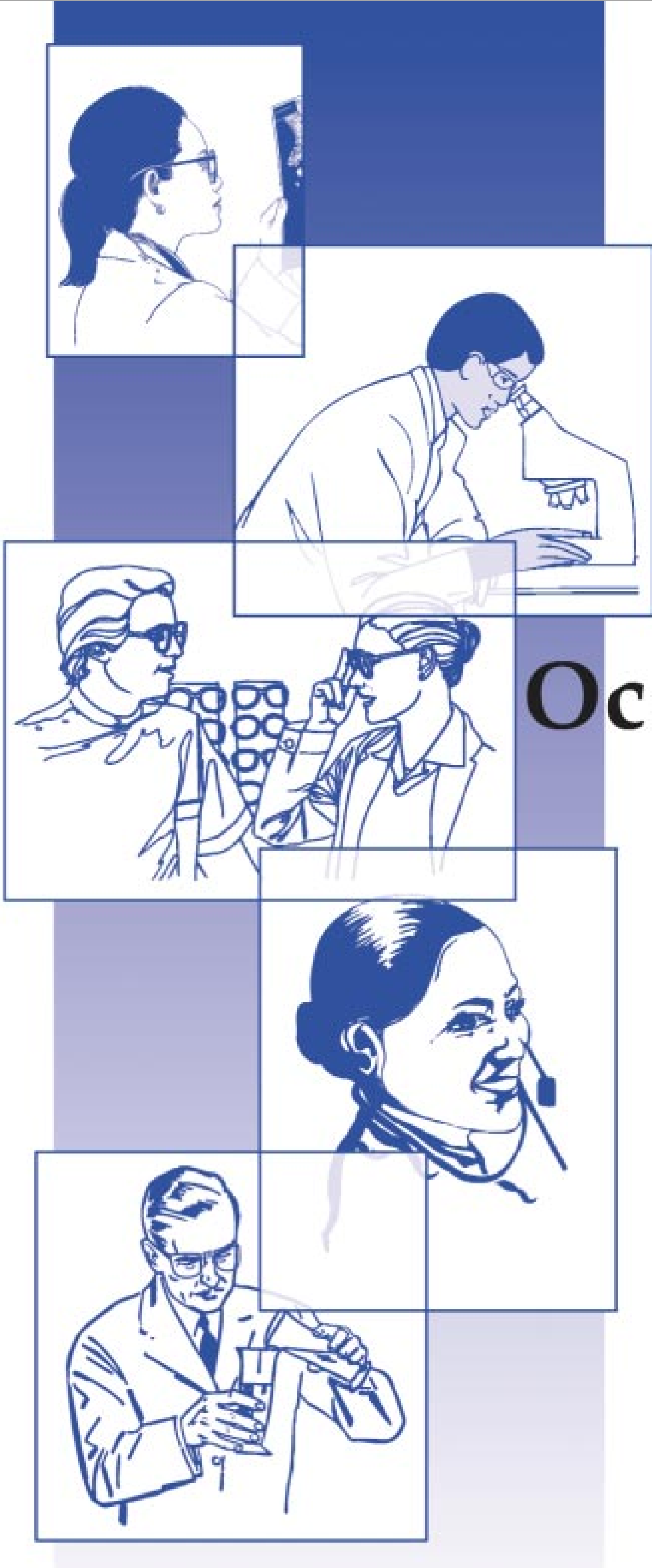

Occupational Vision Manual

American Optometric Association

I. <u>INTRODUCTION</u>

Gregory W. Good, O.D., Ph.D.
The Ohio State University College of Optometry

Occupational optometry is the portion of optometric practice that is concerned with the efficient and safe visual functioning of an individual within the work environment. It encompasses more than just the prevention of occupational eye injuries, although that certainly is a major component. It also includes vision assessments of workers/patients, taking into account their specific vision requirements and the demands these requirements place upon them.

Optometrists provide occupational vision services at three general areas or levels: primary care, eye safety consultation, vision consultation.

Primary Care Optometrist. The primary care optometrist is concerned with all aspects of patients' visual well-being, whether it involves home, work, or play. As a primary care provider, the optometrist must be prepared to meet certain occupational vision objectives (Pitts and Kleinstein, 1993):

- Complete an occupational history on each adult patient
- Diagnose and manage occupationally induced conditions (making referrals when necessary)
- Assess his or her patients' occupational vision demands and provide appropriate treatments as necessary
- Educate patients on the need to incorporate eye safety principles into their daily activities.

An occupational history should include questions concerning the specific visual tasks performed, as well as questions regarding possible exposure to eye and health hazards. The optometrist should also inquire about what personal protective precautions the patient takes to help ensure eye safety. Kleinstein (Pitts and Kleinstein, 1993) provides several sample occupational history forms (see example in Appendix A) that can be used to initiate a vocational dialogue.

When hazards or specific visual tasks reported in the occupational history are unclear, the optometrist may contact the employer and ask to observe plant operations first hand as a way to provide better vision and safety services. A worksite tour can be especially informative when many of the practitioner's patients work in the same facility.

When visiting a plant, the optometrist should first meet with the safety officer or personnel director who should be asked to participate in a tour of the plant. During the tour, information on various aspects of vision conditions and eye protection pertaining to the different jobs within the plant should be recorded. The primary care optometrist who has first hand knowledge of the occupational demands placed upon workers is better prepared to prescribe the proper refractive corrections, lens materials, contact lenses, vision training, or safety devices for each one's specific needs.

Eye Safety Consultant. When retained as a consultant, the optometrist can be more involved in the daily operations of an occupational setting. In this capacity an optometrist can more directly make recommendations and set policies that help to ensure safe visual functioning for all workers.

The duties of an optometrist serving as an eye safety consultant may include overseeing the facility's entire eye safety program. Specific components of such a program may include:

- writing and helping to enforce an eye safety policy
- performing an eye-safety workplace assessment
- overseeing the procurement of eye protection devices (both prescription and nonprescription)
- educating workers on eye safety issues
- overseeing pre-placement and periodic vision screenings
- writing policy concerning contact lens wear.

The Occupational Safety and Health Administration (OSHA) mandates the use of eye and face protection whenever there is a reasonable probability of injury that could be prevented by such equipment. The Code of Federal Regulations specifies that employers must provide personal protective equipment to their employees and that employers are responsible for ensuring employee compliance with its use (29CFR1910.133 OSHA Regulations – Eye and Face Protection).

The optometrist can participate in an eye safety program by helping to determine the types of hazards present at different workstations within a plant (workplace assessment) and selecting protective devices appropriate for each workstation. The optometrist can oversee the ordering, verifying, dispensing, and periodic adjustment of safety eyewear. Safety glasses and other protectors should be individually sized and fit. Inappropriately sized or uncomfortable protectors are much less likely to be worn and therefore may not provide protection when it is needed. The optometrist can lead periodic safety sessions with workers concerning eye safety issues. Workers who understand the issues, including the consequences of eye injury, are more likely to comply with company safety policy.

The identification of individuals with less than optimal vision is an important component of a comprehensive eye safety program because workers can perform most occupational activities more efficiently and safely with clear and comfortable vision. A wide range of possibilities exist as to how optometrists can participate in employee vision screening. One issue to be addressed is contact lens wear in the workplace. Although contact lenses have been shown to be safe for most industrial operations, their use remains controversial. Optometrists can educate workers and safety personnel on contact lens issues as a means of arriving at a wearing policy that has wide acceptance.

Vision Consultant. In addition to addressing eye safety and primary eye care issues, the optometrist is uniquely qualified to provide consulting services concerning the general area of visual efficiency. Poor design of the work environment often limits productivity due to improper or inefficient lighting, contrast, or working distance. By recommending changes the optometrist can help improve productivity and reduce errors.

In areas where poor productivity or high error rates have been identified, a systematic investigation with remediation can lead to enhanced performance. The first step in addressing occupational vision issues is to ensure that workers have the vision skills to see task details clearly with little effort. Custom-designed eyewear may be required to deal with unusual viewing distances or task positioning. When these measures fail to resolve task-related problems, a change in the procedure itself may be needed.

Modification of any one of the following four task characteristics can enhance visual performance (Bullimore et al., 1995):

- Contrast
- Size
- Lighting
- Viewing time.

Increasing task contrast, angular size (by increasing size or decreasing distance), task luminance (increasing illumination or reflectance), or viewing time generally provides greater task visibility.

Occupational eye care is not limited to industrial situations. Many white collar workers can benefit from occupational vision care services as well. Providing eye care for video display terminal operators is a growing area of occupational vision care. Although the concerns for their eye safety may be minimal in comparison with the issues confronting blue collar workers, the issues of visual efficiency, productivity and worker comfort are nevertheless of considerable importance.

