

PHOTOGRAPHIC MATERIAL FACILITIES

Storing Unprocessed Photographic Materials	20.1
Processing and Printing Photographic Materials	20.1
Storing Processed Film and Paper	20.3

PROCESSING and storing sensitized photographic products requires temperature, humidity, and air quality control. Manufacturers of photographic products and processing equipment provide specific recommendations for facility design that should always be consulted. This chapter contains general information that can be used in conjunction with these recommendations.

STORING UNPROCESSED PHOTOGRAPHIC MATERIALS

Virtually all photosensitive materials deteriorate with age; the rate of photosensitivity deterioration depends largely on the storage conditions. Photosensitivity deterioration increases both at high temperature and at high relative humidity and usually decreases at lower temperature and humidity.

High humidity can accelerate loss of sensitivity and contrast, increase shrinkage, produce mottle, cause softening of the emulsion (which can lead to scratches), and promote fungal growth. Low relative humidity can increase the susceptibility of the film or paper to static markings, abrasions, brittleness, and curl.

Because different photographic products require different handling, product manufacturers should be consulted regarding proper temperature and humidity conditions for storage. Refrigerated storage may be necessary for some products in some climates.

Products not packaged in sealed vaportight containers are vulnerable to contaminants. Such products must be protected from solvent, cleanser, and formaldehyde vapors (emitted by particle-board and some insulation, plastics, and glues); industrial gases; and engine exhaust. In hospitals, industrial plants, and laboratories, all photosensitive products, regardless of their packaging, must be protected from x-rays, radium, and radioactive sources. For example, films stored 25 ft away from 100 mg of radium require the protection of 3.5 in. of lead.

PROCESSING AND PRINTING PHOTOGRAPHIC MATERIALS

Ventilation with clean, fresh air maintains a comfortable working environment and prevents fume-related health problems. It is also necessary for the high-quality processing, safe handling, and safe storage of photographic materials.

Processing produces odors, fumes, high humidity, and heat (from lamps, electric motors, dryers, mounting presses, and high-temperature processing solutions). Thus, it is important to supply plentiful clean, fresh air at the optimum temperature and relative humidity to all processing rooms.

Air Conditioning for Preparatory Operations

During receiving operations, exposed film is removed from its protective packaging for presplicing and processing. **Presplicing** combines many individual rolls of film into a long roll to be processed. At high relative humidity, photographic emulsions become soft and can be scratched. At excessively low relative humidity, the

film base is prone to static, sparking, and curl deformation. The presplice work area should be maintained at 50 to 55% rh and 70 to 75°F db. Room pressures should cascade downward from areas of higher air quality.

Air Conditioning for Processing Operations

Processing exposed films or paper involves the use of a series of tempered chemical and wash tanks that emit heat, humidity, and fumes. Room exhaust must be provided, along with local exhaust at noxious tanks. To conserve energy, air from the pressurized presplice rooms can be used as makeup for processing room exhaust. Further supply air should maintain the processing space at a maximum of 75°F dry bulb and 50 to 55% rh.

The processed film or paper proceeds from the final wash to the dryer, which controls the moisture remaining in the product. Too little drying will cause the film to stick when wound, whereas too much drying will cause undesirable curl. Drying can be regulated by controlling drying time, humidity, and temperature.

The volume of incoming air should be sufficient to achieve the design condition. Airflow should be diffused or distributed to avoid objectionable drafts. Apart from causing personnel discomfort, drafts can cause dust problems and disturb the surface temperature uniformity of drying drums and other heated equipment. For automated processing equipment, tempered outside air should be supplied from the ceiling above the feed or head end of the machine at a minimum rate of 150 cfm per machine (see [Figure 1](#)). If the machine extends through a wall into another room, both rooms should be ventilated.

