkle wrote the following list of 57 assorted ideas, tips and best practices. He shared it with Radio World for this ebook.

Right
A documentation shelf, two sizes of ladder and a Shop-Vac are at the ready.

01 Purchase a label maker, and see that all equipment is labeled using the name you commonly use when referring to it. Label everything in your service rack. Label the front and back of each piece of equipment as well as where the plugs and wires are inserted.)

02 Label STLs, Marti units and other RF equipment. Include call signs. Note the date each piece of equipment went into service. Do the same for computers, noting their install date. Label the front of each satellite receiver with the name of the program associated with that receiver. Include the serial number on the front.

03 Label your station "calls" on remote gear including headphones, power cords and of course phone and RF equipment that is used on the road. Take a photo of your remote gear with your smartphone or camera.

04 Learn how to read and take transmitter meter readings. Take the actual readings occasionally to stay fresh. Know the transmitter codes and all passwords relating to everything you own. Keep a central log of passwords, and make sure key personnel know how to access it. Change factory default passwords when new equipment arrives.

05 Make sure all EAS equipment includes written instructions on how to perform an EAS test. Keep instructions in the control room.

06 At an AM station, inspect your antenna tuning unit (ATU) at the tower base to check for snakes, birds or other unwelcome intruders or problems.

07 Confirm that your Antenna Structure Registration Number (ASRN) is displayed clearly at the tower site, that your fence is structurally sound and the gate is locked.

08 Inspect your guy wires for damaged insulators. Inspect tower anchors for possible damage due to mowing or lightning. Keep your tower site mowed and neat. FCC inspectors often can tell who's doing a good job of taking care of their license just by looking at the grass; at least give them a good first impression.

09 Keep a spare set of keys to everything you own. Put it in your vehicle or hidden at the tower site.

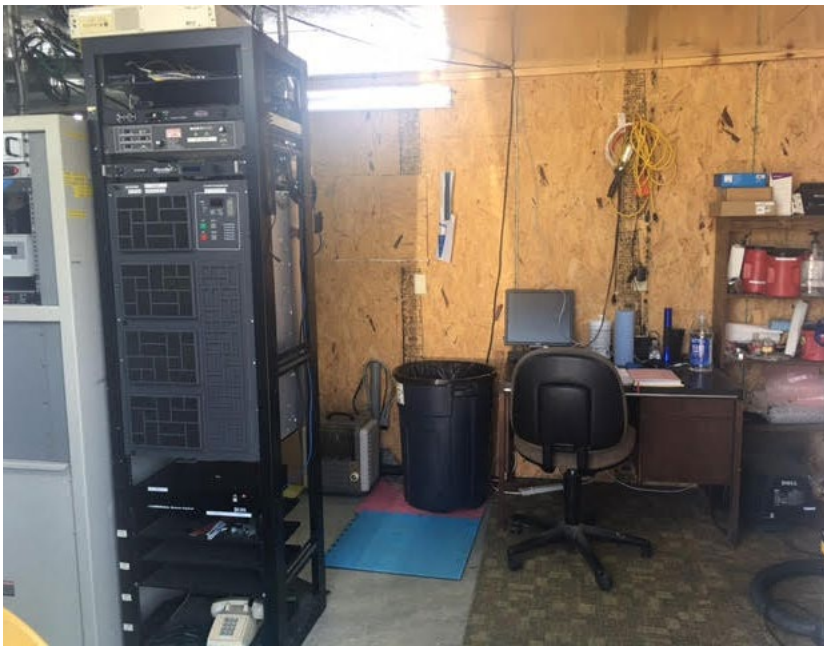
10 Keep a journal or notebook — not just a legal pad — at the remote tower site; mandate that anyone who enters the tower building log tower readings and the time they came in and out of your building and the site. Keep a copy of your "vital" records — e.g. the license — in a binder, in plastic sheets. This includes STL (license) path information and transmitter info. Having these at the tower site allows you to access information like transmitter power out (TPO) quickly.

> **"Ask your engineer, 'Who are the people you would want me to call if you were in the hospital?'"**

11 Keep a spare tube and parts kit for your transmitter and other vital equipment close by. This includes a fan.

12 At the tower site, keep a set of basic tools and a first aid kit. Also put in a supply of drinking water, paper towels, hand sanitizer, toilet paper and a cot for resting. Engineers may need to take a break, especially if they've been working on equipment all night. At some remote sites, for instance where weather might shutter someone in, consider supplies for a longer-term stay such as blankets and non-perishable food.

Above
Proper signage.



13 Change or clean all filters on your broadcast transmitters as well as your HVAC units. Create a schedule. Order spare filters.

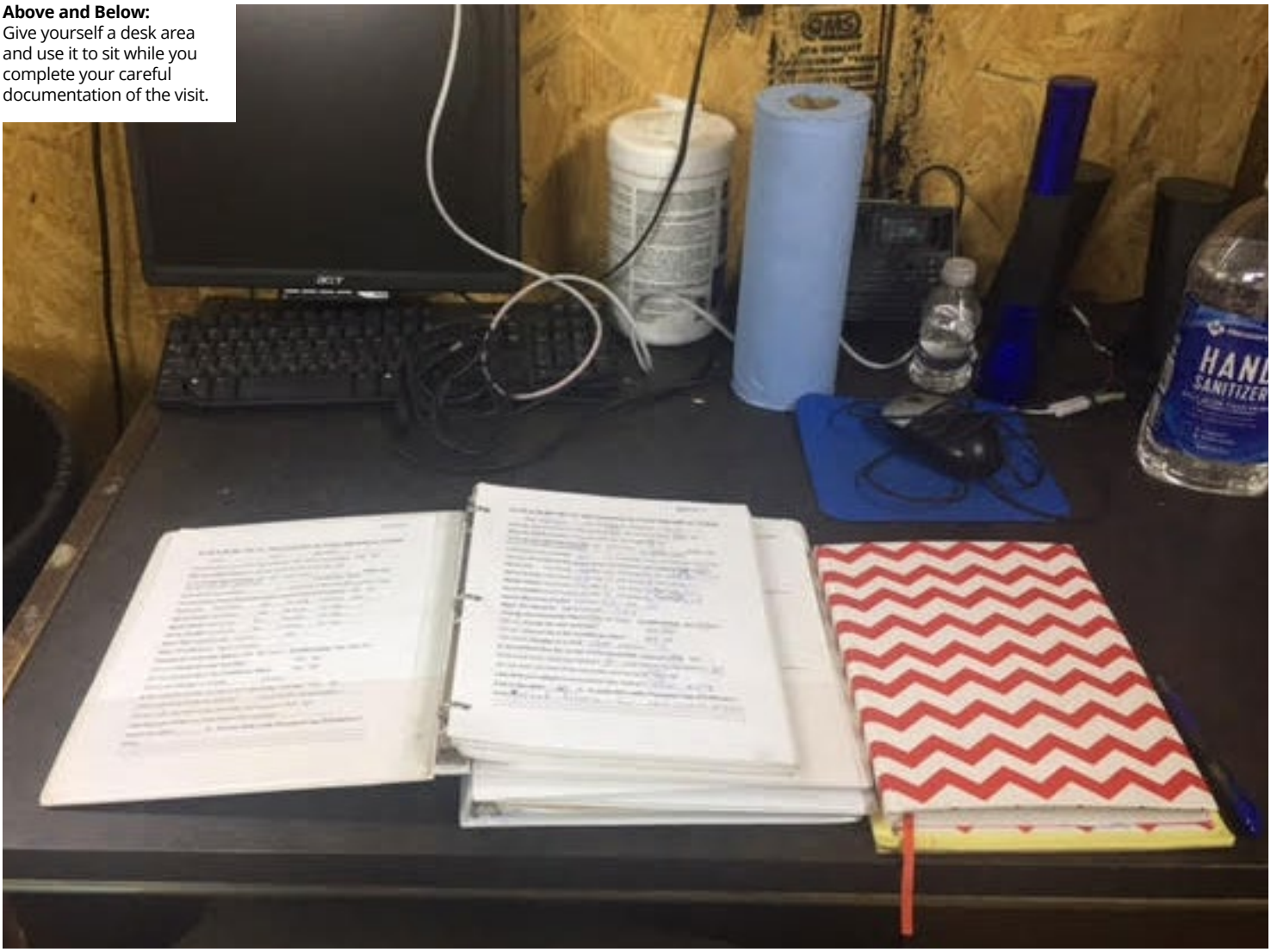
14 Clean all transmitter and computer filters monthly. Suck out the dust for longer life!

15 Keep a Shop-Vac or similar wet/dry vacuum at the site to help keep the building and equipment clean.

16 Store several flashlights and batteries in your building (including studio control rooms too). Check your smoke detectors annually for performance. Change batteries when you adjust your clocks twice a year.

17 If you have a generator, check it monthly and exercise it weekly. Ensure that you have extra oil and coolant. Check the fuel level. Log it in your journal and write down the hours it was exercised. Put it "online" at least every month.