Practicing optometrists have a responsibility to address the occupational vision issues confronted by their patients. The level at which the optometrist decides to participate in occupational vision issues varies depending upon his or her interests and professional opportunities. Regardless of these variations, all optometrists can benefit from the information that follows in effectively carrying out their professional responsibilities in this area.

Providing these specialized and unique occupational vision services (including occupational lens design for patients) will require additional chair time and expertise. This additional chair time and expertise should be assessed in the same manner as is done for providing other specialized services, such as contact lens services and low vision services.

II. PERFORMANCE AND PRODUCTIVITY IN THE WORK PLACE

Gregory W. Good, O.D., Ph.D.
The Ohio State University College of Optometry

Optometrists encounter patients in wide varieties of occupations and workplace environments. During the comprehensive eye examination, the occupational optometrist should assess "… all aspects of the relationship between work and vision, visual performance, eye safety and health. This complex relationship includes the worker's eyes and visual system, as well as the worker and the workplace environments" (Pitts and Kleinstein, 1993).

One of the keys to assessing a patient's workplace tasks is the occupational history (McCunney, 1988). The occupational history includes a complete description of both the visual task and the health hazards within the workplace environment. Completing an assessment of the patient's work environment and multiple workplace tasks should enable the optometrist to prescribe appropriate treatments to maximize the patient’s visual efficiency.

The usual starting point for enhancing a patient's workplace performance is the comprehensive eye examination resulting in treatment of any eye disease, binocular vision disorder, or refractive problem. From this starting point, occupational vision assessment extends beyond the common tests and treatments to those specifically required for the workplace environment.

Vision Screening

Within the workplace, vision screenings or examinations are often conducted to ensure the minimum level of functioning needed to accomplish specific visual tasks. These procedures can be conducted upon employment (placement) and periodically throughout a worker’s career.

Initial Assessment. The examination or screening of a newly hired employee’s vision can provide important information to the company and to the worker. The worker can be placed in the position best suited for his or her visual skills. It can also serve to detect previously undiagnosed disease or refractive error. Identifying and correcting even a small refractive error can greatly increase a worker’s visual efficiency and productivity.

Initial testing should include visual acuity (at various distances), color vision, binocular interaction, refractive error, and possibly visual fields. Tonometry and other ocular health tests may also be performed. Results from these tests can help with proper employee placement and aid in documenting entering visual functioning. Workers should be tested with their present prescriptions to ensure that adequate visual functioning is present at all working distances required for their positions.

Yearly Assessments. Vision screenings conducted on an annual basis allow the employer and occupational optometrist to identify changes in visual function or ocular health that could affect safety or long-term eye health and impact workers’ efficiency. A brief occupational vision history, coupled with tests of visual acuity, binocular interaction, and ocular health, can alert the optometrist to visual problems that can be corrected or compensated. The history should include questions concerning eye safety or injuries, clarity of the visual task at all relevant working distances, and overall ocular health.

Ergonomic Assessment

A survey of their occupational tasks is an important first step to improving workers’ overall visual performance. This survey, which is the basis upon which vision guidelines (standards) are established, helps with placing job applicants in positions that they are visually qualified to perform (Good et al., 1996). In addition, the consulting optometrist will analyze these data from a vision perspective before recommending changes that can improve worker productivity and reduce errors. For example, auxiliary lighting may be recommended when the general illumination level does not meet that recommended by the Illumination Engineering Society (IES, 2000) or where shadows obscure critical detail. Alternatively, the use of larger letters printed with higher contrast on the sides of storage boxes may be recommended when forklift operators have difficulty reading printed letters from the viewing distance of 10 to 12 feet required for efficient operation.

Appendix B offers an example of a sample site survey instrument used during an initial tour of plant facilities (Good et al., 1996). One of these surveys should be completed for each individual job title within the plant. The primary duty for each job title should be given in general terms. The specific visual tasks within each duty of an individual job should be listed in detail. This information provides the basis upon which to determine vision standards and recommendations for specially designed eyewear.

Visual Task Details. During the worksite survey, the occupational optometrist should assess and record information regarding each worker's tasks. The survey must include the specific visual tasks entailed in the essential duties of each position. For example, tasks performed by a lathe operator may include alignment of the cutting tool with the metal or wood stock, observation of the cutting action when the machine is engaged, and setting instrument controls to ensure proper dimensions. A forklift operator may need to move safely throughout a warehouse with a load, to position the load accurately in three dimensions in front of the storage position, and, finally, to move the forklift forward to place the load safely in its precise intended location. The operator may need to read a list on a hand-held piece of paper (from 16 in) or to read numbers or letters on crates or boxes (from 6 to 12 feet) to determine what exact load is required.

Accurate measurement of visual detail (e.g., for the forklift operator, the sizes of letters on a box) can be made to calculate an absolute visual acuity requirement taking into account the maximum required viewing distance. When the visual detail cannot be measured directly (e.g. a fine scratch along the outer wall of a component fabricated on a lathe or mill), the detail can be specified as fine, medium, or coarse, depending upon the ease with which the detail can be seen.

The contrast of the visual detail with its background should be assessed using a scale that includes low (e.g. blue letters on a black background), medium (dark gray letters on a white background), and high contrast (white letters on a dark background). When color assessment is an important element of an essential task, the required level of discrimination (low, medium, high) should also be estimated and recorded.

Experienced workers and supervisors should be queried as to what components of a task they find visually challenging and why. All these measures will not only help in determining the level and type of lighting required for a particular workstation and task; but also in determining the level of visual functioning (vision standards) required for the position. The occupational optometrist can often recommend changes in the visual environment (e.g.. in lighting or the visual tasks) that can improve productivity and increase worker safety.

Four factors are often listed as influencing the visibility of task details. Target size, contrast, light level, and viewing time can greatly influence performance (Bullimore et al., 1995). Many studies have shown that visual performance for reading increases with letter sizes up to 20/80 equivalent (approximately 10 point at 40 cm). When letters are significantly smaller or larger than this, performance decreases. An alternative to increasing actual letter size is to decrease working distance. ***It is the angular size of task detail that is important, not absolute size.***

Contrast plays an important element in visibility. Low contrast objects are difficult to see, regardless of their size. ***Increasing task contrast is an important means of increasing overall performance.*** The *IES Lighting Handbook* (2000) recommends light levels for essentially all industrial and office tasks. When visual performance is less than optimal, even with the recommended level of illumination, auxiliary lighting may be beneficial.

Viewing time also plays a significant role in visual performance. The recognition of details that are more difficult to see requires a longer viewing time. For operations in which viewing time cannot be changed (e.g., assembly line work), color coding and other strategies can reduce search time and improve worker's efficiency.

Lighting. General and specific workstation lighting should be assessed especially in areas of low productivity or low-quality workmanship, and in situations where workers complain of difficulty seeing task detail. The quantity of light (illumination of the task) should be measured and recorded, both with and without the worker in position. Often the measured light level without the worker in place is adequate, but the light level is significantly reduced by a shadow of the worker when he or she is positioned at the workstation. Assessment of the quality of light involves looking for sources of glare and for shadows, and evaluating the color specifications of the lighting systems. Light levels should be compared with those listed for the specific task in the *IES Lighting Handbook* (2000). A worker's complaints to a supervisor about inadequate lighting may go unheeded, but when the occupational optometrist explains the reasons for the complaints, management is more likely to respond with appropriate changes.

Job Requirements and Vision Standards

Vision standards are set for specific jobs to ensure that workers have the necessary vision skills to accomplish their required tasks in a safe and efficient manner. In the work environment, vision standards should be viewed as guidelines, not as absolute limits. Most often, when an individual fails to meet a vision standard, a change in refractive correction is all that is required. This situation often occurs when a person with beginning presbyopia is required to pass a nearpoint visual acuity standard. A specially designed bifocal lens is often all that is necessary for the worker to meet the standard and regain lost efficiency. When a worker fails to meet a vision standard due to a specific visual impairment, individual consideration may be given to determine whether he or she can accomplish the task with assistance (e.g., an illuminating magnifier).

The visual acuity standard should not be arbitrarily set to be overly restrictive. The size of visual details, working distances, need for speed and accuracy, and the consequences of error should be assessed and evaluated before setting the visual acuity standard. A system using a 20/40 visual acuity standard for coarse detail, 20/30 for medium detail, and 20/25 for fine detail can be used to guide workers into appropriate work assignments or to require them to wear refractive corrections when needed. The visual acuity standard for the final inspector of a product may be set slightly higher because the inspector represents the last chance to catch a flawed product before shipping it to the consumer.

