VISION STANDARDS AND TESTING REQUIREMENTS FOR NONDESTRUCTIVE INSPECTION (NDI) AND TESTING (NDT) PERSONNEL AND VISUAL INSPECTORS

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For

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INTRODUCTION

Inspection tasks for aircraft maintenance inspectors are visually intense. Whether personnel are inspecting using only a flashlight, a simple magnifier, or sophisticated NDI/NDT equipment, visual identification is the primary method used to find cracks and other defects, which affect structural integrity. The National Transportation Safety Board (NTSB) has identified the failure by inspectors of finding visually detectable corrosion, cracks, or inclusions as a causative factor of several aviation accidents (NTSB 1989, 1990, 1998).

Maintenance personnel working at aircraft maintenance facilities may have primary responsibilities as visual inspectors where they must use only their vision to assess the condition of aircraft and aircraft components; or they can work in areas where Non-Destructive Inspections (NDI) and Non-Destructive Testing (NDT) are performed. In these latter workareas, NDI/NDT inspectors often use highly sophisticated imaging and scanning devices to aid defect detection. However, even for these inspectors, performing a simple visual inspection is a vital component used to ensure that aircraft are safe to fly. In a recent survey of maintenance facilities, 52% of inspectors were classified solely as visual inspectors, 36% were classified as visual and NDI/NDT inspectors, while only 12% were classified solely as NDI/NDT inspectors (Nakagawara et al., 2003).

To the greatest extent possible, vision standards should ensure that workers have the necessary visual skills to perform job-relevant tasks in an efficient and safe manner. For NDI/NDT inspectors, vision skills should be adequate to identify areas of concern (i.e., *detect* potential defects) and to determine if further action is required (i.e., *decide* if a possible defect is within tolerances or if special tests are necessary) (Drury, 2001). Although the NDI/NDT personnel have many tools to aid in the detection of defects (e.g., fluorescent penetrant and magnetic particle inspections, eddy current and ultrasonic devices, borescopes, magnification aids), simple visual inspection may account for up to 80% of all inspections (Goranson and Rogers, 1983).

The FAA's Production and Airworthiness Division (AIR-200) (PAD, 2001) prepared a memorandum, dated September 26, 2001, to address the need for sharp vision for NDI/NDT personnel. This memorandum follows an FAA advisory circular (FAA, 1999) from February 1999 that addresses the same topic. Several national and international organizations have made recommendations for qualifications of NDI/NDT personnel. The September 2001 memorandum identified the standards found to be acceptable to the FAA for assuring that only qualified individuals perform NDI/NDT inspections and procedures. These "standards" provide recommendations for levels of initial and recurrent training, levels of competence, and vision testing. The memorandum further describes the generic elements of the different standards and states minimal requirements organizations developing NDI/NDT qualification procedures should meet. In terms of vision testing, the memorandum is summarized below:

1. **Vision Examinations**: NDT personnel should receive documented vision and color blindness testing at reasonable intervals (one to two years, shorter preferred). Vision examinations shall be administered by personnel in accordance with the standard to determine qualification.
   (a) <u>Near Distance Vision Requirements</u>:
      Natural or corrected near distance acuity in at least one eye capable of reading the Jaeger #1 Test Chart or equivalent at a distance of not less than 30 cm.
   (b) <u>Color Vision Requirements</u>:
      Ability to differentiate among colors used in NDT method(s).

These vision guidelines are specifically written for NDI/NDT personnel. No such guidelines exist for visual inspectors. Because of the intimacy between the two inspection classifications (i.e., visual inspection vs. NDI/NDT), however, most maintenance facilities use similar testing requirements for the two types of inspectors. Additionally, this "standard" lacks the specificity that FAA vision requirements provide to ensure uniformity of compliance throughout the industry.

In terms of visual acuity, the FAA guidance memorandum specifies a visual acuity requirement at near (no less than 30 cm [12 inches]) but does not address testing at intermediate or far distances even though casual observation of inspectors show working distances at 16 inches or beyond. The vision guidelines, therefore, do not appear to be based upon a detailed task analysis with documentation of required working distances and visual detail dimensions (Good et al., 2002). This type of vision-related task analysis is required for workers before a job-relevant vision standard can be developed.

