

1. Visual Performance

There are many varied and complex types of work in industry today. Any professional engaged to advise on visual performance would need, in the first instance, to visit the place of work to gain full understanding of the task and obtain a precise knowledge of its demand(s) upon the employee. The goal is to minimise stress on the visual system, which will result in an efficient and safe visual performance. In addition to the assessment of the work place and the tasks involved, an assessment of individual capabilities is required of the job. If not, one of the two things can happen 1) changes can be made to the work place or 2) direct assistance can be given to the employee, for example, in the form of spectacles or magnifiers.

The ability to perform most tasks depends on many visual and non-visual variables, and the factors that influence the visual performance can be listed as follows:

- a) The visual capabilities of the individual
- b) The visibility of the task
- c) Psychological and general physiological factors

Visual Capabilities

A knowledge of the capabilities and limits of the visual system is essential so that tasks can be designed to allow maximum performance and a minimum number of errors. A task that requires the visual system to operate to its limit may cause general stress, asthenopia, and decreased performance and efficiency. Far too often insufficient attention is given to determining the visual capabilities of a person and to ensuring that he or she is capable of seeing adequately in relation to the demands of a particular task.

The function of the visual system can be divided into four broad groups

1. Detection: The functions involved in the detection of objects include the following:
 - a. Visual Field
 - b. Head and eye movements (Saccadic, smooth pursuit, Vestibular and vergence)
 - c. Light perception
 - d. Visual adaptation
 - e. Flicker frequency
 - f. Contrast sensitivity
2. Recognition:
 - a. Static Acuity
 - b. Distance and the task
 - c. Size of task
 - d. Luminance and contrast
 - e. Age
 - f. Time available
 - g. Refractive error

- h. Vernier acuity
 - i. Dynamic Acuity
3. Color discrimination: It depends on
- a. State of adaptation of retina
 - b. Region of retina stimulated
 - c. Simultaneous contrast
 - d. Successive contrast
4. Depth perception

Visibility of tasks

The ability to perform a task safely, efficiently and comfortably depends upon its variability, as well as on the visual capabilities of the employee. Naturally, the better the visibility, the easier it is to perform the task, and the factors that influence the variability of a task can be listed as follows:

- a. Size of task
- b. Distance of task
- c. Illumination
- d. Contrast
- e. Colour
- f. Time available to view task
- g. Movement of the task
- h. Glare
- i. Atmospheric condition

Psychological and general physiological factors

Factors such as motivation, intelligence, general health etc., should not be forgotten, because they can all influence the visual performance

2. Vision Screening

The general purpose of any vision screening programme is to detect those people who have defective vision but who do not present with symptoms that result in them seeking attention. Every occupation has specific visual requirements that must be met to perform tasks efficiently, safely, and with comfort. Therefore the main aim of screening is to detect those

people whose visual ability is below the standard required. Vision screening programmes are generally carried out either by government organisations such as education authorities and the forces, or by employers. For instance, vision screening is commonly used to identify young children with defective vision, which can affect their progress at school.

Advantages to Industry of vision screening

Bailey (1973) and Collins (1983) concur their assessment of the advantages to industry of vision screening. These can be summarised as follows:

1. Selection of personnel: Visual abilities can be used in the selection of new employees or the transfer of an employee to a task they can perform efficiently
2. Identify employees with visual disabilities. These may be due to an uncorrected refractive error or ocular pathology. If the visual problems cannot be corrected then the employee can be transferred to a task they would be visually capable of performing efficiently
3. Improved employee – employer relationship
4. Improved visual efficiency can result in
 - a. Increased productivity
 - b. Fewer accidents and therefore reduced insurance costs
 - c. Reduced absenteeism as the task is less visually fatiguing
5. Compensation claims can be settled more easily

Given that an employer decides in favour of a vision screening programme, what steps need to be taken? First, visual standards for the various tasks must be established. This may be a relatively straightforward procedure or, if the task is unique or highly complex, it may involve detailed analysis and assessment. Second, the method of screening must be selected, along with the appropriate tests. For advice on these matters a professional person, such as an optometrist, can be consulted.

