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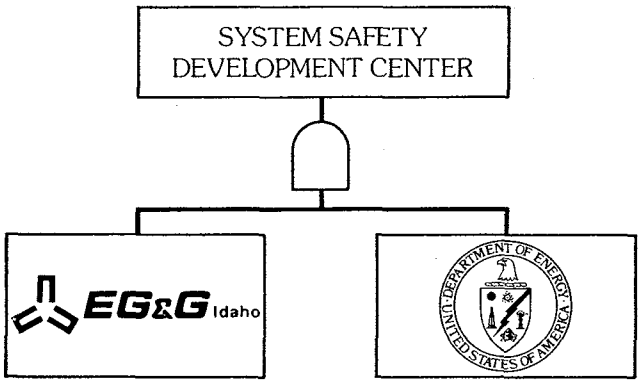
Process Operational Readiness and Operational Readiness Follow-On



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P.O. Box 1625
Idaho Falls, Idaho 83415

February 1987

UNITED STATES
DEPARTMENT OF ENERGY

OFFICE OF THE DEPUTY ASSISTANT SECRETARY
FOR SAFETY, HEALTH, AND QUALITY ASSURANCE

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PROCESS OPERATIONAL READINESS AND OPERATIONAL READINESS FOLLOW-ON

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Published by

System Safety Development Center
EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

Prepared for the
U.S. Department of Energy
Idaho Operations Office

EXECUTIVE SUMMARY

The purpose of this document is to provide additional documentary material dealing with subjects introduced in SSDC-1, Occupancy-Use Readiness Manual, and SSDC-12, Safety Considerations in Evaluation of Maintenance Programs. In augmenting SSDC-1, Part I of this manual provides additional material related to process safety; in the case of SSDC-12, the subject of safety considerations in evaluation of maintenance programs is broadened in Part II to include maintenance of personnel systems and procedural systems as well as hardware. "Maintenance" is related more directly to the concept of operational readiness and an alternative analytical tree is provided for hardware maintenance program evaluation.

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CONTENTS

FIGURES

FIGURES
(continued)

PROCESS OPERATIONAL READINESS

AND OPERATIONAL READINESS FOLLOW-ON

INTRODUCTION

The first document in the SSDC (System Safety Development Center) series deals with the subject of Occupancy-Use Readiness (Reference 1). The material included in that manual provided the basis for development of the SSDC workshop in Operational Readiness (Reference 2). The original Occupancy-Use Readiness Manual, however, deals only generally with the subject of process safety; i.e., the safety of overall "processes" such as solar collection systems, nuclear reactors, and coal fired electrical plants. The manual also fails to detail the considerations involved in maintaining the state of readiness on a continuing basis. Both of the latter subjects are dealt with in some detail in the SSDC's Operational Readiness Workshop.

The purpose of this document is to provide additional documentary material dealing with subjects introduced in SSDC-1, Occupancy-Use Readiness Manual, and SSDC-12, Safety Considerations in Evaluation of Maintenance Programs. In augmenting SSDC-1, Part I of this manual provides additional material related to process safety; in the case of SSDC-12, the subject of safety considerations in evaluation of maintenance programs is broadened in Part II to include maintenance of personnel systems and procedural systems as well as hardware. "Maintenance" is related more directly to the concept of operational readiness and an alternative analytical tree is provided for hardware maintenance program evaluation.

PART I--PROCESS SAFETY

Operational Readiness

We will first discuss operational readiness concepts in the context of getting things off to a good start for new or modified systems. We will proceed in Part II to consideration of use of the operational readiness analytical tools as a basis for ongoing evaluation of system safety and the effectiveness of total system maintenance programs.

What Do We Mean by Operational Readiness?

In the MORT sense, operational readiness means achieving a configuration which places the right people in the right places at the right times working with the right hardware according to the right procedures and management controls. At a secondary level, this implies that these elements are functioning in a proper physical and psychological environment.

What Determines What Is "Right" and "Proper?"

"Rightness" in achieving operational readiness is based on two kinds of criteria:

1. Functional Criteria

    a. The system is accomplishing its functions in an acceptable manner.

    b. The system is operating at acceptable risk level in terms of environment, safety and health risks as well as business risks.

2. Applicable codes/standards and regulations established at all control levels inside and outside of the operating organization.

While the intent of both of these types of criteria is often the same, applicability and relevance as related to specific systems are often quite different in a practical sense.

What Are the Basic Elements of Any System?

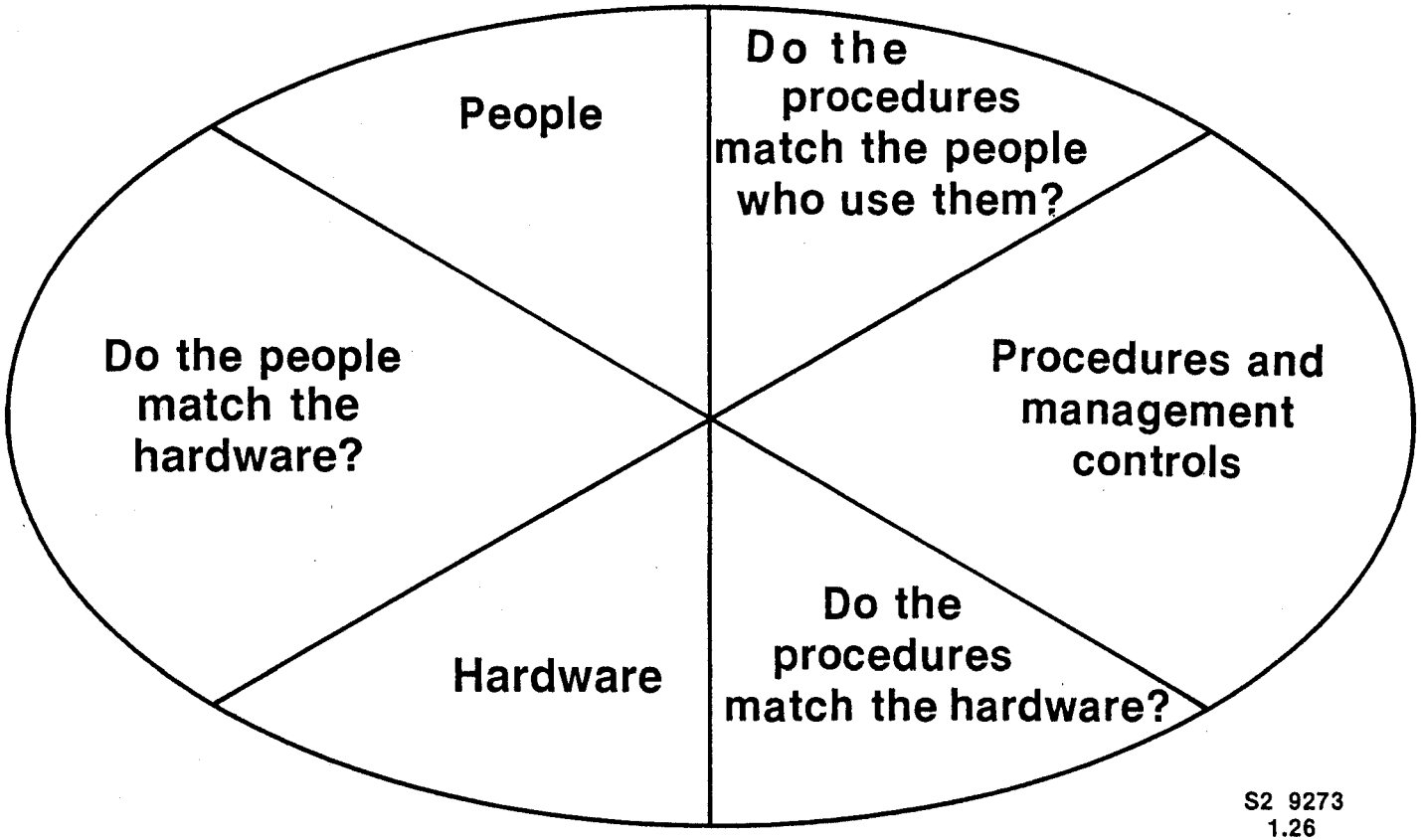
The three basic system elements are:

- People
- Hardware Elements
  - Process hardware/tools, etc.
  - Buildings and Grounds
- Procedures and Management Controls

As indicated in Figure 1, these three elements provide only half of the analytical picture. We must also consider the interfaces among these elements.

- Do the people match the hardware; e.g., is the hardware properly operable for the people who have been selected and trained to operate it; e.g., have we selected people with proper color discrimination to deal with color coded hardware elements?
- Do the procedures match the hardware; e.g., have we avoided situations in which the operators have been given Mark IV procedures manuals to operate Mark V equipment?
- Do the procedures match the people who are to use them; e.g., do we have selection procedures which assure a proper degree of functional literacy for people who must read and understand complex work procedures?

Hardware-People-Procedures Relationships



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1.26

Figure 1

How Do We Achieve Operational Readiness?

Operational readiness is accomplished by proceeding along selection/development lines as indicated in Figure 2. The status of operational readiness is indicated by the bull's-eye at the center of the diagram. As may be seen, each of the major elements achieves its state of readiness by progressing from an establishment of conceptual specifications and selection criteria to a final state of "here-and-now" readiness labeled "go" on the diagram.

It should be noted that the interface development cycles must evolve through the same sort of progression if we are to arrive at a final state of system readiness.

For example, (plant-personnel interface) if we have valves in the system which require "two strong men and a boy" to manipulate, we do not select 90 pound weaklings to operate the system. If components and displays are color coded, we must establish and maintain proper color discrimination criteria in personal selection. Similarly, (personnel-procedural interface) if we select complex written technical procedures as a control medium, we must maintain functional literacy requirements in our personnel selection criteria.

Finally, (plant-procedural interface) we must select procedural types which are appropriate to the hardware systems which our operators are controlling. The procedures should be sufficient to establish proper control but should be no more than are necessary in terms of the hardware design and the characteristics of the personnel themselves.

In short, the personnel, procedures and hardware cannot be taken to a state of readiness individually. They must be in a collective state of readiness in accordance with system operational requirements.

How do we achieve operational readiness?

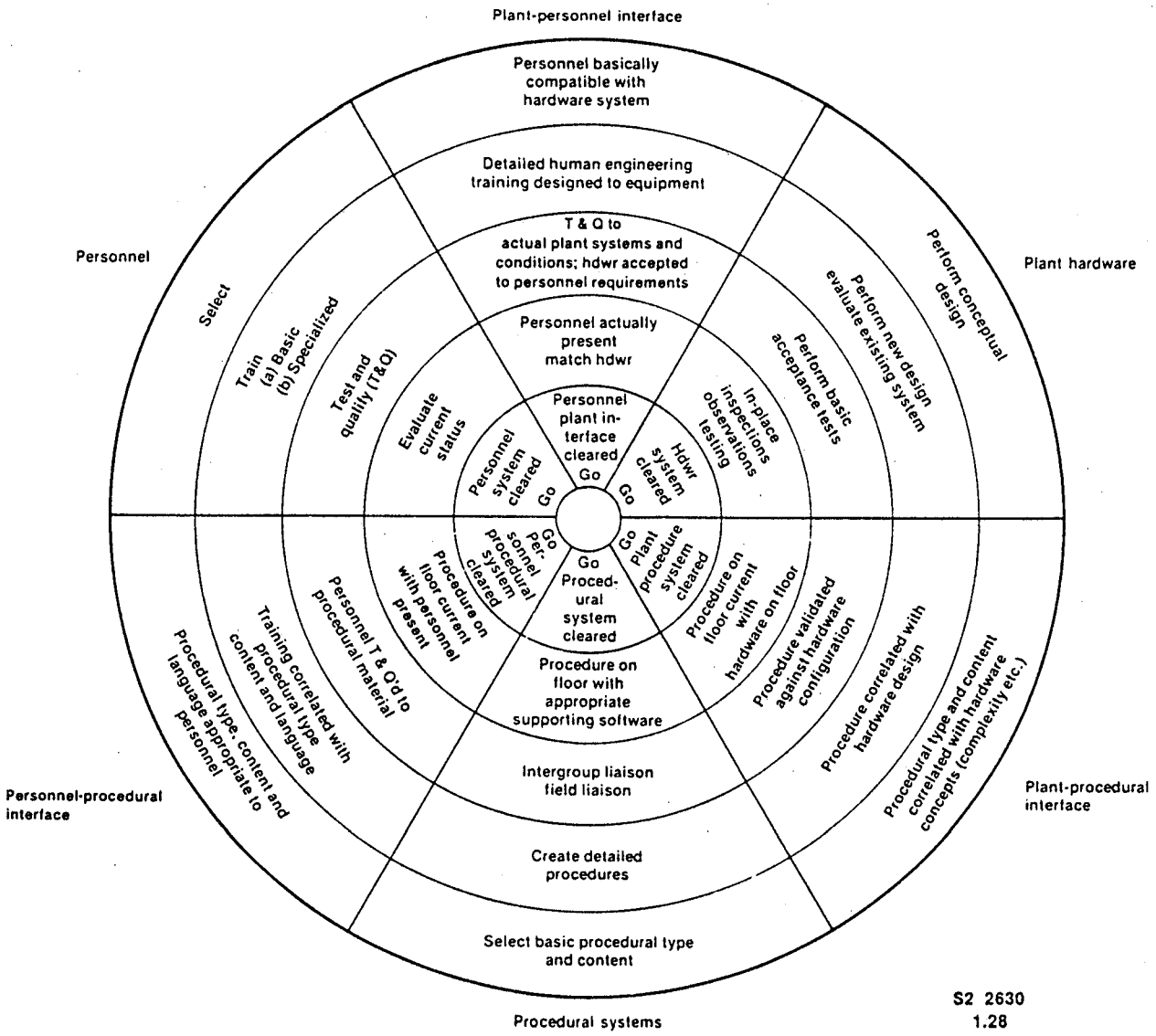

Figure 2

How Can We Prevent Oversights in Complex Systems?

A complex system involves a great many people, hardware, and procedural components. This results in the need for analytical models which can enable us to keep track of all of these elements.

The primary analytical model is the readiness tree shown in Figure 3. This is the same tree which was introduced in SSDC-1 (Reference 1). Going beyond the discussion of Reference 1, however, we may go on to develop the "Basic Structure and Facility" element defined in Reference 1 to a complete hardware/plant process description. This process is indicated in Figure 4. Similarly, plant operator/supervisory/management personnel structures may be defined and be associated with the hardware elements on a one-to-one basis. Finally, the hardware structure may be related to applicable operating procedures and management controls.

This does not require structure of personnel/procedure branches which duplicate the hardware configuration structure. Rather, it may be done through use of hardware based matrices related to individual hardware items. These matrices define the procedural and personnel needs for each hardware element. This methodology is described in detail in the SSDC Operational Readiness Workshop (Reference 2). Once the analytical tree and its matrices are completed, it describes, in any desired level of detail, the individual things which need to be in place if the system is, indeed, in a state of readiness.

The Total Development Cycle

It might appear that this process is simply a matter of tracking a construction job along with parallel personnel staffing and structure of procedural systems. While we may approach this idealized situation in some cases, the more common situation in modern high technology systems is the one shown in Figure 5. In this case, we are evaluating operational

What Is Our Basic Model?

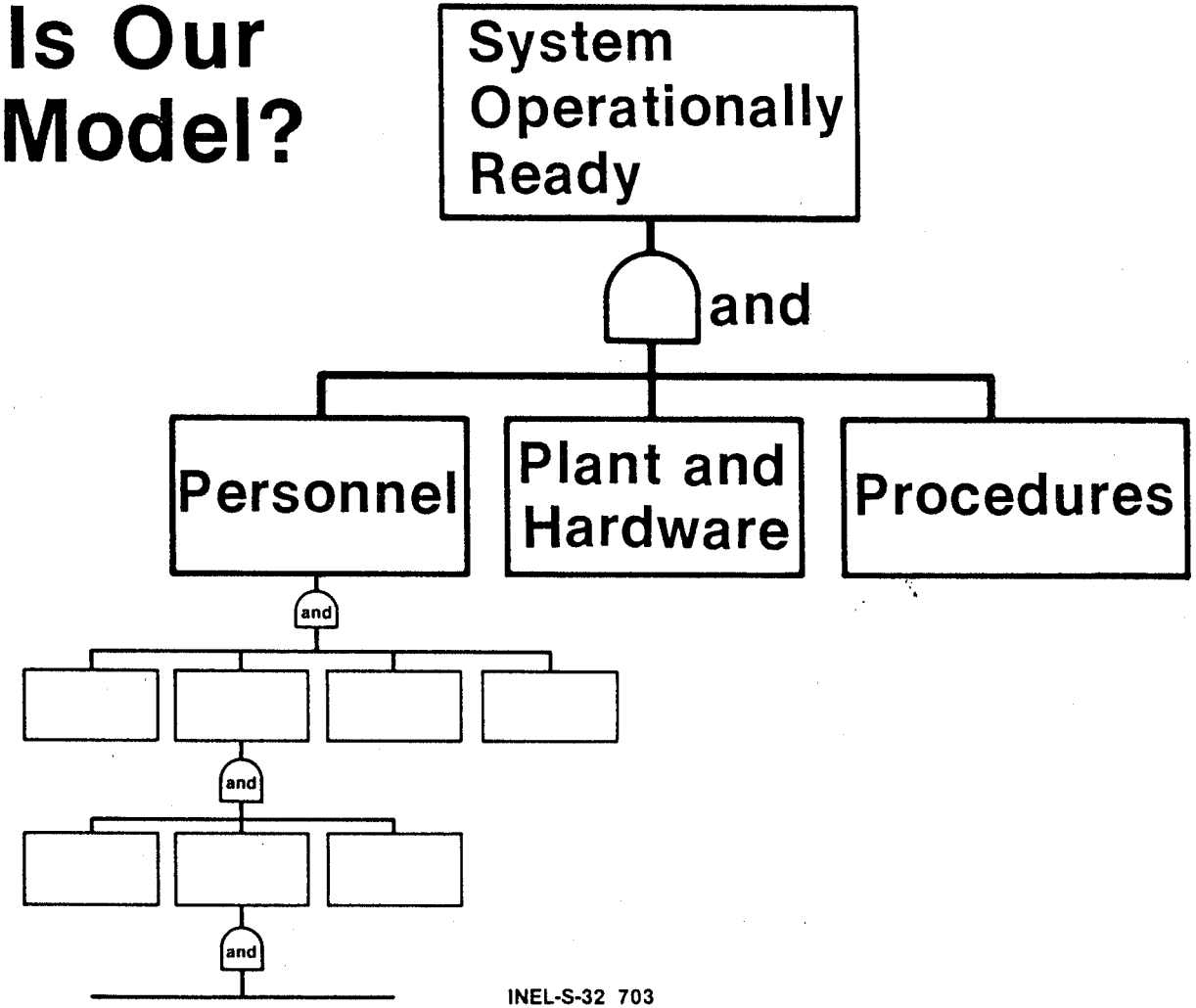

Figure 3

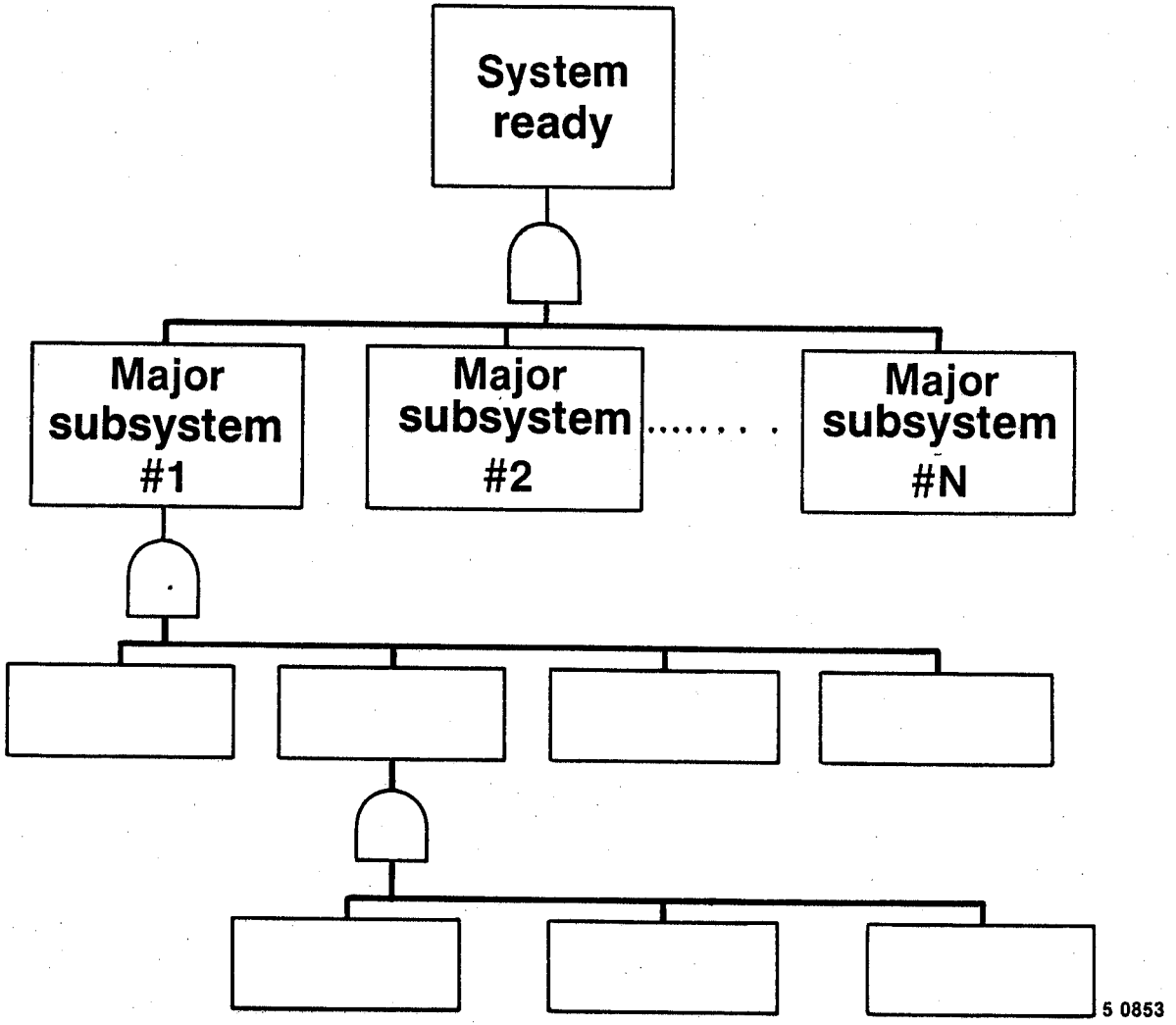
System ready
Major subsystem #1
Major subsystem #2
Major subsystem #N
5 0853

