INFORMAL REPORT ON OBSERVATIONS AND RF FIELD INTENSITY MEASUREMENTS MADE AT A COMMERCIAL FM/TV TOWER LOCATED IN EL PASO, TEXAS

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Notes* on a site visit made on the 11th of December 1978, with OSHA staff (by invitation) to a TV and FM broadcast/transmitter station and transmitting antenna tower located in El Paso, Texas. The objective of the visit was to determine if employees working in the monitoring building at the base of the transmitting antenna tower, or employees working on the antenna tower itself, are exposed to hazardous levels of radiofrequency (RF) energy. Survey results indicate that RF levels in the monitoring building were well below the present OSHA guideline of 10 mW/cm^2. RF levels measured on the transmitting antenna tower (located on a mountaintop north of the city) exceeded the OSHA guideline by a factor of 10.

The station call letters are KDBC-TV, Channel 4. Mr. Edward Sleighel, the Station Director, met us at the Opening Conference. Mr. Frank Jordan is the Chief Engineer. The OSHA staff involved were Cathie Mannion, Supervisory Industrial Hygienist from the Lubbock, Texas area office, and Robert Curtis (Electrical Engineer/IH) from the Health Response Team in Salt Lake City, Utah. Ms. Mannion met me at approximately noon on Monday, December 11, upon my arrival at the El Paso airport. Bob Curtis was not able to arrive until later that day because of the need to stop in Denver to pick up E- and H-field measuring probes from the National Bureau of Standards (NBS). Consequently, Cathie and I (while waiting for Bob) drove over to the TV station and held the Opening Conference, so as to discuss items relating to the visit with management personnel of the station, to obtain some information from them relating to the operation of the station, number of employees, medical monitoring, and to inform them of what we were hoping to be able to accomplish by our visit. We found the station personnel to be cooperative, cordial, and informative.

The Opening Conference was initiated at approximately 2 P.M. Cathie handled things very effectively. As noted earlier, the station management and staff personnel were most cooperative, asked us a number of questions so that they would understand the reasons for our visit, and supplied all the information that was asked for. I indicated (when asked) that the reason for my being present was to gather some additional information regarding a specific potential occupational RF exposure situation, to obtain some RF field intensity measurements on and around the tower, to use the occupational exposure information to broaden our own (i.e., NIOSH) data base, and to get some experience making RF tower measurements (since there have been only two previous measurements made on transmitter towers). I described NIOSH's present effort to develop a criteria document containing recommendations for occupational exposure levels for RF and microwave radiation.

