

APPENDIX A-3

Denny & Associates, P.C., Engineering Report

ENGINEERING REPORT
ELECTROMAGNETIC FIELD STRENGTH SURVEY
AT THE SOUTH TOWER OF THE
WORLD TRADE CENTER

EXECUTIVE SUMMARY

Radio-frequency radiation surveys were conducted in December 1998 and January 1999 on the outdoor observation deck walkway of WTC2 (south tower). Previous surveys identified an area on the outdoor observation deck walkway at WTC2 where the maximum permissible level for general population/uncontrolled exposure is exceeded for certain modes of auxiliary broadcast antenna use at WTC1 (north tower). The previous exposure data were obtained with more than one broadcast station on the air, so it was not possible to analyze the aggregate exposure data to determine each broadcast station's individual contribution to the overall exposure level present in the area of concern.

The December measurements were made to identify those television stations able to use their auxiliary antennas at WTC1 without causing overexposure on the outdoor observation deck at WTC2. The basic finding of this survey is that only the low band VHF television stations can

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operate using their auxiliary antennas without causing overexposure of the outdoor observation deck walkway at WTC2.

The January measurements were made with one station on the air at a time and individual station exposure data were obtained for each station using its main antenna. For those stations with an auxiliary antenna at WTC1, individual station exposure data also were obtained for that station with its auxiliary antenna in use. The January survey was designed to provide individual exposure data for each station and each mode of station operation. Based on all available information, contributions to the overall RF exposure environment at WTC2 from nonbroadcast sources in the area were expected to be small enough to be ignored and any bias statistically eliminated. However, in the final analysis, contributions from other nonbroadcast sources in the area proved to be too great to be ignored, and the individual broadcast station exposure data was biased by the contribution from nearby nonbroadcast sources. Because of the contributions from nonbroadcast sources, analysis of the January exposure data could not produce the desired result of determining the individual broadcast station contributions to the overall exposure present on WTC2.

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Unfortunately, additional surveys will be required to accurately determine the individual broadcast station contributions to the overall exposure present on the outdoor observation deck walkway at WTC2. The next survey to be undertaken should duplicate the December 1998 measurements using new, more accurate instrumentation developed especially for characterizing general population/uncontrolled exposures. Measurements of this type can easily be made with minimal disruption, and the increased accuracy of the instrumentation may allow a conclusion of a slightly less than maximum exposure at WTC2 rather than the present conclusion of a slight overexposure.

If the new instrumentation continues to indicate a slight overexposure on the north side of the outdoor observation deck walkway at WTC2, then the next step will be to define and undertake a survey using instrumentation that will allow the WTC2 exposure to be characterized completely, fully identifying all contributors to the RF energy incident upon the walkway as individual broadcast station, cellular, PCS, paging, community repeater, and so forth. As no off-the-shelf instrumentation is available for this specialized purpose, a measurement system needs to be assembled and tested before this series of measurements can be made.

INTRODUCTION

The electromagnetic field strength surveys described in this report were undertaken on behalf of the television (TV) stations and FM radio stations operating at the World Trade Center as the second report to address exposure levels on the observation deck of the south tower of the World Trade Center (WTC2) from broadcast operations primarily located on the north tower of the World Trade Center (WTC1).¹ A low power television (LPTV) station is located on WTC2, but, as has been previously examined, the LPTV station contributes little to the radiofrequency radiation (RFR) exposure environment at WTC2. The FM and TV stations operating at WTC1 are identified in Figure 1 of this report.

1 The geographic coordinates for the WTC1 site are 40° 42' 43" North Latitude, 74° 00' 49" West Longitude referenced to the 1927 North American Datum (NAD 27).

BACKGROUND

There are two modes of operation for the broadcast stations located at WTC1: the normal mode and the auxiliary mode. In the normal mode of operation at WTC1, the TV and FM stations operate with their main antennas. In the auxiliary mode of operation, the FM stations operate with their main antennas, all of the VHF TV stations except WCBS-TV operate with their auxiliary antennas, and the UHF TV stations are off the air. WCBS-TV is the only VHF TV station that does not have an auxiliary antenna at WTC1. The WCBS-TV auxiliary antenna is located at the Empire State Building, 4.7 kilometers along a bearing of 30 degrees True from WTC1, and, accordingly, the WCBS-TV transmitter at WTC1 is shut down during auxiliary operation.

The need for additional exposure surveys at the World Trade Center was identified in January 1998 during the preparation of the license renewal applications for the FM stations located at WTC1. The FM licensees reviewed the RFR exposure issues related to their operations in light of the new Federal Communications Commission (FCC) Rules establishing new maximum permissible exposure (MPE) levels for human exposure to RFR

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that were adopted in 1996 and implemented on October 15, 1997. Two major areas of concern were identified as a result of that review. One area of concern relates to the exposure levels of the roof of WTC1 and is the subject of a separate report.