Figure 4

Development

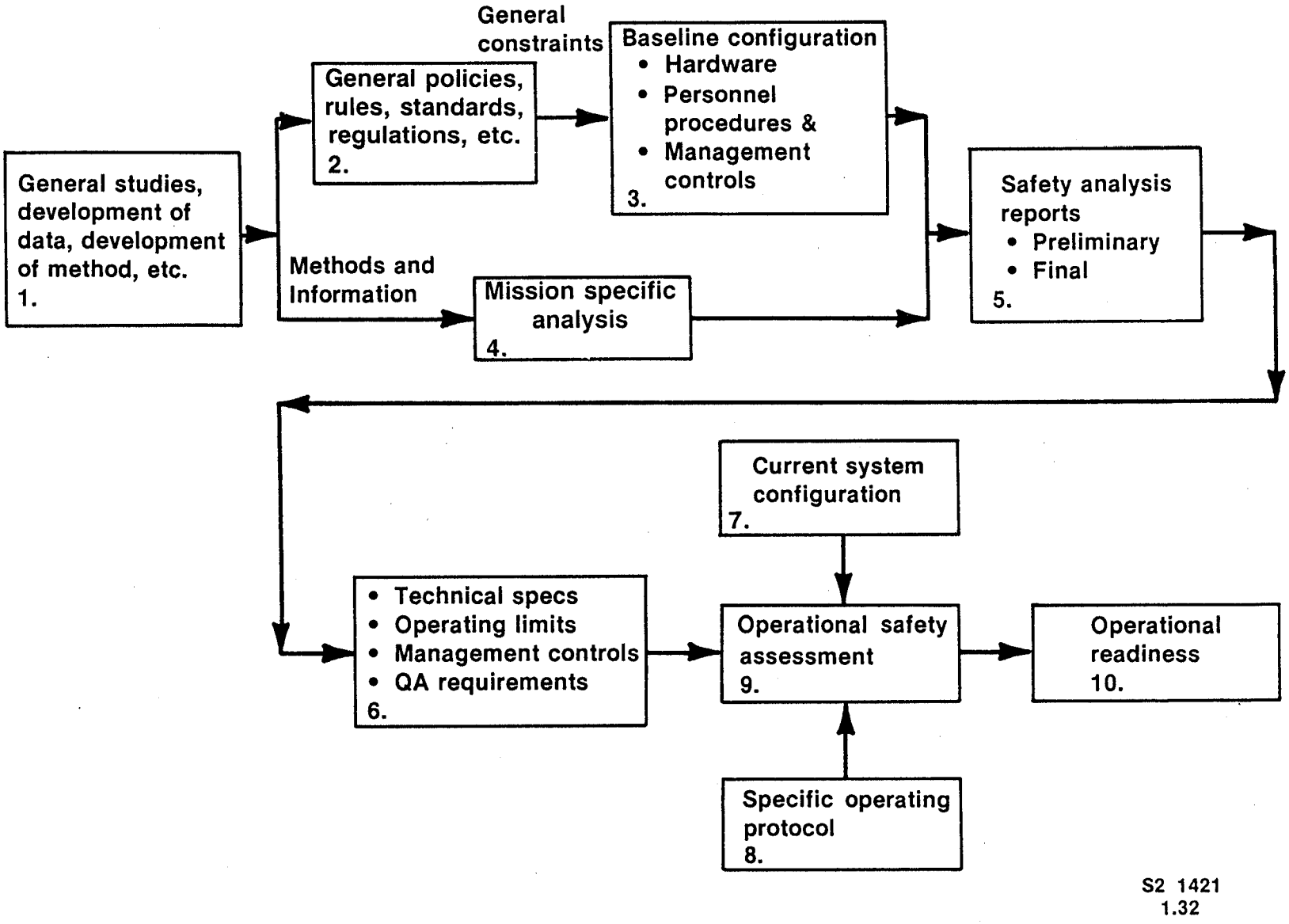

Figure 5

readiness based on the current system configuration and a specific operating protocol indicated inside the dotted rectangle. Acceptability is based on an operational safety assessment (Box 9) which utilizes appropriate technical specifications, operating limits, management controls and quality assurance criteria/information (Box 6).

If we examine the situation closely, however, we find that we are dependent on a great deal of upstream developmental work (Boxes 1-5). This development work has led to the system which we are dealing with. We find, then, that our ability to determine the readiness of a system is always dependent to some degree on the quality, quantity and scope of this upstream work. For example, a number of years ago, considerable difficulty was experienced in establishing operational readiness for a nuclear test reactor to operate because of limitations in parametric scope of the laboratory experiments which had established the empirical equations relating to heat transfer. These supporting laboratory experiments had actually been performed many years earlier and were not related on a one-to-one basis to the current machine.

Generally speaking, we are provided with two choices in a situation of this kind. We may sacrifice time and money to perform additional preparatory work or we may accept the uncertainties and/or lack of system control arising from incomplete upstream preparation.

What Is the Relationship Between Operational Readiness and Mishaps?

The mishap or accident is generally evidence that a system was not, indeed, operationally ready. If we examine Figure 6, we see that this, in turn, represents failure in one or more of the preparatory steps for people, hardware, or procedures/management controls.

Even situations in which conditions which were not under our control were involved as causal factors can still indicate a lack of operational readiness. For example, wind/lightning damage can indicate design deficiencies in system protection from these natural hazards. Other

Case study # 1

Upstream Processes

The mishap is the result of "upstream processes":

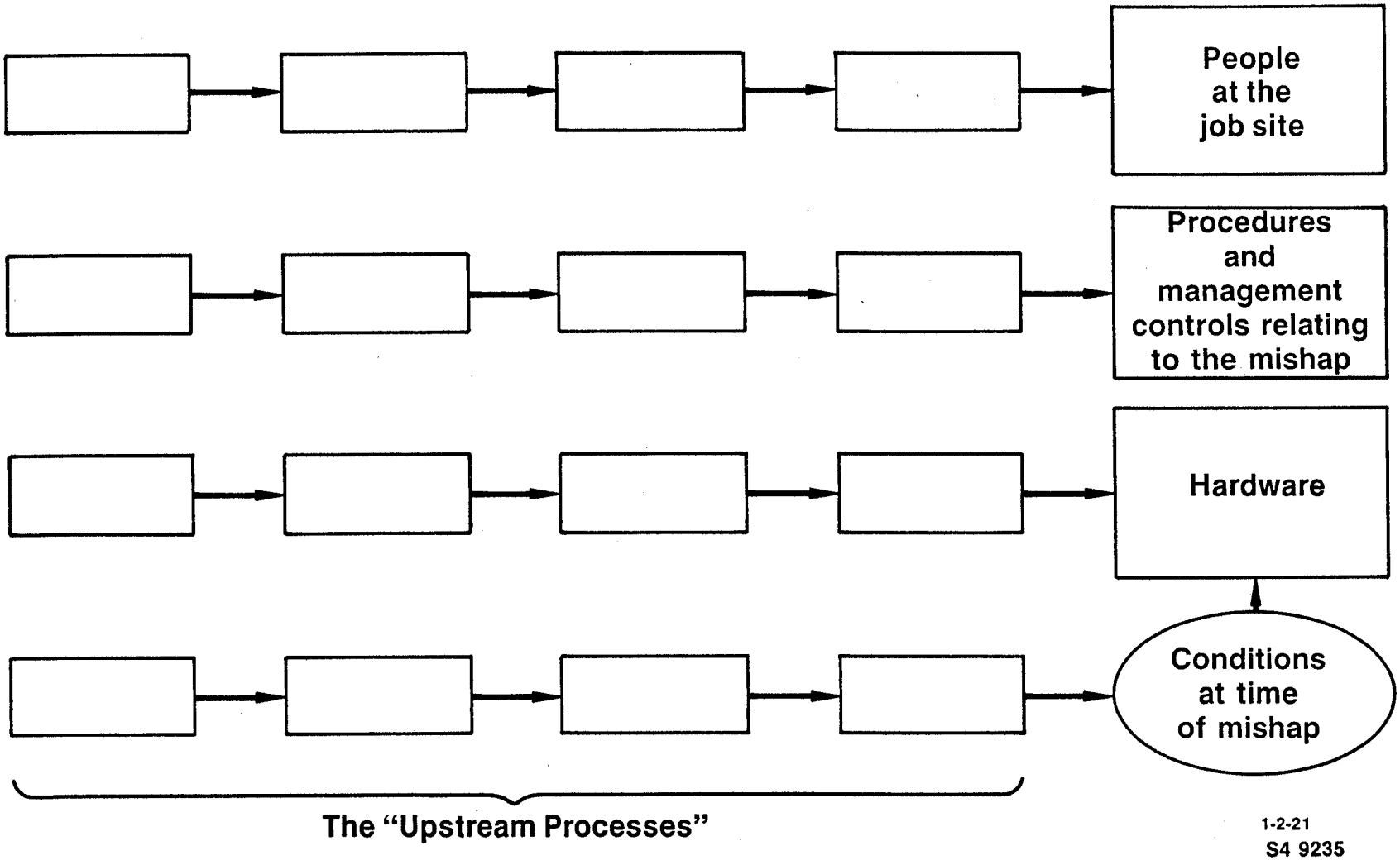

Figure 6

situations may indicate that we failed to establish meteorological controls over our operations in an adequate manner.

The nature of the three upstream processes is indicated in Figures 7, 8, and 9. Figures 7 and 8 are self-explanatory; Figure 9 is discussed in detail in Reference 5. The important points in examining these figures are three:

1. The processes are complex and involve many people and interfaces.

2. The processes are interrelated.

3. The need for system follow-on maintenance and ability to deal with change is evident in all the processes, not just hardware elements.

How Can We Track and Display Progress?

In dealing with complex systems, it is necessary that orderly methods for tracking and displaying readiness information be established. These cannot always be based on final product inspection. For example, certain hardware elements must be inspected prior to the time that they are made physically inaccessible through construction. Similarly, it is not always possible to determine whether a procedure was "reviewed" or whether an operator was "trained" by simple observation after the fact.

Our readiness determination, therefore, must be based to some degree on records, certification, spot checks and descriptions of processes as well as on product examination.

The situation is demonstrated in Figure 10. The readiness elements defined in the analytical trees must be completed by people. These people perform the tasks defined as "what" in Figure 10. Readiness is achieved when, and only when, all of the actors ("who") have completed all of their tasks ("what").

Preparation of Procedures

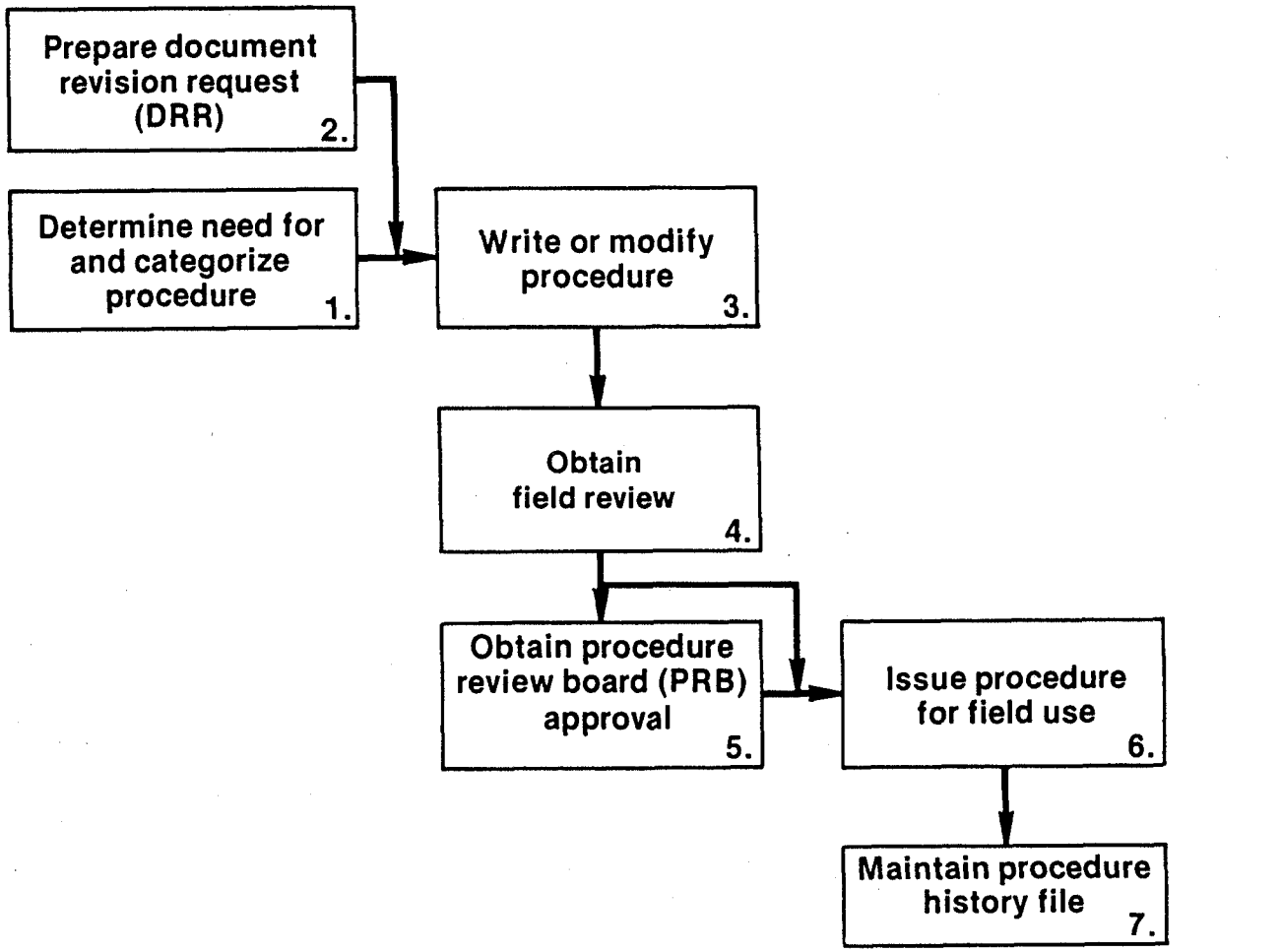

Figure 7

The Hardware Configuration Control Model

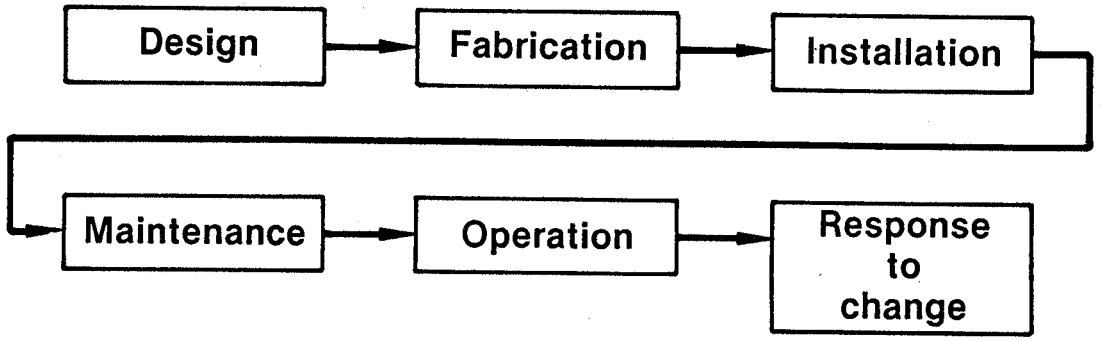

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Figure 8

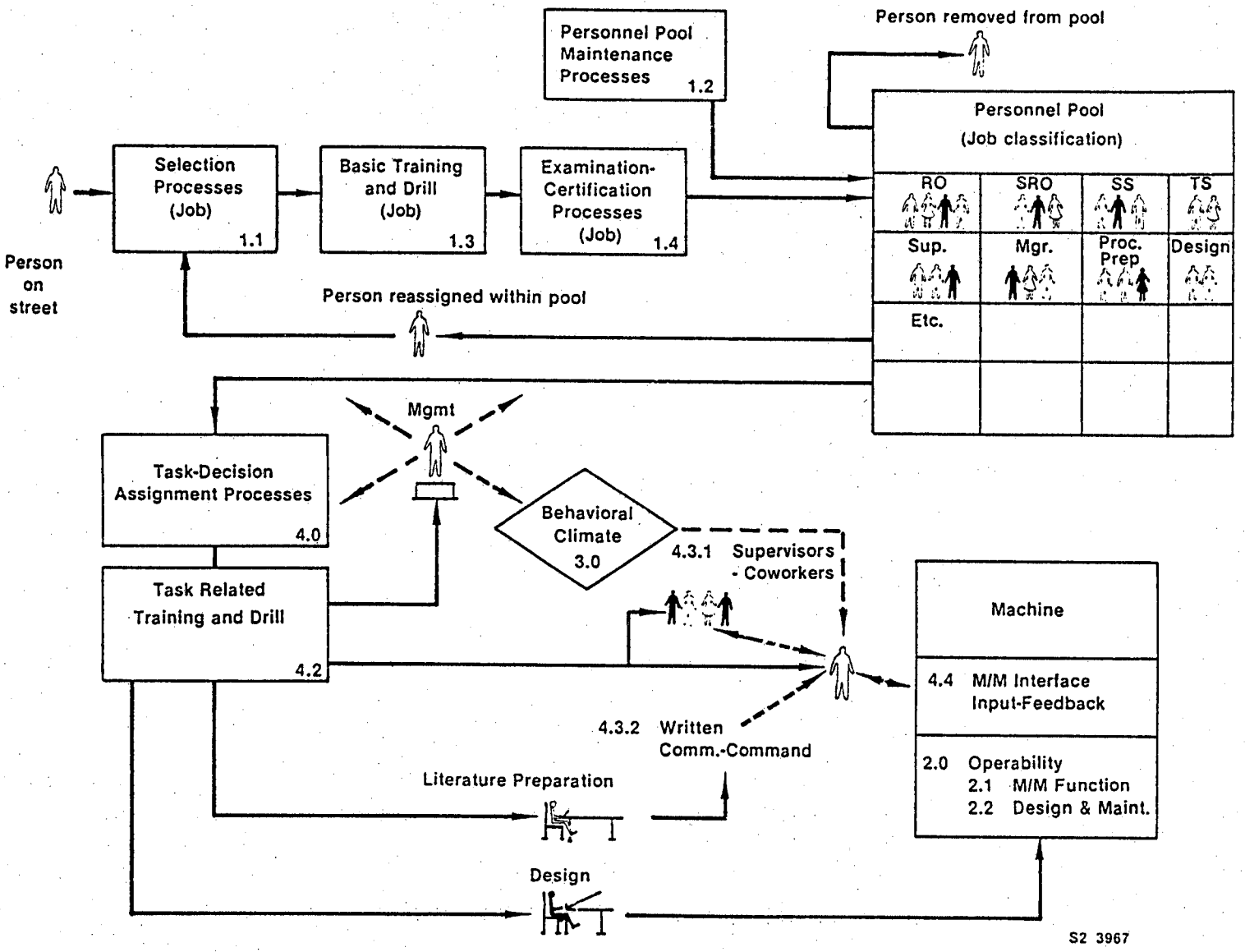

Personnel Pool Maintenance Processes 1.2
Person removed from pool
Personnel Pool (Job classification)
RO
SRO
SS
TS
Sup.
Mgr.
Proc. Prep
Design
Etc.
Person on street
Selection Processes (Job) 1.1
Basic Training and Drill (Job) 1.3
Examination-Certification Processes (Job) 1.4
Person reassigned within pool
Mgmt
Task-Decision Assignment Processes 4.0
Behavioral Climate 3.0
4.3.1 Supervisors - Coworkers
Task Related Training and Drill 4.2
Machine
4.4 M/M Interface Input-Feedback
2.0 Operability
2.1 M/M Function
2.2 Design & Maint.
4.3.2 Written Comm.-Command
Literature Preparation
Design
S2 3967

Figure 9

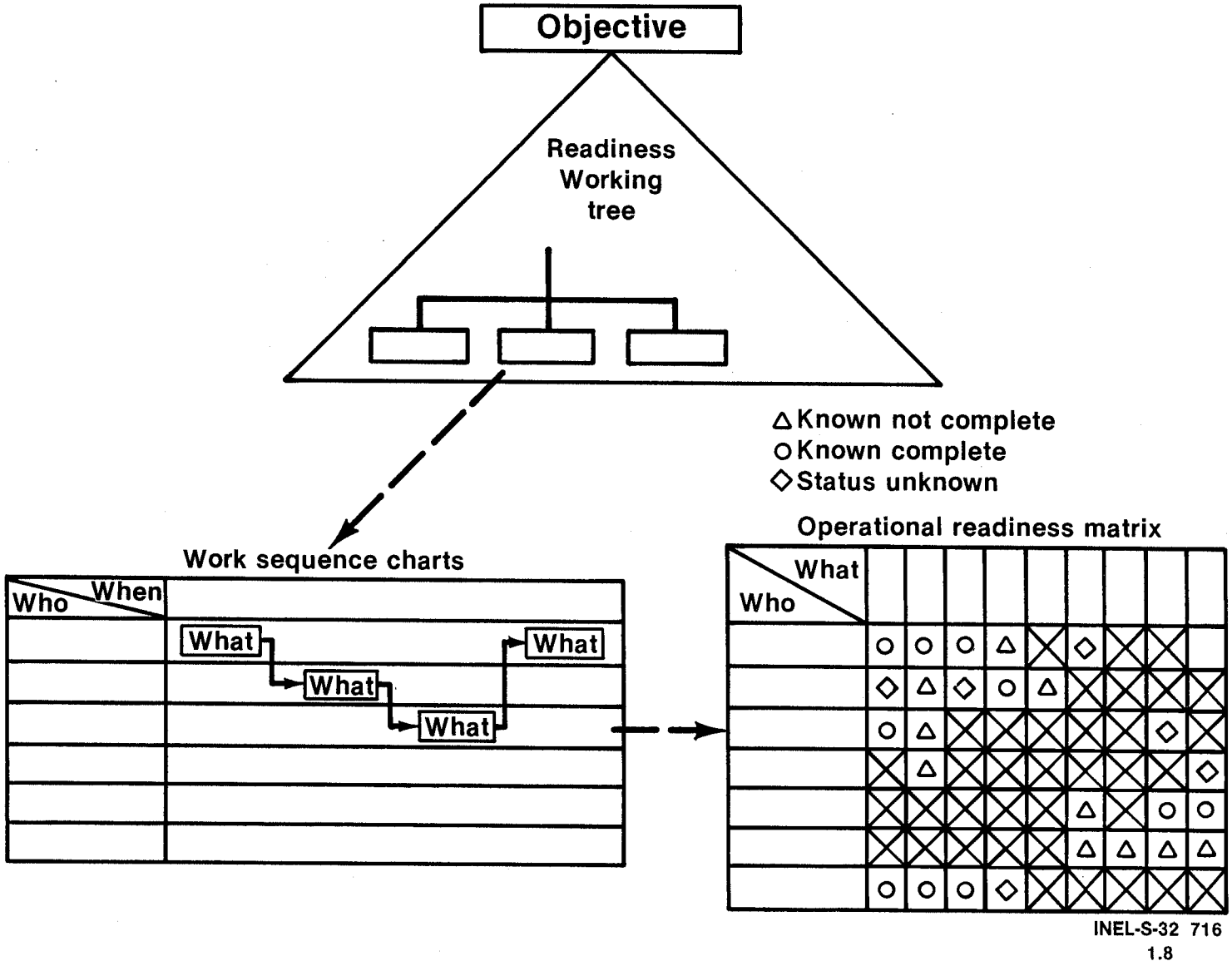

Objective
Readiness
Working
tree
△Known not complete
○Known complete
◇Status unknown
Work sequence charts
Who
When
What
What
What
What
Operational readiness matrix
What
Who
INEL-S-32 716
1.8

Figure 10

Very often the manager or other reviewer will not be concerned with "who" but only that the necessary tasks ("what") have been done; that is, that all of the elements in each vertical column of the matrix have been completed.

