EFFECT OF AECMA SIMPLIFIED ENGLISH
ON THE COMPREHENSION OF AIRCRAFT MAINTENANCE PROCEDURES
BY NON-NATIVE ENGLISH SPEAKERS

by

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ABSTRACT

This study looked for an overall difference between the comprehension of a controlled language called Simplified English (SE) and the comprehension of standard English (non-SE) by non-native English speaking electronics technician students. Further, this study compared the effect of English-reading level on readers' comprehension, ability to locate information, and task completion time for an aircraft maintenance procedure written in SE and an equivalent procedure written in non-SE. The participants were 41 non-native English speaking students from 21 different countries enrolled in electronics technician programs at a technical school in British Columbia. Sixty-three percent of participants were enrolled in aviation-related programs. A reading test, the Accuracy Level Test by Ronald P. Carver, was first administered to participants to measure the English-reading ability of participants by grade level. Participants were then administered a comprehension test for which they were randomly assigned to read either the SE procedure or the non-SE procedure.

The independent samples t-test was used to test for a significant difference between mean test scores for the SE group and the non-SE group. The chi-square test was performed on individual test questions, to look for a significant difference between the SE group and the non-SE group in response to individual questions. Ordinary least squares regression analysis was used to compare the overall difference in the relationship between reading level and comprehension, ability to locate information, and task completion time, for the SE group and the non-SE group. The Fisher Z test for testing independent correlation coefficients (r) was used to determine whether there was a significant difference between the regression lines for the SE group and the non-SE group.
The results indicated that overall there was no significant difference between the comprehension of SE and the comprehension of non-SE by non-native English speakers. However, they showed a trend toward better comprehension of SE than non-SE, and suggested that non-native English speakers with lower reading levels benefit more from the use of SE than those with higher reading levels. Reading level was a significant predictor of comprehension and ability to locate information, but not of task completion time.
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CHAPTER I: INTRODUCTION

The purpose of this study is to look for an overall difference between the comprehension of AECMA Simplified English (SE) and the comprehension of standard English (non-SE) by non-native English speakers. It is also to compare the effect of English-reading level on the comprehension, ability to locate information, and task completion time of non-native English speakers, for an aircraft maintenance procedure written in SE and an equivalent procedure written in non-SE.

SE is a controlled language developed by the aerospace industry to improve the readability of aircraft maintenance documentation. A controlled language is a restricted vocabulary used in the writing of technical documents. Only a predefined selection of words and phrases are allowed, in order to increase consistency and reduce ambiguity. In addition to improving readability, controlled languages are also being used to make the process of translating technical documents into other languages easier.

SE consists of a core vocabulary of about 1000 words that the technical author may supplement with industry-specific words that meet certain criteria, and a set of writing rules for using the vocabulary. SE was developed to help users of English-language documentation—both those who do not have English as their native language and those who do—understand what they read (AECMA, 1995).

As described in more detail in Chapter II, the development of SE proceeded from an investigation into the readability of maintenance documentation in the civilian aircraft industry in

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1 AECMA is the acronym for Association Europeene des Constructeurs de Materiel Aerospatial (in English, the European Association of Aerospace Industries).
the late 1970's. SE was based on an older controlled language called International Language for Servicing and Maintenance (ILSAM), with input from language and publication specialists at companies such as McDonnell Douglas, Boeing, General Electric, Westinghouse, Rolls Royce, and Goodyear. The AECMA Simplified English Guide was first released in 1986. The Guide contains a Dictionary of approved words and 67 writing rules. Each word in the Dictionary has a clearly defined meaning with an approved part of speech. In 1987, SE became a mandatory requirement for most major aircraft manufacturers in the preparation of aircraft maintenance documentation (Shubert, Spyridakis, Coney, and Holmback, 1995 and Chervak, Drury, and Ouellette, 1996). The SE Guide had five subsequent releases with changes or additions and, in 1995, was re-issued with many improved features. This release is referred to as Issue 1. A detailed description of SE is included in Appendix A.

While SE is a mandatory requirement, there is only a small amount of empirical evidence to support the belief that SE improves comprehension. Most of the evidence is anecdotal (Shubert et al., 1995). Shubert et al. (1995) and Chervak et al. (1996) found that the use of SE significantly improved the comprehension of procedures by native and non-native English speakers, with the greatest benefit to non-native English speakers. Chervak (1996) found that the use of Simplified English significantly improved the performance of a task for native English speakers. Eckert (1997) found an improvement in the comprehension of SE by non-native English speakers in a non-native English speaking country, but the improvement was not significant.

This study extends the scope of previous research on the comprehension of SE by investigating the effect of reading level on the comprehension, by non-native English speakers, of a procedure written in SE and an equivalent procedure written in the non-SE. How the benefit of SE for non-native English speakers varies with reading ability has not previously been explored.
The specific questions to be addressed are:

1. Is it significantly easier to comprehend a document written in SE than a document written in non-SE?

2. Is it significantly easier to locate information in a document written in SE than a document written in non-SE?

3. Does the use of SE in a document have a significant effect on time to complete tasks compared to a document written in non-SE?

4. As reading level increases, what is the measurable effect on the comprehension of a document written in SE compared to a document written in non-SE?

5. As reading level increases, what is the measurable effect on the ability to locate information in a document written in SE compared to a document written in non-SE?

6. As reading level increases, what is the measurable effect on time for a document written in SE compared to a document written in non-SE?
CHAPTER II: LITERATURE REVIEW

There are three major sections of this chapter. The first describes controlled languages and
their history, which is closely related to economic globalization and the growing need for
translation of technical documentation into many languages as a result. The second section
reviews the empirical studies involving the comprehension of Simplified English. The third section
introduces the present study.

Controlled Languages

This section presents a description of controlled languages, a history of controlled
languages in general, and of the development of Simplified English in particular, and a statement
of advantages and disadvantages of controlled languages.

Controlled Languages Described

Experts in a particular field communicate technical information among themselves using
their shared natural language, which contains the technical words and phrases descriptive of their
knowledge. Controlled languages are designed to communicate technical information to non-
experts, who may have limited knowledge in the field or be non-native speakers (Kittredge,
1996). They are developed to reduce ambiguity and provide greater consistency and readability in
technical documents, and for the ease of translating documents into other languages (Holmbach,
1996). As a result of increased quality requirements and economic globalization, controlled
languages are increasingly used in technical documentation (van der Eijk, 1998).

Controlled languages are defined by their restrictions. These include restricting the
vocabulary used in a document, restricting the allowable meanings of particular words or phrases,
restricting the kinds of syntactic constructions, and restricting the overall complexity of sentences.
Currently their development is highly customized. Controlled languages have been developed for writing particular kinds of documents (e.g., procedures) within a specific industry or company (Hayes, Maxwell, and Schmandt, 1996).

The production of technical documentation in a controlled language is as follows. An expert may produce the initial draft of a technical document, usually in terse and specific technical language. A professional technical writer then rewrites the draft to conform to the lexical, syntactic, and structural constraints of the controlled language (Heald and Zajac, 1996). In the remainder of this document writer refers to technical writer.

Integral to any discussion of controlled languages is the topic of controlled language tools. When one reviews the literature about controlled languages, it is apparent that the field of controlled languages is primarily concerned with the development of computer translation tools and authoring assistance software for writing within the restrictions of a controlled language.

Controlled languages developed specifically for computer translation are designed to simplify and normalize the linguistic content of documents in order to match the capacities of the computer translation tools. The extent to which the translation tools are accurate is the extent to which the documents comply with the specification of the controlled language (Clemencin, 1996). Although SE was not specifically designed for computer translation, it is claimed that its use would improve the quality of computer translations (van der Eijk, de Koning, van der Steen, 1996).

Authoring assistance software and, more specifically, controlled language conformance checkers, monitor the writer's compliance with the restricted vocabulary and rules, generate diagnostic messages, and, to varying extents, make corrections. Thomas, Jaffe, Kincaid, and Stees (1992) found that a conformance checker lessens the difficulties of writers who are learning to use
SE. Several authors, for example, van der Eijk et al. (1996) and Wojcik and Holmback (1996), claim that they are useful in support of the authoring process. Some authors consider them essential for the success of any writer working within the restrictions of a controlled language (Hayes et al., 1996 and Goyvaerts, 1996).

Computer translation tools and authoring assistance software are similar to controlled languages; however, they are much more complex than controlled languages. For example, they must explicitly define all the implicit rules of grammar that are second nature to a native speaker of the language. This is because these rules are not explicitly defined in the vocabulary and grammar of a controlled language. (An example of an implicit set of rules is the arbitrary placement of articles before nouns.) In addition, they require the encoding of large amounts of domain-specific knowledge. Computer translation systems and conformance checkers must also be able to recognize non-compliant words and phrases and suggest alternatives. Clemencin (1996) states that the enormous amount of information that would need to be stored in a linguistic database for a conformance checker to be fully able to reformulate non-compliant sentences is still out of reach.

History of Controlled Languages

The history of controlled languages is closely related to the need to provide a multilingual customer base with clear and precise documentation on increasingly complex products (van der Eijk et al., 1996). Farrington (1996) describes the increasing complexity of aircraft and the increasing size and complexity of technical documentation. While not empirically based, there is a growing consensus that controlled English documents are translated more easily and hence at a
lower cost and faster than non-controlled documents. They may also have readability advantages over non-controlled documents in the original English (Hayes et al., 1996).

Charles K. Ogden in the 1930’s was the first to work with the concept of using a restricted vocabulary (Sanderlin, 1988). Ogden developed Basic (British American Scientific International Commercial) English to simplify communication with the British colonies (Gingras, 1987). It consisted of 600 nouns, 150 adjectives, and 100 other words, each with a single meaning, and a simplified grammar, all of which can be printed on one page. Despite support from well known communicators Winston Churchill and George Bernard Shaw, Basic English failed to prosper (Hinson, 1988). One problem is that it lacked the technical terms needed (Sanderlin, 1988).

In 1972 the Caterpillar Tractor Company was one of the first to develop a limited form of English for use with international users (Sanderlin, 1988). Caterpillar Fundamental English consisted of 784 core words and a heavily illustrated parts list (Kirkman, 1978). It was the company’s solution to the problems of communicating technical information in 20,000 publications to 10,000 people speaking more than 50 different languages (Gingras, 1987). Caterpillar researchers found that in 30-60 hours they could train operators, who previously knew no English, to recognize the English words as symbols. The operators could then work efficiently on the basis of the information drawn from the controlled English documents (Kirkman, 1978). The plan had some success; however, not all trainees wanted to learn the symbols and some countries still insisted on translations in their own language (Hinson, 1988).

In 1979, McDonnell Douglas developed a technical dictionary of 1,952 words derived from the Navy and Air Force lists of preferred verbs, and from 50 McDonnell Douglas technical manuals. With customers worldwide, McDonnell Douglas was concerned about the readability,
translatability, and standardization of its maintenance manuals (Gingras, 1987). Other companies that developed restricted vocabularies in the 1970s and 1980s were NCR and Kodak.

Caterpillar Technical English, which is part of a combined authoring and translation system, has since replaced Caterpillar Fundamental English. The computer translation system requires its input language to be strictly controlled for vocabulary and grammar, in order to produce an accurate translation. Caterpillar Technical English consists of individual words, both general and technical, technical phrases, with only one unambiguous meaning each, and a collection of syntactic rules designed to allow freedom of expression while minimizing problems for computer translation. To assist writers, an interactive conformance checker tells writers whether what they write conforms to Caterpillar Technical English and helps them make it conform if it does not. Writers tag the English source documents in the Standard General Markup Language (SGML), which are then translated into SGML-tagged source documents in other languages. They can then be automatically formatted. This avoids the expensive reformatting effort often associated with document translation (Hayes et al., 1996).

The General Motors Controlled Automotive Service Language project, to improve the data quality and translation efficiency of General Motors service information, is a similar combined authoring and translation system (Means and Godden, 1996).

Companies may develop their own controlled languages, computer translation systems, and conformance checkers, or they may be developed in conjunction with university research projects. There are also “lingware” development companies that specialize in customizing commercial products.

Table 1 shows some examples of controlled languages in use or currently being developed.
### Table 1

**Examples of Controlled Languages**

<table>
<thead>
<tr>
<th>Controlled Language</th>
<th>Source Language</th>
<th>Target Language(s)</th>
<th>Industry</th>
<th>Developer/User</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplified English</td>
<td>N/A</td>
<td>Aerospace</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caterpillar Technical English</td>
<td></td>
<td>Up to 35 languages</td>
<td>Tractor maintenance</td>
<td>Caterpillar Tractor Company</td>
</tr>
<tr>
<td>Controlled Automatic Service Language (CASL)</td>
<td>English to French</td>
<td>Automotive servicing</td>
<td></td>
<td>General Motors</td>
</tr>
<tr>
<td>Scania Swedish</td>
<td>English, German Dutch, French, Italian, Spanish, Finnish</td>
<td>Truck maintenance</td>
<td></td>
<td>Scania</td>
</tr>
<tr>
<td>Siemens- Dokumentations-deutsch</td>
<td>German to several other languages</td>
<td>Electrical and electronics supply</td>
<td></td>
<td>Siemens</td>
</tr>
<tr>
<td>Perkins Approved Clear English (PACE)</td>
<td>N/A</td>
<td>Engine maintenance</td>
<td></td>
<td>Perkins International</td>
</tr>
<tr>
<td>LinguaNet/ English, French, Dutch/Flemish, Danish</td>
<td>Cross-border police communications</td>
<td></td>
<td></td>
<td>Industrial partners, Prolingua, Philips, &amp; Kent Constabulary, &amp; research groups at Cambridge (Judge Institute), Leuven, Copenhagen, &amp; Bordeaux II</td>
</tr>
</tbody>
</table>
Simplified English is one example of a controlled language. In the late 1970s, the Association of European Airlines asked the European Association of Aerospace Industries (AECMA) to investigate the readability of maintenance documentation in the civilian aircraft industry. AECMA asked the Aerospace Industries Association of America to assist in the project. The AECMA Simplified English Guide evolved out of this effort (AECMA, 1995).

