A small-business guide

Photofinishing Labs

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REPORT SUMMARY

Many of the challenges faced by small business owners can be addressed through efficient use of electric technology. Each volume in the Small Business Guide describes the current state of a business type and details new or alternative electric equipment that can help it meet its characteristic problems.

Background

Members of the small-business community historically have had little contact with their energy providers. These guides were developed to facilitate communication between electric utilities and the small businesses in their communities.

Objective

To provide utility personnel and small business owners and operators with information on the key electrotechnologies that can help these businesses compete effectively.

Approach

The project team researched small business energy, productivity, and environmental concerns and the electrotechnologies that can meet these needs. Telephone surveys, published reports, directories, buyers guides, and technical journals provided information on technology availability, suppliers, information sources and trade associations.

Results

The Small-Business Guide series covers a range of industries:

Volume 1: Wholesale Bakeries

Volume 2: Auto Body Shops

Volume 3: Lodging

Volume 4: Medical Clinics

Volume 5: Drycleaners and Launderers

Volume 6: Metal Finishers

Volume 7: Shopping Centers

Volume 8: Convenience and Grocery Stores

Volume 9: Printers

Volume 10: Office Buildings

Volume 11: Electronic Components

Volume 12: Wood Preservers

Volume 13: Plastics Products

Volume 14: Wood Furniture

Volume 15: Apparel Manufacturers

Volume 16: Photofinishing Labs

Each guide is based on extensive and ongoing research and contains the latest information available at the time of publication. The guides have been organized as a reference document for use on an as-needed basis. Section tabs are included to facilitate quick access to topics of interest; and each volume concludes with lists of equipment suppliers, EPRI information resources, and trade organizations.

EPRI Perspective

The EPRI Small Businesses target is dedicated to research, development, and dissemination of information on electrotechnologies that address the energy, productivity, and environmental concerns of small business owners and operators.

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Interest Categories

Commercial building systems and analysis tools
Commercial appliances
Product and service design
Marketing

Keywords

Electrotechnologies
Load building
Marketing
Customer needs
Commercial buildings

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Wayne Krill manages the Small Businesses Target at EPRI and directed development of this *Guide.*

ABOUT THIS GUIDE

Members of the small-business community historically have had little contact with their energy providers. This guide was developed to facilitate communication between electric utilities and the photofinishing laboratories in their communities.

The *Photofinishing Labs* guide is intended to familiarize readers with the business of photofinishing by providing descriptions of basic processes and practices, and summaries of the issues and challenges faced by photofinishers. It focuses on delineating how electric equipment can address the needs and interests of photo-finishing business owners and operators.

This business guide is one of a series of publications produced by the Electric Power Research Institute (EPRI) about small businesses. The *Photofinishing Labs* guide is based on extensive and ongoing research and contains the latest information available at the time of publication. Nevertheless, it is a work in progress rather than a definitive and final document. The information and resources presented offer the reader a solid base from which to develop electricity-based solutions to energy and business needs.

This guide is organized as a reference document for use on an as-needed basis. Section tabs are included to facilitate quick access to topics of interest; icons representing energy end uses are also provided to help with locating complete information on electrotechnology solutions.

Birthdays, foreign scenery, new pets, family reunions—we record by camera the special moments in our lives. In the contemporary United States, photography is a pastime that cuts across all demographic profiles. But most people just take the photographs and rely on the services of photofinishing labs to develop the film and produce the actual prints.

Three basic types of photofinishing businesses cater to the public: minilab retailers, wholesale laboratories, and mail-order laboratories. Most consumers assess speed, price, and quality in selecting a purveyor of photofinishing services. Generally, minilabs are associated with speed, wholesale labs with price, and mail-order labs with quality; but many companies offer specialized services that blur such easy distinctions. In 1993, consumers could choose from among an estimated 7653 photofinishing businesses, 97% of which were small companies employing fewer than 50 people. The industry's receipts that year were $6.1 billion, an increase of about 8% over the previous four years, when receipts held stable at about $5.6 billion. Market watchers have identified two new trends that may begin to lure customers from traditional photofinishing services: "microlabs" installed in retail stores, and electronic media, such as video cameras and digital imaging, that require no processing of film. Because of the volume of hazardous chemicals involved in film processing, another mounting pressure for traditional photofinishing businesses is compliance with environmental, health, and safety regulations.

To satisfy customers and maintain a healthy market share in an era of increasing competition, most photofinishing labs are looking for opportunities to reduce their operating costs while also improving lab productivity, service flexibility, and product quality. The accompanying table identifies electrotechnologies that can meet these business interests. These electrotechnologies and other high-efficiency electric technologies are described in the *Photofinishing Labs* guide (EPRI TR-106676-V16), which is available from the EPRI Distribution Center. To order this publication or other guides in the series, call the Center at (510) 934-4212.

Electrotechnologies for Photofinishing Labs

	Electrolytic Recovery of Silver	Ion Exchange	Membrane Filtration	Vacuum Evaporation	Outdoor Lighting
Description	Electrolysis strips film processing wastewater of dissolved silver ions (or other heavy metal ions) by passing an electric current through the wastewater, causing the ions to deposit on cathodes as solid metal.	Uses chemically treated resins in rinse water to exchange silver thiosulfate ions for hydrogen or sodium ions, thereby decontaminating the water and permitting silver recovery.	Electrically driven pumps force wastewater through a permeable barrier that filters selected contaminants based on particle size; a "reverse osmosis" membrane captures particles larger than 5 angstroms in size.	A closed-loop system that vaporizes process wastewater under vacuum at relatively low temper-ature; as the water is driven off, dissolved metal salts concentrate in the effluent and then can be recycled in the process tank.	Six types of lighting technologies are available. Each offers different characteristics in wattage, bright-ness, light tone, efficiency, and life span; they can be combined to meet site-specific needs.
Photo-finisher Need	To control costs, photofinishers need to recover silver and capture and recycle the solutions used in photoprocessing operations.	To control costs, photofinishers need to recover silver and capture and recycle the solutions used in photoprocessing operations.	To control costs, photofinishers need to recover silver and capture and recycle the solutions used in photoprocessing operations.	To control costs, photofinishers need to recover silver and capture and recycle the solutions used in photoprocessing operations.	Lighting improves the visibility and attractiveness of a facility, reduces the potential for crime, and increases employee safety.
Application	Electrolytic units are an increasingly popular method of recovering silver from photo-processing process water and wastewater.	Applicable for large volumes of dilute wastewater and/or if a photofinisher must further reduce the silver concentration in lab effluent to meet new discharge limits; in some cases, also used to recover and recycle color developer.	Reverse osmosis removes silver from waste streams for recovery by a secondary process such as electrolysis.	Vacuum evaporation is used to recover temperature-sensitive process solutions that have volatile components and is applicable to many metals, acids, and alkalis.	Signage on or near the facility; general lighting in parking lots, walkways, delivery areas; facade and landscape lighting.
Benefits	Recovers up to 90% of available silver in a marketable form, reduces the volume of hazardous waste, improves rinse quality, and reduces overall process water use.	Effectively extracts about 98% of available silver from a dilute waste stream, produces effluent suitable for discharge, and has relatively low capital and operating costs.	Allows recovery of silver, decontamin-ates wastewater, improves rinse quality and longevity, and reduces overall water use.	Allows recycling of rinse water, minimizes the volume of sludge or concentrate requiring disposal, and nearly completely eliminates water discharge from a facility.	Increased public perception of quality, goodwill, and success from general signage and facade lighting; reduced potential for accidents, injuries, and crime from area lighting.
Cost	Systems cost $1300–$60,000, depending on size and manual versus automatic operation; the energy consumption is 0.01–0.6 kWh per troy ounce of silver recovered.	For a small unit processing 30–480 gallons per hour, the cost range is $1000–$20,000; larger units processing 200–1800 gallons per hour cost $20,000–$100,000.	A reverse osmosis unit processing 300 gallons per hour costs about $34,000 to purchase and about $0.40 per 100 gallons to operate.	Units ranging in capacity from 0.01–1.0 gallon per minute require 1.5–20.0 kW, respec-tively, and cost $7000–$154,000; the payback period is typically 3 months	Systems are custom-designed to meet a facility's needs and budget.

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INTRODUCTION TO THE PHOTOFINISHING INDUSTRY

Photography—the technique of producing permanent images on sensitized film or paper through the use of the photochemical action of light—was developed in the 19th century. Although the photosensitivity of silver nitrate and silver chloride was already known, not until the 1830s were inventors able to produce a permanent image. This early photography required large cameras and glass photographic plates and was therefore only performed by dedicated professionals. The development of roll film in 1889 and the 35-millimeter camera in 1925 enabled the general public to engage in photography for the first time. With the genesis of amateur photography, a market developed for photofinishing.

Business Overview

Since their development in the late 1970s, minilabs—facilities that perform photofinishing on-site—have fostered a revolution in the photoprocessing industry. Consumers are attracted to the convenience, fast processing, and variety of products and services offered by minilabs. To maintain a place in the market, traditional processing establishments, both retail and wholesale, have been forced to alter their film processing services; specifically, they now offer drop-off boxes and faster turnaround times to compete with the convenience and speed of minilabs.

In the 1990s, photofinishers are facing a new era of competition and change. The development of the microlab early in the decade—a smaller, less expensive version of the minilab—has made it easy for drugstores, supermarkets, and other retailers to offer on-site photofinishing services, increasing competition for traditional photofinishing labs and minilabs. To address this competition, photofinishing labs are searching for ways to reduce operating costs while increasing productivity and product quality.

Even more challenging is the need to stay current with changes in photography. There is a growing demand for digital imaging, and a new type of camera and film has been introduced to the market (the “advanced photo system”), a product developed by the large film companies to increase consumer interest in photography. To perform digital imaging requires computer hardware and software; to process advanced photo system film requires other appropriate equipment. The photoprocessing labs that want to cater to these markets must therefore first invest in new equipment.

Photofinishing labs also face the challenge of complying with a number of environmental, health, and safety regulations. The photofinishing process generates silver-containing wastewater regulated by the Clean Water Act, waste chemicals that may contain heavy metals regulated by the Resource Conservation and Recovery Act, and health and safety issues regulated by the Occupational Safety and Health Act.

The photofinishing industry (SIC 7384) includes all establishments that develop film and make photographic negatives, slides, prints, and enlargements for commercial photographers and the general public. Department of Commerce (DOC) data indicate that annual receipts for the industry increased significantly from 1987 to 1993, growing from $4.7 billion to $6.1 billion (see Table 1-1). According to the Photo Marketing Association International, photofinishing receipts for amateur photographers was $5.5 billion in 1993. Using this figure to extrapolate from the DOC's data suggests that amateur photography may represent about 90% of total photofinishing receipts.

Table 1-1
Profile of the Photofinishing Industry (SIC 7384)

Year	Number of Establishments	Number of Employees	Annual Receipts ($ million)
1987	6867	84,635	4703
1988	6567	82,286	5230
1989	5967	73,584	5696
1990	6190	76,038	5604
1991	6438	70,276	5675
1992	7039	95,782*	5678
1993	7653	69,969	6126

Source: U.S. Department of Commerce, Bureau of the Census, *County Business Patterns* (various years), and *Service Annual Survey*, (various years). Note: The large number of employees reported in the Bureau of Census 1992 survey is likely due to misclassification or misinterpretation of survey questions.