In the first portion of this study, data was compiled from observing inspectors (both visual and NDI/NDT) at several maintenance facilities for well over 50 hours of inspecting aircraft. Viewing distances and directions required to conduct fluorescent penetrant, borescope and visual inspections were recorded. This detailed analysis should help determine if the present vision recommendations are appropriate or need modification. Additionally, the information can be used to develop advisory materials to educate inspectors and supervisors on what optical devices and spectacle designs are available to aid in visually detecting aircraft defects.

In the second portion of the study, the intent was to determine the on-the-job visual capabilities of visual and NDI/NDT inspectors. A vision screening was conducted at two representative maintenance facilities on a total of 150 visual and NDI/NDT inspectors. This information can help determine the percentage of inspectors that see clearly at the distances and directions identified in the previous portion of this study. It will show if the present medical surveillance programs at the facilities used in the study are adequately ensuring that inspectors meet the ATA vision recommendations. It is also hoped that visual and medical information obtained can help determine if the present recommendation for the frequency of vision assessment (i.e., not greater than every 2 years) is adequate to ensure a visually competent workforce.

METHODS

The research protocol was approved by the Institutional Review Board of the Ohio State University. The study was divided into two portions: 1) inspector observations to document working distances and viewing directions along with a demographic survey of inspectors, and 2) vision screening of inspector personnel.

Part 1. Observations and Survey

Visual and NDI/NDT inspectors at five aircraft maintenance facilities were observed as they performed inspection duties on several types of commercial aircraft (e.g., B727, B737, B767, A320, DC8, DC9, MD80). Various measures of the visual tasks were recorded, along with the specific auxiliary aids used (i.e., flashlight, magnifier, measuring ruler), during fluorescent penetrant, borescope, and visual inspection procedures. Additionally, visual inspection tasks were divided into two categories depending upon the major intent of the procedures. These categories were termed "buy-back" and "primary" inspection tasks.

Fluorescent Penetrant Inspections. Fluorescent penetrant inspections (FPI) were observed at only one maintenance facility. Inspections were mainly performed on engine parts. These parts were inspected at the "case" shop or the "rotary" shop, depending on whether the part was a rotating or non-rotating engine component. While good practices for FPI lists 7 moderately independent steps (Drury, 1999), only the inspection (visual detection and decision) portion of the procedure was observed and assessed. Within both shops, engine parts would move along while suspended from an overhead conveyor. Workers would divert individual parts from the main conveyor and move it to their workstations in order to complete the fluorescent penetrant inspection procedure.

Borescope Inspections. Borescope inspections (BI) were observed at 2 of the maintenance centers. The inspection procedure involved using a video borescope to inspect internal engine parts (Drury and Watson, 2000). Inspectors viewed a video monitor as they searched for internal engine defects. At one facility, the engines were separated from the aircraft, while at the other, the engines were inspected while still mounted under the wing.

Visual Buy-Back Inspections. Inspections were termed "buy-back" when inspectors checked jobs completed by aviation maintenance technicians (AMTs, i.e., mechanics). These tasks were very specific and generally involved repair or replacement of individual parts or aircraft assemblies. Many involved the inspectors reviewing the AMT's job card for repair descriptions at an inspection station before traveling to the AMT's work bench or aircraft section. A "buy-back" inspection would typically last only 30 to 60 seconds, but could last several minutes when a complicated visual inspection was necessary.

Visual Primary Inspections. Primary inspections were those tasks where workers checked general areas during the initial phases of maintenance to identify specific types of defects identified on work cards. Overall, these inspections could last between several minutes for small jobs to several hours for inspections of large areas.

For FPI, BI, and visual primary inspections, researchers recorded viewing distances and directions at specific points in time while workers performed inspection procedures. Depending upon the type of work and areas under inspection, researchers would record viewing information at 30-second or 1-minute intervals. Therefore, the data represents viewing information similar to that which would be collected if a video recording were sampled at every "n^{th}" frame. For visual buy-back inspections, workers would typically view the indicated parts for 30 seconds to several minutes. Because of this, only a single fixation distance was recorded for these inspections.