SE was constructed from the International Language for Servicing and Maintenance (ILSAM). A variation of Caterpillar Fundamental English, ILSAM was developed to facilitate translation for international product support documentation (Shubert et al., 1995). Language and publication specialists from companies such as McDonnell Douglas, Boeing, General Electric, Westinghouse, Rolls Royce, and Goodyear contributed to the formulation of SE. The AECMA Simplified English Guide was first released in 1986, and had five subsequent releases with changes or additions. In 1995 it was re-issued with many improved features. This release is referred to as Issue 1.

In 1987, the Airline Transport Association of America made AECMA SE a mandatory requirement in its Specification for Manufacturers' Technical Data (ATA 100), Revision 26 (Farrington, 1996). As a result, AECMA SE is used by most major aircraft manufacturers in their documentation (Shubert et al., 1995 and Chervak et al., 1996).

A detailed description of SE is included in Appendix A.

Advantages and Disadvantages of Controlled Languages

There are many claimed advantages of controlled languages, both for companies and their customers; however, there is little empirical evidence to support these claims. There are also some
disadvantages. (Except where stated otherwise, the articles referred to in this section are not research studies.)

Advantages

To the non-native English speaker, every word is a “potential land mine waiting to explode” (Blaschke, 1992). Controlled English languages are one of the few solutions to the problem of providing clear documentation, when English is not the first language of most readers (Goyvaerts, 1996), yet more than 50% of scientific and technical publications are written in English (Peterson, 1990).

The readability of documentation can prove a competitive advantage (Goyvaerts, 1996). Better documentation reduces legal liability, improves safety and efficiency, and results in fewer customer complaints and questions (Gingras, 1987).

Controlled languages can, in some cases, eliminate the need for translation (van der Eijk et al., 1996). However, when translation is required, documents written in controlled languages may be translated more easily and hence at a lower cost and faster than documents written in unrestricted natural language (Hayes et al., 1996). See Shubert, Spyridakis, and Holmback (1995) for an empirical study of the translation of SE into Chinese, Japanese, and Spanish.

Controlled languages also result in the uniformity of documents across an organization, and provide a way to measure document quality (Douglas and Hurst, 1996).

Disadvantages

The disadvantages of controlled languages are primarily for the writer (Sanderlin, 1988). Thomas et al. (1992) found that, while it is easy to understand, SE is difficult to write without a great deal of training and practice. It demands a good knowledge of conventional English and
demands much greater concentration and awareness than writing in standard English (Farrington, 1996). Depending on the author’s familiarity, writing in a controlled language can take up to 20% longer (Goyvaerts, 1996). Estimates of how long it takes to become proficient at using SE range from six months (Gingras, 1987) to two years (Hinson, 1988).

Controlled languages and their computer-assisted writing aids require a significant investment and amount of time to develop and implement (Goyvaerts, 1996). Companies must bear the costs (Gingras, 1987).

Writers may feel resentful if a controlled language is imposed on them by a management decision, without first being persuaded to believe in the concepts (Goyvaerts, 1996). They may feel restricted from expressing instructions in the most obvious manner (Chervak et al., 1996). Sometimes they hate it so much they quit their jobs (Hinson, 1988).

It is possible to follow all the rules and still produce bad technical writing (Goyvaerts, 1996). Use of a controlled language does not compensate for lack of writing skills (Farrington, 1996).

A controlled language does not always have the support of the domain experts, which adversely affects its acceptance in the user community. The domain experts can find the controlled language to be alien in its grammatical features, that is, unlike the grammatical features of their shared natural language (Kittredge, 1996). Writers may be unable to convince them that natural language is sometimes illogical and even contradictory (Goyvaerts, 1996). Furthermore, grammar restrictions often can only be expressed in linguistic jargon that is not always easy to explain to domain experts with no or limited linguistic background (van der Eijk et al., 1996).
Studies Involving Simplified English

While much anecdotal evidence of the benefit of SE exists (Shubert et al., 1995), only a small number of empirical studies have been done on SE. Of these, only four studied the comprehension of SE.

Shubert et al. (1995) looked at the effect of document type (SE versus non-SE) on reading comprehension. One hundred and twenty-one engineering undergraduates at the University of Washington (90 native English speakers; 31 non-native English speakers) participated in the study. Non-native English speaker was not defined, however it is taken to mean one whose first language is not English. The study does not say what level of English language fluency the non-native English speakers had.

The participants read and took a comprehension test on one of four documents: two non-SE documents and their SE counterparts. The two sets of documents (A and B) contained aircraft maintenance procedures. Document A was considered more conceptually difficult than Document B.

The comprehension test consisted of multiple choice, short answer, and true/false questions. As well, the participants were asked to identify where they found the answer in the document. The total time to read the sample and write the test was recorded.

The results were analyzed separately for native English speakers and non-native English speakers. For Document A, the measures of the comprehension test and identification of content location were significantly greater for the SE version than for the non-SE version, for both native and non-native English speakers, with the significance being greatest for non-native English speakers. For Document B, the same measures had no significant differences between the SE version and the non-SE version, for either native or non-native English speakers. The total time to
read the sample and write the test was not significant for either Document A or B, for native or non-native English speakers. However, the non-native English speakers took longer than the native English speakers did.

The conclusion was that SE is helpful for both the native and non-native English speakers when working with more difficult documents. Simpler documents were not significantly more comprehensible when rewritten in SE, for native or non-native English speakers. Holmback et al. (1996) point out that the level of difficulty in a document at which SE becomes beneficial has not been identified.

With similar results, Chervak et al. (1996) extended Shubert et al.'s (1995) comprehensibility study to test the use of SE aircraft workcards with the intended end user — practicing aircraft maintenance technicians. They used four different workcards (two easy and two difficult), each prepared in an SE version and a non-SE version. A variety of methods were used to rate the complexity of workcards, including obtaining a task difficulty rating by an experienced engineer for guidance. In addition, each card was prepared in one of two different layouts, for a total of 16 cards.

One hundred seventy-five technicians (157 native English speakers; 18 non-native English speakers) from seven U.S. sites read and took a comprehension test on one of the 16 workcards. The comprehension test consisted of multiple choice, short answer, and fill-in-the-blank questions, and required the participants to identify where they found the answers in the document. The total time to read the workcard and write the test was recorded.

Analyses were performed separately for native English speakers and non-native English speakers. For the 157 native English speakers, the effect of the three independent variables (SE or non-SE, layout, and complexity of workcard) on the two performance measures, speed and
accuracy, was assessed using analysis of variance or covariance procedures. Co-variates were selected from the following performance predictors: aircraft maintenance experience, inspection experience, age and reading ability. An intercorrelation matrix of performance predictors and performance measures showed that aircraft maintenance experience was highly correlated with age, that inspection experience was uncorrelated with other variables, and that age and reading ability were moderately correlated with speed and accuracy.

For the two easy workcards, the results showed that there was no significant change in accuracy between the easy SE and non-SE versions. For the two difficult workcards, there was a significant improvement in accuracy for the SE version. When a factor of aircraft maintenance experience was added to the ANCOVAs of speed and accuracy, no significant effect on the performance on the comprehension test was found.

The non-native English speakers' results were analyzed with the native English speakers results in a separate 2 X 2 ANOVA for SE versus non-SE, and native English speaking versus non-native English speaking. By chance, there was an even distribution of SE and non-SE workcards among the non-native English speakers. Accuracy increased significantly for non-native English speakers using the SE versions. One of the conclusions from the study was that the use of SE allowed the non-native English speakers to achieve the same level of performance as the native English speakers.

There was no significant difference between the time to read the SE documents versus the non-SE documents, for either the native English speakers or the non-native English speakers. However, there was a significant difference between the time it took the native English speakers and the non-native English speakers to complete the task.
Chervak (1996) measured the effect of SE on the actual physical activity of the task performed, to examine whether SE can actually improve a person's ability to not only comprehend but also perform a task. There were two tasks, an easy task and a difficult task. Each task was prepared in three versions, the original non-SE version, an SE version, and an intermediate non-SE outline version. Because the tasks were based on lawnmower engine maintenance rather than aircraft maintenance, the participants were Automotive Maintenance Mechanics students and experienced mechanics.

Nine student mechanics and nine expert mechanics were randomly assigned to perform both tasks using workcards that were the same version (e.g., both SE). The participants were videotaped and timed as they performed each task. The videotapes were analyzed and errors were classified into the following categories: repetition, omission, delay, premature action, replacement, insertion, intrusion, and wrong amount of oil added. Analysis of variance procedures determined that the expert mechanics made significantly fewer errors and completed the tasks in significantly less time than the student mechanics, and that the easy task was completed in a significantly shorter time than the difficult task. The number of errors committed appeared reduced when SE was introduced, but the reduction in errors was just out of significance range. However, when an additional error classification was introduced called “uncertainty”, there was a significant decrease in the number of errors committed between the SE and the outline version of the workcard, in favour of the SE version. The use of SE did not affect the time to complete tasks.

There was no separate collection or analysis of data from non-native English speakers in this study. It should be noted that there were only three participants in the SE condition, each performing two SE procedures.
Eckert (1997) conducted a study on the comprehensibility of SE using only non-native English speaking participants. He obtained results that showed a trend in the direction of the previous studies, but did not provide empirical support for them. The objective of the research was to determine if the use of SE improved the comprehension of non-native English speaking aircraft maintenance technician students in a non-native English speaking environment. One hundred and forty-eight participants at four aviation schools in Mexico City were administered aviation task cards and tests, which measured subject comprehension of maintenance procedures. The participants were randomly assigned to one of two groups, an SE experimental group and a non-SE group control group. The two groups were found to be homogeneous in distribution of age, gender, country of birth, occupation, native language, use of a second language, English fluency courses and exams taken, aviation classes taken, aviation experience, and reading ability.

The independent samples t-test was used to compare the task card scores. The results indicated that there was no statistically significant improvement in task card comprehension when using SE. However, SE did have a positive effect on comprehension, in that the mean task card score for comprehension was higher for the SE participants than for the non-SE participants.

A multiple regression analysis indicated that comprehension was significantly positively affected by an increase in the number of English courses taken, the number of aviation courses taken, reading ability, and gender. An increase in age significantly negatively affected the task card score. The study also concluded that the SE participants required a higher mean English-reading ability to obtain a mean task card test score similar to the non-SE participants.

In summary, Shubert et al. (1995) and Chervak et al. (1996) found that the use of SE significantly improved the comprehension of procedures by native and non-native English speakers, with the greatest benefit to non-native English speakers. Eckert (1997) found an
improvement in the comprehension of SE by non-native English speakers in a non-native English speaking country, but the improvement was not significant.

The work of Shubert et al. (1995), Chervak et al. (1996), and Eckert (1997) represents overall differences in the comprehension of SE by non-native English speakers compared to their comprehension of non-SE. Information is also required about the relationship between English reading ability and the usefulness of SE for non-native English speakers. Although Chervak et al. and Eckert (1997) did give a reading ability test to all participants and found a positive correlation between reading ability and performance on a comprehension test, reading ability was not an independent variable in these studies. In the present study, as described in the next section, reading ability was an independent variable, and the interaction between reading ability and the SE/non-SE variable was examined.

Description of the Present Study

The purpose of the present study was to look for an overall difference between the comprehension of SE and the comprehension of non-SE by non-native English speakers. It extends the scope of previous research on the comprehension of SE by non-native English speakers by examining how the benefit of SE for non-native English speakers varies with reading ability. This study examines the effect of English-reading level on the comprehension, ability to locate information, and task completion time by non-native English speakers, for a procedure written in SE and an equivalent procedure written in non-SE.

The independent variables in the present study are reading level and document type (SE or non-SE). The dependent variables, comprehension, content location, and time, mirror those of the Shubert et al. (1995) study and are similar to those of the Chervak et al. (1996) study.
The participants were 41 non-native English speaking students in electronics technician programs at the British Columbia Institute of Technology (BCIT), of whom 63% were enrolled in aviation-related programs.

Although the use of SE did not affect the time to complete tasks in these previous studies, this study nevertheless explored the role of time. Two possible reasons given by Shubert et al. (1995) for the lack of significant difference in time are that the documents were too short to reflect the difference for participants, or there was no pressure to finish quickly. The document that was used in this study was longer by comparison (1239 words) than the two documents used in the Shubert et al. (1995) study (686 and 846 words), and the four workcards used in the Chervak et al. (1996) study (ranging from 256 to 554 words).

As in Shubert et al. (1995), Chervak et al. (1996), and Eckert (1997), the document that was used in this study contained an aircraft maintenance procedure. It would have been desirable to use two different documents to show replicability. However, because of the small sample size, only one document was used, with two variations, an SE version and a non-SE version.

Research Hypotheses

Following from the conclusions of previous research on the comprehension of SE by non-native English speakers, the following experimental predictions were made:

1. (a) The comprehension scores for the SE group will be higher than the comprehension scores for the non-SE group.