Above and Below: Give yourself a desk area and use it to sit while you complete your careful documentation of the visit.



18 Personally inspect your towers at night to confirm that all bulbs are burning. Inspect the tower to confirm it will pass FCC paint regulations.

19 When a bulb goes out, document that you have notified the appropriate officials. Keep the Flight Services NOTAM line phone number (877-487-6867) and your ASRN at hand. Store the ASRN for each site in your smartphone.

20 At AM stations, confirm that your annual NRSC Occupied Bandwidth Measurement and Frequency Test was done within the past 14 months and have it ready for the FCC upon request.

21 Visually inspect your STL, Marti and other auxiliary antennas. Are they secure on your service tower? Check that wind has not damaged or loosened radials.

22 Walk around the back of your radio station and transmitter building to see if anything is out of place. This could be anything such as loose cables, vandalism damage, or strange visitors — cats, rats, snakes, deer, bear, opossum, turkey or groundhogs.

23 Keep spare tools in your vehicle including an air pump for flat tires or slow leaks that happen while you are at the tower site. It will happen.

24 Keep wasp/hornet repellant available. Always have duct tape on hand. It can fix most problems.

25 Show full- and part-time employees where vital controls are located including the electrical breaker box. Label your breakers in the electrical box.

26 Communicate with your engineer regularly, especially if something doesn't seem right.

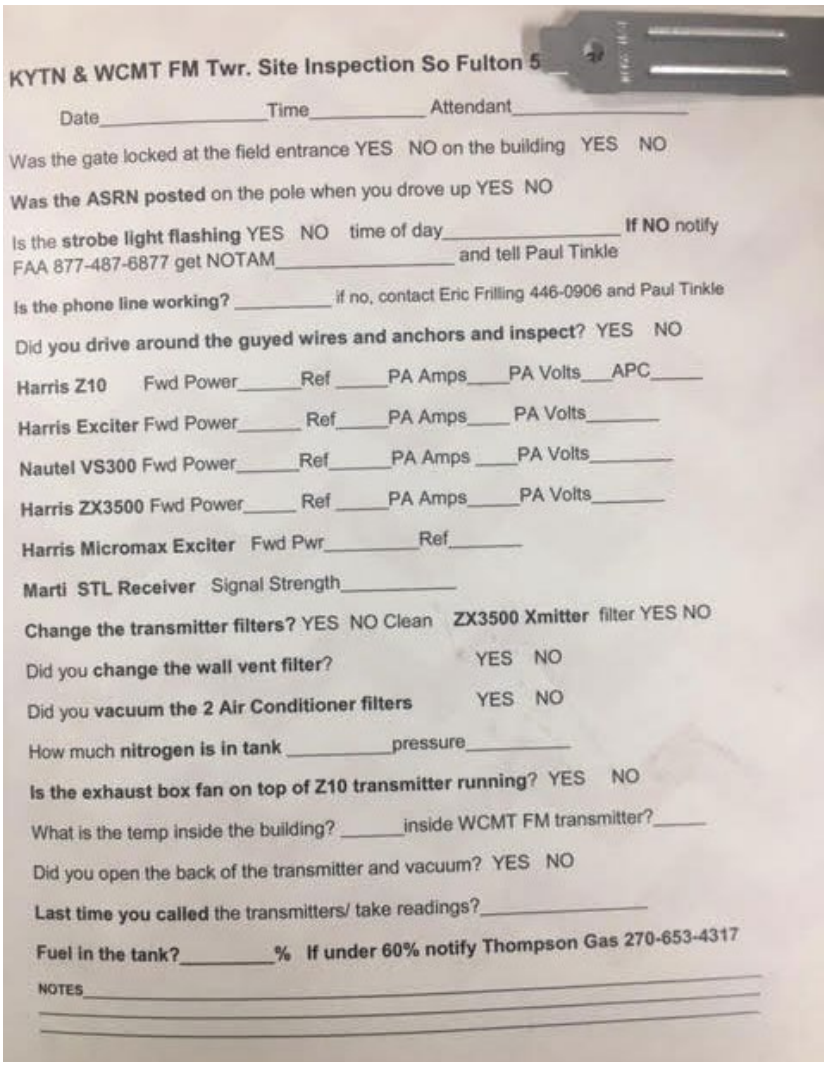
27 Instruct part-timers how to turn on and turn off vital equipment such as a backup transmitter.

28 Place combination locks on all gates and tower entrances. Cover them with a piece of rubber tire and a potato chip clip to keep moisture out and prevent freezing.

29 Keep good records about your equipment, including pictures of all devices. Your smartphone is your friend.

30 If you ship a piece of equipment for repair, tape your business card to it. Use your label maker and put your company's name on the equipment. (If you put your bumper sticker on it, they will definitely know whose it is.)

Above: Well-organized documentation such as FCC rules, checklists and manuals for everything from microphones to generator and STL.



KYTN & WCMT FM Twr. Site Inspection So Fulton 5

Date_____Time_____Attendant_____

Was the gate locked at the field entrance YES NO on the building YES NO

Was the ASRN posted on the pole when you drove up YES NO

Is the **strobe light flashing** YES NO time of day_____ **If NO** notify FAA 877-487-6877 get NOTAM_____ and tell Paul Tinkle

Is the phone line working? _____ if no, contact Eric Frilling 446-0906 and Paul Tinkle

Did **you drive around the guyed wires and anchors and inspect?** YES NO

Harris Z10 Fwd Power_____Ref _____PA Amps____PA Volts___APC_____

Harris Exciter Fwd Power_____ Ref_____PA Amps____ PA Volts_____

Nautel VS300 Fwd Power_____Ref_____PA Amps ____PA Volts_____

Harris ZX3500 Fwd Power_____ Ref _____PA Amps_____PA Volts_____

Harris Micromax Exciter Fwd Pwr_____Ref_____

Marti STL Receiver Signal Strength_____

Change the transmitter filters? YES NO Clean **ZX3500 Xmitter** filter YES NO

Did you **change the wall vent filter?** YES NO

Did you **vacuum the 2 Air Conditioner filters** YES NO

How much **nitrogen is in tank** _____pressure_____

Is the exhaust box fan on top of Z10 transmitter running? YES NO

What is the temp inside the building? _____inside WCMT FM transmitter?_____

Did you open the back of the transmitter and vacuum? YES NO

Last time you called the transmitters/ take readings?_____

Fuel in the tank?_____% If under 60% notify Thompson Gas 270-653-4317

NOTES_____

Above: Tower and site inspection sheet.

31 Be proactive. Ask your engineer what they need to do their job better. Sometimes it's just an extra roll of tape or a new soldering iron. Sometimes they might tell you something really important that you didn't know.

32 Document everything. Keep a paper trail for things you do, things the engineer does, things that need to get done, things that got done and things that are undone.

33 Write or print legibly. Keep in mind there's a good chance someone other than yourself will be reading it.

34 Teach others in your radio station family the important things. Any DJ/announcer, office manager or newsperson might have to fill in suddenly.

35 If you have a remote vehicle, drive it yourself, inspect it for damage and keep a service record. Check the tires and alignment. It may pull to one side or make a noise; it may need to be cleaned of trash. If connected to remote gear, make sure you have tested it personally.

36 Inventory any play-by-play equipment. Learn what needs to be replaced or repaired and is being treated professionally. Put headphones in one- or two-gallon plastic freezer bags, available at your local grocer or box store.

37 If there's a problem at the transmitter site, tell your engineer you want to come watch or hold the flash light — to learn, to help and to keep them company.

38 Find out where the FCC rules are kept in the radio station, tell the staff and encourage everyone to read them.

39 Participate in your state's Alternative Broadcast Inspection program. This is great insurance. It helps your engineer keep equipment running smoothly and in tolerance, and keeps your staff aware of EAS rules.

40 When in doubt about FCC rules and regs, contact your FCC attorney. Spend the money to keep your radio station legal. It's better to spend money on engineering than wait and send money to the FCC to resolve a Notice of Apparent Liability.

41 Get to know people in the technical community. Network at your state broadcast association's events. Keep contact names of helpful people at key equipment suppliers. Ask your engineer, "Who are the people you would want me to call if you were in the hospital?"

FOR THE ENGINEERS

42 Engineers: "Communicate before you medicate." Let the manager or PD know that you're planning to take the station off the air. Sometimes really are better than others for routine service.

Below
The station vehicle is well supplied.

43 Ask for the equipment you need to keep the station running smoothly. Ask again and again. Research your request with costs and how they will help the station, whether to stay on the air or to clean up noise.

44 Remember to put things away after you have completed a project. Put all the fasteners (nuts and bolts) back in the equipment.

45 Keep good notes. It will benefit you later, and it probably will benefit someone else.

46 Don't put yourself in harm's way. Slow down when working with RF. Turn off the main power as well as the power to the transmitter. If you disconnect the failsafe, remember to put it back in place and confirm it's functioning. Work with a partner if at all possible.

47 Provide your password to the manager so they can be helpful to you when you're unable to come right away.

48 Make a date with the manager to show them what you believe needs to be done to assure that the radio station continues to run smoothly.