In any case, methods must be established to determine that all of the necessary tasks required to achieve a state of readiness have been accomplished. Detailed methods for accomplishing this are described and discussed in the Operational Readiness Workshop.

Generic Readiness vs. Mission/Task Specific Readiness

Ordinarily, initial operational readiness is defined in terms of more or less general functions to be performed by the system. This may or may not provide sufficient assurance that a system is operationally ready to accomplish all specific missions and tasks. The general operational readiness methodology admits the possibility of evaluating the readiness process in the context of specific missions or tasks which the system might be asked to perform. This is particularly important for tasks/missions which lie outside the usual system functions. Use of the operational readiness techniques in this way constitutes a form of change/difference analysis.

Collection and Analysis of Readiness Information

In order to provide historical records and to provide inputs for operational readiness review (as compared with "do") processes, it is necessary that we collect and analyze our operational readiness information. Figure 10 indicates that the tasks defined by the operational readiness review tree are performed by responsible individuals and groups within the organization.

In earlier discussion of Figure 10, we indicated that upper management is often not concerned with "who" did particular tasks but rather whether

the complete jobs have been done or not. This means that certain individuals must be responsible for tracking and knowing the status of work completion.

These are not necessarily the same individuals who do the work. For example, an installation of an instrument panel may involve electricians, instrument personnel, pipefitters, laborers, painters, insulators and other craftsmen and their supervisors. Each of these groups may report, independently, that their particular work orders are complete and "clear". The important question, however, is whether or not the control panel is complete and functional in accordance with the intended design and function. This may require additional inputs from the quality assurance and operating groups, as well as "collective" overview reports from line managers and from coordinators. Experience indicates that an important part of the operational readiness process involves identification of individuals who are responsible for knowing and reporting the readiness status of each component and subsystem of the system.

Readiness Review

The review and validation of readiness, as distinguished from achieving an advertised state of readiness, is an important part of the operational readiness process. Review may be performed by staff personnel, by ad hoc committees/boards or this may be an implicit part of upper management overview.

In any case, review should include scrutiny from two points of view by personnel having different skills and knowledge. Review should include:

- Review by technical specialists to assure that the system is adequate from the point of view of technical function of individual subsystems.

- Review by higher command level management to assure that the overall system will do what is needed in the broader sense.

Logical Review vs. a "High Tech Easter Egg Hunt"

While there is much to be said for the benefits of informal technical review by skilled, experienced individuals, there is a high risk of oversights (in the "overlooking" sense) and omissions. On the other hand, rigid checklist type review tends to put blinders on the process. This indicates that an optimum review process should provide sufficient structure to reduce oversights/omissions but should provide adequate unstructured "search-out" latitude to take full advantage of the individual genius of the reviewers.

We need to base our operational readiness processes on:

- Prevention of oversights in dealing with hazards.
- Establishing the individual criteria which define the state of readiness and assuring that these criteria are met.
- Having the proper specialists participate in each operational area in:
  - Achieving the state of readiness.
  - Operational readiness review.

How Do We Set Up the Operational Readiness Trees?

The System Safety Development Center has collected a large number of sample readiness trees covering a wide variety of applications ranging from broad generic material to highly specialized applications. Some of these are shown in SSDC-1 (Reference 1) and in Appendix A of this report. Generally speaking, three rules apply in design of operational readiness material:

1. Use standardized trees and models for straightforward jobs.

2. Develop special trees for unusual and complex systems.

3. Always design operational readiness "do" and "review" analytical models and methods to the organization's own management, work control, configuration control and quality assurance systems.

Scaling and Detailing

The analytical trees and matrices shown in Appendix A relate to large complex systems. The operational readiness technology is scalable to any type of system. For example, consider application of the standard tree shown in Figure 11 to the job of a custodian cleaning up a meeting room. In this case, the model need be developed no further than:

- Person

  Have custodians been assigned to clean the room?

- Hardware

  Do the custodians have brooms, dust cloths, furniture polish and other necessary tools and equipment?

- Procedures

  Do the custodians have adequate instructions relating to when and how they are to proceed in cleaning the room?

Working to this level will often indicate the need to extend the development further. For example, is the furniture polish referred to above flammable or toxic? If this is the case, additional training for the person, special operating procedures and storage cabinets (hardware) may be necessary.

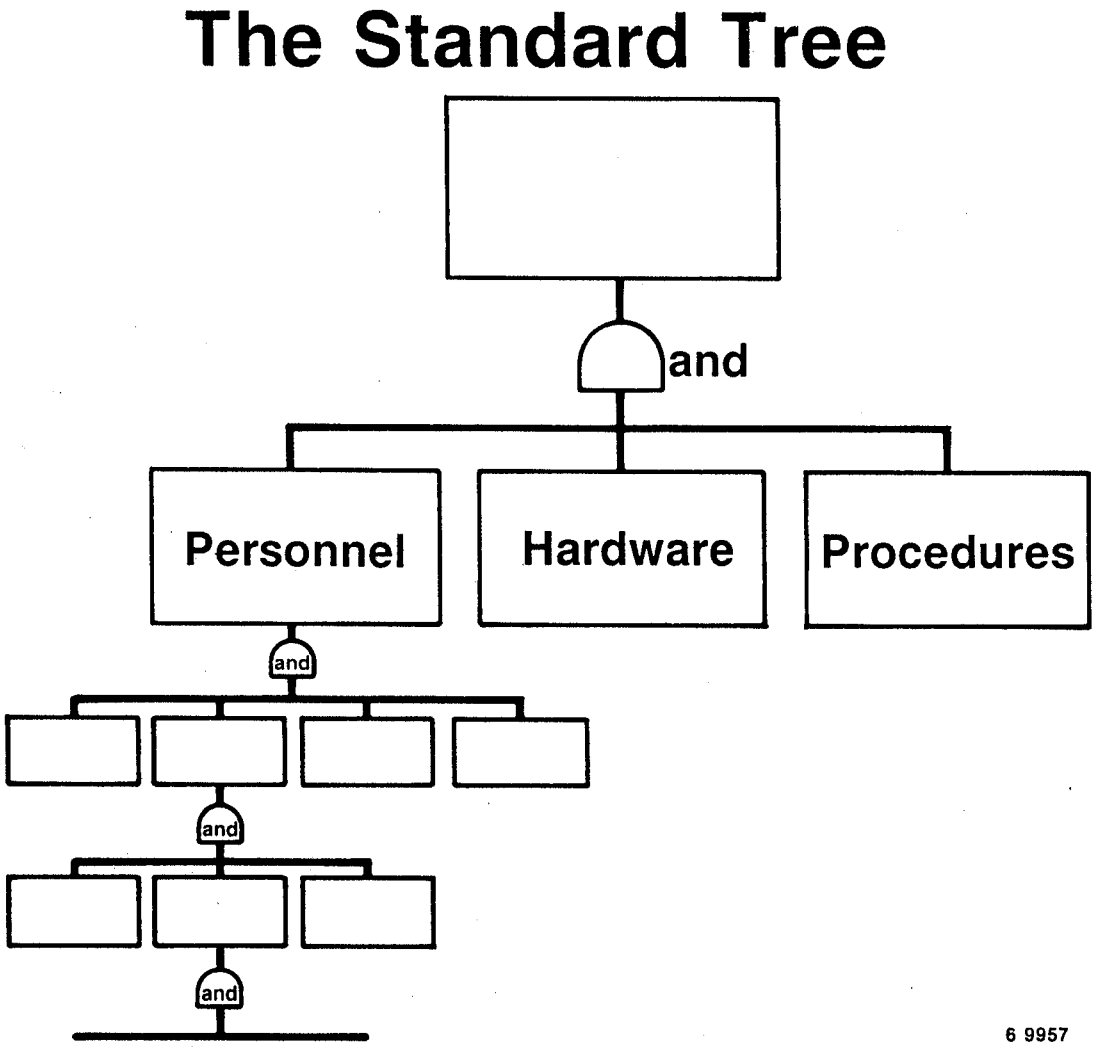

The Standard Tree
and
Personnel
Hardware
Procedures
and
and
and
6 9957

Figure 11

In all cases, the rule is to make the "punishment fit the crime" in terms of necessary and sufficient development to provide adequate hazard control.

Let's Review How the Total Readiness Tree Works

1. Upper echelon personnel specify the top policy, goals, objectives and constraints.

2. Lower echelons and staff provide the detailed task structure necessary to achieve readiness in terms of the stated policy, goals, objectives, and constraints.

3. Lower echelons and staff evaluate and report progress in terms of completion of the detailed task structure (which is related to policy, goals and objectives through the tree logic structure).

4. Upper management reviews and/or directs staff review of the overall picture in terms of the original policy, goals and objectives.

5. Upper management takes appropriate actions:

   (a) Accepts the situation as reported.

   (b) Directs change.

   (c) Requests additional information.

What Are the Biggest Problems?

- Identifying all of the elements of the system (in proper detail).

- Identifying deficiencies, deviations, unknowns.

- Reducing deficiencies, deviations, and unknowns to statements of operational risk.

- Communicating risks to upper level command (decision makers).

How Are Existing Inspections, Reviews, Checklists Used?

As indicated in Figure 12, existing material such as checklists and review and inspection findings are simply used to provide information required to satisfy the analytical tree requirements.

An advantage of structuring the analytical trees in a logical manner is that two sorts of system defects are revealed:

1. Logical deficiencies in information collected.

2. Redundant and superfluous information which is collected but serves no useful purpose in a logical sense.

How Do Operational Readiness Trees Relate to Operational Risk?

Readiness trees should be color coded in the usual manner (References 1 and 3):

Green Code: Item known to be complete as specified.

Red Code: Item known to be incomplete and/or out of specification.

Blue Code: Status of item Unknown.

In the case of "green" items the risk (safety) analyses which have been performed for the system are protected in terms of system design specifications.

How do we use existing inspections, reviews, checklists, etc.?

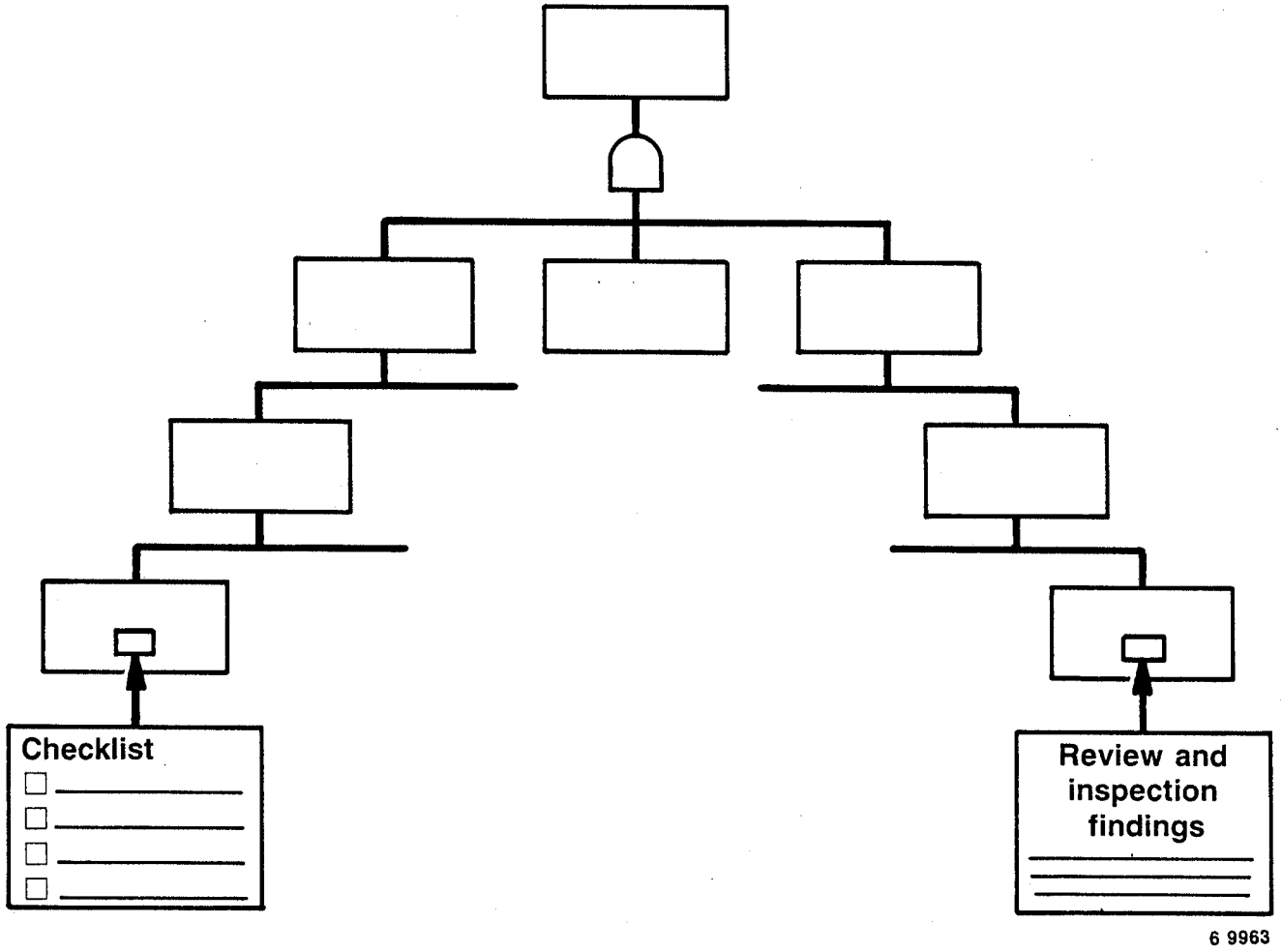


Figure 12

For "red" items risk (safety) analyses must be reevaluated in the context of the known variances. Acceptability of the system must be determined in the context of the revised risk (safety) analyses.

"Blue" items are most difficult to deal with since the nature of potential variances is unknown. The "true" but "unknown" status of the "blue" item can lead to a very wide range of potential consequences:

1. The item might be complete as specified.

2. The item might be in various states of completion/variation from specifications. The state of completion/variation from specifications might:

   (a) Have no effect on operational risks

   (b) Have a negative effect on operational risks

   (c) Actually have a beneficial effect on operational risks.

In the case of "red-code" and "blue-code" items failure mode and effect analyses must be performed in order to evaluate actual/potential effects on operational risks. Once this is done the acceptability of these risks (including uncertainties and unknowns) may be evaluated in accordance with the management control sequence described on page 24.

A similar situation exists in dealing with the ongoing evaluation of maintenance and follow-on activities discussed in Part II of this report.

PART II--FOLLOW-ON ACTIVITIES

Keeping the System Operationally Ready

Keeping the system operationally ready is a "maintenance" task and involves the two elements defined by MORT (Reference 4).

- Plan
- Execution

As indicated in Figure 13, the design and plan of a maintenance program appears as a part of policy implementation on the right side of the MORT diagram. Execution, in the environment, safety and health sense, is related to maintenance of barriers and controls on the left side of the MORT diagram.

If we review our definition of operational readiness, we find that there are three elements involved in achieving an initial state of readiness. As indicated in Figure 14, these include the hardware, the personnel, and the procedures/management controls.

As indicated earlier, one must also consider the three interfaces between these elements. We, therefore, not only have the conventional sort of hardware maintenance to consider, but we must consider both design/plan and execution in "maintenance" of:

- Our personnel pool
- Our procedural/management control systems.

Let's look at these three elements.

MORT

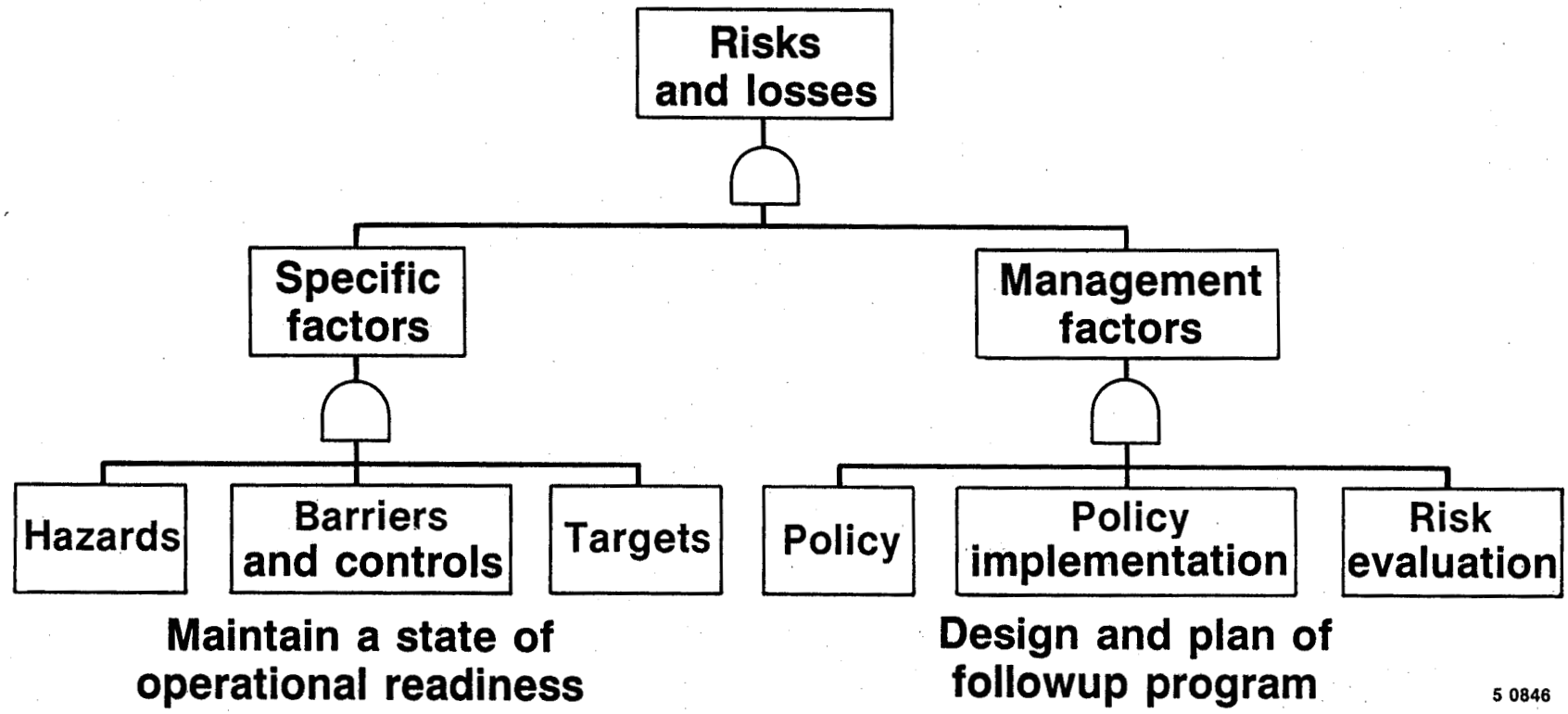


Figure 13

What is operational readiness?