DOC data also indicate there were 7653 photofinishing establishments in the United States in 1993, 97% employing fewer than 50 people (see Table 1-2). Photofinishing labs have averaged 12 employees per establishment since the 1980s.

Table 1-2
Distribution of Photofinishing Shops by Size (1993)

Size	Number	Percent of Total
Small (0–49 employees)	7435	97
Medium (50–99 employees)	117	2
Large (100+ employees)	101	1
TOTAL	7653	100

Source: U.S. Department of Commerce, Bureau of the Census, *County Business Patterns 1992 & 1993* (CBP-92/93), 1996.

The traditional types of photofinishing laboratories fall into three classifications: minilab, mail-order laboratory, or wholesale laboratory.

Minilab. Minilabs are retail outlets that are either independently owned or affiliated with a photofinishing chain. They are located in stand-alone buildings or situated within larger facilities such as shopping malls or office buildings. The photofinishing equipment in a minilab is a compact, self-contained unit that often requires as little as 27 square feet of floor space. These labs serve a local market and specialize in fast photofinishing (photographs are processed in 30–60 minutes); they charge relatively high rates for their services.

Most minilabs are individually owned and operated. According to the U.S. Environmental Protection Agency (EPA), a typical minilab has five employees, annual sales of $300,000, and operates out of a single urban location with one or two color-processing machines. The average store size is approximately 1440 square feet.

Half (51%) of all minilabs are located within strip shopping centers. The remainder are found in stand-alone buildings (22%), main street locations (15%), enclosed shopping malls (10%), and other locations (2%). Although operating hours vary, minilabs operate an average of 10 hours per day, Monday through Friday. Most are open on Saturdays, and approximately one-third are open limited hours on Sunday.

Mail-Order Laboratory. Mail-order laboratories, on the other hand, often serve nationwide markets, and rely on repeat orders from an established customer base of amateur photographers. To recruit customers, they distribute mailing envelopes through camera stores or use advertising methods such as direct-mail campaigns and newspaper inserts. Mail-order labs offer the advantages of at-home convenience (orders can be prepared and sent from anywhere and received at any mailing address) and relatively low prices. Not all are inexpensive, however. Some mail-order labs are premium photofinishing operations that emphasize customized services and rigorous quality control. The disadvantage of mail-order laboratories is the often 1–2 week turnaround to receive finished photos.

Wholesale Laboratory. Wholesale laboratories serve both local and nationwide markets; they process orders for commercial photographers and/or orders dropped off by amateur photographers at supermarkets, discount stores, drugstores, and other locations. Wholesale laboratories typically operate anonymously as a service of their retail host (e.g., Kmart, Walgreen's, Costco). These laboratories process thousands of rolls of film each day and therefore offer less expensive rates than minilabs. Their turnaround times range from one day to one week.

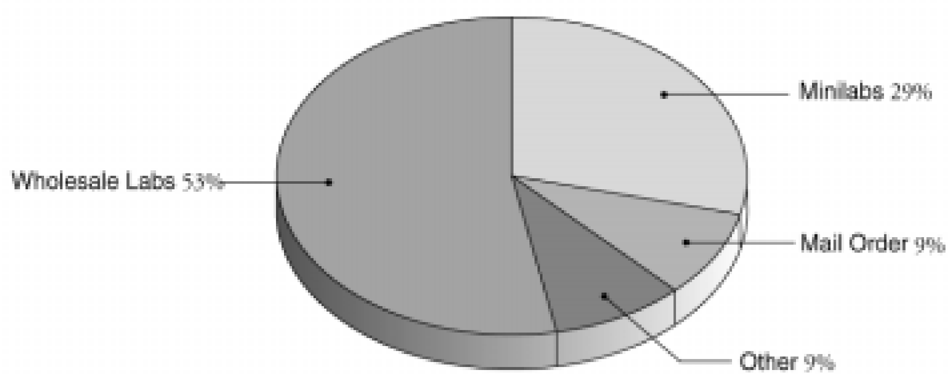


Figure 1-1
Photofinishing Industry Market Shares

Figure 1-1 illustrates the market share for these traditional types of photoprocessors, based on the number of rolls of film processed. Wholesale labs, which process film primarily for commercial accounts (i.e., retail stores), account for more than half of the market for photofinishing services. Minilabs account for the second largest share of the market, nearly 30%.

The advantages offered by microlabs relate to film processing equipment size and space requirements, and a washless process (however, some minilabs also use a washless process). The disadvantages are that microlabs are very small, process only one roll of film at a time, take more time to process each roll of film, and can perform only a few, relatively simple operations. For example, a microlab facility can develop 35-millimeter film and make prints, but cannot enlarge photographs, make reproductions, or process any other type of film.

Since the number of photofinishing laboratories in a state is directly related to its population size, California has the largest number of these businesses, 1103 (see Figure 1-2). Also included in the top five states are New York, Florida, Texas, and

New Jersey. Other states with a significant number of photofinishing labs include Illinois, Pennsylvania, Ohio, Georgia, and Massachusetts.

State	Facilities
CA	1103
NY	741
FL	628
TX	538
NJ	275
IL	267
PA	265
OH	238
GA	225
MA	213

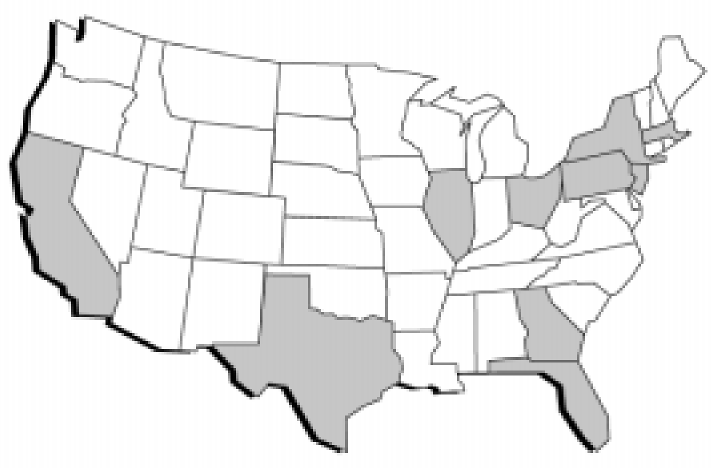


Figure 1-2
Top 10 Photofinishing States

The Photofinishing Process

In photofinishing, film is processed to produce a negative image; the image is then transmitted to printing paper by a contact printing or enlarging exposure; the paper is then processed to produce a positive print.

The photofinishing process as a whole requires the use of a number of chemicals in film development and print production. The waste streams generated vary according to the type (e.g., color versus black-and-white film) and volume of processing. Most of the film processed is color, for prints and slides; black-and-white film processing constitutes just 10% of the market.

In processing black-and-white film, developers produce a negative image; the film is then transferred to a stop bath to fix the image. Next, the film is immersed in fixer solution to remove the remaining unreacted chemicals. Fixer solution adhering to the film is removed in a final rinse step. The process is repeated to produce a positive print on paper. Black-and-white photofinishing uses a variety of toxic chemicals; these include organic developers, metal salts, acids, alkalis, oxidizing powders, and various chemicals in solution. As film is processed, the concentration of reaction products builds up in the developer and fixer solutions. When these solutions become unusable, they must be disposed of along with the concentrated heavy metal wastes.

Color processing is more complex because it involves dye-coupling development. The color process uses highly toxic organic chemicals and is more hazardous than black-and-white photofinishing. Also, because color processing represents the bulk of the work in any given facility, it usually generates a larger waste stream. Processing color film or paper involves five major steps: developing, bleaching, fixing, washing/ stabilizing, and drying (see Figure 1-3).

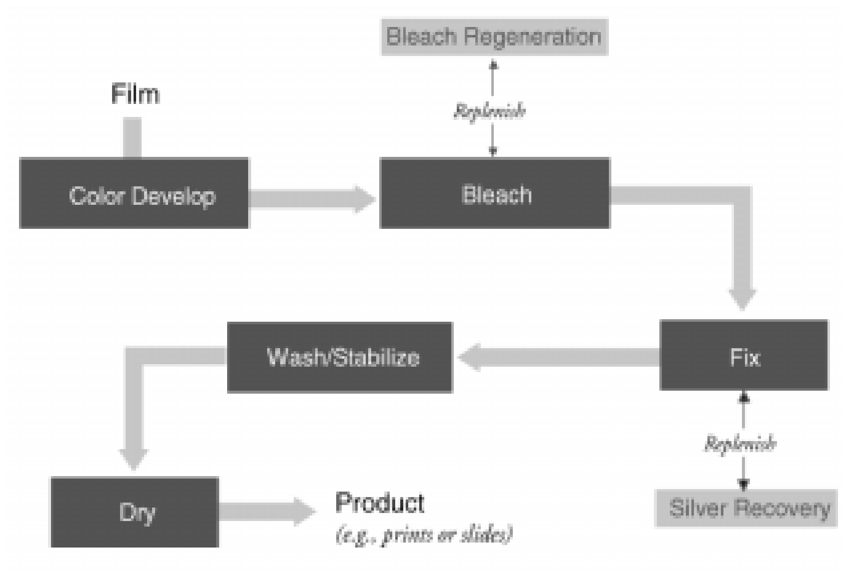


Figure 1-3
The Photofinishing Process (Color Film)

Developing. Color film and paper are made up of various color-sensitive layers. Each layer is sensitive to a specific primary color: red, green, or blue. For example, a layer that is sensitive to blue only responds to blue light, and the latent image developed in that layer corresponds to the exposure to blue light. Each layer also contains a colorless dye-forming coupler and silver halide crystals; when these chemicals are processed in a color-developing solution, a silver image forms in each layer. In this process, the exposed silver halide crystals are reduced to metallic silver, and the developer is oxidized. The oxidized developer then reacts with the dye-forming coupler to produce a dye that is complementary in color to the light for which the layer is sensitive.

To be effective, developers must have a pH in the alkaline range (pH 9–11). To achieve this, an alkali, called an activator or accelerator, must be added. The alkali, typically sodium or potassium carbonate, activates the developing agent and increases its chemical activity rate. Once the developer is activated, the developing process itself is controlled by time and temperature.

Bleaching. Bleaching is used in color film or paper processing to oxidize the silver image so that only the composite dye image remains. Bleaching is an oxidation reaction that converts the free or metallic silver back to a silver halide that can then be dissolved or washed off in the fixer bath.

The bleach most commonly used by small photofinishing labs is ferric EDTA (the ferric salt of ethylenediamine tetra acetic acid), which reacts easily with metals to form metallic complexes. Although EDTA is not classified as toxic, it is not biodegradable and can spread and accumulate in both surface and groundwaters. The ammonium ions of EDTA are an environmental concern because they have the potential to overfertilize wastewater treatment plants and rivers. Overfertilization can cause microorganisms in wastewater treatment facilities and plants in rivers to multiply or grow rapidly, disturbing treatment plant operation and clogging waterways.