49 Make sure you have all the spare parts you need to keep your radio station on the air.

50 Show your manager the projects you have accomplished.

51 Neatness matters. Labeling is a must.

52 Date everything regardless of when it was received, installed or pulled out of service.

53 When there is an emergency and you get the call, communicate with management when you are likely to appear on the scene.

FINAL THOUGHTS

54 Managers:
Emergencies are never so big that it you need to put the engineer in harm's way.

55 Managers:
Don't try to fix what you don't know how to fix. Engineers should not need to fix what you've tried to fix.

56 Managers:
Be patient with your engineer.

57 Engineers:
Be patient with your manager. RW

Your mission: To keep these systems running smoothly.

Life is good — as long as you have internet

Site maintenance benefits from reliable connectivity in many ways

Writer
Josh Bohn
President/CEO
Bohn Broadcast Services

Picture it: 1997.

Bill Clinton is president. Reed Hundt is FCC chairman.

Radio deregulation is now the norm — but so are tube transmitters, analog consoles and dialup-only remote controls.

It was a different world in so many ways.

In 2021 deregulation is still the norm, but solid-state transmitters have overtaken tubes by a large margin. Analog consoles are still in service but AoIP has a huge stronghold in the modern broadcast plant. And remote controls now can call, text and email.

What's the common denominator in all of those modern devices?

IP connectivity

We live in a world where the internet is connected to everything from your phone to your security systems and, in some cases, even your refrigerator.

The modern broadcast plant is no different. Today's solid-state transmitters basically are giant computers with RF amplifiers attached to them. They'll tell you exactly what the fault is and in some cases even order parts for themselves — as long as they have an internet connection.

Remote controls allow you to connect nearly infinite amounts of monitoring and controlling countless devices, plus they'll show you everything visually on a neat little screen — as long as the internet is working.

POTS lines are nearly impossible to get in many locations now, but you want the remote to call you; what's the solution? A reliable VoIP service is great — if you have internet.

> **A wireless internet option such as prioritized LTE provides an alternate program delivery path, which is less prone to lightning strikes and power spikes.**

Many broadcasters have embraced the connected site. Cameras, Burk ArcPlus remote controls, Nautel transmitters —you name it. But the key is reliable and redundant IP delivery. There are a plethora of ways to accomplish this.

The earliest P2P IP option specifically for broadcasters was duplexed ISM radios, offered by Moseley as LANLink nearly 20 years ago. This provided a 512 kbps data link from studio to transmitter site and offered ethernet and RS-232 connectivity.

It was a revolutionary system and allowed, for the first time, networked devices to live at the transmitter site but be part of the studio LAN without adding costly telco circuits or expensive, dedicated, licensed standalone radios.

The IP delivery landscape was altered again with the proliferation of low-cost unlicensed 2.4 GHz and 5.8 GHz radios. These systems, with their significantly higher throughput, altered the way stations delivered content to their sites.

Traditional 950 MHz STL systems were backed up, and in some cases supplanted, by IP-only radios carrying codec audio, HD Radio data, RDS metadata and remote control information.

Now sites without some type of internet connectivity are in the minority.

IP radios have become, by far, the most common method of internet delivery to transmitter sites. Prioritized cellular, such as MaxxKonnect Wireless, is another great option to get connectivity into a site without major tower work, large upfront costs or long-term commitments.

If fiber is available at your site, take advantage of it! Costs on fiber internet are coming down significantly.

Satellite internet is an option as well. In the past, satellite has not always been the fastest or most reliable option. However, with the coming of Starlink and other new LEO technologies, satellite could rival wireline delivery in the not-too-distant future.

And so?

You may be asking yourself, "What does this have to do with site maintenance?"

MaxxKonnect

www.maxxkonnect.com WIRELESS

Prioritized, High Speed LTE Internet Service for Broadcast Applications

IT Security is the new normal for engineers.

Add security and reliability to your remote broadcasts and transmitter sites with our service.

Public static IP with every SIM for secure connections.

You control firewall settings to lock down incoming connections to limit who sees your devices.

Don't be a victim!

Secure your network today.

We can provide a router, modem or just a SIM - whatever you need!

No contracts. No early termination fees!

Service available on the top three major US networks.

Now available in Canada and Mexico!

Need a phone line for your remote control?
Contact us for your solution.

MaxxPhone

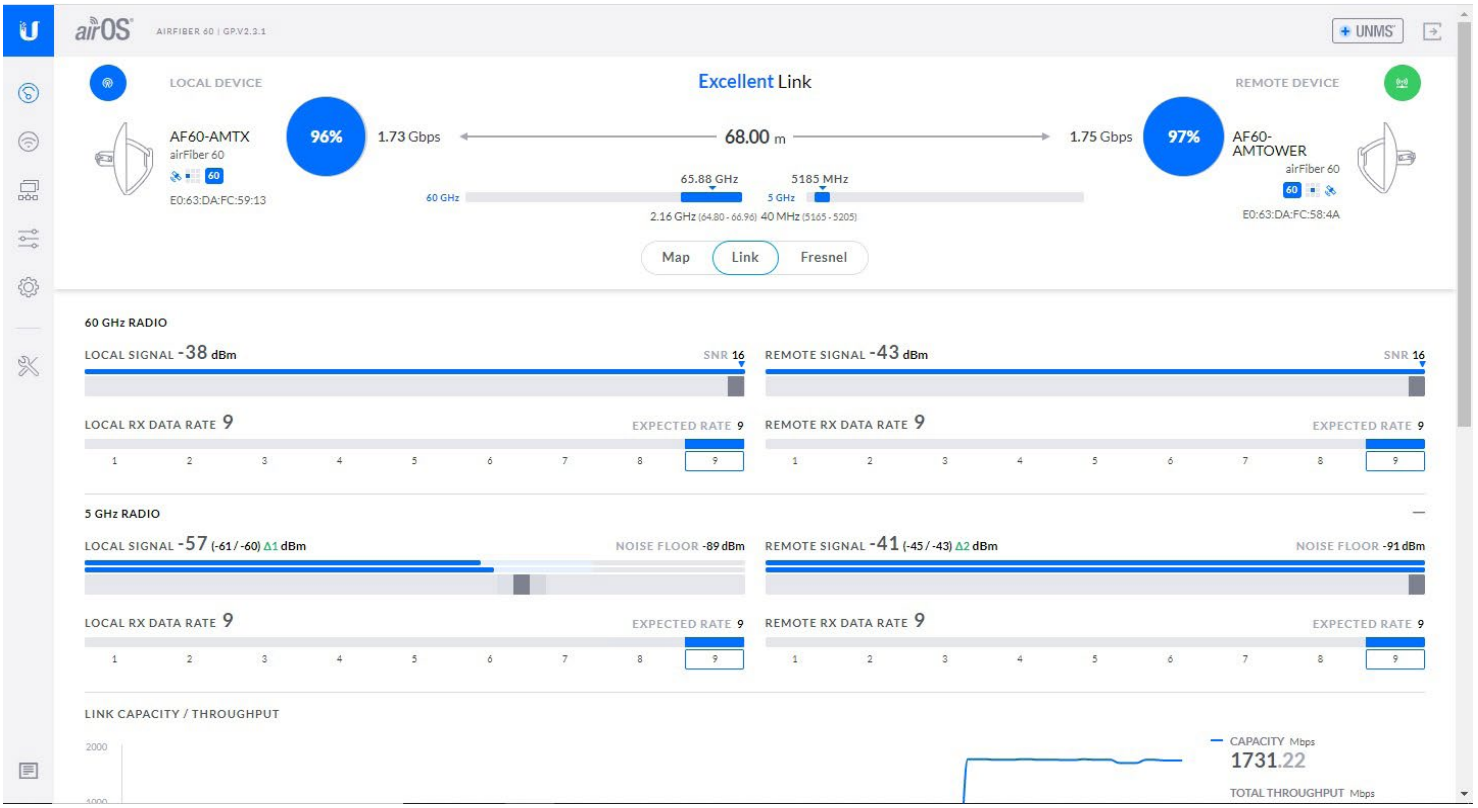
Available from your preferred vendors.

The MaxxKonnect GROUP

BGS

broadcast gear from people you trust
BSW
BROADCAST SUPPLY WORLDWIDE

RON PALEY BROADCAST



Answer: Everything!

Having the ability to know what's going on at your site, even when you can't get there as often as you'd like, is key to keeping things running smoothly.

Example: Install an inexpensive web camera or cameras at your site. We typically install three: one looking at the room as a whole, one outside the door, and one aimed squarely at the front of the transmitter and/or equipment racks.

This allows you to know who or what is lurking at your site, inside and out, plus it allows you to diagnose equipment faults or failures visually before rolling out.

Being able to see which fault indicator is lit on an older transmitter or hear the UPS beeping through the camera lets you plan for what tools and equipment to bring on your trip. This is a huge timesaver for an engineer. And less time spent on a problem means less money spent or lost — which is a win for management.

