VISION GUIDELINES[1]

I. INTRODUCTION

A. OUTLINE OF HIGHLIGHTED CONDITIONS

1) Far Acuity Deficiency
   - Methods of correction
     - Spectacles
     - Contact lenses
     - Orthokeratology

2) Refractive Surgical Procedures
   - LASIK, PRK & LASEK
   - Intrastromal Corneal Rings (ICR)
   - Phakic Intraocular Lenses
   - Radial Keratotomy

3) Color Vision Deficiency

4) Other Visual Functions
   - Visual Field Deficiency
   - Binocular Fusion Deficiency
   - Contrast Sensitivity

A summary of the recommended evaluation criteria presented in this chapter begins on page XI-63**.**

B. PRE-EMPLOYMENT VISION SCREENING AND THE LAW

Despite the importance of vision to the safety of the officer and the public, pre-employment vision standards have been the subject of several legal challenges. Most commonly, agency vision standards have been assailed for: (1) insufficient job relatedness; (2) failure to allow for reasonable accommodation; (3) inconsistency in standards across agencies; and (4) inconsistent enforcement of standards within an agency, particularly with respect to candidates versus incumbents.

1) **Insufficient Job Relatedness**. An agency's selection of a vision standard must be based on job relatedness rather than unsubstantiated suppositions. The vision guidelines presented here are supported by detailed, quantitative summaries of the currently available literature. *However, it is incumbent upon each agency to review to ensure that the assumptions and findings upon which these guidelines are based upon are sufficiently applicable to the job duties and circumstances in its own jurisdiction.*

2) **Failure to Allow for Reasonable Accommodation and Mitigating Measures**. Another frequently adjudicated agency vision policy is the unilateral prohibition against

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the use of a visual correction devices or procedures (e.g., spectacles, contact lenses, refractive surgery). Findings in favor of the candidate are not uncommon when the agency appears to have based its policy on unfounded concerns rather than factual evidence. Included in this section is a detailed discussion of the advantages and risks associated with each method of visual correction and resulting recommendations for establishing far acuity standards.

3) **Agency-Specific Job Demands and Conditions**. While patrol officers across the state share many essential job functions, differences in job demands and environmental conditions do exist across agencies. Thus, the risk posed by an officer with decreased visual function (or the hardship caused by accommodating such individuals) may also vary across agencies. Throughout this section, the influence of position and agency-specific factors are discussed to enable the creation of vision standards that are appropriate for each department.

4) **Inconsistent Enforcement of Agency Standards**. An agency's allegation that its vision standards are job-related is weakened if incumbent officers who no longer meet these standards are successfully performing the job. While at times judges have agreed with law enforcement agency assertions that experience can partially compensate for visual impairment (e.g., *Padilla v. City of Topeka*, 1985), other courts have ruled against law enforcement agencies who maintain stringent vision standards for candidates while failing to enforce these standards among its incumbent officers (e.g., *Brown County v. LIRC*, 1985).

   Fortunately, the stability of most visual functions renders this issue largely moot. Except for near vision, the visual acuity of the vast majority of persons remains stable with age. As evidence, the results of uncorrected vision testing among incumbents of the Los Angeles City Fire Department (Goldberg & Bible, 1993) showed that, after an average of 11 years of service, over 96% of the 1,111 firefighters tested still possessed uncorrected vision that met the pre-placement guideline of 20/40. Even in the class of Captain II, approximately 90% of the 164 incumbents still maintained 20/40 vision after an average of 23 years of service. Good et al, (1998) reported similar results for the Columbus, Ohio police department. Although the average number of years of service was not stated, 94% of incumbent officers met the 20/40 uncorrected acuity that had been in place for 16 years; only 0.9% had an uncorrected acuity worse than 20/63.

C. IMPLICATIONS FOR JOB PERFORMANCE

In 1984, POST conducted a vision-oriented job analysis for the position of patrol officer (Briggs, 1984). After interviewing and observing officers in the field, a panel of vision experts developed a list of 17 relevant visual skills. The importance of these skills for patrol officer performance was then rated by 158 incumbent officers (average patrol experience = 5 years) who had been shown slides depicting and illustrating each of the 17 visual skills. The officers were also asked to provide detailed accounts of actual critical incidents based on their personal experiences. The officers produced 1,291 incidents which involved at least one of the 17 visual skills. The results from both activities are reported in Table XI-1.

As indicated in Table XI-1, no visual skill was rated less than "important." Officers rated dark adaptation as the most important visual skill, followed by peripheral vision. The ability to identify objects was involved in the highest percentage of critical incidents (24.9%), followed by visual pursuit (21.1%), motion detection (17.9%), dynamic far acuity (15.6%), dark adaptation (15.5%), and peripheral vision (11.2%). These results confirm the importance of virtually every visual capacity in the safe performance of patrol officer duties.

Table XI-1. Patrol Officer Importance Ratings of 17 Visual Skills (Briggs, 1984)

Visual Skill	Importance Rating* (N=158)	% of the 1,291 Critical Incidents in Which Skill Was Involved
Dark Adaptation	4.50	15.5
Peripheral Vision	4.34	11.2
Identify Objects	4.29	24.9
Motion Detection	4.13	17.9
Fine Details/Various Light Levels	4.03	9.1
Pursuit	3.95	21.1
Dynamic Near Acuity	3.93	2.5
Accommodation	3.87	4.3
Dynamic Far Acuity	3.81	15.6
Depth Perception	3.68	6.8
Light Adaptation	3.63	3.3
Glare Recovery	3.61	1.1
Glare Tolerance	3.59	9.8
Identify Large Forms	3.54	1.1
Static Far Acuity	3.54	3.8
Color Identification	3.53	5.8
Color Discrimination	3.30	1.2

*Rating scale values: 5 = critically important, 4 = very important, 3 = important, 2 = of some importance, 1 = of little importance

Similar results were found for Ontario police officers, who were asked to identify visual skills essential for successful performance in three frequently occurring scenarios: impaired drivers, domestic disturbances, and breaking and entering (Shaw and Gledhill, 1995). The results are summarized in Table XI-2. Identifying objects was a frequently-identified visual skill, followed by seeing in poor visibility conditions (e.g., at night) and peripheral vision. In contrast to the POST study, the frequency of needing color vision was comparable to that of visual acuity. (This difference may be due, in part, to the limited number of scenarios addressed).

Table XI-2. Visual Skills Identified by Ontario Police Officers as Essential for Responding to Impaired Drivers, Domestic Disturbances, and Breaking and Entering (Shaw & Gledhill, 1995)

Visual Skill	Frequency that skill was mentioned (N=114)
Color Vision Scan for evidence of personal offence such as blood and bruises, changes in complexion, noting details (vehicles, clothes and general description) for evidence and reporting descriptions	28.1%
Visual Acuity See where people go, get descriptions and details for reporting and evidence, not trip over things, read license plates, see with cruiser lights flashing	28.1%
Visual Acuity at night and poor visibility See in poor light, night vision, artificial light, see in shadows. See in poor visibility, bad weather conditions, poorly lit environments, smoked windows on vehicles	9.6%
Peripheral vision	9.6%
Visual Acuity and Peripheral Vision Must have good general observation skills - aware of surroundings, multiple input, description of person	9.6%
Depth perception	2.6%

II. MEDICAL EXAMINATION AND EVALUATION GUIDELINES

A. GENERAL SCREENING RECOMMENDATIONS

1) History

Candidates should be questioned regarding use of spectacles or contact lenses, visual loss, night blindness, refractive surgery and eye diseases (Medical History Statement, POST form 2-252). The candidates' driver licenses should be reviewed to determine if they have any driving restrictions or conditions.

2) Routine Testing

a. Far Acuity

Far acuity testing procedures:

NOTE: It is very important to use standardized charts and methods when measuring visual acuity. Non-standardized testing results in erroneous measurements and increased measurement variability.

1. Use only charts that meet ANSI Z80.21 (1992). To date, the Bailey-Lovie chart and the ETDRS chart - both original and revised - meet this standard (Ferris et al., 1982). The number of letters on each line of these charts is equal, thereby preventing candidates from inferring that the largest letter on the chart is an “E.”

2. Use only charts designed for 13 feet (ft) or 20 ft test distances. Individuals with low to moderate uncorrected myopia (i.e., nearsightedness) may pass at closer viewing distances. The 13 ft charts adjust the letter sizes so that the angular size of the letters viewed from 13 ft is equal to the angular size of the letters viewed from 20 ft; therefore no additional conversion should be necessary.

3. The chart should have relatively even luminance (i.e., brightness) across its surface: luminance should be 160 cd/m^2 with an acceptable range of 80-320 cd/m^2. Self-illuminated charts are available from various ophthalmic supply companies. Printed charts are acceptable if there is sufficient light falling on the chart so that the light reflected from the white background falls within the acceptable range.[2] The illumination on the chart should range from 270 lx to 1000lx with 530 lx being equivalent to 160 cd/m$^{2.}$

   If an illuminance meter is unavailable, direct two 60-watt incandescent lamps (or lights with a lumen output of at least 800 lumens) toward the chart. Two lamps are necessary to maintain a uniform illumination across the chart. The lamps should be separated by 30”-36” and placed 24” from the chart.

   Do not place printed charts in hallways with overhead light fixtures without measuring the light falling on the chart. The variation in the intensity distribution of the light leaving the light fixtures and placement of the chart relative to the fixtures may result in an unacceptable amount of light reaching the chart and/or nonuniformities of the light reflected from various regions of the chart. The variance from the mean illumination should be within $\pm$25% (ISO 8596:2009).

4. The candidate's eyes should be inspected carefully to ensure that contact lenses are not worn during uncorrected vision testing.

5. Testing should be performed with the candidate at the chart’s viewing distance (13 ft or 20 ft). If the candidate is unable to discern the top row of letters at this distance, the acuity should be recorded as worse than the value corresponding to the top row.

6. Conduct monocular testing prior to binocular testing.

7. Measure uncorrected acuities prior to corrected acuities.

8. An occluder should cover one eye while testing the other eye. The candidate can hold the occluder. The occluder can simply be an index card.

[2] Meters to measure the illumination falling on the charts (such as General Light Meter Model # DLM1337 are available from Home Depot and other suppliers for under $100.

9. Candidates should be informed that they cannot squint during the testing. The tester should observe the candidate to ensure compliance.

10. Candidates should read at least one line in which they can identify all five letters. It can be helpful to instruct candidates to start with the smallest line of letters that they can read easily. They should proceed to successively smaller acuity lines until they are unable to correctly identify any letters on a line. They should be encouraged to guess when letter recognition becomes difficult. It is helpful to have a score sheet that corresponds to the chart for recording accuracy.

11. Candidates should be given credit for each letter properly identified. Record the acuity line in which at least 3 of the 5 letters are correctly identified. Include a +/- notation to precisely convey the number of letters properly identified. For example, if the candidate read the entire 20/30 line and one additional letter on the 20/25 line, the acuity would be 20/30+1. Identifying all of the 20/30 line and 3 of the 5 letters on the 20/25 line would result in an acuity of 20/25-2. Since the charts have 5 letters per acuity line, the +/- value will never exceed a value of 2.

    Letters which are properly identified on a smaller line compensate for letters missed on a larger line. For example, if a candidate reads 4 of 5 letters on the 20/30 line and 2 of 5 on the 20/25 line, the score would be 20/30+1.

    The measured acuity should be compared to the agency standard. For example, if a standard has been set at 20/40, a measured acuity of 20/40-1 is not sufficient.

Use of Vision Screeners

Vision screeners are portable, self-contained units with internally calibrated light levels. While popular in occupational medicine, several factors can limit their validity. First, the varying visual acuity charts available poses an impediment to reliability. In particular, there are two types of Landolt ring charts (where the letter C is rotated in different orientations). One has multiple rings on the same line; the candidate's task is to identify the orientation of the break in the ring. The other type has 4 rings, 3 of which are continuous and one has a break in the ring. The candidate must identify which ring is open AND the orientation of the opening, since the candidate could correctly identify which one of the four rings is open 25% of the time by guessing. Since standard scoring sheets only denote which ring has the gap, the score sheet must be modified to include gap orientation.

Hovis and Ramaswamy (2006) assessed police cadets who met the 20/20 acuity requirement with the Optec 2000 using the 4-ring target. Their results suggest that this chart may overestimate the acuity for some individuals[3]: eight percent did not meet the acuity standard of 20/20 using the Bailey-Lovie chart, although no one had acuity worse than 20/25.

The perceived proximity of the acuity chart can cause some candidates to change the focus of their natural lenses as if they are looking at a near object, inducing an artificial

[3] They were not required to identify the location of the gap.

myopia. This may be the reason behind the reported low specificity of vision screeners for police candidates. In reviewing police candidate records, Hovis (2008) found that 35% of candidates whose acuities were worse than 20/40 when measured with the Optec 2000[3] obtained this level of acuity or better when measured with a wall visual acuity chart. Therefore, assessing visual acuity with visual screening units is not recommended. If candidates are assessed with a vision screener, those who fail to meet an acuity requirement should be retested with a wall chart.

b. Color Vision

All candidates should be administered the 4th edition of the Hardy-Rand-Rittler (HRR) pseudoisochromatic plate color vision test.

The test must be administered under proper illumination conditions. All color vision tests are designed to be used with a standard source of illumination, one approximating standard illumination "C" of the CIE (International Commission on Illumination). Ordinary daylight fluorescent, LEDs, compact fluorescent lamps (CFL) or incandescent lamps should NOT be used. The standard illuminant should be the only source of illumination. There should be no other light source in the room; any window shades should be drawn.

The True Daylight Illuminator is a standalone unit, consisting of an easel for the test and a light fixture containing a Verilux True Color Light fluorescent tube (F15T8VLX).[4] This unit has been shown to be sufficient for illuminating color vision tests (Milburn & Mertens, 1993).

Many fluorescent lamps are advertised as “full-spectrum” or “natural daylight.” These may be suitable substitutes provided that they have both a color rendering index of at least 90, and a correlated color temperature between 5000 to 7500 K (Dain et al, 1993, Hovis & Neumann, 1995). These lamps can be found in the “professional lamps” or “high color rendering” section of an online catalog.

Tinted lenses alter the standard illumination required for all color vision tests, thereby invalidating the results. Therefore, the use of colored contact lenses or tinted spectacle lenses (such as the X-Chrom, X-Chrome, Colormax, Enchroma, Chromagen) should not be permitted. The cornea of each eye should be examined for unreported contact lens wear, especially densely tinted lenses such as the X-Chrome lens. Due to the difficulty of judging the density of any contact lens tint, all tinted contact lenses should be removed before testing.

Instructions for Administration and Interpretation of the HRR test:

1. Before administering the test, the candidate, test, and illuminant should be properly positioned. The candidate should be seated 75 cm. (about 30 in.) from the test. The plates should be supported and then tilted until they are perpendicular to the candidate's line of sight. The illuminant should be situated so that the illumination is direct and even, and is incident approximately at an angle of 45° to the plates. It is

[4] Available from Richmond Products, Albuquerque, NM or Good-Lite, Elgin, IL

desirable to have a small paintbrush available for use as a pointer or for tracing symbols on the plates.

2. Open the book to the first demonstration plate and instruct the candidate: *"I am going to show several plates that may contain simple colored figures. Here are examples of a circle and X."* Show the candidate the next plate and state *"Here are examples of a triangle and X."* Show the third plate and state *"Here is circle. There can be one or two figures, or* (as you turn to 4th plate) *no figure. You need to point to the location of each figure that you see with the paintbrush. If you are not sure, trace the figure with the paintbrush."*

3. The order of presentation (and/or orientation of the page) should be randomized to ensure that candidates are not advantaged by prior experience with the test. The viewing time for each plate should be set at approximately 3 seconds.

4. A correct response identifies ***both the shape(s) and location*** of each figure on each page. Mark each figure on the score sheet as correct or incorrect. Each missed figure on a plate counts as an error (Cole et al, 2006).

   a) Any error on plates 5 and 6 constitutes a failure on HRR blue-yellow plates. Failure on the red-green screening plates is more than one error on plates 7-10. Note: these validated failure criteria are different than the test publisher instructions (Cole et al, 2006; Almustanyir, 2014).

   b) The severity of the **red-green defect** is graded as very mild, mild, medium and severe, depending on the whether the candidate sees the figures on plates 11-20:

      Very mild = errors on screening plates only; no errors on plates 11-20
      Mild = any errors on plates 11-15; no errors on plates 16-20
      Medium = any errors on plates 16-18; no errors on plates 19 and 20
      Severe = any errors on plates 19 and 20

      The severity of the **blue-yellow defect** is graded as mild, medium and severe:

      Mild = errors only on plates 5 and 6
      Medium = any errors on plates 21 and 22
      Severe = errors on plates 23 and 24

   c) If the candidate falls into the medium category by just one error on plates 16-18, color vision should be assessed with one of the other tests described under Color Vision Deficiency.[5]

[5] A practical color identification test is currently under development by POST. In the interim, the additional test results should be used to determine whether the candidate has very mild-to-mild color vision deficiency or moderate-to-severe based on all available test results and history. Individuals with a moderate to severe color vision defect are disqualified.

d) Identifying the screening figures correctly but making errors on the diagnostic plates should be treated as a fail; the candidate should be assessed with one of the other tests described under Color Vision Deficiency.

c. Binocular Vision – Extraocular Muscle Dysfunction

Candidates should be tested for gaze restrictions, noticeable strabismus and potential double vision as discussed in the physical examination of the eyes in Chapter IX – Neurology. A history of strabismus surgery, eye patching, visual training or prismatic corrections in spectacle lenses are also risk factors for double vision; these candidates should be evaluated by a vision specialist to determine the risk for double vision when tired or in a reduced visual environment.

B. EVALUATION OF COMMON CLINICAL SYNDROMES

1) FAR ACUITY DEFICIENCY

a. GENERAL CONSIDERATIONS

Various methods have been used to determine the impact of far acuity deficiencies on performance as a patrol officer. The critical patrol officer functions studied include: (1) deciding whether to discharge a firearm; (2) facial recognition; (3) license plate identification; and (4) withdrawal under fire.

1. "Shoot-No-Shoot" Decisions

Deciding whether to discharge a firearm is a critical, not-infrequent task facing patrol officers. In 1986, approximately 1/50 LAPD sworn officers discharged their weapon; 42% of these incidents resulted in a civilian being wounded or killed (Pate & Hamilton, 1991). Since this study included officers who do not work in the field, the firearm discharge rate among officers assigned to field duty would be expected to be higher.

A separate study of LAPD officer-initiated shootings during 1990-92 found that over 30% of the 519 incidents occurring during this period involved shooting at targets over 25 ft away. Moreover, 65% of officer-initiated shootings took place at night or at dawn/dusk (Spilberg, 1993).

In 2010, the U.S. Department of Justice surveyed 295 officers who averaged17 years law enforcement experience. Of these officers, 96% responded that they drew their firearms at least once each year, and 59 (20%) had been involved in at least one critical incident where they had fired their weapon (Pinizzotto, 2012).

An officer's ability to rapidly determine whether a suspect is holding a weapon is typically studied using decorrection lenses in scenarios at distances varying from 7-25 yards. In 1981 study, six California Highway Patrol (CHP) officers with 20/20 or better uncorrected vision were sequentially decorrected to 20/40, 20/80, and 20/200. During each visual condition, the officers were asked to identify whether a "suspect" was holding a gun or a comb at distances of 7, 15, and 25 yards. The study was conducted

during the day under clear skies. No errors were made with 20/20 vision, even at a distance of 25 yards (Table XI-3). With 20/40 vision, the officers correctly identified all of the objects at 7 yards, but misidentified 14% at 15 yards. With 20/80 vision, officers misidentified 8% of the objects at 7 yards and 22% of the objects at 15 yards (Giannoni, 1981).

