- **Weld Crown:** The height has to be measured.
  The simplest tool to use is the palmgren, a weld displacement gage, shown in Figure 6(a). However, this tool also has been designed for specific standards, and the scale tells us about some maximum value. The cambridge, or bridge cam, gage, shown in Figure 6(b), is an alternative device, as is the VWAC (visual weld acceptance criteria) gage (Figure 7).
- **Undercut:** The depth has to be measured.

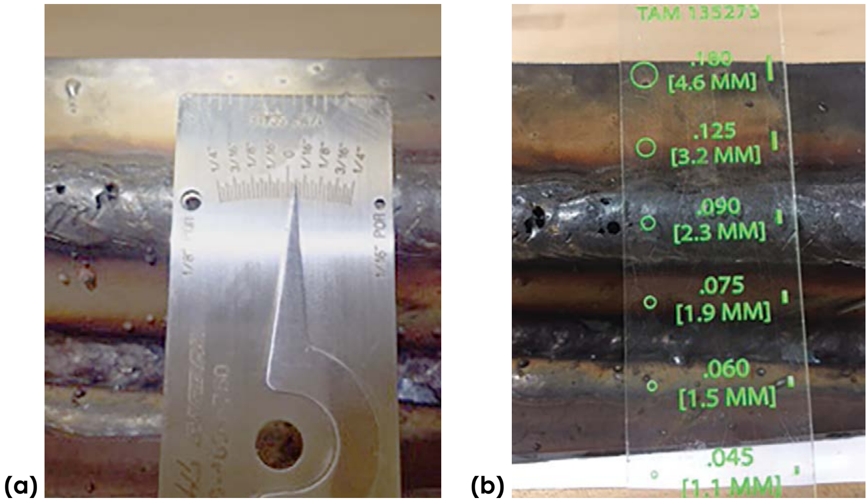


Figure 5: Tools for measuring pore diameter: (a) gage with boreholes; (b) transparency with stepwise circles.

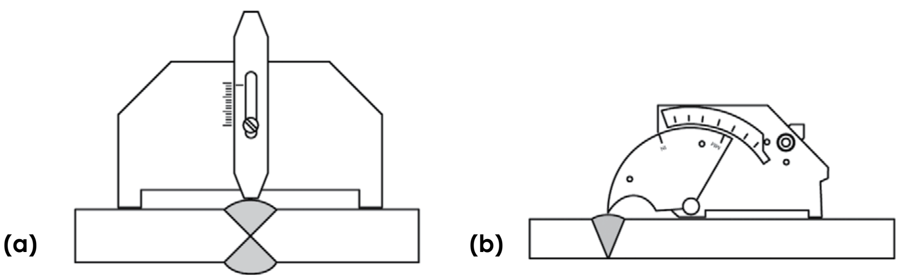


Figure 6: Tools for measuring crown height: (a) palmgren gage; (b) cambridge gage.

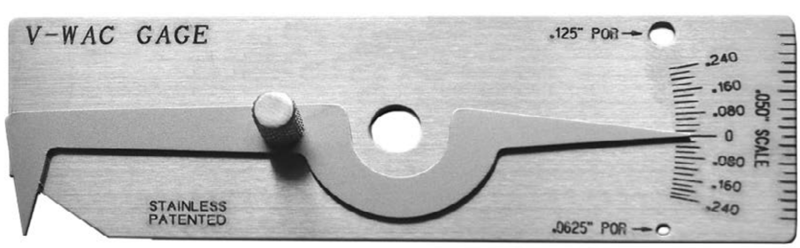


Figure 7: VWAC gage.

Again, the VWAC and cambridge gages are useful as they both have a scale for positive and negative readings. Put the acute tip into the undercut, find the deepest location, and read the depth. Both gages require some space for taking measurements. Thus, specialized tools have been developed to determine the acceptability of undercut that require less space.

Step 3: Compare

For all three discontinuities, the following applies:

- When the measured value $<$ maximum value, the discontinuity is acceptable.
- When the measured value $>$ maximum value, the discontinuity is not acceptable.

