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FIELD ENGINEERING NOTES CONCERNING CHECK LIST TO BE USED IN CONDUCTING A DIRECTIONAL ANTENNA PROOF OF PERFORMANCE

A - GENERAL:

The items discussed in this check list were primarily made up as a guide for the engineer from this office who conducts a proof of performance for one of our clients. There will probably be certain things coming up on all proofs which may not be covered in this check list; hence, when in doubt, call the office.

In checking over antenna system layouts, Joseph Novik's RCA article entitled "Installing Antenna Systems for AM Operation" (reprint from Broadcast News, June 1957, Volume 95) is good reading. Also, we recommend using the Dresser-Ideco Company "hip-pocket" tower check list in looking over the mechanical construction of the array.

Regardless of what happens on a job, if an engineer will keep extensive notes in an orderly manner, there is no problem that can't be solved with the application of a little common sense and a re-check of parameters. Before leaving our office, be sure to check out all of your field equipment to make sure that it is operating properly. When field intensity meters will not agree within 5%, the meter with the latest calibration must be used as the standard. Nothing will be gained by using a meter which is not calibrated properly and trying to apply some correction ratio to your measurements. It is better to airship this meter back to the office for calibration and request another meter to complete the job.

The use of two-way radio is one of the most important tools we have available to us in the setting up of a directional antenna system; consequently, be sure that your two-way equipment is working properly when you leave our office and arrive at the job. A little time spent working on the mobile equipment can save many days in the field where two-way communications cannot be established. Therefore, concentrate on establishing good two-way communications to your monitoring spots before getting too far into the proof.

Remember that there are two basic items with which we must concern ourselves in the operation of a directional antenna system. First of all, the pattern's shape and last, but not least, the pattern's size. The pattern's shape is a function of the design formula (That is the spacing between the towers and the difference in currents and phases between these towers). Assuming no re-radiation objects close to the array, if the proper currents and phases are established, you will obtain the proper pattern's shape. The pattern's size is determined by the driving point characteristics of the towers and how well you match the electrical parameters set forth by the pattern design formulas. A low E_{rms} means that you have loss taking place within the array and assuming that you are working with an array which can develop satisfactory E_{rms}, low values only mean that you are burning up power in some portion of the phasor or coupling units because of improper phase shift or termination. High E_{rms}

A - GENERAL (CONTINUED):

means that you do not have the proper current ratios or power division between towers (assuming the pattern's original E_{rms} has been determined), or for some reason, not determined in the original design, the pattern has a greater gain factor than our mathematics would lead us to believe. If this becomes the case, it is a relatively simple matter to dissipate some of the power by introducing larger apparent resistances in the networks.

Use the following paragraphs as a guide in your work. Take your time, make careful notes, and you should have little trouble in conducting your proof.

Before starting work at a station verify that all necessary instruments of authorization, construction permit, telegrams from FCC, etc. are posted at the transmitter. Read all such documents.

B - PATTERN'S SHAPE REQUIREMENTS:

(1) Design Formula:

(a) Check out sample equation.

(b) What are the protection requirements and what F.C.C. M.P.'s have been assigned? Determine number of radials necessary for proof (eight plus F.C.C. M.P.'s unless one can show that less are needed). This is generally done in office before you leave.

(c) How was center-line and spacing for towers established? Is it accurate? Be sure that true bearings have been used (Ask to see surveyor's report). (See procedure sheet regarding surveying.)

(d) Are base elevations within 3' to 4' of that specified to F.C.C.?

C - PATTERN'S SIZE REQUIREMENTS:

(1) Check office E_{rms} determinations and compare these to equipment company's specifications.

(2) Physical Check of Array Layout:

(a) Check to see that sampling loops are placed from 10' - 14' from base of tower. Make sure that line is insulated from tower. Couple up loops to approximately 70% coupling by moving loop towards tower leg. Be sure that loops are on same side of each tower leg and oriented in same direction because an error in orientation will cause an error of 180^0 in indicated phase. If towers are over 130^0 tall, loops should be located at maximum current point on tower and

C - PATTERN'S SIZE REQUIREMENTS (CONTINUED):

(2) (continued):

line strapped to tower and brought over base insulator by means of an isolation coil.