Establishing occupational visual standards

There are two methods of determining the appropriate visual standard for a particular occupation, namely by the use of predetermined visual standards or by the establishment of the relationship between visual ability and job performance/competence

1. *Predetermined visual standards*

Different tasks require different visual capabilities. For example, train drivers must be able to recognise certain colours whilst crane drivers need good depth perception. Some standards are listed below:

Vision standards for various occupations

1. Vehicle drivers

- a. Private motorists-The motor vehicles (Driving licenses) Regulations 1987 (SI No.1378). The person should be able to read in good daylight (with the aid of glasses or contact lenses if worn) a number of plate at a distance of 20.5 meters containing letters and figures 79.4 mm high. A driving license may not be granted to a person who suffers from some other disability likely to cause the driving of a vehicle to be a source of danger. The standards used are those detailed in the medical aspects of fitness to drive. The recommendations given include a horizontal visual field of not less than 120 degrees, no substantial binocular field loss especially in the lower quadrants, no diplopia, no marked degree of night vision defect. A monocular person may drive providing the visual acuity and visual field are adequate. An adaptation period may be required after the loss of an eye. The driver should report to the Licensing centre if the above requirements cannot be met.
- b. Large goods and passenger carrying vehicles – The person should have a visual acuity (with glasses or contact lenses) of at least 6/9 in the better eye and 6/12 in the worst eye. The uncorrected vision in each eye should be 3/60 or better. If the driver need to wear glasses or contact lenses, the uncorrected acuity must not be less than 3/60 in each eye. A spare pair of spectacles should be carried by those who have an uncorrected vision of 6/18 or worse. Visual fields should be tested by the hand confrontation test, which should be full and show no contraction. Any pathological field defects, insuperable diplopia or monocular vision (except for some renewals) should rule out the driving of large goods and passenger carrying vehicles. The drivers licence should be renewed at 45 or every 5 years, whichever is longer. From the age of 45 renewals are every 5 years and from the age of 65 they are annually.

2. Civil Aviation Authority

The standard required for professional pilots and air traffic controllers are:

- a. There shall be no acute or chronic disease in either eye or adnexa
- b. The visual fields must be normal
- c. A visual acuity of at least 6/9 in each eye (with or without glasses). The unaided vision must not be less than 6/60 or the refractive error must not exceed + or – 3.00 diopters. The medical certificate shall bear an endorsement noting the requirement to wear correcting lenses.
- d. At the initial examination, any degree of heterophoria in excess of 8 prism diopters exophoria, 6 prism diopters esophoria or 1.5 prism diopters hyperphoria will require further evaluation.

- e. Candidates should be able to read N5 or its equivalent at a distance between 30-50 cm with each eye (with or without glasses). It is also required that N14 print should be read at 100cm. The medical certificate should bear an endorsement noting the requirement to have available correcting glasses for near vision purposes.
 - f. Contact lenses may be worn by professional pilots subject to certain conditions. Details of the lenses and a full ophthalmic report should be submitted
 - g. The candidate should have normal colour vision perception as tested by Ishihara Pseudo-Isochromatic plates in good daylight or alternatively be able to recognise colours of signal red, signal green and white using the Holmes Wright Lantern as standard at a distance of 20 feet.
3. Visual display unit operators

Association of optometrists (AOP -UK) recommendations on the visual standards for VDU operators are

- a. The ability to read N6 at a distance of 0.66 metre down to 0.33 metre
- b. Monocular or good binocular vision. Near phorias over ½ prism diopters vertical or 2 prism diopters esophoria and 8 prism diopters exophoria at working distance are contraindicated and should be corrected unless well compensated or deep suppression is present
- c. No central (20 degrees) field defects in the dominant eye
- d. Near point of convergence normal
- e. Clear ocular media examined by ophthalmoscopy and slit lamp. The above recommendations are intended to increase level of operator comfort, and therefore efficiency, but failure to achieve the standard does not exclude a person from working with a VDU.

2. Relating visual ability to job competence

While it is quite simple to establish an employee's visual ability, relating this to their job competence is more complicated. There is no satisfactory method of grading job competence due to non-visual factors influencing the assessment. For example, it may be influenced by age, intelligence, attitude, motivation, and motor reaction times. Bailey (1973) drew up a five step programme for establishing the vision standard:

1. Choose a method for grading job competence
2. Analyse the visual factors required for the task
3. Decide on criteria from visual competence e.g. VA 6/9 or better, and stereopsis
4. Screen the vision of two groups of employees who are judged to be
 - a. Job competent
 - b. Job incompetent

These two groups should be age and gender matched if possible

5. Compare grading of visual competence to job competence. If the appropriate vision standard has been chosen then the majority of the visually incompetent should fall into the job incompetent group.