A strict color vision standard has the most potential for eliminating individuals from consideration for specific task assignments. Approximately 8 percent of males and 0.4 percent of females have inherited a color vision defect. The degree of the defect varies greatly across affected individuals, however, and, even those with dichromatism still possess some ability to discriminate colors. The nature of the task and the consequences of an error should be determined before setting a color vision standard. When possible, the occupational optometrist should administer a functional color discrimination test (e.g., an electrician connecting wires in a test situation). Understanding the intended purpose of particular color vision tests, and knowing what types of color vision defects are associated with passing or failing each test, are required to set a color vision standard (Birch, 1993).

When the task requires a high level of fine color discrimination (e.g., color-mixing dyes to exactly match standard textile dyes), even a person with normal color vision may lack the abilities required. Administering the Farnsworth-Munsell 100 Hue test and using a relatively low cutoff score (e.g., 25) may be necessary to ensure efficient, accurate job performance. The Farnsworth Panel D-15 test is often used when testing to a color vision standard when only moderate levels of color discrimination are required (e.g., color naming). Pseudoisochromatic plates are often used as the initial screening instrument. Plate tests are classically designed to pass all individuals with normal color vision and fail all those with defective color vision. ***Color vision tests produce valid results only when administered under the appropriate lighting conditions (standard illuminant "C").***

The ability to appreciate the depth of one object relative to another is often required for efficient and safe job performance. The monocular cues to depth (e.g. overlay, motion parallax, and atmospheric haze) are often all that are required, however. Only when precise judgment of relative depth is essential to job performance is there justification for a binocular vision (i.e., stereopsis) requirement. The safety an efficiency consequences of an error and the need for speed and/or accuracy should also be considered when evaluating a job with regard to the need for a binocular vision standard. Examples of positions in which stereopsis may be required include crane and forklift operators. A demonstration of a moderate degree of stereopsis (i.e., 80 seconds) is often all that is required for a binocular vision standard (Good et al., 1996).

The degree of visual field required in a worker is primarily a safety issue. Forklift operators often function in crowded surroundings in which other workers are present. If a forklift has a load blocking the forward view, the operator may partially turn in the seat and drive backward, thus limiting the lateral extent to which vision is present on the side of the head facing the new direction of travel. A minimum of 70 degrees of horizontal visual field on each side of fixation is often set as the standard.

III. OCULAR PROTECTION

Gregory L. Stephens, O.D., Ph.D.
Donald G. Pitts, O.D., Ph.D.
University of Houston College of Optometry

Occupational Safety and Health Administration (OSHA) regulations require that workers' eyes be properly protected from potential hazards in the workplace. It is important that optometrists be aware of the regulations covering eye safety and of the protective devices available to workers.

Types of Hazards and Appropriate Protection

The major hazards against which protection is needed in the workplace are projectiles, chemicals (splashes and fumes), and radiation (especially visible light, ultraviolet radiation [UV], and heat or infrared radiation [IR]). Methods of eye protection differ for each type of hazard, although an eye protector may provide more than one type of protection. The protector must be matched to the potential hazard. Laser eye protection recommendations are provided by the ANSI Z136.1-2000 and ANSI Z136.3-1996 standards. The ANSI Z87.1-1989 standard provides guidelines for selection of the appropriate eye or face protector for other types of hazard.

Projectiles. A projectile posing a hazard to the eye can be of almost any size or shape, and it can travel at either high or low velocity. Common projectiles in an industrial setting might include pieces of a screwdriver blade, drill bit, grinding wheel, metal debris, rock, and steel rod. They can cause injuries ranging from corneal or conjunctival foreign bodies, to penetration of the eye, to blunt trauma. Some projectiles (especially metals) can be toxic to the eye.

There are many ways to protect the eyes from projectiles, but the first line of defense is almost always industrial safety glasses. OSHA requires sideshields on the frames whenever there is potential for injury from flying objects, but they are not mandatory in all situations and need not be permanently attached. In practice, hazard assessments show that sideshields are required in many situations.

Any lens material that meets the impact resistance requirements of the ANSI Z87.1-1989 standard may be used in prescription industrial safety glasses. Polycarbonate is the material of choice because of its superior impact resistance, but there may be situations where its use is not indicated. For example, in cold weather a carpenter may have problems with sawdust sticking to polycarbonate lenses because of static electricity. Glass lenses may also be preferable to polycarbonate when scratching of the surface is likely to occur. At one time, workers who wanted photochromic lenses were restricted to glass or CR-39 plastic. The polycarbonate photochromic lenses are now available and are the preferred photochromic lenses for industrial eye protection.

Standard dress eyewear does not meet the ANSI Z87.1-1989 requirements for industrial eye protection. Frames and lenses for industrial use must meet specific requirements, including impact testing and minimum thickness requirements. In addition, lenses and frames must be labeled so that they can be easily identified as meeting the industrial standard. ("Z87" must be stamped on the frame, while the lens manufacturer's or optical lab's logo must be etched on the lenses.) Dress lenses should not be placed in industrial frames or industrial safety lenses in dress frames, because the resultant spectacles will not meet the requirements of the ANSI Z87.1-1989 standard in providing adequate protection from projectiles.

The numbers of industrial eye injuries that occur because proper industrial eye protection is not worn suggest the need to provide employees with industrial eyewear that has a pleasing cosmetic appearance and that fits comfortably. Plano spectacles are available in many different price ranges. Spectacles that are not easily adjustable or are easily broken or bent may not be the best option. Higher quality, more expensive plano eyewear may be more cost efficient in the long run because workers are more likely to wear a protector that has been individually adjusted for maximum comfort. Moreover, when workers experience "ownership" of the spectacles, they may be less likely to regard them as disposable (which can lead to high replacement costs).

Faceshields and goggles may be used to provide protection against projectiles. These types of protectors must meet specific requirements such as impact resistance and optical quality. The ANSI Z87.1-1989 standard provides guidelines for their selection and use. A faceshield, which usually consists of a curved sheet of plastic attached to a headband, provides protection for both the face and eyes. Faceshields are usually recommended for relatively severe exposure situations, such as working with a grinding wheel that rotates at high speeds. When used improperly, the grinding wheel can break apart, sending large, high-velocity projectiles toward the face and eyes. Faceshields must always be used with a so-called "primary protector," i.e. safety glasses or goggles. Goggles might be worn in an environment in which it is necessary to keep dust or chemicals from reaching the eye (e.g., sandblasting, woodworking, handling of chemicals or exposure to fumes). These devices conform to the face around the eyes, provide ventilation to the eyes, and accommodate a spectacle prescription.

Chemicals. The industrial environment often includes hazardous chemicals. In many cases, the major concern is injury caused by a liquid chemical that splashes into the eye; however, fumes, vapors, and dry chemicals can also be sources of eye injury. Chemicals that could cause injury include acids, alkalis, organic solvents, and surfactants. The *NIOSH Pocket Guide to Chemical Hazards* (1996) is an excellent source of hazard and safety information on specific chemical compounds. Included in the NIOSH recommendations are the levels of eye and skin protection needed and the placement of the eyewash stations and showers required for workstations at which the listed chemicals are used.

Protecting the eyes from chemicals requires more than just safety glasses. In most cases, the best solution is face-fitting goggles. Goggles are considered primary protectors, and safety glasses need not be worn under them. However, when a spectacle prescription is required, the prescription must be provided either in safety glasses that fit under the goggle or as prescription lenses in the goggles. Goggles are usually vented to prevent fogging. Chemical goggles have covers over the vents (indirect ventilation) to protect against splashed liquids. Fully sealing goggles, with no ventilation, are also available. Depending upon the potential for exposure, the worker may need a faceshield, respiratory protection, or skin protection.

The ANSI Z87.1-1989 standard does not address the issue of protection from exposure to blood or other body fluids (as encountered by a surgeon or dentist, for example). It is not a good idea to assume that a protector meeting the Z87.1-1989 standard will also provide proper protection against body fluids.

Radiation. The most common types of radiation encountered in industry are infrared radiation (IR) or heat, ultraviolet radiation (UV), and visible light.

Sources of IR in industry are primarily molten materials, specifically glass and metals. Many industries are automated, so that employees are not exposed to large amounts of IR, but activities such as glassblowing may produce significant exposures from low-level, long-term exposure (Oriowo et al., 1997). Epidemiological studies have demonstrated that long-term (chronic) exposure to IR in the glass and steel industries is associated with the development of cataracts (Pitts and Kleinstein, 1993). Relatively few of the available spectacle lens materials provide protection from infrared radiation. The best protector is a lens with a metallic coating (copper) that reflects IR (Pitts and Kleinstein, 1993).

