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16. Abstract

This study evaluated the relative effects of horizontal and vertical misaim of low-beam headlamps. The approach involved analyzing light-output matrices of 150 production low beams, manufactured for sale in the U.S., Europe, and Japan. The specific analysis involved computing, for 225 locations in the central part of each beam pattern, the ratios of nominal intensity to intensity for horizontal and vertical misaim of up to 1.5°. The resultant intensity ratios were then interpreted in terms of their likely effects on visual performance and discomfort glare. Simultaneous horizontal and vertical misaim were not considered.

The results indicate that horizontal misaim of the U.S., European, and Japanese lamps of up to 1.5° in either direction has no practical significance. Vertical misaim of American and Japanese lamps is of practical significance when misaim reaches 1.5°, and is of likely significance at misaim of 1°. European lamps are more sensitive to vertical misaim, with vertical misaim of 1° of practical significance, and misaim of 0.5° of likely significance. The relative difference in the importance of horizontal and vertical misaim is greatest for European lamps.

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## CONTENTS

# INTRODUCTION

Automobile low-beam headlamps provide, by design, nonuniform illumination. This nonuniformity is partly a consequence of the conflict between visibility and glare inherent in low-beam headlighting. In general, illumination below horizontal is desirable. On the other hand, illumination above horizontal, and especially in the upper left quadrant, is frequently a cause of glare to oncoming traffic. Because of the special concern with illumination in the upper left quadrant, illumination gradients exist both vertically and horizontally. Consequently, a correct alignment of the beam pattern is important. However, to the extent that the horizontal gradients of illumination are generally less steep than the vertical gradients, the correct horizontal alignment should be less critical than the correct vertical alignment.

This study was designed to evaluate the relative importance of horizontal and vertical aim of low-beam headlamps. The approach involved analyzing the intensity matrices of 150 production low beams. The specific analysis involved computing, for 225 locations in the central part of each beam pattern, the ratios of nominal intensity and intensity for several different levels of horizontal and vertical misaim. The resultant intensity ratios were then interpreted in terms of their likely effects on visual performance and discomfort glare. Combinations of both horizontal and vertical misaim were not considered.

A typical European low-beam pattern is different from a typical U.S. pattern (Sivak, Helmers, Owens, and Flannagan, 1992). The primary differences are that the European pattern has (1) a sharper transition (cutoff) between where the light is needed for seeing and where it might impinge on the eyes of oncoming drivers, and (2) less light above horizontal. In Japan, low beams have either the U.S.-type pattern (the so-called SAE-J lamps), or the European-type pattern (the so-called ECE-J lamps). Because of these international differences, we examined lamps that were manufactured for sale in the U.S., Europe, and Japan. Since even within one of these three jurisdictions, the lamps differ in terms of their construction, additional analyses were performed by lamp type.

A recent U.S. survey of headlamp aim in 768 in-service cars, vans, and light trucks (Copenhaver and Jones, 1992) found that the mean vertical aim was about 0.04° up with a standard deviation of 0.65°, and the mean horizontal aim was about 0.20° left with a standard deviation of 0.55°. Consequently, we investigated effects of misaim of up to 1.5° in all four principal directions, covering approximately 98% of all observed aims by Copenhaver and Jones (assuming normal distributions).

## METHOD

### Approach

We evaluated the effects of misaim of 0.5°, 1°, and 1.5° in all four principal directions: down (D), up (U), left (L), and right (R). The evaluation was performed by computing, for each location of interest and for each level of misaim, the ratio between the new intensity and the nominal intensity under perfect aim. For example, to evaluate the effect of a vertical misaim of 1.5°U on the intensity at 1°D, 2°R, we computed the ratio of intensities at 2.5°D, 2°R and 1°D, 2°R.

### Sample

We used the same sample of 150 low-beam headlamps that we used in a recent study on international harmonization of low-beam patterns (Sivak and Flannagan, 1993). The sample consists of 107 lamps photometered by the Japan Automobile Research Institute (courtesy of Mr. Kiyokazu Yokoi), 28 lamps photometered as part of a previous study sponsored by the National Highway Traffic Safety Administration, and 15 lamps photometered for the study by Sivak and Flannagan (1993). The sample includes low beams that were produced by 17 different manufacturers for the U.S., European, and Japanese markets. Table 1 lists the number of lamps by the market for which they were manufactured, and by the source and the year of the respective photometric information. Table 2 provides a breakdown of the lamps by construction.

The photometric information for each lamp consisted of a candela matrix (in half-degree steps) from 5°D to 5°U (all lamps), and from 30°L to 30°R (117 lamps) or 20°L to 20°R (33 lamps). All lamps were measured at 12.8 V. To facilitate comparisons across jurisdictions, the candela matrices of lamps manufactured for left-hand traffic were converted to right-hand traffic. The European lamps were measured using a standard bulb.

### Examined locations

Of interest in this study was the central part of the beam pattern, because this is generally the part that contains the steepest illumination gradients. We examined, in half-degree steps, the area from 3.5°D to 3.5°U, and from 3.5°L to 3.5°R, for a total of 225 locations.

Table 1

Number of lamps by market, and the source and the year of the photometric information.

| Market | Number | Year of the photometry | Source of the photometric data |
|---|---|---|---|
| U.S.A. | 43 | 1990-1993 | II Stanley (33*), GE Lighting (5), Inland Fisher Guide Division of GM (5) |
| Europe | 37 | 1983-1987 | Japan Automobile Research Institute (courtesy of Mr. Kiyokazu Yokoi) |
| Japan | 70** | 1983-1987 | |

*Of the 33 lamps photometered by II Stanley, 28 lamps were photometered in 1990 and 1991 as a part of a research contract between the National Highway Traffic Safety Administration and the University of Michigan, and 5 were photometered in 1993 for the study by Sivak and Flannagan (1993).
**Of the 70 Japanese lamps, 48 were ECE-J lamps and 22 were SAE-J lamps.

Table 2

Breakdown of the lamps by construction.

| Lamp type | Tungsten or halogen | Filament orientation | U.S. lamps | European lamps | Japanese lamps |
|---|---|---|---|---|---|
| 9004 | halogen | transverse | 8 | | |
| 9006 | halogen | axial | 9 | | |
| 9007 | halogen | axial | | | 2 |
| H1 | halogen | axial | | 4 | |
| H4 | halogen | axial | | 33 | 40 |
| H6 | halogen | transverse | | | 4 |
| D4 | tungsten | axial | | | 8 |
| sealed beam | tungsten | transverse | 1 | | 10 |
| sealed beam | halogen | transverse | 20 | | 6 |
| sealed beam | halogen | axial | 5 | | |
| Total | | | 43 | 37 | 70 |

## CLASSIFICATION OF THE EFFECTS OF MISAIM

Effects of changes in illumination on both visual performance and discomfort glare are continuous. Consequently, there is no, a priori, magnitude of a change in illumination that is practically significant. However, there is a general consensus in the vision community that a log-unit difference in illumination (a 10-fold change) is important for both visual performance and glare, with a half-log-unit change (approximately a 3-fold change) being of likely importance. Let us consider two illustrative examples of effects of changes in illumination, one on visual performance and one on discomfort glare.

The first example deals with the effect of a change in illumination on nighttime legibility of retroreflective traffic signs. Legibility of signs is affected by both the contrast between the legend and background, as well as the luminances of these two components (Olson, Sivak, and Egan, 1983). The effect under consideration—overall illumination of the sign—will have no effect on contrast. Consequently, any effects on legibility would be because of changes in the absolute levels of the legend and background luminances. The effect of luminance depends, in turn, on the initial level of luminance, surround luminance, letter size, colors involved, age of the observer, direction of the contrast, and contrast level (Olson et al., 1983; Allen, Dyer, Smith, and Janson, 1967). For example, the data of Allen et al. (1967) indicate that for positive contrast (light legend on dark background), a reduction in the legend luminance from 6.8 cd/m$^2$ to 1.7 cd/m$^2$ (a drop of about 0.6 log units) would reduce correct identification of three-letter words from about 55% to about 35% (a drop of about 36% from the baseline performance) for legend-to-background contrast of near 100%, and from about 45% to 35% (a drop of about 22% from the baseline performance) for contrast of 75%. (However, at high initial luminances, a drop of 0.6 log units would produce smaller or no reductions in legibility.)