Fixing. Once an image has been produced, the fixing process clears the image by dissolving any silver halide crystals remaining on the film. The dissolved silver forms a complex silver thiosulfate ion that remains in the fixer. The more silver halide in the film or in the solution from the bleaching process, the longer it takes to fix the film. Once the silver halide has been removed from the film, the film is no longer sensitive to light, and the color dyes become visible.

Most processors of color film and paper use a combination bleach-fix solution that converts the silver to halides and dissolves the halides at the same time. The most commonly used solution contains ferric EDTA and sodium thiosulfate as its major ingredients. In rapid-fixer solutions, which speed up the fixing portion of the process, ammonium thiosulfate is typically used. Rapid-fixer solutions are most often used by mini- and microlabs.

Washing/Stabilizing. The washing/stabilizing bath serves two purposes: it removes any residual fixer or other remaining chemicals before the film passes to the dryer, and it hardens or stabilizes the dye in the color film or paper. An increasing number of minilabs are converting to a “washless” process that employs a stabilizer in place of water washes. This reduces the volume of wastewater generated.

Drying. Film is typically hung in strips or placed in baskets and dried in a cabinet dryer. The dryer fan blows either ambient or heated air over the film. A small (e.g., 200-watt) electric heating element typically heats the air in a drying cabinet; heating is common in areas of the country that experience high ambient humidity. Care must be taken to ensure the film dries evenly and that the air is not hot enough to damage the film.

Energy Use

Energy use represents approximately 1.5% of total operating expenses for a photofinishing facility. Most photofinishing facilities, therefore, are not very concerned about energy issues, unless they relate to productivity and product quality and/or to compliance with environmental regulations. Department of Energy *Commercial Building Energy Consumption Survey* data on “mercantile and service” facilities suggest the average electric intensity for all photofinishing facilities can be estimated as approximately 10.3 kWh per square foot. On this basis, in comparison to other commercial establishments, photofinishers are less electric-intensive than grocery stores, medical clinics, and hotels and motels, but more electric-intensive than dry cleaners and printers. Regionally, more electricity is used per square foot in the South and West, primarily due to the greater use of air conditioning to control both temperature and humidity.

The primary use of electricity in the photofinishing industry is for the photofinishing process itself (approximately 67%) (see Figure 1-4). Electricity is used in the operation of motors and drives; the treatment of wastewater and waste residuals; the recovery of solutions and silver; and other uses, including water heating and heating of solutions, and for miscellaneous plug loads. Heating, ventilation, and air conditioning (HVAC) accounts for an estimated 21% of electricity use in a typical facility. This reflects a lab's need to control both temperature and humidity to ensure quality processing. Lighting accounts for the remaining 12% of electricity use.

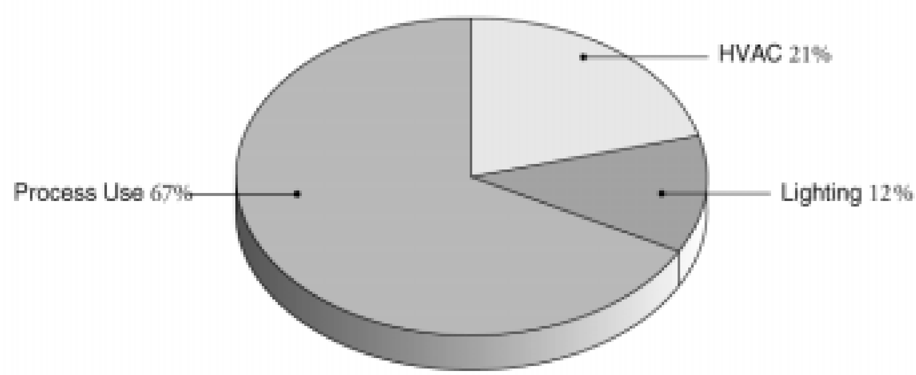


Figure 1-4
Typical Electricity Use in Photofinishing Labs

2

BUSINESS CHALLENGES AND NEEDS

The demand for photofinishing services is determined by a number of factors, the most important of which is the health of the national and/or local economy. The economy determines the level of business activity (new business formation, number of transactions, and advertising budgets), disposable personal income, and the availability of leisure time. This activity in turn influences the amount of photographic film used and the amount requiring development.

Competition

When it comes time to have pictures developed, most amateur photographers choose a lab on the basis of price, although, according to the Photo Marketing Association, nearly 20% of consumers consider the speed of service their priority, regardless of price. Since most consumers lead busy lifestyles, convenience—and therefore a shop's location—is also a key competitive factor in this industry.

To satisfy consumers' demand for cheap, fast, convenient service, photofinishers are continuously looking for ways to reduce operating costs and improve productivity. Because the photofinishing process uses hazardous chemicals, shops must also keep pace with a number of environmental, health, and safety regulations.

The Advanced Photo System

Photofinishers, whether minilabs, mail-order labs, or wholesale labs, compete among themselves on the basis of price, speed, convenience, and quality. With the advent of the microlab in the early 1990s, photofinishers are now also competing with secondary photofinishers. Microlabs are less expensive to establish than minilabs, require as little as 18 square feet of total working space, and are washless, so there is no need for special plumbing. This technology allows retailers such as drugstores, supermarkets, and discount warehouses to own and operate an on-site photofinishing lab with little investment.

Photofinishers also face competition from electronic media, such as computer-based digital imaging technology and photo compact disks (CDs). These technologies are particularly suited for audio/visual media, publishing, and other commercial uses that rely on fast electronic processing, transmission, and reproduction. While digital imaging is not expected to replace film photography, photofinishing laboratories are increasingly offering digital imaging and photo-CD-related services to attract a wider range of customers.

In an attempt to spark new interest in recreational photography, five of the world's largest film and camera manufacturers have developed an entirely new generation of cameras and film called the "advanced photo system." Introduced in early 1996 by Canon, Fuji, Kodak, Minolta, and Nikon, the new system is designed to make it easier and more satisfying to take pictures. The new "smart" film features drop-in loading, negatives that remain inside the cartridge, a full-color index of photos, and the choice of three different picture widths. The paper index, a set of tiny color reproductions of all the photos, makes it easier to decide which images to duplicate or enlarge and prevents damage to the negatives because they stay in the cartridge. The catch is that the new film only works in the new "smart" cameras, which are priced somewhat higher than traditional types. The film is intended to serve as a bridge between the older, chemical-based photography, and the yet-to-come nonchemical digital photography. Digital cameras are currently available, but they are a lot more expensive than traditional types and at present have inferior resolution compared to conventional and advanced photo system technology.

The "advanced" system, if it catches on with the public, could have positive and negative impacts on photofinishers. On the positive side, Kodak and Fuji believe the new system will encourage people to take more pictures, waste fewer frames, and request more reprints and enlargements. This would increase photofinishing revenues. In addition, the film is smaller than conventional 35-mm film, which means it contains less silver. This reduces costs for film manufacturers and the amount of silver by-product generated by photofinishers.

On the other hand, converting to the advanced photo system will require a significant capital investment. For example, a minilab would have to replace older machines, at a cost of more than $100,000 per machine, and/or upgrade newer machines for approximately $25,000 per machine. Wholesale and mail-order labs are expected to have an easier time converting to the new system because of their better access to capital, giving them a competitive advantage over minilabs in capturing this new market.

Need

Increase Productivity/Flexibility

Most customers want fast, convenient, high-quality photofinishing services at a low price. In order to compete with other sources of competition, labs need to increase their productivity and flexibility, while at the same time reducing operating costs. Today, photofinishing labs use primarily automated equipment that produces prints quickly and reliably; increasingly, they have sought equipment that also offers ease-of-use and versatility. In recent years, downtime, speed, and reliability have improved in all processing equipment, such that there is now little differentiation among equipment. However, as a result of increased competition, photofinishers are seeking equipment that will provide new services for existing customers and that will appeal to new markets.

Technology Solutions

In addition to adopting equipment that can process the new advanced photo system film, photofinishers can improve productivity and flexibility by using equipment with energy-efficient electric motors, which tend to be manufactured with higher-quality materials than conventional electric motors and are therefore more reliable. Improving the quality of indoor lighting with energy-efficient lighting can reduce a photofinisher's energy bill and potentially boost employee productivity.

See pages 3-3, 3-10

Need

Reduce Operating Costs

Most photofinishers are small businesses, and many minilabs in particular operate on a shoestring, bringing in just enough revenue to cover costs and make a little profit. As a result, anything that can help to reduce operating costs can improve the economic outlook for these businesses.

Technology Solutions

A number of technologies are appropriate. For example, energy-efficient electric motors, indoor lighting, and outdoor lighting, as well as the use of heat recovery technologies, can help reduce a photofinisher's energy bill. Technologies that can help a lab more effectively recover silver from its waste stream—silver that can be reclaimed for its value—can also help offset operating costs. These technologies include metallic replacement cartridges, electrolysis, ion exchange, and membrane filtration. Vacuum evaporation can help reduce operating costs by reducing the volume of waste that must be sent off-site for treatment and disposal.

See pages 3-3, 3-6, 3-7, 3-9, 3-10

Environmental, Health, and Safety Regulations

As a result of the many hazardous chemicals used or produced in the photofinishing process, the industry is faced with a number of environmental, health, and safety regulations. These regulations are related to compliance with the federal Clean Water Act (CWA), which regulates wastewater disposal; with the Resource Conservation and Recovery Act (RCRA), which regulates the transport and disposal of hazardous waste; and with the Occupational Safety and Health Act (OSHA), which regulates workplace conditions to protect the health and safety of employees. Local environmental regulations, which are often more strict than federal mandates, are sometimes enforced through annual operating permits for photofinishing facilities.

Photofinishers have made great strides in their efforts to recycle chemical drums, toner cartridges, single-use cameras, film cartridges, film canisters, and film spools; to reduce the use of toxic chemicals such as photoreceptors; to recover the silver used in photoprocessing; and to reduce or capture their waste effluent.

Need

Comply with Environmental Regulations

Photofinishers are regulated under several federal laws. The photofinishing process results in the generation of silver-containing wastewater regulated by the CWA, and waste chemicals that may contain heavy metals regulated as hazardous waste by the RCRA. Due to the nature of the chemicals used in the photofinishing process, facilities are also subject to a number of OSHA regulations.

The Clean Water Act. The CWA limits the amounts of certain contaminants allowed in effluent discharged to publicly owned treatment works (POTWs); but the local POTW has the right to set more stringent limits. Silver limits have been removed from the EPA's Primary Drinking Water Standard; however, many POTWs still maintain stringent limits on silver. POTWs can also set limits on other constituents found in photofinishing wastewater, such as ammonia; these limits vary with the municipality and its ability to treat various pollutants. Silver recovery is therefore a basic requirement for meeting POTW discharge guidelines.

