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Limited Electromagnetic Interference Testing of Evidential Breath Testers

Law Enforcement Standards Laboratory
National Engineering Laboratory
National Bureau of Standards
Washington, DC 20234

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

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FOREWORD

This report, released by the National Highway Traffic Safety Administration (NHTSA), summarizes a limited test program conducted to determine the susceptibility of evidential breath testers (EBTs) to radio frequency interference (RFI). The research was conducted for NHTSA by the National Bureau of Standards (NBS) under interagency agreement No. DOT HS 020-2-290. The work reinforces NHTSA's belief that States should subject their instruments to field screening testing for RFI susceptibility. By completing comprehensive testing programs. such as the one recommended by NHTSA in January 1983, the States will protect the integrity of their breath testing programs.

In the spring of 1982, NHTSA became aware that evidential breath test devices may be adversely effected by radio frequency interference. At that time, a State chemical test program director observed a potential RFI-affected reading when calibrating his EBT for field use. He immediately brought his observation and concern to the attention of NHTSA officials. As a result, NHTSA initiated an interagency agreement with the NBS to determine the extent of this potential problem. NBS examined sixteen different evidential breath testers. These were subjected to radio transmissions at the four commonly used police frequencies, and at a field strength reflecting severe operating conditions.

In December 1982, NBS held an oral briefing at NHTSA at which time they presented their initial review of the collected data. The results of this limited research effort indicated that several brand name EBTs currently used by the police have a potential for rendering inaccurate results when subjected to some radio frequency fields.

In view of these preliminary findings, NHTSA staff believed it was important for state chemical program directors to implement comprehensive procedures to screen all EBTs in use for possible RFI susceptibility in the environments in which the devices are used. Accordingly, NHTSA initiated the development of such screening procedures to minimize the chances that undetected RFI might occur.

Several comprehensive test protocols were prepared based on procedures developed by the Minnesota Bureau of Criminal Apprehension and Smith & Wesson (manufacturer of the Breathalyzer EBTs). NHTSA endorsed a modification of the Minnesota protocol and developed a videotape training package to complement its written instructions. NHTSA also recommended that police radios not be allowed to transmit signals in EBT test rooms, mobile vans, and by the roadside when breath analyses are being conducted. These materials, the training procedures and the videotape, were distributed to each Governor's Highway Safety Representative, each State Police chief and each State chemical test program director during January 1983.

As of the date of this publication, comprehensive test programs using the recommended protocol have been conducted in Arizona, Illinois, Maryland, Michigan, Minnesota, New York, North Carolina, South Carolina and Texas. The results of these screening test programs indicate that less than one percent of the devices tested were found to be susceptible to RFI in the environments where they were used.

The limited occurrence of RFI susceptibility among EBTs found by the States which systematically screened for it, indicates that this issue is not of the magnitude it was first alleged to be. RFI susceptibility among EBTs in the field is minimal. On those rare occasions when a device has been identified as susceptible, it has been removed from service or relocated to an environment where it does not display RFI susceptibility.

Even though actual field experience of RFI has been shown to be minimal, NHTSA has recommended to all chemical test program directors that they still periodically check their instruments for this phenomenon. Such testing will provide State chemical test program directors with reproducible evidence that RFI is not a factor in their programs.

The issue of RFI susceptibility among EBTs was recently examined in a case in the State of Minnesota (Heeden V. Dirkzwager, Ramsey County Second Judicial Court). In that case, it was found that the Minnesota testing procedures "...are effective means of preventing RFI from affecting Breathalyzer readings in the future." It is believed that States implementing similar precautionary screening procedures to ensure program integrity should have similar experiences in their courts.

The RFI-susceptibility issue will continue to be raised as long as there remains the slightest suspicion that it remains a problem. States that have screened their devices according to one of the recommended protocols have shown that RFI susceptibility is an issue that can be dealt with appropriately.

Limited Electromagnetic Interference Testing of Evidential Breath Testers

Submitted to

National Highway Traffic Safety Administration
U.S. Department of Transportation
Washington, DC 20590

Submitted by

Law Enforcement Standards Laboratory
National Engineering Laboratory
National Bureau of Standards
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Limited Electromagnetic Interference Testing of Evidential Breath Testers

Contents

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EXECUTIVE SUMMARY

The anomalous behavior of a specific evidential breath tester (EBT) in the presence of an electromagnetic field from a police transceiver was brought to the attention of the National Bureau of Standards (NBS) by the National Highway Traffic Safety Administration (NHTSA) early in 1982. This report presents the results of a limited study, conducted by the NBS, to identify evidence of potential electromagnetic interference (EMI) problems with a selected sample of EBT's currently used by State and local governments.

Since 1974, the NHTSA has maintained a Qualified Products List (QPL) of EBT's that have been tested and found to comply with the NHTSA performance standard for such devices. The current QPL includes 19 manufacturer instruments which are presently being used by State and local law enforcement agencies in significant numbers. The existing NHTSA standards do not include performance requirements with respect to EMI susceptibility. The research required, at this time, to investigate in a statistically meaningful fashion the EMI susceptibility of EBT's, to develop detailed test methods, and to modify the standards to include the necessary performance requirements would necessitate a project of several years duration. NHTSA has concluded that the routine use of EBT's in the enforcement of drunk driving laws has proven to be highly effective, and felt that action on the EMI issue could not be delayed until standards were developed. In view of the urgency of the problem, NBS agreed to undertake a short term, limited-sample study to investigate the extent to which EBT's currently in use are susceptible to EMI.

The phenomenon of electromagnetic interference, as discussed in more detail in this report, is a function of the intensity, frequency, and direction of the electromagnetic field and the characteristics of the electronic equipment in that field. The only reported incidents to date in which EBT's have demonstrated EMI susceptiblity have been as a consequence of transmissions by police transceivers. The scope of this study was limited to tests in electromagnetic fields that simulate those from police transceivers, which may well pose the greatest interference threat to obtaining accurate readings with EBT's, for such equipment is frequently used in police stations or at locations where police vehicles are in close proximity to the EBT's.

The EBT's tested during this effort were provided to NBS by the Transportation Systems Center (TSC) of the U.S. Department of Transportation (DOT). Some were obtained directly from manufacturers, some from TSC, and others were borrowed from State laboratories that were using the instruments for routine breath testing. The tests were conducted at the NBS Boulder, Colorado, laboratories in a shielded room. The EBT under evaluation was mounted on a nonmetallic turntable, 1 m above the floor. An antenna was positioned a few feet away from the EBT with the centerline of the antennas at the same height, and standard laboratory signal generators were used to excite the antenna to produce an electromagnetic field of controlled intensity and frequency. A near-field probe was used to measure the actual field strength at the location of the EBT, and the field strength was adjusted to the desired level at that location.

Most of the EBT's were tested in fields at four specific frequencies; 46 MHz, 160 MHz, 460 MHz, and 850 MHz. These frequencies are representative of the four frequency bands allocated by the Federal Communications Commission for use by State and local government law enforcement agencies. Two antenna orientations, horizontal and vertical, were used in the 160 MHz tests, while only fields from horizontal antennas were generated at the other three frequencies. Except as noted in the report, all tests were conducted with a nominal field strength of 10 V/m. This field strength is considered to be approximately equal to that from a typical 5-W handheld transceiver at a distance of 1 m from the EBT or that from a typical 100-W mobile transceiver at a distance of 10 m.

The field strength of 10 V/m used to conduct the tests has the potential to damage electronic equipment operated in that field if the equipment exhibits resonances that result in significant energy coupling within the equipment. For example, during the time that the project staff was engaged in preliminary tests to develop test procedures and equipment setup, two simulators used to generate alcohol vapor samples, when operated in the presence of the test field, ceased to operate and were permanently damaged. In addition, one of the EBTs that was used as a test object during the preliminary testing ceased to operate following operation in the radiated electromagnetic field with a nominal unperturbed field strength of 10 V/m. While no attempt was made to determine the nature of the failure of this EBT, it is quite possible that the failure was caused directly by the coupling energy in the field.

It should be noted that apparent damage to EBTs as a consequence of operation in electromagnetic fields during this study was a rare occurrence. In all cases, the EBT devices for which data and observations are presented in the report functioned in a normal manner following operation in electromagnetic fields during the test program.

Table 1 presents a summary of the test results of the EBT's subjected to the five electromagnetic fields described above.

Table 1. Summary chart of EMI effects on EBT's.

Unit	46 MHz	160 MHz	160 MHz V	460 MHz	850 MHz
A	0[a]	0	-	0[b]	0
B	S	S	S	0	0
C	0	0	0	0	0
D	0	0	0	0	0
E	0	0	0	0	0
F	0	0	0	S	0
G	0	0	0	0	0
H	??	S	NR	NR	0
I	0	0	0	0	0
J	0	0	0	0	0
K	??	NR	NR	NR	NR
L	0	S	S	S	S
M	S	??	S	0	0
N	0	0	-	S	S
O	NR	NR	-	NR	S
P	S	S	S	0	S

[a]Measurements made at 40 MHz.