The second example deals with the effect of a change in illuminance on discomfort glare. The most widely accepted model of discomfort glare in automotive headlighting is that of Schmidt-Clausen and Bindels (1974), which relates discomfort glare rating on the so-called de Boer scale (de Boer, 1967) to the illuminance at the eyes, the glare angle, and the adaptation luminance. The full equation for the model is:

$$W = 5.0 - 2\log\frac{E_B}{C_{poo}\left[1+\sqrt{\frac{L_U}{C_{pL}}}\right]\theta^{0.46}}$$

where $W$ is a discomfort glare rating on the de Boer scale, $E_B$ is the illumination at the observer's eye point in lx, $C_{poo}$ is a constant equal to 3.0 x $10^{-3}$ lx $min^{-0.46}$, $L_U$ is the luminance to which the observer is adapted in $cd/m^2$, $C_{pL}$ is a constant equal to 4.0 x $10^{-2}$ $cd/m^2$, and $\theta$ is the visual angle in minutes between the glare source and the observer's visual fixation point. (The de Boer scale is a nine-point scale, with qualifiers only for the odd points: 1 [unbearable], 2, 3 [disturbing], 4, 5 [just acceptable], 6, 7 [satisfactory], 8, 9 [just noticeable]. The usual cutoff for tolerable glare in the automobile context has been the value 4 [e.g., Bhise et al., 1977].) Of importance for the present purpose is that a half-log change in illumination would produce, according to the model of Schmidt-Clausen and Bindels, a unit change on the de Boer scale–a change deemed to be of likely importance.

The classification that we used to evaluate the effects of misaim on visual performance and glare is shown in Table 3. Because of the continuous effects of illumination, the precise boundaries of the categories in Table 3 are somewhat arbitrary. Nevertheless, this classification provides a reasonable framework for our analyses.

Table 3
Classification of the effect of misaim.

| Ratio of misaimed to nominal intensities | Log ratio of misaimed to nominal intensities | Coding used in Figures 1 - 19 | Practical significance |
|---|---|---|---|
| 0.0100 – 0.0316 | -2.0 to -1.5 | ---- | Yes |
| 0.0316 – 0.1000 | -1.5 to -1.0 | --- | Yes |
| 0.1000 – 0.3160 | -1.0 to -0.5 | -- | Likely |
| 0.3160 – 1.0000 | -0.5 to 0.0 | - | Unlikely |
| 1.0000 – 3.1600 | 0.0 to 0.5 | + | Unlikely |
| 3.1600 – 10.000 | 0.5 to 1.0 | ++ | Likely |
| 10.000 – 31.600 | 1.0 to 1.5 | +++ | Yes |
| 31.600 – 100.00 | 1.5 to 2.0 | ++++ | Yes |

## RESULTS AND DISCUSSION

### Mean effects by jurisdiction

Figures 1 through 6 summarize the analyses by jurisdiction. These figures list the mean effects, computed by averaging the logarithms of the ratios of intensities. Figures 1 and 2 present the mean effects for the U.S. lamps, for horizontal and vertical misaim, respectively. Figures 3 and 4 present the analogous data for the European lamps, and Figures 5 and 6 present the data for the Japanese lamps. Note that, although we have presented information for both directions of vertical misaim (i.e., down and up) and both directions of horizontal misaim (i.e., left and right), the information for these pairs of directions is redundant, except for the direction of the change. For example, the effect of misaim of 1°L on location 2°L, 2°U (in the left panel of Figure 1) is of the same magnitude as the effect of misaim of 1°R on location 1°L, 2°U (in the right panel of Figure 1). Only the direction of the effect (i.e., the sign of the logarithm of the ratio) is different. Analogously, the left and right panels of Figures 3 through 6 are redundant.

The data in Figures 1 through 6 can be summarized as follows:

**Horizontal misaim.** Horizontal misaim of the U.S., European, or Japanese lamps of up to 1.5° in either direction has no practical significance. With misaim of up to 1.5°, the average ratios of the misaimed to nominal intensities were less than 0.5 log unit for all 225 examined locations in the U.S. and Japanese low beams, and for all but four locations in the European low beams. (The four exceptions exceeded 0.5 log unit only at misaim of 1.5°. They were all near horizontal, and at the center or right side of the beam pattern. However, even for these four exceptions, the ratios were smaller than 1 log unit.)

**Vertical misaim.** Vertical misaim of American and Japanese lamps is of practical significance (i.e., the ratios of misaimed to nominal intensities exceed 1 log unit) when misaim reaches 1.5° in either direction. For European lamps misaim of 1° is already of significance. Similarly, vertical misaim of American and Japanese lamps is of likely significance (i.e., the ratios of misaimed to nominal intensities exceed 0.5 log unit) when misaim reaches 1° in either direction. For European lamps misaim of 0.5° is already of likely significance.

**0.5L**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |
| 3U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 2U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 1.5U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 1U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 0.5U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 0 | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 0.5D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 1D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 1.5D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 2D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |

**1.0L**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 3U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 2U | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 1.5U | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 1U | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 0.5U | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 0 | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 0.5D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 1D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 1.5D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 2D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |

**1.5L**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 3U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 2.5U | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 2U | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 1.5U | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 1U | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 0.5U | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 0 | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 0.5D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 1D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 1.5D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 2D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 2.5D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 3D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |

Figure 1. Effects of horizontal misaim on the U.S. lamps. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

**0.5R**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 0.5D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 1D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |

**1.0R**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 0.5D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 1D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |

**1.5R**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 0.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 1D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |

0.5D

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | + | + | + | + | + | + | + | + |
| 2.5D | - | - | - | - | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

1.0D

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - - | - - | - - | - - | - - | - - | - - | - - |
| 0.5D | - | - | - | - | - | - | - - | - - | - - | - - | - - | - - | - - | - - | - - |
| 1D | - | - | - | - | - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | - | - | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

1.5D

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - - | - - | - - | - - | - | - |
| 0 | - | - | - | - | - | - | - - | - - | - - | - - | - - | - - | - - | - - | - - |
| 0.5D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - - | - - - | - - - | - - - | - - - | - - |
| 1D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - - | - - - | - - - | - - | - - |
| 1.5D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - |
| 2D | - - | - - | - - | - - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | - | - | - | - | + | + | + | + | + | + | + |
| 3D | - | - | - | - | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

Figure 2. Effects of vertical misaim on the U.S. lamps. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

**0.5U**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1.5D | + | + | + | + | + | + | + | - | - | - | - | - | - | - | - |
| 2D | + | + | + | + | - | - | - | - | - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**1.0U**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1U | + | + | + | + | + | + | + | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| 0.5U | + | + | + | + | + | + | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| 0 | + | + | + | + | + | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| 0.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1.5D | + | + | + | + | + | + | - | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**1.5U**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2U | + | + | + | + | + | + | + | + | + | ++ | ++ | ++ | ++ | + | + |
| 1.5U | + | + | + | + | + | + | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| 1U | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | +++ | +++ | +++ | +++ | +++ | ++ |
| 0.5U | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | +++ | +++ | +++ | ++ | ++ |
| 0 | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| 0.5D | ++ | ++ | ++ | ++ | + | + | + | + | + | + | + | + | + | + | + |
| 1D | + | + | + | + | + | + | + | + | - | - | - | - | - | - | - |
| 1.5D | + | + | + | + | - | - | - | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3.5D | - | - | - | - | - - | - - | - | - - | - - | - | - | - | - | - | - |

**0.5L**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | - | + | - | - |
| 3U | + | + | + | + | + | + | + | + | + | + | + | + | + | - | - |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0.5D | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |
| 1D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 1.5D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 2D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |

**1.0L**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 3U | + | + | + | + | + | + | + | + | + | + | + | + | + | - | - |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | - |
| 0.5D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 1D | + | + | + | + | + | + | + | + | + | - | - | - | - | - | - |
| 1.5D | + | + | + | + | + | + | + | + | + | - | - | - | - | - | - |
| 2D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 3D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |

**1.5L**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 3U | + | + | + | + | + | + | + | + | + | + | + | + | + | - | - |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0 | + | + | + | + | + | + | + | + | ++ | ++ | ++ | + | + | + | - |
| 0.5D | + | + | + | + | + | + | + | ++ | + | + | + | - | - | - | - |
| 1D | + | + | + | + | + | + | + | + | + | - | - | - | - | - | - |
| 1.5D | + | + | + | + | + | + | + | + | + | - | - | - | - | - | - |
| 2D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 2.5D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 3D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |

Figure 3. Effects of horizontal misaim on the European lamps. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

**0.5R**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | + | - | + |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 1D | - | - | - | - | - | - | - | - | - | - | - | + | + | + | + |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | + | + | + | + |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |

**1.0R**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 1D | - | - | - | - | - | - | - | - | - | - | - | + | + | + | + |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | + | + | + | + |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |

**1.5R**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - - | - - | - - | - |
| 0.5D | - | - | - | - | - | - | - | - | - | - | - - | - | - | - | + |
| 1D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |

**0.5D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - - | - - | - - | - - |
| 0.5D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - | - |
| 1D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - | - | - | - | - | - |
| 1.5D | - | - | - | - | - | - | - | - | + | + | + | + | + | + | - |
| 2D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

**1.0D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - - |
| 0 | - | - | - | - | - | - | - | - | - | - - | - - | - - | - - - | - - - | - - - |
| 0.5D | - - | - - | - - | - - | - - | - - | - - | - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - |
| 1D | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - | - - | - | - |
| 1.5D | - - | - - | - - | - - | - - | - - | - - | - - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | + | + | + | + | + | + | + | + | + | + |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

**1.5D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - - | - - |
| 0 | - | - | - | - | - | - | - | - | - - | - - | - - | - - | - - - | - - - | - - - |
| 0.5D | - - | - - | - - | - - | - - | - - | - - | - - - | - - - | - - - | - - - | - - - - | - - - - | - - - | - - - |
| 1D | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - - | - - - - | - - - - | - - - - | - - - | - - - | - - - | - - - |
| 1.5D | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - | - - | - | - |
| 2D | - - | - - | - - | - - | - - | - - | - - | - - | - | - | - | - | + | - | - |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

Figure 4. Effects of vertical misaim on the European lamps. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

**0.5U**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0.5U | + | + | + | + | + | + | + | + | + | + | + | ++ | ++ | ++ | ++ |
| 0 | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | + | + |
| 0.5D | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | + | + | + | + | + | + |
| 1D | + | + | + | + | + | + | + | + | - | - | - | - | - | - | + |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**1.0U**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | ++ |
| 1U | + | + | + | + | + | + | + | + | + | ++ | ++ | ++ | +++ | +++ | +++ |
| 0.5U | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ |
| 0 | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ | + | + |
| 0.5D | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | + | + | + | + | + | + | + |
| 1D | + | + | + | + | + | - | - | - | - | - | - | - | - | - | - |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**1.5U**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2U | + | + | + | + | + | + | + | + | + | + | + | + | + | ++ | ++ |
| 1.5U | + | + | + | + | + | + | + | + | ++ | ++ | ++ | ++ | +++ | +++ | +++ |
| 1U | ++ | ++ | ++ | ++ | ++ | ++ | ++ | +++ | +++ | +++ | +++ | ++++ | ++++ | +++ | +++ |
| 0.5U | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++++ | ++++ | ++++ | ++++ | +++ | +++ | +++ | +++ |
| 0 | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ | + | + |
| 0.5D | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | + | + | + | + | - | + | + |
| 1D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**0.5L**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | - | - |
| 3U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | - | + |
| 2U | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |
| 1.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | - | - |
| 1U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | - |
| 0.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | - | - |
| 1D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 1.5D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 2D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |

**1.0L**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | - | - |
| 3U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | - |
| 2U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 1.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | - | - |
| 1U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0.5D | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |
| 1D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 1.5D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 2D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 3D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |

**1.5L**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | - | - |
| 3U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | - | - |
| 2U | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 1.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | - | - |
| 1U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | - |
| 0.5D | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |
| 1D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 1.5D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 2D | + | + | + | + | + | + | + | + | + | + | - | - | - | - | - |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 3D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | - | - | - | - |

Figure 5. Effects of horizontal misaim on the Japanese lamps. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

**0.5R**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| 1D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |

**1.OR**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| 1D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |

**1.5R**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + |

**0.5D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - | - - | - - | - - |
| 0.5D | - | - | - | - | - | - | - | - | - | - - | - - | - - | - | - | - |
| 1D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | + | + | + | + | + | + | + | + |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

**1.0D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - | - | - - | - - | - - | - - | - - |
| 0.5D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - |
| 1D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - |
| 1.5D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

**1.5D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - - |
| 0 | - | - | - | - | - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - |
| 0.5D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - - | - - - | - - - | - - - | - - - |
| 1D | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - |
| 1.5D | - - | - - | - - | - - | - - | - - | - - | - - - | - - - | - - | - - | - - | - - | - - | - - |
| 2D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | - | - | - | - | + | + | + | + | + | + | - |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

Figure 6. Effects of vertical misaim on the Japanese lamps. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

**0.5U**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 0.5U | + | + | + | + | + | + | + | + | + | + | + | + | ++ | ++ | ++ |
| 0 | + | + | + | + | + | + | + | + | + | ++ | ++ | ++ | + | + | + |
| 0.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1.5D | + | + | + | + | + | + | + | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**1.0U**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1U | + | + | + | + | + | + | + | + | + | + | ++ | ++ | ++ | ++ | ++ |
| 0.5U | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| 0 | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | + |
| 0.5D | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | + | + | + | + | + | + |
| 1D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 1.5D | + | + | + | + | - | - | - | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**1.5U**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2.5U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2U | + | + | + | + | + | + | + | + | + | + | + | + | + | + | ++ |
| 1.5U | + | + | + | + | + | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| 1U | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | +++ | +++ | +++ | +++ | +++ |
| 0.5U | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ |
| 0 | ++ | ++ | ++ | ++ | ++ | ++ | ++ | +++ | +++ | ++ | ++ | ++ | ++ | ++ | ++ |
| 0.5D | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | + | + | + | + | + | + |
| 1D | + | + | + | + | + | + | + | + | - | - | - | - | - | - | + |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

## Mean effects by lamp type

**Horizontal misaim.** Consistent with the analyses by jurisdiction, the mean effects of horizontal misaim of up to 1.5° did not exceed 1 log unit change in intensity for any of the locations and any lamp types.

**Vertical misaim.** Figures 7 through 19 summarize the effects of vertical misaim by lamp type, presented for each jurisdiction. These figures include the results for misaim down only. (As discussed above, the results for misaim up are identical to those for misaim down, except for the direction of the effect.)

The information in Figures 7 through 19 indicates that the most sensitive lamp types to vertical misaim were European H1s, followed by European H4s. For both of these types of lamps, the maximum mean effect of misaim of 1.5° down (or up) exceeded 1.5 log unit change in intensity. The next most sensitive lamp types were (in descending order of sensitivity) Japanese H4s, U.S. 9006s, Japanese 9007s, U.S. halogen sealed beams with axial filament, Japanese D4s, and U.S. tungsten sealed beams with transverse filament. For these types of lamps, the maximum mean effect of misaim of 1.5° down (or up) was between 1 and 1.5 log unit change in intensity. Finally, the least sensitive lamp types were (again in descending order of sensitivity) Japanese H6s, U.S. 9004s, Japanese tungsten sealed beams with transverse filament, U.S. halogen sealed beams with transverse filament, and Japanese halogen sealed beams with transverse filament. For these types of lamps, the maximum mean effect of misaim of 1.5° down (or up) was between 0.5 and 1 log unit change in intensity.