For viewing distance, researchers indicated the distance from the inspector's eyes to the visual target using 7 different distance categories (≤ 33, 34 to 40, 41 to 50, 51 to 66, 67 to 100, 101 to 200, and > 200 centimeters). These categories represented equal steps in focusing units (i.e., 0.50 Diopters or inverse meters).

For this report, the 7 fixation distance groups were reduced to 3 by merging data from appropriate groups. The fixation distance data in this report are presented as follows: a) Near – 50 cm or less, b) Intermediate – over 50 cm to 1 meter, and c) Far – over 1 meter.

For viewing direction data, "up" was marked when the object of regard (OR) was above the level of the inspector's eyes, "down" was marked when the OR was between eye level and the inspector's waist, and "full-down" was marked when the OR was below the inspector's waist.

A Chi Square analysis of the distributions of fixation distance and fixation direction was performed across the three types of inspections (visual, fluorescent penetrant, and borescope).

Finally, a voluntary survey was distributed to visual and NDI/NDT inspectors at the various maintenance facilities that solicited demographic and refractive error correction information (e.g., glasses, contact lenses, refractive surgery).

Part 2. Vision Screening

In the second portion of this study, a vision screening was performed at two aircraft maintenance facilities. Facility #1 was a private maintenance facility, while facility #2 was a national airline. Various vision measures were taken on 150 volunteer, visual and NDI/NDT inspectors (59 at facility #1 and 91 at facility #2). After a short visual and medical history that included documentation of age, experience as an inspector, and whether vision care insurance was present, subjects underwent the following visual tests with their current corrections (if appropriate): a) distance visual acuity in each eye (Bailey-Lovie Chart), b) distance binocular low contrast visual acuity (Bailey-Lovie Chart), c) binocular visual acuity at 32 inches, d) binocular visual acuity at 16 inches, e) global and local nearpoint stereoacuity, f) color vision (Ishihara Pseudoisochromatic Plates (PIP) and Farnsworth D-15 for PIP failures), g) nearpoint contrast sensitivity (Pelli-Robson Chart), and h) intraocular pressure (Tonopen). Additionally, the powers of the current spectacles were measured and lens designs were recorded (i.e., normal bifocal or multifocal, occupational, or single vision). Measures of vision were taken by experienced eyecare personnel from The Ohio State University College of Optometry and the Vision Research Team of CAMI from FAA in Oklahoma City, Oklahoma.

RESULTS

Part 1. Observations and Survey.

Data analyzed were from 5 maintenance facilities in the continental United States. Three of these facilities were private, one was a major airline, and one was at a military installation.

Survey. The mean age of inspectors responding to the survey administered at these facilities was 45.1 ± 8.5 years (n = 188). Survey responses are summarized in Table 1 and Figure 1. Of those responding to the survey (approximately 30% of the entire inspection workforce for these facilities), 49.5% reported wearing spectacles for near work activities, 8.0% reported wearing contact lenses at some time on the job, and 6.9% reported to have undergone refractive surgery. Approximately 30% of the respondents wore no refractive correction at either distance or near. For inspectors over 40 years of age using nearpoint correction (see Figure 1), 24.3% reported wearing single vision lenses, 29.5% reported wearing traditional bifocals, 39.7% reported wearing progressive bifocals, 3.8% reported wearing trifocals, and 2.6% reported wearing double bifocals. For those wearing contact lenses, 80% reported to wear soft lenses while none of the respondents reported to wear bifocal or monovision contact lenses.