Reporting

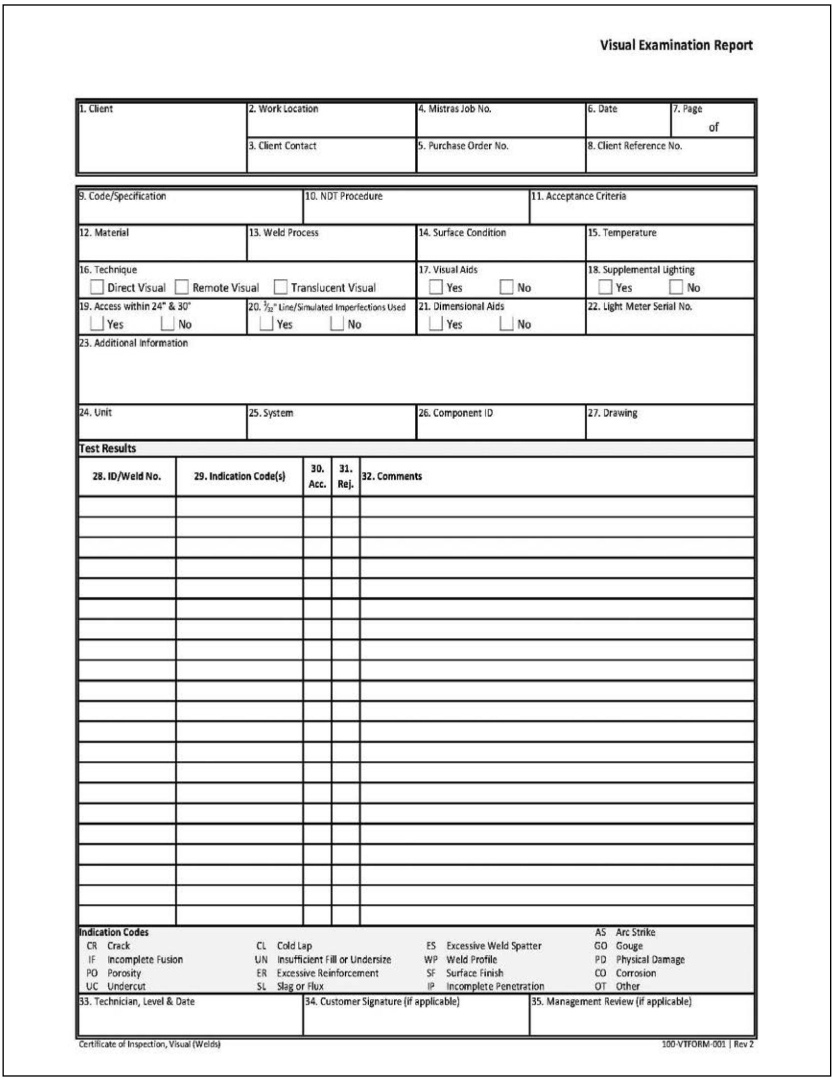
All VT evaluations must be repeatable and traceable to a standard (Figure 8). It is not only that the repair team has to find the unacceptable indication the inspector reported. The inspector's decisions might cost a lot of money and will be questioned. Following a set procedure, other technicians should be able to find the same anomalies and come to the same conclusions. Decisions must be reasonable and justifiable. Therefore, a test report should contain the following information:

- identification of the test object
- test equipment used
- parameters of the test
- discontinuities found
- final results
- date, location, certification, and status

Reports mostly have to be written on forms. Report forms look very different depending on the industry and the specific task. Information needed for the direct visual testing (DVT) report of a weld would include

- name of the component manufacturer;
- name of the testing body, if different from the above;
- identity of the object tested;
- material;
- type of joint;
- material thickness;
- welding process;
- acceptance criteria;
- discontinuities exceeding the acceptance criteria and their locations;
- the extent of testing with reference to drawings as appropriate;
- test devices used;
- result of testing with reference to acceptance criteria; and
- name of tester and date of test.

