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Non-Accident Release of Hazmat from Railroad Tank Cars: Training Issues

Office of Research
and Development
Washington, DC 20590

J. Gertler
S. Reinach

Foster-Miller, Inc.
350 Second Avenue
Waltham, MA 02451-1196

G. Kuehn

IIT Research Institute
10 West 35th Street
Chicago, IL 60616-3799

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16. Abstract

This report presents the results of a study to determine the extent to which written materials used in training railroad tank car hazmat loaders are consistent with the reading skills of the trainees. Data from four case study sites was used to conduct the analysis. Each site trains employees to load hazardous materials into railroad tank cars. The reading level of the trainees was assessed through self-reporting of years of education completed and through the administration of a verbal skills aptitude test. The Fry Readability Index was used to determine the reading level of the written training materials from each site. Each program had some degree of incompatibility between the reading level of the materials and the skills of the trainees. Suggestions are offered for individual companies that want to examine their programs for possible incompatibility. In addition to presenting the results of this analysis, the report contains guidelines and best practices for this type of training. An appendix contains guidelines for preparing written materials for adults with limited reading skills.

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PREFACE

This report presents the findings and results of a research study designed to examine the reading level of trainees and the written materials used in instructing these chemical company employees regarding the loading of hazardous materials into railroad tank cars. The work was performed under contract DTFR53-95-C-00049 with guidance from Dr. Thomas Raslear of the Office of Research and Development, Federal Railroad Administration. The authors also extend their appreciation to Mr. Paul Williams of the Bureau of Explosives, Association of American Railroads, for his guidance and insight on the causes of non-accident releases. Mr. Williams, Mr. Frank Principi, formerly Assistant Director for Distribution Safety and Economic Programs, Chemical Manufacturers Association, and Mr. William Schoonover, the FRA Office of Safety, provided chemical industry contacts and facilitated the identification of suitable case study sites. The authors also wish to thank the four chemical companies that arranged site visits, allowed the study team to collect data from their employees and provided copies of their written instructional materials for our review.

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EXECUTIVE SUMMARY

Shipments of hazardous materials have increased steadily since 1992 and now account for nearly 7 percent of the freight moved by rail. The two primary risks associated with transporting hazmat cargo are the release of hazardous material due to a train accident and a hazardous material non-accident release (NAR), also known as an unintentional release. In 1997, according to the Association of American Railroads (AAR) Bureau of Explosives (BOE) there were 898 NARs in the United States. Although the rate of NARs per 1000 hazmat carload originations has declined substantially since 1992, the railroad and chemical industries and the FRA believe that further reduction is achievable. At a meeting with railroad, chemical and tank car industry representatives and the FRA, proper training of loading and unloading personnel was suggested as a key factor in reducing NARs.

The overall objective of this project was to assess the compatibility between the educational/verbal skill levels of employees responsible for hazmat loading and the training materials used by the chemical industry. A case study approach was used to examine the relationship between employee skills and training materials. Four companies of varying sizes, located in different regions of the country, and producing different types of chemicals were the subjects for the case studies.

Site visits were made to each company. Structured interviews with chemical company managers and training officials were used to obtain company information and a complete description of each training program. A written survey was used to obtain information on the educational background and work experience of each hazardous material loader, and a portion of the Multidimensional Aptitude Battery (MAB), a general intelligence test, was administered to assess verbal skills. Copies of each company's training materials were also collected for reading level analysis.

The Fry Readability Index, a frequently used method for assessing adult reading materials, was selected for this project. The Fry procedure involves the following steps:

1. Select three 100-word passages from different parts of the material.

2. Determine the average number of sentences in the three passages.

3. Determine the average number of syllables for the three passages.

4. Plot the sentence and syllable averages on the Fry graph to determine the grade level for the document.

Determining the compatibility between the trainees and the textual instructional materials required applying a measure of readability to the materials and then comparing it to data on the trainees' formal years of education along with the MAB results. Four different approaches were used. Three involved the Fry readability level. The following analyses were conducted:

1. Comparison of the training materials' Fry readability level with trainees' attained educational level.

2. Comparison of the training materials' Fry readability level with trainees' estimated instructional and independent reading levels.

3. Comparison of the tranining materials' Fry readability level with trainees' estimated reading levels where the Fry index is adjusted to reflect internal text organization.

4. Qualitative application of conclusions derived from the 1993 National Adult Literacy Survey conducted by the National Center for Educational Statistics of the U.S. Department of Education.

Data from a total of 35 employees at the four case study sites was available for comparison of training materials with level of educational attainment. Since MAB data was not available for five employees, comparisons (2) and (3) were done with data for 30 employees. Results of the comparisons are shown in Table 1.

The materials for two of the companies contained statements of objectives and self-study questions, features that improve the readability of textual training materials. When the adjusted Fry indexes were compared with the reading levels for these two companies, the number of employees falling below the Fry index decreased somewhat.

The National Adult Literacy Survey (NALS) found that 51 percent of adult Americans have a reading level correlating to a high school education. This group was likely to be less than 80 percent successful in the interpretive use of text materials that are lengthy and complex. The NALS result can be used qualitatively in conjunction with the Fry index to reinforce the need to reduce the complexity of written training materials.

Table 1. Comparison of results by metric

Reading Skill Metric	Mean	Median	Fry Index	Number of Employees Below Fry Index	% Below Fry Index
Years of School	13.5	13.5	12.4	10	33
Estimated Instructional Reading Level	13.3	12.7	12.4	16	53
Estimated Independent Reading Level	11.3	10.7	12.4	20	67

Regardless of the means of assessment, it appears that the reading level of the materials is excessively high in comparison to the reading skills of the trainees. Some of the substances handled are so hazardous, and the potential consequence of a serious non-accident release is so great, that chemical companies should consider assessing the reading level of their materials and making any necessary modifications to make the materials appropriate to the skills of their employees. The Fry index is recommended, since it is easily computed. Also, guidelines and best practices, based on the case study sites, are offered for this purpose.

Although all four companies had some degree of incompatibility between the reading level of the materials and the reading skills of the trainees, each reported a low NAR rate. Most likely, the dedicated instructors and employees, operating out of a sense of responsibility and understanding of the potential risks of the job, manage to arrive at a favorable training outcome through ample hands-on practice and on-the-job training.

Chemical companies are encouraged to consider the following when reviewing their training programs:

- Although current federal hazmat training requirements emphasize mastery of declarative knowledge, conduct both knowledge and performance testing to ensure that procedural learning has a successful outcome.

- Review the company's NAR history to identify any specific causes that contributed to an incident and place emphasis on these causes in the training.

- Conduct a "root cause analysis" whenever an NAR occurs and incorporate knowledge gained into the training program.

The scope of the study was limited to an assessment of chemical companies' training materials and the reading skills of employees. Other possible factors contributing to the incidence of NARs but that were not addressed in this study include fatigue or loss of alertness, corporate safety culture, maintenance problems, distractions in the workplace and performance pressures.

1. INTRODUCTION

In 1997 railroads in the United States carried 25 million carloads of freight (1). Of this total, over 1.6 million contained hazardous materials (2). While hazardous cargo represents only 6.6 percent of the freight moved by rail, the risks that this type of shipment poses for railroad employees who are responsible for moving the materials are a concern of the Federal Railroad Administration (FRA) as well as railroad management, unions and shippers. As the annual volume of hazmat carloads shipped continues to increase, the risks increase. There are two primary types of risks associated with the rail transport of hazardous materials: release of hazardous material due to train accidents and hazardous material non-accident releases (NARs), also known as unintentional releases. An NAR is an inadvertent release of a hazardous substance during transport, including loading and unloading, and may include leaks, splashes and venting problems.

The railroad, chemical and tank car industries have been working together for several years on various initiatives to reduce the incidence of NARs. Increased safety efforts by the railroads, increased awareness and concern of chemical shippers and changes in tank car fittings and designs have all contributed to controlling NARs. At a March 1996 meeting of representatives from these industries and the FRA, proper training of loading and unloading personnel was suggested as a key factor in reducing the number of NARs. The work described in this report addresses issues surrounding the relationship between the training program for individuals who load hazardous materials into tank cars and the reading skills and abilities of these trainees.

1.1 Background

Shipments of hazardous materials have increased steadily since 1992. Figure 1 shows annual hazmat carloads originating in the United States and Canada for the period 1992-1997. In 1997, total hazmat originations increased 4 percent overall, with tank car shipments increasing 6 percent (2). In 1997, tank cars accounted for 65 percent of all hazardous material shipments. Since tank cars make up a majority of hazardous material transportation by rail, the report focuses on this rail car type.

While shipments of hazardous materials have increased, the number of NARs in all car types, as well as tank cars in particular, has generally declined since 1992. The NAR rate per 1,000 tank car originations has declined from a high of 1.384 in 1992 to 0.75 in 1997 (2). According to the Association of American Railroads (AAR) Bureau of Explosives, there were 898 hazardous material NARs from rail cars in the United States in 1997 (2). Approximately 85 percent of the NARs (760) were from tank cars. The remainder is from intermodal shipments and packages in boxcars.

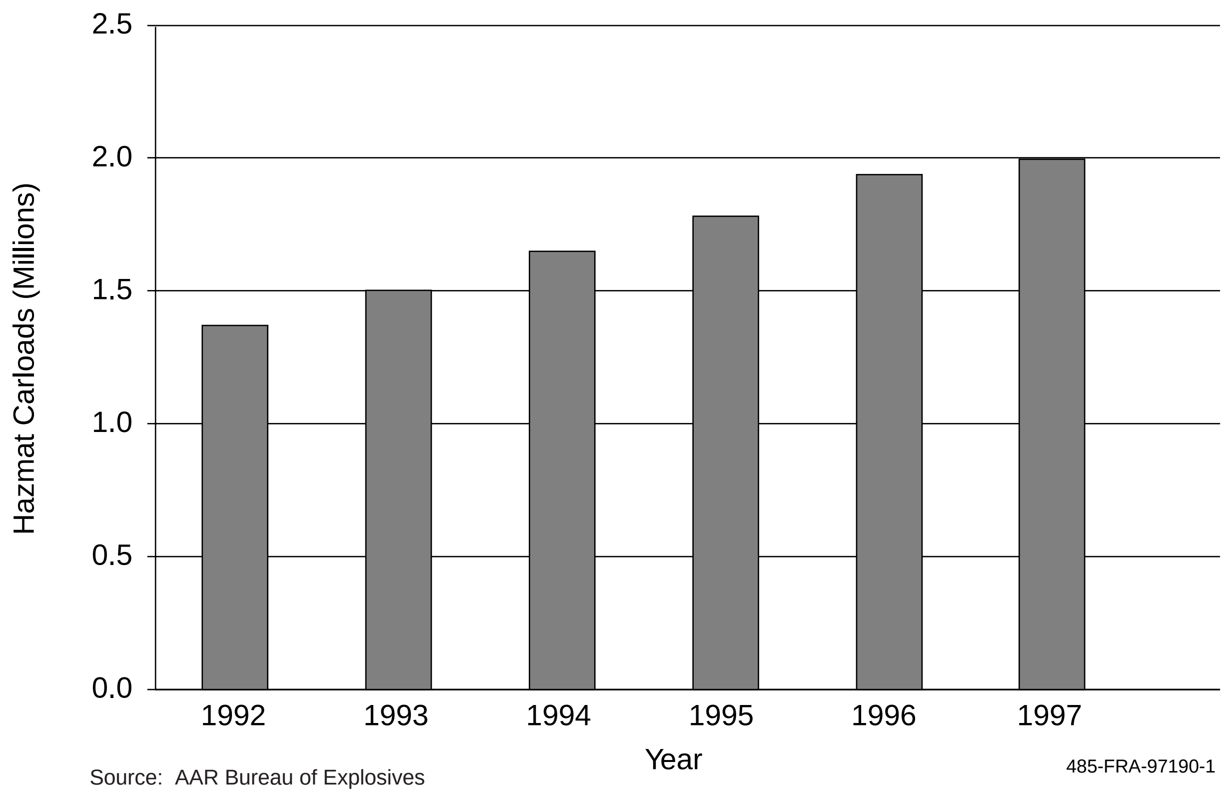

Figure 1. Total U.S. and Canadian hazmat carload originations, all car types

The Department of Transportation's Research and Special Programs Administration (RSPA) also provides data on NARs through its Hazardous Materials Information System. RSPA reported 1045 NARs in 1997 (3), about 150 more than the AAR figure (see Figure 2). The discrepancy between the AAR and RSPA NAR figures ranges from 5 to 10 percent each year and is likely due to the differences in the two reporting processes. Both sources of NAR data indicate that the number of NARs has declined in recent years.

Table 2 displays the distribution of NARs (all car types) by cause for the period 1992-97, as reported by RSPA. From 1992 through 1997, human error has been the cause of an increasing proportion of NARs and human error has accounted for over half of all rail NARs since 1995.

RSPA requires carriers to submit a two-page form (DOT Form 5800.1) for every incident that involves a release of a hazardous material, including releases that result from accidents. RSPA classifies NARs into one of three cause categories based on information provided on this form (4). 'Human error' includes releases attributed to overloading/overfilling, loose fittings or valves, improper loading, improper blocking, dropped package, struck/rammed package, or friction/rubbing. The last three sources of damage apply to packages shipped in boxcars or intermodal containers. 'Package failure' includes defective fittings and valves, corrosion and metal fatigue. A third category, 'other,' includes fire/heat, freezing, venting, vandalism, and incompatible materials.

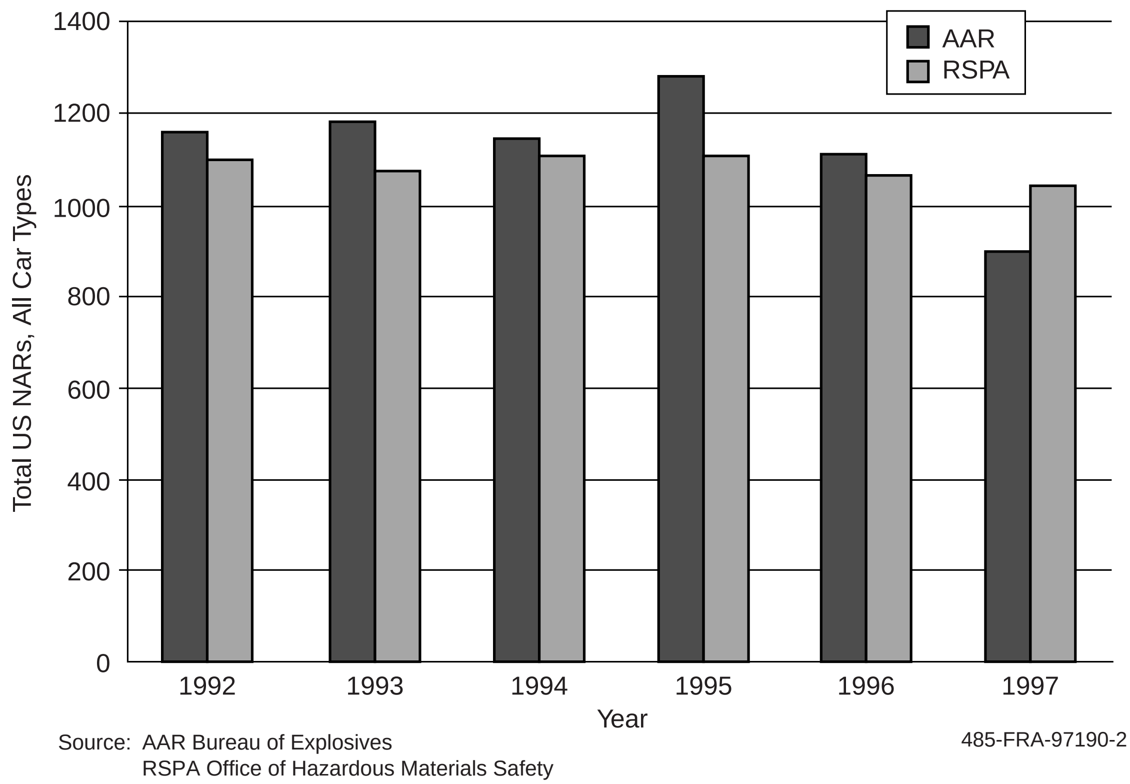

Figure 2. NARs by year as reported by AAR and RSPA

Table 2. NAR by cause (1992-97), all car types

Cause	1992	1993	1994	1995	1996	1997
Human Error	470 (43%)	445 (42%)	539 (49%)	636 (58%)	600 (56%)	569 (54%)
Package Failure	567 (52%)	621 (58%)	556 (50%)	455 (41%)	435 (41%)	448 (43%)
Other	56 (5%)	4 (0%)	10 (1%)	13 (1%)	30 (3%)	28 (3%)
Total	1093	1070	1105	1104	1065	1045

Source: RSPA Office of Hazardous Materials Safety.

