Procedure Writing Across Domains: Nuclear Power Plant Procedures and Computer Documentation

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Computer documentation, and in particular documentation for end-user software applications, is so prevalent today that it is easy to forget the larger world of procedure writing, of which computer documentation is only a part. Numerous types of procedures exist, ranging from administrative procedures that focus on human activities, to procedures for assembling consumer products, to procedures governing the operation, maintenance, and repair of complex industrial equipment. One domain in which procedures play an important role is the large and complex process-control facilities such as oil refineries and chemical plants. This paper discusses procedures and procedure writing at one kind of process-control facility--the nuclear power plant. We think that the differences between nuclear power plant documentation and the documentation of computer systems--especially software applications--are interesting and instructive, and we will try to point out some lessons learned from procedure writing in the nuclear power industry that apply directly to software documentation.

We first provide an overview of recent efforts to improve procedure quality at nuclear power plants and discuss some of the distinctive challenges faced in documenting nuclear power plant procedures. We then describe how some of the techniques used by nuclear power plant procedure writers can be applied to software documentation. We cover the process of developing and testing nuclear power plant procedures and two of the formats that have proven valuable in creating usable plant documentation. The first is a two-column text format in which users can select either general or highly detailed instruction. The second is a flowchart format that reduces the user's cognitive burdens in following highly branching procedures. The paper concludes with comments on the potential of online procedures, an area in which the nuclear power industry could learn from the writers of computer documentation.

This paper has its basis in the work that Battelle's Human Affairs Research Centers (HARC)[1] has done with nuclear power plant procedures over the past twelve years, working for the U.S. Nuclear Regulatory Commission (NRC), the U.S. Department of Energy, and various private utilities.[2] Over a 5-year period, Wieringa has taken part in and managed numerous projects pertaining to nuclear power plant procedures. Farkas has worked for Battelle as a consultant and contributes to the paper an understanding of the relationship between documentation in the nuclear power and computer industries.

EFFORTS TO IMPROVE PROCEDURE QUALITY

Procedures are very much a part of the culture in a nuclear power plant. These procedures govern every aspect of plant operations, including plant administration, maintenance, and normal and emergency operations. This presentation will focus primarily on emergency operating procedures, not only because we are the most familiar with them, but because they are the most difficult type of procedures to write and thus will allow us to consider a worst-case scenario facing a procedure writer.

The emphasis on improving plant procedures began after the accident at Three Mile Island. One of the many causes of this accident was the inferior quality of emergency operating procedures used at that plant.

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The President's Commission on Three Mile Island (1979, p. 10) found that the emergency operating procedures used were "at the very least confusing and could be read in such a way to lead the operators to take the incorrect actions that they did." As a consequence of this finding, one of the many actions taken by the NRC, which regulates nuclear power plants in this country, was to develop regulatory standards for and pay closer attention to emergency operating procedures. Battelle, working as a contractor to the NRC, has played a major role in this effort. Battelle is also involved in efforts to improve procedure quality, a project undertaken for the Department of Energy (DOE). The DOE oversees the operation of a large complex of nuclear reactors, uranium enrichment facilities, nuclear weapons assembly plants, and related facilities, and is presently devoting increased attention to operational safety and environmental impacts.

DISTINCTIVE PROBLEMS

Procedure writers in nuclear power plants face some distinctive and challenging problems. This section explains these problems. Later we examine the procedure-writing methods and the nature of the manuals that have evolved to address these difficulties, and we point out the relevance of some of these solutions to computer documentation.

Consequences of an Error. An obvious difference between emergency operating procedures and computer documentation is that the consequences of an error in a nuclear power plant are typically much higher. While the economic consequences of an error by a computer user may be high if important data are lost, user errors and malfunctions of commercial software seldom pose a threat to life and property. We all know from the Chernobyl accident the importance of safety in nuclear power plant operations. It is important to note, however, that nuclear power plants in this country are engineered with many redundant safety features, so there are multiple lines of defense against errors in procedure execution, equipment failures, and other misfortunes.

Even so, errors in following procedures can have serious consequences. Errors can lead to reactor trips, where the reactor automatically and immediately shuts down due to a potential danger. Utilities experience huge economic losses if a reactor is shut down for even a brief period of time. Furthermore, a series of errors that are minor in themselves can collectively result in a serious situation. At Chernobyl, for example, operators committed a series of procedure violations while performing a test. Individually, none of these violations would have caused the accident; yet, taken together, they were catastrophic (Barnes et al., in press).