[b]Measurements made at 410 MHz.

Notes:

0 - The average reading of five alcohol vapor samples in the presence of EM fields was within ±5 percent of the average of five readings without a field, and the standard deviation was less than 0.0042.

?? - Unit showed small but measurable change in the average alcohol vapor reading or a small increase in the standard deviation of the reading in the presence of EM fields. (0.0042 < SD < 0.008)

S - The average reading of five alcohol vapor samples in the presence of EM fields differed from the average of five readings without a field by more than ±5 percent or the unit showed large variability in measured alcohol concentration in the presence of EM fields. (SD > 0.008)

NR - Unit ceased operation, blanked display, or gave an error flag in the presence of EM fields.

Note that results are provided for only 16 manufacturer instruments. It was not possible in the time allocated for the testing program to obtain and test all units that are in use in the United States. Using the criteria that both the precision and accuracy of an EBT must remain within the limits required by the NHTSA performance standard, 9 of the EBT instruments were found to be susceptible to EMI in at least one of the four selected frequencies, using a nominal unperturbed field strength of 10 V/m.

The selection of the field strength used in the tests conducted during this study (10 V/m) was, as noted in the report, based upon engineering judgment. No data concerning the electromagnetic environment at the locations in which EBTs are used was available during this study; consequently it remains for the individual State and local jurisdictions that use EBTs to evaluate the likelihood of line of sight transmission by hand-held or mobile transceivers at distances of 1 or 10 meters or less during the operation of an EBT in their facilities. It would appear. however, that proper operating procedures can avoid the use of EBTs in inappropriate locations and eliminate the risk of hand-held and mobile police radio transmission interference that could contribute to errors in alcohol concentration measurements.

In reviewing the summary data and observations, as well as the data presented later in this report, it is important to recognize the limited scope of the testing program. As a result, EBT's in this study should be viewed as a class of instruments. rather than as individual instruments to be used for comparison purposes. In particular, these data cannot be extrapolated with validity to cover other frequencies, to other field strengths, to multiple frequency fields. or to other units of the same EBT instruments.

INTRODUCTION

The National Highway Traffic Safety Administration (NHTSA) entered into an interagency agreement with the National Bureau of Standards (NBS) Law Enforcement Standards Laboratory (LESL) in 1972, providing funds to LESL to develop performance standards for instruments used to ascertain the equivalent blood alcohol concentration, through the analysis of the alcohol content of breath samples, of individuals suspected of drunk driving.

A performance standard for evidential breath testers (EBT's), which was developed by NBS/LESL, was promulgated by NHTSA in 1973 [1].[1] Shortly thereafter, the U.S. Department of Transportation's Transportation Systems Center (TSC) tested commercially available EBT's against the requirements of the NHTSA standard, and NHTSA issued a Qualified Products List (QPL) of EBT's that complied with the standard. Since that time, NHTSA has maintained the QPL on a current basis, as additional EBT's were tested. The QPL published in the Federal Register of March 4, 1982, includes 28 manufacturer instruments (see app. B), 11 of which are no longer in general use according to NHTSA. These plus two others were considered for inclusion in this study.

The purpose of the performance standard for EBT's is to establish requirements and methods of test for the critical attributes of such instruments. An EBT that complies with the requirements of the NHTSA standard is capable of providing an accurate analysis of the equivalent blood alcohol concentration (BAC) of a breath sample from an individual suspected of drunk driving that is suitable for use as evidence in the prosecution of the accused. The NHTSA believes that the compliance of EBT's with the standard has resulted in the legal acceptance of BAC readings taken with EBT's, which has resulted in a major upgrading of police agencies' capability to meet the requirements for evidence imposed by the courts. NHTSA has concluded that a properly trained officer is able to use an EBT to make a valid and accurate determination of BAC without lengthy delay, making it unnecessary to rely upon the vastly more cumbersome and time consuming blood, urine, and/or saliva tests.

The NHTSA performance standard for EBT's places emphasis on the precision and accuracy of the analytical determination of the BAC from an alcohol vapor sample and the breath sampling capabilities of the instrument. Breath sampling is important because the analysis must be based on the last portion of an expired breath to measure the alcohol content of breath that is from deep-lung air. In addition, the standard addresses environmental conditions (high and low temperature, humidity, vibration, and operation in high altitude geographical locations), as well as safety.

Early in 1982, the Washington D.C. Metropolitan Police Department reported to NHTSA that EBT's were found to display erroneous BAC readings in the presence of electromagnetic fields from radio transmission. NHTSA contacted LESL and TSC, and it was agreed that if EBT's were susceptible to electromagnetic interference, action must be taken to solve the problem, and that it might be necessary to modify the NHTSA standard to include electromagnetic interference (EMI) susceptibility requirements. On March 24, 1982, representatives of NHTSA, TSC, and NBS were given a demonstration by police officers who routinely conduct breath testing using an EBT in a mobile van. One police officer operated his handheld radio within 0.3 m (1 ft) of the EBT and demonstrated that the electromagnetic field could severely affect the analysis of alcohol vapor samples.

It was noted that a variety of communication systems are in use that extend throughout the frequency range from 10 kHz to 10 GHz and even beyond, any of which could potentially intefere with the electronic components of EBT's. Further, EMI susceptibility is very frequency dependent and can only be determined by testing at many frequencies. LESL also called attention to the fact that the NBS Boulder staff felt that existing test methods to evaluate EMI susceptibility in the frequency range from 50 MHz to 200 MHz were probably not sufficiently accurate to enable the reliable testing of EBT's in that frequency spectrum. It was estimated that a rigorous investigation of EMI susceptibility over the frequency range in question would require several years of research and a significant funding investment. Since

[1]Numbers in brackets refer to references in appendix A.

NHTSA felt obligated to provide State and local governments with information concerning the magnitude of the potential problem as soon as possible, LESL agreed to provide a cost estimate and schedule for a limited series of tests designed to quickly determine the extent to which EBT's are susceptible to EMI at specific frequencies within the four police radio transmission frequency bands and to recommend future efforts to develop standards, if warranted by the test results. A suggested statement of work was discussed with NHTSA which resulted in a modification to the long-standing interagency agreement. The LESL/NHTSA interagency agreement was modified on June 16, 1982, to incorporate the task of limited tests of the EMI susceptibility of EBT's.

The sections of this report that follow discuss EBT's and EMI in general terms, outline the rationale for the tests that were selected, describe the measurement procedures and instrumentation, and present the test results for each EBT included in the program. *Reading the section on test results is essential to understanding the preliminary nature of these results. The reader is cautioned to recognize the limited nature of the testing program and warned that it is not possible to predict the EMI susceptibility of EBT's at other frequencies or field strengths, or in the presence of multiple frequency fields, based solely upon these test results, or for other units of the same instrument.*

BACKGROUND

The phenomena of electromagnetic interference (EMI) are complex. In order to discuss the studies that are described in this report, it is desirable that the reader be familiar with the characteristics of evidential breath testers (EBT's) and the general nature of EMI.

Evidential Breath Testers

When an individual consumes alcoholic beverages, the alcohol is absorbed into the blood [2]. In sufficient concentrations, the alcohol in the blood can modify behavior, reduce physical response time, affect coordination and vision, induce drowsiness, or be lethal [3,4]. Drunk drivers, as a result of impaired senses, are a menace to themselves, their passengers, and others on the same road [5]. Impairment, judged on the basis of visual observation, is clearly subjective· can an individual suspected of drunk driving walk a straight line, touch his nose, or otherwise demonstrate coordination? Rather than rely upon evidence based solely upon the observations of the officer that apprehends an individual suspected of driving while under the influence of alcohol, all States have established laws that define intoxication in terms of the actual blood alcohol concentration (BAC). In almost all jurisdictions, a BAC of 0.100 % w/v (0.1 g of alcohol per 100 ml of blood) is legal evidence of intoxication.

Earlier enforcement of the legal limit of BAC as a basis for prosecution of a drunk driver relied upon chemical analysis of blood, saliva, or urine specimens to establish the amount of alcohol in an individual's system. While accurate, such tests can only be administered by qualified medical and laboratory technicians, and generally require the transport of an individual suspected of drunk driving to a facility staffed by appropriate personnel. The alcohol in the human system is also dissipated through normal breathing, being transferred to the breath from the blood in the alveoli of the lungs. Numerous studies have been conducted, and the Committee on Alcohol and Drugs, National Safety Council, has adopted a conversion factor that permits the use of breath alcohol concentration as an accurate measurement of the blood alcohol concentration [6]. The chosen ratio of breath alcohol content to blood alcohol content of 2100 to 1 is conservative. In actuality, the equivalent blood alcohol concentration measured through breath alcohol concentration is generally no more than the actual BAC and, in most cases, less [7,8].