Grading job competence can be done in a number of ways and Bailey(1973) suggested: i) supervisor rating ii) quality and quantity of production iii) accident frequency iv) absenteeism v) employee turnover vi) wages

Methods of vision screening

Two techniques for screening vision may be used:

1. Modified clinical technique- This method of screening is carried out by qualified personnel e.g. optometrists, who assess the visual functions considered to be particularly important to job performance.

Advantages:

1. Flexibility- tests can be selected depending on the visual functions considered to be important for the task, and the tests can be performed at the appropriate distance
2. Type and magnitude of refractive error can be assessed
3. Ocular pathology may be detected
4. Presence of a squint will be detected
5. very few false referrals

Disadvantages

1. Expensive method of screening due to the use of professional personnel
2. Time consuming
3. Shortage of professional people willing to participate in screening programmes

2. Instrument vision screeners

There are many different instrument vision screeners available, but most of them are basically stereoscopes. The eye piece lenses are arranged so that their prismatic components simulate the viewing of a distant object and the near vision is simulated by either i) moving the targets closer ii) decreasing the separation between the half stereograms iii) changing the lens power i.e. introducing negative lenses

The types of tests commonly included in the instrument screeners are

- a. Visual acuity
- b. Heterophoria
- c. Stereopsis
- d. Fusion
- e. Colour vision
- f. Fogging test
- g. Visual field
- h. Astigmatism

Advantages

1. Operated by lay technician
2. Rapid screening
3. Always available for use
4. Low maintenance costs
5. Cheap method of screening

Disadvantages

1. Lack of Flexibility of tests and testing distance
2. Awareness of the actual target distance may induce proximal accommodation and convergence, even when distance viewing conditions are simulated. This can affect the visual acuity measurement and induce a relative esophoria at distance
3. Cannot detect Ocular pathology
4. Can't detect presence of a squint
5. There can be unnecessary false referrals

THE IDEAL SCREENING PROGRAMME SHOULD:

1. Maximize screening success i.e., correct referral and non-referral
2. Minimize screening errors, i.e. low over and under referral rate. In other words the test needs good sensitivity and specificity

3. Ocular Injuries

Ocular hazards can be divided into two main groups: Mechanical and non-mechanical

Mechanical

The effects of these hazards upon the eye are numerous and have been described in depth by several books. Mechanical injuries may arise from a variety of causes. Their effects are generally divided into two main categories

1. Contusion
2. Perforation'

Contusion

Contusion injuries may result from a variety of causes e.g. flying blunt objects, falling objects, the employee falling, explosions or compressed air accidents, fluid under pressure escaping from burst pipes, or water jets from fire hose.

The resultant ocular damage is due to a wave of pressure traversing the fluid content of the eye. As the fluid is incompressible the blow will act as an explosive force in all directions from the centre outwards resulting in the ocular contents being flung against their outer coat. The globe expands around the equator to take up a vertically oval shape. The effects of contusion on the various structures are numerous.

1. The Eyelids and orbit
 - a. Eyelids- Black eye
 - b. Ptosis
 - c. Ectropion
 - d. Fractures of the orbit
2. Anterior segment damage
 - a. Subconjunctival hemorrhages
 - b. Hyphema
 - c. Iris damage
 - d. Angle recession
 - e. Lens (dislocation or subluxation, Vossius ring, cataract)
3. Posterior segment
 - a. Vitreous haemorrhages
 - b. Scleral ruptures
 - c. Retinal Oedema, cysts, holes and necrosis
 - d. Retinal tears
 - e. Retinal detachment
 - f. Optic atrophy
4. Nerve supply damage

Perforated injuries

1. Foreign bodies
 - a. Subtarsal
 - b. Superficial
 - c. Intra-ocular
 - d. Retained intraocular
2. Lacerations
 - a. Corneal and Scleral
 - b. Prolapsed of Iris, ciliary body and vitreous
3. Infections of the eye

Summary

Contusion and perforating injuries are the most common causes of ocular trauma. The extent of the injuries can be minor or very severe and a person with an eye injury requires medical attention to assess the situation and the treatment needed.