(b) The comprehension scores will increase as reading level increases, for both the SE group and the non-SE group.
(c) (interaction hypothesis) As reading level increases, the increase in comprehension scores for the SE group will be less than the increase in comprehension scores for the non-SE group. In other words, there will be a greater difference between SE and non-SE comprehension scores at lower reading levels than at higher reading levels. This interaction was expected because it was thought that use of SE would compensate to some degree for lack of comprehension due to low reading level. The result would be more correct answers for participants with lower reading levels who read the SE version than for those who read the non-SE version.

2. (a) The location scores for the SE group will be higher than the location scores for the non-SE group.

(b) The location scores will increase as reading level increases, for both the SE group and the non-SE group.

(c) (interaction hypothesis) As reading level increases, the increase in location scores for the SE group will be less than the increase in location scores for the non-SE group. In other words, there will be a greater difference between SE and non-SE location scores at lower reading levels than at higher reading levels, similar to as explained in 1 (c) above.

3. (a) The time scores for the SE group will be lower than the time scores for the non-SE group.
The time scores will decrease as reading level increases, for both the SE group and the non-SE group.

(interaction hypothesis) As reading level increases, the decrease in time scores for the SE group will be less than the decrease in time scores for the non-SE group.

In other words, there will be a greater difference between SE and non-SE time scores at lower reading levels than at higher reading levels. Again, this interaction was expected because it was thought that use of SE would compensate to some degree for lack of comprehension due to low reading level. The result would be faster completion times for participants with lower reading levels who read the SE version than for those who read the non-SE version.

Significance of the Study

Aircraft maintenance is an increasingly complex field with increasingly complex documentation (Farrington, 1996). The quality of the documentation is critical, because poor quality documentation can cause incorrect parts replacement, damage to expensive equipment and, more seriously, injury to people. Damages and injuries may lead to costly liability claims (van der Eijk, 1998).

AECMA SE evolved out of an investigation into the readability of maintenance documentation in the aircraft industry in the late 1970s (AECMA, 1995). In 1987, SE became a mandatory requirement for most major aircraft manufacturers in the preparation of aircraft maintenance documentation (Shubert et al., 1995 and Chervak et al., 1996).
While SE is a mandatory requirement, there is only a small amount of empirical evidence to support the belief that SE improves comprehension. This study, which is the fifth empirical study on the comprehensibility of SE, was aimed at the users who are thought to benefit the most from the use of SE—non-native English speakers (Shubert et al., 1995; Chervak et al., 1996; Chervak, 1996; and Eckert, 1997). It was intended to provide deeper insight into the usefulness of SE for non-native English speakers, and to contribute to the small body of empirical evidence that already exists on the comprehension of SE.
CHAPTER III: DESIGN AND PROCEDURES

This study looked for an overall difference between the comprehension of AECMA Simplified English (SE) and the comprehension of standard English (non-SE) by non-native English speakers. Further, it compared the effect of English-reading level on the comprehension, ability to locate information, and task completion time of non-native English speakers, for an aircraft maintenance procedure written in SE and an equivalent procedure written in non-SE.

Participants

While the population of interest is non-native English speaking aircraft maintenance technicians, the participants were non-native English speaking students enrolled in electronics technician programs at the British Columbia Institute of Technology (BCIT). Data was collected from 41 participants: 19 were enrolled in the Aircraft Maintenance Diploma program, 7 were enrolled in the Aircraft Electronics (Avionics) Diploma program, 13 were enrolled in the Electronics Common Core program, and two were enrolled in the Electrical Pre-apprentice program.

The participants came from 21 different countries, namely Hong Kong (5), Poland (4), the Fiji Islands (4), Canada (4), Taiwan (3), Sri Lanka (3), China (2), the Philippines (2), Vietnam (2), and one each from Czechoslovakia, Egypt, Ethiopia, Hungary, India, Italy, Korea, Mauritius, Romania, Russia, Yugoslavia, and Zambia. The first languages of the four who were born in Canada were French (2), Hindi (1) and German (1).

There were 38 men and three women. They ranged in age from 18 to 40 with an average age of 23.4 years. The number of years participants had been speaking English ranged from 1 to 24 years, with a mean of 9.0 years. Their mean length of residence in Canada was 10.9 years.
Some participants who came to Canada as young children did not learn English until they were old enough to go to school, because only their native language was spoken in the home. Others were speaking English before they came to Canada.

Before entering BCIT, twenty-four participants had Grade 12, six had college diplomas, one had a university bachelor’s degree, another seven had some college or university, two had Grade 13, and one had Grade 11.

Posters were used to attract volunteers. Attracting non-native English speaking volunteers from the electronics technician programs at BCIT was difficult. It was made more difficult because there were two parts to the study, and volunteers had to be at a specified time and place on two separate occasions. Originally, only students enrolled in aviation programs were targeted. However, because of the insufficient response, the target group was expanded to include students in all electronics technician programs. All students in such programs share a common core of electronics courses.

As incentives, volunteers received refreshments in the form of donuts, $10 or $20 cash (depending on the group), and a chance at a draw for a $100 gift certificate at a fine restaurant. The draw was held twice. Despite these inducements, only 41 out of a potential of approximately 200 non-native English speaking students in electronics technician programs volunteered.

Materials

Texts

There was one passage, with an SE version and a non-SE version, for a total of two documents. The two versions are included in Appendix B and Appendix C, respectively.
The non-SE version was selected from six samples provided by Aerospatiale. It was chosen because it is a self-contained procedure with only one diagram, and a substantial length (1239 words). The procedure was a composite of seven subprocedures, totaling 51 steps. The percentage of verbs in the passive voice was four percent.

While the findings of Shubert et al. (1995) and Chervak et al. (1996), that significant improvements in performance occurred only with more complex documents, were kept in mind in choosing the document, there was also a concern to choose a document that was a typical aircraft maintenance procedure.

Because an equivalent SE version was not available, the original procedure was converted to SE by the researcher, and checked by Ms. Kathy Barthe, Chairperson of the AECMA Simplified English Maintenance Group. Ms. Barthe made some corrections, and other changes she suggested were incorporated into the final SE version of the procedure.

The SE version conforms to the latest release of the AECMA Simplified English Guide issued in 1995 (Issue 1).

Tests

There were two tests, a reading test and a comprehension test.

The Accuracy Level Test (Carver, 1987) is a 10-minute timed reading comprehension test which measures how many words an individual knows the meaning of when reading. The raw score can be used to derive a grade equivalent score. This test was also used to measure reading ability in Chervak et al. (1996), Chervak (1996), and Eckert (1997).

The test consists of 100 questions. In each question, the subject reads a word and then chooses which one of three other words is a synonym for that word. The words increase in
difficulty from very easy at the beginning to very difficult at the end. The test has a high reliability (0.91) measured on college students and a high validity (0.77 to 0.84) when compared to the Nelson-Denny Reading Test (Carver, 1987). In addition, Eckert (1997) concluded that the Accuracy Level Test was a reliable measure of English-reading grade level in a non-native English speaking environment.

The comprehension test consisted of an aircraft maintenance procedure and a total of 16 multiple choice, true/false, and short answer questions. The comprehension test is included in Appendix D.

The aircraft maintenance procedure was either in SE or standard English (as described earlier under “Texts”). Information formatted into a table necessitated an additional page in the SE version, such that the SE version was six pages and the non-SE version was five pages. In all other respects, the two versions were equivalent in appearance (format) and in meaning.

The 16 test questions were the same, regardless of whether participants read the SE version or the non-SE version. The wording of the questions was neutral, so as not to bias the test in favour of the SE or the non-SE procedure. There were two parts to each question. In the first part, the participants wrote down the answer to the question. In the second part, the participants wrote down where (e.g., a step number) they found the answer to the question. The steps were renumbered sequentially in the left margin so that the participants could quickly identify the location of an answer. This was done to minimize non-reading related effort during the test and thus shorten the test duration.

A cover sheet gave simple instructions for completing the test, including a sample question. It informed participants that they could refer back to the procedure at any time and they could have up to 50 minutes to complete the test.
One question, number 2, was later discarded. It was rejected because the answer was not found in equivalent locations in both documents. Data analysis was done on 15 questions.

**Procedure**

The study was conducted in two parts. In the first part, the Accuracy Level Test was administered to determine the English-reading level of the participants. To randomly assign participants to either the SE or non-SE group, and to maintain homogeneity in distribution of reading levels between groups, the following procedure was used. First, the participants were ranked in descending order by reading level. Then, of the two highest-ranking participants, the first in the pair was randomly assigned, by flipping a coin, either to the SE group or the non-SE group, and the second in the pair was assigned to the other group. The remaining participants were similarly assigned, in pairs, to either to the SE group or non-SE group. The tests were then pre-coded for each student.

The participants were asked to sign a consent form. They were also asked to indicate their age, first language, length of residence in Canada, number of years speaking English, academic background, and the electronics technician program in which they were currently enrolled.

In the second part, the participants were instructed to read the procedure first and then write the test. They were told that they could refer back to the procedure at any time, and that they would have a maximum of fifty minutes. This information was also briefly stated on a cover sheet for the pre-coded test.

The participants were all instructed to begin at the same time. The finish time for each subject was recorded.
Because of the difficulty in attracting volunteers for this study, and the need to use participants in several different courses, the tests were administered three times with various group sizes, and twice with individuals. There was one group of twenty-six, one group of eight, one group of five, and two individuals.

**Design**

The study was experimental. The two independent variables were:

1. Document Type (SE versus non-SE)
2. Reading Level (a range).

The dependent variables, and the measurement method, were as follows:

1. Comprehension, using multiple choice, short answer, and true/false questions
2. Identification of content location, using short answer questions
3. Total time to read the procedure and complete the questions, using a countdown timer.

The control variable was the equivalent procedure written in non-SE. Participants were tested randomly on either the SE version or the non-SE version.

**Data Analysis**

Ordinary least squares regression analysis was used to compare the overall difference in the relationship between reading level and the dependent variables, for participants who read the SE procedure and participants who read the non-SE procedure.

The dependent variable is expressed in the following manner:

\[ y = ax + b \]
where the dependent $y$-value is a function of the independent $x$-values. The $a$-value is the additional change in the dependent variable attributed to each unit change in $x$, and $b$ is the change in the dependent variable with the baseline value of $x$.

The Microsoft Excel™ data analysis tools and specific worksheet functions were used to analyze the data. The LINEST function was used to determine whether the correlation represented by a regression line was significantly greater than zero.

The Fisher $Z$ test for testing independent correlation coefficients ($r$) was used to determine whether there was a significant difference between the regression lines for the SE group and the non-SE group.

The independent samples $t$-test was used to test for an overall significant difference between the comprehension scores for the SE group and the non-SE group, and between the location of information scores for the two groups.

The chi-square test was performed on each individual comprehension and location of information question, to look for a difference between groups in response to individual questions.

**Test of Homogeneity of Groups**

The homogeneity of the SE and non-SE groups was tested by comparing the distribution of reading levels, and the distribution of participants enrolled in aviation-related programs (i.e., Avionics and Aircraft Maintenance), between groups. These comparisons were done to determine whether any differences between groups in comprehension, location, and time scores could be attributed to a difference in the distribution of these two variables. The assumption was that participants with higher reading levels, and participants enrolled in aviation-related programs,
would tend to obtain higher scores than participants with lower reading levels and participants enrolled in other, non-aviation-related programs.

(a) Distribution of Reading Levels Between Groups. The independent samples $t$-test was performed on the reading levels to compare the distribution between the SE group and the non-SE group. The means were 9.9 and 9.7, respectively, for the SE group and the non-SE group. The difference between the means was found to be statistically insignificant ($t = .1567$, $df = 39$, $p > .05$). The obtained $t$-value of .1567 did not fall beyond the critical region of the tails ($t$-critical = +/- 2.0226), which indicates that the distribution of reading levels was homogeneous between the two groups.

(b) Distribution of Participants Enrolled in Aviation-related Programs. The majority of participants in this study (63.41%) were enrolled in aviation-related programs. Sixty-three percent (63.16%) of the SE group and 63.64% of the non-SE group were enrolled in either Aircraft Maintenance or Avionics. The chi-square statistic was used to measure whether the difference was statistically significant. The obtained $\chi^2$ value of .001 did not fall beyond the critical region (critical value = 3.84), so there was no significant difference, between groups, in the number of participants enrolled in aviation-related programs.

The independent samples $t$-test was performed on the reading levels of participants enrolled in aviation-related programs, to compare the distribution between the SE group and the non-SE group. The means were 10.2 and 10.3, respectively, for the SE group and the non-SE group. The difference between the means was found to be statistically insignificant ($t = -.09$, $df = 24$, $p > .05$). The obtained $t$-value of -.09 did not fall beyond the critical region of the tails.
(\(t\)-critical = +/- 2.068), which indicates that the distribution of reading levels for participants enrolled in aviation-related programs was homogeneous between the two groups.

(c) Distribution of Participants Enrolled in Other Technician Programs. The independent samples \(t\)-test was performed on the reading levels of participants enrolled in non-aviation-related programs, to compare the distribution between in the SE group and the non-SE group. The means were 9.3 and 8.7, respectively, for the SE group and the non-SE group. The difference between the means was found to be statistically insignificant \((t = .3551, df = 12, p > .05)\). The obtained \(t\)-value of .3551 did not fall beyond the critical region of the tails \((t\)-critical = +/- 2.1603\), which indicates that the distribution of reading levels for participants enrolled in other technician programs, besides aviation-related programs, was homogeneous between the two groups.