- Right people
- Right time
- Right place
- Right hardware
- Right procedures and management controls

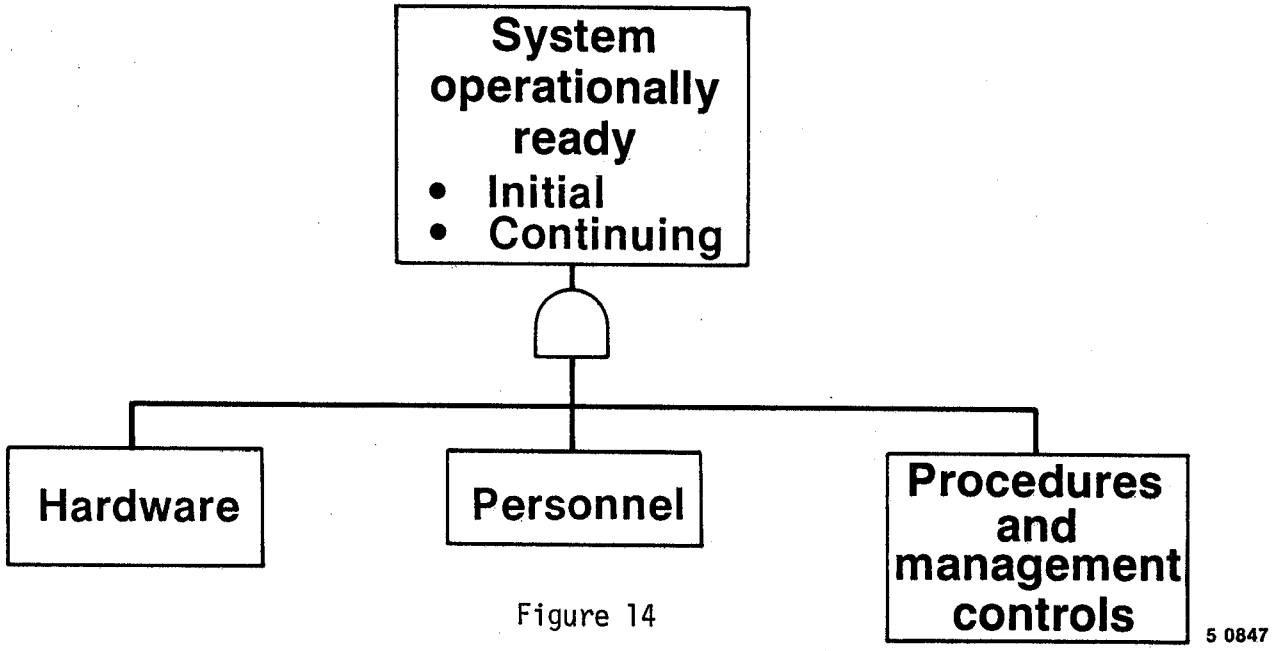


Figure 14

Maintenance of Hardware

We have two areas of interest in establishing and operating hardware maintenance programs:

1. The nature of the basic program.

2. The way that maintenance efforts are prioritized in terms of environment, safety and health considerations.

The MORT diagram itself (Reference 3) provides for the first rudimentary level of maintenance program evaluation. This evaluation is expended and detailed in SSDC-12 (Reference 4).

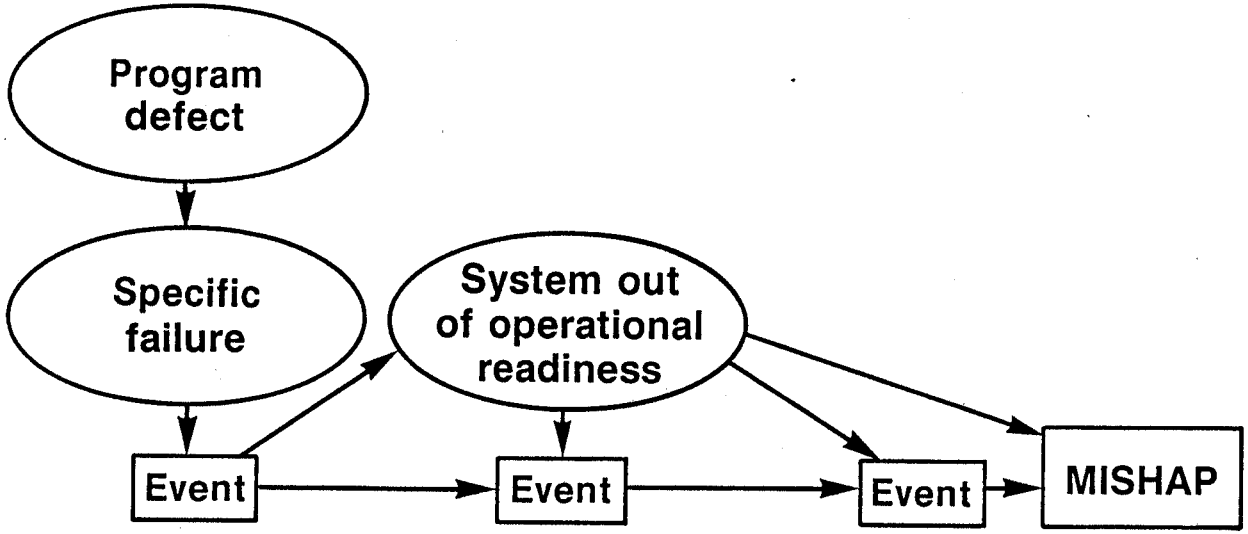
The SSDC-12 evaluation scheme was designed to provide a one-on-one correspondence with a contemporary guide for general maintenance program evaluation in the year 1978. While this SSDC-12 analytic is still valid and appropriate, an alternative analytic has since been designed and appears as Appendix B of this report. The Appendix B version has basically the same technical content as SSDC-12 but the logic format has been markedly changed. For example, the number of first tier items has been greatly reduced from those used in SSDC-12.

Prioritizing of system components must be done on a custom basis for each system and subsystem. This prioritizing is often taken care of automatically by assignment of quality assurance criteria. If this is the case, it must be assured that the maintenance program maintains elements with the same degree of rigor defined by the original quality assurance level assignments.

How Do The Maintenance Elements Fit Together in Operational Mishaps?

As we indicated earlier, operational mishaps and accidents generally indicate a failure to establish and maintain a state of operational readiness. This is illustrated in a generic sense in Figure 15. Figure 15 is a simplified event and causal factor chart (Reference 6). Here we

How do these Elements Fit Together in Operational Mishaps



Failure to:

- Complete mission
- Within budget
- On schedule
- With acceptable side effects

5 0848

Figure 15

have a program defect leading to a specific program inadequacy which takes the system out of its condition of operational readiness. A series of events then carry the system through to the ultimate mishap. For example, the specific failure could be failure to lubricate a coolant pump bearing. The system is then "out of operational readiness" with a dry bearing. This leads to overheating (the second event), to seizing of the bearing (event three), and finally to loss of coolant which the pump was supposed to have provided, with severe damage to components which were to have been cooled by the pump.

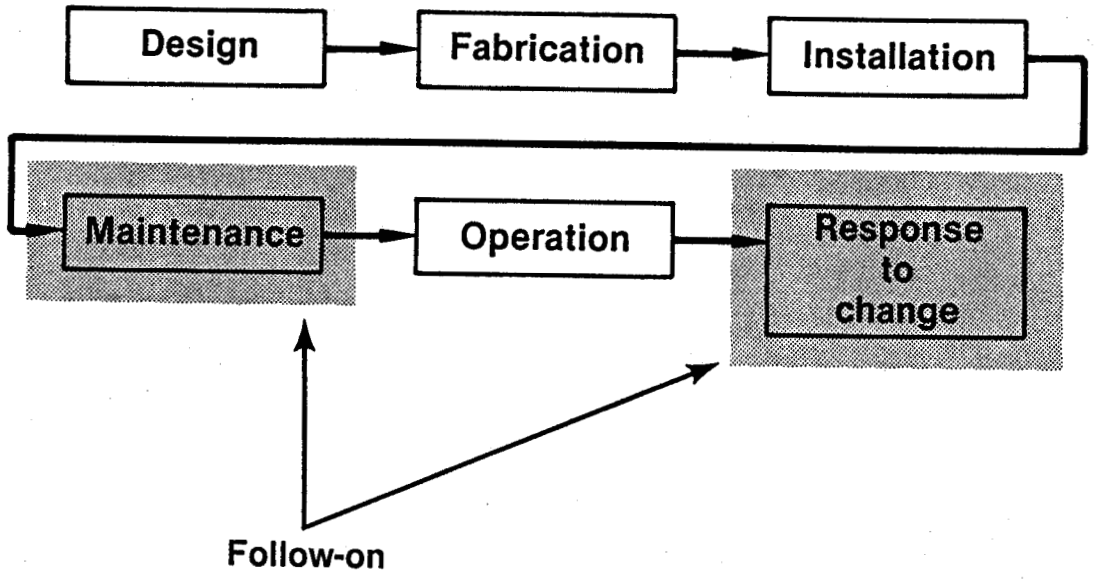
Going back to the program defect (or, more often, defects), we find that "upstream" defects leading to failure to lubricate the pump bearing might be originating in a number of areas. As indicated in Figure 16, the failure could be involved in design, fabrication or installation of the pump in such a way that maintainability was compromised (Reference 7). Lubrication of the pump could involve "maintenance" and/or "operational" activities in a number of ways.

Finally, the ultimate disaster could have been averted had failure to lubricate been detected and corrected prior to catastrophic damage (through response to change). This entire sequence may be related to a typical operational readiness work sheet shown in Figure 17 which includes a number of maintenance related items.

It should be noted that initial operational readiness also included both "personnel" and "procedural" items.

This closes our loop back to Figures 16, 18 and 19 and indicates the need not only to maintain our hardware systems but the need to maintain our personnel pool with personnel who are up-to-date in their capability to operate our systems adequately as indicated in Box 1.2 of Figure 18.

The Hardware Configuration Control Model



1-2-25
S4 9238

Figure 16

For Each Bottom Tier Hardware Item

Operational Readiness Work Sheet

System no.	Job description	SDD numerical code	Responsible person	Configuration control system	Installation work request	Required maintenance and calibration	Spare parts	Key drawings	Quality assurance	Required procedures	Personnel	Final status
Number assigned to description box	Brief job description using simplified nomenclature where possible	Numerical coding system for tree orientation	Individual who knows when the job was done, what was done and the final status	Status of as-build drawings, analysis and reviews to update systems	Status of and including as-built verification of installation processes	Status of maintenance requirements and calibration processes	Status of required spare parts for equipment and systems as identified in the system design description (SDD)	Status of all drawings designated as specific for a special system or equipment required for a particular job of work	Status of and including resolution of quality assurance discrepancies	Status of procedures, i.e., detailed operating procedures (DOP), maintenance, calibration and requalification procedures	Status of the personnel. Selection, training, qualification, and testing	% Complete with sign off date

5 0855

Figure 17

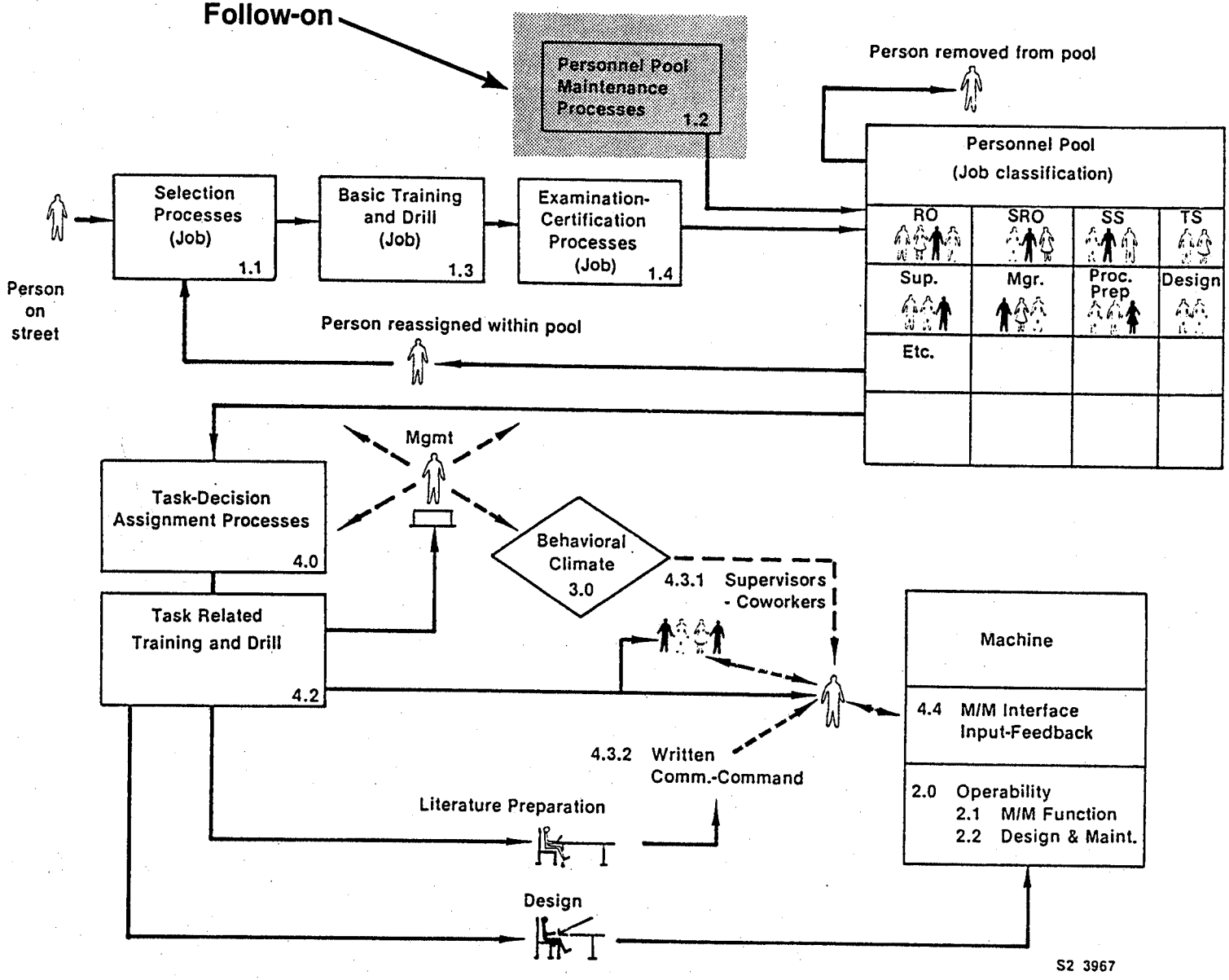

Follow-on
Personnel Pool Maintenance Processes 1.2
Person removed from pool
Personnel Pool (Job classification)
RO
SRO
SS
TS
Sup.
Mgr.
Proc. Prep
Design
Etc.
Person on street
Selection Processes (Job) 1.1
Basic Training and Drill (Job) 1.3
Examination-Certification Processes (Job) 1.4
Person reassigned within pool
Mgmt
Task-Decision Assignment Processes 4.0
Behavioral Climate 3.0
4.3.1 Supervisors - Coworkers
Task Related Training and Drill 4.2
Machine
4.4 M/M Interface Input-Feedback
2.0 Operability
2.1 M/M Function
2.2 Design & Maint.
4.3.2 Written Comm.-Command
Literature Preparation
Design
S2 3967

Figure 18

Preparation of Procedures

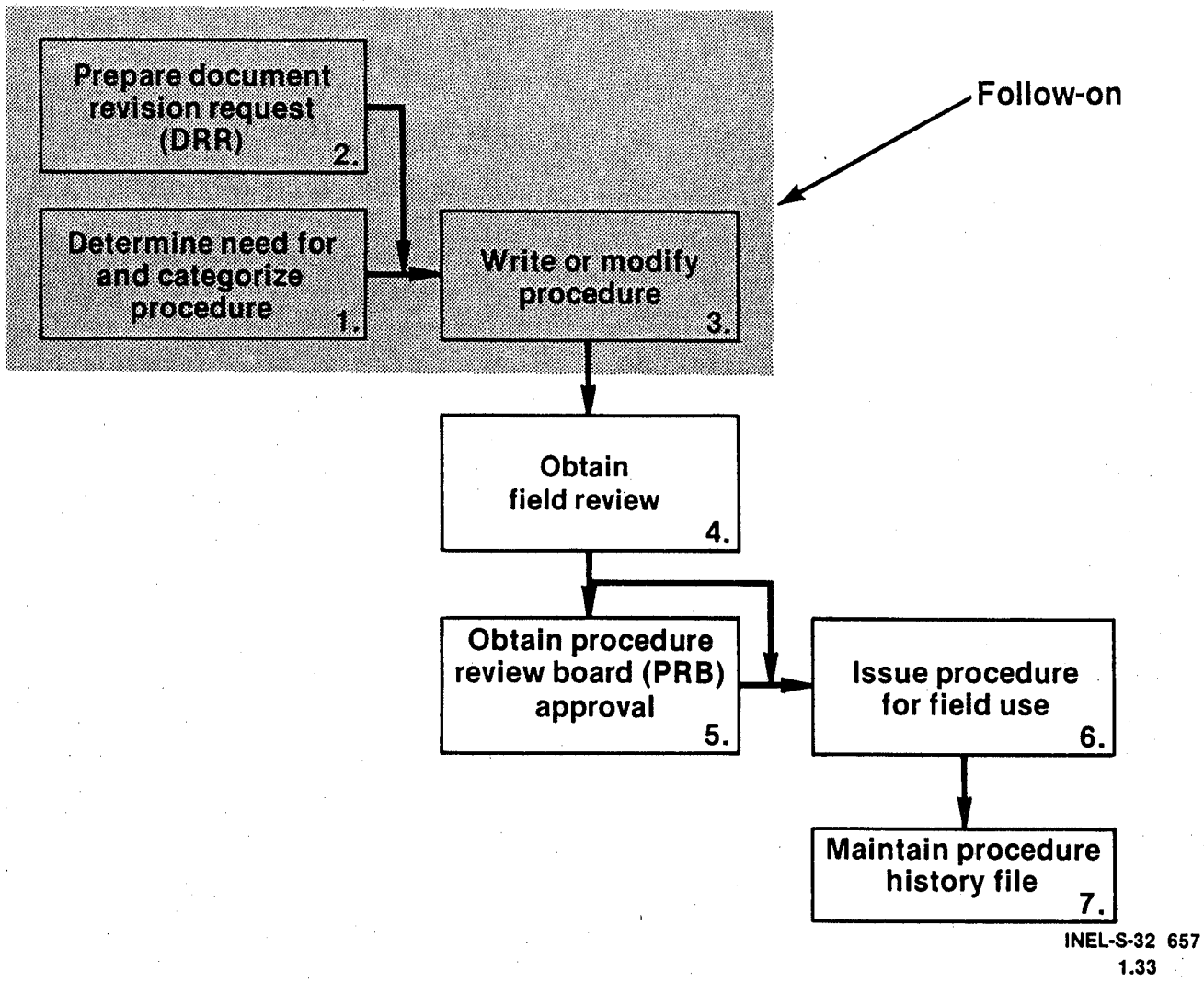


Figure 19

Similarly, Figure 19 indicates, in Box 1, the requirement for a continuing function to establish the need for new and revised procedures based on current operational requirements.

In short, we must "maintain" all of the operational readiness elements and their interfaces, not just the hardware.

REFERENCES

1. U.S. Department of Energy, Occupancy Use Readiness Manual, SSDC-1, September 1975.

2. Operational Readiness Workshop Manual, The System Safety Development Center.

3. U.S. Department of Energy, MORT Users Manual, SSDC-4, May 1983.

4. U.S. Department of Energy, Safety Considerations in Evaluation of Maintenance Programs, SSDC-12, March 1978.

5. U.S. Department of Energy, Basic Human Factors Considerations, SSDC-34, December 1985.

6. U.S. Department of Energy, Events and Causal Factors Charting, SSDC-14, August 1978.

7. James P. Bongarra et al., Human Factors Design Guidelines for Maintainability of Department of Energy Nuclear Facilities, Lawrence Livermore National Laboratory, June 18, 1985.

APPENDIX A

APPENDIX A

SOME SAMPLE OPERATIONAL READINESS TREES

This Appendix includes some examples of operational readiness trees selected from the SSDC files. Due to space limitations, these trees are not included in their entirety but include only enough material to define the logic and structure utilized by the designer.

Complete reports relating to each of these trees are available upon request from the System Safety Development Center.

EXAMPLE 1

This analytical tree was designed to establish operational readiness for restart of a nuclear chemical processing plant which had been out of service for a number of years.

Development included the tree itself along with detailed "punch lists."

