



“BUILDING ON TEST RESULTS TO DESIGN SAFETY SYMBOLS”

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Nora Olgyay's 1995 book, **Safety Symbols Art: Camera-Ready and Disk Art for Designers** provides the only commercially available, copyright-free art for a system of safety symbols that fulfills the American National Standards Institute's comprehension testing & design criteria for safety symbols. This paper reproduces selected sections of its hereto informally published 1996 companion publication, *Safety Symbols Art: The Testing Protocol, Materials & Results*, which documents the research, testing protocol, materials and results for the IIID safety symbol system, now scheduled for publication by IIID, the International Institute for Information Design.

STANDARD-COMPLIANT SYMBOL ART NEEDED

The first national standard for a comprehensive set of safety symbols in the U.S. was adopted in 1991 when symbol design criteria, comprehension testing requirements and the standard image content for 40 symbols were approved by the American National Standards Institute (ANSI) as American National Standards (ANS Z535.3) for signs (Z535.2), labels (Z535.4) and tags (Z 535.5).

These Standards strongly recommended that safety symbols be included in its prescribed formats to supplement written safety messages because research consistently indicates that in direct comparisons of word-only and symbol signs, symbols perform better. Specifically, reaction time is faster, understanding is more rapid, legibility distance is greater and recall is more accurate. In addition, symbols are “language free”, so consequently they can be “read” by a wider audience including the illiterate, non-English speaking, people with low vision and viewers with cognitive impairments. Clearly the widespread use of legible, comprehensible safety symbols will improve hazard communications and thereby help to prevent injuries.

In 1991, there was no source for safety symbol art which complied with the Standard's design, comprehension testing criteria and matched the standard image content. The symbols illustrated in the .3 section of the Z535 Standard itself are for image content reference only. For example, the standard image content for POISON is a “Skull & Crossbones”. Due to their size and quality, the Z535 symbol examples are not suitable for

reproduction. In addition, some of the examples are the property of corporations who require time-consuming requests for permission to use them, several of the symbol examples do not meet the comprehension testing threshold required to be Z535-compliant and the majority do not meet Z535.3's recommended design criteria.

Z535-compliant symbols are also required to meet a comprehension testing threshold of 85% correct answers with no more than 5% critical confusions (opposite meanings) among the target audience. In addition, Z535 recommends (versus requires) that symbol graphics meet its design criteria to maximize legibility; specifically, to use solid forms rather than outlines, simplify details, establish a minimum line thickness as well as to develop a consistent visual system.

As a former chairperson of the Z535.3 symbol subcommittee, the author/designer took it upon herself to develop a product which would meet the forementioned public communication need. Bolstered by an NEA grant, the solution was Safety Symbols Art: Camera-Ready and Disk Art for Designers; a commercially available book published in 1995 by Van Nostrand Reinhold, which provides both digital art on disc and scannable line art for a copyright-free safety symbol system; a system whose graphic style harmonizes with and extends the visual vocabulary of the national public symbol system that had been established by the AIGA (American Institute of Graphic Arts) for the U.S. Department of Transportation in 1979.

In addition, the IIID symbols in the book are provided in a variety of formats (for a total of ninety-six versions) in order to accommodate a range of application requirements for varying surround shapes, color breaks and orientation.

STANDARD COMPLIANCE CRITERIA

To assure compliance with Z535, the IIID safety symbols were designed to match the standard image content, meet the symbol design criteria, and then they were subjected to the formal comprehension testing requirements outlined in Z535.3. For example, The ANS Z535 symbol examples for mandatory protection equipment are not graphically consistent. They are a collection of individual symbols culled from diverse sources including ISO, various U.S. corporations, and an array of national standards agencies. In contrast, the equivalent IIID symbols build upon each other to form a set of graphically interrelated symbols. They function as a visually coherent system.

In addition, the symbols' legibility has been improved by a consistent, considerate graphic rendering exemplified by the cancellation mark designating prohibition which poses many design challenges because it obscures a portion of the same message that it is intended to communicate. The Z535 symbol examples illustrate this challenge for *NO EXIT*, *NO OPEN FLAME*, *NO ENTRANCE* for people, and *DO NOT TOUCH*. Their IIID counterparts were designed to meet these legibility challenges.

SYMBOL TESTING RESEARCH

Before the IIID symbols were drawn, a testing research review was completed in order to assess critical symbol details and qualities which could minimize misreadings, critical confusions and maximize the recrafted symbols' correct comprehension testing responses. Results from fifteen U.S., Canadian, Australian and ISO (International Organization for Standardization) symbol comprehension testing projects were scrutinized to identify individual incorrect responses recorded for a variety of different graphic symbols with the required Z535 image contents.