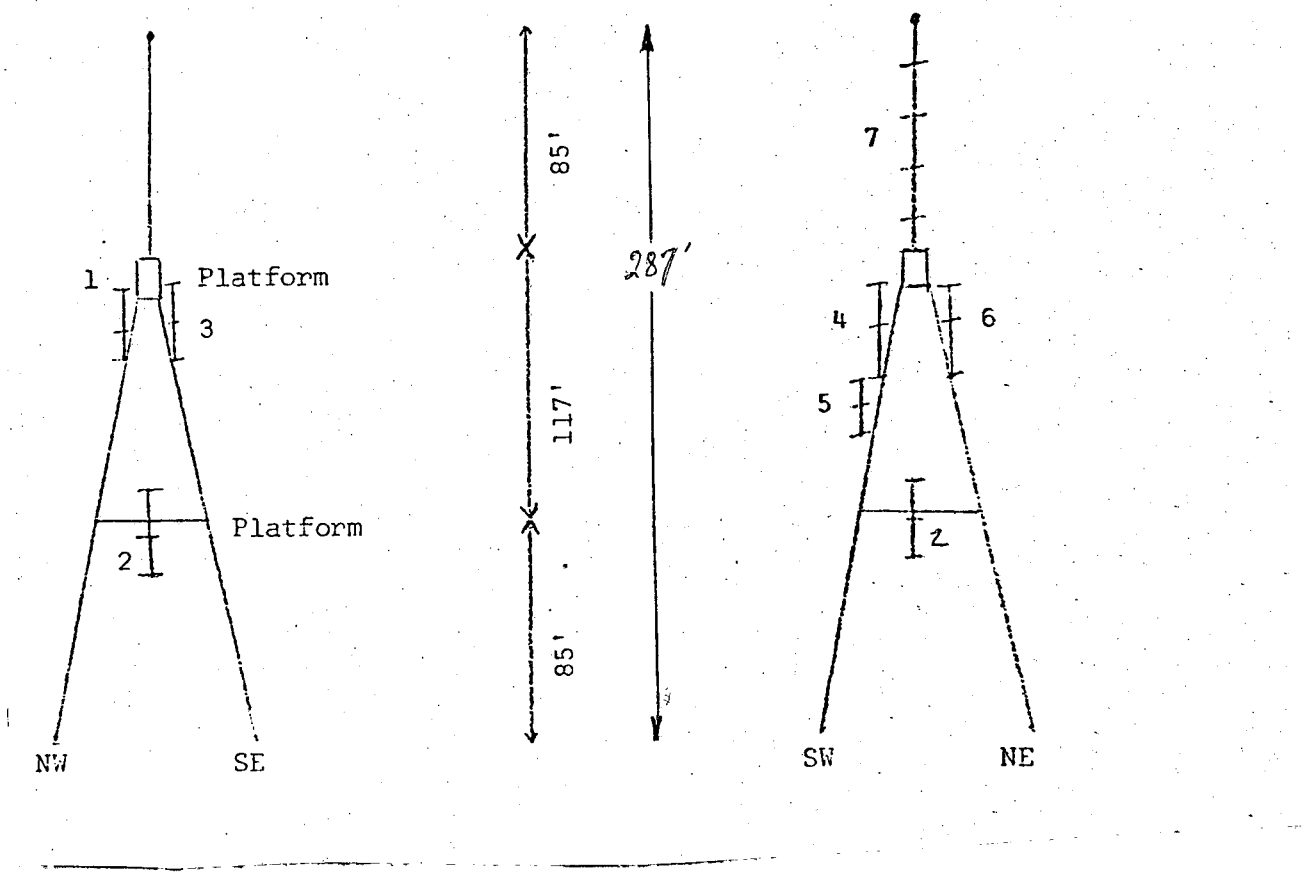
*Transcription of notes dictated onto a tape recorder by Z. Glaser (NIOSH) and R. Curtis (OSHA) on 14 December, 1978.

One correction that Mr. Jordan made relative to the informal complaint (filed with OSHA by a company employee) that Cathie had received, was that although there were approximately five or six personnel out at the transmitter and tower site, they did not all work simultaneously. There were three full-time and two part-time male employees who worked various shifts and days; usually only one person at a time.

We departed the TV station to pick up Bob Curtis at the airport at approximately 4 P.M. The Opening Conference had just been completed by that time. The plan was to return to the station with Bob after we had picked up the second (of 2) NBS monitoring meters that had arrived earlier by air (and was being held for us at the airport) from the OSHA laboratory in Cincinnati, and the field measurement probes that were arriving by air shipment. We (Bob, Cathie, and myself) finally got all of the equipment together, and returned to the station at about 5 P.M. Rejoining Mr. Jordan, we went up the mountain in the TV station's four-wheel-drive vehicle (i.e., a pick-up truck). We arrived at the transmitter site at the top of the mountain in time to see a beautiful view of the city of El Paso in shadows, and to see the sun sinking rapidly on the horizon. We were able to take a few photos before dark, and were able to orient ourselves and see the tower while there was still a little daylight remaining. (See photos.) By the time I got into the climbing harness and lifelines, got all of our equipment assembled and "zeroed," and got ready to go up the tower, it was approximately 5:30 P.M., well beyond twilight. Climbing was initiated, and at the first platform (which was approximately 10 feet above the ground), I oriented myself, "checked out" and "re-zeroed" both the E- and H-field meters, ascertained that everything was working well, and then again began climbing up the ladder.

