Microphone Handbook
Test and Measurement Microphones

Introduction

Pressure variations, whether in air, water or other mediums, which the human ear can detect, are considered sounds. Acoustics is the science or the study of sound. Sound can be generally pleasing to the ear, as in music, or undesirable, referred to as noise. The typical audible range of a healthy human ear is 20 to 20,000 Hz. A Sound Pressure Level (SPL) beyond the detectable frequencies of the human ear can also be very important to design engineers. Noise, Vibration and Harshness (NVH) is concerned with the study of vibration and audible sounds. Vibrations represent a rapid linear motion of a particle or of an elastic solid about an equilibrium position, or fluctuation of pressure level. Harshness refers to the treatments of transient frequencies or shock. Usually treatments are employed to eliminate noise, but in some cases products are designed to magnify the sound and vibration at particular frequencies. The sound produced or received by a typical object, which may be above and below the frequencies that are detectable by the human ear, or amplitudes concerning its resonant frequencies, are important to designers, in order to characterize the items performance and longevity.

Technology Fundamentals and Microphone Types

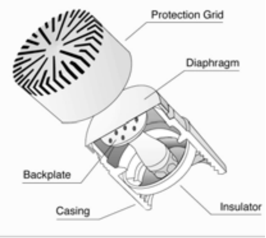
When an object vibrates in the presence of air, the air molecules at the surface will begin to vibrate, which in turn vibrates the adjacent molecules next to them. This vibration will travel through the air as oscillating pressure at frequencies and amplitudes determined by the original sound source. The human eardrum transfers these pressure oscillations, or sound, into electrical signals that are interpreted by our brains as music, speech, noise, etc. Microphones are designed, like the human ear, to transform pressure oscillations into electrical signals, which can be recorded and analyzed to tell us information about the original source of vibration or the nature of the path the sound took from the source to the microphone. This is exhibited in testing of noise reducing materials. Pressure from sound must be analyzed in the design stages to not only protect the materials around it, but also to protect the most precious and delicate mechanism designed to perceive it, the human ear. Like the human ear, microphones are designed to measure a very large range of amplitudes, typically measured in decibels (dB) and frequencies in hertz (Hz.)

In order to convert acoustical energy into electrical energy, microphones are used. There are a few different designs for microphones. The more common designs are Carbon Microphones, Externally Polarized Condenser Microphones, Prepolarized Electret Condenser Microphones, Magnetic Microphones, and Piezoelectric Microphones.

The carbon microphone design is a value-oriented design. This design is a very low quality acoustic transducer type. An enclosure is built. This enclosure houses lightly packed carbon granules. At opposite ends of the enclosure, electrical contacts are placed, which have a measured resistance. When the pressure from an acoustical signal is exerted on the microphone, it forces the granules closer together. This force presses the granules together, which decreases the resistance. This change in resistance is measured and output. A typical use of this item can be seen in early basic designs of a telephone handset.

A condenser microphone operates on a capacitive design. The cartridge from the condenser microphone utilizes basic transduction principles and will transform the sound pressure to capacitance variations, which are then converted to an electrical voltage. This is accomplished by taking a small thin diaphragm and stretching it a small distance away from a stationary metal plate, called a “back plate.” A voltage is applied to the back plate to form a capacitor. In the presence of oscillating pressure, the diaphragm will move which changes the gap between the diaphragm and the back plate. This produces an oscillating voltage from the capacitor, proportional to the original pressure oscillation.

***Figure 1**. Microphone Component*



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The back plate voltage can be generated by two different methods. The first is an externally polarized microphone design where an external power supply is used. The power source on this traditional design is 200 volts. The second or newer design is called a prepolarized microphone design. This modern design utilizes an “electret” layer placed on the backplane, which contains charged particles that supply the polarization. This design, when coupled with an Integrated Circuit Piezoelectric (ICP®) circuit can provide great advantages. An inexpensive constant current supply can power the unit, instead of the more expensive externally polarized power supplies. Standard coaxial cables with BNC or 10-32 connectors can be used, instead of LEMO 7-pin connectors and cables. The coaxial cables can be driven long distances without degradation of the signal. The modern prepolarized designs are becoming increasingly popular for laboratory test and measurement, and field applications, due to their low cost and ease of use.