1.2 Current Training Requirements

In 1992, DOT published a rule that amended the Hazardous Materials Regulations by instituting a training requirement (see 49 CFR Subpart H, Section 172). The new training requirement stipulates that every hazmat employee must receive initial training within 90 days of hire and recurrent training every three years (A hazmat employee is defined as a person who directly affects hazmat transportation safety, including loading and unloading the cargo). CFR Sec. 172.704 requires that hazmat employee training include the following:

1. *General awareness/familiarization training* – including recognition and identification of hazardous materials.

2. *Function-specific training* – specific information applicable to the functions the employee performs.

3. *Safety training* – emergency response information, personal protective equipment, methods and procedures for avoiding accidents.

Although since 1992 the rate of NARs per 1000 hazmat carload originations has declined substantially, the railroad and chemical industries and the FRA believe that further reduction is achievable. The mandatory training requirement has likely contributed to the decline in NARs, but a question that arises is whether or not hazmat training could be more effective. One possible factor limiting the effectiveness of hazmat training is a mismatch between the written training materials and the reading skills of those who are trained.

1.3 Objective

The overall objective of this project is to assess the compatibility between the hazmat loaders' educational/reading skill levels and the written training materials used by the chemical industry. The specific tasks involved in accomplishing the work are to:

1. Gather information on the educational background and reading skills of typical hazmat loaders.

2. Gather information from chemical companies on the written training methods used for hazmat loader training.

3. Analyze the data to determine the compatibility between employee educational background/reading skills and the written training materials.

1.4 Scope of Project

The scope of the project is limited to the assessment of compatibility between hazardous material loading training programs and the trainees. Only the training programs' instructional materials were examined. As a result, there were several areas that were not studied, analyzed or otherwise systematically assessed. They include:

1. On-the-job training practices.

2. Content of the training program.

3. Operational procedures used in loading tank cars.

4. Corporate safety culture.

5. Working conditions, including shift work schedules, and heat/temperature/weather and noise in the work area.

6. Physical environment, including the interface and design of the loading equipment (valves, pumps, lines, etc.).

When reviewing this report, therefore, it is important to keep in mind that there are other factors that potentially affect a hazardous material loader's job performance and the rate of NARs.

To assist chemical companies in evaluating and improving their training programs, a set of guidelines for instructional methods and media was prepared. Examples from actual company training programs illustrate the guidelines and are included as best practices.

1.5 Organization of the Report

The report is organized into seven sections. Section 2 describes the technical approach that was used to assess the hazardous material transportation written training materials. Section 3 provides brief case study summaries of each of the four programs that were reviewed. Section 4 provides the results of the reading level assessments that were performed on each training program. Section 5 provides a general set of guidelines for instructional methods and media as they relate to hazardous material transportation training. The goal of this section is to provide the reader with some best practices. Section 6 discusses the results of the reading level assessment and provides some direction for future research and inquiry. Lastly, Section 7 provides a list of references. In addition, there are two appendices. Appendix A includes the two structured interview guides and employee background survey used to collect data on the chemical companies, the chemical companies' hazmat loader training programs and employee education and work experience. Appendix B includes a list of guidelines for writing instructional materials for individuals with limited reading skills.

2. TECHNICAL APPROACH

The overall approach to determining the reading levels of loaders of hazardous materials and the written training materials used with these employees involved case study evaluations of selected chemical companies that ship hazardous materials by rail. Time and resource limitations did not permit an exhaustive survey of chemical companies. Instead a case study approach was adopted as a means to examine the relationship between employee reading skills and written training materials. This section describes selection of companies for the case studies, data collection methods and analysis methods. Figure 3 illustrates the overall technical approach used in this study.

2.1 Selection of Chemical Companies

Through contacts at the AAR Bureau of Explosives, the FRA Office of Safety and the Chemical Manufacturers Association, candidate case study sites were identified. Companies were recommended based on concerns expressed by their representatives regarding reducing NARs. An attempt was made to secure the cooperation of companies of varying sizes and in different regions of the country. Since corrosives are responsible for the largest number of NARs, companies that ship these substances were specifically included. No attempt was made to identify companies based on their incidence of NARs.

Four chemical companies were selected as sites for case studies. (Section 3 contains descriptions of each of the four companies, their training program and their employees.) Of the four specific facilities that were visited, two sites had more than 500 employees, while the other two sites had fewer than 500 employees. The locations of the companies ranged from the south to the midwest, and each of the four locations drew on different labor populations. The chemicals handled by the four companies ranged from ferrous chloride, a mild corrosive, to ammonia and ethylene oxide. The size of the facility and the number of trainees determined whether classroom or individual self-paced training was employed. For all companies, on-the-job training made up the major component of the training program.

2.2 Data Collection Procedures

Data collection methods included structured interviews, written surveys, and aptitude testing. Structured interviews with chemical company managers and training officials were used to obtain company information and a complete description of each training program. A written survey was used to obtain information on the educational background and work experience of each hazardous material loader, and a portion of a general intelligence test was administered to assess the loader's verbal skills. Copies of each company's training materials were also

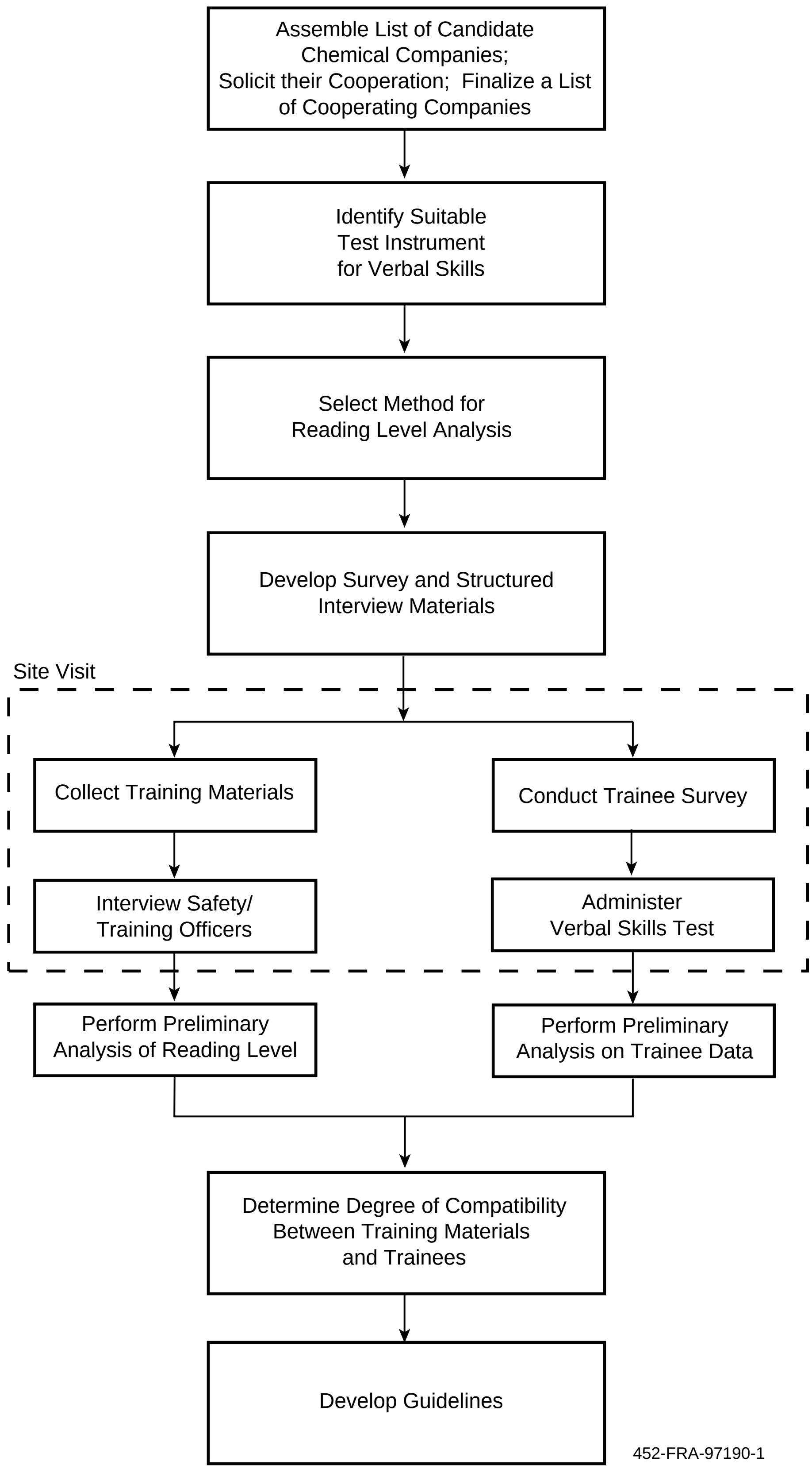

Figure 3. Overall approach for analyzing hazmat training

collected as part of each site visit. Appendix A contains copies of the structured interview guide used to gather company information, the structured interview guide used to gather training program information, and the survey used to elicit information from trainees.

Several candidate test instruments were considered for assessing verbal abilities of the trainees. The Multidimensional Aptitude Battery (MAB) (5) was selected because it is 1) quick and easy to administer, 2) appropriate for group administration and 3) age appropriate. Furthermore, the MAB has been highly correlated with the WAIS-R, an established standardized test that is administered to adults to measure verbal aptitude, among other abilities. The MAB is comprised of two sections, verbal and performance, and each section is made up of five subtests. Two of the five verbal subtests from the MAB were administered to assess hazardous material loaders' verbal skills.

After the cooperation of the four case study sites was secured, site visits were scheduled to each participating location. First, structured interviews were conducted with plant management and/or training officers. Information was collected about the specific facility as well as about their training program. Then the background survey was administered to as many hazardous materials loaders as was possible or convenient to the host chemical company. The two selected verbal tests from the MAB were administered to this same group of employees. It took less than 30 min to administer the two MAB subtests and have the loaders complete the background surveys. Training materials from each of the four companies were also collected as part of each site visit. To ensure complete cooperation and participation from all four companies and all respondents, anonymity of the corporate training materials and participating hazardous materials loader responses was assured.

2.3 Data Analysis Methods

Determining the compatibility between the trainees and the textual instructional materials requires applying a measure of readability to the materials and then comparing it with data on the trainees' formal years of education along with the MAB results. This section explains the Fry readability metric chosen for this study and then offers four different approaches in its application to the materials available from the case study programs. The four different approaches are the following:

1. Comparison of the Fry readability level with trainees' attained educational level.

2. Comparison of the Fry readability level with estimated instructional and independent reading levels of the trainees.

3. Comparison of the Fry readability level with estimated reading levels of the trainees where the Fry index is adjusted to reflect internal text organization.

4. Qualitative application of conclusions derived from the 1993 National Adult Literacy Survey conducted by the National Center for Educational Statistics of the U.S. Department of Education.

Application of each of these four approaches is described in Section 4.

2.3.1 Readability Index

Text comprehensibility has been assessed in terms of word difficulty (familiarity, frequency, length) and sentence complexity or length. These assessments have been formulated into readability formulas that may be applied against text samples. A readability formula is a mathematically obtained rating of the grade reading level of written materials. Some of the better known formulas are Dale-Chall (6), Flesch (7) and Fry (8). The Dale-Chall and Fry methods are often used to assess adult level text.

Readability formulas are typically the product of a multiple-regression analysis of factors found to contribute to the comprehension scores of text of known grade level. The Dale-Chall has been criticized due to its origination in a criterion measure whose text passages were not considered adequately normalized as to grade level (9).

One of the limitations of readability formulas is that they are typically blind to higher-level text organization. For example, readability formula scores for a given text selection will not change if the word order within each sentence of the selection is scrambled. The use of physical indicators of main topic, such as headings and underlining or such cueing features as interspersed questions or the direct presentation of instructional objectives, are factors that may influence comprehension. Reading formulas do not identify or account for this type of text feature.

Another limitation of readability formulas is that they are entirely reliant on factors that exist solely in the text itself. Zakaluk and Samuels (10) have termed these factors “outside the head factors” in comparison to the “inside the head” factors of reader reading skills, familiarity with the subject matter, and understanding of technical words or expressions. In the end, the comprehensibility of a given text selection is the result of an interaction between an individual reader and the text. Zakaluk and Samuels also suggested that word recognition skill and prior knowledge of text content are indicators of reading ability.

Given an awareness of the limitations in interpretation of results, readability formulas still can convey important information about the potential that a given text selection may have for comprehensibility. To that end, the Fry method is recommended, based on its prior use with adult level text and its relative ease of use.

The Fry estimation method requires that the average number of syllables and the average number of sentences be determined for three 100-word passages taken from a text selection. Fry suggested that if a high variability were found in the three selections that additional 100-word selections should be used. The Fry procedure involves the following steps:

1. Select three 100-word passages from different parts of the material.

2. Count the number of sentences in each 100-word passage, rounding to the nearest tenth of a sentence. Average these three numbers.

3. Count the total number of syllables in each passage. Compute the average number of syllables for the three passages.

4. Plot the sentence and syllable averages on the Fry graph, shown in Figure 4, to determine the grade level for the document.

The Fry graph is based on word/syllable averages taken from graded reading materials. The findings from these materials were plotted and then compared against other readability formulas to create the final form of the graph. Fry added high school and adult materials by comparing tests of comprehension for these materials with other readability formulas. Fry warned that all readability formulas share a validity problem in the sense that there is no absolute measure of what constitutes grade level for reading material. Fry reported that the accuracy of his method could be non-technically described as being "within about a grade." Other readability formulas claim wider variation in accuracy. For example, Dale-Chall reports their findings as falling within two grade categories, e.g., "5-6."

Fry intentionally did not copyright his method and graph so that others could readily use the methodology. Figure 4 contains the Fry graph. A copy of the graph in slide rule form is available from Jamestown Publishers, Lincolnwood, IL.

2.3.2 Comparison of Fry Index to Educational Level

There are considerable limitations to a comparison of this type. A readability index is sensitive to text *attributes*, but not to text *content*. Two reading selections might have similar readability indexes and yet demonstrate a considerable difference in an actual test of reader comprehension. Another concern is that a level of educational attainment is not a guarantee of a specific "grade level" of reading skill. There is considerable variability in tested reading level for any grade level group of individuals, even when they are taken from the same educational system and classroom. These differences tend to increase as grade level increases.

Given an understanding of the limitations, selecting or preparing reading materials based on a readability index figure that matches a group's level of educational attainment is certainly better than blindly selecting materials. Since a readability index like the Fry is easily computed and trainee group educational levels can be anticipated, it is not unreasonable to attempt to match material to estimated reading levels in this way.

2.3.3 Comparison of Fry Index to Estimated Instructional and Independent Reading Levels

Given unlimited resources and ample time, a number of reading assessment instruments could have been used in the study to obtain an index of reading skills. For the practical purposes of the study, however, it was decided to administer the MAB. (Subsection 2.2 discusses this instrument.) The virtue of the MAB is that the subtests utilized are known to have high verbal loading. Traditionally, measures of this type show high statistical correlation to measures of reading skills.