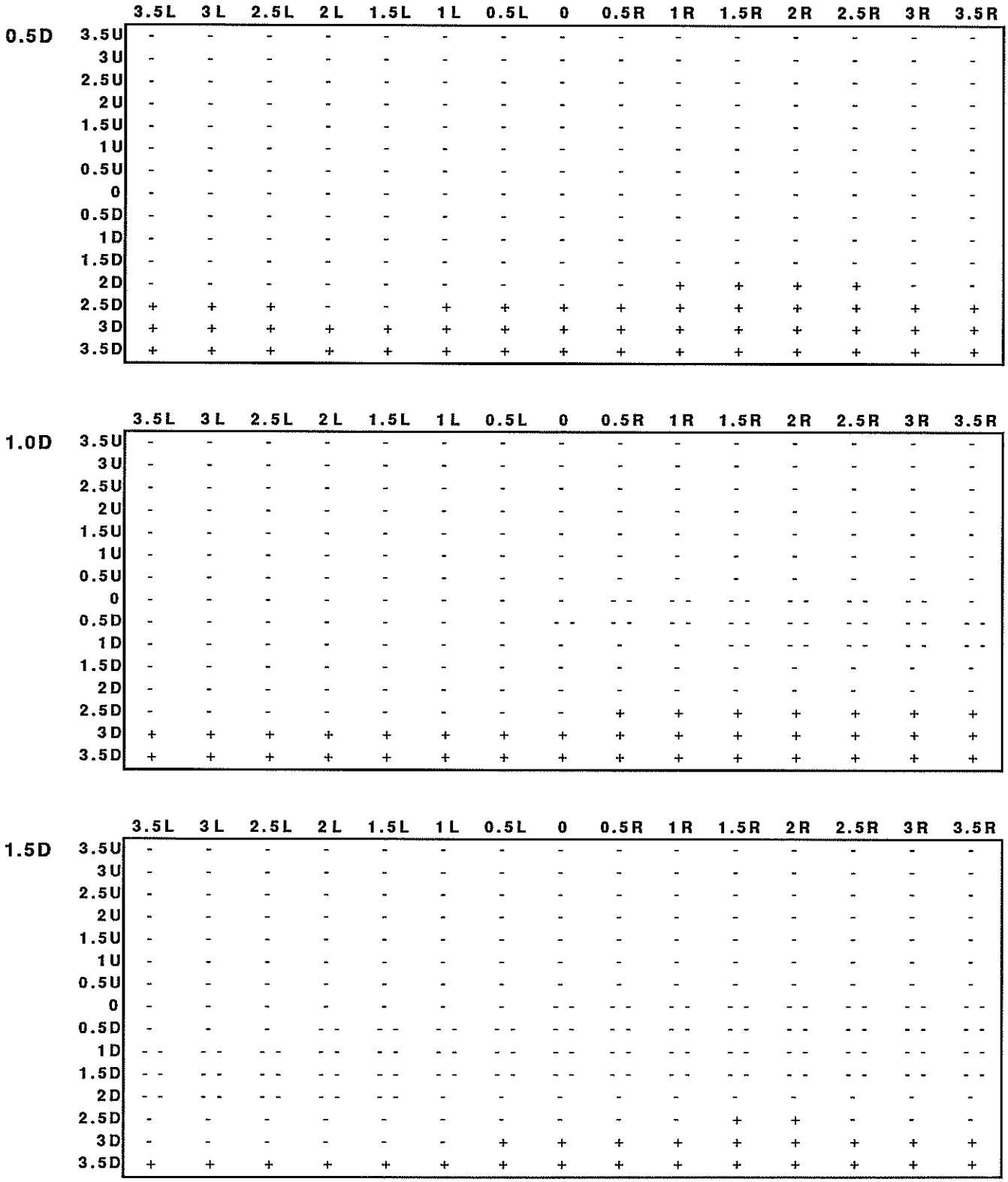


Figure 7. Effects of vertical misaim on the U.S. 9004 lamps. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

**0.5D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - - | - - | - - | - - | - - | - - | - - | - - |
| 0.5D | - | - | - | - | - | - | - | - | - | - | - - | - - | - | - | - |
| 1D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | + | + | + | + | + | + | + | + |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

**1.0D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - |
| 0.5D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - - | - - - | - - - | - - - | - - | - - |
| 1D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - |
| 1.5D | - | - - | - - | - - | - - | - | - | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | - | - | + | + | + | + | + | - |
| 2.5D | - | - | - | - | - | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

**1.5D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - - | - - | - - | - - | - - | - - | - - |
| 0 | - | - | - - | - - | - - | - - | - - | - - | - - | - - - | - - - | - - - | - - - | - - - | - - - |
| 0.5D | - - | - - | - - | - - | - - | - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - |
| 1D | - - | - - | - - | - - | - - | - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - |
| 1.5D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - |
| 2D | - - | - - | - - | - - | - - | - - | - | - | - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | - | - | - | + | + | + | + | + | + | + | + |
| 3D | - | - | - | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

Figure 8. Effects of vertical misaim on the U.S. 9006 lamps. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

**0.5D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5D | - | - | - | - | - | - | - | - - | - - | - - | - - | - - | - - | - - | - - |
| 1D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | + | + | - | - |
| 2D | - | - | - | + | + | + | + | + | + | + | + | + | + | + | + |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

**1.0D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - |
| 1D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - |
| 1.5D | - - | - - | - - | - - | - - | - - | - - | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | + | + | + | + | + | + | + | - |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

**1.5D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - | - | - - | - - | - - | - | - |
| 0.5D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - - | - - - | - - - | - - | - - |
| 1D | - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - |
| 1.5D | - - | - - | - - | - - | - - - | - - - | - - - | - - | - - | - - | - - | - - | - - | - - | - - |
| 2D | - - | - - | - - | - - | - - | - - | - | - | - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

Figure 9. Effects of vertical misaim on the Japanese 9007 lamps. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

**0.5D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - - | - - |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - - | - - | - - | - - |
| 0.5D | - - | - - | - - | - - | - - | - - | - - | - - - | - - - | - - - | - - - | - - | - - | - | - |
| 1D | - - | - - | - - | - - | - - | - - | - - | - | - | - | - | - | - | - | - |
| 1.5D | - | + | - | - | - | - | - | - | - | - | - | + | + | + | + |
| 2D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

**1.0D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - - | - - |
| 0 | - | - | - | - | - | - | - | - | - | - | - - | - - - | - - - | - - - | - - - |
| 0.5D | - - | - - | - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - - | - - - - | - - - - | - - - - | - - - | - - |
| 1D | - - - | - - - | - - - | - - - | - - - | - - - | - - - - | - - - - | - - - - | - - - | - - - | - - | - - | - | - |
| 1.5D | - - | - - | - - | - - | - - | - - | - - | - - | - | - | - | - | - | - | - |
| 2D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

**1.5D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - - | - - |
| 0 | - | - | - | - | - | - | - | - | - | - - | - - | - - - | - - - | - - - - | - - - - |
| 0.5D | - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - - | - - - - | - - - - | - - - - | - - - - | - - - - | - - - - |
| 1D | - - - | - - - - | - - - - | - - - - | - - - - | - - - - | - - - - | - - - - | - - - - | - - - - | - - - - | - - - - | - - - - | - - - | - - |
| 1.5D | - - - | - - - | - - - | - - - | - - - | - - - - | - - - - | - - - - | - - - - | - - - | - - - | - - | - - | - | - |
| 2D | - - | - - | - - | - - | - - | - - | - - | - | - | - | - | - | - | - | - |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

Figure 10. Effects of vertical misaim on the European H1 lamps. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

0.5D

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - - | - - | - - | - - |
| 0.5D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - | - |
| 1D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - | - | - | - | - | - |
| 1.5D | - | - | - | - | - | - | - | - | + | + | + | + | + | + | - |
| 2D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

1.0D

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - - |
| 0 | - | - | - | - | - | - | - | - | - | - - | - - | - - | - - - | - - - | - - - |
| 0.5D | - - | - - | - - | - - | - - | - - | - - | - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - |
| 1D | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - | - - | - | - |
| 1.5D | - - | - - | - - | - - | - - | - - | - - | - - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | + | + | + | + | + | + | + | + | + | + |
| 2.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

1.5D

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - - |
| 0 | - | - | - | - | - | - | - | - | - - | - - | - - | - - | - - - | - - - | - - - |
| 0.5D | - - | - - | - - | - - | - - | - - | - - | - - - | - - - | - - - | - - - | - - - - | - - - - | - - - | - - - |
| 1D | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - - | - - - - | - - - - | - - - | - - - | - - - | - - - |
| 1.5D | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - - | - - | - - | - - | - | - |
| 2D | - - | - - | - - | - - | - - | - - | - - | - - | - | - | - | - | + | - | - |
| 2.5D | - | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