The Uniform Vehicle Code [9] permits the use of breath alcohol analysis as a means of establishing the BAC of an individual suspected of drunk driving. As a result, EBT's have been used in increasing numbers to enforce driving while intoxicated laws. The NHTSA has encouraged the use of EBT's to implement its alcohol countermeasures program by making Federal funds available for the purchase of EBT's that meet the requirements of NHTSA performance standards [1], as evidenced by inclusion on the NHTSA Qualified Products List of EBT's (app. B).

An EBT is an instrument that analyzes the alcohol vapor concentration of the breath exhaled by an individual and displays the measured alcohol vapor concentration in units of blood alcohol concentration. There are a variety of different analytical methods employed by EBT's, including gas chromatography, nondispersive infrared absorption, photometric/wet chemical dichromate oxidation and fuel cell and semiconductor gas detection [10]. The qualification testing of EBT's is directed toward two basic characteristics of the instruments: 1) the capability of an EBT to properly analyze the alcohol content of the breath sample, and 2) the capability of the same EBT to analyze the correct part of the breath sample.

To evaluate the analytical capability of each EBT during qualification testing, 10 samples of known alcohol vapor are measured at three different concentrations [1]. For each set of tests, the average reading must be within ± 5 percent of the known alcohol vapor concentration, and the standard deviation of each set of readings must not exceed 0.0042 BAC units.

When an individual takes a breath and then exhales, the first portion of the exhalation primarily includes air from the mouth and thorax, which would have a low concentration of alcohol, if any is present. The next major portion of an exhalation comes from the lungs, but again, since the air is not necessarily in

MHz, and 806 to 896 MHz. Mobile and handheld police transceivers could often be present at locations where EBT's are used. The electromagnetic signal transmitted by police transceivers produces a high field strength at close range to the unit. A unit operated close to an EBT may well pose the greatest threat of EMI to EBT's.

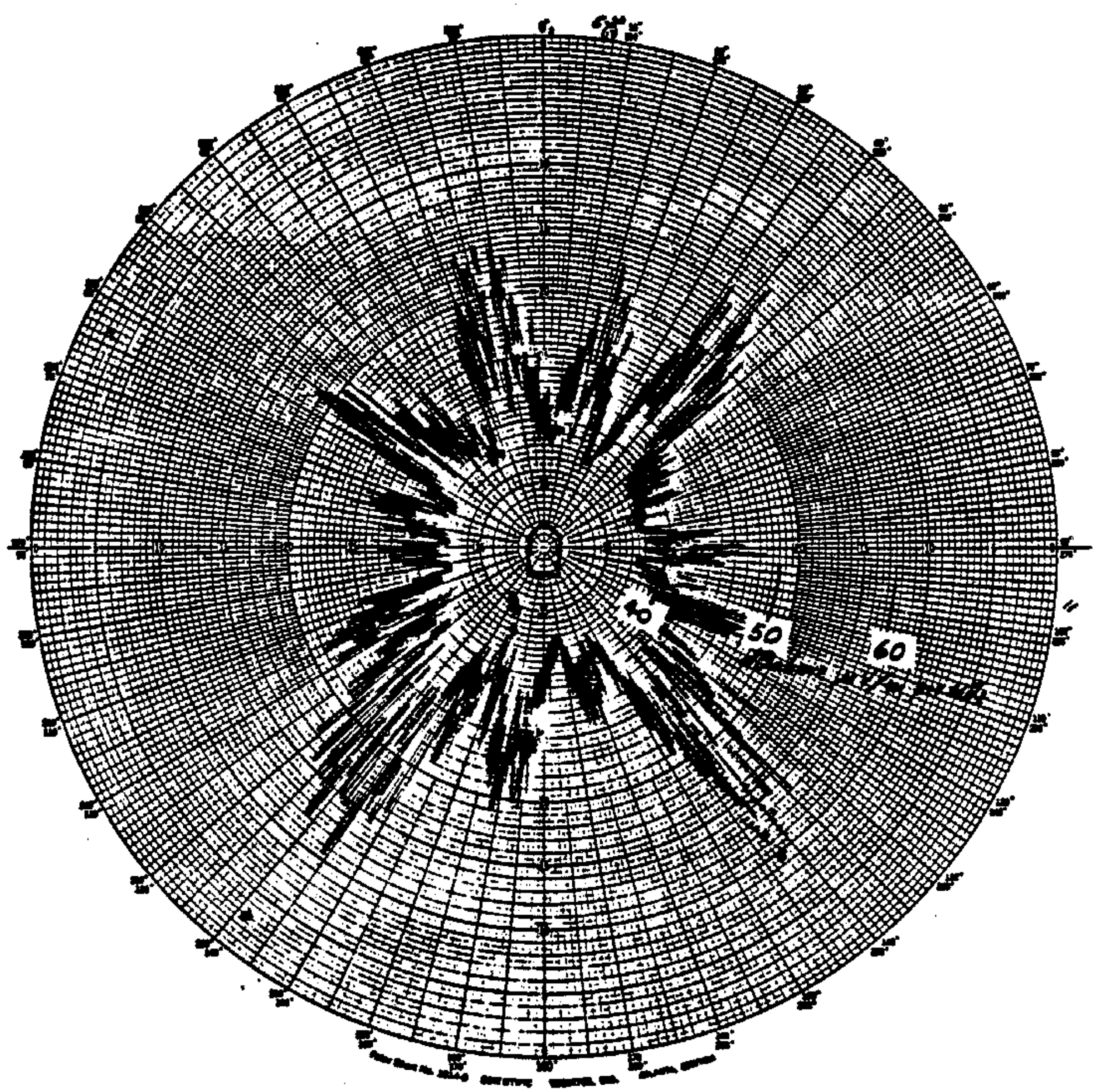
In principle, tests to determine whether a given EBT is susceptible to EMI from the electromagnetic fields of police communication system transmission appear straightforward; expose the EBT to known fields of various frequencies and record any anomalous behavior. However, EMI measurements are complicated by many factors that can adversely affect the accuracy of the results. The discussion that follows is not intended to deal with all of these factors, but to indicate why some of the factors must be carefully considered in order to make reliable and accurate EMI measurements.

The energy and power in electromagnetic (EM) fields are key parameters that relate to EMI. The EM fields, which consist of electric (E) and magnetic (H) fields, contain energy and, if this energy level is comparable to the levels required to operate or control electronic devices or systems, the potential or even the probability of EMI exists. Antennas are energy transducers that covert E and H fields into voltages or currents in a circuit. E and H fields are vector quantities and thus have direction as well as magnitude. The orientation of a receiving antenna with respect to the field vectors from a transmit antenna influences how much energy will be coupled into the receiving antenna. The importance of such alignment is readily apparent to anyone who has operated a television set from rabbit ears or used an exterior antenna with a rotor.

The EMI effects upon an EBT are caused by the EBT acting as a receiving antenna. In communication applications, antennas with known characteristics are used, and the orientation of the field vectors is known. In EMI applications, little is known. Any metallic structure, wire, metal box, etc., is an antenna of unknown characteristics. An EBT is an example. How it couples to EM fields is not known, nor can the coupling be accurately calculated if the geometric shape is at all irregular. Figure 1 is an example of an irregular field strength pattern from a transmitter. The receiving pattern is similar. This illustrates the need for testing a device in all azimuthal orientations to investigate EMI susceptibility.

It is difficult to generate well defined and controlled electromagnetic fields for the purposes of conducting EMI measurements. Approximate levels of the electric field strength may be calculated by far-field equations that consider transmit power, antenna gain, and separation distance between the transmit antenna and a point. However, exact levels can only be obtained by measurement, because perturbations caused by reflecting (metallic) objects, near-field effects or other factors such as change in antenna gain, elevation, or ground conductivity cause variations from the calculated values. The gain of the transmit antenna may change depending on its proximity to ground or nearby reflecting objects. Near-field zones are usually considered to be within approximately a half wavelength of the transmit antenna. The potential EMI effect of the E and H fields is directly related to the magnitude of the field strength. For example, a nearby, low-power source may create the same field strength as a distant, high-power source. In the near field, E and H fields have more spatial variation in magnitude and direction than occur in the far field. Different EBT's under test will perturb the field in different ways. The size and shape of the EBT determines the extent of the perturbation. The perturbations caused by the EBT under test usually are greater than perturbations caused by distant reflecting objects. The most serious perturbations are caused by resonances within the object under test. Resonances can increase the field strength levels of the object under test many times over the unperturbed levels, having the same effect as increasing the power or decreasing the distance. Tests at a limited number of frequencies may not detect problems caused by resonances since resonances can occur over a very narrow bandwidth.

The above variations make it necessary to ascertain the actual field strength to properly determine EMI susceptibility using proper instrumentation. Near-field probes are the key to making accurate EMI measurements on EBT's. The probes have a broadband, isotropic, nonperturbing response [13]. With this instrumentation, it is possible to: 1) measure the levels that characterize the appropriate EM environment, 2) set up test fields, or 3) detect resonances.