As a result of these comprehension test response reviews, it became evident that more than half of the 40 symbol examples in Z535.3/1991 had recurring comprehension problems, which included the following: Seven of the symbol examples did not consistently meet the 85% comprehension threshold; three of the symbol examples had not been appropriately tested for comprehension; four symbol examples recorded consistent critical confusions which were under the 5% threshold but which were disturbing for their consistency; and, eight symbol examples had elicited non-critical but consistent misreadings under the 5% threshold which indicate that, although these symbols are generally well understood, there is room for improvement to minimize their misreadings and thereby improve comprehension levels.

SYMBOL DESIGN RESPONSE

In response to the research findings, design adjustments were incorporated into the IIID safety symbols which addressed misleading symbol details and qualities in order to improve comprehension by minimizing the recorded misreadings and critical confusions. For example, although the Z535 CORROSION hazard symbol example consistently scored above the 85% threshold for correct answers for the required image content ("Test Tube, Hand and Drops"), it also consistently recorded a 2% to 4% reading as an "emergency hand wash location" or a directive to "wash hands"; both of which are critical confusions that could create a hazard rather than prevent one. So, unlike the Z535 symbol example with its graphic of a hand passively held under the liquid dropping from the test tube, the IIID symbol for *CORROSION* below incorporates a reactive hand as part of its visual vocabulary. This reactive hand moves away from the danger in order to reinforce the hazard message and improve comprehension.

Although generally well understood, previous comprehension testing results identified room for improvement even among the "time-tested," widely recognized ISO symbols reproduced in Z535 for *ELECTRICAL*, *SAFETY ALERT*, *POISON*, and *FLAMMABLE* hazards. IIID's recrafting of the required image content of a "lightning bolt" for *ELECTRICAL* hazard deleted the arrowhead and subsequently it did not prompt the earlier misreads as a "crooked road" or "danger below" hazard. The *ISO SAFETY ALERT* symbol was occasionally misunderstood to be a "handle shut off," "keyhole/lock up," or "ball park". IIID's revisions to the mandated "exclamation mark" did not elicit these errors. In addition,

IIID's recrafted *POISON* symbol meets the required "skull & crossbones" image content but adjustments have been made to improve its comprehension; the "smile" is gone to minimize the critical confusions it had elicited of a friendly image or an "elderly person".

COMPREHENSION TESTING

The primary purpose of the comprehension testing was to test the IIID symbols with the target audience to ensure that each symbol meets the Z535 acceptance criteria. However, there were also two other objectives: First to compare the IIID symbol graphics with the Z535 symbol examples to insure that there is no reduction (and, hopefully, an increase) in the comprehension rate as well as a drop in the percent of misreadings and critical confusions recorded; and, also, to examine comprehension for test subjects sub-groups of particular interest. These included a demographic target of at least 40% industrial workers (at least 18 years old) who may encounter safety signs in the workplace and 33% of whom are over 50 years old because studies have found that older people have greater symbol comprehension problems.

METHODOLOGY

The testing materials were designed by NIST's Neil D. Lerner to be user-friendly and to conform to the testing standards specified in Z535. The testing protocol materials included written instructions given for the test administrators, their scripted dialogue (presented in a large, simple bold typeface so that it could be read comfortably at arm's length or as it lay on a desktop for the administrators' reference) and five sample pages from the test booklet.

The test booklets themselves presented the symbols in a format which is considered stringent because the symbols were presented without context and without colors. Specifically, the symbols were presented in black and white, without surround shapes, except cancellation and mandatory action surround shapes were included because they are integral to the message. In addition, the symbols were presented without any environmental context, such as on a sign or product label. Testing the symbols without a context adversely effected the "correct answer" response rate. With a context, it is unlikely that the vehicular *NO ENTRY* symbol would have been misread as a "minus" or a "badge slot", *RADIO FREQUENCY* as a "lighthouse warning", the *LASER* symbol identified as a "kitchen sponge" and a "water leak", or the *FIRST AID* symbol as a "traffic intersection".

The test responses were blind scored in two separate reviews. Answers were scored as "correct", "wrong answer", "poor answer", "no answer", "misreading" or "critical confusion". This scoring established the comprehension rates (percent correct interpretations for each symbol). The forthcoming IIID symbol testing protocol publication includes an analysis of the scoring results, an itemization of the scores for each of the forty symbols by category of response supplemented by a the listing of the answers recorded which were not scored as "correct".