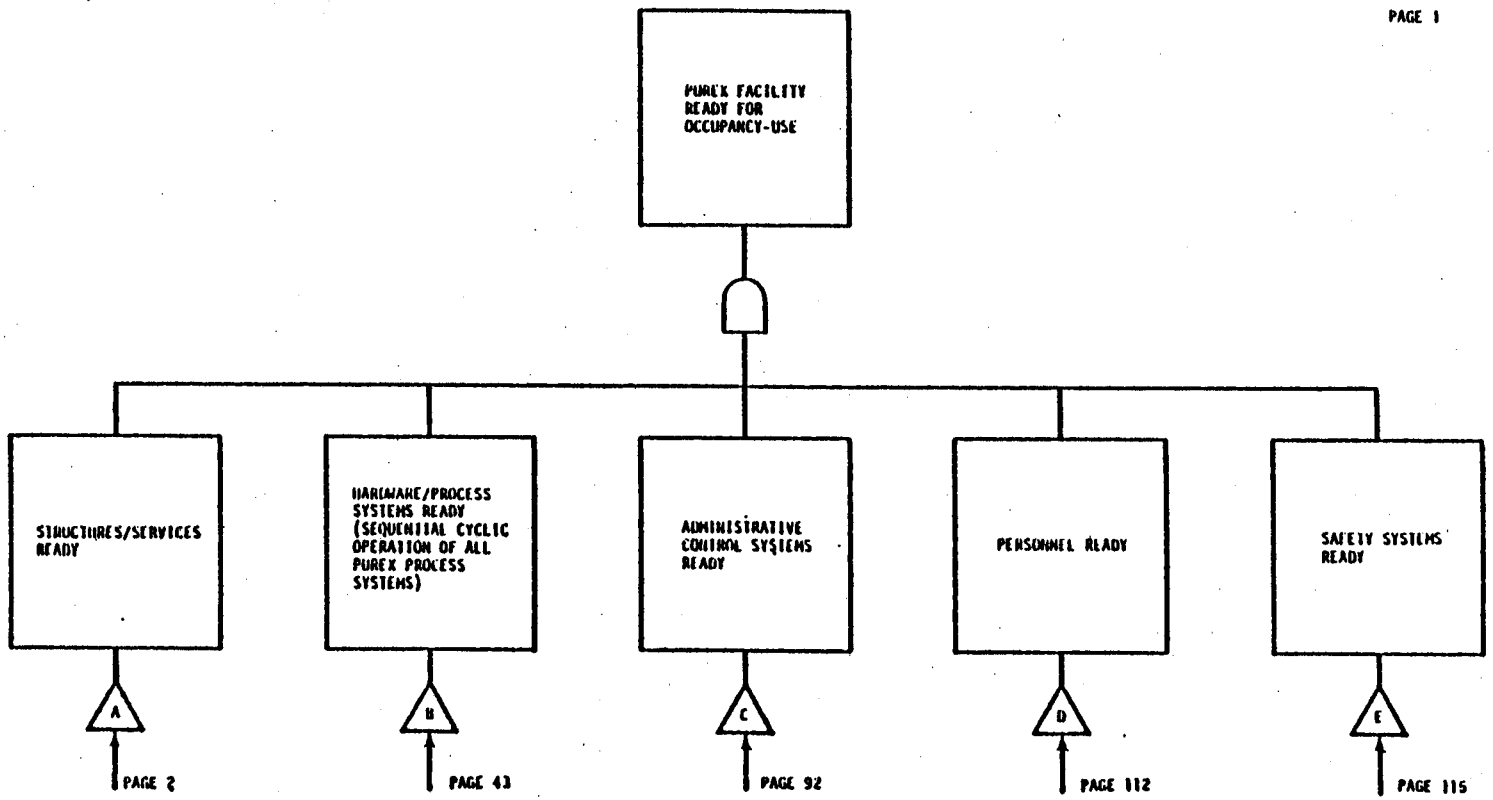

PAGE 1
PUREX FACILITY READY FOR OCCUPANCY-USE
STRUCTURES/SERVICES READY
HARDWARE/PROCESS SYSTEMS READY (SEQUENTIAL CYCLIC OPERATION OF ALL PUREX PROCESS SYSTEMS)
ADMINISTRATIVE CONTROL SYSTEMS READY
PERSONNEL READY
SAFETY SYSTEMS READY
A
B
C
D
E
PAGE 2
PAGE 43
PAGE 92
PAGE 112
PAGE 115

Figure A1

* DEFINE BY EACH CELL/WORK AREA AS SHOWN BY PROCESS SYSTEM REPRESENTATION ON PAGES 50 AND 51.

** EVALUATE FOR ALL CHEMICALS/ FEED INCLUDING, BUT NOT LIMITED TO, E.G., FULL ELEMENTS, RECOVERED NITRIC, SILVER NITRATE, HYDRAZINE, SUGAR, URANIUM REWORK FROM U PLANT,. . .

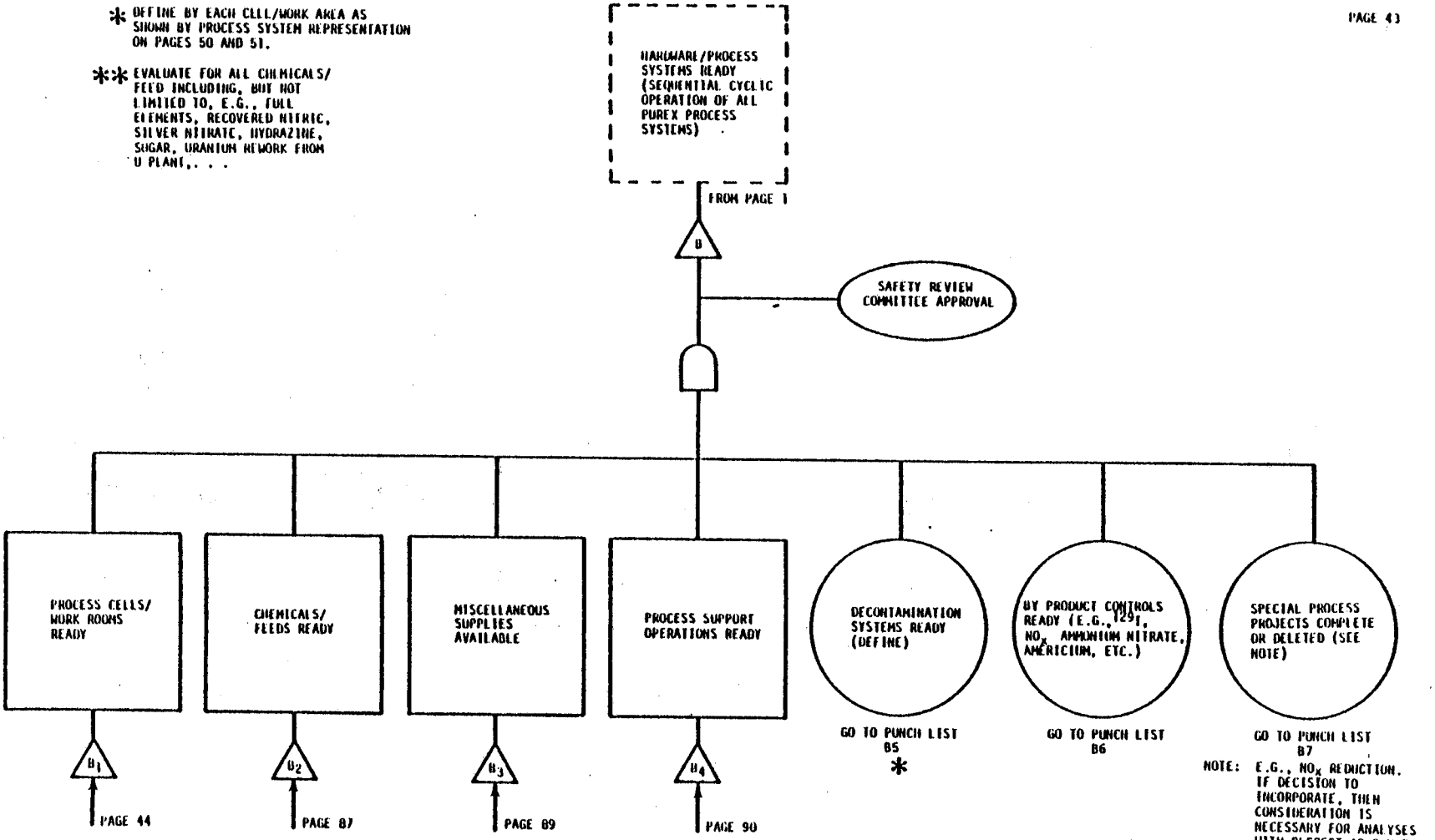


Figure A2

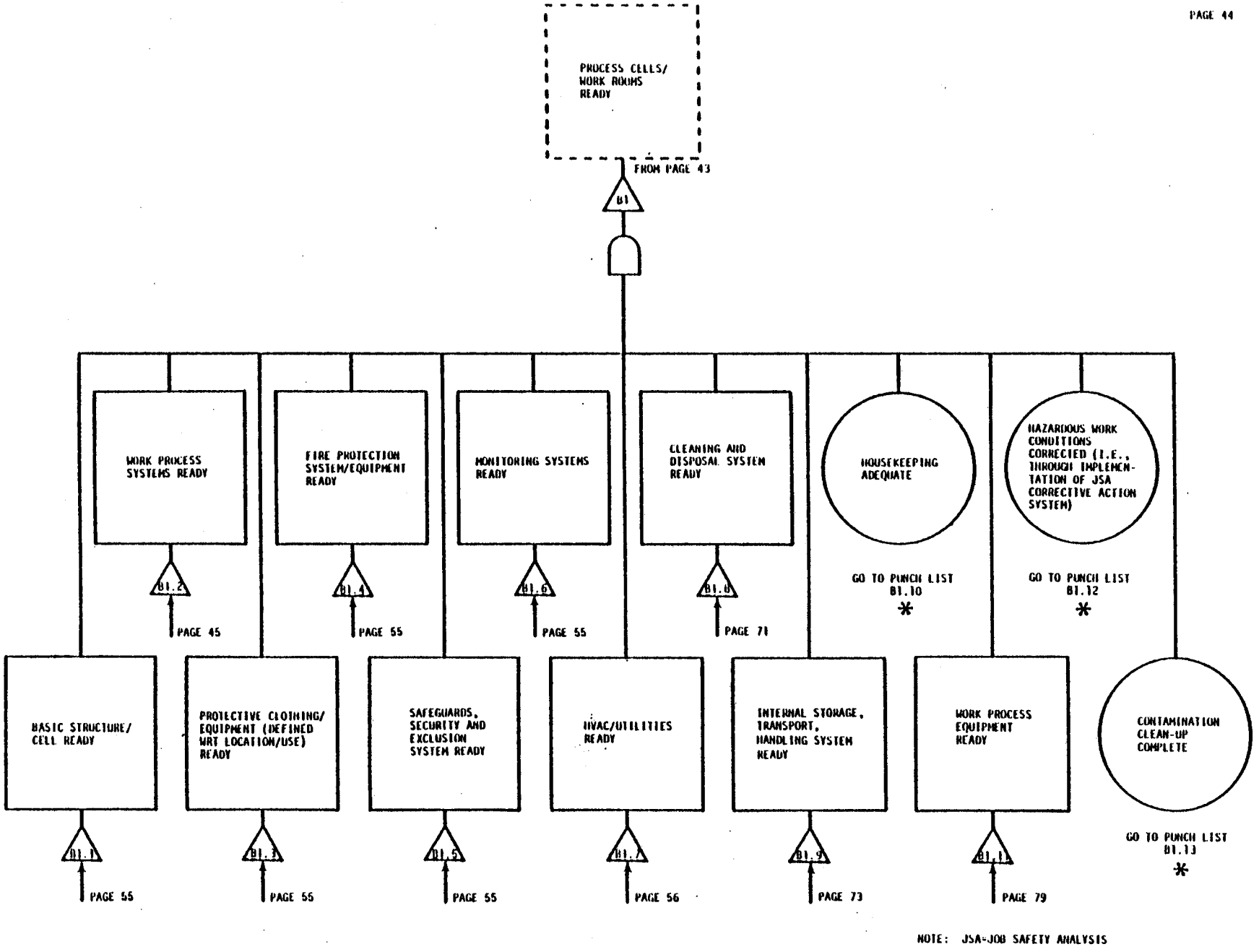

PROCESS CELLS/ WORK ROOMS READY
FROM PAGE 43
B1
WORK PROCESS SYSTEMS READY
FIRE PROTECTION SYSTEM/EQUIPMENT READY
MONITORING SYSTEMS READY
CLEANING AND DISPOSAL SYSTEM READY
HOUSEKEEPING ADEQUATE
HAZARDOUS WORK CONDITIONS CORRECTED (I.E., THROUGH IMPLEMENTATION OF JSA CORRECTIVE ACTION SYSTEM)
B1.2
B1.4
B1.6
B1.8
PAGE 45
PAGE 55
PAGE 55
PAGE 71
GO TO PUNCH LIST B1.10 *
GO TO PUNCH LIST B1.12 *
BASIC STRUCTURE/ CELL READY
PROTECTIVE CLOTHING/ EQUIPMENT (DEFINED WRT LOCATION/USE) READY
SAFEGUARDS, SECURITY AND EXCLUSION SYSTEM READY
HVAC/UTILITIES READY
INTERNAL STORAGE, TRANSPORT, HANDLING SYSTEM READY
WORK PROCESS EQUIPMENT READY
CONTAMINATION CLEAN-UP COMPLETE
B1.1
B1.3
B1.5
B1.7
B1.9
B1.11
PAGE 55
PAGE 55
PAGE 55
PAGE 56
PAGE 73
PAGE 79
GO TO PUNCH LIST B1.13 *
NOTE: JSA=JOB SAFETY ANALYSIS

Figure A3

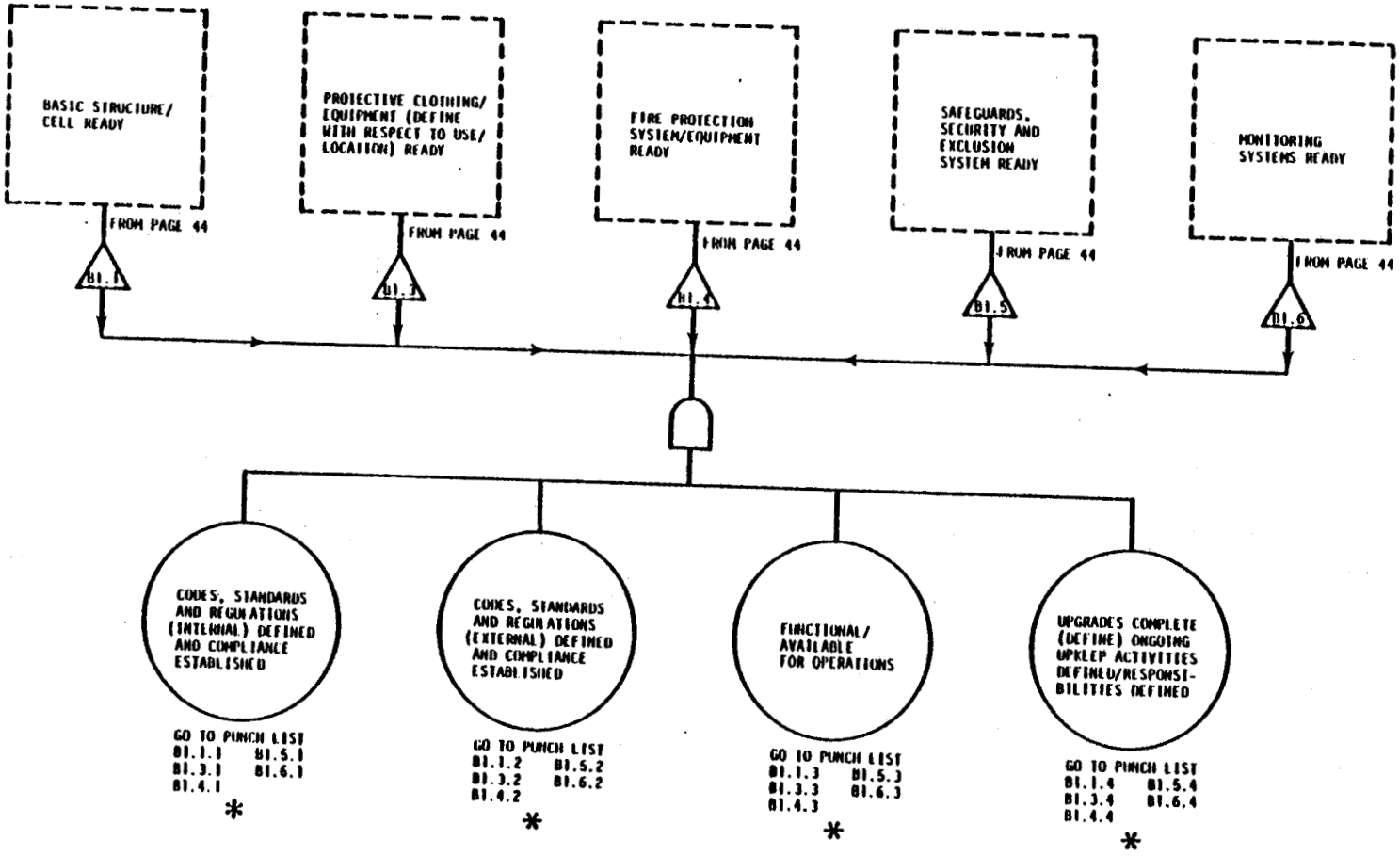

BASIC STRUCTURE/ CELL READY
PROTECTIVE CLOTHING/ EQUIPMENT (DEFINE WITH RESPECT TO USE/ LOCATION) READY
FIRE PROTECTION SYSTEM/EQUIPMENT READY
SAFEGUARDS, SECURITY AND EXCLUSION SYSTEM READY
MONITORING SYSTEMS READY
FROM PAGE 44
B1.1
B1.2
B1.3
B1.4
B1.5
B1.6
CODES, STANDARDS AND REGULATIONS (INTERNAL) DEFINED AND COMPLIANCE ESTABLISHED
CODES, STANDARDS AND REGULATIONS (EXTERNAL) DEFINED AND COMPLIANCE ESTABLISHED
FUNCTIONAL/ AVAILABLE FOR OPERATIONS
UPGRADES COMPLETE (DEFINE) ONGOING UPKEEP ACTIVITIES DEFINED/RESPONSIBILITIES DEFINED
GO TO PUNCH LIST
B1.1.1 B1.5.1 B1.3.1 B1.6.1 B1.4.1
GO TO PUNCH LIST
B1.1.2 B1.5.2 B1.3.2 B1.6.2 B1.4.2
GO TO PUNCH LIST
B1.1.3 B1.5.3 B1.3.3 B1.6.3 B1.4.3
GO TO PUNCH LIST
B1.1.4 B1.5.4 B1.3.4 B1.6.4 B1.4.4

Figure A4

EXAMPLE 2

This tree relates to operational readiness of a large oil drilling platform on the British sector of the North Sea off-shore oil fields.

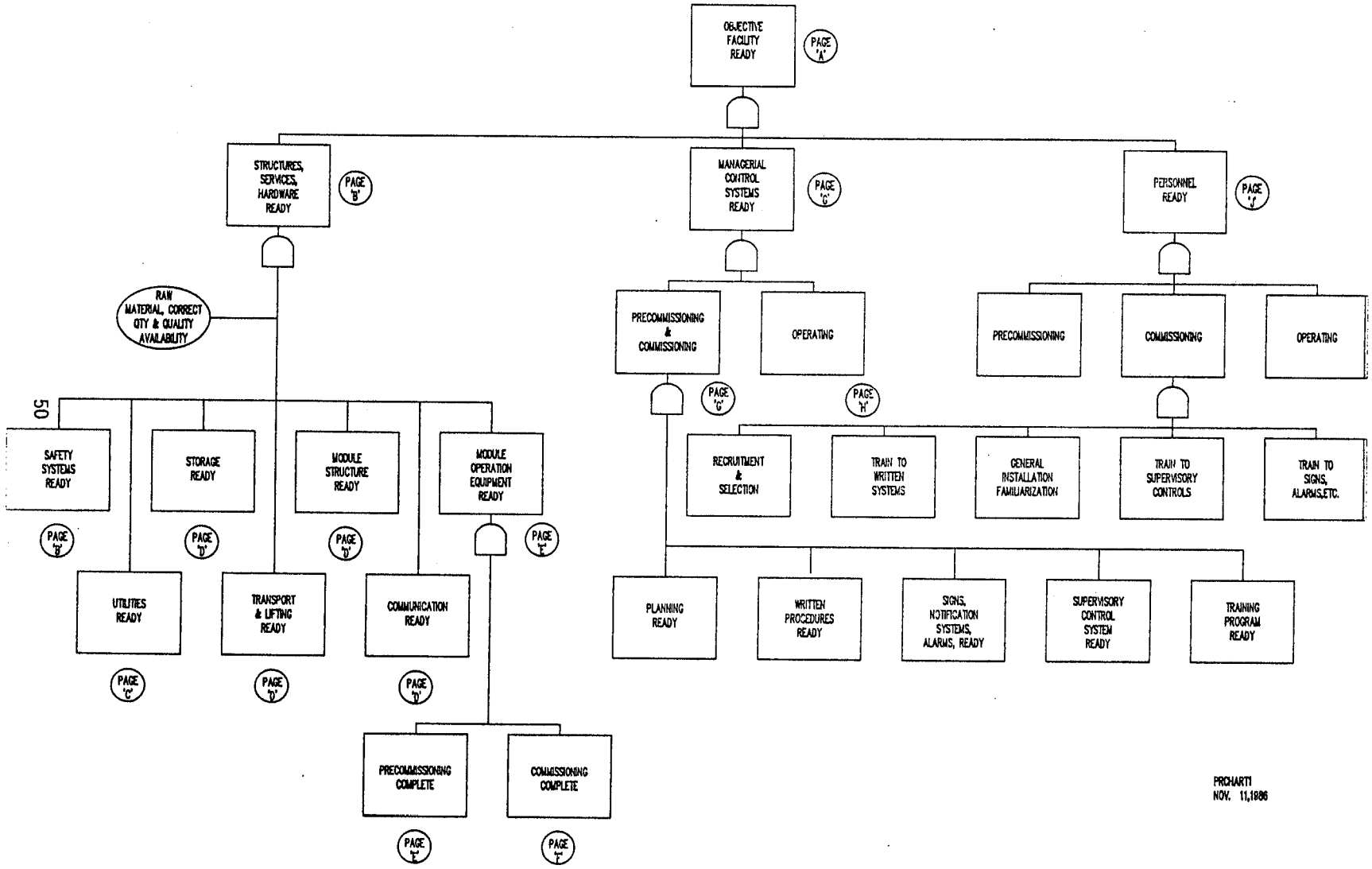

OBJECTIVE FACILITY READY
PAGE 'A'
STRUCTURES, SERVICES, HARDWARE READY
PAGE 'B'
MANAGERIAL CONTROL SYSTEMS READY
PAGE 'G'
PERSONNEL READY
PAGE 'J'
RAW MATERIAL, CORRECT QTY & QUALITY AVAILABILITY
PRECOMMISSIONING & COMMISSIONING
OPERATING
PRECOMMISSIONING
COMMISSIONING
OPERATING
PAGE 'G'
PAGE 'H'
50
SAFETY SYSTEMS READY
STORAGE READY
MODULE STRUCTURE READY
MODULE OPERATION EQUIPMENT READY
RECRUITMENT & SELECTION
TRAIN TO WRITTEN SYSTEMS
GENERAL INSTALLATION FAMILIARIZATION
TRAIN TO SUPERVISORY CONTROLS
TRAIN TO SIGNS, ALARMS,ETC.
PAGE 'B'
PAGE 'D'
PAGE 'D'
PAGE 'E'
UTILITIES READY
TRANSPORT & LIFTING READY
COMMUNICATION READY
PLANNING READY
WRITTEN PROCEDURES READY
SIGNS, NOTIFICATION SYSTEMS, ALARMS, READY
SUPERVISORY CONTROL SYSTEM READY
TRAINING PROGRAM READY
PAGE 'C'
PAGE 'D'
PAGE 'D'
PRECOMMISSIONING COMPLETE
COMMISSIONING COMPLETE
PAGE 'E'
PAGE 'F'
PRCHART1
NOV. 11,1986