'iqure 1. Typical radiation pattern from an irregular-shaped device (passenger car). Frequency is 200 MHz and receiving antenna is horizontal. Receiving pattern will be similar.

TESTING RATIONALE

The precise investigation of EMI requires the ability to create uniform EM fields of carefully controlled levels over the entire volume of the article under test. Since EMI is frequency dependent, investigations should include fields that extend over the entire range of frequencies that might be present in the environment of the article under test. Two approaches are typically taken to measure the effects of EMI: 1) measurements are made to determine the threshold field strength (as a function of frequency) at which EMI occurs, or 2) the item is tested over the frequency range of interest at specific field strengths noting only if the device is immune or susceptible to EMI at that field strength.

From the onset of the present effort, it was recognized that any detailed investigation of the EMI susceptibility of EBT's would have to be deferred until limited laboratory studies had determined whether EMI susceptibility was a common problem among those in use or unique to the single instrument that had been demonstrated to be susceptible to EMI. Further, it was considered important to seek an early answer to the question of the magnitude of the potential EMI problem with EBT's.

The NBS Boulder laboratory facilities include transverse electromagnetic cells [14], which can be used for precise EMI measurements, but such tests are time-consuming and are limited to a frequency range from approximately 10 kHz to 50 MHz. Similarly, anechoic rooms are available to conduct EMI tests at frequencies from 200 to 10,000 MHz but, again, the setup and testing time would have been prohibitive for the objectives of this limited study. There are no indoor test facilities at NBS for the frequency range from 50 to 200 MHz that can be used to accurately generate known EM fields for EMI susceptibility testing.

As an expediency, recognizing the limitation of the data that would be obtained, it was decided to conduct all tests in the same shielded room facility, using two transmit antennas to establish EM fields at test frequencies in each of the four frequency bands used by police communication equipment.

Clearly, it was essential to select criteria for judging whether an EBT would be considered to be susceptible to EMI, as well as the field strengths to which the instruments would be exposed. As noted earlier, the primary concern is whether EMI manifests itself as an error in BAC determination. Thus, a change in instrument reading during the presence of an EM field that causes the precision and accuracy to deviate from the basic EBT performance requirements was selected as the basis for judging EMI immunity or susceptibility. To this end, it was agreed to compare the average and standard deviation of five alcohol vapor concentration determinations in the presence of the field with those of five previous determinations with no EM field present.

In certain cases, it was anticipated that the presence of EM fields might result in an EBT blanking the BAC display or displaying some kind of error "flag" that would cause the operator to discount the breath analysis determination. An EBT response of this type was to be reported as observed.

The question of the field strength to use for the investigation was more arbitrary. The absence of actual field strength data from locations in which EBT's are used made it necessary to select possible operational situations and to choose field strength levels consistent with those situations. Assuming that an officer might transmit with a personal or portable transceiver while in the same room as an EBT that was being used to conduct a BAC analysis, the field strength from a 5-W transceiver at a distance of 1 m was selected as one condition for the EMI testing.

Mobile radios in police vehicles represent a second potential source of EMI. Since certain jurisdictions use EBT's in mobile vans, it seemed probable that a police officer could transmit when near such a van, and a range of 10 m was selected as a reasonable (closest) distance of transmission. In advance of initiating the test program, field strengths of 5 and 15 V/m had been contemplated as the tentative test conditions. As mentioned earlier, four frequency bands were selected. It was also recognized that it would be important to rotate the EBT to determine EMI susceptibility as a consequence of the potential differences in coupling at different horizontal azimuths. Finally, it was considered important to investigate EMI as a consequence of both horizontal and vertical orientations of the transmitting antennas.

TEST PROCEDURES

As noted earlier, there are significant differences in the manner in which various EBT's analyze the alcohol content of a breath sample. Therefore, it was necessary for project personnel to become familiar with the operating cycles (sample collection and analysis) of each individual EBT prior to investigating the effects of EM fields. This enabled them to understand when during the operating cycle the possibility of EMI causing an erroneous determination of BAC is greatest. In addition, the EBT's were obtained from a variety of sources and the condition of the instruments as received was not known. As a consequence, each EBT was subjected to testing in accordance with the acceptance procedure that LESL had previously developed for NHTSA, in advance of any effort to test the units for EMI susceptibility. If a unit did not meet the precision and accuracy requirements of this acceptance standard (see app. C), it was returned to the supplier for repair with no attempt to investigate EMI effects. This was considered essential, for if an individual EBT was not operating properly, it would not be possible to associate abnormal alcohol vapor analysis in the presence of EM fields as primarily due to EMI susceptibility.

It would have been desirable to have all test units available for the entire duration of the test program but, unfortunately, most units could only be retained for a matter of weeks. Thus, the EBT's were tested in the general order in which they were received and returned to the supplier or to the TSC as soon as tests were completed. As a result, it was not possible, at a later date, to retest the EBT's to clarify any results that might be questioned upon subsequent detailed test data analysis.

Figure 2 shows a block diagram of the experimental equipment. Styrofoam blocks were used to build a support approximately 1-m high. A plastic turntable was placed on top of the styrofoam blocks, and a nonmetallic platform was mounted on the turntable to fully support the largest EBT. The physical constraints of the shielded room in which the experiments were conducted limited the distance of the antenna from the center of the turntable to at most 3 m. Two antennas were utilized to establish EM fields over the frequency range of interest. A biconical antenna (see fig. 3) provided transmission in the 30 to 174 MHz frequency range, and a log periodic antenna (see fig. 4) was used to transmit fields in the 400 to 896 MHz range. The antennas were powered by typical radiofrequency signal generators and power amplifiers.

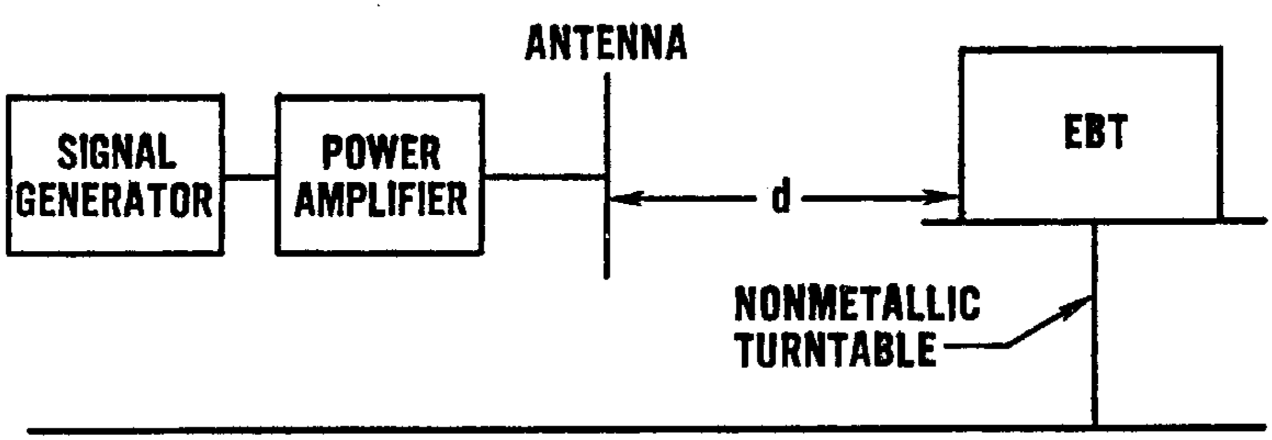


Figure 2. Block diagram for measuring EM susceptibility of EBT systems.