Another example is program delivery redundancy.

IP radio systems are awesome but they're mounted on a tower and will, most likely, get popped by lightning at some point. Same goes for 950 MHz STLs.

A wireless internet option such as prioritized LTE provides an alternate program delivery path, which is less prone to lightning strikes and power spikes. This backup program path can be the difference between minutes of off-air time or hours.

Climate control is another hot topic for internet connectivity. App-linked Wi-Fi thermostats are a great way to give you 24-hour remote control of the temperatures at your site. Set up your own lead/lag controller using the schedule functions, and adjust it from your phone at your house. Plus, you'll know immediately through push notifications if the temperature exceeds the limits you set.

Other benefits include the ability to look up manuals and parts onsite rather than the 4-inch screen of your phone, and Wi-Fi calling capabilities. At many remote sites, Wi-Fi may be the only way to get a call through if cell service in the building is bad.

Our connected world is overtaking our broadcast facilities. There are more options than ever before to know what is going on at your site, without being there.

Above
Dashboard for a Ubiquity AF60 IP radio.

Below
A screen capture from a Wyze Cam Pan camera. Extremely helpfully to diagnose things remotely.

Above: Installation of coax hangers.

Writer
Sean Edwards
Director, RF Engineering, Shively Labs

Tips for RF system installation and maintenance

Just about anything can happen to cause failure in an RF system

We all want to get the most value out of money spent.

RF system repair can be costly. However, a well-implemented maintenance program can greatly reduce the need for repairs — and when there is damage or degradation to a system, that program can detect and address the issue early, when repair costs are low.

One very useful tool in RF system maintenance is baseline measurements. Taken at the time of acquisition or system commissioning, these provide a snapshot of the condition of the RF system. They can then be compared to later measurements and reveal trends in performance.

These measurements might include transmission line sweeps, transmitter operating parameters, forward and reflected power samples, thermal readings of filters, transmission line and connections, current and resistance measurements of deicer systems, RF

spectrum measurements, pressurization and signal coverage.

The hardware between the transmitter output and the antenna radiator is the final stage of the FM transmission system. This part of the transmission system can contain RF switches; directional couplers; elbow complexes; band-pass, band-stop and notch filters; long transmission line runs; power splitters; "T"s; matching networks; feeder cables, etc. It's crucial to the delivery of signal to your coverage area to take the time to get this section right and then keep it right.

During antenna installation, the tower crew and site manager rely on manufacturers to show clearly the antenna position and orientation on the tower.

I've seen this exchange break down, resulting in antenna parasitic elements mounted in the wrong position, causing both high VSWR and poor coverage. Fortunately, it was a quick fix to correct the VSWR and signal coverage. Unfortunately, it required a tower crew and two engineers to visit the site.

If care is taken with the details during installation and the system is optimized, it's at its best and should provide years of service.

(I left the "trouble free" part out intentionally. RF system maintenance … what can break? It's just bent pieces of metal, right?)

Above
Burns are visible where wire had been used to secure a flexible 3-inch line.

Right
These damaged components are an example of the "outside in" sort of burn that can occur when lines pass too close or touch other coax or tower members.

Maintenance of Antenna Systems

Yearly maintenance of your FM antenna and transmission system is essential for the life span of your equipment. Finding minor problems early on can save your station money and time off-air. We suggest the following list.

- **ANTENNA TO DO LIST:**
- **Have documentation of base level test measurements to compare in future, as built and as installed.**
- **Visual inspection of antenna bays for discoloration, component integrity, physical examination.**
- **Be certain of what parts are there now and what should have be there in array when installed. (check installation drawing)**
- **Check all hardware and attachment items (parasitics or cable clamps, etc.) for being in place and set to correct specs.**
- **Look for icing, climber or storm damage. What doesn't look the same…**
- **Check transmission line for holes, hot spots, pressurization.**
- **Take digital pictures of antenna system for future reference.**

Shively Labs®

www.shively.com **888-744-8359**

Above
A feed system secured in only a few spots with tie wraps can experience chafing and will fail prematurely.

Proactive mindset

Just about anything can happen to cause failure in an RF system.

Antenna damage from wind, falling ice, lightning, tower work, vandalism, loose connections and aging components are just a few. When an engineer has multiple systems to take care of, something always seems to be in need of attention.

One way we have some control over such failures is regular system maintenance.

Have you ever checked site parameters after a significant weather event and found that some parameter had changed — not to the point of failure, but enough to prompt an investigation? Then upon a closer look you found damage that needed repair?

Or perhaps on a routine site visit, you discovered excessive heat on one or more components, and upon further investigation found an elbow that was nearly kaput — it would have failed catastrophically within weeks or days.

This is proactive maintenance and repair. If these near-misses haven't happened to you, they likely will.

Had you been unable to check those readings after that storm and thus could not notice increasing VSWR, or had you not visited that site and noticed the hot elbow, the condition would have persisted, worsened and eventually failed, taking your station off the air.

That call usually comes at midnight on Super Bowl weekend.

Checking sites that have suffered through extreme weather events is a prudent practice. So are regular visits, even to sites that may be considered trouble-free.

Right
Standoffs and clamps on this complex feed keep lines from chafing and arcing one outer to another.

The periodicity will vary — more frequent for trouble sites, perhaps quarterly or even semiannually for more reliable sites.

Annual tower climbs are great if it's in the budget, but when they are not possible, we come back to intimate knowledge of system performance and those baselines, and running history logs that allow us to review for any indication that a problem has started and at what rate it is changing.

This can be useful information when determining if you need to scramble to make a maintenance visit immediately or can schedule for a later date.

Sample issues

Some things to look for when inspecting for damage in the antenna:

- Loss of dry air pressure, whether entirely or through a slow leak.
- Missing or damaged radiators. Pay close attention to the ends of the radiator and the feed points.
- Kinked, compressed or burned cables.
- Broken or unsealed radomes and/or plugged drains that cause water to collect.
- Parasitic elements in place and undamaged.

In more complex systems, the power dividers and coaxial lines should be installed without undue mechanical stress on the components.

The coax should have the appropriate hangers and fasteners where they cross tower members or other antenna feed components. Consult the manufacturer for specific recommendations and best practices.

Antennas that have deicers systems usually have an external wiring harness to distribute AC power to each heating element within each radiator. The manufacturer will have the resistive values for each element and current draw to expect.

An ammeter measurement of each leg of the circuit, including the neutral, will give the first clues to the condition of the deicer system.

If the wiring harness was not installed correctly or fasteners have fallen away over time, the harness can hang in the high RF environment. This can cause reflected power issues at the transmitter and changes in coverage; it can cause currents to be induced into the wiring harness, and voltages large enough to cause arcing between the conductors of the wiring harness and tower members or other cables that pass in close proximity.

Visual documentation

Finally, take lots of photos, photos, photos.

This is a great way to document how the antenna was installed and its current state. When you share photographs with the antenna manufacturer, they have very useful information to inform their recommendations.

With a single-radiator antenna it will be obvious when something is not quite right. On panel antennas, the multiple bays, multiple radiators per bay and numerous feeder cables can really mask a problem.

This brings to mind a recent incident where a station engineer noticed a slight increase in VSWR from 1.05 to 1.15. This occurred right after a tower crew had been working above the antenna, removing old TV equipment. The engineer noticed the change and hired a crew to climb and inspect the antenna. They found that a cable had been caught at some point during the rigging and pulled sideways until it caused a severe kink at the point where it attached to the radiator input.

If the indications had not been heeded and the cable replaced, the next indication would have been loss of pressure, resulting from a coax burn. And we know what happens when we let the magic smoke out.

Ultimately, having an intimate knowledge of your system's performance, both within the RF system and in the coverage area, will serve you well. This knowledge will allow you to prioritize your maintenance schedule by need, effecting maintenance to correct small problems before they become big expensive ones.

"Perhaps on a routine site visit, you discovered excessive heat on a component, and on further investigation found an elbow that was nearly kaput."

Power, the transmitter and you

Factors to consider in creating a power utilization plan

Writer
Charles S. Fitch, P.E.
is a longtime contributor whose articles about engineering concepts, DIY projects and radio history are a popular recurring feature in Radio World.

One hundred years is an impressive lifespan not just for any human but for any American industry.

The modern radio business has crossed that demarcation and, for us broadcast technocrats, it's a moment of self-celebration, as our industry remains dependent on the technology that we supply.

In its first years, radio was so novel that it needed an understandable simile. Radio was like a newspaper without paper. It was like a town crier, delivering an abundance of useful information, interesting voices and sounds through the ether to everyone, everywhere.

To continue the romantic analogy, the voice of that crier is our transmitter, arguably the most important element in any station's success story.

Like a lover, we want our transmitter to be reliable, durable and faithful.

But little useful or good happens in life by accident. Achieving high performance and trouble-free transmitter operation takes a thoughtful, attentive design and maintenance program.

Good engineering practice (GEP) in any discipline usually is a function of refinement. A century allows a long journey of refinement, inculcating a plethora of detailed methodology and techniques, culminating in a distilled corpus of best practices.