The other area of concern is related to the exposure of visitors to the indoor observation area and the outdoor observation deck walkway at WTC2. This concern was partially addressed in the June 18, 1998, Denny & Associates, P.C. report which indicated that measured exposure levels within the indoor observation area and the outdoor observation deck walkway were found to be within the FCC MPE levels for general population/uncontrolled exposure for the normal mode of broadcast station operation, but measurements in an area of the outdoor observation deck walkway exceeded the FCC MPE Level for general population/uncontrolled exposure when the broadcast stations were operating in the auxiliary mode. The measurements made in support of this report were aimed at identifying the individual contributions of broadcast stations to the overall exposure levels on the observation deck walkway in order to mitigate exposure on the walkway during the auxiliary mode of operation.

SUMMARY OF FINDINGS

Two additional measurement programs were undertaken to develop procedures for reducing the exposure levels on the observation deck walkway during the auxiliary mode of operation. The first series of measurements made on December 17 and 18, 1998, measured exposure levels with different groups of television stations operating into their auxiliary antennas, while the remaining stations continued to employ their main antennas. The data from these measurements, which are tabulated in Figure 2 of this report, indicate that the exposure on a small portion of the north observation deck walkway, identified as point 2A in Figure 5 of this report, exceeds the FCC MPE for general population/uncontrolled exposure when some of the high-band VHF stations, including WABC-TV, WWOR-TV and WNET, employ their auxiliary antennas.

The December 1998 measurements were made using a conformal electric field probe that yields exposure level data as a percentage of exposure. The exposure levels measured using the occupational/controlled exposure electric field probe were multiplied by a factor of five to re-reference

the measured exposure levels to the MPE for general population/uncontrolled exposure.

Due to the limited sensitivity of the occupational/controlled exposure conformal electric field probe and the desire for greater resolution in the exposure data, a second measurement program was undertaken. The objective of the second course of measurements was to determine individually the exposure from each television station and, as a whole, the FM stations for both the normal and auxiliary modes of operation. To achieve this, all of the broadcast stations that operate from WTC1 and WTC2 went off the air on the morning of January 5, 1999. Exposure measurements were then made on the northern portion of the observation deck walkway with only one broadcast station at a time in operation. Numerous other paging, mobile radio and microwave facilities, over which the surveyors had no control, continued to operate from WTC1 and WTC2 while the individual broadcast station measurements were being made.

The recorded measurement data, tabulated in Figure 3 of this report, suggests higher than predicted exposure levels for most of the broadcast stations. When compared to the data collected in December 1998,

the summation of the individual station exposure levels measured in January 1999 yields total exposures far in excess of the December 1998 values. One possible explanation is the presence of high background exposure levels from nonbroadcast sources that could not be shut down during the survey. An exposure measurement was made at measurement locations 1, 1A, 1B, 2, 2A, 2B, and 3 as shown in Figure 5 with all of the broadcast stations off the air. The measured background exposure ranges from 13 to 30 percent of the MPE for general population/uncontrolled exposure over the seven points measured on the walkway. Further, complicating the presence of a high background exposure levels was the continuously varying level of the background exposure. Subtracting the measured background exposure at each point from the each station's measured level sometimes yields exposure levels less than zero. This is a clear indication that the background exposure was changing during the course of the measurements.

MEASUREMENT METHODOLOGY

The December 1998 broadband measurements were made using a Narda, model 8718, electromagnetic survey meter and a Narda, model 8722B,

occupational/controlled exposure conformal electric field probe. The survey meter and probes were calibrated by the manufacturer as a system in February 1998. The individual station measurements made in January 1999 were made with two virtually identical survey instruments consisting of a Narda, model 8718, survey meter and a Narda, model 8761, broadband electric field probe. The additional Narda survey meter and probe were last calibrated as a system on June 3, 1998. Prior to making formal measurements, both survey meters were compared and found to be in reasonable agreement.

All field strength measurements were made at distances far enough removed from the sources being measured to assume the existence of uniform plane wave conditions. Accordingly, no magnetic field strength measurements were deemed necessary to accurately define exposure.

To facilitate the making of average whole body exposure measurements, the survey meters were configured to make one measurement per second for a period of thirty seconds. At the end of the measurement period, the survey meters calculated the average of the thirty measurement values and stored the average measurement values in its internal memory for

later analysis. The survey meter was initialized to display and record measurement data in units of percent of the FCC MPE for occupational/controlled exposure for the 8722B probe and in units of volts squared per meter squared (V^2/m^2) for the 8761 probe.

Average whole body exposure measurements were made at each location by raising the electric field probe to head height, approximately two meters above ground level, initializing the measurement sequence, and then slowly lowering the probe to knee height, approximately one-half meter above ground level. The duration of the probe lowering motion coincided with the survey meter measurement period.