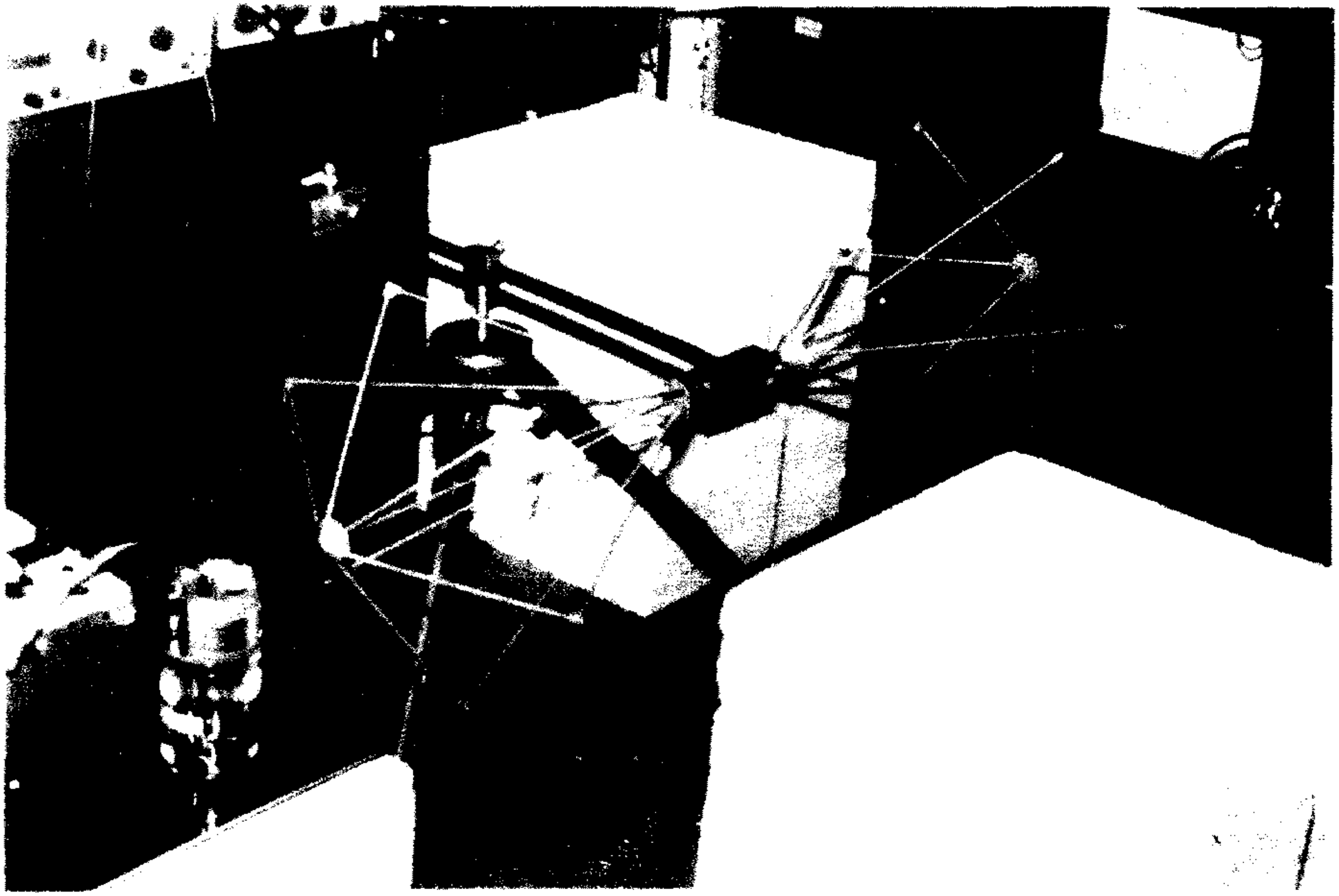


Figure 3. Biconical antenna - 30 to 174 MHz frequency range.

Figure 4. Log periodic antenna - 400 to 896 MHz frequency range.

Prior to conducting any tests with EBT's, the EM fields over the volume of space that would be occupied by the EBT's were investigated using one of two NBS-developed near-field probes. These devices, the Energy Density Meter 3 and the Electric Field lonitor 5, consist of probes with a broadband, isotropic nonperturbing response [12] :apable of accurately measuring the field strength of a field to ±1 dB. When the :ransmit antennas were driven by the signal generator, the unperturbed field ;trength at the center of the test volume was adjusted to 10 V/m as measured by the ›robes.

Since the transmit antennas were in close proximity to the EBT turntable, the EM :ields over the test volume varied from approximately 15 V/m at the side closest to :he antennas to 5 V/m at the opposite side of the support platform when the field ;trength was adjusted to 10 V/m at the center of the platform. Figure 5 shows the :ypical variation in field strength over the surface of the support platform. The lotted lines show the relative size of the larger EBT's. When an EBT was placed in :he field of the antenna, the resulting perturbations resulted in even greater field ;trength variations at various locations surrounding the EBT: field strengths as low ıs 3 V/m were observed at some locations, while levels as high as 60 V/m were noted .n cases of large perturbation. No attempt was made to fully characterize the :ields surrounding the individual EBT's, for this would have required extensive ıeasurements, and even with such data it would be difficult, if not impossible, to :ully identify those factors that contribute to the EM field perturbations.

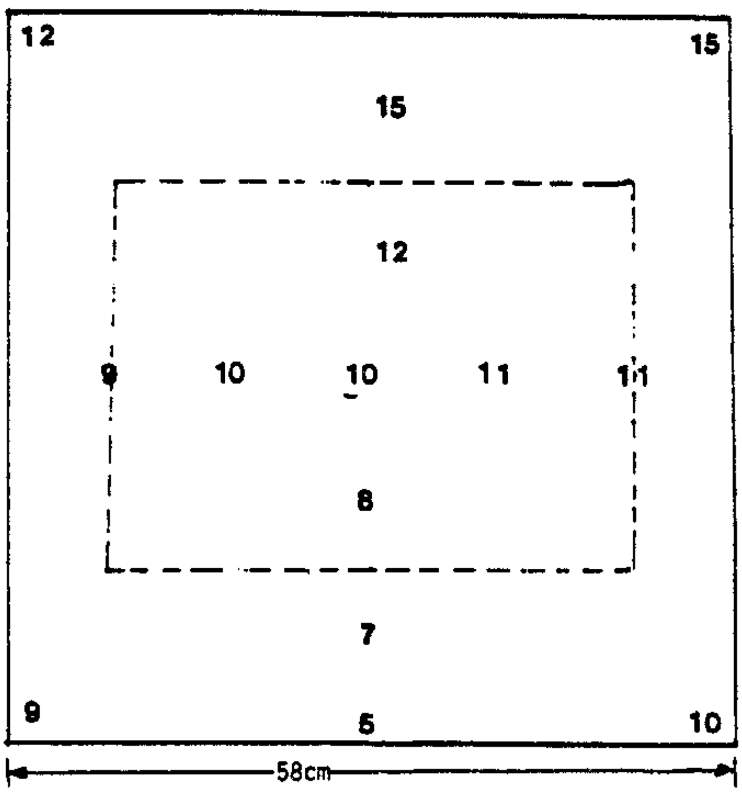


Figure 5. Typical unperturbed electric field (E) distribution in test area, measured in volts per meter.

The variations of the test field and the perturbations of that field due to the presence of the EBT's were such that the project personnel elected to use a single field strength of 10 V/m at the center of the support platform at each test frequency for all EBT tests. It would have been desirable to investigate potential EMI susceptibility over a range of field strength levels, such as the two levels of 5 and 15 V/m originally contemplated for this investigation; however, it was concluded that in view of the variation in field strength such data, even on a relative susceptibility basis, could be very misleading.

In actually performing the tests, the EBT was centered on top of the support platform and connected to a commercial breath alcohol simulator normally used to calibrate EBT's. Preliminary experiments demonstrated that the lengths of tubing between the simulator and the EBT necessary to operate the simulator far enough away from the test field resulted in moisture condensation in the tubes if the alcohol/water solution was heated to the prescribed 34°C. Consequently, it became necessary to operate the simulator next to the EBT under test. At the start of the test, the EBT was operated in the absence of the EM field and used to analyze five alcohol vapor samples from the simulator. The EM field was then turned on. Project personnel found during preliminary experiments that the orientation of the EBT with respect to the EM field did affect the energy coupling, and that the maximum coupling did not necessarily occur when one of the EBT's sides was perpendicular to the transmit axis of the antenna. Consequently, with the field established, the EBT was operated in the breath sampling mode (with the alcohol vapor sample delivered from the simulator) and rotated during the operational cycle. A total of five alcohol vapor samples was analyzed with the EM fields on.

The above procedures were repeated for each of five test conditions: with a horizontal antenna orientation at 46, 160, 460, and 850 MHz, and with a vertical antenna orientation at 160 MHz. A vertical antenna orientation was not used at the other frequencies because the reflections and near-field effects caused such a variety of orientations of the E and H field vectors within the test field that any additional measurements would not have been meaningful.

Three of the units had a real time continuous display of the alcohol vapor concentration during the analysis cycle, and were subjected to a different test procedure which allowed test personnel to observe the effect of EM fields on each separate phase of the instrument cycle. These units incorporate a nulling or zero cycle prior to a separate analysis cycle. The units were centered on the turntable and operated with an alcohol vapor sample while the turntable was rotated to determine the azimuth of maximum effect in the presence of the EM field. The turntable was fixed at that location for all remaining tests. The first analysis was made with no EM field. This was followed by an analysis of alcohol vapor during which the field was transmitted only during the analysis cycle and was not present during the nulling cycle. A third alcohol vapor sample was then analyzed with the EM field on during both instrument operating cycles. During the fourth test, the EM field was transmitted while the unit was operating in the nulling cycle and turned off when the actual analysis cycle was initiated. Following this sequence of tests, the alcohol vapor sample was again analyzed with no EM field present.

The alcohol/water solution used in the simulator was generally replaced prior to each series of tests. However, since the resulting data were to be used for comparison purposes, not as absolute measurements of alcohol vapor concentrations, no attempt was made to adjust the alcohol/water ratio to yield a specific alcohol vapor concentration as would be done in qualification testing.