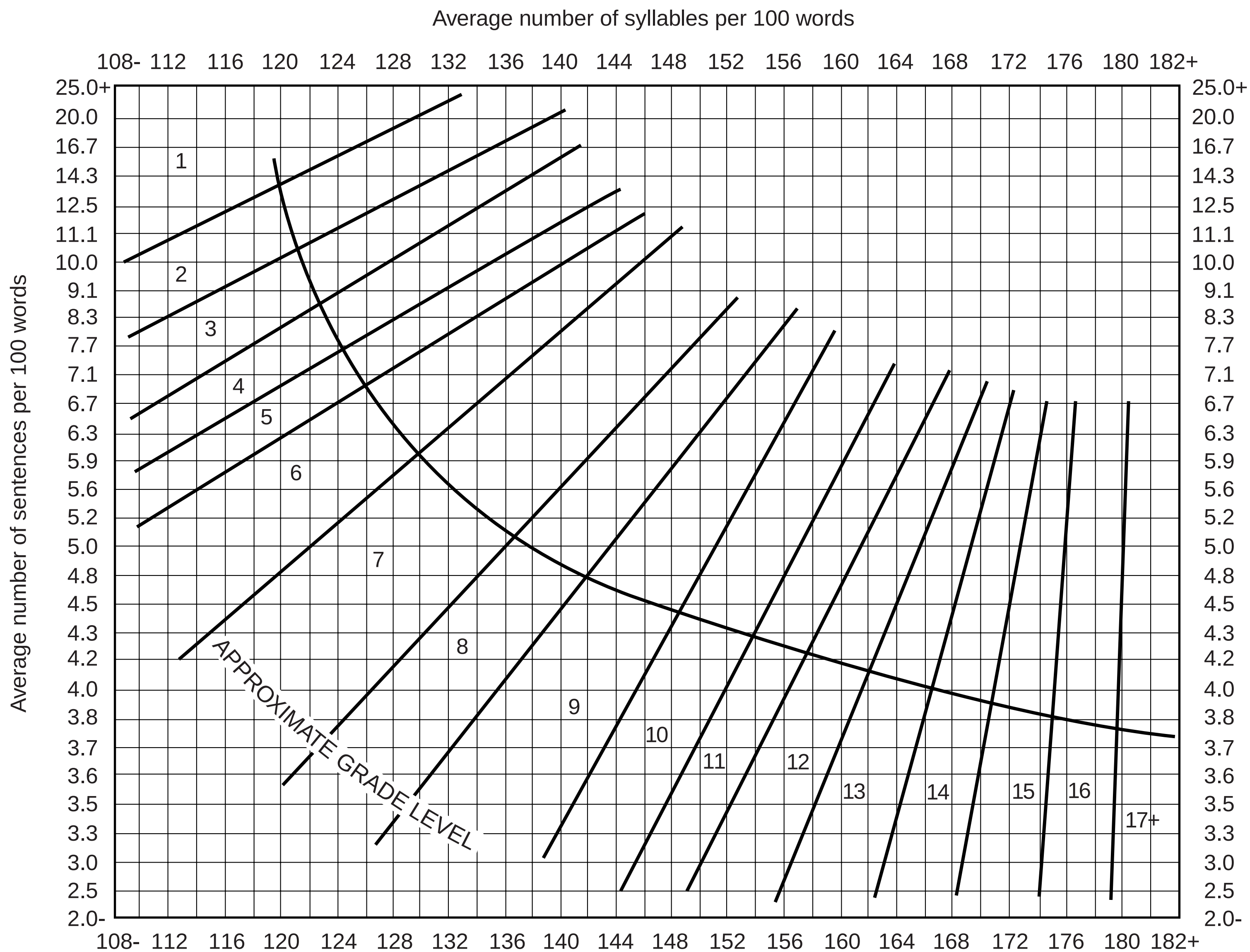

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Figure 4. ***Fry readability graph***

The MAB produces IQ scores. These are standard scores produced relative to an individual's age level. As such, this means that identical scores for two individuals of different ages do not necessarily imply equal skill levels. Particularly in the case of adults, some skills do not increase with age and may, in fact, actually decline. As a practical matter, however, people with higher scores will tend to do better at a given task than people with lower scores regardless of age level. This statement is most true when the task is one that reflects the skills measured by the test.

Prior to the use of standardized scores, the IQ was understood to represent a ratio based on apparent "mental age" over actual chronological age. While this comparison is no longer accurate in a computational sense, it is conceptually valid to understand the IQ score as an index of observed versus expected skill level. For example, a person with an IQ score of 90 for verbally loaded tasks may be understood to be performing slightly poorer than expected for that individual's age or attained educational level. A person with an IQ of 100 in the same situation would be understood to be performing at expectancy level.

Attained educational level is not a reliable predictor of actual reading skill. By the eighth grade, teachers expect reading ability grade levels within a given classroom to cover a span of four or more years. These differences persist through high school. Based on the concept of MAB IQ as an index of reading ability, the MAB score was divided by 100 and then multiplied by the individual's years of schooling to produce an estimate of reading skill level. For example, an individual with a MAB subtest IQ of 90 and an attained educational level of twelfth grade is estimated to have an instructional reading level of 10.8.

Traditionally, reading skill levels have been assumed to represent an "instructional level." This means that an average reader at a given *instructional* level is expected to make errors when attempting to read materials prepared for that level. Betts (11) originally suggested this concept. In practice, instructional level error rates of 15 to 20 percent in oral reading are considered acceptable. Because of this, the Fry index is similarly assumed to suggest instructional reading level, as it is based on actual graded reading materials. Traditionally, the concept of *independent reading level* is used to convey the idea of text difficulty that reduces a reader's error rates to 5 percent or less. In practice, instructors often select materials for independent reading that are two or more year levels below a student's instructional reading level.

There is a trend for training programs to move away from instructor-intensive instruction toward remote site and computer-based forms of instruction. These newer forms of delivery place a higher burden on the reading skill of the trainee in the form of increased need to read materials and computer presentations independently. Due to this trend toward independent learning strategies, the subjects' estimated instructional reading levels can be assumed to be two years lower than their independent reading levels. The estimated instructional reading level can be compared to the Fry index of the training materials.

2.3.4 Adjustment of Fry to Reflect Internal Organization of Text

Zakaluk and Samuels discussed limitations of readability indexes that arise from the focus of these measures on simple text attributes. These authors related findings from their own research that indicated text comprehension was positively affected by what they termed *adjunct aids*. Adjunct aids were defined as statements of objectives and the provision of questions or self-tests within the text designed to focus the reader's attention. The positive impact on comprehension of these aids was such that Zakaluk and Samuels proposed that a Fry Readability Index would more accurately predict comprehension if it were lowered half a grade level for each of the two aids when these were present. This adjusted Fry index can be compared with the estimated instructional reading level described above in subsection 2.3.3.

2.3.5 Qualitative Application of Conclusions from the 1993 National Adult Literacy Survey

The National Center for Educational Statistics periodically conducts studies of adult literacy. A 1998 survey is underway. The prior survey, conducted in 1993, had a total of 26,000 respondents with an age range of 16 to over 65. The National Adult Literacy Survey (NALS) does not use the concept of reading grade level, but instead uses specific tests of functional reading skills. The survey produces proficiency scores on three scales that reflect skill in prose, document and quantitative literacy. Based on standard scores, each of the three scales is divided into five levels. Each level has task characteristics that distinguish it from the next highest level.

Schierloh (12) summarized the characteristics of the lowest two of the five skill levels (Levels 1 and 2). Her summarization stated that "Level 1 readers can read short pieces of text and locate a single piece of information that is identical or synonymous with a question about the material. Level 1 readers can perform single arithmetic operations based on text if the numbers they are to use are provided as digits within the text (such as supermarket advertisements) and the operation they are to perform with the numbers is explicit or stated to them. Level 1 readers can ignore distracters in printed information as long as the distracting material is not placed near the correct information."

Level 2 readers can handle several distracters and are able to synthesize information from various parts of a simple document. Level 2 readers can perform single arithmetic operations if the numbers are easily located in the text as digits.

Level 1 and 2 readers experience difficulty in the synthesis of multiple pieces of information. They are likely to fail in attempts to search through complex tables and graphs with a variety of information and numerous distracters. Level 1 and 2 readers are not likely to succeed in a search for numbers if they are embedded in the text and cannot perform arithmetic operations if the operation to be used is not stated explicitly or made apparent by the format of the document.

The Executive Summary of the 1993 NALS indicated that Level 1 and 2 readers were likely to experience considerable difficulty in dealing with tasks that required them to integrate or synthesize information from complex or lengthy texts. They would also experience difficulty in attempting to perform numerical operations that required them to set up a problem and then perform two or more sequential operations.

The 1993 NALS reported that approximately 51 percent of American adults fall at Levels 1 and 2. Kirsch, et al. (13) reported that the survey levels were found to be correlated with educational attainment. Scale scores that marked the top of the second interval were presented as correlating to a high school education.

The three upper levels of the survey are characterized as representing increasing abilities to synthesize responses based on increasing levels of complexity and length of text. The highest levels require skills such as ascertaining a writer's motivation or drawing mathematical inferences from presentations of data.

It is important to note that individuals can perform tasks that fall above their NALS scale score level. A Level 2 task is designed to be successfully completed by 80 percent of Level 2 readers. This means that at least some Level 1 readers will successfully complete a Level 2 task. The likelihood of success decreases sharply, however, as the gap between reader level and task levels increases. Typically, only 30 percent or fewer Level 1 readers might be able to successfully complete a Level 2 task.

Based on the NALS findings, it is reasonable to ask how many of the employees in the current study have an educational attainment of high school level or less and whether these individuals are provided with text that might be characterized as long and complex or whether the text material requires the reader to integrate or synthesize information. In either instance, it might be suspected that some significant proportion of the "high school or less" employees would be unlikely to profit from material with these characteristics. A review of this type would not have the power of the NALS task classifications since the level of the NALS tasks was determined through statistical analysis of the answers of 26,000 respondents. Nevertheless, this type of review does allow an evaluation of text that goes beyond the simple attributes approach represented by readability indexes and may serve as a worthy adjunct to the other approaches used in this study.

3. COMPANY PROFILES

Four companies, of differing sizes and specializing in different types of chemicals, served as representative case studies for this study. Each company has multiple sites in North America and abroad. One site from each company was included in the case study evaluation. Table 3 gives an overview of these four sites. The following subsections present brief summaries of each of the four sites that participated in the case study evaluation. The general format for each of the four summaries is the same. First, the facility is described in terms of volume, location, and type of product produced or handled. Next, an overview of hazardous material loading responsibilities at each site is provided. Then the training program is described in terms of trainer experience, structure, instructional methods and media, and proficiency testing. Finally, background information from the hazardous material loaders at each of the sites is presented. To maintain anonymity, each company is simply referred to by letter (e.g., Company A, B, C, and D) rather than by corporate identity.

Each training program has two basic components: 1) general introductory or orientation training and 2) job specific training. General introductory training includes topics such as corporate safety policies and equipment, incident reporting, emergency evacuation procedures, personal protective equipment and recognition and identification of hazardous materials. Job specific training encompasses all of the duties and responsibilities involved with loading and unloading hazardous materials.

Table 3. Characteristics of case study sites

	Company A	Company B	Company C	Company D
Location	Texas	Indiana	West Virginia	Oklahoma
Number of Employees	1300*	30	800	100
Types of Chemicals Produced/Shipped	Corrosives Flammables Poisons	Mild corrosives	Flammables Combustibles Corrosives Poisons	Corrosives Flammables
Tank Car Shipments	25 to 30/day	2 to 3/week	8 to 12/day	8/day
Duration of Training	Up to 2 years	1 month	6 months	6 weeks to 6 months

* Includes both company and on-site contractor employees.

Table 4 presents the training methods and materials used by the four companies in each aspect of the training. More detail on the methods and materials is provided in the following subsections.

3.1 Company A

3.1.1 Description of Facility and Loading Responsibilities

Located in Texas, this large chemical processing plant has approximately 1300 employees, about 300 of which are contract workers. Twenty contractor loading operators and four chemical company loading operators work morning or afternoon 8 hr shifts, Monday through Friday, with occasional overtime worked as needed on Saturdays. Loading operators at this facility do not work third shift.

Using three "racks," operators load and unload approximately 25 to 30 rail cars per day during first shift. During second shift, loading that was not completed at the end of first shift is completed and the tank cars are secured for shipment. Loading operators also load and unload about 30 tank trucks a day using a third loading rack; however, discussion of loading procedures and training will be limited to those applicable only to rail tank cars. Loading operators are also responsible for cleaning tank cars. During second shift, a contract switch crew moves the loaded rail cars to a storage area where the cars will be picked up by the railroad. This crew also spots empty cars to be loaded the next day; however, the loading operators perform any switching that needs to be done during first shift.

Table 4. Training methods and materials

	Classroom	Videotape	CBT	Field trip	OJT
Company A					
Introductory Training	√	√		√	√
Job-Specific Training	√			√	√
Company B					
Introductory Training	√		(or) √		
Job-Specific Training					√
Company C					
Introductory Training		√	√		
Job-Specific Training	√			√	√
Company D					
Introductory Training	√	√	(Developing)	√	
Job-Specific Training					√

Only the wash rack is covered; all loading racks are uncovered. Loading operators are, thus, exposed to inclement weather such as rain and the sun. During hot weather, loading operators are encouraged to take frequent breaks, particularly if wearing a lot of personal protective equipment (PPE) such as chemical splash suits, respirators, and rubber gloves.

This facility produces over 15 different chemicals, including corrosives, flammables, and poisons. The most hazardous chemical handled at the facility is ethylene oxide, which requires the use of respiratory protection equipment when hooking up or disconnecting tank cars. (See Figure 5.)

3.1.2 Description of Training Program

Background

Over the past few years this facility has been moving toward using contractor employees to load tank cars. Contractor employees have replaced company employees who are lost through attrition. Currently there are 20 contractor employees and four chemical company employees performing loading and unloading. The training program was developed over the last few years specifically to train the new contractor employees.

Figure 5. Respiratory protection equipment is required when unloading ethylene oxide

Trainer Experience

An instructional designer and an experienced loading operator (i.e., subject matter expert) worked together to develop the training materials and program used at this facility. Both individuals are directly involved in delivering the training.

Training Overview

The overall goal of the training program is to provide the knowledge, skills and attitudes necessary to safely perform the duties of a loading operator. Training covers both tank car loading and tank truck loading, since loading operators are responsible for loading both types of vehicles. The training program is oriented toward novice loaders (i.e., the contractor employees), and is driven by learner-centered objectives (e.g., “At the end of the lesson, you will be able to identify a, b, and c”). At the time that the training program was implemented, there were several contractor employees who had already been trained and were working as loading operators. However, all contractor employees received the training to ensure that they were all privy to the same information.

Structure of Training Program

The training program is divided into three “phases.” Phase I provides the trainee with an introduction to loading and unloading hazardous materials, safety, and team work. As part of Phase I training, employees also receive their DOT General Awareness Training (per 49 CFR 172). Phase I requires 64 hr of training, of which 90 percent is spent in the classroom, and 10 percent is spent in the field. Upon completion of Phase I training, each employee is assigned to the wash rack for 30 days of on-the-job training (OJT). A supervisor monitors and directs the employee’s progress while on the wash rack. The employee progresses to Phase II after completing 30 days of OJT.

Phase II provides employees with a foundation of knowledge on each loading rack and equipment system that they will be working on or using. Phase II requires 40 hr of training, divided into several modules that are function-specific (e.g., switch engine operation, the tank truck rack, the aldehyde tank car rack, etc.). Phase II training is divided into approximately 60 percent classroom instruction, and 40 percent field trips, in which a supervisor goes out with each employee one-on-one and shows, demonstrates, and simulates various devices, activities and functions. Each module in Phase II training consists of classroom instruction followed by a field trip.

Referred to as progression training, Phase III training is on-the-job (OJT). Phase III training enables trainees to acquire hands-on skills under the guidance and supervision of a mentor. Phase III training is also divided into several function-specific modules (e.g., switch engine operation, the tank truck rack, the aldehyde tank car rack, etc.). Training times for each module within Phase III vary, and may last as long as six months. In Phase III training, under the supervision of a mentor, the trainee applies the knowledge learned in Phase II training. Trainees are aided by checklists, which they use to ensure that they are following the exact procedures.

Phases II and III of the training combine to provide employees with the knowledge, skills and attitudes necessary to perform the specific tasks required of a loading operator. Both Phase II and Phase III are made up of multiple modules (e.g., wash rack, aldehyde rack, atmosphere rack, etc.) Immediately after completion of each module within Phase II, Phase III training (OJT) specific to that module begins. For example, a trainee may learn *about* loading chemicals at the aldehyde rack in Phase II. Upon successful completion of this module in Phase II, the trainee begins Phase III training to acquire the skills necessary to load the chemicals at the aldehyde rack. After an employee completes the module-specific Phase III training, the employee returns to the classroom to begin the next module in Phase II training. Figure 6 provides a graphical schematic of the progression back and forth between Phase II and Phase III training. The process of progressing from Phase II to Phase III and back to Phase II continues until all of the Phase II and Phase III training modules have been completed.

Apart from the training program described above, loading operators also receive tank car inspection training from an off-site contracting firm as part of initial training. Thus, including all initial training, it takes loading operators at this facility approximately two years to become fully qualified to load hazardous materials into tank cars.

Instructional Methods and Materials

This facility utilizes a variety of instructional methods for their loading operator training, including lectures, audio-visual aids (e.g., videos), hands-on demonstrations, field trips, and checklists (Phase III training). In addition, a computer-based training (CBT) system is being developed to help train loading operators.