Complexity. Another characteristic of procedures is the complexity of the system being documented. For example, it is not unusual for a single nuclear power plant to have 3,000 procedures. Furthermore, in contrast to most software procedures, the procedures in nuclear power plants are deeply intertwined. That is, there can be a great many conditions in a nuclear power plant that may make it necessary to execute a particular procedure, and executing one procedure can make it necessary to execute many others. Emergency operating procedures can be particularly complex, because during an emergency the plant is likely to be responding in an unusual or difficult-to-predict fashion. Documenting these procedures is akin to writing a manual for a software product in which bugs were the norm or in which the user receives inadequate, confusing, or contradictory feedback.

Problematic Interfaces. This complexity is compounded by the complexity of the "interface" between the plant and the operators. A computer user deals with a keyboard, a mouse, and (typically) the menus, dialog boxes, scrolling windows, and other screen artifacts of the contemporary human-computer interface. In contrast, a nuclear power plant operator deals with hundreds of dials, displays, alarms, and annunciators.

Furthermore, because it takes ten to twelve years to build a nuclear power plant in this country, in even a brand new power plant aspects of the operator interface can be five or more years behind the state of the art. Software writers, on the other hand, describe systems whose interfaces are simpler, reflect more current design concepts, and are more consistent. With the introduction of Windows 3.0, for example, many computer users suddenly had access to an immensely improved, consistent interface. The nuclear power plant operator is not so lucky.

Finally, some nuclear power plant procedures, such as those for maintenance activities, frequently are not mediated through any sort of interface but involve hard-to-describe phenomena in the physical world. A writer for the nuclear power industry, for example, may have to describe the subtleties of corrosion or tell the audience just what degree of "spurtiness" requires a particular action.

Procedure Use. Other distinctive and challenging aspects of nuclear power plant documentation result from the way in which the procedures are used. Most software programs are executed by users who are essentially working on their own at individual tasks. Procedures in nuclear power plants are executed by teams. A team may consist of five control-room operators dealing with an emergency under severe time constraints and stress; of several maintainers working on a valve in a turbine building where levels of heat, humidity, and noise are very high; or of an operator in the control room working via voice link with another operator in the plant to start a piece of equipment.

Collaborative work of any kind creates coordination problems and thus adds a significant new source of potential inefficiency and error (Gall, 1976; Brooks, 1975). In nuclear power plants, collaborative work is performed under adverse conditions, often with time constraints, and in a domain in which errors can have serious consequences. While operators are carefully selected, trained, and drilled, a major role in making complex group activity succeed rests with the procedure writers.

If we look at these problems in the aggregate, it is clear that documenting the operations of a nuclear power plant is certainly a daunting task. The task, in fact, is only manageable because of the background and training of the users. In nuclear power plants, there are no novice or casual users. Operators have technical backgrounds that include years of schooling in digital electronics, thermodynamics, and other subjects that underlie the work they carry out. Also, the operators are highly trained professionals who are regularly drilled in carrying out procedures. Software writers typically write for more diverse audiences that include less proficient users.

APPROACHES TO PROCEDURE DEVELOPMENT

Several approaches have evolved to meet the special challenges of procedure writing in the nuclear power industry. These are presented below. These approaches are applied in the most rigorous form to emergency operating procedures and, often, in a more casual or scaled-down form to routine operation and maintenance procedures.

Team Writing. One aspect of this approach is that procedures are written by a multidisciplinary team consisting of a variety of subject matter experts. Operators write operating procedures, maintainers write maintenance procedures, and so on. This model runs counter to the most common practice in the computer industry, especially in software documentation, where technical communicators are the originators of the documentation. The difference in approach is understandable: software writers can generally master a newly developed or developing product relatively quickly and, while it may require a knowledge of programming, preparation of the documentation usually doesn't require the proficiency of a professional programmer. On the other hand, a knowledge of nuclear power plant procedures (or even a subset) requires years of full-time experience and training. Procedure writers may have some experience in technical communication but are generally not technical communicators. Ideally, they are provided with textbooks, a writer's guide specific to the procedures they are preparing, classroom instruction, and immediately available assistance from technical communicators. Technical communicators would then review the draft procedures, just as these procedures must be reviewed by experts in plant operations, human factors specialists, engineers, and training personnel.