Let's start at the beginning.

What does a transmitter do but take electric power and turn it into radio? Like baking a cake, bad components usually make a bad cake. Similarly, poor electric power makes for bad transmissions.

Let's discuss power and best practices to achieve the goal of "perfect" power utilization.

Power to any broadcast installation can be divided into two universes, hard and soft. The former is supplied by a commercial utility, usually regulated by the government; the latter is generated locally and can come from a variety of sources.

> **"Any piece of powered gear in the main stream of your signal should have surge protection."**

Hard power

- Gather and have ready access to all details concerning your electric supply. If power is lost, having information at hand will help you get your power back much more quickly.

  The list includes direct phone numbers to the trouble section of your utility; your account numbers; whose name is on the account; the exact service address; your meter number; the format of your supply (e.g. 480 volt 3 phase in wye); who else might be on your supply (e.g. the two cell operators on your tower) and on common poles and transformer; the pole numbers; your priority position for restoration; the phone numbers of other site users so you can coordinate your complaints and requests, etc.

- Be aware of your power system. Inspect and review it routinely. Remove temporary connections and attachments soonest. Address points of failure and eliminate potential safety issues.

  One of my confreres tells a story of arriving to work on a hop system at a large common tower site. Looking around for a place to plug in his drill, he was told not to unplug a particular extension cord that ran from his hop equipment closet, out the door, through the hallway, into another station's transmitter room, where STL equipment was plugged into this line.

  Seems they'd run out of outlets and this was the most convenient location to plug in — a point of failure for both users.

- Maintain your power system. Since your transmitter system will be on hard power 99.9% of the time, check at least annually for hot spots, especially around suspect locations including terminations in circuit breaker panels, on the CBs as well as on neutral and ground bar screws.

- Review grounding. Whenever you are inside your electrical system, review the wiring arrangements and take amprobe measurements such that the separation of neutral and ground paths are maintained.

  Our mantra is *that current should flow in the neutral, no current should be flowing on the grounding paths*. The last place where ground and neutral are common is most often in the main breaker panel or main metering where neutral is firmly bonded to (earth) ground. After this

selected point, they must be kept separate.

At least three ground systems should exist at every transmitter site, for power, signal and lightning grounding; we want them to function as separate entities. If these systems become intertwined, current flow becomes unpredictable and can be downright dangerous. Interconnections of these grounding systems, if necessary, should always be at just one point.

- Make certain in original installation as well as retrofits that your conductor and fusing sizes are appropriate. Remember that the National Electric Code addresses minimums to achieve a threshold of safety. More capacious systems are encouraged to accommodate your continuous and critical needs.

- Surge and lighting protection. Utility power is perfect as it leaves the power plant. It's the haphazard distribution and ugly user loads in the real world that make for the noise, sag, phase imbalance and unattractive sine wave that we have to live with or correct.

  Reactive loads (usually operated by others) on your supply system, especially if nearby, can produce horrible surges and sags that can be highly destructive to your plant.

  Protection from these power energy extremes, like most electrical system design, is progressive: You have a main circuit breaker to protect the overall system, a panel board main circuit breaker to protect appliance branches fed from that panel, individual circuit breakers for each significant device, and then usually small current fuses on each piece of gear.

  The best surge protection is similar in design, where a main surge suppressor to protect the site system is followed by panel board units and internally on critical individual items. Any piece of powered gear in the main stream of your signal should have surge protection.

Soft power

Your standby power source uses the same distribution system discussed in hard power, so we'll focus on the actual power source.

- Choose your source of supply carefully. Remember that a soft supply system may be overwhelmed by factors that a commercial electric supply, with its copious energy reservoir, can manage easily.

  The issues most often overlooked are *power factor*, *waveform* and *load variation*.

  Power factor usually is expressed as the ratio difference between the apparent power passing through the consumption system and the actual power consumed. The cause of the peak power which appears to be consumed is reactive components in the system.

  An expressed number of 0.9 would let us know that about 10% more power appears to be consumed that actually is consumed for the operation of your transmitter site or some specific device like the transmitter.

  This power is not lost, it is essentially returned to the generator. In commercial power it goes all the way back to the hydro or nuclear plant's generator that made the power; in your station, running on soft/standby power, this "reactive power" is returned to your UPS supply or engine-driven generator.

  Although not consumed, this power still needs to be generated.

  The prevalence of switching power supplies makes *waveform* purity a critical item.

  A tremendous variation in this quality exists among soft power sources, and manufacturers now carefully annotate this as a separate performance specification. If it is not listed on the generator or UPS supply sheet, insist on having this data. Many UPS and switching supplies will not operate with dirty waveforms.

  Just as critical to the selection process is the

character of the *load's consumption*.

Let's take a simple example. Many years ago on a due diligence trip, we got to the transmitter at night, and in the course of the inspection we asked to see this station's operation on their generator. With a 250 watt night signal, the notable varying load of two sets of beacon flashing caused the generator to gun every time the 2400 watts of beacon bulbs were brought online.

Although the generator ostensibly could handle the power demand on a nameplate basis, the varying load caused a hysteresis effect as the engine was stimulated to produce more horsepower to then produce more current and still maintain voltage.

Obviously this rhythmic up and down was not helpful to the plant's overall performance and ultimately changes were made.

> **"Sample the experiences of your peers and equipment manufacturer before you design, purchase or install any significant soft system."**

Today many FM stations still have Class A transmitter loads, where the transmitter draws essentially the same current all the time. However, many stations use transmitters (an abundance of AMs particularly) with amplifier classes going to digital Class D (or even E) where the power demand can go from nothing to max at a megahertz rate with even that extreme pulsing varying on a time basis.

Between the factors delineated above, you should identify the capacity for handling power factor and complex loads carefully.

Broadcast operations are specialized. Even with the best outside professional help, sample the experiences of your peers and equipment manufacturer before you design, purchase or install any significant soft system.

- Exercise and test your soft/standby system regularly on a disciplined periodic basis. As we learned from the space program, if you want the rocket to work perfectly one time, you need to design and build it to work a thousand times.

  An important key to this is regular exercise under the total loads that will need to be supported if you lose commercial power.

  At least annually but better quarterly, shut off commercial power and observe the entire procedure. How long does it take for the control system to recognize the power loss, for the engine to come to speed and acceptable voltage, for the station to stabilize and go through the steps to bring the station back on?

  Support systems are an equally important part of the operation. Observe and inspect them at the same time. Do the louvers open properly and fully? Does the day tank pump bring up fuel correctly?

  A long run of at least an hour in hot weather is appropriate to see if cooling and lubrication are functioning correctly.

  Needless to say but we'll say it: Change oil and coolants! Do this at least annually. Also test or change gasoline or fuel oil annually. Propane or LP fuel usually needs no attention but follow the guidance of your supplier in this critical area.

  A generator that does not run when needed is a monumental capital waste.

- UPS batteries have a finite life.

  Sealed, wet dielectric batteries have an optimal charging pattern. Because of the limited charge and deep discharge demands, they usually have a limited life.

  To ensure reliability, there is no substitute for an actual deep discharge test where the batteries are taken to the voltage point where the UPS disconnects. Note the time time this takes under the expected loads and compare with the previous exercise. The battery and/or the UPS manufacturer should be able to supply performance data that will guide you in creating your replacement plan.

  Change all batteries in an UPS at the same time.

- Clearly mark all components.

  The National Electric Code requires that all commercial outlets be identified as to panel and overcurrent device (fuse or circuit breaker).

  In addition, clearly identify your various system components and their source of supply, especially when you make changes.

  A quick if imperfect example of this came during the fast change-out of an FM transmitter. The main supply breaker (marked "FM transmitter") was turned off and conductors in the conduit were being pulled out. For a few seconds, a scary shower of sparks flew out of the ceiling.

  The first transmitter in the space had a separate circuit for its crystal heaters. This circuit was never removed and never turned off as it was not marked in the panel or rig.

  Luckily no one was hurt.

Easy no-budget tips for better transmitter care

Improve your maintenance program using the versatility of your remote control

Writer
Peter Burk
President, Burk Technology

If you have transmitter sites to care for, you know each emergency means an engineer on the road and possibly lost airtime.

Remote control systems have traditionally allowed transmitter observations to be made remotely, but modern systems are capable of much more. Here are some tips to improve routine maintenance and reduce emergency calls using the versatility of a modern remote control.

Virtual channels add meaning.

Virtual channels can take data from other channels and synthesize new data mathematically. Each virtual channel uses an equation to process this data in real time. These channels can be logged and used for alarms and to trigger macros and notifications just as regular channels. Here are a few classic examples, but you can probably think of more:

It's getting hot!

Knowing the heat rise in your transmitter is important. Two temperature probes can give you a way to measure the rise in temperature in your transmitter. Simply use a virtual channel to subtract the input temperature (or even the room temperature) from the exhaust plenum temperature. Stack probes make it easy to pick up the temperature in a closed plenum. The virtual equation is simply M1 – M2.