In summary, the various tests for homogeneity of groups described above indicate that there was no difference between the SE group and the non-SE group in the distribution of reading levels or in the distribution of participants enrolled in aviation-related programs which might affect scores.
CHAPTER IV: RESULTS

Hypotheses were tested regarding the overall difference between the comprehension of SE and the comprehension on non-SE. Further, hypotheses were tested regarding the relationship between reading level and comprehension scores, location of information scores, and time scores achieved by two groups of non-native English speakers, one reading an SE procedure and one reading an equivalent non-SE procedure. The results for each of the three dependent variables are reported under the following headings:

1. Comprehension Results
2. Location of Information Results
3. Time Results.

Under each of the above headings, the results of tests for each related hypothesis are described. As applicable, these tests include the independent samples t-test, the chi-square test, regression analysis, and the Fisher Z test for testing independent correlation coefficients (r).

Comprehension Results

Hypothesis 1 (a) The comprehension scores for the SE group will be higher than the comprehension scores for the non-SE group.

Hypothesis 1 (a) was tested in two ways. The difference between the overall scores was tested using the independent samples t-test to compare the mean comprehension scores for the SE group and the non-SE group. The difference in response to individual comprehension questions between the two groups was tested using chi-square tests.

The independent samples t-test was performed on the comprehension scores to determine whether there was a significant difference between the mean comprehension scores for the SE group and the non-SE group. The analysis consisted of the 41 comprehension scores obtained
from this research. The mean scores were 67.67% and 63.33%, respectively, for the SE group and the non-SE group. While the mean comprehension score for the SE group was 4.34% higher than the mean comprehension score for the non-SE group, the difference between the means was not statistically significant ($t = .4879, df = 39, p > .05$). The obtained $t$-value of .4879 did not fall beyond the critical region of the tails ($t$-critical = +/- 2.0226). The results are presented in Table 2.

Table 2
Descriptive Statistics for Comprehension Scores

<table>
<thead>
<tr>
<th>Comprehension Scores</th>
<th>SE</th>
<th>Non-SE</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>67.67%</td>
<td>63.33%</td>
<td>64.87%</td>
</tr>
<tr>
<td>Median</td>
<td>73.33%</td>
<td>70.0%</td>
<td>73.33%</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>19.12%</td>
<td>23.88%</td>
<td>21.6%</td>
</tr>
<tr>
<td>Range</td>
<td>80.0%</td>
<td>93.33%</td>
<td>93.33%</td>
</tr>
<tr>
<td>Minimum</td>
<td>13.33%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Maximum</td>
<td>93.33%</td>
<td>93.33%</td>
<td>93.33%</td>
</tr>
<tr>
<td>$n$</td>
<td>19</td>
<td>22</td>
<td>41</td>
</tr>
</tbody>
</table>

Note, $t = 0.4879, df = 39, p > .05$

Chi-square tests were used to examine whether there were any differences between the SE group and the non-SE group in response to individual comprehension questions. Only one question, number seven, had a significant difference in response between the SE group and the non-SE group. The percentage of participants who answered this question correctly was 84.21% and 50.00%, respectively, for the SE group and the non-SE group. This is a difference of 34.21% (see Table 3). Note that the significant result reported in Table 3 should be interpreted with caution due to the probability of a significant result occurring by chance when multiple chi-square tests are performed individually.
Table 3

Chi-square Statistics for Individual Comprehension Questions

<table>
<thead>
<tr>
<th>Comprehension Question</th>
<th>SE Group</th>
<th>Non-SE Group</th>
<th>Chi-statistic</th>
<th>df</th>
<th>not significant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(critical value = 3.84, $\alpha = .05$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>68.42%</td>
<td>72.73%</td>
<td>0.0913</td>
<td></td>
<td>not significant</td>
</tr>
<tr>
<td>3</td>
<td>73.68%</td>
<td>63.64%</td>
<td>0.4753</td>
<td></td>
<td>not significant</td>
</tr>
<tr>
<td>4</td>
<td>78.95%</td>
<td>77.27%</td>
<td>0.0167</td>
<td></td>
<td>not significant</td>
</tr>
<tr>
<td>5</td>
<td>89.47%</td>
<td>81.82%</td>
<td>0.4783</td>
<td></td>
<td>not significant</td>
</tr>
<tr>
<td>6</td>
<td>31.58%</td>
<td>45.45%</td>
<td>1.8249</td>
<td></td>
<td>not significant</td>
</tr>
<tr>
<td>7</td>
<td>84.21%</td>
<td>50.00%</td>
<td>6.1682</td>
<td></td>
<td>SIGNIFICANT</td>
</tr>
<tr>
<td>8</td>
<td>26.32%</td>
<td>31.82%</td>
<td>0.1491</td>
<td></td>
<td>not significant</td>
</tr>
<tr>
<td>9</td>
<td>36.84%</td>
<td>45.45%</td>
<td>0.3116</td>
<td></td>
<td>not significant</td>
</tr>
<tr>
<td>10</td>
<td>68.42%</td>
<td>68.18%</td>
<td>0.0003</td>
<td></td>
<td>not significant</td>
</tr>
<tr>
<td>11</td>
<td>73.68%</td>
<td>59.09%</td>
<td>0.9656</td>
<td></td>
<td>not significant</td>
</tr>
<tr>
<td>12</td>
<td>84.21%</td>
<td>77.27%</td>
<td>0.3125</td>
<td></td>
<td>not significant</td>
</tr>
<tr>
<td>13</td>
<td>89.47%</td>
<td>90.91%</td>
<td>0.0239</td>
<td></td>
<td>not significant</td>
</tr>
<tr>
<td>14</td>
<td>89.47%</td>
<td>77.27%</td>
<td>1.0719</td>
<td></td>
<td>not significant</td>
</tr>
<tr>
<td>15</td>
<td>63.16%</td>
<td>77.27%</td>
<td>0.9811</td>
<td></td>
<td>not significant</td>
</tr>
<tr>
<td>16</td>
<td>42.11%</td>
<td>31.82%</td>
<td>1.0958</td>
<td></td>
<td>not significant</td>
</tr>
</tbody>
</table>

Several questions showed a difference of more than 10%, which is a large difference in absolute terms, but not a statistically significant difference. For example, the percentage of participants who answered question 11 correctly was 73.68% in the SE group and 59.09% in the non-SE group, a difference of 14.59%. The sample size was too small for this difference to be statistically significant. Several comprehension questions also had a poor response (e.g., 6, 8, 9, 16), indicating that participants found either the format or content of the questions difficult.

On an overall basis, Hypothesis 1 (a) was not confirmed by the results of the independent samples $t$-test. However, the results showed a trend in the hypothesized direction. The mean
comprehension score for the SE group was not significantly different from the mean
comprehension score for the non-SE group, but the SE mean was higher than the non-SE mean.

On an individual question-by-question basis, Hypothesis 1 (a) was confirmed for only one
comprehension question, question seven. Although only one question was significant, readers in
the SE group correctly answered 9 out of 15 comprehension questions a higher percentage of the
time than readers of the non-SE group, which also indicates a trend in the hypothesized direction.

**Hypotheses 1 (b)** The comprehension scores will increase as reading level
increases, for both the SE group and the non-SE group.

Regression analysis was used to examine the relationship between reading level and
comprehension score for participants who read the SE procedure and participants who read the
non-SE procedure. A statistically significant relationship was found between reading level and
comprehension score for both the SE group and the non-SE group, as determined by the LINEST
function (SE group: F = 6.5757, df = 17, p < .05, F critical = 4.45; non-SE group: F = 9.7789, df
= 20, p < .05, F critical = 4.35).

Table 4 shows the intercept, coefficient of determination ($r^2$), and slope of the regression
lines for the SE group and the non-SE group.

**Table 4**

Statistics for Regression Lines—Comprehension Scores

<table>
<thead>
<tr>
<th></th>
<th>SE</th>
<th>Non-SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>30.91%</td>
<td>24.35%</td>
</tr>
<tr>
<td>$r^2$</td>
<td>.2789</td>
<td>.3284</td>
</tr>
<tr>
<td>% increase in comprehension score per grade level increase (slope)</td>
<td>3.61%</td>
<td>4.0%</td>
</tr>
</tbody>
</table>
Figure 1 illustrates that the comprehension scores for both the SE group and the non-SE group improved as reading level improved, as was expected. Hypothesis 1 (b) was confirmed by the results of the regression analysis.

![Regression Lines](image)

**Figure 1.** Fitted regression lines representing the effect of reading level on the comprehension scores of the SE group and the non-SE group

Hypothesis 1 (c) As reading level increases, the increase in comprehension scores for the SE group will be less than the increase in comprehension scores for the non-SE group.

Hypothesis 1 (c) was tested using the Fisher Z test for independent r's, to compare the correlation of comprehension score with reading level for the SE group and the non-SE group. In this test, the r's are first transformed into Fisher Z's. The z-ratio -.1915 is compared with the critical z-value 1.96, with α = .05. Since -.1915 is less than 1.96, the null hypothesis, that there is no significant difference between the correlation of the comprehension scores with reading level, for the SE group and the non-SE group, must be accepted. (See Table 5.)
Table 5

Comparison of r’s for SE/non-SE Comprehension Scores and Reading Levels

<table>
<thead>
<tr>
<th></th>
<th>SE Group</th>
<th>Non-SE Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>.5281</td>
<td>.573</td>
</tr>
<tr>
<td>n</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>Z</td>
<td>.588</td>
<td>.653</td>
</tr>
<tr>
<td>Standard error of the difference in Z’s</td>
<td>.0625</td>
<td>.0526</td>
</tr>
</tbody>
</table>

Note. $z = -.1915, p > .05$

As shown in Figure 1, scores increased less for the SE group, as reading level increased, than they did for the non-SE group. For each grade level increase, scores increased 3.61% and 4.0%, respectively, for the SE group and the non-SE group (see Table 4). It was expected that use of SE would compensate to some degree for lack of comprehension due to low reading level, and the result would be more correct answers for participants with lower reading levels in the SE group than in the non-SE group. Although the results showed a trend in the hypothesized direction, they were not significant. Hypothesis 1 (c) was not confirmed by the results of the Fisher Z test for independent r’s. The comparison of the correlation of comprehension scores with reading level for the SE group and the non-SE group did not find a significant difference between the correlations for the two groups.

Summary

It was hypothesized that the comprehension scores for the SE group would be higher than the comprehension scores for the non-SE group (Hypothesis 1 (a)). On an overall basis, the results did not confirm this hypothesis, but they showed a trend in the hypothesized direction. That is, though the difference between the mean comprehension scores for the SE group and the non-SE group was not statistically significant, the mean SE comprehension score was higher than
the mean non-SE comprehension score. On an individual question-by-question basis, Hypothesis 1 (a) was confirmed for only one comprehension question, in which a significant difference in response was found between the SE group and the non-SE group. However, in total the SE group correctly answered 9 out of 15 comprehension questions a higher percentage of the time than the non-SE group, which also indicates a trend in the hypothesized direction.

A second hypothesis was that comprehension scores would improve as reading level improved (Hypothesis 1 (b)), and this hypothesis was confirmed.

A third hypothesis was that the SE comprehension scores would increase less, as reading level increased, than the non-SE comprehension scores (Hypothesis 1 (c)). While the results showed a trend in the hypothesized direction, they were not significant. The hypothesis was not confirmed by the results of this study.

Location of Information Results

Hypothesis 2 (a) The location scores for the SE group will be higher than the location scores for the non-SE group.

Hypothesis 2 (a) was tested in two ways. The difference between the overall scores was tested using the independent samples t-test to compare the mean location scores for the SE group and the non-SE group. The difference in response to individual location questions between the two groups was tested using chi-square tests.

The independent samples t-test was performed on the location scores to determine whether there was a significant difference between the mean location scores for the SE group and the non-SE group. The analysis consisted of the 41 location scores obtained from this research. The mean scores were 78.95% and 75.45%, respectively, for the SE group and the non-SE group. While the mean location score for the SE group was 3.5% higher than the mean location score for
the non-SE group, the difference between the means was not statistically significant \( t = .5228, df = 39, p > .05 \). The obtained \( t \)-value of .5228 did not fall beyond the critical region of the tails \( t \)-critical = +/-2.0226). The results are presented in Table 6.