Rigorous Consistency. Consistency is a requirement of all quality documentation and, indeed, all quality writing. Farkas and Farkas (1981, p. 16), focusing on specific editorial issues, present a rationale for consistency in technical communication.

> Every manuscript contains mechanical elements of numerous kinds: abbreviations, hyphenated compounds, numerals, spelled numbers, and so forth. The editor must ensure that throughout the manuscript these recurring elements are treated consistently, that is, in a uniform or else logical and harmonious way. The human mind has an inherent need for order, and if these elements are not treated consistently, the reader may perceive the document to be disorderly and unprofessional or may be distracted by the inconsistencies. Worse still, in some instances, the inconsistent treatment of mechanical elements can be genuinely confusing, because the reader may assume that two treatments of the same thing indicate some distinction in meaning that the reader has failed to understand.

Consistency is crucial in the terse world of emergency operating procedures, where each word can convey a great deal of information. Action verbs, for example, prescribe specific actions. The action verb *ensure*, to take one example, denotes a specific action: check to see if something is so; if it is not so, make it so; if it is so, go to the next step. Verbs that might be considered synonymous, such as *assure* or *insure*, are not used. We have become almost compulsive about consistency in order to minimize the risk of a procedure user attributing a difference in meaning to a spurious difference in presentation.

Consistency in nuclear power procedures extends well beyond editorial considerations and includes very rigid specifications for the construction of procedures. For example, all steps must use a verb chosen from a highly restricted list. Action steps are written as imperatives, and begin with one of these verbs, a modifier, or the logic term IF or WHEN. These logic terms (IF, WHEN, IF NOT, NOT, THEN, OR, AND) are generally capitalized and underlined. These rules and many others like them minimize the chance of operator confusion or error in an environment in which information is presented in very terse form and must be acted upon quickly and correctly.

All of these rules are documented in a detailed style guide, which is known in the industry as a ***writers' guide***. In the aftermath of Three Mile Island, the NRC realized that writers' guides were a key to procedure quality and consistency and required that plants develop and submit them to the NRC for review. A writers' guide can become quite extensive; we have developed writers' guides that are over 300 pages.

Most software companies maintain style guides or at least have recognized policies concerning both specific editorial issues and broader questions about the construction of procedures and the design of entire manuals. There is a continuum between giving writers a free rein to handle special problems and situations on a case-by-case basis and rigorously limiting the number of formats and variations on formats from which writers can choose. With a free rein, writers can devise clever and highly appropriate ways of dealing with specific situations; by constraining writers' choices, the user will see more consistency in the documentation. On this very open-ended issue, the nuclear power industry, responding to the special problems it must deal with, weighs in on the side of stringent uniformity.

Willingness to Rely on Users' Prior Knowledge. One principle that informs the development of emergency operating procedures is a willingness to rely upon the prior experience and training of the operators. That is, not all the information needed to carry out these emergency operations is included in the procedures.

Among many people the initial reaction to omitting details from emergency operating procedures is fright--what if the operator forgets an important step? Wouldn't it be better to play it safe and include the detail in the procedure? Fuchs, Engelschall, and Imlay (1981, p. 2-13), who surveyed emergency operating procedures in various plants and identified problem areas, say no:

> In several of the procedures evaluated, extraneous explanatory information is included. Sometimes this information is included in steps; at other times it takes the form of excessive cautions and notes. Citing this as a deficiency is not intended to question the value of this information. Explanatory information serves to motivate the operator and, most importantly, help him understand what is happening. However, such information belongs in training, not in an emergency procedure. In an emergency, the operator needs to know ***what to do and how to do it.*** If he's faced with an unforeseen situation, it is too late for him to learn how the system works and why certain actions must be taken. Such information should be carried by

system explanation manuals to be used in the operator training program.

Following this rationale, not only explanatory information but details pertaining to actions are also omitted. Emergency operating procedures frequently do not specify the control manipulations required to accomplish actions; for example, the procedure may instruct an operator to start a pump without specifying which controls to use or how to operate them. Similarly, emergency operating procedures seldom instruct operators to watch for expected results of the actions they take. The operators are expected to know these things.

