HOW CAN WE HELP YOU?

Where problems exist, we want to help. — The best way is to work out the problems together. In that way, you are completely familiar with what is done and future maintenance will be routine.

1. You will note the SERVICE QUESTIONNAIRE. Fill this out completely and mail back today, if possible. Use an extra sheet of paper if further comments are necessary. The following are statements of fact or things to look for. Always remember that most problems have a simple solution. If some of the statements below are elementary, it is because busy, intelligent people often assume that the simple, elementary things are okay.

2. LOW OR HIGH EFFICIENCY. This is important as a first test. As efficiency will vary with transmitter powers, these estimates will help:

250 watts	—	65 to 75% efficiency
500 watts	—	65 to 75% efficiency
1000 watts	—	68 to 77% efficiency
5000 watts	—	72 to 80% efficiency

   (a) The above variances in limits could be for many reasons such as slight meter error, tune-up and/or variance in transmission line length.

3. COMPUTING EFFICIENCY. To compute wattage input, multiply the plate voltage by the plate current in the final radio frequency amplifier. For example, if plate volts were 2500 and plate current was 550 MA., we have:

$$\begin{array}{r} 2500 \\ \underline{.550} \\ 1375.000 \end{array}$$

   This means the power input to the final P.A. stage as required to compute power is 1375 watts, which would be approximate for a 1000 watt transmitter. If, at this power input, the transmitter is delivering 1000 watts output as computed by antenna current (see Par. 4), then we find the transmitter is approximately 73% efficient, or:

$$\frac{1000}{1375} = 73\%$$

4. COMPUTING POWER OUTPUT. The formula I^2R is employed here. I = the current reading of your antenna meter at the tower and R = the resistance measurement of your tower as provided by your consultant who measured your tower after it was erected. If the tower resistance was 50 ohms (they vary widely from tower to tower), then the antenna current squared, multiplied by the tower resistance, would be the power output. Using 1000 watts as the transmitter power, we find if the antenna current was $4\frac{1}{2}$ amperes that the square of this, or 4.5 x 4.5, is 20.25 and we have this simple problem:

$$20.25 \times 50 = 1012.5 \text{ (watts)}$$

5. CORRECTING LOW EFFICIENCY. Basically a broadcast transmitter by inherent design cannot produce low efficiency unless it is tuned up incorrectly. If you have low efficiency, your first check should be into an approved dummy antenna. Light bulbs or dummy antennas of unknown resistance under power do not help. As every station should have a dummy antenna for off-hours testing, etc., this should be part of your test equipment. Several types are listed in the Gates catalog and they are not expensive. By use of the dummy antenna, we have a known resistance to compute the transmitter efficiency without using the antenna tower, antenna coupling equipment or transmission line. By using the formula in Par. 4 above, we use the resistance of the dummy antenna as R. The I^2R gives us the power out of the transmitter.

6. When using a dummy antenna and efficiency is low or below that in Par. 2, the first thing to do is check the accuracy of the plate voltmeter and P.A. milliammeter. This is the gas tank that is always full but often turns out to be the offender. Meters are delicate and the transportation company could have dropped the box in just a way to render a meter inaccurate. You must have another meter of known accuracy for both circuits. A reliable volt-ohm-meter will suffice. Be careful as the voltage is lethal. If you find either of these meters is off, you have found the trouble.

7. If all is normal, then reconnect the transmitter to the antenna. Get another R.F. ammeter (perhaps you can borrow one from a nearby station) and check the accuracy of this meter. An error of only a couple tenths on the scale makes a huge difference. Using our example in Par. 4 above, you will note we used a meter reading of 4.5 amperes as an example which gave us 1012.5 watts output. If this meter had read 4.4 amperes, the output would have been 968 watts. Thus, if the meter was off only 0.1 amperes, we lose 44 watts or nearly 5% of our 1000 watts output.

8. ARCING PROBLEMS. Power must go to the antenna. When it gets sidetracked, it has to go somewhere and this often causes arcing. As efficiency, discussed above, tells many stories, we often find that low efficiency and arcing go together. If the dummy antenna shows good efficiency and the antenna itself shows poor efficiency, it means part of the power is not getting to the antenna. This could indicate several things:

   — Improper tuning of antenna coupler.
   — Standing waves on the transmission line usually indicated by different current readings at each end of the line.
   — Improper ground return from the ground radials to the transmitter.
   — Incorrect resistance measurement of the tower.