Table 6
Descriptive Statistics for Location Scores

<table>
<thead>
<tr>
<th>Location Scores</th>
<th>SE</th>
<th>Non-SE</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>78.95%</td>
<td>75.45%</td>
<td>77.07%</td>
</tr>
<tr>
<td>Median</td>
<td>80.0%</td>
<td>86.67%</td>
<td>86.66%</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>15.75%</td>
<td>25.15%</td>
<td>21.13%</td>
</tr>
<tr>
<td>Range</td>
<td>66.66%</td>
<td>93.33%</td>
<td>93.33%</td>
</tr>
<tr>
<td>Minimum</td>
<td>33.33%</td>
<td>6.66%</td>
<td>6.66%</td>
</tr>
<tr>
<td>Maximum</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>( n )</td>
<td>19</td>
<td>22</td>
<td>41</td>
</tr>
</tbody>
</table>

Note, \( t = 0.5228, df = 39, p > .05 \)

Chi-square tests were used to examine whether there were any differences between the SE group and the non-SE group in response to individual location questions. There were no significant differences in response to any location questions, although several questions showed a large difference in absolute terms. For example, the percentage of participants who answered question 7 correctly was 100% in the SE group and 81.82% in the non-SE group, a difference of 18.18%. However, this difference was just out of significance range. The sample size was too small for this difference to be statistically significant. (See Table 7.)
Table 7

Chi-square Statistics for Individual Location Questions

<table>
<thead>
<tr>
<th>Location Question</th>
<th>SE Group</th>
<th>Non-SE Group</th>
<th>Chi-statistic df = 1, $\alpha = .05$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(critical value = 3.84)</td>
</tr>
<tr>
<td>1</td>
<td>68.42%</td>
<td>72.73%</td>
<td>0.7073 not significant</td>
</tr>
<tr>
<td>3</td>
<td>73.68%</td>
<td>63.64%</td>
<td>0.4753 not significant</td>
</tr>
<tr>
<td>4</td>
<td>84.21%</td>
<td>72.73%</td>
<td>0.7805 not significant</td>
</tr>
<tr>
<td>5</td>
<td>89.47%</td>
<td>81.82%</td>
<td>0.4783 not significant</td>
</tr>
<tr>
<td>6</td>
<td>89.47%</td>
<td>95.45%</td>
<td>0.5377 not significant</td>
</tr>
<tr>
<td>7</td>
<td>100%</td>
<td>81.82%</td>
<td>3.8280 not significant</td>
</tr>
<tr>
<td>8</td>
<td>84.21%</td>
<td>77.27%</td>
<td>.3124 not significant</td>
</tr>
<tr>
<td>9</td>
<td>36.84%</td>
<td>45.45%</td>
<td>.3115 not significant</td>
</tr>
<tr>
<td>10</td>
<td>68.42%</td>
<td>77.27%</td>
<td>.4069 not significant</td>
</tr>
<tr>
<td>11</td>
<td>84.21%</td>
<td>63.64%</td>
<td>2.1983 not significant</td>
</tr>
<tr>
<td>12</td>
<td>78.95%</td>
<td>77.27%</td>
<td>.0166 not significant</td>
</tr>
<tr>
<td>13</td>
<td>89.47%</td>
<td>90.91%</td>
<td>.0238 not significant</td>
</tr>
<tr>
<td>14</td>
<td>89.47%</td>
<td>81.82%</td>
<td>.4782 not significant</td>
</tr>
<tr>
<td>15</td>
<td>63.16%</td>
<td>72.73%</td>
<td>.4311 not significant</td>
</tr>
<tr>
<td>16</td>
<td>84.21%</td>
<td>77.27%</td>
<td>.3124 not significant</td>
</tr>
</tbody>
</table>

The location questions tended to be answered correctly a higher percentage of the time than the comprehension questions. A typical example is question 16, where 84.21% and 77.27%, respectively, of the SE group and the non-SE group correctly located the answer to question 16, but only 42.11% and 31.82%, respectively, correctly answered the question.

The results of the independent samples t-test or the chi-square tests on individual questions did not confirm hypothesis 2 (b). However, the results showed a trend in the hypothesized direction. The mean location score for the SE group was not significantly different from the mean location score for the non-SE group, but the SE mean was higher than the non-SE
mean. Similarly, although no significant differences were found between the SE group and the non-SE group in response to individual location questions, the SE group correctly answered 9 out of 15 location questions a higher percentage of the time than readers of the non-SE group. This also indicates a trend in the hypothesized direction.

**Hypotheses 2 (b)** The location scores will increase as reading level increases, for both the SE group and the non-SE group.

Regression analysis was used to examine the relationship between reading level and location score for participants who read the SE procedure and participants who read the non-SE procedure. A statistically significant relationship was found between reading level and location score for both the SE group and the non-SE group, as determined by the LINEST function (SE group: $F = 4.56, df = 17, p < .05, F_{critical} = 4.45$; non-SE group: $F = 7.08, df = 20, p < .05, F_{critical} = 4.35$).

Table 8 shows the intercept, coefficient of determination ($r^2$), and slope of the regression lines for the SE group and the non-SE group.

Table 8

Statistics for Regression Lines—Location Scores

<table>
<thead>
<tr>
<th></th>
<th>SE</th>
<th>Non-SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>53.28%</td>
<td>38.83%</td>
</tr>
<tr>
<td>$r^2$</td>
<td>.2116</td>
<td>.2615</td>
</tr>
<tr>
<td>% increase in location score per grade level increase (slope)</td>
<td>2.59%</td>
<td>3.76%</td>
</tr>
</tbody>
</table>
Figure 2 illustrates that the location scores for both the SE group and the non-SE group, similar to the comprehension scores, improved as reading level improved. Hypothesis 2 (b) was confirmed by the results of the regression analysis.

![Fitted regression lines representing the effect of reading level on the location scores of the SE group and the non-SE group](image)

**Figure 2.** Fitted regression lines representing the effect of reading level on the location scores of the SE group and the non-SE group

Hypothesis 2 (c) As reading level increases, the increase in location scores for the SE group will be less than the increase in location scores for the non-SE group.

Hypothesis 2 (c) was tested using the Fisher Z test for independent r’s, to compare the correlation of location scores with reading levels for the SE group and the non-SE group. In this test, the r’s are first transformed into Fisher Z’s. The z-ratio -.1974 is compared with the critical z-value 1.96 with α=.05. Since -.1974 is less than 1.96, the null hypothesis, that there is no significant difference between the correlation of the location scores with reading level, for the SE group and the non-SE group, must be accepted. (See Table 9.)
Table 9

Comparison of r’s for SE and non-SE Location Scores

<table>
<thead>
<tr>
<th></th>
<th>SE Group</th>
<th>Non-SE Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>r</strong></td>
<td>.4599</td>
<td>.5114</td>
</tr>
<tr>
<td><strong>n</strong></td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td><strong>Z</strong></td>
<td>.497</td>
<td>.564</td>
</tr>
<tr>
<td>Standard error of the difference in Z’s</td>
<td>.0625</td>
<td>.0526</td>
</tr>
</tbody>
</table>

Note. z = -.1974, p > .05

As shown in Figure 2, location scores increased less for the SE group, as reading level increased, than they did for the non-SE group. For each grade level increase, scores increased 2.59% and 3.76%, respectively, for the SE group and the non-SE group (see Table 8). It was expected that use of SE would compensate to some degree for lack of comprehension due to low reading level, and the result would be more correct answers for participants with lower reading levels in the SE group than in the non-SE group. Although the results showed a trend in the hypothesized direction, they were not significant. Hypothesis 2 (c) was not confirmed by the results of the Fisher Z test for independent r’s. The comparison of the correlation of location scores with reading level for the SE group and the non-SE group did not find a significant difference between the correlations for the two groups.

Summary

It was hypothesized that the location scores for the SE group would be higher than the location scores for the non-SE group (Hypothesis 2 (a)). The results did not confirm this hypothesis, but they showed a trend in the hypothesized direction. That is, though the difference between the mean location scores for the SE group and the non-SE group was not statistically significant, the mean SE location score was higher than the mean non-SE location score. On an
individual question-by-question basis, no significant differences were found between the SE group and the non-SE group in response to any location questions. However, the SE group correctly answered 9 out of 15 location questions a higher percentage of the time than the non-SE group, which also indicates a trend in the hypothesized direction.

A second hypothesis was that location scores would improve as reading level improved (Hypothesis 2 (b)), and this hypothesis was confirmed.

A third hypothesis was that the SE location scores would increase less, as reading level increased, than the non-SE comprehension scores (Hypothesis 1 (c)). While the results showed a trend in the hypothesized direction, they were not significant. The hypothesis was not confirmed by the results of this study.

**Time Results**

Hypothesis 3 (a) The time scores for the SE group will be lower than the time scores for the non-SE group.

3 (b) The time scores will decrease as reading level increases, for both the SE group and the non-SE group.

3 (c) As reading level increases, the decrease in time scores for the SE group will be less than the decrease in time scores for the non-SE group.

Regression analysis was used to examine the relationship between reading level and time score for participants who read the SE procedure and participants who read the non-SE procedure. No statistically significant relationship was found between reading level and time score for either the SE group or the non-SE group. In other words, reading level was not found to be a significant predictor of the amount of time participants took to complete the comprehension test. There were not enough participants in the study, and there was too much variance in the time scores, to obtain significant results. Hypotheses 3(a), (b), and (c) were not confirmed.
Both the SE group and the non-SE group had a mean completion time of approximately 41 minutes, and a tendency for participants with higher reading levels to finish more quickly. Sixteen percent of the SE group and 23% of the non-SE group took the full 50 minutes to write the test.
CHAPTER V: DISCUSSION AND CONCLUSIONS

The studies by Shubert et al. (1995), Chervak et al. (1996), and Eckert (1997) found an overall difference in the comprehension of SE, compared to the comprehension of non-SE, by non-native English speakers. Based on the findings of these studies, the present study also looked for an overall difference between the comprehension of SE and the comprehension of non-SE by non-native English speakers. In addition, the present study examined the interaction between reading ability and the SE/non-SE variable. Chervak et al. (1996) and Eckert (1997) did give a reading ability test to all participants and found a positive correlation between reading ability and performance on a comprehension test, but reading ability was not an independent variable in these studies, as it was in the present study.

The participants were 41 non-native English speaking students enrolled in electronics technician programs at BCIT. Sixty-three percent of the participants were enrolled in aviation-related programs. A demographic questionnaire, reading test, aircraft maintenance procedure, and comprehension test were administered to participants. The participants were randomly assigned to read either the SE procedure or the non-SE procedure. It was found that both groups were homogenous with regard to the distribution of reading levels and the number of participants in each group who were enrolled in aviation-related programs.

The results of the present study, while falling short of providing substantial empirical support for their conclusions, show a trend in the direction of the studies by Shubert et al. (1995) and Chervak et al. (1996). In these studies, the use of SE was found to significantly improve the comprehension of procedures for both native and non-native English speakers, with the greatest benefit to non-native English speakers. The results of the present study did not show a significant difference between the comprehension of SE and the comprehension of non-SE by non-native
English speakers. The mean scores for comprehension and location of information for the SE group were not significantly different from the mean scores for comprehension and location of information for the non-SE group. However, it is noted that the mean SE scores were higher, which indicates an overall trend toward better comprehension of SE than non-SE by non-native English speakers. These results are similar to those of Eckert (1997), who found an improvement in the comprehension of SE by non-native English speakers in a non-native English speaking country, but the improvement was not significant. Eckert (1997) also compared mean scores and found that the mean score of the SE group was higher than the mean score of the non-SE group, but not significantly higher.

A comparison of responses to individual comprehension and location questions showed that the differences in response between the SE group and the non-SE group were significant for only one comprehension question. This question was answered correctly a significantly higher percentage of the time by the SE group. Though only this one question was significant, it is noted that in total the SE group correctly answered 9 out of 15 comprehension questions, and 9 out of 15 location questions, a higher percentage of the time than the non-SE group. It is also noted that there were no significant questions for the non-SE group. These results again indicate a trend in the direction of the studies by Shubert et al. (1995) and Chervak et al. (1996), who found significantly better comprehension using SE for non-native English speakers, but they fall short of providing substantial empirical support.

Like Chervak et al. (1996) and Eckert (1997), the present study also found a positive correlation between reading ability and performance on a comprehension test. That is, reading level was a significant predictor of comprehension scores and location scores, for readers of both the SE procedure and the non-SE procedure, and scores increased as reading level increased. The
present study went a step further and examined the interaction between reading level and the SE/non-SE variable. It was expected that the use of SE would compensate to some degree for lack of comprehension due to low reading level, resulting in more correct answers for participants with lower reading levels in the SE group compared to those in the non-SE group.

The results of regression analysis, as illustrated in Figure 1 and Figure 2, show a trend in the hypothesized direction. The SE scores were higher than the non-SE scores at lower reading levels than at higher reading levels, and the difference between the scores for the SE group and the non-SE group decreased as reading level increased. However, a comparison of the correlation of comprehension score with reading level for the two groups, and a comparison of the correlation of location score with reading level for the two groups, showed that this trend was not significant. There were no significant differences between the correlations for the SE group and the non-SE group, meaning that the relationship between reading level and the dependent variables for the SE group was not significantly different from the relationship between reading level and the dependent variables for the non-SE group. Although there was a trend toward participants in the SE group performing better than participants in the non-SE group, more at lower reading levels than at higher reading levels, this trend was not significant.

The present study did not find a significant correlation between reading ability and the time participants took to complete the comprehension test. That is, reading level was not a significant predictor of time in this study. Previous studies on the comprehension of SE also did not find significant results for time. Shubert et al. (1995) did not find a significant difference in task completion time between the SE group and the non-SE group, for either the native English speakers or the non-native English speakers. Chervak et al. (1996) found that the use of SE did not affect the time to complete tasks. The present study used a longer procedure than the
procedures used in these two previous studies. It was expected that the length of the procedure (1239 words), and the length of the comprehension test (fifty minutes), would result in a significant difference in task completion time between the SE group and the non-SE group. However, as in the previous studies, no significant results for time were obtained.

The small sample size is the most probable reason why mainly only trends were found in the present study, rather than significant results. With its small sample size, the present study required a very large difference in mean scores between the SE group and the non-SE group for the difference to be statistically significant. It also required a very large difference in score between the SE group and the non-SE group, for each individual question, for the difference to be statistically significant. Only one comprehension question met this requirement and was significant. With a much larger sample size, the required difference would have been smaller and it is likely that more questions would have had a significant difference in response. There were also too few participants with too much variation in their time scores for a reliable prediction to be made from reading level for time scores.