Table XI-3. Percentage Correct Identifications for "Shoot" and "No Shoot" Scenario

	25 Yard Distance				15 Yard Distance				7 Yard Distance				Combined Distances			
Candidates	20/20	20/40	20/80	20/200	20/20	20/40	20/80	20/200	20/20	20/40	20/80	20/200	20/20	20/40	20/80	20/200
Cell B																
1	100	50.0	50.0	50.0	100	50.0	50.0	50.0	100	100	50.0	50.0	100	66.7	50.0	50.0
2	100	50.0	50.0	66.7	100	83.3	50.0	66.7	100	100	100.0	100.0	100	77.8	66.7	77.8
3	100	100.0	50.0	50.0	100	83.3	83.3	66.7	100	100	100.0	66.7	100	94.4	77.8	61.1
Cell A																
4	100	100.0	16.7	50.0	100	100.0	83.3	83.3	100	100	100.0	100.0	100	100.0	66.7	77.8
5	100	100.0	83.3	50.0	100	100.0	100.0	66.7	100	100	100.0	83.3	100	100.0	94.4	66.7
6	100	100.0	50.0	33.3	100	100.0	100.0	33.3	100	100	100.0	100.0	100	100.0	83.3	55.5
Average	100	83.3	50.0	50.0	100	86.1	77.8	61.1	100	100	91.7	83.3	100	89.8	73.2	64.8

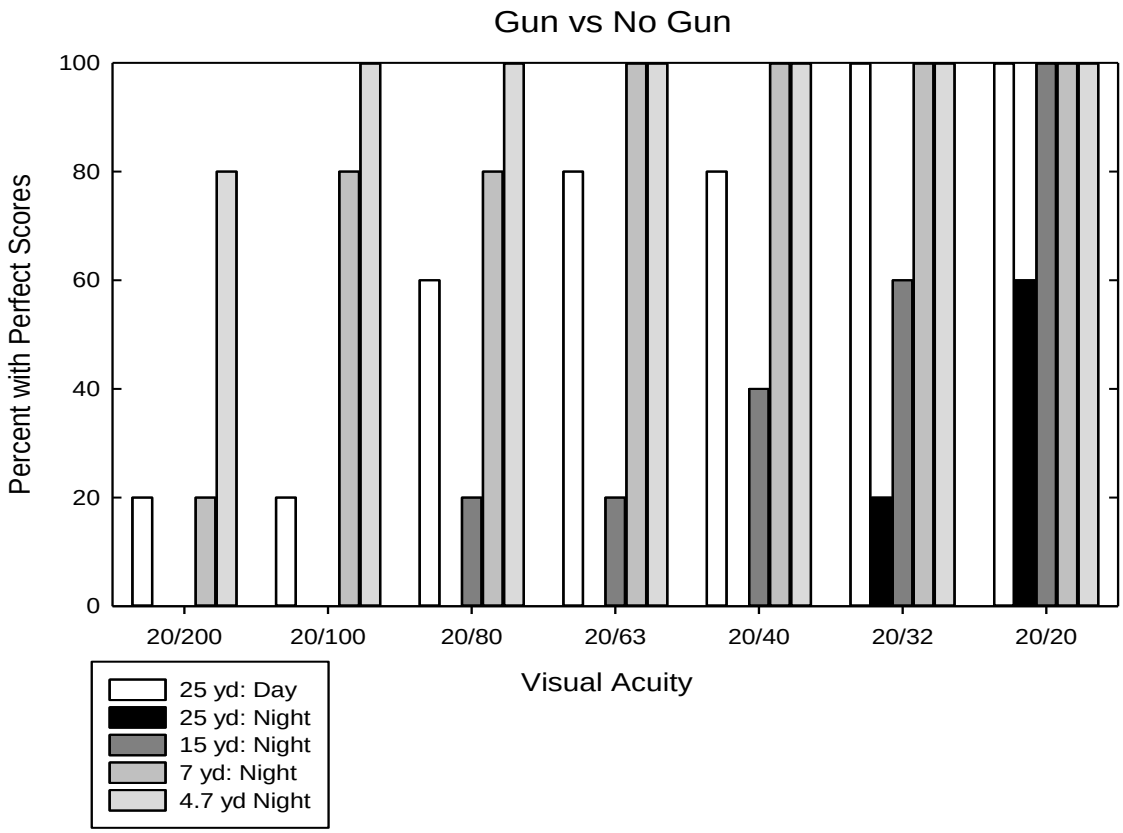
From Giannoni, B. Entry-level vision requirements validation study. Personnel Bureau, California Highway Patrol. October 1981

This study was partially replicated in 1999 using a handgun and four different distracters: a cell phone, a brown beer bottle, a pair of aviator style black sunglasses in the daytime trials and a purse at night (Carmean et al, 2000). Five university students participated in the experiment, which was conducted during the day (7,275 lx) and night (2 lx)[6].

Figure XI-1 displays the percentage of participants who were able to identify all five objects correctly at each distance and level of visual acuity. All participants were able to identify all the objects correctly at 15 yards in the daytime at all levels of acuity; therefore, no further trials were conducted at the closer viewing distances for this condition. Similar to the Giannoni study, the results indicate that visual acuity must be better than 20/40 to distinguish a gun from other handheld items from a distance of 25 yards during daytime. The results also show how low light levels can affect performance. If the acuity (measured in the clinic) is 20/63, at night a person must be within 7 yd of the suspect in order to identify a handheld object correctly 100% of the time. If the officer's acuity is 20/100, the viewing distance reduces to 4.7 yards.

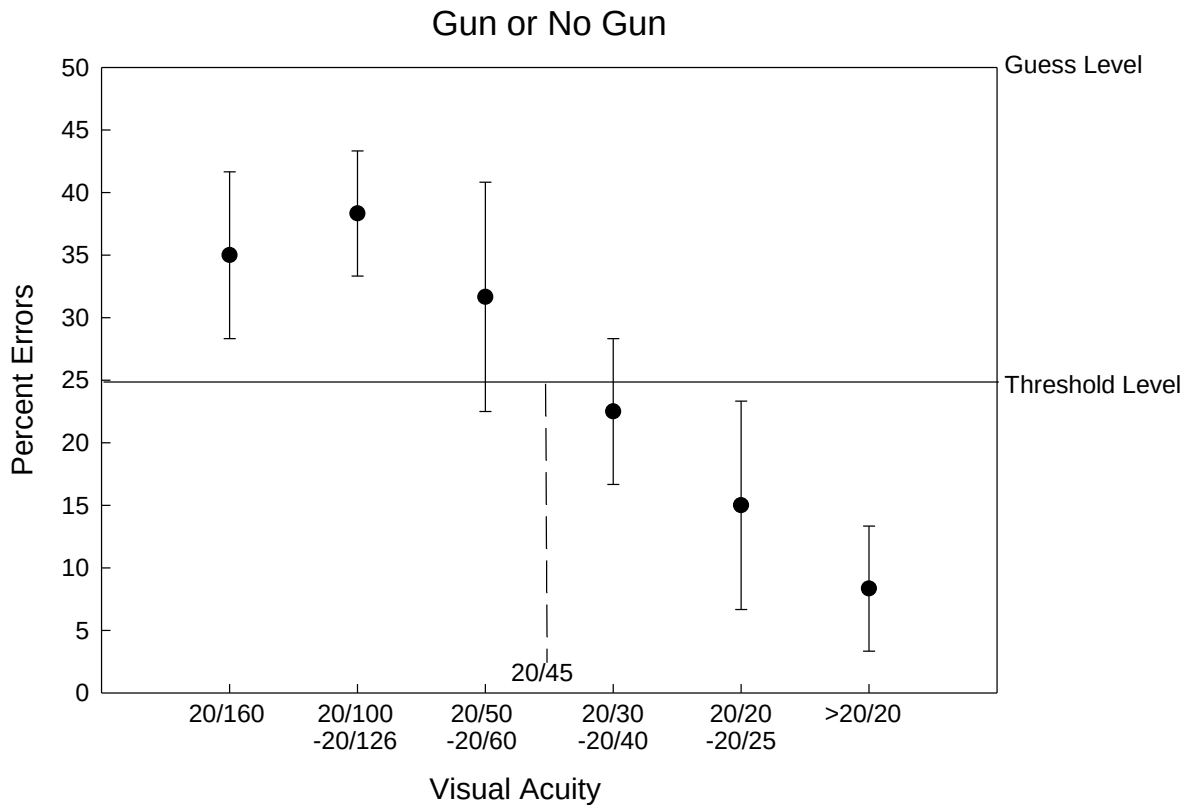
[6] Assuming that average reflectance of the objects in the scene was 0.30 and all objects were matte surfaces, the average luminance of the scene would be 695 cd/m^2 in the daytime and 0.2 cd/m^2 at night.

Figure XI-1. Percent of subjects (n=5) who were able to identify a handgun, cell phone, brown beer bottle and a pair of aviator style black sunglasses in the daytime or purse at night with the various visual acuities and viewing distances during the day and night. (Carmean et al., 2000)



In related research, Good and Augsburger (1987) decorrected 50 Columbus, Ohio patrol officers with 20/20 vision or better and asked them to identify whether a life-size target 20 ft (~7yds) away was holding a firearm. To simulate night conditions (when most shootings in Columbus were found to occur), the trials were conducted under low-light conditions (10 cd/m^2). This resulted in a task that was moderately difficult even without decorrection. As indicated in Figure XI-2, without decorrection, officers misidentified 5-15% of the 60 targets presented. With vision between 20/30 - 20/40, the error rate increased to 15-25%. At 20/50 - 20/60, the error rate increased to 25-40%. An acuity of 20/45 was determined to be minimally acceptable, based on the convention that the threshold level of performance should fall halfway between the guess rate and zero errors. In this experiment, the guess rate was 50% because officers were given two possible choices; therefore, 25% serves as the threshold level of performance. The resulting acuity for this error rate was 20/45.

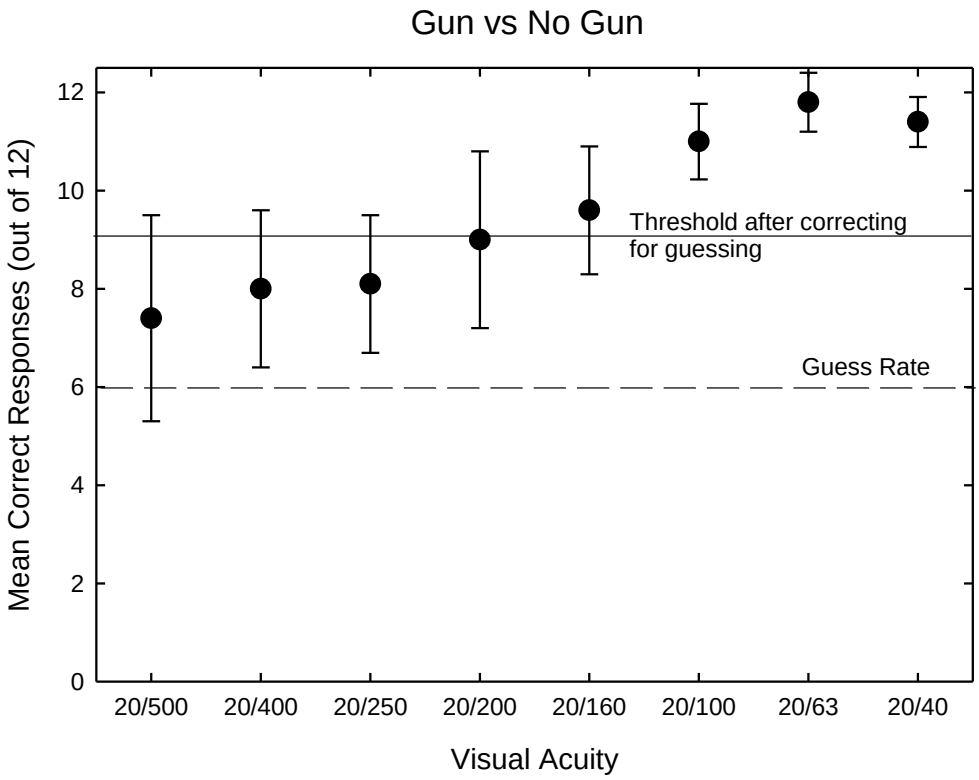
Figure XI-2. Number of errors in identifying gun vs no gun from a distance of 20 ft (~7 yds) under nighttime viewing conditions. Error bars are ± one standard deviation. (Good & Augsburger, 1987)



Good, et al (1998) conducted a similar study based on a domestic disturbance. In this scenario, a person had either a firearm (long barrel shotgun, pistol grip shotgun, handgun) or a distractor (umbrella, golf club, plastic spatula) and the officer had their spectacles dislodged in an altercation. The viewing distance was 20 feet, light levels were representative of indoor light levels, and viewing time was limited to two seconds. They also assessed a individual's ability to locate spectacles on a floor from a viewing distance of 8 ft in low light levels.

Figure XI-3 shows that weapon identification at acuities of 20/160 and lower were significantly worse than no-blur condition ($p \leq .05$). Errors in finding spectacles began at 20/125 and approached chance levels at 20/200 for 80% of the participants. Based on the combined results, they concluded that an uncorrected visual acuity of 20/125 is an appropriate standard when consideration is given to spectacles becoming dislodged during a domestic disturbance call.

Figure XI-3. Mean correct responses in identifying whether a person has either a firearm (long barrel shotgun, pistol grip shotgun, handgun) or a distractor (umbrella, golf club, plastic spatula) under typical room illumination levels, Error bars are ± one standard deviation. (Good et al., 1998)



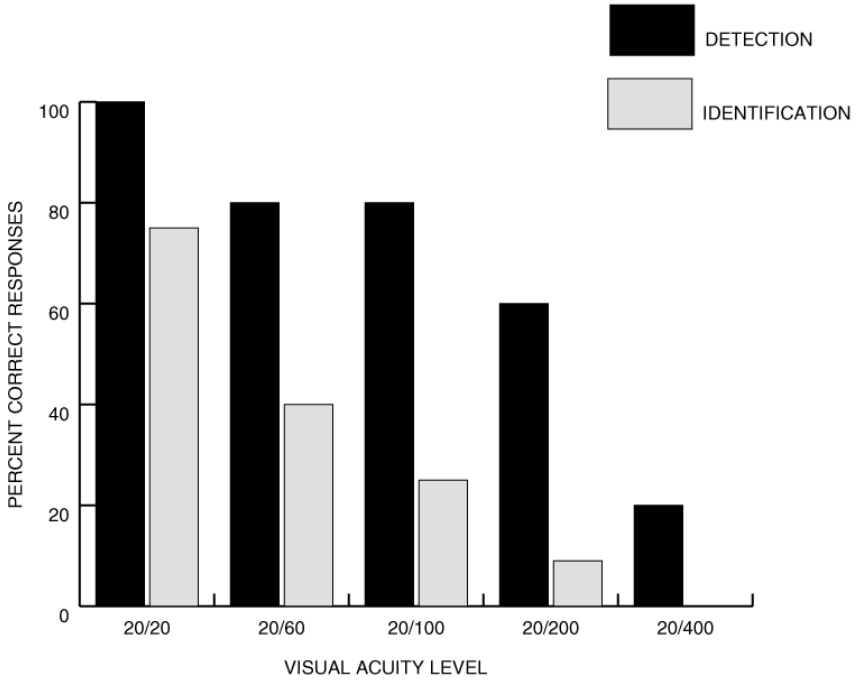
In a fifth study involving weapon identification, Johnson and Brintz (1996) decorrected six California Youth Authority supervisors and counselors whose vision was 20/20 or better. The simulation was conducted under night lighting (5 to 7 cd/m^2) in an open dormitory setting. This luminance range was similar to the light levels used by Good and Augsberger, but brighter than those used by Carmean, et al. (2000) by a factor of at least 10. Fifteen surrogate wards were situated 5-7 ft. (2 yards) away from the participants. In each trial, one ward was holding either a weapon (knife or screwdriver) or a non-weapon (toothbrush or comb). The participants were tasked with detecting which ward was holding an object and identifying whether the object was a weapon or non-weapon.

With visual acuity at 20/20, there was 100% correct detection of which ward was holding an object (Figure XI-4). Detection fell to 80% correct for the 20/60 and 20/100 acuity levels, 60% at 20/200, and 20% at 20/400. The ability to identify whether the object was a weapon or non-weapon declined more rapidly with reductions in visual acuity. Correct identification at the 20/20 level was 75%, which degraded to 40% at 20/60, 25% at 20/100, less than 10% at 20/200, and 0% at 20/400.

A correct identification of only 75% with 20/20 vision from two yards indicates that this visual task was very demanding relative to the other weapon vs. no weapon studies. At this viewing distance, performance dropped when acuities were reduced to 20/60. The

previous studies, particularly the Carmean, et al. (2000) weapon identification experiment, would suggest that identification with 20/20 acuity at a 2-yard viewing distance should be nearly 100% correct, even at the much lower light levels used in the Carmean study.

Figure XI-4. Average correct responses for object detection and weapons identification as function of visual acuity. (Johnson & Brintz, 1996)



The difference in these results is most likely attributable to the difference in the choice of weapons. The knives and screwdrivers used in the Johnson and Brintz study were smaller than a handgun or shotgun and perhaps more similar in appearance to the non-weapons. Given that the task was near the limit of resolution for a person with 20/20 acuity, it is reasonable that a reduction in visual acuity to 20/60 made a large difference in performance, as compared to the smaller changes found in the other studies in which objects were sufficiently above the limit of resolution for those with 20/20 acuity.

The Johnson and Brintz study shows that although a person with 20/60 acuity may be able to detect a small object 80% of the time, an officer would have to be within 0.7 yards (arm's length) in order identify it correctly 75% of the time.

The five studies together highlight the challenge of identifying a weapon at night, even for officers with 20/20 vision. In general, performance is significantly worse in night conditions at a 7-yard viewing distance when acuity falls below 20/4, due in large part to a reduction in the ability to resolve detail in low light levels. Johnson et al. (1992) found that 20/20 vision is degraded to 20/60 under typical night lighting conditions (i.e., sodium vapor streetlights), and 20/60 vision is degraded to 20/200 at night. Weapons identification improves in daylight or normal room illumination. In better lighting, a gun can be identified with reasonable accuracy from 7 yards with acuity near 20/100.

2. Facial Recognition

The recognition of a face or facial expression is another critical job skill. When pursuing or trying to recognize a suspect in a crowded area, only the suspect's face may be visible. Recognizing and recalling facial features is also important when identifying a suspect in a line-up or when testifying in court.[7]

Most of the research into face and facial expression recognition has maintained a fixed distance and varied the contrast of the object, or has been concerned with computer algorithms that mimic human performance in recognizing faces. Three studies actually varied the angular size (i.e. viewing distance) and assessed the ability of individuals to recognize faces or their expressions.

First, Sheedy (1980) reported that facial recognition became difficult in low light levels when acuity became worse than 20/40. This result, however, was based on one subject (himself) and was carried out in lighting conditions that simulated urban street light levels.

Second, McCulloch et al. (2011) measured facial recognition as a function of optical blur using synthetic faces. The task was to identify which of four faces was different from the other three displayed at the same time. The faces were clearly unnatural in appearance; however, the rendering of a face into its basic components allowed the researchers to establish a feature difference that was quantifiable and set so that the difference between the target face and the three distractors was easily recognized in the no-blur condition. The face size was then scaled to simulate different viewing distances for the different levels of blur. Viewing conditions were comparable to a well-lit office.