An exhaust system should be installed to remove humid or heated air and chemical vapors directly to the outside of the building. The room air from an open machine or tank area should be exhausted to the outdoors at a rate sufficient to achieve at least the

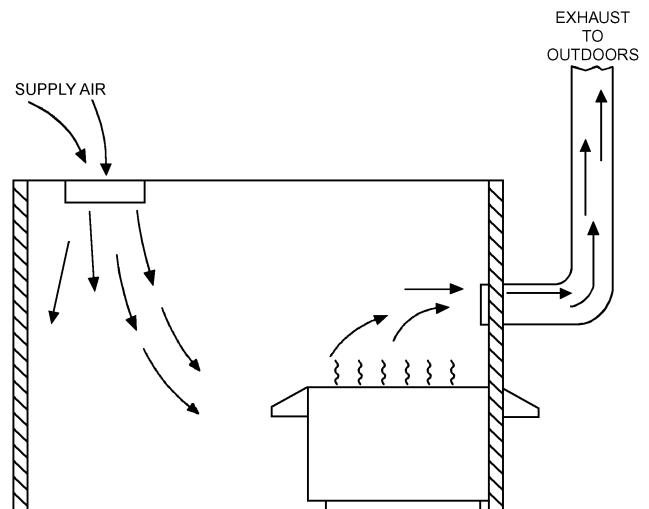


Fig. 1 Open Machine Ventilation

The preparation of this chapter is assigned to TC 9.2, Industrial Air Conditioning.

vapor dilution levels recommended by the American Conference of Governmental Industrial Hygienists (ACGIH 2001). An exhaust rate higher than the supply rate produces a negative pressure and makes the escape of vapors or gases to adjoining rooms less likely. The exhaust opening should be positioned so that the flow of exhausted air is away from the operator, as illustrated in Figure 2. This air should not be recirculated. The exhaust opening should always be as close as possible to the source of the contaminant for efficient removal. For a processing tank, an exhaust hood having a narrow opening at the back of and level with the top edge of the tank should be used.

If the processing tanks are enclosed and equipped with an exhaust connection, the minimum room air supply and exhaust rates may be reduced compared to an open tank (see Figure 3).

Air distribution to the drying area must provide an acceptable environment for operators as discussed in Chapter 8 of the 2001 *ASHRAE Handbook—Fundamentals* and the ACGIH *Industrial Ventilation Manual*. The exposed sides of the dryer should be insulated as much as is practical to reduce the large radiant and convected heat gain to the space. Exhaust grilles above the dryer can directly remove much of its rejected heat and moisture. The supply air should be directed to offset the remaining radiant heat gain to the space.

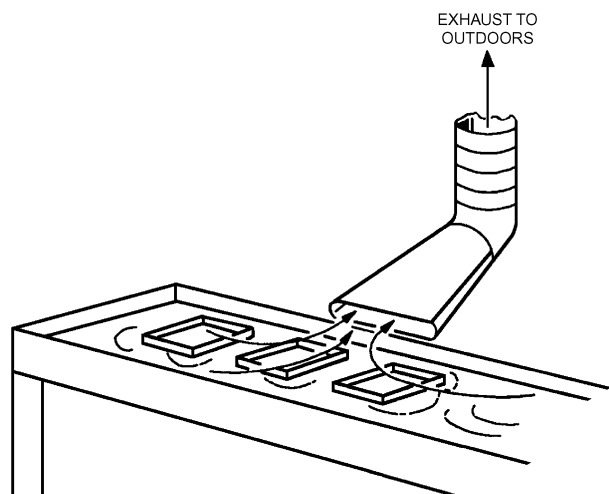


Fig. 2 Open-Tray Exhaust Ventilation from a Processing Sink

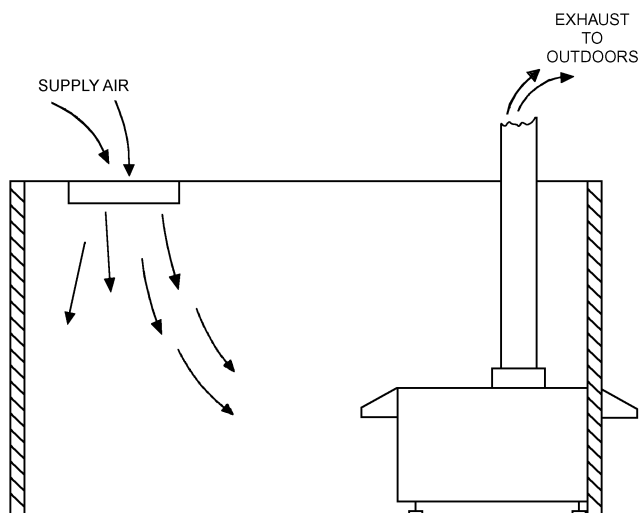


Fig. 3 Enclosed Machine Ventilation

Using processor dryer heat to preheat cold incoming air during winter conditions can save energy. An economic evaluation is necessary to determine whether the energy savings justify the additional cost of the heat recovery equipment.

