TRANSCO MICROWAVE SYSTEM

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The Transco system is approximately 1,780 miles in length and has roughly 9,350 circuit miles in use, all of which are for voice conversation. Our main system consists of 59 stations placed at intervals of 30.7 miles, with the shortest hop 10 miles and the longest 50 miles. Tower heights range from 50 to 350 feet, generally supporting two 6' dishes. The backbone equipment was manufactured by General Electric Company and operates in the 2,000 Mc band. As installed, this equipment is designed to accommodate 12 pulse channels of 3 Kc bandwidths. At 4 intermediate points all circuits or channels are demodulated and terminated or wired through to modulate a new pulse train. Leg circuits operating in the 950 Mc band are used to tie the main system to operational points located at short distances from the pipe line. This system was installed for the purpose of providing communication essential in the maintenance and operation of a 30' high pressure pipe line which runs from southwest Texas to New York.

Theoretically a long haul system is quite identical to a short haul installation. In comparing the actual operation of the short haul versus a long haul system, we found that problems expand exponentially as the system's length increases with the primary contributing factor being distance. This necessitates that a different approach be made to normal operating or maintenance problems. A portion of this probably is psychological since admittedly the magnitude of a problem increases as the distance from the trouble increases.

In the design of a long system, allowances are made for the cumulative effect of random noise, all of which are based on average or normal operating conditions. Many simple deviations from the normal can and will occur, such as a simple misadjustment of intermediate audio levels, which will tend to distort the normal operations on a long system where possibly the same condition would not be noticeable on shorter installations. This means that more attention must be paid to small details on the long systems, which would not be necessary on shorter ones. In maintenance, emphasis is placed on continuity of service from end to end, which reduces the possibility of the circuit being available for scheduled interruptions by maintenance personnel. Generally, as pipe lines are extended they acquire additional personnel requiring conversation time with a result that channel and system usage is greater than for short lines; consequently, a greater effort must be expended to prevent circuit interruptions. In our system this condition is further aggravated by differences in time zones which during the summer months particularly puts a heavy conversational load on the system during an abbreviated work day.

On any system trouble will occur, some of which will require technical assistance from operational headquarters to clear. This means that on long systems better maintenance men should be provided for the more distant points or else the effect of equipment outages will be more pronounced. Difficulties in locating trouble is more pronounced on long systems than short ones, since it is relatively easy to obtain a distorted picture of trouble when making an analysis from a distant point. All the above emphasizes the prime necessity for having a well organized operating force or else difficulties will develop.

In any microwave system the number of fades to be anticipated is a, direct function of the total paths within the system. Due to the probability of simultaneous fades occuring in more than one path along an extended system, total circuit outage time on a mileage basis from fades could be less on a long system than a short one.

When considering the major factors effecting service continuity our first thought naturally turns to the type of equipment involved, but since descriptive literature is available on this as well as on other manufacturers' equipment, an analysis of this will be omitted. Important consideration must, however, be given to the length of time equipment will remain in adjustment after servicing since this can in a large measure determine service outage or maintenance men requirements. If regular routine maintenance schedules are observed, and these schedules are adjusted to accommodate replacement of expendable items plus characteristic drifting of resonant circuits, outages from this source can be controlled. It must be recognized that with microwaves we are dealing with wave lengths where resonance is more difficult to obtain as well as maintain.

The effect of maintenance personnel on service continuity is almost as important as the equipment being used. Since experienced microwave maintenance personnel are not available, these men must be trained. Training can usually be accomplished in from 6 months to one year depending on the attitude and aptitude of the individual involved. An experienced technician can usually acquire enough knowledge in two or three months to keep a circuit working at something less than maximum efficiency. In selecting personnel it is important to have men with a pioneering spirit as well as the requisite technical ability to absorb instructions. The former is very important since the microwave industry is essentially still in its infancy with techniques fluid and subject to rapid change. To further emphasize the importance of personnel it is my belief a system with poor equipment and good personnel will operate more satisfactory than a good system with poor personnel. In any event the system is little better than its weakest man, particularly on extended installations.

Probably the next most important factor in reliable system operation is vacuum tubes. On a system such as ours we have 8,000 active sockets. Based on an average life expectancy of 6 months, 2 tubes should fail each hour. If tubes were permitted to fail maintenance personnel could never change tubes fast enough to keep the circuit in operation. Fortunately manufacturers have improved tubes to such a point that total failure of tubes occur infrequently. Many tubes show a decrease in emission prior to failure and thus can be eliminated before degrading the circuit. Our primary concern with tubes has been the poor quality control by manufacturers on these items. Generally identical tube types show wide variations in characteristics, particularly gain and internal noise conditions requiring quality selection for many circuits. One particular bothersome tube was a rectifier with an emitting surface that flaked badly causing flashovers. By changing tube manufacturer this problem was solved at least temporarily. Additionally we are always concerned with the possibility of new tube failures within the first few hours of service. Most of the above indicates a need by manufacturers for better quality control.