A magnetic microphone is a dynamic microphone. The moving coil design is based on the principal of magnetic induction. This design can be simply achieved by attaching a coil of wire to a light diaphragm. Upon seeing the acoustical pressure, the coil will move. When the wire is subjected to the magnetic field, the movement of the coil in the magnetic field creates a voltage, which is proportional to the pressure exerted on it.

A Piezoelectric microphone uses a quartz or man-made ceramic crystal structure, which is similar to electrets in that they exhibit a permanent polarization and can be coupled with an ICP® design. Although these sensor type microphones have very low sensitivity levels, they are very durable and are able to measure very high amplitude (decibels) pressure ranges.

Conversely, the floor noise level on this type of microphone is generally very high. This design is suitable for shock and blast pressure measurement applications.

The most popular test and measurement microphones are the capacitor condenser designs. The focus of the following will be based on this design.

Selecting and Specifying Microphones

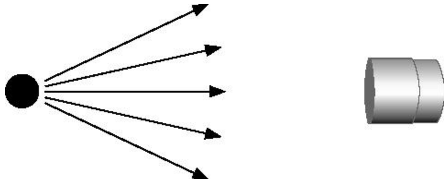
Microphones measure broadband sound pressure levels from a variety of sources. When the microphone signal is post processed, the frequencies can be correlated with the sound source, and if necessary, related back to the wavelength of the sound. Acoustical measurement of this sound, through the use of high-precision condenser microphones, provides a better understanding of the nature of the sound. There are a number of microphones that will work and measure pressure variances. Common diameters for condenser microphones are .125”, 250”, 500” and 1.0”. The trick is to determine which microphone will offer the best solution for a required application.

When choosing the optimum microphone, the parameters to look at include the type of response field, dynamic response, frequency response, polarization type, sensitivity required, and temperature range. There are also a variety of specialty type microphones for specific applications. In order to select and specify a microphone, the first criteria that needs to be looked at is the application and what the sound and environment represent.

Microphones Field Types

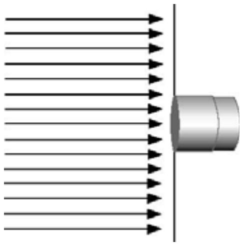
There are three common application fields for precision condenser microphones. The first and most common is the free-field type. The free-field microphone is most accurate when measuring sound pressure levels that radiate from a single direction and source, which is pointed directly (0^o incidence angle) at the microphone diaphragm, and operated in an area that minimizes sound reflections. A freefield microphone is designed to measure the sound pressure at the diaphragm, as it would appear if the microphone were not present. When a microphone is placed in a sound field, diffraction effects will alter the sound pressure when the frequency is high enough so that the wavelengths are similar in size to the dimension of the microphone. The effect is accounted for in the design of the microphone and the resulting correction factors are applied to the actuator response during calibration. These microphones work best in open areas, where there is no hard or reflective surfaces. Anechoic chambers, or larger open areas are ideal for these Free Field microphones.

Figure 2 *Free Field*



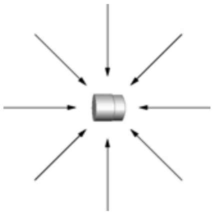
The second type is called a Pressure Field. A Pressure Field microphone is designed to measure the sound pressure that exists in front of the diaphragm. It is described to have the same magnitude and phase at any position in the field. It is usually found in an enclosure, or cavity, which is small when compared to wavelength. The microphone will include the measurement changes in the sound field caused by the presence of the microphone. The sound being measured is typically coming from a single source. Testing of pressure exerted on walls, exerted on airplane wings, or inside structures such as tubes, housings or cavities are examples of Pressure Type microphone applications.

Figure 3 *Pressure Field*



The third type is called a Random Incident Microphone. This is also referred to as a "Diffuse Field Type." The Random Incident type of microphone is designed to be omni-directional and measure sound pressure coming from multiple directions, multiple sources and multiple reflections. The Random Incident type microphone will have typical correction curves for different angles of incidence. The random incidence microphone will compensate for its own presence in the field. An average of the net effect of all the calibrated incidence angles will be taken into account, in order to come up with a net zero correction factor. When taking sound measurements in a church or in an area with hard, reflective walls, you would utilize this type of microphone.