Figure A5

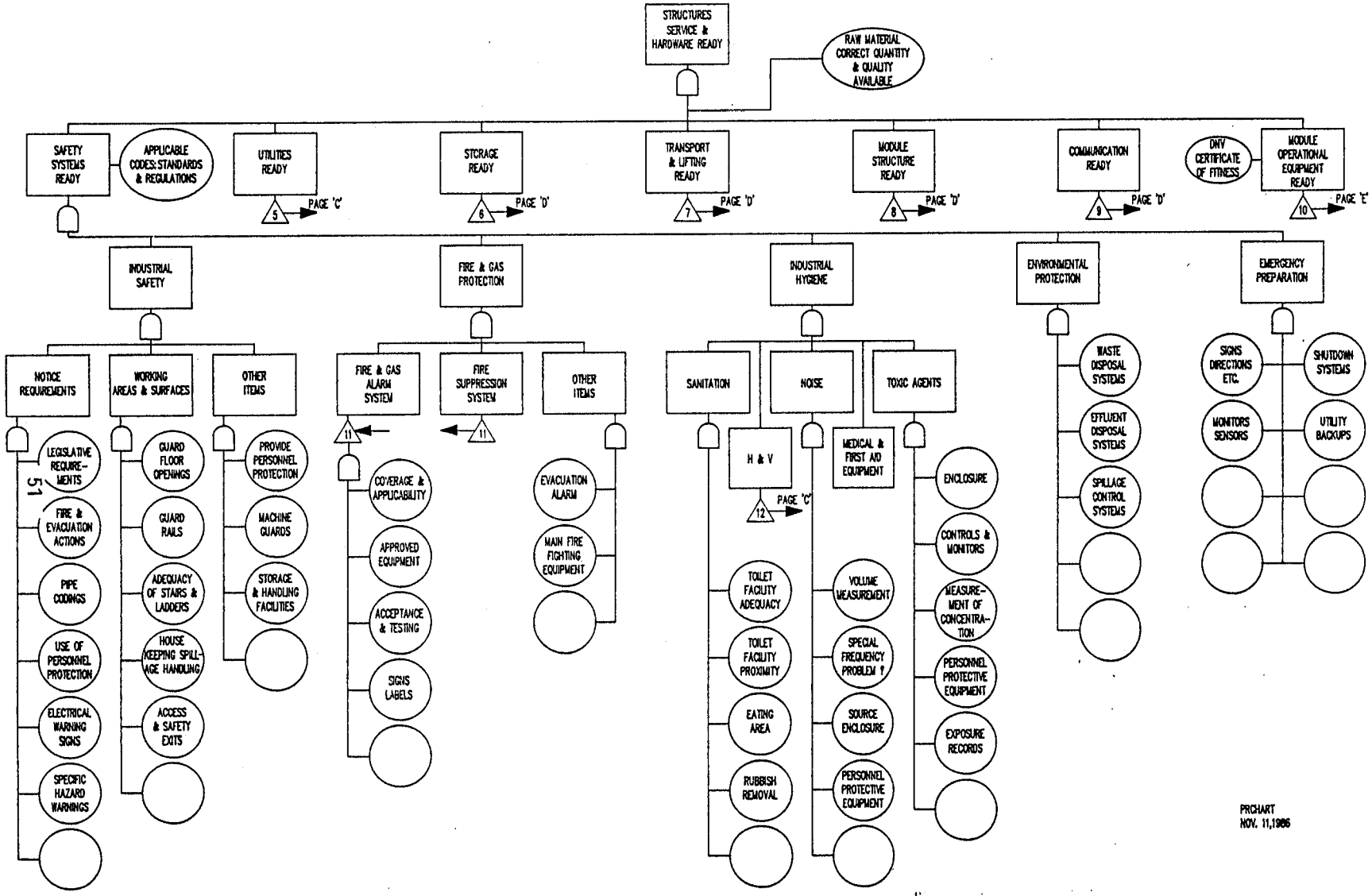

STRUCTURES SERVICE & HARDWARE READY
RAW MATERIAL CORRECT QUANTITY & QUALITY AVAILABLE
SAFETY SYSTEMS READY
APPLICABLE CODES: STANDARDS & REGULATIONS
UTILITIES READY
5
PAGE 'C'
STORAGE READY
6
PAGE 'D'
TRANSPORT & LIFTING READY
7
PAGE 'D'
MODULE STRUCTURE READY
8
PAGE 'D'
COMMUNICATION READY
9
PAGE 'D'
DNV CERTIFICATE OF FITNESS
MODULE OPERATIONAL EQUIPMENT READY
10
PAGE 'E'
INDUSTRIAL SAFETY
FIRE & GAS PROTECTION
INDUSTRIAL HYGIENE
ENVIRONMENTAL PROTECTION
EMERGENCY PREPARATION
NOTICE REQUIREMENTS
WORKING AREAS & SURFACES
OTHER ITEMS
FIRE & GAS ALARM SYSTEM
FIRE SUPPRESSION SYSTEM
OTHER ITEMS
SANITATION
NOISE
TOXIC AGENTS
LEGISLATIVE REQUIREMENTS
FIRE & EVACUATION ACTIONS
PIPE CODINGS
USE OF PERSONNEL PROTECTION
ELECTRICAL WARNING SIGNS
SPECIFIC HAZARD WARNINGS
GUARD FLOOR OPENINGS
GUARD RAILS
ADEQUACY OF STAIRS & LADDERS
HOUSE KEEPING SPILLAGE HANDLING
ACCESS & SAFETY EXITS
PROVIDE PERSONNEL PROTECTION
MACHINE GUARDS
STORAGE & HANDLING FACILITIES
11
11
CO'VERAGE & APPLICABILITY
APPROVED EQUIPMENT
ACCEPTANCE & TESTING
SIGNS LABELS
EVACUATION ALARM
MAIN FIRE FIGHTING EQUIPMENT
H & V
12
PAGE 'C'
MEDICAL & FIRST AID EQUIPMENT
TOILET FACILITY ADEQUACY
TOILET FACILITY PROXIMITY
EATING AREA
RUBBISH REMOVAL
VOLUME MEASUREMENT
SPECIAL FREQUENCY PROBLEM ?
SOURCE ENCLOSURE
PERSONNEL PROTECTIVE EQUIPMENT
ENCLOSURE
CONTROLS & MONITORS
MEASUREMENT OF CONCENTRATION
PERSONNEL PROTECTIVE EQUIPMENT
EXPOSURE RECORDS
WASTE DISPOSAL SYSTEMS
EFFLUENT DISPOSAL SYSTEMS
SPILLAGE CONTROL SYSTEMS
SIGNS DIRECTIONS ETC.
MONITORS SENSORS
SHUTDOWN SYSTEMS
UTILITY BACKUPS
51
PRCHART
NOV. 11,1986

Figure A6

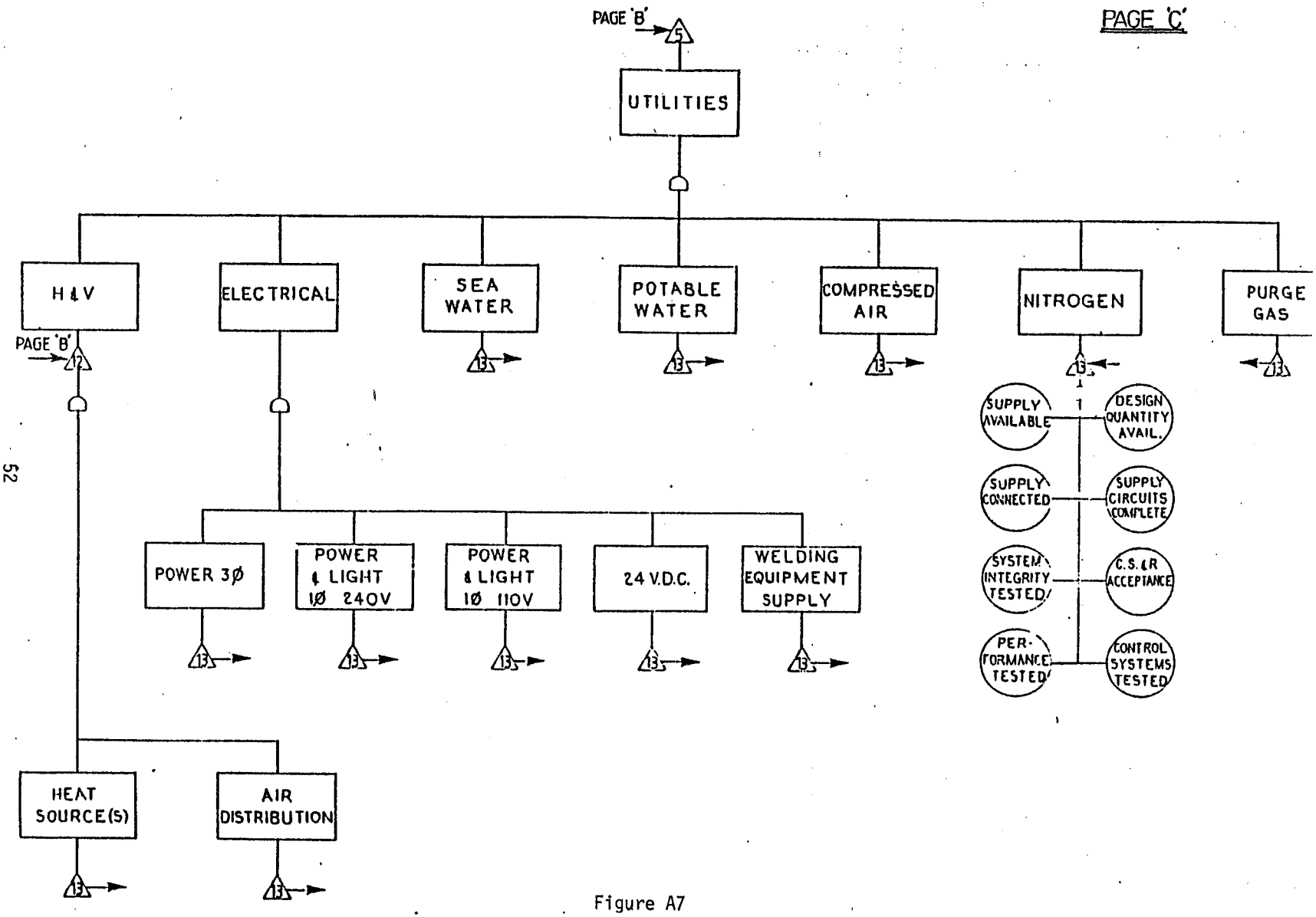
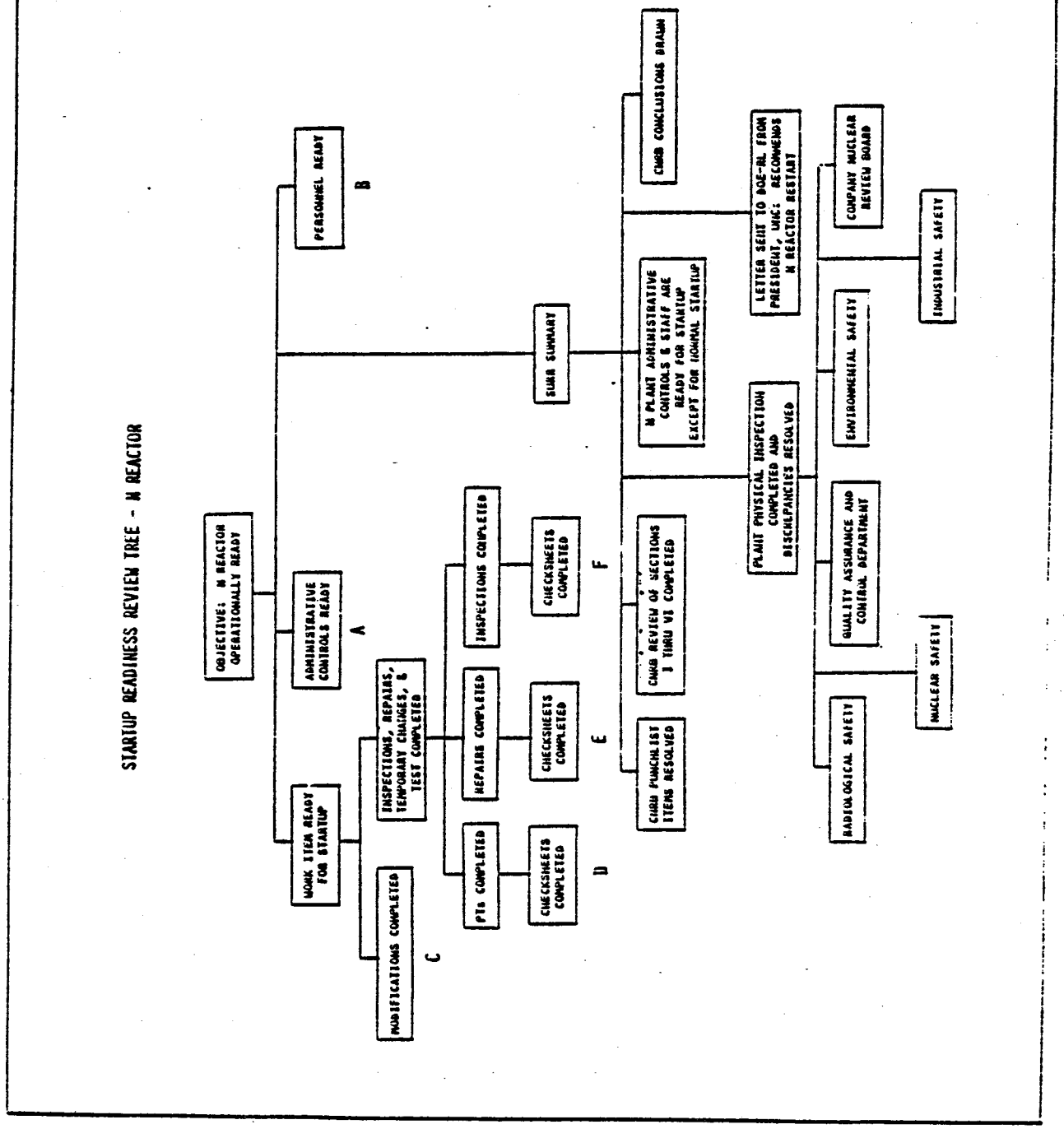

PAGE 'B'
5
PAGE 'C'
UTILITIES
H & V
ELECTRICAL
SEA WATER
POTABLE WATER
COMPRESSED AIR
NITROGEN
PURGE GAS
PAGE 'B'
12
13
SUPPLY AVAILABLE
DESIGN QUANTITY AVAIL.
SUPPLY CONNECTED
SUPPLY CIRCUITS COMPLETE
SYSTEM INTEGRITY TESTED
C.S. & R ACCEPTANCE
PER-FORMANCE TESTED
CONTROL SYSTEMS TESTED
POWER 3Ø
POWER & LIGHT 1Ø 240V
POWER & LIGHT 1Ø 110V
24 V.D.C.
WELDING EQUIPMENT SUPPLY
HEAT SOURCE(S)
AIR DISTRIBUTION

Figure A7

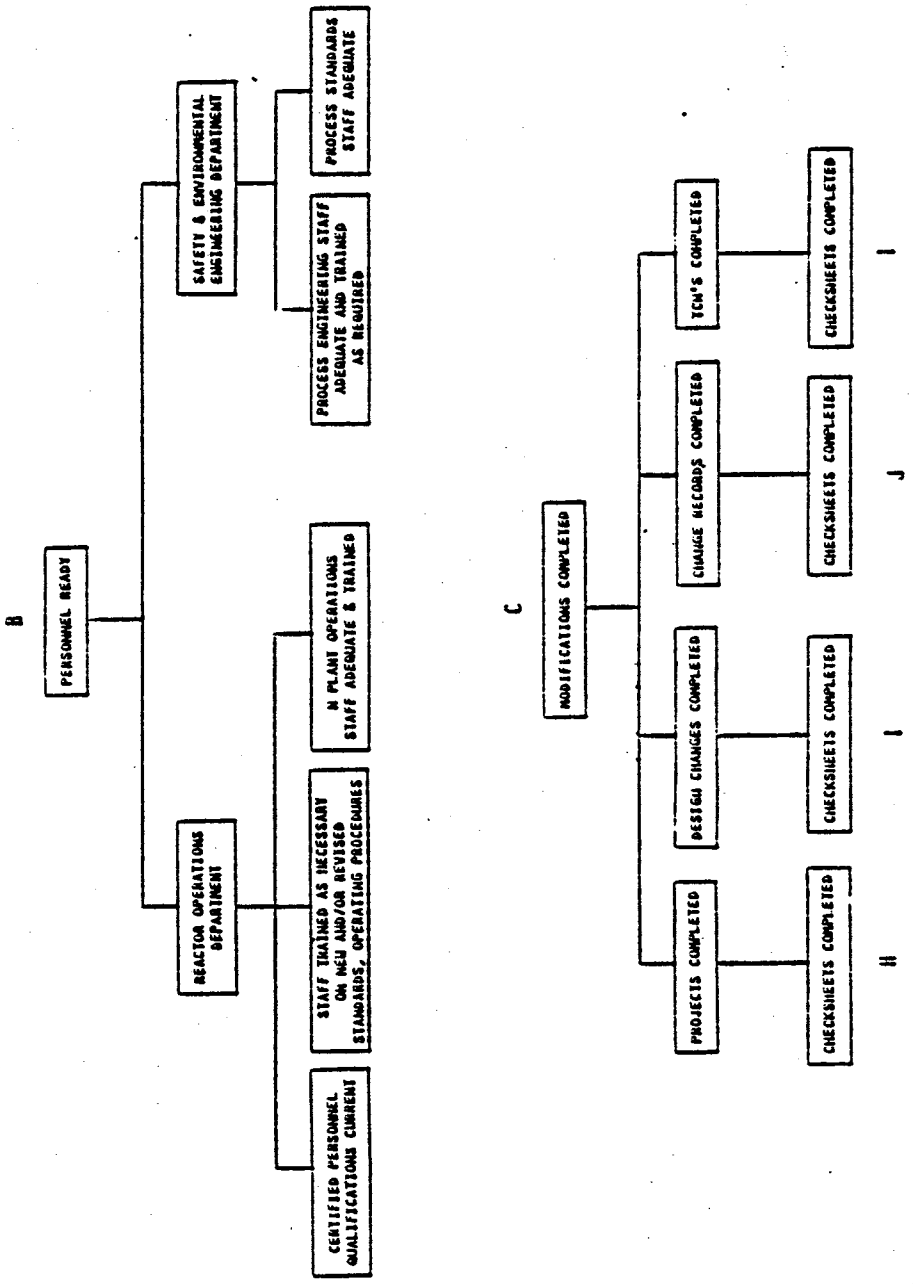
EXAMPLE 3

This example has to do with startup readiness for a nuclear reactor.



SM-5000-050 (4-79)

Figure A8



SM-5000-050 (4-79)

Figure A9

EXAMPLE 4

This is the startup readiness tree for the Princeton Tokamak Fusion Test Reactor (TFTR).

