

Choosing the Best RFID Label Supplier

A White Paper from



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We've heard some scary stories from companies who have recently purchased RFID tags. It's surprising, given that the market for tags should be mature enough that tag suppliers have perfected their processes, but with analysts predicting demand for tags growing in the double digits by 2012, there are new tag makers that have more mature marketing skills than manufacturing skills.

The chorus of complaints include:

Inconsistent quality: "Some tags read further away (or better) than others."

Wrong adhesive: "The tags start peeling off if the product gets wet" or "The tags start peeling off if the product if they sits in a hot trailer too long".

Improper tag design: Having to wrap the product in bubble wrap and affix the tag to the bubble wrap.

Out-of-stock: Just last month we spoke with a gentleman who tried to order 100,000 tags from a very well-known supplier to be told, "we don't have any." Another company, that already waited 8 weeks for an order, was told on the day they expected delivery, "It's going to take *another* 12-16 weeks for delivery."

Obviously, these stories do not instill confidence in an industry that has struggled for growth in recent years. Given the plethora of companies now marketing themselves as RFID tag providers, it is hard to know who you can trust. That is why we have written this white paper, because the more you understand about how passive RFID tags are manufactured, the better educated you can be when making purchasing decisions. We will also explore what makes up the cost of a RFID tag and explain why there is no 5¢ tag just yet.

We need to clarify exactly what kind of RFID tags this article will address. There are active tags (battery-powered), passive tags (powered by the reader), and semi-passive tags (which offer some combination). This article will focus on passive RFID tags. More specifically, we'll break down the cost of an ISO 18000-6C (EPCGlobal Gen 2) smart label.

Who are the players and from whom do you buy?

There are several different types of companies in the RFID tag business:

- Integrated circuit manufacturers;
- Inlay manufacturers;
- Finished label converters;
- Companies that provide some, or all, of these capabilities;
- And resellers or distributors that buy from one or more of these and then offer them to customers.

Passive RFID Integrated Circuit Manufacturers

At the heart of a passive RFID tag is a little integrated circuit, also referred to as an IC or a "chip". The picture below shows some very small RFID chips sitting in the middle of the "D" on a US penny.



The ICs don't start that way. They actually begin life as part of a silicon wafer. The pictures to the right are of an 8 inch silicon wafer. Can you believe this wafer has approximately 30,000 ISO-1800-6C compatible ICs? One of these wafers costs between \$1,200 and \$1,500, but that price includes a highly durable and anti-static carrying case.

In most instances, end users do not ever see the wafers, much less purchase ICs directly. The inlay manufacturer (whom we'll describe next) purchases the ICs.

The features and capabilities of the ICs vary a great deal. For example, ISO 18000-6C IC comes in different configurations of —

- Size (physical dimensions);
- Amount of memory (data storage);
- Single or multiple tag antenna connections;
- Power consumption;
- Sensitivity.



Integrated Circuit (IC)
5.0¢-7.0¢

The Cost of an RFID Tag: The Integrated Circuit

The cost of the IC varies, but is based chiefly on physical size. Every manufacturer pays roughly the same amount for silicon wafers, so divide the number of ICs by the cost of the silicon wafer. The die-cutting process also plays a factor. Companies that purchase ICs can receive a discount based on quantity purchased, and other design factors mentioned above.

Typically, an IC is priced around 4.0¢ – 7.0¢.

Passive RFID Inlay Manufacturers

As we mentioned, the RFID IC is very small and that makes it difficult to stick it to an item. Plus, the tag needs an antenna so that it can “hear” the radio signal from the RFID reader. That’s why the RFID IC becomes part of something called an *inlay*.

Inlay manufacturing is almost an art form because there are so many factors to consider when designing an inlay. Inlay designers are highly skilled engineers with strong backgrounds in physics and chemistry.

First, they select, and prepare, the *substrate*—a clear plastic film to which the tag antenna and IC will be affixed. The substrate must be able to stand up to the environmental conditions to which the finished tag will be subjected. This is not as simple as it sounds; for example, certain polyester substrates are supercharged with static and can blow out chips.

On the substrate you’ll also find the *tag antenna*. The antenna design is one of the most important factors in overall tag performance. As you can see from the picture below, antenna designs can vary a great deal. We’re not going to go into too much detail here except to emphasize the importance of the antenna design.



RFX6000 1x1 Read/Write Inlay



RFX6000 1x4 Read/Write Inlay



RFX6000 1x6 Read/Write Inlay



RFX6000 2x2 Read/Write Inlay



RFX6000 2x4 Read/Write Inlay



RFX6000 4x4 Read/Write Inlay

The antennas are printed or etched, depending on the antenna materials used. The most common antenna materials are:

- Copper, the most expensive but most durable of the materials;
- Aluminum, which is inexpensive, but difficult to work with;
- Silver ink, which is priced between the first two metals and works fairly well. Many passive RFID tags use silver ink.