VT report forms mostly consist of tables on paper or on a computer screen that are filled in along with the option of a sketch. Other reporting methods may be in the form of photography or digital recording. A digital recording is preferred for reporting the results of remote testing. The main advantage is the possibility that another individual or a third party



Visual Examination Report

1. Client	2. Work Location	4. Mistras Job No.	6. Date	7. Page of
	3. Client Contact	5. Purchase Order No.	8. Client Reference No.	

9. Code/Specification	10. NDT Procedure	11. Acceptance Criteria

12. Material	13. Weld Process	14. Surface Condition	15. Temperature
16. Technique ☐ Direct Visual ☐ Remote Visual ☐ Translucent Visual		17. Visual Aids ☐ Yes ☐ No	18. Supplemental Lighting ☐ Yes ☐ No
19. Access within 24" & 30° ☐ Yes ☐ No	20. $\frac{1}{32}$" Line/Simulated Imperfections Used ☐ Yes ☐ No	21. Dimensional Aids ☐ Yes ☐ No	22. Light Meter Serial No.
23. Additional Information			
24. Unit	25. System	26. Component ID	27. Drawing

Test Results

28. ID/Weld No.	29. Indication Code(s)	30. Acc.	31. Rej.	32. Comments

Indication Codes

			AS Arc Strike
CR Crack	CL Cold Lap	ES Excessive Weld Spatter	GO Gouge
IF Incomplete Fusion	UN Insufficient Fill or Undersize	WP Weld Profile	PD Physical Damage
PO Porosity	ER Excessive Reinforcement	SF Surface Finish	CO Corrosion
UC Undercut	SL Slag or Flux	IP Incomplete Penetration	OT Other

33. Technician, Level & Date	34. Customer Signature (if applicable)	35. Management Review (if applicable)

Certificate of Inspection, Visual (Welds) 100-VTFORM-001 | Rev 2

Figure 8: VT report traceable to a standard.

can follow the test step by step and verify the decisions. Direct VT often comes with a sketch attached to the report. Such a sketch should be as simple or basic as possible, nevertheless show unmistakably the locations of the indications. The table must be completed fully with all measures taken with regard to the anomalies. It must also show all the accept-reject decisions. Finally, the inspector must sign the report. Welds that have been tested and approved should be suitably marked or identified.

LEVEL II

8

Elements of Vision

Anatomy of the Eye and Mechanics of Vision

The human eye can be roughly described as an optical instrument or a camera. The light passes through the cornea and the crystalline eye lens where the paths of the rays are changed by focusing and refraction. The eye lens is flexible and can be shaped by the eye muscle (through a process referred to as *accommodation*) to focus light rays at the macula after passing through the vitreous humor of the eye, a gel. The macula is like a small cave and represents the active part of the retina, a thin kind of skin at the backside of the eye that contains the neural receptor elements. If the eye were a film, camera, the retina would represent the film. Other than the film, however, the neural elements are concentrated in the macula. These elements convert light intensity into neuro-electrical signals of different strengths and shapes. The signals are directed through neural pathways to the human brain, which composes an image from the received signals. (See Figure 1.)