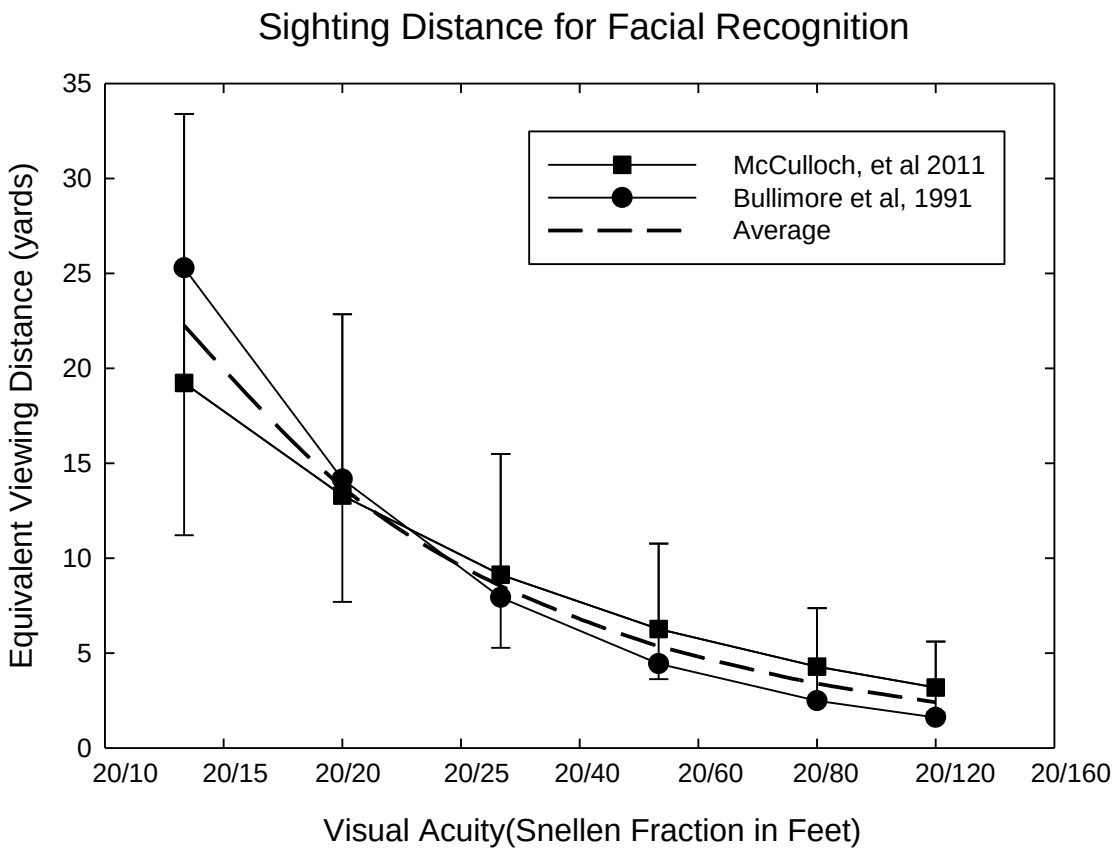
The third study evaluated the ability of individuals with normal and reduced vision (due to macular degeneration) to recognize facial expressions at varying distances (Bullimore et al., 1991). Subjects were asked to identify one of four different facial expressions depicted by models in photographs in lighting conditions similar to a well-lit office.

Figure XI-5 displays the results of the McCulloch and Bullimore studies of viewing distances as a function of visual acuity for facial recognition. The error bars are at the 95% confidence interval for the McCulloch mean values. The mean threshold values are based on slightly different percent correct responses. The Bullimore thresholds are based on a 50% correct performance; the McCulloch thresholds are based on 63% correct. The results are very similar despite slightly different threshold criteria, facial stimuli, and visual task (facial expression vs. facial recognition). This is consistent with

[7] As with the other visual tasks discussed above, facial recognition at a distance or in poor illumination can be affected by numerous factors in addition to visual ability per se; for example, race (whites have difficulty identifying black faces; blacks recognize white and black faces equally well [Cross, et al., 1971]), age (less errors with subjects of same age [Mason, 1986], and gender (less errors with subjects of same gender [Ellis et al., 1973]).

Bullimore's conclusion that the visual acuity required for facial recognition and facial expression is similar as long as visual acuity loss is not large. The similarity of the findings for the two tasks indicates that the same data can be used to determine the visual acuity demands for both facial recognition and facial expression identification. The similarity of results is also remarkable given the different methods for reducing acuity (i.e., optical blur versus disruption of the central field due to age-related degeneration).

Figure XI-5. Viewing distance as a function of visual acuity for facial recognition (McCulloch, et al, 2011) and facial expression recognition (Bullimore et al., 1991). The error bars are the 95% confidence intervals for McCulloch, et al.'s results and the dashed curve is the average of the two studies' results.



The equivalent viewing distances in Figure XI-5 indicate that a person with 20/40 acuity can recognize faces/expressions at a 7-yard (20 ft) viewing distance 50%- 63% of the time. Unfortunately, neither study indicated the values needed for 100% accuracy, although data from McCulloch et al. (2011) auxiliary experiments suggest that acuity values would need to be doubled to achieve a score of 90+% correct. Therefore, an officer requires a visual acuity of 20/20 to recognize faces with 90% accuracy from a distance of 7 yards.

3. License Plate Identification

The ability to read and identify license plate numbers from a distance is another essential job function. When in pursuit of a vehicle at 60 mph, maintaining a safe distance (i.e., 6 car lengths) requires that the officer read the plate from a distance of 100 ft. Sheedy (1980) observed that he could read a license plate from this distance with 20/20 vision and good lighting conditions. By extrapolation, someone with 20/40 vision would be unable to read a license plate from 50 ft (3 car lengths) away. Sheedy noted that these distances assume no movement; under dynamic conditions, viewing distances would be even shorter. He also pointed out that his sighting distance was shorter than predicted by a factor of 1.53, based on the dimensions of the numbers and his acuity of 20/20. He attributed the difference to the narrow width and lower contrast of the license plate numbers and letters.

Given the difficulty of judging car lengths, a 2-3 second interval between cars passing roadway landmarks is commonly adopted as a safe following distance. Assuming a suspect's car and police cruiser are traveling at 55 mph and the license plate characters are 2.75 inches high, the separation time for an officer with 20/20 acuity would need to be 1.96 sec (158 ft) or less to read the rear license plate characters in daylight. If the license plate characters were lower in contrast, such as those viewed by Sheedy, the separation time would be reduced 1.3 sec (105 ft). If the acuity was 20/40, the separation time would be further reduced to 0.98 - 0.65 seconds, depending on the plate characteristics. The task is even more challenging at night: the acuity of an officer with 20/20 acuity in daylight conditions would be reduced to 20/25 under conditions similar to reading license plates at night (Hovis & Ramaswamy, 2006). The resulting separation time would be reduced to 1.04-1.57 seconds, depending upon the characters on the plate.

4. Withdrawal Under Fire

An officer must have sufficient vision to withdraw from a dangerous situation and seek safety. In a study conducted by the Canadian military (Gibbs, 2001), soldiers had to withdraw from trenches to armored personnel carrier. The time required to withdraw increased significantly when the acuities were reduced to 20/200 or 20/400; however, the withdrawal times for 20/20 and 20/120 were similar. The relative increase in time for the two lower acuities was 9% (10 sec). These data suggest that seeking safety could be compromised when the acuity level drops below 20/120.

Table XI-4 summarizes the results of the above-referenced decorrection studies on the impact of visual acuity on critical peace officer task performance. As indicated in that table, unimpaired visual acuity is necessary for quick identification of objects at varying distances. **A 20/20 vision standard is therefore justified, given an officer's need for facial recognition, firing weapons at distant targets, and driving.** The need for unimpaired vision is even more compelling for officers who may be called upon to perform these duties at night.

Table XI-4. Critical Task Performance Determined by Decorrection Studies

VISUAL ACUITY	CRITICAL TASK PERFORMANCE
20/20	● In good light, can consistently identify weapons at distances of up to 25 yards[1] ● In low light, will identify guns correctly at 7 yards with an error rate of 0-15%[2,6,7] ● Under night conditions, from 5-7 feet can detect whether an individual is holding a small object with 100% accuracy and can identify object (comb vs knife) with 75% accuracy[3] ● Facial identification with 75% accuracy at 14 yards[4,8] ● License plate identification from 100 feet (6 car lengths)[5] to 150 feet
20/30	● "Facial identification with 50% to 63% accuracy at 9 yards[4,8]
20/40	● In good light, can consistently identify guns at 7 yards[1,6] at 15 yards the error rate increases to14% [1] ● In low light, can identify guns at 7 yards, but the error rate can be as high as 25%[2,7] ● Legal limit for driving any vehicle without further assessment of visual capabilities ● License plate identification from 50 feet (3 car lengths)[5] to 75 ft ● Facial identification: accuracy is 50% - 63% at 6 yards[4,8]
20/50	● In low light, can misidentify guns at 7 yards with an average error rate of >25%[2] ● Facial identification accuracy is 50% to 63% at 5 yards[4,8]
20/60	● Under night conditions, from 2 yards can detect whether an individual is holding a small object with 80% accuracy, but can only identify the object (comb vs knife) with 40% accuracy[3] ● Under night conditions, errors in identifying a gun can be >25%[2] ● Facial identification is 63% accuracy at 5 yards[4,8]
20/80	● In good light, can identify guns at 7 yards with error rate of 8%; 22% is the error rate at 15 yards[1,6] ● In low light, will misidentify guns at 7 yards with an average error rate that is >30%[2] ● Facial identification possible with 50% to 63% accuracy only at 3 yards[4,8] ● License plate identification at 25 to 38 feet[5]
20/100	● Under night conditions, from 2 yards, can detect whether an individual is holding a small object with 80% accuracy and can identify object (comb vs knife) with 25% accuracy[3] ● Identification of guns from 7 yards is impaired in both good and poor lighting[1,2,6,7]
20/200	● In good light, can identify guns at 7 yards with error rate between 17% and 33%,[1,6] ; 39% error rate at 15 yards[1] ● In low light, identifying guns at 7 yards approaches the guess rate[2,7] ● Under night conditions, from 2 yards, can detect whether an individual is holding a small object with 60% accuracy and but can identify the object with less than 10% accuracy[3] ● Facial identification is impossible beyond an arm's length[4] ● License plate identification impossible at >10 feet[5] ● Locating spectacles from 2.5 yards is by chance[6] ● Legal blindness as defined by the Social Security Administration and the IRS ● Withdraw under fire in the daytime is compromised

[1]Giannoni, 1981; [2]Good & Augsbuger, 1987; [3]Johnson & Brintz, 1993; [4]Bullimore et al., 1991; [5]Sheedy, 1980; [6] Good et al., 1998; [7]Carmean et al., 2000; [8]McCulloch et al., 2011; [9] Gibbs, 2001

b. FAR ACUITY STANDARDS FOR EACH EYE VS. BOTH EYES

In order to justify an "each eye" standard, it must be shown that poor acuity in the weaker eye could hamper safe performance of peace officer functions. Three job demands and circumstances that would influence an each eye standard are: (1) use of a shotgun or long gun; (2) peripheral vision; and (3) trauma to one eye with sudden loss of vision.

1. Use of a Shotgun or Long Gun

Certain tactical situations may require the use of a shotgun or long gun from behind either a left-handed or right-handed barrier (such as a doorway). Figure XI-6(A) illustrates the proper stance. If the officer's vision is impaired in the sighting eye (in this illustration, his left eye), it would very difficult to properly aim, resulting in degraded accuracy. The alternative would be for the officer to sight with the better eye and shoot with the opposite hand [Figure XI-6(B)] . This positioning would require that the officer expose most of the body and entire head, creating a safety risk.

For agencies that use long guns or shotguns, an acuity of at least 20/40 in the weaker eye is necessary to allow for adequate identification of weapons and facial recognition within 7 yards under most lighting conditions.

Figure XI-6. Use of a long gun behind a left barricade. (A) The correct tactical stance requires aiming the weapon with left eye. (B) Aiming weapon with right eye exposes officer to fire. (Photos courtesy of the Training Division, Los Angeles Police Department)

(A) (B)

2. Peripheral Vision

Peripheral vision requires functional vision in each eye. Peripheral vision is discussed under Visual Field Deficiency.

3. Trauma to one eye with sudden loss of vision

The likelihood of losing vision in one eye during a critical incident due to sudden trauma also justifies a minimum far acuity requirement for each eye. In a 1984 survey of 158 California police officers, 41.2% of officers reported an eye injury while on patrol. Based

on the average length of service, the annual rate of eye injuries was estimated to be 25 per 300 officers. If exposure to noxious chemicals is excluded (since this is likely to impair vision in both eyes), the annual rate is reduced to 16 incidents per 300 officers (Briggs, 1984).

The rates of serious eye injuries (i.e., those that result in compensation claims) are lower. LAPD worker's compensation records for the years 1987-1990 revealed that unilateral eye injuries during altercations occurred at an annual rate of approximately 1 per 300 officers assigned to field duty (Goldberg, 1993). The annual rate of all eye injuries for Milwaukee police officers was 4.5 per 300 officers during 1992-1993, and approximately 1 per 300 officers between 1996- 2008 (Brandl, 1996; Brandl & Stroshine, 2012). Eye injuries resulting specifically from assault or suspect-related events were 1.4 per 300 officers, but this only reflects a one year (1992-1993) time frame (Brandl, 1996).

The relatively low likelihoods associated with a traumatic loss of vision in one eye must be balanced against the significant consequences from such an event. Although the incidence of self-reported eye injuries are significantly higher than those injuries that resulted in workers compensation claims, it cannot be surmised that these self-reported injuries were not serious. It is reasonable to assume that the officer’s vision in one eye was either partially or temporally affected, requiring reliance on the other eye during the incident.

Visual acuity of 20/20 for the better eye and 2/40 for the weaker eye should be required of officers whose responsibilities include the use or long guns or shotguns, or that require activities where they may need to rely on either eye separately. For officers who do not use these weapons, the acuity requirement for the weaker eye should be 20/125. This requirement would allow the officer to retreat quickly, detect the presence of a small hand-held objects at a viewing distance of two yards under low light levels (Johnson & Brintz, 1993) identify the presence of guns and knives from a viewing distance of at 4.7 yd with over 80% accuracy in low and bright light levels (Giannoni, 1981; Carmean et al., 2000; Good et al., 1998).

c. METHODS OF CORRECTION

The uncorrected vision of a significant proportion of the population falls short of 20/20. Among a sample of 200 LAPD applicants, for example, 32% were found to have uncorrected vision of less than 20/20; even a far acuity standard of 20/30 uncorrected would eliminate 19% of this sample (Table XI-5).

A variety of methods exist for correcting vision, including spectacles, contact lenses, orthokeratology, and refractive surgery. Each method has its attendant advantages and risks. This section discusses factors to consider when determining the acceptability of each method.

Table XI-5: Distribution of Uncorrected Vision in 200 LAPD Applicants with Both Eyes Open

Uncorrected Vision*	Percent of Applicants With This Level of Vision or Better
20/20	68%
20/25	75%
20/30	81%
20/40	83%
20/50	86%
20/80	90%
20/200	94%

*Single character errors were ignored except at the 20/200 level; 20/40-1 was considered 20/40, 20/200-1 was considered to be worse than 20/200. Goldberg (1993). Uncorrected vision of LAPD applicants. Unpublished data.

1. Spectacles

The level of risk posed by spectacle-wearing officers depends upon the probability that an officer would lose the use of his/her spectacles during a critical incident and the likelihood that this would result in impairment and/or injury. These concerns, in turn, must be balanced against the potential benefits, such as protection against thrown objects, sand, etc. Each of these issues is discussed below.

What is the probability of an officer losing the use of spectacles while on duty, particularly during a critical incident?

Spectacles can become dislodged and/or broken when an officer is assaulted by a resisting suspect, when pursuing a suspect, or when an officer is required to make a sudden vehicle stop. Climatic factors such as rain, snow, and lens fogging may also suddenly deprive an officer of full visual correction.

Results of surveys on spectacle wear and policing bear significant similarities. In a survey of 195 myopic LAPD officers, Mancuso (1987) found that eighty-six officers (44%) indicated that they had been involved in an incident where they needed to see without their spectacles (Table XI-6). Approximately 28% of the officers stated that this occurs less than once per year, 45% stated 1-6 times per year, 13% stated 7-20 times per year, and 14% stated more than 20 times per year. For the entire group (N=195), on average, each officer was required to function without glasses approximately twice per year during a critical incident.

A similar questionnaire survey was conducted on 292 officers from the City of Columbus, Ohio (Good & Augsburger, 1987). Fifty-two percent of the officers reported that their glasses dislodged during performance of their duties at least once in their career, yielding a probability of dislodgement of 34% per year per officer. The Ohio survey also found that 67% of officers reported that they have had to remove their

Table XI-6: 1987 LAPD Vision Questionnaire of Incumbent Police Officers

	% Answering Yes (Spectacles)
Have you ever sustained an on-the-job injury specifically related to your wearing your corrective lenses?	5% (10/194)
Have you ever been involved in critical incidents, including but not limited to the apprehension of suspects, physical altercations, or vehicle pursuits, which necessitated that you see without your corrective lenses?	43% (83/195)
Has your wearing corrective lenses ever been an issue during a court appearance?	15% (27/184)
Do you believe that wearing corrective lenses presents an imminent hazard to your safety, that of your co-workers, or that of the public in any way?	6% (12/195)
Have you ever encountered any job safety problems caused by your corrective lenses?	28.9% (57/197)

Mancuso, R. 1987. Responses of myopic LAPD officers to a vision questionnaire. Unpublished study.

glasses because of rain or snow at least once in their career; 56% reported removing their glasses due to fogging.

These findings and those of three other peace officer surveys on spectacle removal while on duty, are summarized in Table XI-7. As indicated in that table, the percentages of officers reporting at least one dislodgement are very similar. There is considerable variance in the percentages of officers removing their spectacles because environmental factors (lens fogging, snow and rain); it is not surprising that RCMP officers reported the highest percentage of removing spectacles due to environmental factors throughout Canada,. The other result of note is that the percentages within each row sum to values greater than 100% for most of the studies, indicating that officers have their spectacles removed/dislodged several times in their career for different reasons.

Table XI-7. Percentage of Spectacle Wearers Responding “yes” to Questions about Spectacle Wear while on Duty.

Study, Location, Number of spectacle wearers	Spectacles dislodged at least once during career	Spectacles broken at least once during career	Spectacles had to be removed because of environmental factors
Good & Augsburger, 1987 Columbus OH N=292	52%	N/A	61%
Hovis et al., 1998 Ontario Canada N=66	53%	37%	51%
Wells et al., 1997 RCMP N=574	58%	46%	76%
Good et al.,1998 Columbus OH N=403	49%	N/A	22%

There have been two published studies of spectacles reimbursement rates. Sheedy (1980) reported that during a two-year period the City of Columbus, Ohio reimbursed eight officers for spectacles broken during altercations. Giannoni (1981) reported that during fiscal year 1979-80, the CHP reimbursed 17 officers for spectacles broken during altercations and two officers who lost their spectacles during foot pursuits (Table XI-8). Unfortunately, neither study provided data on the total number of spectacles-wearing officers so calculations of the relative rates of loss or breakage are not possible.

Table XI-8. Number of Prescription Eyeglass Reimbursement Requests Submitted by CHP during 1979-80 by Job-Related Loss or Breakage Categories.

Category	Number of Reimbursement Requests
1. Assault/resisting arrest	17
2. CHP patrol car/motorcycle accident	4
3. Removing debris on highways/freeways	1
4. Accident investigations	3
5. Rescue/first aid	4
6. Foot pursuits	2
7. Operating motorcycle	2
8. Routine stop	5
9. Other*	9

*Fall on pavement, sparks from battery, etc.

Giannoni, B. (1981) Entry-level vision requirements validation study. Personnel Bureau, California Highway Patrol. October 1981.

Dodson (1993) and others have argued that the risk of officers losing their spectacles can be virtually eliminated by the use of military spectacles and other devices that secure spectacles to the head. Unfortunately, retaining devices such as straps and cords can be a potential safety hazards since, during an altercation, they could be used to choke the officer. In addition, spectacles held tightly by elastic, as is with athletic eyewear, could be forcibly snapped back into the officer's face. Moreover, it is unlikely that the tight elastic would be tolerated for an 8-hour shift.

Newer types of combat frames that are secured by a "D" shaped ear ring are uncomfortable when fitted tightly enough to avoid dislodgement during altercations -- a light tapping to the side of the frame can cause severe pain to the bridge of the nose. Although more attractive than traditional military frames, the newer generation of combat spectacles are very conspicuous and relatively unattractive, which could hamper their acceptance, use, and public reaction.