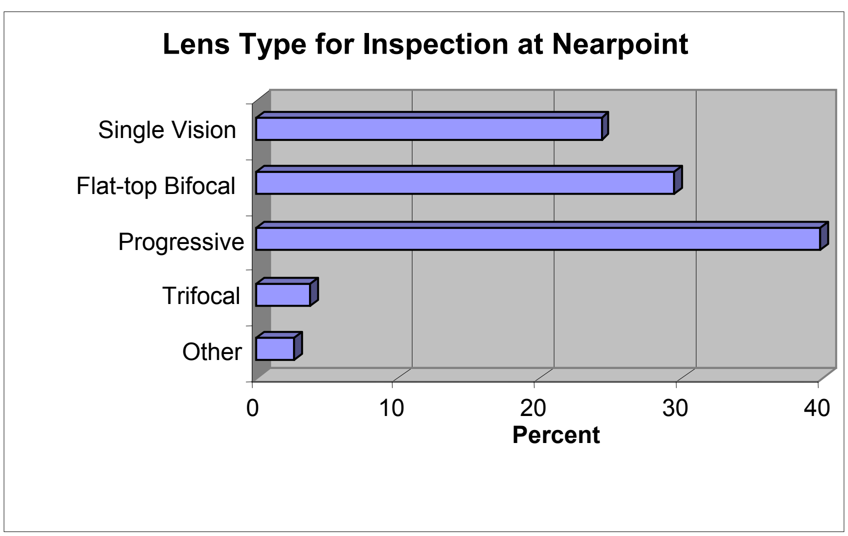
A slight majority of inspectors completing the survey rarely performed any NDI/NDT procedures. Of the respondents, 57.6% reported that less than 10% of their work time is devoted to NDI/NDT procedures. As a group average, however, it was reported that 26.8% of overall inspector time was devoted to NDI/NDT procedures.

Table 1. Survey Results on the Wearing of Refractive Correction.
Inspectors were classified into NDI/NDT or VI only if they reported to perform that procedure for more than 50% of their time at work.

OUTCOME	All n = 188	NDI/NDT n = 46	VI n = 103
Mean Age (yrs)	45.1	44.3	45.6
	[a]t = 0.67, p = 0.50		
Glasses for Near Viewing	49.5 %	**67.4%**	**42.7%**
	[a]Chi-Sq = 7.74, p = 0.005		
CL Wearer	8.0%	10.9%	5.8%
	Chi-Sq =1.18, p = 0.277		
Refractive Surgery	6.9%	4.3%	8.7%
	[a]Chi-Sq = 0.90, p = 0.344		

[a] T-test and Chi-square tests for NDI/NDT and VI comparison.

Figure 1. Percent of different lens types for inspectors reporting to wear spectacles during near viewing activities (n = 99).



Observations. The distribution of fixation distances and directions for visual inspections, fluorescent penetrant inspections, and borescope inspections for over 4,000 recorded fixations are summarized in Table 2.

Fixation Distance. For all inspections, visual detail was often viewed at "normal" reading distances (less than 50 cm). This was particularly true for fluorescent penetrant inspections where working distances at 50 cm or less were observed over 93% of the time. On the other extreme, however, near fixation distances were observed for borescope inspections 33.4% of the time. For these inspections, borescope inspectors primarily viewed a video monitor positioned at an intermediate distance. Visual inspection tasks were most often performed at near viewing distances (72.2%).

Fixation Direction. With borescope and fluorescent penetrant inspections, fixation direction was mainly confined to normal reading locations (down position). For both inspection types, workers had control of the work environment and could move the visual target to a comfortable position. For visual inspections, workers often had to position their bodies relative to a fixed visual target and, therefore, more variable fixation directions were required. This resulted in viewing up nearly 30% of the time with visual inspections and viewing below the waist nearly 16% of the time. When assessing the working distances with upward fixations, the vast majority (75%) were found to involve working distances inside 50 cm.

Chi-square analysis results across inspection types are included in Table 2. The distributions for both fixation distance and fixation direction are shown to be different across the 3 inspection methods. Fluorescent penetrant inspection is heavily weighted at the near fixation distance in the normal down position. Borescope inspections are more evenly distributed across all viewing distances but are heavily weighted in the down viewing position. For visual inspections, a wide distribution is found across both fixation distance and direction.

Table 2. Fixation Distances and Directions (percentages).