Recovery of silver is important for three reasons: it improves activity in the fixer bath, it helps offset operating costs (when the reclaimed silver is sold), and it helps meet CWA regulations limiting the discharge of silver in photofinishing effluent. In some jurisdictions, removing silver from photoprocessing wastewater has become necessary as discharge limits imposed by POTWs have become increasingly stringent. Although some forms of silver are toxic, the silver discharged from photofinishing processes is tightly bound in a thiosulfate complex, which has no detrimental effect on waste treatment plants. Municipal POTWs, however, do not differentiate between the types of silver coming from different industries.

Future regulations may require the industry to meet even stricter discharge limitations. If the local silver discharge limits go beyond the range of on-site control for photoprocessors, silver-bearing waste may need to be separated, collected, and periodically hauled away by a licensed hazardous waste transporter.

Resource Conservation and Recovery Act. Normally, RCRA does not come into play with photofinishing wastes. Only the largest photofinishers generally qualify as small-quantity generators (SQGs) of hazardous waste, a federal designation for facilities generating 200–2200 pounds each month, and are subject to RCRA. However, this regulation is beginning to apply to all photofinishing labs as the criteria for discharging to sewer systems is becoming more stringent. Facilities falling under RCRA must haul their waste off-site for treatment and disposal by licensed handlers.

Technology Solutions

A number of commercially available technologies can help photofinishers recover silver to comply with state or local environmental regulations. These include metallic replacement cartridges, electrolysis, ion exchange, and membrane filtration. Vacuum evaporation, while not actually assisting in compliance, can reduce the volume of hazardous waste that requires disposal.

See Pages 3-6, 3-7

3

TECHNOLOGY SOLUTIONS

This section describes each of the technology solutions identified in the previous section. Each technology is summarized, linked by end-use application to a business need, and categorized as an "electrotechnology" or "efficiency technology." Electrotechnologies are selected new or alternative electric equipment options. In many photofinishing applications, they can increase productivity or operating flexibility, improve product quality, or control pollution, and may couple increased energy costs with an overall decrease in operating costs. Efficiency technologies, in contrast, offer opportunities to decrease energy use, but have little or no direct impact on production.

Each technology is more completely described in Section 4, Electrotechnology Profiles. Vendors of the electrotechnologies, sources of information on efficiency technologies, and trade associations are listed in Section 5, Resources.

Technologies are grouped and discussed below by end use, beginning with "Process Use," the end use that represents the greatest percentage of total photofinishing electricity use. Table 3-1 summarizes the technology solutions.

Table 3-1
Technology Solutions to Photofinishing Needs

			Business Needs		
End Use	**Solution Type**	**Technology Type**	**Increase Productivity/ Flexibility**	**Reduce Operating Costs**	**Comply with Environmental Regulations**
Process	Efficiency Technology	Energy-Efficient Electric Motors	■	■	
Process	Electrotechnology	Electrolytic Recovery of Silver		■	■
Process	Electrotechnology	Ion Exchange		■	■
Process	Electrotechnology	Membrane Filtration		■	■
Process	Electrotechnology	Vacuum Evaporation		■	
HVAC	Efficiency Technology	Heat Recovery		■	
Lighting	Efficiency Technology	Energy-Efficient Indoor Lighting	■	■	
Lighting	Electrotechnology	Energy-Efficient Outdoor Lighting		■	

Process Use

Nearly 70% of all electricity consumed by the photofinishing industry is used in process operations. The majority of this electricity is used to power motors that drive photofinishing equipment. The remainder is used in applications such as wastewater treatment.

Motors and Drives

Most photofinishers process film and paper using automated processing machines. The three types of machines most widely used are “dip-and-dunk,” roller transport, and continuous-length processors. Minilabs use either roller transport or continuous-length equipment; microlabs use roller transport processing technology.

The dip-and-dunk processor, generally used for rolls of film, is an automated version of traditional sink-line processing. The machine consists of a series of deep tanks, elevator or lifter mechanisms, and a movable track or chain drive. The film is attached to hangers; it is automatically transferred from tank to tank by the lifter mechanism, and deposited into each tank by the movable track. Another type of dip-and-dunk processing is the automated basket. In this case, the entire assembly moves on an overhead gantry that raises and lowers a basketful of film into each process tank at preprogrammed times.

Roller transport machines consist of a series of solution tanks. These machines use a combination of pinch rollers and belts to feed materials through each tank in the series. Roller transport machines are commonly used for sheet film, narrow widths of professional and aerial film, and for enlargements/large format prints.

The continuous-length processor is generally used for movie films and long rolls of film and paper. Short rolls can be accommodated if they are first spliced together, end-to-end. A continuous-length processor consists of a series of deep tanks with roller racks or transports in each tank, and feed and take-up mechanisms that typically include a slack box to facilitate splicing without stopping the main drive. The film travels back and forth in each processing tank over a series of rollers on the rack.

Although a significant amount of electricity is used to drive automatic photofinishing machines, the majority of photofinishers are not concerned with the energy efficiency of their motor-based systems. Typically, if a motor or motor system component fails, the part is replaced with one that is identical. The efficiency of a motor system, however, influences the overall energy efficiency of a facility. For this reason, photofinishers may want to consider using high-efficiency electric motors. Likewise, adjustable speed drives could be employed to reduce the amount of electricity used, but they are unlikely to be applied due to their complexity.

Efficiency Technology Solution
Energy-Efficient Electric Motors

Energy-efficient electric motors (also known as high- or premium-efficiency motors) are typically 2–6% more efficient than their standard counterparts, and cost 15–30% more than standard motors. Over a typical 10-year operating life, a motor can consume electricity valued at over 50 times the initial cost of the motor. As a result, energy-efficient motors are extremely cost-effective when compared to purchasing a standard-efficiency motor. Their simple payback of less than 2 years is typically attractive unless electricity prices are very low, or a motor is operated infrequently.

Energy-efficient motors offer more than just reduced electricity consumption. They are generally manufactured to closer tolerances, use better materials, and offer more robust construction, when compared to standard motors. These qualities translate into improved reliability and reduced maintenance requirements.

Wastewater Treatment

Most photoprocessing plants discharge their wastewater to municipal sewer systems after proper on-site treatment. Pollutants enter photofinishing wastewater from working solutions, replenishment solutions, equipment cleanup, and facility washdowns. Commercially available filtration equipment exists to capture and recycle spent developer, bleach, bleach-fix, and fix-processing solutions. Equipment is also available to recover silver that is present in the wash water after the fix bath.

There are many reasons to recover silver from photofinishing operations. Silver is a valuable metal in finite supply, it has monetary value as a recovered metal, and its release into the environment is strictly regulated. Silver compounds are the basic material used in the majority of photographic films and papers.

At a minimum, photofinishing labs can recycle a good portion of their process solutions and recover silver to below 1 milligram/liter before discharging to the sewer by using a combination of filtration and silver recovery methods. If financial resources are less limited, however, the best way for a photofinishing facility to control costs, reduce pollution, and maximize silver recovery, is to first pursue a variety of waste-minimization options.

Waste Minimization. The photofinishing industry is currently emphasizing pollution prevention in the form of chemical recycling, process improvements, and process chemistry changes that can result in a substantial reduction in a facility's use of chemicals. Silver effluent concentrations also have been drastically reduced through process improvements and greater use of silver recovery technologies. The process chemistry changes available to reduce the toxicity of photofinishing wastewater include the use of the following solutions:

- Low-Replenishment Developer. Many facilities choose effluent reduction as a means of complying with local POTW regulations. Although chemical regeneration systems are effective in reducing the amount of effluent discharged to the POTW, many facilities are instead using low-replenishment developer. In contrast to a chemical regeneration system, changing to the use of low-replenishment developer does not require additional equipment, retraining of personnel, or valuable floor space. The use of a low-replenishment developer simply minimizes waste generation: it reduces developer overflow discharge 60–85% when compared to a standard developer, resulting in lower biological oxygen demand and lower chemical oxygen demand (COD) in the effluent.

- Bleach-Fix Replenisher. Photofinishing bleach that contains ammonia can fertilize both wastewater treatment plants and rivers. New, pleasant-smelling, biodegradable bleaches that have 50% less ammonia, 65% lower COD, and a 33% lower replenishment rate have been developed.

- Formaldehyde-Free Stabilizer. Some automated film processing methods use a formaldehyde-containing solution as a stabilizing agent in the final film bath. Formaldehyde, however, is a known carcinogen; it is also a skin irritant. Manufacturers have introduced formaldehyde-free stabilizers that replace formaldehyde with a formaldehyde precursor. The precursor reacts quickly with couplers in the film emulsion and releases no formaldehyde.

Other potential waste-minimization measures include shutting off the water flow when film processing stops. This reduces both water consumption and wastewater generation, but can lead to increased waste concentration in effluent. Squeegees can also be used between photographic baths to wipe excess liquid from the moving photographic material. Wiping decreases chemical carryover into the next bath solution, thereby reducing the potential for contamination and the need for replenishing. This can decrease operating costs. Another possible waste-minimization measure is a counter-current rinsing system. In such a system, the fresh water flows from the last tank in the series toward the first tank in the series so that it comes in contact with the "cleanest" film first and is then reused on the "dirtier" film. This reduces the amount of rinse water needed. These measures are most applicable to labs that use large, automated systems. A self-contained minilab or microlab would have to purchase new equipment that incorporates waste minimization to adopt these measures.

Wastewater Treatment Technologies. Many photofinishers recover silver and capture and recycle photoprocessing solutions; fixer and bleach-fix contain 80–100% of the recoverable silver. In addition, through the regeneration of various solutions, color photoprocessors can reduce their purchases of developer and replenisher by 50%.

The most common methods of silver recovery include metallic replacement and electrolytic recovery. A chemical precipitation method is also available, but is less commonly used. Other technologies, including ion exchange, membrane filtration (specifically, reverse osmosis), and vacuum evaporation, provide a means of concentrating solutions that contain silver, thereby making it easier to recover or refine the silver, or reduce the volume of wastewater that must be transported off-site for treatment and disposal. These technologies are generally used to supplement the more basic silver-recovery options discussed above. In addition to use for silver-bearing wastewater management, these technologies are increasingly effective for capturing and recycling other important photoprocessing solutions.

Metallic replacement cartridges (also known as chemical-recovery cartridges or silver-recovery cartridges) are commonly used for silver recovery in photofinishing labs. Metallic replacement occurs when a metal, such as iron, contacts a solution containing dissolved ions of a less active metal, such as silver. The dissolved silver reacts with the iron and settles out as a sludge that can be collected and shipped (as a nonhazardous waste in some states) to a metal reclamation center. Iron in the form of steel wool is frequently used because of its convenience and economy. Metallic replacement cartridge equipment is relatively inexpensive, and installation involves only a few plumbing connections.

Electrotechnology Solution
Electrolytic Recovery of Silver

Electrolytic units are an increasingly popular method of recovering silver from photoprocessing wastewater. The electrochemical process strips wastewater of its dissolved silver ions by passing an electric current through the wastewater, causing the metal ions to deposit onto a series of cathodes as a highly pure, solid metal. Once the cathodes are full, the high-grade silver can be sold for its metal value.