Note: All spectacles worn by officers on duty should consist of polycarbonate lenses and frames that meet ANSI Z87.1 specifications. This greatly reduces the likelihood and severity of injury to the officer.

How often would the loss of spectacles result in injury or other negative consequences?

It has been argued that losing one's spectacles during a critical incident would be unlikely to result in negative consequences for all but the severely myopic, since a suspect is usually situated very close to the officer in these situations (Holden, 1993; Dodson, 1993). Situations such as these may be further mitigated by the presence of a partner and/or the potential availability of a spare pair of spectacles. However, a study conducted for the California Youth Authority showed that refractive error affects the visual detection and identification of weapons even at distances as short as 5-7 ft (Johnson & Brintz, 1993). Even those who advocate for this position acknowledge the seriousness of the consequences that could (and do) occur in these situations. Holden (1993) reports an incident in which the loss of spectacles is believed to have contributed to the death of an FBI agent.

Dodson (1993) recommended that myopic officers wear combat spectacles and be provided with handguns that have special high-visibility sights; however, as reviewed by Sheedy (1980), approximately 70% of the time officers do not use sight alignment. In addition, standard clinic practice for professional and sport shooters is to provide a correction so that gun's far sight is in best focus, which would be unnecessary for most nearsighted individuals, as their location of clear focus is approximately arm's length.

In a 1984 POST survey, 53 spectacles-wearing officers from various agencies were asked to report any negative experiences (including but not limited to impairment or personal injury) associated with wearing spectacles while on duty. As indicated in Table XI-9, the percent of negative outcomes reported by spectacle wearers was less than 4%. The majority of physical harm outcomes were cuts and bruises to the officer, and the majority of property damage outcomes consisted of broken spectacles. All dislodgements occurred during an arrest or altercation with a suspect. This is equivalent to an annual risk per officer of approximately 1.1% (average length of service = 5 years).

The POST survey also asked a larger group of officers whether they knew of other officers who experienced the same array of negative consequences on the job due to use of spectacles. Table XI-9 reports these results for 140 officers. Although such questions generated a large number of anecdotal cases (rather than incident rates), the percentage witnessed by officers is similar to the self-reported rates. The one major difference between the two survey groups was that two officers witnessed an automobile accident in which dislodgement of spectacles could have been a contributing factor.

Sheedy (1980) reported that during a two-year period, there was one report where an officer's spectacles were broken and, because of his poor vision, the suspect escaped. If it can be assumed that there are 109 spectacle wearers (based on Good and Augsburger's1987 survey of the same police force approximately 10 years later), the estimated annual incident rate is 0.5%.

Table XI-9: Reported Instances of Negative Consequences Resulting from Use of Spectacles by Officers

Impairment	% Self-report (N=53)	% Witnessed (N=140)	Outcome	Circumstances
Chemicals	1.9% (1)	0	Failure to provide required duty (make an arrest, complete search)	Maced in combative situations--arrest delayed
Dislodged	0	1.4% (2)	Failure to provide required duty (make an arrest, complete search)	Spectacles dislodged while making an arrest
Dislodged	3.8% (2)	4.3% (6)	Physical harm to self or others	Altercation – officer struck in face; spectacles broken, knocked off, cut officer's face suspect had to be subdued by other officers
Dislodged	3.8% (2)	5% (7)	Loss or damages of property	Resulted in automobile accident, broken spectacles
Fogged	1.9% (1)	1.4% (2)	Failure to provide or delay in service	Cold to warm; had to clean; other officers had to assist; fogged unable to see

Two later surveys asked spectacle-wearing officers if they felt that their safety or that of the public was compromised when their spectacles were dislodged or removed (Hovis et al, 1998; Good et al, 1998). The percentage that responded positively to these questions ranged from 5%-13%. In addition, 14%-22% of the spectacle wearers in the Good survey reported that their efficiency was compromised without their spectacles. The exact annual incident rate for the spectacle wearers could not be calculated from either study, but the Ontario value was estimated to be 0.6% (Hovis et al., 1998).

These results do indicate safety concerns when officers have their spectacles dislodged or removed while on duty. The potential for a negative outcome appears to be near 1% per year for spectacle wearers. However, it must be remembered that the agencies had uncorrected visual acuity requirements at the time of this research. For example, the Columbus police required uncorrected acuity of 20/40 (although some officers were hired under an earlier 20/50 standard). The uncorrected acuity standard for the Ontario police agencies varied between 20/40 - 20/60.

The degree of risk associated with wearing spectacles is directly proportional to the candidate's degree of visual impairment (see Table XI-4); therefore, it is reasonable to conclude that spectacles are acceptable for candidates with relatively mild degrees of uncorrected refractive errors.

How often do spectacles provide protection from hazards?

The POST survey also studied the potential benefit of spectacle wear. The 53 officers who wore spectacles listed over 50 incidents in which they felt that spectacles protected them from injury (Table XI-10). Some of these incidents involved confrontations with suspects who tried to disable the officer by throwing sand or other

matter into the officer's face. The results from officers in the study who did not wear spectacles were similar. Incidents where the spectacles provided protection from sand, dust, gravel and rocks, whether from the natural environment or thrown by suspects, were so numerous that the number of incidents were not tabulated.

Table XI-10: Reported Instances Where Spectacles Provided Officers Protection

# Times	Circumstances
1	Broken windshield -- eyes protected from glass
5	(1) Lead splatter at range (2) Wall particles -- removing evidence (3) Dura print fumes
4	(1) Flying objects (2) Leaking chemicals in a fire
5	Tear gas, objects thrown, struck in face, spit on
1	Suspect threw sand -- spectacles protected eyes
5	Spectacles protected eyes from thrown gravel
10	Spectacles acted as shield for eyes
10	Prevented dust or hard objects from entering or harming my eyes
Many	Objects thrown, i.e., dirt, sand, etc., by people and natural forces. Also limbs, branches, bushes scratched face but not eyes
-	Strong winds -- debris hit spectacles
Several	Protection from windblown dust/dirt
3	Blowing sand in two storms. Blowback from weapon on range
4	Protection against blowing sand/debris from helicopter blade thrust
Many	Sand/rocks/bugs while a motorcycle officer

Briggs, R., (1984) POST Study of Vision-Related Characteristics/Experiences, Unpublished report.

SUMMARY: An uncorrected visual standard of 20/40 in each eye is recommended for spectacles-wearing officers for officers required to use long guns or shot guns. For all officers, serious eye injuries, although infrequent, occur as a result of an assault in 1/3 of cases, and it is uncertain as to whether the officers were performing critical tasks when the other 2/3 of the injuries occurred. Therefore, an uncorrected standard of 20/40 in the better eye and between 20/40 - 20/125 in the worse eye should be established. A visual acuity worse than 20/125 would leave an officer markedly impaired without spectacles (Table XI-4).

2. Contact Lenses

Contact lenses can be classified by their rigidity:

Rigid Gas Permeable (RGP) lenses are made of an inflexible material that is permeable to oxygen (Key, 1990). Advantages of the RGPs include easy care (no sterilization required) and the ability to correct for corneal irregularities. Disadvantages include low comfort, easy dislodgement, and high risk of particle entrapment.

There are two types of RGP lenses: (1) the *corneal RGP* lens is smaller in diameter (~9 mm) than the candidate's visible iris; (2) the *scleral RGP* lens (diameter varies from 14 to 20 mm) can cover the entire cornea and part of the sclera. As discussed below, discomfort, particle entrapment, and potential for dislodgment are less of a problem with the scleral RGP lenses because they cover the entire cornea.

Soft contact lenses (SCL) are large, flexible and permeable to oxygen. Advantages include better comfort, low risk of dislodgement, low risk of particle entrapment, and availability in extended wear varieties. Disadvantages include the need for regular cleaning/disinfection.

Two issues must be considered when determining the acceptability of contact lens use by peace officers: safety and compliance.

a. Safety. The use of contact lenses could potentially create a safety hazard under the following circumstances:

(1) ***Lenses lost during an altercation*.** Table XI-11 displays the results of six studies that researched the percentages of contact lens-wearing police officers who reported lens removal, dislodgement or fogging while on duty. The results indicate that contact lens dislodgements are less frequent than spectacle dislodgments. Dislodgement of both lenses is very rare: in a survey of 336 RCMP officers who wore contact lenses, only 1.4% reported that it occurred during their career (Wells et al., 1998). However, in general, the percentages of officers reporting that they removed their lenses due to irritation approaches that of spectacle wearers.

In the Mancuso study, four officers (10%) reported occurrences in which they were not wearing contact lenses during a critical incident. One officer had this happen less than once per year; another officer reported occurrences of 1-6 times per year. The remaining two officers reported occurrences of more than 6 times per year.

In general, reported safety concerns are lower than those for spectacle wearers. Nevertheless, contact lenses are still dislodged and/or have to be removed while on duty.

Table XI-11: On-Duty Loss of Use of Contact Lenses

Study, Location, Number of Contact Lens Wearers	Contact lenses dislodged at least once career	Contact lenses blurred vision due to fogging/ freezing or other factors	Contact lenses had to be removed because of environmental factors	Lost a contact lens while on duty
Briggs, 1984 N=17	8% (soft) 0% (hard and RGP)			
Mancuso, 1987 LAPD N=38	11% (all lens types) (Perform without corrective lenses at least once)			
Good & Augsburger, 1987 Columbus OH N=108	19% (soft) 20% (hard and RGP)	47% (soft) 60% (hard and RGP)	46% (soft) 57% (hard and RGP)	10% (soft) 14% (hard and RGP)
Hovis et al., 1998 Ontario Canada N=20	6% (soft) 5% (hard and RGP)		50%(soft) 51%(hard and RGP)	
Wells et al., 1998 RCMP N=330	21% (all lens types)	30% (all lens types)	37% (all lens types)	9.8% (all lens types)
Good et al.,1998 Columbus OH N=183	31% (all lens types)		52% (all lens types)	16% (all lens types)

(2) ***Use of contacts in hazardous environments***. Based on studies researching the use of soft contact lenses in hazardous environment, these lenses could be worn safely while carrying out policing duties (Kok-van Aalphen, 1985; Royall, 1977; Nilsson, et al., 1981; Nilsson & Andersson, 1982; Rengstorff & Black, 1974).

(3) ***Particle entrapment under a lens*.** Particle entrapment can result in acutely painful and incapacitating “contact lens attack." Vision in the non-affected eye is markedly impaired due to sympathetic tearing and photophobia until the other lens is removed. Particle entrapment is more likely to occur with smaller diameter corneal RGP lenses. Surveys of police officers reveal that, due to irritation, RGP lenses are removed at higher frequencies than larger diameter SCLs (Hovis et al., 1998). The increased probability of particle entrapment for corneal RGP lenses has led the American Optometric Association to recommend against the use of these lenses in industrial environments (AOA, 1990); their use in military aviation is also discouraged due to the high levels of particulate in cabin air (Polse et al., 1990).

The available evidence suggests that SCLs can be used by peace officers with minimal risks. SCLs are preferable to corneal RGP lenses due to a lower likelihood of particle entrapment. The resurgence of scleral lenses made of RGP materials may offer a solution to the particle entrapment issue for those individuals who require or prefer RGP lenses.

b. Compliance

(1) ***Temporary discontinuation due to eye infections, corneal abrasions, allergies, or other medical conditions***. Between 17% - 25% of contact lens-wearing peace officers (both RGP and SCL wearers) reported that they could not wear their lenses for at least one day per year due to irritation, discomfort or temporary medical conditions. The median number of days ranged from 2-3 days per year (Hovis et al., 1998; Wells et al., 1998), with 2% of officers discontinuing contact lens wear for more than 50 days. This is comparable to the mean value of three days reported for the general population of SCL wearers (Nilsson & Lindh, 1984).

For persons who have worn soft contact lenses successfully for more than a year, motivational factors are more responsible for episodes of temporary discontinuation than medical complications. Between 1988-1993, the LAPD hired over 300 officers who had worn SCLs successfully for at least one year and who signed a pre-placement agreement (see Figure XI-7), obligating them to wear SCLs whenever assigned to field duty. During five random department-wide inspections conducted between June 1990 and November 1991, non-compliance rates varied between 2-8% on a given day, with an average rate of 5%. Thirty officers were found on duty without their SCLs on 39 occasions; five officers were non-compliant twice, and two officers were found non-compliant three times.

Medical reasons were cited for non-compliance in only 6 (15%) of the incidents. More commonly, officers said they forgot their contacts, lost one, or preferred to wear spectacles. There was a slight, nonsignificant increase in non-compliance in officers who had been on the job for longer periods of time (Figure XI-8). Discipline was limited to written reprimands and quarterly eye inspections had not been conducted regularly; presumably, non-compliance among these patrol officers could have been significantly reduced with stronger administrative controls.

(2) ***Permanent Discontinuation.*** Discontinuation rates appear to be highest during the first year of use. In a retrospective study of 196 SCL users, Robbins (1977) found that 13% quit within the first year after the lenses were prescribed. In a similar retrospective study of 92 new SCL users, Broome and Classe (1979) observed a first year drop-out rate of 28%. These results comport with data on SCL-wearing USAF aircrew, 15% of whom reported discontinuing lens wear in their first year. Unacceptable vision was the most common reason for discontinuing lens wear, accounting for 73% of the aircrew who stopped wearing lenses during the first year (Dennis et al., 1992).

Figure XI-7. Sample Pre-Placement Agreement Involving Use of Soft Contact Lenses

SAMPLE

PRE-EMPLOYMENT NOTICE OF SOFT CONTACT LENS REQUIREMENTS

Name: _____ Date of Hire: _____

Medical Condition: Poor uncorrected distance vision - myopia correctable with soft contact lenses.

I acknowledge that the medical condition noted above was present at the time that the (name of law enforcement agency) *offered me employment. I affirm that I am currently, and have been for the past six months prior to employment, a bona fide, successful soft contact lens wearer. I also understand that my use of soft contact lenses is permitted as a reasonable accommodation for my distance vision myopia.*

I understand that my ability to perform the duties assigned to me as a full-duty patrol officer may be contingent upon my ability to wear successfully soft contact lenses on duty, and I shall wear such lenses whenever I am on duty except when authorized by my supervisor (or the Employee Assistance Unit) to do otherwise. I also understand that it is my responsibility to notify my supervisor (or the Employee Assistance Unit) should I become unable to wear soft contact lenses while on full duty or should I take any other medical action, which would otherwise affect my vision or my ability to wear soft contact lenses. I am aware that if I become unable to wear soft contact lenses while on full duty, I may be assigned to restricted duty assignments.

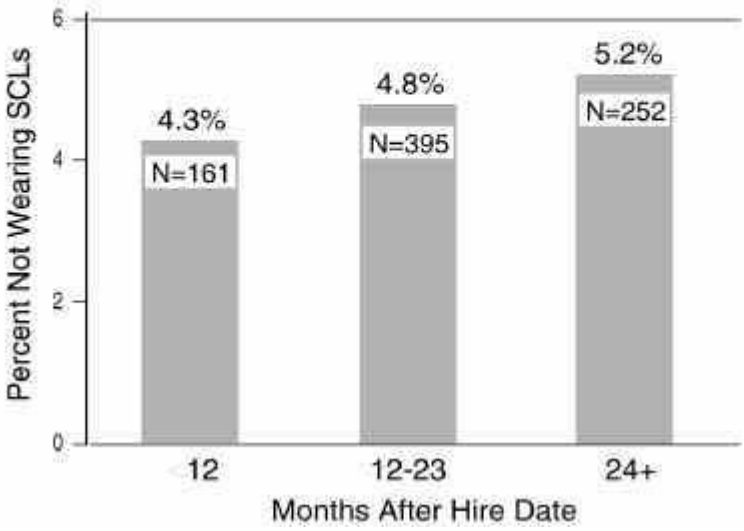
I have been informed that my use of soft contact lenses may be subject to verification by my employer, which may include an eye examination as necessary in the judgment of my employer's medical staff.

By my signature below, I acknowledge that I have read and accept the conditions of this Notice.

_____ _____

SIGNATURE DATE

Figure XI-8. Non-Compliance of LAPD Officers with Soft Contact Lenses Based on Time since Hire (N=808)

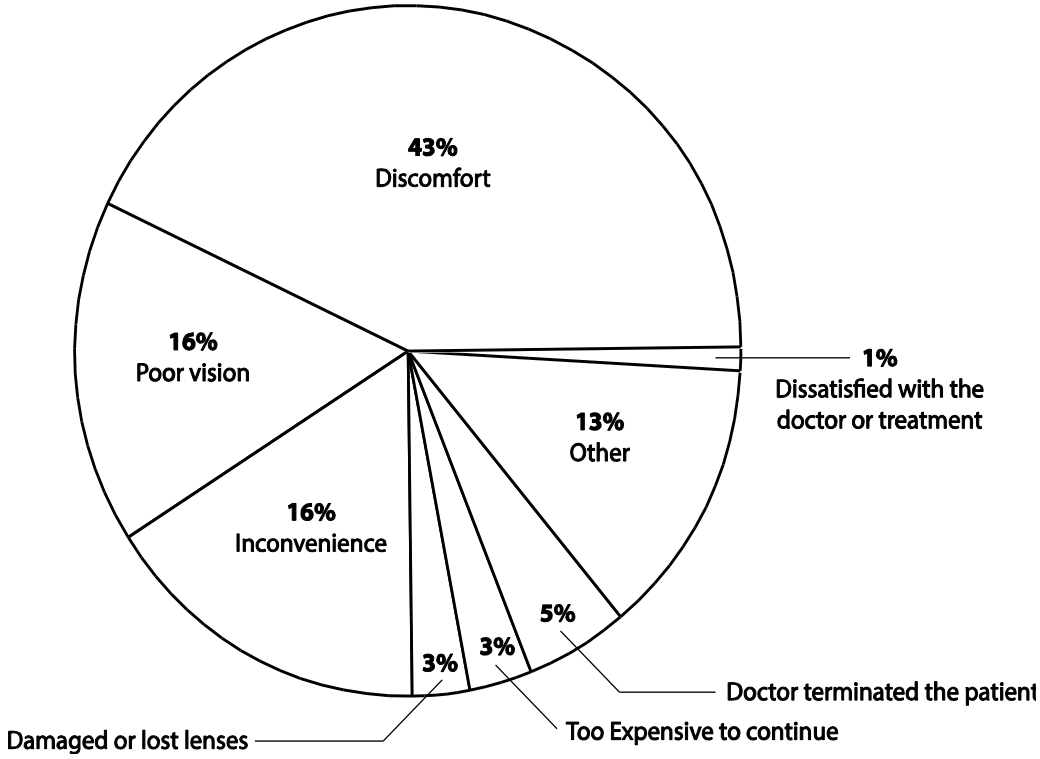


After the first year of use, a slightly different trend appears. After one year, 34%-40% reported discontinuing soft contact lens wear for more than four months; between 12% and 24% discontinued lens wear permanently (Dumbleton et al., 2013; Pritchard et al., 1999, Richdale et al., 2007; Young et al., 2002). The mean number of years before permanent stoppage varies from 5-9 years of contact lens wear. Young, et al. (2002) reported a median value of one year.

The most common reason for discontinuing lens wear was discomfort/dryness, accounting for upwards of 43% of discontinuations (Figure XI-9). Patients refitted had a short-term (i.e., 6-month) success of 77% (Young et al., 2002).

These general population SCL discontinuation rates are higher than both the 5% reported for LAPD officers during 1998-1993 and the USAF aircrew who also experienced a 5% dropout rate over 3 years (Dennis et al.,1993). Even successful contact lens wearers may not always wear their lenses every time they are on duty. Despite the numerous advantages of contact lenses in the cockpit (Dennis, et al, 1992), only 67% of the SCL wearers and 78% of the RGP wearers wore their lenses on over 95% of the missions (Dennis et al., 1996). One of the key differences for LAPD compliance is that wearing SCL is a condition of employment. All the surveys indicated that permanent discontinuation of SCL wear due to medical conditions was uncommon (1/300 officers).