DISTANCE	VI	FPI	BI	All
Near	72.2	93.3	33.4	66.3
Intermediate	18.7	6.5	44.7	23.3
Far	9.2	0.2	21.9	10.4
	[a]Chi-Sq = 620.6, p < 0.001			
POSITION				
Up	29.0	14.2	8.1	17.1
Down	55.4	85.8	88.9	76.7
Full Down	15.7	0.0	2.9	6.2
	[a]Chi-Sq = 494.2, p < 0.001			

[a]Chi-square tests for comparison of 3 type inspections.

Part 2. Vision Screening

The overall results of the vision screening are illustrated in Table 3. Additionally, these results are presented and discussed in the appropriate sections below.

Inspector Demographics.

Inspector Age. The mean age of these 150 inspectors is 44.6 years ± 7.9 years. The ages did not differ between examination sites (Two Sample T, t-value = -0.93, p = 0.357). Age of visual and NDI/NDT inspectors were documented in part 1 for the 188 inspectors from the 5 facilities that participated in the observation portion of this study. One of those 5 facilities was Facility #1 for this portion of the study. Therefore, only the ages of inspectors from facility #2 were compared to the previously surveyed population. The ages of these populations also did not differ (Two Sample T, t-value = -0.89, p = 0.375). Therefore, the two populations were combined to give an age value representative of the overall inspector population. The figures for the combined population (n = 274) are:

Mean Age = 44.8 ± 8.4 years, Range 25 to 68 years.

Experience and Classification of Inspection. Study participants were classified as either NDI/NDT Inspectors or Visual Inspectors based upon which activity participants reported spending the majority of their work time. Fifty of the participants reported that NDI/NDT inspections accounted for more than 50% of their workdays (33.8% classified as NDI/NDT inspectors), while 98 reported less than 50% (66.2% classified as visual inspectors). Two participants reported an equal, 50/50 split of work activities. Data from facility #2 was next combined with the previously reported survey data. The number of years of aviation inspection experience for surveyed inspectors did not differ between inspector classification (NDI/NDT versus Visual, t-value = 0.21, p = 0.836) in spite of visual inspectors being slightly older (mean age 45.7 years (visual) to 43.3 years (NDI/NDT), t-value = 2.02, p = 0.045). The inspector experience for the combined populations is:

Mean Years as Inspector = 10.3 ± 7.7 years, Range: < 1 year to 42 years.

Vision Measures.

Visual Acuity. Visual acuity measures were taken with correction (if normally worn by the inspector) in each eye at 16 feet (distance), but only binocularly at the near (16 inches) and intermediate (32 inches) distances. At distance, the mean visual acuity of the better eye was better than 20/16.6; and, only 9 of the 150 inspectors had less than 20/20 with none measuring worse than the 20/50 specified by the ATA specification 105 recommendation. At nearpoint the mean visual acuity was 20/16.8. Eleven individuals scored worse than 20/20, but only 1 failed to meet the 20/25 ATA recommendation (and this was by just a single letter). Although ATA specification 105 does not specify an intermediate visual acuity requirement, visual acuity at 32 inches was also found to be outstanding (mean acuity = 20/13.4). Only 5 individuals failed to demonstrate 20/20 or better at the intermediate distance.

Contrast Sensitivity. Pelli-Robson contrast sensitivity measures were excellent for these inspectors. Only a single inspector had contrast sensitivity below 1.80. The mean contrast sensitivity was 1.93 (contrast threshold = 1.17%). Low contrast visual acuity (LCVA) is a test which incorporates elements of both contrast sensitivity and visual acuity. It is often claimed to be a better indicator than high contrast visual acuity of "real-world" performance. Of the 150 inspectors, 145 had LCVA measured at distance of 20/32 or better. Median LCVA was near 20/20.

Stereoacuity. Nearpoint stereoacuity was measured using the Randot Stereo Test. Measures of both local and global stereopsis were made. For local stereopsis a median value of 20" of arc was found. This is the limiting value for the test. Only 2 of the 150 inspectors had less than 70" of arc on this test. For global stereopsis only 1 inspector was unable to identify any target and only 4 additional inspectors measured less than the best possible.