Electrolytic units are efficient and cost-effective at recovering up to 90% of any available silver. They can be used alone or in combination with ion exchange units to treat the regeneration effluent. The process has the advantage of producing no toxic sludge, thereby reducing the cost and potential future liability associated with sludge disposal. In addition, electrolysis units operate efficiently at both high and low concentrations of dissolved silver and require only routine replacement of the cathode.

Chemical precipitation is the oldest and least expensive method of silver recovery. It is used mostly by manufacturers of photographic supplies and, in some instances, by photoprocessors. Chemical precipitation can be used for primary or secondary silver recovery but is usually more appropriate for secondary recovery. Sodium sulfide, sodium borohydride, or sodium dithionite are often used as metal precipitating agents and can remove virtually 100% of the silver.

Chemical precipitation involves a relatively small capital investment and uses chemicals that are relatively inexpensive. It is not favored by photofinishers because it involves handling large amounts of chemicals, the separation and concentration processes are difficult and labor-intensive, and careful control is necessary to avoid generating toxic hydrogen sulfide gas. Chemical precipitation is not advisable unless personnel are adequately trained to use these chemicals.

Electrotechnology Solution
Ion Exchange

Ion exchange is a silver-recovery technique applicable to large volumes of low-concentration solutions such as wash waters. It is appropriate for photofinishing facilities that have large volumes of dilute wastewater such that silver recovery from these streams is economical. It is also appropriate for facilities that want to reduce the silver concentration in effluent to meet new, more restrictive discharge limitations.

The ion exchange process uses a weak anionic resin that must be activated by acidification. When activated resin comes in contact with silver-bearing solution, the resin exchanges a hydrogen or sodium ion for the silver thiosulfate and other metal ions present in the effluent, thus allowing the water to be recycled. When the resin reaches capacity, silver is stripped from the resin in a concentrated form using a regeneration solution.

Ion exchange using a strong anionic resin can also recover and recycle color developer. In this case, the process removes bromide ions and decomposition products that accumulate and wear out a developer. Once filled to capacity, the ion-exchange resin is regenerated with sulfuric acid or, in a few cases, sodium hydroxide. Because of the high capital investment required for ion exchange equipment, only larger photofinishing facilities use it to recover developer.

Electrotechnology Solution
Membrane Filtration

Various types of membrane filtration can be used in the photofinishing industry to recover materials and reduce hazardous wastes and contaminants in discharge water. In these systems, electric-driven pumps force wastewater through permeable barriers that filter out the selected pollutant components, depending on the particle size. Reverse osmosis filtration is typically used to remove silver in photofinishing labs. Once the silver is separated from the wastewater, it can be recovered by conventional means—metallic replacement, chemical precipitation, or electrolytic recovery—and sold to a metal reclaimer.

Electrotechnology Solution
Vacuum Evaporation

Several companies have developed a “total recycle system” that removes photographic chemicals and silver from wastewater by vacuum evaporation. The silver is recovered for its value, and the chemicals are recovered for reuse. By heating wastewater under a vacuum, vacuum evaporation vaporizes water at temperatures below the boiling point of water (212°F). Water and chemicals can therefore be separated without the chemical degradation that can occur with vaporization at higher temperatures. This technology allows recycling of nearly 100% of the developer, bleach, fixer, and bleach fix, reducing operating costs and resulting in a very small volume of chemical waste for off-site treatment. Experience shows that to achieve a payback of two to three years, a lab must process a minimum of 1000 rolls per day.

Heating, Ventilation, and Air Conditioning

All photofinishers, from local minilabs to national mail-order facilities, use highly automated equipment that can yield poor-quality finished products if not operated under appropriate ambient conditions. Many facilities also store large quantities of processed and unprocessed photographic material whose rate of deterioration is largely dependent on temperature and humidity. Careful control of ambient conditions is required; high temperature and humidity increase the loss of photosensitivity, while low humidity causes brittleness in film. Each film manufacturer has its own recommendations for film storage and handling; it is important to ensure that proper conditions are maintained for each brand of film.

Film processing generates a considerable amount of heat, humidity, and fumes. The resulting HVAC loads require constant control. Recognizing that product quality is highly dependent on proper space conditioning, an HVAC control system that maintains the necessary ambient properties is a necessary—and relatively inexpensive—quality control measure.

In larger photofinishing labs, the film development process often begins with splicing individual rolls of exposed film into a continuous strip. The splicing is typically done in a special room held at 70–75°F and a relative humidity of 50%.

Film processing involves a series of chemical tanks and rinse tanks that give off heat, water vapor, and noxious fumes. In the processing area, general room exhaust is commonly required, as well as local exhaust at points along the process flow. Some machines are open; they require an exhaust mechanism in the space adjacent to the unit. Enclosed machines typically have built-in exhaust connections. The makeup air must be tempered to hold the processing space at a maximum of 80°F and 50% relative humidity, and ventilation should provide 10 air changes per hour. For example, a 30-foot by 50-foot processing room with a 12-foot ceiling would require about 2250 cfm of ventilation air. At design conditions, this is an outside air cooling load of 8.5 tons, in addition to the regular space conditioning load.

After the final rinse, film is transported to a cabinet dryer where its final moisture content is established. A hood over the dryer exhausts heat and moisture outside of the building. Space conditioning is typically required to provide operator comfort in the drying room.

A dust-free environment is essential for quality photofinishing. Consequently, filter systems should be installed in the HVAC system ductwork to capture particulate in the airstream and prevent them from entering the processing area. Disposable bag filters provide an inexpensive yet effective means of lowering the particulate content of the air. Filters rated at 85% or higher should be used as they remove 85% of the particulate in a typical airstream. It is also advantageous to place lower-efficiency prefilters upstream; the prefilters can improve the effectiveness of the downstream filters and extend the time between filter changeouts.

The HVAC systems used by photofinishers vary with the size of the operation. Minilabs that operate packaged self-contained processing machines typically utilize small packaged air-cooled or water-cooled units (these can be rooftop, slab-mounted, or located behind a building). Such standard packaged units, however, cannot control the temperature or the humidity as well as necessary. Instead, special packaged units are required that have hot gas bypass (to prevent compressor cycling), preheat and reheat coils (for humidity control), and humidifiers (for dry wintertime conditions). Central station air-handling units are also appropriate for applications requiring high levels of control. In this case, cooling is provided by a remote compressor/condensing unit and direct expansion coil or, alternatively, by a remote water chiller and chilled water coil. Heat is usually provided by electric resistance, steam, or hot water coils (in conjunction with a gas or oil boiler). The air-handlers are easy to arrange to cope with outside air requirements and special filters.

Alternative systems are uncommon among photofinishers. Switching to a central chilled-water system from a packaged system would be costly and difficult to justify on the basis of energy cost savings alone. The phaseout of chlorofluorcarbon (CFC) refrigerants is not an impetus for changeout either, because most photofinishers, whether using packaged or central systems, have noncentrifugal compressor cooling equipment that uses HCFC-22. Hydrochlorofluorcarbons (HCFCs) have a lower ozone-depleting potential than CFCs and are not scheduled for phaseout until 2004. Therefore, photofinishers using HCFC-22 have more time to decide on replacing their refrigerants.

Efficiency Technology Solution
Heat Recovery

Energy conservation opportunities in this industry center on heat recovery from exhaust air for use in preheating makeup air. Heat pipes, heat wheels, or other similar heat recovery devices are used. The ongoing discharge of warm wastewater provides an excellent opportunity to recover energy using a concentric tube heat exchanger. Such installations are typically inexpensive and, depending on hot water use, can provide an attractive payback period.

Desiccant Dehumidification

Humidity and temperature control can be provided by conventional equipment alone, or by conventional equipment supplemented by desiccant dehumidification. The size of a facility and the outside ambient conditions drive the equipment capacity requirements and determine the feasibility of a separate humidity control system. Installing a desiccant dehumidification system simply to control humidity is not likely to be a cost-effective investment. However, when adding capacity or retrofitting equipment, desiccant dehumidification can represent an attractive option. Desiccant dehumidification allows humidity control independent of the cooling system. Separate dehumidification allows workers to establish the proper humidity level without overcooling the facility. Conventional systems rely on the cooling system to remove moisture, thus often overcooling the air and creating conditions uncomfortable for workers.

Lighting

Lighting accounts for approximately 12% of the photofinishing industry’s total electricity consumption. Since quality work and reasonable turnaround times are essential to successful photofinishing, lighting systems are needed that provide sufficient illumination in terms of quantity and quality of light. Even in a minilab, an operator must check the prints to ensure their quality. If photoprocessing chemicals or process timing are off, the prints may be too dark, too light, or otherwise damaged. In labs that process commercial work, for a portrait photographer, for example, quality is commonly closely scrutinized by the customer. Adequate lighting is critical to the timely and proper completion of jobs that require keen attention to detail.

Photofinishing labs, therefore, require high lighting levels with good color rendition. Lighting that is too bright, however, can affect equipment operation and balancing. Proper lighting—brightness without glare—can contribute to efficient equipment operation and potentially to employee health, morale, and productivity.

The majority of lighting systems used in photofinishing shops are fluorescent tubes with magnetic ballasts. These systems are the workhorse for commercial lighting. Fluorescent fixtures come in a variety of shapes and sizes. Some of the most common are 4-foot-long tubes used in two-, three-, or four-tube fixtures; 8-foot-long tubes are also used, particularly in large warehouse-type facilities. The basic components of a fluorescent lighting system are fixture, reflector, switch, tubes, ballast, and lens.

Incandescent lighting systems are also frequently used in photofinishing labs. Incandescent lamps are appropriate for retail areas, hallways, and for highlighting certain products; they are also used for decorative lighting (e.g., on signs and displays), and for exit lights. The most common application is in ceiling-mounted down lights, also referred to as recessed cans. These fixtures are relatively inexpensive and easy to install. However, incandescent lighting is the least efficient lighting source available.

Another type of lighting used in larger photofinishing facilities is high-intensity discharge (HID) lamps. The HID family of lamps includes mercury vapor, metal halide, and high-pressure sodium. Although these lamps are typically installed in parking lots and driveways, they can be used in large warehouse-style facilities. Mercury vapor is the least efficient lighting source in this category.

Efficiency Technology Solution
Energy-Efficient Indoor Lighting

The most efficient form of fluorescent lighting available today is the T-8 fluorescent lamp with an electronic ballast. Conversion from a magnetic (T-12, 40-watt) ballast to an electronic (T-8, 32-watt) ballast can be accomplished by either retrofitting the existing fixture or installing a new fixture designed for T-8 lamps, at a cost of roughly $40 or $100, respectively. Ceiling-mounted incandescent lamps can be successfully replaced with compact fluorescent lamps when the ceiling height is less than 12 feet, such as in hallways. Mercury vapor lamps can be replaced with either metal halide or high-pressure sodium lamps with relatively short payback. All of the HID lamps have significantly longer lives than incandescent lamps and many fluorescent lamps.