Figure 4 *Random Incident Field*



Dynamic Response

The main criteria to describe sound, is based upon the amplitude of the sound pressure fluctuations. The lowest amplitude that a healthy human ear can detect is 20 millionths of a Pascal (20mPa). Since the pressure numbers represented by Pascal's are generally very low and not easily managed, another scale was developed and is more commonly used, called the Decibel (dB). The decibel scale is logarithmic and more closely matches the response reactions of the human ear to the pressure fluctuations. Here are some examples of typical sound pressure levels to use as a reference:

Level References

0 dB = 0.00002 Pa Threshold of Hearing
60 dB = 0.02 Pa Business Office
80 dB = .2 Pa Shop Noise
94 dB = 1 Pa Large Truck
100 dB = 2 Pa Jackhammer
120 dB = 20 Pa Airplane Take-Off
140 dB = 200 Pa Threshold of Pain

Manufacturers specify the maximum decibel level based on the design and physical characteristics of the microphone. The specified maximum dB level will refer to the point where the diaphragm will approach the back plate, or where Total Harmonic Distortion (THD) reaches a specified amount, typically 3% THD. The maximum decibel level that a microphone will output in a certain application is dependent upon the voltage supplied, and the particular microphones sensitivity. In order to calculate the maximum output for a microphone, using a specific preamplifier and its corresponding peak voltage, you first need to calculate the pressure in Pascals that the microphone can accept. The amount of pressure can be calculated by using the following formula:

$$P = \frac{Voltage\,(mV)}{Sensitivity\left(\frac{mV}{Pa}\right)}$$

Where P = Pascal's (Pa) & Voltage is the preamps output peak voltage.

Once the maximum pressure level that the microphone can sense at its peak voltage is determined, this can then be converted to decibels (dB), using the following logarithmic scale:

$$dB = 20\log\left(\frac{P}{Po}\right)$$

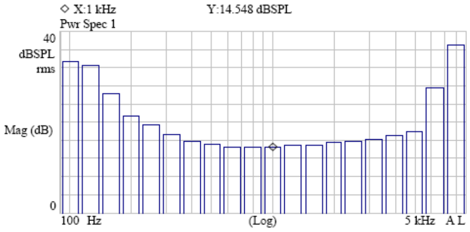
Where: P = Pressure in Pascal's

Po = Reference Pascal's (Constant = 0.00002 Pa)

The above formula will provide the maximum rating that a microphone (when combined with a specific preamplifier) can be capable of measuring. For the low-end noise level, or minimum amount of pressure required, you need to review the Cartridge Thermal Noise (CTN) rating of the microphone. The cartridge thermal noise specification provides the lowest measurable sound pressure level that can be detected above the electrical noise, inherent within the microphone.

The inherent noise level of a microphone and preamplifier combination will be greatest at both the lower and upper capabilities of the microphone. Each microphone will have its own noise characteristics, and the diameter of the microphone will have a major impact on the frequencies and noise levels of the microphone. Below is a typical representation of the noise effect at different frequencies for a microphone when used in conjunction with a preamplifier.

Figure 5 *Typical Noise Floor Data, 1/3 Octave Band Analysis*



Proper selection requires that the pressure levels, that are to be tested, fall between the microphones low-end noise level, called cartridge thermal noise, and the maximum rated decibel level of the microphone. In general, the smaller the microphone diameter, the greater the high-end decibel level will be. The larger diameter microphones are recommended for low range decibel measurements, since the inherent noise or cartridge thermal noise specifications are typically lower.

Frequency Response

Once the type of microphone field response and dynamic range has been taken into consideration, the frequency range (Hz) of interest, for the test requirement should be reviewed. Upon inspecting the microphones specification sheet you will find the usable frequency range of the specific microphone. Smaller diameter microphones will usually have a higher upper frequency level capability. Conversely, larger diameter microphones will be able to detect lower frequencies, generally better.