Another reason why significant results were not obtained may be because the procedure used in this experiment was converted from the original non-SE version. Perhaps significant results would have been obtained if the whole procedure had been rethought in SE rather than simply transposed into SE. The problem with transposing original, non-SE is that there is no SE equivalent for the shortcomings in the original. These shortcomings are more to do with what is said, or not said, rather than how it is said, and the author has to decide whether to keep the same shortcomings in the SE version, or overcome them (Kathy Barthe, personal communication, 23 May 1997). In this study, some of the shortcomings of the original non-SE version were not overcome in the SE version, in order to maintain the equivalency of the two documents.
The question must also be asked whether the procedure used in this study was difficult enough to obtain significant results. Shubert et al. (1995), Chervak et al. (1996), and Chervak (1996) tested the difference in comprehension of SE between simple and difficult documents and obtained significant results only with the difficult documents. The intent of this study was to examine whether the use of SE improved the comprehension of procedures that were at a level of difficulty that the aircraft maintenance technician is most likely to encounter. As explained earlier, the procedure used in this study was selected because it was considered to be a typical aircraft maintenance procedure. It was expected that the procedure’s length and composition from seven subprocedures, totalling 51 steps, would increase its difficulty. The mean scores were in the 60% to 65% range for comprehension and the 75% to 80% range for location of information, which indicates that the participants found the procedure and test reasonably challenging.

Though not significant, the results of this study indicate an overall trend toward better comprehension of SE than non-SE by non-native English speakers. Further, they suggest that SE readers at lower reading levels are more likely to correctly answer questions and locate information than non-SE readers at lower reading levels. As reading level increases, the use of SE to aid comprehension and location of information has less and less effect. At high reading levels, SE readers are about as likely to correctly answer questions and locate information as are non-SE readers. This is what one would expect, namely, that shorter sentences, simpler words, and a controlled vocabulary would aid comprehension at lower reading levels, and that participants with higher reading levels would have enough English language proficiency to find standard English about as easily comprehensible as SE.
Conclusions

The results of this study do not provide substantial empirical evidence to support the conclusions of previous research that SE significantly improves comprehension for non-native English speakers (Shubert et al., 1995 and Chervak et al., 1996). However, the results show a trend in the direction of these previous studies. They suggest that SE improves comprehension and ability to locate information for non-native English speakers, and that SE is of the most benefit to non-native English speakers at lower reading levels. As their reading level increases, the benefit of SE decreases.

Similar to Eckert (1997), these results indicate a positive effect for SE on comprehension but not a statistically significant effect. However, as Eckert (1997) points out, anything that improves the performance of aircraft maintenance technicians, thereby making aircraft safer for everyone, is worthwhile. While the difference between scores on a test may not be statistically significant, the difference between the correct performance of a task, and the incorrect performance of a task because of unclear documentation, could be hugely significant in terms of human lives.

Implications for Further Research

The effect of reading level on the comprehension of SE for non-native English speakers has only just begun to be explored. More research of a similar kind is needed to explore how the benefit of SE varies with reading ability. One aim of further research could be to identify a clearly articulated reading level beyond which SE is no longer beneficial.

The results of this study were hampered by the small sample size. More significant results might have been obtained with a much larger sample size. Lessons learned from this study that
could be applied to further similar studies are that there should be at least 100 to 200 participants, and that a moderately shorter aircraft maintenance procedure and moderately easier comprehension test would have been sufficient.
REFERENCES


APPENDICES
APPENDIX A: DESCRIPTION OF SIMPLIFIED ENGLISH

As described in the AECMA Simplified English Guide (1995), SE consists of a controlled general vocabulary with an additional set of rules for using that vocabulary. The Guide contains a Dictionary of approved words and 67 rules. Each word in the Dictionary has a clearly defined meaning with an approved part of speech. The vocabulary is sufficient to express any technical sentence. Besides this general vocabulary, the writer can also use those words that belong to Technical Names and Manufacturing Processes (discussed below).

The Guide assumes that the writer already has a good command of written English. It states that SE cannot be used to teach a writer English because writing clearly is a complex task that requires language fluency.

All examples in this section are taken from the Guide.

Dictionary

The controlled general vocabulary contains nouns and adjectives (other than Technical Names), verbs (other than Manufacturing Processes), pronouns, adverbs, prepositions, conjunctions, and articles. The words were chosen for their simplicity and ease of recognition. They are typically concrete rather than abstract.

One of the rules is that writers must use the words only as the parts of speech given in the Dictionary. For example, close is a verb, not an adverb. Therefore Do not go near the landing gear is acceptable, but Do not go close to the landing gear is not.

Writers must use only the forms of verbs and adjectives given in the Dictionary. The approved verbs in the Dictionary are high-frequency verbs that are understandable by a majority of people involved in aircraft maintenance. One rule for verbs is that writers are restricted to
making only the following verb tenses: the infinitive (to adjust); the imperative (Adjust the ..); the simple present (it adjusts); the simple past (it adjusted); and the future (it will adjust).

Another rule is that past participles listed in the Dictionary may be used only as adjectives preceding nouns (Connect the disconnected wires), or after the verbs to be and to become (the wires are disconnected; the wires become disconnected). Other rules state that it is unacceptable to use the past participle with a form of the verb have (has been adjusted), or to use the past participle combined with a helping verb and a form of the verb to be (can be adjusted; will be adjusted; must be adjusted).

There are no verbs with -ing endings in the Dictionary. This form is difficult for non-native English speaking people to read and understand (Gingras, 1987).

**One Meaning — One Word**

Whenever possible, each meaning is restricted to one word. For example, when there are several words in English that have the same meaning (synonyms), only of them is included in the vocabulary. Thus, start is approved but begin, commence, initiate, and originate are not. The word most easily recognized worldwide is chosen to represent the family of synonyms.

**One Word — One Meaning**

Whenever possible, each word is restricted to one meaning. For example, to fall means to move down by the force of gravity. Therefore the pressure decreases is acceptable, but the pressure falls is not. Also, follow means come after not obey. Therefore, Obey the safety instructions is acceptable but Follow the safety instructions is not.
Technical Names

Technical Names are unrestricted because there are many, and each manufacturer of aircraft parts uses different names. Technical Names must fall into one of 20 categories, several of which are: names in the official parts information (propeller), names of locations on the aircraft (fuselage), names of materials or consumables (fuel), damage terms (erosion), numbers (one quarter), environmental conditions (turbulence), and colours (orange).

One of the rules for Technical Names is that they can only be used as nouns or adjectives, not verbs. For example, Put oil on the machined surface is acceptable, but Oil the machined surface is not. Other rules are that the writer must use the official Technical Names that are the most common in the international aerospace industry, and, for consistency, always use the same Technical Name when referring to the same thing.

Manufacturing Processes

Manufacturing Processes are unrestricted because there are many, and each manufacturer may use a different verb for the same process. Manufacturing Processes must fall into one of six categories, some of which are: removing material (grind), adding material (retread), attaching material (weld), and changing the mechanical strength, structure, or physical properties of a material (magnetize). Manufacturing Processes must only be used as verbs, not nouns or adjectives (unless the noun form qualifies as a Technical Name). For example, Ream the hole 0.20 inch larger than standard is acceptable, but Give the hole 0.20 inch over-ream is not.

Rules

The rules cover word choice, noun phrases, verbs, sentence construction, procedure writing, descriptive writing, warnings and cautions, punctuation, word counts, and writing
practices. The rules tell the writer what is acceptable and what is not acceptable, and provide examples of both. Some of the rules for word choice and verbs have been discussed earlier in this section. Several other rules are highlighted below.

Noun Phrases

A noun cluster is a group of nouns where the last noun in the group is the main noun and the preceding nouns modify the main noun. An example is *nose landing gear uplock attachment bolt* where *bolt* is the main noun. If noun clusters are too long they can confuse the reader, and they are almost impossible to read for non-native English speakers. One rule is that writers must break up noun clusters of more than three words by rewriting them. For example, the above noun cluster could be rewritten as *the bolt that attaches the uplock to the nose landing gear*. When the noun cluster is a Technical Name, which is the company's official nomenclature and cannot be rearranged, the rule states that the writer must use hyphens to show the relationship between the most closely related words. For example, *landing light cutoff switch power connection* would be hyphenated as *landing-light cutoff-switch power connection*. An alternative is to use the full name, then define a shorter version of the name and use it for the remainder of the document.

Another rule is that wherever possible the writer must use an article (*the, a, an*) or a demonstrative adjective (*this, these*) before a noun. Thus *Lift up the assembly and put it in a box* is acceptable, but *Lift up assembly and put in box* is not. Articles are believed to make understanding easier and help clear possible confusion between nouns and verbs. However, their correct use requires a great deal of linguistic and subject domain knowledge on the part of the writer. Consequently, their correct uses, and misuses, are difficult to capture in a controlled language conformance checker (Heald and Zajac, 1996).
Sentence Construction

To keep sentences short, the rules state that writers should keep to one topic per sentence, and use connecting words such as and, but, also, and then to join consecutive sentences that contain related thoughts. Also, they should not omit words, such as the noun or verb, to make sentences shorter. To help show the relationship between two or more complex actions or events, the writer is told to use a tabular (vertical) layout.

Procedure Writing

SE is designed for procedure writing and descriptive writing, but has primarily been used in procedural writing, that is, maintenance procedures (Holmback, 1996).

The rules state that the maximum length of a procedural sentence is 20 words and that it can contain only one instruction per sentence. A procedural sentence can contain more than one instruction only when more than one action is done at the same time. The verb in a procedural sentence must be in the imperative form, and if the sentence begins with a dependent clause, a comma must separate it from the rest of the instruction (When the light comes on, set the switch to NORMAL).

Another rule tells the writer to make instructions as specific as possible, and gives examples of abstractions that describe only the general effect of an action but do not specifically state how to do the action. For example, Repair all the leaks is acceptable but No leaks permitted is not because it does not give the reader any procedural instruction.

Descriptive Writing

The rules governing descriptive writing call for topic sentences at the beginning of paragraphs, and a maximum of six sentences per paragraph. Sentences can be up to 25 words
long, and keywords should be used to show the relationships between sentences and paragraphs.

Paragraphs should be ordered to show the logic of the text.

**Active and Passive Voice**

The rules state that writers must always use the active voice in procedures, and use it as much as possible in descriptive writing.

**Warnings and Cautions**

Warnings concern the possibility of injury or death. Cautions concern the possibility of damage to equipment. The rules for warnings and cautions tell the writer to identify the command correctly as a warning or a caution and start a warning or caution with a simple and clear command. Then, if necessary, the writer can add a brief explanation to clarify the possible risk. It is important to tell the users exactly what they must do and what can happen, and avoid writing a warning or caution as a general comment.

The following warning is acceptable: *Make sure that the oxygen tubes are fully clean. This will help to prevent contaminations and explosions.* The following warning is not acceptable: *Extreme cleanliness of oxygen tubes is imperative.*

**Writing Practices**

Vaughn (1990) attributes the clear style of SE, not so much to the brevity of words or sentences, but to the use of clearly defined words that convey the same meaning consistently.

The rules for writing practices guide the writer toward semantic precision. One rule reminds the writer that SE words have very restricted definitions and tells the writer to use the Dictionary correctly to get the correct words, meanings, and parts of speech. For example, *Do not*
turn the nose wheel at too acute an angle is acceptable, but Do not turn the nose wheel at too sharp an angle is not because sharp is only used for objects that can cut or pierce. Also, Use (or put on) protective clothing is acceptable, but Wear protective clothing is not because wear is only for damage by friction.

Similarly, another rule tells writers that, when they combine words, they must make sure that the words continue to obey the meanings given to them in the Dictionary. For example, Remove the damage with a fine stone is acceptable but Clean up the damage with a fine stone is not because clean and up together do not use the meanings of clean and up as individual words.

A third rule reminds writers that a simple word-for-word replacement of an unapproved word with an approved word is not always possible. An example of this is when a word or group of words is too abstract or it implies several things. In such cases, ideas must be restated in different words, or a different sentence construction used.
In this test, you will read an aircraft maintenance procedure and then answer 16 multiple choice, true/false, and short answer questions.

Please be sure to read the procedure first, then answer the questions. You may refer back to the procedure at any time. You will be allowed a maximum of 50 minutes to complete this test.

Each question has two parts. Firstly, write down the answer to the question. Secondly, write down the location of the answer to the question on the "Reference line" after the question. Use the number in the left margin, next to the step, to indicate the location.

EXAMPLE:

Question:
How much does the pump weigh? _____ 13 KG
Reference: _____ 13

Location of answer:
Number in left margin
WARNING: MAKE SURE THAT THE GROUND SAFETIES ARE IN POSITION ON THE LANDING GEAR.

MAKE SURE THAT THE WHEEL CHOCKS ARE IN POSITION.

BEFORE YOU PRESSURIZE OR DEPRESSURE THE HYDRAULIC SYSTEM, MAKE SURE THAT THE TRAVEL RANGES OF THE CONTROL SURFACES ARE CLEAR.

BEFORE YOU PRESSURIZE A HYDRAULIC SYSTEM, MAKE SURE THAT THE CONTROLS AGREE WITH THE POSITION OF THE ITEMS THEY OPERATE.