DISCUSSION OF FINDINGS

December 1998 Measurements

As discussed earlier, the purpose of the December 1998 measurements was to determine exposure levels on the observation deck walkway by measuring exposure levels while individual television stations or pairs of television stations used their auxiliary antennas. While the measurements were being made, the other television and FM broadcast stations at WTC1 remained in their normal operating mode. Figure 2 of this

report is a tabulation of measured exposure data for the nine points measured during the survey. The location of each point specified in the tabulation of Figure 2 is identified in the diagram of Figure 5 of this report.

Due to the broad range of frequencies in use by the multiple broadcast stations at WTC1, exposure measurements had to be made employing a survey probe that conforms to the FCC exposure guideline. However, the only probe available at the time of the measurements was a probe that conforms to the MPE for occupational/controlled exposure. Since the environment on the observation deck walkway is classified based on the more restrictive MPE for general population/uncontrolled exposure, the measurement data had to be re-referenced to the more restrictive MPE in order to obtain meaningful results for the general population/uncontrolled environment at WTC2. At the broadcast frequencies in use at WTC1, the FCC MPEs for general population/uncontrolled exposure are five times more restrictive than the FCC MPE for occupational/controlled exposure. Thus, the second tabulation included in Figure 2 of this report re-references the occupational/controlled exposure measurements into percentages relative to the MPE for general population/uncontrolled environments.

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With the exception of one of the points under two operating conditions, exposure levels at all of the measured locations comply with the FCC MPE for general population/uncontrolled exposure. When WABC-TV employs its auxiliary antenna and all other stations are in their normal operating mode, the exposure at point 2A is 111.85 percent of the FCC MPE for general population/uncontrolled exposure. The exposure at the same point is 113.00 percent of the FCC MPE for general population/uncontrolled exposure when WWOR-TV and WNET both switch to their auxiliary antennas. Point 2A corresponds to the location identified in the June 18, 1999, WTC2 report where exposure exceeded the MPE for general population/uncontrolled environments when stations were operating in the auxiliary mode. The auxiliary antennas for WABC-TV, WWOR-TV, and WNET are located relatively low on the mast at WTC1. Additionally, WABC-TV, WWOR-TV, and WNET are all high-band VHF stations which employ higher ERPs than the low-band VHF television stations located on WTC1. It is the combination of the WABC-TV, WWOR-TV, and WNET relatively low auxiliary antenna height and higher ERP that results in higher exposure levels at WTC2 for these stations. However, the exposure levels for these stations do not significantly exceed the MPE for general

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population/uncontrolled exposure. This, coupled with the possibility that any error in the occupational/controlled measurement data was amplified when multiplied by a factor of five to arrive at general population/uncontrolled data, warranted further investigation.

January 1999 Measurements

The measurements made in January 1999 were an effort to breakdown the overall exposure on the WTC2 observation deck walkway into individual station contributions. To achieve this, as was described earlier, all of the broadcast stations located on WTC1 and WTC2 went off the air and were brought back on the air individually, first employing the main station antenna and then the auxiliary station antenna (if the station has an auxiliary antenna at WTC1). In total, there were 18 different operational conditions measured at seven locations for a total of 126 measurements. Since the measurements were made with only one broadcast station on the air at a time, the measurements had to be made in rapid succession without the opportunity for analysis between measurements.

At first look, the data collected in January 1999 suggests exposures far in excess of the exposure data collected in December 1988. The sum of the

individual station exposures for the normal and auxiliary modes of operation are shown in the following table. Exposures are expressed as percentages of the FCC MPE for general population/uncontrolled exposure.

<u>Operating Mode</u>	<u>Point 1</u>	<u>Point 1A</u>	<u>Point 1B</u>	<u>Point 2</u>	<u>Point 2A</u>	<u>Point 2B</u>	<u>Point 3</u>
Normal Mode	149.94	152.27	127.89	202.62	236.83	247.32	240.62
Auxiliary Mode	161.24	187.93	182.64	189.93	264.78	288.27	286.02

Table 1. Summation of Measurement Data

The data shown in Table 1 of this report for the normal mode of operation were obtained with all broadcast stations at WTC1 operating using their main antennas. The data shown in the previous table for the auxiliary mode of operation were obtained with those stations with auxiliary antennas at WTC1 using their auxiliary antennas. Further, for the auxiliary mode, WCBS-TV not using its main antenna at WTC1 and was assumed to be using its auxiliary antenna at the Empire State Building, and the UHF stations at WTC1 were off the air.

It is evident that measured exposure levels for the normal operating mode are much higher than expected at all of the measurement locations. When compared to the measurement data from December 1998,

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increases in exposure of over 100 percentage points are observed. As discussed earlier, this suggests a significant amount of background exposure from other nearby nonbroadcast stations.