Manufacturers will place a typical tolerance of +/- 2 dB on the frequency specifications. When comparing microphones, make sure the frequency range and the tolerance associated are checked. If an application is not critical, you can improve the usable frequency range for that microphone, if you are willing to increase your allowable decibel tolerance. You can check with the manufacturer or look at the individual calibration sheet for a particular microphone in order to determine the actual usable frequency range for specific different decibel tolerances.

Polarization Type

As explained previously, test and measurement microphones can be broken down into two categories, traditional Externally Polarized microphones and modern Prepolarized microphones. For most applications either type will work well. The prepolarized tend to be more consistent in humid applications. They are recommended when changes of temperature may cause condensation on the internal components. This may short-out externally polarized microphones. Conversely, at high temperatures, between 120 – 150o C, externally polarized microphones are a better choice, since the sensitivity level is more consistent in this temperature range.

An Externally Polarized microphone set-up requires the use of a separate 200V power source. 7-conductor cabling with LEMO connectors is required in this set-up. Externally polarized microphones are the traditional design. There are more models available and they are still utilized for special applications or for compatibility reasons.

The modern prepolarized microphone designs are powered by a cost effective and easy-to-operate, 2-20 mA constant current supply. This can be done with a PCB signal conditioner (or directly by readout that has a 2-20 mA constant current power built-in.) This design enables the owner to use standard coaxial cables with BNC or 10-32 connectors (in lieu of the 7 Pin conductor cabling with LEMO connectors), for both current supply and signal to the readout device. The prepolarized design also saves set-up time, since it is interchangeable with vibration accelerometers that have built-in electronics. This newer design has become very popular in recent years due to its time and cost savings and ease of use characteristics.

Temperature Range

Temperature will have an effect on the microphones performance. Sensitivity levels can be directly affected by extreme environmental conditions. As the temperature approaches the maximum specifications of the microphone, its sensitivity specification will decrease. The owner will need to be aware of not only the operating temperature, but also the storage temperature of the microphones. If operated and/or stored in extreme conditions, the microphone can be adversely affected and also will also require to be calibrated more often.

Specialty Microphones

When temperature becomes a concern, a probe microphone offers an alternative solution. The probe microphone was designed for sound pressure measurements in harsh environments. It combines a microphone with a probe extension tube. This enables the user to get very close to sound sources. The probe tip will send the acoustic signal to the microphone inside the probe housing. By placing some of the critical components in the separate housing, this microphone type can be used in extremely high temperature applications, or where access to the sound source is too small for a typical condenser microphone.

Applications that require a microphone to be fully submersible provide their own challenges. Hydrophones were designed to detect underwater sound pressure signals. Industrial and scientific underwater testing, monitoring and measurements are accomplished with this corrosion resistant design. Different models are available for different sensitivities, frequencies decibel levels and operating depths.

Sound Level Meters are designed by manufacturers to provide a fast and convenient way to obtain a sound pressure level reading. This design contains all the components necessary to take a sound pressure reading. This small handheld unit includes the microphone, preamplifier, power source, software and display. This is an excellent choice for taking a dB measurement in an industrial setting, for community noise assessment, noise exposure measurements, artillery fire measurements, and many other applications. The Sound Level Meter can be provided with a number of options, including A-Weighting, real time analyzers, and software options.

When measurements involving the magnitude and direction of the sound need to be captured, an intensity probe is an excellent choice. By taking two phase matched microphones and placing a spacer between them, a user can not only tell the pressure level, but also the speed and direction of the propagating sound waves. Different sized spacers are available for measuring the particle velocity at different frequencies. The higher frequencies typically require a smaller spacer. Larger spacers are suitable for lower frequencies and for situations where reverberation is present.

For Near Field Acoustic Holography (NAH) applications where three dimensional field values are to be studied, an Array microphone set-up is recommended. By taking a number of array microphones and spacing them out in a predetermined pattern, and combining them with the appropriate software, spatial transformation of a complex sound pressure field is projected to effectively map the acoustic energy flow. Array microphones are an excellent choice for large channel count acoustic testing. Transducer Electronic Data Sheet (TEDS) are a recommended option for arrays, since they enable the user to quickly and easily identify a particular microphone. These TEDS chips and software enable the user to store information on the microphones model, serial number, calibration date, along with the specifications of the microphones sensitivity, capacitance, impedance, etc…. that can be downloaded and help ensure accurate test results.

