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To: ANSI Z80.1 Working Group on Tolerances
From: Dick Whitney
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Subject: Summary paper on the evolution and reasons for the ANSI Z80.1 Cyl Axis Tolerances

Introduction -

In January 2004, the ANSI Tolerances subcommittee of Z80.1 met to review the present standards tolerances. Their mission was to make recommendations to the full committee as to whether any changes might be recommended for future documents.

An extensive review of past work in this area was undertaken prior to the meeting. There was areement that any change(s) that might be proposed must have no adverse effect to the end user and be justifiable to all.

The task group agreed that one area that was deemed unduly restrictive, and appropriate for closer examination, was that of the cylinder axis tolerance for weak (-.25) cylinder finished mounted lenses.

The purpose of this document is to examine the history behind how the present tolerances were determined, and to include past information that can assist the committee on making an informed decision on this subject. From this study, it becomes apparent that the 7 degree tolerance for this cyl power was not derived from study of visual need, but rather from what could be tolerated in a standard.

History of Cyl Axis Tolerance in the ANSI Z80.1 Standards documents

In order to understand where we are (and where we propose to go), it is important to review the ANSI Tolerances for cylinder axis for the various revisions. The ANSI Z80.1 Standards committee was formed in 1956, and the first Standard that I have in my files is the ANSI Z80.1 - 1964 standard. In that document, the following extremely tight cyl axis tolerances were specified:

ANSI Z80.1 - 1964	
<u>Cyl</u>	<u>Tol</u>
0.12 to 0.37	±3 degrees
0.50 to 1.00	±2 degrees
1.12 and up	±1 degree

This was written at a time when the majority of product was spherical glass, and the mis-perception existed that this was achievable at that time. Future work showed that to be in error,

but this was the starting point for where we now are today.

The next revision of this standard occurred in 1972, which coincided with the FDA Impact Resistance requirement. The ANSI Z80.1 – 1972 Standard retained the 1964 tolerances for unteated glass, but relaxed them for Impact Resistant plastic as follows (second table below):

ANSI Z80.1 – 1964 & 1972 (glass)

<u>Cyl</u>	<u>Tol</u>
0.12 to 0.37	±3 degrees
0.50 to 1.00	±2 degrees
1.12 and up	±1 degree

ANSI Z80.1 – 1972 (Impact Res)

<u>Cyl</u>	<u>Tol (plus / minus)</u>
0.12 to 0.37	±5 degrees
0.50 to 1.00	±3 degrees
1.12 and up	±2 degree

The documents for and against changes from the 1972 to 1979 Standard are most instructive to review when examining where we are today. The 1972 document was still very tight and included many other restrictive requirements. Among these were tolerances for off axis performance errors, which required specific base curves / designs be used.