A canopy exhaust hood over the drying drum of continuous paper processors extracts heat and moisture. The dryers should be exhausted to the outside of the building to avoid undesirable humidity buildup. A similar hood over a sulfide-toning sink can be used to vent hydrogen sulfide. However, the exhaust duct must be placed on the side opposite the operator so that the vapor is not drawn toward the operator's face.

When drying motion picture film, exhaust should draw off vapor from the solvent and wax mixture that is normally applied for lubrication.

Air Conditioning for the Printing/Finishing Operation

In printing, where a second sensitized product is exposed through the processed original, the amount of environmental control needed depends on the size and type of operation. For small-scale printing, close control of the environment is not necessary, except to minimize dust. In photofinishing plants, printers for colored products emit substantial heat. The effect on the room can be reduced by removing the lamphouse heat directly. Computer-controlled electronic printers transport the original film and raw film or paper at high speed. Proper temperature and humidity are especially important because, in some cases, two or three images from many separate films may be superimposed in register onto one film. For best results, the printing room should be maintained at between 70 and 75°F and at 50 to 60% rh to prevent curl, deformation, and static. Curl and film deformation affect the register and sharpness of the images produced. Static charge should be eliminated because it leaves static marks and may also attract dust to the final product.

Mounting of reversal film into slides is a critical finishing operation requiring a 70 to 75°F db temperature with 50 to 55% rh.

Particulates in Air

Air conditioning for most photographic operations requires 85% efficiency disposable bag-type filters with 30% efficiency prefilters to extend the bag filter life. In critical applications (such as high-altitude aerial films) and for microminiature images, filtering of foreign matter is extremely important. These products are handled in a laminar airflow room or workbench with 95% efficiency HEPA filters plus 30% efficiency disposable prefilters.

Other Exhaust Requirements

A well-ventilated room should be provided for mixing the chemicals used in color processing and high-volume black-and-white work. The room should be furnished with movable exhaust hoods that provide a capture velocity as defined by ACGIH.

If prints are lacquered regularly, a spray booth is needed. Concentrated lacquer spray is both hazardous and very objectionable to personnel; spray booth exhaust must be discharged outside.

Processing Temperature Control

The density of a developed image on photographic material depends on characteristics of the emulsion, the exposure it has received, and the degree of development. With a particular emulsion, the degree of development depends on the time of development, the developer temperature, the degree of agitation, and the developer activity. Therefore, developer solution temperature control is critical. Once a developer temperature is determined, it should be maintained at $\pm 1^\circ\text{F}$ for black-and-white products and $\pm 0.5^\circ\text{F}$ for color materials. Other solutions in the processor have a greater temperature tolerance.

Low processing volumes are typically handled in minilabs, which are often installed in retail locations. Minilabs are usually

self-contained and equipped with temperature controls, heaters, and pumps. Typically, the owner only has to hook the lab up to water, electricity, exhaust (thimble connection), and a drain.

Higher-volume processing is handled with processors that come from the manufacturer complete with controls, heat exchangers, pumps, and control valves designed for the process that the owner has specified. Electricity, hot water, cold water, drainage, and steam may be required, depending on the manufacturer, who typically provides the specifications for these utilities.

Static Electricity in Film Casting and Extrusion

In the manufacturing process of thin films, the generation of static charge can be expected, especially when nonconducting coating materials are used. When conductive coating materials are used, the static electricity hazard increases as the solvent is evaporated from the product, unless the finished product is also conductive. Maintaining the process environment at a relative humidity of 50 to 55% or higher may prevent static accumulations. The static charge on the product can also be reduced by ionizing the air in the immediate vicinity of the film. Ionization can be achieved by the use of static combs, tinsel brass, or by the use of radioactive materials (NFPA *Standard 77*).