Z535.3 requires symbol comprehension testing of a minimum of 50 test subjects in order to adequately test symbol comprehension. To examine symbol comprehension for test subject sub-groups, comprehension-challenged demographic targets for the IIID safety symbols were set to include at least 40% industrial workers with 33% over 50 years old.

TEST RESULTS

The demographic goals set for the 58 test subjects were exceeded: 89% of the test subjects were blue collar industrial workers, 34% were over 50 years old, only 5% were under 30 with an average age of 45. In addition, 59% of the subjects completed high school, but 18% did not finish and English was a second language for 8% of the test subjects.

Despite the stringent testing format and test subjects who disproportionately included those expected to have greater comprehension problems (due to their age, education and language), the scoring established that all of the IIID symbols satisfied the comprehension thresholds established by Z535 and eliminated the targeted, previously recorded, misreadings and critical confusions of the Z535 symbols. The Z535.3 symbol examples, which were included as a control group, scored “correct” answers at rates comparable with their previously recorded testing scores and continued to reiterate the identical misreadings and critical confusions. For example, the Z535 *FIRE HOSE & REEL* was still misread as a “camera” or “heating coil”. The other Z535 symbols which continued to reiterate the same misreadings and critical confusions from previous comprehension testing included the Z535 symbols for *NO ENTRANCE*, *HOT SURFACE*, *DO NOT TOUCH*, *GENERAL ALERT* and *HEAD PROTECTION*.

Design adjustments had been incorporated into the IIID symbol system based on earlier symbol comprehension test results. In response to this research, the IIID mandatory action symbols are placed on a human profile to minimize the misreadings recorded when the ISO/Z535 heads faced the viewer. Retesting confirmed that IIID’s symbol for *HEAD PROTECTION* no longer elicits the misunderstanding that it is a “hair protection” requirement or a “patrol alert” and that IIID’s symbol for a *RESPIRATOR* requirement ceases to be misread as a requirement for “underwater gear” or “safety goggles”. Transparent lens on the *EYE PROTECTION* symbol eliminated the misreadings recorded for its Z535/ISO counterpart as “sunglasses required”.

CONCLUSIONS

The IIID safety symbols, offered in [Safety Symbols Art: Camera-Ready & Disk Art for Designers](#), comply with Z535.3’s standard image content, symbol design criteria and comprehension testing performance requirements. In addition, symbol comprehension has been maximized because the individual incorrect responses recorded during previous comprehension testing of the 1991 Z535.3 symbol examples were reviewed in order to assess critical details and qualities which could minimize confusions and clarify comprehension. These considerations were incorporated into the design of the IIID safety symbols. Subsequent comprehension testing of the recrafted symbols confirmed that the incidence of critical

confusions and misreadings had been reduced by design despite the fact that the testing of the IIID symbols disproportionately included subjects expected to have greater comprehension problems due to their age, education and language. In addition, the consistent application of the Z535.3 symbol design criteria to the IIID safety symbols maximizes their legibility and visual coherence.

Finally, in response to this research, the second (1998) edition of the Z535.3 Standard was revised to include more appropriate symbol examples. And, although on principle, the Standard does not endorse any specific art per se, both the IIID symbols and their comprehension testing materials are referenced as exemplary.

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➤ **WEB SOURCES FOR SYMBOL ART**

AIGA **AMERICAN INSTITUTE OF GRAPHIC ARTS**
www.aiga.org

ICOGRADA **INTERNATIONAL COUNCIL
OF GRAPHIC DESIGN ASSOCIATIONS**
www.icograda.com

IIID **INTERNATIONAL INSTITUTE FOR INFORMATION DESIGN**
www.iiid.net

ONLINE ENCYCLOPEDIA OF WESTERN SIGNS AND IDEOGRAMS
www.symbols.com

SEGD **SOCIETY FOR ENVIRONMENTAL GRAPHIC DESIGN**
www.segd.org

ULTIMATE SYMBOL
www.ultimatesymbol.com

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➤ **STANDARDS ORGANIZATIONS**

ANSI **AMERICAN NATIONAL STANDARDS INSTITUTION**
www.ansi.org

BSI **BRITISH STANDARDS INSTITUTION**
www.bsigroup.com

ISO **INTERNATIONAL ORGANIZATION FOR STANDARDIZATION**
www.iso.org

NEMA **NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION**
www.nema.org

NIST **NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY**
www.nist.gov

SA **STANDARDS AUSTRALIA LIMITED**
www.standards.org.au

SCC **STANDARDS COUNCIL OF CANADA**
www.scc.ca