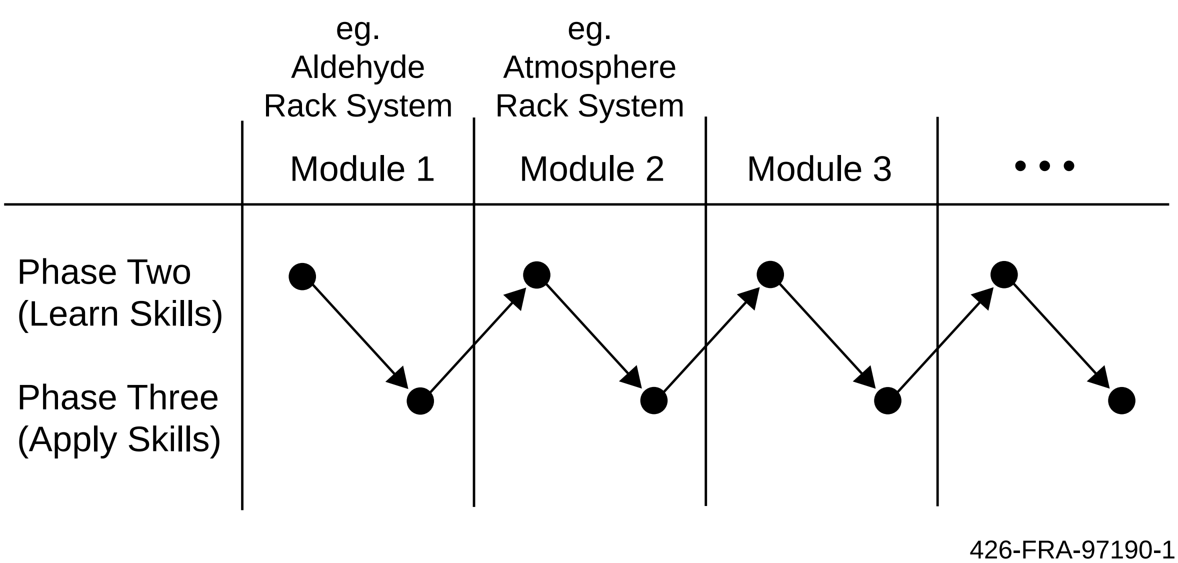

Figure 6. Progression back and forth between Phase II and Phase III training

Proficiency Testing

Throughout Phase I, trainees are expected to score 100 percent on all knowledge tests and demonstrations. If an employee fails to score 100 percent on a test or demonstration, they are coached on the missed items and re-tested. If 100 percent is not obtained on the re-test, the employee is terminated from the program if they have been with the contractor for less than six months, otherwise they are coached again and re-tested.

Trainees must complete multiple skill demonstrations throughout Phase II training, whereby the attending supervisor must sign off on each demonstration. Phase III progression training is similar in that the trainee must complete several skills demonstrations; however, in addition, they must obtain 100 percent on several knowledge tests. Again, the supervisor, aided by a checklist, must sign off on each demonstration or test.

Refresher Training

Apart from the progression training, Phase III training also includes refresher, or ongoing, training that is used to apprise loading operators of any changes in operating procedures, loading process changes or safety issues. Refresher training involves some classroom work and some OJT. Refresher training that covers standard operating procedures and critical loading tasks is conducted annually, while the frequency and specific content of additional training varies depending on the need for training (e.g., there is a change in the loading procedure which warrants immediate re-training). Both the contractor employees and the company employees receive refresher training.

3.1.3 Employee Information

Candidate Screening

The contractor hires individuals specifically to work with hazardous materials. The contractor looks for experienced loaders to work at this facility. When screening, they also look for signs of employee stability. New contractor employees are also tested for illegal drugs (there is also random drug testing of *all* workers at the chemical processing facility). All prospective contractor employees are also interviewed as part of their screening process. One of the goals of the interview is to ensure that each candidate is proficient in English, since it is imperative that all individuals who handle hazardous materials, including loading operators, are able to communicate clearly and effectively to each other and their supervisors. In the past, the contractor screened for certain physical requirements but has abandoned this criterion, believing it to be ineffective at eliminating those individuals who may not be prepared for certain jobs handling hazardous materials.

Employee Backgrounds

Sixteen contractor loading operators and four company employees were surveyed. Since the training program was primarily developed for the newer contractor employees (i.e., target audience), information is reported for this group only. The average age of the contractor loading operators was 32 (range 20 to 59). All 16 operators were male. Thirteen were native English speakers, two were native Spanish speakers, and one respondent did not provide this information. Survey respondents had an average of five years of hazardous material experience (range six months to 38 years). Eleven respondents had at least a high school degree or equivalent (GED), and two had college degrees. One respondent did not provide this information.

3.2 Company B

3.2.1 Description of Facility and Loading Responsibilities

This small privately owned company, headquartered in Illinois, reprocesses "pickle liquor," acid generated during steel production, into iron salts that are used to treat wastewater. Iron salts include ferrous chloride, ferric chloride and ferric sulfate. The company's fleet of tank trucks and tank cars collects pickle liquor at steel mills across North America, transports it to one of three plants for reprocessing, then transfers the iron salts to some 24 distribution sites throughout the United States and Canada. A distribution site in Indiana was visited for this case study. The company currently has a fleet of 282 tank cars and plans to add 20 to 30 over the next year. Each distribution site handles a minimum of two to three carloads a week but volume varies by location. Since many steel mills and many customers do not have rail lines accessing their facilities, the company must use a combination of tank trucks and tank cars to move both raw materials and finished product. Until five years ago, the company moved nearly all products via tank truck, but expansion of the company's business necessitated the use of tank cars, which have four times the capacity of a tank truck. Currently about 10 percent of shipments are in tank cars.

The company has some 25 to 30 trained loaders. Some of the 24 distribution sites are terminals operated by a third party. Product shipped through these locations is unloaded by the terminal operator into tank trucks and does not require that the company's truck driver be trained to unload from a rail car. The remaining distribution sites must have at least one person trained for the unloading operation. Depending upon volume, there may be more than one trained loader/unloader. All are company employees; no contractors are used. These employees perform other duties, in addition to moving raw materials or product from rail car to tank truck and tank truck to rail car. In fact, most of the company's loaders are licensed commercial truck drivers whose primary job is to deliver product to customer locations. As truck drivers they work rotating shifts which are governed by federal or state hours of service regulations.

Loaders work in uncovered open air locations where temperatures can range from sub-zero to 100°F. Employees are provided with personal protective equipment, including gloves, goggles and a rubber splash suit. Due to the mild corrosive nature of the products handled a splash suit is not mandatory.

3.2.2 Description of Training Program

Background and Trainer Experience

In the past year two new rail loaders/unloaders have been trained. Because of the small number of employees that must be trained and their diverse locations, the Logistics Manager does tank car training on a one-on-one basis. The current Logistics Manager, an individual with over 30 years of experience with the movement of hazardous materials, developed the training program. Underlying the training program is the philosophy that the purpose of the training is to enhance the employee's ability to do a safe job.

Training Overview

Depending on the location, most employees are trained to load/unload both tank cars and tank trucks. The truck portion of the training is handled separately from the rail tank car training and is not described in detail here. DOT Awareness Training is covered in the truck portion of the training and is administered by the Traffic Compliance Officer.

Structure of Training Program

A new driver spends up to three days on initial safety and hazmat awareness training. A packaged training program, consisting of four videos with companion workbooks and exams, is used for the DOT Awareness Training. Every employee also goes through a computer-based training system that covers all hazmat regulations, including those for categories of hazardous materials that are not among the company's products. This initial training includes understanding a materials safety data sheet (MSDS), procedures for emergency response and use of personal protective equipment.

After the initial classroom and self-study portion of the training, a driver is trained on tank truck procedures. Only after mastery of the truck duties is the driver ready to begin function specific training for loading/unloading rail tank cars.

The sequence of the rail tank car training session is as follows:

1. Explain the RSPA regulations to the employee to emphasize the importance of following proper procedures. Emphasize the company's commitment to safety.

2. Go over each of the three phases involved in loading and unloading. The three phases are: 1) prepare to load/unload, 2) load/unload, 3) secure for shipment or empty return. Each phase has six steps.

3. Demonstrate the procedures and allow the employee to practice with supervision and guidance.

4. Test the employee by having the trainee write out the six steps for each phase of the loading and unloading processes.

The training session with a new loader may take up to 8 hr. Since it is a one-on-one training session, the trainer can adjust the time to meet the needs and skills of the student. Following the one-on-one session and test, the employee spends two to three weeks riding with an experienced driver for on-the-job training.

Instructional Methods and Materials

The trainer uses true stories to illustrate real life practices and believes this is a major contributor to the success of the one-on-one training approach. Instructional materials used during the training session consist of hardcopy excerpts from the RSPA regulations, shipping and receiving checklists, rail car diagrams and the six step procedures. The current trainer is considering preparing a "homemade" video to use in the training as well.

The company has also adapted the training to the needs of its non-English speaking employees. This training has been offered in Spanish through the use of an interpreter. A similar arrangement has been used for French speaking employees in Canada.

Proficiency Testing

The employee does not become a certified loader/unloader until he or she can successfully write out all steps for each phase of the processes. If an employee has difficulty recalling the process, the trainer works with the individual until the employee knows the procedures.

Refresher Training

Refresher or retraining sessions usually involve only the one-on-one discussion and testing and are completed in 3 hr. If there have been problems with an individual loader, the trainer may include some hands-on training as well.

3.2.3 Employee Information

Becoming a trained loader is considered a "step up." Most trainees are already employees who are being trained for added responsibilities. In addition to truck drivers, plant maintenance staff, trailer mechanics and hazardous material handler technicians may also have responsibility for loading and unloading rail cars.

Employee Backgrounds

Because the company's employees are geographically dispersed, data was gathered from only four employees. All four were male and were native English speakers. Two of the four employees had at least a high school diploma or technical school education. The average age of the four employees was 38 (range 25 to 49). Three of the four employees were experienced handling hazmat and averaged 12 years of experience. They had been working with hazardous materials throughout their tenure with the company. The fourth employee was about to begin training.

3.3 Company C

3.3.1 Description of Facility and Loading Responsibilities

This facility, located in West Virginia, has approximately 800 employees. Loaders work 12 hr rotating shifts. Four loaders typically work each shift, however, about 160 employees at the plant are trained for loading. Operators load both rail cars and tank trucks. This facility does all of its own training, although occasionally a contractor will provide training on a specific device that they manufacture, such as a particular valve.

This facility loads about 8 to 12 rail cars per day, handling all but the Class 1 and Class 7 chemicals, primarily flammable gases and liquids; combustible liquids; corrosives; glycolic acid; and poisons.

This facility is a 24 hr, 365 day/year operation, where four groups of employees rotate through two 12 hr shifts. The morning shift begins at 6:00 am; the evening shift at 6:00 pm. Employees work three day shifts, followed by three night shifts. The average number of consecutive workdays is four, and operators typically work 14 days out of 28. Employees may work an additional 4 hr of overtime per shift if necessary; in a true emergency, they may work an additional 6 hr. According to one of the trainers, the operators are very happy with this work schedule.

All loading areas but one are uncovered. The covered area is a roof only; there are no walls. Temperature-controlled sheds are maintained for the operators to get out of the heat or cold.

3.3.2 Description of Training Program

Background

This facility developed its own training materials, borrowing from other resources and tailoring them to suit their own needs as appropriate. A training program originally developed for emergency response personnel and operators was later adapted for training loaders and unloaders.

Trainer Experience

Trainers have generally come from supervisory positions. The facility has a “promote from within” policy, therefore trainers often served as operators for a stretch of time prior to moving into supervisory roles, or they may have worked in another area of the facility prior to working in the loading area. For example, the training supervisor was a supervisor in another branch of plant operations for 12 years prior to supervising the training of loading operators. Trainers are also chosen for their interpersonal and delivery skills.

Training Overview

The minimum training duration for chemical loaders is just over six months, and includes DOT General Awareness and function-specific training, working with both low pressure chemicals and high pressure chemicals. In addition, off-the-street hires, those individuals with no facility experience, must first complete three months of general training that covers math, physics and chemistry. However, since this facility has not hired an off-the-street loader since 1982, this was not an issue.

Structure of Training Program

Completion of basic training makes the employee eligible for training with hazardous materials. If there are at least eight trainees, formal lecture/classroom training will take place, using a text as well as audio-visual aids. The facility uses the CMA video for the DOT General Awareness training. Function-specific training is then conducted in a classroom using a text. When the number of trainees is less than eight, operators self-manage their training by using the text in conjunction with CBT. All other elements of the function-specific training are the same. Upon completion of the function-specific training, OJT begins. OJT with a designated mentor is a primary component of training, and lasts approximately three months for low-pressure chemical handling, and another three months for high-pressure chemicals. Mentors, who are trained by the training staff, monitor the trainee's job training and performance. The trainee must get 100 percent correct on job skills demonstrations as rated by his or her mentor. The mentor has a checklist of all of the skills in which the trainee must demonstrate proficiency. After the trainee passes all of the job skills demonstrations, the mentor signs off on the proficiency test, followed by the supervisor.

In addition to the above training, spot training in particular methods, procedures, or skills occurs in response to specific incidents or accidents resulting from human error; however, this has not been necessary since instituting the new training program.

Instructional Methods and Materials

This facility uses several types of instructional aid including lecture, textbook, video, on-the-job training, and computer-based training with tutorials. Trainees are provided with a printed text that covers all of the information needed to safely perform hazmat work and pass the proficiency tests. The text is complemented by a computer based training program called the Training and Education Development System (TEDS). TEDS consists of 16 training modules. Some of the modules cover DOT general awareness training and others cover specific areas, methods, and devices. Employees are trained only on the specific functional areas in which they will work. For example, not all hazmat employees will load rail cars, thus they are not trained and tested on that module.

TEDS provides tutorials of the same material that appears in the text, and each module is followed by a self-quiz. Re-quizzing is possible, and the program allows students remediation on specific sections of information. Trainees are expected to use TEDS when not busy on jobs, and there are computers located in various areas of the plant for their use. The facility is currently developing a new CD-ROM program that will use multimedia formats and which will replace TEDS.

Proficiency Testing

For the CBT modules, students must score 100 percent correct on some modules and at least 80 percent correct on others.

The OJT mentor has a checklist of all of the skills in which the trainee must demonstrate proficiency. For OJT, the trainee must score 100 percent correct on job skills demonstrations, as rated by his or her mentor. After the trainee passes all of the job skills demonstrations, the mentor signs off on the proficiency test followed by the supervisor.

Refresher Training

Operators are subject to “job cycle checks,” proficiency re-checks on all of the jobs an individual is qualified to perform. To stay qualified on a particular job, the employee must actually perform the job at least once every 3 months.

Additional training in specific elements of hazmat work (e.g., asbestos, respirators) occurs many times over the course of the year for chemical loaders. In fact, loaders are required to have 140 hr per year of government-mandated training alone.

3.3.3 Employee Information

Candidate Screening

This facility has not hired a new employee since 1982, however when they were hiring, all new employees were subject to a general physical, vision and hearing tests, medications disclosure, and basic aptitude testing in English, science, math, and physics. Employees at this facility receive health re-screenings based on age. Before age 40, employees are re-tested every 3 years. From ages 40 to 45, employees are re-tested every other year. After age 45, re-testing occurs annually. All facility employees are subject to random drug testing.

Employee Backgrounds

Employee information was gathered from eight volunteers; seven were male and one was female. All were native English speakers and all had at least a high school education, with two of the volunteers completing college. The average age of the volunteers was 43 (range 39 to 53). Mean length of hazmat experience was 17.5 years (range: 10 to 21.5). Average length of employment with this company was approximately 20 years (range: 16.5 to 22).

3.4 Company D

3.4.1 Description of Facility and Loading Responsibilities

Located in Oklahoma, this medium-sized chemical processing plant employs about 100 employees. The “Ammonia Plant” facility processes anhydrous ammonia and methanol, while a second “Upgrading Plant” facility located nearby produces and ships urea and UAN solution. Since neither urea nor UAN solution is classified as a hazardous material according to DOT regulations, discussion is limited to training at the Ammonia Plant only.

There are five Process Technician jobs at the Ammonia Plant. Listed in increasing responsibility, they are:

1. UAN and Ammonia Loading Tech I.
2. Utilities Tech II.
3. Gas Generation Tech III.
4. Synthesis Area Tech IV.
5. Process Control Board Tech IV.

The training philosophy at the Ammonia Plant is to train technicians to fill every technician job involved in the plant. Training is sequential, beginning with training new hires on the Technician I’s job responsibilities. Hazardous material loading is an entry-level job responsibility at this facility, and consequently tank car and tank truck loading is taught as part of Technician I and Technician II training. Since training is sequential, technicians are qualified for all positions leading up to their current post (e.g., a Technician III is qualified to perform the duties of a Technician I, II and III). Rather than using only Technicians I and II to load tank cars and tank trucks, technicians rotate in and out of each job for which they are qualified. Thus, there are no full-time loaders. Typically, technicians spend a week at each position, then rotate to another position.

The Ammonia Plant operates around-the-clock; technicians work 12 hr shifts. Technicians typically work three or four 12 hr night or day shifts in a row (equivalent to one work week), followed by 1 to 4 days of rest, and then their schedule alternates—those on night shifts switch to days, and vice versa. Eleven technicians plus a shift supervisor work each shift, and all 12 rotate their shift schedules together as a team. There are four different teams, totalling 44 qualified loaders, at this facility.

Loaders work in pairs, and typically load for an entire week (equivalent to either three or four 12 hr shifts) before rotating to another position. Another pair of technicians then rotates to the loading racks for a week. Under special circumstances the Ammonia Plant will use three loaders at a time. Figure 7 shows a Company D technician working on the loading rack with an ammonia car.