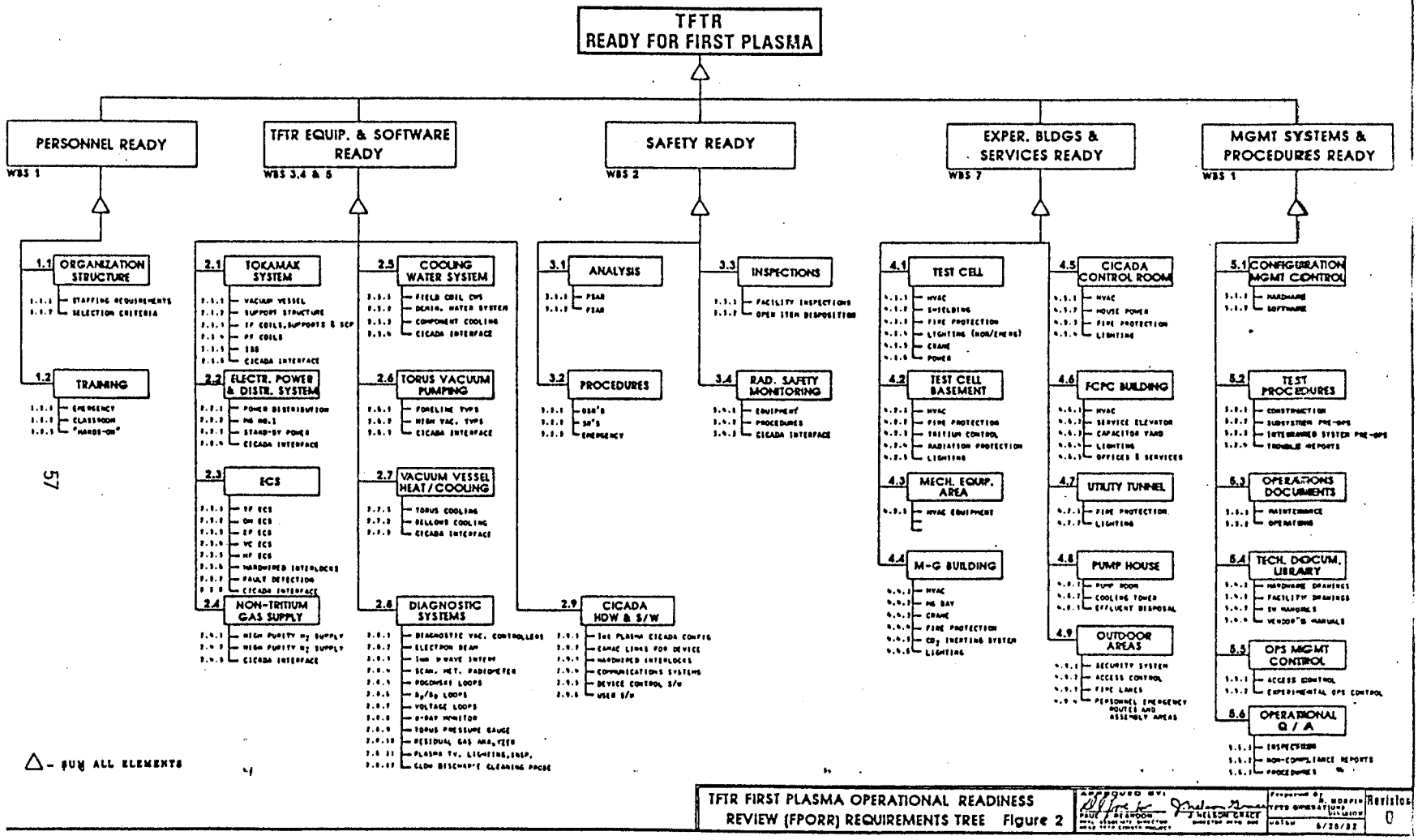

TFTR
READY FOR FIRST PLASMA
PERSONNEL READY
WBS 1
TFTR EQUIP. & SOFTWARE READY
WBS 3,4 & 5
SAFETY READY
WBS 2
EXPER. BLDGS & SERVICES READY
WBS 7
MGMT SYSTEMS & PROCEDURES READY
WBS 1
1.1 ORGANIZATION STRUCTURE
1.2 TRAINING
2.1 TOKAMAK SYSTEM
2.2 ELECTR. POWER & DISTR. SYSTEMS
2.3 ECS
2.4 NON-TRITIUM GAS SUPPLY
2.5 COOLING WATER SYSTEM
2.6 TORUS VACUUM PUMPING
2.7 VACUUM VESSEL HEAT/COOLING
2.8 DIAGNOSTIC SYSTEMS
2.9 CICADA HDW & S/W
3.1 ANALYSIS
3.2 PROCEDURES
3.3 INSPECTIONS
3.4 RAD. SAFETY MONITORING
4.1 TEST CELL
4.2 TEST CELL BASEMENT
4.3 MECH. EQUIP. AREA
4.4 M-G BUILDING
4.5 CICADA CONTROL ROOM
4.6 FCPC BUILDING
4.7 UTILITY TUNNEL
4.8 PUMP HOUSE
4.9 OUTDOOR AREAS
5.1 CONFIGURATION MGMT CONTROL
5.2 TEST PROCEDURES
5.3 OPERATIONS DOCUMENTS
5.4 TECH. DOCUM. LIBRARY
5.5 OPS MGMT CONTROL
5.6 OPERATIONAL Q/A
△ - SUM ALL ELEMENTS
TFTR FIRST PLASMA OPERATIONAL READINESS REVIEW (FPORR) REQUIREMENTS TREE Figure 2
Revision 0

Figure A10

EXAMPLE 5

This is the hardware branch of a nuclear reactor operational readiness tree. The operational readiness work sheet discussed in Figure 17 of this report is completed for each hardware item in this tree. This eliminates the need for much laborious duplication on the personnel, procedures/controls branches.

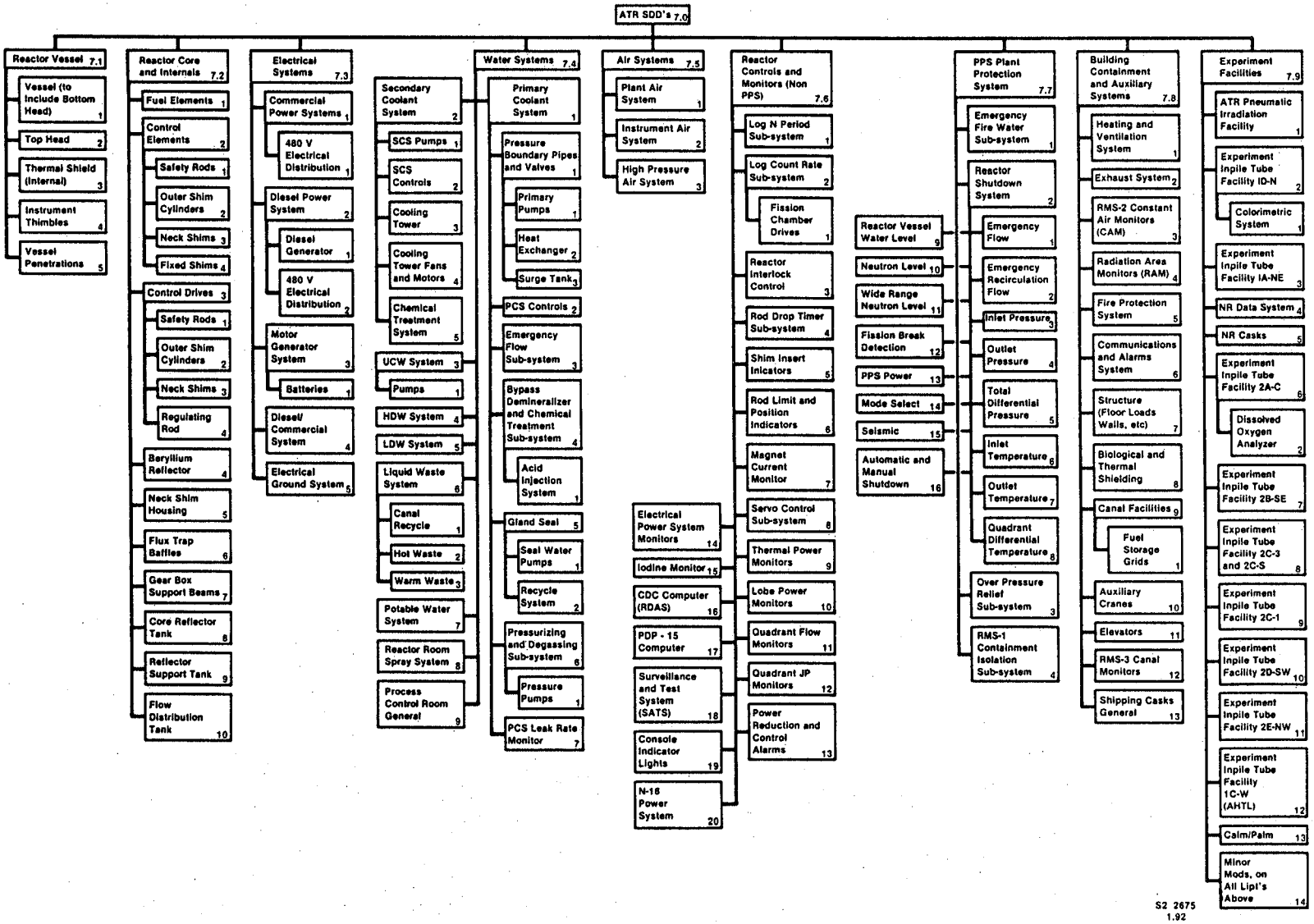

ATR SDD's 7.0
Reactor Vessel 7.1
Vessel (to Include Bottom Head) 1
Top Head 2
Thermal Shield (Internal) 3
Instrument Thimbles 4
Vessel Penetrations 5
Reactor Core and Internals 7.2
Fuel Elements 1
Control Elements 2
Safety Rods 1
Outer Shim Cylinders 2
Neck Shims 3
Fixed Shims 4
Control Drives 3
Safety Rods 1
Outer Shim Cylinders 2
Neck Shims 3
Regulating Rod 4
Beryllium Reflector 4
Neck Shim Housing 5
Flux Trap Baffles 6
Gear Box Support Beams 7
Core Reflector Tank 8
Reflector Support Tank 9
Flow Distribution Tank 10
Electrical Systems 7.3
Commercial Power Systems 1
480 V Electrical Distribution 1
Diesel Power System 2
Diesel Generator 1
480 V Electrical Distribution 2
Motor Generator System 3
Batteries 1
Diesel/ Commercial System 4
Electrical Ground System 5
Secondary Coolant System 2
SCS Pumps 1
SCS Controls 2
Cooling Tower 3
Cooling Tower Fans and Motors 4
Chemical Treatment System 5
UCW System 3
Pumps 1
HDW System 4
LDW System 5
Liquid Waste System 6
Canal Recycle 1
Hot Waste 2
Warm Waste 3
Potable Water System 7
Reactor Room Spray System 8
Process Control Room General 9
Water Systems 7.4
Primary Coolant System 1
Pressure Boundary Pipes and Valves 1
Primary Pumps 1
Heat Exchanger 2
Surge Tank 3
PCS Controls 2
Emergency Flow Sub-system 3
Bypass Demineralizer and Chemical Treatment Sub-system 4
Acid Injection System 1
Gland Seal 5
Seal Water Pumps 1
Recycle System 2
Pressurizing and Degassing Sub-system 6
Pressure Pumps 1
PCS Leak Rate Monitor 7
Air Systems 7.5
Plant Air System 1
Instrument Air System 2
High Pressure Air System 3
Electrical Power System Monitors 14
Iodine Monitor 15
CDC Computer (RDAS) 16
PDP - 15 Computer 17
Surveillance and Test System (SATS) 18
Console Indicator Lights 19
N-16 Power System 20
Reactor Controls and Monitors (Non PPS) 7.6
Log N Period Sub-system 1
Log Count Rate Sub-system 2
Fission Chamber Drives 1
Reactor Interlock Control 3
Rod Drop Timer Sub-system 4
Shim Insert Inicators 5
Rod Limit and Position Indicators 6
Magnet Current Monitor 7
Servo Control Sub-system 8
Thermal Power Monitors 9
Lobe Power Monitors 10
Quadrant Flow Monitors 11
Quadrant JP Monitors 12
Power Reduction and Control Alarms 13
Reactor Vessel Water Level 9
Neutron Level 10
Wide Range Neutron Level 11
Fission Break Detection 12
PPS Power 13
Mode Select 14
Seismic 15
Automatic and Manual Shutdown 16
PPS Plant Protection System 7.7
Emergency Fire Water Sub-system 1
Reactor Shutdown System 2
Emergency Flow 1
Emergency Recirculation Flow 2
Inlet Pressure 3
Outlet Pressure 4
Total Differential Pressure 5
Inlet Temperature 6
Outlet Temperature 7
Quadrant Differential Temperature 8
Over Pressure Relief Sub-system 3
RMS-1 Containment Isolation Sub-system 4
Building Containment and Auxiliary Systems 7.8
Heating and Ventilation System 1
Exhaust System 2
RMS-2 Constant Air Monitors (CAM) 3
Radiation Area Monitors (RAM) 4
Fire Protection System 5
Communications and Alarms System 6
Structure (Floor Loads Walls, etc) 7
Biological and Thermal Shielding 8
Canal Facilities 9
Fuel Storage Grids 1
Auxiliary Cranes 10
Elevators 11
RMS-3 Canal Monitors 12
Shipping Casks General 13
Experiment Facilities 7.9
ATR Pneumatic Irradiation Facility 1
Experiment Inpile Tube Facility ID-N 2
Colorimetric System 1
Experiment Inpile Tube Facility IA-NE 3
NR Data System 4
NR Casks 5
Experiment Inpile Tube Facility 2A-C 6
Dissolved Oxygen Analyzer 2
Experiment Inpile Tube Facility 2B-SE 7
Experiment Inpile Tube Facility 2C-3 and 2C-S 8
Experiment Inpile Tube Facility 2C-1 9
Experiment Inpile Tube Facility 2D-SW 10
Experiment Inpile Tube Facility 2E-NW 11
Experiment Inpile Tube Facility 1C-W (AHTL) 12
Calm/Palm 13
Minor Mods, on All Lipt's Above 14
S2 2675
1.92

Figure A11

EXAMPLE 6

This is the operational readiness tree for preparation of an RFP (Request for Proposal) for an AMO (Aerial Measurement Operations) support facility.

Let's look at an example of readiness for a real life ground support facility.

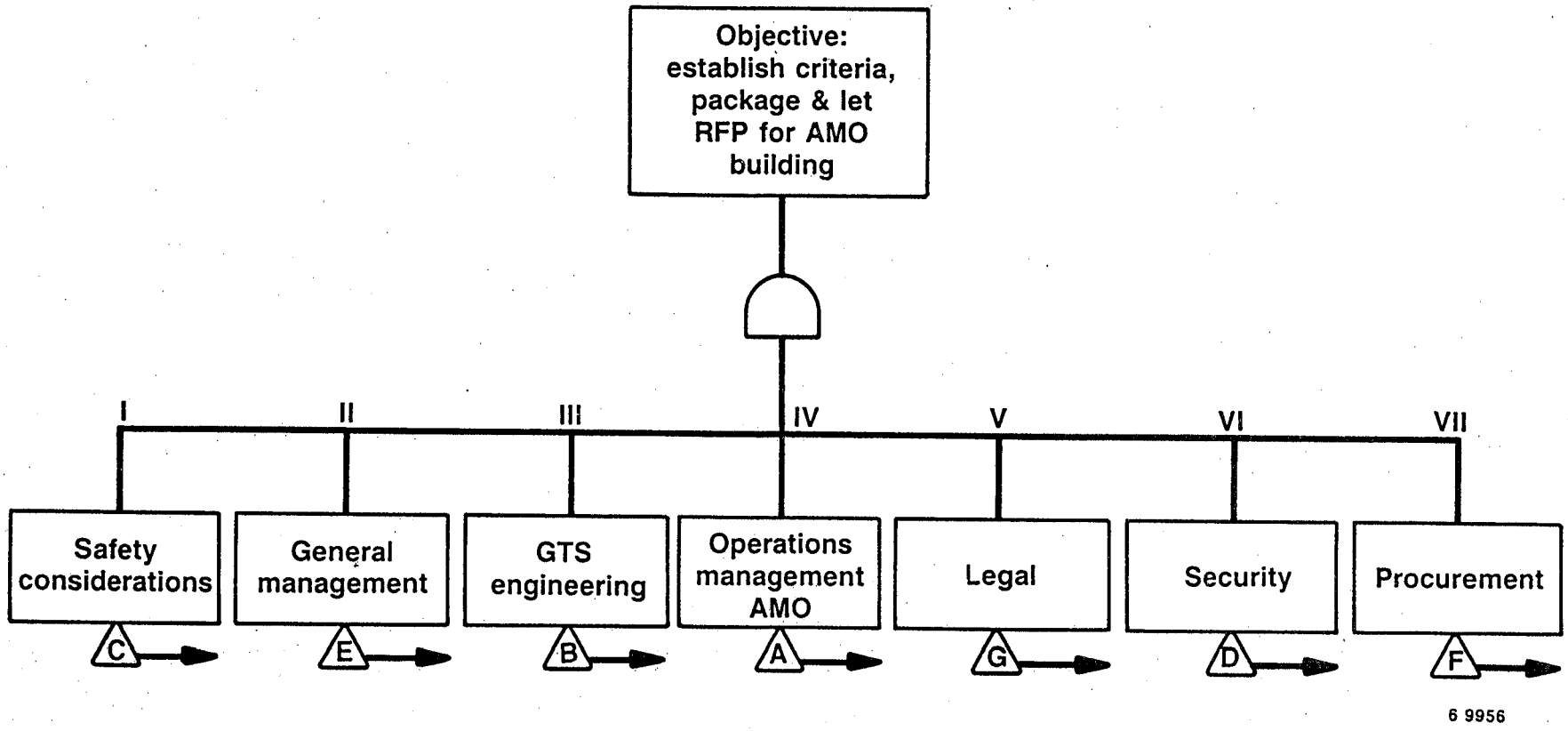


Figure A12

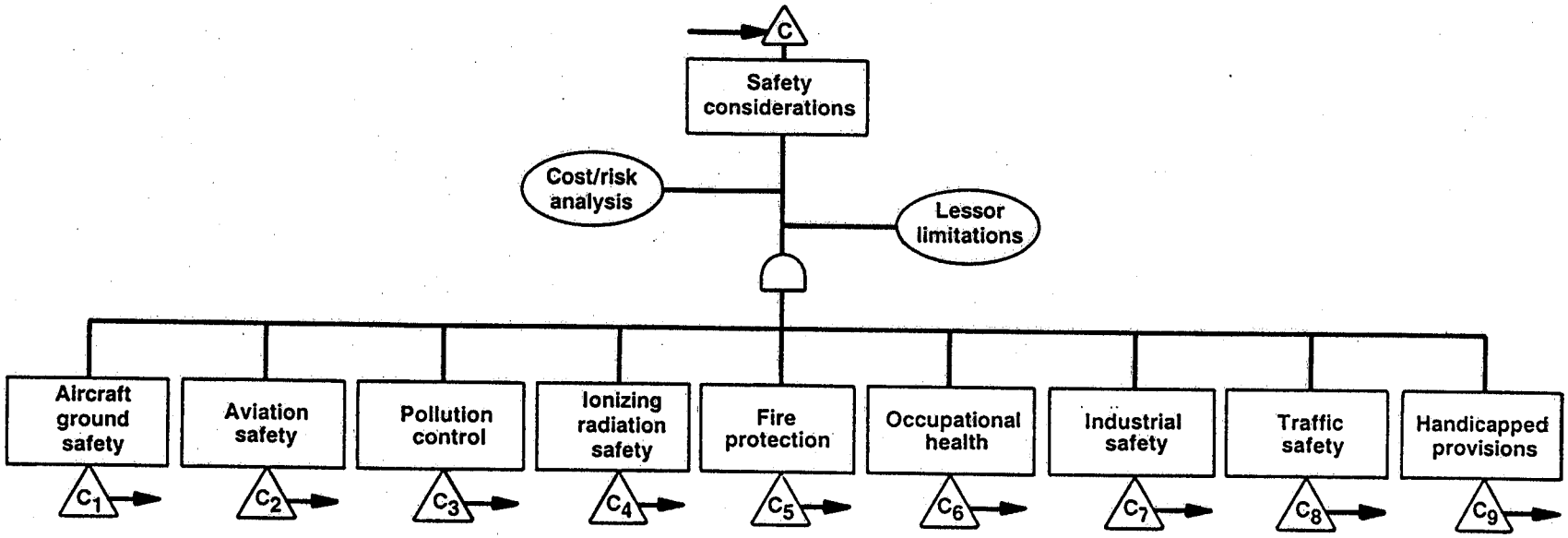

C
Safety considerations
Cost/risk analysis
Lessor limitations
Aircraft ground safety
Aviation safety
Pollution control
Ionizing radiation safety
Fire protection
Occupational health
Industrial safety
Traffic safety
Handicapped provisions
C1
C2
C3
C4
C5
C6
C7
C8
C9
6 10 044

Figure A13

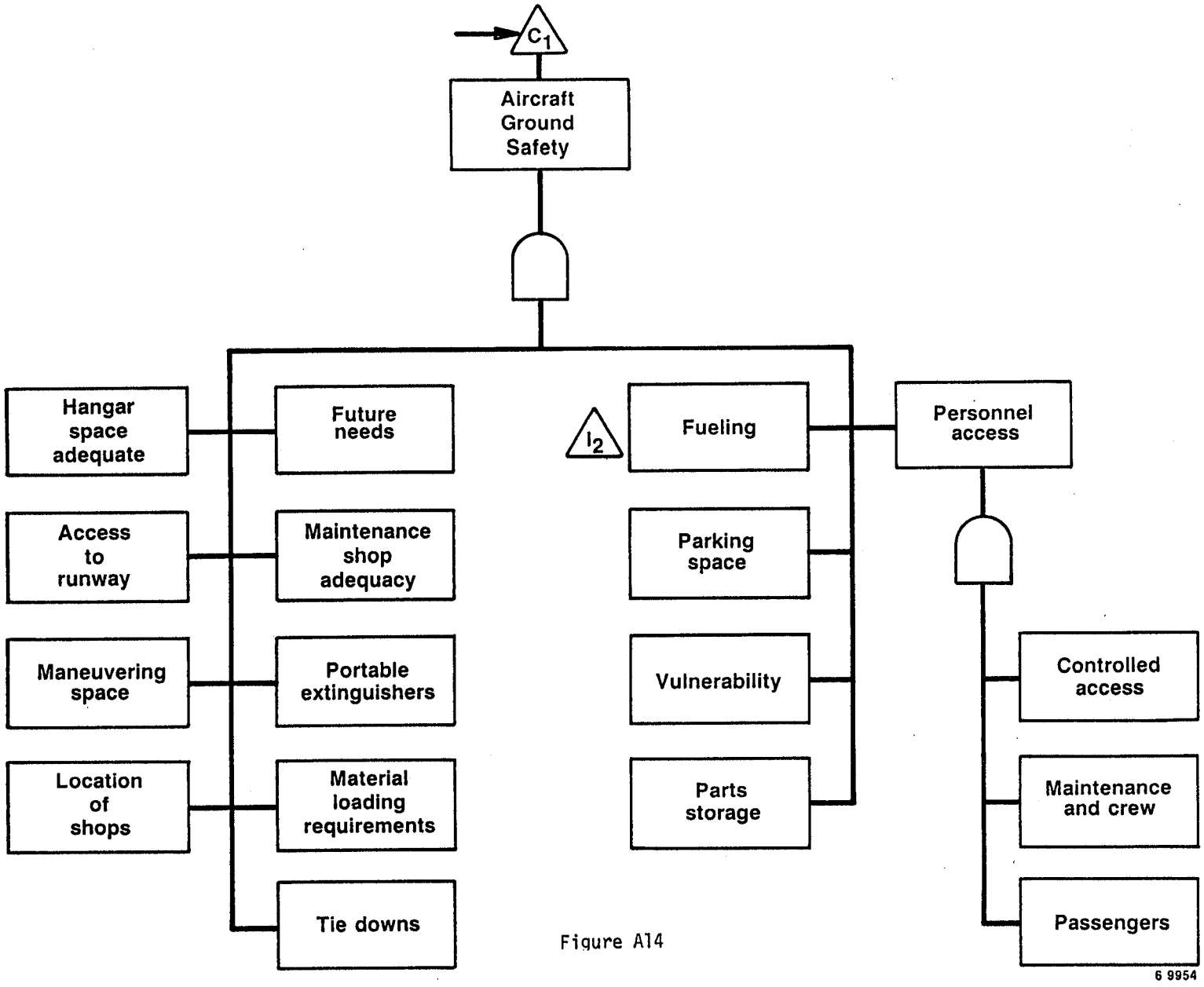

C1
Aircraft Ground Safety
Hangar space adequate
Future needs
Access to runway
Maintenance shop adequacy
Maneuvering space
Portable extinguishers
Location of shops
Material loading requirements
Tie downs
I2
Fueling
Parking space
Vulnerability
Parts storage
Personnel access
Controlled access
Maintenance and crew
Passengers
6 9954

Figure A14

EXAMPLE 7

This is an operational readiness tree prepared to evaluate the readiness of radiation protection systems at nuclear power plants.