The tower impedance should be checked with the sampling line disconnected from the top of the isolation coil to make sure that isolation coil is not shunting down or effecting base impedance

(b) Check telephone system between towers and building. Be sure that telephone at building is located next to phasor.

(c) Check each tower with lights on for leakage voltage by using a VTVM (Be sure if a three wire system is used that the neutral wire is bonded electrically to the tower at several points). If voltage measures over 15 volts, have tower lighting cable checked out for partial shorts. The usual place where shorts are found is at the junction boxes and splices. Also check photo-electric control.

(d) Check coupling house layouts against schematic diagrams for correct wiring and value of components. Also check grounding strap.

(e) Check phasor for layout against schematic diagram for correct wiring and value of components. Also check grounding strap and phasor electrical controls, such as transmitter re-set and day-night pattern switch. Be sure that relays at tower change properly with phasor controls. Check inter-locks on transmitter and phasor doors. Check all fittings for tightness.

(f) If transmitter has not been tuned, use manufacturer's instruction book and tune. Use dummy-load for tuning. Set oscillator frequency to required tolerance required by F.C.C. Have at least three frequency checks made during proof for F.C.C. Form #302.

(g) Make sure that construction which would affect array is completed before starting proof. (Items such as complete ground-system, fences around tower, proper number of insulators in each guy wire, etc.)

(h) If a solid dielectric cable such as RG-17, or RG-8 is used for regular transmission lines or sampling lines and these lines are buried (below the frost line), it is also wise to line the trench where the cables are placed with pebble stone or light sand.

Lines should not be buried unless they have been designed for burial.

C.- PATTERN'S SIZE REQUIREMENTS (CONTINUED):

(2) (continued).

Assuming that the transmission lines are not buried, they are generally supported by poles varying in height from 2' to 4'. Each of these poles should be grounded into the regular ground system. We have found that sometimes when lines are suspended above the ground there will be "hot-spots" along the line - due to the fact that the grounding has been made with a single piece of No. 8 or No. 6 wire which is practically no ground at all.

When a ground is attached to the coax and run down along the side of the pole, it should be at least a 2" piece of copper strap. All connections should be brazed or silver soldered in order to assure a non-corrosive joint.

If the line is of the RG type before attaching the ground strap be sure to first "hard-solder" a piece of braid to the strap, then carefully clean the insulation off of the coax, and use this piece of braid for attaching to the coax. This connection should be "soft-soldered", to prevent burning of the coax insulation. One way to check the "hot-spot" is to walk up and down the length of the lines with a field meter with its loop carried parallel to the ground (minimum pick-up to ground). As the field meter is carried along the side of the line, the field meter will have a tendency to increase in field and possibly try to go off scale if a "hot-spot" is found. This is another way of saying standing waves exist on the line.

(3) Measure the following:

(a) Transmission lines to determine Z_0 and θ shift (See Procedure Sheet #1).

(b) Sampling lines to determine Z_0 and θ shift. Determine correction factor for each line if correction networks are not immediately inserted (See Procedure Sheet #1).

(c) Mutual and self-impedance (See Procedure Sheet #2).

(d) Reactance for each coupling component at each tower. Use piece of adhesive tape for marking number of turns, if they are not marked. Tabulate this information in work book.

(e) From design information determine which tower is to be used for non-directional measurements and then made a series of impedance measurements for this tower plus or minus 30 KC's either side of operating frequency (other towers in array to be floating if height is 90^0 or less, or de-tuned if towers are over 90^0). Make as many 5 KC check point measurements as possible. Obtain a minimum of 10 measurements. If, due to interference or some other reason this is not possible, then extend the band over

C - PATTERN'S SIZE REQUIREMENTS (CONTINUED):

(3) (continued):

which the measurements are taken to obtain the required number of points. Tabulate the data in work-book. Be sure to check to see if lighting chokes have any effect on Z measurements by disconnecting chokes during measurements. Chokes should not affect measurements more than 5%, if at all, and in case they do cause more effect, they should be de-tuned by changing the value of the shunting capacitors across them (If towers being measured are over 90^0 tall, the floating tower must be de-tuned). Also have someone vibrate tower guys and pound on tower with insulated object to make sure it is not affected.