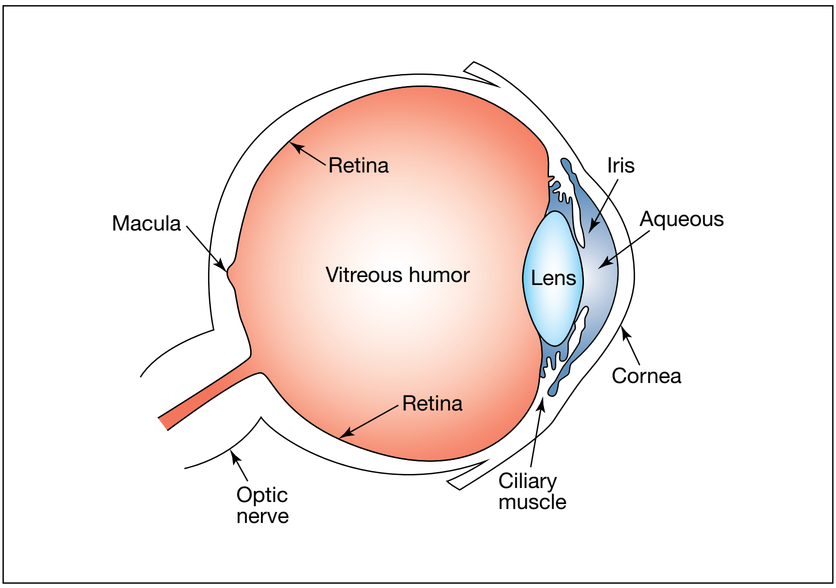


Figure 1: Cross section of the human eye.

For clear vision, it is essential that the light rays meet exactly at the macula/retina (Figure 2). If the maximum refractive power of the eye is such that they can only be focused in front of the retina, it is called *nearsightedness*. If the light rays meet behind it, this is termed *farsightedness*. Additional lenses of suitable refractive power in front of the eye—eyeglasses or contact lenses—may correct for near- and farsightedness. The refractive power of the eye is measured in *diopters*, which is the reciprocal of the eye's focal length in meters.

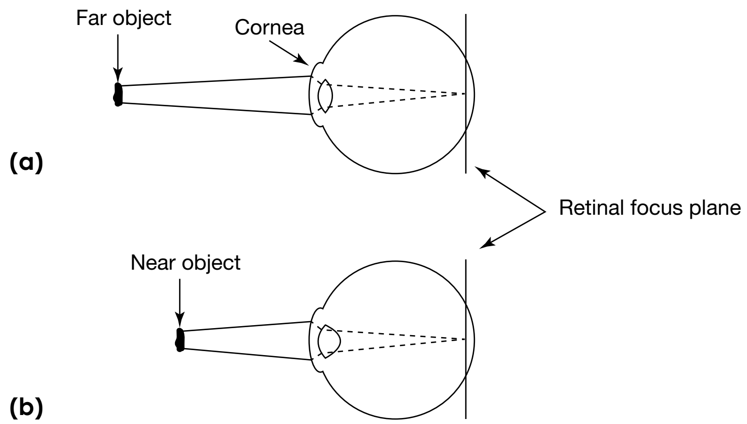


Figure 2: Focusing (refracting) light rays by the eye: (a) relaxed crystalline lens; (b) accommodated crystalline lens.

Adaptation and Accommodation

The retina contains two types of neural cells, *rods* and *cones*. Rods are for viewing under low levels of illumination (dark viewing) and cones are for viewing under high levels of illumination, especially for color vision. The eye must adapt to the different illumination levels in order to get one of the neural cell types to function, which requires some time for adaptation (typically, 1 to 5 min). Adaptation should not be confused with accommodation, the shaping of the eye lens for clear vision at a certain distance.

Vision Limitations, Perception, Orientation, and Disorders

When the brain receives signals from the rods and cones, it collects and processes these signals to form an image. In the first step, *pre-attentive processing*, the brain screens the entire field of vision. As a second step, it segregates localized patterns (lines, spots, edges, shadows, and colors) from the general field and tries to identify them. Identification is mostly accomplished by comparison of the actual impressions with memorized visual impressions. This pattern recognition is a fast process; however, false interpretations of new, unknown patterns or confusion with similar kinds of patterns may occur. Therefore, this process may take several seconds, especially in the case of new, unknown patterns. The detection of boundaries and edges is illustrated by Figure 3, which shows three characters:

1. inverted Ls
2. Ts parallel to the Ls
3. tilted Ts

The first boundary between the inverted Ls and the Ts is harder to discern than the second boundary between the upright Ts and the tilted Ts. The reason for this difference in visibility is the parallelism of the lines that form the Ls and the Ts in patterns 1 and 2. Parallelism is a similarity that causes the brain to assume the patterns are equal, at least as a first attempt.