Is your efficiency sufficient?

A sudden drop in transmitter efficiency means trouble. Look at the other readings to determine a possible cause. If it suddenly gets better, you likely have a faulty meter sample.

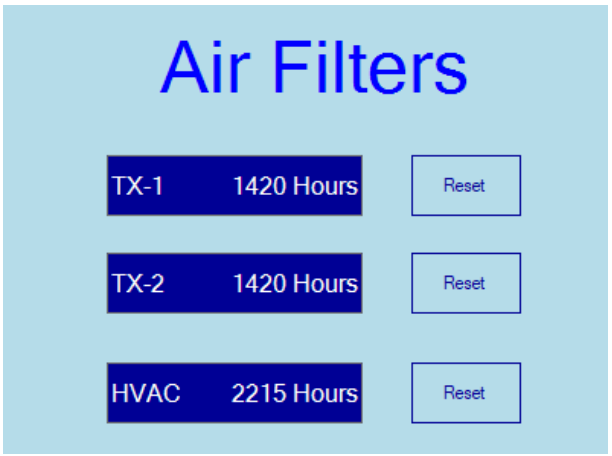
The formula for efficiency we are all familiar with is Power Out divided by Power In. The input power is final volts times current, so efficiency simplifies to P Out / E / I. (If this simplification doesn't make sense, try it on paper.)

Virtual Channel Expression

M1 / M2 / M3 * 100

Mathematical operators:	+ - * / MOD
Logical operators:	AND OR NOT XOR
Functions:	SIN COS TAN LOG10 LN SQRT
Equality:	= <> < <= > >=
Parentheses:	( )
Meter values:	M1 - M256
Meter values with offline state:	MM1 - MM256
Status values:	S1 - S256
Status values with offline state:	SS1 - SS256
Raise relays:	R1 - R256
Lower relays:	L1 - L256
Macro variables:	V1 - V256
Constant values:	Any real number

Right
Fig. 1: Equation for virtual channel showing efficiency.



Left
Fig. 2: Custom view showing hour meters with resets.

Assuming the first three metering channels, Fig. 1 shows the equation.

Set this virtual channel to alarm if too high or too low, and make sure you add it to the log.

It's been a while.

Just how long have those air filters been in there? Set up a virtual channel for each such item and assign it to a timer. Elapsed hours can be accumulated and can trigger a warning if overdue. As shown in Fig. 2, a command button for each can be used to reset the timers when the maintenance is performed.

Straight as an arrow.

Ever have a sample that isn't linear? Here is a fix: Measure across the needed range and record actual and indicated values. You'll need at least three points, but more is better.

Now put the actual and measured values in a graph in excel as shown in Fig. 3. Try different degrees of polynomials and pick the lowest order that gives you a good R squared value.

In this case a second order polynomial works well. The equation for Channel M1 becomes:

.0182 * M1 * M1 + 3.864 * M1 – 93.2.

Voila. A transfer function that is linear.

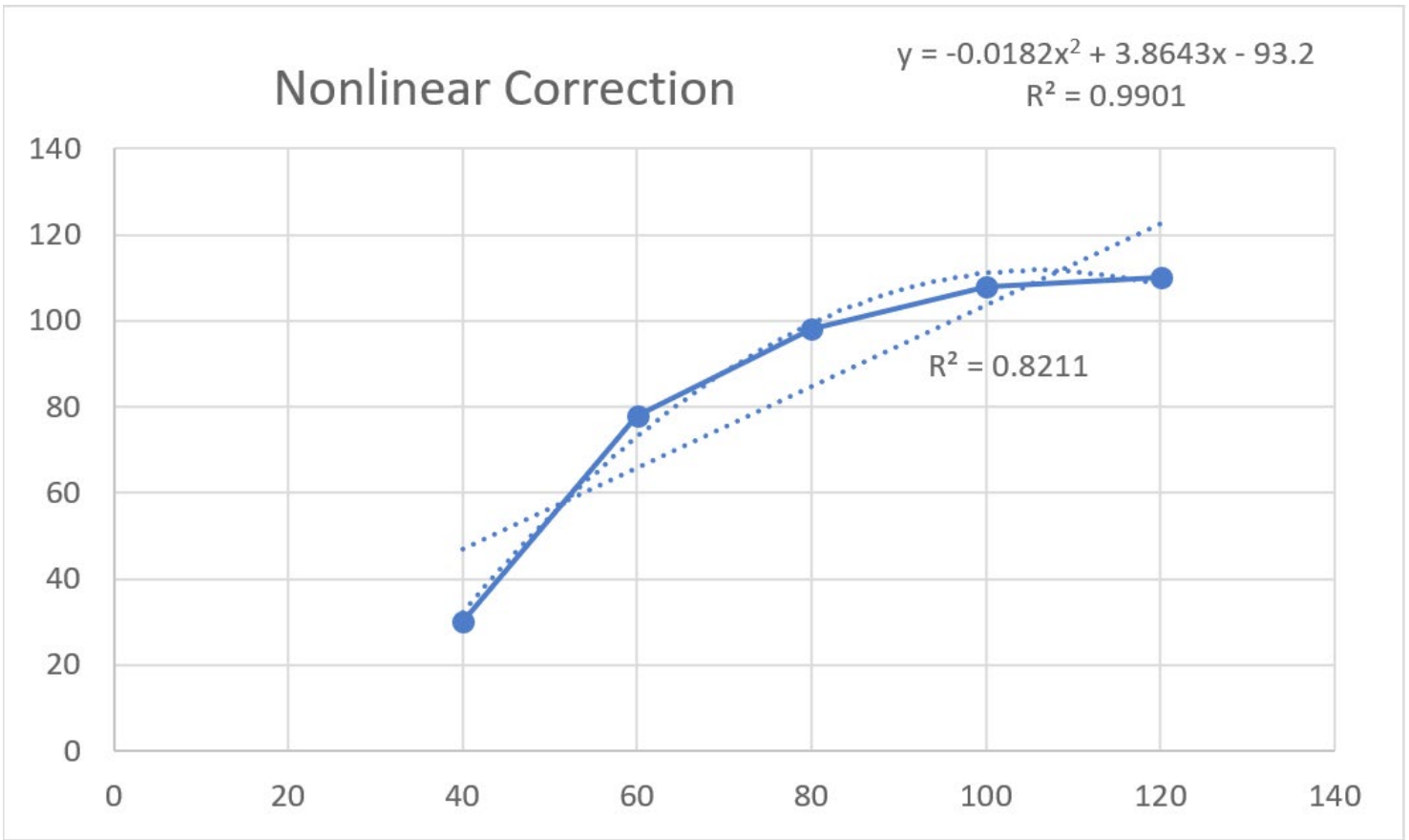
APIs add data.

There are many data sources that are not physically connected at the site but are available through an Application Programming Interface (API).

The obvious example is a source of free weather information such as weather.com. This can provide a virtual weather station that represents the conditions in a radius of about 1,500 meters of your site. Good enough to know when to automatically turn on the deicers. Add 0.35 degrees per 100 feet of antenna height. It's 7 degrees colder at 2,000 feet!

Burk has an app note available that explains how to use APIs.

Below
Fig. 3: Spreadsheet graph used to calculate transfer function for non-linear input.



Turn Your Remote Site into an ISLAND OF RELIABILITY

ARC Plus Touch with AutoPilot® gives you a consolidated view of your entire transmission facility. Instantly verify performance of RF equipment, power systems, processing, environmental and security systems.

Control your remote facility from anywhere. Lost the connection? Jet™ Active Flowcharts keep on working even when the network is down.

Make your remote site an Island of Reliability. Learn how at ***www.burk.com/Jet***.

BURK TECHNOLOGY

www.burk.com | sales@burk.com | 978-486-0086 x700

MADE IN THE USA

Right
Fig. 4: Calculation of Pearson Correlation Coefficient showing no correlation.

D2 =PEARSON(Line_V,Fwd_Pwr)

	A	B	C	D
1	Line V	Fwd Pwr		PMMC
2	212.2	9505		0.00989
3	213.5	9467		
4	217.5	9470		
5	216.5	9520		
6	229.0	9529		
7	231.4	9547		
8	213.7	9502		
9	230.2	9482		
10	219.6	9484		

Alarm on low VSWR.

That's not a typo! Most engineers alarm on high VSWR, as well you should, but there is also a reason to alarm if the meter sits on the left peg. A VSWR indication of near-perfect may look comforting, but it is likely a faulty sample. To assure VSWR protection, alarm if it is too good to be true.

Don't miss a beat.

If you are lucky enough to have an auxiliary transmitter, you should already be switching to it automatically when the main transmitter fails.

It is important to test the aux regularly, but you don't need to get out of bed to do it. Schedule a flowchart or macro to run the text on a regular basis.

Test on-air with the same sequence as your normal recovery. You will be testing the complete backup chain so recovery in a real failure will be smooth. Let your routine tell you about the test in the morning.

Mr. Pearson and his coefficient.