4. Ocular Injuries-Non-mechanical

The non mechanical injuries fall into four main categories

1. Chemical
2. Thermal
3. Electrical
4. Radiational

Chemical injuries

Most chemicals harm the eyes by direct contact with the external ocular tissues, these are amongst the most urgent ocular emergencies. Concentrated sulphuric acid from exploding car batteries, household bleaches, detergents, disinfectants, and lime are examples of chemicals that can cause burns to the eyes. However, it should not be forgotten that chemicals can also cause damage to the internal ocular structures, e.g. retina and optic nerve, through systemic absorption.

Direct effect of chemicals

The main groups of chemicals that produce damage, and that maybe in the form of gas, vapour, liquid, or solid are:

1. Acids
2. Alkalis
3. Organic solvents
4. Surfactants
5. Irritants and allergens
6. Aerosols

Acids

The severity of burn depends on the concentration of the chemical, the duration of the exposure, the protein affinity of the acid anion and the Ph of the solution. Inorganic acids include sulphuric acid, nitric acid, and HCL acid. Examples for organic acids are group of formic, acetic and citric acids. When splashed these acids may burn the eyelids and face, but fortunately the lid closure reflex is so fast that the eyeball is not generally affected.

Acid burns are generally less severe than alkali burns and they tend to improve with treatment and time.

Alkalis

Alkalis penetrate tissues rapidly. They act by combining with the lipid cells of the membranes and produce total disruption of cells with softening of the tissues.

Organic solvents

They rarely cause permanent damage. Exposure to their vapours cause irritation and a more intense reaction occurs if they are splashed in to the eye as a liquid. They cause superficial punctate keratitis of the cornea. Eg Alcohol, acetone, camphor, ether, toluene, benzol and acetates.

Table 1. Classification of organic solvents and their uses (Duke elder 1972)

Type of Organic Solvent	Example	Industrial use
Hydrocarbons-Aliphatic and aromatic	Benzene	In dyeing, leather, rubber, paints, varnish industries, motor fuels
Halogenated hydrocarbons	Trichloroethylene	Solvents for fats, waxes, gums, resins, oils. Used in rubber and cellulose industries and in manufacture of paints, varnishes, insecticides and antiseptics
Alcohols	Ethanol	Solvents and used in lacquers and polishes
Ketones	Acetone	Solvents in plastics, rubber, dyes and paint industries
Aldehydes	Methyl aldehyde	Solvent for oils, resins, cellulose. Used in plastics and rubber industries
Ether	Ethylether	Solvent in plastics manufacture
Ester	Methyl formate	Solvent in many industries, it is the least toxic organic solvent

Surfactants

These compounds have a fat-soluble group at one end of the molecule and a water soluble group at the other end. This structure allows the compound to lower the surface tension of water and to make fat soluble materials miscible. They are used as industrial detergents and as emulsifying agents and cause contact dermatitis, damage to the cornea and conjunctive, and mucosal irritation.

Irritants and allergans

Numerous substances may irritate the eyes without causing permanent damage. A true allergy requires sensitisation of cells by prior exposure to an allergen. Subsequent exposure to the allergen will then result in a typical allergic reaction. Common allergens are organic substances of animal or vegetable origin. E.g. wool, pollen and dairy products. They produce the characteristic redness and swelling of the lids and conjunctiva.

Aerosols

Aerosols are commonly used in households as well as industry. Their fine spray can cause a superficial punctate keratitis.