Produced by both artificial sources and the sun, UV radiation is commonly encountered in industrial situations. Probably the most common industrial source is an electric welding arc, which emits large amounts of UV-C, UV-B, UV-A, visible light, and IR. Both the eyes and the skin must be protected from this radiation, as well as from sparks and molten droplets of metal produced during arc welding. The most common eye and face protector is a welding helmet. The helmet contains a multilayered faceplate (filter plate) that allows the worker to view the work. The faceplate must meet the specific impact resistance and radiation absorption requirements described in the ANSI Z87.1-1989 standard.

When a weld is finished, the welder must raise the helmet to view the work, at which point his or her eyes are vulnerable to injury from projectiles, debris, and radiation from other welders or other workers nearby. For this reason, a welder must also wear UV-absorbing safety glasses, of which polycarbonate lenses are usually the best. Welders' assistants and observers also require protection. Welding curtains can be used to surround the welding site and prevent inadvertent exposure. Tinted spectacle sun lenses do not provide adequate protection and should not be used for arc welding.

Gas welding and the processes of brazing, soldering, and cutting with torches also require protection from radiation. Protectors must meet the specific requirements specified in the Z87.1-1989 standard for both impact resistance and radiation protection (see Tables 1 and 2).

Many employees who work outdoors require sunglasses for comfortable vision in bright sunlight. Such employees are also exposed to UV radiation, which is a risk factor for the development of cataracts. A sunlens that absorbs both UV-B and UV-A radiation provides the best protection from UV radiation. Gray, brown, or green polycarbonate lenses provide excellent UV protection and have the additional advantage of providing protection from flying projectiles. The gray color is best when good color discrimination is important.

AOA guidelines for UV protection recommend that sunglasses provide at least 99 percent protection from solar UV radiation (UV-A and UV-B) at wavelengths below 400 nm. Gray, green, and brown polycarbonate prescription sunglass lenses will provide this level of protection. Gray, green, and brown CR-39 plastic sunglass lenses may require a UV-protective dye to reach 99 percent UV protection. Gray glass prescription sunglass lenses do not usually meet this recommendation.

The effects of visible radiation on the eye are of most concern for persons who are welding or using lasers. Although outdoor workers can be exposed to high levels of visible light, neutral gray sunglasses provide adequate protection.

Lasers have a wide variety of industrial and engineering applications, including welding, cutting and etching, photochemical processes, electronics design and manufacture, metrology, and surveying. Lasers are found in printers, compact disk players, and laser pointers, and they have become important medical and surgical tools. Laser output can be IR, visible, or UV radiation and power levels can easily be high enough to cause damage to the eye and skin.

Guidelines for laser safety and eye protection are provided in the ANSI Z136.1-2000 and ANSI Z136.3-1996 standards. All ANSI standards are classified as "voluntary," and OSHA has not adopted specific laser safety standards; however, OSHA often relies on published voluntary standards when evaluating industry hazards. The U.S. Food and Drug Administration (FDA) has its own specific laser requirements that manufacturers must meet. Lasers are classified primarily by their ability to cause eye and skin damage, as summarized in Table 3.

Engineering and administrative controls are just as important as eye protectors in preventing damage to the eyes from laser beams. Controls include safety interlocks, barriers that block viewing of the beam, shutters, alarms, master switches, door interlocks, and warning signs. Using the proper control can usually prevent laser injury, even in the absence of eye protection.

The ANSI Z136.1-2000 standard recommends eye protection for the use of Class 3b lasers and requires eye protection for Class 4 lasers when engineering and administrative controls do not provide proper protection. Two general types of laser protection are available (Pitts and Chou, 1998). Wrap-around polycarbonate eyeguards are most commonly used to protect against Class 3 lasers. Enclosed monogoggles with replaceable filter plates are recommended for use with Class 4 lasers. The filter plates are designed to resist a laser beam long enough for the wearer to become aware of the problem and to move out of the path of the beam. Laser eyewear must have very high absorption of the laser wavelength for which protection is required, while allowing maximum transmittance of the visible spectrum. Specific labeling requirements are included in both the ANSI Z136.1-2000 standard and in government standards (OSHA, 1991). Protectors should be comfortable and should not be too dark, especially if the employee works in an area with low ambient light levels.

The laser safety officer (LSO) plays an important role in a laser safety program, especially when higher-power (Class 3 and Class 4) lasers are being used. The LSO's duties, as described in the ANSI Z136.1-2000 standard, include providing employee training on laser safety, evaluation of laser hazards, and monitoring compliance with standards.

X-rays (ionizing radiation), microwaves, radio waves, and the electromagnetic fields produced by A-C circuits may also be encountered in industrial settings, but their effects on the eye and methods of protection are beyond the scope of this manual. For further information, see Pitts and Kleinstein (1993) and Chou and Pitts (1998).

Worksite Hazard Assessment

Since 1994 OSHA has required a job site hazard assessment for all workstations in an industrial setting. A hazard analysis begins with an on-site tour and an analysis of all work areas. First-hand information must be obtained about each work area. Input from foremen/supervisors and individual workers regarding potential eye hazards should be solicited. Company safety records should be reviewed to identify areas where past eye injuries may have occurred. The ANSI Z87.1-1989 standard recommends that special attention be paid to:

- sources of motion that can create projectiles
- employee movement patterns that could result in impact with stationary objects
- sources of heat that could cause injury or exposure to IR
- chemical exposures
- sources of dust
- sources of UV, visible or other radiation
- the layout of the workplace
- electrical hazards.

Light levels should be evaluated to determine whether lighting fulfills Illuminating Engineering Society (IES, 2000) recommendations for each task.

Laser hazard analysis may require some additional steps. Laser eye protection needs can often be determined by consulting with the laser manufacturer; however, when this information is not available, the LSO or other qualified personnel may need to calculate the maximum permissible exposures (MPEs) for each laser system to evaluate protection needs. The area around a laser can be hazardous, too, because of reflections or equipment failures, in which case it is necessary for the LSO to determine the nominal hazard zone (NHZ) for each laser system. The NHZ is the space surrounding a laser within which the level of direct, reflected, or scattered radiation exceeds the MPE. Instructions for calculating MPEs and performing an NHZ analysis are presented in the ANSI Z136.1-2000 standard. Finally, non-beam hazards associated with lasers must be evaluated. These include the risk of fire from the laser beam, electric shock from beam power supplies and electronics, exposure to hazardous laser gases and liquids, hazards from compressed gas cylinders, and exposure to fumes, vapors, and particles formed when a laser interacts with a target material.

Whenever possible, the best means of protecting workers' eyes is elimination or containment of the hazard at its source. For a non-laser hazard this might include modification of equipment or the work area, hazard shielding, regular maintenance, and the installation of exhaust systems that remove dust, gases, or fumes from the work area (Collins, 1983). Laser protection is best provided by engineering controls such as safety interlocks and beam shields.

In many cases, complete elimination of all eye hazards is not possible, and some form of personal eye protection is required. Once areas or work tasks have been determined as being hazardous to the eyes, a firm policy should be established regarding the use of protective eyewear:

- all persons working in, passing through, or visiting these areas must wear adequate eye protection
- appropriate warning signs should be conspicuously placed in all eye hazardous areas
- supervisors need to be thoroughly familiar with the eye protection requirements within their areas and strictly enforce their use.

Employers must recognize the existence of eye hazards and provide employees with the necessary protective eyewear and safety training and ensure that employees comply with their use. Company management and a workers' committee should jointly develop specific disciplinary policies to be followed for workers who fail to comply. Some companies have made the use of safety eyewear a condition of employment.

Once a hazard analysis has been completed and proper protective devices have been selected, it will be necessary to re-evaluate the workplace at appropriate intervals. The occupational optometrist and plant safety officer should evaluate new equipment, review accident records, and assess the suitability of previously selected eye protection for a specific task.

Standards and Regulations for Protection Against Hazards

The primary standard pertaining to non-laser eye protection in industry is ANSI Z87.1-1989. This standard was prepared by members of the eyecare professions, industry and the military, among others, and covers all facets of non-laser eye safety and protection, including both prescription and non-prescription industrial safety glasses, face protectors or faceshields, welding hoods or helmets, and goggles. Transmittance requirements for the filters used for welding eye protection are also included. This standard is revised on an ongoing basis every 5 years, so it is important for the optometrist to be aware of the most recent version. Although the American National Standards Institute (ANSI) is a nongovernmental body, the U.S. Occupational Safety and Health Administration (OSHA), a governmental regulatory agency, requires that all industrial eye and face protectors meet the requirements of the ANSI Z87.1-1989 standard. OSHA may also specify additional requirements, such as the requirement for sideshields when there is a potential for injury from flying objects.