Most of us diligently keep transmitter logs, but what do you do with the data? There is a lot of interesting information in there if you dump the log data into Excel and start digging.

Ever wonder if AC line voltage affects power out? Does the STL signal fade on warm days? How does tube age affect efficiency? Those are the kinds of questions that you can answer with a stack of logs and the Pearson correlation coefficient.

In Excel, fill two columns with the values to test and put "PEARSON(Array1,Array2)" in another cell as shown in Fig. 4. The answer will be between –1 and +1, with zero indicating no correlation and one representing a perfect correlation.

Continuous improvement.

If your system has been in place for a few years, there are improvements that you can make to avoid future down time. Call your equipment suppliers or check the web for the latest updates.

FREE SUBSCRIPTION

For more than four decades, Radio World has been the leading news source for broadcast radio owners, managers, and engineers. It is the premier source for information on technology, timely news, equipment reviews, and industry events coverage

To claim your FREE subscription, go to www.myrwmag.com

Keep it cool, clean and well-grounded

Our conversation with Nautel tips maven Jeff Welton

Writer
Paul McLane
Editor in Chief

Jeff Welton is Nautel's regional sales manager for the central U.S., but that job title doesn't capture his better-known role as "go-to" guy for technical tips, problem-solving and entertaining public presentations.

The industry has caught on. In 2018 he received the Society of Broadcast Engineers James C. Wulliman Educator of the Year Award. In 2019 the Association of Public Radio Engineers handed him the APRE Engineering Achievement Award. And in 2020 he received the NAB Radio Engineering Achievement Award.

When we're talking about maintaining a site for broadcast radio operators, you have a philosophy.

Jeff Welton: I'm a guy who works for a transmitter company, but it's a good philosophy for almost any electronic installation. The three principle tenets are: Keep it cool, keep it clean and keep it well grounded.

There are hundreds of things we could talk about to meet those goals. Where do you start?

Welton: My wife likes to say that I can spot a butterfly half a mile away and go chasing it off into the wilderness, totally losing my train of thought. It's easier for me to pick a specific task and approach that first.

I might walk into a facility and look at airflow direction and check to make sure that the air is going to the actual intake so the equipment that needs to be cooled. Or I might go in with a temperature meter — a Fluke infrared temperature sensor, or I've got one of the FLIR infrared camera attachments for my cellphone, it's a wonderful tool — and do temperature readings to spot checks throughout the facility to see if there are any hotspots that may need additional air flow.

I may do another trip and just do a look-around and open a panel or two. If you're seeing piles of dirt building up in your equipment, that's a hint and a half that something needs to be done with air pressure and filtering. You look for the clues as you go. Obviously lightning protection and grounding are easiest. Stuff's blowing up? You need to do more of it.

Have you found that having fewer engineers coming into the business and fewer people who understand RF has made this a lot harder?

Welton: It does make it a little more challenging. With younger folks being so oriented toward IT and IP addresses, management [may forget] there's still a big, heavy piece of equipment out there that generates heat and needs a lot of cooling and some maintenance.

We've been doing Tuesday webinars on maintenance and mentoring; you can find the archives on the Nautel website.

In addition to newer engineers who aren't so intimately familiar with the big, heavy, glowing stuff, a lot of managers are working with lower budgets. When you're running low on time and money, you're not going to put as many resources towards maintenance — the oil changes, if you will.

But most people wouldn't think of going 80,000 miles without changing the oil on their car, so why would you let the transmitter, which generates all the revenue or underwriting for your station, go for a full year without any maintenance whatsoever?

Especially in the year of COVID, where every day became a series of remote broadcasts as on-air hosts and DJs got moved to their living rooms, engineering gets stretched really thin, going from a couple of remote broadcasts a week to half a dozen a day. The resources for site maintenance and transmitter maintenance get stretched

Right
A FLIR infrared camera attachment lets Jeff take quick visual temperature readings.

Below
Keep spares of any "mission critical" components. Managers, ask your engineer what they could not do without in an emergency.

even thinner.

But you can't leave the air filters in the transmitter until they're covered with a half-inch of crud.

Is that the most common problem you're hearing about?

Welton: It's a bunch of things. High winds get into ventilation systems because exhaust fans failed and weren't putting the air out, so the wind blew the rain back into the transmitter.

I've had one that got snowed on. Several leaky roofs, several lightning-damaged systems as a result of lack of maintenance on the grounding system.

It's more from a lack of attention or personal presence at the site to catch these things before they become an issue. Some of it may be purely financial. A new transmitter at a low-power level costs a couple of thousand dollars, an engineer costs tens of thousands, so do the math; it's cheaper to replace the transmitter every so often. It's a conscious decision in some cases. In other cases, "We got busy and forgot."

What is the recommended frequency of visiting a remote site for general inspection?

Welton: If I've got a site in a cornfield in Iowa, where I'm dealing with windblown dust on a regular basis, it needs to be visited once a month, especially in the summer. If I've got a sealed air-conditioned facility and a company was contracted to come in to clean the heat exchanger coils, I may visit that once a year.

I've done Mississippi in cottonwood season; if you're running a forced air system, you're going to be down there every couple of weeks in July and August.

It will depend on your sites; but there needs to be a schedule and you can't vary from it too much.

Let's imagine getting ready to go to a site for a monthly inspection. What's in your kit?

Welton: The number one tool is the two-foot bolt cutters! I call it the skeleton key — for when a power company guy changed locks around my lock at a multi-access site.

Then my infrared camera, which I can attach to my cellphone. I can power it up as I walk in the building, and point it at the power panels and run it over the coax, looking for any hotspots before I've even unpacked my gear.

A caveat is that you need to have a non-reflective surface. Especially with laser-guided infrared cameras, reflective paint can skew the readings. (I'm Canadian so I like hockey tape, a cloth-based tape with matte finish that sticks really well; you can stick that on your electrical panel.)

After the temperature sensor, a small kit of hand tools with a knuckle-buster — a crescent wrench or adjustable wrench.

With stuff coming in from overseas, I'm going to want a combination of metric and Imperial tools.

A Leatherman or Gerber [multi-tool], at your preference, so you've got Phillips and flathead screwdrivers.

If I knew I'd be looking at air filters, I'd want a full set of air filters and belts for the blowers already at the transmitter site, or in my toolkit.

I carry a first aid kit, rather than putting electrical tape, an old paper towel or shop rag on our finger when we cut it. I am known for sticking my fingers in places I probably shouldn't have stuck them.

Ideally you would bring someone with you for safety reasons, but that's probably not practical for a lot of stations.

Welton: The person doesn't have to be RF-trained. Have somebody there, show them where the circuit breaker is in case you get connected across something you shouldn't be connected across.

They need to be able to call 911, whether it's a landline or a cell phone, depending on the service area. A lot of sites tend to be above cell coverage. But have a way to reach emergency services.

Beyond that, they're there to make sure you don't do anything foolish. Ideally somebody who doesn't distract you from what you're doing.

A lot of engineers take their significant other. Or grab the general manager. It's good to have the GM go. I still run into GMs who don't know where their site is.

If time is limited and you're doing a regular visit rather than responding to a specific problem, what are you checking?

Welton: Anything that handled air — whether it's a filtered air intake, an open-air intake transmitter, air filters, heat exchanger coils on an air conditioning system. Check the cooling system, whatever it happened to be.

Listen for blower belts that might be starting to squeak or getting a little persnickety.

If it's a generator site, I'd run the generator to make sure it started. On a regular basis, you also need to do a full load test and switch the whole site over to generator.

Check the foliage. Look for carcasses like snakes or other kind of vermin in and out of the building.

If it's an AM, I'm glancing at the base insulator and taking a quick check on guy wire anchors. Just do a physical once-over. Walk around.

You've probably seen things that made you shake your head.

Welton: A few. I walked into one site where I was convinced, by the end of the visit, that the engineer was trying to find a way to commit suicide. It was the scariest thing I'd ever seen. Open panels, bypassed interlocks, the tuning unit had overgrown to the point you were running a risk of tripping or falling just going into the antenna enclosure.

He had been unwell and somebody had been covering; but it was a collection of "This is not really good."

For the most part, people take pride in their facilities. But there are times when you'll see pieces of Schedule 90 conduit lying on the floor waiting for somebody to step on them, go for a ride, bang their head on a cabinet and lay there unconscious until somebody finds them.

The safety thing is critical. I don't go into any site where I'm going to be touching electrical stuff without safety shoes on. It's just a given. They're a cheap investment and good insurance.

But if you look at the number of engineers found at transmitter sites, most of the time it wasn't electricity that killed them. It was a trip and a fall and bang your head on something, or a heart attack, or an intruder.

We get too busy doing things. You put in a full day at the studio or in meetings, and then a transmitter goes down, and you spend the next 12 hours at the transmitter site. Sometimes you need to know when it's time to pull the plug and say, "I'm too tired to do this coherently, and I'm a danger to myself and my equipment."

Above
Inspect towers by night, and by day, checking paint as well as lights. Know whom to notify if lights are out.