The H-field measurements were made with the Narda Model 8633 magnetic probe and Model 8616 meter. The E-field measurements were made with the 3-axis Instruments for Industry probe (loaned to us by Paul Ruggera of the Bureau of Radiological Health (BRH)). I also had a battery-powered tape recorder. The plan was to dictate and record the measured E-and H-field intensity values on the magnetic tape while climbing the tower. This worked reasonably well at the lower climbing levels, but as I began picking up more and more interference from the RF transmission on the tower, the recording quality became poorer (as expected).

I started climbing at about 5:30 P.M. (local time). The temperature at that time (down in the valley) was about 41° F, and there was quite a bit of wind blowing, so that, as one might imagine, after a short time on the tower, my hands, feet, cheeks, and nose started to feel cold; however, this was not unbearable. I was dressed appropriately for a climb in that sort of weather. Figure 1 (attached) is a schematic of the tower and the approximate location of the antennas. There were approximately 7 major antennas, with perhaps 7 to 10 minor antennas. The figure also lists for each antenna the approximate output (transmitted) power, and approximate frequency. Table I is a description of the E- and H-field measurements at approximate levels on the tower (i.e., height above the ground), and also some comments about the observations that were made.



Note: Transmitter building is located 10 feet south of the tower.

		Frequency	RF Power	Antenna	Comments
1.	KIMT FM Radio	97.3 MHz	18 KW	6 bay	
2.	KTEP FM Radio	88.1 MHz	1 KW	4 bay	
3.	KPAS FM Radio	93.9 MHz	20 KW	6 bay	Not currently operating
4.	KLOZ FM Radio	102.1 MHz	10 KW	6 bay	
5.	KPAS FM Radio	93.9 MHz	20 KW	2 bay	Temporary antenna
6.	KAMA FM Radio	93.1 MHz	10 KW	6 bay	
7.	KDBC TV-4	60-72 MHz	6 KW video 1.3KW aural	6 bay turnstyle	

8. Additional low-power (~50 W) transmitting antennas (not shown) for 2-way communication systems (operating in the frequency band between 150-400 MHz).

Figure 1: Antenna specifications and relative location on the steel tower.

TABLE I - RF Measurements of a Commercial Broadcast Monitoring and Transmitting Facility

	H-Field		E-Field	
	Amps/meter	Equiv.* mW/cm^2	Volts*/meter	Equiv. mW/cm^2
I. Monitoring Building				
FM Transmitter Rm.	0.15	1	-	-
Shop Area	0.10-0.12	0.4-0.55	-	-
TV Transmitter Rm.	0	0	-	-
"Living" Rm.	0.07	0.2	-	-
II. Transmitting Antenna Tower (Approx. height on ladder)				
10 feet	Instrument "zeroed"	0	0	0
20 feet	0.30	3	0	0
26 feet	0.50	10	50	0.7
40 feet	0.50	10	-	-
45 feet	1.25	60	20-30	0.1-0.25
60 feet	1.45	80	-	-
70 feet	0.75	20	20	0.1
85 feet (platform)	1.5	85	-	-
100 feet	0.75	20	-	-
110 feet	1.6	100	300	25
	(Meter actually responds to magnetic field (A/M))	(Meter dial reads)		

NOTE: The * denotes the meter readings which were actually obtained during the survey; the companion column contains values which were calculated [assuming far field conditions (which do not exist)].

Highlighting some of those observations: I found that the E-field probe was less sensitive than the H-field probe to the effects of the metallic tower structure (including the ladder). Holding the probe out at arms length away from the tower gave one reading, while bringing the probe in closer to the tower caused the H-field meter indication to increase. This is possibly because the grounded metallic tower may conduct some current.

We also noted some changes in observed values when we pointed the E-field probe in toward the center of the tower, or out, away from the tower. Although these changes, in general, were minor (i.e., 10 percent of full scale reading), there was a change if we pointed the E-field meter toward the mountain (which rose slightly in one direction behind us), or if we pointed it down toward the town of El Paso (in the valley below). Whether this might be due to reflections from the tower or from the mountain is unclear. (Or antenna directivity?)