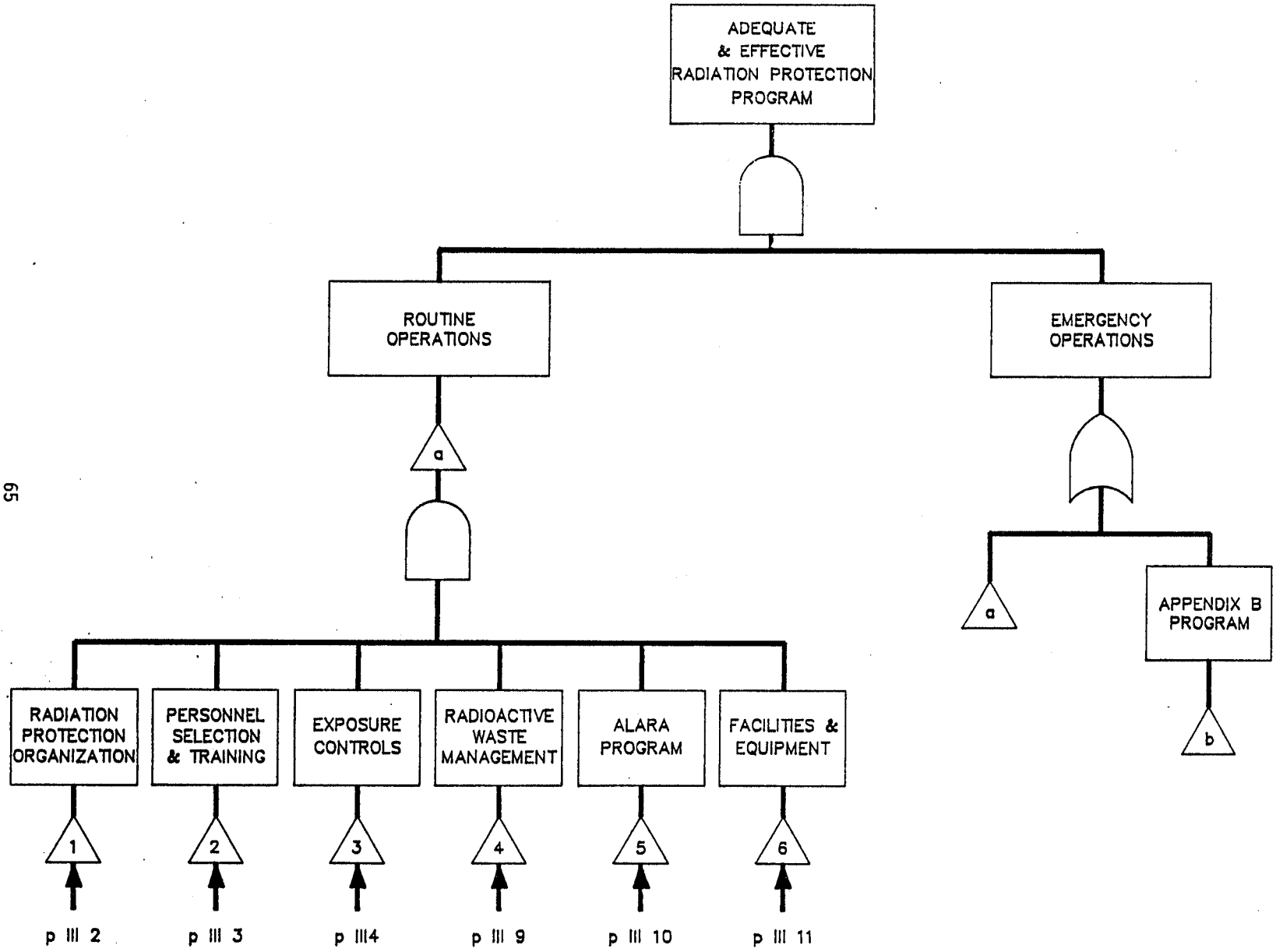


Figure A15

RPCHART NOV 5 1986

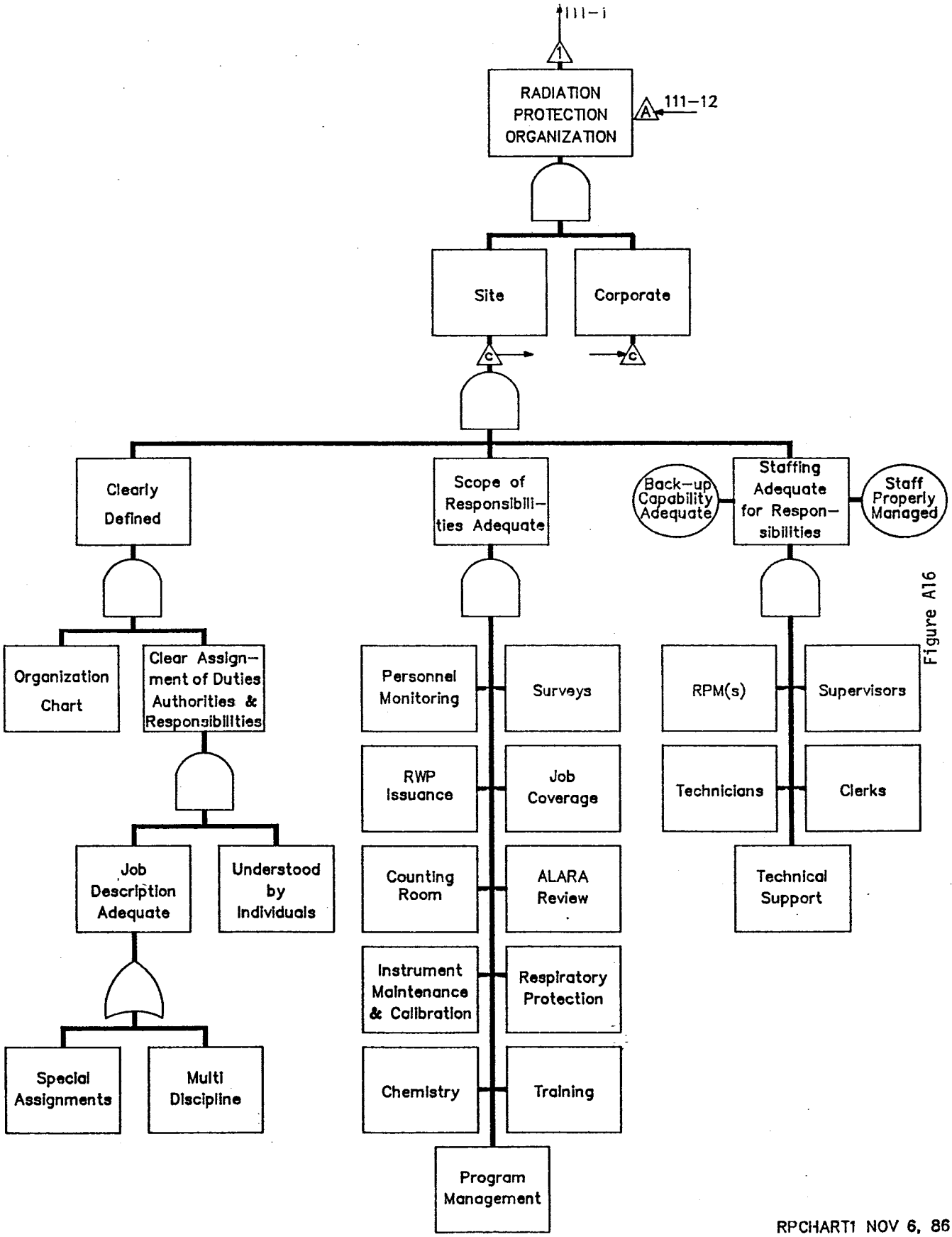


Figure A16

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APPENDIX B

APPENDIX B

AN ALTERNATIVE HARDWARE MAINTENANCE PROGRAM EVALUATION TREE

M. G. Bullock

1. FACILITY MAINTENANCE

Performance Objective

To provide a maintenance organization that is adequately staffed, trained, and has the necessary equipment to maintain the facility in a state of readiness to support the program requirements. The system of administration and control of the maintenance program shall enhance equipment reliability and performance, to assure plant safety and availability (Figure B-1).

1.1 Organization Structure and Administration--Criteria

1.1.1

The maintenance organization shall be of sufficient size and structure to enable safe and efficient performance of duties. The organization chart shall reflect actual reporting lines and show the relationship to other organizational units.

1.1.2

Comprehensive descriptions of maintenance nonbargaining unit positions shall be formally established. Position descriptions shall define job functions, responsibilities, and authorities. Copies of the position descriptions shall be made available to the respective individuals.

1.1.3

A training program shall be established for maintenance job functions that could affect the quality of structures, systems, and components related to reactor safety. The training program shall include applicable administrative controls, special complex system and component instructions, and on-the-job demonstration of performance capability.

1.1.4

Adequate maintenance facilities and equipment shall be provided to support completion of all necessary work and to promote safe and efficient work practices. The variety and quantity of spare parts, equipment, tooling, and consumable materials shall be adequate to prevent unnecessary delays. Methods of storage shall be adequate to prevent degradation of materials during storage.

1.2 Work Control System--Criteria

1.2.1

A work control system shall be established that provides for prompt identification of the need for maintenance action and results in the preparation of a formal work request.

1.2.2

A system of planning and scheduling of maintenance work to be performed during operating and shutdown periods shall be established. Planning and scheduling shall include interdepartmental coordination, work priority, man-hour estimates and special skills, procedures, equipment, and material required. Planning shall include any action needed to ensure personnel safety and to minimize personnel radiation exposure (ALARA).

1.2.3

To assure plant operating and design integrity is maintained, designated maintenance work shall be subjected to quality review. This review shall address at least the following:

1. Proper identification of safety related components, systems, or structures.

2. Appropriate acceptance criteria for post-maintenance verifications and functional test requirements.

3. Nondestructive examination and test requirements.

4. Procedure requirements for the proposed work.

5. Site Work Release (SWR) change controls shall be applied to maintenance work on any system that may affect plant safety or reliability.

1.2.4.

Approval by the operations shift supervisor or other designated operations personnel shall be required prior to starting any maintenance work within the reactor facility. Maintenance supervisory personnel shall monitor work in progress to assure that the work is completed as described.

1.2.5

Inspection instructions and other specific precautions shall be integrated into the work control document to assure no undesirable materials enter the primary system or rotating equipment. Inspection and operational checkouts shall be performed at the completion of maintenance work to assure system integrity and operability where applicable.

1.2.6

Completed work control documents shall be reviewed for completeness and verification of the following:

1. Applicable procedures completed.

2. Applicable data sheets filled out properly.

3. All acceptance criteria have been met.

1.2.7

Personnel required to review and verify completion of work control documents shall be designated formally.

1.3 Maintenance Procedures--Criteria

1.3.1

For safety-related and other critical equipment, specific procedures for preventive and corrective maintenance shall be prepared. A system for timely development and revision of maintenance procedures shall exist.

1.3.2

A clear and consistent format for maintenance procedures shall be used. Maintenance procedures shall contain adequate instructions to assure the safe and reliable completion and accurate documentation of the activities performed.

1.3.3

Maintenance procedure, data sheets, and other work control documents completed during the performance of maintenance activities shall be

reviewed periodically to identify persistent or recurring problems and adjustments made to preventive maintenance activities, maintenance practices, and operating practices to further enhance plant safety and reliability.

1.4 Preventive Maintenance--Criteria

1.4.1

The preventive maintenance program shall be documented including specific criteria that defines plant equipment and instrumentation to be included. The preventive maintenance program shall include at least the following:

1. Equipment affecting personnel safety.

2. Equipment used to perform or satisfy a Technical Specification requirement.

3. Equipment the operator must rely upon for plant assessment and control.

4. Equipment affecting plant reliability or availability.

5. Equipment that requires routine lubrication and/or inspection.

1.4.2

Safety-related equipment shall have specific preventive maintenance procedures available and a history file of completed procedures established and updated routinely as changes to equipment occur.

1.4.3

Preventive maintenance shall be specified and conducted on plant equipment at realistic frequencies. The preventive maintenance

requirements shall be based on manufacturer's recommendations, Technical Specification requirements, past operating experiences, and good maintenance practices, as applicable.

1.4.4

Preventive maintenance status shall be monitored and controlled to ensure activities are completed as scheduled. Any preventive maintenance activities that are deferred shall be reviewed and evaluated by operations management.

1.5 Control of Portable Measurement and Test Equipment--Criteria

1.5.1

The calibration status of measurement and test equipment shall be readily apparent and the equipment shall be uniquely and permanently identified.

1.5.2

Calibration of measurement and test equipment shall be at defined intervals or prior to use. Certified equipment, traceable to nationally recognized standards shall be used for calibrating measurement and test equipment.

1.5.3

Storage and issuance of measurement and test equipment shall be under a controlled system so as to assure product quality.

1.5.4

Any measurement and test equipment that fails to meet calibration specifications shall be identified by attaching a reject tag documenting the rejection and storing rejected equipment in a separate location. Any

measurements made with that instrument during the interval of the out of tolerance condition shall be evaluated and remeasurements performed, if required. The results of the evaluation shall be documented and filed.

1.6 Control of Special Processes--Criteria

1.6.1

A program shall exist for the training, qualification, requalification, and certification of personnel, procedures, and equipment needed to perform special processes. This program shall be under sufficient configuration control to assure consistent product quality. This program shall include the special processes specified by the EG&G Idaho Quality Manual, QP-9.

1.6.2

A program shall be established for periodic routine maintenance of special process equipment

FACILITY MAINTENANCE

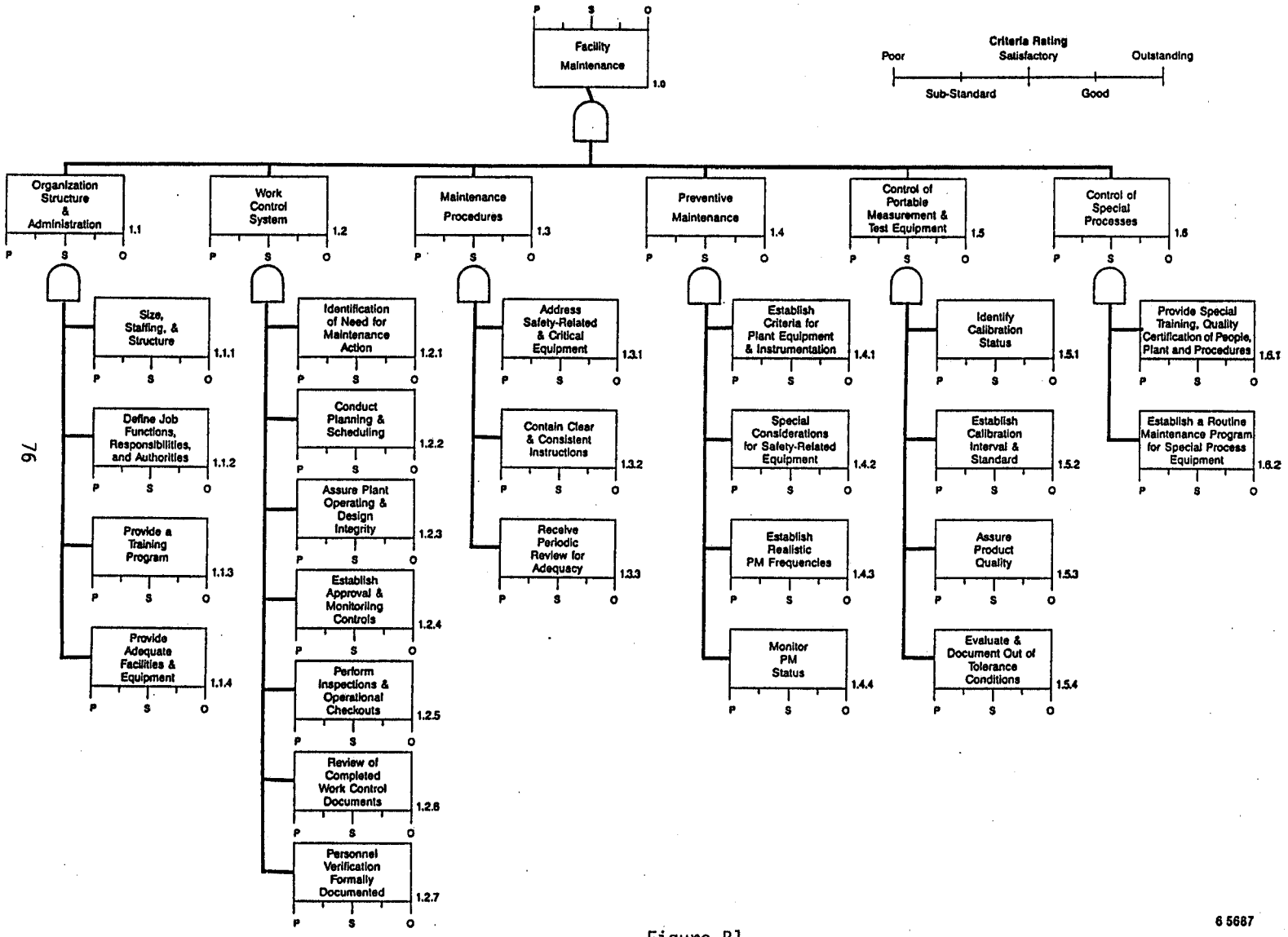

Figure B1

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COMPLETED SSDC PUBLICATIONS

SSDC-1 Occupancy-Use Readiness Manual
SSDC-2 Human Factors in Design
SSDC-3 A Contractor Guide to Advance Preparation for Accident Investigation
SSDC-4 MORT User's Manual
SSDC-5 Reported Significant Observation (RSO) Studies
SSDC-6 Training as Related to Behavioral Change
SSDC-7B DOE Guide to the Classification of Recordable Accidents
SSDC-8 Standardization Guide for Construction and Use of MORT-Type Analytic Trees
SSDC-9 Safety Information System Guide
SSDC-10 Safety Information System Cataloging
SSDC-11 Risk Management Guide
SSDC-12 Safety Considerations in Evaluation of Maintenance Programs
SSDC-13 Management Factors in Accident/Incidents (Including Management Self-Evaluation Checksheets)
SSDC-14 Events and Causal Factors Charting
SSDC-15 Work Process Control Guide
SSDC-16 SPRO Drilling and Completion Operations
SSDC-17 Applications of MORT to Review of Safety Analyses
SSDC-18 Safety Performance Measurement System
SSDC-19 Job Safety Analysis
SSDC-20 Management Evaluation and Control of Release of Hazardous Materials
SSDC-21 Change Control and Analysis
SSDC-22 Reliability and Fault Tree Analysis Guide
SSDC-23 Safety Appraisal Guide
SSDC-24 Safety Assurance System Summary (SASS) Manual for Appraisal
SSDC-25 Effective Safety Review
SSDC-26 Construction Safety Monographs
- 26.1 Excavation
- 26.2 Scaffolding
- 26.3 Steel Erection
- 26.4 Electrical
- 26.5 Housekeeping
- 26.6 Welding/Cutting
- 26.7 Confined Spaces
- 26.8 Heating of Work Spaces
- 26.9 Use of Explosives
- 26.10 Medical Services
- 26.11 Sanitation
- 26.12 Ladders
- 26.13 Painting/Special Coatings
- 26.14 Fire Protection
- 26.15 Project Layout
- 26.16 Emergency Action Plans
- 26.17 Heavy Equipment
- 26.18 Air Quality

SSDC-27	Accident/Incident Investigation Manual (2nd Edition)
SSDC-28	Glossary of SSDC Terms and Acronyms
SSDC-29	Barrier Analysis
SSDC-30	Human Factors Management
SSDC-31	The Process of Task Analysis
SSDC-32	The Impact of the Human on System Safety Analysis
SSDC-33	The MORT Program and the Safety Performance Measurement System
SSDC-34	Basic Human Factors Considerations
SSDC-35	A Guide for the Evaluation of Displays
SSDC-36	MORT-Based Safety Professional/Program Development and Improvement
SSDC-37	Time/Loss Analysis
SSDC-38	Safety Considerations for Security Programs
SSDC-39	Process Operational Readiness and Operational Readiness Follow-On
SSDC-40	The Assessment of Behavioral Climate