The data presented in the section that follows presents the results of the EBT testing. In some cases, the effect of EM fields upon EBT analysis was examined at additional test field frequencies as noted in the test results.

TEST RESULTS

The data for the test results summarized in table 1 are presented for 13 of the EBT's in tables 2 through 14 (pages 19-23). The average alcohol vapor concentration reading in the absence of the EM field of 10 V/m is compared with the average reading in the presence of the EM field, and the percent change in the average reading noted for each test frequency. The standard deviation of each set of EBT readings without and with an EM field applied is also tabulated at each test frequency. With the exception of those data points noted on the tables, each test consisted of five separate measurements of the alcohol vapor samples. The measurements made at 160 MHz with the transmit antenna in a vertical orientation are noted as 160 V in the tables.

The data presented in table 12 (unit M) serve as an example of the frequency dependence of EMI and the possible existence of resonances over narrow frequency bands. This unit shows small changes in the average alcohol vapor concentration reading in the presence of the EM field at frequencies of 460 and 850 MHz, and large changes in the average alcohol vapor concentration reading and standard deviation in the presence of lower frequency EM fields. Unit L (see table 11), by contrast, shows changes in the average alcohol vapor concentration reading, in the presence of the EM field, that exceed ±5 percent at all frequencies except 46 MHz. Also, the variability of the readings increased substantially.

The tests of the three units with direct display that were conducted to observe the effects of EM fields at different times during the analysis cycle were not replicated. Since these data do not permit statistical analysis, the results are discussed as observations only in the paragraphs that follow without tabular test data.

Unit B, when tested at 40 and 46 MHz, appeared to be slightly susceptible to EMI during the analysis cycle only. This was also true at 160 MHz in the field from a horizontal antenna; however, at 160 MHz in the field from a vertical antenna, it was markedly susceptible to EMI during the balance and analysis cycles. This unit appeared to be unaffected in both 460 and 850 MHz EM fields.

Unit C was not observed to exhibit susceptibility from the presence of any of the five test fields.

Unit P appeared to be slightly susceptible to EMI at 46 MHz; however, it was extremely susceptible to EMI at 160 MHz. During the analysis cycle in the field from the vertical antenna, it actually gave a negative alcohol vapor concentration reading and displayed a alcohol vapor concentration reading in error by more than 100 percent with the field present during only the balance cycle. The errors in the presence of a field from a horizontal antenna were not so severe. The unit did not appear to be susceptible to EMI at 460 MHz, but was quite susceptible at 850 MHz.

All of the EBT devices for which data are presented in this report were operated following exposure to the electromagnetic fields to ascertain possible permanent damage to the devices. These tests verified the continued accuracy and proper operation of the device in the absence of electromagnetic fields.

CONCLUSIONS

This study of potential EMI susceptibility included tests of 16 EBT instruments. Using the criteria that both the precision and accuracy of an EBT must remain within the limits required by the NHTSA performance standard, 9 of the EBT instruments were found to be susceptible to EMI in at least one of the four selected police band frequencies, using a nominal, unperturbed field strength of 10 V/m.

It is apparent from some of the data that narrow band resonances may exist for some of the EBT's that were tested. However, the data are too limited to permit the extrapolation of potential EMI susceptibility to frequencies other than those specifically used during the tests. It is also apparent that EMI manifests itself in several ways depending upon the individual EBT instrument being tested. The average alcohol vapor concentration reading may increase or decrease in the presence of an EM field and, in some cases, the EBT may blank the display, set an error flag, or cease operation. It is also clear that the orientation of the EBT within the EM field influences the extent to which the energy within the field is coupled into the EBT.

The majority of the EBT instruments classified as susceptible to EMI by the criteria selected for this study demonstrated a maximum change of less than +10 percent in average alcohol vapor concentration reading in the presence of EM fields, compared with the average reading obtained with no field present. Three of the units, however, demonstrated far greater changes in average alcohol vapor concentration readings. In one case, a change of over 100 percent was registered by one of the EBT's with a direct readout.

The errors in EBT reading as a consequence of EMI noted in this investigation probably represent potential problems that could be encountered when subjected to similar conditions. The variations in the EM fields were such that it is likely that the sensitive components of the EBT were exposed to localized field strengths in excess of the 10 V/m field considered to represent the 5-W transceiver at 1 m and the 100-W transceiver at 10 m. With the exception noted below, it is reasonable to assume that the EBT's would be less susceptible to EMI at lower field strengths than those used in these tests. It is not possible from the data obtained, however, to project the lowest threshold field strength at which any of the EBT's would first demonstrate measurable EMI susceptibility.

Several of the EBT's were observed to blank the instrument display or otherwise display a caution signal in the presence of the 10 V/m test field. It is not known if such response to an EM field is a matter of intentional design to avoid taking measurements in an EM field, or simply coincidental as a byproduct of the manner in which the energy couples into the device. One such EBT did not blank the display when exposed to EM fields of reduced levels but, instead, gave erroneous readings. Future studies should consider the effect of lower level fields in greater detail.

The scope of this investigation was extremely limited, and the reader is again cautioned to be aware of the factors that preclude stating other than the obvious conclusions that some EBT instruments are susceptible to EMI from EM fields of 10 V/m transmitted from two specific antennas at distances of approximately one-half meter. The reader must recognize the following:

- In most cases, the tests were conducted on single units and therefore may or may not be representative of all units of a specific EBT model.

- The EM fields used for these tests were selected on the basis of two specific police radio transmissions (5 W at a distance of 1 m and 100 W at a distance of 10 m), and may not be realistic in any or all jurisdictions that use EBT's.

- The tests were conducted at single frequencies in the public-safety radio service band. Because of the frequency-sensitive nature of some of the electronic components of EBT's, the test results are not transferable to other frequency bands.

- The fields selected for the tests are based on line of sight transmission and do not take into account either attenuation from structures that surround EBT's in use, or possible multipath perturbations from such structures or their surrounding environment.

- o The nature of the data precludes knowledge of the minimum threshold field strength at which EMI introduces significant errors in alcohol vapor concentration measurements.
- o In the absence of field strength measurements at the variety of locations in which EBT's are used to fully characterize the electromagnetic environment over the frequency spectrum of potentially interfering fields, it is not possible to correlate the field strength used for this series of laboratory measurements with the specific environment encountered by any law enforcement agency.

Table 2. Test results for Unit A.

Test Frequency (MHz)	Average BAC Reading (% w/v) No Field	Average BAC Reading (% w/v) 10 V/m Field	Percent Change BAC With 10 V/m Field	Standard Deviation (% w/v) No Field	Standard Deviation (% w/v) With 10 V/m Field
40[a]	0.1027	0.1057	+2.9	0.0015	0.0015[b]
40	0.1073	0.1057	-1.5	0.0025	0.0029[b]
160[a]	0.1017	0.1060	+4.2	0.0006	0.0017[b]
160	0.0976	0.1018	+4.3	0.0037	0.0031
410	0.0957	0.0930	-2.8	0.0042	0.0024[c]
500	0.0973	0.0973	0	0.0015	0.0025[b]
850	0.1123	0.1127	+0.4	0.0021	0.0025[b]

[a]With ac to dc converter attached.

[b]Based on three alcohol vapor samples.

[c]Based on four alcohol vapor samples.

Table 3. Test results for Unit D.

Test Frequency (MHz)	Average BAC Reading (% w/v) No Field	Average BAC Reading (% w/v) 10 V/m Field	Percent Change BAC With 10 V/m Field	Standard Deviation (% w/v) No Field	Standard Deviation (% w/v) With 10 V/m Field
46	0.0972	0.0942	-3.1	0.0013	0.0016
160	0.0674	0.0658	-2.4	0.0013	0.0008
160 V	0.1243	0.1188	-4.4	0.0024	0.0019[a]
460	0.0768	0.0767	-0.1	0.0034	0.0038[a]
850	0.0736	0.0710	-3.5	0.0011	0.0014

[a]Based on six alcohol vapor samples.

Table 4. Test results for Unit E.

Test Frequency (MHz)	Average BAC Reading (% w/v) No Field	Average BAC Reading (% w/v) 10 V/m Field	Percent Change BAC With 10 V/m Field	Standard Deviation (% w/v) No Field	Standard Deviation (% w/v) With 10 V/m Field
46	0.0850	0.0814	-4.2	0.0012	0.0018
160	0.1022	0.1014	-0.8	0.0008	0.0013
160 V	0.0758	0.0734	-3.2	0.0020	0.0011
460	0.0968	0.0954	-1.5	0.0011	0.0011
850	0.0854	0.0824	-3.5	0.0011	0.0013

Table 5. Test results for Unit F.