Another observation that might prove interesting in the future is that the Narda H-meter, while displaying a somewhat variable reading, and reading it on either the ten scale or the hundred scale, showed some significant fluctuations. Values (as noted in the table of data) about 60 miliwatts per square centimeter (mW/cm^2), and indeed above 80 (and as high as 85 mW/cm^2) were seen at a number of locations. The meter did go full scale to 100 mW/cm^2 at one point. At other positions higher up the tower, I noticed that (on the same 100 mW/cm full scale position), the meter was reading zero, and below zero (into the minus direction). I thought, at that time, that perhaps I had overloaded the probe or meter, and burned it out. (However, the probe seemed to work well for Bob Curtis the next day on a different tower, so we apparently temporarily overloaded the probe and/or meter, or in some other way caused some transient problem.*) We also made measurements using the same (as well as a different Narda H-probe and meter) inside the transmitter station. Again, the negative readings were encountered** using the first meter and probe.

The monitoring building, located approximately 10 feet south of the transmitting antenna tower, contains about 1500 square feet of working space on one floor. It includes a small shop, two transmitter rooms, and living space. One of the rooms contains video monitoring equipment, and consequently the employee on duty spends much of his time at this location.

*Subsequent discussions with Ezra Larsen of the National Bureau of Standards, Boulder, suggest that the problem was penetration of the electronics meter case by the intense magnetic (H) fields (near the antennas), which were detected by the electronics, and interpreted as having been picked up by the probe.

**Checking the meter and probe 2 days later in the BRH Microwave Calibration facility (thanks to H. Bassen and P. Ruggera) indicated some meter zero-drift in the negative direction. This could cause the observed results to be low.

The antenna tower height is 287 feet (on the mountaintop), the shape of the tower is 4 legged, and the ladder is on the interior side/surface of one of the legs. While climbing the ladder, I was inside the tower, but my back was essentially up against one of the legs of the tower. I describe the situation because at approximately 85 feet was located a platform (made of expanded metal grid). While climbing up toward the platform, the H-field (magnetic) intensity was noticed to increase at about the fifth, sixth, and seventh cross member (see figure) to approximately 80 mW/cm^2, and (as noted) on occasion to full scale (i.e., 100 mW/cm^2). Beyond this height, the H-field was not nearly as intense, i.e., down to approximately 20 mW/cm^2. We attribute these higher magnetic field intensities to the fact that there was a large FM antenna (number 2 in Figure 1) suspended in the center of the tower from approximately the level of the platform at the 85 foot height. This was probably the reason for high H-fields at that point, as was measured. The distance between the ladder that I was climbing on, and the FM antenna being discussed was perhaps six or eight feet, and I was on the outer side of the ladder (so that the ladder was between the antenna and myself). I made a brief stop on the platform where I climbed off the ladder, looked around, stretched and relaxed (to the extent that one can relax at a height of 85 feet on a tower). It was comforting to be able to stand on a flat surface instead of having all my weight concentrated on my arches and arms. I then got back on the ladder and climbed approximately 30 feet higher, measuring some more E- and H-field values.

The highest field strength levels that I feel with confidence we can report having measured are approximately 85 mW/cm^2 (based on H-field measurements*), and about 300 volts per meter, V/m (based on E-field measurements). Since climbing was beingperformed in the dark, the only light was coming from a couple of small white lights from around the transmitter building on the ground at the base of the tower, and a couple of red lights on the tower (to act as warning for aircraft in the area). Thus, it was necessary to read the meters with a flashlight held with one hand, the probe or meter with another hand, and balancing on the vertical ladder. Upon reaching the 110-foot level (height on the tower), the H-field strength was equivalent to approximately 100 mW/cm^2, and time was also running out (since I had to catch a plane). Thus, it was decided that it was time for me to descend. I packed both meters and the H-field probe into the back-packs that I was wearing on my chest, and started climbing down the tower. I reached the ground at approximately 7:15 P.M. (local time). We then went inside the transmitter building where a brief walk-around survey was conducted.