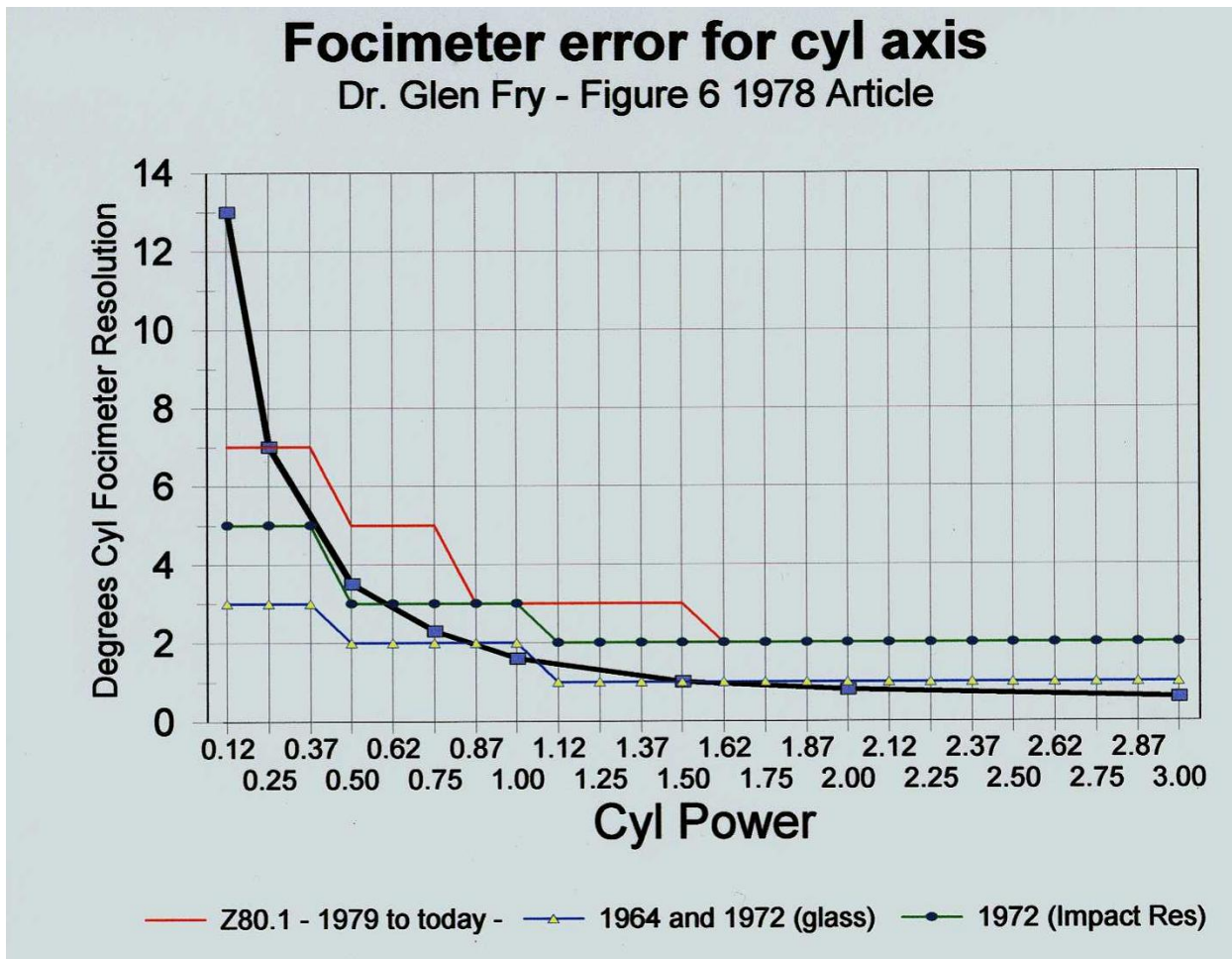
Dr. Glen Fry published a paper (1977) in Optometric Weekly titled “**Tolerances for Cylinder Axis**”. This is the first source where I have found the tolerances that what would become the 1979 (and present cyl axis requirements):

ANSI Z80.1 – 1979 - Present

<u>Cyl</u>	<u>Tol</u>
0.12 to 0.37	±7 degrees
0.50 to 0.75	±5 degrees
0.87 to 1.50	±3 degrees
1.62 and up	±2 degrees

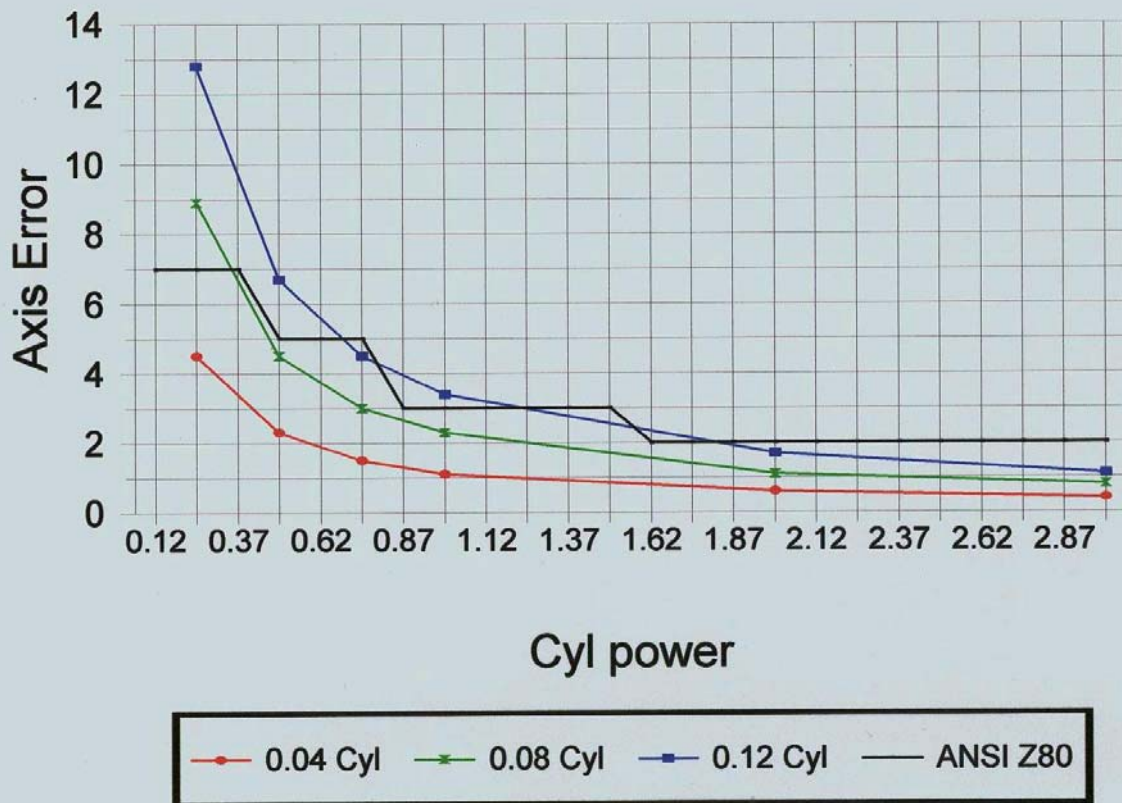
This paper is instructive and has been provided to the committee. Using Dr. Fry’s Figure 6 in this document, the fundamental problem we still face today can best be understood. The solid black line is Dr. Fry’s illustration of the ability of a focimeter to accurately resolve the cyl axis angle as a function of cyl power. His notes indicate that this was derived based upon the assumption that the device can just resolve a sphere error of 0.03. This value is possible for a skilled operator, but is far less than what the typical operator can discern.