Indirect effects of chemicals

Table 2. indirect effect of some commonly used chemicals

Structure	Effect	Chemical	Uses
Cornea and conjunctiva	Discoloration	Iron minerals, dinitrobenzene	Organic solvent
Cornea	Scarring Deposits and opacities Anesthesia Inflammation	Hydroquinone Beryllium gold, silver, mercury Carbon disulphide ethylbenzene	Rayon/Viscose Industry
Lens	Opacities Deposits and discoloration	Dinitrophenol, naphthalene Copper, mercury	Dye industry, insecticides
Anterior uveal tract	Iris atrophy Dilated pupil Constricted pupil and CB Spasms	Quinine Carbon monoxide, nitrous fumes Parathion and lindane	Insecticides
Retina	Oedema Haemorrhages	Cyanide, methanol Benzene, methyl bromide	Solvent for shellacs Cleaning fluid, refrigerants and fire extinguishers
Optic nerve	Neuritis and atrophy Papilloedema Pigment degeneration	Lead, methanol, dinitrobenzol, trichloroethylene, carbon tetrachloride, carbon disulphide, benzene, methylbromide quinine Benzene, lead Copper, iron	Heavy metals, organic solvents
Visual pathways	Cortical blindness Homonymous hemianopia	Carbon monoxide Lead	

Thermal injuries

1. Thermal burns
2. Scalds

Thermal burns are of two types: 1) flame and 2) contact burns. These may be caused by hot bodies, fluids or gases. Burns usually involve the eye lids and not the globe, which will probably have been protected by the blink reflex. The characteristic picture is of marked oedema and tissue necrosis.

Flame burns occur frequently and may result where high temperatures and inflammable liquids are being used. Contact burns may be caused by molten substances, such as metal or glass striking the cornea and entering the conjunctival sac. The molten substance solidifies as soon as it cools on hitting the eye and may fall into the lower fornix, where it continues to burn the surrounding tissue due to its latent heat. Prompt removal and irrigation reduces damage.

Scalds

Burns by hot fluids frequently affect the lids and face, but the eyes are protected by the blink reflex. Scald may be caused by ruptures of pipes containing steam or due to splashes of pitch, tar, molten sulphur or boiling oil. Hence, there is usually partial skin loss of the face and lids.

Electrical injuries

Lightening and high tension electrical appliances are the two main causes of electrical injury. An electrical current may generate temperatures of up to 3000 C on a surface at the point of entry and exit. While tissues are bad generally bad conductors, nerve tissue conducts extremely well. If the current passes through the head, the hair, eyebrows, and eyelashes will be singed, with superficial burns of the lids, usually associated with marked swelling and conjunctival chemosis. The cornea becomes cloudy due to interstitial opacities and edema. There may also be iritis, hyphaema, miosis, slow pupil reactions, retinal edema, papilloedema, retinal detachment, choroidal rupture, chorioretinal atrophy, vitreous opacities or anterior cortical opacities.

Radiation injuries

Ionising and non-ionising

Ionising radiation

1. Source - ionising radiation consists of very short wavelength (<0.01nm) and is caused by the disintegration of atoms. This occurs naturally as cosmic radiation from radioactive isotopes, such as radium, or can be produced by artificial means. People employed in occupations such as radiology, nuclear physics, and uranium mining and engineering, can be at risk from ionizing radiation.
2. Site of absorption – most of the ionizing radiation passes through the eye, but a small amount is absorbed and, depending upon the exposure time and concentration, can cause damage to nearly all of the ocular tissues.
3. Ocular effects- most common effect of radiation is the formation of cataracts

Non-ionizing radiation

Ultraviolet radiation

Table 3. U V radiation and the eye

Uv type	Wavelength	Sources	Site of ocular damage
UV C	200-280	Sunlight lamps-arc,germicial mercury	Corneal epithelium resulting in photokeratitis, corneal opacity
UV B	280-315	Sunlight lamps, welding arc, excimer laser	Same as above
	295-315		Lens epithelium and nucleus resulting in cataract
UV A	314-400	Sunlight lamps sunbeds, excimer laser	Same as above

Long term exposure to the Ultraviolet radiations also cause pingecula, pterygium, retinal pigment epithium and macular damage, and band shaped keratopathy

Infra red radiations

Table 4. Infrared radiations and the eye

Type of radiation	Wavelength	Source	Site of ocular damage
IF A	780-1400	Sunlight, furnaces, electric fires, neodymium YG laser	RPE, iris and lens
IR B	1400-3000	Erbium laser, furnaces, sunlight	Corneal and lens epithelium
IR C	3000-10000	Carbondioxide laser, furnaces	Corneal epithelium

Microwave radiation

The direct effect of microwave radiation is due to an increase in temperature of the tissue. Frequencies range from 10⁹ Hz to 3 x 10¹¹ Hz, damage to the lens in the form of subcapsular cataract is most common.