Figure 11. Effects of vertical misaim on the European H4 lamps. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

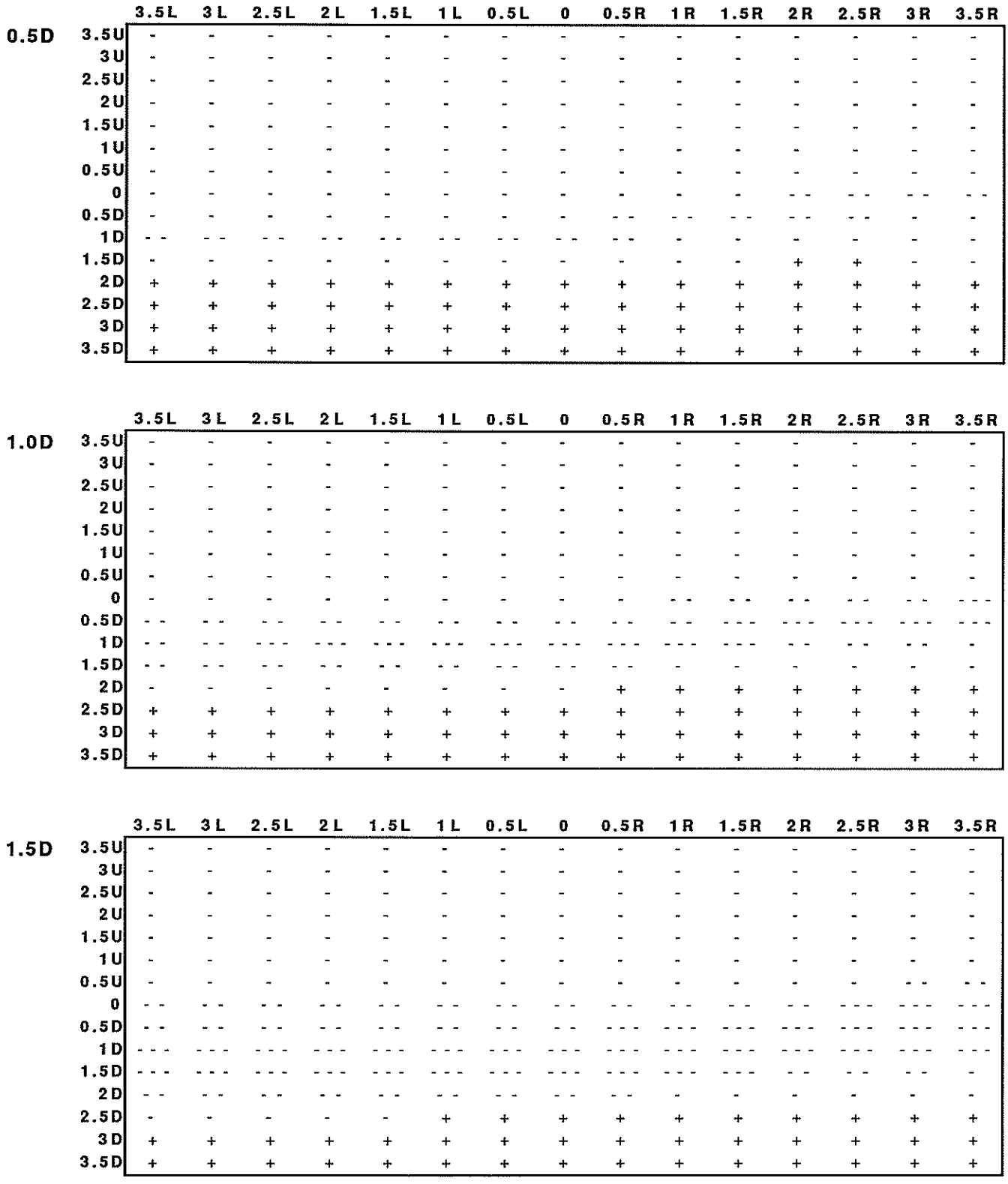


Figure 12. Effects of vertical misaim on the Japanese H4 lamps. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

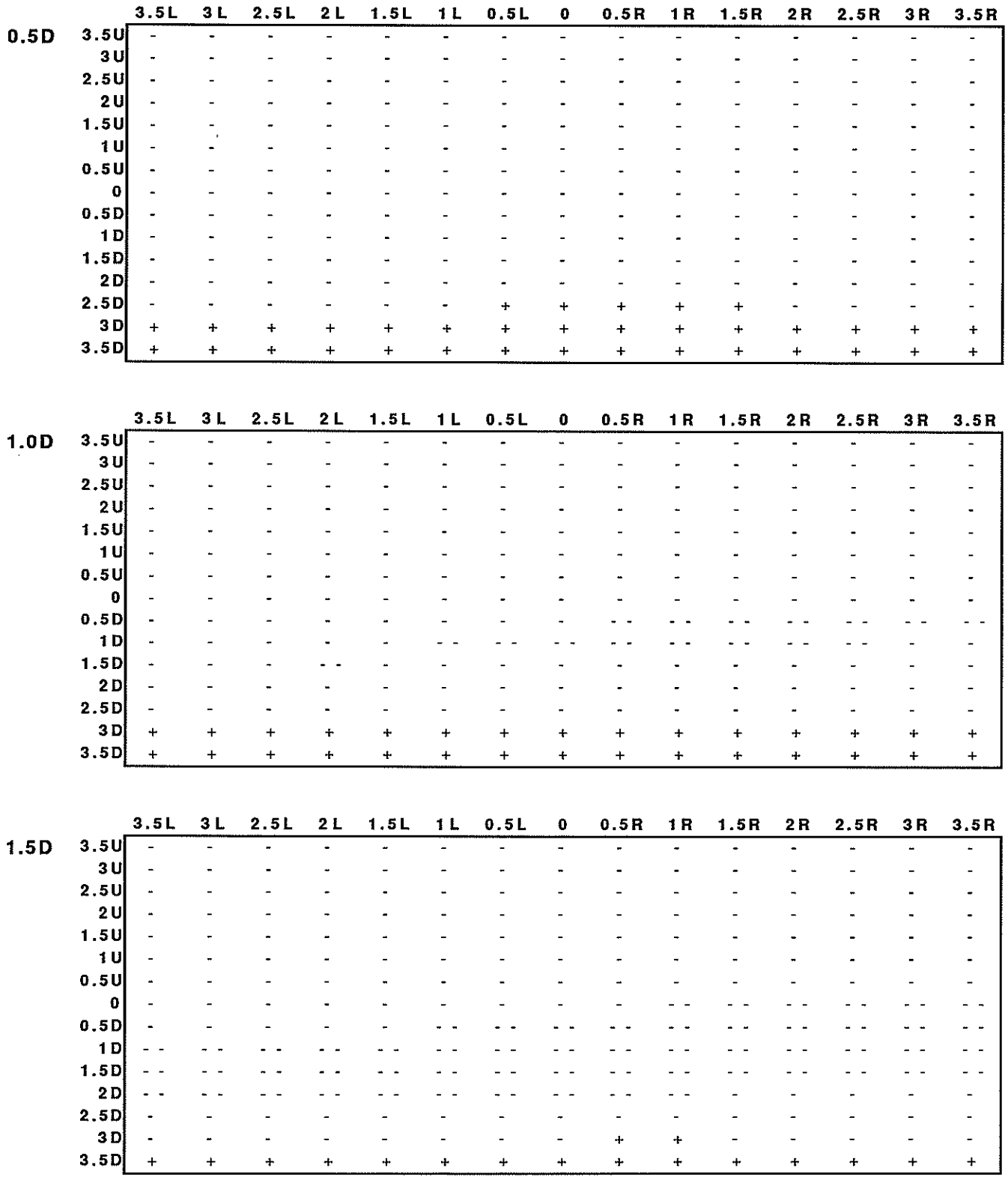


Figure 13. Effects of vertical misaim on the Japanese H6 lamps. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