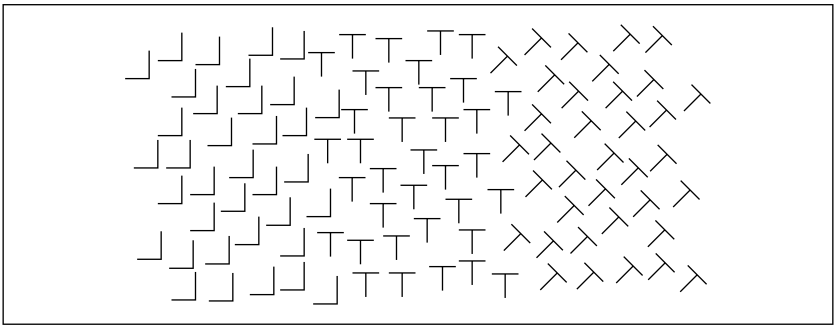


Figure 3: Pattern changes and boundary detection.

Visual Angle

An observer sees an object at a certain distance within a visual angle. The light rays emitted from the outlines of the object in the viewing distance define this visual angle. Suppose the object is the letter "F" of a given size, which the observer sees from a distance of 20 ft (6 m). When this letter "F" is moved one-third of the distance to 6.56 ft (2 m), the visual angle becomes 3× larger and the object covers a larger area of the field of view. A letter "F" one-third the size would be viewed within the same angle as the large letter "F" at 3× the distance. (See Figure 4.)

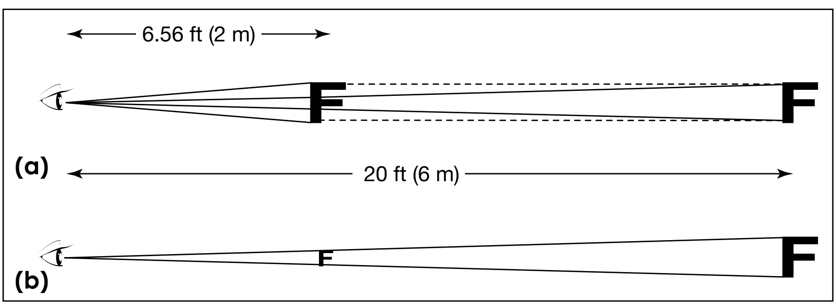


Figure 4: Vision acuity letter and distance: (a) letter of a given size moved to one third of the original test distance; (b) small, near object and large, distant object subtending, or spanning, the same angle of vision.

Vision Acuity Examination, Characters, and Tables

Vision acuity is the ability of the eye to resolve a fine detail or character such as a letter. In a vision examination, such characters need to be presented in black/white contrast.

The smallest letter that can be correctly identified is indicative of vision acuity. A character subtending, or spanning, an angle of 5 min (1/12 degree) normally defines the desired minimum vision acuity.

Visual testing personnel must have adequate far and near vision acuity, each of which has to be tested separately. NDT personnel certification documents typically require a minimum of 20/20 snellen acuity and/or the ability to read text composed of letters of defined sizes J1or J2 (J stands for jaeger). These requirements refer to specific test procedures and test charts.

Snellen Acuity Measure

The snellen acuity measure refers to a standard distance of 20 ft (6 m) and compares the actual vision with this standard. The smallest character recognized by the candidate is expressed in distance. For instance, when the smallest character recognized is 2× the size of the standard for 20/20 vision, the vision acuity of that candidate would be designated 20/40. An example for a snellen far vision chart is shown in Figure 5. Smaller letters are provided for snellen near vision tests normally done at a distance of 16 in. (40 cm).

Landoldt Rings

Landoldt rings (Figure 6) are required in international standards and used in a similar manner as snellen characters. The candidate has to discern the location of the opening in the rings as they get progressively smaller.

Jaeger Test

The jaeger test (Figure 7) is a vision performance test rather than a measurement of vision acuity. The jaeger chart shows text in full sentences of different letter sizes designated by J1 – J10. As the letter sizes on the charts available on the market may vary, it is essential that the candidates read the text from that distance indicated on the chart actually used. However, *SNT-TC-1A* restricts the reading distance to a minimum of 12 in. (30.5 cm).