9. TUNING ANTENNA COUPLER. Your consultant can help you by tuning up your coupler with an R.F. bridge at the same time he measures your tower. — Where this is not possible and a bridge is not available, consult the graphs in the instruction book and use the cut and try method. Result desired is the greatest antenna current without increasing the power input to the transmitter to get the increased antenna current.

10. STANDING WAVES on the transmission line are caused by improper impedance match between the output of the line and the antenna coupler. Poor match between transmitter output and input to line will reduce power transfer and cause low efficiency. Standing waves may also be caused by a poor or no ground on the outer shield of the transmission line. This line should be grounded to the ground radials at the tower end and to the transmitter at the transmitter end.

11. IMPROPER GROUND. Here is where many good installations go astray. We plow in 120 ground radials but fail to connect them well to the transmitter. Remember, this is the second conductor of our radiating circuit. Where the radials are bonded together at the tower, extend at least a 2-inch copper strap directly to the ground of the broadcast transmitter. Do not attach to one radial closest to the transmitter. Vision your transmitter the same as an ordinary light bulb circuit. The transmission line to the tower is one wire. The other is the ground strap from the radials under the tower back to the transmitter. And don't forget to ground the antenna coupler box too. In fact, you can't do enough good grounding.

12. INCORRECT RESISTANCE MEASUREMENT OF TOWER. Here is where Gates might offend a consulting engineer. It can be said that consultants seldom miss because they know the importance but it has happened. We recall one world-famous consultant that came up with a wrong one and there are lots of good reasons, such as an error in the R.F. bridge. One cause is making changes in the ground system after the measurements are made. This one has upset all of us at times. Any good consultant will recheck his measurements if everything points that way. Be sure first because these consultants are mighty accurate. — The importance of this point is understood by reading Par. 4 again. If the resistance was actually 40 ohms instead of 50 ohms, the power output would be 20% less and the efficiency would be nothing short of horrible.

13. FUSE BLOWING. This doesn't happen often but when it does, it is a big problem. Especially in remote control unattended operation. It is a little embarrassing to suggest the fuses as too small. Don't forget the fuse power is computed by a good safety factor as you may have some things on these fuses that you have forgotten about, such as a window fan or a well pump. — Also fuse rating and heat go together. A hot day and border line fuses is asking for trouble.

14. More important is the deeper causes of fuse blowing. Here are a few points:

— In extremely cold weather if you blow a fuse at morning turn-on, it is a safe bet the temperature of the room has gone very low and the mercury in your rectifiers has collected, causing an arc-back. You can correct this by placing a light bulb or small heating element next to the rectifiers which turns on when the transmitter is turned off.
— Dirt or scum is the evil of all transmitters. Enough will cause arc-overs that will blow fuses.
— Look for cable abrasions.

15. It is also important to note that if you have had a fuse blowing ordeal, that after locating the cause, the fuse clips may be so badly charred that you will continue to blow fuses until the clips are replaced. Fuses will often blow while circuit breakers either in the transmitter or in the wall will not act. Fuses are faster but if you have proper size fuses the circuit breaker ahead of them will usually operate first.

16. UNEXPLAINED OUTAGES. This is the one that puzzles all technicians and often the best of them. A transmitter that goes off the air for no reason and can be turned back on by pushing the start button always brings the question, "What caused that?" — Of course, if this happens infrequently we can say it is normal as power line dips, a jump across the arc gap at the tower base, or other normal things will cause this and it should remove the transmitter momentarily to protect it. Some circuits include an automatic carrier reset while other transmitters require the operator, either remote or in attendance, to push the start button. In either case, frequent outages demand the cause to be located.

17. Your transmitter always looks like the offender. It is the device with meters and it is the device that quits if there is a failure anywhere in the entire system. An open or short circuit in a transmission line does not hoist a flag at the point of trouble in the transmission line. It does react at the transmitter. A faulty insulator in an antenna guy wire or a bad connection in the antenna tuning unit only shows at the transmitter. — In fact, as you can see, the transmitter always shows as the offender. Often it is not, in fact more often it is not. — If the drive shaft between your car motor and the rear wheels fails, it does not mean the motor is defective.

18. Earlier we mentioned the need of a dummy antenna at every radio station. Here again we see how valuable it becomes because you can disconnect everything after the transmitter and use the dummy antenna. By quick process of elimination of the tower, coupler, transmission line, tower chokes and ground system, you are able to determine if the transmitter is the offender. By modulating the transmitter and doing regular programming for an hour or so into the dummy antenna you experience the same transmitter outages, then you can hang it on the transmitter. Conversely, if the transmitter gives no trouble into the dummy, you can conclude that the fault is not the transmitter but in what is connected to it.

