Thiele – Small-parameters:

F_s

Also called F_0, resonance frequency measured in hertz (Hz). The frequency at which the combination of the energy stored in the moving mass and suspension compliance is maximum, and results in maximum cone velocity. A more compliant suspension or a larger moving mass will cause a lower resonance frequency, and vice versa. Usually it is less efficient to produce output at frequencies below F_s, and input signals significantly below F_s can cause large excursions, mechanically endangering the driver. Woofers typically have an F_s in the range of 13–60 Hz. Midranges usually have an F_s in the range of 60–500 Hz and tweeters between 500 Hz and 4 kHz. A typical factory tolerance for F_s spec is ±15%.

Q_{ts}

A unitless measurement, characterizing the combined electric and mechanical damping of the driver. In electronics, Q is the inverse of the damping ratio. The value of Q_{ts} is proportional to the energy stored, divided by the energy dissipated, and is defined at resonance (F_s). Most drivers have Q_{ts} values between 0.2 and 0.5, but there are valid (if unusual) reasons to have a value outside this range.

Q_{ms}

A unitless measurement, characterizing the mechanical damping of the driver, that is, the losses in the suspension (surround and spider.) It varies roughly between 0.5 and 10, with a typical value around 3. High Q_{ms} indicates lower mechanical losses, and low Q_{ms} indicates higher losses. The main effect of Q_{ms} is on the impedance of the driver, with high Q_{ms} drivers displaying a higher impedance peak. One predictor for low Q_{ms} is a metallic voice coil former. These act as eddy-current brakes and increase damping, reducing Q_{ms}. They must be designed with an electrical break in the cylinder (so no conducting loop). Some speaker manufacturers have placed shorted turns at the top and bottom of the voice coil to prevent it leaving the gap, but the sharp noise created by this device when the driver is overdriven is alarming and was perceived as a problem by owners. High Q_{ms} drivers are often built with nonconductive formers, made from paper, or various plastics.

Q_{es}

A unitless measurement, describing the electrical damping of the loudspeaker. As the coil of wire moves through the magnetic field, it generates a current which opposes the motion of the coil. This so-called "Back-EMF" (proportional to Bl * velocity) decreases the total current through the coil near the resonance frequency, reducing cone movement and increasing impedance. In most drivers, Q_{es} is the dominant factor in the voice coil damping. Q_{es} depends on amplifier output impedance. The formula above assumes zero output impedance. When an amplifier with nonzero output impedance is used, its output impedance should be added to R_e for calculations involving Q_{es}.

Bl

Measured in tesla-metres (T·m). Technically this is B×l or B×l sin(θ) (a vector cross product), but the standard geometry of a circular coil in an annular voice coil gap gives sin(θ)=1. B×l is also known as the 'force factor' because the force on the coil imposed by the magnet is B×l multiplied by the current through the coil. The higher the B×l value, the larger the force generated by a given current flowing through the voice coil. B×l has a very strong effect on Q_{es}.

V_{as}

Measured in litres (L) or cubic metres, is a measure of the 'stiffness' of the suspension with the driver mounted in free air. It represents the volume of air that has the same stiffness as the driver's suspension when acted on by a piston of the same area (S_d) as the cone. Larger values mean lower stiffness, and generally require larger enclosures. V_{as} varies with the square of the diameter. A typical factory tolerance for V_{as} spec is ±20–30%.

M_{ms}

Measured in grams (g) or kilograms (kg), this is the mass of the cone, coil and other moving parts of a driver, including the acoustic load imposed by the air in contact with the driver cone. M_{md} is the cone/coil mass without the acoustic load, and the two should not be confused. Some simulation software calculates M_{ms} when M_{md} is entered. M_{md} can be very closely controlled by the manufacturer.

R_{ms}

Units are not usually given for this parameter, but it is in mechanical 'ohms'. R_{ms} is a measurement of the losses, or damping, in a driver's suspension and moving system. It is the main factor in determining Q_{ms}. R_{ms} is influenced by suspension topology, materials, and by the voice coil former (bobbin) material.

C_{ms}

Measured in metres per Newton (m/N). Describes the compliance (ie, the inverse of stiffness) of the suspension. The more compliant a suspension system is, the lower its stiffness, so the higher the V_{as} will be. Cms is proportional to Vas and thus has the same tolerance ranges.