Photographs and some E- and H-field measurements were made inside the building. We also had an opportunity to discuss the working situation with one of the transmitter employees. The figure (1) describing the tower

*Note, the Narda meter and probe measure the magnetic (H) component of the field, but the meter reads the equivalent plane wave (far field) power density in mW/cm^2. One must keep in mind that the occupational exposure situation is near field (not far field!).

contains information relating to the approximate position of the various antennas, and the call letters of the various stations using the assortment of antennas. The TV antenna and the main FM antenna operated by this station were on the tower owned by the station. The other users were renting space on the tower for their antennas. This apparently is a common situation.

We packed up our measuring/monitoring/recording and photography equipment following the "walk-around" inside the transmitter building, some picture taking, and some discussion with the transmitter operator on duty. After loading our equipment back into the truck, we "bounced down" the mountain in Mr. Jordan's pick-up truck. I changed clothes in the TV station, then headed to the airport, arriving just barely in time to catch my 9 P.M. flight for San Antonio.

The following morning, Bob Curtis and Cathie Mannion went back out to the TV studio/station, to hold a Closing Conference with the President and the Chief Engineer. (Their comments, notes, and recommendations are attached.) I conducted a plant visit the next day at the Microwave Bioeffects Laboratory at the U.S. Air Force School of Aerospace Medicine, Brooks Air Force Base, San Antonio, TX.

During the Closing Conference, the formal requirements were reviewed, as were the employers' and employees' responsibilities, rights, etc. It was recommended to the TV station manager that, due to the intense levels of RF radiation measured, workers should not be permitted to climb the tower while the antennas are energized. The station manager indicated that for the TV station, compliance with this recommendation would be no problem, since they could schedule most maintenance during the off-hours, probably early morning (before the TV station began broadcasting). This would be appropriate, for instance, for the painting of the tower which is not performed very often, and could easily be scheduled during the summer months when there is daylight at approximately 5 A.M. Could the other stations using the tower also schedule a period when their antennas are not radiating? One is concerned with the urgent need to climb the tower if the beacon light on top of the tower goes off/out (i.e., bulb burned out). The other lights on the tower are felt not to be of as much concern (perhaps they have more than one light at various levels on the tower), but the top beacon has to be changed immediately. They did feel that the other light bulbs could be changed in the early morning hours. This brings up a question in terms of our recommendation that someone not be permitted to climb the tower to replace the burned out beacon light, versus the risk of having the tower beacon light "off," as far as a hazard for aviation is concerned.

A few comments on the RF field measurements taken inside the transmitter building located at the base of the antenna tower: The highest level was recorded in the "FM transmitter room," i.e., 1 mW/cm^2. The operating personnel normally do not spend much time in this room. The "shop area" exhibited levels of 0.4 to as high as 0.55 mW/cm^2. The "living room" area was at a level of 0.2 mW/cm^2, and the TV station "north room" (the TV transmitter room) had a level of essentially zero as measured with the

Narda H-field meter. Again, during the measurements in the "transmitter room," the H-field meter would indicate a negative (below zero) reading at certain times. We do not quite understand what caused this. This was a different H-field meter (BRH equipment) than the one Zory used (OSHA equipment) while climbing the tower.

A comment regarding the employee who normally climbs the tower while it is energized: he has been climbing for about ten years, and reports no adverse health effects due to his climbing.