Laser eye protection recommendations are provided in two separate standards, ANSI Z136.1-2000 and ANSI Z136.3-1996.

Standards for industrial eyewear differ considerably from those for everyday, non-industrial (dress) prescription eyewear. Some of the most important differences include the impact resistance requirements and, for the industrial standard, specific requirements for the design and strength of the frame. Approval of dress eyewear requires only the FDA-regulated drop-ball test, while industrial eyewear must meet all requirements of the ANSI Z87.1-1989 standard.

Eye Emergency Procedures

Regardless of an eye safety program’s effectiveness, eye injuries will occur. In such an emergency, knowing what to do and how to do it may mean the difference between a minor eye injury and permanent eye damage. Everyone who works in an eye-hazardous area should be familiar with the general principles of first aid needed to deal with eye emergencies.

Occupational eye injuries may occur due to trauma or mechanical injury, from contact with chemicals or gases, or from exposure to radiation. Although injuries to the eyes may not be life-threatening, they can result in serious eye damage and disability. Quick, effective treatment can often mean the difference between a return to normal and permanent loss of vision. This is particularly true in the case of a chemical splash into the eyes. Immediate and constant flushing of the eyes and face is essential. This flushing action serves to dilute the chemicals and minimize their effect on eye tissue. Whenever chemical eye injury is possible, workers must have immediate access to appropriate eye wash stations.

Today's legal climate suggests the need for caution when examining a patient with a job-related eye injury. First, the most basic step in the evaluation of any eye injury is a good case history. Although obviously important for diagnostic and treatment purposes, a good history, along with comprehensive record keeping, can minimize the legal problems commonly encountered following occupational eye injury. Likewise, it is important that visual acuity be measured before any other procedure is performed.

TABLE 1

Transmittance Properties of Welding Filters

Shade number	Luminous1 (%) transmittance[1] Far UV[2]	Ultraviolet transmittance (%)	Ultraviolet transmittance at 313 nm[3] (%)	Ultraviolet transmittance at 365 nm[4] (%)	Infrared transmittance[5] (%)
1.5	62	0.1	0.0003	30	25
1.7	50	0.1	0.0003	22	20
2.0	37	0.1	0.0003	14	15
2.5	23	0.1	0.0003	6.4	12
3.0	14	0.07	0.0003	2.8	9.0
4.0	5.2	0.04	0.0003	0.95	5.0
5.0	1.9	0.02	0.0003	0.30	2.5
6.0	0.72	0.01	0.0003	0.10	1.5
7.0	0.27	0.007	0.0003	0.037	1.3
8.0	0.10	0.004	0.0003	0.013	1.0
9.0	0.037	0.002	0.0003	0.0045	0.8
10.0	0.014	0.001	0.0003	0.0016	0.6
11.0	0.005	0.0007	0.0003	0.0006	0.5
12.0	0.002	0.0004	0.0002	0.0002	0.5
13.0	0.0007	0.0002	0.000076	0.000076	0.4
14.0	0.00027	0.0001	0.000027	0.000027	0.3

Sources: ANSI Z87.1–1989, Table 1, and Canadian Standards Association (CSA) Z94.3–1999, Table 3.

[1]Luminous transmittance values are nominal values for the waveband 380–780 nm with reference to CIE Illuminant A and the CIE 1931 Standard Observer (ANSI Z87.1–1989). For specific limits, see also CSA Z94.3–1999.

[2]Recommendations for waveband 200–315 nm; average transmittance in the waveband 315–385 nm should be less than 1/10 of the luminous transmittance (ANSI Z87.1–1989).

[3]Transmittance for wavelengths 210–313 nm shall not exceed this level (CSA Z94.3–1999).

[4]For wavelengths 313–365 nm, transmittance shall not exceed this level; for wavelengths 365–400 nm, mean spectral transmittance shall not exceed luminous transmittance (CSA Z94.3–1999).

[5]Recommendation for waveband 780–2000 nm (ANSI Z87.1-1989). Maximum mean transmittance values for wavebands 700–1300 nm and 1300–2000 nm (CSA Z94.3-1999).

TABLE 2

Recommended Shade Numbers for Welding Operations

Operation	Shade	Recommended Protector
Torch soldering	1.5-3	Spectacles or welding faceplate
Torch brazing	3-4	Welding goggles or faceshield
Cutting	3-6	Welding goggles or faceshield
Gas welding	4-8	Welding goggles or faceshield
Gas tungsten arc welding	8-10	Welding helmet or shield
Gas metal arc welding	7-11	Welding helmet or shield
Flux core arc welding	7-11	Welding helmet or shield
Plasma arc welding	6-11	Welding helmet or shield
Electric arc welding	10-14	Welding helmet or shield

Although recommended shade numbers prevent radiation-induced ocular injury (ANSI Z87.1-1989), Sliney and Wolbarsht (1980) have noted that filters with higher shade numbers may be needed to ensure visual comfort throughout a full working day of exposure to a welding arc.

TABLE 3

Summary of the ANSI Z136.1-2000 Laser Hazard Classification

Laser class	General Description
1	Incapable of producing damaging radiation levels during operation and maintenance. No eye or skin hazard from full-day exposure.
2	"Low-power" laser. Emits in visible portion of the spectrum. No eye hazard from intrabeam exposure within aversion reflex time.
3	"Medium-power" laser. Eye hazard from intrabeam exposure and from specular reflection within aversion reflex time. Diffuse reflections do not usually present a hazard (unless laser beam is focused or of small diameter and viewed from a short distance).
4	"High-power" laser. Eye and beam hazard from intrabeam viewing or diffuse reflection. Fire hazard if combustible materials are exposed to beam. May also produce air contaminants and hazardous plasma radiation.

IV. CONTACT LENS USE IN INDUSTRY

Robert A. Koetting, O.D.
St. Louis, Missouri
Gregory W. Good, O.D., Ph.D.
The Ohio State University College of Optometry

The use of contact lenses in industrial settings has been controversial since the early 1960s. Authors debated the pros and cons of wearing contact lenses in environments posing great risk of eye injury (Kuhn, 1961; Silberstein, 1962). The potential for contact lenses to increase both the number and severity of eye injuries in industry led the National Society to Prevent Blindness to recommend that contact lenses be prohibited for wear in industrial environments (NSPB, 1972).

The ANSI Z-80 Subcommittee on Contact Lenses addressed the question of the safety of wearing contact lenses in industry in 1972. The discussions led to a survey of practitioners to determine the extent of eye injuries associated with contact lens wear (Rengstorff and Black, 1974). Rengstorff and Black reported on 128 documented incidents in which individuals wearing contact lenses were exposed to physical trauma or chemical irritation. In not one of the cases did the reporting practitioner believe that the eye injury was caused, or made worse, by the wearing of a contact lens. In fact, in many cases the practitioners believed that the contact lens provided some protection.

During the 1970s and 1980s, researchers tried to simulate injuries resulting from industrial-type hazards in subjects (often rabbits) wearing contact lenses (Guthrie and Seitz, 1975; Lovsund et al., 1979; Nilsson et al., 1981; Nilsson and Andersson, 1982; Nilsson et al., 1983). These studies overwhelmingly showed that wearing contact lenses does not place the eyes at special risk of injury in industrial-type settings. Nevertheless, these studies were typically performed in laboratory settings, using research protocols. One can only speculate on the influence of the human element and a worker's possible noncompliance with other safety standards in actual settings.

One thing is clear, however, and it is something on which everyone agrees: "Contact lenses of themselves do not provide eye protection in the industrial sense." (ANSI Z87.1-1989). OSHA-mandated and ANSI-recommended eye protection must be worn over contact lenses exactly as if the worker required no refractive correction. Moreover, when environmental conditions cause discomfort or interfere with vision (e.g. such as smoky, dirty, or dusty conditions), extra protection (e.g. such as fully sealing goggles instead of spectacles with side shields), may be needed.

Whether workers should wear their contact lenses around potentially toxic chemicals continues to elicit varying points of view. Although studies have shown that contact lenses do not worsen chemical injuries (Wesley, 1966; Rengstorff, 1969; Nilsson and Andersson, 1982; Kok-van Alphen et al., 1985), these studies often did not take into account the human element. If a chemical is splashed into the eye of a worker wearing a contact lens, valuable time may be lost before the eye is flushed with water, while the worker tries unsuccessfully to remove the lens or fails to rinse the eye at all, for fear of losing the lens (Kingston, 1981). In such a scenario, additional injury may occur.

