Clarify the Customer's Requirements

- Snellen Acuity Chart
  - 20/15 VA

- Convert to Angular Measure
  - 45 cycles/degree

- Convert to Linear Measure
  - 150 line pairs/millimeter
    (for 20.0 D IOL)

- Convert to Resolution Efficiency
  - 48% RE

- Convert to Group Element #
  - USAF target 4 - 1

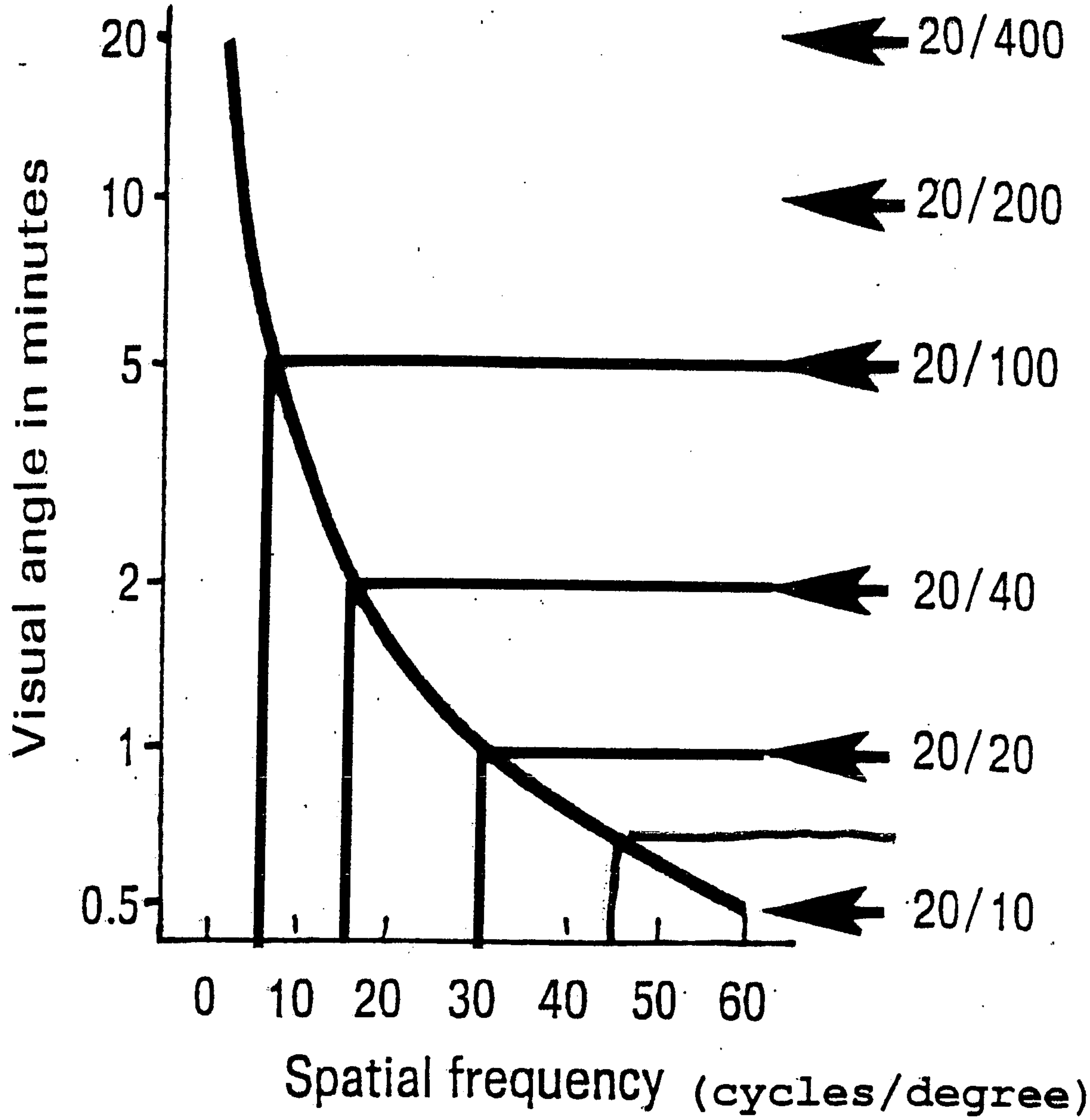
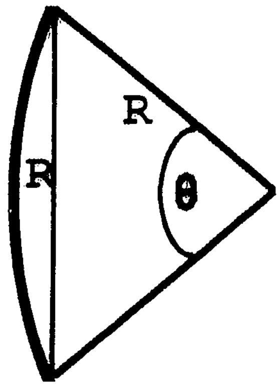


Figure 2. Relationship between Snellen Acuity (or visual angle) and spatial frequency.

Radius R
can be equal to
the effective focal
length of the eye,
about 17 mm.



θ = 1 radian = 57.3 degrees

1 cycle/degree = 57.3 cycles/radian.

1 cycle/mm = R cycles/radian

R mm/radian = 1 (cycle/cycles)

R mm/57.3 degrees = conversion factor

for R = 17 mm

$$\frac{17\text{ mm}}{57.3\text{ degrees}} = 0.3\text{ mm/degree}$$

which is the conversion factor between
cycles/mm and cycles/degree
for the Gullstrand Eye model.