STORING PROCESSED FILM AND PAPER

Storage of developed film and paper differs from storage of the raw stock because the developed materials are no longer photosensitive, are seldom sealed against moisture, and are generally stored for much longer periods. Required storage conditions depend on (1) the value of the records, (2) the length of storage time, (3) whether the films are on nitrate or safety base, (4) whether the paper base is resin coated, and (5) the type of photographic image.

Photographic materials must be protected against fire, water, mold, chemical or physical damage, high relative humidity, and high temperature. Relative humidity is much more critical than temperature. High relative humidity can cause films to stick together—particularly roll films, but also sheet films. High humidity also damages gelatin, encourages the growth of mold, increases dimensional changes, accelerates the decomposition of nitrate support, and accelerates the deterioration of both black-and-white and color images. Low relative humidity causes a temporary increase in curl and decrease in flexibility, but when the humidity rises again, these conditions are usually reversed. An exception occurs when motion picture film is stored for a long time in loosely wound rolls at very low humidities. The curl causes the film roll to resemble a polygon rather than a circle when viewed from the side. This **spokiness** occurs because a highly curled roll of film resists being bent in the length direction when it is already bent in the width direction. When a spoky roll is stored for a long time, the film flows permanently into the spoky condition, resulting in film distortion. Very low relative humidity in storage may also cause the film or paper to crack or break if handled carelessly.

Low temperature (−10 to 50°F) is desirable for film and paper storage if (1) the relative humidity of the cold air is controlled, and (2) the material can be sufficiently warmed (for 2 to 8 h) before opening to prevent moisture condensation. High temperature can accelerate film shrinkage, which may produce physical distortions and the fading of dye images. High temperature is also detrimental to the stability of nitrate film.

Film Longevity

The American National Standards Institute (ANSI *Standard IT9.11*) defines longevity of films with a life expectancy (LE) rating. The **LE rating** is the minimum number of years information can be retrieved if the subject film is stored under long-term storage conditions. In order to achieve the maximum LE rating, a product must be stored under long-term storage conditions. Polyester

black-and-white silver gelatin films have an LE rating of 500, and acetate black-and-white silver gelatin films have an LE rating of 100. No LE ratings have been assigned to color films or black-and-white silver papers. Medium-term storage conditions have been defined for materials that are to retain their information for at least 10 years.

Medium-Term Storage

Rooms for the medium-term storage of safety base film should be protected from accidental water damage by rain, flood, or pipe leaks. Air conditioning with controlled relative humidity is desirable but not always essential in moderate climates. Extremes of relative humidity are detrimental to film.

The most desirable storage relative humidity for processed film is about 50%, although the range from 30 to 60% is satisfactory. Air conditioning is required where the relative humidity of the storage area exceeds 60% for any appreciable period. For a small room, a dehumidifier may be used if air conditioning cannot be installed. The walls should be coated with a vapor retarder, and the controlling humidistat should be set at about 40% rh. If the prevailing relative humidity is under 25% for long periods, and problems from curl or brittleness are encountered, humidity should be controlled by a mechanical humidifier with a controlling humidistat set at 40%.

For medium-term storage, a room temperature between 68 and 77°F is recommended. Higher temperatures may cause shrinkage, distortion, and dye fading. Occasional peak temperatures of 95°F should not have a serious effect. Color films should be stored at temperatures below 50°F to reduce dye fading. Films stored below the ambient dew point should be allowed to warm up before being opened to prevent moisture condensation.

An oxidizing or reducing atmosphere may deteriorate the film base and gradually fade the photographic image. Oxidizing agents may also cause microscopically small colored spots on fine-grain film such as microfilm (Adelstein et al. 1970). Typical gaseous contaminants include hydrogen sulfide, sulfur dioxide, peroxides, ozone, nitrogen oxides, and paint fumes. If such fumes are present in the intended storage space, they must be eliminated, or the film must be protected from contact with the atmosphere.