Outdoor microphones have been developed to be able to withstand the rigorous environmental exposure that these microphones will be subjected to. Airport noise, or highway traffic noise has become increasing popular spots for test and measurements, to provide safety for humans. The Environmental microphones and Outdoor microphones provide different levels of protection for the internal components, while maintaining their high-accuracy specifications.

Applicable Standards

Prior to selecting an acoustical instrument, the consumer should determine whether there are certain standards that the product must comply with, for the application in which the product will be used. Whether for legal purposes, or for quality assurance programs, these standards will help determine the quality, accuracy and consistency of the products. Standards have been set for sound level meters, calibrators, microphones, or other related measurement components. There are numerous standards that correspond to the performance requirements, dimensions and characteristics of acoustical components. The most popular organizations for establishing these standards are the American National Standards Institute (ANSI) and the International Electrotechnical Commission (IEC.)

ANSI S1.4 is the American National Standards Institute's standard for Sound Level Meters. It deals with the specifications for this product, and was originally written in 1983 and later amended to S1.4A in 1995, and is currently used today. ANSI S1.43 established in 1997 deals with setting a standard for compliance for Integrating-Average Sound Level Meters.

IEC 60942 was created with the specifications on sound calibrators in mind. There are three classes concerned with the standards of sound calibrators. The most stringent is the Laboratory

Standard (LS). The LS class has the tightest tolerances and is designated for calibrators that will be used only in the laboratory. Class 1 instruments are considered for field usage applications, as is the class 2 standard. The difference of the class one verses the class 2 calibrator depends upon which class the associated sound level meter, that will be used in conjunction with the calibrated is classified as. A class one calibrator is intended to be used with a class one sound level meter. A class 2 calibrator is designed to be used with a class 2 sound level meter.

IEC 61094 deals with the condenser microphone. It establishes specifications on the mechanical dimensions and certain electroacoustic characteristics for working standard microphones, which are to be used as laboratory reference microphones. These condenser microphones require the highest accuracy, due to the fact that these units will determine the accuracy of other microphones in primary calibrations by the reciprocity method.

IEC 61672 was instituted to replace 60651 and 60804. 61672 provide electroacoustical performance standards for Sound Level Meters. There are standards that range from the simplest integrated sound level meter that measures sound exposure levels, to sound level meters that measure time-average sound levels, to conventional sound level meters that measure exponential time-weighted sound levels. A sound level meter can have one, all or a combination of the previously mentioned measurements. There are two classes for the sound level meters. The standards are based around the same design characteristics, but differ in the tolerance limits and operational temperature specifications. To conform to class one or class two, a specified frequency response for sound incident on the microphone from either, one sound source and direction in an acoustic field, or from random directions. Class two tolerances are more liberal, compared to the class one standards.

There are certain classifications that are commonly referenced. Types ranging from Type 0 through Type 2 dictate the tolerance and accuracy of the microphone system. These standards were created for Sound Level Meters, and get commonly referred to when mentioning components of the system, such as the microphone cartridge and the preamplifier. Type 0 refers to Laboratory reference. It is not required to satisfy the environmental requirements for field instruments, but must be is an extremely accurate type, since this is what other microphones will be judged against or tested to. Type 1 is for both laboratory use and for use in the field. The Type 1 standard is extremely accurate and durable. It is designed to take the challenges of the environment and still compile highly accurate and reliable acoustic measurements. This is a very popular type for research and design engineers. Type 2 microphones have standards that are more relaxed and easily achieved. The Type 2 is a general purpose type. These microphones do not have the high-frequency response, low cartridge thermal noise levels, or accuracy as the first two types, but offer a less expensive alternative for when the measurement accuracy is not critical.