19. Step by step trouble shooting is always best. Trouble shooting is never on the basis of "It might be this or that." Instead, follow through from the beginning. If the transmitter was okay on the dummy antenna, the question becomes — "Where is the trouble?" If a transmission line connects the transmitter to the antenna coupler, then move the dummy antenna to the far end of the line and repeat the tests. Always remember that tests should be made, in part, under full modulation because often an open or an arc will occur under conditions of the greatest voltage and/or current. If, in this condition, an irregularity is noted, you have found the point of trouble in the transmission line. If not, reconnect the antenna coupler and the next job is to visually observe the antenna coupler under operation. In so doing, you may actually note a small arc or corona during a modulation peak. This could be caused by dirt, a bad connection, or even a component that is defective.

20. It is well to remember that one bad connection in the radiating system can cause outages. Several years ago an engineer solved weeks of investigation by stepping on a poorly brazed connection at the base of the tower. When he did so, he noted the antenna current increase nearly ½ ampere. So don't assume. Be sure the entire chain is well connected. Carelessness around the base of the tower, where wires are brazed and at which point is the hub of the entire ground system, has caused many problems.

21. Other outage conditions not affecting the transmitter are listed for their value in checking:

- Under certain conditions, especially at higher altitudes, the guy insulators will arc across, caused by static. This will always cause an outage as it changes the antenna characteristics. This is hard to find as it is hard to see. Use of field glasses at night is the best way. If it happens, the vulnerable insulators should be shunted with a resistor. Write our Engineering Department for advice, giving full antenna detail when writing.
- At times the arc gap at the base of the tower is set too close or has accumulated dirt. This causes an arc to ground under high modulation.
- A crack in the tower base insulator is unlikely but keeping it clean is very necessary. A low resistance path at this point can cause trouble.
- Look at the tower chokes. Though they are husky, they are in a vulnerable position as to lightning.
- Shunt fed towers (no base insulator) are usually more sensitive to static bursts than series fed towers. The best method is to try and make the feed line to the tower equal the impedance of the transmission line.
- One side of the tower lighting circuit shorted to the tower itself can cause a lot of trouble, yet the lights may function perfectly.

22. OTHER OUTAGES. If the transmitter is the offender or it acts improperly on a dummy antenna, the process of elimination by starting at the first and following through is preferred unless the cause is actually known. The following hints may help both as to outages and improper operation:

(FALL OUT) The transmitter kicks out a relay at high modulation. Possibly the overload relay is set too sensitive. Look for an arc at any variable condenser. If this condition is noted, it usually indicates improper tune-up or lack of complete neutralization. Improper L/C ratio means the amount of coil to the amount of capacitor used can cause high circulating current and arcs. Use of more coil and less capacity, and in some instances just the reverse, will solve the problem.

(HARD TO MODULATE) Cause can be either improper impedance match at output of transmitter or low grid drive to the final power amplifier. Consult instruction book for recommended grid drive. Correct match of transmitter to load is covered, in part, in the instruction book. The remainder depends on local conditions. It is a very important part of good performance. Indication is a sluggish line or antenna meter, does not move up under modulation or even moves down.

(BAD REGULATION) Usually power line is too small and voltage varies at input under modulation. Often hard to find as public utility meters and graphs are slow speed. Best check is to apply sine wave to transmitter. Check line voltage at zero modulation and then at 100% modulation. If line voltage drops at 100% modulation, then call your utility company. Watch for high line voltage. If much over the stated primary voltage for the transmitter, you are headed for parts failure. Likewise, low line voltage causes poor performance. —— Improper loading of the transmitter to the tower will also cause poor regulation.

23. SHORT TUBE LIFE is usually not the fault of the tubes. Instead, is caused by over-working the tubes. If efficiency is low, tubes must put out more watts to make it up and thus last longer. Answer is get the efficiency up (see Par. 2). Arc-overs anywhere, may under certain conditions, cause the big tubes, the expensive ones, to self-oscillate. Find and stop the arc-over. Short tube life is compared to using more gas if the car is running up hill all the time. Eliminate the cause for your running up hill and tube life will be long.