Figure XI-9. Reasons for Discontinuing Contact Lens Wear (N=92). Adapted from Broome, P.W. and Classe, J.G. (1979). Long-term success in contact lens wear. *Contact Lens Forum*. September, 15-27.



Taken together, these studies indicate that agencies who allow a waiver for the uncorrected visual acuity requirements for soft contact lens wearers should monitor compliance on a continuous basis.

SUMMARY: Soft contact lenses and scleral rigid gas-permeable lenses are an acceptable alternative to spectacles; however, corneal RGP contact lenses should not be permitted. Those who have worn contact lenses for less than six months should be required to meet the same corrected and uncorrected acuity as spectacle wearers. The uncorrected vision requirement may be waived for candidates who have been successful SCL wearers for at least six months. However, compliance is best ensured with a pre-placement agreement requiring officers to wear their SCLs while on duty (see Figure XI-7). Due to a lack of research in the area, scleral RGP wearers should meet the same uncorrected far acuity standards as required for spectacle wearers.

3. Orthokeratology

Orthokeratology (corneal reshaping) involves the use of special RGP lenses overnight to reduce myopia by changing the shape of the cornea. It is a technique used to slow the rate of myopia progression in children and adolescents (Koffler & Sears, 2013). The procedure can enable the individual to have good vision without corrective lenses for a short period, usually 1-3 days. Two trademarked corneal reshaping procedures have FDA approval: Paragon CRT from Paragon Vision Science, and Bausch + Lomb's Vision Shaping Treatment (VST).

An individual's vision deteriorates as the cornea returns to its original shape after lens removal. In as little as one day after overnight wear, the refractive error can change by 0.25 to 0.75 diopters (Swarbrick, 2006). A 0.75 D change could reduce acuity to 20/40-20/50 range. These lenses are therefore not an acceptable method of correction.

Candidates who have worn corneal shaping lenses within the prior two months should be required to demonstrate that their refractive error and visual acuity have been stable for at least one month. This is not necessary for candidates whose treatment has been discontinued for two months or longer.

d. FAR ACUITY SUMMARY

The following recommended far acuity standards take into consideration both environmental factors may impede an officer's use of the corrective lenses, the likelihood of assaults on officers occurring in low light levels, and/or may the need to use lethal force. These guidelines are depicted in Table XI-12.

No Correction Needed

- Better Eye: **20/20**
- Weaker Eye: **20/40** for officers who use of long guns or shotguns, or activities where they may need to rely on either eye separately; otherwise **20/125**.

Use of Spectacles or Scleral Rigid Gas Permeable Lenses

- Uncorrected vision: 20/40 for *each* eye for officers who use long guns or shotguns; otherwise 20/40 - 20/125[8] in the better eye and 20/125 in the weaker eye.
- Corrected vision: 20/20 in better eye; weaker eye of 20/40 for officers who use of long guns or shotguns; otherwise, weaker eye of 20/125.

Note: To reduce the likelihood and severity of injury to the officer, spectacles worn on duty should consist of polycarbonate lenses and frames that meet ANSI Z87.1 specifications.

Use of Soft Contact Lenses

Candidates who have worn soft contact lenses (SCLs) for ***less*** than six months should meet the same far acuity standards as the above standards for spectacle/scleral RGP wearers. Those who have successfully worn SCLs for longer six months need not meet an uncorrected acuity standard, provided that there is a pre-placement monitoring program in place to ensure continued the use of SCLs while on duty.

[8] The choice of an uncorrected standard should take into consideration the likelihood of assaults on officers, light levels, inclement weather and other environmental conditions that may affect visibility with spectacles.

The use of corneal RGP lenses is not recommended due to the risk of particle entrapment.

Table XI-12. Summary of Far Acuity Guidelines

	No Correction Needed	Spectacle Wearers or Scleral RGPs		SCL > 6 Months and SCL Waiver Program		SCL < 6 Months or No SCL Waiver Program	
		Uncorrected	Corrected	Uncorrected	Corrected	Uncorrected	Corrected
***Regular patrol officer duties**	20/20 better eye 20/125 weaker eye	**20/40 – 20/125 better eye 20/125 weaker eye	20/20 better eye 20/125 weaker eye	None	20/20 better eye 20/125 weaker eye	**20/40-20/125 better eye 20/125 weaker eye	20/20 better eye 20/125 weaker eye
Duties include sighting/ viewing with either eye	20/20 better eye 20/40 weaker eye	20/40 each eye	20/20 better eye 20/40 weaker eye	None	20/20 better eye 20/40 weaker eye	20/40 each eye	20/20 better eye 20/40 weaker eye

*Regular patrol officer duties include working in low lighting conditions, using weapons, and conditions that could result in trauma and/or spectacle dislodgement. See Patrol Officer Job Demands: Their Implications for Medical Screening.

**The likelihood of assaults, inclement weather and other environmental conditions that could affect visibility (e.g., low lighting) with and without spectacles must be considered in establishing an uncorrected standard for the better eye.

Orthokeratology

Due to the potential for fluctuating vision and difficulty in ensuring compliance, orthokeratology is not an acceptable method of vision correction.

e. RECOMMENDED EVALUATION PROTOCOL

Corrected Vision. The most common cause of corrected vision worse than 20/20 in either eye is inadequate corrective lens prescription. However, poor corrected vision may also be indicative of serious eye disease. A vision specialist should evaluate the candidate unless the screening physician is confident that the reduction is due to childhood amblyopia.

Uncorrected Vision. Candidates who do not meet the uncorrected vision standard should be given an opportunity to have their vision retested by their vision specialist. Since measurement of uncorrected vision can vary with squinting, time of day, and the lighting conditions during testing, discrepancies between the results of pre-employment vision testing and the results reported by a private specialist are not uncommon. Resolving this discrepancy requires an understanding of a few basic concepts on the optics of corrective lenses:

Lenses with a spherical shape correct either nearsightedness (myopia) or farsightedness (hyperopia). The "strength" or curvature of the lens is measured in units known as diopters (D). The diopter strength of a lens is always preceded by either a

minus (-) or a plus sign (+) to denote concavity or convexity, respectively. Minus (-) lenses correct for myopia; plus (+) spherical lenses correct for hyperopia.

Astigmatism is an optical irregularity along an axis. Cylindrical lenses aligned along the same axis can correct this error. By convention, cylindrical correction is expressed as "minus" (-) diopters, followed by the axis of the cylinder expressed in degrees.

Eyeglass prescriptions are based on the subjective measurement of the individual's spherical and cylindrical refraction. When performed manually, this is known as the manifest refraction (MR). Although refraction can also be conducted by an automated process, it is not as accurate. Refraction is always expressed as the spherical correction, followed by the cylindrical correction. For example, -1.50 -1.00 x 90 indicates that lenses require a minus 1.5 diopter sphere combined with a 1.0 diopter cylinder aligned along an axis of 90 degrees. If there is no astigmatism, the cylinder correction is omitted. If there is only an astigmatism, the spherical correction is designated as "plano" (for example, plano -4.50 x 135).

By knowing a candidate's MR, the likelihood that squinting occurred during private testing can be determined. Peter's Table (Table XI-13) can predict the most probable uncorrected distant acuity based on the manifest refraction. To use Table XI-13, find the candidate's spherical correction along the far left side of the table. If there is no astigmatism, the predicted acuity is located in the first column to the right (minus cylinders = 00). For example, if the MR is [-1.25], distant acuity is most likely 20/70.

Predicted acuity in hyperopes decreases with age. For example, an MR of [+3.00] indicates an acuity of 20/25 in a 15-year-old, but 20/200 in a 50-year-old. This age-related effect is due to the gradual loss of accommodative power of the crystalline lens in the eye. In young persons, accommodation can completely compensate for mild hyperopia.

Cylindrical correction is found along the top of the table. The axis of the cylinder can be ignored in estimating acuity. For example, [plano -2.00 x 125] = 20/70; [+1.75 -1.25 x 275] in a 28 year-old = 20/30; [-0.25 -0.75 x 50] = 20/40. Note that a small amount of astigmatism can actually improve the vision of older hyperopes. For example, a 45-year-old with an MR of [+3.00 - 2.00 x 45] is likely to have 20/80 vision, while the predicted vision of a similar hyperopic 45-year-old without astigmatism (MR of [+3.00]) is 20/200.

Astigmatisms must be expressed as a "minus" cylinder when using Peter's Table. MRs written with a "plus" cylinder can be converted to minus by adding the number of cylindrical diopters to the spherical correction (axial changes can be ignored). For example, an MR of [+1.00 +1.00] is equivalent to [+2.00 -1.00]; [-1.00 +1.00] = [plano -1.00]; [-.25 +3.75] = [+3.50 -3.75].

Table XI-13: Peter's Relationship between Manifest Refractive Error and Uncorrected Visual Acuity

minus cylinders																	
Sphere	00	.25	.50	.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
-2.00	200	200	200	200	or poorer												
-1.75	100	100	100	200	or poorer												
-1.50	80-100	80-100	100	100	100	200											
-1.25	70	70	70	80	80	100	100	100	200								
-1.00	60	60	70	70	80	80-100	100	100	100	100-200	200						
-0.75	50	60	60-70	70	70-80	80	80	80-100	200								
-0.50	30-40	40	50	50	60	60-70	70	80	80	100	100	100	100	200			
-0.25	25	25-30	30-40	40	50	60	60-70	70	80	80	100	100	100	100	100-200	200	
00	20	20-25	25-30	30-40	40-50	50	60	70	70	80	80	80-100	100	100	100	200	
+0.25	20	20	25	25-30	30-40	40-50	50-60	60	70	70	80	80	100	100	100	100	100-200
+0.50	20	20	20	25	30	40	50	50-60	60	60-70	70	80	80	100	100	100	100
+0.75	20	20	20	25	25-30	30-40	40-50	50	60	60-70	70	70-80	80	80	100	100	100
+1.00	20	20	20	25	25	30	40	50	50-60	60	70	70	80	80	80-100	100	100
+1.25a	20	20	20	25	25-30	30	40	50	50-60	60	70	70	80	80	80-100	100	100
b	20	20	20	25	25-30	30	40	50	50-60	60	70	70	80	80	80-100	100	100
c	25	25	25	25-30	30	40	40-50	50	60	60-70	70	70-80	80	80	100	100	100
+1.50a	20	20	20	25	25	30	40	50	50	60	70	70	70	80	80	80-100	100
b	20	20	25	25	25-30	30	40	40-50	50	60	60-70	70	70-80	80	80	100	100
c	30	25-30	25-30	30	30-40	40	50	50	60	60-70	70	70-80	80	80	100	100	100
+1.75a	20	20	20	25	25	30	40	40	50	50	60	60	70	70-80	80	100	100
b	25	25	25	25	25-30	30	40	40-50	50	60	60	70	70	80	80	100	100
c	40	30-40	30	30-40	40	40-50	50	50-60	60	60-70	70	70-80	80	80	100	100	100
+2.00a	20	25	25	25	25	30	30-40	40	50	50-60	60	70	70	70	80	80	100
b	25	25	25	25	30		40	40-50	50	60	60	70	70	80	80	100	100
c	50-60	40-50	40	40	40-50	50	50-60	60	60-70	70	70	80	80	80-100	100	100	100
+2.25a	25	25	25	25	25	30	40	40	50	60	60	60-70	70	70	80	80	100
b	25	25	25	25-30	30	30-40	40	40-50	50	60	60	70	70	80	80	100	100
c	60-70	60	50	50	50-60	60	60-70	70	70	70-80	80	80	100	100	100	100	100-200
+2.50a	25	25-30	25	25	25-30	30	30-40	40	50	50-60	60	60-70	70	70	80	80	100
b	30	30	25	30	30	40	40	50	50	60	60	70	70	80	80	100	100
c	70-80	70	60	60	60	60	60-70	70	70	70-80	80	80	80-100	100	100	200	200
+2.75a	25	25	25	25	30	30	30-40	40	50	50-60	60	60-70	70	70	80	80	100
b	30	30	30	30	30-40	40	40-50	50	50-60	60	60-70	70	70	80	80	100	100
c	100	80	70-80	60-70	70	70	70	70-80	80	80	80	80-100	100	100	100	200	200
+3.00a	25	25	25	25	30	30	30-40	40	50	50-60	60	70	70	70	80	80	100
b	40	30-40	30	30-40	40	40	50	50	60	60	70	70	70-80	80	80	100	100
c	200	100	80	70-80	70-80	80	80	80	80	80-100	100	100	100	100	200	200	200
+3.25a	30	30	25	30	30	40	40	50	50	60	70	70	70	70-80	80	80-100	100
b	40-50	40	40	40	40	40-50	50	50-60	60	60-70	70	70	80	80	80-100	100	100-200
c	200	200	100	80	80	80	80-100	100	100	100	100	100-200	200	200	200	200	200
+3.50a	30	30	30	30	30	30	40	40-50	50	60	60-70	70	70	80	80	100	100
b	50	50	40-50	40	50	50	50-60	60	60	70	70	70-80	80	80-100	100	100	200
c	200	200	200	100	100	100	100	100	100	100-200	200	200	200	200	200	200	200
+3.75a	40	30-40	30	30	30	30	40	50	50-60	60	70	70	70-80	80	80-100	100	100
b	60	50-60	50	50	50	50-60	60	60	70	70	70-80	80	80	100	100	100-200	200
+4.00a	40-50	40	30	30	30	30-40	40-50	50	60	60-70	70	70-80	80	80-100	100	100	100-200
b	70	60	50-60	50	50-60	60	60	70	70	70-80	80	80	100	100	100-200	200	200
+4.25a	50	40-50	40	30	30	40	50	50-60	60	70	70-80	80	80	100	100	100-200	200
b	70-80	70	60	60	50-60	60	60-70	70	70	70-80	80	80	100	100	100-200	200	200
+4.50a	60	50	40	30	30-40	40-50	50	60	60-70	70	80	80	100	100	100-200	200	200
b	80-100	70-80	60-70	60	70	70	70	80	80	80	100	100	100-200	200	200	200	200
+4.75a	70	50-60	40-50	40	40	50	50-60	60-70	70	70-80	80	80-100	100	100	200	200	200
b	100-200	80-100	70-80	70	70	70-80	80	80	80-100	100	100	100-200	200	200	200	200	200
+5.00a	70	60-70	50	40	40-50	50-60	60	70	70-80	80	80-100	100	100	200	200	200	200
b	200	100	80	70-80	80	80	80-100	100	100	100-200	200	200	200	200	200	200	200

Composite chart of refractive state to V.A. Derived from Peter's multiple tables. All figures are the denominator of the Snellen Fraction, whose numerator is 20/. Where given, a indicates age group from 5 to 15; b indicates age group from 25 to 35; c indicates age group from 45 to 55. Where not indicated, data applies to all ages. Above +3.50 sphere, acuity for c group poorer than 20/200 for all errors. From Borish, I.M., Visual Acuity. Clinical Refraction, 1970.

The following protocol for evaluating candidates whose uncorrected distant acuity is below the hiring agency's standard assumes that a recommended chart was used during the examination rather than a vision screening unit. A "line" refers to the lines on a vision chart (e.g., the 20/40 line).

GROUP I: UNCORRECTED ACUITY IS WORSE THAN THE AGENCY STANDARD BY ONLY ONE LINE

These candidates should be given the opportunity to submit results from a current, private examination, using the protocol described in General Screening Recommendations - Routine Testing," including the MR. Past records of previous eye exams should be requested, as they may reveal the candidate's true vision when not motivated to squint.

- If past records and the current private exam indicate acceptable vision, the candidate is passed.[9]

- If either the current private exam results *or* past records confirm unacceptable vision, the candidate should be deemed unqualified. Past records, unlike the results of a current private exam, are unlikely to be biased by squinting.[10]

- If the current private exam results are acceptable, but no past records are available, use the MR and Table XI-13 to assess the likelihood of squinting.

GROUP II: UNCORRECTED ACUITY IS WORSE THAN THE AGENCY STANDARD BY TWO LINES OR MORE

Repeat testing by a private vision specialist is not worthwhile (unless acuity was initially screened using a vision screening unit). These candidates should be restricted from involvement in critical situations that can result in loss of spectacles. The use of soft contact lenses or refractive surgery may be an acceptable option.

Soft Contact Lens Wearers. The records from the candidates' current vision specialist should be obtained (see form provided in Figure XI-10) to evaluate their experience with contact lenses and to identify possible contraindications – both absolute and relative - to successful contact lens use.

[9] This accounts for measurement error, since the standard deviation of individual differences with EDTRS or Bailey-Lovie charts on different days is approximately 3 letters and 95% of the differences fall between ±1 line (Raasch, et al., 1999; Hazel & Elliott, 2002).
[10] Note: Vision does not improve with age.

Figure XI-10. Sample Soft Contact Lens Examination Form

SAMPLE

SOFT CONTACT LENS (SCL) DATA SHEET FOR PEACE OFFICER CANDIDATES

PLEASE HAVE YOUR PRIVATE OPTOMETRIST OR OPHTHALMOLOGIST COMPLETE THE FOLLOWING INFORMATION AND PROVIDE IT AND A COPY OF YOUR CURRENT *[WITHIN THE LAST THREE (3) MONTHS]* EYE EXAMINATION TO THE PEACE OFFICER MEDICAL SCREENING PHYSICIAN.

a. When did patient begin using SCLs: _____

b. Date last pair of lenses dispensed: _____

c. Condition of current lenses: _____

d. Is there a history of any difficulties with SCL use?: _____

e. Date of last full examination of eyes: _____

f. Uncorrected distant visual acuity: OD=20/ _____ and OS=20/ _____

g. Corrected distant visual acuity with current contacts: OD=20/ _____ OS=20/ _____

h. Refractive error: OD= _____; OS= _____

i. Please list all prescription and OTC medications: _____

j. Does the patient have any of the following conditions:

_____ Dry Eyes
_____ Scleroderma
_____ Sjorgen's Syndrome
_____ Diabetes
_____ Rosacea
_____ Rheumatoid Arthritis
_____ Lupus
_____ Epilepsy

k. Statement of any medical contraindication to continued wearing of SCLs.

_____

l. Doctor's Name: _____

Doctor's Signature: _____

Office Address: _____ Phone Number: _____

Absolute contraindications include autoimmune disorders, which are commonly complicated by the sicca syndrome (dry eyes and mouth). These include scleroderma, Sjorgen's syndrome, rosacea, rheumatoid arthritis, and lupus. Diabetes is a contraindication if there are signs of ocular surface disease, a history of recurrent erosions, or corneal insensitivity (O'Donnell & Efron, 2012).

Relative contraindications to contact lens use include dry eyes, use of antihistamines (which decrease tear flow), or a history of medical complications from contact lens use. Complications include corneal abrasion, corneal infection, neovascularization of the cornea (often seen in post-radial keratotomy patients who wear contacts), and giant papillary conjunctivitis (GPC). GPC is a sterile inflammatory reaction of the upper eyelid caused by friction and irritation from repetitive blinking over the upper portion of the contact lens. This condition occurs more commonly with extended wear lenses. It is often treated with steroids and discontinuation of contact lens use for a period of time and refitting with a daily disposable lens.

Corneal RGP Contact Lens Wearers. Candidates who currently wear corneal RGP lenses should be advised to change to soft lenses or scleral RGP lenses. Those with astigmatism may require "toric" lenses. Corneal RGP lens wearers who have been refit with larger diameter SCLs can find the new lenses uncomfortable and may not adapt to the larger size and/or be unwilling to care for the lenses. Differences in material and lens size can also result in an initial change in refractive error, which will stabilize over two months. Therefore, a minimum period of two months of successful wear of the SCL or scleral RGP should be required before being reevaluated.

Use of Contact Lenses after Refractive Surgery. In rare cases, post-refractive individuals may require contact lenses (most likely, sclera RGP lenses) in order to meet the corrected acuity standard. In these cases, contact lenses are necessary to correct corneal irregularities created by the surgery. These candidates should be evaluated further to determine whether they have an increased sensitivity to glare or impaired night vision.