Technicians at the loading rack are responsible for loading both tank cars and tank trucks using three uncovered loading racks. Technicians at the loading rack are also responsible for

Figure 7. Company D technician loading ammonia car

moving and spotting the tank cars within the limits of the facility. Technicians do not clean the tank cars since each tank car is dedicated as either an anhydrous ammonia or methanol container; if a tank car needs to be cleaned, it is sent out to an off-site contractor. Tank cars in need of maintenance are also sent to an off-site contractor for repair.

The Ammonia Plant produces about 400 tons of methanol and 1350 tons of anhydrous ammonia per day (approximately 400 to 450 tons of the anhydrous ammonia that is produced each day at the Ammonia Plant are used by the Upgrading Plant to produce urea and UAN solution). The Ammonia Plant ships, on average, 5.2 tank cars and 22 tank trucks of anhydrous ammonia per day and three tank cars and four tank trucks of methanol per day. Since urea and UAN solution are produced and loaded at the Upgrading Plant down the road, their shipments are not reflected in these numbers.

3.4.2 Description of Training Program

Background

As described above, there are five technician jobs at the Ammonia Plant, and all technicians are hired with Process Control Board Tech IV as their target position. Training is for the most part sequential, so that all new hires must begin by being trained as a Technician I. Loading skills are trained at this level. Since the goal is to train each individual to perform every job at the plant, as soon as an individual becomes qualified as a Technician I, s/he begins training to become a Technician II (while working as a Technician I). This process of progressive training continues until the individual becomes qualified as a Process Control Board Tech IV or until it is determined that the individual has reached their potential at a lower level position. Since the scope of the project is limited to the training of those individuals responsible for loading hazardous materials, discussion is limited to Technician I and II training, where loading procedures are taught.

Trainer Experience

The trainer overseeing trainees' progress has years of hazardous materials experience and is qualified at every technician position. Those individuals who are responsible for the OJT portion are, at a minimum, qualified at the position for which they are training.

General chemical industry knowledge training materials were developed by a professional training company and are used at all of the company's processing plants. The job-specific training materials were developed in-house over the years by many individuals, including trainers, shift supervisors, and corporate-level managers. The structure of the training program, a four-phased approach that is described below, is used by both the Ammonia Plant and the Upgrading Plant, though the specific operating procedures implemented may differ (e.g., loading an anhydrous ammonia tank car versus a UAN solution tank car).

Training Overview

The plant has adopted a general four-phased approach to training all employees. At a minimum, the first and fourth phases must be followed, and where appropriate, the second and third phases are also followed. The four phases are:

- Phase I - The trainee studies all relevant methods and procedures.

- Phase II - Under close supervision, the trainee practices the skills and procedures involved in the particular application or task.

- Phase III - The trainee performs the particular activities or skills without a supervisor looking over their shoulder; however, there is someone present to assist the trainee when necessary.

- Phase IV - The trainee completes a written exam and demonstrates proficiency in a "walk-through" exam.

The overall goal of the technician training program is to train every technician to be qualified at each of the five technician positions at the plant. The overall process used to train individuals at each position is, thus, the same; however, the content varies depending on the job responsibilities at each technician position.

Structure of Training Program

Prior to entering the plant, trainees receive two weeks of orientation, including general industry knowledge and plant policy and procedure training. Orientation training follows only Phases I and IV of the four-phased training approach, and is self-paced. The training covers a safety process overview, basic chemistry, emergency plan procedures, and hazardous communications, among other topics. All new employees must complete this two-week course. The portion of training that addresses general industry knowledge training was developed by an outside training company, and is used by all of the company's United States facilities. The orientation is divided into 19 units.

Upon successful completion of the orientation training, the trainee begins on-the-job training (OJT), where a qualified loader teaches the trainee how to load ammonia and methanol into tank cars and tank trucks. As part of the OJT, the trainee learns how to operate all of the necessary equipment (e.g., trackmobile), and learns about other fundamental aspects of loading tank cars and trucks (e.g., railroad yard spurs and switching, and relevant computer applications). The OJT portion of training is overseen by a Process Control Board Tech IV and is trained by a qualified Technician I or II. The Technician I and II OJT follows all four phases of training. They are:

- Phase I - Under close supervision, the trainee observes and studies all of the methods and procedures involved in loading the materials.

- Phase II - Under close supervision, the trainee practices the skills and procedures involved in loading the materials. Phase II provides the first hands-on opportunity for the trainee to practice their newly learned skills. The trainee should be able to demonstrate basic knowledge and proficiency of the loading methods and procedures.

- Phase III - The trainee is allowed to perform the loading functions and procedures without a supervisor looking over their shoulder; however, there is someone present to assist the trainee when necessary.

- Phase IV - The trainee completes a written exam and demonstrates their proficiency in a "walk-through" exam.

Trainees take a minimum of 6 weeks to qualify as a Technician I, though some trainees have taken as long as 6 months. As soon as the trainee is qualified as a Technician I, s/he begins training to qualify as a Technician II while performing the responsibilities of a Technician I. It takes a total of 3 to 5 years to become fully qualified at every position at the Ammonia Plant (i.e., Process Control Board Tech IV). However, a few employees have qualified in as little as 2 years.

The Ammonia Plant uses a training program developed by the Association of American Railroads' Bureau of Explosives (BOE) for DOT general awareness and function-specific refresher training. Half of all technicians receive the 8 hr training each year (i.e., technicians receive refresher training every two years). A BOE trainer delivers this training in a classroom format.

Instructional Methods and Materials

Videotapes and a corresponding workbook are used for the general industry knowledge training. Lectures and a lecture book are used for the plant policy and procedure training.

OJT is used for the remainder of the Technician I and II training. Trainees are provided with all operating procedures and checklists. Many of the operating procedures are written in the form of steps that the trainee/technician must follow. The checklists require the trainee/technician to inspect various aspects of the tank car and to check off as either "OK" or "Defect[ive]" the various items. In addition to the materials that are provided to the trainee, technicians responsible for OJT are also provided with specific checklists (e.g., ammonia loading, methanol loading, and trackmobile operation) to aid them in overseeing and instructing the trainee. These checklists help ensure that all of the relevant information is conveyed and that all of the necessary tasks and skills are learned.

The Ammonia Plant is planning to develop a computer-based training (CBT) program for some portions of the Process Technician training as well as for refresher training on regulations and procedures. CBT modules for other plant positions have already been developed.

Videotapes are used for DOT general awareness and function-specific refresher training.

Proficiency Testing

Trainees must satisfactorily complete a test at the conclusion of each module in the general orientation training. The trainee must complete an oral exam upon completion of each of the first three phases of the OJT. A Shift Supervisor or Process Control Board Tech IV administers the exam. To complete Phase IV of the OJT, the trainee must complete both a written exam and an oral exam/demonstration. The written exam consists of open-ended essay questions. The trainee must answer all questions correctly to be certified for the position.

Refresher Training

The Ammonia Plant is planning to develop a computer-based training (CBT) program for some portions of refresher training for regulations and procedures.

3.4.3 Employee Information

Candidate Screening

The Plant's Human Resources department is responsible for screening new hires. Annually, the plant receives approximately 300 applications for an average of 5 to 6 positions, 2 to 3 of which may be technician positions. All new hires undergo a comprehensive background check, and must pass a pre-employment physical and a scheduled drug test.

The Ammonia Plant has recently implemented a new hiring procedure that provides an extra layer of candidate screening. All job candidates at the Ammonia Plant are contract employees. Many of the 300 annual applications come directly from the contracting agency; the plant tells those candidates that do not come from the agency that they must go through the agency to be hired by the plant. Job candidates are hired on a "trial basis" for about six months to determine the fit between the employee and the plant. After six months, the plant makes a decision whether or not to permanently hire the job candidate.

Employee Backgrounds

Eight Process Technicians were surveyed. The average age of the technicians that were surveyed was 36.5 years (range 32 to 43). Seven of the eight technicians were male, and all were native English speakers. The eight technicians who were surveyed had an average of 10 years of hazardous material experience each (range 8 months to 17.5 years). All eight technicians had at least a high school degree and two have earned college degrees.

4. EDUCATIONAL LEVEL ASSESSMENT

Background employee data and MAB results were used to describe the employee populations from each of four companies. This information along with the training materials from each case study site provided the basis for assessing the degree to which training program materials were consistent with the skills of the trainees. A total of 36 employees were contacted at the study locations.

Level of educational attainment for one of the employees at Company A was not obtained. Consequently this employee was not included in the study. The Company B site was a small operation with only four hazmat-handling employees. The training program for these employees was systematic but delivered on a one-on-one basis without any extensive reading of materials required of the employees. Additionally, it was not feasible to administer the MAB at this site. The educational attainment level for these employees was available and recorded, however. At the remaining three sites, training materials were available for assessment. At Company D, one employee provided personal background data but had to attend to an urgent work problem and did not complete the MAB.

In summary, data from 35 employees was available for comparison of training materials with level of educational attainment. Data for 30 of the 35 employees included the MAB, which allowed estimation of instructional and independent reading levels. This section presents an analysis of the employee reading level data in comparison with the Fry readability metric for written course materials.

4.1 Comparison of Fry Index to Level of Educational Attainment

Educational attainment refers to the number of years of formal education. Thirty-five employees provided this information. Both the mean and median number of years of education for this group of employees was 13.5. The median years of education ranged from 12 to 15 years. (See Table 5.)

Written training materials were assessed at three of the four sites, covering 31 employees. The average Fry index for all site-prepared materials was 12.4 years. Ten of the 30 employees (33 percent) who provided their educational level and for whom reading materials were available, had an attained education level that fell below the Fry readability grade index for the materials from their training programs. The Fry index and level of educational attainment did differ by site, as did the proportion of employees whose educational level fell below the Fry index for the site.

Table 5. Comparison of educational level to Fry index across all employees

Source	Number of Employees	Mean Educational Level	Median Educational Level	Fry Index	Number of Employees Below Fry Index	Percent Below Fry Index (%)
Company A	15	13.4	13.0	13.0	6	40
Company B	4	11.8	12.0	N/A	N/A	N/A
Company C	8	13.6	13.3	13.0	4	50
Company D	8	14.5	15.0	11.0	0	0
Totals	**35**	**13.5**	**13.5**	**12.4**	**10***	**33***
AAR BOE	35	13.5	13.5	12.0	1	3
DOT Regs	35	13.5	13.5	12.0	1	3

*Percentage computed based on 30 employees for whom MAB results were available.

As can be seen from Table 5, none of the workers at Company D had an educational level that fell below the readability index of the materials from their site. This location did make use of Association of American Railroads (AAR) prepared materials and text from the U.S. Department of Transportation Hazardous Materials regulations. These materials were not included in the site-specific comparison but were analyzed separately. Since the AAR and DOT materials are used on a national basis, a separate comparison was conducted versus the educational level of all 35 of the employees instead of just the Company D employees.

AAR's Bureau of Explosives DOT Awareness Training is widely used by chemical companies. Materials from this program and the text from 49 CFR Sec. 173 and 174 of the U.S. Department of Transportation (DOT) regulations are often used in hazardous materials training programs, particularly to meet the regulatory requirement for recurrent triennial training. A Fry index was calculated for material taken from AAR Hazardous Materials Training Module 6 and DOT regulations for interstate transport of hazardous materials, Section 174.

The Fry Readability Index for both the DOT and the AAR materials fell at the twelfth grade level. Only one of the 35 employees for whom information was available had less than 12 real or equivalent years of education. This one employee constituted 3 percent of the total employees whose level of education fell below the level of the material sampled.

4.2 Comparison of Fry Index to Estimated Instructional and Independent Reading Levels

As described in subsection 2.3, instructional reading level refers to the reading level of materials that is appropriate to each student. Instructional level was estimated by multiplying each employee's educational level by their MAB subtest IQ/100. The instructional reading level for each employee was computed and then the mean and median were calculated. MAB data was available for 30 employees. The mean estimated instructional reading level for these employees was 13.3 and the median was 12.7. (See Table 6.)

Table 6. Comparison of estimated instructional reading level to Fry index

Source	Number of Employees	Mean Estimated Instructional Reading Level	Median Estimated Instructional Reading Level	Fry Index	Number of Employees Below Fry Index	Percent Below Fry Index (%)
Company A	15	11.7	11.7	13.0	13	87
Company B	N/A	N/A	N/A	N/A	N/A	N/A
Company C	8	14.5	14.8	13.0	3	38
Company D	7	15.1	15.0	11.0	0	0
Totals	**30**	**13.3**	**12.7**	**12.4**	**16**	**53**
AAR	30	13.3	12.7	12.0	9	30
DOT	30	13.3	12.7	12.0	9	30

Sixteen of 30 employees' estimated instructional reading levels fell below the Fry readability index for their location's reading materials. The reason for the difference between this comparison (using estimated instructional reading level) and the comparison calculated against years of education comes as a result of differences in MAB subtest IQ scores. The IQ scores of employees at Company A were markedly lower than those of the employees at the other two sites. The consequence was that the average estimated instructional reading level for the first site fell markedly and produced a finding of 87 percent of the employees falling below the Fry index level. In the other two sites, the IQ scores were comparatively higher, with the result that the group averages for estimated reading level were actually higher in these groups than the average based on years of educational experience.

With respect to the DOT and AAR materials, the estimated instructional level of nine of the 30 employees (30 percent) falls below the twelfth grade readability index the both sets of materials. This percentage is larger than when the Fry index is compared with educational level.

As discussed in subsection 2.3.3, *instructional* reading level implies a 15 percent to 20 percent reading error rate. It is a common practice for instructors to select reading materials that are two or more year levels lower than the instructional level when the need arises for students to read the materials independently. Since the trend in industrial training is toward non-classroom approaches that are more dependent on trainee reading skills, a comparison against the Fry index level was made in which the employees' estimated instructional reading levels were reduced by 2 years to represent *independent* reading level. Table 7 presents the data for this comparison.

The mean and median estimated independent reading levels of the employees were 11.3 and 10.7, respectively. From this perspective, nearly 67 percent of the employees would be incapable of reading their programs' materials with few or no errors. In the most extreme comparison, none of the employees at the first location are estimated to be capable of reading that program's materials without error, while 86 percent of Company D's employees would be likely to read their materials without error.

Table 7. Comparison of estimated independent reading level to Fry index

Source	Number of Employees	Mean Estimated Independent Reading Level	Median Estimated Independent Reading Level	Fry Index	Number of Employees Below Fry Index	Percent Below Fry Index (%)
Company A	15	9.7	9.7	13.0	15	100
Company B	N/A	N/A	N/A	N/A	N/A	N/A
Company C	8	12.5	12.8	13.0	4	50
Company D	7	13.1	13.0	11.0	1	14
Totals	**30**	**11.3**	**10.7**	**12.4**	**20**	**67**
AAR	30	11.3	10.7	12.0	17	57
DOT	30	11.3	10.7	12.0	17	57

With respect to the DOT and AAR materials, the estimated independent reading level of 17 of the 30 employees (57 percent) falls below the readability index of the materials.

4.3 Comparison of Adjusted Fry Index to Estimated Instructional Reading Levels

As discussed in subsection 2.3.4, the provision of text reading aids such as statements of objectives and self-study questions within reading materials is known to increase reading comprehension. Zakaluk and Samuels have suggested reducing the Fry readability index for text by one-half year for the provision of objectives and one-half year for the provision of attention-focusing questions. Company C uses statements of objectives in its text while Company A's text features both objectives and questions. Neither the AAR nor DOT materials have these features.

As shown in Table 8, each of the reading performance estimation approaches was reassessed for the two sites that used these text features in their materials. In terms of the educational level and instructional reading level metrics, the presence of organizational aids in the text results in

Table 8. Employees falling below reading cut-off levels when text aids are considered

	Number Below Fry Index		Percent Below Fry Index (%)	
	Original	Adjusted	Original	Adjusted
Company A				
Years of Education	6	0	40	0
Instructional Reading Level	13	8	87	53
Independent Reading Level	15	14	100	93
Company C				
Years of Education	4	3	50	38
Instructional Reading Level	3	1	38	13
Independent Reading Level	4	4	50	50

fewer employees falling below the Fry index. However, when independent reading level is considered, the results are virtually unchanged.

The estimated benefit of embedding aids to comprehension within the text is apparent under nearly all methods of assessment used. Differences in years of education and IQ scores are the cause of the differences between Company A and Company C.

4.4 Qualitative Application of Conclusions Derived from the 1993 National Adult Literacy Survey

As discussed in subsection 2.3.5, Kirsch, et al. (13) interpreted the NALS results relative to level of education. They determined that persons with no more than a high school education were likely to be less than 80 percent successful in the interpretive use of text materials in prose, quantitative and document form when those materials were lengthy and complex.