Examples:

17 cycles/mm x 0.3 mm/degree
= 5.1 cycles/degree = 20/100

33 cycles/mm x 0.3 mm/degree
= 9.9 cycles/degree = 20/70

50 cycles/mm x 0.3 mm/degree
= 15 cycles/degree = 20/40

100 cycles/mm x 0.3 mm/degree
= 30 cycles/degree = 20/20

Figure 3. Conversion of cycles (or line pairs) per millimeter to cycles per degree.

24 D line pairs/mm	20 D line pairs/mm	cycles/degree	Snellen Acuity
10	8.3	2.5	20/400
20	17	5.0	20/200
30	25	7.5	20/100
65	58	17.5	20/40
90	75	22.5	20/30
120	100	30	20/20
180	150	45	20/15
240	200	60	20/10

FIGURE 3. RESOLUTION CONVERTION FACTORS FOR THE EYE MODEL (with water)

PROPOSED STANDARD ***

- GOAL - The lens should not be the limiting factor in the patient's vision.

- TARGET - IOL must give "20/15" Snellen Acuity or better in Water.

- Translation Example - 20.0 D IOL

"20/15" = 150 lp/mm

***48 % RE = 160 lp/mm = 4 - 1

40 % RE = 143 lp/mm = 3 - 6

APPENDIX A

RELATIONSHIP BETWEEN SNELLEN ACUITY AND RESOLUTION EFFICIENCY (RE)

The line width and space between letter features on the Snellen eye chart (for example the letter 'E') on the 20/20 line are about 0.0625 inches. This dimension subtends about one (1) minute of arc at twenty (20) feet, as shown in Figure 1.

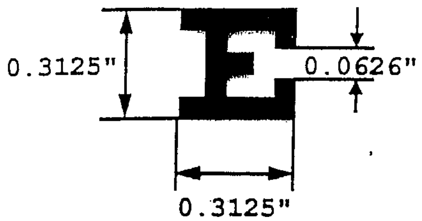
Figure 2 graphs the relation between Snellen Acuity (or visual angle) and spatial frequency.

One cycle (or line pair) is equal to a line width plus an equal size space which is 0.125 inches or two (2) minutes of arc at twenty (20) feet.

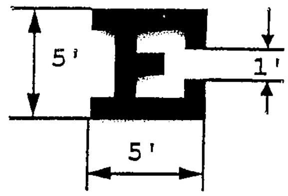
1 cycle / 2 minutes = 0.5 cycles / minute

and since 60 minutes = 1 degree,
0.5 cycles x (60 minutes/degree)/minute
= **30 cycles / degree** = **"20/20"**.

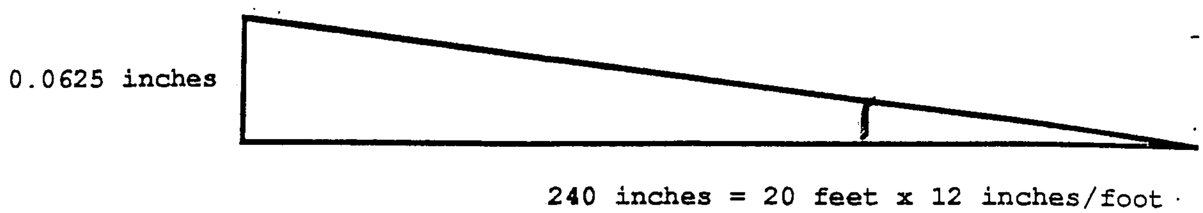
Figure 3 shows how to convert cycles (or line pairs)/mm to cycles/degree for a given focal length eye.



Snellen 'E' on 20/20 line physical dimensions.



Snellen 'E' on 20/20 line angular dimension as measured from 20 feet.



1/sin (0.0625/240) = 0.015 degrees = 0.9 minutes of arc (about 1)

FIGURE 1. CONVERSION OF SNELLEN ACUITY (at 20/20) TO VISUAL ANGLE (minutes of arc)

APPENDIX B

RELATIONSHIP BETWEEN RESOLUTION EFFICIENCY AND USAF TARGET ELEMENTS

$$\%\ RE = \frac{100 \times RP_{measured}}{RP_{theory}}$$

$$RP_{measured} = \frac{\text{Target Spacing} \times FL}{fl} \quad \text{[line pairs/millimeter]}$$

$$RP_{theory} = n\ d\ /\lambda\ fl \quad \text{[line pairs/millimeter]}$$

where:

FL = focal length of the collimator
fl = focal length of the IOL
n = refractive index of the medium (air / water)
d = pupil diameter (3 mm)
λ = 555 nm wavelength of light

Therefore % RE is independent of the optical power (or focal length) of the IOL as shown below.

$$\%\ RE = \frac{100 \times \text{Target Spacing} \times FL}{(n\ d\ /\ \lambda)}$$

Consequentially, since FL, n, d, and λ are all fixed for the BFL bench, % RE varies only with target spacing, for example:

40 % RE = 3 - 6

48 % RE = 4 - 1

60 % RE = 4 - 3

67 % RE = 4 - 4

75 % RE = 4 - 5.