Using this curve from Dr. Fry's paper, the three levels of cyl axis tolerances are also plotted on the same scale. The initial 1964 tolerance scheme is shown by the lower blue line. As can be seen, it was extremely tight even or higher cyls, and for those values matched the Focimeter resolution curve. The green line showed the first relaxation for Impact Resistant lenses in 1972, while it would seem by looking just at the numbers that all were relaxed equally, we still see that weaker cyl's are a problem. Finally, in 1979 Dr. Fry's proposal was adopted, which made more sense for most of the cyl's but did not treat the 0.25 example adequately. If the cyl is exactly 0.25, then the operator's ability to measure cyl axis equals the tolerance which is not a good case. But what about the range of allowed cyl's between .13 and .25? In those cases, the resolution is limited to 13 degrees assuming the operator and instrument can resolve 0.03 D sphere power error. Thus, reliable measurement of a 7 degree tolerance is impossible. In addition, the end user cannot discern this error.



Complicating life is the introduction of Progressive lens surfaces since the 1979 standard was adopted. The ISO 10322-2 lens blank standard permits Distance Portion cyl of .09. Don Whitney's data of cross cyl shows that 0.08 front surface cyl angled 45 degrees to the intended RX cyl will throw the axis off by 9 degrees! This effect combined with the measurement uncertainty makes the 7 degree tolerance unachievable and has resulted in costly and unnecessary waste to the industry.

Axis Angle Error / Crossed Cyl @ 45°



Dick Whitney - 02/19/04

ANSI Z80.1 Tolerance Subcommittee Report

CrossCylExamples.wb3

The above plot shows the effect that unintended second surface cylinder of 0.04, .08 and .12 have should they be angled at 45 degrees from the cylinder axis of the Rx Cyl. The black line shows the ANSI Z80.1 Tolerance, and this is where the problem with weak cylinders becomes apparent.

In conclusion, the documentation examined makes it clear that:

- 1.) The Cylinder Axis tolerance of 7 degrees for weak cylinder powers is artificially tight and was not derived from what is required for good vision. This tolerance has a long history and is based upon what the standards writers perceived to be the industry capability and / or what would be deemed acceptable in a committee vote.
- 2.) When axis tolerances were relaxed, first in 1972 and again in 1979, the tolerances for weak cylinder powers were not changed because such changes were too drastic to be agreed upon.
- 3.) The 7 degree present tolerance for -.25 cyl's is at or below the angular resolution of the focimeter as documented by Dr. Glen Fry when the 1979 tolerances were being proposed.
- 4.) The 7 degree tolerance was adopted before Progressive lens surfaces were commonplace. Progressive surfaces may contain Distance Portion cyl of up to 0.09 D in accordance with ISO Standards. This surface tolerance can shift the intended cyl axis by 9 degrees!