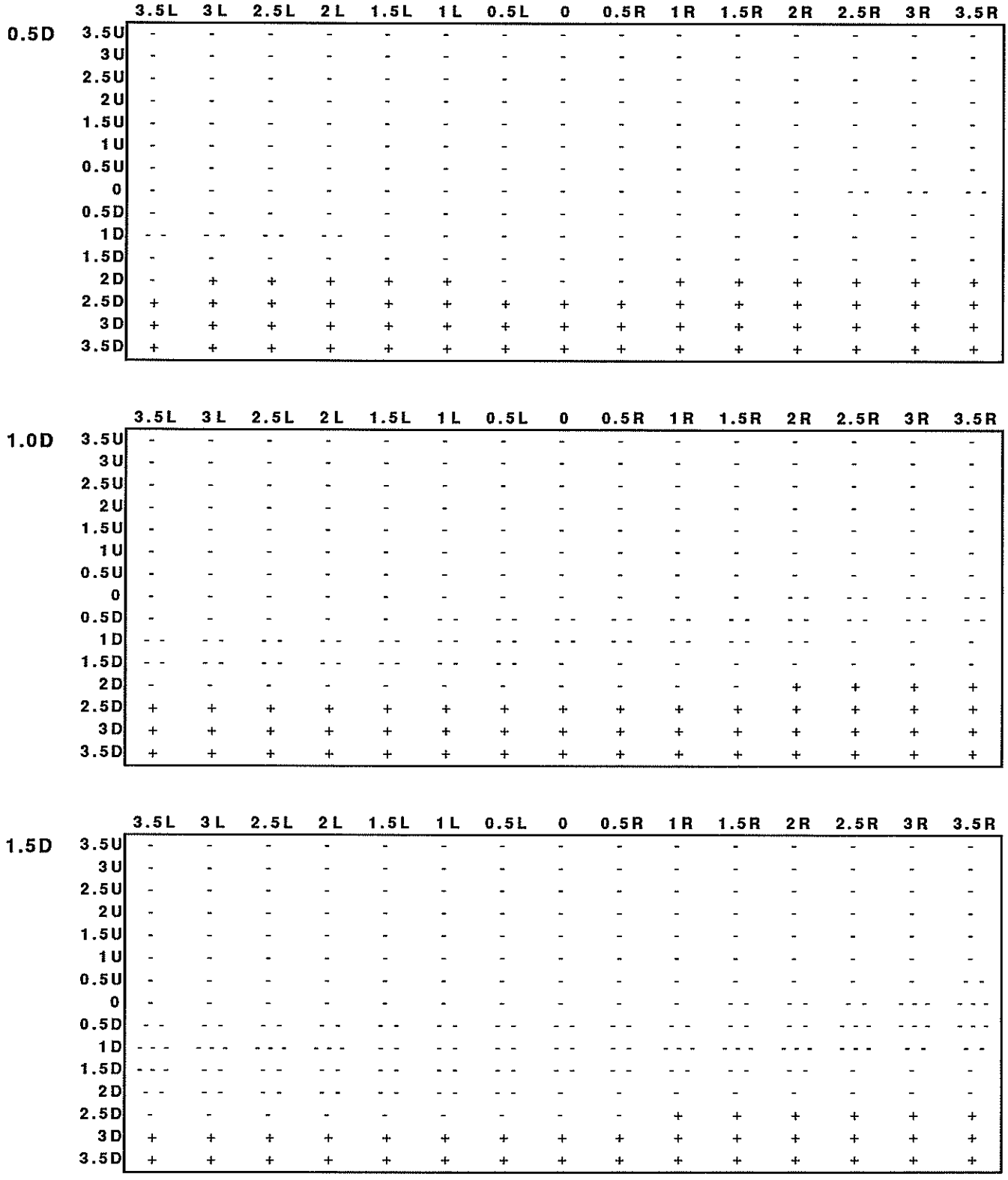


Figure 14. Effects of vertical misaim on the Japanese D4 lamps. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

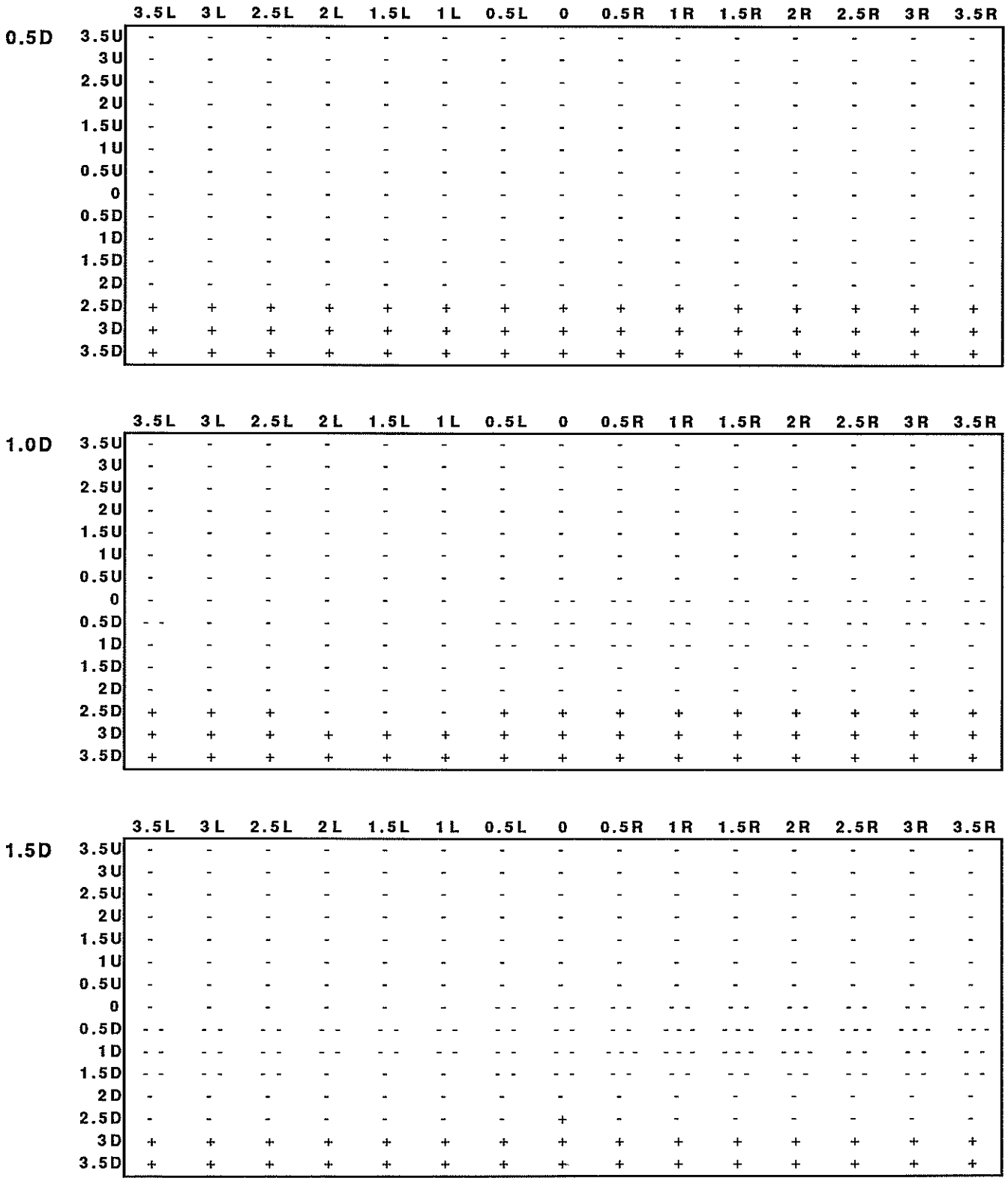


Figure 15. Effects of vertical misaim on the U.S. tungsten sealed beams with a transverse filament. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