This policy points directly at an issue that faces every documentation writer: how much detail to include and what level of knowledge to take as the starting point for the documentation. The most frequent strategy in the world of software applications is to assume that the user knows how to use the keyboard and mouse, the basics of the underlying operating system, and the conceptual domain of the product (accounting, music composition, etc.), but to explain the operation of the software completely and from "ground zero." John Carroll, on the other hand, as part of his minimalist documentation program, favors radically cutting introductory material and determinedly cutting all detail. His intent is for users to begin learning and using computer software quickly, and he is willing to remove the safety net provided by complete and explicit procedures in order to promote problem-solving behavior and inferential learning (Carroll, 1990; Farkas & Williams, 1990). Barbara Mirel (1988), in her work on internal software documentation, advocates sensitivity to an organization's existing culture and communication patterns--so that a writer might omit information that will be communicated in training sessions or via oral interaction among the user community As we will see, Battelle uses a very different approach to the detail problem in the instance of normal operating and maintenance procedures, but in the case of emergency operating procedures, our policy is one more exception to the standard practice of fully detailed documentation.

Supporting Group Tasks with Customized Procedures. Documentation must help meet the challenge of having several operators working together on the same procedure. One current approach is to write customized procedures for different operators working on the same task. For example, each operator will follow a procedure that details that operator's specific task, and the control room supervisor, since he or she must manage and coordinate the efforts of the entire team, will use a manual that covers the entire task but at a higher level of generality.

This approach is obviously very difficult and expensive to implement and is used primarily for emergency operating procedures. The longer-range solution, while it may include customized procedures, is to put the information required to operate a nuclear power plant online and to develop multi-user interfaces that will effectively support all aspects of group work.

User Testing. In concert with a strong trend in the computer industry, emergency operating procedures in nuclear power plants are scrupulously tested with the ultimate users. One form of testing is known as a walkthrough. It is what the name implies--users perform a dry run of the procedure, walking through the steps without actually performing them. In doing so, they can find instances where nomenclature in the procedure fails to match labels in the plant and instances where the procedure cannot be physically performed as written (e.g., the procedure requires that the user open a valve while reading a gauge, but the gauge is positioned so that it cannot be seen from the valve). Users may also be alerted to potential technical problems in the procedure, as walking the procedure through also encourages them to think it through.

Emergency operating procedures are also tested in a simulator. A simulator is a duplicate of the control room that is linked to a computer so that the simulated control room behaves as if it were actually controlling the plant. Simulators are very expensive and complex, but are essential for developing and testing emergency operating procedures. During these simulator exercises, operators must use emergency operating procedures to diagnose and address a simulated emergency condition. These exercises can reveal a host of problems, from technical errors in the procedures to areas where procedures contain an inadequate level of detail to situations where operators are required to use too many procedures concurrently. It is good that user testing is well established in both the nuclear power and computer industries; but, as Donald Norman (1988, p. 156) points out, the practice of user testing should be universal.

THE ACTIONS-DETAILS FORMAT

In this and the next section we discuss two specific formats that are frequently employed in nuclear power plant procedures and that have application to computer documentation. We begin with the action-details format.

Although operators are trained intensively in emergency operating procedures, the number of normal operating and maintenance procedures is far too great to permit this kind of training. Consequently, there is apt to be greater variance in operators' knowledge in the tasks documented in normal operating and maintenance procedures. To reduce the reliance on operators' knowledge, a format that presents procedures in two levels of detail can be used.

The action details format is shown in Figure 1. The left-hand, or actions, column presents the general actions that the operators must take--in the case of Step 7, turning on the turbine generator core monitor. The right-hand column provides detailed information on the activities required to perform the action; in Step 7, the item in the details column tells operators which control to manipulate and where it is located. The experienced operator, therefore, can read down the actions column, looking over to the details column only when necessary. But the less experienced operator can read detailed information on each step of the procedure.

The benefits of this format are equally relevant to computer documentation. A significant drawback, however, is that presenting two levels of detail in separate columns takes up a lot of space and greatly increases the page count of a manual. While thick manuals are acceptable in the nuclear industry, both cost considerations and the question of customer acceptance limit the use of this format in commercial software documentation. But the concept of offering the user more than one level of detail is very amenable to various forms of hypertext implementation on the computer screen, both in the nuclear power industry and computer documentation.