Long-Term Storage

For films or records that are to be preserved indefinitely, long-term storage conditions should be maintained. The recommended space relative humidity ranges from 20 to 50% rh, depending on the film type. When several film types are stored within the same area, 30% rh is a good compromise. The recommended storage temperature is below 70°F. Low temperature aids preservation, but if the storage temperature is below the dew point of the outside air, the records must be allowed to warm up in a closed container before they are used, to prevent moisture condensation. Temperature and humidity conditions must be maintained year-round and should be continuously monitored.

Requirements of a particular storage application can be met by any one of several air-conditioning equipment combinations. Standby equipment should be considered. Sufficient outside air should be provided to keep the room under a slight positive pressure for ventilation and to retard the entrance of untreated air. The air-conditioning unit should be located outside the vault for ease of maintenance, with precautions taken to prevent water leakage into the vault. The conditioner casing and all ductwork must be well insulated. Room conditions should be controlled by a dry-bulb thermostat and either a wet-bulb thermostat, a humidistat, or a dew-point controller.

Air-conditioning installations and fire dampers in ducts carrying air to or from the storage vault should be constructed and maintained according to National Fire Protection Association (NFPA)

recommendations for air conditioning (NFPA *Standard* 90A) and for fire-resistant file rooms (NFPA *Standard* 232).

All supply air should be filtered with noncombustible HEPA filters to remove dust, which may abrade the film or react with the photographic image. As is the case with medium-term storage, gaseous contaminants such as paint fumes, hydrogen sulfide, sulfur dioxide, peroxides, ozone, and nitrogen oxides may cause slow deterioration of the film base and gradual fading of the photographic image. When these substances cannot be avoided, an air scrubber, activated carbon adsorber, or other purification method is required.

Films should be stored in metal cabinets with adjustable shelves or drawers and with louvers or openings located to facilitate circulation of conditioned air through them. The cabinets should be arranged in the room to permit free circulation of air around them.

All films should be protected from water damage due to leaks, fire sprinkler discharge, or flooding. Drains should have sufficient capacity to keep the water from sprinkler discharge from reaching a depth of 3 in. The lowest cabinet, shelf, or drawer should be at least 6 in. off the floor and constructed so that water cannot splash through the ventilating louvers onto the records.

When fire-protected storage is required, the film should be kept in either fire-resistant vaults or insulated record containers (Class 150). Fire-resistant vaults should be constructed in accordance with NFPA *Standard* 232. Although the NFPA advises against air conditioning in valuable-paper record rooms because of the possible fire hazard from outside, properly controlled air conditioning is essential for long-term preservation of archival films. The fire hazard introduced by the openings in the room for air-conditioning ducts may be reduced by fire and smoke dampers activated by smoke detectors in the supply and return ducts.

Storage of Nitrate Base Film

Although photographic film has not been manufactured on cellulose nitrate film base for several decades, many archives, libraries, and museums still have valuable records on this material. Preserving the nitrate film will be of considerable importance until the records have been printed on safety base.

Cellulose nitrate film base is chemically unstable and highly flammable. It decomposes slowly but continuously even under normal room conditions. The decomposition produces small amounts of nitric oxide, nitrogen dioxide, and other gases. Unless the nitrogen dioxide can escape readily, it reacts with the film base, accelerating the decomposition (Carroll and Calhoun 1955). The rate of decomposition is further accelerated by moisture and is approximately doubled with every 10°F increase in temperature.

All nitrate film must be stored in an approved vented cabinet or vault. Nitrate films should never be stored in the same vault with safety base films because any decomposition of the nitrate film will cause decomposition of the safety film. Cans in which nitrate film is stored should never be sealed, because this traps the nitrogen dioxide gas. Standards for storing nitrate film have been established (NFPA *Standard* 40). The National Archives and the National Institute of Standards and Technology have also investigated the effect of a number of factors on fires in nitrate film vaults (Ryan et al. 1956).

The storage temperature should be kept as low as economically possible. The film should be kept at less than 50% rh. The temperature and humidity recommendations for the cold storage of color film in the following section also apply to nitrate film.