Some manufacturers will designate their microphone, preamp or filter as a certain type or to meet a particular standard. In order to conform, the complete system must be reviewed. The whole system is what must meet the standard, not just one component. PCB® designs each individual component to exceed the specifications, so that when installed it meets the Type 1 specifications, even after the accumulation of tolerances of each component is taken into consideration. For more information on the above standards, please contact the above organizations. They can answer your questions and send you documentation on the specific standards that you may have an interest in.

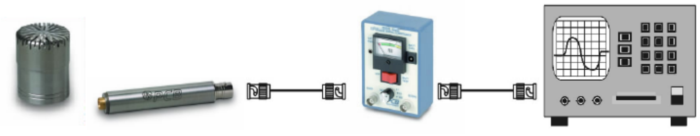
Inter facing and Design Information

After the proper selection of the microphone has been determined, the corresponding preamplifier, and ancillary equipment must be specified and installed. The necessary cabling, power supplies, signal conditioning and data acquisitions selections are to be made. Not all of these components are required for all test set-ups. Figure number 6 will show the typical set-up for an externally polarized system.

Figure 6 *Externally Polarized set-up*

The diagram for the prepolarized system is shown in figure number 7 below.

Figure 7 *Prepolarized set-up*



Components of the prepolarized design may be used with the externally polarized set-up. The prepolarized microphone can be used with a Power Supply that is designed for externally powered microphones, and its associated preamp, provided that you set the supply voltage to zero.

Applications

Acoustical testing is performed for a variety of reasons, ranging from the design of new products, to monitoring products, to predictive maintenance functions, to personal protection. Some typical applications, for acoustical studies that require microphones may include:

Research and Product Design – Excessive sound pressure can cause damage to products or human hearing. Microphones are used to measure the pressure level exerted on a surface. Sound pressure can shake plaster off walls or cause damage to an airplane wing. Sound measurement is used in a variety of applications including: the study of door slams, clutch engagements, starter impact and sunroof noise. Analysis of engine noise in a cabin or car interior, or sound exhibited from consumer appliances are tested to extend the lifespan of the product and keep the external noise minimal, for the comfort of the user.

Preventive Maintenance – Increased sound levels or changes in frequency can indicate that a product is not working to its capacity. Motors, gears, bearings, blades, or other industrial components can all experience changes in decibel level or frequency shift when not working properly. High precision microphones can be utilized to confirm that a product is experiencing a problem, or can be used to predict failure of a component.

Audiometric Calibration – Universities, governments and independent companies have audio testing equipment to perform hearing tests and research projects. Microphones are used to test and calibrate the systems to ensure the accuracy of the test equipment.

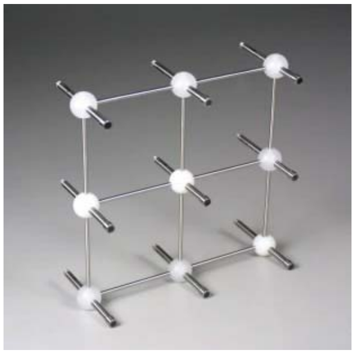
Compliance – Microphone tests can be performed and recorded for verification of pressure levels on products, and can be utilized in legal situations. Companies will use high precision microphone tests for proof of sound pressure levels during design. Microphones are used on sound level meters to ensure compliance with national standards for shop noise.

Environmental Noise Analysis – There are certain sound pressure levels that the human ear can be subjected to for specific amounts of time before ear damage can occur (dose). A few of these are industrial shop noise, airports, and automotive highway noise. Acoustic testing is performed so that a better understanding of the sound levels that are experienced in these surroundings is achieved, and the necessary adjustments can be made in order to provide greater personal protection. The automotive market will utilize high precision microphones for “Squeak and Rattle” tests in order to provide a quieter ride.

Multiple Channel Testing – Acoustic holography and pressure mapping are areas where microphone use has been increasing. Grids of microphones can be set-up to tell the difference in the sound pressure at different points around an engine or a car tire well. Calculations can be made per zone or spectrum. Some applications include Seismic activity monitoring, satellite tracking, and automotive and Industrial noise source identification. Microphones can be utilized to transform 2-dimensional complex sound pressure information, into 3-dimensional acoustic fields, using basic wave equations, to indicate surface intensity and radiation patterns.