Electrotechnology Solution
Energy-Efficient Outdoor Lighting

Outdoor lighting also can be a part of a photofinishing lab’s energy bill. Existing applications range from incandescent lights on building signs to mercury vapor lights in parking lots and driveways. These lighting systems normally represent only a small portion of the energy bill because they are on for limited periods of time and seldom contribute to a facility’s peak electrical demand. This means that the cost of operation, in terms of cents per kilowatt-hour, is normally less than that of other systems (e.g., HVAC and indoor lighting) and that the potential savings from energy conservation projects may be smaller. Increasing outdoor lighting can have other important benefits in reducing the potential for crime, increasing employee safety, and enhancing the visibility of a facility.

4

ELECTROTECHNOLOGY PROFILES

This section provides profiles of the electrotechnologies identified in Sections 2 and 3. Each profile explains the technology, its advantages and disadvantages, commercial status, and costs. The profiles have been designed as stand-alone descriptions so they can be utilized separately from this guide. Turn to Section 5 for a list of equipment vendors that can provide further information as needed.

Electrolytic Recovery of Silver

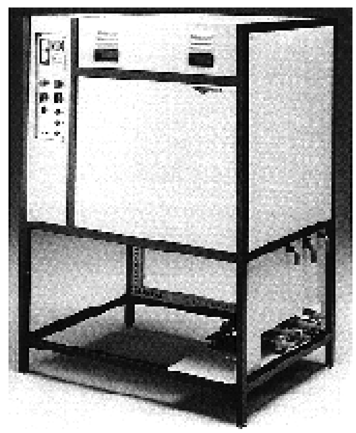
Basic Principle

Electrolysis uses an electric current to cause a chemical change in a substance in solution. In one type of electrolysis, metal ions in solution are reduced to metals plated onto a series of cathodes. Loaded cathodes can be sold to a metal reclaimer. The process (sometimes referred to as "electrowinning") is generally used to treat spent process or rinse water prior to subsequent treatment or discharge to a publicly owned treatment works (POTW).

Most facilities remove metal from wastewater through chemical precipitation and sedimentation, producing a toxic sludge that requires proper disposal as a hazardous waste. Electrolysis produces no sludge, thereby eliminating the cost and the potential liability associated with hazardous sludge disposal. Electrolysis is an efficient process at both high metal concentrations (process streams) and low metal concentrations (rinse streams). The only maintenance task is routine replacement of the cathodes. Electrolysis can recover precious metals, such as gold and silver, and other metals, such as copper, brass, nickel, zinc, and cadmium. The imagemaking film used in photoprocessing and printing contains silver; film development generates silver-bearing wastewater. The platemaking step of the printing process can also generate heavy metal-bearing wastewater.

System Description

There are two types of electrolytic silver recovery systems: terminal (or tailing) and closed loop. The terminal system usually is connected to the spent-fixer overflow pipe of a photoprocessor. Spent fixer trickles into the terminal system at the same rate as fresh fixer is introduced into the processor; it flows out of the terminal system at the same rate at which it was introduced. Any silver present in the spent fixer plates out at the rate of 4 grams per amp per hour. The main disadvantage of a terminal system is that it does not manage the substantial volume of silver that is transported from the processor's fixers into the wash tank as film is moved from one tank to the next. This can result in nonrecovery of approximately 30% of the silver released from the film. Another disadvantage is that spent fixer is generally introduced into a terminal system faster than the system can plate out the silver content. Consequently, the spent fixer that is released for sewage disposal still contains silver. This not only results in a further loss of recoverable silver but may hamper compliance with pollution control regulations.



Courtesy of R.J. Brimo Enterprises, Ltd.

Figure 4-1
Electrolytic Silver Recovery System

A closed-loop electrolytic system is attached to a processor's fixer tank and acts as a continuous electronic filter. As the fixer solution is pumped through the system, the silver is removed through electrolysis and the desilvered fixer is returned to the fixer tank. This type of system can recover significantly more silver than a terminal system and reduce the tank carryover losses to negligible levels. Maintaining a low silver concentration in the fixer tank (less than 1 gram per liter) minimizes silver carryover to the wash tank. A closed-loop unit recovers up to 15% more silver than a conventional system and reduces overall fixer consumption by as much as 75%. It is considered to be the most effective system for silver pollution control for facilities that utilize photoprocessors. The only drawback is that improper operation of the system can cause problems in overall production.

Advantages

- Reduces the volume of hazardous waste, thereby minimizing the need for chemical waste treatment
- Reduces or eliminates the costs associated with hazardous waste disposal
- Improves rinse quality and life
- Reduces water use
- Efficient operation at both high and low silver concentrations
- Reduces the costs of chemicals and labor
- Permits the recovery of silver

Disadvantages

- Terminal system: The fixer released to the sewer contains some silver.
- Closed-loop system: Improper operation can result in production problems.

Commercial Status

Electrolytic silver recovery is common among printers and photofinishers. Units are available from vendors nationwide in sizes of 1–100 square feet (or more) of cathode surface area. Larger custom units are also available.

Cost and Electrical Requirements

The installed cost for a standard flat-plate cathode unit depends on the cathode surface area, which is itself dependent on the amount of metal to be recovered. For small, bench-top batch systems requiring manual wastewater input, the cost range is $1300–$3300. This type of system can recover 0.4–2.0 troy ounces of silver per hour utilizing a cathode surface area of 1–2 square feet. Larger units with automatic controls and a cathode surface area of 3–10 square feet can recover 3.2–10 troy ounces of silver per hour; these systems cost $13,000–$20,000. Very large systems with 100 square feet of cathode surface can cost $60,000. These costs can be partially offset by annual savings from recycling bleach fix, reduced need for wastewater treatment chemicals, and a reduced volume of hazardous sludge, as well as the value of the recovered silver. The electrical requirements for a particular application are difficult to predict due to variables including, but not limited to, conductivity, required voltage, and rectifier and current efficiency.

Table 4-1
Electrolytic Recovery of Silver System Characteristics

Dimensions	Length: 8–40" Width: 10–40" Height: 10–70"
Cathode Size	10–100 sq ft
Energy Consumption	0.01–0.6 kWh per troy ounce
Key Inputs Power Other	 Electricity Cathodes and anodes
Key Outputs Solid Waste Air Emissions Water Effluent	 Cathodes loaded with silver Venting required in most applications Treated or desilvered fixers are returned to the image-processing or film-development step
Cost Purchase Installation Other Supplies	 $1300–$60,000 Minimal $0.003–$0.085 per troy ounce of recovered silver

Ion Exchange

Basic Principle

An ion exchange unit can remove low concentrations of heavy metals from wastewater. The process employs specially charged materials, called ion exchange resins, that exchange metal ions for nonmetal ions and later release the metal ions to a regeneration solution. The resins have high removal capacities and a relatively long operating life.

Ion exchange units have several applications, including separating metals from dilute rinse waters, regenerating acid baths that contain metals, and recycling rinse water. An ion exchanger separates metal salts (metal ions) from the rinse waters of anodizing, etching, stripping, and electroplating operations. The resulting concentrated metal-acid solution (regenerate) is often treated by electrodialysis or electrolysis for solid metal or metal salt recovery. Gold, silver, copper, nickel, chromium, and zinc are among the metals that can be removed from wastewater. However, to remove more than one metal from a waste stream typically requires a resin bed for each metal.

System Description

In an ion exchange unit, metal-bearing wastewater is pumped through columns of chemically treated resin. Metal ions are removed from the wastewater and concentrated as they chemically attach to the resin, which exchanges a hydrogen or sodium ion for a metal or chemical ion. When the resin sites are filled, the resin can be regenerated with an acid solution; this solution causes the resin to reexchange a metal or chemical ion for a hydrogen or sodium ion. The metal-rich regenerate is then treated with electrolysis to recover the metal. The resin must be replaced periodically, when it can no longer be regenerated. Organic contaminants in the wastewater can lead to a loss of resin capacity.

Courtesy of the Engineering Systems Division of Kinetico Inc., Newbury, Ohio.

Figure 4-2
Ion Exchange System

Advantages

- Extracts essentially all metal ions from relatively dilute waste streams
- Produces effluent suitable for discharge without further treatment
- Low capital and operating costs compared to other recovery technologies
- Low energy demand compared to other recovery technologies

Disadvantages

- May not be capable of recycling a highly concentrated waste stream
- Requires precise operation and maintenance
- Produces metal hydroxide sludge

Commercial Status

Ion exchange units have been used for decades. This technology is well-established and commonly used in a variety of industries, including electronics and photofinishing, to treat heavy metal-bearing wastewater.

Cost and Electrical Requirements

Ion exchange systems have relatively low capital and operating costs. The purchase cost depends on system size and complexity. For a small unit processing 30–480 gallons per hour, the cost is $1000–$20,000. For larger units, processing 200–1800 gallons per hour, the cost is $20,000–$100,000. A fully automated system processing 14,000 gallons per day with two sets of beds has a capital cost of about $35,000. Operating costs are approximately $3500 per year, based on a 150-ppm metal waste stream.

Table 4-2
Ion Exchange System Characteristics

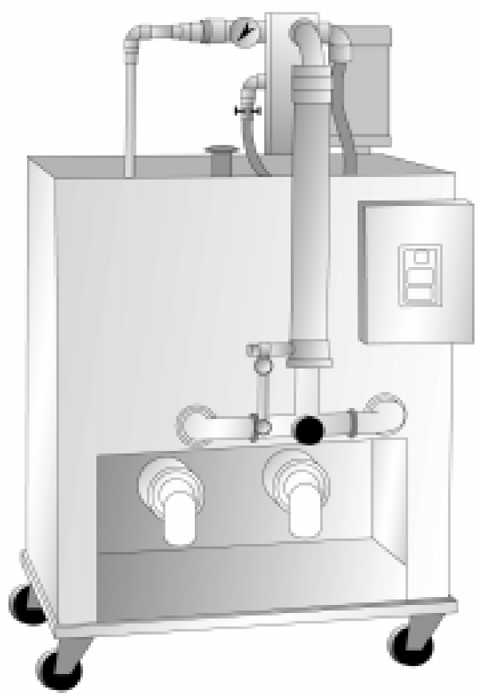
Capacity	30–1800 gal/h
Dimensions	Diameter: 2–12' Height: 6–10'
Energy Consumption	0.07–5.6 kW
Key Inputs	
Power	Electricity
Other	Resins
Key Outputs	
Solid Waste	Recovered metal
Air Emissions	None
Water Effluent	Treated water can be discharged
Cost	
Purchase	$1000–$100,000
Installation	Minimal
Other Supplies	Resins

Membrane Filtration

Basic Principle

Membrane filtration is used by various industries to recover materials and reduce hazardous wastes and contaminants in discharge water. In this process, electrically driven pumps force wastewater through a permeable barrier that filters out selected pollutant components, depending on their particle size.

Membrane separation processes include microfiltration, ultrafiltration, and reverse osmosis, and are distinguishable on the basis of the particle size filtered. Microfiltration systems have the largest pore size and capture particles from 1000–10,000 angstroms (i.e., suspended solids). Ultrafiltration systems capture particles larger than 10 angstroms—with greatest efficiency up to 1000 angstroms—which includes emulsified oil and grease, detergents, and precipitated metal hydroxides. The smallest membrane filtration systems are reverse osmosis systems, which act as a barrier to everything larger than 5–20 angstroms, including heavy metals and salts. As membrane pore size decreases, additional pressure is needed to force wastewater through the filter.