24. POOR QUALITY can be for so many reasons that to list them all would take many pages. It seems foolish to even suggest that a poor stylus in the transcription turntable is a cause for poor quality, but it happens. —— Every station must take proof of performance measurements. This proof of performance equipment is usually owned by the radio station. In fact, it is difficult to keep a radio station at top performance without one. With this equipment, each major equipment may be checked for distortion, noise and frequency response and it is these checks that tell good or bad quality. Where studios are separate from transmitter, even the quality of the telephone line may be checked.

25. Poor quality is often guessed at as to cause and yet we all know that the finest broadcast transmitter is only as good as the microphone used, which is to say, "A broadcast system is as strong as its weakest link." We thus can agree that poor quality usually ties down to any one item in the entire system. By use of proof of performance equipment, we find out what this item is and fix it. — Though this data is not intended in any way to be sales data, some may wonder where to get "Proof of Performance Equipment". This will be found in the Gates catalog. The SA-131 complete proof of performance package sells for $498.00 and is available on time payments as we feel every station should have one regardless of budget.

26. Earlier it was stated that poor quality is possible from many places. The obvious is easiest to find, such as the poor microphone or bad turntable styli. Radio frequency leakage is often a cause for poor quality. This leakage is where a small amount of R.F. voltage gets into other equipment, such as the limiter, audio cables, and in combination installations the speech input console. —— In most cases, this leakage is small enough to be quickly eliminated but also small enough to be hard to indicate by use of the usual methods such as a small neon lamp, etc. ———— R.F. leakage is usually caused by lack of grounding or grounds at varied potentials. Grounding to one common ground is best. Of course, be sure you have a ground connection. Once in awhile a

full rack of equipment will be found with the only ground coming through a shield of the audio cable. This, of course, is poor grounding and copper strap should be employed.

27. Care should always be taken not to run R.F. cables in the same conduit or cable group as audio cables. For example, running the coaxial connecting cables from transmitter to monitors in the same cable as audio lines would be very wrong. Likewise, inserting high and low level cables, even if individually shielded, in the same conduit or cable group is very wrong. A high level circuit would be any output circuit. A low level circuit would be any input circuit. Thus, a microphone or turntable pair in the same conduit or cable group as the output of the program amplifier or monitoring amplifier would be asking for trouble.

28. Poor quality is possible through overloading. All equipment is usually rated as to maximum input and output levels. For example, if an input circuit is rated at 0 Db., this means that putting more than 0 Db. into this circuit is overloading. If an output circuit is rated at +18 Db. and you are developing +24 Db., the distortion goes up. ---- Careful attention to good sensible engineering practice is the answer. Short-cuts, speed in getting the equipment installed and throwing long known precautions to the wind cause many quality problems and usually demand rework.

29. THE CHIEF ENGINEER. He has the job of keeping everybody happy --- listeners, manager and stockholders. When trouble comes, he is under pressure. He will do his best to correct trouble as fast as he can. It is well to remember that electronic equipment has many circuits and many avenues of travel. Where problems are known, the solution is usually quick. Where the problem has to be found, the solution will take longer. ---- It is well to remember that if equipment did not need maintenance, it would not need a Chief Engineer. The greatest service he renders is the insistence on regular preventive maintenance and his being there when problems arise.

30. PREVENTIVE MAINTENANCE. Few of us would fly in commercial airlines if we felt the planes were not carefully checked after every flight and, of course, they are. --- We even check our automobile tires before we take a trip. Our lives are lived and protected, even our homes are run on preventive maintenance. The good wife cleans to prevent moths. -------- In broadcasting equipment, preventive maintenance is mandatory. Most offages can be eliminated before they happen by checking before instead of fixing afterwards.

31. Dirt is the first cause of all trouble. Excessive heat is Number 2. With the advent of unattended operation, both have grown. With the transmitter in a locked building, it is cleaned much less and with the windows closed it becomes an oven in summer months. In all cases, remember:

---- The dirt-free transmitter is the trouble-free transmitter.
---- The cool transmitter is the longest lasting transmitter.

Clean once weekly and duct hot air out of closed transmitter buildings. Check tubes at least monthly. Poor tubes mean poor quality and eventual outage. Rotate the bigger tubes every month. Include spares in this rotation, both to prevent gassing and also remember the guarantee will run out. If you have a defective spare and you rotate it into the equipment, you will find the defect before the guarantee runs out.