Array microphones, are Free Field Type microphones, which are designed to offer a cost effective solution for multiple channel sound measurement. This makes Nearfield Acoustic Holography (NAH) measurements practical. Grids can be constructed to take 2D mapping measurements. The 130D20 and 130D21 have an integrated Microphone and Preamplifier. The 130 series utilizes the Prepolarized microphone design, and incorporate ICP® type circuitry, powered by a constant current signal conditioner. The 130 series provide an inexpensive alternative to the 377 series. The 130 series are accurate for frequency responses and great for trending, but are more sensitive to changes in temperature, and less accurate than the 377 series of high precision condenser microphones, when measuring dB.

Figurer 8 *Multiple Channel Array*



Maintenance for Microphones and Preamplifiers

Microphones are very stable over long periods of time, provided that they are handled properly. Components of the microphone are fragile and can get damaged by misuse. The diaphragm is made up of a very thin proprietary material that should be kept clean of dust, dirt, moisture and any type of imperfection (scratch, dent, etc.) The grid cap is designed to let through the true sound pressure level. The only function for the grid cap is to prevent items from coming in contact with the diaphragm. We do not recommend that you ever remove the grid cap, if possible. We do not recommend cleaning the microphone and if you take the precautionary measures to keep it clean and dry, it should not be necessary. In the event that you absolutely must take off the grid cap and clean the microphone diaphragm, we recommend using a soft cotton swab with a little alcohol. Make sure that the alcohol fully dries before supplying power to, and using the microphone. Do not touch the microphones diaphragm with your fingers or let it come in contact with any sharp or pointed object.

Accessories, like windscreens and desiccants, will help keep moisture off the microphone, and help maintain the specified sensitivity level. Nose Cones will help keep turbulence off the microphone diaphragm and still let the sound pressure level come in unobstructed.

Dust and dirt may not only in adversely affect the microphones performance, but also the preamplifier. If you should get dirt or dust on the backside of the microphone, or inside the connection area of the preamplifier, use a rubber bulb to blow clean, dry air into the unit in order to remove the dust. Keep the microphone and preamplifier assembled while preparing for testing. Keep the maintenance caps on them and store them in their protective cases, when not in use. With proper maintenance, your microphone and preamplifier should provide stable and accurate results for years to come.

Latest and Future Developments

Due to the ease of use and the cost savings mentioned earlier, consumers have been dictating where research and design time be spent. Manufacturers have been coming up with a more diverse prepolarized microphone designs, so that end users have a larger selection to match that of the traditional microphones for different applications.

The rise in applications concerning Nearfield Acoustic Holography (NAH) has driven manufacturers to not only coming up with array microphone designs for large channel counts, but also the ancillary equipment to be enhanced. Array grids, both stationary and linear guided systems are becoming increasingly popular. This in turn has also promoted new designs in software systems designed for sound pressure mapping, large channel signal conditioning units, and newer readout and data acquisition designs that can handle the increased inputs and necessary data output.

Advanced designs of Sound Level Meters are very popular in both the industrial sector, and for health related measurements. End users want items that are both mobile and easy to use. These products come complete in one battery operated hand-held unit that does not require any assembly for daily usage. Sales of this product group continue to be strong, due to its convenient design. Future developments will be in the expanded software systems and designs made for specific target applications.

Transducer Electronic Data Sheets are becoming increasingly popular with the rise of large channel count tests, and for obtaining accurate results on a consistent basis. This system makes it easy to manage a number of microphones, by enabling the user to locate a specific microphone within a group of microphones. Data storage, calibration historical information, and physical characteristics of each individual microphone and preamplifier are easily retrieved, with the TEDS set-up. Software companies and data acquisition companies are placing a higher emphasis to manufacture designs to take advantage this technology, so that the end consumer can reap the rewards.

In general, consumers are looking for smaller packages that will accurately measure sound pressure levels and make their jobs easier and quicker in both the set-up process and data recording areas. They also want the costs to be minimized. The manufacturers will continue to look at designs that will offer the customer the best value for the application.