Storage of Color Film and Prints

All dyes fade in time. ANSI *Standard* IT9.11 does not define an LE for color films or black-and-white images on paper. However, many valuable color films and prints exist, and it is important to preserve them for as long as possible.

Light, heat, moisture, and atmospheric pollution contribute to the fading of color photographic images. Storage temperature should be

as low as possible for the preservation of dyes. For maximum permanence of images, the materials should be stored in light-tight sealed containers or in moisture-proof wrapping materials at a temperature below freezing and at a relative humidity of 20 to 50%. The containers should be warmed to room temperature before opening to avoid moisture condensation on the surface. Photographic films can be brought to the recommended humidity by passing them through a conditioning cabinet with circulating air at about 20% rh for about 15 min.

An alternative is the use of a storage room or cabinet controlled at a steady (noncycled) low temperature and maintained at the recommended relative humidity. This eliminates the necessity of sealed containers, but involves an expensive installation. The dye-fading rate decreases rapidly with decreasing storage temperature.

Storage of Black-and-White Prints

The recommended storage conditions for processed black-and-white paper prints should be obtained from the manufacturer. The optimum limits for relative humidity of the ambient air are 30 to 50%, but daily cycling between these limits should be avoided.

A variation in temperature can drive relative humidity beyond the acceptable range. A temperature between 59 and 77°F is acceptable, but daily variations of more than 7°F should be avoided. Prolonged exposure to temperatures above 86°F should also be avoided. The degradative processes in black-and-white prints can be slowed considerably by low storage temperature. Exposure to airborne particles and oxidizing or reducing atmospheres should also be avoided, as mentioned for films.

REFERENCES

- Adelstein, P.Z., C.L. Graham, and L.E. West. 1970. Preservation of motion picture color films having permanent value. *Journal of the Society of Motion Picture and Television Engineers* 79(November):1011.
- ACGIH. 2001. *Industrial ventilation: A manual of recommended practice*, 24th ed. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.
- ANSI. 1998. Imaging media—Processed safety photographic films—Storage. *Standard* IT9.11-98. American National Standards Institute, New York.
- Carroll, J.F. and J.M. Calhoun. 1955. Effect of nitrogen oxide gases on processed acetate film. *Journal of the Society of Motion Picture and Television Engineers* 64(September):601.
- NFPA. 2000. Protection of records. ANSI/NFPA *Standard* 232-00. National Fire Protection Association, Quincy, MA.
- NFPA. 1999. Installation of air conditioning and ventilating systems. ANSI/NFPA *Standard* 90A-99. National Fire Protection Association, Quincy, MA.
- NFPA. 1997. Storage and handling of cellulose nitrate motion picture film. ANSI/NFPA *Standard* 40-97. National Fire Protection Association, Quincy, MA.
- NFPA. 1999. Static electricity. NFPA *Standard* 77. National Fire Protection Association, Quincy, MA.
- Ryan, J.V., J.W. Cummings, and A.C. Hutton. 1956. Fire effects and fire control in nitro-cellulose photographic-film storage. *Building Materials and Structures Report No. 145*. U.S. Department of Commerce, Washington, D.C. (April).

BIBLIOGRAPHY

- ANSI. 1991. Photography (photographic film)—Specifications for safety film. *Standard* IT9.6-91. American National Standards Institute, New York.
- ANSI. 1996. Imaging materials—Ammonia-processed diazo photographic films—Specifications for stability. *Standard* IT9.5-96. American National Standards Institute, New York.
- Carver, E.K., R.H. Talbot, and H.A. Loomis. 1943. Film distortions and their effect upon projection quality. *Journal of the Society of Motion Picture and Television Engineers* 41(July):88.
- Kodak. 1987. Current information summary—General guidelines for ventilating photographic process areas. *CIS-58*. Eastman Kodak Company, Rochester, NY.
- Kodak. 1990. Photolab design for professionals. *Publication K-13*. Eastman Kodak Company, Rochester, NY.
- UL. 1995. Tests for fire resistance of record protection equipment, 14th ed. *Standard* 72-95. Underwriters Laboratories, Northbrook, IL.