Another situation that warrants discussion is that in which a worker is unable to call "time-out" when he or she becomes visually incapacitated by debris under a contact lens. For example, consider a welder working on scaffolding or on an I-beam. If smoke or welding debris gets trapped behind the contact lens and incapacitates the worker, he or she may be at extra risk of injury from a fall, burn, or even electrocution. Care must be exercised when authorizing contact lens wear for industrial workers. Workers, coworkers, and safety personnel must be apprised of the risks and responsibilities that accompany contact lens wear. Education of all individuals involved is an important first step in developing a contact lens policy for industry. The AOA's Guidelines for The Use of Contact Lenses in Industrial Environments should be reviewed (Appendix B). It lists the questions that should be asked and answered in arriving at an informed decision concerning contact lens use.

V. MEDICO-LEGAL AND ETHICAL CONCERNS REGARDING STANDARDS AND REGULATIONS

James Scholles, O.D., J.D.
Cincinnati, Ohio

Every employer stands to benefit from an appropriate philosophy toward employee safety and visual performance. One goal of the optometric consultant to industry is to help management appreciate the risks and benefits of eye protection and correction.

The "golden rules" for industry are three: (1) What is good for the employee is good for the company, (2) Protect your employees as you would your own family, (2) Industrial ethics includes putting the interest of protecting your employee foremost.

Two important laws that provide requirements, guidelines, and standards with which employers must comply are the Occupational Safety and Health Act of 1970 (OSHA), administered by the U.S. Department of Labor, and the Americans with Disabilities Act (ADA) administered by the U.S. Department of Justice.

"Standards" include a measure of what a reasonable or prudent person would do in a given situation, whereas "Guidelines" detail procedures to follow under particular circumstances. Standards can be determined which measure safe levels. Breaching a standard could be construed to be reckless or negligent behavior. The term "occupational safety and health standard" is defined by OSHA as a standard that requires conditions reasonably necessary or appropriate to provide safe or healthful employment and places of employment.

OSHA Standards

OSHA has issued standards in two areas that are especially related to eye care:

Eye and Face Protection -1910.133. The general requirements state in part:

(a)(1) *The employer shall ensure that each affected employee uses appropriate eye and face protection when exposed to eye and face hazards from flying particles, molten metal, liquid chemicals, acids, or caustic liquids, chemical gases or vapors or potentially injurious light radiation.*

(a)(2) *The employer shall ensure that each employee uses eye protection that provides side protection when there is a hazard from flying objects.*

(a)(3) *The employer shall ensure that each affected employee who wears prescription lenses while engaged in operations that involve eye hazards wears eye protection that incorporates the prescription in its design, or wears eye protection that can be worn over the prescription lenses without disturbing the position of the prescription eyewear or the protective lenses.*

(a)(4) *Eye and face PPE [personal protective equipment] shall be distinctly marked to facilitate identification of the manufacturer.*

(a)(5) *The employer shall ensure that each affected employee uses equipment with filter lenses that have a shade number appropriate for the work being performed for protection from injurious radiation.*

OSHA has incorporated by reference the American National Standard Practice for Occupational and Educational Eye and Face Protection of the American National Standards Institute (ANSI Z87.1 – 1989).

Bloodborne Pathogens - 1910.1030.

The second area especially related to eyecare comprises OSHA regulations that address occupational exposure to blood or other potentially infectious materials. "Bloodborne Pathogens" means pathogenic microorganisms that are present in human blood and can cause disease in humans. These pathogens include, but are not limited to, hepatitis B virus (HBV) and human immunodeficiency virus (HIV). The

OSHA regulations stipulate that the employer shall provide *"appropriate protective equipment such as, but not limited to, gloves, gown, laboratory coats, face shields or masks, and eye protection."*

OSHA regulations also contain provisions for hand washing facilities and disposal of sharp objects. With reference to "Masks, Eye Protection, and Face Shields", the OSHA regulation states, *"Masks in combination with eye protective devices, such as goggles or glass with solid eye shields, or chin-length face shields, should be worn whenever splashes, spray, splatter or droplets of blood or other potentially infectious materials may be generated and eye, nose, or mouth contamination can be reasonably anticipated."*

The OSHA regulations provide directives for labeling, signs, record keeping, communication with employees, and confidentiality regarding the application of the protections.

Americans with Disabilities Act

Passed in 1990, the Americans with Disabilities Act (ADA) prohibits discrimination on the basis of disability in employment, programs and services provided by state and local governments, goods and services provided by private companies, and in commercial facilities. The ADA covers effective communication with people with disabilities, prohibits eligibility criteria that may prevent access to employment, and requires reasonable modification of policies and practices that might be discriminatory.
The ADA authorizes the Department of Justice (DOJ) to issue regulations, to provide technical assistance, and enforce those regulations. The Act defines "disability" to mean, with respect to an individual:

1. *A physical or mental impairment that substantially limits one or more of the major life activities of such individual;*
2. *A record of such an impairment; or*
3. *Being regarded as having such an impairment.*

Under the ADA, an "employer" is defined as a person engaged in an industry affecting commerce who has 15 or more employees for each working day in each of 20 or more calendar weeks in the current or preceding calendar year.

A "qualified person with a disability" is an individual with a disability who, with or without reasonable accommodation, can perform the essential function of the employment position that the individual holds or desires.

"General rule: No covered entity shall discriminate against a qualified individual with a disability because of the disability of such individual in regard to job application procedures, the hiring, advancement or discharge of employees, employee compensation, job training, and other terms, conditions and privileges of employment." Discrimination includes in part *"utilizing standards, criteria or methods of administration that have the effect of discrimination at the basis of disability."* It also includes *"using qualification standards, employment tests or other selection criteria to screen out or tend to screen out an individual with a disability unless the standard, test or other selected criteria is shown to be job related for the position in question and is consistent with business necessity."*

It is the job of the vision consultant to industry to evaluate both vision requirements and standards for job performance and the safety of the employee and others. It is important that the application of such requirements and standards be consistent with the directives of the ADA.

REFERENCES AND SOURCES FOR FURTHER INFORMATION

ANSI Z80.1–1999. American National Standard for Ophthalmics– Prescription Ophthalmic Lenses– Recommendations. Available from the Optical Laboratories Association (OLA), P.O. Box 2000, Merrifield, VA 22116-2000. Telephone (703) 359-2830. Also available from the American National Standards Institute (ANSI), 11 W. 42nd St., New York, NY 10036. Telephone (212) 642-4900. Internet address: http://www.ansi.org.

ANSI Z87.1–1989. American National Standard Practice for Occupational and Educational Eye and Face Protection. Available from the American Society of Safety Engineers, 1800 E. Oakton St., Des Plaines, IL 60018-2187. Telephone (847) 699-2929. Internet address: http://www.asse.org. Also available from ANSI.

ANSI Z136.1–2000. American National Standard for the Safe Use of Lasers. American National Standards Institute, 2000. Available from ANSI.

ANSI Z136.3–1996. American National Standard for the Safe Use of Lasers in Health Care Facilities. Available from ANSI.

Bader O, Lui H. Laser safety and the eye: hidden hazards and practical pearls. Poster presented at the American Academy of Dermatology Annual Meeting, 1996. Available on the Internet from the Lions Laser Skin Center at http://www.derm.ubc.ca/laser/eyesafety.html.

Birch, J. *Diagnosis of Defective Colour Vision.* Oxford:Oxford University Press, 1993.

Bullimore MA, Howarth PA, Fulton EJ. Assessment of visual performance. In *Evaluation of Human Work: A practical ergonomics methodology,* 2nd ed., edited by Wilson JR, Corlett EN. London:Taylor & Francis, Ltd., 1995.

Chou BR, Fong WKL. Impact resistance of Transitions Plus spectacle lenses. *Optometry and Vision Science* 72:608-611, 1995.

Code of Federal Regulations. Laser Products, Title 21 – Food and Drugs. 21CFR1040.10.

Code of Federal Regulations. Eye and Face Protection. OSHA Regulations. 29CFR1910.133.

Collins M. *Occupational Public-Health Optometry*. Queensland, Australia:Department of Optometry, Queensland Institute of Technology, 1983.

Eng WG. Laser eye protection. Problems in Optometry 2(1)116-130, 1990.

Good GW, Weaver JL, Augsburger AR. Determination and application of vision standards in industry. *American Journal of Industrial Medicine* 30:633-640, 1996.

Guthrie JW, Seitz GF. An investigation of the chemical contact lens problem. *Journal of Occupational Medicine* 17(3):163-6, 1975.