2) REFRACTIVE SURGICAL PROCEDURES

A. GENERAL CONSIDERATIONS

1. LASIK, PRK & LASEK

Laser assisted in-situ keratomileusis (LASIK) and photorefractive keratectomy (PRK) are commonly-accepted procedures for correcting refractive errors. Although less common, laser epithelial keratomileusis (LASEK) is also acceptable.

PRK and LASIK offer respective advantages and disadvantages. In general, LASIK provides a more rapid improvement in vision and less discomfort. PRK requires more time to recover good vision and causes more discomfort during the first weeks. The major difference between LASIK and PRK, however, is the degree of post-surgical corneal haze. Relative to PRK, haze is less common after LASIK. Some

surgeons prefer PRK due to concerns that the corneal flap will become dislodged due to trauma, as has been reported with LASIK. Although there are several reports of flap dislocation due to ocular trauma up to 14 years postoperative, there are no known published reports of flap dislodgments in peace officers treated with LASIK (Patel, 2001; Iskander, 2001; Sridhar, 2001; Holt et al., 2012).

Laser refractive surgery is not without complications. The evaluation must establish that the cornea has healed, the refractive error is stable, and visual acuity meets requirements and is stable. The time required to heal and stabilize is directly related to the degree of the original refractive error (Soong & Malta, 2009; Stonecipher et al., 2006; Gil-Cazorla, 2008; Javaloy et al., 2011).

Table XI-14 reports the prevalence of post-LASIK symptoms (McDonald, 2001). The most common complaint six months after LASIK relates to driving at night: 6%-14% of patients reported that driving was significantly more difficult than before surgery. However, the study did not segregate individuals into those who obtained 20/20 uncorrected acuity from those whose uncorrected acuity ranged between 20/25-20/40. Individuals whose acuities range between 20/25-20/40 are likely (and legally) able to drive without glasses, although they do not see as well as they did prior to surgery if their corrective lenses gave them 20/20 acuity.

Table XI-14. Summary of (Post-LASIK) Symptoms Reported Significantly Worse at 6 Months[a,b]

	% Spherical Myopia n = 142	**% Myopia with Astigmatism n = 109**
Night driving difficulty	6.4	13.8
Glare	3.5	9.2
Halos/starbursts	4.2	6.4
Light sensitivity	2.8	5.5
Dryness	4.2	2.8
Fluctuation of vision	2.1	1.8
Blurring of vision	2.1	0.9
Redness	0.7	1.8
Double vision	0.7	0.0
Headache	0.7	0.0

[a] Some subjects may represent more than one symptom.

[b] None of the following symptoms were reported as significantly worse: pain, burning, excessive tearing, and gritty feeling. McDonald et al. (2001)

Objective testing for glare sensitivity and contrast sensitivity can also help ensure that the essential job duties can be performed safely; however, test results need to be referenced to a nonrefractive surgery control group (Hovis & Ramaswamy, 2006).

Determination of a minimum deferral period following surgery depends on the time course of: (a), symptoms, (b) complications, and (c) regression of the surgical effect:

a*) Symptoms.* The vast majority of symptoms develop in the first weeks post-op (Autonomous Technologies Corp., 2000; Nidek Technologies Inc., 2000; Bausch &

Lomb Surgical, Inc., 2000; Summit Technologies, Inc., 1999). Therefore, a one month deferral period should be a sufficient for candidates who are symptom-free.

b) Complications. The vast majority of significant surgical complications are evident at one month post-op. One exception would be ectasia, or bulging of the cornea due to excessive thinning. Ectasia can develop months after surgery, but is seen primarily in patients with treatments above 10 D.

c) Regression of surgical effect. The time course for the regression of the surgical effect is related to the amount of correction attempted. Most individuals experience regression for only a few weeks. However, those with high degrees of myopia may progressively regress over months or years. In one FDA approval study, only 5% of patients whose pre-op manifest error were under 7 D had >1 D of regression between the 1st and 3rd months post-op. However, 12% of patients with > 7 D pre-op regressed >1 D between 3-6 months (Summit Technologies, Inc.,1999). In a study involving patients with 9-25 D pre-op refractive errors, continuous myopic regression was observed for over two years. The average regression at two years post-op was over 2.6 D (Han, 2000). In individuals with 10 D pre-op, 20% will regress by >1 D between 1-12 months post-op (Knorz,1998).

Regression towards myopia can occur between 10-13 years post-op. As with short-term regression, the amount varies according to the type of surgery and initial refractive error. For refractive errors less than 6 diopters of myopia prior to surgery, the mean change in refractive error over 10-13 years for PRK ranges from 0.46-0.64 more myopic and 0.33 for LASIK. The higher the initial refractive error, the greater the regression towards myopia (Alio, et al, 2008a,b,c,d; Dirani et al, 2010). PRK eyes become 1-1.2 diopters more myopic over a 10-13 year period; LASIK eyes become 0.63-1.76 diopters more myopic. In LASIK eyes, this regression occurs mainly in the first 2-5 years (Alio et al., 2008c,d); in PRK patients, the greater rate of regression occurs within the first two years (Alio et al., 2008a,b). Except for initial refractive errors over 10 diopters, uncorrected visual acuity remains stable after two years (Alio et al., 2008b,d; Shojaei et al., 2009).

The majority of individuals who undergo laser refractive surgery to correct low to moderate refractive errors continue to meet the uncorrected visual acuity requirement of 20/40 after 10 years without requiring retreatments (Alio et al., 2008a,c; Dirani et al, 2010). However, spectacles, contact lenses, or retreatment may be needed to obtain 20/20 vision. Those with high initial refractive errors (> 6 diopters) are likely to require retreatment to attain 20/40 uncorrected and spectacles or contact lenses to achieve 20/20 corrected. Because of risk of refractive error regressing to unacceptable levels, annual vision testing is advised to ensure that vision remains within agency standards.

2. Intrastromal Corneal Rings (ICR)

In 1999, the FDA approved intrastromal corneal rings (ICR) for persons with mild myopia (≤ -3.00 diopters). ICRs have the benefit of being reversible if serious side effects occur. Over time, persons treated with ICRs appear to achieve better uncorrected visual acuity than those corrected with LASIK (Suiter et al., 2000).

However, the procedure has become rare except for cases with keratoconus. Intacs have been approved to manage keratoconus and other corneal thinning disorders and diseases with good long-term success (Levinger & Pokroy, 2005; Bedi et al., 2012).

ICR for correcting myopia requires evaluation per the general guidelines for evaluating refractive surgery, as some individuals experience problems with fluctuating acuity, glare, and double images, especially at night. Stability of the refractive error usually occurs by three months post-op (Schanzlin, 1999). Because ICRs are removable (removal rate during the first year is 11%), monitoring to ensure assurance that officers wear rings is necessary.

3. Phakic Intraocular Lenses

In 2004, phakic intraocular lens implants (PIOL) were approved to correct refractive errors too large (spherical refractive errors greater than -10.00D or + 3.50D) to be corrected by laser refractive surgery, or when laser refractive surgery is contraindicated. Three PIOLs are currently approved by the FDA: the ***Artisan intraocular lens*** (Ophtec USA, Boca Raton, FL), the ***Verisyse*** (Advance Medical Optics, Santa Ana, CA) and the ***Visian*** (also known as the Implantable Collamer Lens from STAAR Surgical, Monrovia, CA). The Artisan and Verisyse are actually the same AC PIOL, distributed by two different companies. The Visian is a PC PIOL. Other PIOLs designs are in various stages of development, and once approved, will be listed at the FDA website.

PIOLs can be implanted in the eye's anterior chamber (AC PIOL) or posterior chamber (PC PIOL). The surgery to implant the devices is similar to cataract surgery. PIOL surgery to correct refractive error (primarily high degrees of myopia) is one of the least common ways of correcting refractive error (Waring & Durrie, 2008). Although the PIOLs can be removed, there are no known reports of individuals doing so without precipitating complications.

PC PIOLs have been associated with cataract formation and potential night vision problems (glare, halo), cataract formation being the most common post-surgical complication. Cataracts can be caused by surgical trauma, disruption of the aqueous flow that brings nutrients to the crystalline lens, or the crystalline lens touching the implant. About 70% of cataract cases occur within three months, although it can take up to two years to develop. Surgically-induced cataracts that occur within the first year post-op tend to remain stable; cataracts that occur later are progressive. The incidence of surgically-induced cataracts for the Visian PC PIOL ranges from 2.5%-33%, depending on the definition of cataract and the skill of the surgeon (Lackner et al., 2003, 2004; Sanders et al., 2002, 2003, 2004). Most surgically-induced cataracts are trace or mild; about half of these individuals experience symptoms. In this type of cataract surgery, both the Visian PC PIOL and the human crystalline lens are replaced by a single implant with generally successful results.

Based on the PIOL studies, it is difficult to determine whether the more subtle cataracts/opacities would cause vision loss detrimental to policing. These studies report that individuals with trace focal cataracts tend to be asymptomatic; however, those with more dense cataracts report problems with glare, halos, and night vision problems. Approximately half of individuals with cataracts after PC PIOL implantation require cataract surgery within 2-3 years. In the case of cataract surgery, the PIOL and the human crystalline lens are replaced by a single implant with generally successful results. Cataract progression is more likely for those over 40 years old, females, and those with earlier PC PIOL models. The incidence of cataract formation after one year for the approved Visian PC PIOL model is less than 1% (Sanders et al., 2002).

The incidence of surgically-induced cataracts with AC PIOL's ranges from 2-3% (Menezo et al., 2004; Alio et al., 2002; Maloney et al., 2002). Cataracts usually appear during the first two months and remain stable. In addition to surgically induced cataracts, there is a slight regression towards myopia during the first six months after surgery (Maloney et al., 2002).

Night vision problems with both types of PIOLs arise occur primarily due to a small optical zone in the PIOL relative to the pupil size (Arne & Lesueur, 2000). The incidence of new night vision problems after anterior and posterior PIOLs - glare, halos and night driving difficulties – ranges from 4-12% (Arne & Lesueur, 2000; Sanders et al., 2003, 2004; ITM Study Group, 2004; Moshirfar et al., 2007b; Qasem, et al., 2010). This incidence is equivalent to problems reported for refractive surgery patients.

Effects of trauma. There are two known reports of dislocation/dislodgement of Visian PC PIOL due to trauma (Kong et al., 2010; Schmidt et al., 2012). One case involved a dislocation due to trauma to the back of the head; the other was due to a fist to the area around the eye. In both cases, the lens was repositioned successfully and acuity returned to 20/20 within a week. Both incidents occurred in a dark environment when the pupil was relatively dilated. The larger pupil may have made dislocation more likely.

Eight cases of AC PIOL dislodgement due to trauma were reported between 2002-2007 (Yoon et al., 2002; Munzo et al., 2003; Moshirfar et al., 2007a). The trauma in all cases was moderate and confined to one eye. The incidence of Artisan dislodgement is very low (near 0.1%); however, the levels of trauma were not severe – roughly equivalent to that required to displace spectacles without severely damaging an eye. Moreover, these incidents occurred in the general population where the risk of ocular trauma was probably extremely low. Nevertheless, of the eight patients who experienced non-penetrating blunt trauma to the eye, only two patients had the AC PIOL dislodge (Moshirfar et al., 2007a).

Given the above, candidates who wear FDA-approved PIOLs and those with higher refractive errors should be deferred to ensure that: 1) the incisions have healed, 2) the refractive error is stable, and 3) cataracts are unlikely over a 12-month period. Officers with PIOLs should be required to wear protective eyewear.

4. Radial Keratotomy

Radial keratotomy (RK) has fallen out of favor due in good part to the relatively high number of complications, diurnal fluctuation in vision, (Schanzlin et al., 1986; McDonnell et al., 1996) and rupture of the globe. (Vinger, et al.,1996). Candidates contemplating RK surgery should be strongly encouraged to investigate laser refractive surgery techniques. Protective eyewear is highly recommended for officers who have had RK (Groves, 1996).

B. RECOMMENDED EVALUATION PROTOCOL

Candidates should be carefully questioned regarding problems of glare, night vision and halos. Dates of surgeries and any repeat procedures ("touch-ups" or enhancements) should be noted. Records related to the surgery and follow-up care should be obtained.

Laser Refractive Surgery and Intrastromal Corneal Rings (LCR)

GROUP I: PRE-OP MANIFEST ERROR ≤ 6 D (<3 D for the ICR)

A) 1- 3 months post operation or last enhancement:

Acceptable if asymptomatic, refractive error has been stable, and acuity is well within acceptable limits. The refractive error is considered stable if the spherical and cylindrical components for each eye are within ±0.50 diopter for the two assessments, separated by at least 30 days. The presence of significant symptoms or an acuity that is at the limit of acceptability would warrant deferral and reevaluation for an additional three months.

B) 4-5 months post operation or last enhancement:

Acceptable if asymptomatic and acuity is within acceptable limits. The presence of significant symptoms would warrant deferral and re-evaluation at 6 months post-op.

C) 6 months (or more) post operation or last enhancement:

Acceptable if asymptomatic and visual function is within acceptable limits. However, a history of significant symptoms at 6 months or longer post-op renders the candidate unsuitable, regardless of current status.

GROUP II: PRE-OP MANIFEST ERROR > 6 D

Acceptable if asymptomatic, visual function is within acceptable limits, and there is documentation that the manifest refraction has been stable for at least 6 months post-operative. The refractive error is considered stable if the spherical and cylindrical components for each eye are within ±0.50 diopter for the two

assessments, separated by at least 180 days. However, a history of significant symptoms at 6 months or longer post-op renders the candidate unsuitable, regardless of current status.

Due to the risk of regression, these candidates should undergo annual vision testing to ensure that visual acuity is maintained within agency standards.

Phakic Intraocular Lenses (PIOL)

Anterior Chamber

Acceptable if asymptomatic and visual function is within acceptable limits six months postoperative. If any lens opacities, vacuoles, or cataracts have developed, the minimum waiting period should be extended to at least six months after their first appearance.

Posterior Chamber

Acceptable if asymptomatic and visual function is within acceptable limits one year postoperative. If any lens opacities, vacuoles, or cataracts have developed, the minimum waiting period should be extended to at least six months after their first appearance.

3) COLOR VISION DEFICIENCY

a. GENERAL CONSIDERATIONS

Classification of Color Vision Deficiencies

The human eye has three different classes of cone photoreceptors, each with a unique photopigment that preferentially absorbs different wavelengths of light (red, green, and blue). The majority of individuals with a CVD are referred to as red-green defective due to their loss of color discrimination along the red-green color axis. The major classification of CVD depends on whether: (1) one of the three distinct photopigments is different from the color-normal population in terms of which wavelengths are preferentially absorbed ("anomalous trichromats"); or (2) one of the photopigments has been replaced such that retina contains only blue and green cones or blue and red cones. ("dichromats").

CVD is further subclassified based on which pigment is involved. "Protans" have an alteration of the red receptor; "deutans" have an alteration of the green receptor. A small minority of individuals having color discrimination losses along the blue-yellow axis are referred to as "tritans". Tritans have either a nonfunctioning or partial functioning blue receptor (Table XI-15).

Table XI-15. Nomenclature, Classification, and Prevalence in Caucasian Males (Females) of Different Types of Human Color Vision

Type		Percentage
Trichromatic		
Normal		92 (99.6)
Anomalous		
Protan (protanomalous)	Red-green	1 (0.01)
Deutan (deuteranomalous)	Red-green	5 (0.25)
Tritan (tritanomalous)	Blue-yellow	Trace
Dichromatic		
Protan (protanopia)	Red-green	1 (0.01)
Deutan (deuteranopia)	Red-green	1 (0.01)
Tritan (tritanopia)	Blue-yellow	0.002
Monochromatic		
S, M, or L cone (incomplete or atypical achromasy)		0.000001
Rod (typical achromasy)		0.003

From Bailey, J.E. Color vision. Chapter 13 In: Clinical Procedures in Optometry. J.B. Eskridge, J.F. Amos, J.D. Bartlett (eds). Lippincott, pp. 99-120, 1991.

For the vast majority of candidates with CVD, the condition will be congenital. However, CVD can be secondary to ocular/systemic disease (such as diabetes and glaucoma) or medications (Table XI-16). Clinical characteristics that distinguish acquired CVD characteristics from those that are hereditary are presented in Table XI-17 (Bailey,1991).

Table XI-16. Examples of Some Commonly Prescribed Drugs Classified According to Color Deficiencies They Reportedly Induce

Blue Defect	Red-Green Defect
Chloroquine Indomethacin Phenothiazine Methimazole Trimethadione	MAO-inhibitors Chloramphenicol Oral contraceptives Ethambutol Digoxin

From Bailey, J.E. Color vision. Chapter 13 In: Clinical Procedures in Optometry. J.B. Eskridge, J.F. Amos, J.D. Bartlett (eds). Lippincott, pp. 99-120, 1991.

Table XI-17. Clinically Distinguishable Differences Between Acquired and Hereditary Color Vision Defects

Hereditary	Acquired
Always bilateral and equal	Usually more severe in one eye, often unilateral
Almost always a red-green deficiency; much more prevalent in males	Predominantly blue-yellow defects; males and females equally susceptible; can combine with hereditary defect
Other visual functions not affected	May affect visual acuity, visual fields, and other vision functions
Stable throughout life	Color vision varies with status of underlying condition; more stable if long-standing
Unambiguous color confusions on color vision tests	Often no clear-cut types of errors

From Bailey, J.E. Color vision. Chapter 13 In: Clinical Procedures in Optometry. J.B. Eskridge, J.F. Amos, J.D. Bartlett (eds). Lippincott, pp. 99-120, 1991.

Relevance of Color Vision to Patrol Officer Duties

In the 1984 POST vision study, incumbent officers rated color identification as being "important" to "very important" (Table XI-1). Color vision was cited as being involved in an estimated 6% of critical incidents. Table XI-18 shows the frequencies for which color was used in identification of the object.

Table XI-18. Frequency of Objects in the Critical Incidents Where Color Was Used for Identification (POST, 1984).

Object	Percentage (N=69)
Vehicle	67%
Suspect clothing	23%
License plate	4%
Container	3%
Traffic light	1%
Residence	1%

Color identification, especially of cars and clothing, is an important component of almost all patrol officer communications. For example, when someone calls 911 and reports a suspect or vehicle, the dispatcher generally asks the caller to describe identifying colors. The subsequent radio call to a patrol car includes this information.

Steward and Cole (1989) reported that 75% of the color-defectives surveyed reported problems in selecting paints, clothes, cars, furniture and cosmetics as a result of their color vision deficiency. In survey of 11 police officers with self-reported mild color-defects, 45% reported problems with identifying the color of cars and 18% reported problems with identifying the color of clothes (Shaw & Gledhill, 1995). In many

jurisdictions, officers must be able to write legal reports and testify in court regarding their observations. A jury would likely discredit information from a CVD officer who is uncertain as to whether s/he saw a green car or a brown car leaving the scene of a crime, or whether a suspect had a tan or pink shirt.

Beyond color identification, color vision is also important in the recognition of signal light color. Many CVD persons report having difficulty distinguishing the color of traffic signal lights, confuse traffic lights with streetlights in the background, and have trouble seeing brake lights on cars (see Table XI-19). No CVD police officer reported problems in identifying the color of the signal light, but 9% reported difficulties in distinguishing the traffic signals from the surrounding streetlights.

Table XI-19. Percentage of Color Defective Individuals Reporting Difficulty with Color When Driving

Question	Dichromats (N=37)	Anomalous Trichromats (N=65)	Color Normals (N=102)
Have you ever had difficulty distinguishing the color of traffic signal lights?	49	18	0
Do you ever confuse traffic lights with streetlights?	33	31	2
Do you find brake lights on other cars difficult to see?	22	8	0
Do you find hazard or warning lights on temporary barricades difficult to see?	11	2	0
Do you find dashboard warning lights hard to see?	14	5	0
Do you find some road signs such as those on freeways or school crossings difficult to read?	5	11	0

Steward, J.M. & Cole, B.L. 1989. What do color vision defectives say about everyday tasks? *Optom. Vis. Sci.* 66(5):288-295.