R_e

Measured in ohms (Ω), this is the DC resistance (DCR) of the voice coil, best measured with the cone blocked, or prevented from moving or vibrating because otherwise the pickup of ambient sounds can cause the measurement to be unreliable. R_e should not be confused with the rated driver impedance, Re can be tightly controlled by the manufacturer, while rated impedance values are often approximate at best.. American EIA standard RS-299A specifies that R_e (or DCR) should be at least 80% of the rated driver impedance, so an 8-ohm rated driver should have a DC resistance of at least 6.4 ohms, and a 4-ohm unit should measure 3.2 ohms minimum. This standard is voluntary, and many 8 ohm drivers have resistances of ~5.5 ohms, and proportionally lower for lower rated impedances.

L_e

Measured in millihenries (mH), this is the inductance of the voice coil. The coil is a lossy inductor, in part due to losses in the pole piece, so the apparent inductance changes with frequency. Large L_e values limit the high frequency output of the driver and cause response changes near cutoff. Simple modeling software often neglects L_e, and so does not include its consequences. Inductance varies with excursion because the voice coil moves relative to the polepiece, which acts as a sliding inductor core, increasing inductance on the inward stroke and decreasing it on the outward stroke in typical overhung coil arrangements. This inductance modulation is an important source of nonlinearity (distortion) in loudspeakers. Including a copper cap on the pole piece, or a copper shorting ring on it, can reduce the increase in impedance seen at higher frequencies in typical drivers, and also reduce the nonlinearity due to inductance modulation.

S_d

Measured in square metres (m²). The effective projected area of the cone or diaphragm. It is difficult to measure and depends largely on the shape and properties of the surround. Generally accepted as the cone body diameter plus one third to one half the width of the annulus (surround). Drivers with wide roll surrounds can have significantly less S_d than conventional types with the same frame diameter.

X_{max}

Specified in millimeters (mm). In the simplest form, subtract the height of the voice coil winding from the height of the magnetic gap, take the absolute value and divide by 2. This technique was suggested by JBL's Mark Gander in a 1981 AES paper, as an indicator of a loudspeaker motor's linear range. Although easily determined, it neglects magnetic and mechanical non-linearities and asymmetry, which are substantial for some drivers. Subsequently, a combined mechanical/acoustical measure was suggested, in which a driver is progressively driven to high levels at low frequencies, with X_{max} determined by measuring excursion at a level where 10% THD is measured in the output. This method better represents actual driver performance, but is more difficult and time-consuming to determine.

P_e

Specified in watts. Frequently two power ratings are given, an "RMS" rating and a "music" (or "peak", or "system") rating, usually peak is given as ~2 times the RMS rating. Loudspeakers have complex behavior, and a single number is really unsatisfactory. There are two aspects of power handling, thermal and mechanical. The thermal capacity is related to coil temperature and the point where adhesives and coil insulation melt or change shape. The mechanical limit comes into play at low frequencies, where excursions are largest, and involves mechanical failure of some component. A speaker that can handle 200 watts thermally at 200Hz, may sometimes be damaged by only a few watts at some very low frequency, like 10Hz. Power handling specifications are usually generated destructively, by long term industry standard noise signals (IEC 268, for example) that filter out low frequencies and test only the thermal capability of the driver. Actual mechanical power handling depends greatly on the enclosure in which the driver is installed.

V_d

Specified in litres (L). The volume displaced by the cone, equal to the cone area (S_d) multiplied by X_{max}. A particular value may be achieved in any of several ways. For instance, by having a small cone with a large Xmax, or a large cone with a small X_{max}. Comparing V_d values will give an indication of the maximum output of a driver at low frequencies. High X_{max}, small cone diameter drivers are likely to be inefficient, since much of the voice coil winding will be outside the magnetic gap at any one time and will therefore contribute little or nothing to cone motion. Likewise, large cone diameter, small X_{max} drivers are likely to be more efficient as they will not need, and so may not have, long voice coils.

η_0 - Reference Efficiency

Specified in percent (%). Comparing drivers by their calculated reference efficiency is often more useful than using 'sensitivity' since manufacturer sensitivity figures are too often optimistic.

Sensitivity

The sound pressure, in dB, produced by a speaker in response to a specified stimulus. Usually this is specified at an input of 1 watt or 2.83 volts (2.83 volts = 1 watt into an 8 ohm load) at a distance of one meter.