All metals can oxidize over time; however, silver has the least affect on the conductivity of the chip. This is an important consideration when you require a tag with a long life.



- ✓ Works with the leading manufacturers of UHF inlays and can provide finished tags based on existing designs.
- ✓ When off-the-shelf inlays don’t work, the Mid South-RFID team can design application-specific inlays tailored to client-specific requirements.
- ✓ One of only a few companies in the world that can manufacture the entire Symbol tag product line.
- ✓ Uses state-of-the art equipment and ISO 9001:2000-based quality systems.

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The IC is affixed to the inlay backing and antenna using an adhesive. This process is commonly referred to as the *"Flip Chip Assembly process"*. You may have heard the phrases "pick and place" or "fluidic self-assembly". These terms refer to the manufacturing process used to make the inlay. Keep in mind that the placement of the IC must be extremely precise in order for the IC to make contact with the antenna connects. If placement is off by as little as 1 millimeter, the tag will probably not work.

Most IC manufacturers have a portfolio of different antennas designed for their IC operating under common conditions.



The Cost of an RFID Tag: The Inlay

Start with the cost of the integrated circuit: **4.0¢-7.0¢**.

Inlay
Substrate
1.0¢

The clear film used as the foundation for the inlay.

Strap
Attachment
1.2¢

Optional. Some, but not all ICs require something called a strap attachment in order to adhere to the substrate.

Antenna
1.0¢ - 5.2¢

Depends on antenna design; the larger the antenna, the more expensive it is. The type of metals used in the antenna and the process by which the antenna is manufactured (additive vs. subtractive process) affects costs as well.

Adhesives
0.25¢

Adhesives are an extremely important part of the RFID tag and are used in several places. Adhesives secure the IC or strap attachment to the substrate.

For more information on types of adhesives, see our In-depth article: [Adhesives and RFID Tags](#)

Inlay Coating
0.1¢

Optional. The coating can help the tag resist static and other environmental conditions.

QA
1.0¢ - 2.0¢

The quality assurance process used to test the inlay.

Labor and
Machine Costs
1.0¢ - 2.0¢

The process used to manufacture the inlay can have a significant impact on the final tag price. When you consider that millions of tags are made, adding half a cent noticeably increases the overall price. The machines that manufacture inlays are extremely sophisticated and cost millions of dollars. Also consider that there is labor involved in setting up the machine, electricity, and waste from defective materials.

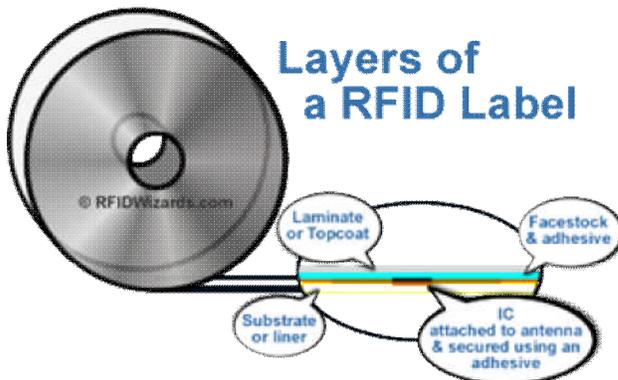
**Average
Inlay Cost
9.5¢ - 18.75¢**

Of course, this varies by the number of inlays you purchase. Again, volume can significantly increase or decrease the cost. We're basing our inlay costs on 1 million tags

Passive RFID Finished Tag Manufacturers

A finished tag manufacturer takes an inlay and turns it into a RFID tag. Like inlays, finished RFID tags come in many different forms. Some of the more common types of passive RFID tags include:

- **RFID smart labels** (average cost: 9.5¢ - 25.5¢), which typically come on a roll such as the one pictured left;
- **Durable tags** (average cost: 75.0¢ - \$3.50), which can be mounted on metal, reusable plastic containers, or other items that can encounter harsh environmental conditions;
- **Smart cards and tickets** (average cost: .?¢ - \$1.50), which are used for payment processing systems, mass transit, and access control;
- **Smart forms** (average cost: .?¢ - \$1.50), which are paper forms with RFID in them. One example is the I-94 Form from the US Government, for nonimmigrant visitors entering the US with a visa.



To make finished tags such as these, the inlay is sandwiched between a *backing* and a *facing* (or "topcoat"). On a label, the backing peels away from the inlay to reveal the adhesive that affixes the tag to an item. The facing is not only what you see, but the part that protects the antenna and IC from the environment. The image above graphically depicts the layers on a roll of smart labels.

