

Ferrofluid Dispensing for Loudspeaker Manufacturing



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Take a walk alongside any loudspeaker production line and you'll see a fluid dispenser, likely more than one. In most cases, these dispensers will be delivering the adhesives used to join the various soft and hard parts of the loudspeaker.

Since many of these adhesive applications, such as the woofer surround to frame, or spider OD to frame, don't require high accuracy and repeatability, a relatively low-tech dispense valve will usually do the job. However, for reasons of both performance and cost, certain materials require greater precision during the dispensing process. One material in particular, ferrofluid, demands high precision dispensing and this will be the focus of our article.

Loudspeaker



Ear Buds

Dispensing

Most liquid dispense valves depend on a variety of parameters to determine just how much material is dispensed during each cycle. Air pressure, valve stroke, nozzle size, cycle time, and material viscosity all have an influence on the final value. While valve stroke, nozzle size, and cycle time are easy to control, precision regulation of air pressure is not always easy. Additionally, changes in ambient temperature will influence the viscosity of a ferrofluid. Unless expensive measures are taken to regulate air pressure and stabilize ferrofluid temperature, frequent calibration of the dispensing system will be required to maintain the specified amount of ferrofluid. Challenges like this get the production engineer dreaming... "If I only had a fluid metering system that didn't rely on air pressure, was impervious to changes in viscosity, was better than 1% accurate, could deliver hundreds of cycles per minute, required no calibration, and had just one moving part..." Well, yes Virginia, there is a Santa Claus and it comes in the form of the valveless fluid metering pumps offered by Fluid Metering, Inc. (FMI) of Syosset, NY.

Ferrofluids

Ferrofluids have been used in loudspeakers for over 30 years. The commercial development of ferrofluid was pioneered by Ferrofluidics Corporation (now Ferrotec Corporation) and Ferrotec continues to be the world leader in this technology, producing the vast majority of ferrofluid used in loudspeakers today. The benefits of ferrofluids in loudspeakers are well known. Improved thermal power handling, damping, voice coil centering, and distortion reduction are just some of the many reasons an engineer chooses ferrofluid for a particular design. In selecting a ferrofluid, you must determine the optimum values of viscosity and saturation magnetization for the transducer. Once these values are selected, you rely on your supplier to maintain a tight tolerance on these specs.

But there is another important value you must choose: the quantity of fluid to be dispensed into the magnetic air gap of the loudspeaker. In some ways, this may be the most critical value, since variations in ferrofluid quantity can influence the thermal power handling, impedance curve, and frequency response of a loudspeaker. Because the ferrofluid supplier cannot control their customers' dispensing processes, it is up to the manufacturer to be aware of the importance of precision dispensing for ferrofluids and to utilize the proper equipment in the dispensing process during manufacturing.

Micro-Dispensing

Using ferrofluid in the manufacture of ear buds, head phones, and hearing aids significantly improves product yield. However, accurately dispensing the required 1uL volumes is extremely difficult. **FMI's Sub-Microliter Pump Head** can be integrated with a variety of FMI stepper motor dispensers for accurate dispensing down to 1uL.



IDS 2000 is ideal for automated production applications



STH Miniature Pump for OEM Equipment integration



PIP Micro π -petter is ideal for testing & short production runs.

Why Choose an Fluid Metering Pumps for Ferrofluid Dispensing ?

CUSTOMER CONCERNS

1. Quality overfill/underfill
2. Calibration
3. Micro speakers
4. Cost
5. Payback
6. Long term usage
7. Fluid migration from tip to coil
8. Viscosity
9. Handfills
10. Air operated dispensers—time pressure fills
11. Tubing (peristaltic) pumps
12. Speed

ISSUES

1. Fluid volume variations affect quality and scrap. Overfill leads to leaks and costly material waste. Underfill directly affects speaker quality.
2. Requirement to re-calibrate and check the dispensing volume.
3. Fluid volumes are small and harder to deliver and control.
4. Fluid is expensive, no room to waste.
5. Why use a precision metering pump?
6. Magnet in coil can draw extra fluid from the dispensing tip into the coil.
7. Material, temperature, and humidity affect volume delivery.
8. Hand delivery is very slow, inconsistent, & very tiring.
9. Volumes change due to faulty valves, fluctuations in compressed air, and fluid viscosity.
10. Squeezed tube deteriorates fast. Volume delivery can change by as much as 50%.
11. As speed increases, accuracy and delivery control typically decrease.

THE FMI SOLUTION

1. Unique positive displacement ceramic pump always delivers the optimum Ferrofluid volume $\pm 1\%$ of calibrated value. Overfill and underfill conditions are totally resolved with this technology.
2. Dispensed volume maintained for millions of maintenance- free cycles. No need to re-calibrate or recheck. Set it and forget it.
3. FMI can deliver fluid volumes from 2 microliters (0.002 cc) and up, all with better than 1% precision.
4. Delivering the right quantity within 1%. Pump can pay for itself in weeks - (three weeks dispensing 0.09ml (cc) into a size 25 voice coil at a rate of 20 coils per minute with better than 1% accuracy- payback is calculated in terms of weeks, not years.
6. The oil carrier in Ferrofluid lubricates the pump. Volume stays the same for millions of cycles. Example: dispensing 50 microliters for over 80 million cycles with better than $\pm 1\%$ precision.
7. Crisp, distinct, and sharp shots injected at optimum velocity required. No hanging drops sticking to tips, no siphoning onto or back into the dispenser.
8. FMI pumps are viscosity independent and are unaffected by viscosity changes. Standard pumps will handle all Ferrofluids up to 10,000 cp. For special very high viscosity applications, temperature controlled pump heads are available.
9. Semi-automated and automated systems are available. Or systems made to order.
10. Mechanically operated (no air) positive displacement fixed volume pump without valves ensures precise repeatability.
11. Ceramic internals, positive displacement with fixed volume: ensures precise repeatability. 12. Accuracy is maintained at speeds up to 500 shots per minute. Integrating electronic systems compatible with most factory automation controls.

Return on Investment

Some calculations (courtesy of FMI) on how quickly the cost of a precision dispensing of ferrofluids pays for itself are in **Table 1**. Depending on the spec of the ferrofluid used and the speaker company's volume of fluid purchases, the cost of ferrofluids can vary from over \$1000 per liter to half that. For our calculation we have used \$600 per liter. New generation multimedia fluids being introduced this year will be far less expensive, but regardless whether the dispenser pays for itself in a month or quarter year, it still makes sense.

For More Information Contact:

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TABLE 1: Major Savings and Fast Pay Back.

Application	
Dispense volume - ml per shot ..0.1	Your Fluid Costs =
Dispensed shots - per minute21	Per shot \$ 0.06
Flow ml min2.1	Per Milliliters \$ 0.60
Fluid Cost per liter \$\$600	Per Second \$ 0.02
Cost of FMI pump \$\$1,000	Per Minute \$ 1.26
Current pump accuracy %10	Per Hour \$ 76
Hours used per day8	Per 8 Hrs Day ...\$ 605

Savings using an FMI pump

In one day = 8 hrs	\$ 54
In one year (220 days)	\$ 11,975
You will pay for the FMI pump in	18 days

By not using the FMI pump you are wasting:

In 1 minute	One hour	8-hour Day
\$0.13	\$7.56	\$60.48