		Actions	Details
___	[7]	Turn on the turbine generator core monitor.	Depress the POWER pushbutton, which is located on the Turbine Generator Recorder Cabinet, ZJN-C07, behind the control room.
___	[8]	Record the time the core monitor was turned on in the control room logs.	
___	[9]	Start Motor Suction Pump, LON-P03.	Take MOTOR SUCTION PUMP P03, LON-HS-21, to the START position and check that the red indicator light comes on.
___	[10]	Direct a nuclear operator to check that the Main Shaft Oil Pump Suction Pressure Indicator, LON-PI-70, reads between 15 and 25 psig.	LON-PI-70 is located on the main turbine front standard.
___	[11]	Direct a nuclear operator to transfer and maintain temperature control of the main turbine to manual.	Directions for local operations are provided for the nuclear operator in Appendix Y.
___	[12]	Check that turbine bearing oil temperatures are between 130 and 150°F.	Use temperature recorder MTNTR-303, Points 1 through 12, on board B07.
___	[13]	IF the AUTO ACTUATE OUT OF SERVICE LIGHT is NOT on, THEN PERFORM Section 8.0 of Reactor Power Cutback, 41OP-1SF04.	The AUTO ACTUATE OUT OF SERVICE light is located on the REACTOR POWER CUTBACK panel on board B04.
		RETURN TO Step [14] in this procedure.	

Figure 1. Actions-Details Format

FLOWCHART PROCEDURES

Another procedure format that has become prevalent in the nuclear power industry is the flowchart. A flowchart is "a diagram in which text and graphics are combined to present instructions for performing a task" (Barnes et al., 1989, p. 3-1). Although flowcharts take many forms, the standard kind of flowchart is the *algorithmic flowchart*, as shown in Figure 2. Algorithmic flowcharts simplify decision making by guiding the user through the decision-making process (Barnes et al., 1989; Moore et al., 1990). Compare the flowchart in Figure 2 with the equivalent text procedure in Figure 3. Note how the text procedure requires the user to skip through the steps in the procedure in an order that is dependent on the reactor power level, torus temperature, and so on. The flowchart, on the other hand, guides the user through the decision-making process. With the flowlines to guide the user, there is little chance of becoming lost. In the text procedure, conversely, users can readily lose their place as they go from one step to another or become confused as they skip actions that do not apply (e.g., if reactor power can be determined, they skip the action in Step 1).

There is some support in the literature for the benefits of flowcharts in support of decision making. Kammann (1975, p. 190) developed flowchart procedures for telephone dialing and found that the "flowchart format can produce a higher level of direct comprehension than is obtained with the standard prose format." Flowcharts have also been shown to be a superior format for diagnostic activities, both in X-ray diagnosis (Tuddenham, 1968) and diagnoses conducted by nurses (Aspinall, 1976).

Flowcharts are also useful for the diagnostic procedures used in nuclear power plants. Due to the complexity of a nuclear power plant, the cause of an emergency will not be immediately evident. Operators must systematically check various instruments and readouts to determine the exact nature of the situation. Without some type of operator aid, this diagnosis can be very difficult and is likely to lead to errors. During the Three Mile Island accident, for example, operators misdiagnosed the situation, believing that a crucial valve was closed when it was in fact stuck open (President's Commission on Three Mile Island, 1979).

A flowchart such as that shown in Figure 2 can walk operators through the diagnostic process. One plant that Battelle has worked with uses just such a flowchart. It is presented ingenuously on three panels of hard plastic hinged in the middle,