During the process, tags are rolled, unrolled, and rolled again, which results in failed tags. The quality assurance process for finished labels is absolutely critical and normally done in three parts:

- Pre-test**, which verifies the inlay is good;
- Inline test**, which verifies the tag during the process of adding the backing and the facing;
- Post test**, which verifies the finished tag works to specification.



- ✓ One of the premier finished label manufacturers for over ten years.
- ✓ Guarantees 100% usable tags and labels. Even offers a credit back for failed tags.
- ✓ Provides complete finished rolls of tags with no bad tags or tag gaps.
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The Cost of an RFID Tag: The Finished Label

Start with the cost of the inlay: **9.5¢ - 18.75¢**

Backing or Liner 1.0¢	The inlay must be placed on the backing as per the specifications of the printer or label applicator being used. If it is off by more than a millimeter, the equipment may not be able to program that tag.
Facestock 0.5¢ - 2.0¢	This is the part of the RFID tag you actually see. It could be white paper, a high end polyester, a glossy green finish, or something else.
Adhesives 0.25¢	Adhesives are applied to both the back and the front of the inlay. <i>Exception to the rule:</i> A Pressure Sensitive Adhesive (PSA) Inlay is an inlay that has an adhesive backing so that it can be used as a tag. For more information on types of adhesives, see our In-depth article Adhesives and RFID Tags
QA 0.5 - 3.0¢	Quality assurance of the finished tag roll is also critical and adds cost to the tag. For example, if the QA process finds a bad tag on a roll, what should be done with it? Leaving it there is the cheapest way to go, but that means you have bad tags. The common options include punching a hole in the tag and removing the IC, or printing an "X" on the tag. The preferred, but most expensive method is to remove the bad tags from the roll and replace them with good tags.
Roll Core 0.5¢ - 1.0¢	The round cardboard tube in the center of the roll costs money. The size of the core varies based on what kind of printer you're using and how many tags are on the roll.
Labor and Machine Costs 0.5¢ - 2.0¢	Like inlay manufacturing, the machines used to make finished labels also cost in the millions of dollars and it takes tag sales to obtain a return on investment for their purchase cost. These machines also wind and unwind rolls, cut the inlay, cut the tags, add perforations, etc. and someone needs to operate them.
Profit Margin ???¢	If your finished tag manufacturer doesn't make a profit, you're eventually going to have to find a new one.
Average Finished Label Cost 9.5¢ - 25.5¢	Of course, this varies by the number of inlays you purchase. Again, volume can significantly increase or decrease the cost. We're basing our finished label costs on 1 million tags. Given the price we've listed here, you may be wondering why some tag providers offer finished tags starting at 10¢. That's because they supplement the cost in order to gain market share. They're not making money now, but they hope to in the future – given enough volume.

Why Tag Quality is More Important Than Price

Would you pay for a RFID tag that doesn't work?

That's essentially what you do when you purchase cheap tags. *All of the tags* you receive need to meet the design specifications of your RFID system otherwise some tags may not work. In our experience *it costs more to deal with tags that fail than to pay a few extra pennies for more reliable tags.* It is no different from handling exceptions in a manufacturing process: How much do exceptions add to the bottom line?

We recently spoke with Scott Anderson, at Rush Tracking Systems, regarding a container tracking solution his team is implementing for a \$30 billion durable goods manufacturer.

The manufacturer uses reusable plastic containers to track metal parts and turned its standard bar code label into a RFID tag. Not wanting to lose the business, their current label provider claimed it could add RFID but had no previous experience doing so. Without informing the manufacturer, the company subcontracted to a third party to produce a prototype. The picture to the right shows 1) the original bar code label; 2) the prototype from their bar code label provider; 3) and a second prototype from Mid South-RFID – a company that has been specializing in RFID tags for over ten years.



After doing some tests, the company selected Mid South-RFID over the competition. Scott explains, "It wasn't price—we didn't even really get that far to compare. Mid South-RFID produced a much better product. The tag was more rigid and highly durable. It also had a superior coating—the plastic containers sometimes get wet and are periodically washed. The tags actually had the same inlay and IC so that wasn't a factor either. Mid South-RFID was very fair. We worked on numerous iterations to get the tag exactly the way we needed it."



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- ✓ Guarantees 100% Usable tags and labels.
- ✓ Provides complete finished rolls of tags with no bad tags or tag gaps.
- ✓ One of only a few label manufacturers that can produce rigid labels.