1. Job Set-up Information

A. Equipment, Materials, and Referenced Information

<table>
<thead>
<tr>
<th>REFERENCE</th>
<th>DESIGNATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>no specific</td>
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</tr>
<tr>
<td>no specific</td>
<td>circuit breaker safety clips</td>
</tr>
<tr>
<td>no specific</td>
<td>container 8 L approx.</td>
</tr>
<tr>
<td>no specific</td>
<td>warning notice</td>
</tr>
<tr>
<td>Material No. P02-001</td>
<td>Hydraulic Fluids (Ref. 70-00-00)</td>
</tr>
<tr>
<td>Material No. P03-001</td>
<td>Oils (Ref. 70-00-00)</td>
</tr>
</tbody>
</table>

Referenced Information

- 12-12-29, P. Block 1: Hydraulics
- 24-41-00, P. Block 301: AC External Power Control
- 29-10-00, P. Block 301: Main Hydraulic Power - Pressurization/Depressurization
- 29-14-00, P. Block 301: Hydraulic Reservoir Pressurizing System
- 71-00-00, P. Block 501: Power Plant - General
- 71-13-00, P. Block 301: Cowl Doors

B. Procedure

(1) Job Set-up

(a) Open, safety and tag these circuit breakers:

<table>
<thead>
<tr>
<th>PANEL</th>
<th>DESIGNATION</th>
<th>IDENT.</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>101VU</td>
<td>HYD/PUMP</td>
<td>1GE</td>
<td>GEN1/B8</td>
</tr>
<tr>
<td>101VU</td>
<td>HYD/PUMP</td>
<td>2GE</td>
<td>GEN2/B8</td>
</tr>
<tr>
<td>128VU</td>
<td>ELEC/PUMPS/WARN &amp; CTL</td>
<td>4GE</td>
<td>801/R70</td>
</tr>
<tr>
<td>128VU</td>
<td>ENG/PUMPS/WARN</td>
<td>5GD</td>
<td>801/R69</td>
</tr>
<tr>
<td>128VU</td>
<td>ENG1/PUMP CTL/G</td>
<td>99GK</td>
<td>801/R73</td>
</tr>
<tr>
<td>128VU</td>
<td>FIRE VALVES/ENG1</td>
<td>101GK</td>
<td>802/P73</td>
</tr>
</tbody>
</table>

For the Engine 2 Green Pump:

<table>
<thead>
<tr>
<th>PANEL</th>
<th>DESIGNATION</th>
<th>IDENT.</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>101VU</td>
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<td>GEN1/B8</td>
</tr>
<tr>
<td>101VU</td>
<td>HYD/PUMP</td>
<td>2GE</td>
<td>GEN2/B8</td>
</tr>
<tr>
<td>128VU</td>
<td>ELEC/PUMPS/WARN &amp; CTL</td>
<td>4GE</td>
<td>801/R70</td>
</tr>
<tr>
<td>128VU</td>
<td>ENG/PUMPS/WARN</td>
<td>5GD</td>
<td>801/R69</td>
</tr>
<tr>
<td>128VU</td>
<td>ENG2/PUMP CTL/G</td>
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<td>801/R74</td>
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<tr>
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<td>FIRE VALVES/ENG2</td>
<td>103GK</td>
<td>802/P74</td>
</tr>
<tr>
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<td>DESIGNATION</td>
<td>IDENT.</td>
<td>LOCATION</td>
</tr>
<tr>
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<td>-------------</td>
<td>--------</td>
<td>----------</td>
</tr>
<tr>
<td>6</td>
<td>128VU ENG/PUMPS/WARN</td>
<td>5GD</td>
<td>801/R69</td>
</tr>
<tr>
<td></td>
<td>128VU ENG1/PUMP CTL/B</td>
<td>31GJ</td>
<td>801/R72</td>
</tr>
<tr>
<td></td>
<td>128VU FIRE VALVES/ENG1</td>
<td>101GK</td>
<td>802/P73</td>
</tr>
<tr>
<td></td>
<td>128VU PTU CTL/G/B</td>
<td>1GL</td>
<td>801/R76</td>
</tr>
</tbody>
</table>

For the Engine 1 Blue Pump

For the Engine 2 Yellow Pump

(b) Release the pressure from the related hydraulic system (Ref. 29-10-00, P. Block 301).

(c) Release the pressure from the related hydraulic system reservoir (Ref. 29-14-00, P. Block 301).

(d) On panel 427VU, put a warning notice in position to tell persons not to pressurize the related hydraulic system.

(e) Open the engine 1 fan cowl or engine 2 fan cowl (Ref. 71-13-00, P. Block 301).

(f) Put a container below the engine pump.

(2) Removal of the Engine Pump

(Ref. Fig. 1).

CAUTION: DO A VISUAL CHECK OF THE RELATED CASE-DRAIN FILTER ELEMENT, IF YOU REMOVE THE PUMP:
- BECAUSE OF OPERATION WITHOUT FLUID (DRY RUNNING)
- OR BECAUSE OF MALFUNCTION IF YOU THINK THAT THERE IS INTERNAL DAMAGE.

If you find metal chips or decomposed hydraulic fluid (jelly) in the case-drain filter element, do also a visual check of the related high-pressure filter element.

If you find contamination on the filters, flush the lines which connect the pump to the filters.

CAUTION: MAKE SURE A PERSON HOLDS THE PUMP DURING REMOVAL AND INSTALLATION. THE PUMP WEIGHS APPROXIMATELY 13 KG (28 LB.)

NOTE: This procedure gives the steps for removal and installation of only one pump. But the procedure is the same for all four pumps.

(a) Cut and remove the lockwire and disconnect the electrical connector (4).


(b) Disconnect the suction hose (13) from the pump port union (12).

(c) Disconnect the case drain hose (16) from the reducer (15).

(d) Disconnect the pressure hose (10) from the pulsation dampener (9).

(e) Remove the pulsation dampener (9).

(f) Remove and discard the backup rings (5, 7) and the packings (6, 8) from the pulsation dampener.
Figure 1
Green, Blue and Yellow Hydraulic Pumps - Engine
(g) If the replacement part does not have a pump port union and a reducer:
- Remove and keep the pump port union (12) and the reducer (15)
- Discard the packings (11, 14).

CAUTION: INSTALL BLANKING PLUGS ON THE DISCONNECTED HOSES AND ON THE PUMP PORTS. THIS WILL PREVENT CONTAMINATION OF THE FLUID IN THE HYDRAULIC SYSTEM.

(h) Loosen the four attaching nuts (1).
(i) Turn the pump clockwise until the 4 studs are opposite the large part of the holes in the pump base. Pull the pump off the studs.
(j) Remove and discard the packing (2) from the pump shaft.
(k) Remove and discard the gasket (3) from the studs.

(3) Preparation Before Installation
(a) Lubricate a new packing (2) with Material No. P03-001.
(b) Install the packing (2) on the pump shaft.
(c) Install a new gasket (3) on the mount pad on the accessory gear box side.
(d) If the replacement part does not have a pump port union and a reducer:
- Install new packings (11, 14)
- Install the pump port union (12) and the reducer (15) from the removed pump.
(e) Lubricate the new packings (6, 8) and the new backup rings (5, 7) for the pulsation dampener (9) with Material No. P02-001.
(f) Install the new packings (6, 8) and the new backup rings (5, 7) on the pulsation dampener (9).
(g) Install the pulsation dampener (9) moderately tight on the replacement part.

(4) Installation of the Hydraulic Pump
CAUTION: WHEN YOU INSTALL THE HYDRAULIC PUMP, MAKE SURE THAT ITS POSITION ON THE STUDS IS CORRECT. AN INCORRECT POSITION OF THE PUMP CAN CAUSE AN UNWANTED LOAD ON THE CARBON SEAL OF THE MOUNT PAD.

(a) Put the pump on the four studs, with the nuts through the large end of the holes in the pump base.
(b) Turn the pump counterclockwise until it touches the studs.
(c) TORQUE the attaching nuts (1) to between 275 and 300 lbf.in (3.1 and 3.39 m.daN).
(d) TORQUE the reducer (15) to between 600 and 700 lbf.in (6.77 and 7.9 m.daN).
(e) Connect the case drain hose (16) to the reducer (15).
(f) TORQUE the coupling nut to between 215 and 245 lbf.in (2.43 and 2.77 m.daN).
(g) TORQUE the pump port union (12) to between 1350 and 1450 lbf.in (15.52 and 16.38 m.daN).
(h) TORQUE the pulsation dampener (9) to between 950 and 1050 lbf.in (10.73 m.daN and 11.86 m.daN).
(i) Connect the pressure hose (10) to the pulsation dampener (9).
(j) TORQUE the coupling nut to between 855 and 945 lbf.in (9.66 and 10.67 m.daN).
(k) Connect the self-sealing coupling on the suction hose (13) to the pump port union (12).
(l) TORQUE the coupling nut to between 1900 and 2100 lbf.in (21.47 and 23.72 m.daN).

(m) Connect the electrical connector (4) to the pump and safety it with lockwire.

(5) **Bleed the Hydraulic System**

(a) Open, safety, and tag these circuit breakers:

<table>
<thead>
<tr>
<th>PANEL</th>
<th>DESIGNATION</th>
<th>IDENT.</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>123VU</td>
<td>ENG1 &amp; 2/FIRE EXITING/SQUIB A/BTL1</td>
<td>1WE</td>
<td>335/D59</td>
</tr>
<tr>
<td>123VU</td>
<td>ENG1 &amp; 2/FIRE EXITING/SQUIB A/BTL2</td>
<td>3WE</td>
<td>302/D60</td>
</tr>
<tr>
<td>22VU</td>
<td>ENG1 &amp; 2/FIRE EXITING/SQUIB B/BTL1</td>
<td>5WE</td>
<td>207/C19</td>
</tr>
<tr>
<td>22VU</td>
<td>ENG1 &amp; 2/FIRE EXITING/SQUIB B/BTL2</td>
<td>7WE</td>
<td>207/C20</td>
</tr>
</tbody>
</table>

(b) Remove the safety clips and tags and close the related circuit breakers:
- 101GK for the Engine 1 Green and Blue pumps, or
- 103GK for the Engine 2 Green and Yellow pumps.

(c) Pull the applicable fire handle to close the fire valve.

(d) Disconnect the case drain hose (16) from the filter assembly. Put the open end in a clean container.

(e) Pressurize the related system reservoir (Ref. 29-14-00, P. Block 301).

(f) Push the fire handle to open the fire valve. Push until there are no air bubbles in the fluid that flows out of the case drain hose into the container.

NOTE: If necessary, do steps (5) (c) and (5) (e) again or continuously pressurize the reservoir.

(g) Pull the fire handle to close the fire valve.

(h) TORQUE the coupling nut to between 270 and 300 lbf.in. (3.05 and 3.39 m.daN).

(i) Push the fire handle to open the fire valve and safety it with lockwire.

(k) Make sure that the level of hydraulic fluid in the reservoir is correct. If necessary, fill the reservoir (Ref. 12-12-29, P. Block 1).

(l) Remove the safety clips and the tags and close these circuit breakers:
- 1WE, 3WE, 5WE, 7WE.

(6) **Operational Tests**

(a) Make sure that the clogging indicator on the case drain filter is not in the extended position. If necessary, push the indicator manually to retract it.

(b) Remove the safety clips and the tags and close these circuit breakers:

<table>
<thead>
<tr>
<th>PUMP</th>
<th>CIRCUIT BREAKER IDENT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>For the Engine 1 Green Pump</td>
<td>1GE</td>
</tr>
<tr>
<td></td>
<td>2GE</td>
</tr>
<tr>
<td></td>
<td>4GE</td>
</tr>
<tr>
<td></td>
<td>5GD</td>
</tr>
<tr>
<td></td>
<td>99GK</td>
</tr>
<tr>
<td></td>
<td>101GK</td>
</tr>
<tr>
<td>For the Engine 2 Green Pump</td>
<td>1GE</td>
</tr>
<tr>
<td></td>
<td>2GE</td>
</tr>
<tr>
<td></td>
<td>4GE</td>
</tr>
<tr>
<td></td>
<td>5GD</td>
</tr>
<tr>
<td></td>
<td>100GK</td>
</tr>
<tr>
<td></td>
<td>103GK</td>
</tr>
</tbody>
</table>
For the Engine 1 Blue Pump
- 5GD
- 31GJ
- 101GK
- 1GL
- 1GL

For the Engine 2 Yellow Pump
- 1GD
- 5GD
- 103GK
- 6GL

(c) Pressurize the related hydraulic system reservoir (Ref. 29-14-00, P. Block 301).

(d) Supply power to the electrical network of the aircraft (Ref. 29-14-00, P. Block 301). Make sure that the airflow in the electronics racks is correct.

(e) On the ECAM control panel, push the HYD pushbutton switch. On panel 427VU, make sure that the related ENGPUMP pushbutton switch is also pushed (in).

(f) Do the dry-motoring procedure for the engine (Ref. 71-00-00, P. Block 501).

(g) During the dry-motoring procedure:
   - Make sure that there are no leaks from the hydraulic connections of the pump
   - On the right ECAM display unit, make sure that the pressure shown for the hydraulic system is 3000 +/- 200 psi (206 +/- 13.5 bars).

(h) Stop the dry-motoring procedure for the engine (Ref. 71-00-00, P. Block 501).

(i) On the right ECAM display unit, make sure that the pressure indication for the related hydraulic system decreases.

(j) Make sure that the level of hydraulic fluid in the reservoir is correct. If necessary, fill the reservoir (Ref. 12-12-29, P. Block 1).

(k) Make sure that the hoses of the hydraulic system will not rub together or against the structure. If necessary, adjust their position.

(7) Close-up

(a) Remove power from the electrical network of the aircraft (Ref. 24-41-00, P. Block 301).

(b) Remove the container.

(c) Close the fan cowl (Ref. 71-13-00, P. Block 301).

(d) Remove the warning notice.
APPENDIX C: NON-SE PROCEDURE

TEST INSTRUCTIONS

In this test, you will read an aircraft maintenance procedure and then answer 16 multiple choice, true/false, and short answer questions.

Please be sure to read the procedure first, then answer the questions. You may refer back to the procedure at any time. You will be allowed a maximum of 50 minutes to complete this test.

Each question has two parts. Firstly, write down the answer to the question. Secondly, write down the location of the answer to the question on the "Reference line" after the question. Use the number in the left margin, next to the step, to indicate the location.