Color Vision. Five of the 150 inspectors (3.3%) were found to have abnormal color vision by failing the Ishihara PIP test. Of these five, three showed a moderate to severe color vision defect by failing the Farnsworth D-15 test.

Intraocular Pressure. Intraocular pressure (IOP) was measured using the Tonopen tonometer. Mean intraocular pressure as 13.7 mm Hg. Only one inspector was found with IOP measures above 21 mm Hg.

Refractive Correction. For the 150 inspectors, eighty-nine wore some type of spectacles. Sixty-six required a special correction for near activities. Of these, 25 were single-vision near glasses, 32 were no-line, progressive bifocals, and only 9 were traditional straight-top, line bifocals. None of these workers wore special design, occupational multifocals with a near focusing segment across the top of the lenses.

Table 3. **Vision Screening Results (n = 150).**

	Mean ± SD
Inspector Age	
Facility #1	45.3 ± 7.2 years
Facility #2	44.1 ± 8.3 years
Overall	44.6 ± 7.9 years
Visual Acuity (with correction)	
(Log MAR, 20/20 = 0.0)	
16 ft. (better eye)	-0.08 ± 0.08 (20/16.6)
32 in (binocular)	-0.17 ± 0.09 (20/13.4)
16 in (binocular)	-0.08 ± 0.05 (20/16.8)
Contrast Sensitivity	
Low Contrast VA (16 ft)	
LogMAR	0.03 ± 0.09 (20/23.2)
Pelli-Robson (1 m)	1.93 ± 0.05
Stereopsis (seconds of arc)	
Global	255.0 ± 45.5
Local	33.2 ± 35.1
Intraocular Pressure	
Tonopen	13.7 ± 3.3 mm Hg
Color Vision	**(% Failed)**
Ishihara PIP	3.3%
Farnsworth D-15	2.0%

DISCUSSION

The establishment of a vision standard shares many similarities with the determination of a cut-off score for any ability test. The essential job functions must be identified as well as the consequences of non-performance. While the frequency of task performance is an important element in setting a standard, task frequency cannot always be equated with task importance. When the consequences of an error are dire (missed crack in a critical component, for example), even a rarely performed task can drive a vision standard. The majority of inspection work performed by all inspectors in this study was performed at viewing distances of less than 50 cm (i.e., 66.3%). Thus, the essence of this work is the identification of defects at near working distances. Coupled with the extreme potential consequences of missing a defect, the frequency data greatly supports the need for a nearpoint visual acuity standard for visual inspectors who are currently not required to meet acuity requirements at any distance.

The data supporting the need for an intermediate visual acuity standard is also strong, especially for visual and borescope inspections. Visual inspectors must observe aircraft components that are difficult to reach and to visualize. These inspectors often cannot physically position themselves to obtain "normal" viewing distances and directions. Intermediate distance viewing is often required. For borescope inspections, workers do have greater control for the inspection. Inspectors can position television monitors for viewing at convenient locations, even though the parts inspected can be relatively inaccessible to the inspector. Borescope inspectors, however, often chose intermediate viewing distances for viewing the monitor to allow for full body movements to more easily hold and position the borescope probe.

The differences in the distributions of working distances and directions across the different types of inspections are due both to the nature of the inspection task and to the control (or lack of control) the inspector has on the part being inspected. With FPI, the majority of the work is done at near working distances in a normal reading position (down). This was the case for fluorescent penetrant because most inspections are done on individual parts taken off aircraft, allowing greater control of part positioning.

Visual inspectors have the least viewing flexibility as the object of regard is often firmly fixed to the aircraft and inspectors must change body and head position, often in cramped quarters, to gain an acceptable viewing posture. Nearly 20% of visual inspections are done at an intermediate viewing distance (between 50 cm and 1 meter). Visual inspectors often inspect large areas of an aircraft for cracks and other defects from intermediate distances. Because a longer working distance translates into smaller visual angles for visual detail subtended to the eye, it could be argued that it is more important for inspectors to be capable of clear focusing at intermediate distances than it is for near working distances. For borescope inspections, nearly one-half (44.7%) of the viewing distances were observed to be between 50 cm and 1 meter. It is clear that a large portion of aircraft inspection must be done with a fixation distance of greater than 50 cm.