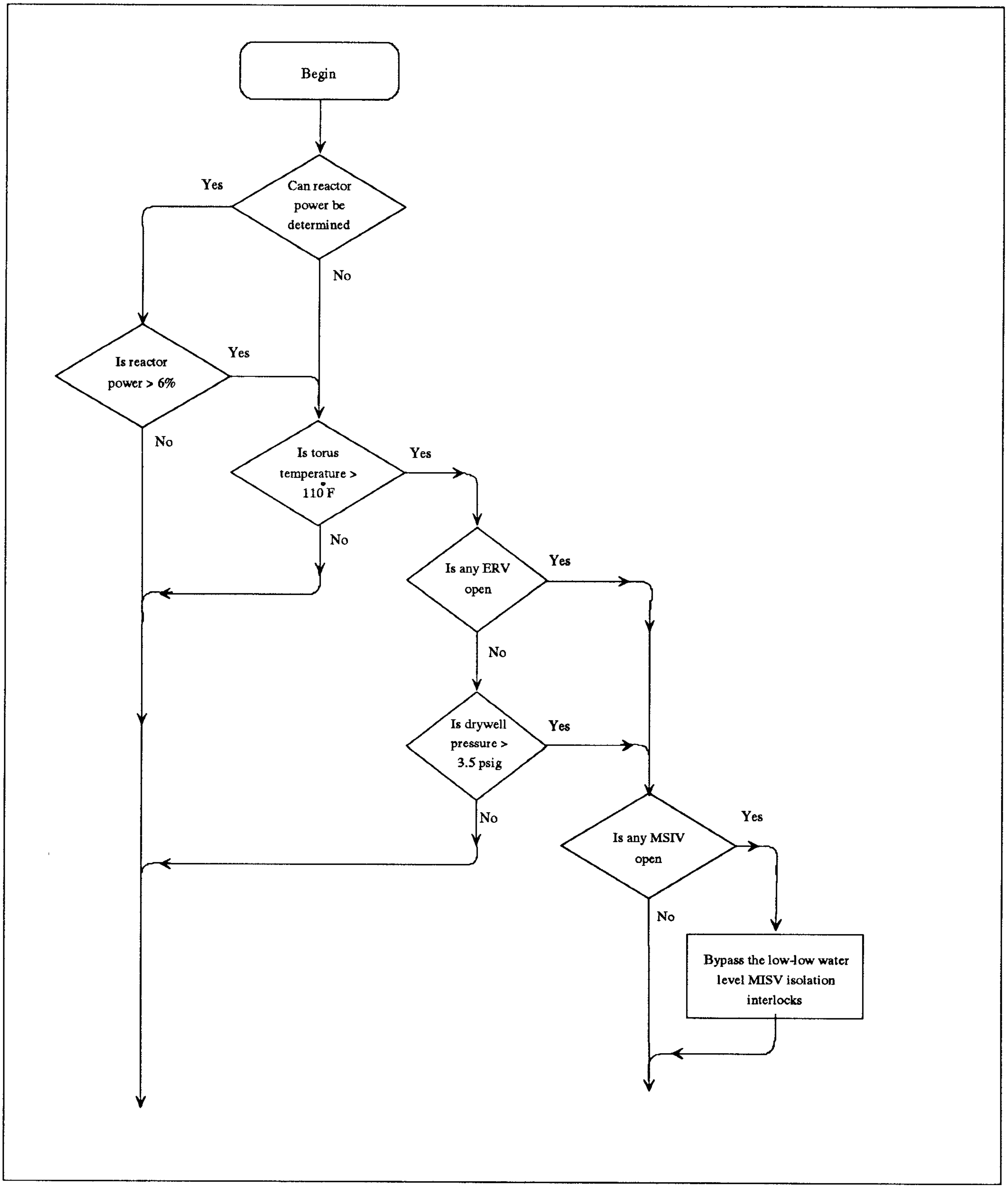

Figure 2. Algorithmic Flowchart

___ [1] IF reactor power can NOT be determined,
THEN GO TO Step [3] in this procedure.

___ [2] IF reactor power is less than 6%,
THEN GO TO Step [10] in this procedure.

___ [3] IF torus temperature is less than 110° F,
THEN GO TO Step [10] in this procedure.

___ [4] IF any ERVs are open,
THEN GO TO Step [6] in this procedure.

___ [5] IF drywell pressure is less than 3.5 psig,
THEN GO TO Step [10] in this procedure.

___ [6] IF any MSIVs are open,
THEN bypass the low-low water level MSIV isolation interlocks.

Figure 3. Complex Series of Steps

so that the operator can cradle it in his arm as he walks around the control room, checking controls and indications.

Drawbacks of Algorithmic Flowcharts. Flowcharts do have their limitations, however. First, they can easily take up a lot of space, and when they span more than one page, users may make errors as they follow a procedure from page to page. Many flowchart-format procedures used in nuclear power plants are relatively small; but others must be printed on large sheets of paper. Second, the graphical nature of flowcharts generally restricts the amount of space available for text. Flowchart steps, for example, will not fit into symbols unless the steps are very brief. This brevity is typically not a problem in emergency operating procedures, where operators are highly trained on procedure content and require little detailed information. However, it can be problematic in other procedures, where users require more detail. Third, flowcharts are not terribly efficient for presenting procedures that consist primarily of steps and contain few decisions. In these procedures the graphics (i.e., arrowed lines between steps) occupy space and contribute little, as the movement between steps is so simple.