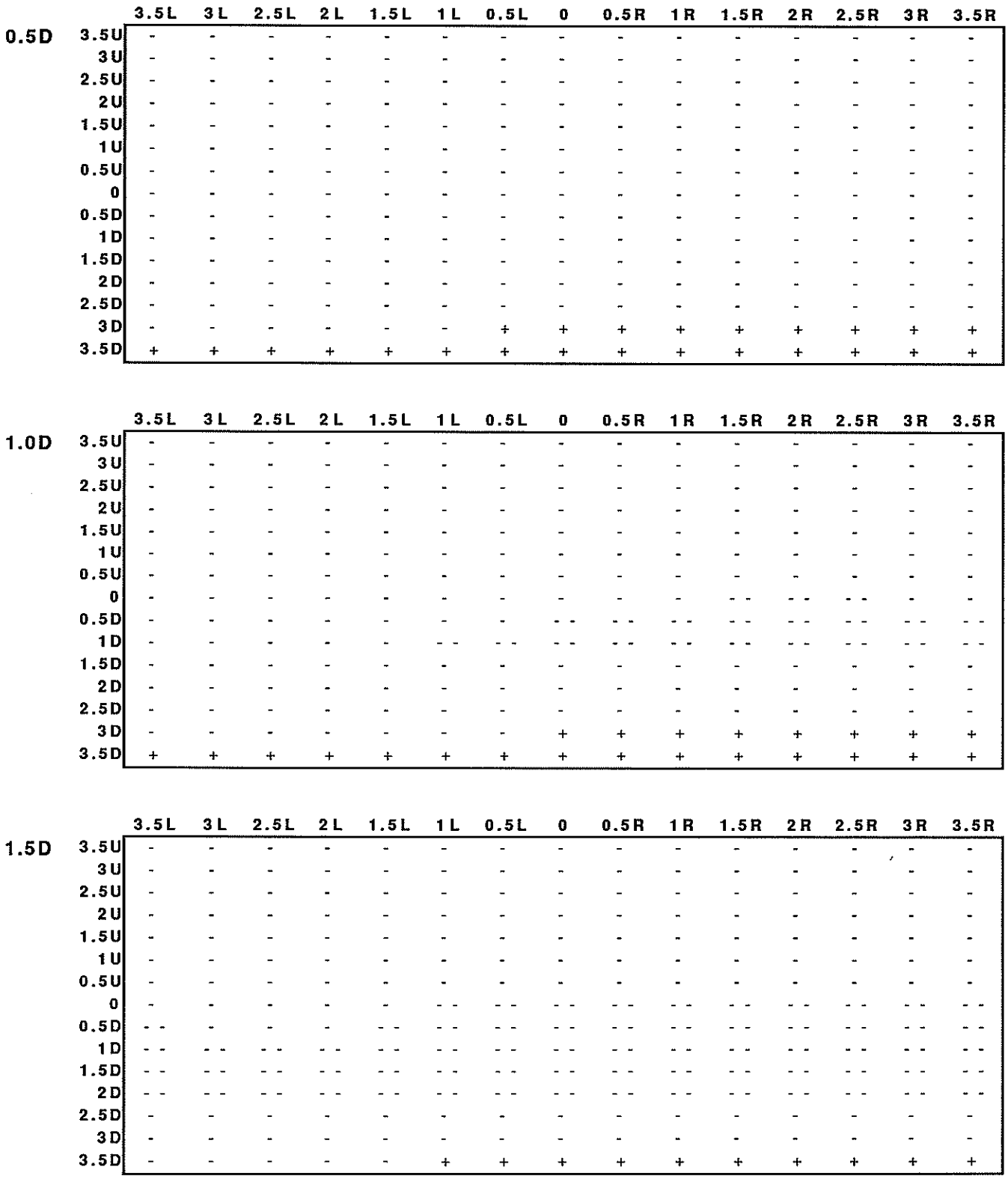


Figure 16. Effects of vertical misaim on the Japanese tungsten sealed beams with a transverse filament. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

**0.5D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | + | + | + | + | + | + | + | + |
| 2.5D | - | - | - | + | + | + | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

**1.0D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0 | - | - | - | - | - | - | - | - | - - | - - | - - | - - | - - | - - | - - |
| 0.5D | - | - | - | - | - | - | - | - - | - - | - - | - - | - - | - - | - - | - - |
| 1D | - | - | - | - | - | - | - | - - | - - | - - | - - | - - | - - | - - | - - |
| 1.5D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2D | - | - | - | - | - | - | - | - | - | - | - | + | - | - | - |
| 2.5D | - | - | - | - | - | - | + | + | + | + | + | + | + | + | + |
| 3D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

**1.5D**

| | 3.5L | 3L | 2.5L | 2L | 1.5L | 1L | 0.5L | 0 | 0.5R | 1R | 1.5R | 2R | 2.5R | 3R | 3.5R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1.5U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1U | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 0.5U | - | - | - | - | - | - | - | - | - | - - | - - | - - | - - | - - | - |
| 0 | - | - | - | - | - | - | - | - - | - - | - - | - - | - - | - - | - - | - - |
| 0.5D | - | - | - | - | - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - |
| 1D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - |
| 1.5D | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - | - - |
| 2D | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2.5D | - | - | - | - | - | - | - | + | + | + | + | + | + | + | + |
| 3D | - | - | - | + | + | + | + | + | + | + | + | + | + | + | + |
| 3.5D | + | + | + | + | + | + | + | + | + | + | + + | + | + | + | + |

Figure 17. Effects of vertical misaim on the U.S. halogen sealed beams with a transverse filament. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

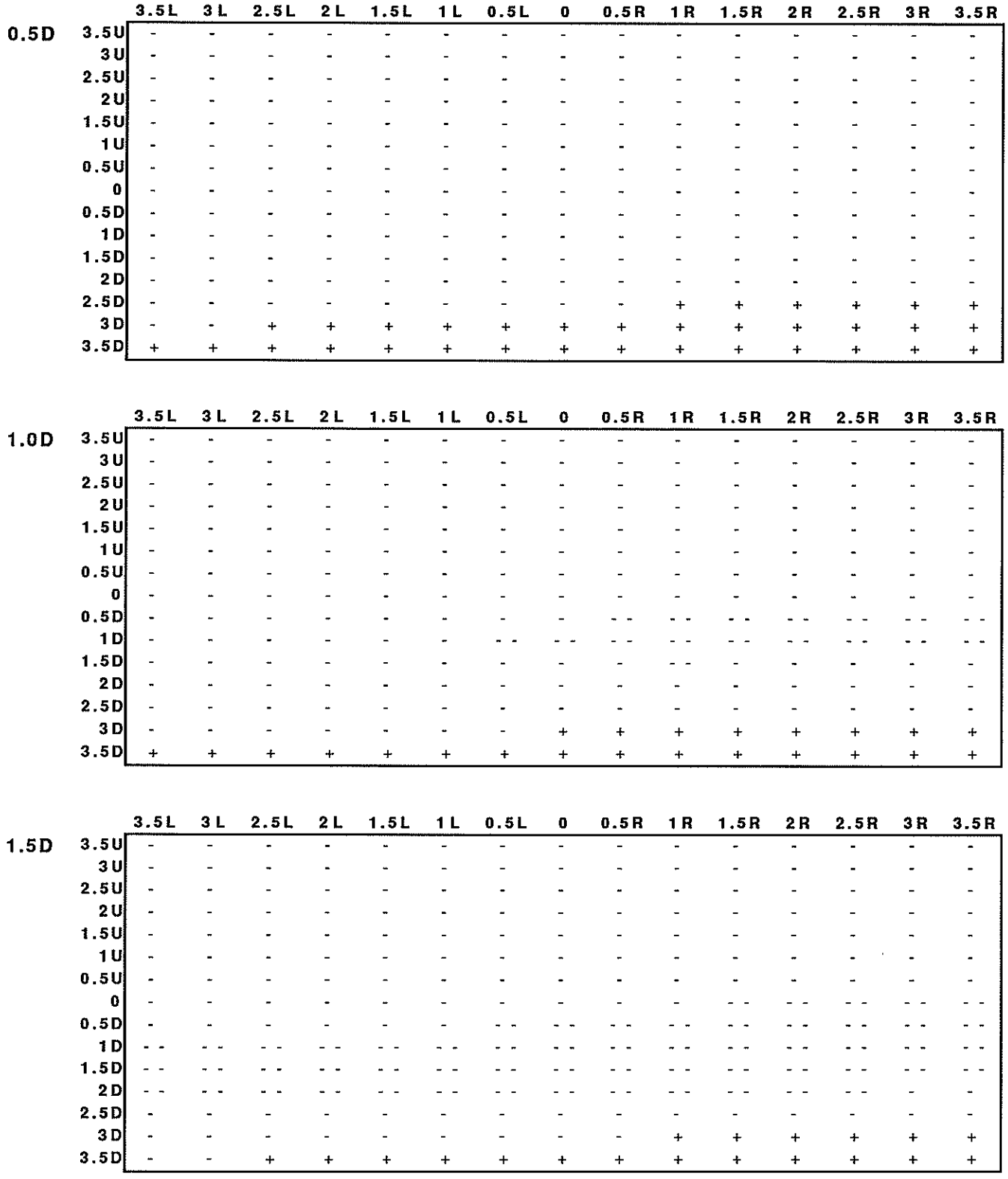


Figure 18. Effects of vertical misaim on the Japanese halogen sealed beams with a transverse filament. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