Another point that we might make, as reported by Rick Tell (in his 1976 report entitled "Measurement of RF field intensities in the immediate vicinity of an FM broadcast station antenna," EPA Report No. ORP/EAD-76-2, that as of January 1975, there were approximately 4500 AM radio stations in the U.S., approximately 3400 FM radio stations, and approximately 950 TV stations operating. Tell also noted that a number of the stations required work on their broadcast towers, and that this work included painting the tower, beacon replacement, light bulb replacement, repairs to the de-icing equipment, antenna adjustment, and work on the tower riggings and other structural features. It was noted at that time that it was common practice for this tower work to be performed while the broadcast station was operating at full power. This reinforces our experience in talking with the tower operating and management personnel, that this work generally is performed while the antennas are energized. Sometimes a radio station has a back-up secondary antenna. Most often, the back-up antennas are mounted on the same tower as the primary antenna. Thus, the station can switch to a different antenna. The worker climbing the tower while the back-up antenna is in use, however, is probably exposed to the same radiated power, and perhaps (because of smaller antennas, or fewer bays), he might even be exposed to higher power levels because of concentration of power into a smaller antenna, or fewer antenna elements, i.e., fewer bays.

Rick Tell noted in his report that sometimes the operators who climb the tower would report a tingling in their body, or a sensation of heat. It has been noted that some operators have reported that their feet got hot inside their boots. Tell also commented that high levels of power on the tower could cause a tingling sensation in the hands of the operator when they touch the metallic ladder or certain other portions of the tower.

I am not aware of having experienced any sensation of heating, no sensation of tingling, and no shocks. However, it might be worthy to note that the ambient temperature while I was climbing was approximately 40° F (or lower), with a considerable wind blowing across the tower. I took my gloves off at one point to make some adjustments to the radiation monitoring equipment; I did not notice my hands getting cold, and consequently I did not put my gloves back on. However, Cathie (who was down on the ground watching me, recording some of the field strength measurement data on her clipboard, handling a light, and so on), found that she was very cold at the end of the approximately two hours that I had been climbing. Her feet, hands, etc., were quite cold. Perhaps I was receiving enough energy by absorption to warm me up. Of course, I realize that climbing a tower involves some degree of physical exertion, and not only was my

respiratory rate increased but I noticed some sweating when I got back down on the ground. After relaxing and feeling a little calmer, I began to notice that I was then getting cold, and feeling tired. (Note: It was at that time approximately 10 P.M. Washington, D.C. time, and I had departed home at approximately 6 A.M. that morning for the airport.)

As a closing comment, we would like to recommend that a comprehensive study of RF/microwave tower climbers, and measurement of the magnetic and electric fields on and around the tower be conducted. Also, a determination should be made of any health effects that may occur in the population of workers who regularly climb transmission towers. There is also a need to standardize the survey procedures and measuring equipment to use while performing such a survey. We recommend, also, a need to investigate the Narda meter reading of a negative (below zero) value to see if this may be due to an instrument overload (or other cause), which may indicate that there are actually larger H-fields present than we now think exist on the FM/TV towers.

NOTE:

Due to the negative "zero" drift of the Narda meter, the H-field measurements should be viewed as the lower bound of the actual exposure level. The magnitude of the error is unknown but becomes more significant with elapsed time since zeroing. Because the measurements were obtained in the standard procedure without re-zeroing the meter, it can be expected that the values observed for the lower portion of the tower are more accurate. The values observed closer to the top of the tower (i.e., longer time since the meter had been zeroed) may understate the actual exposure levels by a factor of 1.5 to 3.

APPENDIX

Instrumentation

1. E-field Radiation Hazard Monitor, Model RHM-2, manufactured by Instruments for Industry (IFI), Inc., Farmingdale, N.Y.

   FDA Ser. #116417 (from BRH)
   IFI Serial No.? (plate missing)

   Full Scale Ranges

Sensitivity Switch Position	Antenna Length			
	Long	Medium	Short	Very Short
up	10 V/m	100 V/m	300 V/m	1000 V/m
down	3 V/m	30 V/m	-	-

   Remote Read-out using fiber-optic cable, Model LDI, Serial No. LDI-146, FDA No. 139366

2. H-field isotropic, broad band Probe and Meter, Model 8633 and 8616 respectively, manufactured by the Narda Microwave Corp., Plainview, N.Y.

3. Tape Recorder, Model 848, battery-powered, manufactured by the Dictaphone Corp., Rye, N.Y.

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