The total accident rates for CVD drivers tend to be higher, although not at a level that reaches statistical significance (Verriest et al., 1980; Norman, 1980). The odds ratio for CVD drivers in the Verriest et al (1980) study was 1.1, but Cole and Maddocks (1997) suggest that the rate could be as high as 1.3. With an odds ratio 1.1 and the assumed prevalence of CVD in population, the sample size would have had to been at least double in the Verriest et al study in order to reach statistical significance.

There is less controversy surrounding the types of accidents. Individuals who have decreased brightness sensitivity to red lights (i.e. protan defect) have twice as many accidents involving responses to red signal lights and brake lights than drivers with normal color vision, especially when conditions are wet or slippery. CVD individuals with normal brightness sensitivity (i.e. deutan defect) have twice as many accidents at intersections controlled by traffic signals, although this finding did not reach statistical significance, perhaps again due to the small sample size (Verriest et al., 1980; Cole & Maddocks, 1997).

Assessing Functional Abilities

On average, dichromats have more difficulty in color-related task than anomalous trichromats, and protans generally have more difficulty driving than deutans (Verriest et al.,1980; Vingrys, 2002; Wolfe et al., 2002). Beyond these generalities, there is a wide range of functional capacity among individuals within and between all classification groups. Consequently, the primary focus of color vision testing is to first screen for color vision deficiencies prior to assessing their functional capacity, rather than classifying an individual's specific deficiency. The common tests include the following:

Pseudoisochromatic Plates (PIP) require the identification of a number or symbol consisting of colored dots embedded in a background of different colored dots. The most common PIP test is the Ishihara. Different versions of the test have different numbers of test plates. If the Ishihara is used as a screening test, only the 24 plate or 38 plate editions should be administered and the plates should be presented in random order.

Although it can quickly and accurately differentiate color "normals" from color "abnormals," the Ishihara can be compromised due to its on-line availability. Besides problems with test security, the Ishihara test has a overly-high sensitivity: 8% of males will fail, although not all of those who do fail will have a disqualifying degree of color vision deficiency.

A pseudoisochromatic plate test that is less subject to compromise is the Hardy-Rand-Rittler Color Vision Test (HRR). The HRR consists of two parts: a screening series that distinguishes color-normals from color-defectives, and a diagnostic series that identifies the type of color vision defect and grades the severity of the defect from very mild, mild, moderate to severe. Cole, et al (2006) reported that the HRR performance is comparable to the 38-plate Ishihara test for screening red-green color vision defects if more than one error on the HRR screening series is considered a failure. Although the answers to the HRR are also readily available, the order and orientation of the test plates can be randomized, making it more difficult to memorize. To reduce the likelihood of memorization, all plates should be administered.

Computerized versions of the PIP are available. The ColorDx (Konan Medical Irvine, CA 92618), for example, has sensitivity and specificity values that are nearly identical to the 38-plate edition of the Ishihara (Almustanyir, 2014; Ng et al., 2015). Not all the plates are presented once a fixed number of errors is made, making it more difficult to memorize. Other computerized-based color vision tests should have been independently validated before being considered as a screening instrument.

Arrangement Tests involve arranging colored samples in a logical color sequence. The Farnsworth-Munsell D-15 (D-15) is the most widely used arrangement test. It requires an individual to place 15 colored samples (standardized paper disks mounted in caps) in a logical color sequence. The test was designed to identify CVD individuals with more severe defects who were likely to encounter problems in making color judgments encountered in ordinary occupations (Farnsworth, 1947), such as identifying color of clothes and paints. It is well standardized, readily available, inexpensive, and relatively easy to administer and score.

Table XI-20 lists the sensitivity and specificity of the D-15 for a number of practical color identification tasks. The general findings indicate that the sensitivity and specificity vary depending on the practical task. This variation is likely due to the number of colors to be identified, the vividness (i.e., saturation) of the sample colors and any brightness differences that may be present that provide secondary color clues. For example, in the Hovis et al. (1994) study, the sensitivity and specificity of the D-15 were greater for the small wire (i.e. low voltage applications) task than the large wire (typically 110 to 120 volt applications) task. The higher sensitivity and specificity values for the low voltage wire task were due to several factors, including smaller sized wires, the more pastel color of the small wires colors, the greater number of potential confusions in the small wires samples, and the difference in brightness relationships between the various colored small wires relative to the relationships in the large wire set. For colors used in signage, the sensitivity values generally fell between 0.70 and 0.80 (Cole & Orenstein, 2003; Cole et al., 2006).

Table XI-20. Sensitivity and Specificity of the D-15 for Various Practical Color Naming Tasks.

Study	Task	**Specificity** (Pass both D-15 and Practical Task)	**Sensitivity** (Fail both D-15 and Practical Task)	Comments
Kuyk et al. (1986,1987)	Air Traffic Control. Both surface colors and signal lights	0.58	0.95	Combined results for both protan and deutan subjects. Mild defects passed the D-15.
Hovis et al. (1994)	Identifying wire colors	High voltage wires: 0.72 Low voltage wires: 0.93	High voltage wires: 0.73 Low voltage wires: 0.85	Low voltage wires contained more colors, were smaller in size and had more pastel shades
Mahon & Jacobs (1991)	Colors on Video display (Electronic Flight Information System)	Single Color Presentation: 0.5 Paired Color Presentation: 0.58	Single Color Presentation: 1.0 Paired Color Presentation: 0.92	Values for the single presentation are based on the second series. The worst normal score was the cut off score for passing the practical.
Sui & Yap (2003)	Road markings and signal lights used in airports	0.44	0.88	Limited set of surface colors (n=3) and the colors and intensities of the signal lights were not given.
Cole & Orenstein (2003)	Paint, thread, fabric samples 10 Colors purple, blue, green, yellow, orange, brown, red, black, grey and white.	Large objects: 0.68 Small objects: 0.72 Combined: 0.74	Large objects 0.81 Small objects 0.74 Combined: 0.78	Colors across materials were basically the same set, but may not have had the same brightness relationships Small objects (<3 deg in length) and large objects (>5 deg) in length
Ramaswamy & Hovis (2004)	Colors on Video Display	0.82	0.68	Limited to a specific railway company's display
Cole et al. (2006)	10 Printed dots and lines on gray background approximately the same colors used by Cole & Orenstein	Large Sizes: 0.81 Combined: 0.92	Large Sizes: 0.69 Combined: 0.70	Large sized objects were larger than 0.5 deg in diameter/width 1 error (0.8%) was allowed

There are two major limitations to using the D-15. First, it has low sensitivity for predicting performance on job-related duties. In 1984, POST conducted a color simulation test in which participants were shown slides and asked to name the colors of specific vehicles, suspects' clothing, traffic lights, license plates, and to determine whether vehicles' brake lights were on or off. The results indicated that persons who failed both the Ishihara test and the D-15 made significantly more errors than color normals (Table XI-20). Those who failed the Ishihara but passed the D-15 made fewer errors on all tasks than those who failed both tests; however, their error rate was almost twice that of color normals when naming the color of cars, and almost three times that of color normals when naming the color of clothing.

Individuals who receive a borderline pass on the D-15 test are more likely to have difficulty naming pastel colors (Zisman & Adams, 1985). The difference in error rates for color naming shown in Table XI-21 among color-normals, CVD individuals who pass the D-15, and CVD individuals who fail the D-15, are typical of the differences reported in other studies (Cole et al., 2003, 2006; Cole & Orenstein, 2003).

Table XI-21. Color Simulation Test Results (POST, 1984)

Color-Dependent Task	Color Normals (n=19)	Fail Ishihara Pass D-15 (n=6)	Fail Both Tests (n=6)
	Number of Slides Misidentified		
Color Naming:			
Vehicles (20)*	4.7	8.9**	11.0**
Clothing (11)	1.0	2.7**	5 .8**
License plate (5)	1.8	1.4	2.5
Driving-Related:			
Brake lights (24)	2.7	1.8	7.4**
Traffic lights (20)	0.8	1.3	5.4**

*Total number of simulation slides; average number identified incorrectly is shown in table
**Significantly worse than normals by t-test

In studies performed at the City of Los Angeles, candidates who failed the Ishihara but passed the D-15 were asked to name colors of cars, clothes, buildings and paint catalog samples. Both studies found that individuals who passed the D-15 made errors in identifying colors (Goldberg, 1994, 2004). In the 2004 study, 59% (40/68) of the candidates who passed the D-15 made several errors in identifying the color of buildings and cars. Seventy-six percent (52/68) made a substantial number of errors in identifying paint chip colors. Based on these results, the ability of CVD officers who pass the D-15 to identify colors is called into question.

The D-15 is also susceptible to improvement through practice. If shown the correct cap sequence and provided with an opportunity to practice, persons with severe color vision impairment can improve their score up to the point of passing.[11] Given the availability of

[11] W. H. Ridder, M.D., Personal communication 2012.

the test both on line and through purchase, the test can be compromised through practice and memorization.

In summary, unacceptably low sensitivity and the potential for test comprise seriously impact the D-15's effectiveness for determining color identification ability in peace officer candidates.

Hardy-Rand-Rittler, 4th edition (HRR) Diagnostic Plates

Cole et al. (2007) reported that the HRR diagnostic plates were more sensitive than the D-15 in identifying individuals who named surface colors incorrectly. They and others have recommended that the predictive values of a clinical test for passing or failing the practical test are more useful indices than sensitivity and specificity, because the true negatives (true positives) and false negatives (false positives) are combined into one value (Fletcher et al., 1982).

The predictive value for passing is (P_p) is:

$$\frac{\text{Number who pass both the clinical test and practical test}}{\text{Number who pass the clinical test}}$$ [12]

The predictive value for failing is (P_f) is:

$$\frac{\text{Number who fail both the clinical test and practical test}}{\text{Number who fail the clinical test}}$$

Table XI-22 depicts the predictive values and percent correct for various color vision tests in identifying color-defective individuals who can identify surface colors of red, orange, brown, green, yellow, blue, purple, black, white and gray based on research conducted by Cole. The studies conducted in 2007 drew from the same participant group and used the same surface colors. Cole's 2003 study used different subjects as well as colored objects that differed in color and size; moreover, the color identification task was more difficult based on worst-normal number of errors. Percent correct represents the sum of the predictive values weighted by the probability of passing and failing the color vision test.

As indicated in Table XI-22, there is a marked similarity in percent correct values across studies. The overlap in the confidence intervals indicates that these similarities are statistically significant, consistent with Cole et al.'s 2007 finding that the predictive pass and predictive failure values for the various clinical tests were statistically identical. Notwithstanding this similarity, the HRR's higher predictive pass values indicates that it is better than the D-15 in identifying who will be able to name colors correctly. Although the HRR passed fewer individuals, the ability of 87% of these individuals to name a set of colors is comparable to that of color normals. It is therefore the preferred test for screening candidates for color vision deficiencies.[13]

[12] Specificity is equal to number of individuals who pass both the clinical test and practical test divided by the number who pass the practical test. Sensitivity is equal to number of individuals who fail both the clinical test and practical test divided by the number who fail the practical test.

[13] Despite its advantages over the D-15, the HRR diagnostic plates are still imperfect predictors of performance in identifying colors. Consequently, a practical color identification test is currently under development.

Table XI-22. Predictive Values and Percent Correct for Clinical Color Vision Tests in Identifying Color-Defective Individuals Who Can Identify Surface Colors.*

Study	Test (Failure criterion)	Percent who passed the clinical test (number of CVD subjects)	Predictive value for passing	Predictive value for failing	Percent correct (95% confidence interval)
Cole et al., 2007	HRR (4th ed) (Worse than mild	30 (n=99)	0.87	0.70	75.1 (65.8 to 82.6)
Cole et al., 2007	D-15 (more than one major crossing)	60 (n=99)	0.73	0.90	79.8 (70.8 to 86.5)
Cole et al., 2007	Anomaloscope (Range greater than 35)	67 (n=99)	0.66	0.97	76.0 (66.7 to 83.3)
Cole et al., 2003	D-15 (more than one major crossing)	41 (n=102)	0.76	0.73	74.2 (65.9 to 82.5)
Cole et al., 2007	Optec 900 Lantern (Farnsworth Lantern) (standard instructions)	19 (n=99)	0.73	0.74	73.8 (65.8 to 82.6)

* red, orange, brown, green, yellow, blue, purple, black, white and gray

There appears to be limited value in administering the D-15 in addition to the HRR, since the latter test has been shown to be more sensitive in identifying milder forms of color vision defects. Almustanyir (2014) found that only 17% of CVDs who passed the D-15 (n=18) were classified as mild or very mild by the HRR, and no one who failed the D-15 (n=29) was classified as mild or very mild. These data indicate that situations in which a candidate fails the D-15 but is classified as mild by HRR should be treated with suspicion.

Additional Tests:

The Farnsworth Munsell 100 Hue test (FM-100) is one of the few clinical tests that can measure fine color discrimination of both color-normal and color-defective individuals. It is commonly used to assess the color discrimination ability of quality control personnel and in acquired color vision defects. Using a total error score greater than 90 as a failure, the FM-100 performs better than the D-15 in predicting performance on this color wire identification task (Hovis et al., 1994). However, the recommended cut score rises for individuals older than 25 years old, particularly for those in their late 40's and 50's, thereby making it a poorer predictor than the D-15 for those age groups.

The sensitivity of FM-100 for identifying high voltage wire colors is 1.0 with a specificity of 0.79. For low voltage wire color identification, the sensitivity remains at 1.0 with a specificity of 0.91 (Hovis et al., 1994). Although it may also be useful in assessing a candidate's color vision with borderline results on other color vision tests; the FM-100 requires 30-60 minutes to administer and score.

Lantern Tests such as the Farnsworth Lantern test, (replaced by the Optec 900), require the identification of small colored lights. These tests are commonly used to certify pilots and ship captains (Hackman & Holtzman, 1992). Some have advocated their use in determining whether CVD individuals qualify for commercial driving licenses (Cole, 1993). Practical problems with the test include the limited availability of testing equipment and a testing protocol that requires modification due to problems with the accompanying

instructions (Cole et al., 2008). The D-15 is slightly easier than the Farnsworth/Optec Lantern; approximately 60% of the CVD individuals who pass the D15 can pass the lantern. Of those that fail the D-15, 90% fail the lantern test (using the traditional testing protocol) (Cole & Vingrys, 1983).

The Nagel Anomaloscope uses color matching to identify and classify red-green color vision. Candidates adjust the relative amounts of red and green lights until they match a reference yellow standard. The severity of the defect is determined by the range of red-green mixtures that appear identical to the reference yellow light. A Nagel range ≤ 35 units would be considered acceptable (Cole et al., 2007).

The Nagel Anomaloscope and Optec 900 Lantern test may be of value in more challenging cases. These tests are more likely to be found at Schools and Colleges of Optometry or Departments of Ophthalmology. The Optec scoring criterion should follow the recommendation by Cole et al. (2008) of one practice run followed by two runs of the nine pairs. The passing criterion should be no more than one total error (each misnamed light is a mistake) on the two runs.

As discussed above, the HRR diagnostic is preferable to the Farnsworth D-15, Farnsworth Lantern and Nagel tests in assessing the ability to determine a candidate's ability to name surface colors (see Table XI-22). Despite its advantages, the HRR plates are nevertheless imperfect predictors of performance. POST is currently researching the development of a practical color identification test to assist in the evaluation of CVD candidates.

SUMMARY: Color vision is critical in performing a variety of job functions (e.g., identification of cars, clothing, etc., identifying traffic lights, distinguishing traffic lights from streetlights). However, candidates with very mild or mild color vision deficiencies possess sufficient color identification and color discrimination ability. The HRR is the most effective test in distinguishing those with mild deficiencies from candidates who have more severe forms of CVD.

Color Corrective Lenses

Colored contact lens or spectacles (i.e., X-Chrom, X-Chrome, Colormax, Enchroma, Chromagen) introduce both brightness and color differences between the figure and the background colors. The effect is similar to looking at the plates through a red filter. This violates the basic illumination requirements for any pseudoisochromatic plate test, including the Ishihara, D-15, and HRR. Performance on other color vision tests may be worse and discrimination of colors not previously confused may be poorer (Matsumoto, et al.,1983; Kassar et al., 1984; Hovis, 1997; Swarbrick et al., 2001; Moreland et al., 2010).

Functional ability can be adversely affected by color correction lenses as well. If a single lens is worn, depth perception may be impaired (Matsumoto, et al., 1983). Any "corrective lens" has approximately the same luminous transmittance as sunglasses (Hovis, 1997; Moreland et al, 2010); therefore, these lenses cannot be worn at night. Moreover, some lenses may make traffic light signals and LED information signs difficult to detect when worn in front of both eyes during the daytime. For these reasons, "color corrective" spectacles or contact lenses are not acceptable devices to aid in color discrimination.

b. RECOMMENDED EVALUATION PROTOCOL

HISTORY - Table XI-23 lists the common problems encountered by color-defectives in their daily lives and the percentages responding “yes” to each question. The first 5-7 questions can serve as the basis for determining whether there is a disqualifying color vision problem based on the relatively high percentages of CVDs who encounter these problems. However, the reverse is not true: a failure to acknowledge problems does not negate the findings of objective testing, especially in high-stakes situations such as employee screening. Steward and Cole (1989) found that 5% of dichromats and 25% of anomalous trichromats were not aware of their CVD. In certain cases, consideration may be given to whether the CVD is non-hereditary and potentially reversible (see Tables XI-16 & XI-17). This is especially important if the CVD candidate is female, taking medication, or if the deficiency follows a tritan pattern.

Table XI-23: Percentage of Individuals Reporting Difficulty with Everyday Tasks that Involve Color

Question	Dichromats (N=37)	Anomalous Trichromats (N=65)	Color Normals (N=102)
Have you ever had any difficulty in selecting the colors of clothes, accessories, cars, paints, carpets, furniture, wallpaper, or cosmetics?	86**	66*	0
With craftwork and hobbies, do you have any trouble distinguishing the colors of wires, threads, materials, wools, paints, or other things?	68***	23***	0
Do you find plant or flower identification difficult because of color?	57***	18***	0
Have you ever had difficulty distinguishing the color of traffic signal lights?	49**	18*	0
Do you have any difficulty determining when fruits and vegetables are ripe by their color?	41*	22*	0
Can you determine if meat is cooked by its color?	35*	17*	0
Do you ever confuse traffic lights with streetlights?	33	31	2
Do you have any difficulties because of color as either a spectator or participant in sporting activities?	32	18	0
Do you find it difficult to adjust the color balance on a color TV satisfactorily?	27	18	2
Have you ever had difficulty in recognizing skin conditions such as sunburn and rashes?	27	11	0
Do you find brake lights on other cars difficult to see?	22	8	0
Do you find dashboard warning lights hard to see?	14	5	0
Do you find hazard or warning lights on temporary barricades difficult to see?	11	2	0
Do you find some road signs such as those on freeways or school crossings difficult to read?	5	11	0
Have you ever taken the wrong tablet or medicine because of difficulties with its color?	0	3	0

Significant difference between dichromats and anomalous trichromats at *p < 0.05, **p < 0.01, or at ***p < 0.002 using Yates x^2. From Steward, J.M. & Cole, B.L. (1989). What do color vision defectives say about everyday tasks? *Optom. Vis. Sci.* 66(5):288-295.

Set-up of Testing Area

The only light source in the test room should be the illumination provided by a True Daylight Illuminator (with slant easel) utilizing a single Verilux F15T8VLX 15w tube [or tube of equivalent correlated color temperature (between 5000 K and 7000 K and color rendering index (at least 90)]. Any other sources of extraneous light should be eliminated.

Pre-Testing Procedures

Prior to a candidate entering the testing room, carefully inspect the subject's eyes to ensure that colored contact lenses or spectacle lenses (such as a red X-Chrom or Enchroma) are not worn.

Seat the patient so that their eyes are about 30 inches from the test book when it is placed on the easel of the Illuminator.

HRR Pre-Testing Procedures

Demonstration Plates (1-4):

Show the first plate in the sequence and say:

The test itself is made up of just these three symbols, an "X", an "O", or a "Δ", with two symbols, one symbol, or no symbols on a page. Some of them will be harder for you to see as they may be less strong in color.)