Illuminating Engineering Society. *IES Lighting Handbook*. New York:IES, 2000.
Kingston DW. Contact lenses in the laboratory. *Journal of Chemical Education* 58:A289-93, 1981.

Kok-van Alphen CC, van der Linden JW, Visser R, Bol AH. Protection of the police against tear gas with soft contact lenses. *Military Medicine* 150:452-4, 1985.

Kuhn HS. Contact lenses–Threat to vision? *National Safety News*, June, 1961.

Laser Institute of America. *Laser Safety Reference Guide.* Orlando, FL, 1995.

Lovsund P, Nilsson SEG, Lindh H, Oberg PA. Temperature changes in contact lenses in connection with radiation from welding arcs. *Scandinavian Journal of Work Environment and Health* 5:271-9, 1979.

McCunney RJ (ed.). *Handbook of Occupational Medicine.* Boston:Brown, Little, Brown and Co., 1988.

Monaco WA, Barker FM. Laser hazards and safety. *Optometry Clinics* 4(4):1-15, 1995.

National Institutes for Occupational Safety and Health. *NIOSH pocket guide to chemical hazards.* Washington, DC, U.S. Dept. of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, 1997. (For sale by the Superintendent of Documents, U.S. Government Printing Office.)

National Society for the Prevention of Blindness, Chicago. Position statement on the wearing of contact lenses in industry,1972.

Nilsson SEG, Lovsund P, Oberg PA. Contact lenses and mechanical trauma to the eye. *Acta Ophthalmologica* 59:402-8, 1981.

Nilsson SEG, Andersson L. The use of contact lenses in environments with organic solvents, acids or alkalis. *Acta Ophthalmologica* 60:599-608, 1982.

Nilsson SEG, Lindh H, Andersson L. Contact lens wear in an environment contaminated with metal particles. *Acta Ophthalmologica* 61:882-8, 1983.

Occupational Safety and Health Administration. *Assessing the Need for Personal Protective Equipment: A Guide for Small Business Employers*. U.S. Department of Labor, OSHA 3151, 1997.

Occupational Safety and Health Administration. *Guidelines for Laser Safety and Hazard Assessment.* U.S. Department of Labor, OSHA Publication 8-1.7, 1991.

Occupational Safety and Health Administration. *Job Hazard Analysis* (revised). U.S. Department of Labor, OSHA 3071, 1992.

Occupational Safety and Health Administration. Section II- Chapter 6, Laser Hazards, *OSHA Technical Manual.* U.S. Department of Labor.

Oliver AL, Chou BR. A ballistic evaluation of the impact resistance of spectacle lens materials. *Optometry and Vision Science* 70:822-927, 1993.

Oriowo OM, Chou BR, Cullen AP. Glassblowers' ocular health and safety: optical radiation hazards and eye protection assessment. *Ophthalmic and Physiological Optics* 17(3):216-224, 1997.

Pitts DG, Chou BR. Prescription of absorptive lenses. In Benjamin WJ (ed)., *Borish's Clinical Refraction.* Philadelphia:Saunders, 998, pp. 928-955.

Pitts DG, Kleinstein RN. *Environmental Vision*. Boston:Butterworth-Heinemann, 1993.

Rengstorff RH. The effects of riot control agent CS on visual acuity. *Military Medicine* 134(3):219-221, 1969.

Rengstorff RH, Black CJ. Eye protection from contact lenses. *Journal of the American Optometric Association* 45:270-275, 1974.

Silberstein IW. Contact lenses in industry. *American Journal of Optometry and Archives of the American Academy of Optometry* 39(3):111-29, 1962.

Sliney DH (ed). *Guide for Selection of Laser Eye Protection*, 4th ed. Publication 104. Laser Institute of America, 12424 Research Parkway, Suite 125, Orlando, FL 32826. (407) 380-1553. Internet address: http://www.laserinstitute.org.

Sliney D, Wolbarsht M. *Safety With Lasers and Other Optical Sources*. New York:Plenum Press, 1980.

Wesley NK. Chemical injury and contact lenses. *Contacto* 10(3):15-20, 1966.

AUTHOR CONTACT INFORMATION

Gregory W. Good, O.D., Ph.D.
College of Optometry
The Ohio State University
320 W. 10th Avenue
P.O. BOX 182342
Columbus, OH 43218-2342
614-292-5203
good.3@osu.edu

Robert A. Koetting, O.D.
1034 S. Brentwood Boulevard #333
St. Louis, MO 63117-1203
314-863-0003
rakoett@i1.net

Donald G. Pitts, O.D., Ph.D.
6943 South Jamestown Avenue
Tulsa, OK 74136-2611
918-494-6779
pittsdandl@aol.com

James R. Scholles, O.D., J.D.
8970 Winton Road
Cincinnati, OH 45231
513-522-0035
jscholles@aol.com

Gregory L. Stephens, O.D., Ph.D.
College of Optometry
University of Houston
Houston, TX 77203-6052
713-743-1933
gstephens@uh.edu

AOA Staff
Jeffrey L. Weaver, O.D., M.S.
American Optometric Association
243 N. Lindbergh Blvd.
St. Louis, MO 63141
314-991-4100 Ext.244
JLWeaver@aoa.org

WEB ADDRESSES

American Optometric Association	www.aoa.org
ANSI (American National Standards Institute)	www.ansi.org
ASSE (American Society of Safety Engineers)	www.asse.org.
Eye Protection Council	www.eyesafety.org
NIOSH (National Institute for Occupational Safety and Health)	www.cdc.gov/niosh/
OHSA (Occupational Health and Safety Administration)	www.ohsa.gov
Protective Eyewear Certification Council	www.protecteyes.org
Prevent Blindness America	www.preventblindness.org

APPENDIX A

Occupational History

I. Work and Exposure History

A. Current Employment

Questions 1–7 refer to your current or most recent job.

1. Job title ______
2. Type of industry ______
3. Name of employer ______
4. Year job began ______
   Still working? ______
   Yes ______ No ______ If no, year job ended ______
5. Briefly describe this job, noting any part that you feel may be hazardous to your health. ______
   ______
6. Do you wear protective equipment on this job?
   Yes ______ No ______ If yes, check equipment used:
   Gloves ______ Air supply respirator ______
   Mask respirator ______ Coveralls or aprons ______
   Hearing protection ______ Safety glasses ______
7. In this job, are you exposed to any of the following?
   If yes, mark those to which you are exposed:
   Fumes and dusts ______ Elements and metals ______
   Solvents ______ Other chemicals ______ Noise ______
   Vibration ______ Excess heat/cold ______
   Emotional stress ______ Other ______

B. Employment History

It is important that we know all the jobs you have had. Job #1 is your current or most recent job. Beginning with the job before this one—Job #2—please fill in as much of the information requested as you can remember, and continue to do so until all previous jobs have been listed. Include any military service you have had. If you need additional space, use the back of this form.

	YEARS From—To	JOB TITLE	EXPOSURES
Job #2	______	______	______
Job #3	______	______	______
Job #4	______	______	______
Job #5	______	______	______
Job #6	______	______	______
Job #7	______	______	______
Job #8	______	______	______
	______	______	______

C. Other Exposures

1. Does anyone in your household work at a job that you suspect involves exposures that may be brought home from work (e.g., asbestos fibers on clothes)?
   Yes ______ No ______
2. Are there any industries in the area in which you live that may pollute your environment?
   Yes ______ No ______
3. Do you have any hobbies that expose you to chemicals, metals, or other substances?
   Yes ______ No ______
4. Have you ever smoked cigarettes? ("No" means less than 20 packs of cigarettes in your entire life.)
   Yes ______ No ______
   If yes, please answer the following:
   a. Do you now smoke cigarettes (that is, as of 1 month ago)? Yes ______ No ______
   b. How many years have you smoked? ______
   c. Of the entire time you have smoked, about how many cigarettes per day do or did you smoke on the average?
   ______

II. General Health History

1. Is there any particular hazard or part of your job that you think relates to your problems? Yes ______ No
2. Do any of your coworkers have problems or complaints similar to yours? Yes ______ No ______

From Rosenstock L: Clinical Occupational Medicine. Philadelphia, WB Saunders, 1986; with permission.

APPENDIX B

AMERICAN OPTOMETRIC ASSOCIATION GUIDELINES FOR THE USE OF CONTACT LENSES IN THE INDUSTRIAL ENVIRONMENTS

Anthony P. Cullen, M.Sc., O.D., Ph.D., D.Sc.

The American Optometric Association has adopted the following policy statement concerning the use of contact lenses in industrial environments:

"Contact lenses may be worn in some hazardous environments with appropriate covering safety eyewear. Contact lenses of themselves do not provide eye protection in the industrial sense."