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Once the manufacturer realized that Mid South-RFID had so much flexibility in final tag design, they started to make improvements to the RFID tag over the original bar code label. More specifically, Mid South-RFID:

- made the bar code wider;
- increased the size of the human readable number;
- added newer, higher resolution, better quality artwork;
- changed the colors to be closer to the corporate colors;
- made it more durable than the current label provider;
- improved the adhesive properties.

All in a slightly smaller form factor.

The result is a better-quality RFID label tag with a 5-10 year lifetime versus a lower-quality tag with half the life. You're probably asking how much its cost for customizing the tag? Design services for customizing an RFID inlay were included in the price of the tag.

What You Need to Know Before Talking to Your RFID Tag Provider

Here is some information you should have before contacting a tag provider. The answers to these questions will affect how your tag is designed.

What are the maximum and minimum dimensions of the tag? This typically depends on what you are tagging and where the tag will be placed.

At what distances do you need to be able to read the tag?

How many tags do you need to read at a time and how long do you have to read them?

To what surface will you affix the tag? The tag needs to be tuned to that surface, be it glass, wood, plastic, corrugate, etc.

Will the tag be flat or bent?

Once attached, will the tag ever need to be removed?

Is there a security requirement? That is, if the tag is removed, does it need to stop working?

How are you going to encode (write data) to your tags? Typical methods include using an RFID printer/encoder, a high speed label applicator, a RFID hand-held, or a stationary RFID reader.

Do you have to print anything on the tag?

If you are using a RFID printer/encoder or high-speed label applicator, what manufacturer / model are you using? Your RFID tag provider needs to know because there are specific insertion specifications for each unit. The inlay has to be placed in the exact position on every label.

How long is the life-cycle of the tag? How long do you expect the tag to work? Do you need the tag to operate for only a year, 15 years, or some time in between? Remember, the wrong antenna materials can oxidize over time, leaving you with a dead tag.

What are the environmental conditions the tag will experience during its' life-cycle? Note the temperature, humidity, electrostatic discharge. Will it be washed with water and soap?

How many tags do you need? Forecasting your tag consumption is extremely important to both you and your supplier. By forecasting, you can get you better volume discounts and delivery of exactly what you need and when you need it. Ideally, each month the supplier sends you the number of tags you need and charge it to a blanket purchase Order. It is a lot easier than waiting six months for tags.



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- ✓ Can help design a tag based on your specific requirements.
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- ✓ One of only a few label manufacturers that can produce rigid labels.

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Summary

It is our sincere hope that this article has given you a better understanding as to how passive RFID tags are manufactured, the costs, and what you should know. We'd also like to reiterate a short list of some of the most important factors that affect tag performance:

- Antenna design (size and shape);
- Antenna composite materials;
- Antenna connections (on the IC);
- IC Sensitivity;
- Environmental conditions;
- And adhesives used.

In a project in which RFID tags are consumable, tags will be the most expensive part of the equation. Keep in mind that some "one-stop-shops" mark-up the price of tags 10-20% over what you'll pay if you purchase directly from a finished tag manufacturer.

Finally, purchasing tags on price alone is not wise. In the end, the vendor with lowest bid may end up having the most expensive tag.

Throughout this article, there are breakout boxes that list some of the benefits of working with Mid South-RFID. Mark Davenport and his team have been providing the RFID tags used in some of the largest deployments in the world. If you are an integrator or application service provider, Mid South-RFID is currently looking for experienced companies to help build solutions for customers. I strongly encourage everyone to take a look at their unique offerings. You may also contact Mark Davenport for more information.

About the Authors



Louis Sirico is an industry-recognized expert with over 23 years of experience. He has successfully implemented RFID solutions for Target, the Department of Homeland Security, Kimberly-Clark, and numerous Fortune 1000 companies. He is the founder of IndustryWizards.com, an Internet based community including the world's leading subject matter experts in Industry. He a founding member of EPCglobal, served as a Subject Matter Expert for the RFID+ certification exam, and was nominated for Entrepreneur of the Year in 2003. He can be reached at Louis@RFIDWizards.com.



Mark Davenport has over 25+ years of label converting experience and 10+ years of RFID converting experience. His customers include some of the largest companies in the mobile computing world as well as several of the top 100 Wal-Mart & DOD suppliers. He is recognized as one of the worlds leading suppliers / manufactures of Symbol UHF RFID inlay product line. Mark was responsible for producing one of the largest single RFID tag orders in history to Abercrombie & Fitch with over 10 million + tags that was rolled out in a 60 day time frame, produced over 60+ million RFID bag tags for one of the world largest airports located in Asia, and the largest single RFID order ever deployed in the Middle East. He also produced the first UHF smart form for the US Department of Homeland Security. He can be reached via his e-mail address at mdavenport@midsouthrfid.com.