Courtesy of Koch Membrane Systems, Inc.

Figure 4-3
Ultrafiltration Unit

System Description

In membrane filtration systems, wastewater is circulated under pressure in contact with a specially constructed membrane. Water and some dissolved matter (depending on the type of membrane) passes through, while other contaminants do not. The systems are generally modular, designed as self-contained pressure vessels; microfiltration typically operates at pressures of 1–25 psi; ultrafiltration, at 10–100 psi; and reverse osmosis, at 400–800 psi. Continuous pressure is maintained by an electrically driven pump.

Advantages

- Pollution control: Membrane filtration systems decrease the waste load, thereby reducing the amount of treatment required prior to discharge.
- Low energy requirements: Membrane filtration systems require less energy than conventional phase-change processes.
- Limited maintenance requirements: No moving parts reduces the need for maintenance.
- Limited water use: Membrane filtration systems allow for recycling and reuse of the permeate by removing suspended solids.
- Modular, compact systems: The systems require less space than either evaporation or distillation processes and can be added to an existing wastewater treatment process.
- Cost savings: In general, membrane filtration systems cost a fraction of phase-change systems.
- Labor savings: Fewer person-hours are required due to reductions in materials handling and process control requirements (compared to chemical precipitation).

Disadvantages

- Membrane filtration systems are susceptible to damage by a variety of inorganic and organic compounds.
- Fouling can occur when particles collect on membrane surfaces.

Table 4-3
Membrane Filtration System Characteristics

	Microfiltration	Ultrafiltration	Reverse Osmosis
Energy Consumption	1.0–3.0 kWh/100 gal of permeate	1.0–6.0 kWh/100 gal of permeate	1.0–7.0 kWh/100 gal of permeate
Capacity	0.1–10.0 gal/min	0.1–10.0 gal/min	0.1–10.0 gal/min
Key Inputs			
Power	Electricity Membrane	Electricity	Electricity
Other		Membrane	Membrane
Key Outputs			
Solid Waste	Organics, metals	Oil, grease, solids	Heavy metal, salts
Air Emissions	None	None	None
Power	None	None	None
Cost			
Capital	$5000–$100,000	$5000–$100,000	$10,000–$130,000
Installation	10–30% of purchase price	10–30% of purchase price	10–30% of purchase price
Operating	$0.05–$0.40/100 gal	$0.05–$0.30/100 gal	$0.10–$0.30/100 gal

Commercial Status

Membranes have been used for over a decade to remove toxic metals and organics from wastewater. Membrane separation processes are currently used in such industries as wood preserving, electroplating, metal finishing, food processing, chemical processing, printing, photofinishing, and pulp and paper processing. Membrane filtration units are available from a large number of vendors nationwide; unit capacities range from 0.1 to more than 500 gallons per minute.

Cost and Electrical Requirements

Capital and operating costs depend primarily on the type of membrane and its specific application. The purchase cost for either an ultrafiltration system or a microfiltration system for a plant processing 5 gallons per minute is about $34,000, and the operating cost is about $0.40 per 100 gallons. A reverse osmosis system processing the same amount would cost $30,000–$35,000, and have an operating cost of about $0.30 per 100 gallons.

Electrical requirements depend on the type of application, unit size, membrane type (pore size), waste stream temperature, pressure, and flow rates. Electricity is required for pumping water through the system. Units for small operations range in size from 0.1–10.0 gallons per minute and require 4–10 kilowatts of electricity, respectively. In this range, the electricity usage of a microfiltration unit is 1.0–3.0 kWh per 100 gallons of filtered water (permeate), the usage of an ultrafiltration unit is 1.0–6.0 kWh per 100 gallons of permeate, and the usage of a reverse osmosis unit is 1.0–7.0 kWh per 100 gallons of permeate.

Vacuum Evaporation

Basic Principle

Vacuum evaporation technology vaporizes wastewater at temperatures below the boiling point of water (212°F). The water and chemicals can then be separated without the chemical degradation that can occur with vaporization at higher temperatures. The water can be recovered for reuse or disposal. The concentrated liquid left in the vacuum chamber can be sent to a filter press for further dewatering, or to the plating tank for reuse. This process reduces the residual waste to a fraction of the amount produced with conventional wastewater treatment technology, allowing the recycling of water and chemicals and reducing disposal costs.

Courtesy of R. J. Brimo Enterprises, Ltd.

Figure 4-4
Vacuum Evaporation Unit

System Description

In metal processing or finishing facilities, solution chemicals are dragged from plating tanks or parts-cleaning baths and into rinse tanks. With vacuum evaporation, the chemical-bearing rinse water is pumped into a vacuum chamber, where the wastewater is vaporized at temperatures as low as 110°F. The vapor rises through a mist separator where particulate matter is removed. A cooling coil causes the steam to condense, and distilled water forms in the reservoir and can be returned to the rinse tank for reuse. As the water is driven off, dissolved metal salts concentrate in the effluent. This valuable liquid is collected and returned to the plating or other process tank. Because of the low temperatures, degradation of heat-sensitive plating chemicals is held to a minimum. This process can recover many plating chemicals and detergents; metals such as chrome, nickel, copper, cadmium, brass, zinc, silver, gold; alkalies and acids; and industrial wastewater.

Advantages

- All rinse water can be recycled.
- No fumes or odors are produced.
- Nearly complete recovery of metal waste.
- Low-temperature operation.
- Continuous discharge operation possible.
- Reduces operating costs by recovering/recycling metals, solutions, and water.
- Reduces the amount of sludge for disposal.
- Requires minimal space.

Disadvantages

- Potential buildup of condensing organics requires periodic cleaning.
- High initial investment.
- The residual waste can contain traces of hazardous materials and requires proper disposal.

Commercial Status

Ion exchange and electrolysis are mature waste stream recovery technologies now in common use. Vacuum evaporation nearly completely eliminates water discharge from metal or electronics processing/finishing facilities and, therefore, may be adopted widely in the future if pretreatment standards tighten further. This technology can also be used to minimize wastewater discharge in other industries, such as photofinishing. Vacuum evaporation units are commercially available from a number of companies nationwide in capacities ranging from 0.6–3000 gallons of wastewater per hour. One manufacturer has an automatic recirculating system in which aqueous effluent is continuously introduced into the evaporation chamber.

Cost and Electrical Requirements

Vacuum evaporation has low operating costs (as low as $0.01 per gallon), requires no operating chemicals, and generates few residual chemicals and/or sludge, while also minimizing water use. The payback period is typically 3 months to 1 year.

The small units typically used by metal finishing or photofinishing operations process 0.01–1.0 gallon per minute and have a power draw of 1.5–20.0 kW, respectively. The primary electricity user is the vacuum pump; the secondary user is the recirculating pump. Most small vacuum evaporation units cost $7000–$28,000, with larger units reaching costs of $154,000. An operation with a 1.0-gpm unit would consume less than 100,000 kWh/yr, assuming an operation rate of 5000 h/yr.

Table 4-4
Vacuum Evaporation System Characteristics

Evaporation Rate	0.01–1.0 gal/min
Dimensions	Length: 18–71" Width: 12–99" Height: 12–115"
Energy Consumption	1.5–20.0 kW
Key Inputs	
Power	Electricity
Other	None
Key Outputs	
Solid Waste	Metal-bearing sludge
Air Emissions	None
Water Effluent	Water can be recycled or discharged to the sewer
Cost	
Purchase	$7000–$154,000
Installation	Minimal
Other Supplies	None

Outdoor Lighting

Basic Principle

Many small businesses benefit from enhanced outdoor lighting through reduced potential for crime, increased employee safety, and improved visibility and attractiveness of the facility.

These benefits are obtained for a relatively small operating cost because, in most cases, outdoor lighting does not contribute to a facility's peak electrical demand. This means that the average energy cost for outdoor lighting (in terms of cents/kWh) is typically less than the energy cost of other improvements.

There are three principal methods for using outdoor lighting in small businesses:

1. Signage on the exterior of the building or illuminated signs near the building to generate attention for the building or the small business
2. General lighting in parking lots, driveways, parking garages, and walkways
3. Facade lighting to increase the visibility of the structure and surrounding architectural features and landscaping

Different lighting technologies are typically used for different applications. Existing lighting systems can often be retrofitted or replaced by energy-efficient lighting systems. In addition, existing lighting systems can be supplemented with new lighting systems to increase safety, security, visibility, and name recognition.

Table 4-5
Typical Outdoor Lighting Applications

Type of Light	Exterior Signage	Parking Garages	Parking Lots/ Driveways	Walkways	Facade and Landscaping
Incandescent	■			■	■
Compact Fluorescent		■		■	■
Fluorescent	■	■		■	■
Metal Halide		■	■	■	■
High-Pressure Sodium			■		
Mercury Vapor			■		

Note: Additional applications are possible for each of the lighting types, but the chart identifies the most efficient applications for each of the light sources. Low-pressure sodium lamps are not normally used in small businesses because of their poor color quality.

System Description

Mercury vapor, high-pressure sodium (HPS), and metal halide lamps are referred to as high-intensity discharge (HID) lamps. Metal halide lamps and HPS lamps provide approximately 100 and 140 lumens per watt, respectively, while mercury vapor lamps provide up to 60 lumens per watt. Mercury vapor lamps emit a blue-green light, while HPS lamps emit a yellow-orange light. Metal halide lamps emit a predominately white light. Most HID lamps require a spacing-to-mounting height ratio of 1.0–1.9, which means that the spacing is roughly one to two times the pole height.

Each HID lamp requires a specific ballast to drive the lamp; however, some manufacturers offer metal halide and HPS lamps that can be operated by a mercury vapor lamp ballast. This allows easier conversion from inefficient mercury vapor lamps to higher-efficiency metal halide and HPS lamps. HID lamps are available in a variety of wattages from 35–1500. The HID ballast adds approximately 8–15% to the wattage of the lamp.

Fluorescent lamps are also used as outdoor lighting sources for small businesses. Conventional 4-foot and 8-foot tubes are used in many parking garages and covered walkways. Compact fluorescent lamps are also becoming popular as replacements to incandescent lamps in stairways. Newer T-8 lamps and electronic ballasts are approximately 30% more energy-efficient than older 40-watt T-12 lamps with magnetic ballasts.

Incandescent lamps are the least efficient form of outdoor lighting. However, incandescent lamps are still used as spotlights on signs and as floodlights on building facades and landscaping. The short lifetime of incandescent lamps often has a bigger impact on operating costs than does the additional energy use.

Common controls used for outdoor lighting systems include time clocks, photocells, and programmable controllers.

Table 4-6
Typical Lamp Characteristics for Outdoor Applications

Type of Lamp	Typical Wattages	Initial Lumens/Watt	Avg Rated Life (h)
Incandescent	60–1,500	15–24	750–2,500
Compact Fluorescent	12–35	25–75	8,000–12,000
Fluorescent	20–215	50–100	9,000–20,000
Metal Halide	175–1,500	69–115	10,000–20,000
High-Pressure Sodium	35–1,000	51–140	7,500–24,000
Mercury Vapor	40–1,000	24–60	12,000–24,000

Note: Initial lumens/watt includes ballast losses.