Most successful contact lens wearers wish to wear their contact lenses in all aspects of their lives, including the workplace. This may conflict with government or industry imposed restrictions on the use of contact lenses in a given industrial environment. These restrictions, in turn, may be unreasonable and discriminatory.

In risk management it is necessary to balance risk with benefits and to differentiate perceived risk from actual risk. Because both contact lens or certain environments may produce adverse ocular effects it is tempting to assume that there may be additive or synergistic effects when contact lenses are worn in that environment. When considering the advisability of wearing contact lenses in a given industrial setting a number of questions should be addressed:

- Is there an actual hazard?
- Does the wearing of contact lenses place the eye at greater risk than a naked eye?
- Does the removal of the contact lens increase the risk to the eye, the wearer or co-workers?
- Is the risk different for various contact lens materials and designs?
- Are there other risks to the wearer or co-workers?
- Do contact lenses decrease the efficacy of other safety strategies?

Ocular hazards are greater in some occupations than others. Those who prescribe contact lenses for industrial workers should be concerned as to the advisability of wearing the lenses in a given environment. The type of work may influence the selection of lens material and design, and wearing the replacement schedules. The following factors may be of value in making these decisions:

- The toxic chemicals and/or physical agents that may be encountered
- Raw material and by-products involved
- Potential for ocular exposure
- Protective equipment provided, available and used
- Hygiene facilities available
- Presence or absence of health and safety personnel
- Factors that may influence compliance with cleaning and wearing schedules

An evaluation of the published material, including laboratory and human studies, and well documented case reports, indicates that contact lenses may be worn safely under a variety of environmental situations including those which, from a superficial evaluation, might appear hazardous. Indeed, some types of contact lenses may give added protection to spectacle lens and non-spectacle lens wearers in instances of certain fume exposure, chemical splash, dust, flying particles and optical radiation. The evidence also refutes the claims that contact lenses negate the protection provided by safety equipment or make the cornea more susceptible to damage by optical radiation, in particular arc flashes. Thus a universal ban of contact lenses in the workplace or other environments is unwarranted.

Regulations limiting the wearing of contact lenses in any given circumstance must be scientifically defensible and effectively enforceable. They should not be based on perceived hazards, random experience, isolated unverified case histories or unsubstantiated personal opinions.

Conversely, it would be imprudent for a practitioner to prescribe contact lenses in order to circumvent uncorrected visual acuity standards in those occupations where individuals may be required to function without correction on some occasions or in environments contraindicated for the type of lens prescribed.

All practitioners must stress that personal protective equipment, including safety eyewear, is not replaced by contact lenses.

Where circumstances create the necessity eye protection must be worn.

APPENDIX C

SAMPLE OCCUPATIONAL VISION POLICY

Smith Manufacturing considers the health and safety of its employees to be of the greatest importance. Therefore, we have developed a company-wide occupational eye care policy. It provides for strict compliance with all aspects of the Occupational Safety and Health Administration (OSHA) regulations relating to eye safety. This policy covers the following areas:

- Designation of eye-hazardous areas
- Provision of protective eyewear
- Contact lens wear
- Employee vision screening program
- Eye safety training program.

Failure to comply with any aspects of this policy is grounds for disciplinary action.

Section I – Eye-Hazardous Areas

The specific eye hazards to which workers are exposed have been identified in all work areas and are clearly marked. All individuals who enter an eye-hazardous area must wear the appropriate OSHA-approved personal protective equipment. This policy pertains to all employees and visitors and will be upheld regardless of the length of time an individual spends in a given work area.

Results of the latest site surveys, which show potential hazards for each of the plant's primary workstations, are on file with each workstation supervisor. Employees are required to review these surveys yearly. Employees are encouraged to propose recommendations for changes to these surveys to their immediate supervisors or the plant's safety officer. (See sample site survey in Appendix B.)

Section II – Protective Eyewear

Only OSHA/ANSI Z87-approved eye and face protection, both prescription (corrective) and nonprescription (plano), are provided by Smith Manufacturing for employees working in eye-hazardous areas. Nonprescription eyewear is issued to employees through the company Safety Office. Employees are encouraged to keep their eyewear clean and properly adjusted. Opticians in the Safety Office are available for professional adjustment of eyewear when required. If safety eyewear becomes scratched, broken, or otherwise non-useable, the employee can obtain new eyewear from the Safety Office. Because eyewear must be individually sized and fit, plano eyewear will be dispensed to individual employees on a personal basis only.

The employee who requires prescription (corrective) eyewear must first obtain an occupational safety eyewear order form from the safety office. The employee may take this form to the eye doctor of his or her choice to obtain an examination and prescription information. The employee will be provided a workstation information sheet (Appendix B) to review with the eye doctor to ensure that the correct powers and designs for the prescription eyewear are obtained. The eyewear order form must be returned to the Safety Office following completion by the doctor.

Employees are required to schedule their own periodic eye examinations with eye doctors of their choice. Smith Manufacturing provides employees a vision care insurance program that provides for eye examinations and dress spectacles every 2 years. Safety eyewear shall be ordered by the company Safety Office. Opticians are available within the safety office for sizing, ordering, dispensing, repairing, and adjusting all safety eyewear. The company will pay for repair or replacement of occupational safety lenses or frames damaged during work activities. Replacement or repair of damage to safety eyewear which occurs off the job will be at the employee's expense.

Section III – Contact Lens Wear

Contact lenses of themselves do not provide eye protection in the industrial sense. Eye protection mandated by OSHA and the ANSI Z87.1–1989 recommendations must be worn over contact lenses exactly as if the worker required no spectacle correction.

Although studies have not demonstrated that contact lenses increase the risk of injury or illness for individuals working in industrial settings, special precautions must be observed when working around chemicals, welding, and other industrial operations. Because these conditions exist within our facilities, employees who choose to wear contact lenses must register with the company safety office. Mandatory training, including review of the risks associated with wearing contact lenses in industrial settings and the proper procedures to undertake should an injury occur, is required. Employees not adhering to this policy are subject to disciplinary action.

Informational materials concerning chemical exposures and special contact lens risks related to our operations at Smith Manufacturing are available from the Safety Office to provide to your eye doctor.

Section IV – Vision Screening

All new employees will be given a preplacement vision screening to ensure they have the necessary vision and vision skills required to accomplish their prospective job duties. Individuals who do not pass the vision screening will be required to obtain a complete eye examination at company expense.

Periodic rescreening will be conducted to ensure all employees continue to maintain visual abilities that are adequate for functioning efficiently and safely in the work environment.

Section V – Eye Safety Training

Each employee shall be trained in the proper use and care of safety eyewear. Each employee shall clean and inspect his or her safety eyewear daily prior to use. All employees shall be trained to provide first aid for eye emergencies and to properly use emergency showers and eyewash stations.

Questions regarding any aspects of this Occupational Eye Care Policy should be directed to the Safety Office.

APPENDIX D

SAMPLE
Occupational Site Survey

Location: Smith Manufacturing

Date:______________________

Job Title: Forklift Operator (Warehouse)

Primary Duty: Transport cartons and materials and finished product within warehouse, between warehouse and work areas, and around loading dock.

Specific Visual Tasks:

1) Operate forklift
    a. Position forks under load & ensure load stability
    b. Safely and efficiently maneuver forklift throughout factory
    c. Accurately position forks at appropriate height and location, load and unload material
2) Read codes (4 cm) and dates (1.2 cm) on cartons from 4 meters
3) Read and/or fill out inventory sheets and order requests (12-pt. print)
4) Read schedule and notices on bulletin board.

Safety – Specific Hazards:

1) Possible chemical exposure when transporting sealed 55-gallon drums (lacquers and dyes)
2) Flying wood chips when delivering materials through wood processing areas
3) Pedestrian and forklift traffic throughout warehouse and plant
4) No additional risk from wearing contact lenses

Recommended Eye/Face Protection:

1) Safety spectacles with clear side shields (full peripheral vision required) (phototropic lenses not allowed)

Diagram of Work area: **See Attached Page**

Recommended Vision Standards:

Visual Acuity – 20/40 distance, 20/50 near (identify codes and dates on cartons from 4 meters; read inventory sheets, order requests)

Binocularity – Normal binocular vision, screening criterion 80" of stereopsis (position fork under load, position at appropriate height to stack or retrieve product)

Color Vision – No requirement

Visual Field - 70^{o} on both sides of fixation (detect pedestrians and other forklifts while moving throughout warehouse and loading docks)

Diagram of Work area: Site Survey - Warehouse