You're not doing the station any good if you get yourself killed —

Welton: Right.

Or yourself.

Welton: Well —

> **But you can't leave the air filters in the transmitter until they're covered with a half-inch of crud.**

Above
While reliable cooling is important, remember that an air conditioner that is oversized for your space may cause condensation and mold.

Go ahead.
Welton: Somebody used to say, "Nobody ever died from a lack of rock and roll."

Are there common questions or service issues that come up?
Welton: I get a lot of questions on grounding. If you're laying on a new site and want a good resource to get started, I refer people to the grounding for transmitter stations paper in the Resources tab of our website. Or Google the Motorola R56 standard. It goes into massive detail. If you follow that, you're probably going to have the best grounded facility you can have.

One of the biggest questions I get is when somebody is putting a new piece of equipment into a facility that they've owned for decades and that has seen several transmitters, several engineers, and things have been laid on top of other things. Sometimes you need to assess whether it's best to rip it all out and start again or whether you can add without creating loops and more challenges. Just take the time to sit down and assess where you are before you start.

The bulk of what we see in emergency situations? You're not going to stop an "out-of-a-blue 200,000 amp lightning strike," but the vast majority of [problems] could have been prevented by scheduled site visits and replacement cycles.

Everybody's like, "Oh, the transmitter guy's saying buy a new transmitter." Well, I'm not saying buy a new transmitter this week. But when you have a piece of gear that's 40 years old, you probably should be starting to think about the time to get a new one. And the best time is not when it's got smoke coming out the top of it.

We've all heard stories about an engineer finding a bullet hole in a pressurized line. That makes me think about the question of personal safety. Are a lot of clients going up there with a sidearm?
Welton: I'm a Canadian, which is an unarmed American with health insurance. I'm not really qualified to answer that. But I grew up in a farm country with guns, and when we went back in the woods, typically we had a weapon with us of some sort, whether it was for vermin control or because we had bears back there.

The Alaskan folks, you better have a sidearm going up there because running into a Kodiak bear is going to make for a bad day.

Sometimes it's not the rural sites. Some of the urban locations I've been to — I was at a site in Houston where they had double razor wire fencing, and you had to go in through the outer gate, and the inner gate wouldn't open until the outer gate was closed.

Again, it's situational. I've got sites in Wyoming where I wouldn't think anything of driving in there at one o'clock in the morning. You might see a bighorn sheep.

If you're coming to a facility you're not familiar with, do it during the day until you get a feel for the area.

There's so much we could talk about — documentation or stocking the facility with emergency supplies.
Welton: Oh my goodness. Documentation. You said that and my eyes lit up.

So often, things are done with no hint of a note as to what was done or why. Document everything.

The older I get, the less inclined I am to remember why I did whatever I did 20 years ago. Also, for the value of the

A Few More Tips

Here's a further sampling from Welton's "Tips and Tricks" presentations:

- **Steel wool is an effective barrier to vermin when stuffed in gaps and cracks.**
- **Keep a full set of spare keys where they are easy to find. You will need them eventually.**
- **Change default passwords on all equipment.**
- **Use a VPN. There are free ones listed at *www.techradar.com/vpn/best-free-vpn* but paid ones can be very affordable.**
- **Keep spare batteries handy and remember they have a shelf life. Change frequently on smoke detectors and any key components where batteries provide backup.**
- **Provide backups to your STL or other primary link. Is there a redundant method of control?**
- **Take advantage of the Alternative Broadcast Inspection Program to check yourself and to help keep your staff aware of relevant rules.**

Adrian Crook / Getty Images

station — at some point somebody is going to look at this going, "What was he thinking?"

[At one time] you walked into a site, the first thing you did was sign into the logbook; and before you left, you filled in notes on everything you did. We need to get back to that.

With tools like Evernote, you can do audio transcription or attach photos, put in handwritten notes and have character recognition — tools like that on a cellphone are huge.

Now, doing a full spreadsheet, a list of every wire in the facility, starting from scratch, that's going to take some time; but it takes a lot less to update it as you go than it does five years from now to have to create it from nothing.

So, document, document, document.

Is there a section of the Nautel website you want people to be aware of?

Welton: When you go to the support page, there are links to "how-to" videos. If the service guys get regular calls on something they'll create a short how-to video for our YouTube channel.

And there's the latest software. Things we used to do with bags of resistors, capacitors and a sheet of instructions are done with software updates now, so you can find the latest software, read through the release notes to see if it applies to your situation. And my "Tips and Tricks" articles, the quarterly Waves newsletter that we put out.

Final thoughts, Jeff.

Welton: The laptop is less a luxury item than a necessary tool. Obviously we pioneered this with the AUI back in the early 2000s, but more and more equipment will have features that you can access over an IP connection that you won't necessarily have access to from the front panel.

For a contract engineer, you almost can't do your job properly without a station or personal laptop or a tablet anymore. Some sort of electronic device that you can plug into an RJ-45 connection.

Above
Stock your site with emergency supplies like drinking water, paper towers, cleaning wipes and first aid kit, and if the site is remote, consider a survival kit. For ideas, see http://fivegallonideas.com/emergency-kit/.

> **'Sometimes you need to know when it's time to pull the plug and say, 'I'm too tired to do this coherently, and I'm a danger to myself and my equipment.'**

10 dumb things smart people do when testing electricity

A quick reminder of what not to do when taking electrical measurements

Source
Fluke Corp.
The company is a manufacturer of compact professional electronic test tools and software for measuring and condition monitoring.

Anyone who makes their living by working with electricity quickly develops a healthy respect for anything with even a remote chance of being "live." Yet the pressures of the getting a job done on time or getting a mission-critical piece of equipment back online can result in carelessness and uncharacteristic mistakes by even the most seasoned electrician.

This list was developed as a quick reminder of what not to do when taking electrical measurements. Paying attention to three specific categories when thinking about the most common mistakes made when making electrical measurements, personal protective equipment, tools, and culture of safety.

Personal Protective Equipment (PPE)

Having the right equipment to keep you save comes first.

01 Leave your safety glasses in your shirt pocket.

Take them out. Put them on. It's important. The same goes for taking the time to put on insulated gloves and flame-resistant clothing. All of these steps fall under wearing proper PPE. Follow the table method to figure out what level of gear you need on, as detailed by NFPA 70E Standard for Electrical Safety in the Workplace.

02 Work on a live circuit.

De-energize the circuit whenever possible. If the situation requires you to work on a live circuit, use properly rated tools paired with the correct PPE for the environment. Make sure you wear safety glasses or a face shield and insulated gloves, remove watches or other jewelry, stand on an insulated mat and wear flame-resistant clothing, not regular work clothes.

Tools

Once you're geared up and you're appropriately protected, it's just as important to make sure the tool in your hand is the right one for this situation, and the test tool and its accessories are safe to use.

03 Replace the original fuse with a cheaper one.

If your digital multimeter meets today's safety standards, that fuse is a special safety sand fuse designed to pop before an overload hits your hand. When you change your meter fuse, be sure to replace it with an authorized fuse.

04 Use the wrong test tool for the job.

It's important to match your digital multimeter to the work ahead. Make sure your test tool holds the correct CAT rating for each job you do, even if it means switching DMMs throughout the day.

05 Grab the cheapest meter on the rack.

You can upgrade later, right? Maybe not, if you end up a victim of a safety accident because that cheap test tool didn't actually contain the safety features it advertised. Look for independent laboratory testing marks on your test tools to ensure they have been proven to handle what they're advertised at.

06 Neglect your leads.

Test leads are an important component of digital multimeter safety, they are an extension of your test tool. Make sure your leads match the CAT level of your job as well as the tool. Look for test leads with double insulation, shrouded input connectors, finger guards, and a non-slip surface.

07 Hang onto your old test tool forever.

Today's test tools contain safety features that were unheard of, even a few years ago. Even if your old test tool is still working, many of the new features, both safety and test features, can be well worth the cost of an equipment upgrade.

Culture of Safety

How your company thinks about and learns about safety influences how individuals conduct their work, what the culture of safety around them looks like. Mistakes are made when you're pushed to work too quickly or new employees aren't properly trained.

08 Use a bit of wire or metal to get around the fuse all together.

That may seem like a quick fix if you're caught without an extra fuse, but that fuse could be all that ends up between you and a spike headed your way.

09 Fail to use proper lockout/tagout procedures.

Remember to folltow the correct steps to remove power from an electrical circuit or panel, and to lock out and tag the panel or circuit, so that no one can re-energize it while work is in progress. Lockout/tagout procedures are detailed as part of NFPA 70E.

10 Keep both hands on the test.

Saved a big one for last on this list: Do not keep both hands on the test. When working with live circuits, remember the old electrician's trick to keep one hand in your pocket. That lessens the chance of a closed circuit across your chest and through your heart. Hang or rest the meter if possible. Try to avoid holding it with your hands to minimize personal exposure to the effects of transients.

This article originally appeared on the Fluke website. The company has posted online courses and other resources at www.fluke.com/en-us/learn.