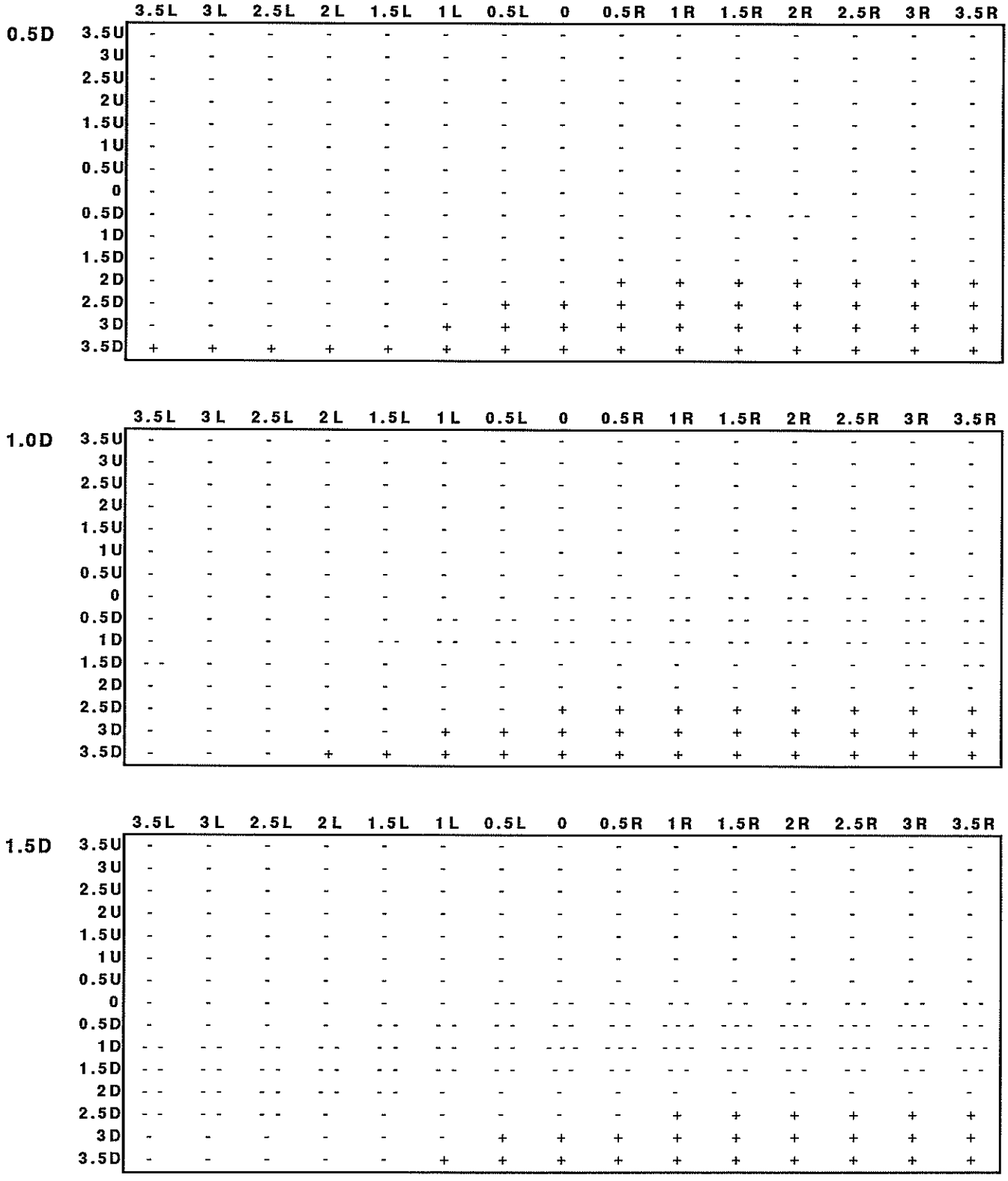


Figure 19. Effects of vertical misaim on the U.S. halogen sealed beams with an axial filament. The entries are codes corresponding to ranges of mean log ratios of misaimed to nominal intensities (see Table 3).

### Maximum effects

The above analyses were based on the *mean* effects for our sample of 150 lamps. The obtained *maximum* effects are presented by jurisdiction in Table 4, and by lamp construction in Table 5. The pattern of the maximum effects is analogous to the pattern for the mean effects, with the effects of horizontal misaim being substantially less pronounced than the effects of vertical misaim.

### Simultaneous horizontal and vertical misaim

This study considered the effects of horizontal and vertical misaim independently. In other words, the effect of horizontal misaim was calculated with the assumption of perfect vertical aim, and vice versa. Whether the effect of horizontal misaim at a certain level of vertical misaim is greater or smaller than the effect with perfect vertical aim depends on the beam pattern and the location within the beam pattern. (The same applies for the effects of vertical misaim at different levels of horizontal misaim.)

### Relative importance of horizontal and vertical aim

Overall, it is clear that, in comparison to vertical aim, horizontal aim is relatively unimportant. Furthermore, the relative difference in importance between horizontal and vertical aim increases as the sensitivity to vertical misaim increases. (This is the case because, when examined by lamp type, the effects of horizontal misaim are all relatively small and thus do not increase much with increasing horizontal misaim.) Specifically, for H1 and H4 lamps the difference in the relative importance of horizontal and vertical aim is greatest because these lamps are most sensitive to vertical misaim. On the other hand, for 9004s, H6s, and sealed beams the difference in the relative importance of horizontal and vertical aim is smallest because these lamps are least sensitive to vertical misaim.

Table 4

Maximum effects of misaim by jurisdiction.

| Jurisdiction | Maximum effect for 1.5° of horizontal misaim (log units) | Maximum effect for 1.5° of vertical misaim (log units) |
|---|---|---|
| U.S.A. | 0.5 - 1.0 | 1.5 - 2.0 |
| Europe | 1.0 - 1.5 | 2.0 - 2.5 |
| Japan | 0.5 - 1.0 | 1.5 - 2.0 |

Table 5

Maximum effects of misaim by lamp type.

| Lamp type | Maximum effect for 1.5° of horizontal misaim (log units) | Maximum effect for 1.5° of vertical misaim (log units) |
|---|---|---|
| U.S. 9004 | 0.5 - 1.0 | 1.0 - 1.5 |
| U.S. 9006 | 0.5 - 1.0 | 1.5 - 2.0 |
| Japanese 9007 | 0.0 - 0.5 | 1.0 - 1.5 |
| European H1 | 1.0 - 1.5* | 1.5 - 2.0 |
| European H4 | 1.0 - 1.5** | 2.0 - 2.5 |
| Japanese H4 | 0.5 - 1.0 | 1.5 - 2.0 |
| Japanese H6 | 0.0 - 0.5 | 1.0 - 1.5 |
| Japanese D4 | 0.5 - 1.0 | 1.0 - 1.5 |
| U.S. tungsten sealed beam with transverse filament | 0.5 - 1.0 | 1.0 - 1.5 |
| Japanese tungsten sealed beam with transverse filament | 0.5 - 1.0 | 1.0 - 1.5 |
| U.S. halogen sealed beam with transverse filament | 0.5 - 1.0 | 1.0 - 1.5 |
| Japanese halogen sealed beam with transverse filament | 0.0 - 0.5 | 1.0 - 1.5 |
| U.S. halogen sealed beam with axial filament | 0.5 - 1.0 | 1.0 - 1.5 |

* 1 log unit was exceeded by three locations at 1.5° misaim, and by one locations at 1° misaim.
**1 log unit was exceeded by four locations at 1.5° misaim, and by one location at 1° misaim.

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