Shades of Gray and Color Differentiation

Some personnel certification standards emphasize the need to differentiate between shades of gray. However, for the most part, no specific test chart or minimum contrast difference is mandated. Typical charts in use contain equally sized letters displayed in declining shades of gray or a step wedge of shades of gray viewed from distances of 3 ft (1 m).

Color is an important factor that affects visual contrast and even enhances or obscures other types of contrast. Color discrimination ability is therefore essential for a visual inspector. Color vision deficiencies may be inherited or acquired. For genetic reasons, men

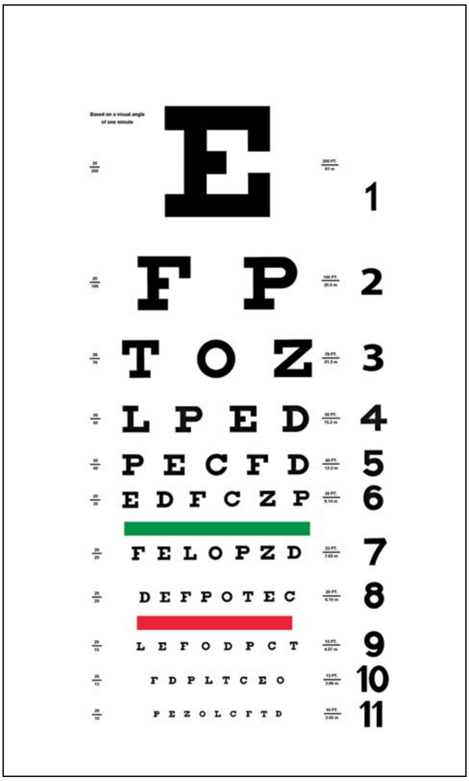


Figure 5: Snellen chart for far vision.

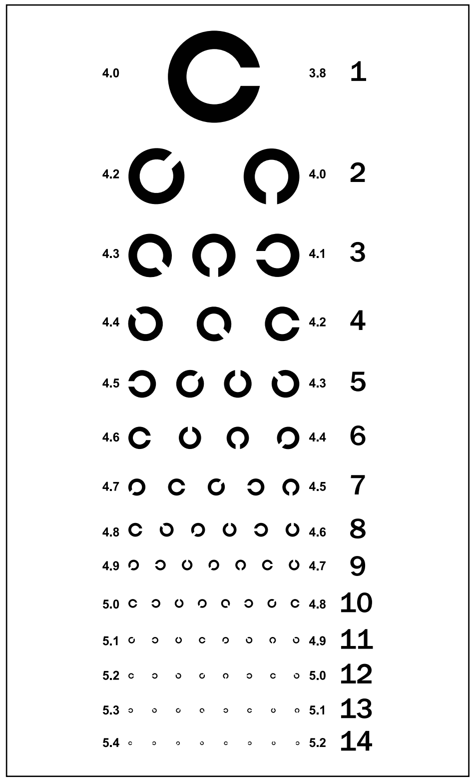
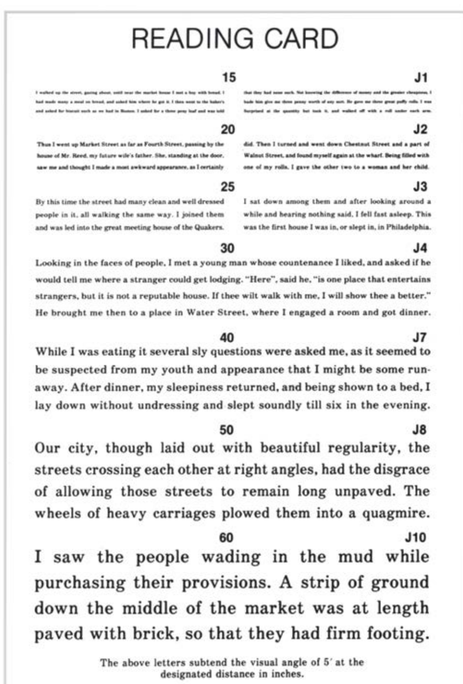


Figure 6: Landoldt rings.