Test Frequency (MHz)	Average BAC Reading (% w/v) No Field	Average BAC Reading (% w/v) 10 V/m Field	Percent Change BAC With 10 V/m Field	Standard Deviation (% w/v) No Field	Standard Deviation (% w/v) With 10 V/m Field
46	0.0782	0.0756	-3.3	0.0020	0.0013
160	0.0790	0.0760	-3.8	0.0016	0.0021
160 V	0.0872	0.0842	-3.4	0.0013	0.0019
460	0.0972	0.0910	-6.4	0.0036	0.0014
850	0.0810	0.0798	-1.5	0.0017	0.0022

Table 6. Test results for Unit G.

Test Frequency (MHz)	Average BAC Reading (% w/v) No Field	Average BAC Reading (% w/v) 10 V/m Field	Percent Change BAC With 10 V/m Field	Standard Deviation (% w/v) No Field	Standard Deviation (% w/v) With 10 V/m Field
46	0.1352	0.1318	-2.5	0.0008	0.0011
160	0.0820	0.0818	-0.2	0.0012	0.0040
160 V	0.0763	0.0750	-1.7	0.0013	0.0039[a]
460	0.1064	0.1016	-4.5	0.0011	0.0015
850	0.0998	0.0972	-2.6	0.0004	0.0008

[a]Based on four alcohol vapor samples.

Table 7. Test results for Unit H.

Test Frequency (MHz)	Average BAC Reading (% w/v) No Field	Average BAC Reading (% w/v) 10 V/m Field	Percent Change BAC With 10 V/m Field	Standard Deviation (% w/v) No Field	Standard Deviation (% w/v) With 10 V/m Field
46	0.1216	0.1212	-0.3	0.0005	0.0043
160	0.1104	0.1060	-4.0	0.0009	0.0270
160 V	N/A	Would not operate properly in the presence of EM fields.			
460	N/A	Would not operate properly in the presence of EM fields.			
850	0.0958	0.0932	-2.7	0.0011	0.0022

Table 8. Test results for Unit I.

Test Frequency (MHz)	Average BAC Reading (% w/v) No Field	Average BAC Reading (% w/v) 10 V/m Field	Percent Change BAC With 10 V/m Field	Standard Deviation (% w/v) No Field	Standard Deviation (% w/v) With 10 V/m Field
46	0.0876	0.0864	-1.4	0.0017	0.0009
160	0.0990	0.0947	-4.3	0.0029	0.0028[a]
160 V	0.1035	0.0995	-3.9	0.0012	0.0019[b]
460	0.0870	0.0832	-4.4	0.0007	0.0011
850	0.0864	0.0874	+1.2	0.0015	0.0015

[a]Based on seven alcohol vapor samples.

[b]Based on six alcohol vapor samples.

Table 9. Test results for Unit J.

Test Frequency (MHz)	Average BAC Reading (% w/v) No Field	Average BAC Reading (% w/v) 10 V/m Field	Percent Change BAC With 10 V/m Field	Standard Deviation (% w/v) No Field	Standard Deviation (% w/v) With 10 V/m Field
46	0.0708	0.0712	+0.6	0.0015	0.0036
160	0.0732	0.0720	-1.6	0.0015	0.0014
160 V	0.0720	0.0712	-1.1	0.0019	0.0019
460	0.0752	0.0767	+2.0	0.0011	0.0024
850	0.0758	0.0742	-2.1	0.0004	0.0024

Table 10. Test results for Unit K.

Test Frequency (MHz)	Average BAC Reading (% w/v) No Field	Average BAC Reading (% w/v) 10 V/m Field	Percent Change BAC With 10 V/m Field	Standard Deviation (% w/v) No Field	Standard Deviation (% w/v) With 10 V/m Field
46	0.0936	0.0964	+3.0	0.0034	0.0047
160	N/A	Would not operate properly in the presence of EM fields.			
160 V	N/A	Would not operate properly in the presence of EM fields.			
460	N/A	Would not operate properly in the presence of EM fields.			
850	N/A	Would not operate properly in the presence of EM fields.			

Table 11. Test results for Unit L.

Test Frequency (MHz)	Average BAC Reading (% w/v) No Field	Average BAC Reading (% w/v) 10 V/m Field	Percent Change BAC With 10 V/m Field	Standard Deviation (% w/v) No Field	Standard Deviation (% w/v) With 10 V/m Field
46	0.0964	0.0964	0	0.0009	0.0009
160	0.1026	0.1094	+6.6	0.0005	0.0280
160 V	0.0952	0.0868	-8.8	0.0008	0.0467
460	0.0978	0.0728	-25.6	0.0013	0.0348
850	0.0984	0.0852	-13.4	0.0009	0.0304

Table 12. Test results for Unit M.

Test Frequency (MHz)	Average BAC Reading (% w/v) No Field	Average BAC Reading (% w/v) 10 V/m Field	Percent Change BAC With 10 V/m Field	Standard Deviation (% w/v) No Field	Standard Deviation (% w/v) With 10 V/m Field
46	0.0936	0.1616	+72.6	0.0027	0.0922
160	0.1000	0.1028	+2.8	0.0028	0.0079
160 V	0.0920	0.0990	+7.6	0.0032	0.0032
460	0.0940	0.0910	-3.2	0.0019	0.0031
850	0.0952	0.0932	-2.1	0.0019	0.0004

Table 13. Test results for Unit N.

Test Frequency (MHz)	Average BAC Reading (% w/v) No Field	Average BAC Reading (% w/v) 10 V/m Field	Percent Change BAC With 10 V/m Field	Standard Deviation (% w/v) No Field	Standard Deviation (% w/v) With 10 V/m Field
46	0.0912	0.0930	+2.0	0.0011	0.0039
160	0.0962	0.0955	-0.7	0.0011	0.0035[a]
460	0.0896	0.0960	+7.1	0.0017	0.0055[b]
850	0.0850	0.0764	-10.1	0.0007	0.0054

[a]Based on two alcohol vapor samples.

[b]Based on four alcohol vapor samples.

Table 14. Test results for Unit O.

Test Frequency (MHz)	Average BAC Reading (% w/v) No Field	Average BAC Reading (% w/v) 10 V/m Field	Percent Change BAC With 10 V/m Field	Standard Deviation (% w/v) No Field	Standard Deviation (% w/v) With 10 V/m Field
46	N/A	Either ceased operation or set an error flag in the presence of EM field.			
160	N/A	Either ceased operation or set an error flag in the presence of EM field.			
460	N/A	Either ceased operation or set an error flag in the presence of EM field.			
850	0.0820	0.0920	+12.2	0.0010	0.0000[a]

[a]Based on two alcohol vapor samples.

APPENDIX A - REFERENCES

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Highway Safety Program; Amendment of Qualified Products List of Evidential Breath Measurement Devices

AGENCY: National Highway Traffic Safety Administration (NHTSA), DOT.

ACTION: Notice

SUMMARY: This notice amends the Qualified Products List for devices which have been found to qualify under the Standard for Devices to Measure Breath Alcohol (38 FR 30459).

EFFECTIVE DATE: March 4, 1982.

ADDRESSES: Administrator, NHTSA, 400 Seventh Street, SW., Washington, D.C. 20590.

FOR FURTHER INFORMATION CONTACT: Ronald Engle, Office of Driver and Pedestrian Programs, Traffic Safety Programs, NHTSA, Washington, D.C. 20590, 202-472-4913.

SUPPLEMENTARY INFORMATION: The Qualified Products List of Evidential Breath Measurement Devices was initially issued November 21, 1974 (39 FR 41399), and was most recently amended September 11, 1980 (45 FR 60103). Devices on the list may be purchased with Federal funds under the Highway Safety Act, Pub. L. 89-594, 80 Stat. 731, 23 U.S.C. 402, 403.

In accordance with the Breath Measurement Standard, semi-annual testing of devices was conducted during 1981. During these tests one device, not previously on the Qualified Products List, the Intoximeter 3000, met all performance requirements for mobile and non-mobile evidential breath testers. Three devices, not previously on the Qualified Products List, the Alco-Analyzer 2000, the Breathalyzer 2000, and the Breath Analysis Computer System, met all performance requirements for non-mobile evidential breath testers.

The Qualified Products List is therefore amended as follows:

Qualified Products List

The qualified products meeting all performance requirements, including those for Mobile Evidential Breath Testers, are as follows, listed alphabetically by manufacturer:

Device and Manufacturer

1. Alert J3AD Breath Tester (battery powered), Alcohol Countermeasure Systems, Port Huron, Michigan (formerly Borg-Warner Corp., Des Plaines, Illinois).
2. Alert J3AC, Alcohol Countermeasures Systems, Port Huron, Michigan (formerly Borg-Warner Corp., Des Plaines, Illinois).
3. S-11 Breath Tester, Alcohol Countermeasure Systems, Port Huron, Michigan (formerly Borg-Warner Corp., Des Plaines, Illinois).
4. Intoxilyzer Model 4011, CMI, Inc., Minturn Colorado.
5. Intoxilyzer 4011A, CMI, Inc. Minturn, Colorado.
6. Intoxilyzer 4011A 27-10100, CMI Inc., Minturn, Colorado.
7. Intoxilyzer 4011A 27-10100 with fixed filter calibration option, CMI, Inc., Minturn, Colorado.
8. Intoxilyzer 4011AS, CMI, Inc., Minturn Colorado.
9. Alco-limiter, Energetics Science, Inc., Elmsford, New York.
10. Auto-Intoximeter AI-1000, Intoximeters, Inc. St. Louis, Missouri.
11. Gas Chromatograph Intoximeter Mark IV, Intoximeters, Inc., St. Louis, Missouri.
12. Gas Chromatograph Mark IV A, Intoximeters, Inc., St. Louis, Missouri.
13. Intoximeter 3000, Intoximeters, Inc., St. Louis, Missouri.