The NALS used test standardization techniques based on a large sample size to reach its determination of text complexity and did so on the basis of how well survey participants responded to samples of text rather than on the attributes of the text itself. It is subjective to look at the attributes of unrelated text and then assume that the educational level of survey participants will correlate perfectly to the levels of reading competency set forth by NALS. Nevertheless, the NALS does provide substantiated conclusions as to the types of skill deficits in reading that persons with a high school education or less are likely to have. Text materials that are less complex and lengthy are more likely to be successfully read than ones that are not.

The Fry index does give some insight into text length in the sense of measuring sentence length and complexity as inferred by number of syllables within a fixed length sample. On this basis, the DOT material sampled in this review is both long and complex. Since 15 of 35 employees assessed in this study have a twelfth grade education or less, it is unlikely that they would be able to understand or apply the text based on reading alone.

Only one of the sites visited used materials that had a Fry grade level index lower than the educational level of all of their employees.

5. TRAINING GUIDELINES AND BEST PRACTICES

The four programs described in Section 3 include instructional approaches and materials that exemplify best practices in delivering procedural training. Using examples from the four case studies, this section offers training guidelines that are applicable to hazmat loader training. Subsection 5.1 contains suggestions regarding instructional methods and subsection 5.2 presents guidelines for four types of instructional media.

5.1 Instructional Methods

The guidelines that follow address topics and issues relevant to the preparation, format, and organization of instruction for hazardous material loading/unloading training. The first three guidelines focus on the instructors, while the next 16 guidelines concentrate on the instructional process and events of instruction. Finally, the remaining four guidelines concern post-training activities such as assignment to duties and refresher training. Following each guideline there is an example of how the guideline may be implemented. Real examples drawn from one or more of the four case study sites are used where possible.

- *Select instructors and on-the-job trainers based on pre-established and explicit selection criteria.*

  A formal procedure for selecting instructors should be implemented to increase the effectiveness of training. The procedure might include one-on-one interviews and demonstrations of teaching ability. Though important, the instructor's years of experience on-the-job should be only one of the selection criteria. Other criteria may include the ability to effectively communicate to others both orally and through documentation, and the ability to lead others (interpersonal skills).

  Example: Company C considers interpersonal and delivery skills in selecting trainers.

- *Use an instructor's guide to increase consistency of training across trainers and over time.*

  An instructor's guide serves as a job aid to instructors as they train individuals to load and unload hazardous materials into railroad tank cars. The existence of an instructor's guide is no guarantee of program quality, but the absence of one means that there is less likely to be consistency of training. Further, the lack of an instructor's guide can be especially problematic if a new instructor must step in to train.

Example: As part of OJT, mentors from Company C use checklists to guide and evaluate trainees. The checklist contains a list of all of the skills in which the trainee must demonstrate proficiency. The checklist serves as a training aid to the mentor, and provides some degree of consistency across different mentors and over time.

- *Include trainer preparation and oversight (a.k.a. train-the-trainer).*

  Like an instructor's guide, train-the-trainer programs help to increase the consistency of how training is carried out, and increase the likelihood of consistent training outcomes (i.e., trainee performance on-the-job).

  Example: A primary component of Company C's training program is OJT. Because of the large responsibility placed on the OJT portion of training, mentors are trained by the training staff prior to supervising trainees on-the-job. The mentor monitors on-the-job training and performance.

- *Explicitly state the skills that the trainee is expected to master in the training program.*

  At a minimum, the trainee should receive direct communication prior to any instructional sequence expressed in terms of the observable behaviors that they will be expected to master and subsequently produce. Usually the expected behaviors are explicitly conveyed in the form of training objectives, though the content and structure of the objectives vary widely. Some examples of relevant training objectives that address a range of activities, encompassing both factual and procedural information, include:

  - Objective 1 - Name all of the component parts of a tank car's loading valve system.

  - Objective 2 - List the steps involved in inspecting a tank car before it is loaded.

  - Objective 3 - Demonstrate loading a tank car within acceptable limits specified in the standard operating procedures <include reference to the specific SOP >.

  In the absence of explicit training objectives that are provided prior to instruction, programs that contain evaluation criteria or methods that call for specific behaviors that the trainees will have to produce by the end of instruction may be considered as having implicit training objectives.

  Example: Company A's training program is divided into multiple courses; each course is further divided into lessons. Company A provides each of its trainees with a workbook that contains general course objectives as well as more specific lesson objectives that are written from the trainee's perspective. The lesson objectives clearly state the expected learning outcomes (e.g., "List the prerequisites for team development").

- *To maximize the transfer of training, the skills, behaviors and activities required in practice and assessment should take the same form as those that are required when performing the actual skill.*

  Instruction and assessment should be designed and developed to be consistent with the desired outcomes. Reading or listening to an explanation of how a skill is to be performed is not a substitute for practicing the skill. Since it is likely that most hazardous material loading and unloading training programs include an OJT component, the issue becomes one of proportion of time spent in hands-on learning.

  The content of the training program should also be functionally related to the desired outcomes of the training program. The question to be asked is “How does knowledge of this content refine or enable the skills called for in the stated (or implicit) outcomes?”

  Trainee assessment should also take the same form as the desired outcomes. Thus, if the desired outcomes of the training are procedural skills, then the assessment should involve procedural demonstrations. Paper and pencil examinations are not likely to provide a reliable or valid measure of competency in the performance of a skill that does not involve paper/pencil responses. At best, paper and pencil exams for psychomotor or procedural skills convey only a measurement of a trainee’s knowledge of a process. In the worst case, such tests are more influenced by language/reading skills than they are about the skills they purport to measure.

  Example: Company A requires each trainee to demonstrate the entire loading process in the field, explaining how the various systems tie together as a loading process. The trainee must do this for four different loading racks as well as switch engine operation.

- *Use factual information to support procedural learning.*

  Lists, facts, figures and documented procedures are training aids that should be used to augment or supplement instruction. Since training hazardous material loaders involves application of procedural skills, lists, facts, figures and procedures should support procedural learning, by providing factual information regarding when to use, or how to perform, a particular procedure.

  Example: Company C provides the trainee with a copy of the relevant process control operating instructions (OI’s) that are used when loading the tank cars. These OI’s document the upper boundaries for filling tank cars, the effects of exceeding the limit, and corrective actions to take. Thus, trainees are provided with the actual documented procedures which they will use and refer to later on-the-job. Similarly, Company B includes shipping and receiving checklists in its training materials.

- *Help trainees visualize or anticipate the nature of the activity or procedure they are about to learn.*

  Instruction should begin with activities that help trainees visualize or anticipate the nature of the activity or procedure they are about to learn. Such "pretraining" has both cognitive and motivational benefits in that it prepares trainees for what they will be doing. In some situations, simply providing the trainees with an overview of the job and the conditions under which it is performed may be satisfactory. If the training will cover several related procedures, then some form of an "advance organizer" which relates all of the elements of the training may be more effective. Instructors may also pretrain trainees by providing them with the course objectives before the training begins. Providing trainees with the objectives before training begins can help the trainees to focus on the relevant information and material during the training. Preparing the trainee will help him or her to learn more efficiently and thus make the instruction more effective.

  Example: Company A's introduction to the loading rack covers all of the systems that make up the loading rack. The course materials include an overview chart, shown in Figure 8.

- *Select or design instructional materials to be consistent with instructional methods.*

  The instructional materials for the training program should support the instructional methods that are used. For example, when teaching procedures, the instructor might first use printed step-by-step lists to convey what the trainee must do in the procedure, or a videotape that demonstrates the procedure to the trainee.

  Some training approaches are sequential in that they build up layers of skills and understandings that are components of the desired learning outcomes, starting with simple outcomes and moving to more complex outcomes. The instructional materials that would be used with these approaches should reflect and support this methodological organization from simple to more complex learning outcomes.

  Example: Company A's training module on the wash rack system begins with an itemization of the major equipment used in the system. The next module includes charts to explain the functions of each subsystem. This knowledge becomes the basis for learning how to control and operate the wash rack in a subsequent module.

- *Since tank car loading and unloading involves the application of procedural skills, instruction that involves factual information should be oriented toward its application in the appropriate procedure.*

  Anderson (9, pp. 49-54) distinguishes between declarative knowledge ("knowing that") and procedural knowledge ("knowing how"). Both are essential for learning procedural skills; typically procedural knowledge is built upon the foundation created by the acquisition of relevant declarative knowledge. For example, factual information may

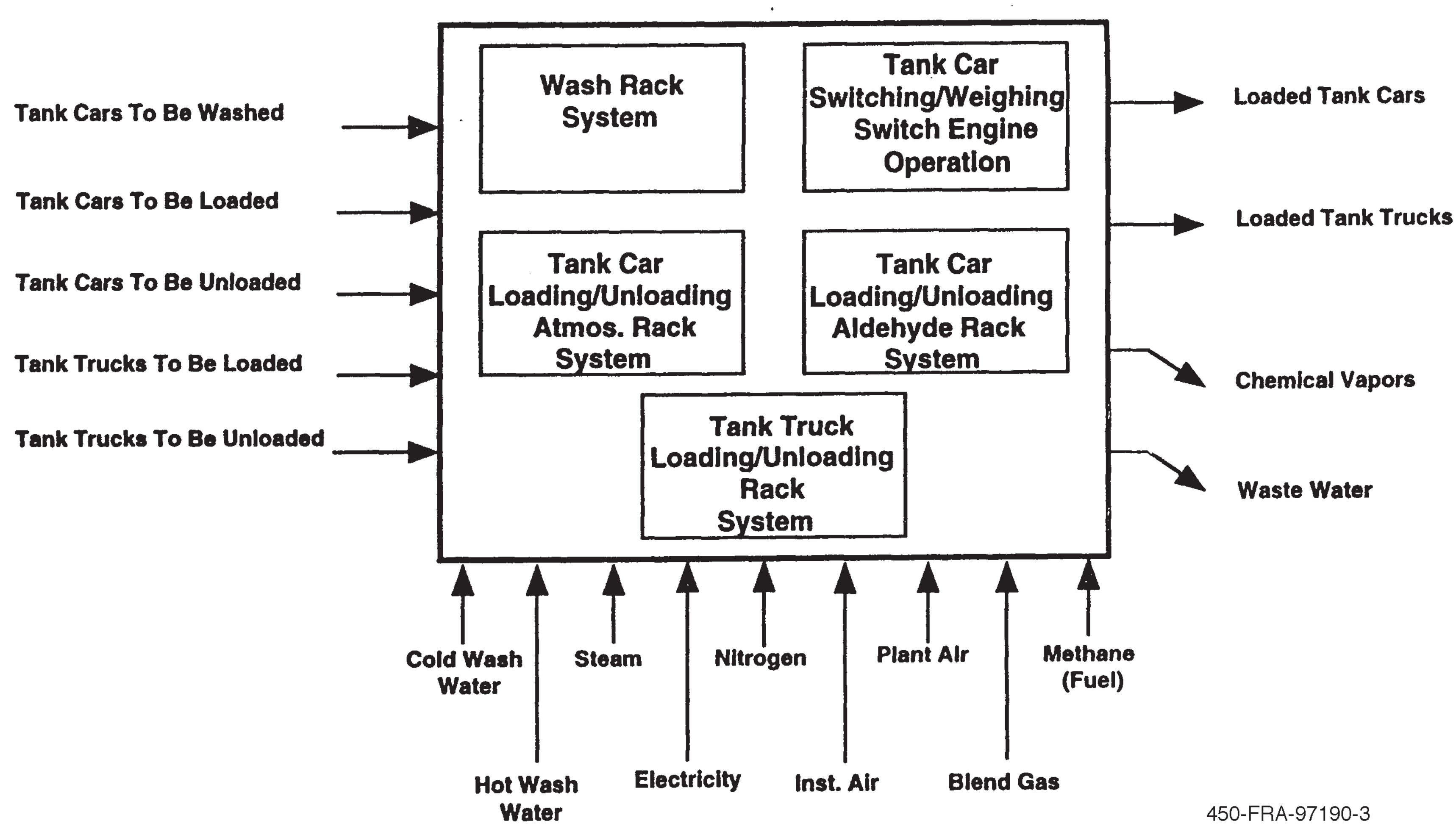

Figure 8. Overview of the loading rack process at Company A

first be provided about tank car components, markings and fittings. Then, procedural information can build on such knowledge, for example, learning how to inspect a tank car prior to loading. The teaching of procedural knowledge should consist of a series of steps or activities that progresses logically to mastery of a desired outcome.

Example: Phase II of Company A's training program deals with the specific loading racks. The first rack that employees are trained for is the wash rack. The wash rack training materials include a module on tank car structure and identification. Employees must be able to identify the type of car and materials that it carried so that the proper wash procedure is employed.

- *Training materials should provide everything the trainee needs to know to carry out the procedures.*

  The training materials should provide everything the trainee needs to know to carry out the procedures, including *what* to do, and *how* to do it. For example, an improper procedure may say, "tighten valve," while a proper procedure would say, "Using a 36 in. wrench, tighten valve by turning wing-nut clockwise until nut no longer rotates."

  Example: Company D's Operating Procedure for Ammonia Railcar Loading specifies that the normal shutdown procedure includes: "Disconnect the liquid and vapor loading arms, remove the three 2 in. loading connections, install the three 2 in. plugs and secure with a 24 in. wrench."

- *Presentation of factual information should be integrated with hands-on practice to reinforce learning.*

  Hands-on practice enables the trainee to apply the new information to realistic situations and reinforces learning through such new association. A classroom presentation of information about personal protective equipment (PPE) might be followed immediately by examining, handling and trying on the equipment.

  Example: Company B's training program involves one-on-one training, whereby the instructor first describes a procedure to the trainee, then demonstrates it, and then allows the trainee to practice the procedure.

- *Offer a range of practice experiences that includes both supervised and independent practice.*

  Practice is an essential component of procedural learning. Supervised practice provides the trainee with immediate feedback during the early stages of learning, while independent practice enables the trainees to practice the skills they have previously learned under supervision. Independent practice requires the trainee to be able to judge, or regulate, his or her own performance, and affords the trainee the opportunity to seek assistance when he or she desires or when it is deemed necessary by the individual supervising the trainee. First the instructor might lead the trainee through a procedure. Next the trainee might perform the procedure under the guidance of the instructor, an experienced employee, or OJT supervisor who can provide immediate feedback to the trainee. Then the trainee might practice the procedure independently but with a supervisor in the work area who is available to review the trainee's work and answer questions. OJT must be organized sufficiently so that both the trainee and the participating mentor understand the skills the trainee is to practice, and the level of proficiency that is to be achieved.

Example: All four programs provided a variety of practice experiences, ranging from supervised practice, where the instructor observed the trainee demonstrating newly learned procedures, to OJT, where the trainee was primarily responsible for his or her own work but had access to a supervisor or mentor when they needed assistance.

- *Spend the majority of the instructional time in supervised practice and on-the-job training.*

Since loading hazardous materials into rail tank cars involves primarily carrying out procedures, emphasis should be placed on practicing the procedures. As a rule of thumb, the proportion of instruction that is presentation or instructor-led discussion should be limited to no more than one-third of the instructional time. Instructor presentation should consist of a mixture of factual information, procedural descriptions, visual materials and demonstrations since individuals differ markedly in their ability to learn from verbal, visual and auditory inputs. Good training provides a mixture of these types of presentation styles.

Example: Trainees in Company A spend a majority of their training on-the-job. Phase I of their three phase training includes 64 hr of classroom training, followed by one month of training on-the-job. Then trainees alternate between Phase II (primarily classroom) and Phase III (OJT) training. Phase II training requires a total of 40 hr of classroom and field trip time, while each module of Phase III may last as long as six months.

- *Provide feedback to trainees.*

To enhance the effectiveness of the instruction throughout the program, trainees should be provided with feedback regarding the results of their performance in practice and during testing and assessment. Such knowledge of results will make learning more efficient by illuminating the difference between the trainee's behavior and the target behavior (14). Feedback may come in a variety of forms, including written comments and instructor demonstrations.

Example: All four companies incorporate feedback in their training programs; such feedback addresses both trainee demonstrations and testing and assessment.

- *Provide guidance to trainees.*

  Guidance involves providing clear and unambiguous information to the trainee about what to do just prior to the activity or practice. Guidance is similar to feedback; the primary difference is when the information is provided to the trainee: guidance is provided just prior to performance, while feedback is given after performance. Guidance comes in many forms, including physical guidance, verbal guidance, demonstration, and cueing. Some are more appropriate for particular types of learning. For example, for procedural learning, demonstrations and verbal guidance (i.e., advice about what to do) may be the most suitable forms of guidance. Demonstrations involve showing the trainee what to do, while verbal guidance involves prompting an action, or involves some other form of verbal preparation or direction (either spoken or written) immediately before practice.

  Example: The one-on-one nature of Company B's training program enables the instructor to provide ample guidance to the trainee while s/he is learning new procedures.