Finally, it is difficult in a flowchart to group steps or provide other types of hierarchical information (e.g., substeps are grouped into steps, which are grouped into sections, which are grouped into a procedure). A hierarchical structure is beneficial in procedures (Bovair & Kieras, 1989; Fuchs, Engelschall & Imlay, 1981; Huckin, 1983). Hierarchical procedures are easier to comprehend (Dixon, 1987) and to learn and remember (Holland, Charrow & Wright, 1988, p. 35): "If procedures are to be learned and remembered, then the hierarchical structure appears to be essential." Flowcharts, on the other hand, emphasize sequential information over hierarchical information.

Many proven techniques exist for presenting hierarchical information in text procedures, yet equally practical techniques have yet to evolve in flowcharts, if they are possible at all. Flowchart steps can be grouped by proximity, placing related steps nearer to each other and separating steps that are unrelated (Barnes et al., 1989; Moore et al., 1990). This technique, however, will likely increase the space required by the flowchart and yet users may still fail to understand the connection between proximity and hierarchical organization. Graphic techniques, such as drawing a border around related steps, can be used, but there is danger that the borders can be confused with the lines that direct movement through the flowchart.

Flowcharts in the Computer Industry. Flowcharts and closely related kinds of graphics are used in computer documentation. For example, the instructions for getting up and running on Xerox's 6085 series workstations take the form of an algorithmic flowchart. It is notable, however, that the flowchart is accompanied by a text procedure that presents more detail on each step than can be fitted into the flowchart.

Although syntax diagrams most commonly employ a vocabulary of brackets, parentheses, and other non-graphical elements, flowchart presentation may be better. When IBM re-wrote the traditional Unix *man* help for their online AIX command reference, they used a flowchart-like format to indicate the complex relationships among the optional and required switches in the Unix command set as shown in Figure 4. Currently, the database software company Revelation Technologies is experimenting with flowchart-format syntax diagrams that are more elaborate and more graphically rich than the IBM design. Although writers of computer documentation have found some good applications for the flowchart format, they too face the same drawbacks described above. Fortunately, the trend toward online information promises to mitigate these drawbacks in both domains.

CONCLUSION: THE PROMISE OF ONLINE INFORMATION

Several times in this paper we have concluded that online presentation of information offers some of the most promising solutions to problems facing procedure writers in the nuclear power industry and that these solutions can readily be applied to computer documentation.

Online documentation is beneficial in many respects, but most important here is the ability to allow users to see just the information they need. In the online equivalent of the actions-details format, users can select the level of detail they require and not be distracted by other information. Extending this principle further, at the click of a hypertext button an operator could be shown the deep-level technical information underlying a step in a particular procedure or a video clip showing how something is done.

Similarly, flowchart symbols can become hypertext nodes, so that users can readily zoom in and out to view either the "big picture" or a very specific part of the flowchart. There is already evidence that reactor operators want flowcharts that offer not just specific decision paths but broad overviews of reactor design and operations. Already, online flowchart products, such as Kaetron's TopDown, are available. TopDown not only has various zoom and detail control capabilities, but has ways of displaying the hierarchical structure of flowchart information.

The problem of supporting teams of operators working at remote locations on a single problem is more complex, but an important trend in the computer industry is the development of *groupware* that supports all forms of collaborative activity, including real-time tasks performed at remote locations (Grief, 1988). Various groupware products not only can facilitate communication among teams of operators but can serve as "shells" for both the appropriate sharing and individual display of procedural information (Andrews, 1991). Interestingly, while nuclear power industry personnel may well become end users of this type of collaborative software, documentation writers will face the challenge of documenting the multi-user interfaces of these products and the collaborative tasks in which users will engage.