14. Mark II Gas Chromatograph, Intoximeters, Inc., St. Louis, Missouri.

15. Alcolmeter AE-D1, Lion Laboratories, Ltd., Cardiff, Wales, United Kingdom.

16. Intoxilyzer Model 4011, Omicron Systems Corp., Palo Alto, California.

17. Breathalyzer Models 900A, 1000, Smith & Wesson Electronics Co., Springfield, Massachusetts.

18. Roadside Breath Tester, U.S. Department of Transportation, Washington, D.C.

The qualified products meeting all performance requirements, excluding those for Mobile Evidential Breath Testers are as follows, listed alphabetically by manufacturer:

1. Atalmeter, BDT, c/o Federal American Research Corp., Portsmouth, New Hampshire.

2. Breath Analysis Computer System, BAC Systems, Inc., Guelph, Ontario, Canada.

3. Intoxilyzer Model 4011 AS-A, CMI, Inc., Minturn, Colorado.

4. Alco-Tector Model 500, Decatur Electronics, Decatur, Illinois.

5. Auto-Intoximeter AI 1, Intoximeters, Inc., St. Louis, Missouri.

6. Intoximeter Model 3000, Intoximeters, Inc., St. Louis, Missouri.

7. Photo-Electronics Intoximeter, Intoximeters, Inc. St. Louis, Missouri.

8. Auto-Alcometer, Lion Laboratories, Cardiff, Wales, United Kingdom.

9. Alco-Analyzer Models 1000, 2000 Luckey Laboratories, Inc., San Bernardino, California.

10. Brethalyzer 2000, Smith & Wesson Electronics Co., Springfield, Massachusetts.

Issued on February 24, 1982.

Charles F. Livingston,

Associate Administrator for Traffic Safety Programs.

[FR Doc. 82-5795 Filed 3-3-82; 8:45 am]

BILLING CODE 4910-59-M

ACCEPTANCE PROCEDURES FOR EVIDENTIAL BREATH TESTERS

1. PURPOSE

The purpose of this document is to establish procedures for the acceptance testing of Evidential Breath Testers (EBT). The procedures are intended for use by State and local governments for incoming inspection and testing of EBT's as received from the manufacturer.

2. SCOPE

The scope of the procedures is limited to the minimum testing and inspection required to insure that a manufacturer's routine production lots of EBT's included in the National Highway Traffic Safety Administration (NHTSA) Qualified Products List (QPL) continue to meet the requirements of the NHTSA performance standard for EBT's[1].

3. DEFINITIONS

3.1 Acceptance Test

A compliance test to determine the acceptability of delivered items that have been purchased under a contract requiring compliance with the appropriate standard, code, or other requirement.

3.2 Qualification Tests

Tests performed to check the compliance of a product with the requirements of a standard in advance of, and independent of, any specific procurement action. Qualification tests are often used to establish qualified products lists.

3.3 Qualified Products List (QPL)

A list of products identified by trade name, model number, and their manufacturer, which have been tested and found to comply with the requirements of applicable standards, codes, or other requirements.

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(1) Copies of the performance standard for EBT's and the qualified products list currently in effect may be obtained from the Office of Driver and Pedestrian Programs, National Highway Traffic Safety Administration, U.S. Department of Transportation, Washington, D.C. 20590.

3.4 Standard Deviation

A common indication of precision among repeated measurements of a single quantity given by:

$$\text{Standard Deviation} = \sqrt{\frac{\text{Sum } (X-\bar{X})^2}{N-1}}$$

where:

N = the number of measurements,

X = the value of a single measurement, and

$\bar{X}$ = the mean (average) of all X's.

An equivalent formula which is often more convenient for performing calculations is:

$$\text{Standard Deviation} = \sqrt{\frac{SS}{N-1}}$$

$$\text{where SS} = \text{Sum of } X^2 - \frac{(\text{Sum of } X)^2}{N}$$

.5 Systematic Error

As used in this document, the difference between the mean measured value and the known value, expressed as a percentage of the known value.

4. REQUIREMENTS

The requirements presented in the following paragraphs apply to each EBT of a given production lot. The procuring agency shall inspect and test each delivered item individually (100% inspection).

4.1 Physical Inspection.

The EBT and any accessories shall be free of manufacturing defects, shall show no evidence of damage during shipment, and the instruction manual shall accompany the individual unit.

4.2 Functional Operation

When tested in accordance with paragraph 5.2, all functional parts, controls, displays, and indicator lights shall operate as specified in the manufacturer's instruction manual.

4.3 Precision

Evidential breath testers shall measure the alcohol content of vapor mixtures with an average standard deviation of no more than 0.020 mg/l (0.0042% w/v) when tested in accordance with paragraph 5.3.

4.4 Accuracy

Evidential breath testers shall measure the alcohol content of vapor mixtures with a systematic error of no more than ±5% (.005% w/v) when tested in accordance with paragraph 5.3.

5. TEST METHODS

All tests shall be conducted under ambient conditions at temperatures within the range from 20 to 30°C (68 to 86°F). Each evidential breath tester shall be operated in accordance with the manufacturers instructions. All instrument readings [equivalent Breath Alcohol Concentration[2] (BAC)] shall be recorded to three decimal places.

5.1 Physical Inspection

Remove the EBT from its shipping container and examine it and any accessories for any evidence of damage during shipment, and determine that the required instruction manual has been provided with the unit. Inspect the EBT for workmanship (i.e., defects in surface finish, scratches, etc.) and inspect the power cord and any external electrical parts for potential safety hazards.

[2] The BAC readings of EBT's are in units of % w/v.

5.2 Functional Tests

Connect the EBT to the required source of electrical power, and set the unit up in accordance with the manufacturer's instructions. Operate the unit to insure that all controls, displays, and indicator lights and displays function as stated in the manufacturer's manual.

5.3 Precision Test Using Known Ethanol Vapor Concentration

5.3.1

Connect the evidential breath tester, in accordance with the instructions in the operator's manual, to a calibration device that supplies known concentrations of ethanol vapor. The calibration device and the ethanol mixture used therein shall meet the requirements of the NHTSA performance standard for calibrating units[3].

5.3.2

Allow the instrument to warm up for a period of 30 min, or as specified by the manufacturer, then flush the sampling assembly of the instrument completely with the alcohol vapor sample as described in the operator's manual.

5.3.3

Using the evidential breath tester, measure a known ethanol vapor concentration of 0.48 mg/l (0.101% w/v) five times.

5.3.4

Calculate the standard deviation of the five measurements made in accordance with paragraph 5.3.3, to two significant figures. (See sample calculation in appendix A.)

5.3.5

Calculate the systematic error of the five measurements made in accordance with paragraph 5.3.3 (see appendix A).

(3) 40FR36167, August 1975. Calibrating Units for Breath Alcohol Testers (Federal Register, Vol. 40, No. 161, pp. 36167-36171, August 19, 1975).

Appendix A--Sample Calculations of Precision and Accuracy

The results of five sample measurements made in accordance with a known ethanol vapor concentration level are as follows:

Table A-1.

Measurement number	.48 mg/l (.101% w/v)
1	.096
2	.097
3	.099
4	.099
5	.099

Average of Measurements

$$\frac{\text{Sum of Measurements}}{\text{Number of Measurements}} = \frac{0.490}{5} = 0.098\%\ \text{w/v}$$

Standard Deviation

$$\sqrt{\frac{\text{Sum}(X-\bar{X})^2}{N-1}} = \sqrt{\frac{(0.096-0.098)^2+(0.097-0.098)^2+(0.099-0.098)^2+(0.099-0.098)^2+(0.099-0.098)^2}{5-1}}$$

$$= \sqrt{\frac{0.000008}{4}} = \sqrt{0.000002}$$

$$= 0.0014\%\ \text{w/v}$$

Systematic Error

$$\frac{\text{Average of Measurement-Known Value}}{\text{Known Value}} \times 100 = \frac{0.098-0.101}{0.101} \times 100$$

$$= -2.97\%$$

Average = 0.098% w/v
Std. Dev. = 0.0014% w/v
Systematic Error = -2.97%