- *Motivate trainees.*

  When learners have a vested interest in the outcome of training, they become more focused, attend more carefully to activities and consequently are more likely to achieve the desired outcomes. Consequently, instructional methods and materials should address learners' interests in the training outcome. The use of teams can be an effective means to increase trainees' involvement during training. External rewards may also be used to motivate employees already on-the-job and thus, serve to motivate trainees to learn as much as possible to benefit from the external rewards once they begin working. External rewards might range from a special recognition for the safest employee every year, to tangible goods such as a cash bonus or other benefits.

  Example: This aspect of training was not explored in the case studies.

- *Elicit positive attitudes from trainees.*

  Positive attitudes toward instructional activities can strengthen a trainee's involvement in learning and can enhance a positive training outcome. Positive attitudes can be a by-product of instruction, or they may be desired learning outcomes for which instructional objectives are designed, such as to facilitate a "safety culture" in all aspects of the trainee's work. This may entail simple rules or procedures such as always holding a banister while ascending or descending stairs, or always looking both ways before crossing railroad tracks on-site.

  Example: Company B's instructor emphasizes the importance of safety at the start of his training sessions.

- *The training program should incorporate some self-paced learning to accommodate individual differences among trainees.*

  Self-paced learning is one form of a broader category of training called "adaptive training," in which individual differences are accommodated. Since individuals learn at different rates depending on their educational background and experience, self-paced learning is particularly beneficial when learning more difficult aspects of a job. Self-paced learning may take one of several forms. For example, task difficulty while learning a particularly difficult procedure may be adjusted to accommodate individual differences in mastering the procedure. Fast learners may rapidly encounter more and more difficult steps when practicing a procedure while slower learners may encounter more gradual changes in task difficulty. Another way to accommodate differences among individuals is to provide an opportunity for trainees to progress through training modules or components such as OJT at their own pace. Self-paced learning may be conducted through computer-based training (CBT), text self-tutorials, and self-paced progression of videotape training, to name but a few.

  Example: All of the programs that were visited provided evidence of self-paced learning at some stage of training. The first two weeks of Company D's training program are self-paced, in which the trainee receives a general orientation to handling hazardous materials that covers general industry knowledge and plant policy and procedure training. Company B's one-on-one method of training fully enables self-paced procedural learning since there are no other trainees in a class to impose a particular rate of learning. Finally, the on-the-job portion of training for each of the four companies was self-paced in that the duration of OJT depended on each trainee's progress as determined by a mentor or supervisor as well as the trainee himself or herself.

- *Allow for remedial instruction where trainees show deficiencies.*

  The training program should allow for remedial instruction as required for trainee deficiencies. The remedial instruction and its post-assessment should be consistent in form with the declared program outcome, instructing trainees on the procedure for loading hazmat into tank cars. Merely verbally "going over" a trainee's deficiencies and having the trainee acknowledge his or her mistakes is inadequate, however. Post assessment should involve the trainee demonstrating the proper procedures. Since different trainees will have difficulty at different parts of the training, remedial instruction is a second form of adaptive training since it accommodates individual differences among trainees.

  Example: Company B's one-on-one method of training provides an opportunity for the trainee to receive specific, timely remedial instruction where it is needed. In addition, Company C's computerized Training and Evaluation Development System (TEDS) program enables trainee remediation on specific sections of information as well as requizzing.

- *Overtrain.*

  There is some evidence (14, p. 373-4) that there are benefits to overtraining. Overtraining involves the continuation of training even after a trainee has achieved a pre-specified and often basic level of performance. Evidence of performance level may come from passing a one-time skill demonstration test. Even though the criterion level of performance has been achieved (demonstrating the skill once), additional learning can still take place. In particular, it appears that overtraining improves skill retention and speeds task re-learning after a period of time not performing the particular task. According to Fitts (15), overtraining also increases resistance to mental fatigue, stress and interference.

  One form of overtraining might require trainees to encounter and complete multiple performance and final evaluation criteria, both in terms of breadth (the trainee must meet or exceed several criteria) and depth (high performance achievement or evaluations required). Trainees may face a variety of situations and may be expected to perform several different procedures while performing their job duties; the use of multiple performance criteria and final evaluation criteria better prepares trainees by exposing them to many different situations during their training.

  Example: This aspect of training was not explored in the case studies.

- *Assign trainees to duties immediately after training.*

  Research has shown that procedural learning decays very rapidly if not used or applied. Thus, there should be no delay between the completion of training and assignment to duties.

  Example: Individuals who qualify as Technician I's in Company D immediately begin performing their duties loading hazardous materials in preparation for transportation.

- *When determining the need for refresher training, consider the amount of time since the last assessment/training, and the amount of time spent away from the particular job.*

  In general, there is no formula with which to determine the frequency of refresher training. Rather, the time when refresher training should take place is typically dependent on the amount of time since the trainee was last trained, and the amount of time that the trainee has spent away from performing the critical duties required of the job. A general rule of thumb is to provide refresher training more frequently than not, to reduce the possibility that a trainee's knowledge and ability has lapsed or eroded.

  Example: Company A conducts refresher training every year; it addresses basic operating procedures and critical loading tasks. In contrast, Company C requires loaders to perform the job at least once every three months to remain qualified; otherwise, they must undergo refresher training to re-qualify.

- *Refresher training should address both new and existing procedures.*

  Refresher training is often used to apprise employees of a new or modified procedure, or a new policy that affects loading hazardous materials for transportation. However, another reason for refresher training is to promote parity across different trainees who were trained at different times and/or by different instructors. Refresher training helps to ensure that the loaders practice the same methods and conduct the same procedures, even if initial training was dissimilar.

  Procedures that are infrequently, if ever, used, (e.g., emergency procedures) should be the target of refresher training since procedures that have not been used since initial training are more susceptible to eroding.

  Example: In addition to annual refresher training that covers basic operating procedures and critical loading tasks, Company A conducts refresher training as needed, such as when there is a change in an operating procedure.

- *Design periodic reassessment so that it takes the same form as assessment following initial training.*

  Since hazardous material loading training involves performance-oriented skills, reassessment should be performance-oriented. Failures or performance deficits observed in periodic reassessment should result in hands-on refresher training that reflects the actual performance of the skill area in question.

  Example: Company C institutes periodic "job cycle checks," proficiency re-checks (reassessments) on all of the jobs that the individual is qualified to perform. Such re-checks occur on-the-job while the individual is performing the actual work.

- *Periodically reassess training program effectiveness.*

  Exit testing and post-training evaluations of trainees by supervisors should be used periodically to evaluate the effectiveness of the program and to identify aspects of the training that need to be improved.

  Example: This aspect of training was not explored in the case studies.

5.2 Instructional Media

The following section presents guidelines for the development, selection and use of text, video and computer-interactive materials for the training of hazardous material loading. They represent only a subset of all possible guidelines, and are therefore not intended to be an exhaustive list.

5.2.1 Physical Attributes of Text Materials

The physical attributes of text materials can influence their effectiveness. Wilson, et al. (16) reviewed research in regard to the design of printed instructional materials and concluded that the following characteristics influenced comprehension:

1. Text lines of equal length (justification) have no demonstrable benefit. Conventional, left justified text reduces reading errors and may assist in comprehension.

2. The use of headings and underlining to indicate central and important concepts can increase learner retention and reduce errors.

3. Readers prefer double columns on a page. This is apparently related to the finding that long lines of text increase reading errors as a consequence of causing more eye regressions and errors in locating the beginning of following lines.

4. A generous use of open space in page layout can aid comprehension.

5. Variations in layout design, including text blocking and the use of color, do not seem to hinder comprehension, although low text to background color contrast can reduce reading accuracy.

In addition, text designers should avoid use of all capitalization (“Caps”) as this decreases text readability. Bolding, italics and underlining can be used for emphasis.

5.2.2 Composition of Text Materials

The written course materials must be designed for the reading skills of the trainees. Appendix B presents detailed guidance on writing for individuals with limited reading skills.

In a review of research, Zakaluk and Samuels (10) suggested that interspersed questions in text could focus reader attention and influence comprehension. These authors also concluded that appropriate presentation of instructional objectives directly to readers in the text also could have a positive effect on comprehension.

5.2.3 Video Materials

In the last decade, the cost of videotape production equipment has decreased and the quality has increased. The cost of professional videotape production for limited distribution remains high, but the level of skill required for self-produced video using new generation equipment makes this task much easier than it was in the past. VHS players are easily available, so the in-house production of local video for local tasks followed by dissemination to trainees has become a practical adjunct to training.

Whether professionally prepared or locally prepared videos are used, the guidelines for instructional methods presented in subsection 5.1 still apply. In addition, the following guidelines should be considered. For more information, the reader is referred to Kemp and Smellie (17).

- *If a video is to show complex equipment, it may be more effective if the initial introduction is in the form of a simple diagram, followed by the introduction of the actual equipment.*

  This is the preferred approach to avoiding viewer comprehension problems caused by an excess of visual information (18).

- *If a video is intended to teach a task performance, it is generally preferable that the camera angle provides a subjective view that represents the job through the eyes of the person performing the task.*

  This approach has long been considered the most effective instructional approach (19).

- *The visual presentation of a video should be the primary means of demonstrating processes, while the audio channel should be limited to interjected commentary.*

  The audio channel should not attempt to be in continuous parallel with the pictorial channel as this is likely to distract the learner's attention (20).

- *The skills that the trainee is expected to master should be explicitly stated in the training program.*

  The video should include an explicit statement of the material that will be covered in the video and what knowledge the student should expect to gain from viewing the video.

- *Include an overview of the contents of the video and provide clear delineation of sections within the video.*

  The various topics that the video covers should be clearly stated and listed on screen. In addition, as the video progresses there should be textual cues indicating the start of a new topic or section.

- *If there are accompanying workbooks or other materials, explain how these materials are to be used in conjunction with the video.*

  When skills are being taught, accompanying workbooks or response sheets in printed form can be used to provide an opportunity for practice or reinforcement of factual information. At appropriate points in the video the narrator must instruct the student to stop the video and do selected exercises in the workbook. For example, if the video covers basic DOT Awareness Training, after discussing the various types of placards, a companion exercise might involve identifying the correct placard for specific hazardous cargoes (21).

5.2.4 Computer-Based Training (CBT) Materials

In the last few years business and industrial training programs have begun to take full advantage of computers. The expanded use of computers in various instructional applications has created a veritable lexicon of terms. CMI, CBT, CAI, IVI , CD-ROM, “multi-media” and the use of local, wide area and the ever-expanding Internet networks constitute a barrage of terms, if not necessarily a substantial difference in learning outcomes. The guidelines for instructional methods presented in subsection 5.1 also apply to computer-interactive materials. In addition, the following CBT-specific guidelines are proposed, based on human-computer interaction theory (rather than on instructional design theory). It is important to remember that this list is not meant to be exhaustive. Rather, it serves as a starting point for those interested in designing their own CBT application or for those interested in acquiring a CBT application for their training program.

- *The materials or system should be easy to use.*

  The learner should be able to start with little or no outside instruction. Learners who lack any computer experience will require assistance with things as “simple” as the manipulation of mouse, keyboard or other required input devices.

- *The instructions within the applications should be clear, concise, and consistent across similar operations.*

  To increase understanding and to minimize navigational or operational errors, the instructions should be consistent across all of the components (e.g., modules) of the CBT application. Knowledge that is gained by reading the instructions in one part of the CBT application should be able to be applied to another part of the CBT application that has similar operations.

- *Help screens should be available and should include practical examples.*

  On-line help screens with practical examples provide convenient, immediate, and directly relevant information to the trainee about the problem for which they are seeking help. Help screens should be written from a novice user’s perspective to be maximally effective. Furthermore, practical examples should focus on tasks that are used most frequently and those that are the most difficult.

- *Forms of user input to the application should be consistent throughout the application.*

  Requiring consistent user input minimizes operational errors, speeds learning, and increases comprehension by helping the trainee to develop a basic framework for how to use the software application. For example, movement to a new area within an application should be consistently accomplished by pressing enter, or clicking a “next” button.

- *The application should allow the user to exit before completion.*

  To provide maximum flexibility, the CBT application should allow the trainee to quit at any time, and upon re-entry, the program should allow the trainee to resume where they left off. In other words, the CBT program should allow for self-paced learning.

- *The application should allow instructor tracking of trainee progress through the application.*

  CBT typically serves as one component of a larger training program. To increase the coordination among various components of the training program, and to increase the effectiveness of the training, the CBT application should enable instructors to follow the trainee’s progress during the CBT and should provide feedback to the instructor regarding the trainee’s progress.

- *If the application is delivered through any type of network, all of the software’s functions should operate smoothly under these conditions.*

  Before implementing a network-based program, it should be tested on multiple machines to ensure that the audio and video components can be smoothly delivered and synchronized while operating over the network simultaneously.

- *The application should be capable of running on all of the computers planned for its use.*

  Before making a decision regarding which computer platform or which specific computers the CBT program will operate on, it is important to check to be sure that the CBT program can run on each platform and each type of computer that will be used. This is particularly important for new CBT programs (which take advantage of advanced technology) that are going to be used on older computers.

  Technologies and their buzzwords will undoubtedly continue to increase. The learners, however, will continue to work in the same manner. Good instructional practice and common-sense standards of operability may, therefore, be consistently applied, even as the technologies change.

6. CONCLUSIONS AND RECOMMENDATIONS

Analysis of written materials from the four case study sites suggests that, regardless of the means of assessment, the reading level of the materials is excessively high in comparison to the reading skills of the trainees. Even when viewed from the instructional reading level perspective, which tolerates a 15 to 20 percent error rate, the materials are too high in level. Due to the limited number of programs examined, a rigorous statistical analysis could not be conducted. It is reasonable, however, to assume that these four companies are representative of the chemical industry and that there may be a more widespread problem in the reading level of printed training materials.

Some of the substances handled are so hazardous, and the potential consequence of a serious non-accident release is so great, that chemical companies should consider assessing the reading level of their materials and making any necessary modifications to make the materials appropriate to the reading skills of their employees. The Fry index is readily computed, as explained in subsection 2.3.1. At a minimum, the Fry index for written materials can be compared with the median educational level of the trainee population. The guidelines in Section 5 and Appendix B can aid in modifying written course materials to achieve the desired reading level.

No attempt was made to examine the relationship between number or rate of NARs and the nature or quality of training. However, during the site visits all four companies reported having low NAR rates. One company even mentioned receiving safety awards from the Class 1 railroads that carry their products. If the reading level of the materials is for the most part above the reading skills of the trainees, there are other aspects of the training and the overall work environment that are responsible for the low NAR rates. Most likely, the dedicated instructors and employees, operating out of a sense of responsibility and understanding of the potential risks of the job, manage to arrive at a favorable training outcome through ample hands-on practice and on-the-job training. All four companies devote at least three-quarters of the training time to supervised practice and OJT.

The job of a hazmat loader relies heavily on procedural knowledge. Yet federal hazmat training requirements (see 49 CFR Sec. 172.704) emphasize mastery of declarative knowledge. Furthermore, federal regulations do not address the need for hands-on practice and on-the-job training, both of which are imperative to procedural learning and hazmat loader job performance. A change in these regulations to prescribe both knowledge and performance testing would promote a successful outcome in hazmat loader training.

FRA regulations offer an example of how this might be done. Regulations governing certification of locomotive engineers require both testing of knowledge and examination of skill performance. (See 49 CFR Sec. 240.125 and 240.127.) According to the FRA regulations, “a railroad shall have procedures for testing a person being evaluated for qualification as a locomotive engineer to determine that the person has sufficient knowledge of the railroad’s rules and practices for the safe operation of trains.” [Sec. 240.125(b)] In addition, “a railroad shall have procedures for examining the performance skills of a person being evaluated for qualification as a locomotive engineer to determine whether the person has the skills to safely operate locomotives and/or trains, including the proper application of the railroad’s rules and practices for the safe operation of locomotives or trains…” [Sec. 240.127(b)] The four case study companies, recognizing the need for a demonstration of performance skills and procedural knowledge, have effectively followed the FRA locomotive engineer certification model in designing their hazmat loader training. All four training programs include a substantial amount of supervised practice and on-the-job training, which prepares trainees to demonstrate their procedural knowledge and performance skills. Other companies are encouraged to do likewise.

The railroad, chemical and tank car industries have been working cooperatively for several years to identify and correct the causes of NARs. The number of non-accident releases per 1,000 tank car originations has declined from 1.38 in 1992 to 0.75 in 1997 (2). Structural and design changes have contributed to this decline. In particular, improvements have been made on the rupture disks on tank cars carrying corrosive materials such as sulfuric and hydrochloric acid. However, loose or defective fittings continue to be a significant source of the majority of NARs. According to the AAR (2), in 1997, 68 percent of tank car NARs were due to loose or defective fittings.

This data suggests that training programs should place emphasis on identifying loose or defective fittings both during the inspection of the tank car prior to loading and after the loading process is complete during securement for shipment. Each company should also review its NAR history to identify any specific causes or casual trends that were responsible for an incident. Information gleaned from identifying NAR causes can then be used to focus on specific steps in the loading procedure that should be emphasized.