Advantages

Well-designed outdoor lighting systems can offer the following advantages:

- Increased perception of comfort and friendliness
- Increased security for customers and employees
- Reduced number of accidents in driveways, parking areas, and walkways
- Increased visibility for the facility and the small business

Disadvantages

Other than installation and operating costs, there are no overall disadvantages of outdoor lighting. However, specific lamps do have weaknesses:

- HID lamps require 2–7 minutes to warm-up before reaching full output.
- Metal halide lamps require up to 15 minutes to cool before restrike.
- Special low-temperature fluorescent lamps are required in cold climates to maintain a relatively constant lumen output when temperatures are below freezing.

Commercial Status

All of the lamps described above are readily available from a variety of manufacturers. However, mercury vapor and older T-12 fluorescent lamps are being phased out of production.

Gradual improvements have been made in the efficiency of outdoor lighting systems. In addition, color-corrected HPS lamps are available, as well as improved metal halide lamps that contain incandescent or fluorescent lamps that come on if the power is interrupted.

EPRI Information

Additional information on lighting technologies is available from the EPRI Lighting Information Office, (800) 525-8555.

5

RESOURCES

This section contains three lists: 1) equipment suppliers for the electrotechnologies profiled in this guide, by equipment type; 2) EPRI information sources on efficiency technologies; and 3) photofinishing trade associations. Information used to compile these lists was based on a combination of a telephone survey, published reports, directories, buyer's guides, and technical journals. The information was current at the time of publication and is expected to change over time.

Electrolytic Recovery of Silver

Equipment Suppliers

Andco Environmental Processes, Inc.
595 Commerce Drive, Amherst, NY 14228
(716) 691-2100, fax: (716) 691-2880

Hallmark Refining Corp.
1743 Cedardale Rd., P.O. Box 1446, Mt. Vernon, WA 98273
(800) 255-1895, fax: (360) 424-8118

Kinetico Engineered Systems, Inc.
10845 Kinsman Road, Newbury, OH 44065
(216) 564-5397, (800) 633-5530, fax: (216) 564-1988

Manchester Corporation
280 Ayer Road, P.O. Box 317, Harvard, MA 01451
(508) 772-2900, fax: (508) 772-7731

Memtek Corporation
28 Cook Street, Billerica, MA 01821
(508) 667-2828, fax: (508) 667-1731

Safety-Kleen/Drew Products
1717 Fourth St., Berkeley, CA 94710
(510) 527-7100, (800) 624-4506, fax: (510) 525-5294

Ion Exchange

Equipment Suppliers

Aquapure Technologies, Inc.
2224 E. 14 Mile Rd., Warren, MI 48092
(800) 792-6178, fax: (810) 795-0420

Dewallace Technical Sales, Inc.
366 5th Avenue, Suite 303, New York, NY 10001
(800) 969-0969, fax: (212) 643-1270

Kinetico Engineered Systems, Inc.
10845 Kinsman Road, Newbury, OH 44065
(216) 564-5397, (800) 633-5530, fax: (216) 338-8694

Napco, Inc.,
A Subsidiary of Thermo-Elec
16 N. Harwinton Ave, Terryville, CT 06786
(860) 589-7800, fax: (860) 589-7304

Osmonics, Inc.
5951 Clearwater Dr., Minnetonka, MN 55343
(800) 848-1750, (612) 933-2277, fax: (612) 933-0141

Serfilco, Ltd.
1777 Shermer Road, Northbrook, IL 60062
(847) 559-1777, (800) 323-5431, fax: (847) 559-1141

United States Filter Corp.
10 Technology Dr., Lowell, MA 01851
(800) 466-7872, fax: (508) 970-2465

Membrane Filtration

Equipment Suppliers

Applied Membranes, Inc.
110 Bosstick Blvd., San Marcos, CA 92069
(619) 727-3711, fax: (619) 727-4427

Koch Membrane Systems, Inc.
10 State Ave., Suite 205, St. Charles, IL 60174
(708) 513-0550, fax: (708) 513-0551

544 E. Eisenhower Parkway, Suite 150, Ann Arbor, MI 48108
(313) 761-3836, fax: (313) 761-3844

850 Main Street, Wilmington, MA 01887
(508) 935-7840, fax: (508) 657-5208

LCI Corporation
P.O. Box 16348, Charlotte, NC 28297
(704) 394-8341, fax: (704) 392-8507

Memtek Corporation
28 Cook Street, Billerica, MA 01821
(508) 667-2828, fax: (508) 667-1731

Osmonics, Inc.
5951 Clearwater Drive, Minetonka, MN 55343
(612) 933-2277, (800) 848-1750, fax: (612) 933-0141

U.S. Filter
181 Thorn Hill Road, Warrendale, PA 15086
(412) 772-0044, fax: (412) 772-1360

P.O. Box 560, 4669 Shepard Trail, Rockford, IL 61103
(815) 877-3041, fax: (815) 877-0172

Vacuum Evaporation

Equipment Suppliers

Calfran International, Inc.
P.O. Box 269, Springfield, MA 01101
(413) 732-3616, fax: (413) 732-9246

QVC Process Systems, Inc.
35 West William St., Corning, NY 14830
(607) 936-2500/2516, fax: (607) 936-1192

Roilgard, Inc.
5600 Thirteenth St., Menominee, MI 49858
(906) 863-4401, fax: (906) 863-5889

Technotreat Corporation
5800 W. 68th St., Tulsa, OK 74131
(918) 445-0996, fax: (918) 445-0994

Outdoor Lighting

Equipment Suppliers

Bairnco Corp.
2251 Lucien Way, No. 300, Maitland, FL 32751
(407) 875-2222, fax: (407) 875-3398

Bieber Lighting Corp.
970 W. Manchester Blvd., Inglewood, CA 90301
(213) 776-4744, fax: (310) 216-0333

Bulbtronic, Inc.
45 Banfi Plaza, Farmingdale, NY 11735
(800) 647-2852, (516) 249-2272, fax: (516) 249-6066

Carlon (Lanson & Sessions Co.)
25701 Science Park Dr., Cleveland, OH 44122
(216) 831-4000, fax: (216) 831-5579

Cooper Lighting Group
400 Busse Rd., Elk Grove Village, , IL 60007-2195
(847) 956-8400, fax: (847) 956-1475

Crouse-Hinds Co.
Lighting Production Div., P.O. Box 4999, Syracuse, NY 13221
(315) 477-8185

Doane, L.C., Co.
55 Plains Rd., P.O. Box 975, Essex, CT 06428
(203) 767-8295, fax: (203) 767-1397

Duro-Test Corp.
9 Law Dr., Fairfield, NJ 07004
(201) 808-1800, fax: (201) 808-6622

Federal APD, Inc., Federal Signal Corp.
24700 Crestview Ct., Farmington Hills, MI 48335
(800) 521-9330, (810) 477-2700, fax: (810) 477-0742

Gardco Lighting
2661 Alvarado St., San Leandro, CA 94577
(510) 357-6900, fax: (510) 357-3088

G.E. Company
3135 Easton Turnpike, Fairfield, CT 06431
(800) 626-2004, fax: (518) 869-2828

Hapco Division of Kearney-National, Inc.
P.O. Box 547-KN, Abingdon, VA 24210
(540) 628-7171, fax: (540) 628-7707

Litetronics International
4101 W. 123rd St., Alsip, IL 60658
(708) 389-8000 ext 195, fax: (708) 371-0627

Mason, L.E., Co.
98 Business St., Boston, MA 02136
(617) 361-1710, fax: (617) 361-6876

Philips Lighting Co.
200 Franklin Sq. Dr., Somerset, NJ 08875
(908) 563-3000, (800) 631-1259, fax: (908) 563-3975

Rig-A-Light
P.O. Box 12942, Houston, TX 77217
(713) 943-0340, fax: (713) 943-8354

Sterner Lighting Systems
351 Lewis Ave., Winisted, MN 55395
(320) 485-2141, fax: (320) 485- 2899

Thomas and Betts
Corporate Headquarters, Memphis, TN 38119
(800) 888-0211, fax: (800) 888-1366

Unique Solution Division of Holophane Corp.
515 McKinley Ave., Newark, OH 43055
(614) 349-4194, fax: (800) 346-5923

Information on Efficiency Technologies

This list provides EPRI resources on efficiency technologies identified in the guide. Copies of these publications can be ordered through the EPRI Distribution Center, (510) 934-4212.

Energy-Efficient HVAC

Space-Conditioning System Selection Guide, TR-103329, December 1993.

Additional information on HVAC can be obtained from the EPRI HVAC&R Center, (800) 858-3774.

Energy-Efficient Lighting

Proceedings—Efficient Lighting 1993: A Lighting Symposium for Electric Utility Lighting and DSM Professionals, TR-105963, January 1996.

Electronic Ballasts, BR-101886, May 1993.

High-Intensity Discharge Lighting, BR-101739, May 1993.

Advanced Lighting Technologies Applications Guidelines: 1990, TR-101022-R1, May 1993.

Lighting Fundamentals Handbook, TR-101710, March 1993.

Commercial Lighting Efficiency Resource Book, CU-7427, September 1991.

Additional information on lighting can be obtained from the EPRI Lighting Information Office, (800) 525-8555.

Energy-Efficient Motors

Assessment of Electric Motor Technology: Present Status, Future Trends, and R&D Needs, TR-101264, December 1992.

Electric Motors, TR-100423, June 1992.

Heat Recovery

Field Performance of Heat Recovery Chillers and Heat Recovery Heat Pumps, TR-103416, November 1993.

Heat Recovery Heat Pumps, BR-020250, August 1990.

Trade Associations

Association of Professional Color Laboratories
3000 Picture Place, Jackson, MI 49201
(517) 778-8146, fax: (517) 788-8371

Members are labs that process film for professional photographers. Managed by Photo Marketing Association International.

International Minilab Association
2627 Grimsley Street, Greensboro, , NC 27401-2605
(919) 273-6300, fax: (919) 273-9207

Members are firms that provide on-premises retail photofinishing services (i.e., "one-hour photo").

National Association of Photographic Manufacturers
550 Mamaroneck Avenue, Harrison, NY 10528
(914) 698-7603

Members are manufacturers of photographic supplies and equipment.

Photo Marketing Association International
3000 Picture Place, Jackson, MI 49201
(517) 788-8100, fax: (517) 788-8371

Members are owners of photofinishing labs and individuals working in the photofinishing industry.

Society for Imaging Science and Technology
7003 Kilworth Lane, Springfield, VA 22151
(800) 478-5218, fax: (703) 642-9094

Members are individuals engaged in imaging science or engineering.

Society of Photofinishing Engineers
3000 Picture Place, Jackson, MI 49201
(517) 788-8100, fax: (517) 788-8371

Members are individuals who have achieved a significant expertise in the field of photoprocessing. Most members work in wholesale photoprocessing labs or in minilab operations.