In an effort to further examine the validity of the measurement data, exposure predictions were made at each measurement location for each of the operating modes. Where available, manufacturer's antenna data were employed to determine the ERP toward each target point. However, in many cases it was necessary to use approximations. The results of this comparison are presented in graphical form in Figure 4 of this report. Each graph shows the calculated and measured data for each mode of operation. In virtually all cases, the measured exposure is higher than the calculated exposure indicating that possibly other radio-frequency sources were present and contributing to the exposure at the measurement points.

For each mode of operation surveyed, a trace was saved on a spectrum analyzer. The spectrum analyzer input was connected to a broadband biconic antenna placed in the center of the north observation deck walkway. The spectrum analyzer traces are included as Figure 6 of this report for each operational mode measured. The traces are uncorrected for

antenna gain and are included to illustrate the presence of a significant number of other radio-frequency sources while the survey measurements were being made.

RECOMMENDATIONS FOR FUTURE STUDIES

Since the initial objective of finding procedures by which the television stations operating from WTC1 could employ either the normal or auxiliary mode of operation without causing exposures in excess of the FCC MPE for general population/uncontrolled exposure on the observation deck walkway of WTC2 has not been achieved, further study is warranted. Descriptions of the next two steps recommended for further study follow.

The first step involves use of a new measurement probe recently made available to this firm by Narda. This probe, a Narda, model B8742D, is a shaped probe that conforms to the FCC MPE for general population/uncontrolled exposure.² The probe has a dynamic range of 30 dB,

² Up until the Narda, model B8742D, conformal electric field probe became available for use in measuring general population/uncontrolled exposures, a Narda, model 8722B, conformal electric field probe was used. Data obtained using the Narda, 8722B probe is expressed in terms of the MPE limit for occupational/controlled exposures and is divided by a factor of 5 to change the data reference to the MPE limit for general population/uncontrolled exposures.

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which permits measurement of exposure levels from 0.6 percent to 600 percent of the FCC MPE for general population/uncontrolled exposure. Early experience with the probe indicates that the B8742D probe is much more stable than other conformal probes and has very little zero drift.

It is recommended that the December 1998 course of measurements, in which stations or pairs of stations switched to their auxiliary antennas while the remaining stations remained on the air, be repeated. The only change to the December protocol would be to measure the seven points (1, 1A, 1B, 2, 2A, 2B, 3) on the north walkway measured in January 1999 instead of all nine points around the walkway since previous measurements localized the exposure excursion to the north walkway. If exposures in excess of the MPE for general population/uncontrolled exposure are confirmed, then scenarios for reducing power can be explored and tested.

If the first step survey does not show exposure to be below the MPE limit for general population/uncontrolled exposures, the next recommended step involves employing a wide-band calibrated isotropic sensor with a constant antenna factor to characterize all of the RF energy incident upon the WTC2 outdoor observation deck walkway. The output of the sensor is

connected through a fiber optic cable to a computer-based receiver. The receiver converts the optical information back to radio-frequency energy that can be viewed on a spectrum analyzer. Employing the features of the spectrum analyzer to collect and store data points, an accurate depiction of the spectrum across a wide bandwidth can be achieved. The field strength data points can then be analyzed to determine the exposure contributions within specified bandwidths. This technique offers the ability to provide greater resolution of exposure data and provides the ability to breakdown exposure from multiple sources into individual station contributions. However, this technique will require time to develop and test. Since the equipment is not as suited to field use as other survey equipment, it will very likely take longer to collect and analyze the data.

CONCLUSIONS

The measurement surveys made at WTC2 have each produced vital information that has furthered the understanding of the complex radio-frequency exposure environment at WTC2. The December 1998 measurements clearly highlighted the auxiliary operating conditions under which the FCC MPEs for general population/uncontrolled exposure were

exceeded on the observation deck walkway of WTC2. The December 1998 data show that the FCC MPE for general population/uncontrolled exposure is only exceeded when WABC-TV, WWOR-TV, and WNET employ their auxiliary antennas. The January 1999 measurements, when analyzed as the worst-case, demonstrate that the auxiliary operations of WABC-TV, WWOR-TV, and WNET are not singularly responsible for the FCC MPE for general population/uncontrolled exposure being exceeded on the observation deck walkway at WTC2.

Further investigation of the WTC2 exposure levels is warranted. Since the initial objective of identifying procedures by which the broadcast stations at WTC1 can employ either their main or auxiliary antennas without exceeding the FCC MPE for general population/uncontrolled environments on the observation deck walkway at WTC2 has not been achieved and new instrumentation is available that is capable of measuring exposure directly in units of percent of the FCC MPE for general population/uncontrolled environments, additional studies will permit broadcasters at WTC1 to move closer and ultimately fulfil their objective of assuring compliance with the FCC Rules.

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March 17, 1999