32. Other things in preventive maintenance include oiling of motors in blowers and turntables, burnishing relay contacts as needed, cleaning attenuators, checking batteries where used, cleaning inside of all equipment. The inside is more important than the outside. Every station should have a small suction type cleaner such as used to clean an overstuffed chair. This will pick out dirt and dust from pesky trouble-making nooks and corners. If we take a leaf from the Navy book which says everything must at all times be sparkling clean or what is called "Shipshape" ------ we have preventive maintenance in the complete form.

33. ADEQUATE TEST EQUIPMENT. When you go out to take pictures you must have a light meter to test exposure time. This light meter has nothing to do with the camera. It is test equipment.

34. Comparatively, you can neither maintain nor correct without the tools to do the job. An investment in expensive broadcasting equipment dictates a modest investment in the necessary equipment to keep it operating at top performance. Listed below is suggested test equipment for the average radio station. Where the station is directional (uses more than one tower), an item or two more will be required, such as a field strength meter for sure. Here is the suggested list:

---- Dummy antenna.
---- Proof of performance equipment consisting of:
1. Audio oscillator.
2. Distortion meter.
3. Gain set.
4. R.F. pickup coil or rectifier.
---- Good grade volt-ohm-meter.
---- Spare antenna current meter.
---- Oscilloscope.

35. GATES ASSISTANCE TO HELP YOU. The Gates Radio Company sincerely believes that the best type of assistance it can render to the technical personnel in the radio broadcast field is in full cooperation with them in solving any problem, no matter how small. It is believed that the solution of any problem is best accomplished by getting to the seat of it through mutual working together between the station engineer and Gates technical people. As we all have a certain amount of pride, there is often some reluctance to write, asking about a problem that might seem simple. It is emphasized that often the problem that appears the simplest might be the most complex. It is only by the asking of questions that assistance can be rendered.

36. Gates engineers and technical personnel invite the correspondence of the technical people that are using Gates equipment, and for that matter, even if they are not using Gates equipment, and are willing and ready to spend any amount of time necessary to not only be of help and assistance but to make the life of the broadcast technician more pleasant -- and most important of all, to make the radio broadcasting equipment always a pleasant experience by continued satisfactory performance.

GATES RADIO COMPANY -- QUINCY, ILLINOIS, U. S. A.

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EQUIPMENT PROOF OF PERFORMANCE

Use Keuffel & Essel Graph Paper 358 - 125, 3 x 5 cycles

OVERALL FREQUENCY RESPONSE

STUDIO CONSOLE MICROPHONE INPUT TO TRANSMITTER OUTPUT

RADIO STATION____________________________

DATE___________________________________

MEASURED BY_____________________________

FREQUENCY (CPS)	30	50	100	400	1,000	5,000	7,500	10,000
DB DEV. FROM 1 KC.				25% MODULATION				
DB DEV. FROM 1 KC.				50% MODULATION				
DB DEV. FROM 1 KC.				85% MODULATION				
DB DEV. FROM 1 KC.				95% MODULATION				

NOTE: FCC allows ± 2 DB variation 100 CPS to 5,000 CPS.

NOISE LEVEL BELOW 100% MODULATION

Overall Noise Level (30 CPS to 45KC)____________DB. (FCC Minimum 40 DB)

Overall Noise Level (150 to 45KC)______________DB. (FCC Minimum 50 DB)

CARRIER SHIFT AT 400 CPS

25% Modulation____________________ 85% Modulation____________________

50% Modulation____________________ 100% Modulation____________________

NOTE: Carrier level indicator of modulation monitor adjusted to 100 with no modulation. Percent carrier shift with modulation reads directly from carrier level meter.

FCC ALLOWABLE CARRIER SHIFT IS 5%

OVERALL DISTORTION CHARACTERISTICS

STUDIO CONSOLE TO TRANSMITTER OUTPUT

RADIO STATION ______________________

DATE ______________________

MEASURED BY ______________________

FREQUENCY (CPS)	50	100	400	1,000	5,000	7,500	10,000
MEASURED DISTORTION			25% MODULATION				
FCC MAX. DISTORTION	5%	5%	5%	5%	5%	5%	5%
MEASURED DISTORTION			50% MODULATION				
FCC MAX. DISTORTION	5%	5%	5%	5%	5%	5%	5%
MEASURED DISTORTION			85% MODULATION				
FCC MAX. DISTORTION	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%
MEASURED DISTORTION			95% MODULATION				
FCC MAX. DISTORTION	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%	7.5%

NOTE: ALL DISTORTION MEASUREMENTS INCLUDE AUDIO FREQUENCY HARMONICS TO 45,000 CPS