READING CARD

15 J1

20 J2

Thus I went up Market Street as far as Fourth Street, passing by the house of Mr. Read, my future wife's father. She, standing at the door, saw me and thought I made a most awkward appearance, as I certainly did. Then I turned and went down Chestnut Street and a part of Walnut Street, and found myself again at the wharf. Being filled with one of my rolls, I gave the other two to a woman and her child.

25 J3

By this time the street had many clean and well dressed people in it, all walking the same way. I joined them and was led into the great meeting house of the Quakers. I sat down among them and after looking around a while and hearing nothing said, I fell fast asleep. This was the first house I was in, or slept in, in Philadelphia.

30 J4

Looking in the faces of people, I met a young man whose countenance I liked, and asked if he would tell me where a stranger could get lodging. "Here", said he, "is one place that entertains strangers, but it is not a reputable house. If thee wilt walk with me, I will show thee a better." He brought me then to a place in Water Street, where I engaged a room and got dinner.

40 J7

While I was eating it several sly questions were asked me, as it seemed to be suspected from my youth and appearance that I might be some run-away. After dinner, my sleepiness returned, and being shown to a bed, I lay down without undressing and slept soundly till six in the evening.

50 J8

Our city, though laid out with beautiful regularity, the streets crossing each other at right angles, had the disgrace of allowing those streets to remain long unpaved. The wheels of heavy carriages plowed them into a quagmire.

60 J10

I saw the people wading in the mud while purchasing their provisions. A strip of ground down the middle of the market was at length paved with brick, so that they had firm footing.

The above letters subtend the visual angle of 5′ at the designated distance in inches.

Figure 7: Jaeger chart (not to size).

rather than women inherit deficiencies such as red/green defectiveness, which is essentially a shift or lack of sensitivity for certain wavelengths. Acquired deficiencies change with time or age, and typically progress in severity. For instance, the eye lens yellows as it ages, increasing the absorption in the blue region of the light spectrum. For this reason, color differentiation ability must be tested regularly. Charts include recognition of numbers composed of colored dots (ishihara, DMV), as shown in Figure 8.

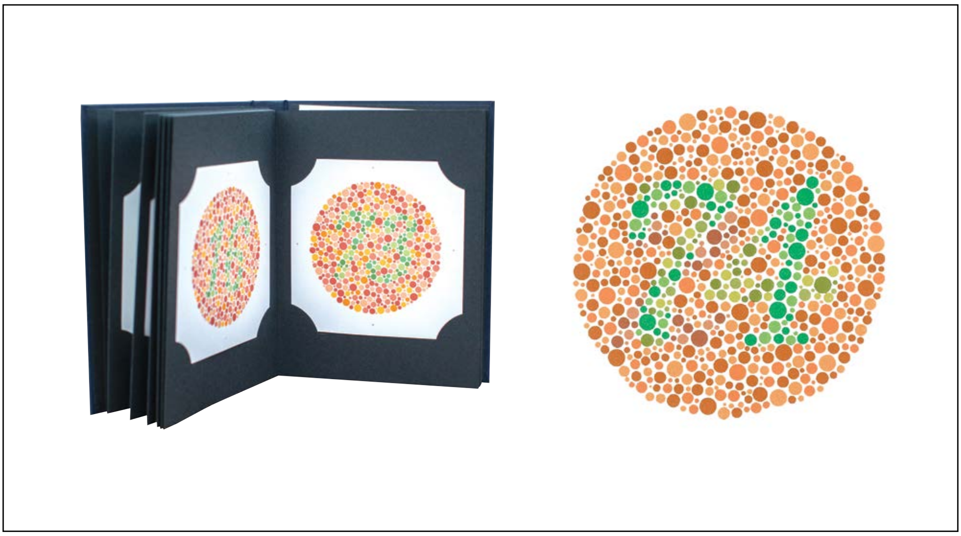


Figure 8: Color discrimination tests.