Open the book to the first demonstration plate. *"Here are examples of a circle and X"*

Show the second plate and state *"Here are examples of a triangle and X".*

Show the demonstration third plate and state:

"Here is circle. There can be one or two figures, or (as you turn to 4th plate) *no figure.* Y*ou need to point to the location of each figure that you see with the paintbrush. If you are not sure, trace the figure with the paintbrush."*

It is important for you to tell me immediately how many symbols you see and where they are located on each page. You cannot change your answer. If you do not give me an answer within 3 seconds, I will have to turn the page.

"Do you understand the instructions" Do you have any questions?"

Test Plates:

Due to the limited number of screening plates, it is possible to memorize the correct answer for each. For this reason, all the plates should be presented and the order should be randomized. Each plate should be rotated so that the figures are in a

different location from the one on the score sheet. Careful recording of results is critical.

OK, we are now ready to start the test"

(Turn to the first test plate and proceed.)

"What colored symbols do you see here?"

"Locate them with the brush."

If the candidate responds within 3 seconds, record the response (X, O, Δ) in the box provided on the customized scoring sheet, recording the exact symbols seen in the location indicated by the candidate. If no response is given within approximately 3 seconds, mark the missed figures as errors and turn to the next test plate.

Score the test as previously described. A very mild or mild color vision deficiency is acceptable. Moderate to severe color vision deficiencies are disqualifying.

4) OTHER VISUAL FUNCTIONS

Visual Field Deficiency

a. GENERAL CONSIDERATIONS

Partial loss of visual field in one or both eyes affects about 3% of the population between the ages of 16 to 60 (Johnson & Keltner, 1983). This increases to about 6% between the ages of 61 to 65, and 13% in persons over the age of 65. A large number of eye conditions can cause loss of visual field, the most common being glaucoma.

The 1984 POST vision survey indicated that peripheral vision is one of the most important visual abilities for safe patrol officer performance (Table XI-1). Examples of critical situations in which peripheral vision are important include:

- a suspect approaching the officer from the far right or left side;
- a hostile crowd surrounding an officer;
- an officer attempting to look out of the side of a patrol car to spot a suspect while still controlling the vehicle;
- driving under emergency conditions.

Several studies have examined the performance of persons with visual field defects in situations similar to those cited above. Johnson et al., (1992) tested the impact of spectacles that restrict peripheral vision on the ability of a correctional officer to detect suspicious behavior by inmates gathered in a day room. Restricting the binocular horizontal field to 120 degrees in each eye had no impact, but further restriction to 60

degrees significantly impaired performance, especially in detecting more subtle behavior, such as hand/arm movements and inmates reaching for the door.

In a scenario in which a parole officer was interviewing a parolee in his residence, the parole officer's ability to detect another person walking into the room or a person peaking around the corner dropped from nearly 100% for full binocular visual fields to 40% when the field was restricted to 120°. Correct responses dropped to less than 10% when the visual field was restricted even further (Johnson & Brintz, 1996).

Good et al. (2005) reported that individuals with monocular vision missed 11.4% of lighted targets overall, compared to their full binocular visual fields performance, even though eye, head and body movements were allowed. The difference between monocular and binocular performance was greater for the shorter duration flashes, with 16.7% more misses monocularly for the 0.1 sec flashes and 8.6% more misses monocularly for the 0.8 sec flashes.

Driving and Visual Field Defects. Johnson and Keltner (1983) found only slightly higher accident rates among drivers with unilateral field defects or monocularity. The drivers' visual defects were rated as severe in only 13% of the drivers with unilateral defects. However, the results of most studies that focus on monocular drivers or those with gross reductions of the visual field on one side paint a different picture. Kite and King (1961) observed a seven-fold increase in intersection crashes and pedestrian injuries. Keeney (1968) found that monocularity was four times more common in those cited for multiple driving violations. A pathology study concluded that long-standing lesions, which likely produced visual field defects, contributed to the death of two drivers and five pedestrians in Maryland (Freytag & Sachs, 1969).

Johnson and Keltner (1983) found that accident and conviction rates of drivers with visual field loss in both eyes were more than twice as high as those with normal visual fields. This finding is consistent with that of Hedin and Lovsund (1987), who evaluated individuals in a driving simulator. Eighty-five percent of the 27 patients with a variety of field defects had significantly increased reaction times to stimuli presented in visual areas of relevance to traffic safety. Despite the participants' ability to move their heads during testing, only 4 (15%) could compensate for their field defects.

Results from general driving field trials of those with bilateral visual losses are consistent with the previous studies. Wood et al. (2009) and Kasneci et al. (2014) reported that 25%-40% of drivers with bilateral quadranopsia or hemianopsias were judged as unsafe. They had problems maintaining lane position and in gap judgment ability. In the Kasneci, et al. study (conducted in the United States), the majority of those who failed had left hemianopsias (visual field loss on the left side of the fixation point in each eye).

Similar peripheral vision standards were upheld in a 1988 case heard by the California Fair Employment and Housing Commission involving a monocular police officer candidate (DFEH v. City of Merced PD, FEP85-86, 88-20). In finding for the city, the Commission agreed that "peripheral vision is among the most important visual abilities that a police officer needs to safely fulfill his or her duties," and that safety concerns

were not mitigated by that candidate's seven years of prior experience as a patrol officer.

SUMMARY: Monocularity or significant bilateral field defects threaten personal and public health and safety. Peripheral field losses impair driving, the ability to maintain situational awareness and to detect potential hazards when monitoring a scene or when interviewing a person in the field. Significant field defects include monocularity and cases in which total horizontal field is restricted to < 120 degrees in either eye, total vertical field is less than 100 degrees, or when large scotomas are present.

b. RECOMMENDED EVALUATION PROTOCOL

Routine testing techniques for visual field defects have poor sensitivity and specificity. Confrontation visual field testing has a sensitivity of only 37% (Johnson & Baloh, 1991), which is not surprising, given that the technique is unsuitable for detecting small patchy defects and accurate scotomas. Sensitivity is 81% for large defects such as homonymous hemianopia and altitudinal defects is 81%.

Formal perimetry testing should be conducted on those with either a personal or family history of glaucoma, any personal history of visual problems related retinal/optic nerve diseases or disorders, or decreased visual acuity (worse than 20/40) in either eye which cannot be corrected with lenses and was not previously diagnosed as amblyopia. History of severe head trauma or stroke also indicate formal testing. Candidates with monocular vision, <120 degrees of total horizontal field in either eye, <100 degrees of vertical field, or significant scotoma should are not acceptable.

The required visual field tests will depend on the specific case; however, a Humphrey's Full Field 120 screening test (or equivalent) for each eye should be included in every evaluation.

Binocular Fusion Deficiency

a. GENERAL CONSIDERATIONS

Abnormal binocular vision can occur when there is a strabismus and the eyes are directed at different points in the environment. The eye may be intermittently or constantly turned inward (esotropia), outward (exotropia), or vertically deviated (hypertropia). Strabismus is observed in about 4-7% of children. In childhood onset strabismus, the resulting diplopia and visual confusion become the stimuli for suppression of the deviated eye; if not treated at a young age, this may result in permanent loss of vision in the deviated eye (amblyopia). In the case of adult-onset strabismus, suppression rarely develops and therefore double vision is a continuing problem.

Diplopia (i.e., double vision) occurs when there is a misalignment of the eyes. It can be constant or intermittent. It is more likely to occur in reduced visual environments (i.e. nighttime) or when the individual is tired. If the diplopia is intermittent, the individual can

simply close one eye; however, this reduces field of vision and depth perception, and the duration of the diplopia is difficult to predict.

Diplopia is incompatible with many if not most law enforcement activities. For example, 82% (14/17) of patients with strabismus who experienced diplopia reported difficulty in driving: specific comments were “driving is terrible,” “extra caution when driving” and “afraid of hitting something on the side of the road” (Hatt et al., 2007).

Strabismus can also result in a reduction in the binocular visual field. This occurs in individuals who have large angle esotropia (>5 degrees or 10 prism diopters) because the monocular temporal field crescent in the turned eye now overlaps with the nondeviating eye’s visual field (Kushner, 1994; Quah & Kaye, 2004). The reduction in the extent of the visual field is approximately 13% on average as compared to individuals without strabismus (Quah & Kaye, 2004), but the difference could be larger for individuals with larger amounts of esotropia (Kushner, 1994).

SUMMARY: The risk of diplopia and the restriction of the binocular visual fields in the cases of large angle esotropia is a contraindication to job performance.

b. RECOMMENDED EVALUATION PROTOCOL

Candidates with a difference of at least two lines in their corrected monocular acuities or a history of strabismus or lazy eye should be referred to a vision specialist for further assessment to determine whether double vision is likely under both day and night conditions. Several tests are available for this purpose, such as the Worth 4 dot, red lens test and Bagaloni lenses. These tests should be administered in both light and dark and in the six cardinal positions of gaze (straight right, straight left, upper right/left and lower right/left). A significant esotropia (>10 prism diopter) is a disqualifying reduction in binocular visual field. One automated visual field test that can assess the binocular visual field is the Esterman Binocular protocol. The total extent in the horizontal meridian should be at least 140 degrees.

Ancillary Tests

Contrast Sensitivity. Peace officer duties depends on both visual acuity and contrast sensitivity - the ability to rapidly and accurately detect and identify objects that range in size and contrast with the background. Examples of particularly challenging visual tasks include detecting a dark colored weapon lying on an asphalt-covered road, or identifying a dark-colored object in a suspect’s hand held closely to a dark-colored jacket.

Standard testing of visual acuity involves identification of a black letter on a white background. The size of the letter is varied, while the contrast between the letter and the background is held constant. Given that the real world consists of more complex targets which vary in both size and contrast, both parameters are critical to the visibility of an object.

Contrast sensitivity can be measured in two general ways. One method is to maintain a constant letter/grating (i.e. alternating black and white bars) size and vary the contrast until the pattern is no longer visible. This is repeated for different sized patterns (i.e., spatial frequencies). Two clinical charts are available that have a fixed letter size and reduce the contrast until the letter is no longer visible. The Pelli-Robson chart has large-sized letters to measure low spatial frequency contrast sensitivity and the Small Letter Acuity Charts measure contrast sensitivity to high spatial frequencies (Rabin, 1994).

Low Contrast Letter Acuity. Charts that measure visual acuity using low contrast letters include low contrast versions of the Bailey-Lovie chart, ETDRS, and Regan Charts. In conjunction with the high contrast visual acuity, the low contrast acuity measure is often used as a surrogate for measuring contrast sensitivity.

Glare Testing. Glare sensitivity is normally measured by repeating some type of visual resolution test with glare light sources slightly off the direct line of sight. Commercial glare testing equipment is available from Vectorvision or the Mesotest IIb from Oculus. These tests may be useful in assessing glare sensitivity in post-refractive surgery individuals and in those who have cataracts but relatively good acuity.

Low Light Level Acuity. Low light level acuity is measured by repeating a visual resolution test while wearing filters that reduce the amount of light entering the eyes. The filters are selected for a specific condition or are standard with a commercial test (Miller et al., 2005; Hovis & Ramaswamy, 2006). It is notable that officers interviewed in the 1984 POST vision study rated dark adaptation as the most important visual skill used on the job (see Table XI-1). However, based on officer interviews in Canada, this skill may involve seeing and detecting objects in low light levels rather than dark adaptation per se.

Contrast sensitivity has been found to correlate with performance in detecting aircraft, flight performance, simulated aircraft crash sites, object recognition and military vehicle recognition (Ginsberg et al., 1982; Stager & Hameluck, 1986; Shinar & Gilead, 1987); however, the results were not always replicable within or across studies (Kruk & Regan, 1983; O'Neal & Miller, 1987; Temme et al., 1991). The lack of repeatability could be due to the use of different equipment and procedures to measure acuity and contrast sensitivity. Studies that have used a finer scale for both measurements were less likely to find correlations between performance and contrast sensitivity (Kruk & Regan, 1983; O'Neal & Miller, 1987; Temme et al., 1991).

Routine testing on candidates who are visually normal and have a visual acuity of 20/20 or better is not necessary. However, testing contrast sensitivity, low contrast acuity, low light level acuity, or glare testing can be useful for candidates whose corrected or uncorrected acuity is borderline. This could be due to corneal irregularities, mild cataracts, out-of-date spectacle or contact lens prescriptions or contact lenses with moderate-to-heavy deposits on the surface. Their contrast sensitivity or glare sensitivity could be impaired.

Testing contrast sensitivity on all refractive surgery candidates is inefficient. Less than 10% of officers and candidates who undergo refractive surgery and have 20/20 acuity

would have unacceptable low contrast acuity and glare sensitivity. Only 15% have unacceptable low contrast acuity in low light levels (Hovis & Ramaswamy, 2006). Only a minority of the post-refractive surgery candidates have enhanced glare sensitivity or reduced vision in low light levels (Jacobs et al., 1998; Miller et al., 2005).

Several risk factors increase the probability of impaired low light level acuity or glare sensitivity. These include borderline acuity results on typical clinic acuity charts, only one eye at 20/20 or better, vague symptoms of glare sensitivity, original refractive error greater than 6 diopters, corneal irregularities, radial keratotomy, post-surgical complications, or a persistent mild haze in the central corneal.

A candidate's results must be interpreted relative to an age and acuity matched normative database. In one study (Hovis & Ramaswamy, 2006), low contrast acuity was measured using the Bailey-Lovie low contrast letter chart while wearing filters that transmitted approximately 1% of the light. This filter equates the light levels of an urban environment at night. Individuals with low contrast acuity worse than 20/80 (0.62 logMAR) were unable to read license plates from a safe distance. The 20/80 cut-off was three standard deviations from the mean acuity value of police officers and recruits who did not undergo refractive surgery.

SUMMARY OF VISION GUIDELINES

The vision guidelines summarized below assume that: (1) officers may work in areas where environment factors impede the use of the corrective lenses; (2) assaults on officers may occur in low light levels; and (3) the use of lethal force may be required. It is important to consider the relevance of these duties and conditions when developing agency-specific vision standards.

1) FAR ACUITY[14]

The following far acuity guidelines are a repeat of the Far Acuity Summary pp. XI-34–35. Table XI-12 provides a summary of the far acuity guidelines.

No Correction Needed

- Better Eye: 20/20
- Worse Eye: 20/40 for officers whose responsibilities include the use of long guns or shotguns, or activities where they may need to rely on either eye separately; otherwise 20/125.

Use of Spectacles or Scleral Rigid Gas Permeable Lenses

- uncorrected vision of 20/40 for *each* eye for officers who are required to use long guns or shotguns; otherwise 20/40 - 20/125[15] in the better eye and 20/125 in the worse eye
- corrected vision of 20/20 in better eye; 20/40 in weaker eye for officers who are required to use long guns or shotguns; otherwise 20/125 in the weaker eye

Note: To reduce the likelihood and severity of injury to the officer, all spectacles worn by officers on duty should consist of polycarbonate lenses and frames that meet ANSI Z87.1 specifications.

Use of Soft Contact Lenses

Candidates who have worn soft contact lenses (SCLs) for less than six months should meet the same far acuity standards established for spectacle/RGP wearers. However, candidates who have successfully worn SCLs for longer six months need not be required to meet an uncorrected acuity standard, provided that there is a program is in place to ensure continued the use of SCLs while on duty (i.e., as pre-placement agreements with monitoring).

[14] The use of standardized charts and methods when measuring visual acuity is critical. Non-standardized testing results in erroneous measurements and increased measurement variability.

[15] The choice of an uncorrected standard should take into consideration the likelihood of assaults on officers, light levels, inclement weather and other environmental conditions that may affect visibility with spectacles.

Orthokeratology

Due to the potential for fluctuating vision during and across days and the difficulty in establishing protocols for monitoring compliance, orthokeratology is not an acceptable method of vision correction for peace officers.

2) REFRACTIVE SURGICAL PROCEDURES

Laser Refractive Surgery (LASIK, LASEK & PRK) and Intrastromal Corneal Rings (ICR)

Pre-Op Manifest Error ≤ 6 D (<3 D for the ICR)

A) 1- 3 months post operation or last enhancement:

Acceptable if asymptomatic, refractive error has been stable for at least one month, and acuity is well within acceptable limits. The presence of significant symptoms, or acuity that is at the limit of acceptability would warrant deferral and reevaluation after three months.

B) 4-5 months post operation or last enhancement:

Acceptable if asymptomatic and acuity is within acceptable limits. The presence of significant symptoms would warrant deferral and re-evaluation at 6 months post-op.

C) 6 months (or more) post operation or last enhancement:

Acceptable if asymptomatic and visual function is within acceptable limits. However, a history of significant symptoms at or beyond 6 months post-op would warrant disqualification, regardless of current status.

Pre-Op Manifest Error > 6 D

Acceptable if asymptomatic, visual function is within acceptable limits, and there is documentation that the manifest refraction has not changed by more than 0.5 D over the last six post-operative months. However, a history of significant symptoms, at or beyond six months post-op would warrant disqualification, regardless of current status.

Due to the risk of regression, these candidates should undergo annual vision testing to ensure that visual acuity is maintained within agency standards.

Phakic Intraocular Lenses (PIOL)

Anterior Chamber

Acceptable if asymptomatic and visual function is within acceptable limits six months postoperative. If any lens opacities/vacuoles/cataracts have developed, the minimum

waiting period should be extended to at least six months after the first appearance of the opacities/vacuoles/cataracts.

Posterior Chamber

Acceptable if asymptomatic and visual function is within acceptable limits 12 months postoperative. If any lens opacities/vacuoles/cataracts have developed, the minimum waiting period should be extended to at least six months after the first appearance of the opacities/vacuoles/ cataracts.

Radial Keratotomy

Radial keratotomy (RK) is less common, due in good part to the relatively high number of complications, diurnal fluctuation in vision, and rupture of the globe. Candidates contemplating RK surgery should be strongly encouraged to investigate newer laser refractive surgery techniques. Protective eyewear should be worn by officers who have had RK.

3) COLOR VISION DEFICIENCY

Those with a very mild or mild color vision deficiency as identified on the HRR have sufficient color identification and color discrimination abilities. Greater degrees of color vision deficiency are unacceptable.

Use of colored contact lens or spectacles (i.e., X-Chrom, X-Chrome, Colormax, Enchroma, Chromagen) should not be permitted during testing.

4) OTHER VISUAL FUNCTIONS

Visual Field Deficiency

Candidates with monocular vision, <120 degrees of total horizontal field in either eye, <100 degrees of vertical field, or significant scotoma should be restricted from field duty. However, a monocular scotoma that overlaps onto a normal visual field in the other eye may be acceptable.

A significant scotoma is defined as an area extending more than 5 degrees in any direction where sensitivity is less than 10 dB.

Binocular Fusion Deficiency

Candidates with a difference of at least two lines in their corrected monocular acuities or a history of strabismus or lazy eye should be referred to a vision specialist for further assessment to determine whether double vision is likely under both day and night conditions. A significant esotropia (>10 prism diopter) constitutes a disqualifying reduction in binocular visual field. The total extent in the horizontal meridian should be at least 140 degrees.

Contrast Sensitivity, Low Light Acuity and Glare

Testing candidates who are visually normal and have a visual acuity of 20/20 or better is unlikely to be helpful. Testing contrast sensitivity, low contrast acuity, low light level acuity, or glare testing can be useful for candidates who are borderline with respect to meeting the corrected or uncorrected acuity requirement, as well as those with a history of corneal disorders, cataracts, retinal disease or disorders, and optic pathway diseases and disorders, even if their acuity meets the requirements.

For positions in which a large percentage of work is carried out in low light conditions, low contrast visual acuity testing with dim lighting (simulated by using tinted lenses that transmit 1% of the light) may be used for the above candidates and candidates who have had refractive surgery. Although results must be interpreted relative to an age and acuity matched normative database, individuals with a low contrast acuity in dim lighting worse than 20/80 (0.62 logMAR) may be unable to read license plates from a safe distance.

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