In addition to reviewing past NARs, each company should consider conducting a “root cause analysis” whenever an NAR occurs. A “root cause analysis” works backward from the occurrence of the NAR and examines where the car has been and what was done to it that may have contributed to the NAR. While the Hazardous Materials Incident Report describes the immediate circumstances that led to the NAR, a root cause analysis will examine the series of events leading up to the NAR. Any or all of these events may have contributed to the NAR, and once identified, they can be addressed and remedied to prevent future NARs. Knowledge gained from the root cause analysis can also be incorporated into the training program. Many airlines use this approach when an aircraft malfunction occurs.

Adequate training is one of many possible factors contributing to the incidence of NARs. Other possible causes, not addressed in this study, but worthy of consideration include:

- *Fatigue or loss of alertness* – Rapidly rotating and irregular shifts are known to produce fatigue. A 12-on/12-off rotating work schedule, used by two of the case study sites, is common in the chemical industry. Employees need to be aware of the potentially fatiguing effects of this type of schedule. Where truck drivers perform loading/unloading operations, fatigue may also be a potential problem contributing to the risk of an NAR.

- *Safety culture* – Handling hazardous chemicals carries a high risk of injury to the employee, damage to the company's facilities and environmental pollution. A corporate commitment to preventing injuries and damage must be evident in the workplace. The lack of a serious commitment to safety may lead to shortcuts in standard procedures thus increasing the risk of an NAR.

- *Maintenance problems* – Tank car maintenance is usually performed by a separate organization under contract to the chemical company. Improper or inadequate repairs may be a contributing factor. Inadequate communication between chemical companies and the maintenance organization may also lead to problems. For example, if a new model gasket, requiring a different securement procedure, is being used on tank cars the maintenance organization must be sure to notify the chemical companies of the change.

- *Distractions in the workplace* – A busy loading rack, or concurrent responsibilities, may present distractions to the loader.

- *Performance pressures* – Shipment quotas or pressure to meet a schedule may result in shortcuts to standard loading procedures.

Each of these factors likely affects the performance of hazardous material loaders, and chemical shippers should identify and work to minimize their impact on loading hazardous material into rail tank cars.

7. REFERENCES

1. Association of American Railroads, *Railroad Facts*, 1998.
2. Association of American Railroads, "Annual Report of Hazardous Materials Transported by Rail, Calendar Year 1997," Report BOE 97-1, November 1998.
3. U.S. Department of Transportation Research and Special Programs Administration, (1999), "Biennial Report on Hazardous Materials Transportation, Calendar Years 1996-97."
4. U.S. Department of Transportation Research and Special Programs Administration, (1998), Personal Communication.
5. Jackson, D., *Multidimensional Aptitude Battery Manual,* Research Psychologists Press, Inc., 1984.
6. Dale, E. and Chall, J., "A Formula for Predicting Readability," *Education Research Bulletin,* 1948, V27, 11-20.
7. Flesch, R., "A New Readability Yardstick," *Journal of Applied Psychology,* 1948, V32, 221-233.
8. Fry, E. "A Readability Formula That Saves Time," *Journal of Reading*, 1968, V11, 513-16, 575-78.
9. Stevens, K.C., "Readability Formulae and McCall-Crabbs Standard Test Lessons in Reading," *The Reading Teacher*, 1980, V33, 413-15.
10. Zakaluk, B. and Samuels, S., (Eds.), "Toward a New Approach to Predicting Text Comprehensibility," in *Readability, Its Past, Present and Future,* Newark, DE, International Reading Association, 1988.
11. Betts, E., *Foundations of Reading Instruction*, New York, American Book, 1946.
12. Schierloh, J., "Adult Literacy in America," Kent University: http://literacy/kent.edu/Oasis/Pubs/nalsrev.htm/, January, 1998.
13. Kirsch, I., et al., "Adult Literacy in America: A First Look at the Results of the National Adult Literacy Survey," Educational Testing Service, 1993.
14. Patrick, J., *Training: Research and Practice*, San Diego, CA, Academic Press, 1992.
15. Fitts, P.M., "Factors in complex skills training," in Glasser, R. (Ed.) *Training Research and Education*. New York: Wiley, 1962.
16. Wilson, T.C.; Pfister, F.C. and Fleury, B.E., "The Design of Printed Instructional Materials: Research on Illustrations and Typography," Syracuse, NY, ERIC Clearinghouse on Information Resources, Syracuse University, 1981.
17. Kemp, J. and Smellie, D., *Planning, Producing and Using Instructional Media*, New York, Harper & Row, 1989.
18. Brown, J.W., "Recent Manpower Studies: Some Implications for AECT. Media Manpower Supplement No. 2," Washington, DC, Media Manpower, March 1971.

19. Hoban, C.F., Jr., and van Ormer, E.B., "Instructional Film Research 1918-1950," Technical Report No. SDC 269-7-19, Port Washington, NY: U.S. Naval Special Devices Center, 1950.
20. Hartman, F.R., "Single and Multiple Channel Communication: A Review of Research and a Proposed Model," *AV Communication Review*, V9, 235-62, 1961.
21. Reiser, R.A. and Gagne, R.M., *Selecting Media for Instruction*, Educational Technology Publications, Englewood Cliffs, NJ, 1983.

APPENDIX A

EMPLOYEE QUESTIONNAIRE AND INTERVIEW FORMS

Employee ID: ______

Anonymous
Employee Information Survey

Instructions: Please answer the following questions to the best of your knowledge and recollection. There are no right or wrong answers. The information that you provide will remain anonymous.

1. Age: ____________ 2. Sex: ________ ________ Male ________Female

3. Company: ______________________

4. Job Title: _____________________

5. Briefly describe your duties: ____

____

____

6. How many years of chemical company experience do you have? ________Years and ________ Months.

7. How long have you worked at *this* company? ________Years and ________ Months.

8. How long have you worked in your *current* job at this company? ________Years and ________ Months.

9. How many years of experience do you have handling hazardous materials? ________Years and ________ Months.

10. How many times have you received hazardous material training in your current job? ________

Please go to the next page →

11. What was the month and year of your *last* hazardous materials training: ______________________________

12. Are you a native English speaker? _________Yes _________No
If *not*, what is your primary language: ___________________________

13. Education level: Please check the *highest* level of education that you have achieved.

__________ No High School __________ Techncial School

__________ Some High School (____ years) __________ Some College (____ years)

__________ GED __________ College Degree

__________ High School Diploma __________ Other: _________________

Thank you for your participation!!

APPENDIX B

GUIDELINES FOR WRITING FOR INDIVIDUALS WITH LIMITED READING SKILLS

The guidelines presented in this section are extracted, with permission, from *Guidelines: Writing For Adults With Limited Reading Skills*, by Nancy Gaston and Patricia Daniels, FNS, USDA CSREES, 1988. A copy of the entire document is available at http://www.cyfernet.org/writeadult.html.

Know Your Audience

To be effective in writing for adults with limited reading skills, you must understand some of their characteristics. Keep in mind one basic point — the lack of good reading and comprehension skills is not an indication of your readers' intelligence. Your writing style should be simple and direct without "talking down" to them. A reader with limited reading skills often:

- Reads at a level at least 1 to 2 school grades below the highest grade completed. Anyone with a reading level below the 5th grade does not have enough language fluency to make good use of written materials.
- Has a short attention span. The message should be direct, short, and specific.
- Depends on visual cues to clarify and interpret words. Appropriate pictures, illustrations and graphics must work in conjunction with words.
- Has difficulty in understanding complex ideas. The message must be broken down into basic points with supporting information.
- Lacks a broad set of inferences other than personal experiences from which to draw when reading. Personally involving readers by applying the material to their lifestyle makes it more meaningful.

Deciding On and Organizing Your Message

Ask yourself what the reader needs to know about the subject. List the ideas or concepts you want to convey and refine them to their simplest forms. Then organize the presentation of your message.

- Be consistent in presenting and organizing the information, from idea to idea and from page to page. Consistency provides continuity to help the reader follow the points you want to make.
- Put important information either first or last. Even good readers have a tendency to forget or skip over information between the introductory and summary sections.
- Summarize or repeat ideas or information often to refresh a reader's memory, particularly when preparing materials in a series.
- Present one idea on a single page (or two pages if they are face to face). This allows the reader to complete an idea without the distraction of having to turn pages. Simple ideas should not need more than two facing pages.
- Stay with one idea at a time, presenting only the most relevant information. Avoid going off on tangents.

- Be specific, concise, and accurate so the reader has only the most essential information to think about or decisions to make while reading. Break complex ideas down into sub-ideas.
- Start with the completed idea you want understood, then provide an explanation or give "how to" information.
- Sequence information logically. The following are all good sequencing techniques:
  - Step - by - step (1., 2., 3.)
  - Chronological (a time line)
  - Topical (using main topics and sub-topics)

Writing Your Message

To the unskilled reader all of the physical elements of the written message are important. Words, sentences, and paragraphs should all work together to make reading easier, enjoyable, and more easily comprehended. Your goal is to keep the "story" or message moving so it does not get boring.

Tips On Using Words

Choose and use your words carefully. That does not necessarily mean using fewer words to explain an idea. Unskilled readers can become frustrated and disinterested in the material if they do not understand or relate to the words on a page.

The list of frequently used written words given at the end of this appendix can be helpful in word selection. Words appropriate to the cultural and environmental backgrounds of the readers can be added to the list.

- Avoid using abstract words/phrases. If you must use them, help the reader understand them through examples and pictures. For example:

  Avoid: "Labels let you on the inside."

  Better: "Food labels can tell you a lot about the food inside the package."
- Use short, non-technical words of two syllables or less. Hyphenated words are counted as one polysyllabic word.
- Use live, active **verbs** and strong, concrete **nouns** to add strength and emphasis to sentences. Avoid adjectives and adverbs. For example:

  Keep your own **yard** and **street** clean.

  Pick up **trash** around your **home**.

  Put trash in the proper **container**.

  Work with your **neighbor** to clean up **areas** in your **neighborhood** and to keep them clean.

- Use words and expressions familiar to the reader. If you must introduce unfamiliar words, explain them through simple definition, word/picture associations, or by example. Repeat new words at short intervals to make them familiar. For example:

  Aquaculture

  Many farmers raise catfish and other fish in ponds on their farms. This kind of farming is called aquaculture.

  Aquaculture farming works this way. Farmers buy small fish called fingerlings and feed them in the farm ponds. The fish grow to weigh about one or two pounds. Then they are caught and sold to grocery stores and restaurants.

  A lot of catfish can be raised in a pond. Aquaculture is a good way to raise a lot of food in a small space. Aquaculture is a good way for some farmers to make money.

- Avoid sentences with double negatives. Use of negative words may not be objectionable, but positive statements are more motivating. For example:

  Avoid: “Do not eat non-nutritious snacks.”

  Better: “Choose snack foods that are high in nutrients.”

- Avoid a writing style that uses:

  -abbreviations (unless commonly recognizable, i.e., USA)

  -contractions

  -acronyms

  -unfamiliar spelling of words

  -quotation marks

- Persons with limited reading skills may not understand them and, more importantly, their eyes may not read over them smoothly.
- Avoid statistics. Often they are extraneous and difficult for unskilled readers to interpret.
- Use words with single meanings. Based on how they are used, words, like pictures, can mean different things to different people. For example:

  “Poor readers” (unskilled)

  “Poor readers” (limited income)

Tips On Writing Sentences

- The three key elements of a sentence (length, punctuation and structure) work together to provide sentence rhythm. Their use or misuse influences the clarity and comprehension of a sentence and the reader’s attention. To keep your reader’s attention vary sentence rhythm.

Sentence length. Short sentences averaging 8 to 10 words are ideal. Longer ones tend to contain multiple ideas. They probably should be made into two sentences. To keep sentences short avoid unnecessary words, descriptive phrases and clauses, and parenthetical expressions (clarifying or explanatory remarks put in parenthesis).

Sentence punctuation. Asking questions to emphasize a point is a good technique, wouldn't you say? Exclamation points are good for emphasizing your message, too! But, they can get misused through overuse! So watch it!

Sentence structure. Usually the subject precedes the verb in a sentence. But sometimes, to vary sentence structure, try putting the verb in front of the noun. For example:

"The use of exclamation points should be minimized."

"Minimize the use of exclamation points."

- Write generally in the active voice. Active sentences place "doers" before "action," clearly showing the "doer" doing the action. Active sentences present more direct information to the readers, making a stronger statement than passive sentences. Passive sentences have a form of the verb "to be" (am, is, are, was, were, be, being, been) plus a main verb ending in "en" or "ed". Often passive sentences are wordy and roundabout. The receiver of the verb's action comes before the verb, and the "doer" comes after. For example:

  Active: "Jane identified a variety of trees."

  (doer) (verb) (receiver)

  Passive: "A variety of trees were identified by Jane."

  (receiver) (verb) (doer)

Tips On Writing Paragraphs

- Tell readers only what they need to know. Excess information can be confusing and distracting. For example:

  Excessive:

  "There are many ways to keep food safe to eat. One way to help keep food safe is to always wash your hands before getting food ready to eat. Other things that touch the food should be clean, too, such as pans, knives, spoons, countertops, mixing bowls and dishes. This is very important if you plan to eat the food raw, such as in green salads. You can pick up bacteria on your hands from things you touch during the day. The bacteria can get on the food you are preparing. There are many kinds of bacteria. Some bacteria will not hurt you, but some of the bacteria can cause you to be ill. Every year many people get ill from eating foods that were prepared by someone who did not keep their hands or cooking tools clean."

  Better:

  "Always wash your hands before getting food ready to eat. Make sure the pans, knives, bowls, spoons, cutting boards and other cooking tools are clean before you use them.

Keeping your hands and cooking tools clean is VERY important if you plan to eat the food raw, such as in a green salad."

- Sequence information logically. Build connections between what the reader already knows and any new information presented. For example:

  "You may know someone who was sick from eating food that was spoiled. Sometimes spoiled food does not look or taste spoiled. Here are some rules that can help you keep food safe to eat.

  Keep food clean.

  Keep hot foods hot.

  Keep cold foods cold.

- Use short paragraphs.

Tips On Headings

Headings are useful organization tools. They give an ordered look to the material, help readers locate information quickly, and give cues about the message content.

- Short explanatory headings are more instructional than single words that tend to be abstract.
- Abstract words are not specific enough. If readers must decipher words, you may lose their attention.
- Visuals with headings allow readers to react before more detailed information is given, particularly if the information is new.
- Headings are most effective when used with longer paragraphs, but for unskilled readers they are also appropriate for shorter messages.
- Captions or headings should summarize and emphasize important information.

Checklist For Written Materials

Check how your materials meet some of the basic techniques on writing for adults with limited reading skills.

- Need for information is established.
- Information is useful without being extraneous.
- Target Audience is identified. Its characteristics are understood and not forgotten as the primary receiver of the information.
- Audience is made to feel personally involved and motivated to read the material.
- Sentences are simple, short, specific, and mostly in the active voice.
- Each idea is clear, logically sequenced, and limited to one page or two pages, face to face. Important points are highlighted and summarized.

- Illustrations are relevant to text, meaningful to the audience, and appropriately located.
- Words are familiar to the reader. Any new words are clearly defined. None, or very few, are three syllables or more.
- Layout balances white space with words and illustrations.

Word List

High frequency words that make up about 60% of written language.

a	*	have	many	put	through
about		he	may	*	time
above	day	head	me		times
across	days	help	men	read	to
after	did	her	might	right	today
again	different	here	more	*	together
air	do	high	most		too
all	does	him	mother	said	took
almost	don’t	his	mr.	same	two
along	down	home	much	saw	*
also	during	house	must	say	
always	*	how	my	school	under
an		however	*	second	until
and	each	*		see	up
animals	earth		name	sentence	us
another	end	I	near	set	use
any	enough	if	need	she	used
are	even	important	never	should	*
around	ever	in	new	show	
as	every	into	next	side	want
asked	eyes	is	night	since	was
at	*	it	no	small	water
away		its	not	so	way
*	far	*	now	some	we

	father		number	something	well
back	feet	just	*	sometimes	went
be	few	*		soon	were
because	find		of	sound	what
been	first	keep	off	still	when
before	following	kind	often	story	where
began	food	know	old	study	which
being	for	*	on	such	while
below	form		once	*	white
best	found	land	one		who
better	four	large	only	take	why
between	from	last	or	tell	will
big	*	left	other	than	with
both		let	others	that	without
boy	get	life	our	the	words
boys	give	light	out	their	work
but	go	like	over	them	works
by	going	line	own	then	world
*	good	little	*	there	would
	got	live		these	write
called	great	long	page	they	*
came	*	look	paper	things	year
can		looked	part	think	years
children	had	*	parts	this	you
come	hand	made	people	this	your
could	hard	make	picture	thought	*
country	has	man	place	three	