EXAMPLE:

Question:
How much does the pump weigh? 13 KG
Reference: 12
Location of answer:
Number in left margin
AIRCRAFT MAINTENANCE MANUAL
ENGINE PUMP – REMOVAL/INSTALLATION

1 WARNING: CHECK THAT THE LANDING GEAR GROUND SAFETIES INCLUDING WHEEL CHOCKS ARE IN POSITION.

2 BEFORE APPLYING OR RELIEVING HYDRAULIC SYSTEM PRESSURE, MAKE CERTAIN THAT THE TRAVEL RANGES OF THE CONTROL SURFACES ARE CLEAR.

3 BEFORE PRESSURIZING HYDRAULIC SYSTEMS, CHECK THAT ALL CONTROLS ARE SET TO CORRESPOND WITH THE ACTUAL POSITION OF THE SERVICES THEY OPERATE.

1. Engine Pumps

A. Equipment and Materials

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESIGNATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Blanking Plugs/Caps</td>
</tr>
<tr>
<td>(2)</td>
<td>Circuit Breaker Safety Clips</td>
</tr>
<tr>
<td>(3)</td>
<td>Container</td>
</tr>
<tr>
<td>(4)</td>
<td>Warning Notice</td>
</tr>
<tr>
<td>(5) Material No. P02-001</td>
<td>Hydraulic Fluids (ref. 70-00-00)</td>
</tr>
<tr>
<td>(6) Material No. P03-001</td>
<td>Oils (Ref. 70-00-00)</td>
</tr>
</tbody>
</table>

Referenced Procedures
- 12-12-29, P. Block 1
- 24-41-00, P. Block 301
- 29-10-00, P. Block 301
- 29-14-00, P. Block 301
- 71-00-00, P. Block 501
- 71-13-00, P. Block 301

B. Procedure

(1) Job Set-up

(a) Open, safety and tag the following circuit breakers associated with pump to be removed

<table>
<thead>
<tr>
<th>PANEL</th>
<th>SERVICE</th>
<th>IDENT.</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
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<td>HYD/PUMP</td>
<td>1GE</td>
<td>GEN1/B8</td>
</tr>
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<td>101VU</td>
<td>HYD/PUMP</td>
<td>2GE</td>
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</tr>
<tr>
<td>128VU</td>
<td>ELEC/PUMPS/WARN&amp; CTL</td>
<td>4GE</td>
<td>801/R70</td>
</tr>
<tr>
<td>128VU</td>
<td>ENG/PUMPS/WARN</td>
<td>5GD</td>
<td>801/R69</td>
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<td>ENG1/PUMP CTL/G</td>
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<td>128VU</td>
<td>FIRE VALVES/ENG1</td>
<td>101GK</td>
<td>802/P73</td>
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</table>

Engine 2 Green Pump

<table>
<thead>
<tr>
<th>PANEL</th>
<th>SERVICE</th>
<th>IDENT.</th>
<th>LOCATION</th>
</tr>
</thead>
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<tr>
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<td>2GE</td>
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<td>128VU</td>
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<td>801/R70</td>
</tr>
<tr>
<td>128VU</td>
<td>ENG/PUMPS/WARN</td>
<td>5GD</td>
<td>801/R69</td>
</tr>
<tr>
<td>128VU</td>
<td>ENG2/PUMP CTL/G</td>
<td>100GK</td>
<td>801/R74</td>
</tr>
<tr>
<td>128VU</td>
<td>FIRE VALVES/ENG2</td>
<td>103GK</td>
<td>802/P74</td>
</tr>
</tbody>
</table>
Depressurize associated hydraulic system (Ref. 29-10-00, P. Block 301).

Depressurize associated hydraulic system reservoir (Ref. 29-14-00, P. Block 301).

Display a warning notice on panel 427VU prohibiting operation of the system associated with the pump to be removed.

Open engine 1 or engine 2 fan cowl (Ref. 71-13-00, P. Block 301).

Place container under pump to be removed.

CAUTION: IF THE PUMP IS REMOVED BECAUSE OF OPERATION WITHOUT FLUID (DRY RUNNING), OR BECAUSE OF MALFUNCTIONING AND IF INTERNAL DAMAGE IS SUSPECTED, VISUALLY CHECK THE ASSOCIATED CASE DRAIN FILTER ELEMENT. IF METAL CHIPS OR DECOMPOSED HYDR. FLUID (JELLY) IS FOUND IN FILTER ELEMENT, VISUALLY CHECK ALSO THE ASSOCIATED HIGH PRESSURE FILTER ELEMENT. IF CONTAMINATION IS FOUND ON THE FILTERS, THE LINES CONNECTING THE PUMP TO THE FILTERS MUST BE FLUSHED.

SUPPORT THE PUMP DURING INSTALLATION AND REMOVAL OPERATIONS. APPROXIMATE WEIGHT: 13 KG (28 LB.)

As removal/installation operations are identical for each of the four pumps, this topic deals with only one pump.

Cut and remove lockwire and disconnect electrical connector (4).

Disconnect suction and case drain hoses (13), (16) from pump port union (12) and reducer (15).

SUCTION HOSE SELF SEALING COUPLING (13) MUST BE DISCONNECTED AT PUMP PORT UNION (12) SIDE. IF IT WERE DISCONNECTED AT THE HOSE SIDE, IT WOULD NO LONGER FULFIL ITS FUNCTION, RESULTING IN CONSIDERABLE HYDRAULIC FLUID SPILLAGE.

Disconnect hose (10) from pulsation dampener (9).

Remove pulsation dampener (9), discard backup rings (5, 7) and packings (6, 8).

If replacement component is without union and reducer, remove union (12) and reducer (15) from removed pump. Discard packings (11, 14).
Figure 1
Green, Blue and Yellow Hydraulic Engine-Driven Pumps
CAUTION: INSTALL BLANKING PLUGS ON DISCONNECTED HOSES AND ON PUMP PORTS TO PREVENT CONTAMINATION OF HYDRAULIC SYSTEM FLUID.

(f) Loosen the four attaching nuts (1), support pump and rotate clockwise to remove.

(g) Discard packing (2) and gasket (3).

(3) Preparation of Replacement Component

(a) Install a new packing (2) lubricated with Material No. P03-001, on pump shaft.

(b) On mount pad on accessory gear box side: install a new gasket (3).

(c) If replacement component is without union and reducer, install new packings (11, 14) and install unions (12) and reducer (15) taken from removed pump.

(d) On pulsation damper (9) install new packings (6, 8) and new backup rings (5, 7) previously coated with Material No. P02-001.

(e) Install pulsation dampener (9) on pump. Tighten moderately.

(4) Installation

CAUTION: TO PREVENT INDUCING LOADS INTO THE MOUNT PAD CARBON SEAL, CARE SHOULD BE TAKEN TO PROPERLY ALIGN AND SUPPORT THE HYDRAULIC PUMPS DURING INSTALLATION.

(a) Position pump on to the four mounting studs, rotate counterclockwise until stopped by studs. TORQUE nuts (1) to between 275 and 300 lbf.in. (3.1 and 3.39 m. daN).

(b) TORQUE reducer (15) to between 600 and 700 lbf.in. (6.77 and 7.9 m. daN).

(c) Connect case drain hose (16) to reducer (15) and TORQUE to between 215 and 245 lbf.in. (2.43 and 2.77 m. daN).

(d) TORQUE union (12) to between 1350 and 1450 lbf.in. (15.52 and 16.38 m. daN).

(e) TORQUE pulsation dampener (9) to between 950 and 1050 lbf.in (10.73 m. daN and 11.86 m. daN).

(f) Connect pressure hose (10) to pulsation dampener (9) and TORQUE to between 855 and 945 lbf.in. (9.66 and 10.67 m. daN).

(g) Connect suction hose self-sealing coupling (13) to union (12) and TORQUE to between 1900 and 2100 lbf.in. (21.47 and 23.72 m. daN).

(h) Connect electrical connector (4) and safety with lockwire.

(3) Bleeding

(a) Open, safety and tag the following circuit breakers:

<table>
<thead>
<tr>
<th>PANEL</th>
<th>SERVICE</th>
<th>IDENT.</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>123VU</td>
<td>ENG1 &amp; 2/FIRE EXITING/SQUIB A/BTL1</td>
<td>1WE</td>
<td>335/D59</td>
</tr>
<tr>
<td>123VU</td>
<td>ENG1 &amp; 2/FIRE EXITING/SQUIB A/BTL2</td>
<td>3WE</td>
<td>302/D60</td>
</tr>
<tr>
<td>22VU</td>
<td>ENG1 &amp; 2/FIRE EXITING/SQUIB B/BTL1</td>
<td>5WE</td>
<td>207/C19</td>
</tr>
<tr>
<td>22VU</td>
<td>ENG1 &amp; 2/FIRE EXITING/SQUIB B/BTL2</td>
<td>7WE</td>
<td>207/C20</td>
</tr>
</tbody>
</table>

(b) Remove safety clips and tags and close circuit breakers associated with pump (101GK or 103GK).

(c) Pull applicable fire handle to close the fire valve.

(d) Disconnect case drain hose (16) at connection with filter assembly and place the open end in a clean container (8 liters capacity approx.).
(e) Pressurize associated system reservoir. (Ref. 29-14-00, P. Block 301).

(f) Push fire handle (fire valve opens) until airfree hydraulic fluid flows out from case drain hose into the container. Pull fire handle (fire valve, closes) when bleeding is completed.

NOTE: If necessary, repeat operations (5) (c) and (5) (e) above or continuously pressurize the affected reservoir.

(g) Connect case drain hose (16) to filter assembly and TORQUE to between 270 and 300 lbf.in. (3.05 and 3.39 m.daN).

(h) Push fire handle (fire valve opens) and safety with lockwire.

(i) Check level of hydraulic fluid in reservoir and top up if required (Ref. 12-12-29, P. Block 1).

(j) Remove safety clips and tags and close circuit breakers 1WE, 3WE, 5WE, 7WE.

(6) Tests

(a) Check that case drain filter clogging indicator is in retracted position. Manually press if necessary.

(b) Remove safety clips and tags and close circuit breakers 1 GE, 2 GE, 4 GE, 5 GD, 99GK, 101GK or 1GE, 2GE, 4GE, 5GD, 100GK, 103GK or 5GD, 31GJ, 101GK, 1GL or 1GD, 5GD, 103GK, 6GL.

(c) Pressurize associated system reservoir (Ref. 29-14-00, P. Block 301).

(d) Energize the aircraft electrical network (Ref. 29-14-00, P. Block 301). Make sure that electronics racks ventilation is correct.

(e) On ECAM control panel, press HYD pushbutton switch and on panel 427VU, make certain that corresponding ENGPUMP pushbutton switch is pressed (in).

(f) Dry-motor the engine (Ref. 71-00-00, P. Block 501).

(g) Check connections for leakage.

(h) On right ECAM display unit, check that pressure reading is 3000 +/- 200 psi (206 +/- 13.5 bars) for corresponding hydraulic system.

(i) Stop dry-motoring engine.

(j) On right ECAM display unit, check that pressure reading decreases for corresponding hydraulic system.

(k) Check level of hydraulic fluid in reservoir and top up if required (Ref. 12-12-29, P. Block 1).

(l) Check that associated hoses are installed in such a manner, that no chafing against each other or against structure is possible.

(7) Close-up

(a) De-energize the aircraft electrical network (Ref. 24-41-00, P. Block 301).

(b) Remove container.

(c) Close fan cowl (Ref. 71-13-00, P. Block 301).

(d) Remove warning notice.
APPENDIX D: COMPREHENSION TEST

Test Questions

1. Where should the warning notice be displayed? 

Reference: 

2. What size container do you need to do the bleeding? 

Reference: 

3. What problem with the hoses must you prevent from occurring after testing the pump? 

Reference: 

4. This procedure is for which of the following pumps? 

   Engine 1 Blue 
   Engine 1 Green 
   Engine 2 Green 
   Engine 2 Yellow 

Please circle the letter (a, b or c) of the correct answer. 

a) all of the above  

b) Engine 1 Green and Engine 2 Green only  

c) none of the above 

Reference: 

5. What should the pressure reading for the hydraulic system be during the dry-motoring test? 

Reference: 

6. T/F (Please circle either True or False.) If the self-sealing coupling on the suction hose is disconnected at the pump port union, hydraulic fluid will spill.  

Reference: 

7. T/F (Please circle either True or False.) If you replaced the Blue pump, you need to close the 103GK circuit breaker before bleeding the hydraulic system. 

Reference: 

8. T/F (Please circle either True or False.) After you remove the pulsation dampener, to prevent dirt from getting into the hydraulic system fluid, you should put a blanking cap on the pulsation dampener. 

Reference: 

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9. Before pressurizing the hydraulic system, the controls must be set such that ____________

Reference: __________________________

10. The case drain hose is connected to:
   a) reducer
   b) pulsation dampener
   c) pump port union
   d) none of the above

Reference: __________________________

11. What parts of the pump should you remove and keep to put on the replacement pump, if necessary?

Reference: __________________________

12. Before you install the new packings and the new backup rings on the pulsation dampener, how should they be prepared?

Reference: __________________________

13. T/F (Please circle either True or False.) The pressure hose is connected to the pulsation dampener.

Reference: __________________________

14. What can happen if the pump is not fitted properly on the mount pad during installation?

Reference: __________________________

15. How much should you torque the suction hose to the union?

Reference: __________________________

16. T/F (Please circle either True or False.) If the pump has run dry, and no contamination is found on the case drain filter element, are you required to check for metal chips or decomposed hydraulic fluid on the high pressure filter element?

Reference: __________________________