(f) After step (e) is completed, match coupling components (coupling house components) to transmission lines (See Procedure Sheet #3 for technique).

(g) Calibrate all transmission line and base antenna meters by placing them in series in the non-directional tower and adjusting power input to coupling unit so that meter's full scale deflections will not be exceeded. It may be necessary to use different combinations of the meters because of their scales in order to make this check. It is not uncommon to find new r.f. meters of the same type which differ as much as 20%. Inasmuch as the F.C.C. requires meters with a tolerance of 2%, this situation can sometimes create a problem. The best way to solve this, if other meters are not available for changing, is to select the meter with the most accuracy, or recalibrate each meter in the field. Procedure Sheet #4 describes this technique.

(h) After step (3)(c) is completed and driving point Z's are determined, set up individual driving points for each tower, using work-book tabulation for settings. Once this is completed, the towers are now ready for power, either non-directional or directional.

(i) Measure T-network components in phasor, power dividing networks, θ shift networks, etc. Tabulate in work-book and mark with adhesive tape if turns are not marked.

(j) The phasor is now ready for setting up. Determine desired power division from driving point calculations and then select true common point Z desired (from original office work sheets) and then set up in same manner described in Procedure Sheet #5. Once the above is completed, the array is ready for proof.

(k) Put power on and calibrate phase monitor according to manufacturer's instruction book. Then adjust sampling line meters by use of "calibration pots". Also, install phase correction networks for sampling lines (See Procedure Sheet #6), if required.

C - PATTERN'S SIZE REQUIREMENTS (CONTINUED):

(3) (continued):

(l) We assume that the site is generally a good one. That is, no high tension lines, smoke-stacks or other re-radiating objects are within several wave-lengths of the array, because we have cautioned our client about these factors and further, we have tried to check his aerial photos to make sure that such objects are not around; however, in spite of these precautions, upon arrival at a site, we sometimes find a power line (other than a normal service line) going through the array or right next to one of the towers, large metal buildings, or smoke-stacks next to the array, etc. These objects generally play "hob" with the array and must be "neutralized" before D. A. measurements can be made (See Procedure Sheet #7 for technique used in reducing or eliminating these effects).

(m) Now check array with regular power for base currents, phase shift, powerdivision, etc. Adjust phasor for proper settings, if original set-up did not produce correct pattern according to monitor, and field checks.

(n) Now run non-directional measurements along with cross-radials. Select prospective M.P. locations during non-directional measurements.

(o) After non-directional measurements are completed set up several check points for array and establish two-way communication between these locations and the transmitter building. Then touch up phasor for pattern's shape and E_{rms}, using these points as a criteria (See Procedure Sheet #8). When array is adjusted to proper ratios for "check points" or M.P.'s, then run DA cross-radial measurements (same location as used for non-DA). Check cross-radial measurements by ratios and plots on polar paper. This technique should indicate proper shape of the pattern and the DA measurements can then be made.

(p) After the DA measurements are completed and analyzed, the final portions of the proof can now be completed. All items on F.C.C. Form #302 should be answered. Some additional pointers to consider are:

(1) Check C.P. against known facts for any changes.

(2) Write up description of how to locate M.P., draw a map showing locations, and make photo of M.P. locations.

C - PATTERN'S SIZE REQUIREMENTS (CONTINUED):

(3) (continued):

(q) Make up tabulation for chief engineer of dial-division changes versus field intensity readings at M.P., assuming phase shift and currents read correctly on monitor.

(r) Go over proof and entire array with chief engineer, outlining maintenance requirements, operation, location of M.P.'s, etc.