Another source of trouble we encounter is with equipment auxiliary to the microwave gear. Auxiliary power supplies as designed and delivered to most microwave systems were not particularly applicable to our service requirements. Most were equipped with starting batteries not designed for intermittent service with a result life was short and service unsatisfactory. Also, trickle chargers kept batteries dry. A fourth source of trouble and outage source was the power changeover equipment, associated relays and cutouts. These units have given entirely too much trouble and future designs should profit by these mistakes. Our system was equipped with timers that supposedly kept auxiliary power sources running for 15 minutes when started but none of these worked and all were replaced. Another faulty device was a thermal cranking limiter connected in our starting battery supply which operated erratically causing circuit outages. Our experience indicates standard telephone type relays operate more satisfactorily than the special models, one of which is a video relay that habitually causes trouble. This unit was improperly designed and it is doubtful whether it would work in any service. Dust is an ever present problem with relays even at remote and isolated locations.

A considerable amount of literature has been written on propagation most of which emphasizes the desirability of short paths for reduction of outages from fades. These articles generally are correct in most assumptions. However, in the Transco system some of our long paths are not bothered with night time fades while others are. Also, a short path does not necessarily assure relief from fades. It is not the intention of this article to take issue with all published information on propagation. However, our experience indicates a portion of this material is entirely too conservative with respect to quantity and magnitude of propagation aberrations as well as distances signals travel. Experimental data from isolated tests should not be assumed to apply for all areas.

Our experience has indicated fades occur with more severity along the Gulf Coast than any other section of our line. Two other bothersome small areas exist, one of which is in the vicinity of Atlanta and the other along the Potomac River. In each place fog layers are prevalent, which means high humidity and low turbulence. It is quite common to find 15 to 20 DB fades over a period of 8 to 10 hours along our system with this phenomena being more pronounced in the Gulf Coast area. These prolonged fades occur more often in flat areas when wind velocities drop to the neighborhood of 4 miles per hour. In many instances fades are accompanied by overshooting of signals with these being observed to skip more than 160 miles at fairly regular intervals.

Increased signal strength or improved receiver sensitivity can effectively combat most fading problems, especially in our service where interruptions of short duration are not a major problem, particularly if they occur at night time when service requirements are at a minimum. During the fading season maintenance personnel must be alert keeping all equipment operating at maximum efficiency or else service will degrade.

We have found that the quality selection of receiver mixer crystals and expendable items such as tubes will contribute enormously to maintaining equipment at optimum operating efficiency. Each of the above are found to vary widely in noise characteristics, requiring an actual operating test to eliminate the undesirable units.

A source of considerable annoyance to us has been the unreliable nature of some commercial power sources, particularly in certain areas. Most microwave systems are designed to give approximately one minute signal interruption following a power failure. In our system we purchase power at 42 locations with 2 adjacent installations having interruptions as high as 25 each per month. Fortunately most areas have fairly reliable service, otherwise communication service would be considerably degraded unless battery banks were used as standby for auxiliary power. One contributing factor to our power interruptions is that a large percentage of our line is located in a high isokeraunic area where lightning storms have given us up to 9 power interruptions at one location in a single day.

Lightning is also a source of considerable annoyance and trouble to a long system. Tall antenna towers offer excellent discharge paths for accumulated charges and it is to be anticipated an occasional discharge will develop sufficient potential to cause trouble.

All the above is emphasized in an effort to be helpful to those having or contemplating microwave installations. Additionally this article would stress the fact that the microwave art is still in its semi-infancy with additional developmental work essential to encourage the continued rapid expansion of this new communication tool. This work should not be relegated entirely to the manufacturer since all users can contribute immeasurably by a free exchange of useful information with each other as well as with equipment producers. An active program of this nature was initiated within the petroleum service shortly after this group began pioneering work with microwave. Additionally, other services have been encouraged to participate in this program.

As a further impetus to microwave growth all interested groups and services should assist the FCC by making all useful data available to them, in order that adequate rules for microwave can be written. These rules should be written in such a manner as to encourage the orderly growth of this new service. This we believe can be best accomplished by adopting flexible technical standards plus an entirely new approach to other sections of these proposed regulations in which only rules pertinent to this particular portion of the frequency spectrum would be adopted. With the exception of technical standards, petroleum service organizations have preliminary rules available for examination covering the microwave. Technical standards should be furnished by manufacturers, and we urge that group to finalize these in order that the service rules can be completed and the present developmental status abandoned.