Because of our normal physiologic accommodative ability, if a worker under 40 years of age can pass a vision standard at a given distance using normal, single vision glasses, he/she should be able to pass the same standard at all working distances. For workers older than 50 years, however, specially designed lenses may be required to allow sharp vision at the nearer working distances.

Bifocal lenses can provide appropriate focus for a given working distance, for example, at 16 inches with a +2.5 Diopters (D) reading addition. For a normally-sighted presbyope, with vision correctable to 20/20, these bifocal spectacles would allow for passage of the present Air Transport Association Specification 105 standard. Should the inspector be required to view at a distance of 32 inches, however, the search area would be 1.25 D out of focus in both the distance and near portions of bifocal spectacles. The inspector would now be inspecting the aircraft with reduced visual acuity, estimated to be 20/50 to 20/60. The FAA manages this situation for pilots 50 years of age and over by requiring that pilots demonstrate required visual acuity at both 16 and 32 inches (Nakagawara and Wood, 1998). This age-related requirement is based upon the need for pilots to see cockpit instruments at intermediate distances and the normal physiological changes that limit a person's ability to focus at near and intermediate distances after 50 years of age.

The visual functioning of the 150 inspectors examined in this study was excellent. Only 9 inspectors had less than 20/20 visual acuity at distance with the better eye, and none failed to meet the ATA specification 105 visual acuity recommendation for distance vision of 20/50. At nearpoint, only 11 inspectors had less than 20/20 visual acuity and only 1 did not meet the 20/25 requirement (and this was by just a single letter). Additionally, although ATA Specification 105 has no intermediate distance visual acuity recommendation, inspectors performed excellently at this distance. An intermediate distance mean visual acuity of better than 20/15 was demonstrated. This was at least partially due to the finding that a high percentage of inspectors requiring bifocals use progressive additions which provide for clear focus at far, intermediate, and near viewing distances. Also, it should be noted that at both of these facilities, yearly vision screening were required at Facility 1 (59 inspectors) while biennial vision screening were required at Facility 2 (91 inspectors). The FAA (PAD 2001) requires that the inter-test interval for vision be no greater than 2 years. As the mean age of surveyed inspectors is 44.8 years, it is apparent that vision is changing quickly for a large percentage of the inspection workforce. As sharp vision is indicated for inspectors both by the importance and the nature of aviation inspection tasks, it is recommended that yearly vision screenings become the industry standard.

With a mean age of 44.8 years, a large proportion of inspectors have certainly lost significant natural accommodative power. Eyewear must be designed with viewing distances and directions in mind. Although the majority of fixation directions for aircraft inspection correspond to the normal bifocal position (slightly down), there is considerable inspection activity with upward fixation (29%) and at intermediate to long viewing distances (27.9%). Inspectors should thoroughly discuss the variations in object distance and direction required of their jobs with their eye care practitioners. In order to ensure clear and comfortable vision at all working distances, special eyewear designs may be required. Inspectors older than 50 years may require trifocals or progressive addition bifocals (i.e., no-line) to allow clear vision at all required viewing distances. As viewing directions vary for near and intermediate viewing, it may be beneficial to use clip-on near lenses to accommodate some working distances and/or awkward directions. A set of clip-on lenses of different powers can be obtained to ensure that clear focusing is obtainable at all fixation distances and directions.

The data presented supports vision requirements for visual inspectors as well as the addition of an intermediate visual acuity requirement to the present distance and near vision standard for all inspectors over 50 years of age. As inspectors age, more frequent vision screenings would help ensure that refractive correction is adequate to accommodate the three working distances. While it is impossible to design eyewear that will accommodate all fixation directions and viewing directions, occupational lenses can be special ordered that may benefit workers who must frequently perform specific visual tasks. Therefore, a worker education program should be included within the overall vision program. Such a program will help inspectors understand the limitations of multifocal lenses for aviation inspection tasks and learn what lens devices are available to better accomplish their visual tasks in a safe and efficient manner.

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