The nuclear industry has thus far been slow to abandon printed procedures, although we have seen progress. The importance of online procedures for the nuclear power industry has been noted by Tolbert, Moore, and Wieringa (in press) and some experimental on-line procedures have been developed (Krogsaeter et al., 1989a, 1989b). For now, the nuclear power industry will follow the lead of computer professionals in the area of online information. The industry, however, and the federal agencies that support and regulate it have a history of investing considerable resources to research problems pertaining to safety, ergonomics, documentation, and related issues. It is not unlikely that research of this kind, performed by Battelle and other organizations, may yield findings and insights that will be valuable to those engaged in computer documentation.

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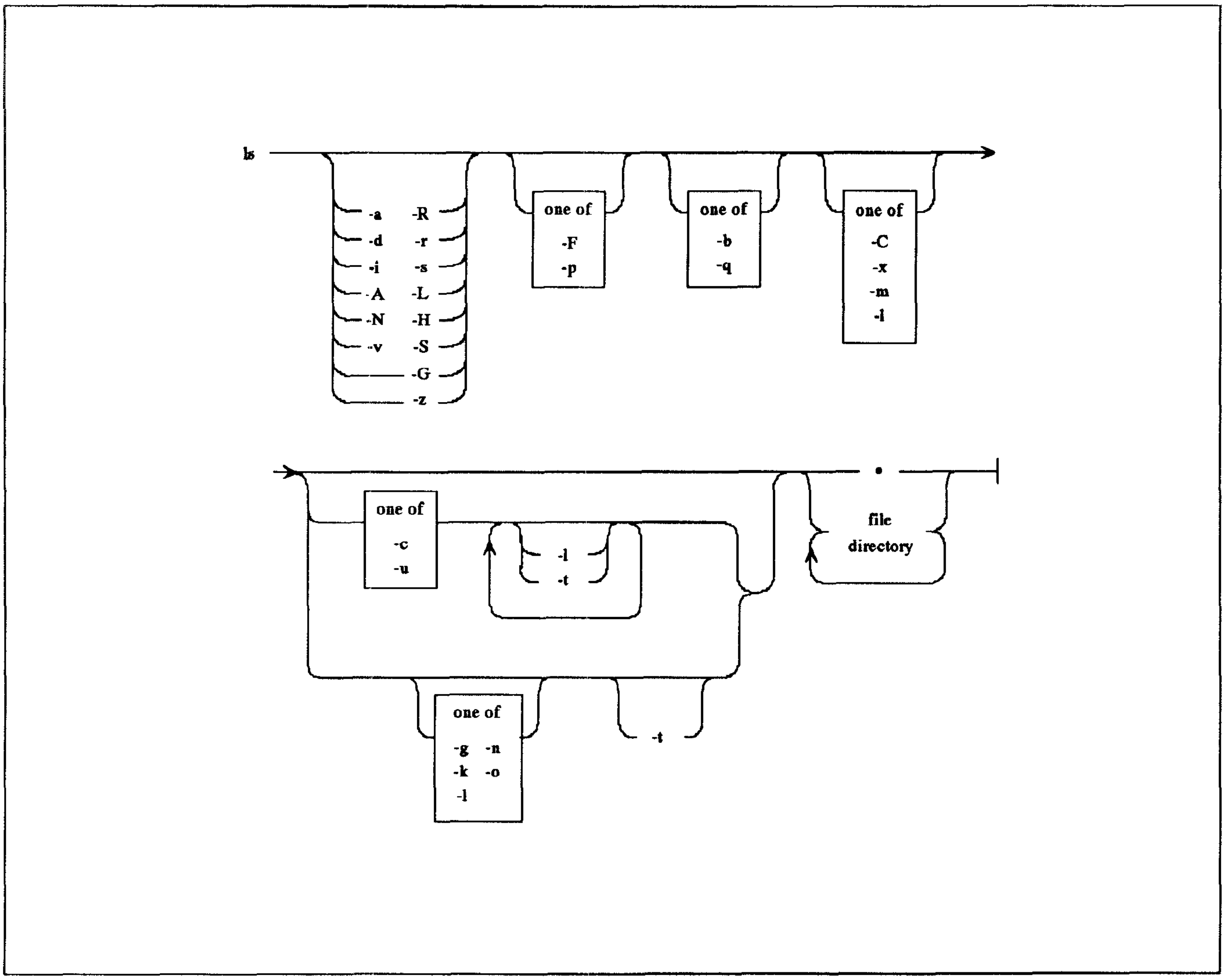

Figure 4. Syntax Diagram

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